WILLIAMSONIA SANTALENSIS SP. NOV.—A MALE FRUCTIFICATION FROM THE RAJMAHAL SERIES, WITH REMARKS ON THE STRUCTURE OF *ONTHEANTHUS POLYANDRA* GANJU

R. V. SITHOLEY & M. N. BOSE
Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

W. santalensis sp. nov. is a male fructification from the Rajmahal series of the Upper Gondwanas. The material on which this species is based was discovered at Sakrigalighat in the Santal Parganas of Bihar. The fructification consists of a whorl of 20(?) microsporophylls coalescent towards the centre to form a shallow cup; the mode of attachment of the cup is not known. Each microsporophyll bears on its upper surface two rows of finger-like appendages believed to be the spore-producing members. Inside each appendage there are two contiguous rows of small chambers. The spores are not preserved. The distal, sterile portion, of the microsporophyll shows an asymmetrical and obliquely twisted expansion of the lamina.

The present discovery has thrown light on the structure of *Ontheanthus polyandra* Ganju, described as a unique type differing from the Bennettitales in several important features. A comparison of *W. santalensis* and *O. polyandra* shows that the two flowers had a similar plan of construction, and that the supposed differences from the Bennettitales seen in the latter are based on a mistaken conception of its morphology.

W. santalensis and *O. polyandra* are kept separate for the present, but it is suggested that the discovery of more complete material in the future may make it possible to unite them under a common name.

INTRODUCTION

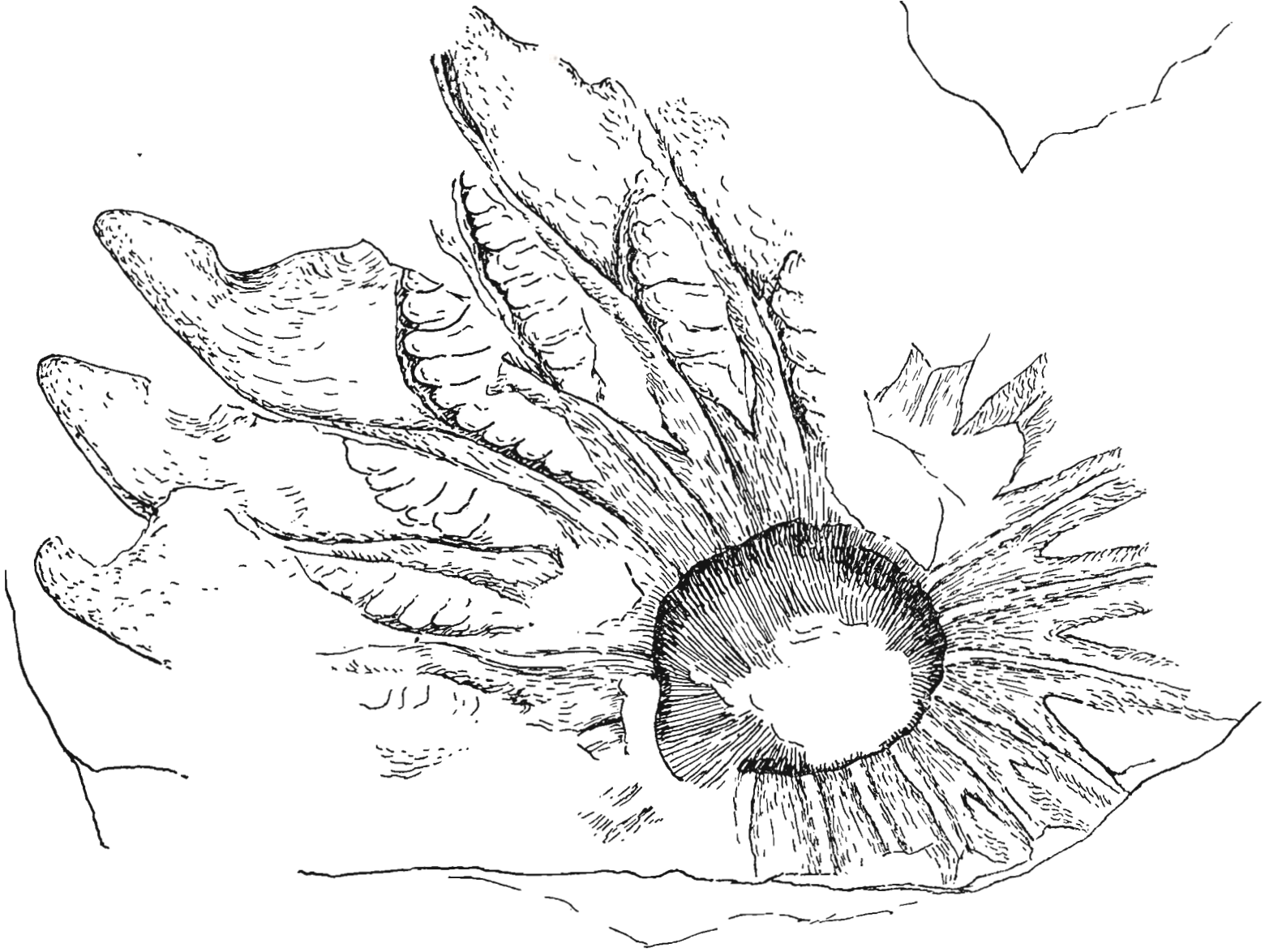
THE specimens of *W. santalensis* were first discovered by M. N. Bose at Sakrigalighat (Santal Parganas) in March 1952. In January 1953 he visited the locality again and found some more specimens. One specimen (PL. 3, FIG. 7) was collected at Sakrigalighat by a student from the Agra College, Agra, in October 1952 and sent to us by Dr. S. Sinha, Professor of Botany at the college.

Locality and Horizon — The fossiliferous beds at Sakrigalighat occur in a hillock, near the ferry, on the right bank of the Ganges. The river has exposed here a section containing several intertrappean beds with plant remains. All of the present specimens were found in a bed of hard shale, associated with numerous leaves of *Ptilophyllum acutifolium* and other fossils, e.g. *Pterophyllum, Nilssonia, Bucklandia, Brachyphyllum* and *Protocyathea rajmahalense*. The outcrop belongs to the Rajmahal series of the Upper Gondwanas. This series has contributed, with one exception, all the species of *Williamsonia* known so far from India.

Previous Records of Bennettitalean Microsporophylls from India— In 1877 Feistmantel described from Bindraban in the Rajmahal hills a specimen of *Williamsonia* which he compared with the "carpellary disc" of *Williamsonia gigas* from the Yorkshire coast. This specimen (designated by Seward in 1917 as *Williamsonia* sp. cf. *W. setosa*) shows close to the edge of one of the bracts a linear structure which is believed to represent two alternately arranged rows of synangia (*see* SEWARD & SAHNI, 1920, PL. 6, FIGS. 54a, b, c). The specimen shows ten hairy bracts fused at their bases; and these, according to Wieland, represent a whorl of microsporophylls originally attached to the lower portion of the receptacle of a bisexual flower (*see* SEWARD, 1917, p. 445). None of the ten bracts in the whorl have their distal part preserved. The linear structure associated with this fossil looks very similar to the fertile appendages of *W. santalensis*.

A bunch of elongated cones from Murrero in the Rajmahal hills was referred by Wieland (1916, FIG. 81B) to *Williamsonia*(?) *rajmahalensis*, under the impression that they represented a whorl of staminate scales. These cones were later proved to be seed-bearing; and in 1937 B. P. Srivastava suggested that they might belong to one of the two species of his new genus *Carnoconites*, a view with which Professor Sahni seemed to agree (*see* SAHNI, 1948, p. 74).

A new species, *Williamsonia Sahnii*, believed to be bisexual, was described by K. M. Gupta in 1943 from Khairbani in the Rajmahal hills. The type specimen shows,



TEXT-FIG. 1 — *Williamsonia santalensis* sp. nov. Photo-tracing of specimen No. 1530 shown in Plate 1. Natural size.

between the female receptacle and the outer covering of bracts, a number of narrow strap-shaped scales which are regarded by Gupta as stalks of the microsporophylls. The synangia are not preserved.

In 1934 Sahni and Rao published an account of a peculiar impression from the Rajmahal hills which they named *Rajmahalia paradoxa*. This is a rhomboid object, bearing on the central portion of its inner surface the impress of seeds and interseminal scales. In their revised interpretation of the fossil, the authors (1935) regard it as an inverted funnel-like organ (possibly part of a deciduous androecium) fallen from the top of a Bennettitalean receptacle. There is, however, no trace of the microsporangia in the specimen.

In 1947 P. N. Ganju described a male flower from the Rajmahal hills under the new generic and specific name *Ontheanthus polyandra*, after Onthea, the locality of its occurrence. Ganju believed that this flower represented a unique type among fossil gymnosperms, though it showed some affinity with the Bennettitales. The structure of this fructification will be discussed on page 36. Fortunately, the more important of Ganju's figured specimens were available to us, and on examining them we discovered a close similarity between *Ontheanthus polyandra* and *W. santalensis*.

DESCRIPTION[1]

Williamsonia santalensis sp. nov.

Pls. 1-4, excepting Fig. 9 in Pl. 3; Text-figs. 1-6 and 7A-C

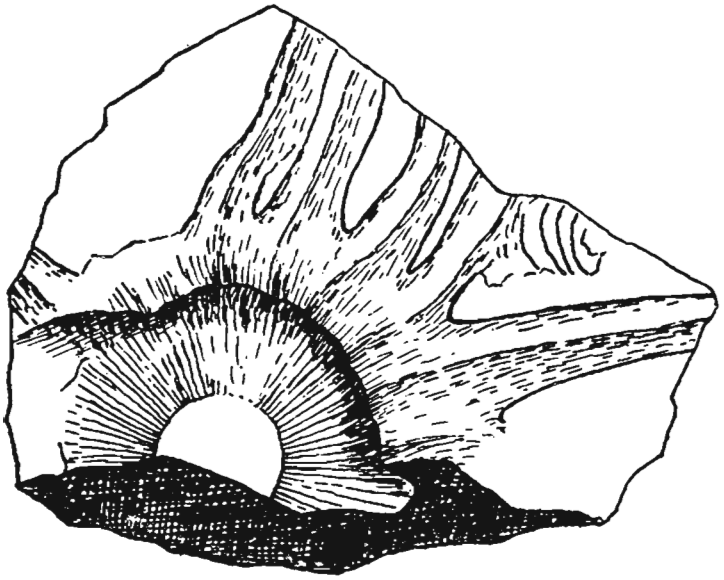
The following description is based on six separate flowers. Pl. 1, Fig. 1 and Pl. 2, Fig. 2 show the counterparts of one flower. The second is also in two counterparts of which only one (Pl. 2, Fig. 3) is shown in the plates. The two counterparts of the third flower are shown in Pl. 3, Figs. 4 and 5; and those of the fourth in Pl. 4, Figs. 10 and 11. The remaining two flowers are represented by single specimens (Pl. 3, Figs. 7, 8). Of these the specimen in Fig. 8 consists only of the upper part of a single microsporophyll.

The new species is named after the Santal Parganas[2] of Bihar in which the outcrops of the Rajmahal series are situated. The flower, as preserved, consists of a shallow cup from the margin of which radiate 20(?) microsporophylls (Fig. 1, Text-fig. 1). It is probable that there were 20 microsporophylls in a whorl. Portions of 19 can be easily counted in the specimen shown in Fig. 1 and Text-fig. 1, and there seems just sufficient space in the specimen (*see* arrow in Fig. 1) to accommodate one microsporophyll. In the bottom of the cup (Fig. 4, Text-fig. 2) is a circular opening, about 1·5 cm. in diameter. The whorl of microsporophylls was obviously attached to the rest of the flower in this region. The hole is not due, as in some specimens of another male flower, *W. spectabilis*, to the lower part of the cup breaking away from the coherent bases of the sporophylls (*see* Nathorst, 1909, Pl. 1, Figs. 1-3). The appearance of the cup in our specimens does not suggest that it was prolonged downwards. The edge of the lamina surrounding the circular space is quite even; the opening, moreover, occupies a position in which the existence of a receptacle can be imagined. The surface of the cup is wrinkled by prominent striae radiating from the centre and continued less conspicuously over the rim into the bases of the microsporophylls.

At the rim the cup is bent sharply into a double curve, shown in sectional view in Text-fig. 3. A similar bending of the rim is found in *Williamsonia* sp. cf. *W. setosa* from Bindraban (Seward & Sahni, 1920, Fig. 59c). Seward and Sahni ascribed this to the compression of the vertical part of the disc. In our specimens the double curve of the rim appears to be of a morphological character. The cup is from 4 to 5 cm. in diameter at the rim. In one

1. After this paper had been sent to the press a few more specimens were discovered which cannot be figured here. They are all fragmentary and do not materially alter the description already given. One of the specimens (No. 3108) which shows the expanded distal part of a microsporophyll, however, needs mention. It is nearly one and half times the size of the figured specimens. While it is not possible at this stage to state with certainty that this specimen belongs to the same species, its discovery indicates that flowers of the *W. santalensis* type attained a size considerably larger than 26 cm. across in the fully opened condition. The new specimens do not throw further light either on the structure of the fertile appendages or the construction of the distal part of the microsporophyll. On the last point, namely the asymmetry of the distal portion of the microsporophyll, we wish again to say that our interpretation is not to be regarded as the last word. There may indeed be some surprise in store when further material is discovered.

2. Name of a district inhabited by a tribe known as Santals.



TEXT-FIG. 2 — *W. santalensis* sp. nov. Photo-tracing of specimen No. 1523 shown in Pl. 3, Fig. 4. Natural size.

TEXT-FIG. 3 — *W. santalensis* sp. nov. Sketch showing vertical section of the cup formed by the coalescent bases of the microsporophylls (diagrammatic). Approximately natural size.

specimen (FIG. 3) the mouth of the cup is much narrower. This may be an example of individual variation, but it seems that compression was also partly responsible for the difference seen in this specimen. The depth of the cup is about 1 cm. In the living condition it may have been a little more.

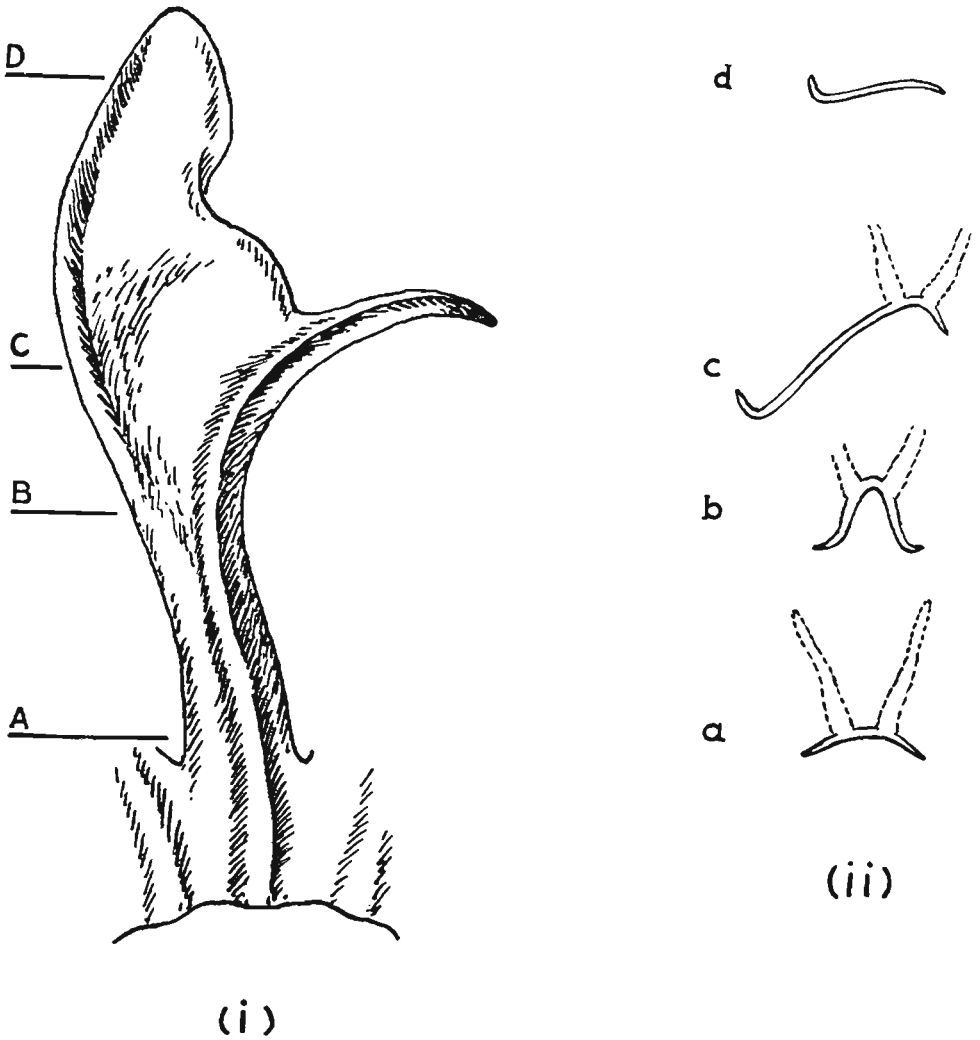
The Microsporophylls — The microsporophylls are tough, coriaceous structures with a much-wrinkled surface. Their united bases form a border, 20-25 mm. wide, round the rim (FIGS. 1, 3). The length of the microsporophyll from its tip to the rim of the cup is about 10·5 cm. The diameter of the fully expanded flower would thus be about 26 cm. (more than 10 in.). In Text-fig. 4(i) an attempt has been made to reconstruct a microsporophyll in order to explain its peculiar construction. In its upper part each microsporophyll expands into a broad asymmetrical structure with a narrow prolongation towards one side (cf. FIG. 8); the lamina then narrows again to end in a rounded tip. In its lower (proximal) part the microsporophyll is folded along the median line. The folds so formed show on the upper surface of the flower as prominent ridges spreading out from the rim of the cup (FIGS. 1, 4). In Figs. 5 and 6 the folds are seen from the reverse side. The fold ceases to be median in the upper part of the microsporophyll where, owing to the asymmetrical expansion of the lamina, it comes nearer to one side and is then continued in the narrow prolongation.

The broad part of the lamina seems to have been twisted anti-clockwise through an angle of nearly 45 degrees. Hence in the open flower this portion of the microsporophyll probably stood obliquely, while the lamina near the tip and in the lower part remained horizontal. The folding and twisting of the lamina at different places in the microsporophyll are shown in Text-fig. 4(ii).

The asymmetry and twisting exhibited by the microsporophylls do not seem to be accidental. They appear, as far as we can judge, to be characteristic of the present fossils. On the other hand, it has to be kept in mind that the material on which the reconstruction shown in Text-fig. 4 is based is not well preserved and future discoveries may reveal errors in our interpretation of the form of the microsporophyll.

We believe that the microsporophylls of *Ontheanthus polyandra* Ganju were constructed on the same plan as described here for the microsporophylls of *W. santalensis*.

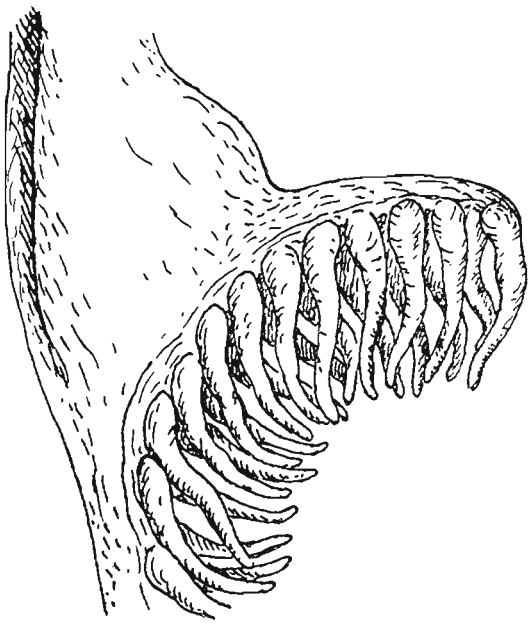
Fertile Appendages — The upper surface of each microsporophyll bears two rows of closely arranged linear appendages (FIGS. 1, 8, 10; TEXT-FIGS. 5, 6). Each finger-like appendage is about 2 cm. in length and is attached to the microsporophyll by a somewhat swollen base (FIGS. 13, 14), from where the body narrows gradually towards



TEXT-FIG. 4 — *W. santalensis* sp. nov. (i) Reconstruction of a microsporophyll; the fertile appendages are not shown. (ii) Transverse sections a, b, c and d of the lamina at A, B, C and D respectively (diagrammatic); the position of the fertile appendages is indicated by broken lines. All drawings approximately natural size (cf. TEXT-FIGS. 5, 6 and PL. 3, FIG. 8).

the tip. The two rows of appendages start near the rim of the cup, one on each side of the median ridge, and are continued in the upper part of the microsporophyll along the course of the fold of the lamina to end at the tip of its curved prolongation (FIGS. 8, 10; TEXT-FIG. 5).

In the normal condition the appendages probably stood more or less erect on the microsporophyll, becoming variously bent after maturity and when the flower began to wilt (TEXT-FIG. 6). Each appendage contains two series of small chambers (FIG. 15, TEXT-FIGS. 7A-C) extending along its entire length. The two rows are in contact and the chambers of one row alternate with those of the other. No microspores are preserved within the chambers. Although the evidence of the microspores is lacking, we have no doubt that the appendages were spore-producing organs. Text-figs. 7A-C show camera lucida sketches of portions of three appendages. The two rows of chambers are enveloped by a rather thick and considerably wrinkled wall with a tendency to split longitudinally. This is how the appendages most probably



TEXT-FIG. 5 — *W. santalensis* sp. nov. Reconstruction of the upper part of a microsporophyll with the fertile appendages in two rows. Slightly enlarged (cf. PL. 3, FIG. 8).

TEXT-FIG. 6 — *W. santalensis* sp. nov. Reconstruction of the lower part of a microsporophyll with two rows of fertile appendages seen in their normal condition. Slightly enlarged.

dehisced. The line of dehiscence lay along the junction of the two rows of chambers and seems to have been predetermined as shown by the narrow distinctive border of the split edges of the wall. The mode of dehiscence of the chambers is not known.

In structure these appendages are closely similar to the organs of *Ontheanthus polyandra* described as microsporophylls by Ganju. The arrangement of the chambers (called microsynangia by Ganju) is the same as in our fossils (cf. TEXT-FIG. 7D).

In their external form and mode of attachment the appendages recall to some extent the fertile appendages of the microsporophylls of *Cycadocephalus* Nathorst and *Weltrichia* Braun (*see* NATHORST, 1912, PL. 1; 1909, TEXT-FIG. 5). In size the appendages of *W. santalensis* are nearer to those of *Cycadocephalus* (2-3 cm.) than to those belonging to *Weltrichia* (5-8 mm.). Internally, the appendages of *W. santalensis* differ from those of *Cycadocephalus*. In the latter the large number of loculi line the inner surface of the appendage, leaving a space in the middle (NATHORST, 1912, p. 9, TEXT-FIG. 2). In our specimens the two rows of chambers fill the whole space within the appendage.

Morphological Nature of the Appendages — Whether each of the appendages in *W. santalensis* should be regarded as a synangium or an organ bearing a group of synangia are questions which must remain unsettled till better preserved material is discovered. It is possible that each chamber within the appendage constitutes a synangium. This is the view adopted by Ganju in the case of the similar appendages found in *Ontheanthus polyandra* (*see also* p. 36). In one of

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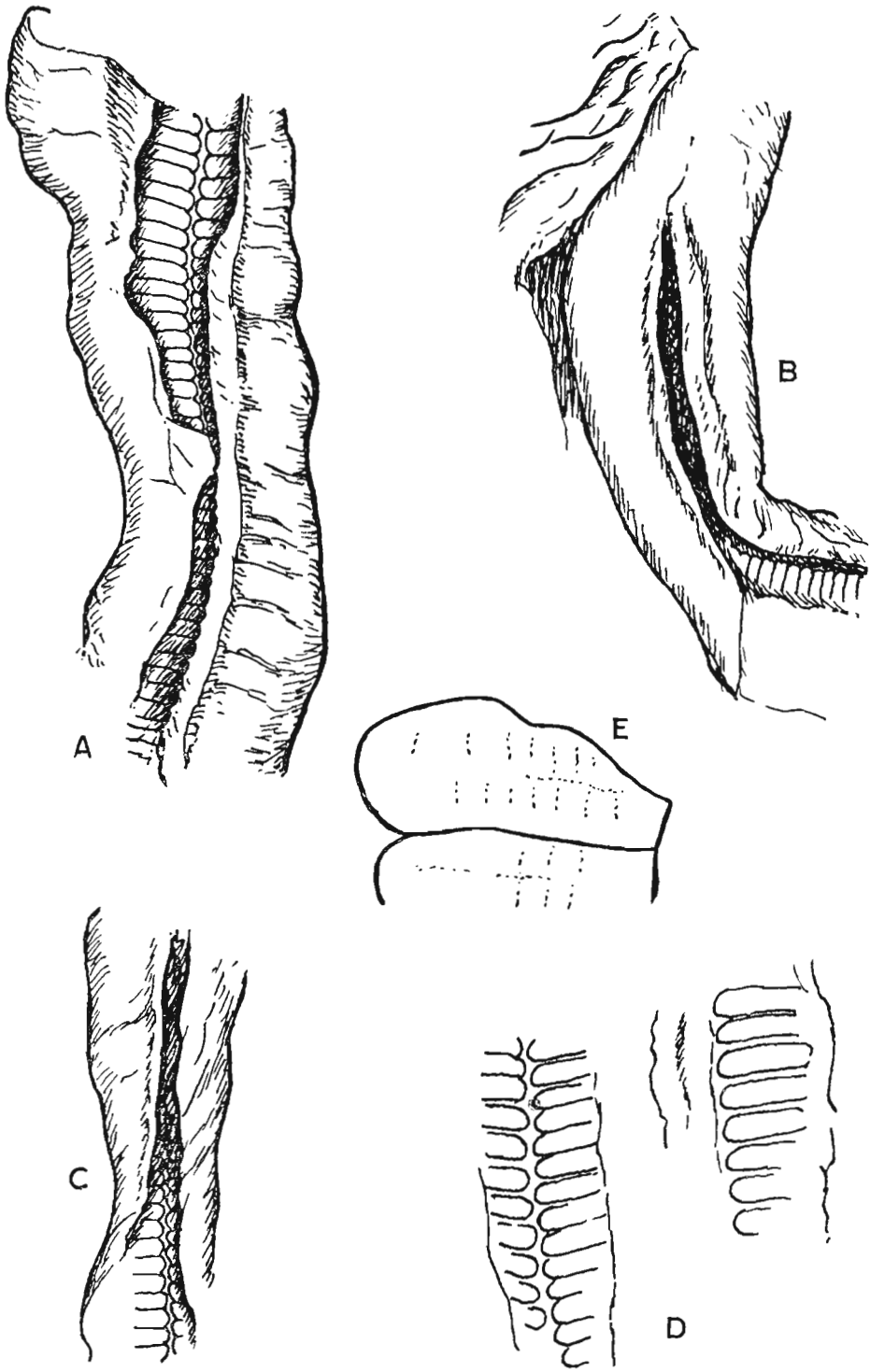
TEXT-FIG. 7 — A and B, C, *W. santalensis* sp. nov. Camera lucida sketches of portions of three fertile appendages, showing the wall longitudinally split and the two rows of chambers inside. D, *Ontheanthus polyandra* Ganju. Camera lucida sketches of portions of two similar appendages (described by Ganju as microsporophylls) showing the two rows of chambers. E, *O. polyandra*. Camera lucida sketch of a chamber to show faint suggestion of septation. A-D × *ca.* 12; E × *ca.* 60.



TEXT-FIG. 7

the specimens of *O. polyandra* there is a very faint suggestion of septation within a few chambers as shown in Text-fig. 7E. In none of our specimens the preservation is good enough to show this character.

The appendages borne on the microsporophylls of *Cycadocephalus* were regarded by Wieland and Nathorst as large synangia containing many sporogenous compartments. Nathorst compared each of the tubular structures with a fertile pinnule of *Danea elliptica* in which the lamina was rolled so as to unite at the edges (*see* SEWARD, 1917, pp. 474, 475). Seward (1917) was inclined to interpret the appendages as highly modified pinnules rather than synangia, and Scott (1923) believed that they represented pinnae bearing synangia.

COMPARISONS

W. santalensis differs from the other *Williamsonia* microsporophylls (*W. gigas*, *W. spectabilis*, *W. whitbiensis*, *W. setosa* and *W. mexicana*) in possessing fertile organs in the form of linear appendages in place of the more or less reniform synangia. In the attachment of the appendages, and to some extent in their external form, the new species resembles the genus *Cycadocephalus*, but it differs in the internal structure of the appendages. In *Cycadocephalus* the concrescent bases of the microsporophylls do not form such a prominent structure as the broad cup of *W. santalensis*. In this feature the Rajmahal fossils show much greater resemblance to *Williamsonia*.

In hardly any of the *Williamsonia* flowers or in *Cycadocephalus* and *Weltrichia* does the sterile part of the microsporophyll show so great and peculiar a development as in *W. santalensis*. A growth of the sterile region of the microsporophyll is more common in *Cycadeoidea*, the most striking example being that of the American Lower Cretaceous species, *Cycadeoidea colossalis* (*see* WIELAND, 1916, FIGS. 23, 25). Here the back of each microsporophyll develops a pair of wings which with the wings of the other microsporophylls forms a kind of dome in the unexpanded flower.

There is a good deal of similarity between the central portion of *W. santalensis* and *Williamsonia* sp. (cf. *W. setosa*) from Bindraban. In both cases the rim of the cup is bent in a double curve. The linear structure associated with the Bindraban fossil seems very much like a fertile appendage of the present specimens. The comparison cannot be carried further as neither the upper part of the microsporophylls nor the bottom portion of the cup is preserved in the Bindraban species.

We have no doubt that the male flower from Onthea, *Ontheanthus polyandra* Ganju, is constructed on the same plan as *W. santalensis*. The points of resemblance between these two have been briefly mentioned already. The structure of *O. polyandra* is further discussed below.

REMARKS ON THE STRUCTURE OF *ONTHEANTHUS POLYANDRA* GANJU

The first and the most complete specimens of this fructification (GANJU, 1947, PL. 9, FIGS. 1, 2) together with a few others were discovered by Sitholey in 1942 while breaking a large block of silicified fossiliferous shale from Onthea. At the suggestion of the late Professor Sahni all these specimens were handed over to Ganju for description.

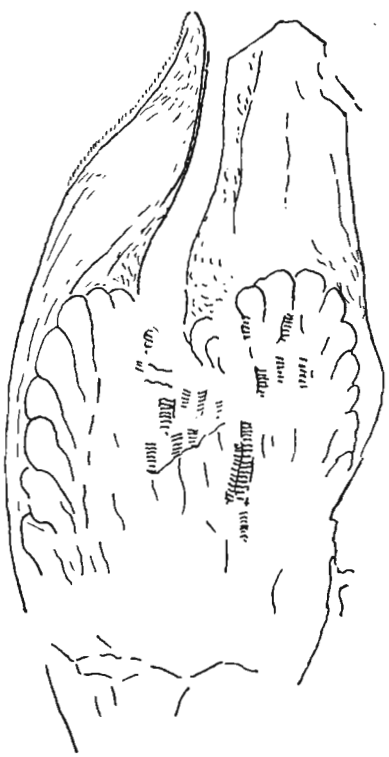
Ganju describes *Ontheanthus* as a genus of male flowers with numerous microsporophylls crowded round an elongated central receptacle which is enclosed within a cup-like perianth; each sporophyll bears two contiguous rows of crowded, transversely elongated synangia (1947, pp. 107, 108). The only species, *Ontheanthus polyandra*, is stated to be a pedunculated flower possessing a deeply funnel-shaped perianth; the elongated microsporophylls, 128-144 in each flower, are attached to the receptacle in a densely crowded manner, all round it and throughout its length; the peduncle is short, about 1 cm. in thickness, and the receptacle is about 2 cm. thick and at least 3·5 cm. long. According to Ganju while the flower shows Bennettitalean affinities, the densely crowded and spiral arrangement of the microsporophylls on a long receptacle makes it a unique type within this group.

In our Pl. 3, Fig. 9 we reproduce a new and slightly enlarged photograph of the specimen O/71 of *Ontheanthus polyandra* shown in Pl. 9, Fig. 1 of Ganju (1947). This specimen is shown in our plate in what we believe to be its correct orientation, i.e. with what Ganju regarded as the peduncle end of the flower brought to the top. Viewed in this manner the specimen proves to be the upper part of an unopened flower of the type of *W. santalensis*. The structure described by

Ganju as perianth is now found to consist of two microsporophylls bearing fertile appendages. These microsporophylls show great similarity with *W. santalensis* in the asymmetrical expansion of the sterile portion and in the form and mode of attachment of the linear appendages (cf. photo-tracing in TEXT-FIG. 8). The lower part of the flower, where the microsporophylls would unite to form a cup, is not preserved in Ganju's specimen.

There are only two microsporophylls preserved in the above specimen, and both of them show fertile appendages attached by their swollen bases. In the middle portion of the specimen there is a large number of appendages pressed together; these belong to the microsporophylls which have not been preserved. Ganju regarded the appendages as microsporophylls borne round a receptacle. There is no evidence of such a receptacle either in specimen O/71 or any other specimen figured by Ganju.

Text-fig. 9 is a photo-tracing of specimen O/42 shown in Pl. 9, Fig. 4 of Ganju. This specimen was figured by him to show the peduncles and receptacles of two flowers lying side by side. We have examined the original specimen carefully and find no trace of either peduncles or receptacles in the places indicated by Ganju. What he regarded as two separate flowers are in reality portions of two microsporophylls lying side by side in the block and perhaps belonging to one flower. This will be clear from Text-fig. 9 given by us. The narrow portion towards the tip of each microsporophyll has been interpreted by Ganju as the peduncle, and the wrinkled and expanded lamina as the receptacle. In another photograph (1947, photo 10) he has shown the " lateral view of a row of about 7 microsporophylls attached to a receptacle ". The original specimen reveals this to be the fragment of the upper part of a microsporophyll with 7 linear appendages attached.



TEXT-FIG. 8 — *Ontheanthus polyandra* Ganju. Photo-tracing of specimen O/71 shown in Pl. 3, Fig. 9 of the present paper. *ca.* 1½.

TEXT-FIG. 9 — *Ontheanthus polyandra* Ganju. Photo-tracing of specimen O/42 shown in Pl. 9, Fig. 4 of Ganju (1947). Natural size.

Dr. Ganju seems to have been misled in his conception of the flower because he examined his specimens upside down. Most of his published figures consequently need turning through 180 degrees for their proper orientation.

To summarize, the features in which *Ontheanthus polyandra* was believed by Ganju (1947, p. 114) to differ from the Bennettitales are as follows: (1) the mode of attachment of the microsporophylls which instead of being placed in a single whorl are disposed spirally on a thick elongated receptacle; (2) the absence of a basal cup-like portion of the androecium such as is found in *Williamsonia*, *Cycadeoidea* and other Bennettitales; and (3) the presence of a cup-like perianth. Our investigation shows that the description of *Ontheanthus polyandra* as given in (1) and (3) is based on a wrong interpretation of its structure. The cup-like portion of the androecium is not seen in the specimens described by Ganju because in all of them only the upper (free) part of the microsporophylls is preserved.

CONCLUDING REMARKS

Although there is very great similarity in structure between *Ontheanthus polyandra* and our specimens, we still lack sufficient evidence of their complete identity. Therefore, for the present it seems advisable to keep them separate. With the discovery of more complete and better preserved material it is probable that the flowers from Onthea and Sakrigalighat may be united under one name. We have preferred to refer our specimens to *Williamsonia* because in their general plan of construction the flowers can be better accommodated within this genus than in any other genus of the Bennettitales.

Several important questions about *Williamsonia santalensis* remain to be answered: Was it a unisexual flower or the staminate whorl of a hermaphrodite fructification thrown off, as in the Cycadeoideas, at maturity; how was this whorl of microsporophylls attached; and, lastly, what was the form of the microspores? No information on these points is available at present. It is to be hoped that the discovery of more material in future will throw some light on these problems.

ACKNOWLEDGEMENTS

The authors are grateful to Professor O. A. Höeg, Director, Birbal Sahni Institute of Palaeobotany, for helpful suggestions, and to Dr. Sinha, Head of the Department of Botany, Agra College, Agra, for the loan of the specimen shown in Pl. 3, Fig. 7.

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EXPLANATION OF PLATES

All the figured specimens (except the one shown in Pl. 3, Fig. 7) are preserved at the Birbal Sahni Institute of Palaeobotany. The specimen in Fig. 7 is preserved at the Botany Department, Agra College, Agra.

PLATE 1

1. *Williamsonia santalensis* sp. nov. No. 1530 (holotype). The photograph shows a whorl of 20(?) microsporophylls coalescent below into a cup-like portion (*see* p. 31). Note the asymmetrical expansion of lamina of the distal parts of the microsporophylls and the attachment of fertile appendages. Natural size (cf. TEXT-FIG. 1).

PLATE 2

2. *W. santalensis* sp. nov. Counterpart in two pieces (Nos. 1528 & 1531) of the specimen shown in Fig. 1. Natural size.

3. *W. santalensis* sp. nov. Another flower showing part of the cup with 6 microsporophylls. No. 1533. Natural size.

PLATE 3

4, 5. *W. santalensis* sp. nov. Counterparts (Nos. 1523 & 1524 respectively) of a flower. Fig. 4 shows 9 microsporophylls emanating from the cup which has a circular hole in the centre (cf. TEXT-FIG. 2). Note the ridges (FIG. 4) formed by the folding of the microsporophylls. Natural size.

6. Part of specimen in Fig. 5 enlarged. Note the sharp fold of the lamina and the swollen bases of fertile appendages. × 2.

7. *W. santalensis* sp. nov. Another flower with bases of 10 microsporophylls preserved. Agra College specimen No. 3. Natural size.

8. *W santalensis* sp. nov. Distal part of a microsporophyll belonging to another flower. The expanded lamina has a narrow and somewhat curved prolongation on the left and shows several appendages attached. No. 1527 Natural size (cf. TEXT-FIGS. 4, 5).

9. *Ontheanthus polyandra* Ganju. New photograph of the type specimen (No. O/71) re-oriented so as to bring the " peduncle " end of the flower to the top. × *ca.* 1½ (cf. TEXT-FIG. 8).

PLATE 4

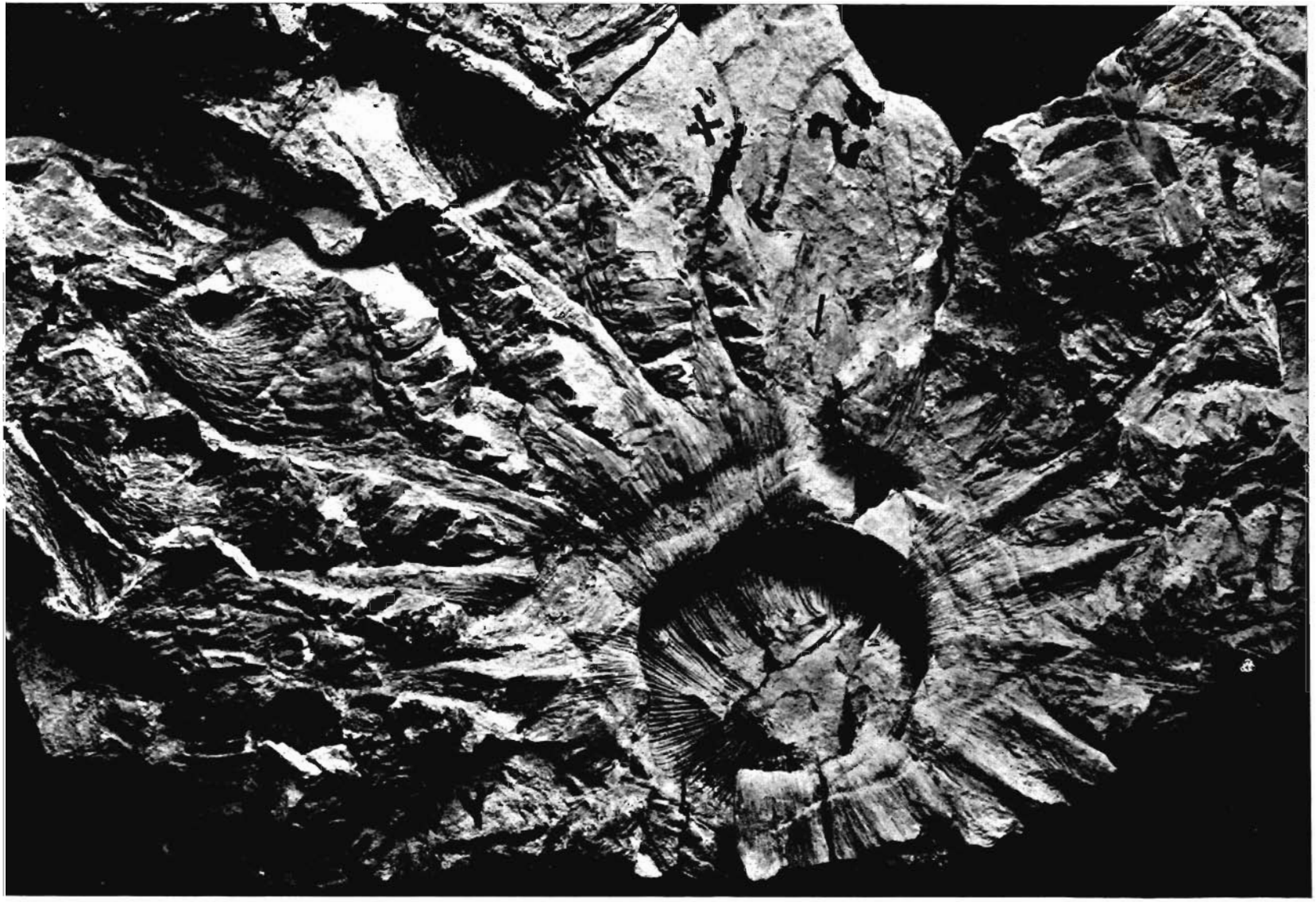
10, 11. *Williamsonia santalensis* sp. nov. Counterparts (Nos. 1525 & 1526 respectively) of a flower. Fig. 10 shows parts of 6 microsporophylls bearing fertile appendages in two rows. In most of the microsporophylls only the bases of the appendages are seen. The microsporophyll on the extreme right is nearly complete and shows the sterile distal portion and some of the appendages in side view. Natural size.

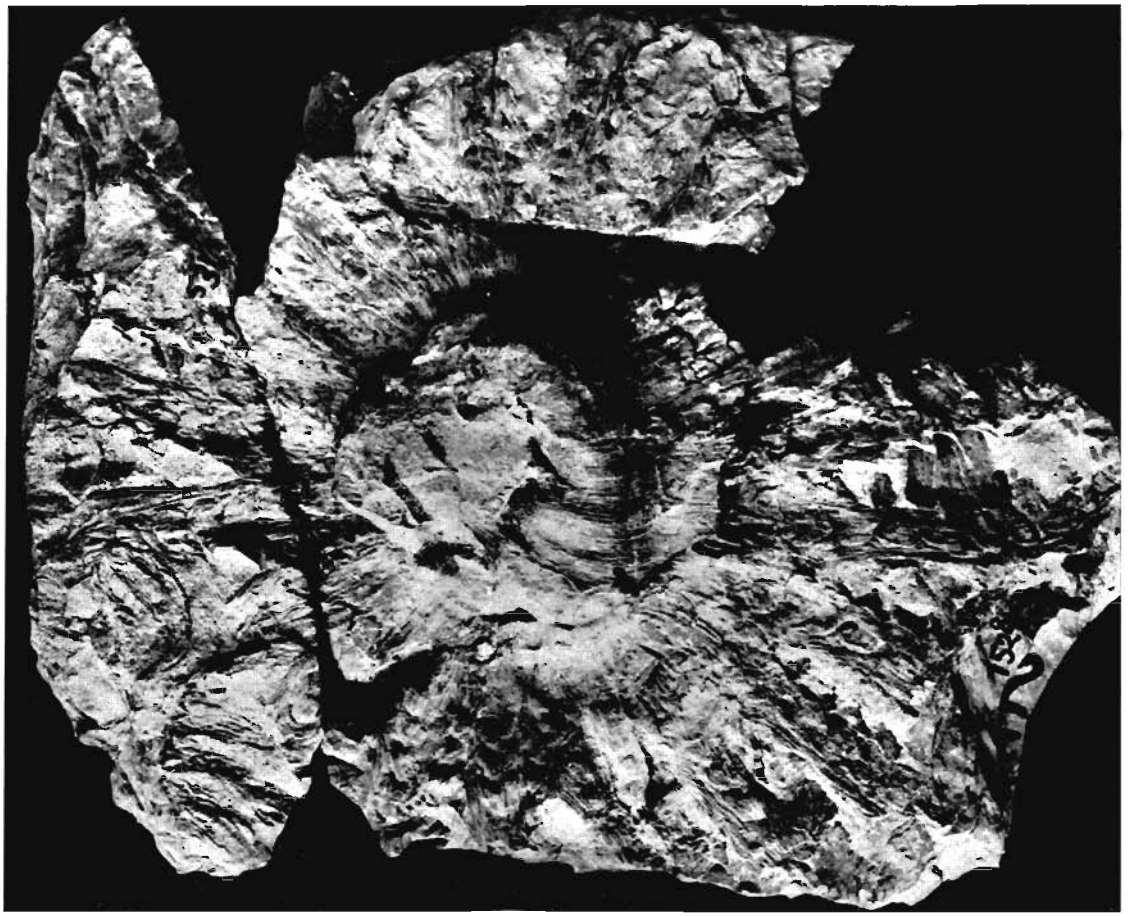
12. The microsporophyll on extreme right in Fig. 10 enlarged. × *ca.* 2.

13. Lower part of specimen in Fig. 10 enlarged to show the two rows of appendages in each microsporophyll. × *ca.* 2½.

14. Part near × of a microsporophyll in Fig. 10 enlarged. The photograph shows two rows of appendages, only the swollen bases are visible in the right hand row, while in the left hand row a portion of the body of each appendage is also seen. × *ca.* 4½.

15. Microsporophyll in Fig. 12 further enlarged to show the two rows of chambers in the appendages. × *ca.* 4 (*see also* TEXT-FIG. 7).





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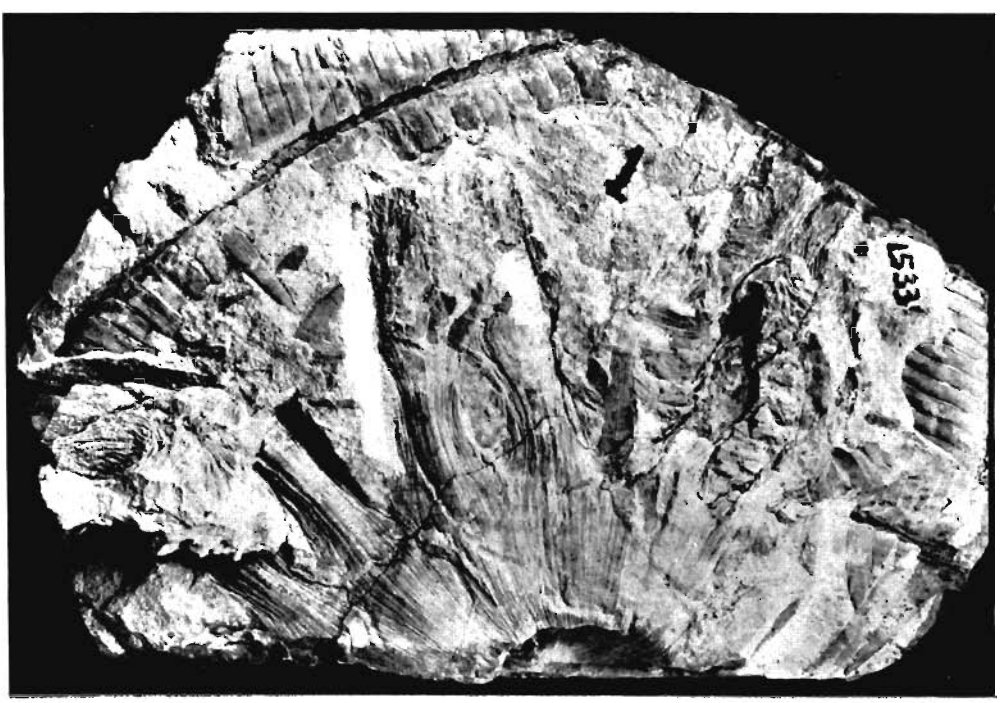

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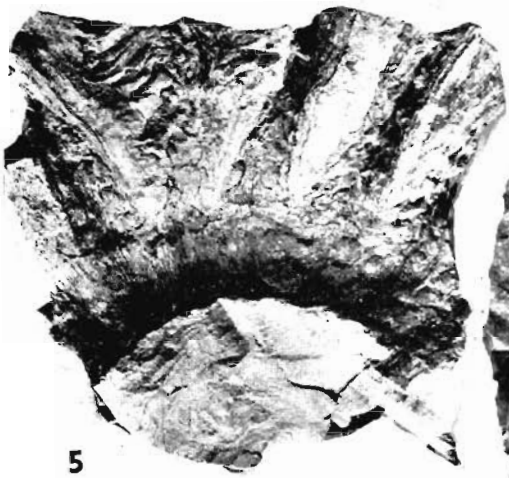

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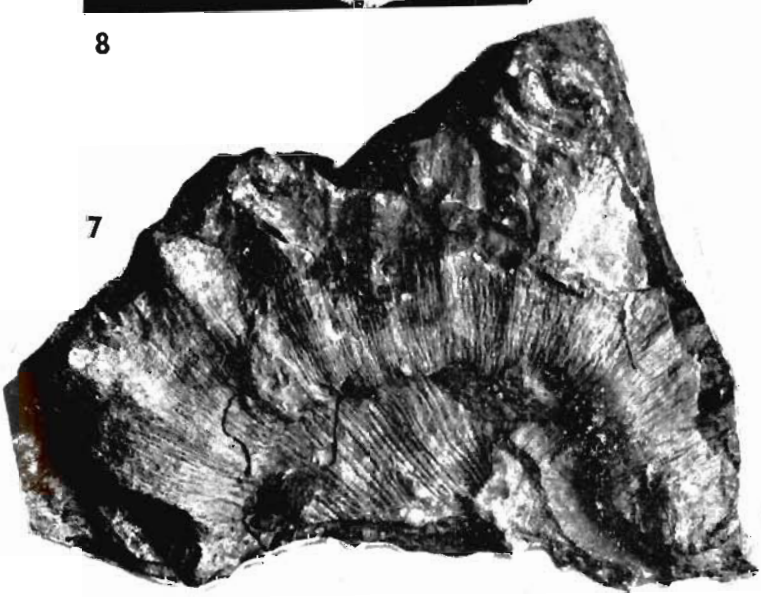

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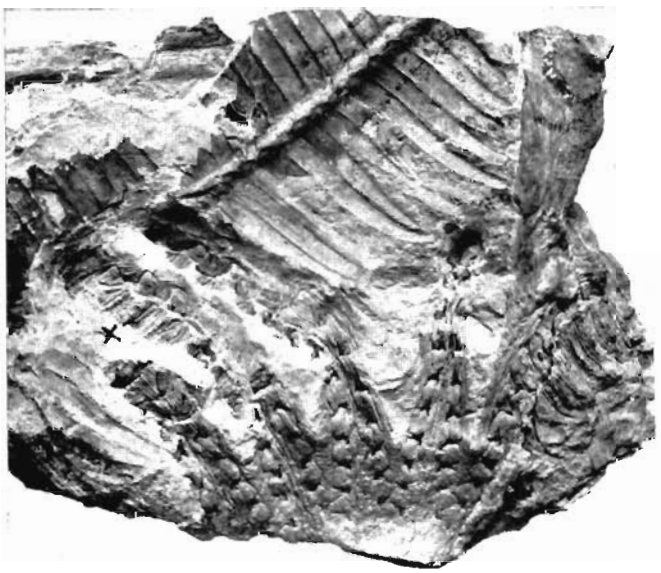

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