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CYCADOPHYTIC LEAVES FROM JURASSIC-LOWER CRETACEOUS ROCKS OF INDIA

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ABSTRACT

Under Cycadophytic leaves, various Indian species of *Taeniopteris* Brongniart, *Morrisia* Bose, *Cycadites* Brongniart, *Anomozamites* Schimper and *Pterophyllum* Brongniart have been described here. The study is based on specimens described or figured since 1850 and a large number of specimens collected during the last two decades from the Jurassic-Lower Cretaceous rocks of India.

It has been observed that the genera mentioned above are most abundant in some of the localities of the Rajmahal Hills. They are completely missing in most of the undoubted Lower Cretaceous beds of India. So far only a single species, viz., *Pterophyllum princeps* Oldham & Morris is known from the Lower Cretaceous beds of Than, Gujarat.

Key-words — Cycadophytic leaves, Megafossils, Rajmahal Hills, Jurassic-Lower Cretaceous (India).

सारांश

भारत की जुरेसिक-अधर क्रीटेश्यस कालीन चट्टानों से साइकेडोफ़िटी पत्तियाँ – महेन्द्र नाथ बोस एवं जयश्री बैनर्जी

साइकेडोफ़िटी पत्तियों के अन्तर्गत् टीनिऑप्टेरिस ब्रोन्गनिया, मौरिसिया बोस, साइकेडाइटिस ब्रोन्गनिया, ऐनॉमोज़माइटिस शिम्पर एवं टेॅरोफ़िलम् ब्रोन्गनिया की विभिन्न भारतीय जातियाँ वर्णित की गई हैं। यह अध्ययन सन् 1850 तक वर्णित अथवा आलेखित प्रादर्शों तथा भारत की जुरेसिक-अधर क्रीटेश्यस कालीन चट्टानों से पिछले दो दशकों में बहुत संख्या में एकत्रित प्रादर्शों पर आधारित है।

यह प्रेक्षित किया गया है कि उपरोक्त प्रजातियाँ राजमहल पहाड़ियों के कुछ स्थानों में बहुतायत में पाई जाती हैं। भारत की अधिकतर असंदिग्ध क्रीटेश्यस कालीन संस्तरों में ये पूर्णतया अनुपस्थित हैं। गुजरात में थान की अधर क्रीटेश्यस कालीन संस्तरों से अभी तक केवल एक जाति टेॅरोफ़िलम् प्रिंसेप्स ओल्डहम एवं मौरिस ज्ञात है।

INTRODUCTION

IN the Mesozoic rocks of India there are a large number of fossil fronds, belonging to Cycadales and Bennettitales, whose exact affinities are not known due to lack of cuticle. Such specimens are described here under the genera *Taeniopteris*, *Morrisia*, *Cycadites*, *Anomozamites* and *Pterophyllum*.

Taeniopteris Brongniart, 1832 — Simple, spatulate or strap-shaped leaves with prominent midrib and simple or forked secondary veins have been described under this genus. Some of the species of *Taeniopteris* now described were earlier described by Feistmantel (1877a) and others under *Macrotaeniopteris* Schimper (1869). The generic name *Macrotaeniopteris* has been discarded here because it was founded only on the basis of size difference. The various species of *Taeniopteris* here described, may belong either to Cycadales, Pentoxyleae or Bennettitales.

Morrisia Bose, 1958 — Under this genus unipinnate leaves with pinnae resembling some of the species of *Taeniopteris* have been described. Three species with doubtful affinities have been recorded.

Cycadites Sternberg, 1825 — Only one species, viz., *Cycadites rajmahalensis* Oldham

has been described. Specimens described under this genus also resemble some of the species of *Pseudocycas* Nathorst and *Paracycas* Harris, but in the absence of cuticle they have been placed under the form genus *Cycadites*.

Anomozamites Schimper, 1870 — Some of the species of *Anomozamites* are difficult to differentiate from *Pterophyllum*. Harris (1932b) tried to distinguish *Anomozamites* from *Pterophyllum* on the basis of cuticle. In 1969 he, however, dropped those distinguishing characters and gave more importance to external features for the identification of these two genera. Harris (1969) while dealing with *Anomozamites*, mentioned, "The sole distinction from *Pterophyllum* is in the shape of lamina segment which in *Pterophyllum* are typically much longer than broad. Thus when a specimen is not satisfactorily placed on this character, the difficulty is obvious". According to Harris (1969, p. 74), in *Anomozamites* the lamina is divided into segments which are typically as broad as long. In this volume Harris (1969, pp. 79, 84) described two species of *Anomozamites* (*A. nilssoni*, Phillips & *A. thomasi*, Harris). In both these species, most of the specimens figured have segments which are longer than broad. In *A. nilssoni* the majority of the leaves figured show segments twice as long as broad.

In the case of Indian specimens, under *Anomozamites*, we have included those specimens whose segments are either squarish in shape or up to twice as long as broad. The rest of the specimens whose pinnae or segments are linear in shape have been dumped under *Pterophyllum*.

Pterophyllum Brongniart, 1828 — Both *Pterophyllum* and *Pseudoctenis* Seward (1911) do not have a sound basis. They are now distinguished solely on the basis of cuticle. The original *Pterophyllum* was *P. minus* and *P. majus* from Lower Lias of Hör, Sweden (which were later placed in a "subgenus" *Anomozamites*). Then *P. longifolium* Brongniart of the Keuper was regarded as Type (see Andrews, 1970). Presumably all these are Bennettitalean but we do not know of the proof. Later, many species were added mostly we expect Bennettitalean but doubtless not all. Seward's *Pseudoctenis* (*P. eathiensis*) was vaguely separated on form and veins from *Ctenis* and *Zamites*, no cuticle was available. Only later was the cuticle idea added strongly. Thomas (1913) identified *Pseudoctenis lanei* and described its cycad-like stoma and Harris (1932a, 1964) described quite a few species, some not looking a bit like *P. eathiensis* but all with Cycad-like stomata. Most of these, in external features, are indistinguishable from *Pterophyllum*.

For the Indian specimens we are now using *Pterophyllum* as a form genus, practically in its old sense for leaves with no cuticle preserved. Amongst these some are doubtless *Pseudoctenis*.

DESCRIPTION

CYCADALES

Taeniopteris spatulata McClelland

Pl. 1, figs 1-3, 6; Pl. 5, figs 28, 29; Text-figs 1A-F, 9B

1850 *Taeniopteris spatulata* McClelland, p. 53, pl. 16, fig. 1.

1863 *Stangerites spatulata* McClelland sp.: Oldham & Morris, p. 34 (*partim*), pl. 6, figs 1, 2.

1869 *Angiopteridium spathulatum* (McClelland): Schimper, p. 606.

1876b *Taeniopteris* (*Angiopteridium*) *mcclellandi*: Feistmantel, p. 40.

1877a *Angiopteridium spathulatum* (McClelland) Schimp.: Feistmantel, p. 45.

1877b *Angiopteridium spathulatum* (McClelland) Schimp.: Feistmantel, p. 10, pl. 1, figs 6b, 7b.

1879 *Angiopteridium spathulatum* (McClelland) Schimp.: Feistmantel, p. 16, pl. 1, figs 8-10, 12-18; pl. 2, figs 3, 5, 6; pl. 15, fig. 11.

1881 *Angiopteridium spathulatum* (McClelland) Schimper: Feistmantel, p. 150, pl. 1, fig. 3.

1922 *Taeniopteris spatulata* McClelland; Seward & Holttum, p. 273, pl. 12, figs 1-10.

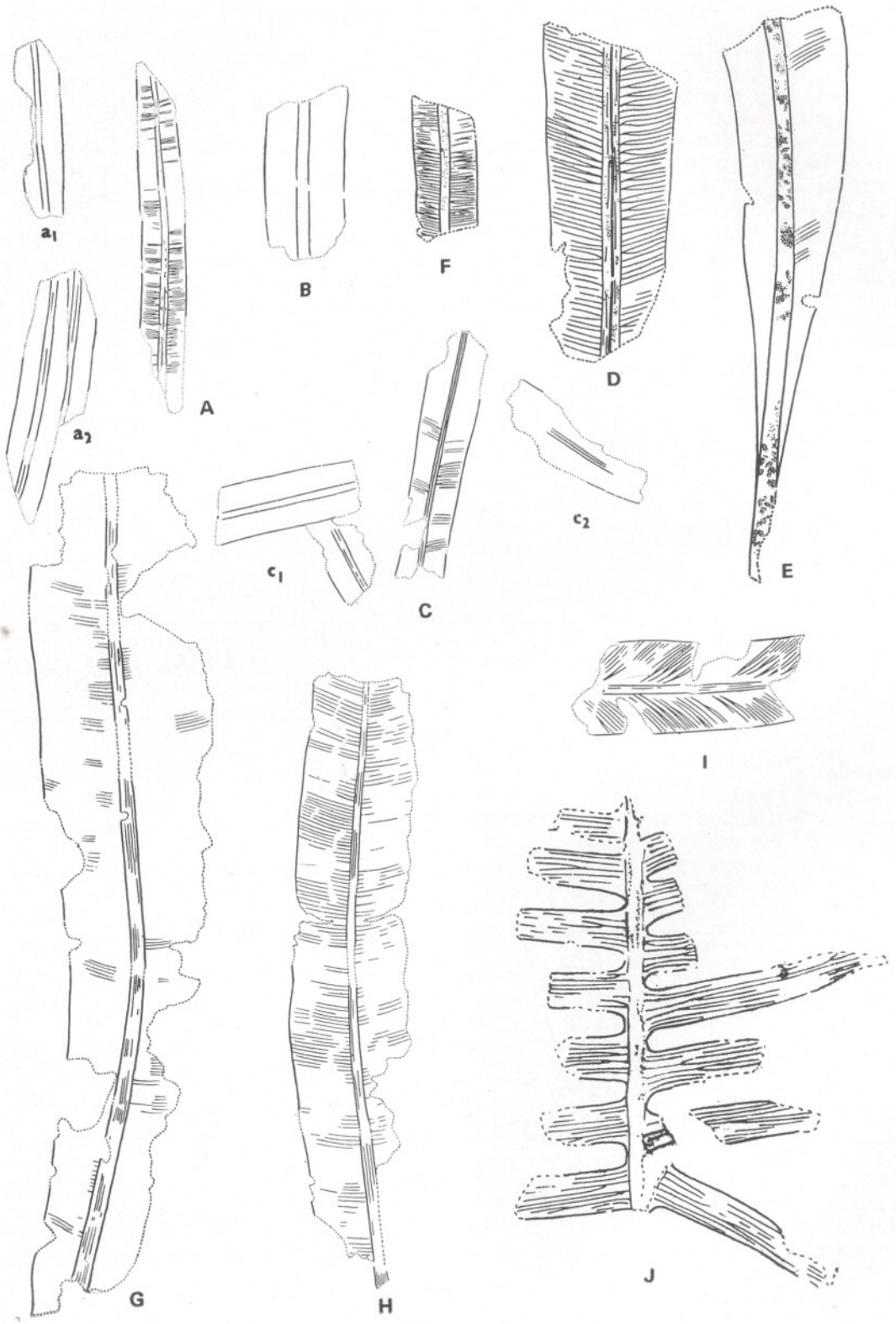
1933 *Taeniopteris spatulata* (McClelland): Sahni & Rao, p. 196.

1938a *Taeniopteris spatulata* (McClelland): Jacob, p. 152.

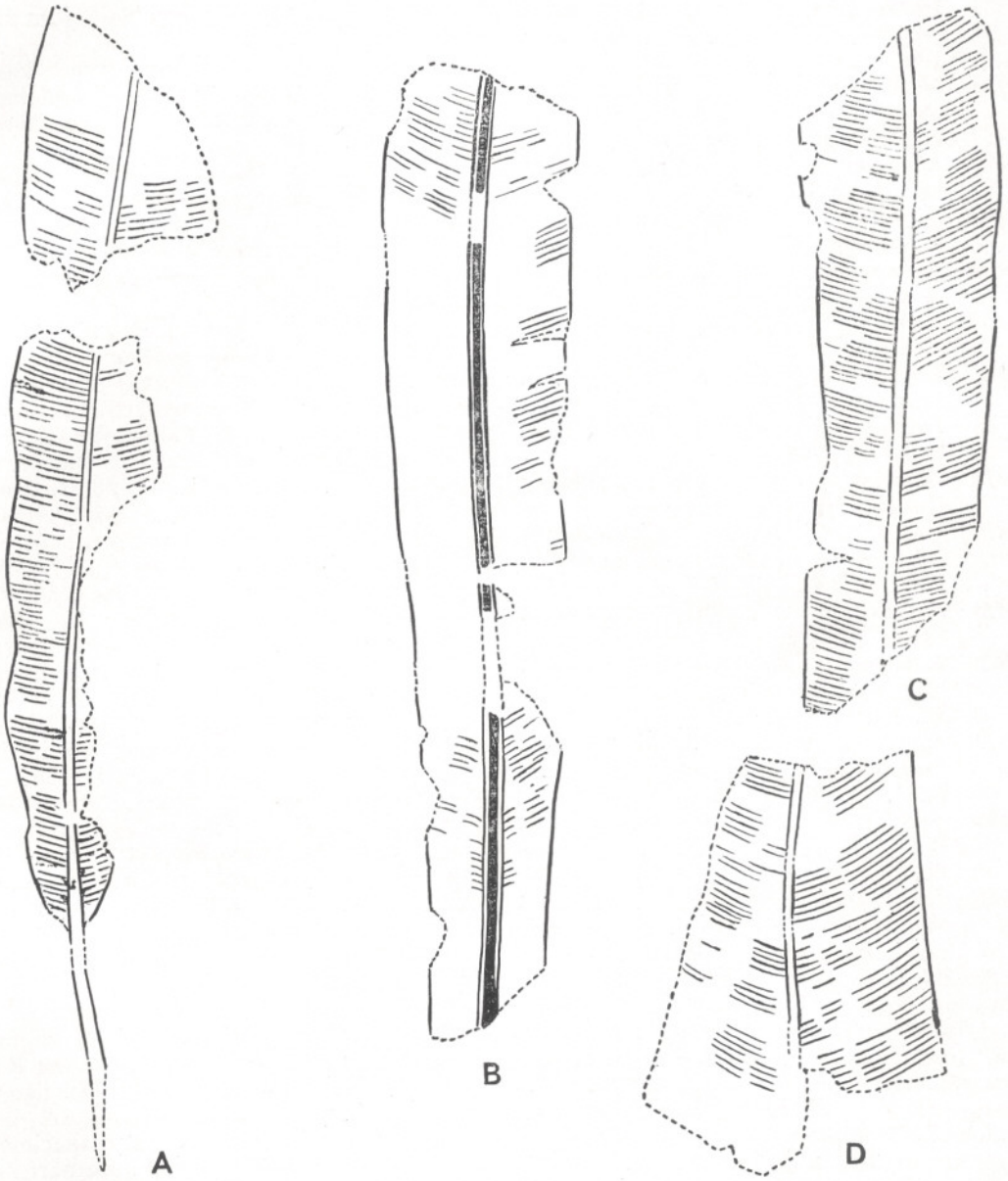
1938b *Taeniopteris spatulata* (McCl.): Jacob, p. 153.

1944 *Taeniopteris spatulata* McClelland: Sitholey, p. 10, figs 11-14.

1946 *Taeniopteris spatulata* (McClelland): Ganju, p. 68, pl. 1, fig. 3; pl. 4, fig. 26,



TEXT-FIG. 1



TEXT-FIG. 2 — **A-D,** *Taeniopteris kutchensis* n. sp. from Kakadbhit, G.S.I. nos. 4777 (holotype), 4778, 4780, 4785, × 1.

←

TEXT-FIG. 1 — **A, a_1, a_2,** *Taeniopteris spatulata* McClelland from near Murrero (all in same block), G.S.I. no. 4366, × 1. **B,** *T. spatulata* from Dharesi, B.S.I.P. no. 5/2004B, × 1. **C, c_1, c_2,** *T. spatulata* from near Murrero (all in same block); lectotype, G.S.I. no. 4367, × 1. **D,** *T. spatulata* from Vemavaram showing only a part of the specimen, G.S.I. no. 4605, × 1.5. **E,** *T. spatulata* from Parsapani, B.S.I.P. no. 66/1438. × 2.5. **F,** *T. spatulata* from near Burio, G.S.I. no. 19558, × 1. **G-H,** *T. haburensis* n. sp. from Habur, B.S.I.P. nos. 4/2011 and 13/2011 (holotype). **I,** ?*Morrisia rajmahalensis* (Feistmantel) comb. nov. from Murrero showing venation, G.S.I. no. 4/373, × 1. **J,** *Pterophyllum* sp., B.S.I.P. no. 16779, × 2.

1953 *Taeniopteris spatulata* McClelland: Gopal *et al.*, p. 486 (*partim*), figs 3-6.
1953 *Taeniopteris spatulata* var. a.: Gopal *et al.*, p. 486, figs 5, 6.
1959 *Taeniopteris* cf. *spatulata* McCl.: Adyalkar & Rao, p. 321, pl. 38, fig. 3.
1960 *Taeniopteris* cf. *spatulata*: Adyalkar & Rao, p. 278.
1960a *Taeniopteris spatulata*: Rao & Shah, p. 278.
1960b *Taeniopteris spatulata*: Rao & Shah, p. 279.
1967 *Taeniopteris spathulata*: Mahabale, p. 312.
1968 *Taeniopteris spatulata* McClelland: Baksi, p. 207, pl. 1, fig. 9.
1970 *Taeniopteris spatulata* (McClelland): Gururaja & Pant, p. 387.
1970 *Taeniopteris spatulata* var. *multinervis* Oldham & Morris: Gururaja & Pant, p. 387.
1973 *Taeniopteris spatulata* McClelland: Patra, p. 329, pl. 2, figs 12-14.
1976 *Taeniopteris spatulata* McClelland: Maheshwari & Singh, p. 119, pl. 2, fig. 13; text-fig. 5.
1979 *Taeniopteris spatulata* McClelland: Mahabale & Satyanarayana, p. 78, pl. 3, fig. 18; text-figs 31, 32.
1980 *Taeniopteris spatulata* McClelland: Bose *et al.*, pl. 1, fig. 4; text-fig. 4C.
1980 *Taeniopteris spatulata* McClelland: Sukh-Dev & Zeba-Bano, p. 206, pl. 2, fig. 11; text-fig. 1A, B.

Emended Diagnosis — Leaf simple, 5-9 cm long, 0·4-1·6 cm broad (broadest region slightly below distal end), mostly 0·5-0·8 cm, linear-spatulate, gradually narrowing towards base; apex obtuse, rarely rounded; margin entire. Midrib 1-2 mm wide, finely striated in longitudinal direction, sometimes with a median ridge or groove. Lateral veins arising at an angle of 60°-90°, simple or forked, parallel, mostly forking just after emergence, sometimes forking closer to margin, near apex forking less frequent, rarely after bifurcating two arms may rejoin to form a loop. Veins 18-40 per cm, mostly 20-30 per cm.

Lectotype — No. 4367 of the Geological Survey of India, Calcutta.

Occurrence:

East Coast — Ghantikhal near Athgarh, Narsimha meta (Raghavapuram mudstone), Vemavaram, Sriperumbudur, Naikulum and Sivaganga.

Rajmahal Hills — Murrero (type locality), Burio, Basgo Bedo, Bindaban, Maharajpur, Onthea, Amarjola and Jhenagaria.

Godavari & Satpura basins — Kota, Chikiala and Parsapani, District Hoshangabad.

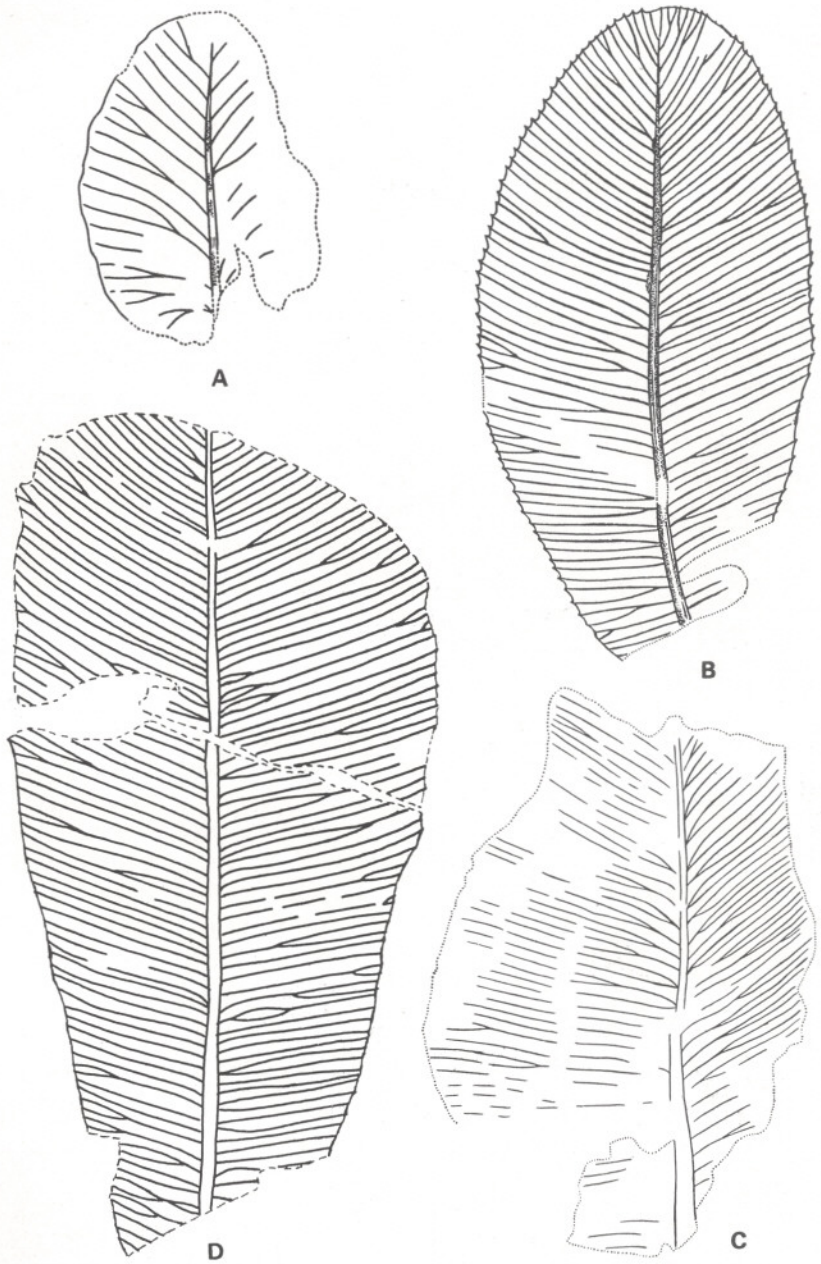
Kachchh — Kakadbhit and Dharesi.

Rajasthan — About 1 km east of Habur, district Jaisalmer.

Remarks — Sahni (1948, p. 51) had raised doubts concerning the accuracy of McClelland's (1850, pl. 16, fig. 1a) description and figure (1a) of *Taeniopteris spatulata*. In the Museum of the Geological Survey of India, Calcutta we found two specimens (figured here in Pl. 1, fig. 1 and Text-fig. 1A, C) with the labels — "McClelland, Collection". The one figured by him (1850, pl. 16, fig. 1a) has the number 4367. We have designated this specimen as the lectotype. The other is numbered as 4366. Both these specimens have been figured by Oldham and Morris (1863, pl. 6, figs 1—No. 4366 and 2—No. 4367). The description and the sketch (1a) of McClelland (1850) do not match with these specimens. The two specimens (G.S.I. nos. 4366 & 4367) here figured in Pl. 1, fig. 1 and Text-fig. 1A and C agree with the majority of the narrower specimens of *Nipaniophyllum raoi* Sahni (1948), in form, venation and texture. The only difference is that the specimens here figured as *Taeniopteris spatulata* are preserved in the form of compression and cast.

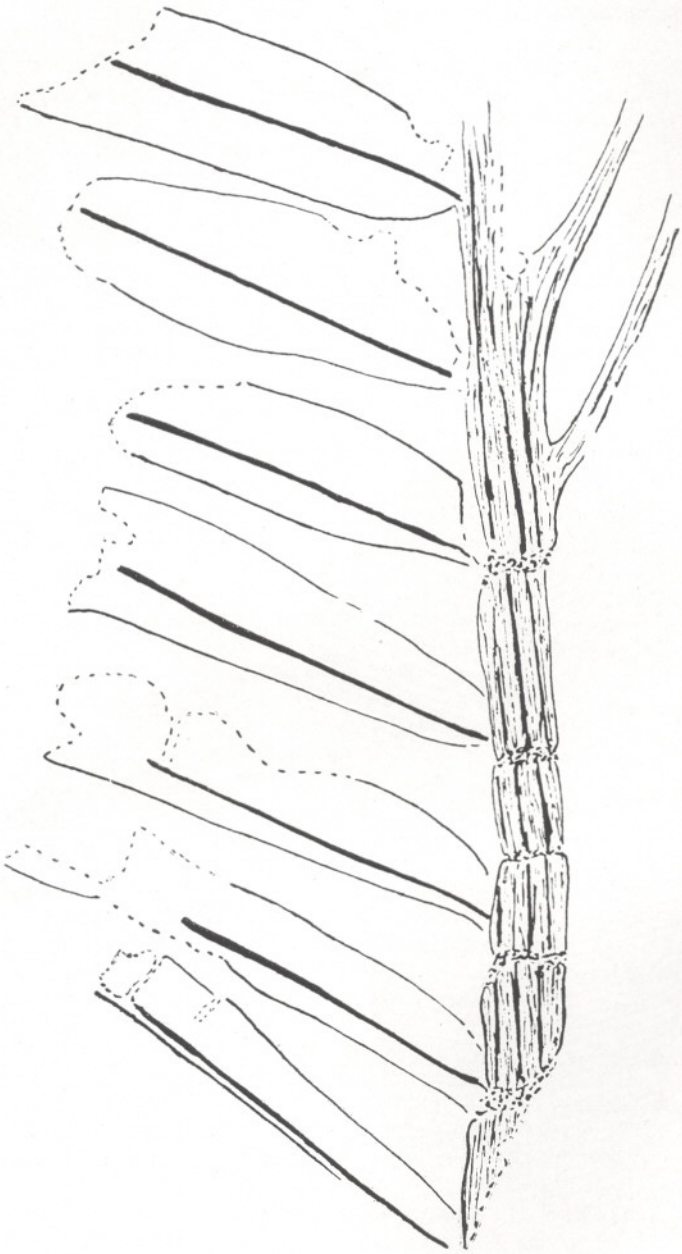
The majority of the specimens of *T. spatulata* from Vemavaram are slightly narrower than the specimens from the Rajmahal Hills. Feistmantel's (1879) figures in Pl. 1, figs 12 and 13 are part and counterpart. Similarly, the specimens figured in Pl. 1, figs 10 and 18 are part and counterpart. In one of the specimens from Vemavaram it has been seen that the lateral veins on one side of the midrib, at places, mostly forked just after emergence, whereas, on the other side forking was slightly away from the midrib.

Comparison — The narrower leaves of *Taeniopteris spatulata* described by Seward and Holttum (1922, pl. 12, figs 1-6a) and Sitholey (1944, pl. 3, figs 11, 12, 14) from Tabbowa, Sri Lanka match exactly the ones described by Feistmantel (1879, pl. 1,



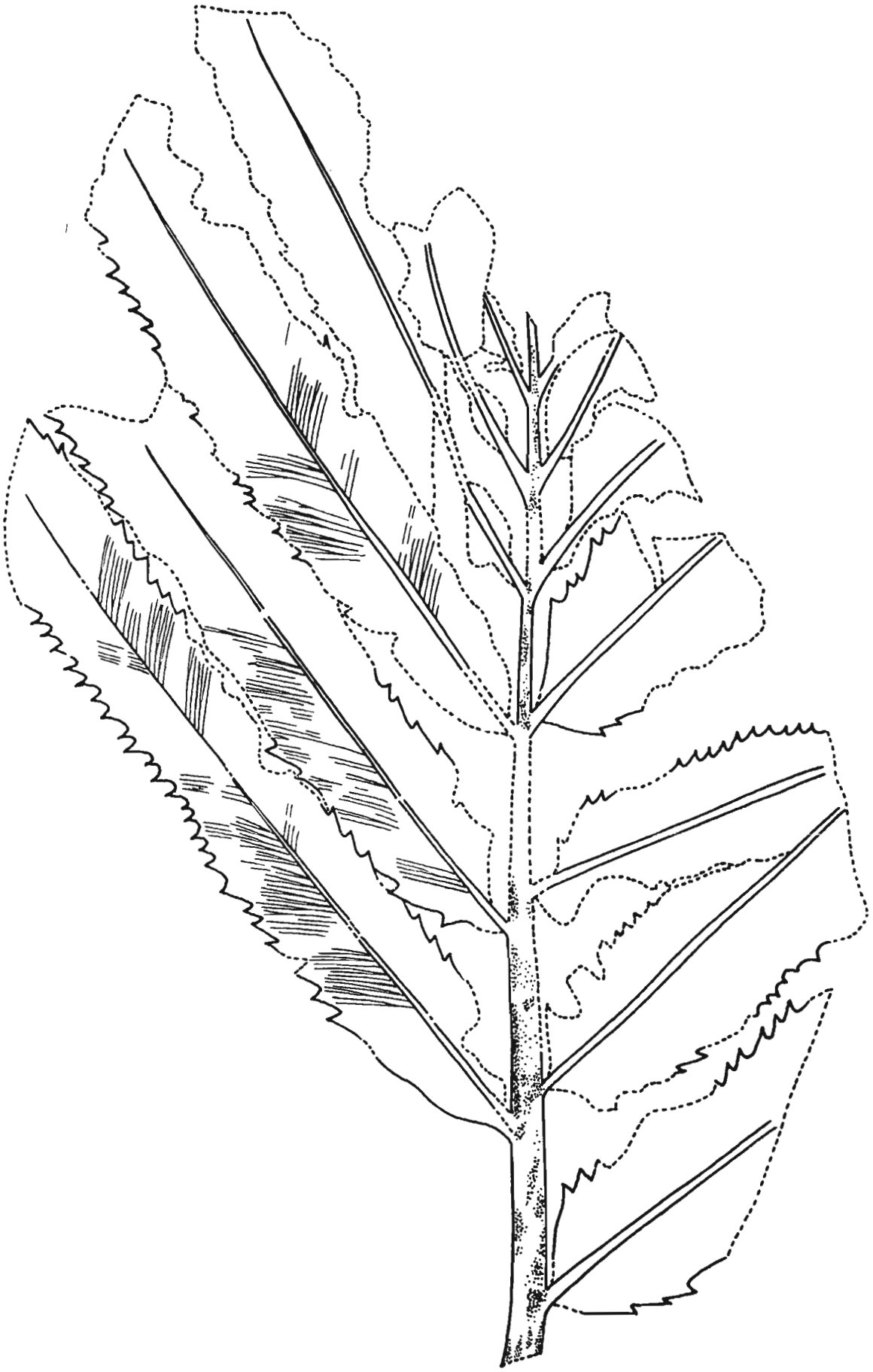
TEXT-FIG. 3 — **A,** a young leaf of *Taeniopteris oldhamii* n. sp. from Bindaban, B.S.I.P. no. 2573/277, × 2. **B, C,** *T. oldhamii* from Bindaban, B.S.I.P. nos. 5710 and 35366, × 1. **D,** *Taeniopteris buskoghatensis* n. sp. from Buskoghat, B.S.I.P. no. 7/710, × 1.

figs 8-10, 12-14) from Vemavaram. *T. spatulata* var. *daintreei* McCoy described by Chapman (1908) from Victoria, Australia resembles, both in shape and venation pattern, the narrower leaves of *T. spatulata* known from India (Feistmantel, 1879, pl. 1, figs 8, 9). In shape and size the leaves of *T. spatulata* figured by Glaessner and



TEXT-FIG. 4 — *Morrisia mcclellandii* (Oldham & Morris) Bose from Bindaban; holotype, G.S.I. no. 4438, × 1 (from Bose, 1958).

Rao (1955) from Mount Babbage, Australia resembles the Indian forms. The Australian leaves, however, differ in having secondary veins which are simple. *T. spatulata* of Du Toit (1927) seems to have similar type of venation. *T. spatulata* from Ussuriland described by Kryshtofovich (1910) has more closely set veins and their frequency of bifurcation just after emergence is less than the Indian specimens. *T. spatulata* may



TEXT-FIG. 5 — *Morrisia dentata* (Rao & Jacob) comb. nov. showing a part of the specimen from Mandro, G.S.I. no. 17472, × 1.

be compared with *T. gracilis* Kimura (1959) in general shape and size, but the latter has unforked secondary veins. The narrower leaves of *T. spatulata* from the Rajmahal Hills resemble *T. daintreei* McCoy described by Arber (1917) from New Zealand. *T. daintreei* is much longer in size than the normal Rajmahal specimens.

Taeniopteris kutchensis n. sp.

Pl. 1, figs 7-9; Pl. 5, fig. 26; Text-figs 2A-D, 9A

1876a *Oleandridium vittatum* Brongn.: Feistmantel, p. 15, pl. 1, figs 1-3; pl. 2, figs 1-5; pl. 12, fig. 1.
1876a *Taeniopteris densinervis* Feistmantel, p. 19, pl. 2, fig. 6.
1876b *Oleandridium vittatum* Schimper: Feistmantel, p. 30.
1963 *Taeniopteris vittata* Brongniart: Sitholey, p. 71.

Diagnosis — Leaf simple, petiole 2·5-3 cm long, base of petiole swollen, midrib uniformly broad, 2-2·5 mm wide, near apex slightly narrower, longitudinally striated. Leaves exceeding? 20 cm in length, 1·5-4 cm wide, strap-shaped. Lamina occasionally inequilateral towards base, substance thin, margin entire or at places torn to give a false idea of incomplete segmentation; apex obtuse. Secondary veins arising at 80°-90°, near apex at 55°-65°, majority simple, when forked at various levels, rarely veins forking just after emergence and out of these the ones closer to margin may fork again. Veins after emergence slightly curving upwards and then running parallel, reaching up to margin, 10-13 per cm, rarely 14 per cm.

Holotype — No. 4777 of the Geological Survey of India, Calcutta.

Locality — Kakadbhit and Dhawrha Mota, Kachchh.

Remarks — The status of *Taeniopteris vittata* Brongniart (1832) and *Nilssoniopteris vittata* (Brongniart) Florin has been discussed by Harris (1969) and Maheshwari and Singh (1976). We think the name *vittata* should only be used for leaves which are believed genuinely identical with the Yorkshire ones. *N. vittata* has quite a thick cuticle, the specimens from Kuchchh clearly differ in this aspect. They seem to have a thin lamina. *N. vittata* has minute marginal teeth pointing downwards which are absent in *T. kutchensis*. Also margin in the former species is usually slightly recurved. In *T. kutchensis* the lamina usually tapers more finely towards base than in *N. vittata*.

Another species with which *T. kutchensis* resembles in external form, is *T. tenuinervis* Brauns, but the latter species has never been fully described. Amongst these quite a few with cuticle have been referred to *Nilssonia*. In such specimens the lamina is attached over the midrib and they have simple veins. In *T. kutchensis* lamina is laterally attached and it has both simple and forked veins.

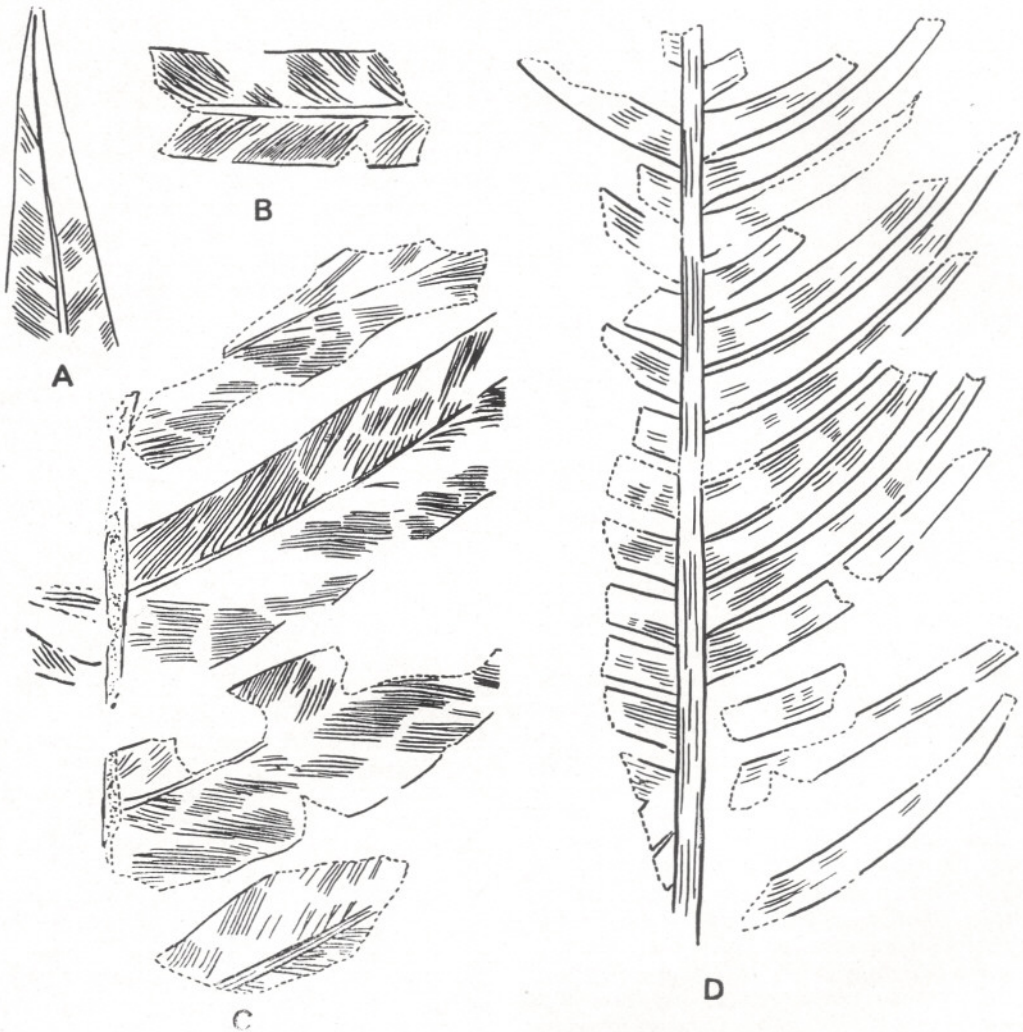
The specimen of *T. densinervis* originally described by Feistmantel (1876a, pl. 2, fig. 6) is only slightly broader (3·2 cm) than the rest of the specimens described by him as *Oleandridium vittatum* (Feistmantel, 1876a, pl. 1, figs 1-3; pl. 2, figs 1-5), but like the specimens of the latter species, *T. densinervis*, too, has 12-13 veins per cm. We have collected from Kakadbhit quite a few specimens which are even broader than the original specimen of *T. densinervis* Feistmantel (1876a, pl. 2, fig. 6), but they all have similar type of venation. So we have now placed *T. densinervis* under *T. kutchensis*. The specimens of *T. vittata* and *T. densinervis* described by Maheshwari and Singh (1976, pl. 1, fig. 5; pl. 2, figs 9, 12) from Pariwar Formation differ from *T. kutchensis* in having 20-24 veins per cm. Also the specimens from Pariwar Formation seem to have a thicker lamina.

Comparison — *Taeniopteris kutchensis* resembles most *T. fluctuans* Etheridge, described by Chapman and Cookson (1926), in venation pattern. The lamina of *T. fluctuans* is crumpled. In *T. elongata* Walkom (1918) the lateral veins bifurcate more frequently, also its lamina has much tapering base. *T. vittata* Brongniart, described by Matsuo and Omura (1968) has almost the same size range as *T. kutchensis*, but the former differs in having more frequently forked lateral veins. In gross features *T. eurychoron* Schenk, described by Kryshtofovich and Prynada (1933a), resembles the present species, however, the former can be distinguished by its finer and more closely set veins.

Taeniopteris haburensis n. sp.

Text-fig. 1G, H

1976 *Taeniopteris vittata* Brongniart: Maheshwari & Singh, p. 119, pl. 2, figs 9, 12.



TEXT-FIG. 6 — **A, B,** ?*Morrisia rajmahalensis* **(Feistmantel) comb. nov. from Murrero, G.S.I. nos. 4543, 4373 and 4510,× 1. C,** *Morrisia rajmahalensis* **(Feistmantel) comb. nov. from Onthea; holotype, G.S.I. no. 4510,× 1. D,** *Pterophyllum kingianum* **Feistmantel from Gollapalle, G.S.I. no. 4571,× 1.**

1976 *Taeniopteris densinervis* Feistmantel: Maheshwari & Singh, p. 119, pl. 1, fig. 5; text-fig. 4.

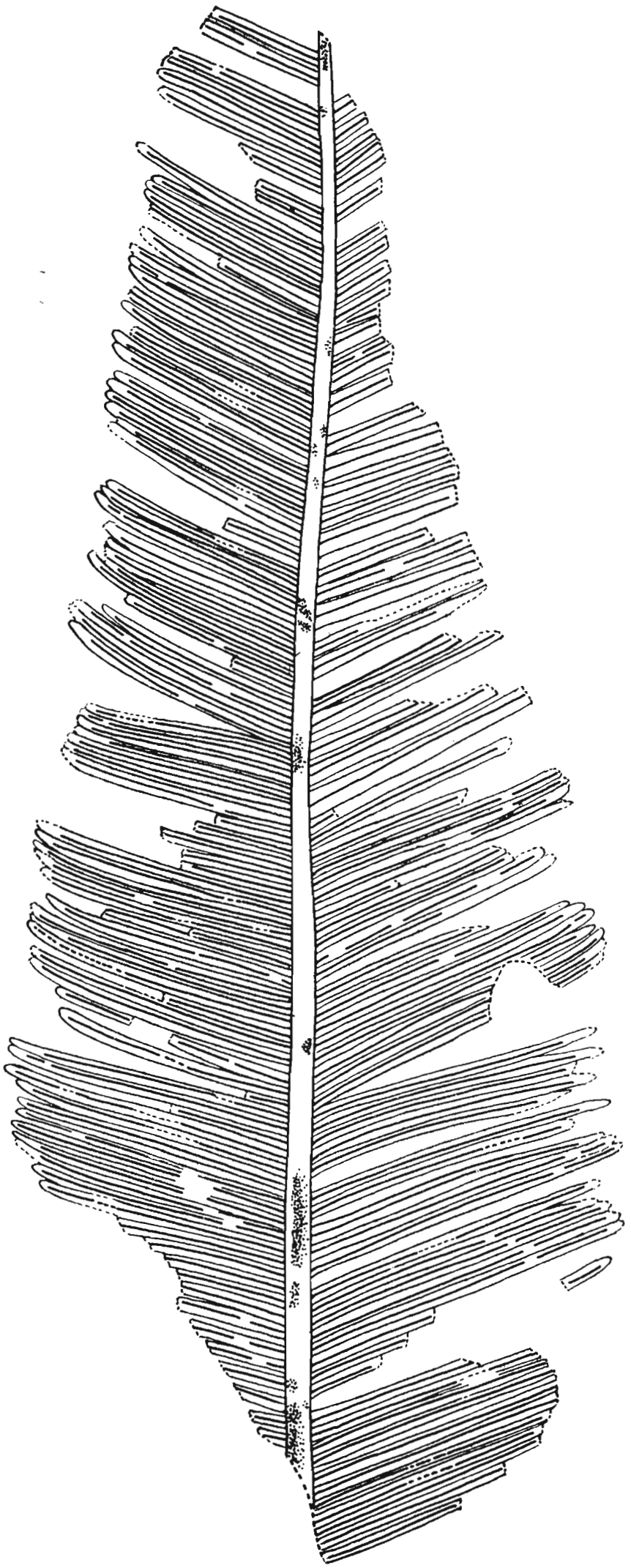
1980 *Taeniopteris vittata* Brongniart: Bose *et al.*, (in Press).

Diagnosis — Leaves simple; petiolate, base of petiole swollen, about 2·5 cm long, 3 mm wide; midrib 1-3 mm wide, gradually narrowing towards apex, finely striated. Leaf as a whole linear-lanceolate, substance of lamina thick, maximum available length 22·4 cm, breadth 1·3 cm (mostly 2·4-2·6 cm); margin entire; apex obtuse; lamina gradually tapering towards base. Lateral veins arising at angles of 75°-90°, slightly curving upwards and then running parallel up to margin, majority simple, sometimes forking at different levels, veins 20-26 per cm.

Holotype — No. 13/2011 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — About 1 km east of Habur, district Jaisalmer, Rajasthan.

Comparison — *Taeniopteris haburensis* can readily be distinguished from *T. kutchensis*



TEXT-FIG. 7 — *Cycadites rajmahalensis* Oldham from Bindaban, B.S.I.P. no. 28312, × 1.

by its finer veins (20-26 per cm) and thicker lamina. *Nilssoniopteris vittata* (Brongniart), described by Harris (1969), has minute marginal teeth, whereas, *T. haburensis* has entire margin. Like the present species, *T. eurychoron* Schenk of Kryshtofovich and Prynada (1933a), too, has finer and more closely set veins. In *T. eurychoron*, at places, lamina is crumpled and its exact number of veins per cm is not known. In external form *T. uwatokoi* Ôishi (1935) looks like some of the specimens of *T. haburensis*, but the former has more closely set lateral veins.

Taeniopteris oldhamii n. sp.

Pl. 1, fig. 4; Pl. 2, figs 14, 15; Text-fig. 3A-C

1863 *Taeniopteris ovalis* Lind. & Hutton: Oldham & Morris, p. 43, pl. 3, figs 3-6.
1869 *Macrotaeniopteris ovata* (Oldh.): Schimper, p. 613.
1876b *Taeniopteris ovata* Schimper: Feistmantel, p. 36.
1877a *Macrotaeniopteris ovata* Schimper, O. & M.: Feistmantel, p. 51, pl. 37, figs 1, 1A, B.
1963 *Macrotaeniopteris ovata* Schimp.: Sitholey, p. 70, pl. 7, fig. 43.

Diagnosis — Leaf petiolate; petiole 1·1 cm long; rachis about 1 mm wide, rachis near distal end bifurcating. Lamina oval, substance of lamina (?) thick; 2·8-10 cm long, 2·3-6·6 cm broad; margin serrate, serration straight; apex obtuse; base asymmetrical. Veins thick and prominent, arising mostly at an angle of 60°-65°, simple or once forked, forking just after emergence or at different levels, parallel, rarely slightly wavy, about 7-12 per cm (mostly 7-9).

Holotype — No. 4358 of the Geological Survey of India, Calcutta.

Occurrence — Bindaban, Rajmahal Hills, Bihar.

Remarks — *Otopteris ovalis* Lindley & Hutton (1837, pl. 210A) has been merged with *Nilssoniopteris major* (L. & H.) Florin (see Harris, 1946, 1969). *N. major* differs from *Taeniopteris oldhamii* in having much smaller marginal teeth and having finer lateral veins.

The specific name is after late Mr Thomas Oldham.

Comparison — In overall shape *Taeniopteris oldhamii* resembles most *T. emarginata* Ôishi described by Kimura and Sekido (1966) and Matsuo and Ômura (1968), however, the secondary veins in the latter species are more closely set and they do not bifurcate as frequently as in the former species. *T. hildesiensis* Salfeld (1909) has somewhat similar shape as *T. oldhamii* but the former has much finer veins. The secondary veins in *Taeniopteris* sp., described by Herbst (1964), are more frequently divided, but their setting is somewhat like *T. oldhamii*. *Nilssonia johnstrupi* Heer, described by Yokoyama (1894, pl. 25, fig. 1), resembles in external features *T. oldhamii*, but it has finer veins.

Taeniopteris buskoghatensis n. sp.

Pl. 1, fig. 5; Text-fig. 3D

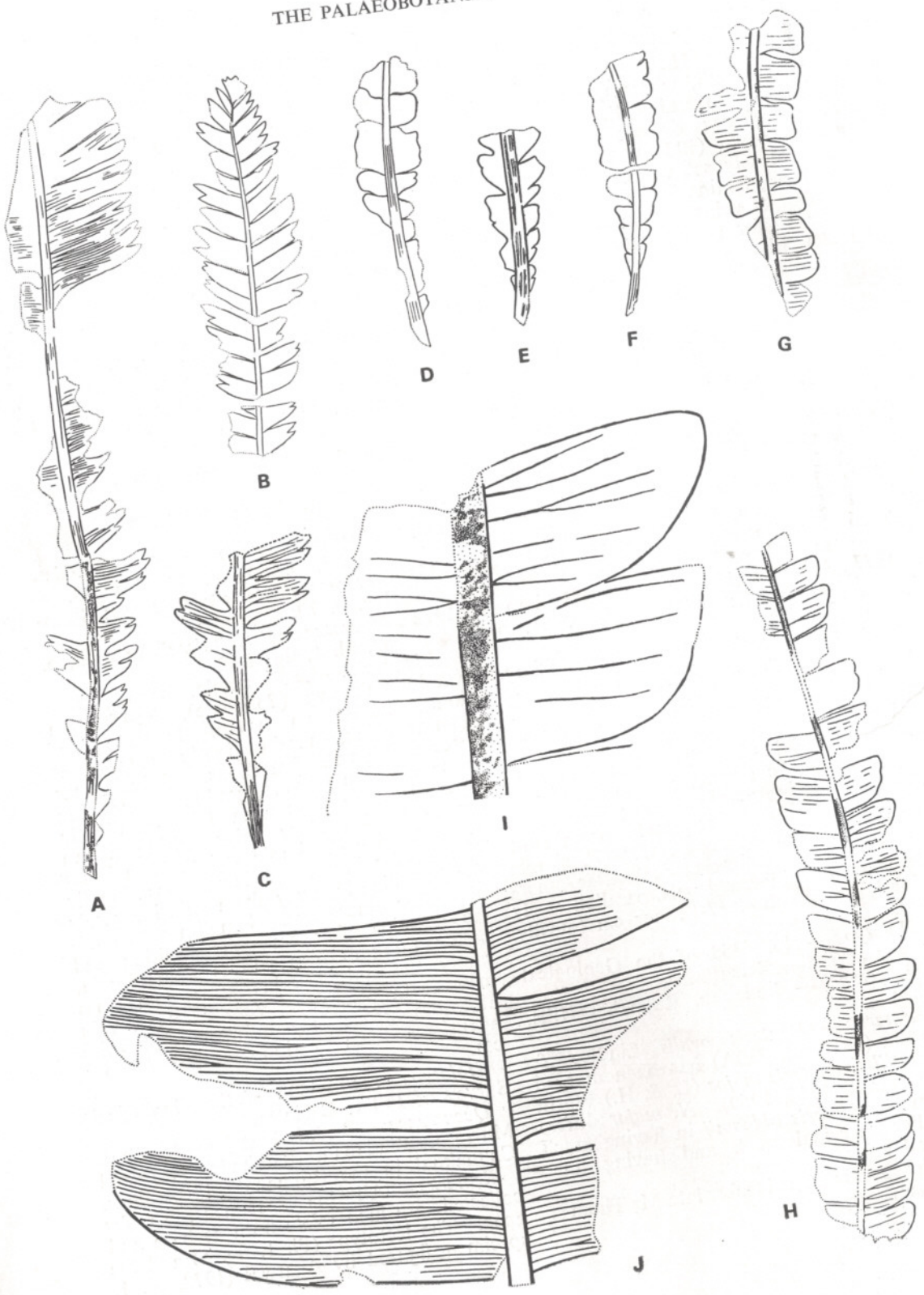
1877a *Macrotaeniopteris crassinervis* Feistmantel, p. 50, pl. 38, figs 1-3.
1963 *Macrotaeniopteris crassinervis*: Sitholey, p. 70.
1972 *Macrotaeniopteris misrai* Agarwal, p. 69, pl. 1, figs 1, 2.

Diagnosis — Leaf simple, shape as a whole unknown (?obovate), 6·2-15·8 cm long, 2·4-6·2 cm broad. Substance of lamina thick, margin slightly wavy or at places with small dentations. Midvein near base 0·3-0·8 cm broad, gradually narrowing towards apex (less than 1 mm), slightly grooved. Secondary veins arising at an angle of 75°-85°, simple or forked, majority simple, forking at all levels, occasionally forking slightly away from midrib, rarely just after emergence. Sometimes two adjacent veins after emergence uniting and then running up to margin as a single vein, rarely the united veins after sometimes may again bifurcate. Very rarely a vein after emergence may bifurcate and unite again to form a loop, about 7-8 per cm.

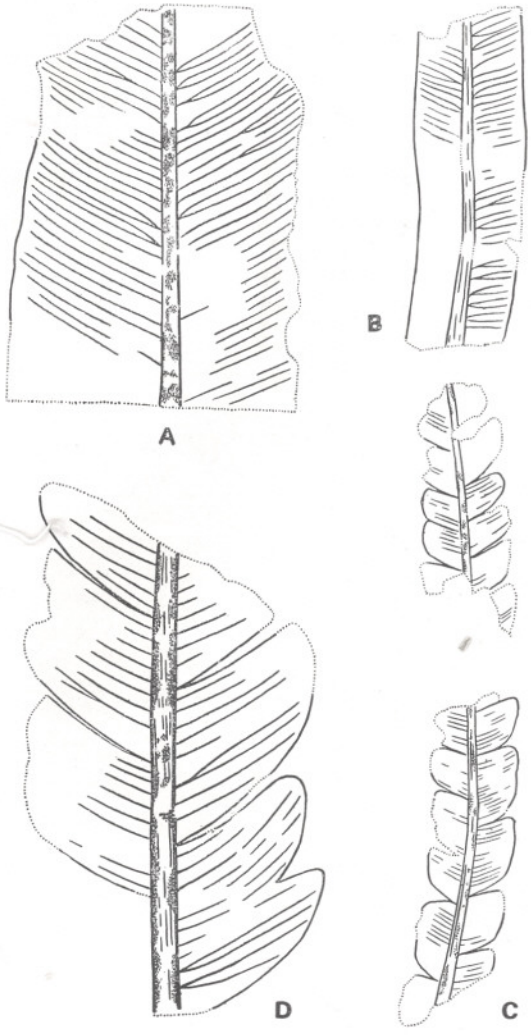
Holotype — No. 4508 of the Geological Survey of India, Calcutta.

Occurrence — Busko Ghat (type locality), Murrero, Bindaban, Balbhadri Hill and Chunakhal in the Rajmahal Hills, Bihar.

Remarks — All the specimens, so far collected, are incomplete both at base and apex. The lectotype (Pl. 1, fig. 5) and the specimen figured by Agarwal (1972, pl. 1,



TEXT-FIG. 8



TEXT-FIG. 9 — **A,** *Taeniopteris kutchensis* n. sp. from Kakadbhit, B.S.I.P. no. 1/2000A, × 1.5. **B,** *Taeniopteris spatulata* McClelland from Kakadbhit, B.S.I.P. no. 2/2000A, × 2. **C, D,** *Anomozamites haburensis* n. sp. from Habur, B.S.I.P. nos. 126/2095 and 112/2095; **C,** × 1; **D,** × 2.

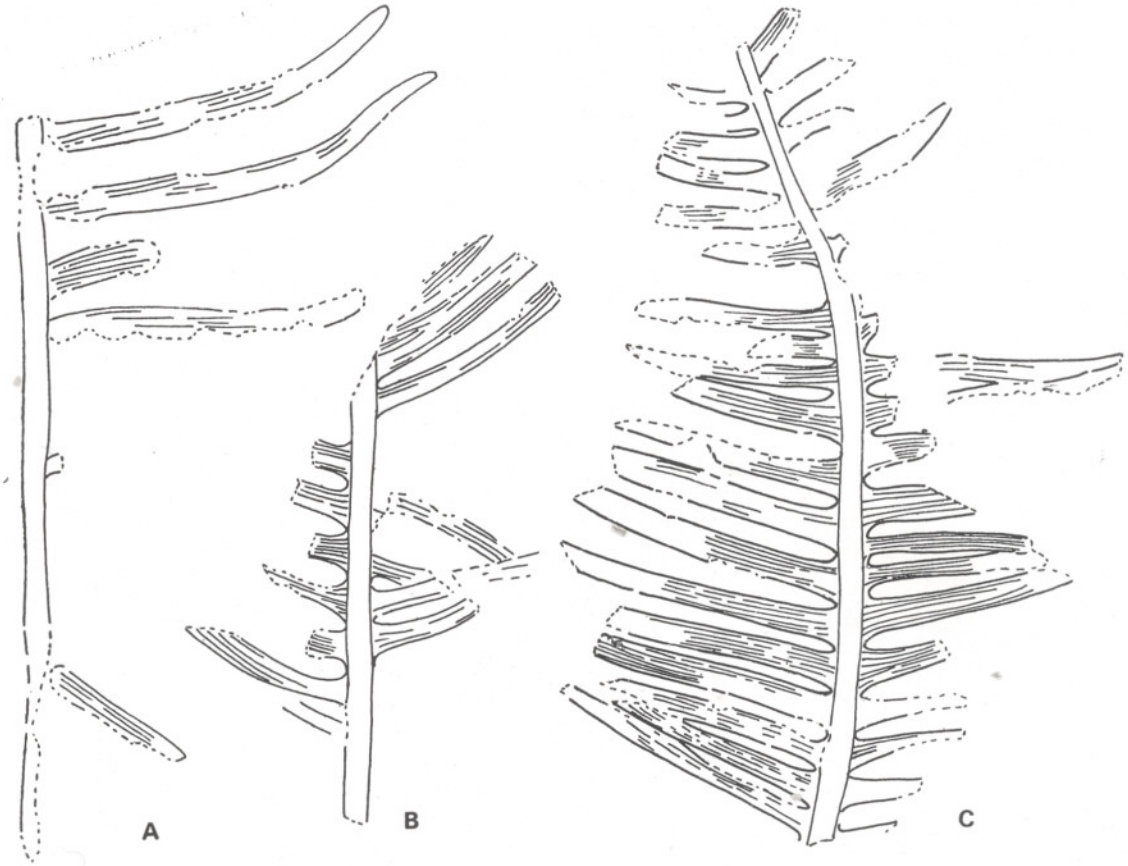
fig. 1) perhaps belong to basal parts of leaves, whereas, the one figured in Text-fig. 3D is likely to be the apical part of a frond.

The specific name is after the type locality, viz., Busko Ghat. The name *crassinervis* has already been used by Stanislavasky (1971, pl. 22, figs 4-6) for some specimens of *Taeniopteris* from the Upper Triassic of Donets basin, U.S.S.R.

Comparison — Taeniopteris buskoghatensis differs from *T. oldhamii* in being obovate in shape and in having less forking secondary veins. In the former species two adjacent veins after emergence, sometimes unite and then run as a single vein. Such veins are not found in *T. oldhamii*. Also margin in *T. oldhamii* is serrate. The venation of *T. crassinervis*, described by Du Toit (1927), is closest to the venation of *T. buskoghatensis*. In both, at places, two adjacent veins rejoin before reaching margin. The former differs in being irregular in shape and also in having more forked veins. The specimens of *T. crassinervis* Stanislavsky (1971) are narrower than *T. buskoghatensis* and its veins are more closely set than in the latter species. *T. crassinervis*, described by Arber (1917), from New Zealand has a stout midrib measuring up to 1 cm in width and it has simple or once forked veins. It differs from *T. buskoghatensis* in having more closely set veins and unlike the latter species its secondary veins do not unite with each other. In the sparse nature of secondary veins *T. buskoghatensis* resembles *T.* (?*Danaeopsis*) *crassinervis* described by Walkom (1924) from Bellevue, Queensland. In the latter species the veins are mostly simple and they show transverse strands. *T. crassinervis*, figured by Flint and Gould (1975), too, has mostly simple veins and the veins do not unite. In shape *T. leclerei* Zeiller, described by Chuan, Yao and

←

TEXT-FIG. 8 — **A-C,** *Anomozamites fissus* Feistmantel from Bindaban (8A, B) and Burio (8C), B.S.I.P. nos. 35367, 32/847 and G.S.I. no. 4467; A, B, × 1; C, × 2.5. **D-F,** *Anomozamites amarjolense* Sharma *et al.* from Amarjola, B.S.I.P. nos. 2154, 2713 and 3175, × 1. **G,** *Anomozamites crenata* (McClelland) comb. nov. from Murrero, holotype, G.S.I. no. 4366, × 1. **H,** *Anomozamites hasnapurensis* n. sp. from near Hasnapur; holotype, B.S.I.P. no. 29/1442, × 1. **I,** *A. hasnapurensis* from near Hasnapur; B.S.I.P. no. 29/ 1442, × 4. **J,** *Pterophyllum princeps* Oldham & Morris from Bindaban; B.S.I.P. no. 31150/422, × 1.



TEXT-FIG. 10— **A-C**, *Pterophyllum distans* Morris; **A**, from Bindaban, G.S.I. no. 4380; **B**, from near Ghutiari, G.S.I. no. 4382 (holotype); **C**, from Kakadbhit, B.S.I.P. no. 105/1212; all, × 1.

Ching (1976), resembles the narrower specimens of *T. buskoghatensis*, but the former differs in having more closely set secondary veins.

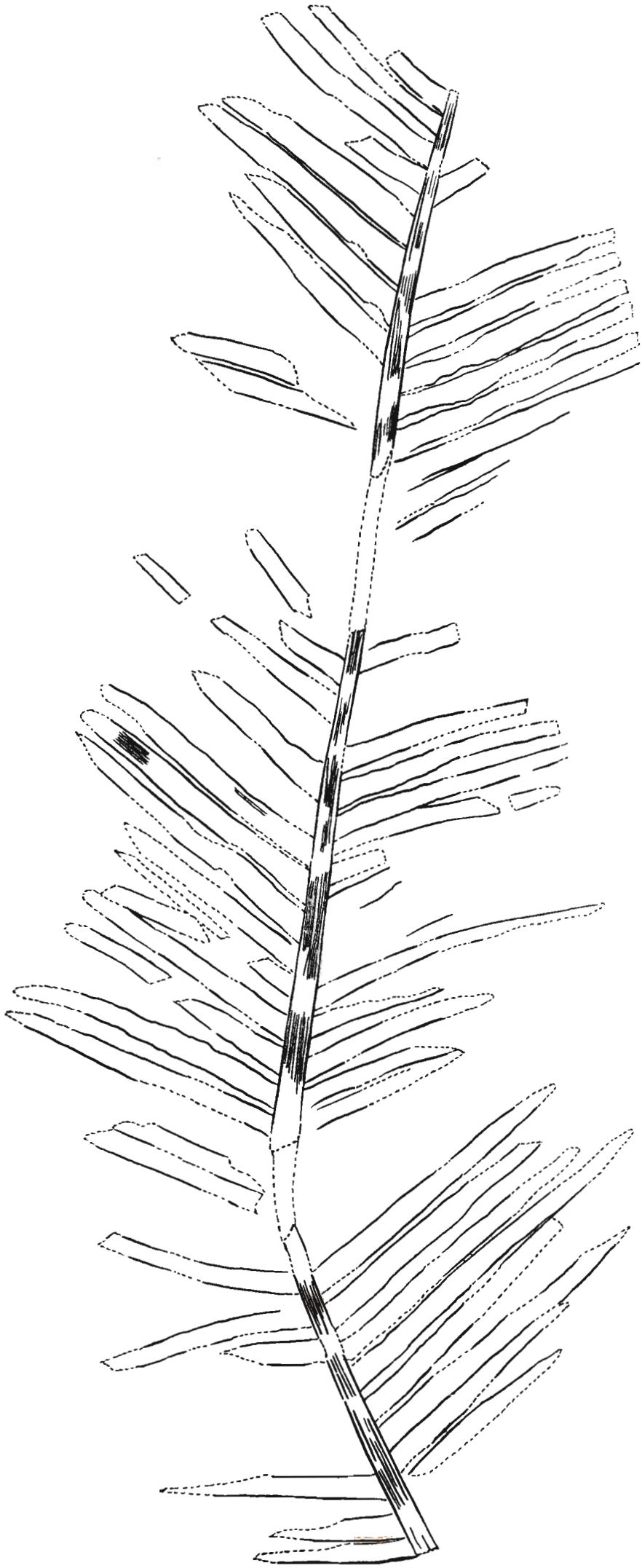
Morrisia mcclellandi (Oldham & Morris) Bose

Pl. 2, fig. 16; Text-fig. 4

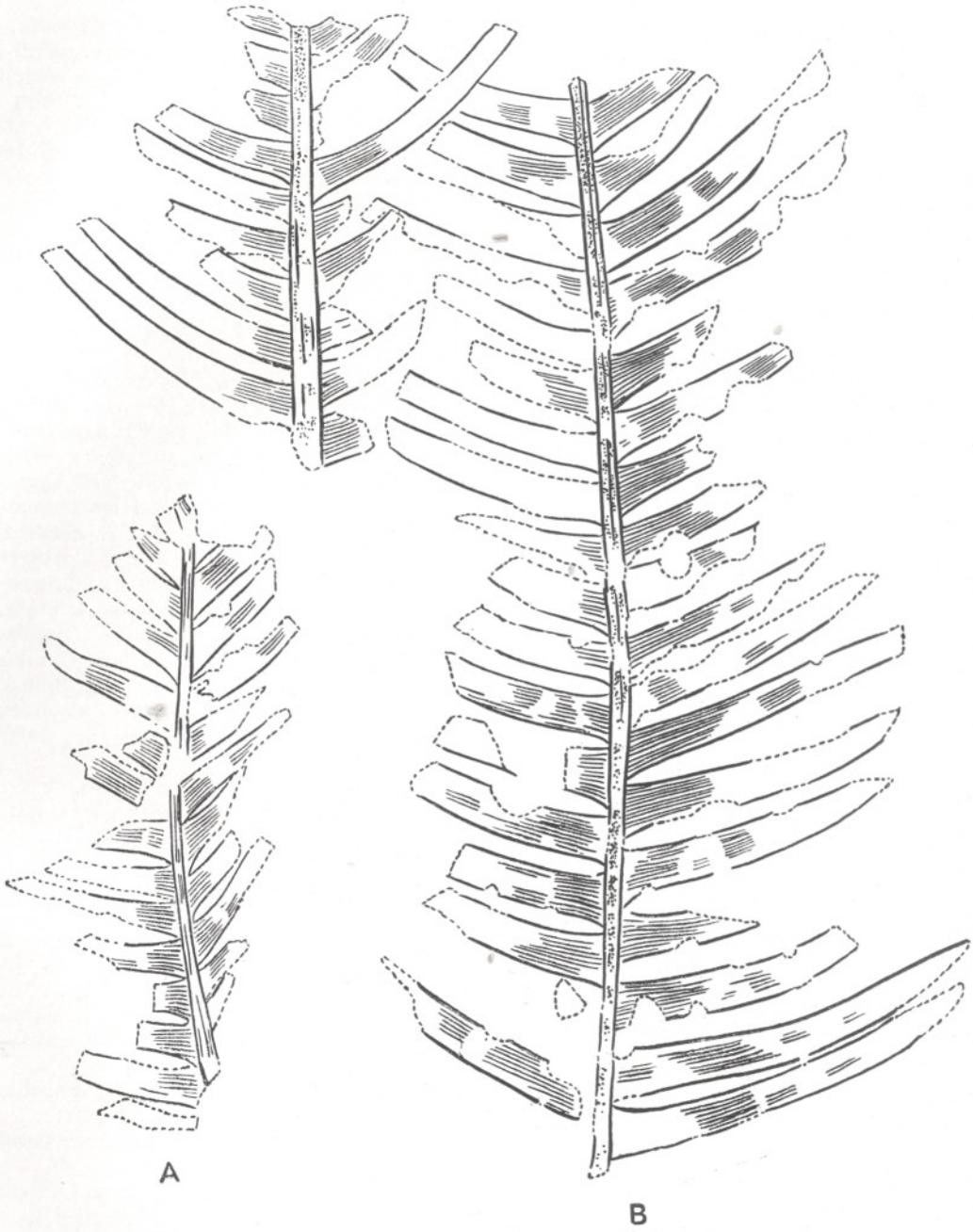
1863 *Stangerites mcclellandi* Oldham & Morris, p. 33, pl. 23, figs 1-3.
1869 *Angiopteridium mcclellandi* (Morris) Schimper, p. 605.
1876b *Taeniopteris* (*Angiopteridium*) *mcclellandi* Oldham & Morris: Feistmantel, p. 36.
1877a *Angiopteridium mcclellandi* Schimper: Feistmantel, p. 44 (*partim*).
1933 *Taeniopteris mcclellandi* Oldham & Morris sp.: Sahni & Rao, p. 197.
1958 *Morrisia mcclellandi* (Oldham & Morris) Bose, p. 21, pl. 1, fig. 1; pl. 2, figs 2-4; pl. 3, figs 5-7.
1963 *Morrisia mcclellandi*: Sitholey, p. 21, pl. 3, fig. 18.
1979 *Morrisia mcclellandi* (O. & M.): Bose, p. 55, figs 1-3.

Detached pinna doubtfully referred to Morrisia mcclellandi

1863 *Stangerites* (*Taeniopteris*) *spatulata* McClelland: Oldham & Morris, p. 34, pl. 6, fig. 7.



TEXT-FIG. 11 — *Pterophyllum kingianum* Feistmantel from Gollapalle holotype, G.S.I. no. 4566, × 1.



TEXT-FIG. 12 — A, B, *Pterophyllum kingianum* Feistmantel from Gollapalle, G.S.I. nos. 4568 and 4572, × 1.

1877a *Angiopteridium mcclellandi*, Schimper: Feistmantel, p. 44 (*partim*), pl. 46, fig. 5.

1879 *Angiopteridium mcclellandi* Oldham & Morris sp., Schimper: Feistmantel, p. 17, pl. 1, figs 14-16; pl. 2, fig. 4.

1953 ?*Taeniopteris mcclellandi* Oldham & Morris: Gopal, Jacob & Jacob, p. 487, fig. 7.

Diagnosis (from Bose, 1958 with minor changes) — Pinnate leaf of unknown size (length perhaps exceeding 40 cm), width 15-20 cm near middle region. Main rachis 0·3-1 cm wide, showing prominent longitudinal ridges and fine striations in between. Pinnae alternate, attached at an angle of 50°-60° (rarely up to 85°) to rachis, mostly distantly placed, sometimes touching each other. Pinnae linear-elliptical, about 6-14 cm long, 1-2·2 cm broad, substance of lamina thick, margin entire, apex obtuse; base more or less obtuse. Pinnae attached to main rachis by a petiole; petiole about 3 mm long, 1-2 mm broad; midrib 0·5-1 mm wide, uniformly broad (near apex slightly narrower). Secondary veins numerous, 18-30 per cm (mostly 28-30), after emergence curving upwards and then running parallel, arising from midrib at an angle of 85°-90°, majority simple, forking at different levels, when forking mostly slightly away from midrib.

Holotype — No. 4438 of the Geological Survey of India, Calcutta.

Occurrence:

East Coast — ?Raghavapuram, ?Vemavaram (Nellore), ?Sriperumbudur and ?Sivaganga.

Rajmahal Hills — Bindaban (type locality), Khairbani, Sakrigalighat and ?Amarjola.

Comparison — In pinnae size and venation pattern *Morrisia mcclellandi* resembles the broader leaves of *Nipaniophyllum raoi* Sahni (1948, fig. 1). Leaves of *Taeniopteris spatulata* McClelland are narrower and in them the secondary veins mostly bifurcate just after emergence.

Morrisia dentata (Rao & Jacob) comb. nov.

Pl. 3, fig. 18; Text-fig. 5

1957 *Taeniopteris dentata* Rao & Jacob, p. 509, pl. 11, fig. 1; pl. 12, figs 2-4.
1958 *Taeniopteris dentata*: Bose, p. 23.
1963 *Taeniopteris dentata* Rao & Jacob: Sitholey, p. 21.

Diagnosis — Pinnate leaf of large size (available length 18·7 cm, width 18·2 cm), shape as a whole broadly oval. Main rachis about 0·8 cm wide, gradually tapering towards apex (1·5 mm), slightly grooved. Pinnae arising at an angle of 35°-45°, lanceolate, alternate, rarely towards apex subopposite, 12-15 cm long and 2-3 cm broad; margin serrate. Apex subacute; base obtuse or rounded. Petiole inconspicuous; midrib prominent, 1·5-2 cm wide, gradually tapering towards apex. Secondary veins distinct, arising from midrib at an angle of 35°-45°, after emergence slightly arching and then running parallel; simple or forked, mostly dichotomising after emergence, rarely slightly away from midrib or near margin, majority dichotomising once, very rarely more than once, about 12-14 veins per cm near middle region.

Holotype — No. 17472 of the Geological Survey of India, Calcutta.

Occurrence — Mandro, Rajmahal Hills.

Comparison — *Morrisia dentata* differs from *M. mcclellandi* in having pinnae with dentate margin. Also its secondary veins arise at narrow angles. *Taeniopteris stenophylla* Kryshtofovich, described by Menendez (1951), has venation like *M. dentata*. The leaves of *T. stenophylla* are narrower and their margin do not show such prominent dentations as present in *M. dentata*. *Taeniopteris* (?) sp. described by Toyama and Ôishi (1935) has somewhat similar type of nervation as that of the pinnae of *M. dentata*, but the former is much broader than the pinnae of the latter species.

Morrisia rajmahalensis (Feistmantel) comb. nov.

Pl. 4, figs 21-24; Text-figs 1I, 6A-C

1877a *Danaeopsis rajmahalensis* Feistmantel, p. 53, pl. 38, figs 4, 4a; pl. 48, fig. 3.
1946 *Taeniopteris ensis* Oldham: Ganju, p. 69, pl. 5, figs 27, 28; text-figs 7, 8.

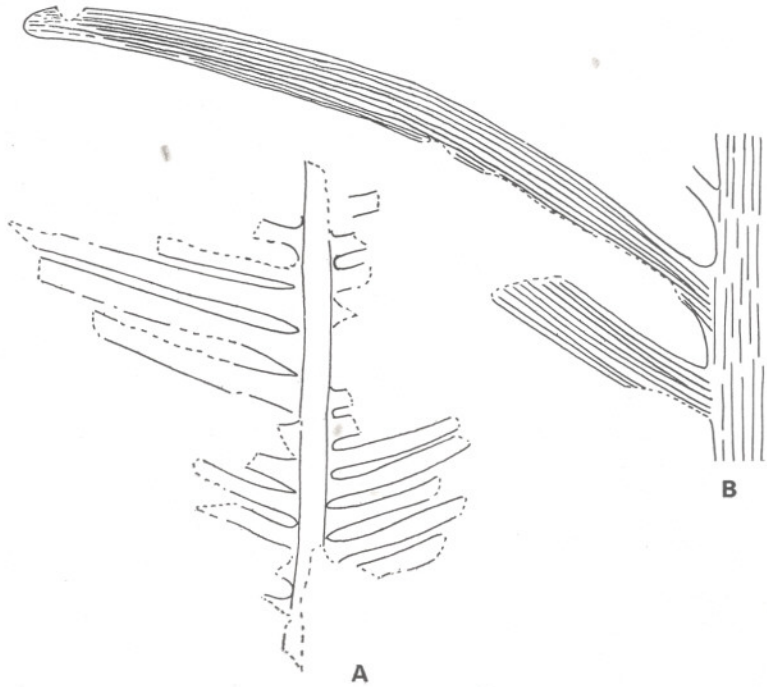
The following are supposed to be detached (?) pinnae of *Morrisia rajmahalensis*:

1850 *Taeniopteris acuminata* McClelland, p. 53, pl. 16, fig. 2.
1863 *Stangerites ensis* Oldham: in Oldham & Morris, p. 35, pl. 6, figs 8-10.
1869 *Angiopteridium ensis* Schimper, p. 606.
1876b *Taeniopteris* (*Angiopteridium*) *ensis* Oldham & Morris: Feistmantel, p. 40.
1877a *Angiopteridium mcclellandi* Schimper: Feistmantel, p. 44 (*partim*), pl. 46, fig. 6.

TEXT-FIG. 13 — A-C, *Pterophyllum footeanum* Feistmantel from Vemavaram, G.S.I. nos. 4655, 4658 (holotype) and 4661, × 1.

1877a *Angiopteridium ensis* (Oldh.) Schimper: Feistmantel, p. 45.
1877b *Angiopteridium* comp. *ensis*, Oldham: Feistmantel, p. 11, pl. 1, figs 6a, 7a.
1934 *Taeniopteris ensis* Oldham sp.: Sahni & Rao, p. 262, pl. 35, figs 3, 4.
1967 *Sagenopteris*: Roy, p. 60.
1970 *Taeniopteris ensis* (Oldham): Gururaja & Pant, p. 387.

Diagnosis — Pinnate leaf, main rachis about 3 mm wide. Pinnae attached to rachis by entire base, arising at an angle of 65°. Pinna shape as a whole unknown, about 10 cm long, 1·5-4·2 cm broad;



TEXT-FIG. 14— **A**, *Pterophyllum distans* Morris from Kakadbhit, B.S.I.P. no. 35118, × 1. **B.** *Pterophyllum footeanum* Feistmantel from Vemavaram, G.S.I. no. 4657, × 1.5.

margin entire; both acroscopic and basiscopic margins truncate; apex acute or bluntly acute. Midrib of pinna 1-2 mm wide, gradually tapering towards apex; secondary veins making an angle of 40°-45°, mostly forking once, rarely twice, forking at different levels, majority forking slightly away from midrib, all veins reaching up to margin, about 14-16 veins per cm.

Holotype — No. 4510 of the Geological Survey of India, Calcutta.

Occurrence :

East Coast — Golapili.

Rajmahal Hills — ?Bindaban, Khairbani, Onthea (type locality), ?Burio, ?Murcha pass and ?Sitalpur.

Remarks — Pinnate nature of the frond is visible in the specimen shown in Pl. 4, fig. 21. All the remaining specimens are detached (?) pinnae. Their venation pattern is same as is found in the holotype. The whereabouts of the McClelland's specimen (1850, pl. 16, fig. 2) of *Taeniopteris acuminata* is not known. However, in the G.S.I. collection there is a specimen (no. 4373) which bears the label—McClelland collection (Pl. 4, figs 23, 24). This specimen do not really match with the specimen figured by McClelland (1850). The specimen has also been figured by Oldham and Morris (1863, pl. 6, fig. 8).

Comparison — The venation of *Morrisia rajmahalensis* is more like *M. dentata*. In *M. rajmahalensis* the pinnae are narrower and their margin is not dentate. In *Taeniopteris minensis* Ôishi, described by Okafuji (1971), the secondary veins arise at a narrow angle like *M. rajmahalensis*. The former is much longer and narrower than the pinnae of *M. rajmahalensis*. *T. stenophylla* Kryshtofovich (1910) has secondary veins which make narrow angles with the rachis, but here the veins mostly divide more than once. *T. ensis* described by Kryshtofovich and Prynada (1933b, pl. 3, figs 5, 7) resembles *M. rajmahalensis* in venation pattern. Chang (1930) had figured a few specimens as *T. mcclellandi* (?) Oldham & Morris; these specimens look more like the pinnae of *M. rajmahalensis*.

Most of them are only slightly narrower than the pinnae of *M. rajmahalensis*.

Cycadites rajmahalensis Oldham

Pl. 11, fig. 44; Pl. 13, figs 48, 49; Text-fig. 7

1863 *Cycadites rajmahalensis* Oldham: in Oldham & Morris, p. 15, pl. 7, figs 1, 2; pl. 8, fig. 1.

1863 *Cycadites conferta* Morris: in Oldham & Morris, p. 15, pl. 7, fig. 4; pl. 8, fig. 2.

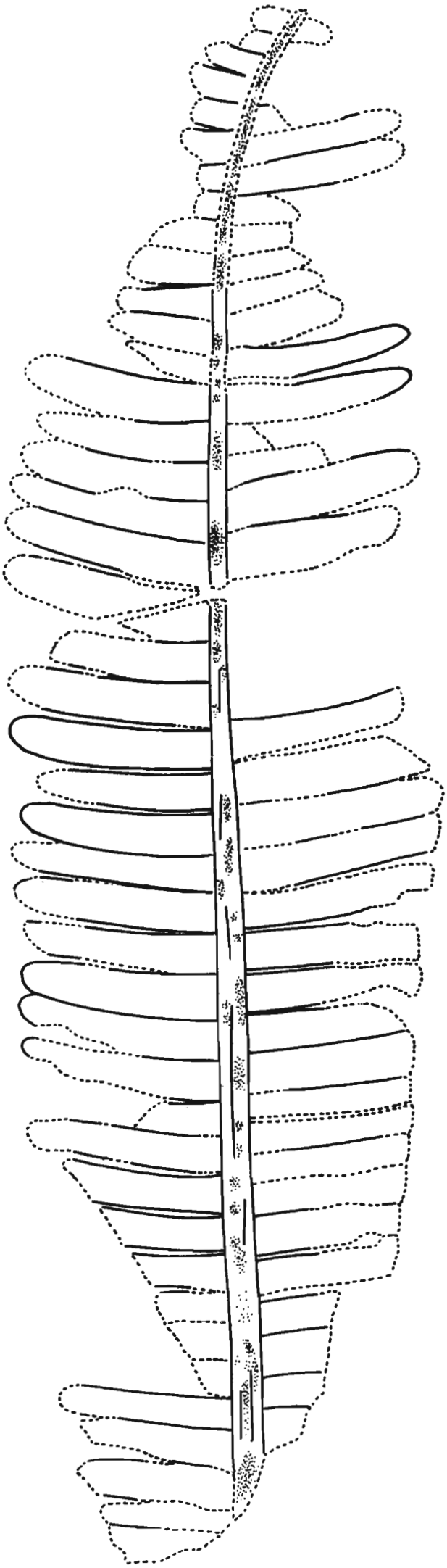
1863 *Cycadites blanfordianus* Oldham: in Oldham & Morris, p. 16, pl. 9, fig. 2.

1876b ?*Cycadites rajmahalensis* Oldham: Feistmantel, p. 37.

1876b ?*Cycadites confertus* Morris: Feistmantel, p. 37.

TEXT-FIG. 15 — *Pterophyllum medlicottianum* Oldham & Morris from Imjhiri, B.S.I.P. no. 55/1440, × 0,75.

TEXT-FIG. 16 — **A-D,** *Pterophyllum medlicottianum* Oldham & Morris; **A,** from Onthea B.S.I.P. no. 35116; **B,** from Bindaban, G.S.I. no. 4526; and **C, D,** from Imjhiri, B.S.I.P. nos. 14/1440, 45/1440; all, × 1.



TEXT-FIG. 17 — *Pterophyllum rajmahalense* Morris from Bindaban; B.S.I.P. no. 28312, × 1.

1877a *Cycadites confertus* Morris: Feistmantel, p. 72, pl. 48, fig. 1.
1877a *Cycadites blanfordianus* Oldham: Feistmantel, p. 72.
1877a *Cycadites rajmahalensis* Oldham: Feistmantel, p. 72.
1917 *Nilssonia rajmahalensis* Seward, p. 571, fig. 621.
1920 *Nilssonia rajmahalensis* Morris: Seward & Sahni, p. 32, pl. 3, fig. 34; pl. 5, fig. 42.
1963 *Nilssonia rajmahalensis* (Morris) Seward: Sitholey, p. 71, pl. 6, fig. 40.
1968 *Cycadites rajmahalensis* Oldham: Bose, p. 10, pl. 1, figs 1, 2.

Diagnosis (slightly modified from Bose, 1968) — Leaf simply pinnate, large (length perhaps exceeding 50 cm, largest available specimen measuring 27 cm), 7-16 cm broad, somewhat broadly elliptic, substance of lamina thick. Rachis near base about 1-1·5 cm wide, towards apex about 0·5 cm wide, surface smooth, sometimes towards base grooved. Pinnae laterally attached by entire base, arising at an angle of about 65°-80° (less near apex), contiguous, margins of adjacent pinnae touching each other, but never overlapping. Pinnae linear, 3·5-7 cm long (near extreme base smaller), 2·5-4 mm broad, breadth nearly uniform throughout; base truncate; apex acute. Margin entire, slightly thickened. Midrib prominent, 0·5 mm wide.

Lectotype — No. 4378 of the Geological Survey of India, Calcutta.

Occurrence — Bindaban (type locality) and Onthea in the Rajmahal Hills.

Comparison — *Cycadites confertus* (Oldham & Morris) described by Patra and Pattnaik (1974) is imperfectly preserved and its real affinity is doubtful. *C. blomqvisti* Antevs (1919) and *Pseudocycas dubius* Turutanova-Ketova (1936) resemble most *C. rajmahalensis* (Pl. 13, fig. 1) in gross features. Externally, *C. rectangularis* Braun, described by Seward (1904), looks like the present species, but the former is smaller in size and its pinnae bases are joined with each other. The pinnae of *Nilssonia rajmahalensis* (Oldham) Seward and Sahni, described by Sixtel (1962), are narrower and they seem to be attached on the upper side of rachis almost concealing it. Similarly, the pinnae of *Pseudocycas thomasi* Seward & Conway (1935) are also narrower than *C. rajmahalensis*.

BENNETTITALES

Anomozamites crenata (McClelland) comb. nov.

Pl. 2, fig. 10; Text-fig. 8G

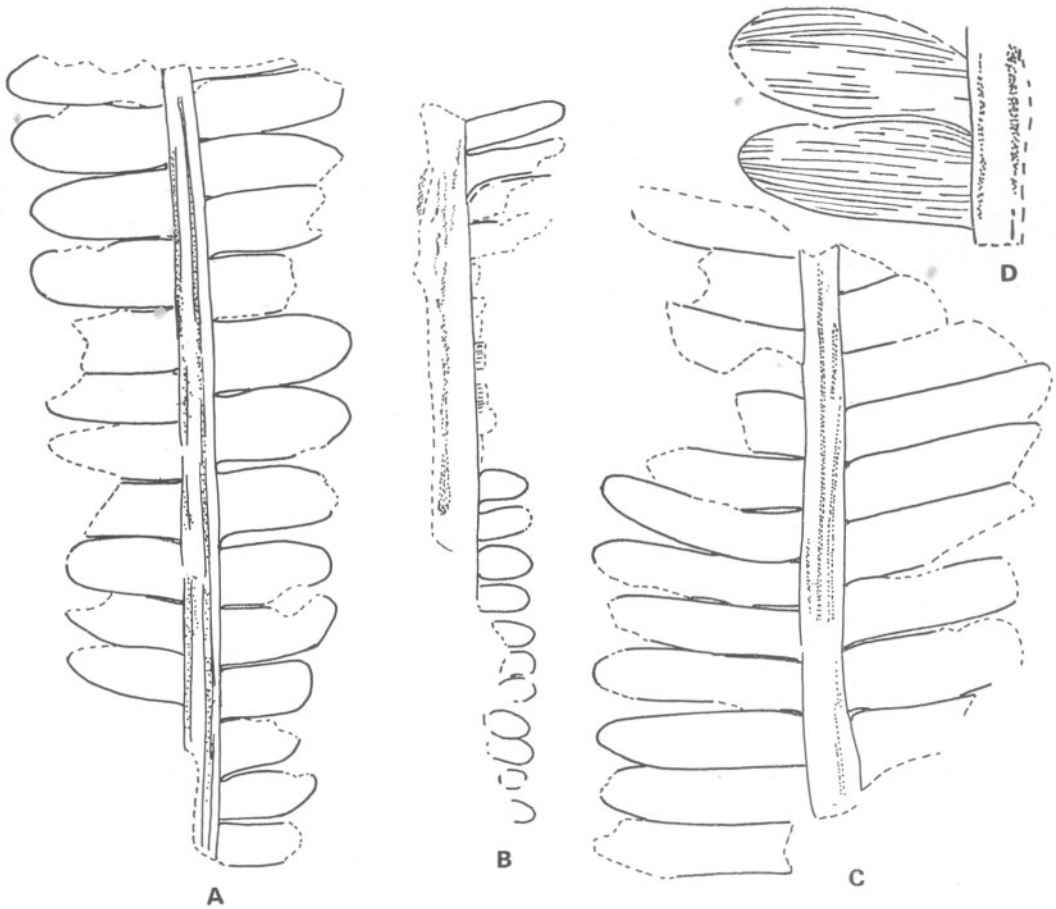
1850 *Taeniopteris crenata* McClelland, p. 53, pl. 16, fig. 3.

Diagnosis — Leaf linear, segmented; rachis about 1 mm wide, longitudinally striated. Segments attached to rachis almost at right angles by entire base, 4-5 mm long, 4-5 mm broad, lateral margins straight, on apical side margins rounded at corners, acroscopic and basiscopic margins slightly curved upwards and downwards, joining the bases of adjoining segments. Veins arising at right angles to rachis, rarely at an angle of about 85°, parallel, majority simple, rarely forked, when forked mostly just after emergence, about 8-10 veins per segment.

Holotype — No. 4366 of the Geological Survey of India, Calcutta.

Occurrence — Near Murrero, Rajmahal Hills.

Comparison — In gross features the segments of *Anomozamites crenata* resemble most the segments of *A. marginatus* (Unger) Nathorst (Krassilov, 1969 has referred this species to *Pterophyllum*) described by Harris (1932b). The midrib in *A. marginatus* is transversely wrinkled and its secondary veins are scarcely visible. In *A. crenata* surface of midrib is striated and its segments have mostly simple veins. Amongst the specimens of *Pterophyllum marginatum* Unger, figured by Krassilov (1969), the specimen figured in Pl. 15, fig. 5 is closest to *A. crenata*. The rest of the specimens figured by Krassilov (1969, pl. 15, figs 2-4) have narrower and more elongated segments. The smaller leaves of *A. nilssoni* (Phillips) described by Harris (1969, text-fig. 37C) agree with the present specimens, but in the former the segments have mostly forked veins. *Nilssonia* (*Anomozamites*?) *fissa*, described by Patra (1973, pl. 2, figs 10, 11) has segments with forked veins. However, two of the segments are somewhat like the ones seen in the present specimens. *A. crenata* matches very well with *A. gracilis* Nathorst (1878, pl. 2, figs 8, 10). One of the specimens of *A. gracilis* Nathorst (referred by Harris, 1932b to *A. marginatus*)



TEXT-FIG. 18 — **A-C**, *Pterophyllum rajmahalense* Morris from Bindaban, B.S.I.P. nos. 28301/303, 28301/303 and G.S.I. no. 4361, × 1. **D**, two pinnae enlarged to show venation, B.S.I.P. no. 28301/303, × 2.

described by Antevs (1919, pl. 4, fig. 29) is like *A. crenata*. The former differs in having slightly larger segments and in having bifurcated secondary veins. Both *A.* ex gr. *minor* Nathorst described by Stanislavsky (1971) and *A. minor* (Brongn.) Nathorst described by Kon'no and Asama (1973) have slightly longer segments.

Anomozamites amarjolense Sharma, Surana & Singh

Pl. 2, figs 11, 17; Text-fig. 8D-F

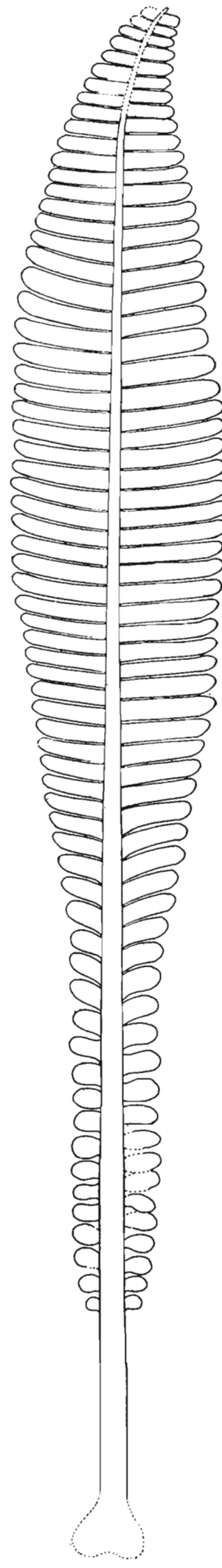
1863 *Pterophyllum*?: Morris in Oldham & Morris, p. 25 (*partim*), pl. 12, figs 1-4.

1879 *Anomozamites fissus* Feistmantel, p. 18 (*partim*), pl. 7, figs 11-13.

1879 *Anomozamites lindleyanus* Schimper: Feistmantel, p. 18, pl. 16, figs 3, 3a.

1971 *Anomozamites amarjolense* Sharma *et al.*, p. 32, pl. 1, fig. 5; text-figs 10, 11.

Emended Diagnosis — Leaf as a whole ovate, 3·5-6 cm long, 0·8-1 cm broad, segmented. Petiole 4-6 mm long; rachis prominent, about 1-1·5 mm wide, near apex extremely thin. Segments sub-opposite, mostly incised up to midrib, near base and apex a few may be partially fused showing only small indentations. Segments measuring 4-5 mm in length and 3-5 mm in width, lateral margins entire, distal margin with rounded corners, occasionally distal margin



TEXT-FIG. 19 — *Pterophyllum rajmahalense* Morris. Restoration of a leaf. *ca.* × 0.5 of estimated length.

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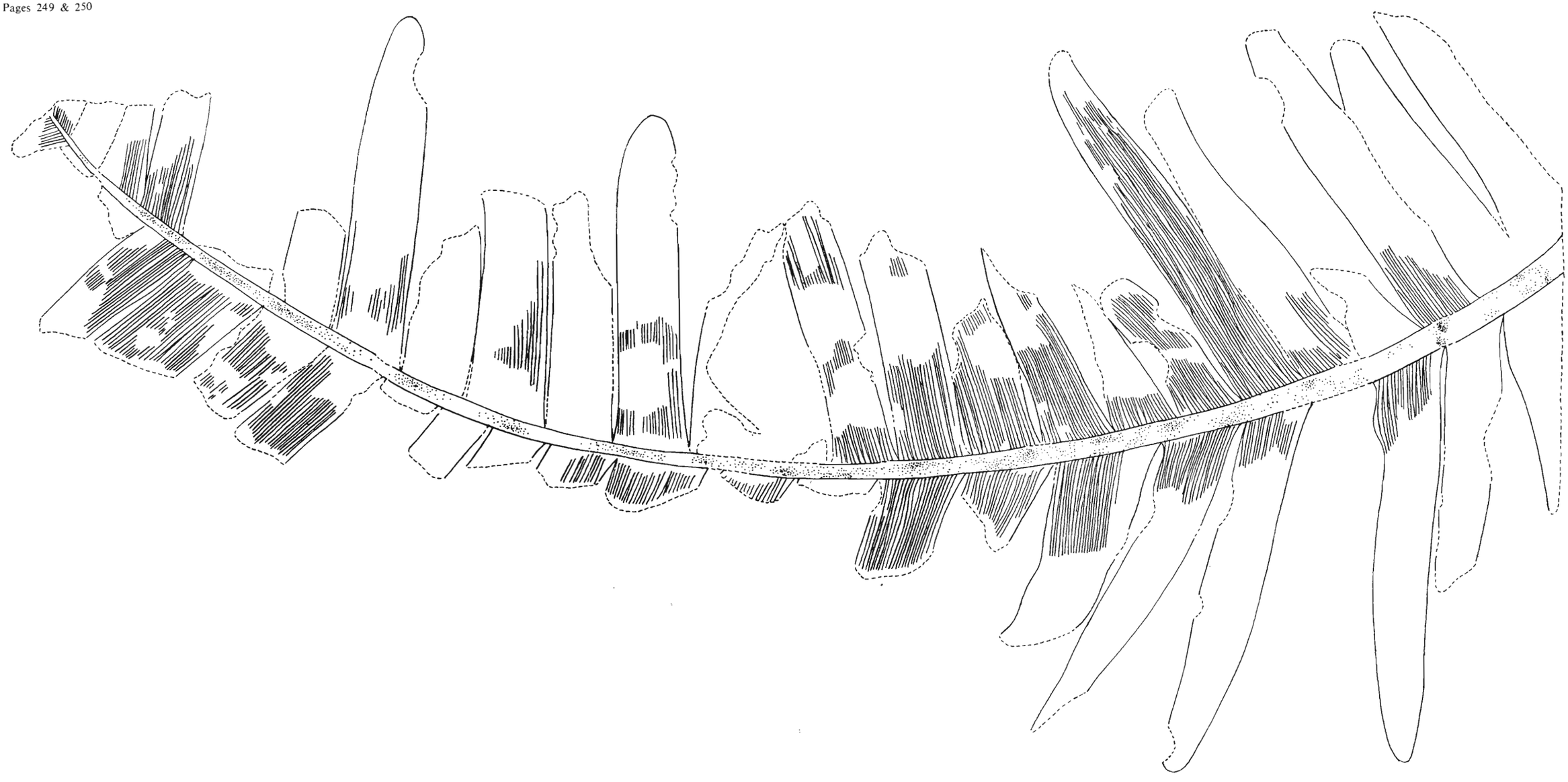


TEXT-FIG. 20 — *Pterophyllum morrisianum* Oldham from Bindaban, B.S.I.P. no. 35368, × 1.

slightly notched near middle, rarely wavy at places; acroscopic and basiscopic margins straight or sometimes slightly curved upwards and downwards. Veins arising at right angles, simple or forked, mostly just after emergence forking once, rarely closer to margin one of the arms may fork again.

Holotype — No. BSAI/Raj. A-B.D. Sharma collection, University of Jodhpur.

Occurrence — Balbhadri Hill (type locality), Burio and Amarjola in the Rajmahal Hills.

Remarks — The leaves from Amarjola are partially petrified. Under strong reflected light, the upper surface shows elongated cells along the veins and irregularly packed polygonal cells between veins. On the lower surface, at places, stomata are visible between veins, but their details are not clear. The ordinary epidermal cells on the lower surface, too, are polygonal.

Comparison — *Anomozamites amarjolense* differs from *A. crenata* in having segments of variable size and shape, also the secondary veins in the former species are occasionally forked. In external form *Nilssonia* cf. *schaumburgensis* (Dunker), figured by Glaessner and Rao (1955, pl. 12, fig. 8), agrees most *A. amarjolense*. However, the secondary veins in the former species have been shown to be simple. Some of the segments of *N. schaumburgensis* (?) Dunker described by Walkom (1919) are like the segments of *A. amarjolense*.

Anomozamites fissus Feistmantel

Pl. 2, figs 12, 13; Text-fig. 8A-C

1863 *Pterophyllum*?: Morris in Oldham & Morris, p. 25 (*partim*), pl. 12, fig. 5.

1877a *Pterophyllum fissum* Feistmantel, p. 61, pl. 39, figs 2-4.

1879 *Anomozamites fissus* Feistmantel, p. 18 (*partim*).

1886 *Anomozamites fissus* (Oldham & Morris) Feistmantel, p. 36.

1920 *Nilssonia fissa* (Feistmantel): Seward & Sahni, p. 32, pl. 4, fig. 39.

1933 *Nilssonia* (?*Anomozamites*) *fissa* Feistmantel): Sahni & Rao, p. 198, pl. 15, figs 27-29.

1946 *Nilssonia* (?*Anomozamites*) *fissa* (Feistmantel): Ganju, p. 70.

1963 *Nilssonia* (?*Anomozamites*) *fissa*: Sitholey, p. 19, pl. 7, fig. 45.

1969 *Anomozamites fissa* Feistmantel: Sharma, p. 117, pl. 1, fig. 2; text-fig. 2.

1970 *Nilssonia fissa* (Feistmantel): Gururaja & Pant, p. 387.

Emended Diagnosis — Leaf linear-lanceolate, imparipinnate, 5-12·5 cm long, 1·2-3 cm broad. Rachis 1-1·5 mm broad, showing fine striations in longitudinal direction. Lamina divided into segments of varied shape, at places lamina may not be dissected up to midrib, majority almost twice as long as broad, typically 0·7-1·3 cm long, 0·25-0·4 cm broad, smaller near base and apex; lateral margins entire; distal margin deeply notched, apical segment trident, the pair of segments lying just below the apical segment may or may not be notched, basal segments, too, may not be notched. Bases of segments mostly joined with each other. Veins simple or forked, majority forking little away from midrib.

Holotype — No. 4512 of the Geological Survey of India, Calcutta.

Occurrence — Burio (type locality), Basgo Bedo, Bindaban, Onthea and Amarjola in the Rajmahal Hills.

Comparison — The segments in *Anomozamites fissus* are mostly twice as long as broad. So in this aspect it differs from both *A. crenata* (McClelland) and *A. amarjolense* Sharma *et al.* Moreover, in *A. fissus* the majority of veins are dichotomising. *Anomozamites* sp. (?) described by Delle (1967, pl. 15, fig. 10) seems to have somewhat similar type of venation pattern as is seen in the present species, but its segments are not notched like *A. fissus*. The specimens of *Nilssonia lobatidentata* Vassilevskaja, described by Kimura and Sekido (1976a, b), have similar type of segments as *A. fissus*. The former species, however, differs in having segments attached over rachis and they have only simple veins.

On the whole *A. fissus* looks rather different from most species of *Anomozamites*. When its cuticle will be known it may prove to be a new genus.

Anomozamites hasnapurensis n. sp.

Pl. 14, fig. 57; Text-fig. 8H, I

1979 *Pterophyllum* sp.: Bose & Zeba Bano, p. 5, pl. 1, fig. 4; text-fig. 3A-D.

Diagnosis — Leaf linear lanceolate, largest available leaf 12 cm long and 2 cm broad;

rachis 2 mm wide. Segments alternate, sub-opposite or opposite, attached to rachis almost at right angles by entire base, size and shape of segments variable, mostly more or less squarish, rarely somewhat cuneate, 8-9 mm long and 7-8 mm broad; lateral margins straight, sometimes lower lateral margin curving upwards, distal margin mostly entire, rarely slightly notched, bases of adjacent segments mostly joined together. Veins 6-8 per segment, arising at an angle of 80°-85°, parallel, simple or forked, mostly forking once, forking at different levels.

Holotype — No. 29/1442 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — Near Hasnapur, district Narsinghpur, Madhya Pradesh.

TEXT-FIG. 21 — A-B, *Pterophyllum morrisianum* Oldham from Bindaban and Sakrigalighat, G.S.I. no. 4404 and B.S.I.P. no. 7/848, × 1.

Comparison — The specimens of *Anomozamites hasnapurensis*, in general shape and size of segments, may be compared with *A. minor* Brongniart described by Nathorst (1878). In *A. hasnapurensis* the secondary veins are mostly forked, whereas, in *A. minor* they are simple. *A. hasnapurensis* also resembles the narrower leaves of *A. minor* described by Harris (1932b, pl. 2, fig. 6) and Antevs (1919, pl. 4, figs 8, 17). *A. nitida* Harris (1932b, text-fig. 11F) has once forked veins but its segments are narrower and longer than *A. hasnapurensis*. Some of the leaves of *A. thomasi* Harris (1969, text-fig. 39A-F) are like *A. hasnapurensis*, but in the former the number of veins per segment and their frequency of branching is more.

Anomozamites haburensis n. sp.

Pl. 5, fig. 25; Pl. 10, figs 40, 43; Pl. 14, fig. 55; Text-fig. 9C, D

1976 *Pterophyllum* sp.: Maheshwari & Singh, p. 120, pl. 1, figs 3, 4; text-fig. 3.

Diagnosis — Leaf linear, segmented, estimated length of larger leaves 20-25 cm (largest available measuring 11 cm in length and 1·6 cm in breadth). Rachis 2-4 mm wide, gradually tapering towards apex, some with longitudinally running ridges on either sides. Segments attached to upper edges of rachis by their entire bases at angles of 65°-75°, alternate, distant or touching each other, of varied shape and size, shape as a whole rectangular, squarish or somewhat cuneate, typically 5-7 mm long and 4-7 mm broad (range noted 0·4-1·2 cm long and 0·4-1·2 cm broad) upper lateral margin straight, lower lateral margin straight up to about 2/3 length and then curving upwards to meet the distal margin, distal margin entire or occasionally notched, bases of segments mostly joined with each other. Veins arising at an angle of 65°-75°, reaching up to distal margin, majority simple, rarely forked, when forked mostly away from rachis, parallel, about 10-19 per cm (majority 10-12).

Holotype — No. 107/2095 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — About 1 km east of Habur, District Jaisalmer, Rajasthan.

Comparison — *Anomozamites haburensis* differs from *A. hasnapurensis* in having mostly simple veins. Also the segments in the latter species are more squarish. The segments of *A. inconstans* Schimper described by Saporta (1875, pl. 9, fig. 3) and *Pterophyllum* (*Anomozamites*) *inconstans* described by Du Toit (1927, pl. 25, fig. 1), are more longer than broad and they are more distantly placed than the present species. Besides, in the former two species veins are mostly forked. The segments of *Anomozamites* sp. described by Kimura (1959) are like some of the leaves from Habur. The veins in the former species are obscure. The smaller leaves of *A. nilssoni* (Phillips) described by Harris (1969) are like *Anomozamites haburensis*. However, the former differs in having forked veins.

Pterophyllum distans Morris

Pl. 4, fig. 19; Pl. 5, fig. 27; Text-figs 10A-C, 14A

1863 *Pterophyllum* (*Ctenis*) *distans* Morris: in Oldham & Morris, p. 18, pl. 9, fig. 3.

1863 *Pterophyllum hislopianum* Oldham: in Oldham & Morris, p. 19, pl. 9, fig. 1.

1870-72 *Pterophyllum distans* Morris: Schimper, p. 136.

1870-72 *Pterophyllum hislopianum* Oldham: Schimper, p. 136.

1877a *Pterophyllum distans* Morris: Feistmantel, p. 56.

1877a *Pterophyllum hislopianum* Oldham: Feistmantel, p. 57.

1933 *Pterophyllum* sp. α : Sahni & Rao, p. 194, pl. 13, fig. 17.

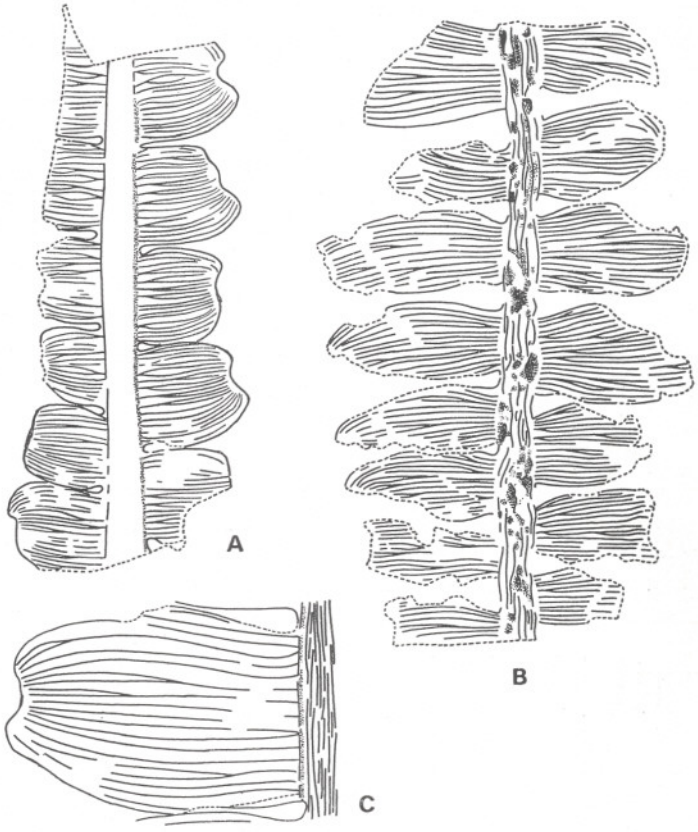
1933 *Pterophyllum* sp. β : Sahni & Rao, p. 194, pl. 13, fig. 18.

1969 *Nilssonia distanse* (Morris) Sharma, p. 115 (*partim*).

1974 *Pterophyllum distans* Morris: Bose, p. 190.

1979 *Pterophyllum* sp. cf. P. *distans* Morris: Bose & Zeba-Bano, p. 4, pl. 2, fig. 6; text-fig. 3E.

Emended Diagnosis — Leaf large, total length and shape as a whole unknown, width up to 12 cm in middle region, probably narrowing towards base and apex. Rachis 4-5 mm wide near middle region, nearer base 0·7 mm, gradually tapering towards apex, marked with fine longitudinal



TEXT-FIG. 22 — **A, B,** *Pterophyllum guptai* n. sp. from Sakrigalighat, B.S.I.P. no. 35114 and holotype, Gupta collection no. K154/Raj. Sak., × 1. **C,** a pinna showing venation, B.S.I.P. no. 35115, × 2.

striations. Pinnae laterally attached, opposite or sub-opposite, arising at an angle of about 80°-90° near middle, but less near apex. Pinnae not crowded, separated by a distance of about one-fourth to about their own width. Pinnae linear, 4-6·5 cm long, 2·5-5 mm wide near middle, diminishing gradually towards apex; apex acute or sub-acute; base slightly expanded, bases of adjoining pinnae mostly joining each other. Veins simple, 4-6 per segment, very rarely 8 or 9, parallel.

Lectotype — No. 4382 of the Geological Survey of India, Calcutta.

Occurrence:

Rajmahal Hills — Ghutiari (type locality), Bindaban, Butaha Pahar and Tetria Basti.

Godavari & Satpura basins — Jatamao, district Hoshangabad, Madhya Pradesh.

Kachchh — Kakadbhit.

Remarks — All the pinnae in the lectotype are incomplete and they are about 3 mm wide. The veins are mostly 4-5 in number and are simple. In the specimen described by Oldham (in Oldham & Morris, 1863, pl. 9, fig. 1) as *Pterophyllum hislopianum* the veins are indistinct and seem to be about 6 in number. *Pterophyllum* sp. α described by Sahni and Rao (1933), too, is incomplete but its pinnae are like the lectotype. Some of the pinnae in Sahni and Rao's specimen are up to 5 mm wide. The other specimen described by Sahni and Rao (1933) as *Pterophyllum* sp. β is rather imperfectly preserved. The pinnae in this specimen are slightly more closely placed, occasionally even touching each other. Veins are 4-5 in number.

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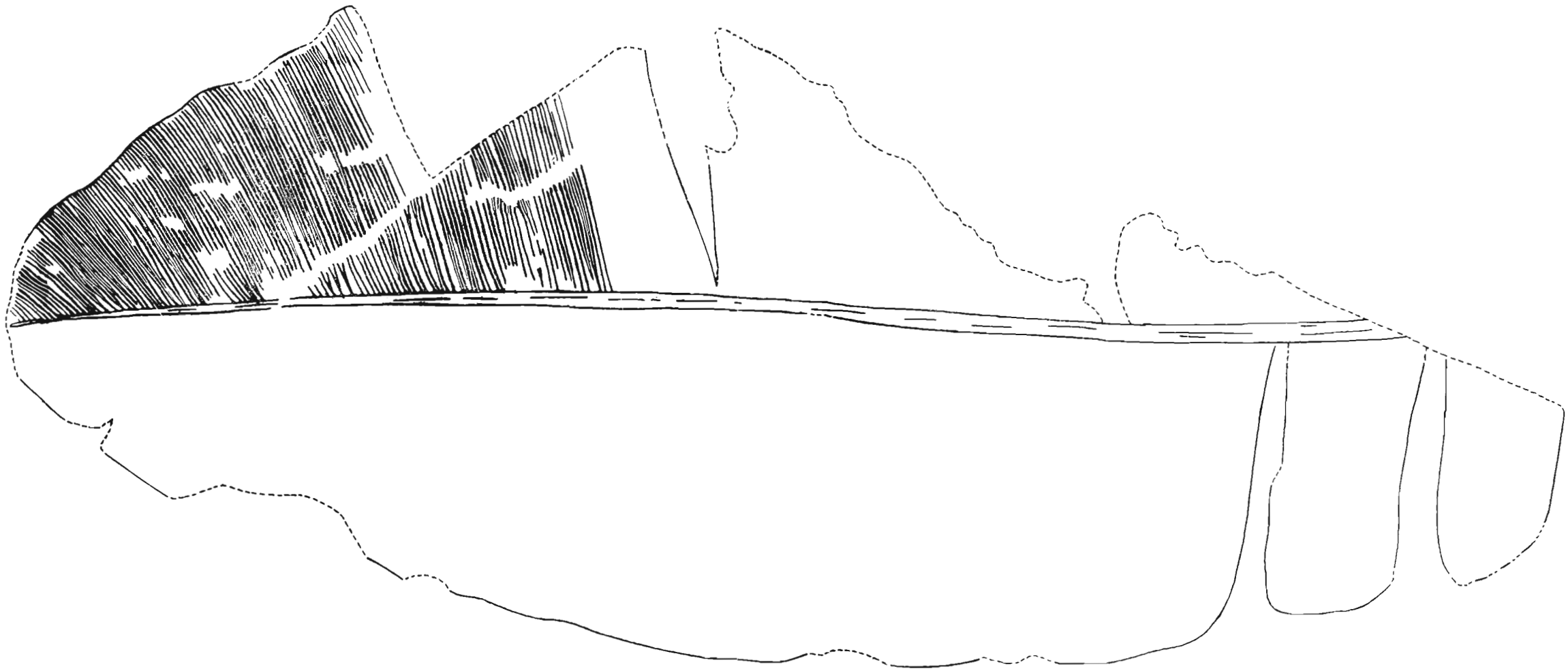
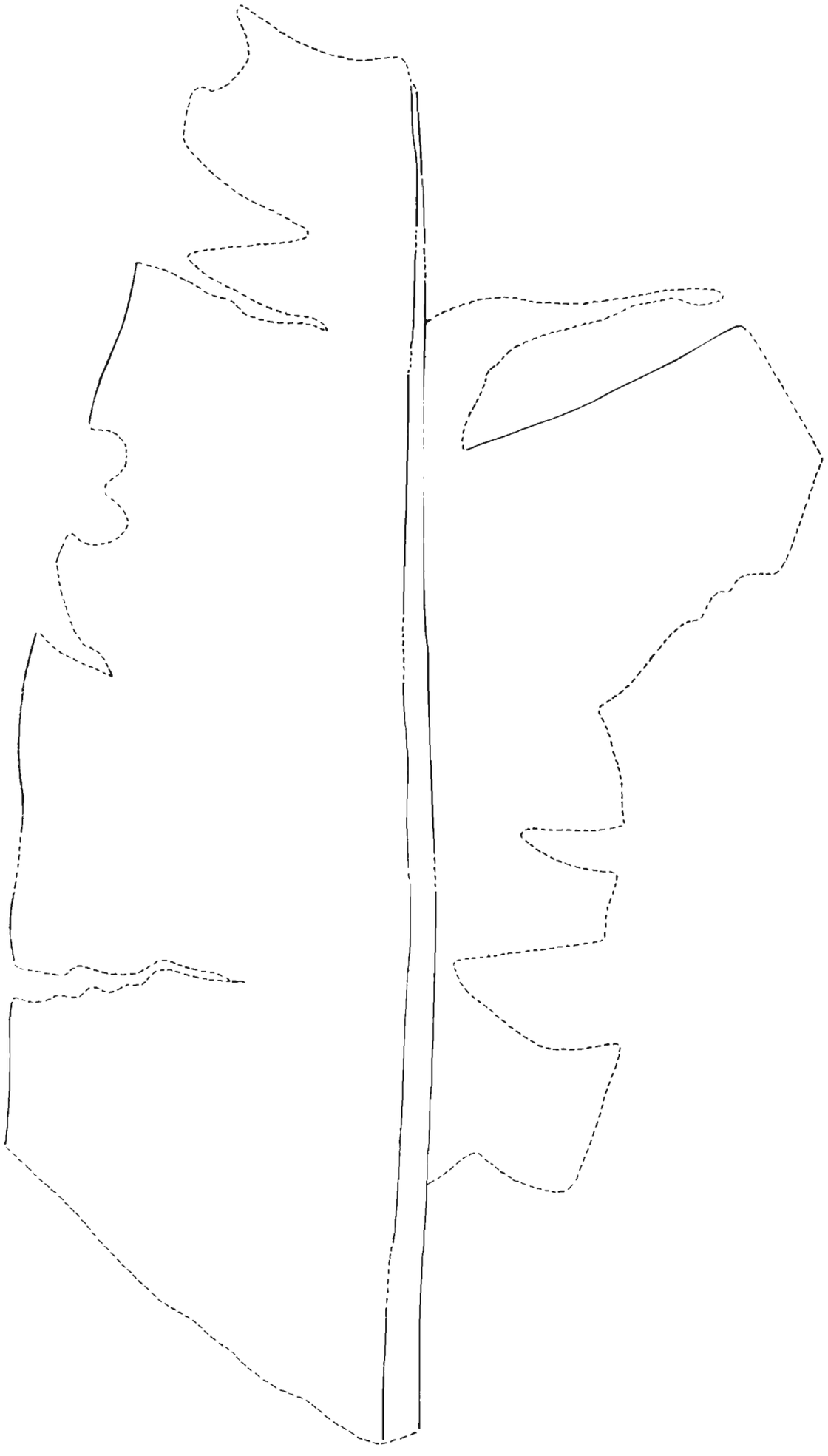


TEXT-FIG. 23 — *Pterophyllum princeps* Oldham & Morris from Bindaban, showing apical portion of a leaf and a few segments lying below, B.S.I.P. no. 31125/422, × 1.



TEXT-FIG. 24 — *Pterophyllum princeps* Oldham & Morris from Bindaban, showing apical portion of a frond (the specimen was originally described as *Taeniopteris lata* Oldham & Morris, 1863), G.S.I. no. 4350, × 1.

The best preserved specimens of *P. distans* have been collected from Kakadbhit, Kachchh. The pinnae have mostly 5-6 veins. In very rare cases veins may be up to 8 or 9 in number. The pinnae are fairly uniform in width, rarely in the same frond a few may be slightly wider or narrower. In general habit they are indistinguishable from the Rajmahal specimens.

Recently, an incomplete specimen has been described as *Pterophyllum* sp. cf. *P. distans* Morris by Bose and Zeba-Bano (1979) from Jatamao, district Hoshangabad, Madhya Pradesh. The specimen seems to be an apical part of a frond of *P. distans*. The pinnae here are attached at 50°-60° and they have simple, parallel running veins which are 4-5 in number.

Comparison — *Pterophyllum distans* resembles most *P. validum* Hollick (1930) in external features as well as venation pattern. The latter species has 6 veins in each pinna which do not bifurcate. The pinnae of *P. nathani* Walkom (1924) described from Bellevue, Australia and *P. subaequale* Hartz described by Kawasaki (1939) from Korea look more like the pinnae of *P. distans*. Like the present species they, too, have few veins. However, in the former two species the veins occasionally fork. *P. jaegeri* Brongniart, described by Ôishi (1932), has 12 veins in each pinna, otherwise, externally it resembles some of the present specimens. In the other species, viz., cf. *P. distans* Morris, also described by Ôishi (1932), the veins are not clear, but the pinnae are like the Indian specimens. In gross features, *P. ishpushtanum* Jacob & Shukla (1955) resembles the specimens from Kakadbhit, but it has 12-14 veins which bifurcate near base. In *P. barrealense* Frenguelli (1950) the distance between adjacent segments is much more than *P. distans*. The pinnae of *P. raripinnatum* Doludenko & Svanidze (1969) are like *P. distans* but they are more distantly placed. Superficially *P. thomasi* Harris (1952, 1969) shows some resemblance with *P. distans*. The pinnae in the former species, however, have a few forked veins. *P. angustum* (Braun), described by Yabe and Ôishi (1929), has narrower pinnae, but it has simple veins (5-6) like *P. distans*.

Pterophyllum kingianum Feistmantel

Pl. 14, figs 51, 52; Text-figs 6D, 11, 12A, B

1877b *Pterophyllum morrisianum* Oldh.: Feistmantel, p. 13, pl. 3, fig. 2; pl. 4, fig. 2; pl. 6, fig. 2.
1877b *Pterophyllum distans* Morris: Feistmantel, p. 14, pl. 5, fig. 1; pl. 6, fig. 1.
1877b *Pterophyllum carterianum* Oldham: Feistmantel, p. 14; pl. 3, fig. 3; pl. 5, fig. 2.
1877b *Pterophyllum kingianum* Feistmantel, p. 15, pl. 3, fig. 1; pl. 4, fig. 1.
1974 *Pterophyllum kingianum* Feistmantel: Bose, p. 190.

Emended Diagnosis — Frond as a whole ovate, maximum available length 27·3 cm (perhaps exceeding 70 cm in length) and breadth 16·4 cm. Rachis fully exposed, showing fine longitudinal striations, at places with transverse ridges, maximum available width 0·6 cm, gradually narrowing towards apex (1·5 mm). Pinnae alternate or subopposite, very rarely opposite, attached to rachis at angles of 60°-75°, near apex arising at an angle of 55°; 5-8 cm long (near apex less), 4·5-7 mm broad, straight or slightly falcate; margins parallel; apex sub-acute; both acroscopic and basiscopic margins curving upwards and downwards, joining the bases of pinnae lying above and below. Veins indistinct, 7-10 in number, simple, parallel.

Lectotype — No. 4566 of the Geological Survey of India, Calcutta.

Occurrence — Gollapalle, East Coast Gondwana.

Rajmahal Hills — Chunakhal.

Comparison — *Pterophyllum kingianum* differs from *P. distans* in having more upwardly inclined pinnae and in having 7-10 veins per pinna. The segments in *P. irregulare* Nathorst (1878-86) are incomplete and they have 4-15 veins. In external form *P. validum* Hollick (1930) resembles *P. kingianum*, but the former has pinnae with only 6 veins. The broader segments of *P. kingianum* are like *P. inconstans* Göppert described by Kryshtofovich (1933). The latter species, however, differs in having finer veins.

Pterophyllum footeanum Feistmantel

Pl. 4, fig. 20; Pl. 6, fig. 30; Text-figs 13A-C, 14B

1879 *Pterophyllum footeanum* Feistmantel, p. 19, pl. 6, figs 1-6; pl. 8, fig. 1; pl. 16, fig. 9.

TEXT-FIG. 25 — **A,** *Pterophyllum princeps* Oldham & Morris from Bindaban showing basal part of a leaf, G.S.I. no. 4387, × 1. **B, C,** *P. princeps* from Bindaban showing two apical segments, G.S.I. nos. 4363 and 4357, × 1.

1879 *Zamites proximus* Feistmantel, p. 20, pl. 7, figs 1-3.
1917 *Pterophyllum footeanum*: Seward, p. 557.
1920 *Pseudoctenis footeana* (Feist.) Seward & Sahni, p. 33, pl. 4, fig. 40.
1963 *Pseudoctenis footeana*: Sitholey, p. 21, pl. 7, fig. 49.

Emended Diagnosis — Leaf shape and size unknown, largest leaf measuring 13·8 cm in length, breadth up to 15 cm. Rachis 0·4-0·9 cm wide, fairly thick even near apex (2·5 mm), striated in longitudinal direction, both the edges showing a fine ridge. Pinnae attached to rachis at an angle of 40°-60°, distantly placed (1·5-4 mm apart), 5·2-6·8 cm long, 3-4·5 mm broad; margin entire, parallel along major part of frond, in some little above base slightly contracted; apex bluntly acute or obtuse, acroscopic margin curving upwards and joining the base of the pinna above; basiscopic margin decurrent, base slightly expanded. Veins 6-9 (mostly 8-9), rarely 10 near middle region, parallel, simple or forked, when forking mostly nearer base.

Lectotype — No. 4658 of the Geological Survey of India, Calcutta.

Occurrence — Vemavaram, East Coast Gondwana.

Remarks — In majority of the specimens the pinnae apices are missing and the veins are not so well preserved. The specimens of *Zamites proximus* resemble the specimens originally described as *Pterophyllum footeanum* Feistmantel (1879) in general shape of pinnae and venation pattern. This was also observed by Seward and Sahni (1920). Feistmantel's (1879) figures in Pl. 6, fig. 2 and Pl. 6, fig. 3 are part and counterpart. Similarly figs 1 and 2 in Pl. 7 (Feistmantel, 1879) are part and counterpart.

Comparison — *Pterophyllum footeanum* is distinguished from both *P. distans* and *P. kingianum* by its pinnae which have both simple and forked veins. In *P. kingianum* pinnae bases are not expanded. *P. georgiense* Doludenko & Svandize (1969) shows only superficial resemblance with *P. footeanum*. It differs in having fewer number of veins. The pinnae of *P. longifolium* Brongniart, described by Compter (1874), are much longer than *P. footeanum*. *Pseudoctenis lanei* Thomas (1913, pl. 26) matches with some of the specimens of *P. footeanum*, but according to Harris (1964) in *P. lanei* concentration of veins in middle of pinna is about 17 per cm. Likewise, *P. weberi* (Seward) Prynada, described by Delle (1967), differs in having pinnae with more veins.

Pterophyllum sp.

Pl. 6, fig. 31; Text-fig. 1J

Description — Specimen incomplete, measuring 8·5 cm in length and 2·8 cm in width. Major part of rachis 1·5 mm wide, near base 2 mm in width, with fine longitudinal striations. Pinnae incomplete, largest pinna 1·7 cm long and 0·3 cm broad; apices not preserved; margin parallel, entire; acroscopic margin straight or bending upwards; basiscopic margin slightly decurrent. Pinnae attached to rachis at an angle of 85°-90°. Veins 6-8, majority forking once.

Collection — No. 16779 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — Khatangi Hill, Rajmahal Hills, Bihar.

Comparison — In *Pterophyllum* sp. not a single pinna is complete and the pinnae are characterized by forked veins. From this latter character alone *Pterophyllum* sp. can be distinguished from the previous three species. *P. andraeanum* Schimper, described by Johansson (1922), looks like *Pterophyllum* sp. but it has more veins in each pinna.

Pterophyllum medlicottianum Oldham & Morris

Pl. 6, fig. 32; Pl. 7, fig. 34; Text-figs 15, 16A-D

1863 *Pterophyllum* (*Podozamites*) *medlicottianum* Oldham & Morris, p. 21, pl. 15, fig. 3; pl. 17, fig. 1.
1870-72 *Anomozamites medlicottianum* (Oldham *et* Morris): Schimper, p. 142.
1877a *Pterophyllum medlicottianum* Oldham & Morris: Feistmantel, p. 59, pl. 43, fig. 2; pl. 44, fig. 1.
1920 *Nilssonia medlicottiana* Morris: Seward & Sahni, p. 31, pl. 5, figs 43, 43a.
1933 *Podozamites* sp.: Sahni & Rao, p. 202, pl. 16, fig. 35.
1947 *Podozamites* sp.: Ganju, p. 76.
1969 *Nilssonia medlicottiana* (Oldham) Sew. & Sahni: Sharma, p. 118.

1974 *Pterophyllum medlicottianum* Oldham & Morris: Bose, p. 190.

1979 *Pterophyllum medlicottianum* Oldham & Morris: Bose & Zeba-Bano, p. 3, pl. 2, fig. 7; text-fig. 2A, B.

Emended Diagnosis — Leaf large (largest leaf possibly over 1 m in length), width 19 cm at broadest region, broadly elliptic or ovate. Rachis fully exposed, furrowed, 1·4 cm wide. Pinnae laterally attached, arising from rachis at angles of 75°-90°, less near apex, closely set; pinnae touching each other or slightly distantly placed, about 7-10 cm long and 1-1·2 cm wide near middle, may be smaller near apex and base. Pinnae of the same leaf mostly of equal width, rarely showing variation in width; apex obtuse, base slightly expanded, rarely contracted. Veins 5-9, mostly 7, rarely up to 17, simple, channelled, parallel.

Lectotype — No. 4525 of the Geological Survey of India, Calcutta.

Occurrence:

Rajmahal Hills — Bindaban (type locality) Ghutiari, Murrero and Onthea.

Satpura Basin — Imjhiri, about 6 km South of Bachai Rest House, Narsinghpur District.

Remarks — Both the figured specimens of Oldham and Morris (1863, pl 15, fig 3; pl. 17, fig. 1) are at present not available. So the lectotype has been made out of the specimens described by Feistmantel (1877, pl. 43, fig. 2).

Most of the Rajmahal specimens are rather fragmentary. None of them represent the basal portion. However, one specimen (Pl. 7, fig. 34) seems to belong to the apical region. From the nature of veins it seems that the substance of lamina was tough and coriaceous. The veins in the Rajmahal specimens are prominently channelled, they are 6-9 in number.

The specimens from Imjhiri show a great variation in pinna size and shape. The most complete specimen has been figured in Text-fig. 15. The specimen seems to belong to an apical part of a leaf and its pinnae are narrower than the Rajmahal specimens. But the number of veins are almost same as present in the Rajmahal specimens, viz., 5-8. In the Imjhiri specimens width of pinna varies from 0·3 to 1·8 cm. The leaves with narrow pinnae have 4-5 veins.

Comparison — *Pseudoctenis ensiformis* Halle (1913) and *P.* cfr. *medlicottiana* (Oldham & Morris), described by Halle (1913), resemble most *P. medlicottianum* both in the shape of segments and venation pattern. In all these the secondary veins are channelled. However, the former two species differ in having both simple and forked veins. Like *P. medlicottianum* the secondary veins are coarse in *P. matauriensis* Hect. described by Arber (1917) from New Zealand. The latter differs in having a few forked secondary veins. The broader segments of *P. medlicottianum* (Text-fig. 16C) are like *Zamites* cf. *takuraensis* Walkom described by McQueen (1956). Both the species have simple, channelled veins. The narrower segments of the present species (Text-fig. 16D) are more like *Pterophyllum* sp. described by Menendez (1966) from Tico, Santa Cruz Province, Argentina. *Sinoctenis grabaniana* Sze (1931) and *Pterophyllum ctenoides* Ôishi (1932) show superficial resemblance with the present species but these differ in having segments with a few forked lateral veins.

Pterophyllum rajmahalense Morris

Pl. 7, fig. 35; Pl. 8, fig. 38; Pl. 13, fig. 50; Text-figs 17, 18A-D, 19

1863 *Pterophyllum rajmahalense* Morris: in Oldham & Morris, p. 25, pl. 13, figs 3-5; pl. 14, figs 1-3.

1863 *P.* (*Podozamites*) *rajmahalense*, var. *latum* Morris: in Oldham & Morris, p. 25, pl. 18, fig. 2.

1870-72 *Pterophyllum rajmahalense* Morris: Schimper, p. 136.

1876b *Pterophyllum rajmahalense* Morris: Feistmantel, p. 36.

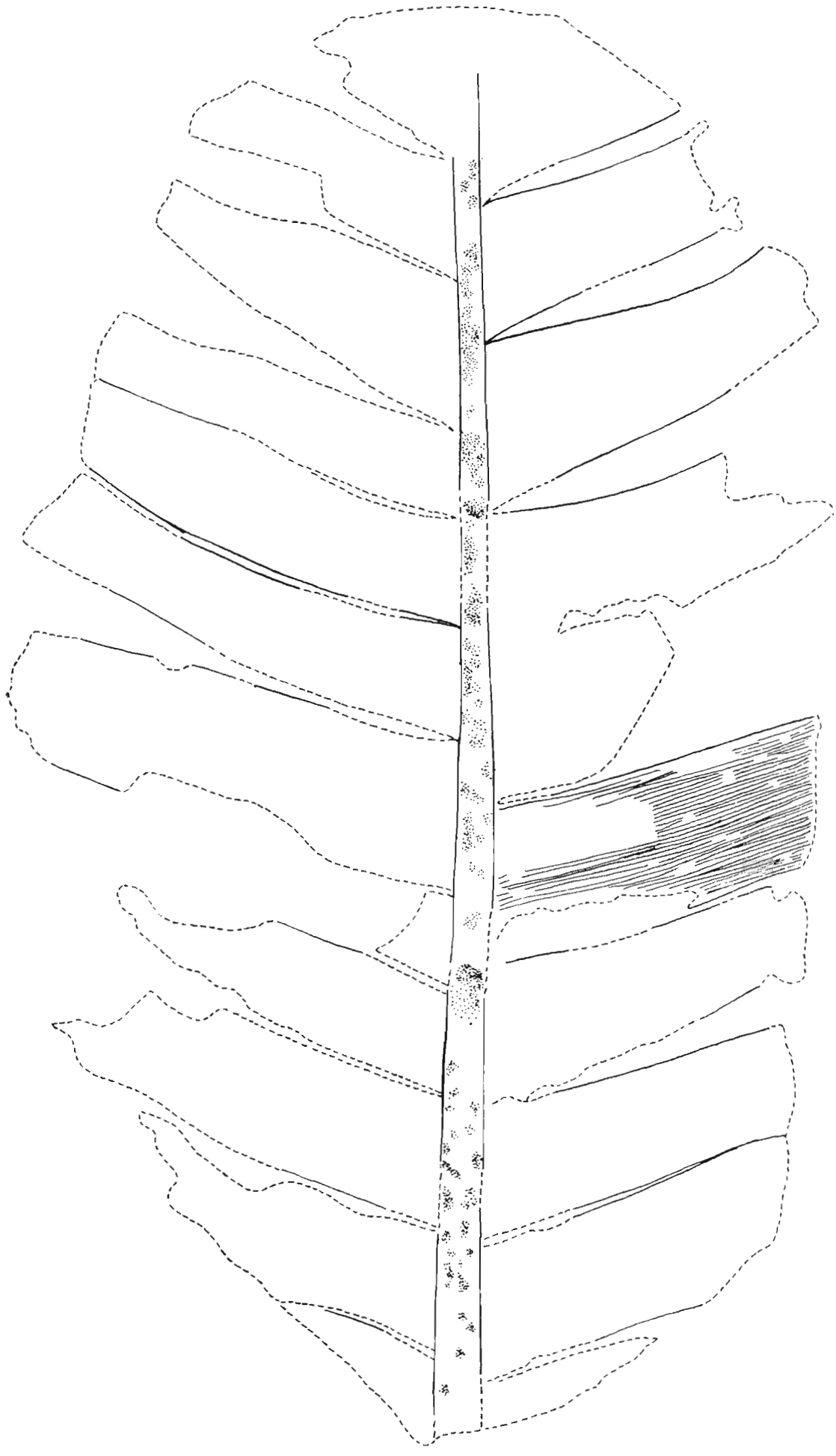
1877a *Pterophyllum rajmahalense* Morris: Feistmantel, p. 58.

1920 *Nilssonia bindrabanensis* Seward & Sahni, p. 31, pl. 3, figs 31, 32.

1963 *Nilssonia bindrabanensis* Seward & Sahni: Sitholey, pl. 4, figs 24, 25.

1969 *Nilssonia bindrabanensis*: Sharma, p. 118.

Emended Diagnosis — Leaf as a whole oblanceolate, lamina tapering more gradually below, apex obtuse or rounded, length probably exceeding 45 cm (largest available leaf 29·2 cm in length), width about 4-13 cm. Rachis broad, near base 0·4-0·9 cm, gradually narrowing towards apex, showing prominent ridges and grooves. Pinnae at-



TEXT-FIG. 26 — *Pterophyllum princeps* Oldham & Morris from Bindaban showing apical segments which are also like the ones met with near middle region, G.S.I no. 4546, × 1.

tached on upper edges of rachis by their entire base, arising almost at right angles, rarely towards apex arising at an angle of 80°-85°, opposite or sub-opposite, closely set, almost touching each other. Pinnae mostly 2-5·3 cm long (typically 3-4 cm), 0·8-1·2 cm wide, near base pinnae much smaller (6-8 mm long, 3-5 mm wide); apex obtusely rounded; margin parallel; both acroscopic and basiscopic margins truncate or slightly bending upwards or downwards respectively, they may even be slightly constricted. Veins mostly simple, very rarely forking near base, running parallel up to distal margin, closely set, about 15-25 per pinna, in narrower and basal pinnae 10-14 in number.

Lectotype — No. 4399 of the Geological Survey of India, Calcutta.

Occurrence—Bindaban (type locality), Onthea and Burio in the Rajmahal Hills, Bihar.

Restoration — The restoration shown in Text-fig. 19 is based on specimens figured in Text-fig. 17 (B.S.I.P. no. 28312) and Text-fig. 18A, B (B.S.I.P. no. 2830/303).

Comparison — The pinnae of *Pterophyllum rajmahalense* are smaller and more closely set than those of *P. morrisianum*. The veins in the former are mostly simple, whereas, in the latter the veins occasionally bifurcate. *P. rajmahalense*, described by Knowlton (1916) from Alaska, has pinnae like the basal pinnae of the Indian specimens. Unfortunately, the specimen from Alaska is imperfectly preserved and does not allow detail comparison. *P. portali* Zeiller, described by Sze (1949, pl. 6, fig. 6), agrees with *P. rajmahalense* in gross features, but its pinnae are smaller in size. Externally, *P. kalawchiensis* Barnard (1967, 1970) looks like *P. rajmahalense*, but it differs in having more forked veins. Though the pinnae of *P. vamanoiensis* Ôishi & Takahasi (1936), in gross features, resemble the smaller pinnae of *P. rajmahalense*, yet it differs from the latter in having pinnae which have mostly dichotomising veins. In overall shape *P. astartense* Harris (1932b, figs 20C, D, 211) looks like *P. rajmahalense*, but it has veins which dichotomise more frequently.

Pterophyllum morrisianum Oldham

Pl. 9, fig. 39; Pl. 14, fig. 54; Text-figs 20, 21A, B

1863 *Pterophyllum* (*Ctenis*) *falconerianum* Morris: in Oldham & Morris, pl. 15, fig. 2; pl. 16, figs 1, 3.

1863 *Pterophyllum morrisianum* Oldham: in Oldham & Morris, p. 20, pl. 15, fig. 1; pl. 17, fig. 2.

1863 *Pterophyllum carterianum* Oldham: in Oldham & Morris, p. 22, pl. 15, fig. 4; pl. 18, fig. 1.

1863 *Pterophyllum crassum* Morris: in Oldham & Morris, p. 24, pl. 16, fig. 2.

1869 *Anomozamites morrisianus* (Oldham): Schimper, p. 143.

1876 *Pterophyllum morrisianum* Oldham: Feistmantel, p. 40.

1876 *Pterophyllum carterianum* Oldham: Feistmantel, p. 40.

1877a *Pterophyllum falconerianum* Morris: Feistmantel, p. 57.

1877a *Pterophyllum carterianum* Oldham: Feistmantel, p. 57.

1877a *Pterophyllum propinquum* Göppert: Feistmantel, p. 58.

1877a *Pterophyllum morrisianum* Oldham: Feistmantel, p. 59, pl. 42, fig. 1.

1920 *Nilssonia morrisiana* Morris: Seward & Sahni, p. 30, pl. 5, fig. 44.

1933 *Nilssonia morrisiana* (Oldham & Morris): Sahni & Rao, p. 198.

1938 *Nilssonia morrisiana* Oldham: Jacob, p. 153.

1946 *Nilssonia morrisiana* (Oldham & Morris): Ganju, p. 71.

1963 *Nilssonia rajmahalensis*: Sitholey, pl. 6, fig. 39.

1969 *Nilssonia distanse* (Morris): Sharma, p. 115, pl. 1, fig. 3; text-fig. 3.

1970 *Nilssonia morrisiana* Oldham: Gururaja & Pant, p. 387.

Emended Diagnosis — Leaf large, length possibly exceeding 60 cm, largest available leaf measuring 42 cm in length and 20·4 cm in breadth, substance of lamina thick. Rachis fully exposed, fairly wide (maximum available width 0·6 cm), gradually narrowing towards apex, longitudinally striated. Pinnae laterally attached, along major part of lamina about 6-12·6 cm long, 1·2-2·7 cm broad (in rare cases 2·9-3·3 ×0·6 cm), towards base and apex gradually diminishing in size; lateral margins slightly thickened, gradually narrowing towards apex. Apex obtuse; both acroscopic and basiscopic margins slightly curving upwards and downwards, mostly joining the pinnae bases above and below, occasionally acroscopic and basiscopic margins straight and attached to rachis by entire pinna base. Veins mostly

simple, when forking mostly once, rarely twice, parallel, veins of middle region running up to apex, mostly 17-19 per cm near middle region of pinna, forking just after emergence or at different levels, mostly forking closer to rachis.

Lectotype — No. 4401 of the Geological Survey of India, Calcutta.

Occurrence — Bindaban (type locality), Sakrigalighat and Onthea in the Rajmahal Hills, Bihar.

Comparison — Superficially *Pterophyllum morrisianum* resembles most *P. tietzei* Schenk (1887) and also the specimens figured by Sze (1949), Barnard (1965) and Corsin and Stampfli (1977) as *P. tietzei*. The former differs in having longer pinnae with obtuse apices. The majority of the veins in *P. tietzei* dichotomise closer to rachis. The pinnae and venation pattern in *P. aequale* (Brongniart) Nathorst, described by Johansson (1922), are more like *P. morrisianum*. In P. *aequale* the pinnae are not complete. The pinnae of *P. propinquum* Göppert, described by Antevs (1919) and Stiplanicic and Bonetti (1965) are smaller in size than the pinnae of *P. morrisianum*. In general form of leaves, *P. magnum* Doludenko & Svanidze (1969) looks somewhat like *P. morrisianum*. The former, however, differs in having narrower pinnae which are more distantly placed. The pinnae of *Sinoctenis yunnanensis* Chuan (in Chuan, Yao & Ching, 1976) are very similar to those of *P. morrisianum*. However, in the former species the pinnae are attached on the upper surface of rachis. *Zamites* cf. *rajmahalensis*, described by Du Toit (1927), has longer pinnae than *P. morrisianum* and also the former has mostly simple veins.

Pterophyllum guptai n. sp.

Pl. 8, figs 36, 37; Pl. 11, fig. 45; Pl. 14, fig. 53; Text-fig. 22A-C

1969 *Nilssonia sahnii* Gupta, p. 271, pl. 1, fig. 1; text-figs 2-4.
1969 *Nilssonia sahnii* Gupta: Sharma, p. 118.
1974 *Pterophyllum sahnii* (Gupta) Bose, p. 190.

Diagnosis — Pinnate leaf having a broad rachis. Largest available specimen measuring 18·8 cm in length and 5·4 cm in breadth. Rachis finely striated in longitudinal direction, width about 6 mm. Pinnae attached on upper edges by their entire base, closely set, sometimes touching each other, bases of adjoining pinnae distant or occasionally in contact with each other. Pinnae 1·1-3·7 cm long, 1·2-1·7 cm wide, apex notched. Veins arising from base, parallel, near apex converging, simple or forked, forking just after emergence or at different levels, mode of bifurcation varying from pinna to pinna, about 15-17 per cm.

Name — The specific name is after Prof. K. M. Gupta. The name *sahnii* has been replaced because Lele (1955) has already described a species as *Pterophyllum sahnii*.

Holotype — No. K154/Raj. Sak. (collection — Dr K.M. Gupta, Jai Vilas, 5B, Mayur, Alwar Gate, Ajmer, Rajasthan).

Occurrence — Sakrigalighat, Rajmahal Hills, Bihar.

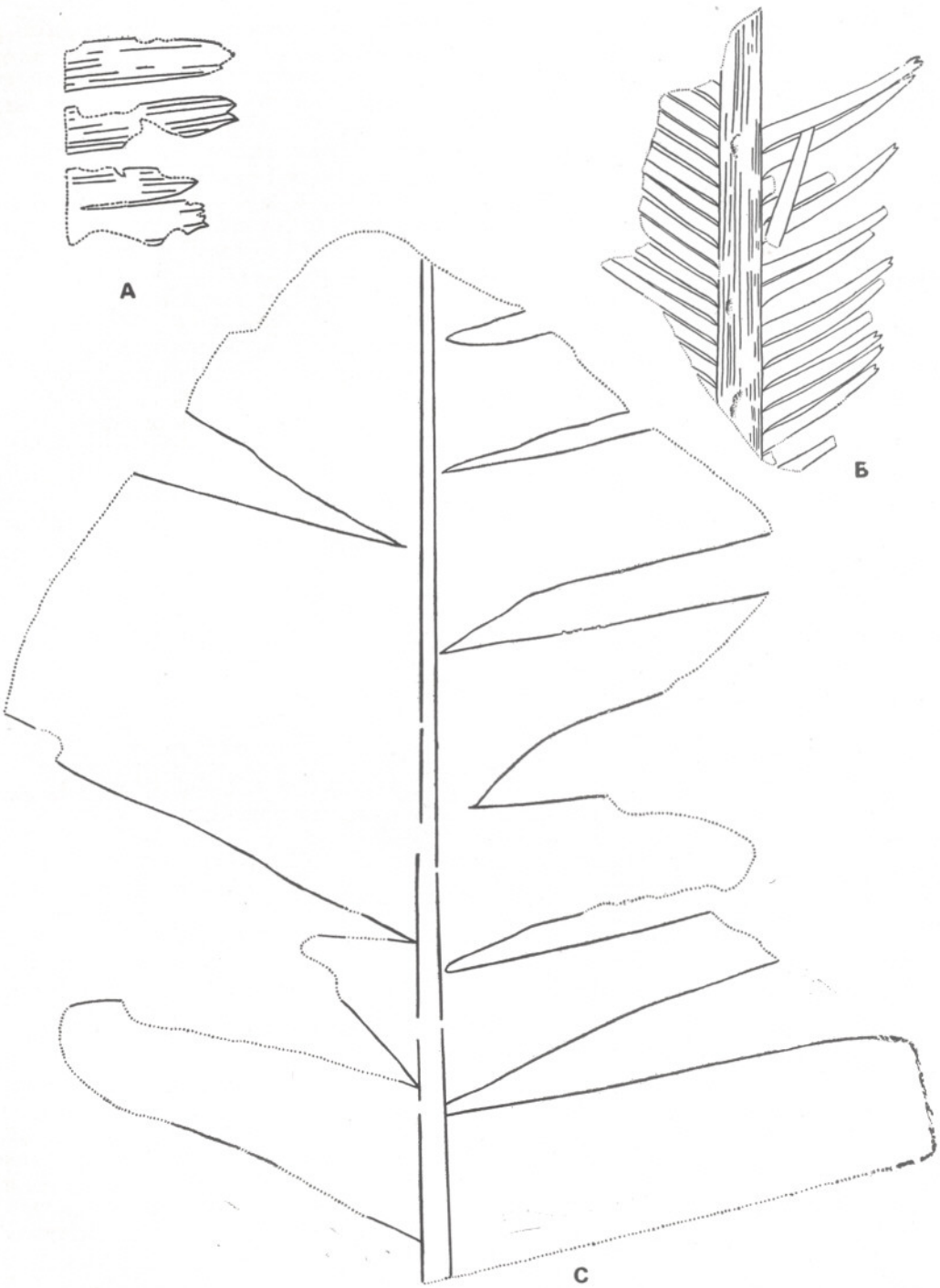
Comparison — In venation pattern *Pterophyllum guptai* is closest to *P. morrisianum* Oldham. Concentration of veins and mode of forking in the two are similar. But for the notched apex the specimen with the largest pinna (Pl. 14, fig. 53) is indistinguishable from the smaller pinnae of *P. morrisianum*. *P. guptai* has been collected from Sakrigalighat, where *P. morrisianum* is extremely common (next to *Ptilophyllum acutifolium* type of leaf). It is interesting to note that in all the specimens of *P. guptai*, so far collected, the rachis is fairly broad (about 6 mm), whereas, the rachis in *P. morrisianum*, from the same locality, is mostly less than 5 mm in width. It is not unlikely that *P. guptai* is only a basal portion of *P. morrisianum*. But till we find more intermediate forms like the one figured in (Pl. 14, fig. 53) and some bigger forms we prefer to keep *P. guptai* separate from *P. morrisianum*. In *P. guptai* the pinnae apices may have got notched during the early stages of development. The notch is not so regular because in some the pinnae are notched near middle region of distal margin, while in others notches are slightly below or above middle region.

In pinnae size, *P. guptai* comes closest to some of the smaller pinnae of *P. rajmahalense* (Text-fig. 18A, B).

Pterophyllum princeps Oldham & Morris

Pl. 12, fig. 47; Pl. 11, figs 41, 42; Pl. 14, fig. 56; Text-figs 8J, 23, 24, 25A-C, 26, 27C, 28, 29

1863 *Taeniopteris lata* Oldham: in Oldham & Morris, p. 41, pl. 1, fig. 1; pl. 2, fig. 1; pl. 3, fig. 2; pl. 5, figs 1, 2.



TEXT-FIG. 27 — **A,** *Pterophyllum incisum* Sahni & Rao probably from Butaha Pahar showing incised tips of pinnae and their venation pattern, no. 129 of the Botany Department, University of Lucknow, × 1.5. **B,** *Pterophyllum incisum* Sahni & Rao from Vemavaram, B.S.I.P. no. 8108, × 1. **C,** *Pterophyllum princeps* Oldham & Morris from Bindaban showing great variation in size and shape of segments. In this specimen the margins of the segments are incurved, G.S.I. no. 4389, × 1.

1863 *Taeniopteris musaefolia* Oldham: in Oldham & Morris, p. 42, pl. 4, figs 1, 2.
1863 *Pterophyllum princeps* Oldham & Morris, p. 23, pl. 10, figs 1-3; pl. 11, figs 1, 2; pl. 12, fig. 1; pl. 13, figs 1, 2.
1863 *Pterophyllum* (*Ctenis*) *princeps* var. *curta* Oldham & Morris: p. 23, pl. 11, fig. 2.
1876 *Anomozamites princeps* Schimper, p. 142.
1877a *Macrotaeniopteris lata* Oldham & Morris sp.: Feistmantel, p. 47, pl. 43, fig. 1.
1877a *Pterophyllum crassum*, Morris: Feistmantel, p. 57.
1877a *Pterophyllum princeps* Oldham & Morris: Feistmantel, p. 60, pl. 47, fig. 1.
1917 *Nilssonia princeps* (Oldham & Morris): Seward, p. 576, fig. 623.
1920 *Nilssonia princeps* Oldham & Morris: Seward & Sahni, p. 29, pl. 3, fig. 33; pl. 4, figs 35-38; text-fig. 5.
1931 *Nilssonia princeps*: Sahni & Rao, p. 198, pl. 15, fig. 30.
1934 *Nilssonia princeps* (Oldham & Morris) Sahni & Rao, p. 264, text-fig. 5.
1946 *Macrotaeniopteris lata* Oldham & Morris sp.: Ganju, p. 70, pl. 5, figs 29, 30; text-fig. 9.
1946 *Nilssonia princeps* (Oldham & Morris): Ganju, p. 71.
1963 *Nilssonia princeps* (Oldham & Morris) Seward: Sitholey, p. 71, pl. 6, fig. 34.
1965 *Macrotaeniopteris lata* (O. & M.) Feistm.: Sah, p. 219, pl. 1, fig. 9.
1969 *Nilssonia crassum* Morr.: Sharma, p. 116 (*partim*), pl. 1, fig. 1.
1974 *Pterophyllum princeps* Oldham & Morris: Bose, p. 190.
1981 *Pterophyllum princeps* Oldham & Morris: Jana & Bose, p. 43, pl. 1, figs 4, 5; text-fig. 1B, C.

Emended Diagnosis — Leaf as a whole broadly ovate, estimated length 55-60 cm, breadth 14-18 cm. Rachis near base 0·7-1 cm wide, near middle 0·4-0·6 cm, gradually narrowing towards apex, longitudinally striated, mostly slightly grooved, lower part devoid of segments. Lamina attached laterally or on upper edges of rachis, substance of lamina seems to be thick and leathery, segmented. Segments alternate, opposite or sub-opposite, much varied in shape and breadth, lateral margins entire, sometimes incurved; rarely distal margin at places with minute teeth. Apical segment triangular in shape, occassionally largest in size, largest available apical segment measuring 27·3 cm in length and 18 cm in breadth. Basal segments distantly placed, small, rectangular, apices more or less convex or obtuse; both acroscopic and basiscopic margins curved, joining the bases of the adjacent segments. Segments lying below the apical segment and most of the segments of middle region varied in shape, width often unequal, rectangular or long rectangles, distant or rarely touching each other near base, distal margin straight or slightly convex or with rounded sides; base truncate.

Veins arising almost at right angles, sometimes at angles of about 70°-80°, near apex arising at 65°-70°, 10-14 veins per cm, rarely up to 21 per cm, simple or forked; when forked, forking just after emergence or at different levels, a few forking more than once. Rarely a vein may fork and then unite again to form a loop or very rarely even anastomose. Veins mostly about 0·5-1 mm apart.

Lectotype — No. 4388 of the Geological Survey of India, Calcutta.

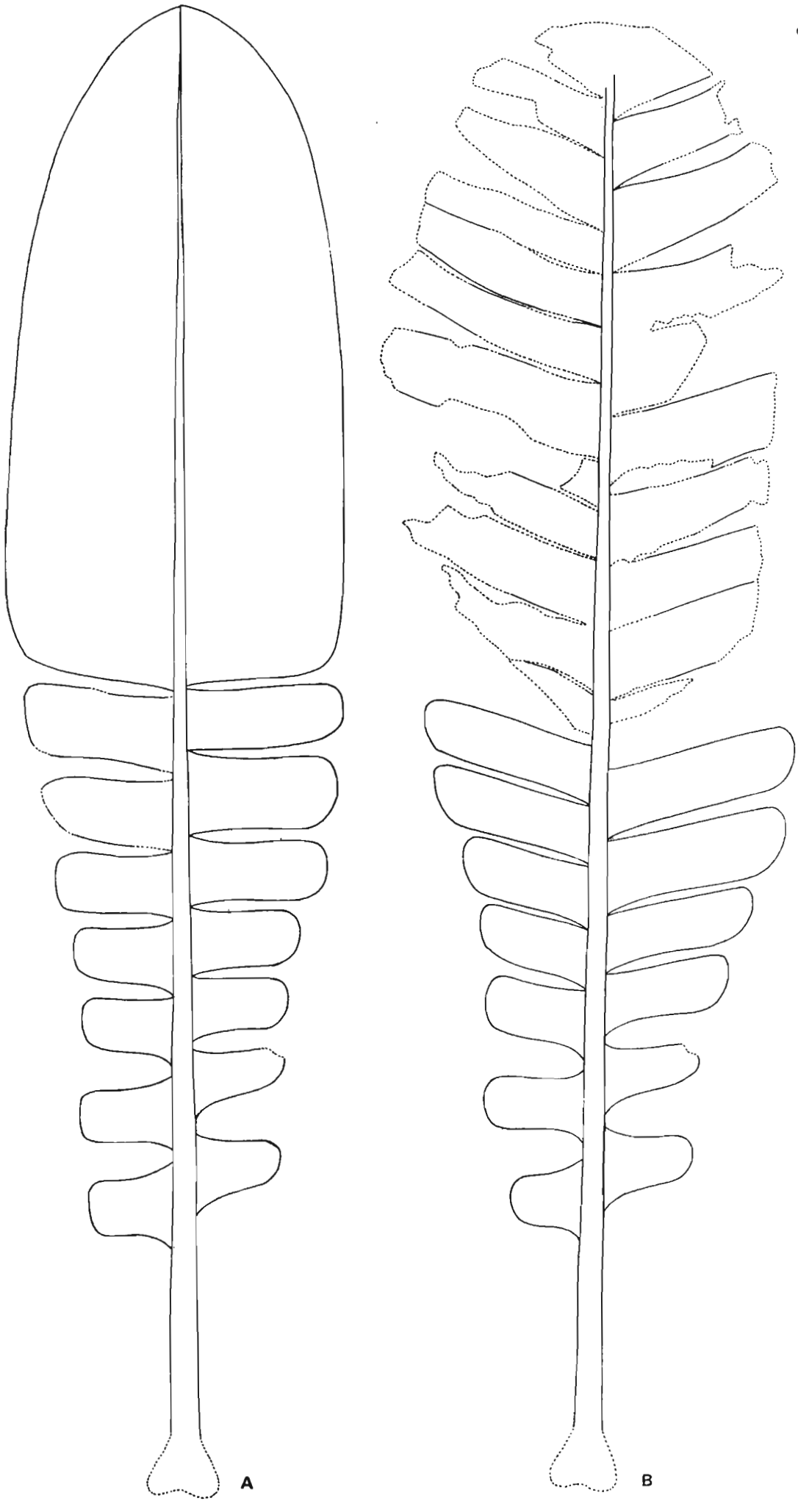
Occurrence:

Rajmahal Hills — Bindaban (type locality), Khairbani and Onthea.

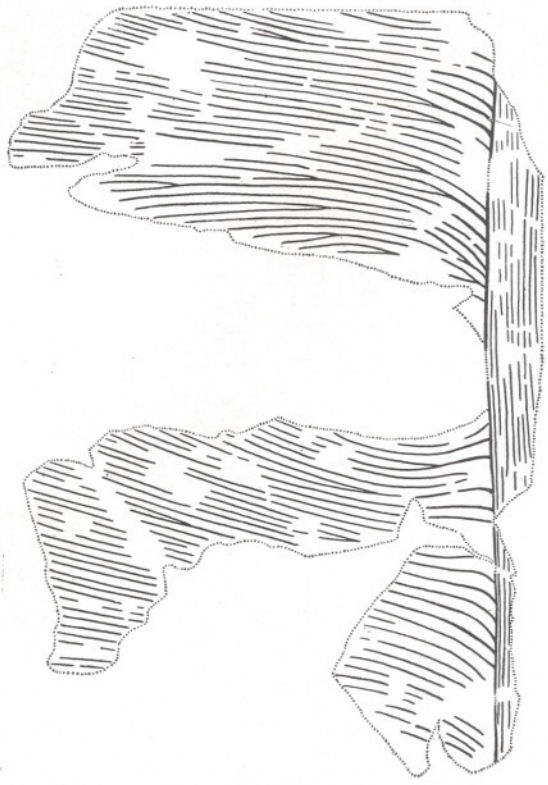
Gujarat — Than, Saurashtra.

Description — In *Pterophyllum princeps*, apical segments are much variable in shape and size. The specimen figured in Pl. 12, fig. 47 and Text-fig. 23 has an apical segment, measuring 24·8 cm in length and 13·8 cm in breadth. This apical segment resembles the specimen earlier figured by Oldham (in Oldham & Morris, 1863, pl. 1) as *Taeniopteris lata* (here figured in Text-fig. 24). The margin of the latter specimen is torn at places and it measures 27·3 cm in length and 17·2 cm in breadth. The segments lying below the apical segment of the specimen, here figured in Pl. 12, fig. fig. 47, are like the segments of the lectotype (Pl. 10, fig. 41). Some of the other larger apical segments have been figured in Pl. 10, fig. 42 and Text-fig. 25B, C. In the specimen figured in Text-fig. 26 the apical segment is rather small and narrow.

Some of the specimens (Text-fig. 27C) have segments with thickened and incurved



TEXT-FIG. 28 — A, B, restorations of two fronds of *Pterophyllum princeps* Oldham & Morris — the apical segment in A is fairly large, whereas, in B the apical segment has undergone further dissection in order to form narrower segments. *ca.* × 0.5 of estimated length.



TEXT-FIG. 29 — *Pterophyllum princeps* Oldham & Morris from Than, B.S.I.P. no. 20A/1998, × 1.

margin. So it seems that the lamina in *Pterophyllum princeps* was thick and leathery. In this species in the apical segments the veins generally arise at angles of about 65°-70° and in the rest of the segments at 70°-80°. The veins per cm are generally 10-14 in number.

From Than, Gujarat three fragmentary specimens of *Pterophyllum princeps* (Text-fig. 29) have been collected. Their venation pattern is somewhat similar to the specimen figured in Pl. 14, fig. 56.

Restoration — The restoration shown in Text-fig. 28A is based on the specimens figured in Pl. 12, fig. 47 and Text-fig. 25A and the other (Text-fig. 28B) is based on specimens figured in Text-fig. 25A and Text-fig. 26.

Comparison — The segments of *Pterophyllum hanesianum* Harris (1932b) look more like *P. princeps*. The former differs in having much more veins in each segment and the veins are also finer than in *P. princeps*. *P. braunsi* Schenk, described by Antevs (1919), agrees in gross features with the present species. *P. braunsi* has finer veins than *P. princeps*, also they do not dichotomise as frequently as in the latter species. Some of the apical segments of *P. princeps* are like *Taeniopteris* (*Macrotaeniopteris*) *gigantea* Schenk figured by Nathorst (1878-86, pl. 9). In the latter species the veins are not so commonly forked as in *P. princeps*. Some of the leaves of *Pseudoctenis spectabilis* Harris (1932a, fig. 12A, B) have segments like *P. princeps*, but in the former veins branch near rachis, whereas, in the latter they branch at all levels.

Pterophyllum incisum Sahni & Rao

Pl. 7, fig. 33; Pl. 11, fig 46; Text-fig. 27A, B

1933 *Pterophyllum incisum* Sahni & Rao, p. 193, pl. 13, figs 15, 16.
1954 *Pterophyllum bifurcatum* Suryanarayana, p. 88, pl. 1, figs 3-5.
1963 *Pterophyllum incisum* Sahni & Rao: Sitholey, pl. 6, figs 35, 36.
1974 *Pterophyllum incisum* Sahni & Rao: Bose, p. 190.
1974 *Pterophyllum bifurcatum* Suryanarayana: Bose, p. 190.

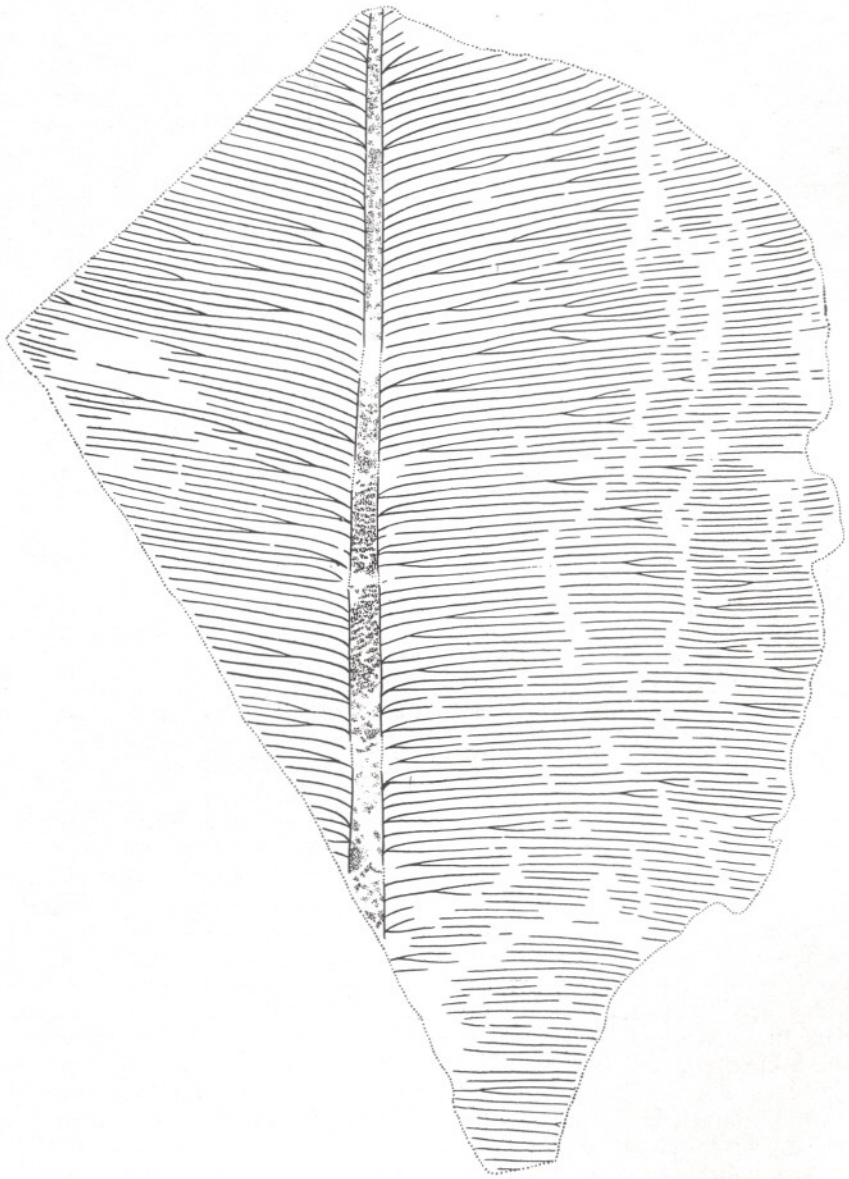
Emended Diagnosis — Pinnate frond, 5·8-8·8 cm long, 4·6-8·5 cm broad. Rachis fully exposed, longitudinally striated, 0·6 cm wide. Pinnae linear, 2-4·5 cm long and about 0·25-0·4 cm broad, attached to rachis by full width of base, making an angle of 70°-85°, margin parallel, sometimes lower margin slightly curved, gradually tapering towards apex; acroscopic margin slightly curved upwards; basiscopic margin decurrent, pinnae bases joined with each other. Apices of pinnae mostly incised once, rarely twice, incisions equal or unequal, teeth bluntly pointed. Veins 6-8, parallel, mostly simple, distribution of veins in bifurcated tips varying in number (1-3, rarely 4).

Holotype — No. 129 of the Department of Botany, University of Lucknow.

Occurrence:

Rajmahal Hills — Probably Saddle on Butaha Pahar, due south of Tetria Basti.

East Coast — Vemavaram, about 14 miles N.E.N. of Ongole in Guntur District.



TEXT-FIG. 30 — ? *Taeniopteris* sp./*Pterophyllum* sp. from Bindaban, B.S.I.P. no. 50/846, × 1.

Remarks — The above diagnosis is based on two fragmentary specimens. The holotype was collected from the Rajmahal Hills, whereas, the other was obtained from Vemavaram. The latter specimen seems to be the basal part of a frond. Its pinnae are slightly narrower than the pinnae of the holotype and also they are slightly curved. Tips of pinnae in both the specimens are incised. The veins in the holotype are faintly marked and they are 6-8 in number, whereas, in the Vemavaram specimen the veins are obscure (in one pinna seems to be 6).

Comparison — The pinnae of *Pterophyllum incisum* are more like *P. distans* Morris. The

TABLE 1

Name of Species	East Coast Gondwana							Rajmahal Hills																								Satpura & Godavari basins							Saurashtra			Kachchh & Rajasthan					
	Athgarh	Gollapalle	Raghavapuram	Vemavaram	Sriperumbudur	Naikulam	Sivganga	Basgo Bedo	Mandro	Bindaban	Khairbani	Chunakhal	Tetria	Balbhadri Hill	Butaha Pahar	Murrero	Ghutiari	Sakrigalighat	Maharajpur	Onthea	Burio	Jhenagaria	Chilgojuri	Khatangi Hill	Amarjola	Buskoghat	Morcha Pass	Sitalpur	Jatamao	Parsapani	Hasnapur	Imjhiri	Maleri	Kota	Chikiala	Than	Songad	Tarnetar	Dhawrha Mota	Kakadbhit	Kurbi	Trambau	Dharesi	Habur
Taeniopteris **Brongniart**																																													
T. spatulata McClelland	+	–	+	+	+	+	+	+	–	+	–	–	–	–	–	+	–	–	+	+	+	+	–	–	+	–	–	–	–	+	–	–	–	+	+	–	–	–	–	+	+	+	+	+	+
T. kutchensis n. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
T. haburensis n. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
T. oldhamii n. sp.	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
T. buskoghatensis n. sp.	–	–	–	–	–	–	–	–	–	+	–	+	–	+	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Morrisia **Bose**																																													
M. mcclellandi (O. & M.) Bose	–	–	?	?	?	–	?	–	–	+	+	–	–	–	–	–	–	+	–	–	–	–	–	–	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. dentata (Rao & Jacob) comb. nov.	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. rajmahalensis (Feistmantel) comb. nov.	–	?	–	–	–	–	–	–	–	?	?	–	–	–	–	–	–	–	–	+	?	–	–	–	–	–	?	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cycadites **Sternberg**																																													
C. rajmahalensis Oldham	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Anomozamites **Schimper**																																													
A. crenata (McClelland) comb. nov.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. amarjolense Sharma *et al.*	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. fissus (Feistmantel)	–	–	–	–	–	–	–	+	–	+	–	–	–	–	–	–	–	–	–	–	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. hasnapurensis n. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. haburensis n. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Pterophyllum **Brongniart**																																													
P. distans Morris	–	–	–	–	–	–	–	–	–	+	–	–	+	–	+	–	+	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–
P. kingianum Feistmantel	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. footeanum Feistmantel	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. medlicottianum Oldham & Morris	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	+	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
P. rajmahalense Morris	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. morrisianum Oldham	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. guptai n. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. princeps Oldham & Morris	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. incisum Sahni & Rao	–	–	–	+	–	–	–	–	–	–	–	–	–	–	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
?Taeniopteris/Pterophyllum	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

+=Present; –=Absent; ?=Doubtful forms

former has mostly 6-8 veins per segment, whereas, the latter has mostly 4-6 veins per segment., In *P. incisum* pinnae apices are mostly incised.

? *Taeniopteris* sp./*Pterophyllum* sp.

Text-fig. 30

There are two specimens in our collection which have frequently forked and sparsely placed lateral veins. The specimens are rather fragmentary and it is difficult to say whether they belong to leaves with entire lamina or segmented type of leaves. As such they are here being described as ? *Taeniopteris*/*Pterophyllum*.

Fragmentary specimens, 9·9-13·5 cm long and 8·3-11·4 cm broad. Rachis 5 mm wide near base, gradually tapering towards apex, near apex about 2 mm wide. Lateral veins arising at an angle of about 70°-80°, after emergence slightly curving upwards and then running parallel to each other, simple or forked, mostly forking once, sometimes twice, forking at all levels. Veins 7-8 per cm near midrib and 10-11 per cm near margin.

Collection — No. 50/846 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — Bindaban, Rajmahal Hills, Bihar.

Remarks — The specimens resemble the specimen of *Taeniopteris lata*? figured by Morris (in Oldham & Morris, 1863, pl. 7, fig. 3) in venation pattern. In shape it resembles some of the apical segments of *Pterophyllum princeps* but the latter has more crowded veins. In the concentration of lateral veins ? *Taeniopteris*/*Pterophyllum* is more like *Taeniopteris buskoghatensis* (7-8 per cm). The former differs in having much broader lamina.

CONCLUDING REMARKS

Of all the Mesozoic localities in India, the Rajmahal Hills have the maximum representation of cycadophytic leaves. Except for Than, Gujarat, all the undoubted Lower Cretaceous beds of India are completely devoid of the genera described in the preceding pages. At Than, so far, only a few fragmentary specimens of *Pterophyllum princeps* Oldham & Morris have been found.

Amongst the species described here, *Taeniopteris spatulata* McClelland is most widely distributed (see, Table 1). It is known from some of the localities of the East Coast Gondwana, Rajmahal Hills, Satpura and Godavari basins, Kachchh and Rajasthan. *Pterophyllum distans* Morris comes next — this species is known from the Rajmahal Hills, Satpura Basin and Kachchh. *Pterophyllum medlicottianum* Oldham & Morris has been found both in the Rajmahal Hills and Satpura Basin. The rest of the species are not so widely distributed. Within the the Rajmahal Hills, the largest number of species belonging to *Taeniopteris* and *Pterophyllum* are represented at Bindaban.

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EXPLANATION OF PLATES

PLATE 1

1. *Taeniopteris spatulata* McClelland from near Murrero; G.S.I. no. 4366.× 1.
2, 3. *T. spatulata* McClelland from Vemavaram; G.S.I. nos. 4595 and 4599.× 1.
4. *T. oldhamii* n. sp. from Bindaban; B.S.I.P. no. 25731/277.× 1.
5. *T. buskoghatensis* n. sp. from Busko Ghat; holotype, G.S.I. no. 4508.× 1.
6. *T. spatulata* McClelland sp. from near Burio; G.S.I. no. 19558.× 1.
7, 8. *T. kutchensis* n. sp. from Kakadbhit; G.S.I. nos. 4778 and 4777 (holotype).× 1.
9. *T. kutchensis* n. sp. from Kakadbhit; G.S.I. no. 4785.× 1.

PLATE 2

10. *Anomozamites crenata* (McClelland) comb. nov. from near Murrero; holotype, G.S.I. no. 4366.× 1.
11. *A. amarjolense* Sharma *et al.* from near Burio; G.S.I. no. 4390.× 1.
12, 13. *A. fissus* (Feistmantel) from Burio (fig. 12) and Balbhadri Pahar (fig. 13); lectotype (fig. 12), G.S.I. no. 4512 and no. B96 of the Botany Department, University of Lucknow.× 1.
14, 15. *Taeniopteris oldhamii* n. sp. from Bindaban; holotype; G.S.I. no. 4501 and B.S.I.P. no. 5710.× 1.
16. *Morrisia mcclellandi* (Morris) Bose from Sakrigalighat; B.S.I.P. no. 30671.× 1 (from Bose,1958).
17. *Anomozamites amarjolensis* Sharma *et al.* from Amarjola; B.S.I.P. no. 16695.× 1.

PLATE 3

18. *Morrisia dentata* (Rao & Jacob) comb. nov. from Mandro Hills; holotype, G.S.I. no. 17472. × 1.

PLATE 4

19. *Pterophyllum distans* Morris from near Ghutiari; lectotype, G.S.I. no. 4382.× 1.
20. *P. footeanum* Feistmantel from Vemavaram; G.S.I. no. 4655.× 1.
21. *Morrisia rajmahalensis* (Feistmantel) comb. nov. from Onthea; holotype, G.S.I. no. 4510.× 1.
22-24. ?*M. rajmahalensis*, showing a few detached pinnae; fig. 22 belongs to apical region, whereas, figs 23 & 24 are perhaps from basal regions. Fig. 22 from Murrero; G.S.I. no. 4543 and figs 23 and 24 are also from Murrero; G.S.I. no. 4373.× 1.

PLATE 5

25. *Anomozamites haburensis* from Habur; holotype, B.S.I.P. no. 107/2095.× 1.
26. *Taeniopteris kutchensis* n. sp. from Kakadbhit; B.S.I.P. no. 1/2000A.× 1.
27. *Pterophyllum distans* Morris from Kakadbhit; B.S.I.P. no. 111/1212.× 1.
28, 29. *Taeniopteris spatulata* McClelland from Kakadbhit; B.S.I.P. no. 2/2000A; fig. 28.× 1 and 29.× 2.

PLATE 6

30. *Pterophyllum footeanum* Feistmantel from Vemavaram; lectotype, G.S.I. no. 4658.× 1.
31. *P.* sp. from Khatangi Hill; B.S.I.P. no. 16779.× 1.
32. *P. medlicottianum* Oldham & Morris from Bindaban; lectotype, G.S.I. no. 4525.× 1.

PLATE 7

33. *Pterophyllum incisum* Sahni & Rao from Vemavaram; B.S.I.P. no. 8108.× 1 (from Suryanarayana, 1954).
34. *P. medlicottianum* Oldham & Morris from Onthea; B.S.I.P. no. 35117.× 1.
35. *P. rajmahalense* Morris from Bindaban; G.S.I. no. 4361.× 1.

PLATE 8

36. *Pterophyllum guptai* n. sp. from Sakrigalighat; holotype, no. K154/Raj. Sak. of Dr K. M. Gupta collection, 5B Mayur Ajmer, Rajasthan.× 1.
37. *P. guptai* n. sp. from Sakrigalighat; B.S.I.P. no. 35115.× 1.
38. *P. rajmahalense* Morris from Bindaban; G.S.I. no. 4398.× 1.

PLATE 9

39. *Pterophyllum morrisianum* Oldham from Sakrigalighat; B.S.I.P. no. 1492.× 1.

PLATE 10

40. *Anomozamites haburensis* n. sp. from Habur; B.S.I.P. no. 94/2095.× 1.
41. *Pterophyllum princeps* Oldham & Morris from Bindaban; lectotype, G.S.I. no. 4388.× 1.
42. *P. princeps* Oldham & Morris from Bindaban, apical region of a frond; B.S.I.P. no. 4596.× 1.
43. *Anomozamites haburensis* n. sp. from Dharesi, Kachchh, B.S.I.P. no. 20/2084A.× 2.

PLATE 11

44. *Cycadites rajmahalensis* Oldham from Bindaban; holotype, G.S.I. no. 4378.× 1.
45. *Pterophyllum guptai* n. sp. from Sakrigalighat; B.S.I.P. no. 35114.× 1.
46. *P. incisum* Sahni & Rao probably from Butaha Pahar; no. 129 of the Botany Department, University of Lucknow.× 1 (from Sahni & Rao, 1933).

PLATE 12

47. *Pterophyllum princeps* Oldham & Morris from Bindaban; B.S.I.P. no. 31125/422. × 1.

PLATE 13

48, 49. *Cycadites rajmahalensis* Oldham from Bindaban; G.S.I. nos. 4381 and 4547. × 1.
50. *Pterophyllum rajmahalense* Morris from Bindaban; lectotype, G.S.I. no. 4399. × 1.

PLATE 14

51, 52. *Pterophyllum kingianum* Feistmantel from Gollapalle; G.S.I. nos. 4571 and 4569 (counterpart of holotype no. 4566). × 1.
53. *P. guptai* n. sp. from Sakrigalighat; B.S.I.P. no. 35114. × 1.
54. *P. morrisianum* Oldham from Bindaban; lectotype G.S.I. no. 4401. × 1.
55. *Anomozamites haburensis* n. sp. from Habur, B.S.I.P. no. 126/2095. × 1.
56. *Pterophyllum princeps* Oldham and Morris from Bindaban; B.S.I.P. no. 31150/422. × 1.
57. *Anomozamites hasnapurensis* n. sp. from Hasnapur; B.S.I.P. no. 29/1442. × 1 (from Bose & Zeba-Bano, 1979).

PLATE 1

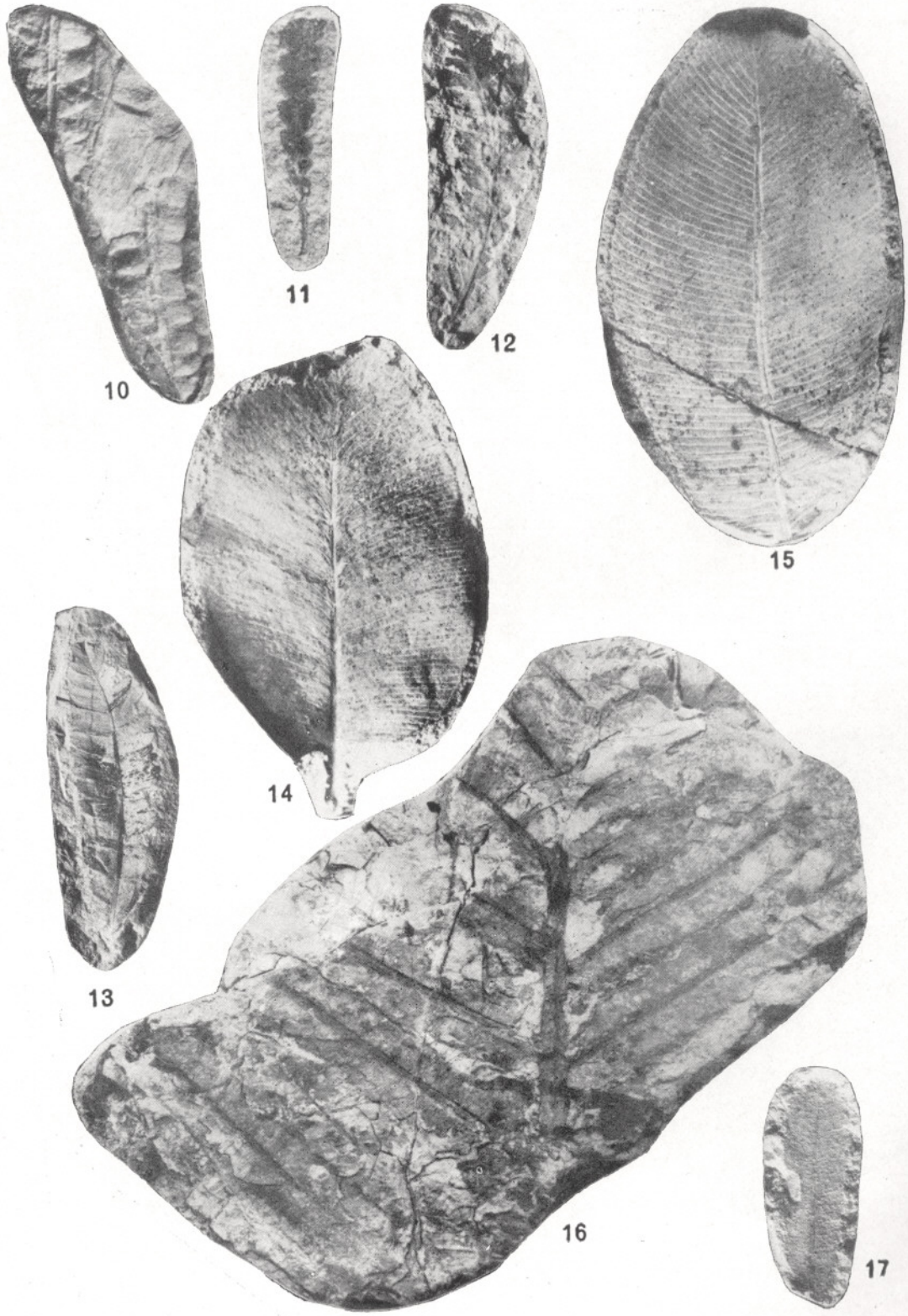
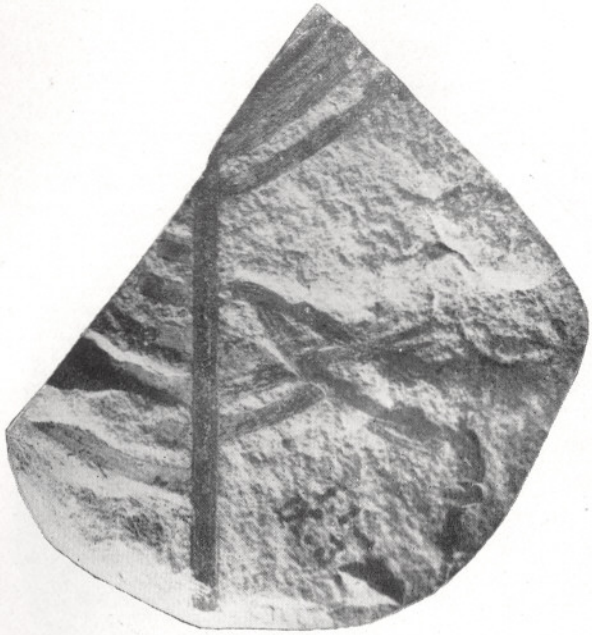


PLATE 2

PLATE 3



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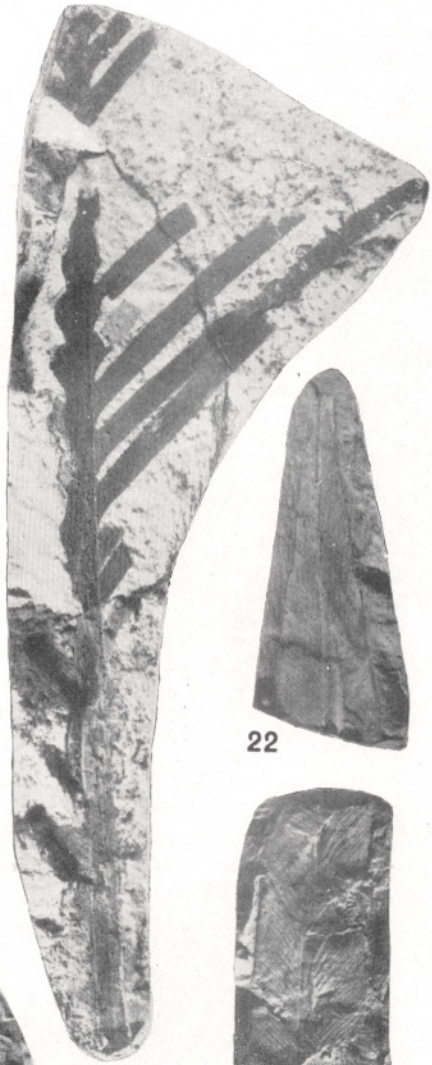

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PLATE 4

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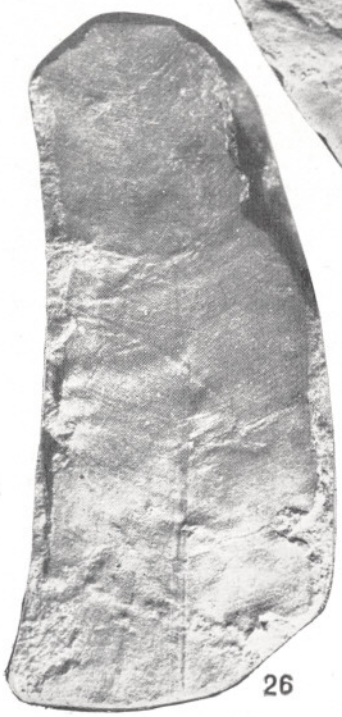

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PLATE 5

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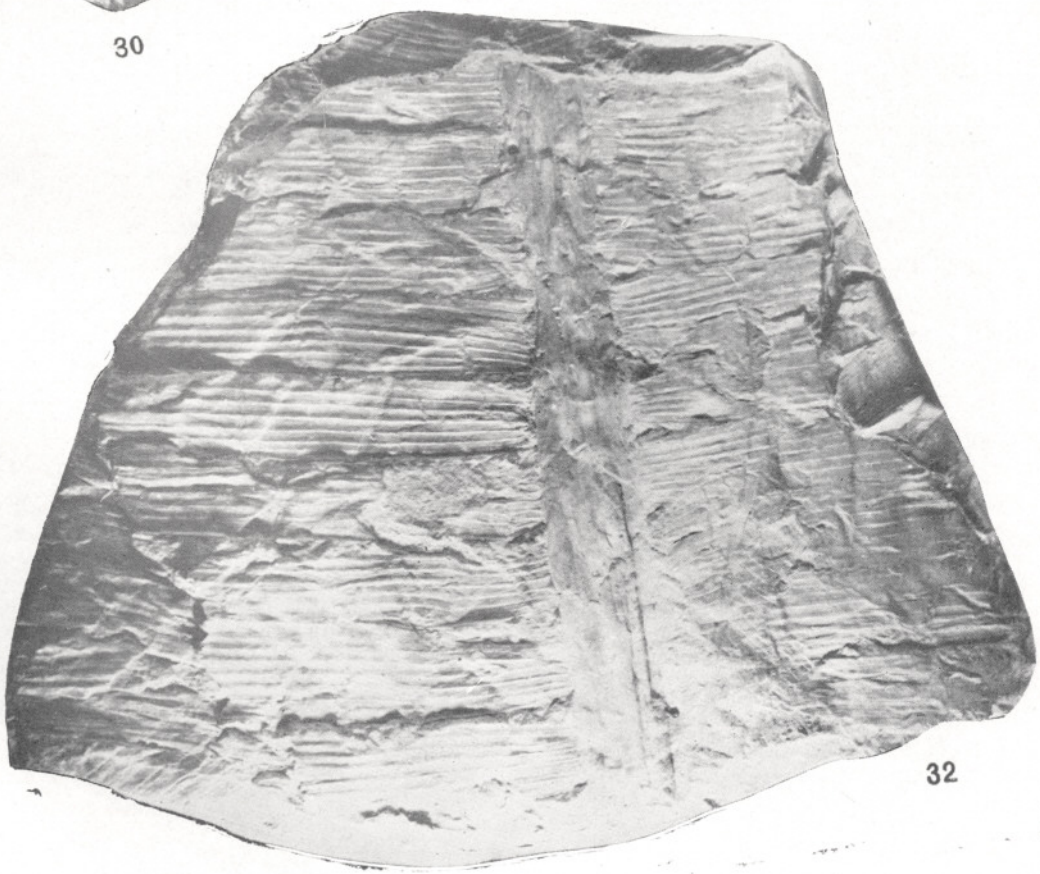

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PLATE 6

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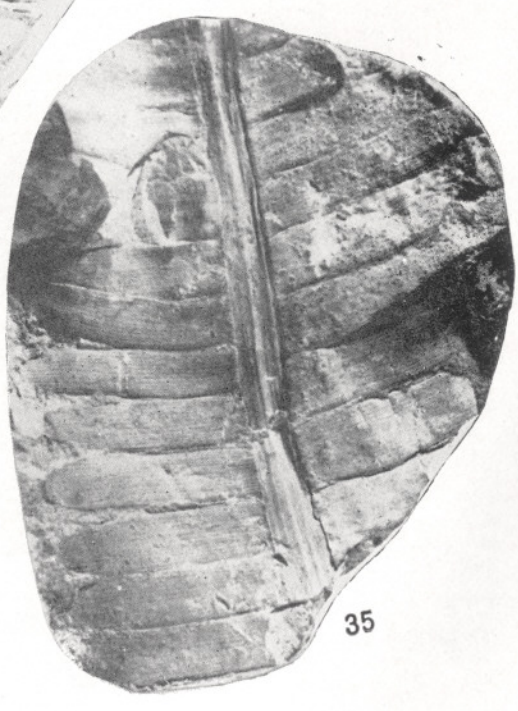

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PLATE 7

PLATE 8

PLATE 9

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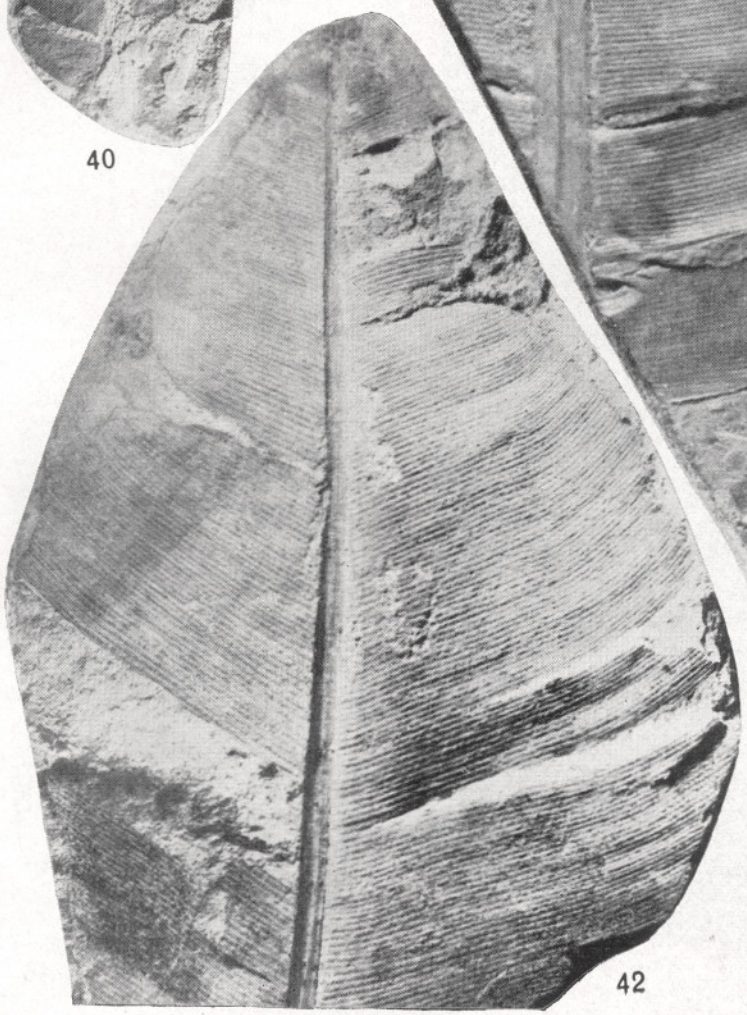

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PLATE 10

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PLATE 11

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Plate 12

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PLATE 13

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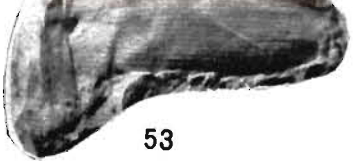

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PLATE 14