

# STUDIES IN THE GLOSSOPTERIS FLORA OF INDIA: 1. SOME NEW FOSSIL PLANTS FROM THE LOWER GONDWANAS OF THE RANIGANJ COALFIELD, INDIA

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## ABSTRACT

The plants described here are: (1) one species of *Sphenopteris*, viz. *Sphenopteris lobifolia* Morris, which is being recorded for the first time from the Lower Gondwana rocks of India; (2) a fertile frond of *Pecopteris* probably belonging to the genus *Ptychocarpus*; (3) an interesting specimen most probably referable to the genus *Ctenis*; (4) a new species of the problematical genus *Actinopteris*, viz. *Actinopteris indica*; and (5) a fructification, a cone most probably belonging to *Schizoneura gondwanensis*.

## INTRODUCTION

**G**LOSSOPTERIS flora found in the Lower Gondwana rocks is the oldest well-preserved flora of India. Earlier it had attracted the attention of palaeobotanists because of its association with the coal, but in later years it did not receive the attention it deserved. Since the completion of the memoirs by Feistmantel in the years 1879-86, not much work has been done on this flora in India. After Feistmantel, only Zeiller (1902), Seward and Sahni (1920) and Sahni (1928) have revised some of the Lower Gondwana plants, described earlier by Feistmantel.

This paper deals with the description of some new fossil plants, collected by the author from the Raniganj coalfield, Bengal, India.

## MATERIAL AND METHODS

All the fossils mentioned above come from the Raniganj stage of the Lower Gondwanas (Upper Permian?). They are in the form of compressions on black carbonaceous shales having sometimes well-preserved carbonized crust.

In addition to studying these compressions externally, I have studied, wherever possible, their epidermal structures also. The well-known maceration method of cuticular study did not prove very successful in these plants. As an alternative, Canada

balsam and cellulose peel transfers were prepared to study their epidermal structures. Cellulose peel transfers yielded better results, because wherever necessary they could be treated with dilute nitric acid for oxidizing the carbonized crust further.

## DESCRIPTION

### ? Filicales

#### 1. *Sphenopteris lobifolia* Morris

The genus *Sphenopteris* was instituted by Brongniart (1822) and since then a large number of species have been described under this genus. It is reported from the Palaeozoic and Mesozoic rocks of both the northern and southern hemispheres. *Sphenopteris* is the largest form genus, including compound fronds of fern-like plants, deeply cut or lobed in habit. It includes many fronds of unknown systematic position. Some of the Sphenopterids bore fern-like fructifications and others produced seeds like those of Pteridosperms. Fertile specimens have been separated from the form genus *Sphenopteris* and they are described under different generic names and *Sphenopteris* is now retained mainly for the sterile foliage. From the Lower Gondwana rocks of India only two species of *Sphenopteris* are known so far. *Sphenopteris lobifolia* is the third I am recording from here.

*Sphenopteris lobifolia* was first described by Morris (1845) from New South Wales. Feistmantel (1878) has also recorded this species from the Permo-Carboniferous rocks of New South Wales and Queensland. From Tasmania it is reported from the Upper Coal Measures of the Mesozoic age. Arber (1905) included in this species the fronds designated as *Sphenopteris hastata*, *Sphenopteris flexuosa*, *Sphenopteris germana* and *Sphenopteris plumosa* McCoy. *Sphenopteris lobifolia* has so far not been reported from the Lower Gondwana rocks of India. My specimen,



which comes from the Raniganj stage of the Lower Gondwanas, is identical with this species.

LEAF — SPECIMEN No. 9385

Carbonized impression of the apical portion of a frond (PL. 1, FIG. 1) consisting of a bipinnate, slightly winged rachis. There are about six pinnae on each side, the basal ones are larger, gradually becoming smaller in length towards the apex, giving a triangular look to the frond. The pinnae are alternate and lanceolate in shape. The axis of each pinna is grooved. The pinnules are more or less oval with slightly lobed margins (PL. 1, FIG. 2). They are slightly contracted towards the base and are not very close to each other. Each pinnule has a median nerve which is slender and sinuate (TEXT-FIG. 1). The median nerve gives out branches right and left which bifurcate and run up to the margin of the pinnule.

*Epidermal Characters as Revealed by the Transfer Preparation* — The epidermal cells (PL. 1, FIG. 3) are polygonal or sometimes rectangular in outline. They are not much longer than broad. The walls of these cells are straight and somewhat thick.

*Comparison* — My specimen shows a striking resemblance in size, shape and form of the frond to *Sphenopteris lobifolia* Morris described by Arber (1905, pp. 136, 137, PL. 4, FIGS. 2, 3). In age also there is no difference, since Raniganj stage of the Damuda division is equivalent to the New Castle series of Australia.

2. A Fertile Frond of *Pecopteris*—  
? *Ptychocarpus* sp.

1881 — *Alethopteris Lindleyana* Feistmantel  
1905 — *Cladophlebis Roylei* Arber

From the Raniganj coalfield, I have collected two specimens of the fertile pinnae of a fern. Fertile specimens of the ferns are of very rare occurrence in the Lower Gondwana rocks of India. So far fragmentary specimens of only two fertile ferns have been reported by Feistmantel from here. He described one of his fertile impressions as *Alethopteris Lindleyana*, which Arber (1905) included in *Cladophlebis Roylei*.

My specimens compare with Feistmantel's specimens of *Alethopteris Lindleyana*, later changed to *Cladophlebis Roylei* by Arber. *Cladophlebis*, however, is a typically Meso-

zoic genus, retained for describing the sterile fronds of the ferns, intermediate in habit between *Pecopteris* and *Neuropteris* (SEWARD, 1910, p. 579). These specimens, therefore, cannot be referred to the genus *Cladophlebis*, because they are Palaeozoic ferns and also they are fertile specimens.

The attachment of the pinnules by their entire bases in these specimens is a character typical of the Pecopterid type of ferns. *Pecopteris* is a form genus which includes the Upper Carboniferous and Permian fern-like fronds. The genus *Pecopteris* has already been recorded from the Lower Gondwana rocks of India by Arber (1905), who transferred to this genus the fronds described as *Alethopteris phegopteroides* by Feistmantel.

Fertile ferns of the Pecopterid type have been described under different genera, viz. *Asterotheca*, *Ptychocarpus* and *Scolecopteris* (BOWER, 1926, p. 115) on the character of their fructification. These genera essentially belong to the northern flora, but Walton (1929, p. 69) has described two fertile fronds of *Asterotheca* from Karroo system in southern Rhodesia.

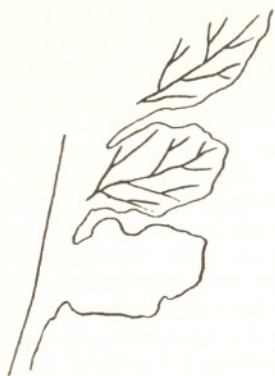
In the arrangement and the nature of the sori my specimen resembles most with *Ptychocarpus*.

LEAF — SPECIMEN No. 8669

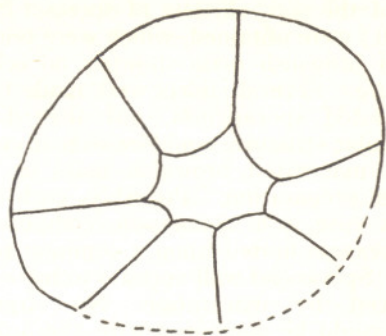
Carbonized impression of the pinna of a fertile fern (PL. 1, FIG. 4) slightly broken at the two ends, measuring nearly 9.5 cm. in length. Closely set pinnules are alternate in arrangement. They are attached by their whole bases to the rachis. The pinnules are oblong in shape, measuring nearly 1.2 cm. in length and 5 mm. in breadth. Their margin is crenulate. From the rachis a median nerve enters into each pinnule (PL. 1, FIG. 5), extending up to the tip. Secondary nerves come out from the median nerve and dichotomize once, immediately after which one branch of the veinlet ends below the sorus.

*Description of the Sori* — The sori are arranged in double linear rows, one on each side of the median nerve of the pinnule (PL. 1, FIG. 6). There are usually 6-8 sori in a row. They occupy a position midway between the median nerve and the margin of the pinnule. Each sorus is placed on a branch of the dichotomizing lateral nerve which ends below it (PL. 1, FIG. 5).

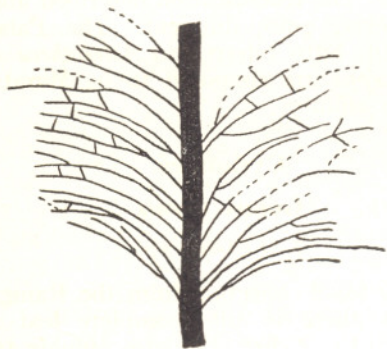




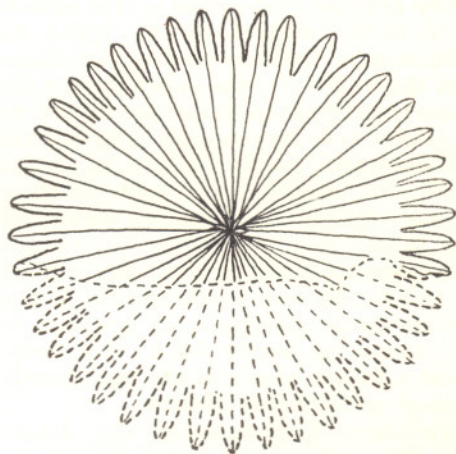
1



2



3



4

TEXT-FIGS. 1-4 — 1, *Sphenopteris lobifolia*, a line drawing of the photograph represented in Pl. 1, Fig. 2, to show the venation in the pinnules.  $\times$  Ca. 3. 2, ?*Ptychocarpus* sp., enlarged drawing of a sorus showing seven loculi.  $\times$  50. 3, ?*Ctenis* sp., a line drawing of the photograph represented in Pl. 2, Fig. 11, to show the anastomosing and cross-connections between the secondary veins.  $\times$  Nat. size. 4, *Actinopteris indica* sp. nov., a line drawing (partial restoration) from the photograph represented in Pl. 3, Fig. 26.  $\times$  Nat. size.

A sorus appears like a circular disc to the naked eye. However, a careful examination of a plasticene cast prepared from the

specimen under a low power microscope showed some sori having 6-7 loculi (TEXT-FIG. 2). On macerating the carbonized



discs of the sori, clusters of spores (PL. 2, FIG. 10) were obtained, which were released from a brownish mass showing no cellular structure. Several efforts were made to get an isolated sporangium, but they failed. No cellular structure could be seen anywhere in the macerated brownish mass or in a transfer preparation. Probably, each sorus in this case is a synangium, composed of 6-7 sporangia united upon a common receptacle. Sporangial wall appears to have been destroyed by maceration. No structure which could be compared with the annulus of a sporangium was seen. The sporangia in this case may be exannulate. Spores are very large in number.

*Spores* — The spores (PL. 1, FIG. 7) are roughly spherical in shape, measuring nearly 60  $\mu$ . Trilete mark is conspicuous. Individual rays of the triradiate suture are more than two-thirds of the radius of the spore. Spore coat shows several folds. It is finely granulose in texture.

*Epidermal Characters of the Leaf as Revealed by Transfer Preparation* — The epidermal cells of the two surfaces (PL. 1, FIG. 8) are different in their shape and the thickness of the walls. On the upper surface the cells are rectangular in shape, placed end to end. These cells are usually longer than broad, measuring nearly 100  $\mu$  in length and 37  $\mu$  in breadth. The walls of these cells are straight and thick, measuring nearly 11  $\mu$ .

The epidermal cells of the lower surface (PL. 1, FIG. 8) seen in the centre of the figure are small, polygonal or irregular in shape, measuring nearly 44  $\mu$ . The walls of these cells are also straight but thinner than those on the upper surface.

*Discussion* — Unfortunately, the details about the sporangium in my specimens could not be studied. But in other respects, such as the structure and the arrangement of the sori and the probable exannulate nature of the sporangia, my specimen compares with Pecopteroid fertile ferns, *Asterotheca* and *Ptychocarpus*.

In *Asterotheca* and *Ptychocarpus*, as well as in my specimen, the sori are found arranged in linear rows on the two sides of the median vein, occupying a position intermediate between the margin and the mid-vein. Each sorus or synangium consists of 3-8 (in my specimen I have counted 7) sporangia attached to a central receptacle. In *Asterotheca*, however, the number of

sporangia is usually less, 4-5 (ARNOLD, 1947, p. 191) and the sporangia stand upright in the immature condition, but at maturity they usually appear to bend outwards and lie horizontally on the surface of the pinnule forming a star-shaped body (KIDSTON, 1924, p. 482). On the other hand, in *Ptychocarpus* the sorus or a synangium is rounded, consisting of usually 7 sporangia, united upon a common receptacle. This appears to be the case in my specimen also. No where on the two pinnae examined, the sori in my specimen were seen looking like a star-shaped body as in *Asterotheca*. It, therefore, appears that my specimen compares more with *Ptychocarpus* than with *Asterotheca*.

My specimen differs from all the other species of *Ptychocarpus* in the size of the pinnules, their crenulate margin and dichotomizing secondary veins.

Feistmantel (1881) thought that this frond belonged to Polypodiaceae. Arber (1905) doubted its Polypodiaceous nature as the structure of the fructification was not known. In Polypodiaceae the sporangia form naked or indusiate sori and possess vertical, incomplete annulus (SEWARD, 1910, p. 296). The fructification described above is, however, quite different. The Palaeozoic fertile ferns referred to *Asterotheca* and *Ptychocarpus* are supposed to be Marattiaceous in affinity.

## Cycadales

### Genus *Ctenis*

#### 3. ? *Ctenis* sp.

In my fossil collection from the Raniganj coalfield, there is an incomplete leaf impression (PL. 2, FIG. 11) of a pinnate type of frond. The impression shows veins coming out of a strong rachis at acute angles. They bifurcate near the rachis and then join either by forking or cross-bars. A leaf showing this type of venation had never been described before from the Lower Gondwana rocks of India. The only fossil leaf which shows some resemblance to my impression is that of a pinnate frond, described from the Barakar group by Feistmantel (1881) as *Pterophyllum* (*Anomozamites*) *Balli*. This he later (1886) changed to *Platypterygium Balli*. Zeiller (1902) described similar fronds from the Rhaetic beds of Tonquin as *Pterophyllum* (*Anomozamites*) *Balli*. Later



Seward (1917) included all these fronds in the genus *Pseudoctenis*.

My specimen, however, differs from *Pseudoctenis Balli* in having probably broader pinnae, more distant nerves 1-2 mm. apart and regular anastomosing formed either by forking or cross-connections. Genus *Ctenis* differs from *Pseudoctenis* in having regular anastomoses (SEWARD, 1917, p. 584). In my specimen the anastomosing of the veins by forking or cross-bars is a regular feature and, therefore, most probably it belongs to the genus *Ctenis*. *Ctenis* and *Pseudoctenis* are, however, essentially Mesozoic genera, but since Seward (1917) has recorded *Pseudoctenis* from the Lower Gondwanas of India, I have ventured to refer my specimen to the genus ?*Ctenis*. As my specimen is rather incomplete, I am putting a query mark before the genus.

#### LEAF—SPECIMEN NO. 9043

Incomplete impression of a pinnate frond with badly preserved carbonized crust (PL. 2, FIG. 11). The impression shows a strong woody rachis, measuring nearly 2.5 mm. in width. From the rachis veins are seen coming out at acute angles. The veins are 1-2 mm. apart, and they bifurcate at the base and then join either by forking or cross-bars (PL. 2, FIG. 12; TEXT-FIG. 3). A little above, the rachis appears to be broken, turning sharply towards the right. Here a part of another pinna (PL. 2, FIG. 11) is seen attached, showing similar venation.

*Epidermal Characters as Revealed by a Transfer Preparation*—The specimen due to bad preservation of the carbonized crust did not yield good cuticles. A peel transfer prepared from the specimen revealed the following information.

The cells on the upper surface (PL. 2, FIG. 13) are elongately polygonal or rhomboidal in shape. They are much longer than broad, having thick, slightly curved or straight walls. Sometimes the cell walls show irregular thickening. Stomata are not seen on the upper surface. The cells of the lower surface (PL. 2, FIG. 14) are of irregular shape. The walls of these cells are highly sinuous, but less thick than those of the upper epidermis.

Stomata are seen on this surface. The cells near the stomata possess slightly less sinuous and thicker walls (PL. 2, FIG. 15). In the transfer preparation, the stomata have

not been found in sufficient number to show their distribution and orientation. A stoma (PL. 2, FIG. 16) measures nearly 62.5  $\mu$ . It is difficult to make out the structure of the guard cells. About 6-7 subsidiary cells are seen surrounding the stomatal opening which is oval to linear in shape.

*Tracheids of the Rachis*—The woody portion of the rachis in the transfer preparation showed well-preserved pits on the radial walls of the tracheids. The pits show considerable variation in their arrangement. They are 1-4 seriate, the uniseriate and tetraseriate conditions being rare. The uniseriate pits may be either separate or contiguous (PL. 3, FIGS. 18, 20), while both the biseriate and triseriate pits are generally distinctly opposite to each other and in some cases possess even a common wall (PL. 3, FIGS. 17, 19). These biseriate pits may be separate or contiguous radially (PL. 3, FIG. 18), but the triseriate pits are always separate. Very often both the biseriate and triseriate pits are alternate and contiguous (PL. 3, FIGS. 17, 19). The tetraseriate radial pits are both opposite and alternate and more or less contiguous (PL. 3, FIG. 21). The slit of the bordered pits is generally round to elliptical and the border is round to oval. The elliptical slit is generally directed horizontally. The vertical diameter of the slit is 8  $\mu$ . The diameter of the tracheids is 24-40  $\mu$ . Only at one place the field is seen preserved (PL. 3, FIG. 17), but the pits are not clearly seen.

*Comparison*—Several species of the genus *Ctenis* and their cuticles have been described from the Mesozoic beds. My specimen, unfortunately, is very fragmentary and so it is not possible to compare it with the other known species of *Ctenis*. The information about the epidermal structure obtained from the transfer preparation of my specimen is also far from complete. However, the epidermal cells on the upper surface of my leaf and the shape of the stoma show some resemblance with those of *Ctenis* sp. described by Harris (cf. PL. 2, FIGS. 13, 16 & HARRIS, 1932, Pt. 2, p. 16, FIG. 8, A, C).

#### Plantae incertae sedis

##### 4. *Actinopteris indica* sp. nov.

The genus *Actinopteris* was instituted by Schenk (1867) for the reception of certain



Mesozoic fern-like plants. Feistmantel (1876) referred a plant from Raniganj coalfield to this genus and named it *Actinopteris bengalensis*. Zeiller (1902) re-examined this plant and believed that it belonged to the Equisetales and he, therefore, modified Feistmantel's description. Arber (1905) agreed with Zeiller and thought that it may be a new genus of Equisetales group. He put the generic name in square brackets (ARBER, 1905, p. 15) indicating that the name was incorrect.

*Actinopteris bengalensis* was reported only from the Raniganj coalfield in India. Recently, Elias Dolianti (1953) has also recorded the occurrence of this species from the Upper Carboniferous rocks of Tubaroo series, Brazil.

I have collected two specimens of *Actinopteris* from Raniganj coalfield. One of these (PL. 1, FIG. 9) is identical with *Actinopteris bengalensis* Feistmantel, but the other differed in several characters from Feistmantel's specimen. I am, therefore, describing the other specimen under a new specific name, *Actinopteris indica*.

**Diagnosis** — Leaves whorled, united at the base for about three-fourths of their length. Whorls disc-like, spreading horizontally, circular, about 6 cm. in diameter. Free segments, measuring 3 mm. in width, all equal in size, uninerved. A complete specimen probably possesses forty to fifty free segments.

The chief distinguishing characters of this species are (1) lesser number — forty to fifty — and equal length of the free segments arranged in a circular disc-like whorl; (2) breadth of the free segments; and (3) attachment of the adjacent leaves for nearly three-fourths of their length.

LEAF — SPECIMEN NO. 8663

Incomplete impression of a whorl of leaves (PL. 3, FIG. 26) having poorly preserved carbonized crust. More than half of the whorl, measuring about 6 cm. in diameter, is preserved in the specimen. It consists of nearly 25 free segments, all equal in size. In the complete specimen the segments must be forty to fifty in number (TEXT-FIG. 4). The leaves are 3 cm. in length and 3 mm. in breadth. They are joined together for about three-fourths of their length. The tips of the free segments are straight and broadly pointed. Each leaf

has a median nerve which becomes very faint near the apex.

**Comparison and Discussion** — So far only one species, *Actinopteris bengalensis*, was known from the Glossopteris flora. My specimen differs from Feistmantel's species in the following points:

TABLE 1 — MAIN DIFFERENCE IN THE TWO SPECIES OF *ACTINOPTERIS*

<i>Actinopteris bengalensis</i> FEIST.	<i>Actinopteris indica</i> SP. NOV.
1. Whorl disc-like, elliptical	1. Whorl disc-like, circular
2. Free segments 80 or more in a whorl	2. Free segments not more than 40-50 in a whorl
3. Leaves joined for about two-thirds of their length	3. Leaves joined for about three-fourths of their length
4. Free segments unequal in length	4. Free segments all equal in length
5. Free segments 1.5-2 mm. in width	5. Free segments 3 mm. or sometimes more in width

Feistmantel believed that *Actinopteris bengalensis* is a fern and showed its resemblance with the Mesozoic fern *Actinopteris peltata* Schenk. Zeiller (1902) re-examined this specimen and believed it to belong to Equisetales group. He compared it with the foliage of some equisetalean plants, viz. *Schizoneura wardi*, *Annularia* and *Asterophyllites*, and thought, if more information were available, this plant would have represented a new genus in the Equisetales group. Arber (1905) also corroborated Zeiller's view.

*Actinopteris indica* also shows some resemblance with the foliage of some equisetalean plants. Among the southern genera of Equisetales, it shows some resemblance with the foliage of *Schizoneura wardi* Zeiller. In *Schizoneura wardi* (for figures see ZEILLER, 1902, PL. VI, FIGS. 5-8), the leaves are numerous, free or sometimes partly connate at the base, uniformly striated lengthwise by fine and close lines which in the median region become better defined and constitute a more or less distinct median nerve. However, *Actinopteris indica* differs from leaves of *Schizoneura wardi* in having no longitudinal striations on their surface and the leaves in a whorl are united for a greater part of their length.

The other equisetalean genus common in the southern hemisphere is *Phyllothea*. A whorl of leaves of *Actinopteris indica* shows some resemblance with the large leaf-sheaths of *Phyllothea Etheridgei* (for figures,



see ARBER, 1905, p. 27, FIG. 9) which are like open peltate discs having 20-23 free segments in the form of very short teeth, 3 mm. in length. My specimen, however, differs from it in the larger size of the disc-like whorl and more number of free segments in a whorl. Moreover, the free segments in *Actinopteris indica* are not pointed and do not look like teeth.

Among the equisetalean genera of the northern hemisphere, my frond shows some superficial resemblance with the foliage of *Annularia* and *Asterophyllites*. In *Asterophyllites equisetoides* (SEWARD, 1898, p. 334) we find flat, linear leaves, free to the base traversed by a simple median nerve. The leaves of *Actinopteris indica* differ from them in their much larger size and in their attachment for a greater part of their length.

In *Annularia stellata* (SEWARD 1898, p. 339, FIG. 88), each whorl contains 16-32 segments, which are connected basally into a collar or narrow sheath and the lateral segments are usually longer than the upper and the lower. However, *Actinopteris indica* differs in having larger number of free segments in a whorl and no differentiation of size between the lateral and the upper or lower segments.

Thus, from the above comparison, it appears that *Actinopteris indica* does not resemble with any of the known equisetalean foliage.

I tried to study the cuticles of this plant in the hope that their epidermal structure may throw some light on their affinity. My specimens, especially that of *Actinopteris bengalensis*, possessed a well-preserved carbonized crust, promising to yield good cuticles. But, in spite of my best efforts, I could not succeed in getting any piece of cuticle. Is it possible that these plants do not possess a resistant cuticle? If it is so, then it is possible that Feistmantel was not altogether wrong in placing this plant in the ferns. But the leaf is surprisingly equisetalean in type. However, the whole question, as regards its affinity, will have to wait till we get more and better material.

##### 5. A Cone Probably Belonging to *Schizoneura gondwanensis*

In my collection from the Raniganj coal-field I have a specimen of an isolated cone attached to an incomplete stalk. The occur-

rence of this cone has been recorded by me previously (SRIVASTAVA, 1952).

##### SPECIMEN NO. 8471

Impression of an isolated compact strobilus (PL. 3, FIG. 22) with carbonized matter preserved at some places. It is roughly elliptical in outline with a broadly pointed apex and a slender stalk at the base. The strobilus measures 30 mm. in length, exclusive of the stalk and 15 mm. in its widest part. The preserved portion of the stalk measures nearly 5 mm. in length. On the surface of the strobilus (PL. 3, FIG. 23) are seen polygonal or hexagonal discs, about 2 mm. across and closely fitting with one another. In the centre of each disc (PL. 3, FIG. 24) is seen a circular mark, measuring about 1 mm. in diameter. The strobilus at its broadest part bears 5-6 polygonal discs and twelve such discs can be counted lengthwise.

Unfortunately, the information about the sporangia and spores could not be obtained from this strobilus in spite of several efforts. The carbonized film from the surface of the cone has yielded a few small pieces of cuticles (PL. 3, FIG. 25) showing epidermal cells of a rectangular shape, arranged end to end. The cross walls of the cells are oblique. The cell walls are thin and straight. No spores were found.

*Comparison* — The strobilus shows a resemblance with the fructifications of the family Equisetaceae. Most probably the hexagonal or polygonal discs represent the peltate heads of the stalked sporangiophores on the axis. The circular elevated mark in the centre of each disc would then be the point of attachment of the sporangiophore with the peltate head.

This type of cone, as far as I am aware, is not known in the other common equisetalean genus *Phyllothea*. In *Phyllothea Ralli*, for example, the fructification consists of alternate verticils of sterile bracts and sporangiophores and in *Phyllothea deliquescens* there are several verticils of sporangiophores between two successive whorls of sterile bracts (ARBER, 1902, p. 16). In my specimen there is no indication of the presence of sterile bracts; on the other hand, the strobilus is compact.

My specimen, however, shows a great resemblance with the cone of *Schizoneura australis* described by Etheridge (Jun.) (1903, pp. 3, 4). The species *Schizoneura*



*australis* Etheridge was later merged with *Schizoneura gondwanensis* Feistmantel by Arber (1905).

Etheridge's specimen of *Schizoneura gondwanensis* consisted of the terminal portion of a leaf-bearing branch and a stalk bearing two strobili. The bigger strobilus of the pair measures 30 mm. in length and 8 mm. in breadth and the smaller one measures 20 mm. in length and 7 mm. in breadth. The bigger strobilus is pod-like in shape, slightly curved towards the side facing the other strobilus. The other strobilus does not show any curved face. Etheridge mentions that the cones seem to be attached to the stalk by very short stalks. However, this is not at all clear from his photograph. On the other hand, it appears that the so-called two strobili are fused in the lower portion just above a single stalk, and it is very likely that what appear as two strobili are just split portions of a single strobilus. If the

two strobili are joined, then it resembles my specimen in shape, structure and even in size.

If Etheridge's contention that this strobilus belongs to *Schizoneura gondwanensis* is correct, then I agree with him that this type of cone shows a great resemblance with the modern cones of *Equisetum* proper. And if Etheridge's specimen is really a single strobilus on a single stalk (split into two perhaps during fossilization), then even the strobilus appears to have been borne singly as in *Equisetum*. It, therefore, follows that the *Schizoneura* type of cones are much closer to *Equisetum* group than the *Phyllothea* type.

#### ACKNOWLEDGEMENT

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## EXPLANATION OF PLATES

## PLATE 1

1. A pinna of *Sphenopteris lobifolia*.  $\times$  Nat. size.
2. A few pinnules from the pinna in Fig. 1, enlarged to show lobed margin and venation.  $\times$  Ca. 3.
3. Transfer preparation of a portion of the pinna in Fig. 1, showing epidermal cells.  $\times$  200.
4. A fertile pinna of ?*Ptychocarpus* sp.  $\times$  Nat. size.
5. A few pinnules enlarged from the fertile pinna of ?*Ptychocarpus* sp. numbered 9324, showing venation.  $\times$  3.
6. A few pinnules enlarged from the fertile pinna in Fig. 4, showing arrangement of sori.  $\times$  3.
7. A single spore from the brown mass shown in Pl. 2, Fig. 10, enlarged.  $\times$  792.
8. Transfer preparation of a pinnule from the specimen No. 9324, of ?*Ptychocarpus* sp. showing epidermal cells. Uc, upper cuticle; Lc, lower cuticle.  $\times$  115.
9. A broken part of a whorl of leaves of *Actinopteris bengalensis*.  $\times$  Nat. size.

## PLATE 2

10. Brown mass showing cluster of spores after maceration of a sorus.  $\times$  90.
11. Leaf of ?*Ctenis* sp.  $\times$  Nat. size.
12. Leaf as in Fig. 11, enlarged.  $\times$  2.
13. Epidermal cells of the upper surface as revealed by a transfer preparation of the leaf in Fig. 11.  $\times$  230.
14. Epidermal cells of the lower surface as revealed by a transfer preparation of the leaf in Fig. 11.  $\times$  230.

15. Epidermal cells near the stomata in the transfer preparation of the leaf in Fig. 141. s, stomata.  $\times$  230.

16. A stoma enlarged from the lower surface as shown in Fig. 15.  $\times$  640.

## PLATE 3

FIGS. 17-21, Transfer preparation of the woody rachis of the leaf shown in Fig. 141, showing the pitting on the radial walls of the tracheids and the field.

17. Photo showing the field.  $\times$  360.
18. Radial strip showing tracheids having uniseriate and biseriate type of pitting.  $\times$  210.
19. Radial strip showing tracheids with biseriate and triseriate pitting.  $\times$  210.
20. Radial strip showing tracheids with uniseriate pitting.  $\times$  210.
21. Radial strip showing tracheids with tetraseriate pitting.  $\times$  210.
22. A cone probably belonging to *Schizoneura gondwanensis*.  $\times$  Nat. size.
23. Cone as in Fig. 22, enlarged.  $\times$  Ca. 3.
24. A portion of the cone shown in Fig. 22, enlarged to show the circular elevated portion in the centre of the polygonal discs.  $\times$  Ca. 5.
25. A piece of cuticle from the cone in Fig. 22.  $\times$  210.
26. A broken part of a whorl of leaves of *Actinopteris indica* sp. nov.  $\times$  Nat. size.





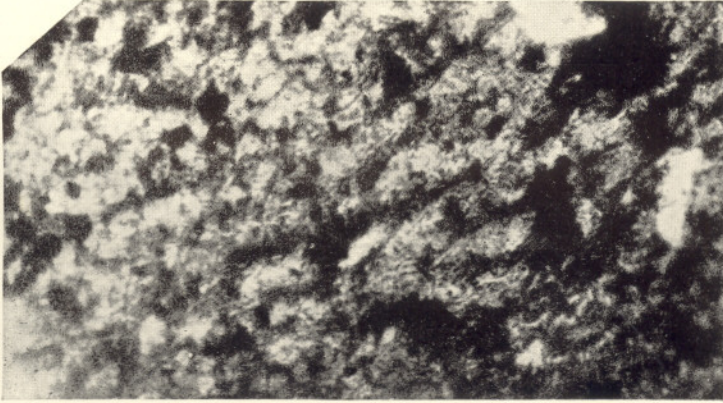
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2



6



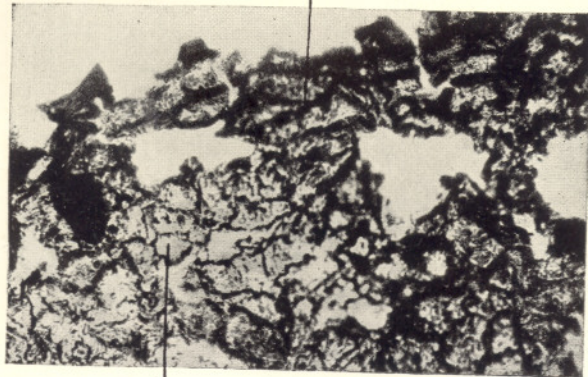
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4



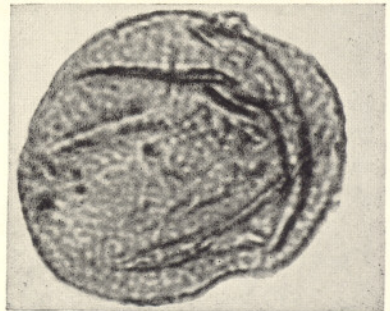
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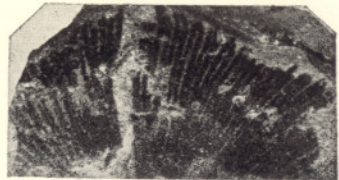
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Uc

Lc

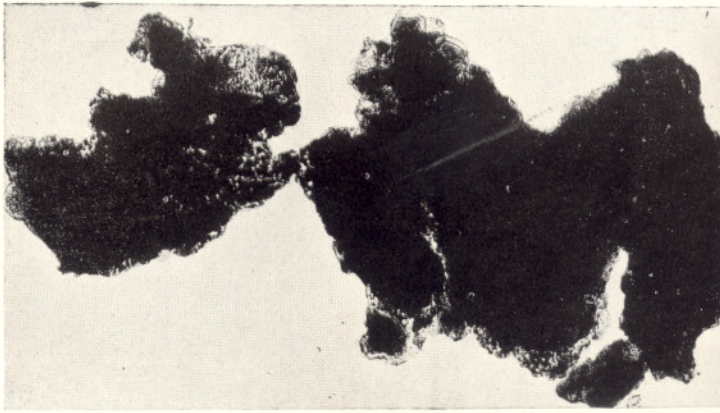


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9





10

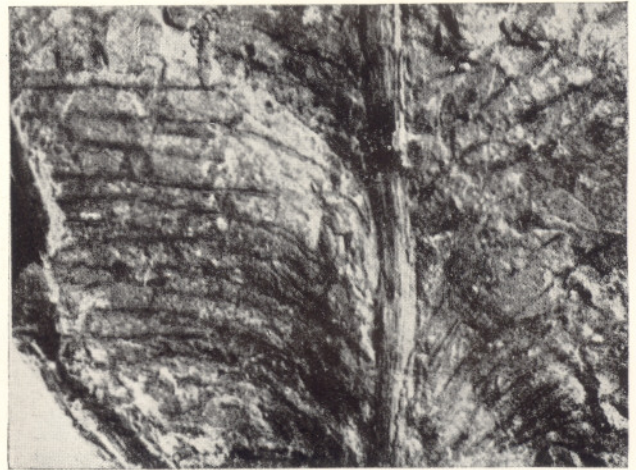


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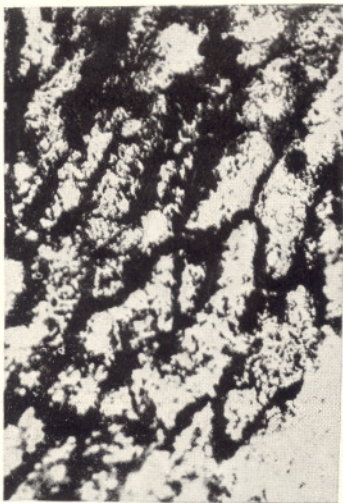
15



11



12



13



16



14



