THE GENUS *PTILOPHYLLUM* IN INDIA*

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ABSTRACT

The present study is based on all the Indian specimens of *Ptilophyllum* Morris described since 1840 and new specimens collected during the last 20 years. The different species have been grouped under the headings "Impressions", "Incrustations" and "Petrifactions". Under impressions four species, viz. *P. acutifolium* Morris (1840), *P. cutchense* Morris (1840), *P. rarinervis* (Feistmantel) n. comb. and *P. tenerrimum* Feistmantel (1877) have been included. All these four species are based on external characters alone. Eight species based on cuticular structure have been described under incrustations. These are *P. oldhamii* Jacob & Jacob (1954), *P. indicum* Jacob & Jacob (1954), *P. horridum* Roy (1963), *P. sakrigaliensis* Sah (1958), *P. distans* (Feistmantel) Jacob & Jacob (1954), *P. institacallum* Bose (1959), *P. jabalpurense* Jacob & Jacob (1954) and *P. gladiatum* Bose & Sukh Dev (1958). The remaining species, i.e. *P. amarjolense* Bose (1953), *P. sahnii* Gupta & Sharma (1968) and *P. nipanica* Vishnu-Mittre (1957) are preserved in the form of petrifactions. In these three species, besides the surface characters, the anatomy of the fronds have been studied in detail.

INTRODUCTION

THE genus *Ptilophyllum* was instituted by Morris (1840) on some fragmentary pinnate fronds from Kutch, India. He had then given the generic diagnosis as, "Stem — ? Fronds pinnate; pinnae closely approximated, linear, lanceolate, more or less elongate, imbricate at the base, attached obliquely; base semicircular or rounded; veins equal, slender, parallel". Under this genus two species were described, viz. *Ptilophyllum acutifolium* and *P. cutchense*. The former was described as, "Frond pinnate; pinnae narrow, linear-elongate, acute at apex" and the latter as "Frond pinnate; pinnae short, scarcely overlapping at the base, apex obtuse". In 1841, Morris further commented on the nature of the pinnae in *Ptilophyllum*. But in 1843, he, however, discarded this name in preference to the generic name *Palaeozamia* Endlicher (1836). Under *Palaeozamia* quite a few species, viz. *P. bengalensis* Oldham, *P. acutifolium* Morris, *P. rigida* Oldham, *P. cutchense* Morris etc. were described by Oldham and Morris (1863) from the Rajmahal Hills, Bihar, India. Schimper (1870-72) rejected the name *Palaeozamia* and instead used the original name *Ptilophyllum* for all the species previously assigned to *Palaeozamia*. This name was later adopted by Saporta (1875) as well. Further justification for the maintenance of the genus *Ptilophyllum* has recently been given by Harris (1969).

Feistmantel (1876-79) examined some of the specimens of *Ptilophyllum* earlier described by Morris (1840) and Oldham and Morris (1863) and also described a few new species from Kutch, Rajmahal Hills, Gollapalle, Jabalpur, Sehora and Madras Coast. Since then these collections, along with other specimens collected from time to time, were studied by Seward (1917), Seward and Sahni (1920), Sahni and Rao (1933, 1934) and Jacob and Jacob (1954). Besides them, Ganju (1946), Bose (1953), Vishnu-Mittre (1957), Bose and Sukh Dev (1958), Bose (1959), Roy (1967), Sharma (1967), Gupta and Sharma (1968) and Rao and Achuthan (1968) have described a few new species based on incrustations and petrifactions.

The present study is based on most of the previous collections and also a large number of specimens (more than two thousands) mostly collected by one of us (M.N.B.) since 1949 from the following localities:

Basgo-Bedo
Bindaban
Sakrigalighat
Onthea
Kasamu
Nipania
Amarjola
Chilgojuri
Khatangi Hills
Soorujbera
} Rajmahal Hills, Bihar

*Dedicated to Professor Chester A. Arnold in the year of his official retirement as Professor of Botany at the University of Michigan, and in honour of his distinguished service to the fields of Morphology and Palaeobotany.

Gollapalle, Raghavapuram, Vemavaram, Sriperumbudur, Terany and Karai, Sivaganga	East Coast
Sehora, Marpiparia	District Narsinghpur, M.P.
Bansa	South Rewa Gondwana basin, M.P.
Trambau, Kakadbhit, Ghuneri, Khara river, Yax, Kurbi	Kutch

The majority of the specimens studied are preserved in the form of impression. The incrustations are from Sakrigalighat, Sehora, Bansa, and Trambau only. Besides impressions and incrustations quite a few specimens, preserved in the form of petrifaction, have been collected and studied from Amarjola and Nipania in the Rajmahal Hills.

In the case of impressions most of the specimens have been described either under *Ptilophyllum acutifolium* Morris or *P. cutchense* Morris. It may be mentioned that Morris (1840) had distinguished his two species on the basis of pinnae apex. All his specimens were very fragmentary and their exact locality was not known. He had mentioned the locality as "South of the Charwar range". Out of the two species described, only the specimens of *P. acutifolium* had some veins preserved in them. In the specimens of *P. cutchense* no veins were visible. Morris had referred the specimen under *P. cutchense* because of the pinnae shape and as for the veins, he wrote as follows "but the absence of all true venation in this fossil must render its correct determination very doubtful". Since then from Kutch, a large number of specimens have been collected from different localities. Most of them in external form resemble *P. cutchense* of Morris. But when their cuticular structure was studied it was found that there were five distinct species. Out of these five species only one resembled, in external characters, *P. acutifolium*. The remaining species in gross features resembled more *P. cutchense* of Morris. But when the pinnae of the various specimens belonging to those species were studied under the binocular microscope they showed a good deal of variation. Their apices were either acute, obtuse or apiculate. The nature of pinnae apices even varied from specimen to specimen within the same species. Under these circumstances it was very difficult to decide the ones which really belonged to *P. acutifolium* or *P. cutchense*. As such, we are, here retaining *P. acutifolium* and *P. cutchense* only for the impressions, although, it is quite probable that under these two species quite a few different species are dumped together. Besides these species, two more species based on impressions, are also described here, viz. *P. tenerrimum* and *P. rarinervis*. In both these species pinnae shape and venation are different from the former two species. Amongst the incrustations, eight distinct species based on cuticular structure are described here. In addition, the description includes three more species based on petrifaction.

Genus — *Ptilophyllum* Morris

Recently, Harris (1969) examined some of the figured specimens of Morris (1840) and based on them and other specimens gave an emended diagnosis of the genus *Ptilophyllum*. He, however, in his diagnosis did not include the anatomical characters of the rachis and pinna. So here the genus has been further re-defined.

Emended diagnosis — Pinnate frond with prominent rachis. Pinnae attached to upper surface of rachis, mostly obliquely placed, rarely almost at right angles, alternate or sub-opposite, closely set, sometimes imbricate. Pinnae linear, lanceolate or rhomboidal; acroscopic margin contracted, forming a rounded angle, basiscopic margin decurrent; apex acute, obtuse or apiculate; veins parallel, arising from entire base, forked or unforked.

Rachis cells on both upper and lower surfaces rectangular or squarish, rarely polygonal; anticlinal walls wavy, sometimes sinuous, periclinal wall mostly unspecialized, sometimes papillate or with hair-bases. Stomata rare, confined to lower surface, transversely orientated, rarely oblique.

Epidermal cells of pinna on upper surface rectangular, squarish or polygonal; anticlinal walls sinuous, periclinal wall unspecialized. Stomata confined to lower

surface, differentiated into marginal astomatic and central stomatic regions. Cells of marginal astomatic region rectangular or squarish; anticlinal walls sinuous, periclinal wall smooth or papillate. Central stomatic region mostly differentiated into stomatiferous and non-stomatiferous bands, sometimes stomata scattered over entire region. Cells rectangular, squarish or polygonal; anticlinal walls sinuous or wavy, periclinal wall papillate or unspecialized. Stomata irregularly scattered, mostly transversely orientated, sometimes obliquely placed.

In cross section, petiole and rachis showing an outer layer of epidermis followed by 6-7 layered cells of hypodermis. Epidermal cells rectangular and broad, hypodermal cells mostly hexagonal and thick walled. Cells of ground tissue isodiametric with intercellular spaces. Near base (petiole) vascular bundles 11, arranged in a kidney shaped manner. Further up vascular bundles 24-32 in number arranged in double series in the form of 'U'. Vascular bundles collateral, xylem facing inwards. Xylem elements made up of scalariform pitting. Sclereids present in between vascular bundles and in ground tissue.

Pinna in cross section, showing upper and lower epidermis both followed by a single layer of hypodermis. Upper hypodermis followed by 1-2 layered palisade tissue. Mesophyll spongy. Vascular bundles 4-14 in number, placed in a single row in between palisade and lower hypodermis, collateral. Xylem situated on upper side; phloem on lower side. Sclereids present in palisade and in spongy mesophyll.

Type species — *Ptilophyllum acutifolium* Morris, 1840.

IMPRESSIONS

Ptilophyllum acutifolium Morris

Pl. 1, Figs. 1-6, Pl. 14, Figs. 115-116

1840 *Ptilophyllum acutifolium* Morris: In Grant, p. 327, pl. 21, figs. la-3.
1841 *Ptilophyllum acutifolium* Morris, p. 117.
1850 (?) *Zamia theobaldi* McClelland, pl. 12, fig. 1.
1860 *Palaeozamia acutifolium* Oldham, p. 323.
1863 *Palaeozamia acutifolium* Morris: Oldham & Morris, p. 29, pl. 20, fig. 1.
— *Palaeozamia acutifolium*, var. *conferta* Oldham & Morris, p. 29, pl. 20, figs. 2, 3.
— *Palaeozamia rigida* Oldham: Oldham & Morris, p. 30, pl. 22, figs. 1, 4, 5.
1867 *Palaeozamia acutifolium* Morris: Blanford, pp. 9-16.
1870-72 *Ptilophyllum acutifolium* Morris: Schimper, p. 166.
1872 *Palaeozamia acutifolium* Morris: Wynne, p. 173.
1875 *Ptilophyllum* Morris: Saporta, p. 85.
1876 *Otozamites* conf. *galdiaei* Brongniart: Feistmantel, p. 49, pl. 11, figs. 3, 4.
1877 *Ptilophyllum acutifolium* Morris var. *maximum* Feistmantel, p. 65, pl. 40, figs. 1-5.
Zamites proximus Feistmantel, pl. 41. figs. 1, 2.
1877a *Ptilophyllum acutifolium* Morris: Feistmantel, p. 16, pl. 2, fig. 2.
1877b *Ptilophyllum acutifolium* Morris: Feistmantel, p. 14, pl. 5, fig. 2, pl. 6, fig. 2.
1879 *Ptilophyllum acutifolium* Morris: Feistmantel, p. 23, pl. 10, figs, 1, 2, 8.
1933 *Ptilophyllum acutifolium* Morris: Sahni & Rao, p. 191.
1934 *Ptilophyllum acutifolium* (Old. & Morr.): Sahni & Rao, p. 263, pl. 37, fig. 11.
1960 *Ptilophyllum acutifolium* Morris: Krishnan, p. 291, pl. 7, fig. 4.
1963 *Ptilophyllum acutifolium* Morris: Sitholey, pl. 4, fig. 21.

The following specimens are doubtfully referred to *Ptilophyllum acutifolium* Morris:

1863 *Palaeozamia acutifolium* Morris: Oldham & Morris, p. 29, pl. 20, figs. 4-7, pl 21, fig. 2.
1877a *Ptilophyllum acutifolium* Morris: Feistmantel, p. 16, pl. 2, figs. 1-4.
1879 *Ptilophyllum acutifolium* Morris: Feistmantel, p. 23, pl. 10, figs. 3, 7, 9, pl. 11, fig. 1, pl. 16, fig. 14.
1968 *Ptilophyllum acutifolium* Morris: Baksi, p. 208, pl. 1, figs. la, b.

Emended diagnosis — Leaves pinnate, measuring more than 42 cm. in length,

width 4-10.5 cm., lamina as a whole broadly lanceolate. Rachis fully or partially concealed, about 2-5 mm. broad, in some rachis with fine longitudinal striations. Pinnae attached on upper surface of rachis, arising at an angle of about 53°-72°, sometimes at right angles, closely set, often touching each other, mostly attached by entire base, rarely acroscopic margin free. Pinnae as a whole linear, elongate, narrow; margin straight or falcate; apex acute. Acroscopic margin slightly rounded, basiscopic margin decurrent. Veins arising from entire base, more or less parallel, forked or unforked, when forking mostly once.

Lectotype — No. V21330 (9942) of the British Museum (Natural History), London.

Localities — Ghuneri, Kakadbhit, Manzal, Kurbi etc. in Kutch; Bindaban, Bureo, Basgo-Bedo, Sakrigalighat and Onthea etc. in the Rajmahal Hills, Bihar; Gollapalle, Raghavapuram and Vemavaram in the East Coast Gondwana and Marpiparia in Narsinghpur District, M.P.

Age & Horizon — Upper Jurassic and Lower Cretaceous: Rajmahal and Jabalpur series.

Remarks — Morris (1840, Pl. 21, Figs. 1a, 2, 3) figured three badly preserved specimens belonging to *Ptilophyllum acutifolium*. Since then one of them (Pl. 1, Fig. 2) has been subjected to considerable rubbing over. Pinnae apices of this particular specimen is not at all clear and also in most of them apex is missing. Similarly, the specimen figured by Morris (1840) in Pl. 21, Fig. 3 is equally badly preserved. The third specimen has better preserved pinnae (including apices), but it has complete pinnae (Pl. 1, Fig. 1) only on one side. Here the pinnae apices, wherever present, are acute. So out of the three, we have chosen this specimen [no. V21330 (9942)] as the lectotype. Also under *P. acutifolium* we have put only those specimens which are 4-10.5 cm. in width and which have pinnae with distinct acute apices. This is because the lectotype is about 4 cm. in width and has pinnae with distinct acute apices. In addition to the specimens mentioned under synonymy we have also referred doubtfully (list already given above) some of the specimens described from Bureo in the Rajmahal Hills, Bihar and Gollapalle, Vemavaram and Raghavapuram in the East Coast Gondwana. In all these specimens pinnae apices are distinctly acute but width of the lamina is only 2-2·5 cm. (Pl. 1, Fig. 6). Because of this difference and also in the absence of any cuticle we have, at present, preferred to keep them as doubtful forms.

Specimens resembling the original specimens of *P. acutifolium* (Morris, 1840) are very commonly met with at Kakadbhit in Kutch (Pl. 1, Figs. 4,5) and Marpiparia, Narsinghpur district. Besides these, from Basgo-Bedo, Bindaban, Sakrigalighat and Onthea in the Rajmahal Hills, quite a good many specimens have been collected which are very similar to the lectotype (Pl. 14, Fig. 116). Many of the Rajmahal specimens are much broader than the lectotype. One of them (Pl. 14, Fig. 115) is about 10.5 cm. in width and is the largest specimen of *Ptilophyllum* so far collected from India. It measures 42 cm. in length. In this and many others (Pl. 14, Fig. 115) pinnae are attached almost at right angles. But in all these, pinnae apices are distinctly acute. One of the best specimen of *P. acutifolium* so far collected is from Sakrigalighat (Pl. 14, Fig. 116). Here a few leaves are seen arranged in a spiral manner, representing the apical crown.

Ptilophyllum cutchense Morris

Pl. 1, Figs. 7-10, Pl. 2, Figs. 14-17

1840 *Ptilophyllum cutchense* Morris: In Grant, p. 327, pl. 21, fig. 4.

1841 *Ptilophyllum cutchense* Morris, p. 117.

1850 *Zamia indica* McClelland, pl. 12, fig. 4.

1860 *Palaeozamia cutchensis* Morris: Oldham, p. 323.

1863 *Palaeozamia acutifolium* Morris: Oldham. & Morris, p. 29, pl. 20, figs. 8, 9.

— *Palaeozamia cutchensis* Morris: Oldham & Morris, p. 30, pl. 21, figs. 5, 6, pl. 22, figs. 2, 6.

— *Palaeozamia affinis* Morris: Oldham & Morris, p. 30, pl. 22, figs. 3, 7.

1867 *Palaeozamia cutchensis* Morris: Blanford, p. 9.

1870-72 *Ptilophyllum cutchense* Morris: Schimper, p. 167.
1872 *Palaeozamia cutchensis* Morris: Wynne, p. 173.
1875 *Ptilophyllum* Morris: Saporta, p .85.
1876 *Ptilophyllum cutchense* Morris: Feistmantel, p. 42, pl. 4, figs. 6, 7, pl. 5, figs, 1, 2a, 3, pl. 6, fig. a, pl. 7, fig, 2, pl. 12, fig. 4.
— *Ptilophyllum acutifolium* Morris: Feistmantel, p. 44, pl. 5, figs. 4, 4a.
— *Ptilophyllum cutchense*, var. *distans* Feistmantel, p. 43, pl. 5, fig. 2b, pl. 6, fig. b.
— *Ptilophyllum cutchense* var. *curvifolium* Feistmantel, p. 44, pl. 6, fig. c.
— *Ptilophyllum cutchense* var. *minimum* Feistmantel. p. 44, pl. 7, figs. 1, la.
— *Ptilophyllum brachyphyllum* Feistmantel, p. 45, pl. 7, figs. 3, 3a.
— *Otozamites contiguus* Feistmantel, p. 48, pl. 7, figs. 4, 4a.
1877 *Ptilophyllum cutchense* Morris: Feistmantel, p. 66.
1877a *Ptilophyllum cutchense* Morris: Feistmantel, p. 17, pl. 2, fig. 3.
1879 *Ptilophyllum cutchense* Morris: Feistmantel, p. 23, pl. 2, figs. 11-13, pl. 10, fig. 10.
— *Otozamites hislopi* Oldham: Feistmantel, p. 22, pl. 7, fig. 4, pl. 8, fig. 4.
— *Otozamites abbreviatus* Feistmantel, p. 21, pl. 8, figs. 6, 6a, pl. 9, fig. 3.
— *Otozamites acutifolius* Morris: Feistmantel, p. 22, pl. 8, fig. 12.
— *Otozamites rarinervis*? Feistmantel, p. 21, pl. 9, fig. 6.
— *Ptilophyllum cutchense* var. *minimum* Feistmantel, p. 23, pl. 9, figs. 7, 8, pl. 10, fig. 5.
— *Ptilophyllum acutifolium* Morris: Feistmantel ,p. 23, pl. 10, fig. 4, pl. 15, figs. 12, 13.
— *Otozamites* sp. Feistmantel. p. 22, pl. 10, fig. 6.
1917 *Ptilophyllum* (*Williamsonia*) *pecten* (Phillips): Seward, p. 522, figs. 588 a, c, 589 a, b.
— *Ptilophyllum cutchense* Morris: Seward, p. 518, fig. 591.
1920 *Ptilophyllum acutifolium* Morris: Seward & Sahni, p. 20, pl. 5, figs. 48, 50, 51a, pl. 6, figs. 53, 54, 54a.
1933 *Ptilophyllum* cf. *cutchense* McCl. sp. Sahni & Rao, p. 191, pls. 11-12, figs. 7, 8, 8a.
1934 *Ptilophyllum* cf. *cutchense* McCl. sp. Sahni & Rao, p. 263.
1946 *Ptilophyllum* cf. *cutchense* McCl. sp.: Ganju, p. 65, pl. 2, figs. 11, 12, pl. 3, fig. 18.
— *Ptilophyllum acutifolium* Morris: Ganju, p. 65, pl. 3, figs. 13, 19.
1963 *Ptilophyllum* cf. *cutchense* McCl.: Sitholey, pl. 4, fig. 23.
1968 *Ptilophyllum cutchense* Morris: Baksi, p. 208, pl. 1, figs. 2a-b.
— *Ptilophyllum tenerrimum* Feistmantel: Baksi, p. 208, pl. 1, fig. 3.
1969 *Ptilophyllum cutchense* McCl.: Randhawa *et al*, pl. 48, fig. 1.

The following specimens are doubtfully referred to *Ptilophyllum cutchense* Morris:

1863 *Palaeozamia bengalensis* Oldham: Oldham & Morris, p. 27, pl. 19, figs. 1, 2, 6.
— *Palaeozamia bengalensis* var. *obtusa* Oldham & Morris, p. 28, pl. 19, figs. 3-5.
— *Palaeozamia cutchense* Morris: Oldham & Morris, p. 30, pl. 21, figs. 1 (specimen on left hand side and also 1a), 3, 4.
1870-72 *Ptilophyllum bengalense* (Oldham): Schimper, p. 166.
1877 *Otozamites abbreviatus* Feistmantel, p. 68.
— *Otozamites oldhami* Feistmantel, p. 68.
1917 *Otozamites bengalensis* (Oldham & Morris): Seward, p. 543, fig. 607.
1920 *Otozamites bengalensis* Morris: Seward & Sahni, p. 28, pl. 5, fig. 52.
1963 *Otozamites bengalensis* (Oldham) Feistmantel: Sitholey, pl. 5, fig. 20.

Emended diagnosis — Lamina as a whole linear-lanceolate, pinnate, exceeding 30 cm. in length, width 0·5-3 cm. in middle, attenuate towards base and apex. Rachis partially exposed, sometimes concealed, about 1-3·5 mm. wide. Pinnae attached on upper surface of rachis, closely set or imbricate, mostly attached by entire base, arising at an angle of about 50°-70°. Pinnae as a whole linear, rhomboidal, subulate or ovate, margin straight or sometimes slightly falcate. Apex obtuse or obtusely acuminate, sometimes apiculate. Acroscopic margin mostly rounded, basiscopic margin straight, contracted, rounded

or slightly decurrent. Veins arising from whole base, more or less parallel, forked or unforked, forking at all levels.

Lectotype — No. V20191 (9943) of the British Museum (Natural History), London.

Localities — Ghuneri, Kakadbhit, Manzal and Kurbi in Kutch; Bindaban, Basgo-Bedu, Onthea, Soorujbera, Amarjola, Chilgojuri and Nipania in the Rajmahal Hills, Bihar; Raghavapuram and Vemavaram in the East Coast Gondwana and Sehora.

Age & Horizon — Upper Jurassic and Lower Cretaceous; Rajmahal and Jabalpur series.

Remarks — *Ptilophyllum cutchense* Morris was based on a badly preserved specimen (Morris 1840, PL. 21, FIG. 4). This specimen (PL. 1, FIG 7) too, has undergone a considerable rubbing over and in it apices in most of the pinnae are missing and also in none of them veins are preserved. The pinna apex in this specimen was described by Morris (1840) as obtuse. But here under the synonmy such specimens of *Ptilophyllum* which range in width from 0·5-3 cm. and which have pinnae with obtuse, obtusely acuminate or apiculate apices have been included. Specimens resembling the original specimen of Morris (1840) are very commonly met with in Kakadbhit, Kutch (PL. 1, FIG. 10). Somewhat similar specimens have also been collected from Vemavaram in the East Coast (PL. 1, FIG. 9). But the Vemavaram specimens have narrow lamina (about 0·8 cm.) and they are more or less uniformly broad (PL. 2, FIG. 17) except near apex where they are narrowing gradually. The pinnae apices in these specimens are rather varied.

Quite a good many specimens resembling the original specimen of P. *cutchense* have also been collected from the Rajmahal Hills. In the Rajmahal Hills from Soorujbera and Chilgojuri al arge number of specimens (PL. 2, FIG. 15,) have been collected, which exceed 10 cm. in length. They are uniformly broad except near apex where they are abruptly narrowing. Also in these, near base, the pinnae are very small (PL. 2, FIG. 16) about 2-3 mm. in length and 1-2 mm. in breadth. Basal most portion of the rachis (about 1-3 cm. in length) is devoid of pinna. In these specimens, the pinnae are ovate or rhomboidal in shape and the pinnae apices are broadly obtuse or rounded. So the pinnae shape as a whole is quite different from the original specimen of *P. cutchense* (PL. 1, FIG. 7). However, in the absence of cuticle they have been provisionally placed here under *P. cutchense*. Similar specimens, but preserved in the form of petrifaction, have been collected from Amarjola and Nipania. In these, it has been possible to study the nature of the surface cells and also the anatomical details of rachis and pinna. Such petrified specimens have been described here under *P. sahnii* Gupta & Sharma (1968).

Recently, a few specimens have been described by Kilpper (1968) as *P. bengalense* (Oldh.) Schimper from the Lias of Karmozd-Zirab, Northern Iran. While describing the Iranian specimens Kilpper also included under synonymy the original specimens of Oldham and Morirs (1863, PL. 19, FIGS. 1, 2, 6). In our opinion, the specimens of *P. bengalensis* (Oldh.) Schimper from the Rajmahal Hills are quite distinct from the Iranian specimens. The specimens from Iran have more or less deltoid shaped pinnae, whereas, the Indian specimens have rhomboidal pinnae.

Ptilophyllum rarinervis (Feistmantel) n. comb.

Pl. 2, Figs. 11-13

1879 *Otozamites rarinervis* Feistmantel, p. 21, pl. 8, figs. 8-11.

1946 *Ptilophyllum* sp. A: Ganju, p. 66, pl. 3, figs. 14, 15.

1968 *Otozamites rarinervis* Feistmantel: Baksi, p. 208, pl. 1, fig. 4.

Diagnosis — Leaves pinnate, available length 2-5·4 cm., about 0·4-0·8 cm. broad. Substance of lamina fairly thin. Rachis slender, prominent, 1-1·5 mm. wide. Pinnae attached on upper surface of rachis, pinnae bases of opposite sides almost touching each other, arising at an angle of about 59°, alternate, closely set, lower margin overlapped by upper margin of pinna below. Margin very silghtly curved; apex rounded; acroscopic margin rounded, basiscopic margin straight or slightly curved. Pinna base as a whole convex. Veins mostly 3, rarely 2, dividing at all levels.

Holotype — No. 4682 of the Geological Survey of India, Calcutta.

Localities — Vemavaram (type locality) Raghvapuram (East Coast) and Onthea (Rajmahal Hills).

Age & Horizon — Upper Jurassic; Kota and Rajmahal stages.

Remarks — *Ptilophyllum rarinervis* is a very rare species. So far only three specimens have been collected, one each from Vemavaram, Raghavapuram and Onthea. The specimens from Vemavaram is in counterparts (PL. 2, FIGS. 11, 12). From the fine preservation of veins, the substance of lamina seems to be fairly thin. Here the basiscopic margin of the pinna does not seem to be decurrent.

Comparison — *Ptilophyllum rarinervis* differs from all the other species of *Ptilophyllum* in having pinnae with 2-3 veins only. In the nature of venation, it comes closest to *P. nipanica* Vishnu-Mittre (1957) where the pinnae are having 3-5 veins.

Ptilophyllum tenerrimum Feistmantel

Pl. 2, Fig. 18

1877 *Ptilophyllum tenerrimum* Feistmantel, p. 66, pl. 41 figs. 3 3a.

1920 *Ptilophyllum acutifolium* Morris: Seward & Sahni, p. 20, pl. 5, fig. 47.

1933 *Ptilophyllum tenerrimum* Feistmantel: Sahni & Rao, p. 192.

1946 *Ptilophyllum* sp. B.: Ganju, p. 66, pl. 3, figs. 16-17.

1963 *Ptilophyllum tenerrimum* Feistmantel: Sitholey, pl. 4, fig. 22.

Pinnate frond of slender habit, length exceeding 9 cm., except near base and apex uniformly broad; breadth 1-1·2 cm. near middle. Shape of lamina as a whole narrowly lanceolate. Rachis slender, having somewhat uniform breadth, about 1 mm. or slightly more in breadth. Pinnae attached on upper side of rachis by whole breadth but never concealing it, 6-7 mm. long, 1-1·5 mm. broad at base, arising at an angle of about 61°-65°, closely set or imbricate; margin straight; apex acute; acroscopic margin slightly curved, basiscopic margin straight or slightly decurrent. Veins few, rarely 5, mostly 2-3, arising from whole base, nearly parallel, mostly undivided.

Lectotype — No. 4519 of the Geological Survey of India, Calcutta.

Locality — Onthea, Rajmahal Hills, Bihar.

Age & Horizon — Upper Jurassic, Rajmahal Stage.

Comparison — *Ptilophyllum tenerrimum* is so far known only from Onthea in the Rajmahal Hills, Bihar. It is an extremely rare species. The pinnae are very narrow (less than 2 mm. broad) and have few veins. In the nature of veination it resembles *P. rarinervis* (Feistmantel) but the latter species has broader and shorter pinnae. From *P. nipanica* Vishnu-Mittre (1957), the present species can be easily distinguished by the general form of the pinnae alone. In *P. nipanica* pinnae are about 2 mm. broad, near base but in *P. tenerrimum* the pinnae are long and narrow.

INCRUSTATIONS

Ptilophyllum oldhamii Jacob & Jacob

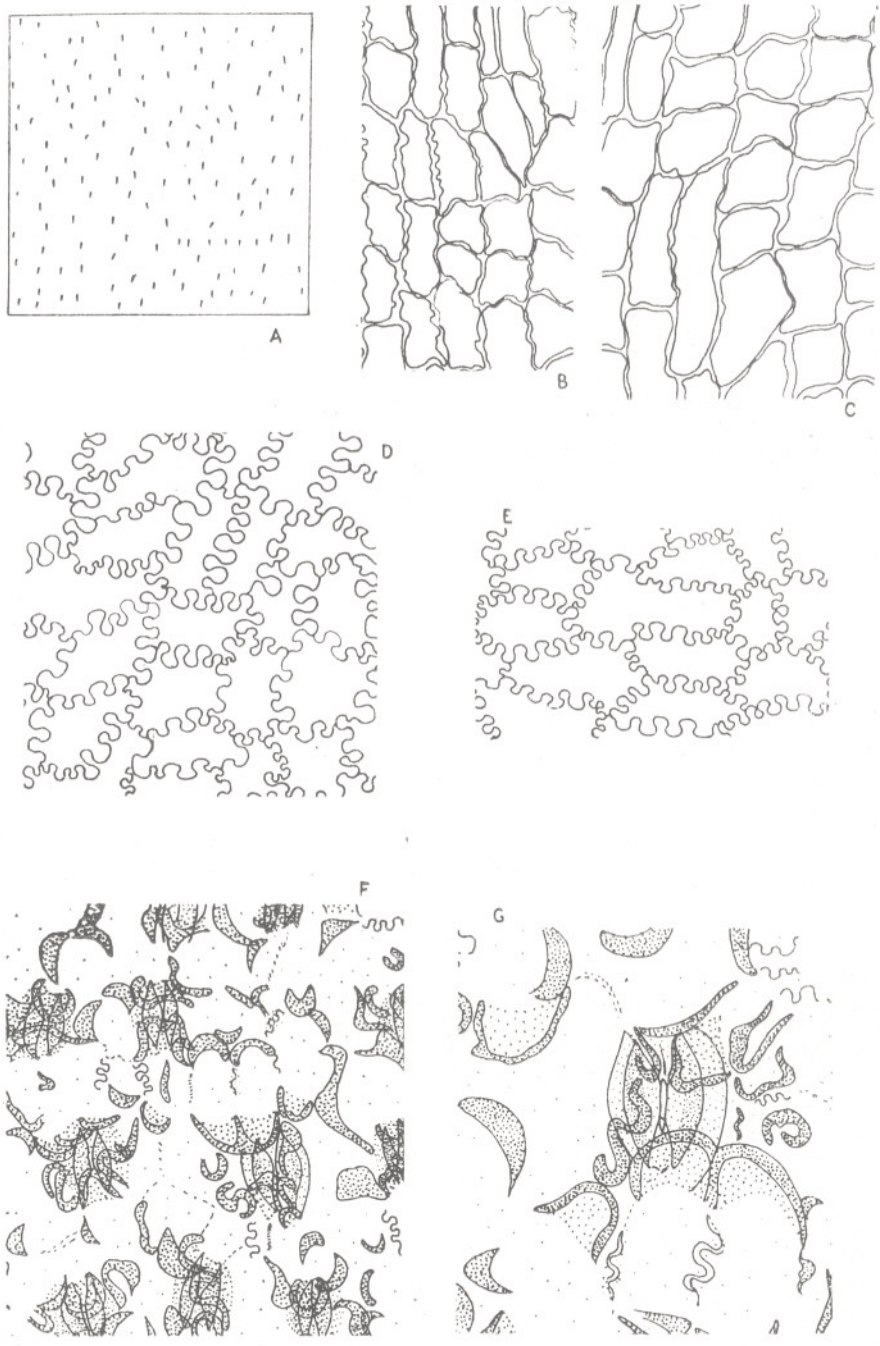
Pl. 3, Figs. 19, 20, 24, 26, 27, 29; Text-fig. 1A-G

1954 *Ptilophyllum oldhamii* Jacob & Jacob, p. 12 pl. 3, figs. 26-33, pl. 9, fig. 77, text-figs. 29-36.

Emended diagnosis — Fragmentary fronds, measuring 2·2-3·5 cm. in length and 0·6-0·8 cm. in width. Rachis concealed by pinnae. Pinnae closely set, imbricate, alternate or sub-opposite, arising at an angle of about 45°-57°. Pinnae 5-9 mm. long, 2-3 mm. broad near base; apex apiculate; acroscopic margin somewhat rounded, basiscopic margin slightly decurrent; veins obscure.

Rachis cells on both upper and lower sides squarish or rectangular; anticlinal walls thick, slightly wavy at places, sometimes a few cells with sinuous walls, periclinal wall unspecialized.

Upper cuticle of lamina thin. Cells rectangular, squarish or polygonal, not very regular in arrangement; anticlinal walls sinuous, periclinal wall unspecialized. Lower cuticle with two distinct zones, a marginal zone devoid of stomata and an inner zone with stomata. Marginal zone about 5-6 cells broad, near apex upto 10 or more. Cells along margin mostly rectangular, sometimes polygonal or squarish; anticlinal walls sinuous, periclinal wall unspecialized. Within stomatal zone stomata crowdedly placed, tending to



TEXT-FIG. 1 — *Ptilophyllum oldhamii* Jacob & Jacob — A, lower cuticle showing distribution of stomata; slide no. 33767-3, × 40. B, lower cuticle of rachis; slide no. 33763-2, × 250. C, upper cuticle of rachis; slide no. 33767-2, × 250. D, upper cuticle of pinna; slide no. 33767-1, × 250. E, lower cuticle showing marginal cells; slide no. 33767-1, × 250. F, lower cuticle showing a few stomata; slide no. 33767-1, × 250. G, a stoma; slide no. 33767-1, × 500.

form single files, files discontinuous and irregular, occasionally a few stomata lying outside files. Stomata transversely orientated, a few slightly oblique. Guard cells sunken, crescent shaped, mostly concealed by overhanging papillae. Subsidiary cells slightly more cutinized than ordinary epidermal cells. Epidermal cells within stomatal zones papillate. Papillae 1-3 or more, crescent, dome or mushroom-shaped, sometimes forming circular to oval rings.

Neotype — No. 33767 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Trambau, Kutch.

Age & Horizon — Upper Jurassic or Lower Cretaceous; Umia Stage, Jabalpur Series.

Remarks — The figured specimens and slides of Jacob and Jacob (1954) are not available now. So the above diagnosis is based on two specimens recently collected by us from Trambau. The cuticle from the neotype no. 33767 resembles the cuticle of the specimens earlier described by Jacob and Jacob (1954). *Ptilophyllum oldhamii* is a very rare species. Out of about 110 carbonized specimens of *Ptilophyllum*, recently collected, only two have been found to be *P. oldhamii*. In this species Jacob and Jacob (1954, p. 13) had described the pinnae apices as "roundly obtuse and not falciform". But in both the specimens, here described, the pinnae apices have been found to be apiculate.

Comparison — In the distribution of stomata *Ptilophyllum oldhamii* resembles somewhat the cuticle of *P. nipanica* described by Vishnu-Mittre (1957) from Nipania, Rajmahal Hills and *P. boreale* (Heer) Seward described by Thomas (1930) from Greenland. *P. oldhamii* differs from *P. nipanica* in having papillate cells within the stomatal zones. *P. boreale* can be distinguished from *P. oldhamii* on the basis of papillae alone because in the former species, cells on the lower side are devoid of papillae.

Ptilophyllum indicum Jacob & Jacob.

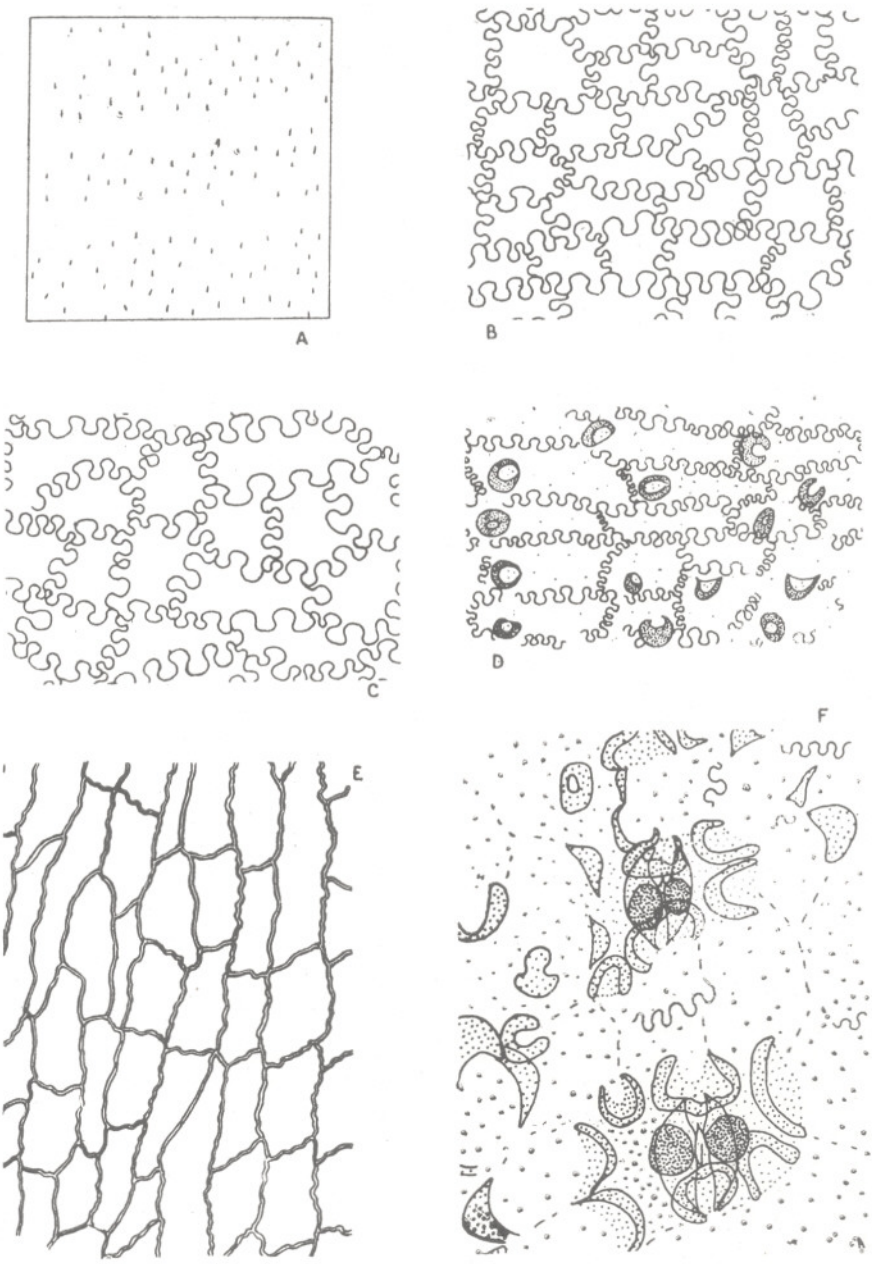
Pl. 3, Figs. 21-23, 25, 28, Pl. 4, Figs. 39, 40; Text-figs. 2A-F

1954 *Ptilophyllum indicum* Jacob & Jacob, p. 4, pl. 1, figs. 1-10, pl. 2, figs. 11-21, pl. 3, figs. 22-25, pl. 8, figs. 72-74, pl. 9, figs. 75, 76, text-figs. 1-28.

Emended diagnosis — Leaves pinnate, available length 1·6-6·7 cm., width near middle 0·4-0·9 cm. Lamina as a whole of even width, gradually tapering towards base and apex. Rachis completely covered by pinnae. Pinnae linear or linear-lanceolate, alternate, closely set, sometimes imbricate, arising at an angle of about 60°-65°. Apex apiculate, rarely acute. Acroscopic margin gradually curved, basiscopic margin rounded or slightly decurrent. Veins obscure, forked or unforked.

Upper cuticle of rachis thickly cutinized, cells arranged in regular manner, rectangular, a few much larger than broad. Anticlinal walls wavy or sometimes slightly sinuous but without any prominent loops, periclinal wall devoid of papillae or hairs. Cells of lower cuticle similar to those of the upper.

Upper cuticle of lamina thinner than the lower, devoid of stomata, papillae or hairs. Cells more or less regularly arranged, mostly rectangular, a few squarish or polygonal. Anticlinal walls sinuous, loops distinct, adjacent loops not touching each other. Lower cuticle differentiated into broad, stomatal bands and narrow non-stomatal bands over veins. Marginal non-stomatic area 4-6 cells wide, near tip more than 6 cells wide. Marginal cells rectangular with sinuous anticlinal walls, loops slightly less in number than upper cuticle; periclinal wall unspecialized. Bands over veins 2-5 cells wide, cells mostly rectangular, sometimes a few polygonal; anticlinal walls sinuous, loops like those of marginal cells, loops of end-walls smaller than lateral-walls, sometimes walls near corners more thickened than marginal cells. Periclinal wall smooth or slightly thickened, sometimes papillate. Papillae varying in shape, cicular or crescent-shaped. Cells of stomatal bands smaller than non-stomatal bands, rectangular or polygonal; anticlinal walls sinuous, mostly walls thicker than non-stomatal bands. Cells mostly papillate; papillae, circular, hollow or crescent-shaped, often cells with one or two papillae. Stomatal bands 2-6 stomata wide, mostly 5. Stomata transversely orientated, rarely slightly oblique. Subsidiary cells more cutinized than ordinary



TEXT-FIG. 2 — *Ptilophyllum indicum* Jacob & Jacob — A, lower cuticle showing distribution of stomata; slide no. 31884-1, × 40. B, upper cuticle; slide no. 31884-3, × 250. C, lower cuticle showing marginal cells; slide no. 31884-4, × 250. D, lower cuticle showing cells of non-stomatal zone; slide no. 33771-2, × 250. E, rachis cells; slide no. 33771-1, × 250. F, two stomata; slide no. 32422, × 500.

epidermal cells, occasionally with two solid circular or rounded, raised papillae. Mostly subsidiary cells and guard cells covered by papillae of adjacent cells, each stomatal apparatus covered by about 4-5 papillae near the guard cells. Guard cells sunken, crescent-shaped.

Neotype —No. 33770 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Trambau, Kutch.

Age & Horizon — Upper Jurassic or Lower Cretaceous; Umia Stage, Jabalpur Series.

Remarks — Like *Ptilophyllum oldhamii* the present species, too, is rather rare in Kutch. So far only eight specimens have been collected by us from Trambau besides the ones described by Jacob and Jacob (1954).

Unfortunately, all the figured specimens of Jacob and Jacob (1954) are now misplaced, so out of our collection we have selected the specimen no. 33770 as neotype. In all the specimens, in the present collection, pinnae apex is mostly apiculate, rarely acute. According to Jacob and Jacob (1954) pinnae apex was falciform, acuminate or obtusely acuminate.

Comparison — The pinnae of *Ptilophyllum indicum* resembles the pinnae of *P. oldhamii* Jacob & Jacob in general shape. In both, pinna tip is apiculate. The former can readily be distinguished from the latter by the mere distribution of stomata. While in the former case the lower cuticle shows both stomatal and non-stomatal bands, in the latter, except in the marginal zone, stomata are distributed all over the surface without showing distinct stomatal and non-stomatal bands. Also unlike *P. oldhamii* the subsidiary cells of *P. indicum* are papillate. In the nature of papillae *P. indicum*, to some extent, resembles *P. okribense* Doludenko & Svanidze (1964) described from the Bathonian of Georgia. It also resembles the latter species in having mostly papillate subsidiary cells. *P. indicum*, however, differs from *P. okribense* in general shape of pinnae and also in having cells with large, crescent-shaped, 4-5 papillae overhanging the stomata. *P. sokalense* Doludenko (1963) described from Western Ukraine also resembles *P. indicum* in having papillate cells. But in *P. sokalense* stomata are not covered by papillae of the adjacent ordinary cells. The subsidiary cells of *P. pectinoides* (Phillips) described by Harris (1969) from Yorkshire are also papillate but, here, unlike *P. indicum*, the ordinary epidermal cells on lower surface are devoid of papillae.

Ptilophyllum horridum Roy.

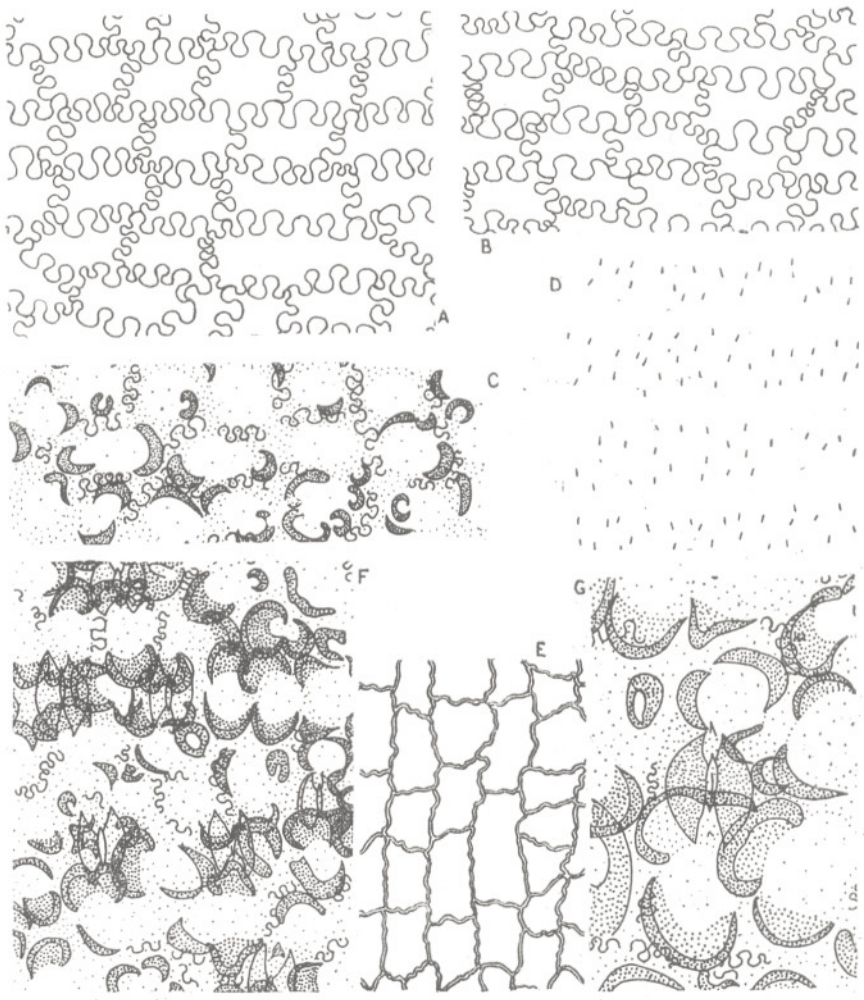
Pl. 4, Figs. 30-38, Pl. 5, Figs. 47-49; Text-figs. 3A-G

1963 *Ptilophyllum horridum* Roy, p. 396.
1967 *Ptilophyllum horridum* Roy, p. 581, figs. 1-2.

Emended diagnosis — Leaf pinnate, exceeding 19·5 cm. in length, uniformly broad, near base and apex gradually tapering, width near middle 0·9-2 cm. Rachis concealed by pinnae, 1-2 mm. wide. Pinnae closely set, almost touching each other, sometimes imbricate, mostly alternate, occasionally sub-opposite, arising at an angle of about 55°-68°. Pinnae 4-11 mm. long, 1-3 mm. broad near base, linear or linear-lanceolate; acroscopic margin rounded, basiscopic margin decurrent. Apex apiculate, sometimes acute or obtuse. Veins faintly marked, forked or unforked.

Rachis cells rectangular or squarish, very rarely polygonal; anticlinal walls thick, wavy, sometimes sinuous with less prominent loops, periclinal wall unspecialized.

Cells of upper surface mostly rectangular, a few squarish or polygonal, more or less regular in arrangement. Anticlinal walls sinuous, loops wide, head of loops rounded; periclinal wall smooth or mottled. Lower cuticle differentiated into stomatiferous and non-stomatiferous bands. Stomatiferous bands broader than non-stomatiferous bands. Marginal non-stomatiferous bands devoid of hairs or papillae, 5-6 cells wide, cells mostly rectangular or squarish, a few polygonal, generally arranged serially. Anticlinal walls sinuous, loops prominent with rounded heads. Other non-stomatiferous bands 3-4 cells wide. Cells rectangular, a few squarish or polygonal, arranged in regular rows. Anticlinal walls sinuous, fairly thick-walled, mostly cell wall obscured by papillae, surface with 1-3 papillae, mostly 2 or 3, papillae rounded, crescent arch or mushroom-shaped. Sometimes 2-3 papillae of same cell joining together, and completely obscuring cell-wall. Stomatiferous bands 2-6 stomata wide, mostly 3-4, rarely 2 (near margin).



TEXT-FIG. 3 — *Ptilophyllum horridum* Roy — A, upper cuticle, slide no. 31940-1, × 250. B, lower cuticle showing marginal cells; slide no. 31935, × 250. C, lower cuticle showing cells of a non-stomatal band; slide no. 33762, × 250. D, lower cuticle showing distribution of stomata; slide no. 31889-1, × 40. E, rachis cells; slide no. 31952, × 250. F, lower cuticle showing a few stomata; slide no. 33762, × 250. G, a stoma; slide no. 33762, × 500.

Ordinary epidermal cells with 2-3 papillae, nature of papillae same as those of cells of non-stomatiferous bands. In each cell, papillae fused together forming a sort of ring over cell wall and completely obscuring it. Cells smaller in size than those of non-stomatiferous bands, rectangular or polygonal; anticlinal walls when visible, sinuous, rarely wavy. Subsidiary cells slightly more cutinized than those of ordinary epidermal cells, devoid of papillae. Guard cells, thickly cutinized, crescent-shaped, sunken. Stomatal apparatus covered by papillae of adjacent cells.

Holotype — No. 31889 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Localities — Trambau (type locality), Kutch; Sehora, district Narsinghpur; Bansa, South Rewa Gondwana basin.

Age & Horizon — Upper Jurassic or Lower Certaceous; Jabalpur Series.

Remarks — *Ptilophyllum horridum* was instituted by Roy (1963, 1967). All his specimens were collected from Trambau. Since then a large number of new specimens have been collected from Trambau and also

a few specimens have been collected from Sehora and Bansa. *P. horridum* is the commonest species of *Ptilophyllum* occurring in Trambau. But in the other two localities it is rather rare. The diagnosis given above is based on all these specimens.

Comparison — In the nature of pinna apex most of the specimens of *Ptilophyllum horridum* resemble *P. indicum* Jacob & Jacob and *P. oldhamii* Jacob & Jacob. But their cuticular structure is markedly different. In *P. indicum*, the papillae are much less developed but the subsidiary cells are papillate, whereas, in *P. horridum* the subsidiary cells are non-papillate. Unlike the present species, in *P. oldhamii* there is no distinct stomatal and non-stomatal bands. In the nature of papillae, *P. horridum* resembles somewhat *P. ukrainense* Doludenko (1963) described from Ukraine but in the latter species the stomata are not obscured by papillae and also the stomatal bands are only 2-3 stomata wide. As far as the papillae are concerned *P. horridum* resembles very much the cuticle of *P. caucasicum* Doludenko & Svanidze (1964) described from Georgia (Bathonian and Callovian). But *P. caucasicum* differs in having narrower stomatal bands, also the pinnae apices in *P. causasicum* is quite different from the present species. In *P. khargaense* Kilpper (1966), the cells of the lower cuticle have 2-6 papillae. These papillae, like *P. horridum*, also join together to form rings but here they give a frilled appearance and also they do not overlap cell-walls. The pinnae apices in *P. khargaense* are rounded and not apiculate like *P. horridum*. The lower cuticle of *P. horridum* may be compared with the lower cuticle of *P. hirsutum* Thomas & Bancroft described by Harris (1949, 1969) from Yorkshire. In the latter species, the cells are highly papillate but unlike the former species, in *P. hirsutum* the subsidiary cells are papillate.

Ptilophyllum sakrigaliensis Sah

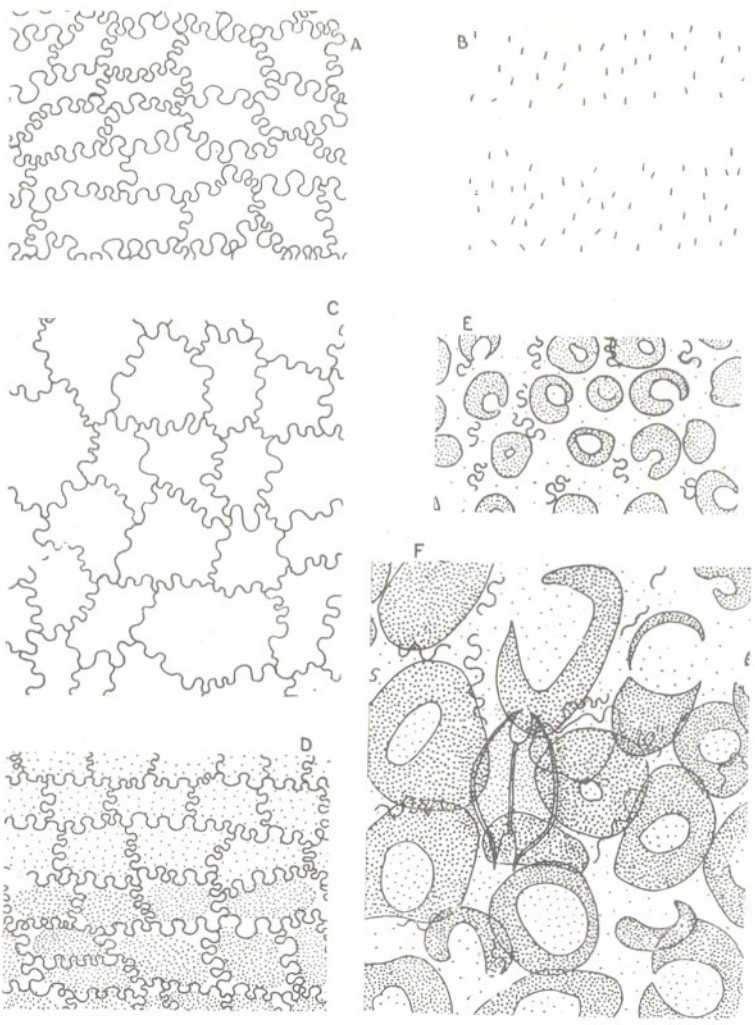
Pl. 5, Figs. 41, 42, 50, Pl. 6, Figs. 56, 57; Text-figs. 4A-F

1958 *Ptilophyllum sakrigaliensis* Sah, p. 337

Emended diagnosis — Leaves pinnate, available length 4-4·5 cm., width about 6 cm. Rachis mostly concealed. Pinnae linear, arising at an angle of about 70°-85°, closely set or slightly imbricate, 2-5·3 cm. long, 0·2-0·3 cm. broad near base. Apex acute; acroscopic margin straight or slightly curved, basiscopic margin decurrent, sometimes covered by upper basal angle of pinna below. Veins arising from entire base, forked or unforked, when forking mostly once.

Upper cuticle devoid of stomata, hairs or papillae. Cells closer to margins rectangular, a few squarish or polygonal, arranged in regular rows; anticlinal walls sinuous, loops small but prominent. Cells in central region polygonal, a few squarish, irregularly arranged; anticlinal walls sinuous, loops less prominent as compared to marginal cells. Cells near base polygonal, with wavy anticlinal walls. Lower cuticle differentiated into stomatiferous and non-stomatiferous bands, often bands indistinct due to papillae; near base, because of papillae, bands indistinct. Stomatiferous bands broader than non-stomatiferous bands. Marginal non-stomatiferous bands 9-10 cells wide, less towards base and apex. Cells rectangular, a few polygonal, arranged in regular series; anticlinal walls sinuous, loops more prominent near margin, periclinal wall of cells near margin (1-5 cell in width) either unspecialized or showing faint thickening, while remaining cells showing a single, solid papilla. Other non-stomatiferous bands 2-4 cells wide; cells mostly polygonal, anticlinal walls obscure, when visible sinuous with less prominent loops than marginal cells; periclinal wall with a single, mostly circular hollow papilla, a few with solid circular or dome-shaped papillae, sometimes papillae dividing into unequal domes. Within stomatal bands, cells somewhat similar to those of non-stomatal bands, very rarely cell outline visible; periclinal wall of each cell bearing papillae like those of cells of non-stomatal bands but near base cells, mostly having a solid papilla, rarely a few with semicircular papillae. Stomatal bands 2-5 stomata wide, mostly 3-4, marginal stomatal bands narrower, within bands stomata irregularly scattered. Stomata transversely orientated, a few slightly oblique, concealed by papillae. Guard cells well cutinized, crescent-shaped. Subsidiary cells non-papillate.

Lectotype — No. 4923 of the Birbal Sahni Institute of Palaeobotany, Lucknow.



TEXT-FIG. 4 — *Ptilophyllum sakrigaliensis* Sah — A, upper cuticle showing marginal cells; slide no. 31872-3, × 250. B, lower cuticle showing distribution of stomata; slide no. 31872-1, × 40. C, upper cuticle showing cells near middle region; slide no. 31872-3, × 250. E, lower cuticle showing cells of a non-stomatal band; slide no 31872-4, × 250. F, a stoma; slide no. 31872-1, × 500.

Localities — Sakrigalighat, Rajmahal Hills and Khara river, Kutch.

Age & Horizon — Upper Jurassic or Lower Cretaceous; Rajmahal and Jabalpur series.

Remarks — Sah's (1958) diagnosis of *Ptilophyllum sakrigaliensis* was based on a fragmentary specimen collected from Sakrigalighat, Rajmahal Hills. This specimen was not figured by him. It was, however, possible to trace the specimen and its original photographs after going through Dr. Sah's collection. A print of that specimen has been reproduced here in Pl. 5, Fig. 42. The specimen was found to be very incomplete. It seems since the specimen was photographed a part of the specimen had got broken and was missing. The specimen at present shows two incomplete pinnae on one side only. In none of them apex is visible. The original photograph of the specimen too does not show apex in any of the pinnae. Besides the specimen, a cuticular preparation showing both upper and lower cuticle was also obtained. In addition to this specimen, one more specimen was collected during the year 1961 from Khara river, near Bhuj. It

has been figured here in Pl. 5, Fig. 41. The cuticle of this specimen is similar to the cuticle of Sah's specimen. This specimen too, is rather incomplete but some of its pinnae show the apices very clearly. The above emended diagnosis is based on these two specimens.

Comparison — Ptilophyllum sakrigaliensis, in external form, resembles most the lectotype of *P. acutifolium* Morris (Pl. 1, Fig. 1). In both, pinnae are linear, elongate and their apices are acute. It also resembles the other speciemens of *P. acutifolium* (Pl. 1, Figs. 2-5, Pl. 14, Fig. 116) in size and shape. Among the Kutch species, whose cuticle is known, *P. horridum* Roy, to some extent, may be compared with *P. sakrigaliensis*. In both, the lower cuticle is differentiated into broad stomatiferous and narrow non-stomatiferous bands, also the stomatal apparatus is obscured by papillae. But in *P. sakrigaliensis*, the pinnae are 2·5-3 cm. long and 0·2-0·3 cm. broad, whereas, in *P. horridum* the pinnae are 0·4-1·1 cm. long and 0·1-0·3 cm. broad. But unlike *P. sakrigaliensis*, in *P. horridum* cells of the lower cuticle have more than one papilla.

The cuticle of *P. sakrigaliensis* also resembles the cuticle of *P. hirsutum*. Thomas & Bancroft described by Harris (1949, 1969) from Yorkshire. In both, the lower cuticle is differentiated into stomatal and non-stomatal bands and on the lower side the cells are papillate. *P. hirsutum* can be distinguished from the present species by the nature of subsidiary cells which are papillate.

Ptilophyllum distans (Feistmantel) Jacob & Jacob

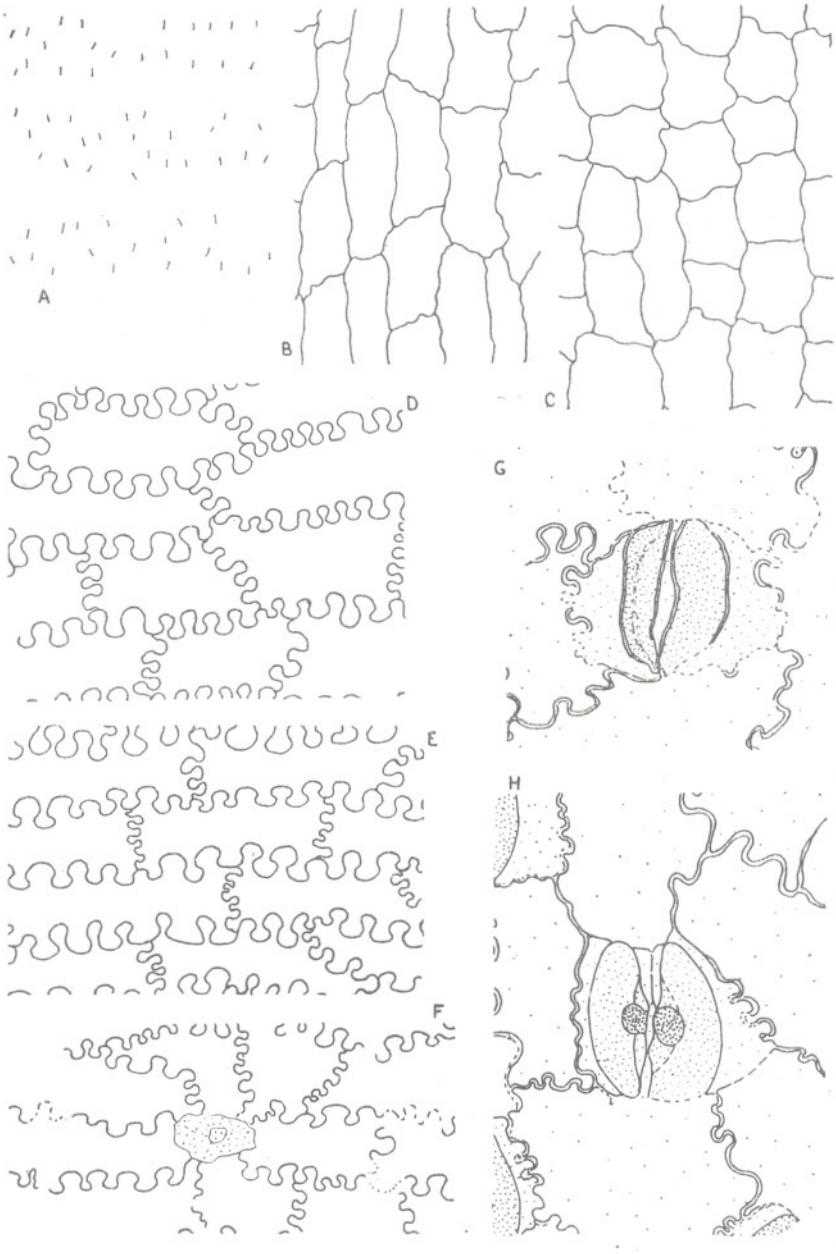
Pl. 5, Figs. 43-46, Pl. 6, Figs. 51-55, Pl. 8, Figs. 66, 67, 74-77; Text-figs. 5A-H

1877b *Otozamites hislopi* Oldham: Feistmantel, p. 12, pl. 6, figs. 3, 4.
— *Otozamites gracilis* Schimper: Feismantel, p. 13, pl. 6, figs. 5-7.
— *Pterophyllum nerbuddaicum* Feistmantel, p. 14, pl. 6, fig. 9.
— *Otozamites distans* Feistmantel, p. 13, pl. 7, fig. 3.
1920 *Ptilophyllum acutifolium* Morris: Seward & Sahni, p. 20, pl. 6, fig. 60.
1954 *Ptilophyllum ?acutifolium* Morris: Jacob & Jacob, p. 18, pl. 5, figs. 42-46, text-figs. 44-50.
Ptilophyllum distanse (Feistmantel): Jacob & Jacob, p. 21, pl. 5, figs. 47-50, pl. 6, figs. 51, 52, pl. 10, fig. 80, text-figs. 51-56.

Frond imparipinnate, length exceeding 8·5 cm., width 1·5-3·5 cm. in middle, gradually narrowing towards base and apex Rachis partially or completely concealed by pinnae. Pinnae linear, 0·5-2 cm. in length, 0·2-0·3 cm. in breadth, mostly 1·5 cm. long and 0·2 cm. broad, closely set or imbricate, arising at an angle of about 50°-85°. Pinnae shape varying, linear-oblong attached on upper surface of rachis. Pinna apex sub-acute or acute, sometimes apiculate; acroscopic margin rounded, rarely very slightly auriculate, basiscopic margin mostly concealed by acroscopic margin of pinna below, decurrent. Veins arising from entire base, forking once or twice, very rarely thrice.

Rachis cells on upper surface rectangular, rarely squarish or polygonal; anticlinal walls thick and straight, slightly wavy at places, periclinal-wall unspecialized. Cells on lower surface squarish, rarely rectangular or polygonal, arranged in regular rows; anticlinal walls thick, wavy at places, periclinal wall unspecialized.

Upper cuticle of lamina devoid of stomata, hairs or papillae. Cells rectangular, rarely polygonal, arranged in regular rows; anticlinal walls thick, sinuous, loops very prominent with rounded heads. Lower cuticle of lamina clearly differentiated into stomatiferous and non-stomatiferous bands. Stomatiferous bands broader than non-stomatiferous ones. Marginal non-stomatiferous band 6-13 cells wide; cells rectangular, usually more than two times breadth, arranged in regular rows; anticlinal walls sinuous, loops prominent, lateral walls with bigger loops than end-walls, periclinal wall unspecialized, rarely a few cells having a slightly more cutinized circular area without forming distinct papillae. Other non-stomatiferous bands 2-5 cells wide, mostly 3-4, rarely 5. Cells rectangular, sometimes rhomboidal or polygonal, arranged in regular series; anticlinal walls sinuous, loops smaller in size than marginal cells, periclinal wall unspecialized, rarely a few cells bearing oval or circular hair-bases. Stomatiferous bands 1-5 stomata wide, mostly 3-4, rarely near margin only one stoma wide. Cells rectangular, sometimes squarish or polygonal,



TEXT-FIG. 5 — *Ptilophyllum distans* (Feistmantel) Jacob & Jacob — A, lower cuticle showing distribution of stomata; slide no. 28864B-1, × 40. B, upper cuticle of rachis; slide no. 28864B-2, × 250. C, lower cuticle of rachis; slide no. 28864B- 2, × 250. D, upper cuticle of a pinna; slide no. 28864B-3, × 250. E, lower cuticle showing marginal cell; slide no. 28827A-3, ×250. F, lower cuticle showing cells of a non-stomatal band; slide no. 28827A-3, ×250. G-H, two stomata; slide nos. 4905 and 31930-2, × 500.

smaller than those of non-stomatal bands. Cell walls unspecialized, very rarely a few cells showing thickened circular area, but without any distinct papillae. Within stomatal bands, stomata irregularly scattered, very rarely a few stomata occurring over non-stomatal bands. Stomata transversely orientated, rarely slightly oblique, crowded or sparse. Stomata broad, guard cells slightly sunken, crescent shaped, wall cutinized, inner wall surrounding pore more cutinized. Subsidiary cells more cutinized than ordinary cells but less cutinized than guard cells; anticlinal walls sinuous, or wavy, periclinal wall with or without papillae; papillae rounded, solid.

Holotype — No. 4905 of the Geological Survey of India, Calcutta.

Localities — Sehora, district Narsinghpur, M.P. and Trambau, Kutch.

Age & Horizon — Upper Jurassic or Lower Cretaceous; Jabalpur Series.

Remarks — Jacob and Jacob (1954) based their description of *Ptilophyllum distans* on a single specimen (G.S.I. No. 4905) previously described by Feistmantel (1877b, Pl. 7, Fig. 3) as *Otozamites distans*. Cuticular preparations were made by us out of a few more specimens from Feistmantal's (1877b) collection and it was found that *Pterophyllum nerbuddaicum* (Feistmantel, 1877b, Pl. 6, Fig. 9) and later described by Jacob and Jacob (1954) as *Ptilophyllum ?acutifolium, Otozamites hislopi* (Feistmantel, 1877b, Pl. 6, Figs. 3, 4) and *Otozamites gracilis* (Feistmantel, 1877b, Pl. 6, Figs. 5-7) too, had similar type of cuticle. In addition to these specimens, 22 new specimens recently collected from Sehora showed similar type of cuticle. Besides these specimens, from Sehora, two fragmentary specimens of *P. distans* (Pl. 8, Figs. 66, 67) have been collected from Trambau in Kutch. The Trambau specimens differ from the Sehora specimens in the absence of hair-bases (hair-bases in the Sehora specimens are few and that too are of doubtful nature).

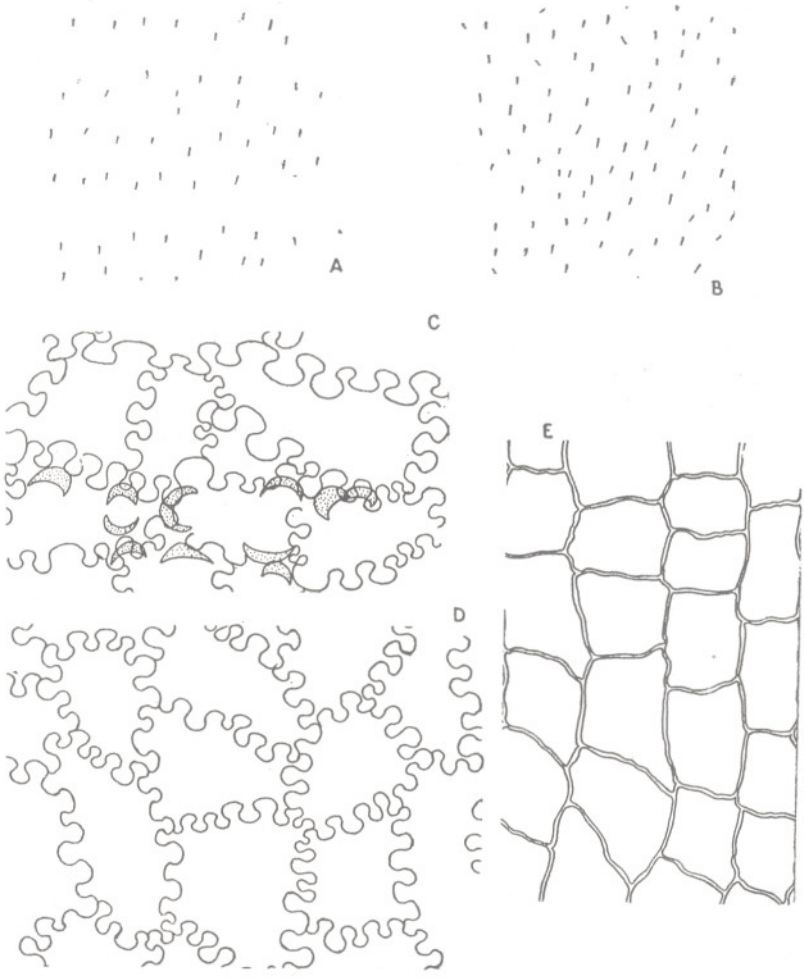
Comparison — *Ptilophyllum distans*, to some extent, may be compared with *P. gladiatum* described by Bose and Sukh Dev (1958) from Bansa, South Rewa Gondwana. In both, pinnae have acute apices, lower cuticle is differentiated into broad stomatiferous and narrow non-stomatiferous bands and outer walls of the subsidiary cells are looped. But *P. distans* is different in many ways, viz. its rachis cells and cells on the lower side of the lamina are devoid of papillae. Also, unlike *P. gladiatum*, the subsidiary cells in *P. distans* are papillate. The cuticle of the present species also resembles *P. pectinoides* described by Harris, (1946, 1969) from Yorkshire. In both, pinnae apices are acute, the lower basal margin is decurrent and the lower cuticle is differentiated into stomatal and non-stomatal bands. But the presence of a few bulging cells on the lower cuticle of lamina in *P. pectinoides* distinguishes it from *P. distans*. *P. distans* may be compared with *P. longipinnatum* described by Menéndez (1966) from Argentina. In both, the lower cuticle of lamina is differentiated into stomatiferous and non-stomatiferous bands and outer walls of the subsidiary cells are wavy. But in *P. distans* the stomatiferous bands are 1-5 stomata wide, whereas, in *P. longipinnatum* the stomatiferous bands are 2 stomata wide. Also the presence of hair bases (?) over non-stomatiferous bands in the present species distinguishes it from *P. longipinnatum*.

Ptilophyllum institacallum Bose

Pl. 7, Figs. 59, 60, 62-65, Pl. 8, Figs. 68-73; Text-figs. 6A-E

1877b *Ptilophyllum cutchense* Morris: Feistmantel, p. 14, pl. 6, fig. 1.
— *Otozamites angustatus* Feistmantel, p. 13, pl. 6, fig. 8, pl. 7, fig. 1.
— *Otozamites gracilis* Schimper: Feistmantel, p. 13, pl. 7, fig. 2.
1917 *Otozamites angustatus* Feistmantel: Seward, p. 514, fig. 588B.
1920 *Ptilophyllum acutifolium* Morris: Seward & Sahni, p. 20, pl. 5, fig. 49.
1954 *Ptilophyllum cutchense* Morris: Jacob & Jacob, p. 24, pl. 6, figs. 53-61, pl. 7, figs. 62-64, pl. 10, fig. 91, text-figs. 57-70.
1959 *Ptilophyllum institacallum* Bose, p. 26, pl. 1, figs. 1-8, text-figs. 1A-D.

Emended diagnosis — Leaf pinnate, measuring 2·5-15 cm. in length and 0·9-2 cm. in breadth near middle, commonly 1·5 cm. in breadth. Rachis concealed, rarely visible at places. Pinnae arising at an angle of about 69°-80° near middle, near apex and base angle of divergence less, closely set, usually imbricate, attached by their entire base. Pinnae typically 0·8-1·2



TEXT-FIG. 6 — *Ptilophyllum institacallum* Bose — A, lower cuticle showing stomata distributed within distinct bands; slide no. 28807A, × 40. B, lower cuticle showing irregularly distributed stomata, without forming definite bands; slide no. 28820, × 40. C, lower cuticle showing marginal cells; slide no. 28820, × 250. D, cells of upper cuticle; slide no. 28804; × 250. E, rachis cells; slide no. 28838B, × 250.

cm. long, 0·2-0·3 cm. broad, linear or narrowly ovate, sometimes somewhat falcate. Acroscopic margin slightly rounded, basiscopic margin also slightly rounded; apex mostly sub-acute, rarely acute. Veins inconspicuous, arising from entire base, nearly parallel, sometimes forking.

Rachis slender, cuticle thick on both sides. Cells on upper side rectangular or rhomboidal; anticlinal walls straight or undulated, periclinal wall unspecialized. Cells on lower side squarish or rectangular; anticlinal walls thick, straight or slightly wavy, periclinal wall unspecialized.

Cells of upper cuticle of lamina rectangular or squarish, a few polygonal, generally regular in arrangement; anticlinal walls sinuous, loops prominent, periclinal wall unspecialized. Lower cuticle comparatively thick, showing two distinct zones, an outer non-papillate zone (including marginal and apical regions) and an inner papillate and stomatal zone. Inner stomatal and papillate zone, either with stomatal and non-stomatal bands or without any bands. When differentiated into stomatal and non-stomatal bands, there may be either two outer broad stomatal bands (7-9

stomata wide) and a narrow median band (3-4 stomata wide) or there may be 4-5 stomatal bands (3-7 stomata wide) alternating with 3-4 cells wide non-stomatal bands. Sometimes when inner zone divided into stomatal and non-stomatal bands a few stomata may even occur over non-stomatal bands. Mostly lower cuticle with 3 bands, rarely 5, less commonly stomata distributed irregularly over entire surface. Outer marginal zone 5-9 cells wide in middle; cells rectangular or squarish, rarely polygonal, regularly arranged; anticlinal walls sinuous, loops prominent. Cells nearer margin, devoid of papillae and those closer to stomatal bands usually papillate. Anticlinal walls of cells within stomatal and non-stomatal bands obscured by papilla, periclinal wall of almost all cells bearing mostly more than one large papillae. Papillae crescent-shaped or semi-lunar. Papillae of each cell joining one another at ends and forming a 'frill-like' structure. Papillae of adjoining cells overlapping each other. Stomata sunken and almost concealed by overhanging papillae. Guard cells crescent-shaped, highly cutinized. Subsidiary cells more cutinized than ordinary cells but less cutinized than guard cells.

Holotype — No. 28832 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Sehora, district Narsinghpur, M.P.

Age & Horizon — Upper Jurassic or Lower Cretaceous; Jabalpur Series.

Remarks — Jacob and Jacob (1954) redefined *Ptilophyllum cutchense* after studying the cuticular structure of three specimens of Feistmantel (1877b) previously described by him as *Ptilophyllum cutchense* (FEISTMANTEL 1877b, PL. 6, FIG. 1), *Otozamites angustatus* (FEISTMANTEL 1877b, PL. 7, FIG. 1) and *O. gracilis* (FEISTMANTEL 1877b, PL. 7, FIG. 2). The cuticular structure of none of these specimens resemble the cuticle of any of the species, so far known, from Kutch from where *P. cutchense* was first described by Morris (1840). The cuticle of the above three specimens, when examined was found to resemble exactly the cuticle of *P. institacallum*, earlier described by Bose (1959) from Sehora. As such these three specimens are here described under *P. institacallum* and not under *P. cutchense* where only those specimens have been referred which are preserved in the form of impressions. Besides the above three specimens we had the opportunity to study the cuticle of some of the other specimens of Feistmantel (1877b) and a large number of specimens collected by us from Sehora during the years 1956-67. Out of all the specimens collected from Sehora it was found that the largest number of specimens belonged to *P. institacallum*. It was also found that the majority of the specimens belonging to this species showed distinct stomatal and non-stomatal bands unlike the specimens (including the holotype no. 28832) described by Bose (1959). According to Bose, except at the marginal region stomata are distributed irregularly over entire lower surface. Actually in most of the specimens, stomata are distributed in two outer broad bands (7-9 stomata wide) and a narrow median band.

Comparison — *Ptilophyllum institacallum* is the commonest species of *Ptilophyllum* occurring at Sehora. *P. institacallum* differs from *P. horridum* Roy (which is a dominant species of *Ptilophyllum* in Trambau) in the nature of pinnae apices. While the pinnae of the former species have sub-acute or acute apices, the pinnae apices of the latter species are apiculate. Also in *P. institacallum* there are very few stomatal bands unlike *P. horridum* where the stomatal bands are about 7-9 in number. Both these species resemble each other in being heavily papillate on the lower side. In both the species, surface wall in each cell has mostly more than one papillae. But while in *P. institacallum* papillae of the adjoining cells join together obscuring completely the cell walls, the papillae of *P. horridum* do not join each other in that fashion. *P. oldhamii* Jacob & Jacob resembles some of the specimens of *P. institacallum* in the nature of stomatal distribution, viz. in *P. oldhamii*, except the marginal non-stomatic region, stomata are distributed all over the entire lower surface. Such a type of stomatal distribution is seen only in a very few specimens of *P. institacallum*. Cells of *P. oldhamii* on lower side are also papillate but their ends do not join each other in the same manner as in *P. institacallum*. Moreover, each stoma in *P. oldhamii* is covered by 4-5 papillae. Also unlike the present species, the pinnae apices of *P. oldhamii* are apiculate. The pinnae of *P. sakrigaliensis*

Sah are much larger than *P. institacallum* and they have distinctly acute apices, also the lower cuticle shows stomatal and non-stomatal bands, but they are very faintly marked. Papillae in *P. sakrigaliensis* are circular or arch-like. In the nature of papillae, *P. institacallum* very much resembles *P. caucasicum* described by Doludenko and Svanidze (1964) from the Bathonian and Callovian of Georgia. But the latter species unlike the former has about 10 stomatal bands and each band is about 2 stomata wide. In *P. institacallum* stomatal bands are 3-5 in number and each band is about 3-9 stomata wide.

Ptilophyllum jabalpurense Jacob & Jacob

Pl. 7, Figs. 58, 61, Pl. 9, Figs. 78-84; Text-figs. 7A-G

1877b *Ptilophyllum acutifolium* Morris: Feistmantel, p. 14, pl. 5, figs. 1, 3-5.
— *Otozamites hislopi* Oldham: Feistmantel, p. 12, pl. 11, fig. 1.
1954 *Ptilophyllum acutifolium* Morris: Jacob & Jacob, p. 15, pl. 4, figs. 34-41, pl. 10, figs. 78, 79, text-figs. 37-43.
— *Ptilophyllum jabalpurense* Jacob & Jacob, p. 29, pl. 7, figs. 65-71, pl. 10, fig. 82, text-figs. 71-76.

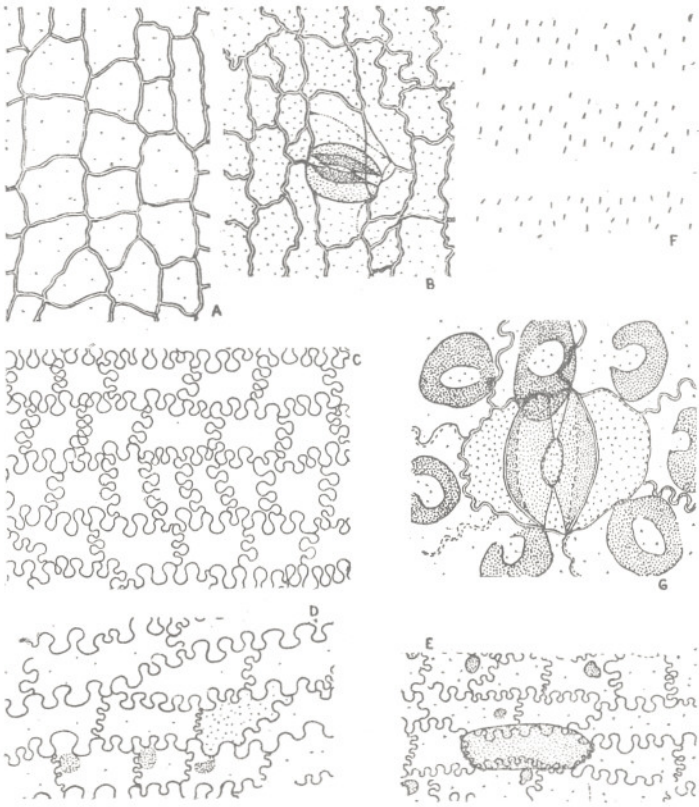
Emended diagnosis — Pinnate frond, exceeding 18 cm. in lengrh, width 2-3·5 cm. Rachis partially or completely concealed by pinnae. Pinnae linear, 1·1-2·4 cm. in length, 0·2-0·3 cm. in breadth, closely set or imbricate, arising at an angle of about 46°-70°, angle of divergence less towards apex. Acroscopic margin rounded, basiscopic margin slightly decurrent, generally concealed by acroscopic margin of pinna below. Apex mostly apiculate, sometimes acute. Veins arising from entire base, forked or unforked, when forked mostly once, rarely twice.

Rachis cells on both upper and lower surfaces, squarish or rectangular, rarely polygonal; anticlinal walls thick, slightly wavy at places or undulated, periclinal wall unspecialized. Lower cuticle rarely having a few obliquely orientated stomata. Guard cells crescent shaped, highly cutinized. Subsidiary cells more cutinized than ordinary epidermal cells but less cutinized than guard cells. Outer wall of subsidiary cells straight.

Upper cuticle of lamina devoid of stomata. Cells rectangular, rarely polygonal, more or less arranged in regular rows. Anticlinal walls thick, sinuous; loops of cells away from margin bigger and prominent, near margin and base loops less prominent, loops with rounded heads, occasionally reaching upto centre of cell. Periclinal wall somewhat mottled or smooth. Lower cuticle of lamina differentiated into stomatiferous and non-stomatiferous bands. Marginal non-stomatiferous bands 5-15 cells wide. Cells rectangular, mostly more than twice the breadth, arranged in regular rows; anticlinal walls sinuous, loops prominent, lateral-walls with bigger loops than end-walls. Periclinal wall unspecialized, rarely closer to stomatal bands, a few cells having slightly more cutinized circular areas, also very rarely with arch shaped, circular or oval papillae. Other non-stomatiferous bands 2-5, mostly 3-4 cells wide. Cells rectangular, sometimes rhomboidal or polygonal, arranged in regular rows; anticlinal walls sinuous, loops smaller in size than marginal cells, periclinal wall with or without papillae, when papillate, papillae 1-2, or rarely more in number. Papillae variously shaped, solid-circular, semi-circular, hollow-circular or crescent-shaped. In addition to papillae, a few cells bearing circular or oval hair-bases. Stomatal bands 2-5 stomata wide. Cells of stomatal bands smaller than non-stomatal bands. Cells rectangular, length in transverse direction, sometimes squarish or polygonal; anticlinal walls sinuous, obscured by papillae. Each cell consisting of 1-3 papillae, papillae more developed than non-stomatal bands, mostly bearing single, circular, hollow papilla, rarely semi-circular or crescent-shaped. No hair-bases visible within stomatal bands. Stomata within bands irregularly arranged, crowded, transversely or slightly obliquely orientated. Guard cells well cutinized, crescent-shaped, aperture oval or slit-like. Outer wall of guard cells well marked and more cutinized. Subsidiary cells slightly more cutinized than ordinary cells but less cutinized than guard cells, fairly prominent and occasionally each inner wall bearing a solid papilla, outer wall undulated or wavy. Stomatal apparatus surrounded by circular, hollow papillae of adjacent cells.

Lectotype — No. 4892 of the Geological Survey of India, Calcutta.

Locality — Sehora, district Narsinghpur, M.P.



TEXT-FIG. 7 — *Ptilophyllum jabalpurense* Jacob & Jacob.— A, upper cuticle of rachis; slide no. 28898B-2, × 250. B, lower cuticle of rachis; slide no. 28813B-2, × 250. C, upper cuticle; slide no. 28825, × 250. D, lower cuticle showing marginal cells; slide no. 28868A-1, × 250. E, lower cuticle showing cells of a non-stomatal band; slide no. 29221-1, × 250. F, lower cuticle showing distribution of stomata; slide no. 28868-A, × 40. G, a stoma; slide no. 28868A-1, × 500.

Age & Horizon — Upper Jurassic or Lower Cretaceous; Jabalpur Series.

Remarks — At Sehora, *Ptilophyllum jabalpurense* is as common as *P. institacallum* Bose. The length and breadth of the lamina, pinnae apices and cuticle in *P. jabalpurense* are variable. Jacob and Jacob (1954) had described the pinna apex as "obtuse or obtusely pointed" but according to the present findings the apex is mostly apiculate but sometimes acute as well. Besides the nature of pinna apex quite a few differences have been noted from the original description of Jacob and Jacob (1954). The main difference lies in the nature of papillae and their position over ordinary epidermal cells and subsidiary cells. According to Jacob and Jacob the marginal cells are non-papillate and each cell of non-stomatal band is having a single hollow papilla but present study shows that the marginal cells closer to the stomatal bands are sometimes papillate and each cell of non-stomatal bands (when papillate) is having 1-3 papillae which are solid-circular, semi-circular, hollow-circular or crescent-shaped. Regarding the ordinary cells of the stomatal bands Jacob and Jacob had mentioned "smaller cells have a single, hollow papilla occupying the entire cell; the largeer have 2-3 smaller papillae". Actually it has been observed that the number of papillae per cell is not at all dependant on the size of the cell.

Comparison — Some of the broader specimens of *Ptilophyllum jabalpurense* (PL. 9, FIGS. 78, 79) are very similar to the lectotype of *P. acutifolium* (PL. 1, FIG. 1). In these, like *P. acutifolium*, the apices of the

pinnae are acute. *P. jabalpurense* resembles most *P. distans* (Feistmantel) Jacob & Jacob. In both, pinnae apices are apiculate or acute and the lower cuticle of pinna is differentiated into broad stomatal and narrow non-stomatal bands. But in *P. jabalpurense* the ordinary epidermal cells of lower cuticle are papillate, whereas, in *P. distans* the epidermal cells are non-papillate. The present species, to some extent, resembles *P. indicum* Jacob & Jacob. In both, the pinnae apices are apiculate or acute and stomata are surrounded by the papillae of adjacent cells. But the absence of hair bases over the non-stomatal bands in *P. indicum* distinguishes it from *P. jabalpurense.* Also in *P. jabalpurense,* the stomata are present over the lower cuticle of rachis, whereas, in *P. indicum* lower cuticle of rachis is lacking stomata.

Among the Russian species, *P. sokalense* Doludenko (1963) and *P. okribense* Doludenko & Svanidze (1964), to some extent, may be compared with *P. jabalpurense.* In these, the lower cuticle is differentiated into stomatal and non-stomatal bands and the subsidiary cells are papillate. But in the Russian species, on lower side, each ordinary epidermal cell is bearing a single papilla, whereas, in *P. jabalpurense* 1-3 papillae are met with.

Ptilophyllum gladiatum Bose & Sukh Dev

1958 *Ptilophyllum gladiatum* Bose & Sukh Dev, p. 12, pl. 1, figs. 1-5, text-figs. 1A-F.

This species is extremely rare and so far it has not been collected from any other locality in India except Bansa, Madhya Pradesh.

PETRIFACTIONS

Ptilophyllum amarjolense Bose

Pl. 10, Figs. 85-89, 91-93, Pl. 12, Figs. 108-111, Pl. 13, Fig. 113; Text-figs. 8A-F

1953 *Ptilophyllum amarijolense* Bose, p. 605, pl. 26, figs. 1-3, 5-11, pl. 27, figs. 15, 16, text-fig. 2a-e.

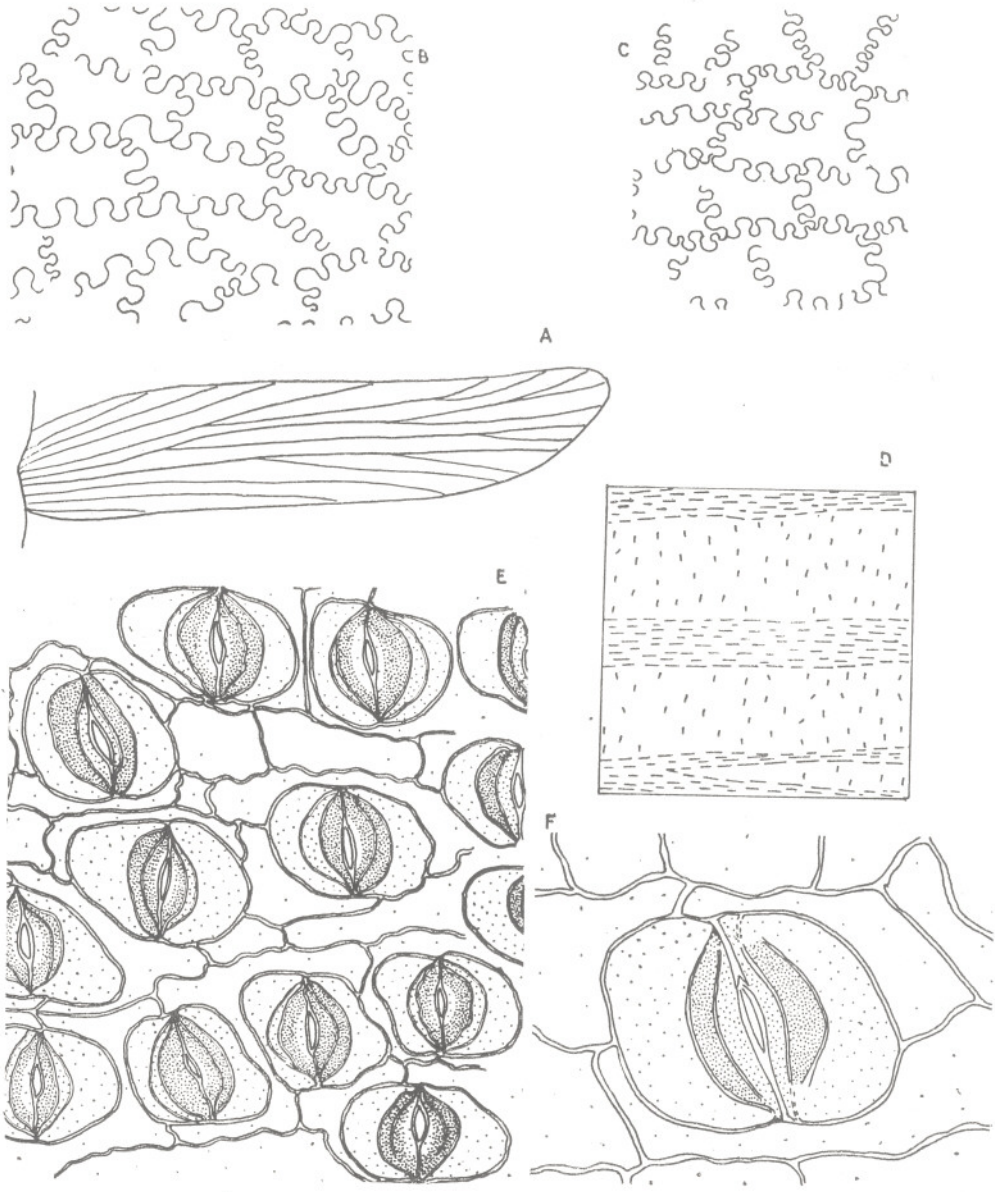
1967 *Ptilophyllum guptai* Sharma, p. 143, pl. 24, figs. 1-8, text-figs. 1-8. *Ptilophyllum sparsifolium* Sharma, p. 145, pl. 25, figs. 1-6, text-figs. 9-13.

Emended diagnosis — Frond pinnate, length 3-8 cm., breadth 3-5 cm. in middle, abruptly narrowing towards apex. Lower expanded end of petiole forming pulvinus, at base 0·3-1 cm. in width. Rachis concealed, sometimes partially exposed, lower portion of rachis devoid of pinnae (about 2·5-3 cm. from base). Pinnae attached on upper surface of rachis, alternate, rarely sub-opposite, closely set or imbricate, arising at an angle of about 60°-70°. Pinnae linear, 1·5-2·8 cm. long, 0·3-0·5 cm. broad; acroscopic margin rounded, basiscopic margin sometimes concealed by acroscopic margin of pinna below, slightly decurrent. Apex obtusely pionted or acute. Veins forked or unforked, when forking mostly once or twice, rarely thrice.

Upper surface of pulvinus showing a few prominent parallel ridges. Lower surface wrinkled. Surface cells of rachis rectangular, elongated or squarish, anticlinal walls straight, periclinal wall un-specialized.

Cells of upper surface of pinnae squarish, rectangular of polygonal; anticlinal walls sinuous, periclinal wall unspecialized. Lower surface differentiated into stomatal and non-stomatal bands. Marginal non-stomatal bands about 9 cells wide; cells rectangular or squarish, sometimes polygonal; anticlinal walls sinuous, periclinal wall unspecialized. Other non-stomatal bands 3-5 cells wide, cells rectangular with oblique end-walls; anticlinal walls wavy or sinuous, periclinal wall unspecialized. Stomatal bands 4-5 stomata wide; cells rectangular or polygonal with sinuous or wavy walls, surface unspecialized. Stomata irregularly scattered, majority transversely orientated, rarely oblique. Guard cells crescent-shaped. Subsidiary cells broad, outer wall straight, surface lacking papillae. Stomatal aperture oval or slit-like.

In cross section, rachis near base (pulvinus) more or less oval, but dorsal side more convex than ventral. Further above somewhat circular (ventral side flat), dorsal side highly convex. Pulvinus showing an outer layer of epidermis followed by hypodermis 6-7 cells thick. Epidermal cells rectangular, hypodermal cells thick walled and polygonal. Ground tissue consisting of isodiametric, circular or oval cells with intercellular spaces. Vascular bundles 11 (5 abaxial, 2 lateral and 4 adaxial), collateral, arranged in kidney



TEXT-FIG. 8 — *Ptilophyllum amarjolense* Bose.— A, a pinna showing venation; slide no. 3741, × 5. B, lower cuticle showing marginal cells; slide no. 33886, × 250. C, cells of upper cuticle; slide no. 33889-1, × 250. D, lower cuticle showing distribution of stomata; slide no. 28069, × 40. E, lower cuticle showing a few stomata; slide no. 33899, × 250. F, a stoma, slide no. 33899, × 500.

shaped manner. Xylem pointing inwards, showing scalariform thickening on radial walls. Phloem badly preserved, cells polygonal.

Epidermal, hypodermal and ground tissue cells of rachis (viz. the portion where pinnae are attached) are similar to the cells of the pulvinus. An incomplete ring of mechanical tissue present outside vascular bundles; cells elongated, polygonal. Vascular bundles about 20-32 in number, collateral, arranged in double series in the form of "U", opening of "U" facing upwards. Xylem pointing inwards, showing

scalariform thickening on radial walls. Phloem badly preserved, cells polygonal. Sclereids present in ground tissue and in between vascular bundles.

In cross-section, pinna showing a ventral and a dorsal layer of epidermis consisting of small rectangular cells. Both layers followed by a single layered hypodermis. Hypodermal cells thick, bluntly tapering inwards. Upper hypodermis followed by 1-2 layered palisade tissue consisting of elongated cells. Mesophyll cells loosely packed. Vascular bundles about 14, situated in a row above hypodermal layer. Xylem cells adaxial, phloem cells abaxial.

Lectotype — No. 33899 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Amarjola, Rajmahal Hills, Bihar.

Age & Horizon — Upper Jurassic; Rajmahal Series.

Remarks — *Ptilophyllum amarjolense* was founded by Bose (1953) on some petrified fronds from Amarjola, Rajmahal Hills, Bihar. His description was based on two types of fronds firstly — pinnae elongated, narrow (about 2·5 cm. long, 0·4 cm. broad) and secondly — pinnae small, oval or oblong (about 0·3-0·7 cm. long, 0·3 cm. broad). Bose had described the anatomical details of these fronds and had also studied the surface cells under reflected light. After the publication of Bose's paper, during the years 1954-1967, al arge numberof new specimens have been collected from Amarjola. Out of these specimens, a large number of peel sections of rachis and pinnae have been prepared. On the basis of these new specimens and preparations it has now been possible to differentiate between the larger and smaller forms previously included under *P. amarjolense* Bose (1953). From the present study, it was possible to distinguish two distinct species. Here, the specific name *P. amarjolense* has been retained for those specimens which have larger pinnae and whose stomatal bands are 4-5 stomata wide. The remaining specimens which have smaller pinnae and whose stomatal bands are 2-3 stomata wide are placed under *P. sahnii* Gupta & Sharma (1968).

In addition to these specimens, we had also the opportunity to examine some of the "Durofix" peel preparations of *Ptilophyllum guptai* Sharma (1967), *P. sparsifolium* Sharma (1967) and *P. sahnii* Gupta & Sharma (1968). From their preparations it was clear that the structure of surface cells (including stomata) of *P. amarjolense*, *P. guptai* and *P. sparsifolium* was similar. The only difference, however, was in the interpretation of papillae over ordinary cells on the lower surface. According to Sharma (1967) in *P. guptai* cells on the lower surface were papillate. No such papillae were observed in *P. amarjolense* and *P. sparsifolium*. The *Ptilophyllum* leaves at Amarjola are all preserved in the form of petrifactions in a pisolitic bed. The petrifactions are soft and fragile. When the pinnae of such fronds were covered with "Durofix" or other similar substances for peel preparations and when the pulls were made, it was found very often a part of the underneath matrix came out along with the "pulls". When such sections were examined under microscope it was observed that in some, in different focii, both the epidermal cells as well as the hypodermal cells were visible. While in others even the palisade cells or the mesophyll cells were present. Among these, the ones with hypodermal cells very often gave the deceptive idea of papillae (Pl. 13, Fig. 113). Some of these preparations were treated with HF, and after the treatment it was found that the portions of matrix attached to the peel had dissolved. When washed properly and again reexamined under the microscope such deceptive papillae were completely missing over the cells and the cells resembled exactly the cells of those preparations where there was no matrix attached, i.e. cell surface was found to be devoid of papillae. In our opinion, the papillae in *P. guptai* as mentioned by Sharma (1967) are really portions of these underneath matrix. Even in some of Sharma's preparations we had seen, at places where there was no matrix, the cells were devoid of the so-called papillae.

Besides the papillae, according to Sharma, in *P. guptai* the stomatal and non-stomatal bands are not well differentiated. But in all our specimens, the stomatal and non-stomatal bands are distinct and in Sharma's preparations too (examined by us) we found that the lower surface had well differentiated stomatal and non-stomatal bands.

The surface cells of *P. sparsifolium* in every respect resemble the cells of all our specimens. The only difference lies in the

external features. While in the type specimen of *P. amarjolense* the pinnae are closely set, in the figured specimens of *P. sparsifolium* Sharma (1967) the pinnae are not so closely set, we too, have such specimens in our collection (PL. 10, FIG. 89) but on the basis of structure of surface cells we do not consider them to be different from *P. amarjolense*. As such we have merged *P. sparsifolium* Sharma (1967) under *P. amarjolense*.

Comparison — In external features some of the specimens of *Ptilophyllum amarjolense* (PL. 10, FIGS. 85-87) are very similar to the lectotype of *P. acutifolium* (PL. 1, FIG. 1). In external characters, one of the specimen of *P. sakrigaliensis* (PL. 5, FIG. 41) is also comparable to some of the specimens of *P. amarjolense* (PL. 10, FIGS. 85, 86). But in *P. sakrigaliensis*, the pinna apex is more acute. *P. sakrigaliensis* can also be distinguished from *P. amarjolense* in the details of the surface sturcture. In the former species, the lower cuticle is highly papillate, whereas, in the latter species, lower cuticle is devoid of papillae. *P. amarjolense*, to some extent, may be compared with *P. distans*. In these, the lower cuticle is differentiated into stomatal and non-stomatal bands and epidermal cells of lower cuticle are non-papillate. But unlike *P. amarjolense*, the subsidiary cells in *P. distans* are papillate.

Ptilophyllum sahnii Gupta & Sharma

Pl. 10, Fig. 90, Pl. 11, Figs. 94-105, Pl. 12, Figs. 106, 107, Pl. 13, Fig. 112; Text-figs. 9A-E

1913 *Ptilophyllum cutchense* Feistmantel: Bancroft, p. 73, pl. 7, figs. 13, 17, 18, pl. 8, figs. 1-4, 7, 8, pl. 9, figs. 3a, b, d, 5-9.

1953 *Ptilophyllum amarjolense* Bose, p. 605, pl. 26, fig. 4, pl. 27, figs. 12-14, 17-20, pl. 28, figs. 21-26, text-figs. 1, 3a-f.

1968 *Ptilophyllum* Rao & Achuthan, p. 249, pl. 1, figs. 1-5, pl. 2, figs. 6-10, text-figs. 1-40.

1968 *Ptilophyllum sahnii* Gupta & Sharma, pl. 1, figs. 1, 2, 4, 6, text-figs. 1-4.

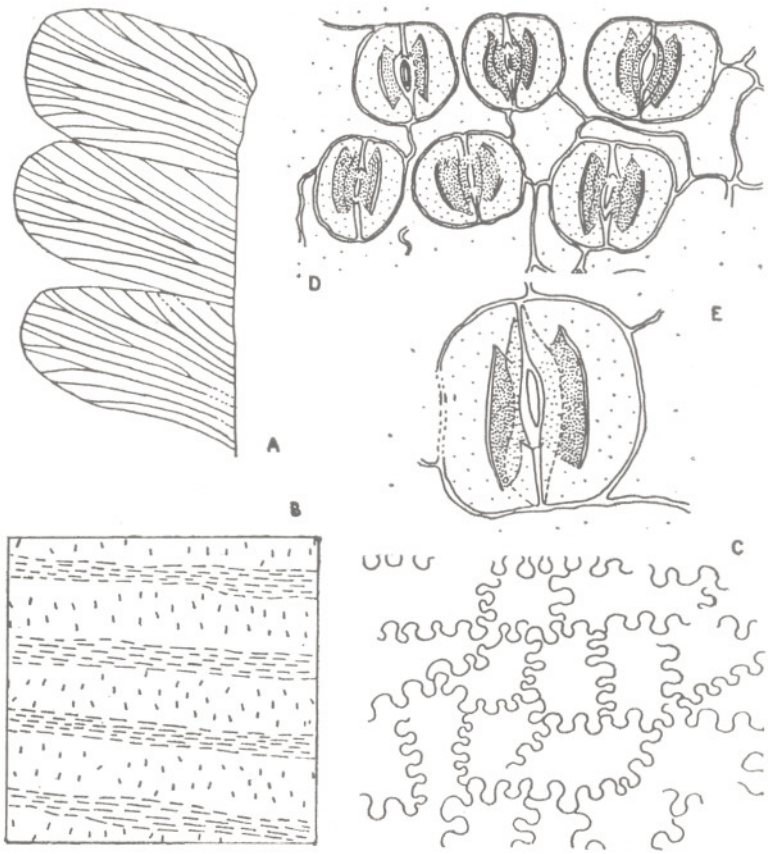
— *Ptilophyllum amarjolense* Bose: Gupta & Sharma pl. 1, figs. 3, 5, 7.

Emended diagnosis — Leaves imparipinnate, measuring 3-7·5 cm. in length, major part of lamina uniformly broad, 0·6-1·9 cm. wide in middle, less towards apex and base. Rachis mostly concealed, sometimes partially exposed. Pinnae attached on upper surface of rachis, alternate, rarely sub-opposite, closely set or imbricate, 0·3-1 cm. long, 0·2-0·4 cm. broad in middle; arising at an angle of about 60°-85° in middle, less towards apex and base. Pinnae oblong or oval, acroscopic margin rounded, basiscopic margin sometimes concealed by acroscopic margin of pinna below, sometimes slightly decurrent. Near base, pinnae very small, almost circular. Apex mostly obtuse, rarely obtusely pointed. Veins forked or unforked, mostly once, rarely twice.

Surface cells of rachis rectangular or squarish, anticlinal walls straight, periclinal wall unspecialized.

Cells of upper surface of pinnae squarish or rectangular, sometimes polygonal; anticlinal walls sinuous, periclinal wall unspecialized. Lower surface differentiated into stomatal and non-stomatal bands. Stomatal bands broader than non-stomatal bands. Marginal non-stomatal bands 5-8 cells wide. Cells rectangular or squarish, sometimes polygonal; anticlinal walls sinuous, periclinal wall unspecialized. Other non-stomatal bands 2-4 cells wide, rarely 5. Cells squarish or rectangular; anticlinal walls sinuous, periclinal wall devoid of papillae or hair bases. Stomatal bands mostly 2-3 stomata wide, very rarely 4. Ordinary epidermal cells smaller than cells of non-stomatal bands; anticlinal walls wavy or sinuous, periclinal wall smooth. Stomata within bands closely set, a few touching each other, irregularly scattered, transversely orientated, a few oblique. Guard cells crescent-shaped, stomatal aperture oval or slit slike. Subsidiary cells broad, outer wall straight, surface wall devoid of papillae.

In transverse section, rachis showing an outer layer of epidermis followed by 6-7 layered hypodermis. Epidermal cells rectangular, hypodermal cells thick-walled and mostly hexagonal. Cells of ground tissue isodiametric or oval with intercellular spaces. An incomplete ring of mechanical tissue present outside vascular bundles. Vascular bundles 23-32, collateral, arranged in a double series in the form of "U", xylem pointing inwards. Xylem showing scalariform thickening on radial walls. Phloem cells indistinct, polygonal.



TEXT-FIG. 9 — *Ptilophyllum sahnii* Gupta & Sharma.— A, a few pinnae showing venation; slide no. 33890, × 5. B, lower cuticle showing distribution of stomata; slide no. 33895, × 40. C, cells of upper cuticle; slide no. 33893, × 250. D, lower cuticle showing a few stomata; slide no. 33895, × 250. E, a stoma; slide no. 33895, × 500.

Sclereids present in ground tissue and in between vascular bundles.

In transverse section, pinna showing upper and lower epidermis made up of rectangular cells. Both followed by a single layer of hypodermis. Upper hypodermis followed by 1-2 layers of elongated palisade cells. Mesophyll spongy, not well preserved. Vascular bundles varying in number from base to apex, mostly 4-12, collateral, lying between lower hypodermis and mesophyll tissue. Xylem situated on upper side, phloem on lower side. Sclereids present both in palisade and in mesophyll.

Holotype — No. K 1/Raj. A. Gupta coll., department of Botany, University of Jodhpur, Rajasthan.

Localities — Amarjola, Chilgojuri and Nipania, Rajmahal Hills, Bihar.

Age & Horizon — Upper Jurassic; Rajmahal Series.

Remarks — *Ptilophyllum sahnii* Gupta & Sharma is preserved in the same way as *P. amarjolense* Bose. Also the "Durofix" pulls come out in the same manner as *P. amarjolense*. So in our opinion, the presence of papillae in *P. shhnii* as described by Gupta and Sharma (1968) is very doubtful. We have more than 100 specimens of *P. sahnii* and none of the peel sections, which are devoid of matrix, show papillate cells on the lower surface. No papillate cells on the lower surface were found by Rao and Achuthan (1968) in the specimens from Nipania. The specimen

from Nipania is preserved in a hard, silicified chert and as such pulls obtained from the *Ptilophyllum* from Nipania had no matrix attached to them. The specimens from Chilgojuri too are preserved in silicified cherts but the peel sections prepared from them did not show the cells very clearly. In none of them, however, papillate cells were visible on the lower surface.

Both at Amarjola and Chilgojuri, *P. sahnii* is very common and aslo at Amarjola, this species is much more common than *P. amarjolense*.

Comparison — In shape, size and pinna apex, *Ptilophyllum sahnii* resembles exactly the specimens of *P. cutchense* (Pl. 2, Figs. 15, 16) from Soorujbera. Perhaps they are same as the specimens from Amarjola, Chilgojuri and Nipania but in the absence of details of the surface cell in the specimens from Soorujbera we have, at present, preferred to keep them separate from *P. sahnii*.

The details of surface structure of *P. sahnii* are very similar to *P. amarjolense*. But the former species differs in being much less wide (0·6-1·9 cm.) as compared to the latter which is 3-5 cm. wide. Also the pinnae apices in *P. amarjolense* are mostly obtusely pionted or acute, whereas, in *P. sahnii* it is mostly obtuse, very rarely obtusely pointed. *P. sahnii* also differs from *P. amarjolense* in having less broad stomatal bands. In the former species they are 2-3 stomata wide, whereas, in *P. amarjolense* they are 4-5 stomata wide. *P. rarinervis* differs from *P. sahnii* in having pinnae with 2-3 veins only. In *P. sahnii* veins are 8-12 in number.

Ptilophyllum nipanica Vishnu-Mittre

1957 *Ptilophyllum nipanica* Vishnu-Mittre, p. 96, pl. 1, p. 4, text-figs. 1-5.

Emended diagnosis — Leaf about 6 mm. long and 10 mm. broad. Pinnae attached on upper surface of rachis, overlapping, about 5-6 mm. long and 2-3 mm. wide, margin entire, apex apiculate, acroscopic margin rounded, basiscopic margin straight. Veins few, 3-5 in number, rarely forking.

Surface cells on upper side squarish; walls sinuous, surface without papillae. Lower surface with two distinct zones, a marginal zone devoid of stoma and an inner zone with stomata. Stomata transversely orientated, rarely oblique. Cells squarish or rectangular, walls sinuous, surface unspecialized. Guard cells flanked by subsidiary cells. Subsidiary cells crescent shaped, devoid of papilla.

Holotype — Slide no. 856 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Nipania, Rajmahal Hills, Bihar.

Age & Horizon — Upper Jurassic; Rajmahal Series.

Remarks — *Ptilophyllum nipanica* was instituted on a fragmentary specimen from Nipania. The specimen has only four incomplete pinnae on one side of the rachis and a part of a pinna on the other side. It was first found in a silicified chert. It was then sectioned and mounted on a glass slide for microscopic study. During grinding one of its surface was completely used up. As such cells of the upper surface are no more present in the slide. The stomatal surface, too, due to differential grinding is rather difficult to study in detail. In our opinion, the presence of papillae in *P. nipanica* is extremely doubtful. Therefore, at present, we have not included their description in the diagnosis.

Comparison — In external features and in the distribution of stomata, *Ptilophyllum nipanica* resembles most *P. oldhamii* Jacob & Jacob (1954). The former species, however, differs from the latter in having non-papillate cells.

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We are grateful to Mr. G. C. Chaterjee, the then Director-General of the Geological Survey of India, Calcutta, for allowing one of us (M. N. Bose) to photograph and study some of their figured specimens. To Professor B. N. Mookerjee, Botany Department, T.N.B. College, Bhagalpur we are thankful for the specimen figured in Pl. 14, Fig. 116.

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EXPLANATION OF PLATES

PLATE 1

1-5. *Ptilophyllum acutifolium* Morris — fig. 1 [lectotype, Br. Mus. no. V21330 (9942); from south of the Charwar range], fig. 2 (Br. Mus. no. V20190 (9941); from south of the Charwar range), fig. 3 (B.S.I.P. no. 33765; from Yax), fig. 4 (G.S.I. no. 4836; from Kakadbhit), fig. 5 (B.S.I.P. no. 33766; from Kakadbhit). All × **1.**

6. *P. acutifolium* Morris — G.S.I. no. 4706; from Raghavapuram (this specimen has been doubtfully referred to *P. acutifolium*). × 1.

7-10. *Ptilophyllum cutchense* Morris — fig. 7 [lectotype, Br. Mus. no. V. 20191 (9943); from south of the Charwar range], fig. 8 (G.S.I. no. 4808; from Kakadbhit), fig. 9 (G.S.I. no. 4699; from Vemavaram), fig. 10 (B.S.I.P. no. 33772; from Kakadbhit). All × 1.

PLATE 2

11-12. *Ptilophyllum varinervis* (Feistmantel) n. comb.— fig. 11 (holotype, G.S.I. no. 4682; from Vemavaram), fig. 12 G.S.I. no. 4683; from Vemavaram). × 1.

13. *P. varinervis* (Feistmantel) n. comb.— fig. 12 magnified. × 3.

14-17. *Ptilophyllum cutchense* Morris — fig. 14 (G.S.I. no. 4804; from Kakadbhit), fig. 15 (G.S.I. no. 4411; from Soorujbera), fig. 16 (B.S.I.P. no. 33847; from Soorujbera), fig. 17 (G.S.I. no. 4691; from Vemavaram). All × 1.

18. *Ptilophyllum tenerrimum* Feistmantel-lectotype, G.S.I. no. 4519; from Onthea). × 1.

PLATE 3

19-20. *Ptilophyllum oldhamii* Jacob & Jacob — fig. 19 (B.S.I.P. no. 32415; from Trambau), fig. 20 (neotype, B.S.I.P. no. 33767; from Trambau). × 1.

21-23. *Ptilophyllum indicum* Jacob & Jacob — fig. 21 (B.S.I.P. no. 31884; from Trambau), fig. 22 (B.S.I.P. no. 33771; from Trambau), fig. 23 (neotype, B.S.I.P. no. 33770; from Trambau). × 1.

24. *P. oldhamii* Jacob & Jacob, a few pinnae enlarged, B.S.I.P. no. 33767. × 10.

25. *P. indicum* Jacob & Jacob, a few pinnae enlarged, B.S.I.P. no. 33770. × 10.

26. *P. oldhamii* Jacob & Jacob, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 32415-2. × 40.

27. *P. oldhamii* Jacob & Jacob, lower cuticle. B.S.I.P. slide no. 32415-1. × 150.

28. *P. indicum* Jacob & Jacob, lower cuticle showing distribution of stomata. B.S.I.P. slide no. 33768. × 40.

29. *P. oldhamii* Jacob & Jacob, showing a few stomata. B.S.I.P. slide no. 33737-1. × 500.

PLATE 4

30-35. *Ptilophyllum horridum* Roy — fig. 30 (holotype, B.S.I.P. no. 31889), fig. 31 (B.S.I.P. no. 31937), fig. 32 (B.S.I.P. no. 33873), fig. 33 (B.S.I.P. no. 33874), fig. 34 (B.S.I.P. no. 31911) and fig. 35 (B.S.I.P. no. 33875). All the specimens from Trambau. × 1.

36-38. *P. horridum* Roy, a few pinnae enlarged showing pinnae apices and venation (fig. 37), fig. 36 (B.S.I.P. no. 31911), fig. 37 (B.S.I.P. no. 33761) and fig. 38 (B.S.I.P. no. 31937). × 5.

39. *Ptilophyllum indicum* Jacob & Jacob, showing lower cuticle. B.S.I.P. slide no. 33768. × 150.

40. *P. indicum* Jacob & Jacob, showing a stoma. B.S.I.P. slide no 33768. × 500.

PLATE 5

41-42. *Ptilophyllum sakrigaliensis* Sah — fig. 41 (B.S.I.P. no. 31872; from Khara river) and fig. 42 (lectotype, B.S.I.P. no. 4923; from Sakrigalighat). × 1.

43-46. *Ptilophyllum distans* (Feistmantel) Jacob & Jacob — fig. 43 (G.S.I. no. 4899), fig. 44 (G.S.I. no. 4900), fig. 45 (G.S.I. no. 4896) and fig. 46 (G.S.I. no. 4902). All the specimens from Sehora. × 1.

47-48. *Ptilophyllum horridum* Roy, lower cuticle showing stomatal and non-stomatal bands; fig. 47 (B.S.I.P. slide no. 31940-1), × 40; fig. 48 (B.S.I.P. slide no. 33762). × 150.

49. *P. horridum* Roy, showing a few stomata. B.S.I.P. slide no. 33762. × 500.

50. *P. sakrigaliensis* Sah, lower cuticle showing stomatal and non-stomatal bands. B.S.I.P. slide no. 31872-4. × 40.

PLATE 6

51. *Ptilophyllum distans* (Feistmantel) Jacob & Jacob. Holotype, G.S.I. no. 4905; from Sehora. × 1.

52-54. *P. distans* (Feistmantel) Jacob & Jacob, a few pinnae enlarged showing pinnae apices and venation. fig. 52 (G.S.I. no. 4900), × 4; fig. 53 (B.S.I.P. no. 28802), × 5; fig. 54 (G.S.I. no. 4896). × 3.

55. *P. distans* (Feistmantel) Jacob & Jacob, lower cuticle showing stomatal and non-stomatal bands. B.S.I.P. slide no. 28864B-1. × 40.

56. *Ptilophyllum sakrigaliensis* Sah, lower cuticle showing stomata and papillae. B.S.I.P. slide no. 31872-4. × 150.

57. *P. sakrigaliensis* Sah, showing two stomata. B.S.I.P. slide no. 31872-1. × 500.

Plate 7

58. *Ptilophyllum jabalpurense* Jacob & Jacob — lectotype, G.S.I. no. 4892; from Sehora. × 1.

59-60. *Ptilophyllum institacallum* Bose, a few pinnae enlarged showing pinnae apices and venation. Fig. 59 (B.S.I.P. no. 28804) and fig. 60 (B.S.I.P. no. 28827B). × 5.

61. *P. jabalpurense* Jacob & Jacob, a few pinnae enlarged showing the apices. B.S.I.P. no. 33881. × 5.

62. *P. institacallum* Bose, showing stomata distributed irregularly over entire surface. B.S.I.P. slide no. 28871B. × 4.

63. *P. institacallum* Bose, showing stomatal and non-stomatal bands. B.S.I.P. slide no. 28897. × 40.

64. *P. institacallum* Bose, lower cuticle showing stomata and papillae. B.S.I.P. slide no. 28897. × 150.

65. *P. institacallum* Bose, showing a stoma. B.S.I.P. slide no. 28804. × 500.

Plate 8

66-67. *Ptilophyllum distans* (Feistmantel) Jacob & Jacob — fig. 66 (B.S.I.P. no. 31918; from Trambau) and fig. 67 (B.S.I.P. no. 31930; from Trambau). × 1.

68-73. *Ptilophyllum institacallum* Bose — fig. 68 (B.S.I.P. no. 28859), fig. 69 (B.S.I.P. no. 28802 D), fig. 70 (G.S.I. no. 4904), fig. 71 (G.S.I. no. 4901), fig. 72 (G.S.I. no. 4903) and 73 (holotype, B.S.I.P. no. 28832). All the specimens from Sehora. × 1.

74. *P. distans* (Feistmantel) Jacob & Jacob, lower cuticle showing distribution of stomata in one of the specimens collected from Trambau. (B.S.I.P. slide no. 31918). × 40.

75. *P. distans* (Feistmantel) Jacob & Jacob, lower cuticle showing stomatal and non-stomatal bands (from a specimen from Sehora). B.S.I.P. slide no. 28864B-2. × 150.

76-77. *P. distans* (Feistmantel) Jacob & Jacob, showing stomata; fig. 76 (showing non-papillate subsidiary cells; B.S.I.P. slide no. 4905; from Sehora) and fig. 77 (showing papillate subsidiary cell; B.S.I.P. slide no. 31918; from Trambau). × 500.

Plate 9

78-81. *Ptilophyllum jabalpurense* Jacob & Jacob — fig. 78 (B.S.I.P. no. 33881), fig. 79 (B.S.I.P. no. 28868), fig. 80 (G.S.I. no. 4893) and fig. 81 (G.S.I. no. 4889). All the specimens from Sehora. × 1.

82. *P. jabalpurense* Jacob & Jacob, lower cuticle showing distribution of stomata. B.S.I.P. slide no. 28952. × 40.

83. *P. jabalpurense* Jacob & Jacob, showing stomatal and non-stomatal bands. B.S.I.P. slide no. 28868A. × 150.

84. *P. jabalpurense* Jacob & Jacob, showing two stomata. B.S.I.P. slide no. 28868. × 500.

Plate 10

85-89. *Ptilophyllum amarjolense* Bose — fig. 85 (lectotype, B.S.I.P. no. 33899), fig. 86 (B.S.I.P. no. 24026), fig. 87 (B.S.I.P. no. 33889), fig. 88 (B.S.I.P. no. 33896) and fig. 89 (B.S.I.P. no. 24068). All the specimens from Amarjola. × 1.

90. *Ptilophyllum sahnii* Gupta & Sharma, lower surface showing a few cells (P) which give a false impression of papillae. B.S.I.P. slide no. 38/646-2. × 250.

91. *P. amarjolense* Bose, radial longitudinal section of rachis showing scalariform thickening. B.S.I.P. slide no. 33887-3. × 400.

92. *P. amarjolense* Bose, transverse section of rachis showing the vascular bundles. B.S.I.P. slide no. 33887-1. × 28.

93. *P. amarjolense* Bose, a few vascular bundles magnified from the above slide. × 100.

Plate 11

94-99. *Ptilophyllum sahnii* Gupta & Sharma — fig. 94 (B.S.I.P. no. 33892), fig. 95 (B.S.I.P. no. 24057), fig. 96 (B.S.I.P. no. 33891), fig. 97 (B.S.I.P. no. 3746), fig. 98 (B.S.I.P. no. 33898) and fig. 99 (B.S.I.P. no. 33897). All the specimens are from Amarjola. × 1.

100-101. *P. sahnii* Gupta & Sharma, a few pinnae enlarged showing venation. Fig. 100 (B.S.I.P. no. 33894) and fig. 101 (B.S.I.P. no. 33890). × 5.

102. *P. sahnii* Gupta & Sharma, transverse section of a pinna showing the vascular bundles (v). B.S.I.P. slide no. 3639. × 20.

103. *P. sahnii* Gupta & Sharma, transverse section of rachis. B.S.I.P. slide no. 33885-1. × 28.

104. A few vascular bundles enlarged from the above slide. × 100.

105. *P. sahnii* Gupta & Sharma, radial longitudinal section of rachis showing scalariform thickening. B.S.I.P. slide no. 33895 × 400.

Plate 12

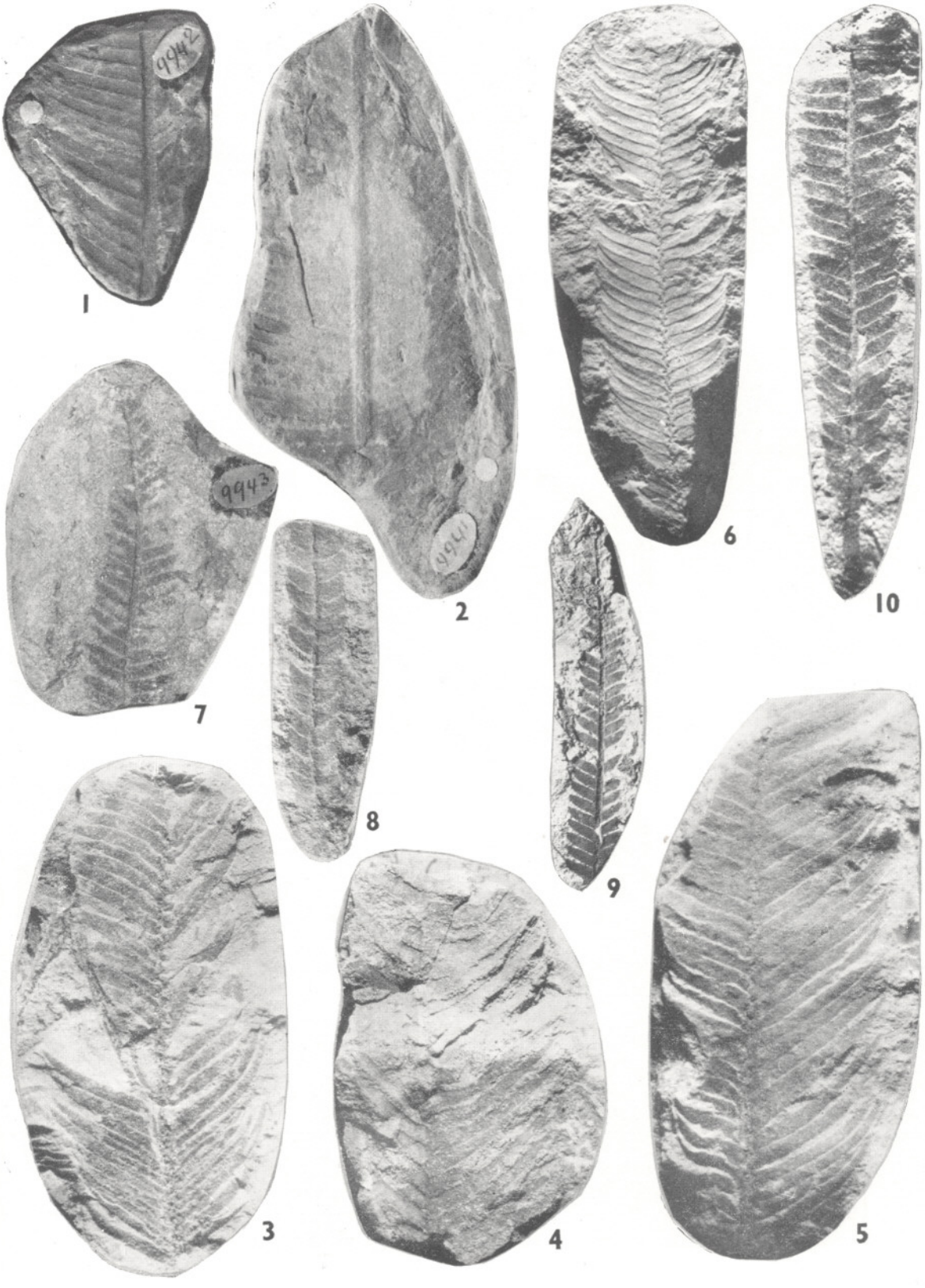
106. *Ptilophyllum sahnii* Gupta & Sharma, lower surface showing stomatal and non-stomatal bands. B.S.I.P. slide no. 33895. × 150.

107. *P. sahnii* Gupta & Sharma, showing a few stomata. B.S.I.P. slide no. 33898. × 500.

108. *Ptilophyllum amarjolense* Bose, a pinna enlarged showing venation. B.S.I.P. no. 3741. × 5.

109. *P. amarjolense* Bose, lower surface showing stomatal and non-stomatal bands. B.S.I.P. slide no. 28069. × 150.

110. *P. amarjolense* Bose, showing a few stomata. B.S.I.P. slide no. 33888-1. × 500.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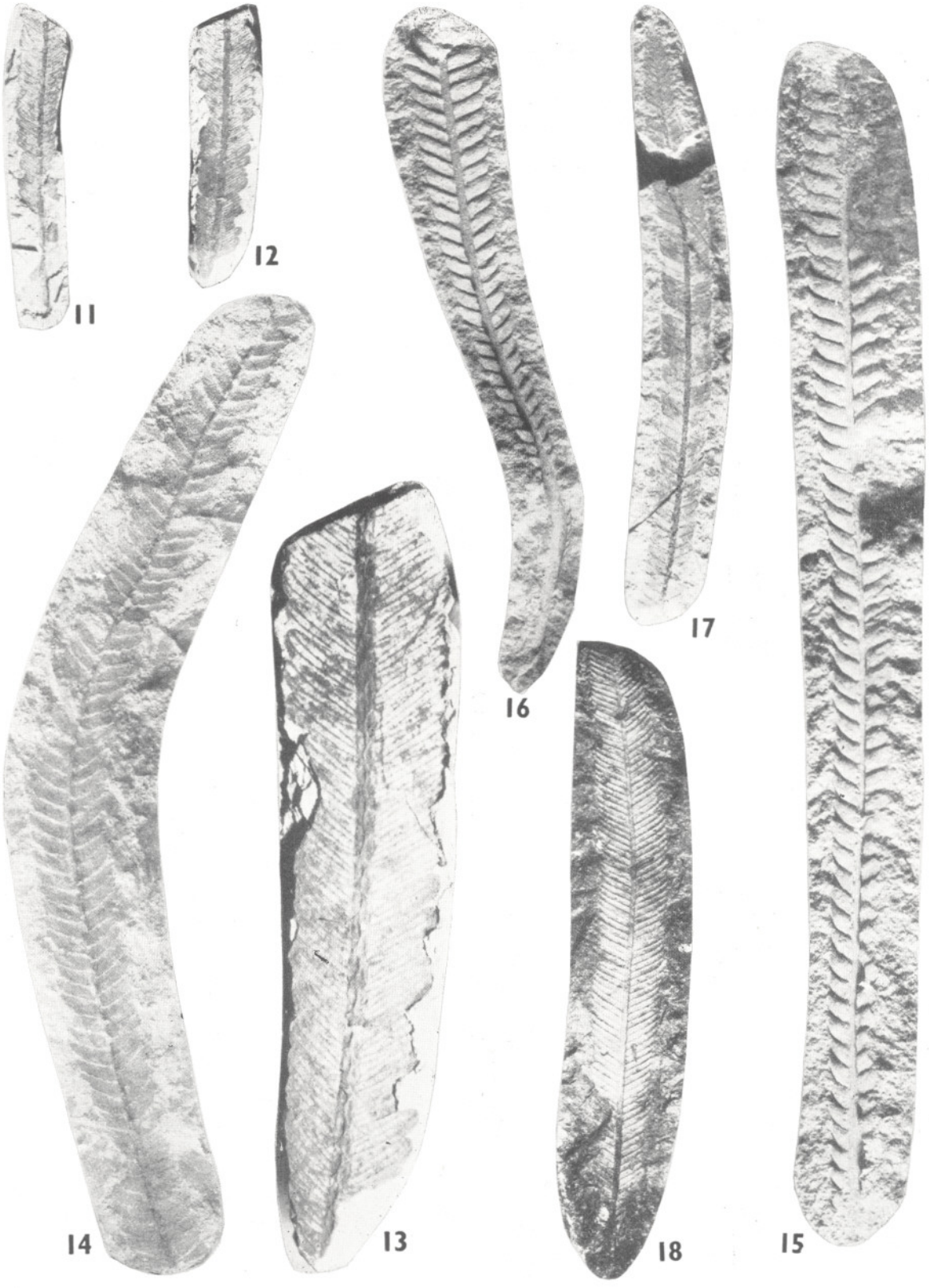
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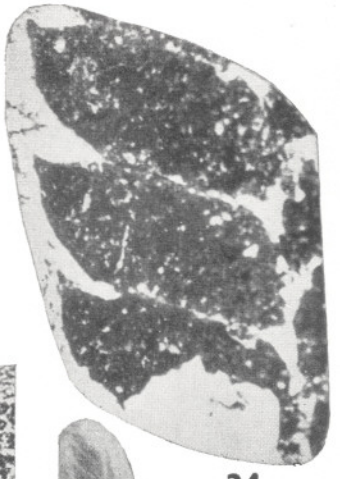

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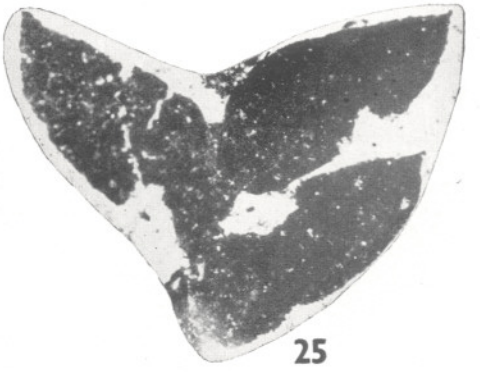

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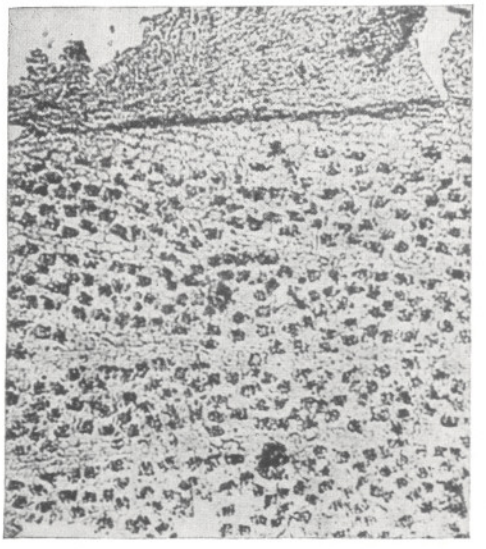

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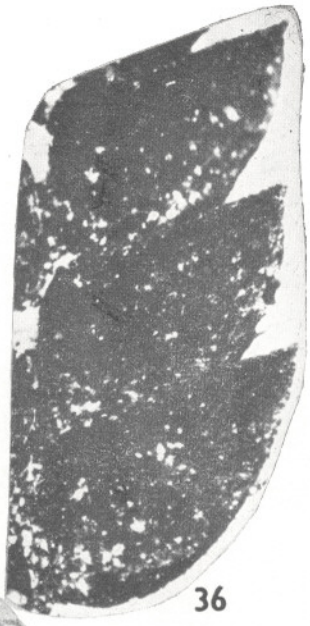

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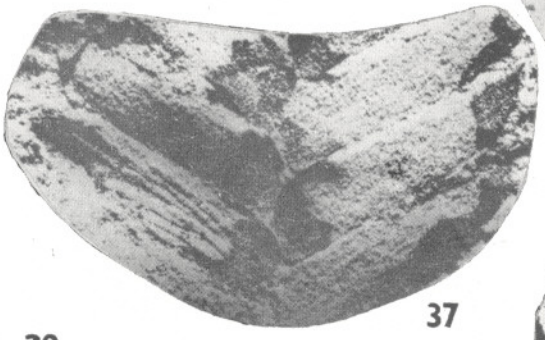

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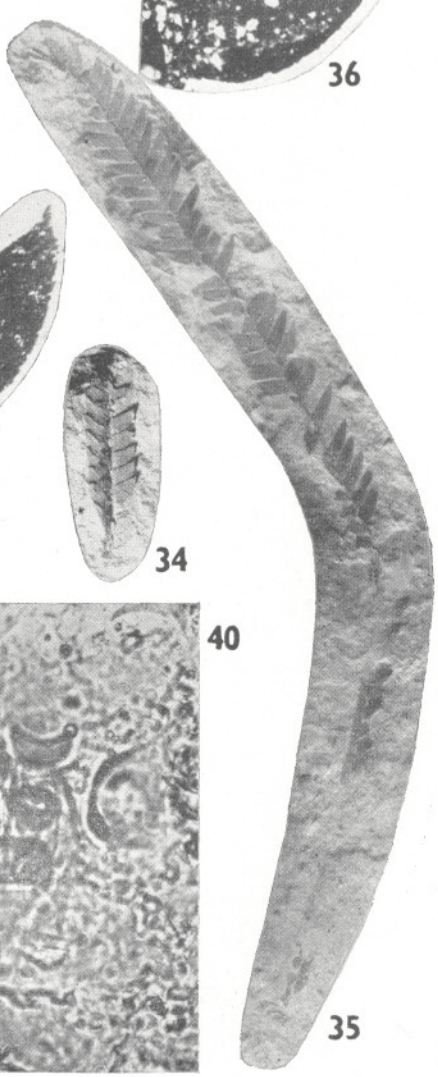

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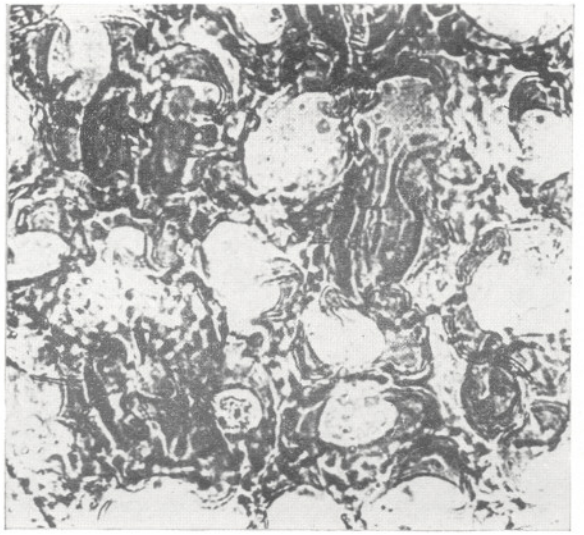

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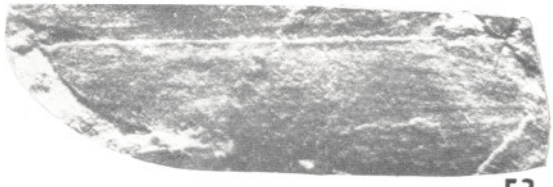

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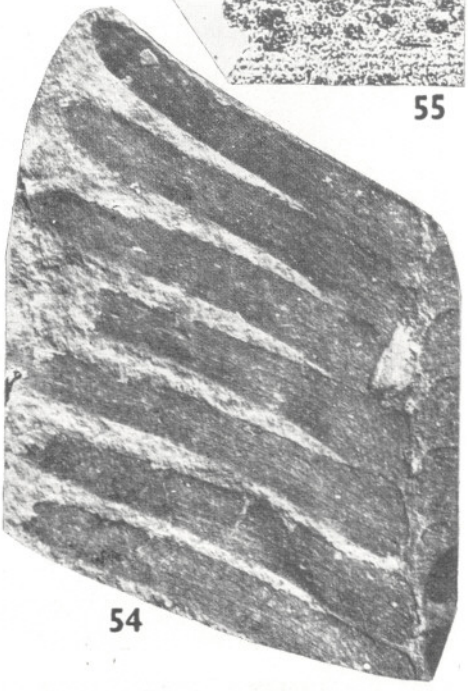

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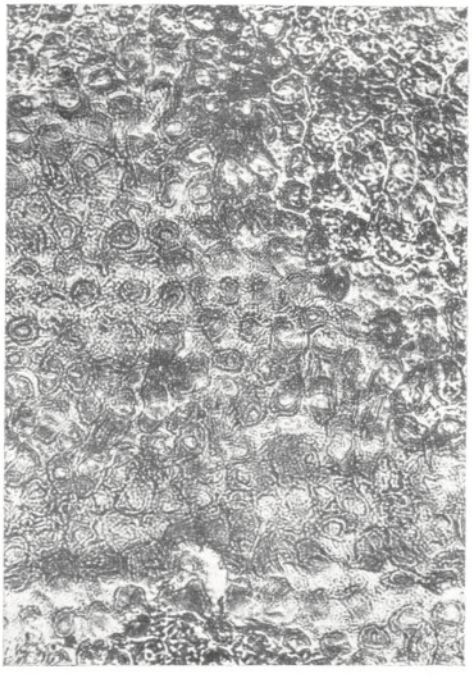

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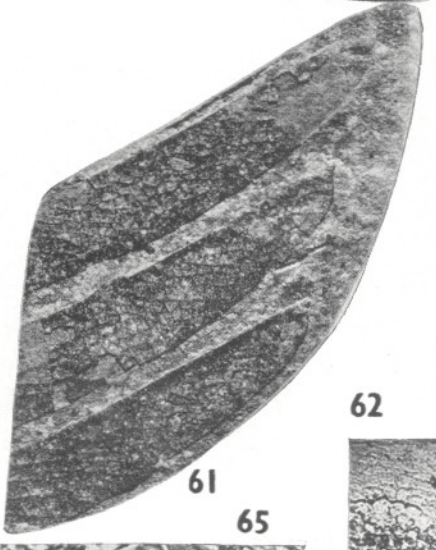
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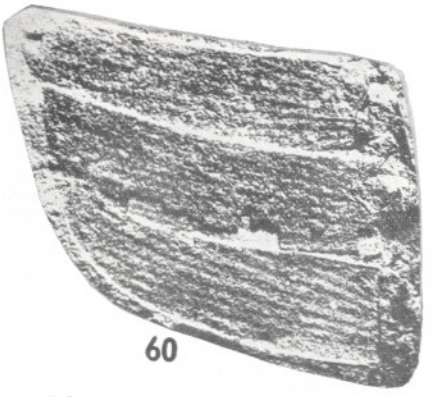
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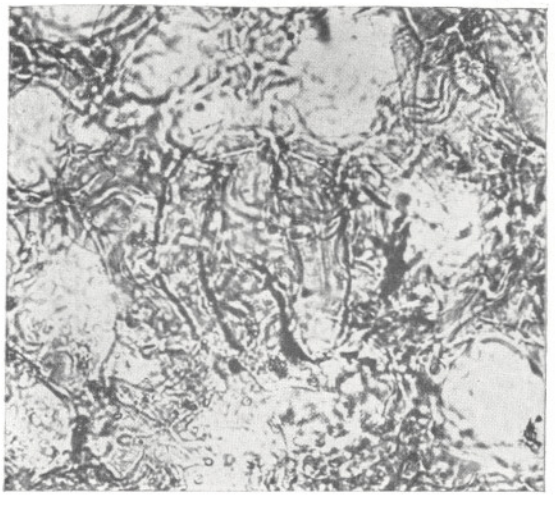


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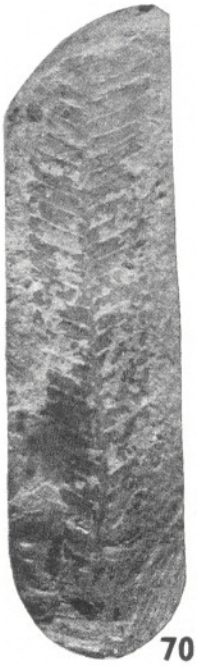
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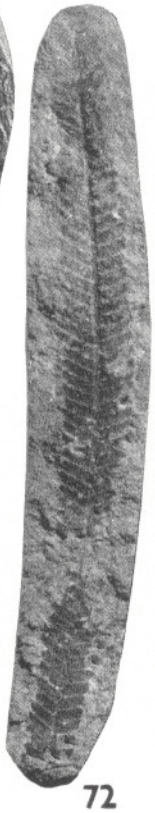
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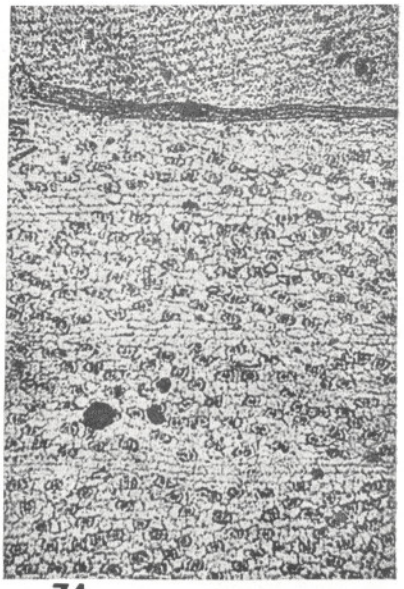
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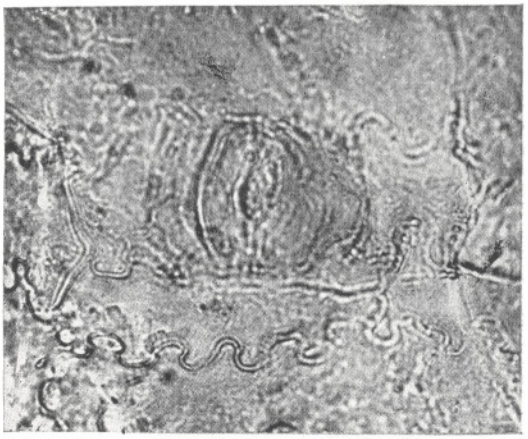
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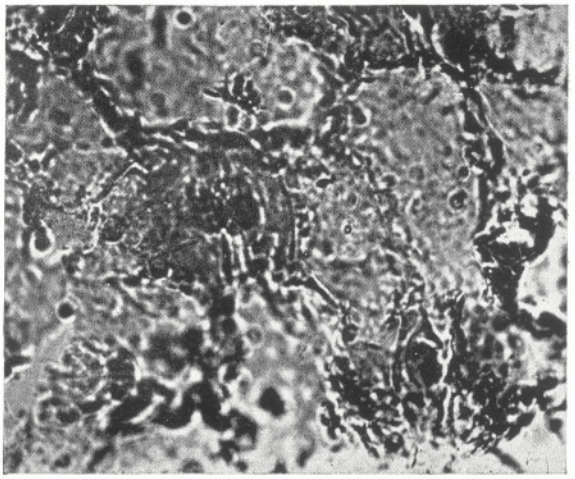
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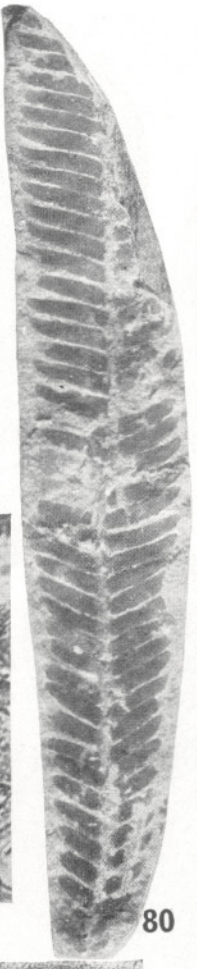

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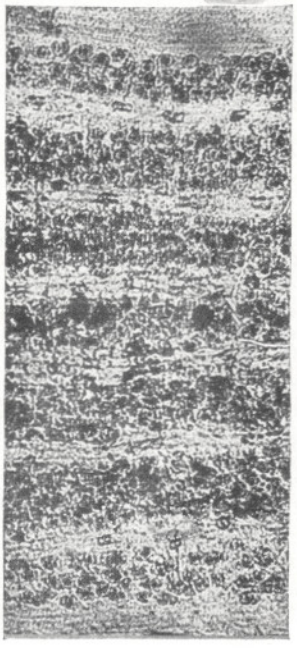

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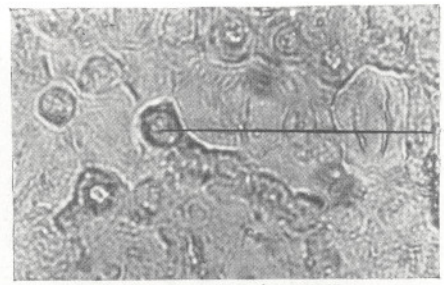

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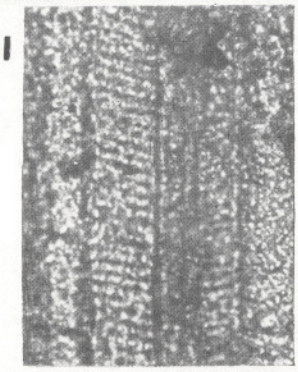

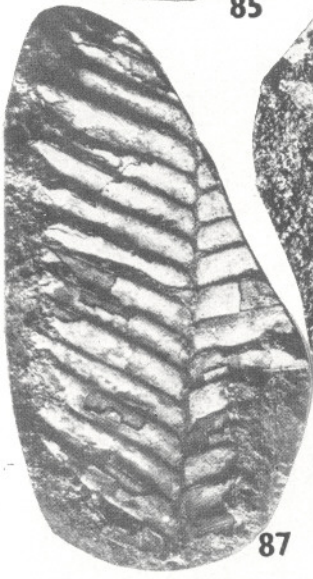

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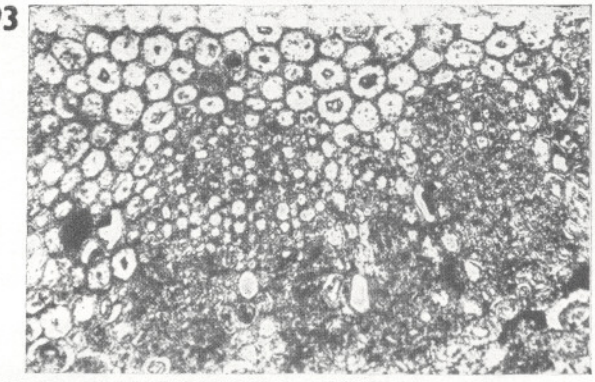

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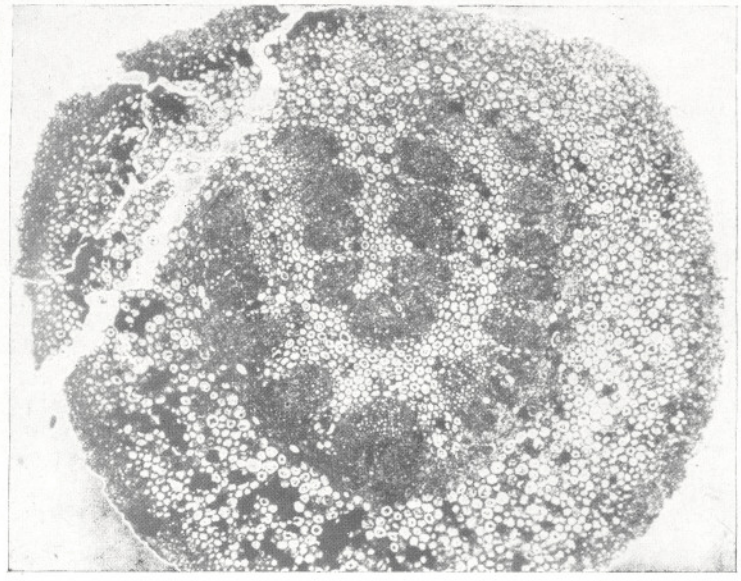

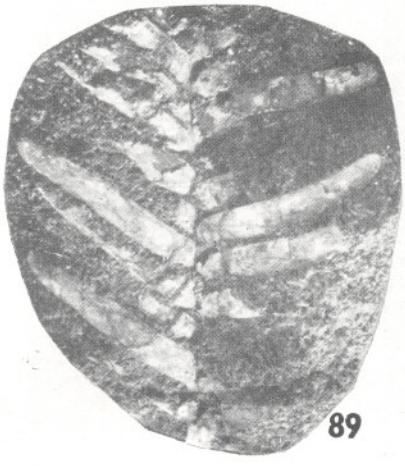

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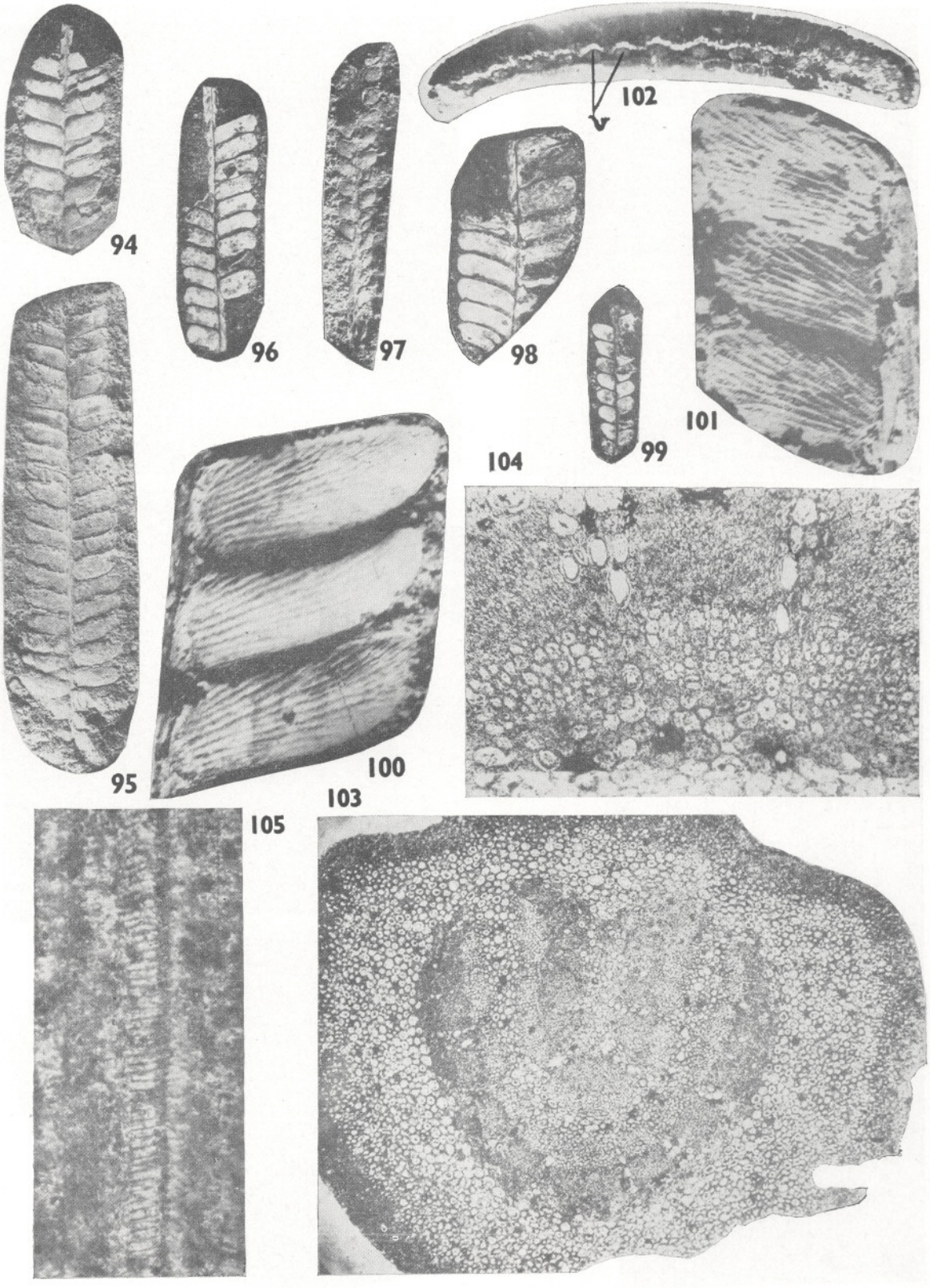
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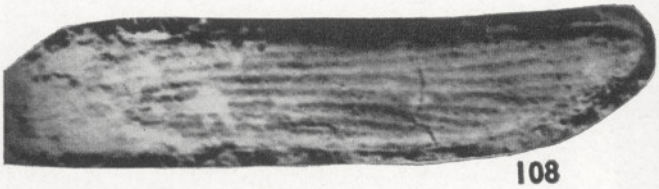

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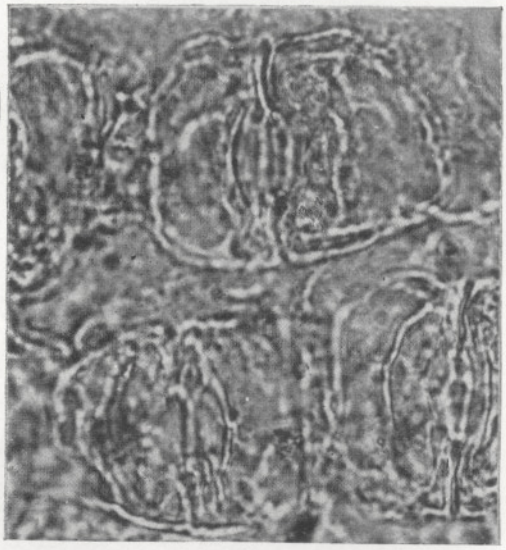

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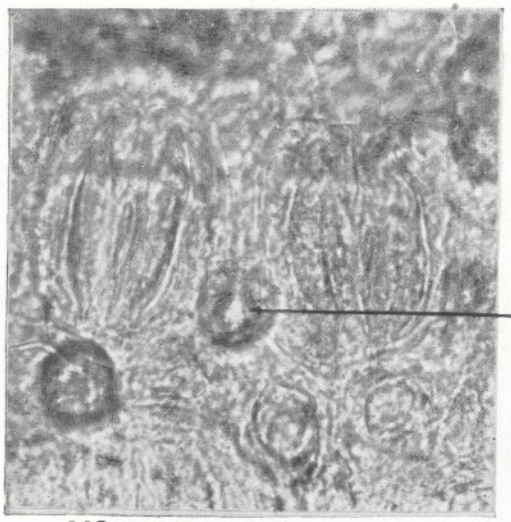

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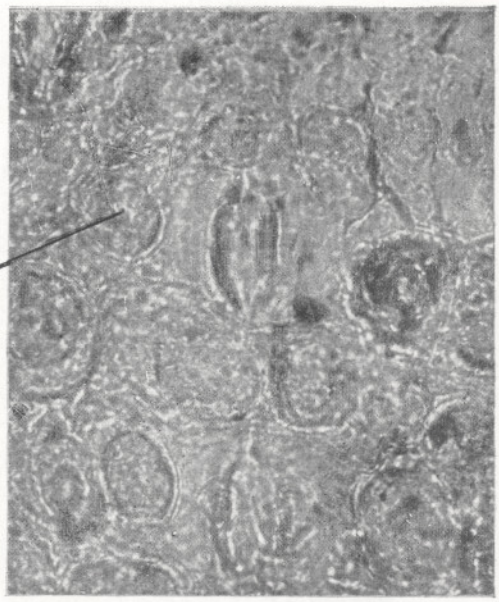

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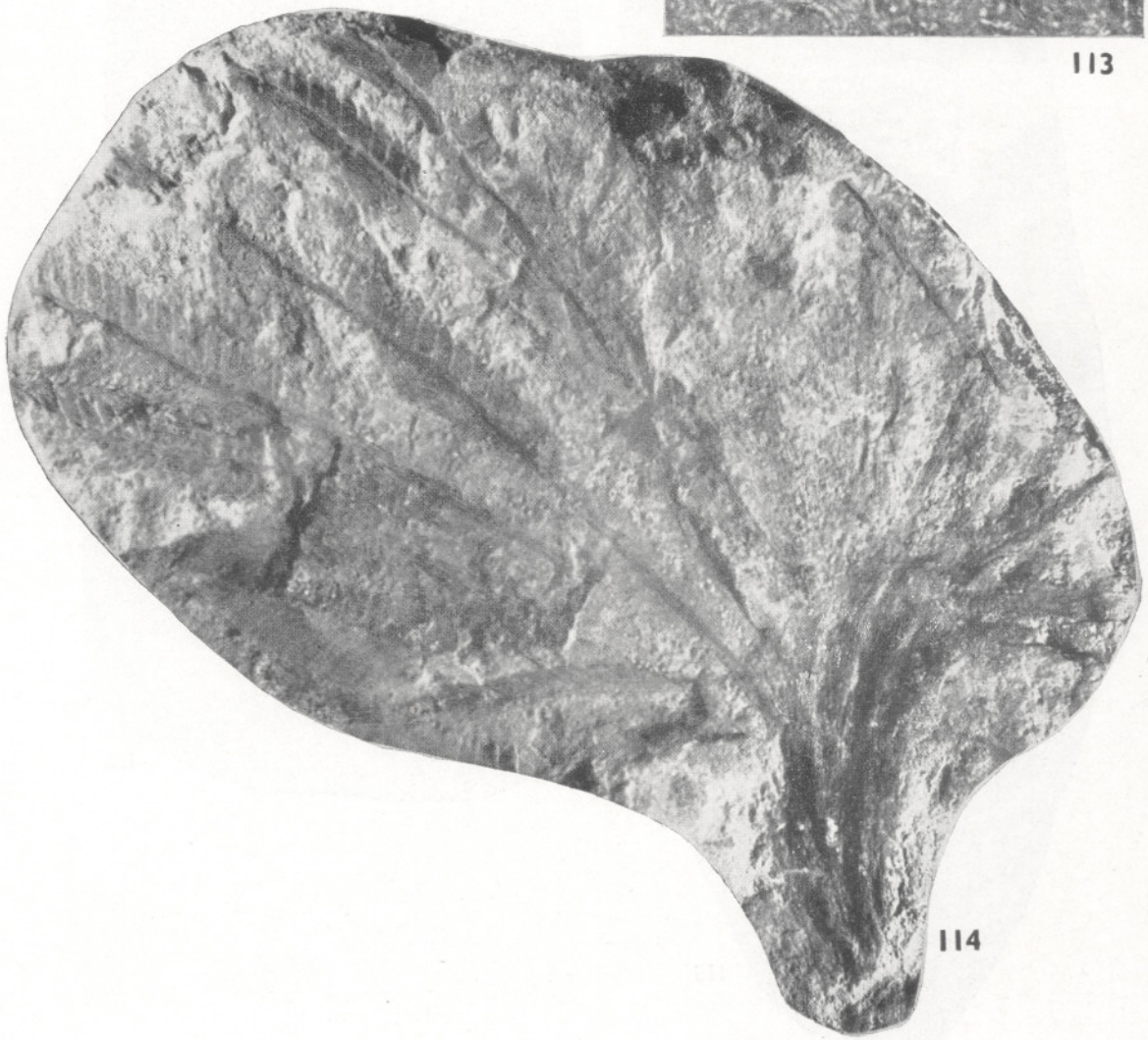

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111. *P. amarjolense* Bose, transverse section of petiole showing arrangement of vascular bundles. B.S.I.P. slide no. 3636. × 15.

PLATE 13

112. *Ptilophyllum sahnii* Gupta & Sharma, showing stomata and a few cells (P) which give a false impression of papillae. B.S.I.P. slide no. 38/646-1. × 500.

113. *Ptilophyllum amarjolense* Bose, showing a few cells (P) which give a false impression of papillae. B.S.I.P. slide no. 33899. × 500.

114. *Ptilophyllum cutchense* Morris, showing a few leaves attached to a *Bucklandia* type of stem. B.S.I.P. no. 34094; from Kurbi. × 1.

PLATE 14

115. *Ptilophyllum acutifolium* Morris, the largest specimen so far collected from India. B.S.I.P. no. F465; from the Rajmahal hills. × 1/2.

116. *P. acutifolium* Morris, showing an apical crown of leaves. B.S.I.P. no. 34095; from Sakrigalighat. × 1/2.