STUDIES IN THE GLOSSOPTERIS FLORA OF INDIA—22. ON SOME SPECIES OF THE GENUS *GLOSSOPTERIS* FROM THE RANIGANJ STAGE OF THE RANIGANJ COALFIELD, BENGAL

HARI K. MAHESHWARI
Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

This paper contains a description of some *Glossopteris* species recorded for the first time from the Raniganj stage of the Lower Gondwana of India and also further observations on two species already known from this horizon. The species described are *Glossopteris* cf. *G. fibrosa*, *Glossopteris* sp., *G. intermedia*, *G. emarginata*, *G. linearis*, *G. taeniopteroides*, *G. decipiens*, *G. longicaulis*, *G. tortuosa*, *G. verticillata*, *G. euryneura* sp. nov. and *G. retusa* sp. nov.

INTRODUCTION

OF all the stages of the Lower Gondwana of India, the fossil flora of the Raniganj stage is the richest in genera as well as in species. The fossils occur as impressions on pale brown clayey shales, or as compressions on black argillaceous shales and also as petrifactions (only woods).

In the Raniganj stage of the Raniganj coalfield the distribution of the plants is not the same everywhere. In those localities where *Vertebraria* is dominant other fossils are not found in any appreciable number. Equisetales, ferns and Sphenophyllales have a rather restricted distribution occurring only at one or two places. The plants belonging to the Glossopteridales form the major part of the vegetation of the Raniganj stage. *Gangamopteris* which appeared during the Talchir period and probably outnumbered *Glossopteris* during the Talchir-Karharbari times was on the verge of extinction during the Raniganj period. A new plant, viz., *Palaeovittaria* appeared and became extinct during the Raniganj period. *Rhabdotaenia* is represented only at a few localities. *Rubidgea* is not known from the Raniganj stage. A few fructifications belonging to the Glossopteridales have also been reported from the Raniganj stage. The most dominant element of this group is the *Glossopteris* complex.

The name *Glossopteris* was instituted by Brongniart to receive certain tongue-shaped leaves from Australia and India. These leaves have a very wide geographical distribution and occur in abundance in the Lower Gondwana strata of all the provinces of Gondwanaland. Arber (1905) enlarged and modified the diagnosis of this genus. Since then some work has been done on the epidermal structure and the fructifications of this genus. Hence the definition of this genus needs further elaboration. The genus may be defined thus:

Leaves simple, sessile or petiolate, entire or slightly notched in the upper half; shape and size variable; midrib prominent and stout or flat, persistent or evanescent; secondary veins numerous, arise from the midrib at acute or open angles, arched or more or less straight, dichotomize and anastomose to form meshes of various shapes and size.

Leaf cuticle resistant; epidermal cells of varied shapes with sinuous, toothed or straight and thick or thin walls; stomatal apparatus with many subsidiary cells; stomata generally irregularly orientated and distributed.

Fructifications ?bisexual, ?cupular, consisting of two halves(?) and attached to the midrib.

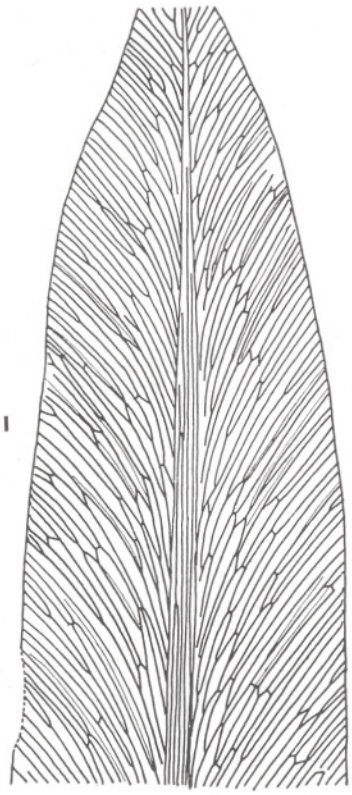
In the following pages are described some *Glossopteris* species which have been recorded for the first time from the Raniganj stage of India with further remarks on a couple of species already known from this stage. In the end a chart showing salient features of *Glossopteris* species from the Raniganj stage is given.

Genus *Glossopteris* Sternb.

Glossopteris cf. G. fibrosa Pant

In the present collection there are some leaves which agree with *Glossopteris fibrosa* Pant in most of the morphographical characters but as no cuticle could be recovered they have been provisionally assigned to *G. fibrosa*.

The figured specimen (PL. 1, FIG. 1) is simple, linear-lanceolate, 11·5 cm. long and 2·5 cm. broad at the widest, two sides of the lamina being of slightly unequal width. The apex is obtuse with an indistinct notch and the basal part tapers very gradually, but the petiole is not known. The midrib is flat, about 2·5 mm. broad at the base and continues almost up to the apex where it becomes resolved in finer veins. The secondary veins (PL. 1, FIG. 2) arise from the midrib at acute angles and after a bend pass obliquely towards the margins where they show a slight upward bend. The veins dichotomize and anastomose to form narrow, elongate meshes slightly broader at the midrib than near the margins. Concentration of the veins at the margins is 18-20 per cm. Inside the meshes are seen slender fibres running parallel to the main secondary veins, ending blindly or joining the main veins (PL. 1, FIG. 2; TEXT-FIG. 1).



TEXT-FIG. 1 — *Glossopteris* cf. *G. fibrosa* Pant, enlarged line drawing of a part of the leaf represented in Pl. 1, Fig. 1 to show interstitial veins. × 2.

Remarks — Pant (1958) described two new species of the genus *Glossopteris* from the *Glossopteris* flora of Tanganyika. These two species, viz., *G. fibrosa* and *G. hispida* are characterized by the presence of interstitial elongated fibres running parallel with main secondary veins, which character is not reported in other known species of the genus *Glossopteris*. These two species though resembling each other in venation and fibres between the veins, differ in their epidermal structure. A careful study of the description and the figure of *G. hispida*, however, shows that this leaf, probably is a *Gangamopteris*. Pant states that this leaf has a midrib with anastomosing longitudinal strands. But from my study of *Glossopteris* leaves I find that the midrib may have longitudinal strands but they never anastomose. On the other hand in *Gangamopteris* the strands (veins) in the median portion always anastomose. Pant's specimen of *Glossopteris hispida* probably belongs to the genus *Gangamopteris*. In addition to the presence of fibres, the present specimen also resembles with *G. fibrosa* in the nature of venation in general and upward curve of secondary veins at the margins in particular. However, as pointed out above in the absence of a cuticle the present specimen has been provisionally assigned to *Glossopteris fibrosa*.

Glossopteris sp.

This species is represented by an incomplete specimen (PL. 1, FIG. 3) measuring 7·7 cm. in length and 4 cm. in width at the broadest. The leaf was probably lanceolate in shape with a broadly pointed apex. The midrib is prominent and persists throughout the preserved length of the leaf. The secondary veins which are very strong come out of the midrib at acute angles and after a gentle curve proceed to the margins and are somewhat flexuous. They dichotomize and anastomose to form broad-elongate meshes which become gradually narrower towards the margins. Concentration of veins near the midrib is 5-6 per centimeter and 12-16 per cm. at the margins. Inside the meshes are seen slender fibres running parallel to main secondary veins, ending blindly or joining the main veins (PL. 1, FIG. 4).

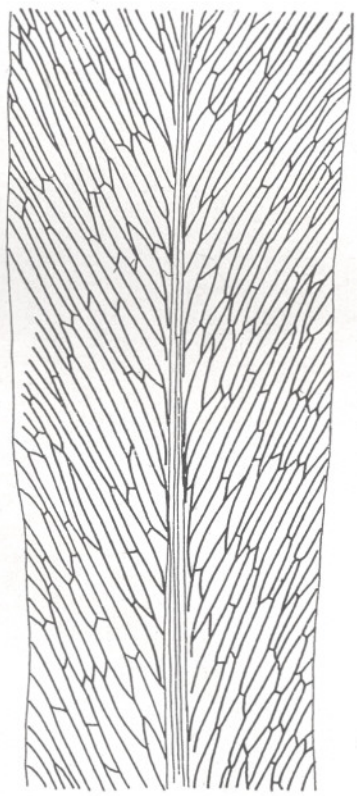
Comparison — The only known species of *Glossopteris* with interstitial fibres is *G. fibrosa* Pant which differs from the present specimen in the shape of the leaf, the shape

of the meshes and also in the concentration of the secondary veins. There is some resemblance with *G. colpodes* Pant in the shape and size of the meshes but that species lacks in interstitial fibres. Because of incompleteness the present specimen, however, has not been given a new name.

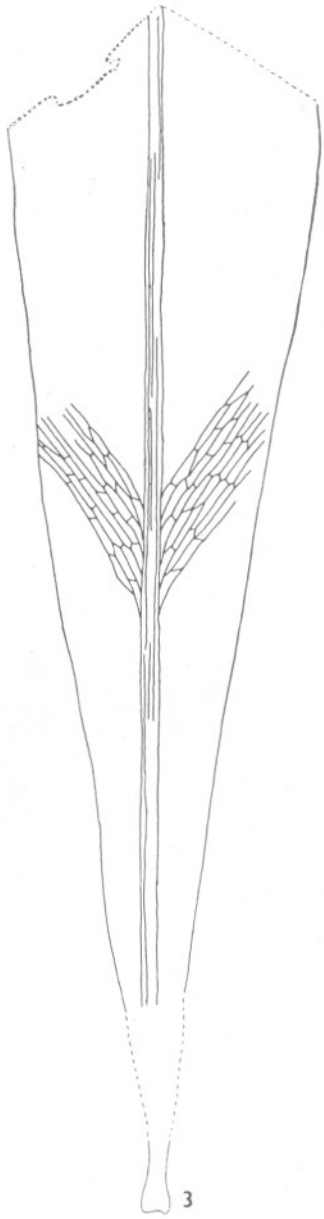
Glossopteris intermedia Feistm. emend.

The specimen figured (PL. 1, FIG. 5) is lanceolate-spathulate in shape, 14·5 cm. long, 3 cm. broad at the widest and gradually contracts towards the base. Apical and basal parts are broken. The midrib is stout, longitudinally striated and about 3 mm. broad in the basal part. In the apical part the midrib resolves into fine veins. The secondary veins (PL. 1, FIG. 6; TEXT-FIG. 2) arise at acute angles and pass straight to the margins after a gentle curve. From the midrib about 3 veins arise per cm. Soon they dichotomize several times near the margins. The meshes are oblong-polygonal, 5-6 times longer than broad.

TEXT-FIG. 3 shows the basal region of this species. The venation of all the specimens



TEXT-FIG. 2 — *Glossopteris intermedia* Feistm., enlarged line drawing of a part of the leaf represented in Pl. 1, Fig. 5 to show details of venation. × 2.



TEXT-FIG. 3 — *Glossopteris intermedia* Feistm., line drawing of another specimen (No. 32904) of the species showing the basal region and a part of the venation. × 1.

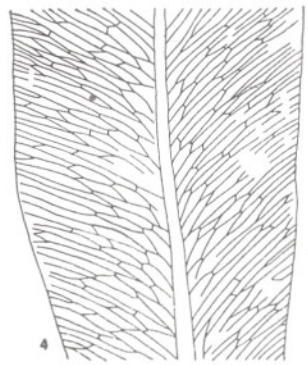
agrees closely with figures of *G. intermedia* Feistmantel (1880, p. 6; 1881, PL. 29, FIGS. 3, 6) which he later (1881, p. 103) included in *G. brownii*. Some leaves from Barakar placed by Feistmantel (1881; PL. 29, FIGS. 1, 2) in *G. brownii* also resemble my specimens.

Remarks — Feistmantel (1880, p. 6) proposed the name *Glossopteris intermedia* for certain leaves from Raniganj (1881; PL. 29, FIGS. 3, 6) but later (1881, p. 103) he thought that retention of the name *G. intermedia* would only complicate the matter and hence placed these leaves in *G. brownii*. A large number of leaf specimens of the present collection from Ningah colliery show characters similar to those specimens figured by Feistmantel as *G. intermedia*. An examination of these leaves convinces me that they are different from *G. brownii*, and may be comparatively closer to *G. conspicua* though differing from it also. I have therefore, retained the name *G. intermedia*. As no diagnosis of this species was given by Feistmantel, the following definition is proposed for *G. intermedia*: " Leaves linear-lanceolate or lanceolate-spathulate, gradually contracting towards the base into a stalk; apex broadly acute or obtuse; leaves 5-6 times longer than broad; midrib stout, longitudinally striated, continues almost to the apex resolving into finer veins just below the apex; secondary veins arise at acute angles from the midrib and after a gentle arch pass straight to the margins parallel to one another, dichotomizing and anastomosing to form long and oblong-polygonal meshes of almost equal size throughout."

Leaves of *G. brownii* are spathulate in shape as compared with linear-lanceolate or lanceolate-spathulate shape of *G. intermedia*. In *G. brownii* the meshes (TEXT-FIG. 4) are of intermediate size and become narrower towards the margins. In *G. intermedia* the secondary veins are comparatively more oblique, meshes are comparatively broader and of almost equal size throughout. In the openness of the veins *G. intermedia* comes close to *G. conspicua* but in the latter species the meshes are very wide.

Glossopteris emarginata Maheshw. & Prak.

In the present collection there is a fragmentary leaf specimen showing the same characters as described for *Glossopteris emarginata* from the Lower Gondwana of Rajmahal Hills, Bihar. The incomplete leaf (PL. 1, FIG. 7) is about 4·5 cm. long, 2·5 cm. broad and with almost parallel margins and an emarginate apex. The midrib is distinct, about 1·5 mm. broad and reaches the apex. The secondary veins arise from the midrib at acute angles and after a slight arch pass straight to the margins, dichotomizing and anastomosing to form narrow-elongate meshes. The number of the veins per cm. at the margins is 16-20. In the apical region the secondary veins bend towards the midrib, almost running parallel to it and finish in the apical margin of the leaf.



TEXT-FIG. 4 — *Glossopteris brownii* Brongn., showing venation details. × 2.

This specimen resembles favourably with the description and figure of *Glossopteris emarginata* (MAHESHWARI & PRAKASH, 1965) and hence is an additional example of this species from the Damudas of India.

Glossopteris linearis McCoy

The figured specimen (PL. 1, FIG. 8) measures 1·7 cm. at the widest part and is 13 cm. long including about 2·5 cm. of the petiole (TEXT-FIG. 5) which is overlapped by another leaf and has not been shown in the photograph. The leaf is simple, petiolate, linear with entire margins and slightly notched apex. The midrib is distinct and longitudinally striated. Secondary veins (PL. 2, FIG. 9) arise at acute angles and after a gentle arch pass straight to the margins. The meshes are elongate-polygonal, slightly narrower towards the margins. The concentration of the veins is 8-10 per cm. at the midrib and 18-20 per cm. near the margins. Smaller fronds of this species measure about 5 cm. in length and 0·9 cm. in breadth.

TEXT-FIG. 5 — *Glossopteris linearis* McCoy, line drawing of the leaf in Pl. 1, Fig. 8 to show the basal region and the venation of the leaf. × 2.

In shape, size and venation this leaf compares favourably with the figure and description of *Glossopteris linearis* (FEISTMANTEL, 1890, p. 126; PL. 16, FIG. 2).

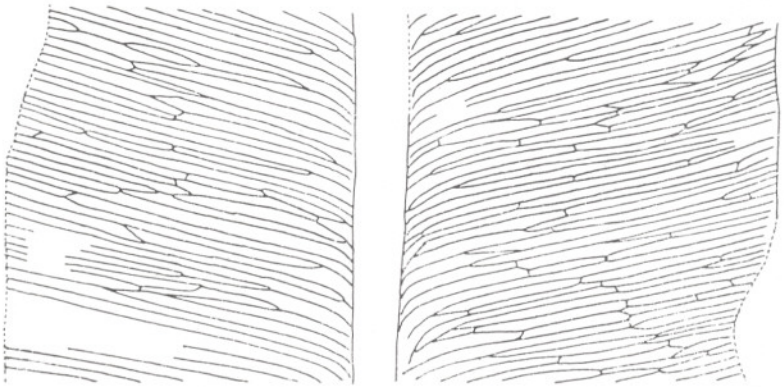
Remarks — This species instituted by McCoy (1847) was defined by Feistmantel (1890) as follows: " Leaves long, narrow, with nearly parallel sides; costas very distinct; veins fine, forming fine nets ". McCoy compared this leaf with the Indian form *Glossopteris angustifolia* but Feistmantel distinguished the two as he believed that *G. angustifolia*, unlike *G. linearis*, had a marginal fructification; and also the veins in the former species were much more oblique than in the latter species. Arber (1905) believed that *G. linearis* was narrow leaf type referable to *G. brownii* and he also published a figure (*l.c.*; PL. 2, FIG. 2) of it. A study of Feistmantel's and Arber's figures as well my specimens of such narrow forms convinces me that *G. linearis* is a type different both from *G. brownii* and *G. angustifolia*. Leaves of *G. brownii* are comparatively larger and spathulate, sub-oval or oval-lanceolate in shape while those of *G. linearis* are linear in shape. Meshes in *G. linearis* though of *G. brownii* type are comparatively narrower and smaller. Shape of *G. angustifolia* and *G. linearis* is almost the same but in the former the apex is acute while in the latter the apex is obtuse or slightly notched. Besides the meshes in *G. angustifolia* are comparatively narrower.

Glossopteris taeniopteroides Feistm.

The specimen (PL. 2, FIG. 10) is oval-spathulate in shape and is broken both at the apex and the base but shows a definite tendency of contracting towards the base. The incomplete specimen measures 12·7 cm. in length and 2·5 cm. in breadth on one side of the midrib. The midrib is distinct, longitudinally striated and about 3 mm. broad in the basal part. The secondary veins (PL. 2, FIG. 11; TEXT-FIG. 6) arise from the midrib at acute angles but immediately they take a sharp bend and follow a course at right angles to the midrib. The number of secondary veins per cm. near the midrib is about 12-14 and near the margins is 16-20. The veins dichotomize a few times and anastomose to form narrow-elongate meshes of almost equal breadth throughout.

Remarks — The venation of this leaf at first sight reminds that of *Taeniopteris feddenii* which, however, does not show anastomosing of the secondary veins. The other leaf which shows a straight and close venation is *Glossopteris damudica*, but here the meshes near midrib are much shorter and broader than those near the margin, while in the present leaf the meshes do not differ much in breadth from one another. In all characters the present leaf agrees closely with *G. taeniopteroides* (FEISTMANTEL, 1890; PL. 18, FIG. 1).

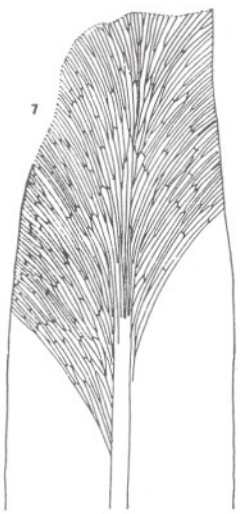
Arber (1902), on the basis of a specimen from the New Castle series of New South



6

TEXT-FIG. 6 — *Glossopteris taeniopteroides* Feistm., enlarged line drawing of a part of the leaf represented on Pl. 2, Fig. 10 to show details of venation. × 2.

Wales, regarded *Glossopteris taeniopteroides* to be a smaller frond of *G. ampla* Dana, but later (1905) agreeing with Zeiller's (1902) view, he included *G. taeniopteroides* in *G. indica*. It is interesting to note that while Feistmantel regarded the secondary veins of this species to be almost at right angles to the midrib, Zeiller and Arber thought them to be very oblique.



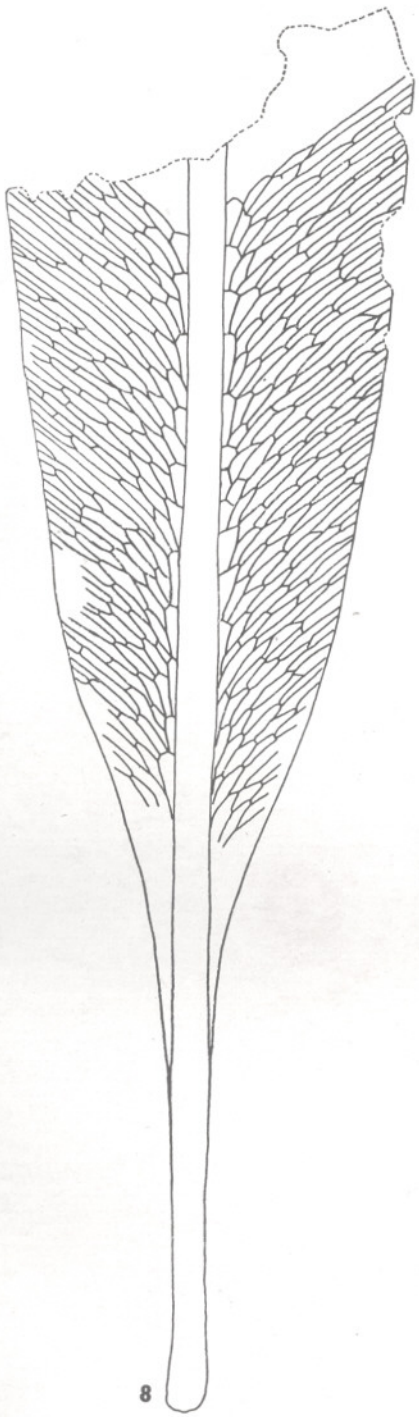
7

TEXT-FIG. 7 — *Glossopteris decipiens* Feistm., enlarged line drawing of the apical part of the leaf represented on Pl. 2, Fig. 12 to show resolution of the midrib into finer veins in the apical region. × 2.

Srivastava (1956) reported a leaf with above characters from the Raniganj stage of the Raniganj Coalfield, Bengal and though his specimen differed from Feistmantel's specimen in size, on the basis of the characteristic venation he included it under *G. taeniopteroides*. On the basis of the cuticular studies he was able to show that *G. taeniopteroides* was a species distinct from *G. indica* or *G. damudica* (? *G. ampla*). I have re-examined Srivastava's specimen and found that it is not a leaf of *G. taeniopteroides*.

Glossopteris cf. *G. longicaulis* Feistm.

This species is represented in the present collection by only one specimen (PL. 2, FIG. 13) showing only the lower half of the leaf. The incomplete specimen is 2·5 cm. broad at the widest and is 9 cm. long including about 3 cm. of petiole. The midrib is distinct and stout with longitudinally running striations and is about 2·5 mm. in width in the basal region. Due to the incompleteness of the specimen it is not possible to say whether the midrib was evanescent above. The secondary veins (TEXT-FIG. 8) emerge from the midrib at very acute angles and are 2-3 mm. apart at the midrib. The number of veins at the margin is 10-13 per cm. Just after its emergence a secondary vein dichotomizes, the lower branch soon after anastomoses with the upper branch of the vein below while the upper branch continues



TEXT-FIG. 8 — *Glossopteris* cf. *G. longicaulis* Feistm., enlarged line drawing of the leaf represented on Pl. 2, Fig. 13 to show the long petiole, stout midrib and oblong-polygonal meshes. × 2.

for a short while before anastomosing. Further dichotomies and anastomoses are frequent resulting in the formation of narrow oblong-polygonal meshes which are somewhat narrower towards the margins.

Remarks — Feistmantel (1880) instituted this species to describe some oblong-oval leaves with a long petiole, and strong midrib which became evanescent above. Srivastava (1957) reported this species from the Raniganj stage but in his figured specimen the veins come out at much more acute angles. He also described the cuticular structure of this species. Plumstead (1958) reported this species from Transvaal and ascribed a fructification, viz., *Pluma longicaulis* to it. More recently this species has been reported from the Panchet stage of Auranga coalfield, Bihar (BHATTACHARYA, 1963). In none of the known specimens the venation is clear. I have examined both the figured specimens of Feistmantel (*l.c.*, PL. 31, FIGS. 1, 3; specimen nos. 5084 and 5086 respectively kept at the Geological Survey of India, Calcutta) and have failed to find any appreciable thinning of the midrib in the upper region of the leaves. The venation of the present specimen resembles to a certain extent with that of specimen 5086 of G.S.I. The only similarity between the specimens referred to this species is a long petiole otherwise all of them differ from one another in venation. As many other species of *Glossopteris* are petiolate it may be that these specimens represent broken basal parts of other species of *Glossopteris*.

Glossopteris decipiens Feistm.

In India this species was so far recorded only from the Karharbari stage of the Lower Gondwana. Here it is being reported for the first time from the Raniganj stage.

In the present collection *Glossopteris decipiens* is represented by few specimens none of which, however, is complete being broken both at the apex and the base. The figured specimen (PL. 2, FIG. 12) is 13 cm. long and 2·3 cm. broad in the widest part. The leaf is lanceolate-spathulate in shape with clearly defined midrib running for about two-thirds of the length of the leaf from the base. In the upper part the midrib becomes resolved into secondary veins giving it a Gangamopteris-like appearance (TEXT-FIG. 7). The leaf gradually tapers towards the base which most probably was truncated. The secondary

veins come out from the midrib at acute angles and after a gentle curve proceed to the margins. The secondary veins are dichotomous and anastomose to form narrow, oblong meshes.

In general characters and shape the present specimen compares favourably with that of Feistmantel (1879; p. 17, PL. 18, FIG. 4) but differs from it in having a comparatively narrower basal region.

Remarks —Till recently the main character of the species *Glossopteris decipiens* was supposed to be the evanescent nature of the midrib, but now Plumstead (1962, p. 43) believes that fading of the midrib is a character of secondary importance and hence she has included some of the Antartic specimens with a persistent midrib in *Glossopteris decipiens*. A careful examination of previously published specimens of this species kept at the Geological Survey of India, Calcutta as well as specimens collected from Raniganj by me clearly shows that the diagnostic character of this species is the evanescent nature of the midrib and as such the Antarctic specimens can not be included in it.

Glossopteris tortuosa Zeiller

In the present collection this species is represented by about eight incomplete specimens. The leaves are simple, lanceolate to oval-lanceolate in shape and contract gradually towards the base. In none of the specimens the apex is preserved but from one of the specimens it seems that it was broadly acute. The leaves at their widest are 3·5-4 cm. broad. The leaves were more than 10 cm., probably 15-18 cm. long. The midrib (PL. 2, FIG. 14) is distinct and stout sometimes with indistinct longitudinal striations. The secondary veins (PL. 2, FIG. 15) arise from the midrib at varied angles (45°-80°) in different parts of the same leaf and follow a sinuous course towards the margins. The secondary veins are dichotomous and anastomose to form oblong-polygonal to trapezoidal meshes which are far broader near the midrib than at the margins, and measure 2·5-5 mm. in length and 0·5-2·5 mm. in breadth.

The only figures known of *Glossopteris tortuosa* are those by Zeiller (1902; PL. 3, FIGS. 2, 2a) and Walkom (1922; PL. 3, FIGS. 15, 16). In the venation of the lower part the present leaves resemble Zeiller's figure and in that of the upper part they resemble very closely Walkom's figures. Arber (1905) mentions that the secondary veins form two series of large polygonal meshes near the midrib followed by narrower meshes, but a detailed study of the present specimens and Zeiller's and Walkom's figures shows that it is not always the case; the broader meshes may be in 1-3 or more series and then start becoming narrower.

Remarks — Arber (1905) thought *Glossopteris tortuosa* to be comparable with *G. damudica* but maintained its separate identity. Walton (1929) reported its presence in the Karroo beds of Southern Rhodesia, and thought it to be intermediate between *Glossopteris brownii* and *G. retifera*. He gave no figures of *G. tortuosa* but his figure 22 on Plate C, which he refers to as *G. retifera* looks more like *G. tortuosa* than *G. retifera*. In this figure the meshes near the midrib are much broader than those near the margins while in *G. retifera* meshes are of almost equal size throughout the lamina.

Plumstead (1952, 1956a) described the fructification of *G. tortuosa* as *Scutum rubidgeum* attached to the midrib by a short and stiff pedicel. In identification of her leaves as *G. tortuosa* she was probably influenced by Walton's (1929) view that *G. tortuosa* is intermediate between *G. retifera* and *G. brownii*. As the original publication of Zeiller (1902) was not available, she compared her specimens with a figure from Walton (*l.c.*; PL. C, FIG. 22) which he refers as *Glossopteris* cf. *browniana* and which she took to be the leaf of *G. tortuosa*, as Walton in the text mentions it to be intermediate between *G. brownii* and *G. retifera*. Thus it seems that Plumstead's identification of *G. tortuosa*, at least that of Fig. 4, Pl. 9, is not correct. It is not unlikely that these leaves are but variations of a typical *G. brownii*. The fructification *Scutum rubidgeum* also shows only a few minor differences from *S. leslium*, the fructification of *G. brownii*. As such her *G. tortuosa* may be a *G. brownii*. In fact, the leaf represented in figure 5 of the same plate, which she refers as *G. retifera* looks more like *G. tortuosa*. In the identification of this leaf as *G. retifera*, she again seems to have compared it with Walton's (*l.c.*) figure, the identification of which as said above is open to question. Archangelsky (1958) referred a leaf (FIG. 4) to *G. retifera* which again seems to be an example of *G. tortuosa*. A similar type of leaf was referred

by Seward & Leslie (1908) to *G. retifera* but due to poor preservation it is difficult to say anything about it. Plumstead (1958) again described a fructification of *G. tortuosa* but this time attached to a leaf which she thought was different from the type and she created a new variety for it. Even in this case, the specimen appears to be more probably a variant of *G. brownii* than of *G. tortuosa*.

Surange & Maheshwari (1962) figured a whorled cluster of *G. tortuosa* leaves around an axis of *Vertebraria*. Though there is no organic connection between the axis and the leaves, on the basis of the peculiar preservation a probable connection between the two was suggested. As pointed out by Pant (1962) *Vertebraria* fossil represents the vascular part only of the axis and as such no organic connection between it and the leaves is expected.

Glossopteris verticillata Thomas

Thomas (1952) described certain whorled leaves from the Molteno beds of South Africa, which he thought closely resembled *Sagenopteris longicaulis* (DU TOIT, 1927) a leaf with net-work very similar to that of *Glossopteris*. On the basis of the peculiar net-work he transferred du Toit's leaf to the genus *Glossopteris* as *G. longicaulis* overlooking the fact that the name *G. longicaulis* had already been used by Feistmantel (1876) for a certain leaf with a long petiole, from the Karharbari beds of India. In 1958 he therefore, renamed the Molteno bed leaves as *G. verticillata*. Leaves of *G. verticillata* are petiolate, lanceolate with bluntly pointed apex and gradually contract towards the base. The midrib is distinct, longitudinally striated and near the apex resolves into finer veins. The secondary veins arise from the midrib at acute angles, take a gentle curve and run towards the margins forking two or three times. Anastomosing of the veins is rare near the midrib but is more abundant near the margins, meshes being elongate and curved.

In the present collection this species is represented by a large number of specimens, all of which are incomplete. The best specimen (PL. 3, FIG. 16) is 8 cm. long and 2·7 cm. broad at the widest. Other specimens are 1·8-2·5 cm. broad. The leaf is lanceolate in shape and gradually contracts towards the base, but in none of the specimens the complete basal region is preserved. The midrib is distinct. longitudinally striated, resolving into finer veins near the apex. The secondary veins (PL. 3, FIG. 17; TEXT-FIGS. 9, 10) follow a sinuous course parallel to one another and the distance between them is more or less 1 mm. The veins are dichotomous but anastomoses are very rare, only 1-3 meshes being formed, some of the veins not anastomosing at all. The concentration of the veins is about 8-10 per cm. near the midrib and 14-18 per cm. near the margins.

The present specimen resembles in all characters *Glossopteris verticillata* Thomas (1952; PL. 1, FIGS. 1-3).

Glossopteris euryneura sp. nov.

This species is represented by 4 specimens in all of which the upper half is missing. The holotype which is an incomplete specimen (PL. 3, FIG. 18) is 13·5 cm. long and 3·5 cm. broad at the widest. The midrib in this case is 2·5 mm. broad at the base and 1·5 mm. in the upper part. The other specimens are 9-12 cm. long and 3-3·5 cm. broad. The whole leaf was much larger, probably twice this size. This assumption is based on the fact that in all these leaves the breadth of the lamina goes on increasing towards the upper part without showing any sign of apical contraction. The midrib in other cases is also fairly broad, being up to 4 mm. In all the specimens the secondary veins (PL. 3, FIG. 19; TEXT-FIG. 11), arise from the midrib at broad angles and traverse straight to the margins, almost at right angles to the midrib giving at first sight the appearance of a *Taeniopteris* leaf. The secondary veins are sinuous, about 1 mm. apart and dichotomize only once or twice. Anastomosing of the secondary veins is very rare, only 1-3 elongate and wide meshes being formed. The concentration of veins is 6-8 per cm. near the midrib and 15-20 per cm. near the margins.

Diagnosis — Leaf simple, shape and apex not known, gradually contracts towards the base; midrib distinct and broad; secondary veins arise at broad angles, run straight to the margins, fork once or twice; anastomoses rare near the midrib, more frequent at the margins, meshes broad and elongate.

Holotype — 32901/495, Birbal Sahni Institute of Palaeobotany, Lucknow.

Horizon — Raniganj stage.

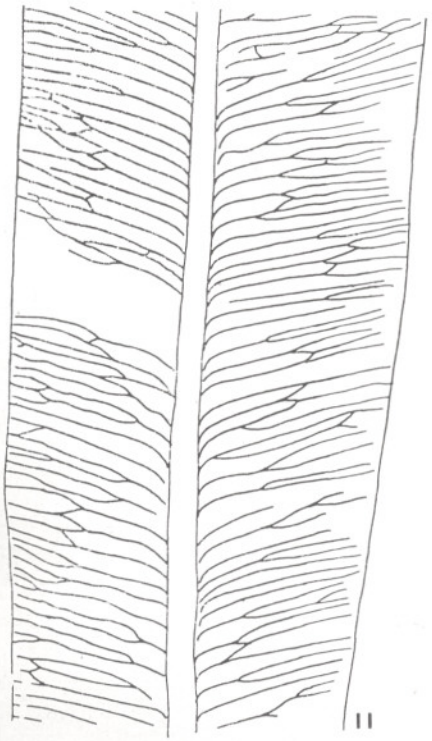
Age — Upper Permian.

Locality — East Satgram colliery, East Raniganj coalfield, Bengal.

TEXT-FIG. 9 — *Glossopteris verticillata* Thomas., enlarged line drawing of a specimen (No. 32908) to show sinuous secondary veins, anastomosing rarely. × 2.

TEXT-FIG. 10 — *Glossopteris verticillata* Thomas, enlarged line drawing of the leaf represented on Pl. 3, Fig. 16 to show venation. × 2.

Comparison — This leaf at first sight gives the appearance of a *Taeniopteris* leaf (specially *T. danaeoides*) which, however, does not show anastomosing of the secondary veins. The other species of *Glossopteris* with straight veins are *G. damudica* and *G. taeniopteroides*. In *G. damudica* the anastomosing of the secondary veins is frequent and the meshes near the midrib are broader and shorter than those at the margins. In *G. euryneura* on the other hand the anastomoses of the secondary veins are rare and the meshes are elongate. *G. taeniopteroides* is distinguished from the present species by much closer venation. The species of *Glossopteris* with rare anastomoses are *G. angustifolia* var. *taeniopteroides*, *G. intermittens*, *G. mitchelli* and *G. verticillata*. The first three leaves, however, have acute, oblique and close secondary venation. In *G. verticillata* the veins are distant but they arise at acute angles and follow an oblique course. *G.*



TEXT-FIG. 11 — *Glossopteris euryneura* sp. nov., enlarged line drawing of a part of the holotype to show venation. × 2.

TEXT-FIG. 12 — *Glossopteris retusa* sp. nov., line drawing of the specimen represented on Pl. 3, Fig. 20 to show the retuse apex and notched margins. × 2.

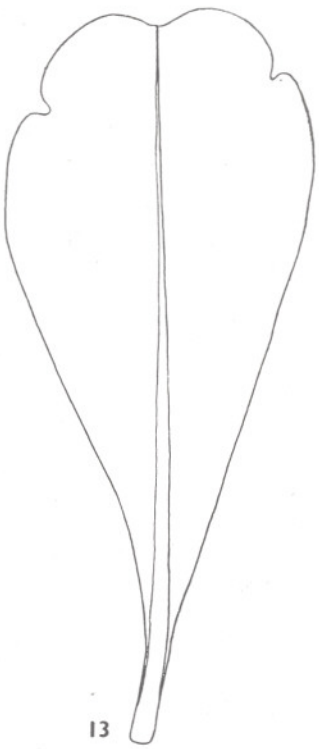
conspicua and *G. retifera* differ widely in having acutely set veins as well as in the size and shape of the meshes. The present leaves thus seem to be different from all the species of *Glossopteris* and hence have been described under the new specific name *Glossopteris euryneura*.

Glossopteris retusa sp. nov.

The figured specimen (PL. 3, FIG. 20) is an incomplete impression on a greyish shale. The leaf is obovate, margin entire except for two deep notches (TEXT-FIG. 12) on both the lateral sides about 1 cm. removed from the apex which is broadly obtuse with a very small notch (retuse apex). The basal portion of the leaf is broken. The incomplete leaf is 4·6 cm. in length and 2·8 cm. in breadth at the widest part. The lamina gradually tapers down towards the base. The secondary veins come out from an indistinct and flat midrib at acute angles and after a gentle curve pass to the margins. They are dichotomous and anastomose to form elongate-narrow meshes. The concentration of the veins is 35-40 near the margins.

There are two other specimens referable to this species. The leaves are obovate and cuneate. In one of the specimens (no. 32907) which is 9·9 cm. in length and 3·2 cm. in breadth at the widest part, the apex is broken but probably it was broadly rounded. Near the apex, about 7·5 cm. removed from the base, the leaf lamina is notched on both sides. The lamina gradually tapers towards the base where it nearly reaches the midrib, which is flat and not distinctly marked out and extends downward along the petiole. The venation is not distinct. The other leaf, which is smaller in size, 5·4 cm. long, 2·2 cm. broad at the widest part, is complete (PL. 3, FIG. 21; TEXT-FIG. 13). It is cuneate, obovate with notched margins and distinctly retuse apex. The venation is similar to that in the type specimen.

Diagnosis — Leaf cuneate, obovate; margin with two deep notches below the apex; apex retuse; midrib flat; secondary veins oblique, arched, dichotomous; meshes elongate-



TEXT-FIG. 13 — *Glossopteris retusa* sp. nov., enlarged line drawing of the specimen represented on Pl. 3, Fig. 21 showing the complete leaf form. × $1\frac{3}{4}$.

narrow; concentration of veins 35-40 per cm. near the margins.

Holotype — 32902/498, Birbal Sahni Institute of Palaeobotany, Lucknow.

Isotypes — 32903/432, 32907/538.

Horizon — Raniganj stage.

Age — Upper Permian.

Locality — Mukherji's Jyoti Janaki quarry, East Raniganj coalfield, Bengal.

Comparison — The venation of the present leaf closely simulates that of *Glossopteris communis* Feistm. in all respects but as that species is known to have an entire margin and pointed apex, the present specimens which have notched margins and a retuse apex cannot be referred to it.

The other comparable species is *G. emarginata* which also has a notched apex. However, in that species the shape of the leaf is oblong unlike in the present one where the shape is obovate. The two also differ in the shape and size of the meshes which are oblong-polygonal in *G. emarginata* and elongate-narrow in *G. retusa*.

ACKNOWLEDGEMENT

My most grateful thanks are due to Dr. K. R. Surange under whose inspiring guidance this study was completed. I also wish to thank Dr. K. M. Lele for going through the manuscript. I am thankful to the managements of Damodar, Mahabir, Kajora Selected, Gillander, Madanpur, Lacchipur, Jyoti Janaki Khas, Mukherji's Jyoti Janaki, Selected Kajora Jambad, Bankola, New Kenda, West Jamuria, Kalipahari, Nagkothi, Lodna, Ningah and East Satgram collieries in the East Raniganj coalfield, Bengal for permission to collect fossils from their respective areas. Thanks are also due to the Director of Geological Survey of India, Calcutta for permission to examine Feistmantel's figured specimens kept in the Museum of the Survey.

REFERENCES

ARBER, E. A. N. (1902). On the Clarke collection of fossil plants from New South Wales. *Quart. J. geol. Soc. Lond.* **58**: 1-26.

Idem (1905). Catalogue of the fossil plants of the Glossopteris flora in the Department of Geology, British Museum (Natural History). London.

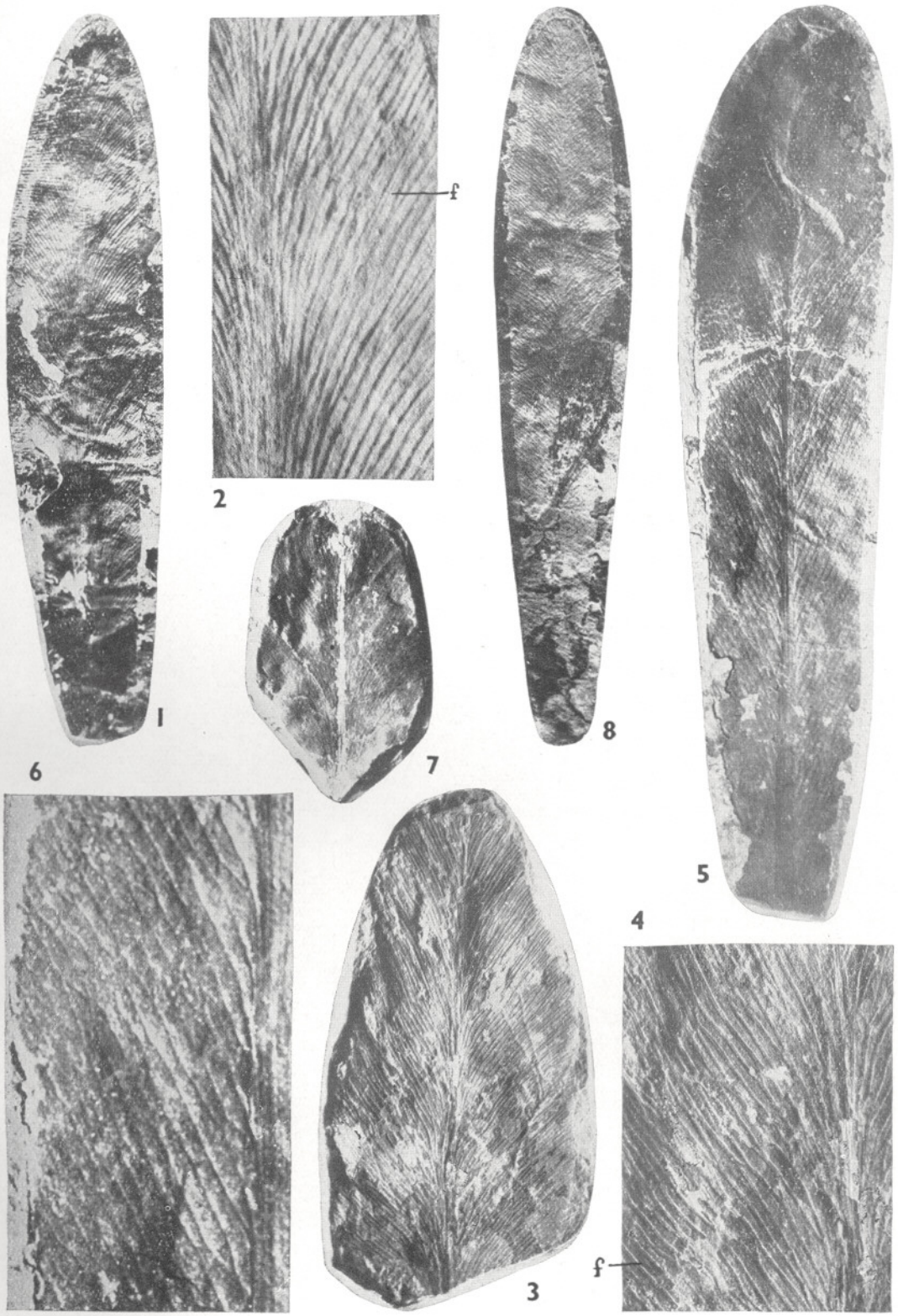
ARCHANGELSKY, S. (1958). Estudio Geologica y Palaeontologica del Bajo de la Leona (Santa Cruz). *Acta Geol. Lilloana* **2**: 5-133.

BHATTACHARYYA, A. K. (1963). The assemblage of megaplant fossils from the Lower Gondwana rocks of the western part of the Auranga Valley Coalfield, Palamau district, Bihar. *Quart. J. geol. Soc.* **35**: 123-128.

DU TOIT, A. L. (1927). Some fossil plants from the Gondwana beds of Uganda. *Ann. S. Afr. Mus.* **28** (4).

FEISTMANTEL, O. (1876). On Some fossil plants from the Damuda series in the Raniganj coalfield, collected by Mr. J. Wood-Mason. *J. Asiat. Soc. Beng.* **45**: 329.

Idem (1878). Palaeozoische und mesozoische Flora des östlichen Australiens. *Palaeontographica.* Suppl. 3, **3**.

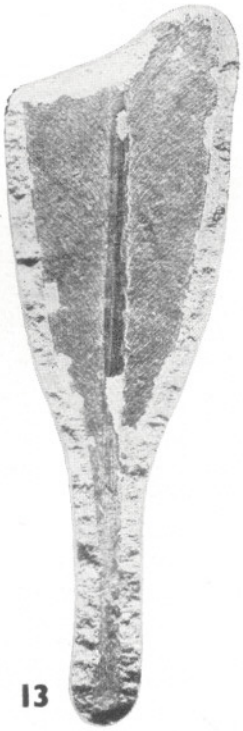

f
1
2
3
4
5
6
7
8
f

9

10

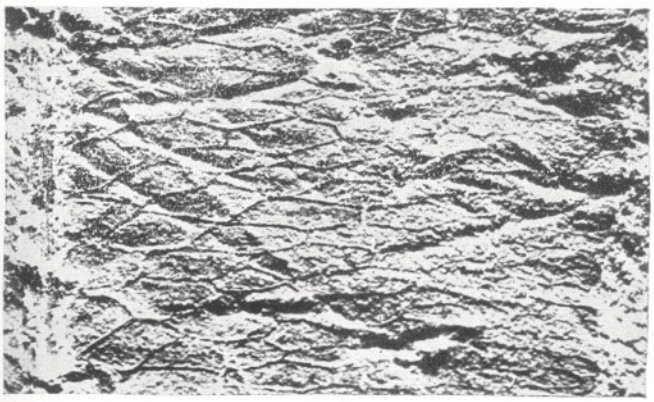
12

14



13

11



15

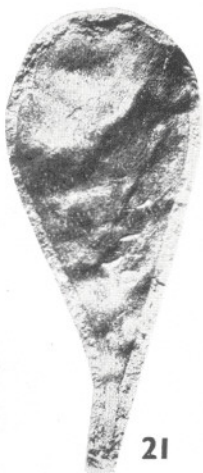
18

16

17

19

20



21

Idem (1879-80). The fossil flora of the Lower Gondwanas 1. The flora of the Talchir Karharbari beds. *Palaeont. indica*. Ser. XII. **3** (1): 1-64.

Idem (1880-81). The fossil flora of the Gondwana System (Lower Gondwanas). 2. The flora of the Damuda-Panchet Divisions. *Ibid*. **3**(2): 1-149.

Idem (1890). Geological and palaeontological relations of the coal and plant-bearing beds of Palaeozoic and Mesozoic age in Eastern Australia and Tasmania, etc. *Mem. geol. Surv. N.S.W. (Palaeont.)* **3**: 1-183.

MAHESHWARI, H. K. & PRAKASH, G. (1965). Studies in the Glossopteris flora of India-21. Plant megafossils from the Lower Gondwana Exposures along Bansloi river in Rajmahal Hills, Bihar. *Palaeobotanist* **13**: 115-128.

MCCOY, F. (1847). On the fossil botany and zoology of the rocks associated with the coal of Australia. *Ann. Mag. nat. Hist.* **20**.

PANT, D. D. (1958). The structure of some leaves and fructifications of the Glossopteris-flora of Tanganiyaka. *Bull. Brit. Mus. (nat. Hist.)* **3**: 127-176.

Idem (1962). Some recent contributions towards the knowledge of Glossopteris-flora. *Proc. Sum. Sch. Bot. Darjeeling*: 302-319.

PLUMSTEAD, E. P. (1952). Description of two new genera and six new species of fructifications borne on *Glossopteris* leaves. *Trans. geol. Soc. S. Afr.* **55**: 281-328.

Idem (1956). Bisexual fructifications borne on *Glossopteris* leaves from South Africa. *Palaeontographica* **100B**: 1-25.

Idem (1958). Further fructifications of the Glossopteridae and a provisional classification based on them. *Trans. geol. Soc. S. Afr.* **61**: 51-76.

Idem (1962). Fossil floras of Antarctica. Trans-Antarctic Expedition (1955-58). *Scientific Reports* No. 9 (Geology-2): 1-112. London.

SEWARD, A. C. & LESLIE, T. N. (1908). Permo-Carboniferous plants from Vereeniging. *Quart. J. geol. Soc. Lond.* **64**: 109-126.

SRIVASTAVA, P. N. (1957). Studies in the Glossopteris flora of India.-4. *Glossopteris, Gangamopteris* and *Palaeovittaria* from the Raniganj Coalfield. *Palaeobotanist* **5**: 1-45 (1956).

SURANGE, K. R. & MAHESHWARI, H. K. (1962). Studies in the Glosspteris flora of India–11. Some observations on *Vertebraria* from the Lower Gondwanas of India. *Ibid*. **9**: 61-67 (1960).

THOMAS, H. H. (1952). A *Glossopteris* with whorled leaves. *Ibid*. **1**: 435-438.

Idem (1958). *Lidgettonia*, a new type of fertile *Glossopteris*. *Bull. Brit. Mus. (nat. Hist.)*, **3** (5): 179-189.

WALKOM, A. B. (1922). Palaeozoic floras of Queensland. Part I. The flora of the Lower and Upper Bowen Series. *Qd geol. Surv. Publ.* No. 270.

WALTON, J. (1929). The fossil flora of the Karroo System in Wankie district, Southern Rhodesia. *Bull. geol. Surv. S. Rhodesia* **15**: 62-75.

ZEILLER, R. (1902). Observations sur quelques plantes fossiles des Lower Gondwanas. *Palaeont. indica N.S.* **2** (1):

EXPLANATION OF PLATES

PLATE 1

1. *Glossopteris* cf. *G. fibrosa* Pant. Specimen No. 32891. × 1.
2. A part of the leaf in Fig. 1 enlarged to show details of venation and the interstitial fibres (f). × 4.
3. *Glossopteris* sp. Specimen No. 32892. × 1.
4. A part of the leaf in Fig. 3 enlarged to show details of venation and the interstitial fibres (f). × 2.
5. *Glossopteris intermedia* Feistm. Specimen No. 32893. × 1.
6. A part of leaf in Fig. 5 enlarged to show details of venation. × 3.
7. *Glossopteris emarginata* Maheshw. & Prak. Specimen No. 32894. × 1.
8. *Glossopteris linearis* McCoy. Specimen No. 32895. × 1.

PLATE 2

9. A part of leaf in Fig. 8, Pl. 1 enlarged to show details of venation. × 3.
10. *Glossopteris taeniopteroides* Feistm. Specimen No. 32896. × 1.
11. A part of leaf in Fig. 10 enlarged to show details of venation. × 3.
12. *Glossopteris decipiens* Feistm. Specimen No. 32897. × 1.
13. *Glossopteris* cf. *G. longicaulis* Feistm. Specimen No. 32898. × 1.
14. *Glossopteris tortuosa* Zeiller. Specimen No. 32899. × 1.

PLATE 3

15. A part of leaf in Fig. 14, Pl. 2, enlarged to show details of venation. × 4.
16. *Glossopteris verticillata* Thomas. Specimen No. 32900. × 1.
17. A part of leaf in Fig. 14 enlarged to show details of venation. × 4.
18. *Glossopteris euryneura* sp. nov. (Holotype No. 32901). × 1.
19. A part of the leaf in Fig. 18 enlarged to show details of venation. × 4.
20. *Glossopteris retusa* sp. nov. Holotype No. 32902). × 2.
21. *Glossopteris retusa* sp. nov. Specimen No. 32903. × 1.

CHART SHOWING THE SALIENT FEATURES OF GLOSSOPTERIS SPECIES FROM THE RANIGANJ STAGE

Species	Shape	Base	Apex	Midrib	Secondary veins	Meshes
Glossopteris indica	Lanceolate or oval-lanceolate	Contracted	Acute	Distinct, Stout & persistent	Acute, oblique	Short and broad near midrib, narrower and longer towards margins
Glossopteris arberi	Linear-lanceolate	—	—	Stout, striated	Acute, arched, subparallel	Long, narrow, oblong-polygonal
Glossopteris communis	Obliquely obovate or spathulate	Contracted	Acute	Distinct, thick, continues almost to the apex	Acute, oblique	Long and narrow, almost equal sized
Glossopteris fibrosa	Lanceolate	—	Obtuse	Flat but continues almost to the apex	Acute, oblique, turned slightly upwards at the margins, interstitial veins present	Narrow, elongate
Glossopteris intermittens	—	Slightly contracted	Round or broadly acute	Distinct	Acute, arched	Narrow, elongate (all the veins do not anastomose)
Glossopteris angustifolia	Linear	Petiolate	Acute	Persistent	Oblique, arched, crowded (24-30 per cm.)	Narrow, elongate-polygonal
Glossopteris stricta	Elongate-lanceolate	—	Acuminate	Strong	Arched, reach the margin almost at right angles	Broad and short-polygonal near midrib; narrow transversely-elongate at the margins
Glossopteris brownii	Spathulate or oval-lanceolate	—	Obtuse	Distinct, persistent or evanescent	Acute, oblique, arched ($\pm$15 per cm.)	Oblong-polygonal, comparatively narrower towards the margins
Glossopteris intermedia	Linear-lanceolate or lanceolate-spathulate	Petiolate	Obtuse	Stout, persistent, longitudinally striated	Acute, oblique, (10-13 per cm.)	Long, oblong-polygonal, equal sized
Glossopteris emarginata	Oblong	—	Emarginate	Distinct	Acute, oblique, in apical region bend towards the midrib, becoming almost parallel to it	Narrow polygonal elongate
Glossopteris linearis	Linear	Petiolate	Slightly notched	Distinct, longitudinally striated	Acute, oblique	Elongate-polygonal, narrower towards margins

Glossopteris taeniopteroides	Oblong, ovato-spathulate	?Attenuate	—	Distinct, longitudinally striated	Acute, steeply arched, reaching margins almost at right angles (16-20 per cm.)	Long, narrow, elongate
Glossopteris decipiens	Spathulate or lanceolate-spathulate	Attenuate	?Obtuse	Evanescent, persisting only for about 2/3 length of the lamina	Acute, oblique, arched	Narrow, oblong
Glossopteris longicaulis	Oblong-oval	Petiolate	—	Evanescent	Sub-acute, oblique	Broad, oblong
Glossopteris tortuosa	Lanceolate or oval-lanceolate	Contracted	—	Distinct, longitudinally striated	Arise at different angles (45°-80°), sinuous	Oblong-polygonal or trapezoidal
Glossopteris sahnii	—	—	—	Distinct, striated	Arise at right angles from the midrib	Large, open, oblong or rhomboidal, equal-sized
Glossopteris retifera	Lanceolate or oval-lanceolate	Petiolate	Acuminate or (?) obtuse	Distinct, longitudinally striated	Arched	Broad, polygonal, equal sized, not much longer than broad
Glossopteris conspicua	Spathulate or oval-lanceolate	—	—	Distinct	Acute, oblique, (5-7 per cm.)	Large, broad, elongate
Glossopteris srivastavae	—	—	—	Strong, striated	Acute	Large, oblong, irregularly shaped
Glossopteris damudica	Broadly ovate	—	Obtuse	Distinct, stout	Arise at open angles	Broad near midrib, narrow at margins
Glossopteris divergens	(?) Ovate	—	—	Strong	Oblique, sinuous	Broad, irregularly shaped
Glossopteris verticillata	Lanceolate	Petiolate	Pointed	Distinct, longitudinally striated	Acute, oblique (14-18 per cm.)	Anastomoses rare, meshes elongate and curved
Glossopteris euryneura	—	Contracted	—	Distinct, broad	Sinuous, at right angles to midrib (8-12 per cm.)	Anastomoses rare, meshes broad
Glossopteris formosa	Linear or linear-lanceolate	Sessile	Obtuse	Slender	Acute, oblique, ($\pm$12 per cm.)	Broad, oblong-polygonal, equal sized
Glossopteris retusa	Obovate, margins notched below the apex	Cuneate	Retuse	Flat, indistinct	Acute, oblique, (35-40 per cm.)	Elongate-narrow
Glossopteris orbicularis	Orbicular	Petiolate	Sub-emarginate	Distinct	Acute, arched	Broad, oblong-polygonal