STUDIES ON THE FOSSIL FLORA OF THE JABALPUR SERIES FROM THE SOUTH REWA GONDWANA BASIN — 2. *ONYCHIOPSIS PARADOXUS* N. SP.

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ABSTRACT

Both sterile and fertile pinnules of *Onychiopsis paradoxus* n.sp. have been described here. Sterile pinnules are irregularly wedge-shaped and are mostly lobed. Fertile pinnules are elliptical and have numerous smooth-walled trilete spores.

In the light of the present findings the affinities of the genus *Onychiopsis* Yokoyama have been further discussed.

INTRODUCTION

THE plant material herein described was collected by Sukh Dev in March 1958 and February 1960 from four localities near Bansa and Chandia. Out of these two specimens have already been figured by Bose and Sukh Dev (1959). All the specimens gathered are fragmentary and belong to the fertile region. Only the fragment from Tekan, about 1½ miles SE. of Jhála, has both sterile and fertile pinnules. The material from the two localities near Bansa (½ mile NNW. and ½ mile NE.) comprised a number of dark carbonaceous shales all having well-preserved fertile pinnae. A single specimen, in counterparts, from Patparha near Chandia is also from the fertile region, but it is preserved only in the form of an impression. Well-preserved spores could be obtained from all the specimens except this last specimen. Diagnosis and description of *Onychiopsis paradoxus* is based on the observations made on all these specimens. As they resemble each other in gross features and in the character of spores, they have all been included under the same species.

Onychiopsis paradoxus n. sp.

Pl. 1, Figs. 1-9 and Pl. 2, Figs. 10-20; Text-figs. 1-3

Diagnosis — Frond bipinnate. Main rachis fairly thick, surface with longitudinal striations. Pinnae with both sterile and fertile pinnules linear, alternate, arising at an angle of about 40°. Sterile pinnules irregularly wedge-shaped, lobed; lobes with acute apex, margin entire or dentate near the apex. Venation faintly marked, dichotomous. Fertile pinnules mostly like the pinnules borne separately on pinnae having only fertile pinnules. Pinnae with only fertile pinnules also linear, arising at an angle of about 20-25°. Fertile pinnules in the form of 'elliptical bodies', shortly stalked, alternately arranged. Each 'elliptical body' with numerous spores. Spores triangular, size variable, about 50-90 μ, mostly between 50 and 70 μ, smooth-walled, Y-mark distinct.

Locality — Tekan, about 1½ miles SE. of Jhála; ½ mile NNW. and ½ mile NE. of Bansa; Patparha near Chandia.

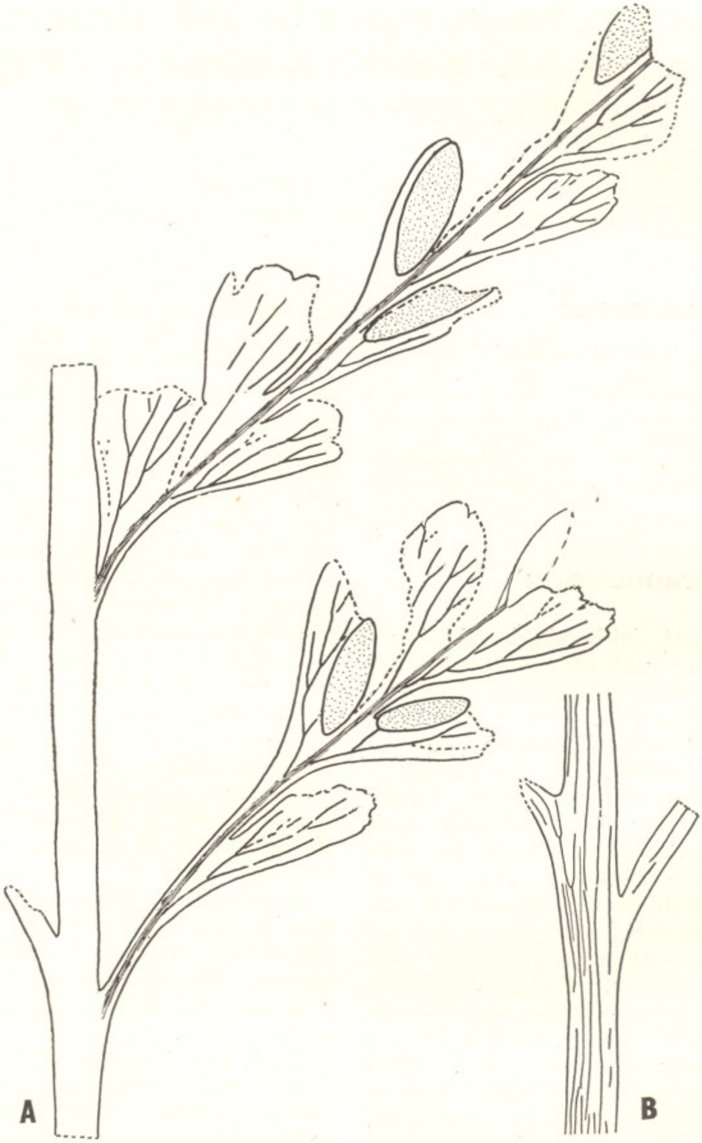
Horizon — Jabalpur series, South Rewa Gondwana Basin.

Collection — Holotype No. 31616 and paratype Nos. 30722, 30663, 30071 and 30611 of the Birbal Sahni Institute of Palaeobotany Museum.

Description — All the fragmentary specimens belong to the fertile region. Therefore, the size and form of the entire leaf are unknown. However, on the evidence of these fragments the frond is assumed to be bipinnate.

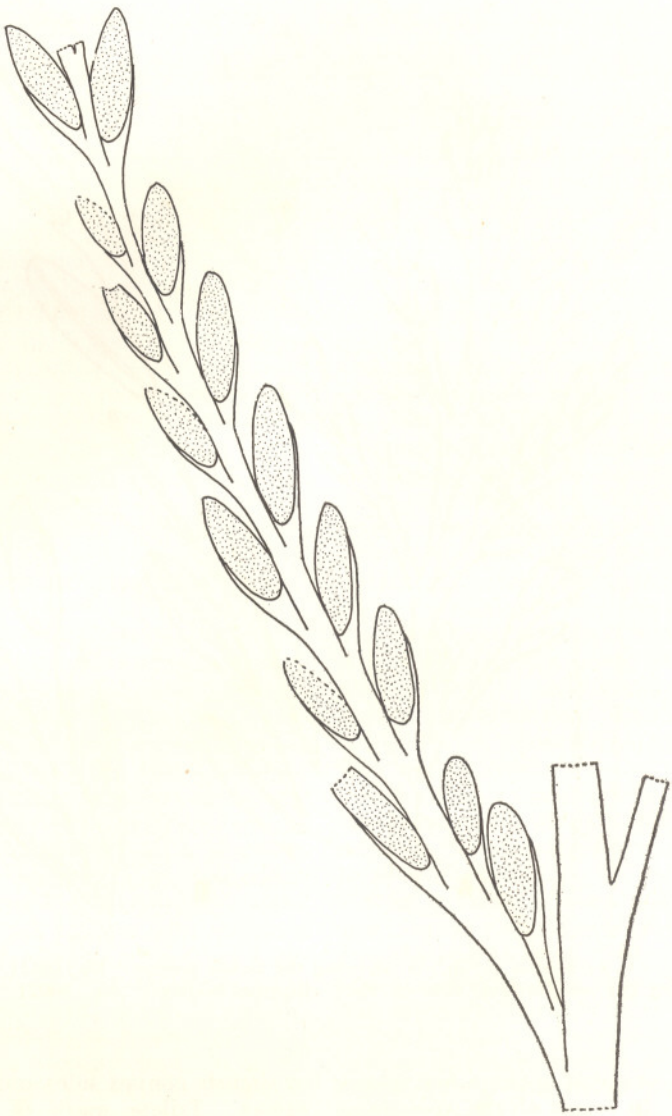
Pl. 1, Fig. 1 and Pl. 2, Fig. 12 show two fronds with pinnae having both sterile and fertile pinnules. The pinnae of the rest of the specimens (PL. 1, FIGS. 3-5, 8 and PL. 2, FIG. 10) are composed entirely of fertile pinnules. Pinnae in all the specimens are alternately arranged. In the case of the specimen figured in Pl. 1, Fig. 1, the pinnae arise at an angle of about 40°, the pinnae with only fertile pinnules (PL. 1, FIGS. 4-5 and PL. 2, FIG. 10) make an angle of about 20-25°, but in the case of the specimen shown in Pl. 1, Fig. 8, they are attached at an angle of 52-60°.

In the specimen with both sterile and fertile pinnules there seems to be no fixed order as to the respective position of the sterile and fertile pinnules, but in almost every pinna



TEXT-FIG. 1 — A, *O. paradoxus* n. sp., showing the fertile and sterile pinnules. No. 30722. × 5. B, a portion of the main rachis from the above specimen, showing the longitudinal striations. × 5.

the basal pinnules are sterile. Further up the sterile and fertile pinnules are irregularly distributed. Mixed with these entirely sterile or fertile pinnules there also occur a few pinnules whose adaxial part is in the form of a fertile 'elliptical body' and the basal part is like the abaxial portion of a sterile pinnule. The sterile pinnules are irregularly wedge-shaped and the fertile pinnules are in the form of 'elliptical bodies'. Both sterile and fertile pinnules are alternately arranged and are acutely directed forward. The venation in the sterile pinnules is faintly marked. The principal vein after entering the base of a sterile pinnule bifurcates regularly and enters each lobe. Each fertile pinnule has a short stalk and is elliptic in shape. Under a binocular these pinnules seem to consist of two



TEXT-FIG. 2 — *O. paradoxus* n. sp., showing a fertile pinna. No. 30663. × 5.

parts, a basal somewhat saucer-shaped portion which appears to be the prolongation of the stalk and an 'elliptical body' closely fitting into the concave prolongation. Each 'elliptical body' is supplied with a single vein and it measures 3·5-5 mm. in length and 1-1·5 mm. in breadth. Surface of each of these is very finely striated in transverse direction. The circular areas as observed by Velenovský (1888) and Seward (1894) are not seen here.

The compressed 'elliptical bodies' can easily be separated from the fronds by a sharp needle. When separated, they are elliptical in shape and under a binocular they seem to consist of two zones — a central thickened portion and the marginal less thickened region. The central region is the area occupied by the spores. Both upper and lower surfaces, besides the transverse striations, also show a few transverse cracks. From these cracks even in an unmacerated,

TEXT-FIG. 3 — *O. paradoxus* n. sp. A, showing the fertile pinnae. No. 30611. × 2. B, portions of two pinnae showing the longitudinal slits on the 'elliptical bodies'. No. 30071. × 5.

'elliptical body' one can notice a few spores projecting out. In some of the specimens (PL. 1, FIGS. 8-9; TEXT-FIG. 3B) in addition to the transverse striations and cracks, in some of the pinnules also a longitudinal slit is present as has been observed in some of the fertile pinnules of *O. psilotoides* Stokes & Webb and *O. elongata* Geyler. When these detached 'elliptical bodies' were kept for maceration, the outer wall readily dissolved in acid leaving an oval mass of spores and we failed to observe any sporangia or even cells suggestive of annulus.

The spores (PL. 2, FIGS. 13-18) recovered from each 'elliptical body' are rather varied in size and shape. Spores are mostly triangular in shape with distinctly concave, straight or slightly convex sides and are with rounded apices. Trilete mark is distinct, extending almost to the periphery. Exine is smooth, 2-4 μ thick. Diameter is about 51-90 μ but mostly about 68-80 μ.

Along with these trilete spores, the 'elliptical bodies' of the specimen shown in Pl. 2, Figs. 10 and 12, also contain a few fairly large alete circular spores (PL. 2, FIG. 19). These spores are all smooth-walled and measure mostly 86-130 μ (range noted 55-130 μ). The trilete spores (PL. 2, FIG. 20) of these specimens are like the trilete spores of the other specimens and also in external features these specimens resemble in every aspects the other fertile specimens.

COMPARISON

From the Cenomanian beds of Bohemia a few sterile and fertile fronds belonging to the Filicales were described by Velenovský (1888) as *Thyrsopteris capsulifera*. Nathorst (1890) noted a great similarity between these fertile fronds from Bohemia and *Onychiopsis elongata* Geyler described by Yokoyama (1889). Nathorst, therefore, suggested that *T. capsulifera* be transferred to the genus *Onychiopsis*. This was later supported by Seward (1894) and Yabe (1905). Of all the species of *Onychiopsis* so far described, *O. paradoxus* resembles most the sterile and fertile fronds of *O. capsulifera*. Unlike the narrow and lanceolate pinnules of *O. psilotoides* Stokes & Webb and *O. elongata* Geyler, the pinnules of *O. paradoxus* and *O. capsulifera* are broader and also the venation in them is quite different. While the pinnules in *O. psilotoides* have been found to be with a mid-vein by Kryshtofovich (1933), the pinnules of *O. paradoxus* and *O. capsulifera* do not have any mid-vein. In both these latter species the nervules are often forked, but in *O. elongata* the venation is obsolete and, moreover, the secondary veins are simple. Ôishi (1940) mentions the nervation in *O. elongata* as *Sphenopteris* type. Although there is a great similarity between the pinnules of *O. paradoxus* and *O. capsulifera*, one can distinguish the two by the size, shape and venation of the pinnules. Most of the sterile pinnules of *O. capsulifera* seem to be a little larger in size and they have larger number of lobes than *O. paradoxus*. Also the venation in the two is different. The pinnules of *O. capsulifera* have much more nervules and they divide freely. The fertile pinnules of *O. paradoxus* are markedly elliptical in shape, whereas they seem to be oval in *O. capsulifera*. Some of the fertile pinnules of *O. capsulifera* were found to be dotted with a thick granular structure, which were supposed by Velenovský to be the numerous sporangia. No such granular structure is seen in the case of *O. paradoxus*. In *O. paradoxus* in a partially macerated fertile pinnule only the spores could be observed.

O. paradoxus can readily be distinguished from *O. psilotoides* and *O. elongata* by the mere shape of the sterile pinnules. Even the broader sterile pinnules of *O. elongata* described by Michael (1936) seem to be narrower than the pinnules of *O. paradoxus*. Although the sterile pinnules in these two species are so different, yet the fertile pinnules resemble each other very much both in size and shape. The fertile segments of *O. psilotoides* were described by Seward (1894) as ovate bodies with an awn-like termination at the apex. In none of the fertile pinnules of *O. paradoxus* such an awn-like structure has been noticed. In *O. psilotoides* Seward noticed on the fertile pinnules circular areas marking probably the position of sporangia. No such circular areas are seen in *O. paradoxus*. The fertile pinnules of *O. elongata* as figured by Yokoyama (1889) seem to be bigger in size and are elongated. The other details are not known in this species. The fertile pinnules of *O. elongata* described by Ôishi (1940) are oblong and are obtusely pointed at the apex.

Among the numerous species of fossil *Thyrsopteris* described by Fontaine (1889), to some extent, some of the pinnules of *T. divaricata* Fontaine may be compared with the sterile pinnules of *O. paradoxus*. But they differ in the nature of venation and lobes. In general shape of the pinnules *T. microloba* Fontaine may also be compared with the pinnules of *O. paradoxus*. But like the former this species too differs in venation and in the nature of the lobes. Moreover, due to lack of any fertile pinnules, at present, it is not possible to compare them fully with *O. paradoxus* and also we do not know the exact affinities of these species and the various other species of *Thyrsopteris* described by Fontaine. As, so far, only a few of his specimens have been transferred under the genus *Onychiopsis* by Seward (1894) and Berry (1911). Affinities of the remaining species are not yet known with certainty.

From what has been mentioned above it is clear that among the Mesozoic fossil fronds, *O. paradoxus* resembles most the various species of *Onychiopsis*. But the structure of the fertile pinnules of *O. paradoxus*, as is at present known, may also be compared with some of the Palaeozoic ferns which possess exannulate monosporangiate fructifications, such as *Acrangiophyllum pendulatum* (Lesley) Mamay (1955). But from all those Palaeozoic forms *O. paradoxus* can readily be distinguished by the mere shape and arrangement of the fertile pinnules.

The earlier workers, like Yokoyama (1889), Nathorst (1890), Seward (1894) and Yabe (1905), etc., have already pointed out the similarities between the various species of *Onychiopsis* and the living genus *Onychium* Kaulfuss and *Thyrsopteris* Kunze. So, here, we would only like to mention that in the light of the present findings the fertile pinnules of *Onychium* and *Thyrsopteris* are quite different from *O. paradoxus*. Saporta (1894) on examining a fertile frond of *O. psilotoides* from Portugal was inclined to bring the position of this species under the genus *Davallia* or at least into Davallieae. This view has, however, already been criticized by Seward (1894). The fertile and sterile pinnules of *O. paradoxus* are quite different from any of the known members of Davallieae. If we assume that the sporangia in *O. paradoxus* were not grouped in sori but were solitary instead, then each fertile pinnule representing the ' elliptical body ' may be considered as a sporangium as is the case in Schizaeaceae. But in general habit of the frond and shape and size of both sterile as well as fertile pinnules, *O. paradoxus* is very different from any of the living member of the Schizaeaceae, so it is most unlikely that *O. paradoxus* belongs to the Schizaeaceae. Moreover, so far we have failed to see the characteristic annulus which is always present in the recent and fossil members of the Schizaeaceae. In the absence of annulus *O. paradoxus* comes nearest to the members of Ophioglossaceae. But in all other features it is very different from any of the living or fossil members of Ophioglossaceae, most of all it lacks the fertile spike characteristic of the family.

DISCUSSION

Nature of Fertile Pinnules — From the above description it is evident that the fertile pinnules of *Onychiopsis paradoxus* are quite different from any of the recent species of Gymnogrammoid ferns. Even the spores of *O. paradoxus* are quite different (*see* PL. 2, FIGS. 21-23). The complete absence of sporangia and annulus inside the fructifications prevents us from using the term ' sori ' for the fertile pinnules. From what is known, at present, each fertile pinnule of *O. paradoxus* may be interpreted as exannulate monosporangiate fructifications and the dispersal of the spores perhaps took place due to a longitudinal slit on one side of the sporangial wall. But till the time we definitely know the exact nature of the fertile pinnules, in this species (*O. paradoxus*) and the other species of *Onychiopsis*, we have thought best to use the term ' elliptical bodies ' for the fertile pinnules, as it is also quite possible that the spore mass could have been produced by the decay of a lot of ripe sporangia in a rather protected sorus.

Although the fertile pinnules of *O. paradoxus* have proved to be quite different from what was previously supposed to be by Yokoyama (1889), Velenovský (1880) and Seward (1894) in the case of the earlier described species of *Onychiopsis*, yet the sterile and fertile pinnules of *O. paradoxus* are so similar to them in external feature that until we definitely know the exact nature of the fertile pinnules of *O. psilotoides*, *O. elongata* and *O. capsulifera*, we feel that there is no justification for describing our specimens under a separate genus.

Systematic Position — Because of the apparent resemblance of the fertile pinnules of *Thyrsopteris elongata* described by Geyler (1877) to that of the recent plant *Onychium* and *Cryptogramme*, Yokoyama (1889) instituted a new genus *Onychiopsis* for the reception of Geyler's species. Yokoyama further found the general appearance of the fertile pinnules and the terminal nature of the sori closer to that of *Onychium*. But due to lack of sporangia in Geyler's specimens he placed *Onychiopsis* only provisionally under *Polypodiaceae*. Although this elegant fern is so common in the Wealden and has been reported from various localities all over the world, yet so far no one has succeeded in observing the sporangia inside the fertile pinnules. Velenovský (1888) noticed on the inner walls of some of the fertile pinnules of *O. capsulifera* impressions of some granular structure, which he thought to be the numerous sporangia, but he failed to observe the nature of the sporangium. Besides this author, Seward (1894) seems to have observed only the positions of sporangia in *O. psilotoides*. He found the surface of the fertile segments rugose, which when magnified looked as small circular areas. These circular areas Seward thought to be the positions of sporangia. On the basis of this observation he mentioned (SEWARD, 1894, p. 50), " Among recent ferns there can be little doubt that *Onychium* comes nearest to *O. Mantelli* in the form of the fertile segments. The sporangia are clustered together in oval sori covered by an indusium, and often prolonged apically into a delicate appendage. The circular areas referred to in the fossil no doubt indicate sporangia, and the median groove seen in some cases, if not an accident of preservation, may correspond to a similarly situated depression in the sori of *Onychium*." Our fertile pinnules, however, do not support this view of Seward as although our fertile pinnules are so well preserved, yet in none of them we have been able to observe the sporangia either by examining them under reflected light or by partially or fully macerating them or by preparing balsam transfers. Entire specimens of the fertile pinnules in the shape of ' elliptical bodies ' could easily be separated even by a needle. The ' elliptical bodies ', when separated, were first observed under reflected light for sporangia, later they were macerated in different reagents, such as water, very dilute and strong KOH, H_2O_2 and HNO_3. In each case, when observed under a microscope, the surface showed only fine striations and a few transverse cracks. No trace of any sporangium could be seen. From some of the transverse cracks a few spores could be seen projecting out (PL.1, FIGS. 6, 7). When these partially macerated ' elliptical bodies ' were further broken to bigger or smaller pieces or even crushed, even then no sign of any sporangial wall or annulus could be detected. Only compact groups or masses of spores were readily liberated. When an ' elliptical body ' was fully macerated in HNO_3+KClO_3 and washed in dilute KOH, only an oval mass of spores was left The external resemblance between the fertile pinnules of *O. paradoxus* and some of the species of the living genus *Onychium* is so marked that in such a case like this, one may doubt that perhaps the sporangial walls and the annulus were destroyed during preservation or maceration. But as no sporangia or even the annulus were observed, we, however, think that there is also a possibility that the spores were enclosed directly inside the ' elliptical bodies '. Therefore, although it is possible to point out similarities of *Onychiopsis* to recent *Onychium* in the details of fertile segments, yet unless we definitely know the existence of sporangia inside the fertile pinnules, the systematic position of the genus *Onychiopsis* should be left open.

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EXPLANATION OF PLATES

PLATE 1

1. *Onychiopsis paradoxus* n. sp., showing fertile and sterile pinnules. No. 30722. × 1.

2. A few sterile pinnules from the above specimen showing the venation. × 5.

3. *O. paradoxus*, showing portions of three fertile axes. No. 30602. × 1.

4-5. *O. paradoxus*, showing the fertile region of a frond in counterparts. No. 30663. × 1.

6. A partially macerated ' elliptical body ' from the specimen shown in Fig. 5. Sl. No. 30663/1. × 8.

7. A portion of the above magnified, showing the spores. Sl. No. 30663/1. × 150.

8. *O. paradoxus*, showing three fertile axes joined to the main rachis. No. 30071. × 1.

9. A portion of the above magnified. Some of the ' elliptical bodies ' show clearly the longitudinal slits. × 5.

PLATE 2

10. *Onychiopsis paradoxus* n. sp., showing only the fertile region. No. 30611. × 1.

11. A portion of the above magnified. × 4.

12. *O. paradoxus*, the largest fertile specimen. Holotype No. 31616. × 1.

13-18. A few isolated spores. Fig. 13, Sl. No. 30722/1; Fig. 14, Sl. No, 30663/2; Fig. 15, Sl. No. 30608/1; Fig. 16, Sl. No. 30602/1; Fig. 17, Sl. No. 30663/2; Fig. 18, Sl. No. 30602/1. All × 500.

19, 20. A few isolated spores from the specimen shown in Fig. 10. Fig. 19, Sl. No. 30611/3; Fig. 20, Sl. No. 30611/1. All × 500.

21. *Onychium auratum*. Sl. No. 1747. × 500.

22. *Cryptogramma crispa*. Sl. No. 1451. × 500.

23. *Onychium siliculosum*. Sl. No. 1751. × 500.


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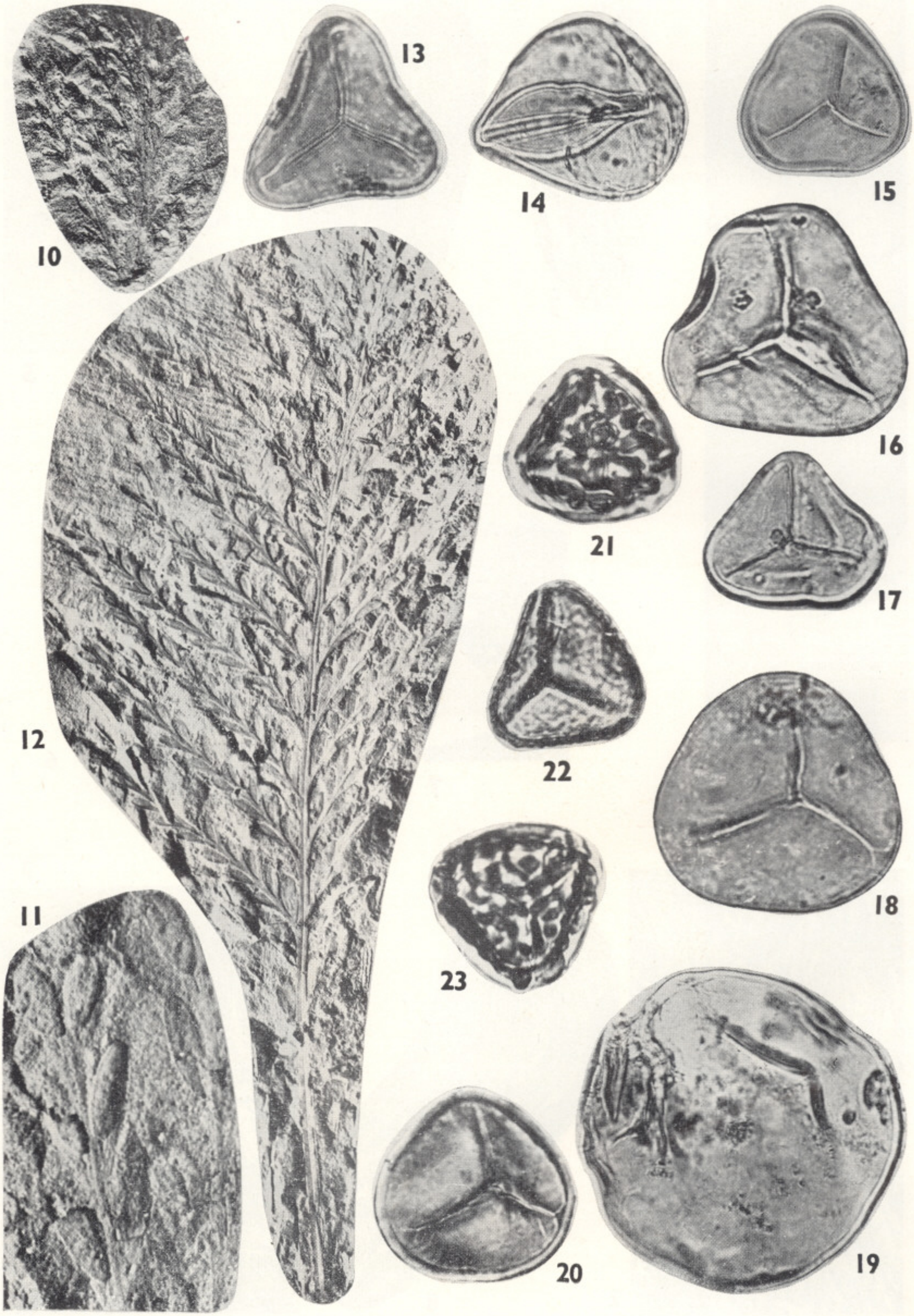
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