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THE FOSSIL FLORAS OF KACHCHH. I — MESOZOIC MEGAFOSSILS

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ABSTRACT

Mesozoic plant remains from Kachchh form the subject matter of this paper. Out of the 44 genera described, three are new. The new genera are — *Trambaua*, *Lorumformophyllum* and *Kachchhia*. The former two are based on detached leaves, whereas *Kachchhia* is a male fertile organ related to the so-called Mesozoic Pteridosperms. Besides, some of the genera which have been recorded for the first time from Kachchh are *Thallites*, *Hepaticites*, *Hausmannia*, *Dictyophyllum*, *Coniopteris*, *Caytonia*, *Linguifolium*, *Ctenozamites*, *Pseudoctenis*, *Anomozamites*, *Nilssoniopteris*, *Dictyozamites*, *Bennetticarpus* and *Allocladus*. Thus in all more than 80 species have been described.

On the basis of megafossil assemblage it has been suggested that the Mesozoic plant bearing beds in Kachchh may range in age from Middle to Upper Jurassic.

Key-words — Megafossils, Bryophytic remains, Pteridophytes, Gymnosperms, Middle-Upper Jurassic, Kachchh (India).

सारांश

कच्छ के अश्मित वनस्पतिजात. 3 — मध्यजीवी गुरुपादपाश्म – महेन्द्र नाथ बोस एवं जयश्री बैनर्जी

कच्छ से उपलब्ध मध्यजीवी पादप अवशेष इस शोध-पत्र का विषय हैं। इस शोध-पत्र में वर्णित 44 वंशों में से तीन वंश नवीन हैं। ये तीन वंश ट्राम्बुआ, लोरमफ़ार्मोफ़िल्लम् एवं कच्छिआ हैं। इनमें से पहले दो वंश वियुक्त पर्णों पर आधारित है तथा शेष तीसरा कच्छिआ नामक वंश एक अबंध्य नर अंग है जो कि मध्यजीवी टेरिडोस्पर्मों से सम्बन्धित है। इसके अतिरिक्त कच्छ से पहली बार वर्णित किये जाने वाले कुछ वंश भी हैं। ये थैलाइटिस, हिपेटिसाइटिस, हाउसमैनिआ, डिक्टियोफ़िल्लम्, कोनिऑप्टेरिस, केटोनिआ, लिंगुइफ़िल्लम्, टीनोज़ॅमाइटिस, स्यूडोटीनिस, ऍनोमोज़ॅमाइटिस, निलसोनिऑप्टेरिस, डिक्टियोज़माइटिस, बैन्नेटिकॉर्पस एवं ऍलोक्लेडस नामक वंश हैं। इस प्रकार कुल मिलाकर 80 से भी अधिक जातियों का वर्णन किया गया है।

गुरुपादपाश्म समुच्चय के आधार पर यह प्रस्तावित किया गया है कि कच्छ में मध्यजीवी पादप-धारक संस्तर आयु में मध्य जूराई से उपरि जूराई तक सीमान्तरित हो सकते हैं।

INTRODUCTION

VALUABLE contributions to the geology of Kachchh (formerly spelt as Kutch, Kach, Kuch & Cutch) Basin have been made by Grant (1840), Wynne (1869, 1872), Raj Nath (1932, 1942, 1952), Agarwal (1956, 1957), Mitra and Ghosh (1964), Biswas (1977) and Biswas and Deshpande (1983). Out of these, the papers published by Raj Nath (1942, 1952) and Biswas (1977) deal with the Mesozoic stratigraphy of Kachchh in detail.

The first report of fossil plants from Kachchh was by Morris (in Grant, 1840). He had then figured and described: *Fucoides dichotomus*, stems resembling *Equisetites*, *Lycopodites affinis*, *Ptilophyllum acutifolium* and *P. cutchense*. All these specimens are available in the British Museum (Natural History), London. Affinities of *Fucoides dichotomus* and *Equisetites* are extremely doubtful. *Lycopodites affinis*, when re-examined by one of us (M.N.B.), proved to be a badly preserved species of *Ptilophyllum*. The genus *Ptilophyllum* is so well known in the Jurassic-Cretaceous formations in India as *Glossopteris* is in the Indian Permian formations. After Morris a monograph on the Fossil Flora of Kachchh was published

by Feistmantel (1876). His monograph included 29 species described mainly from Dudhai, Loharia, Trambau, Bhajodi, Kakadbhit and Ghuneri. Since Feistmantel's (1876) publication small papers and notes on Mesozoic plant remains have been appearing from time to time. Amongst them mention may be made of Holden (1915), Seward and Sahni (1920), Sahni (1928), Jacob and Jacob (1954), Roy (1963, 1965, 1966, 1967, 1968), Bose and Roy (1964, 1968), Sitholey and Bose (1971), Bose and Kasat (1972), Bose and Banerji (1980, 1981), Bose and Zeba-Bano (1981), Zeba-Bano and Bose (1981) and Banerji (1982).

The present work is based mainly on the specimens described by the various authors mentioned above and new collections made during the last five years. Fragmentary as well as well-preserved specimens have been collected from a large number of localities (see Map 1). Those from which plant fossils have been dealt with are as follows:

1. *Mardakh-Bet* (23°22′58″: 71°7′45″)— The exposures are about 26 km north of Adeser.

2. *Gamdau Nala* (23°25′0″: 70°0′37″)— The fossiliferous beds are exposed along a "*nala*" south-east of Gamdau Village (about 3 km from Adhoi).

3. *Dudhai* (23°19′14″: 70°7′34″)—About 46 km east-north-east of Bhuj town.

4. *Loharia* (23°5′29″: 69°53′3″)—Rare occurrences of fossils are noticed in grey as well as ferruginous sandstone along a "*nala*" flowing closed to the abandoned village named Loharia Jhuna.

5. *Trambau* (23°19′15″: 69°44′)—Fossiliferous beds are exposed at various places in the Pur River about 2.5 km north-west of the village Trambau. Here the plant remains are mostly preserved as incrustations.

6. *Bhajodi* (23°13′28″: 69°44′11″)—Grey or pinkish shales are exposed on the river bed which is about 1 km east-south-east of Bhajodi.

7. *Khari River Section* (Rudra Mata Dam site; 23°21′43″: 69°42′15″)—Fossils were collected from the northern bank of Khari River (about 75 m north of Khari River Bridge). This is the only locality belonging to the Jhuran Formation which has yielded identifiable plant remains.

8. *Kera* (23°5′20″: 69°35′52″)—Fossils were collected from shale dumps of well diggings near the village Kera.

9. *Sukhpur* (23°13′2″: 69°36′18″)—Fossils were obtained from shale dumps of well-diggings close to Bhuj-Lakhpat Road (about 3.5 km from Sukhpur on way to Bhuj).

10. *Daisara* (23°5′29″: 69°31′10″)—A few fossils were collected out of a shale dump lying close to well, about 3 km north of the village Daisara.

11. *Kuar Bet* (23°59′42″: 69°42′30″)— About 18 km north-north-west of Khavda.

12. *Jamthara* (23°6′20″: 69°25′49″)— Fossils were collected from two sections exposed along the Rukmawati River, about 3/4 km from Jamthara Village.

13. *Kurbi* (23°0′46″: 69°20′32″)—The fossiliferous beds are exposed about 1/2 km south-west and south of Kurbi Village.

14. *Gadhsisa* (23°6′14″: 69°20′45″)—The fossils were collected from a river section, exposed on the eastern bank, about 5 km north-east of the village.

15. *Kakadbhit* (23°16′16″: 69°21′46″)— Kakadbhit is about 40 km north-west of Bhuj. Fossils are available at two different sites.

(i) *Road cutting*—Fossiliferous section is exposed by the side of Bhuj-Lakhpat Road. The fossiliferous rocks are black or grey in colour.

(ii) *River cutting*—This spot is exposed by the side of a "*nala*" which is about 1.5 km north-west of Motayax temple. The plant fossils are preserved here in pink coloured shales.

16. *Dauda Mota* (23°19′6″: 69° 19′15″)— The fossiliferous beds are exposed at the base of a hillock close to the western side of Bhuj-Lakhpat Road.

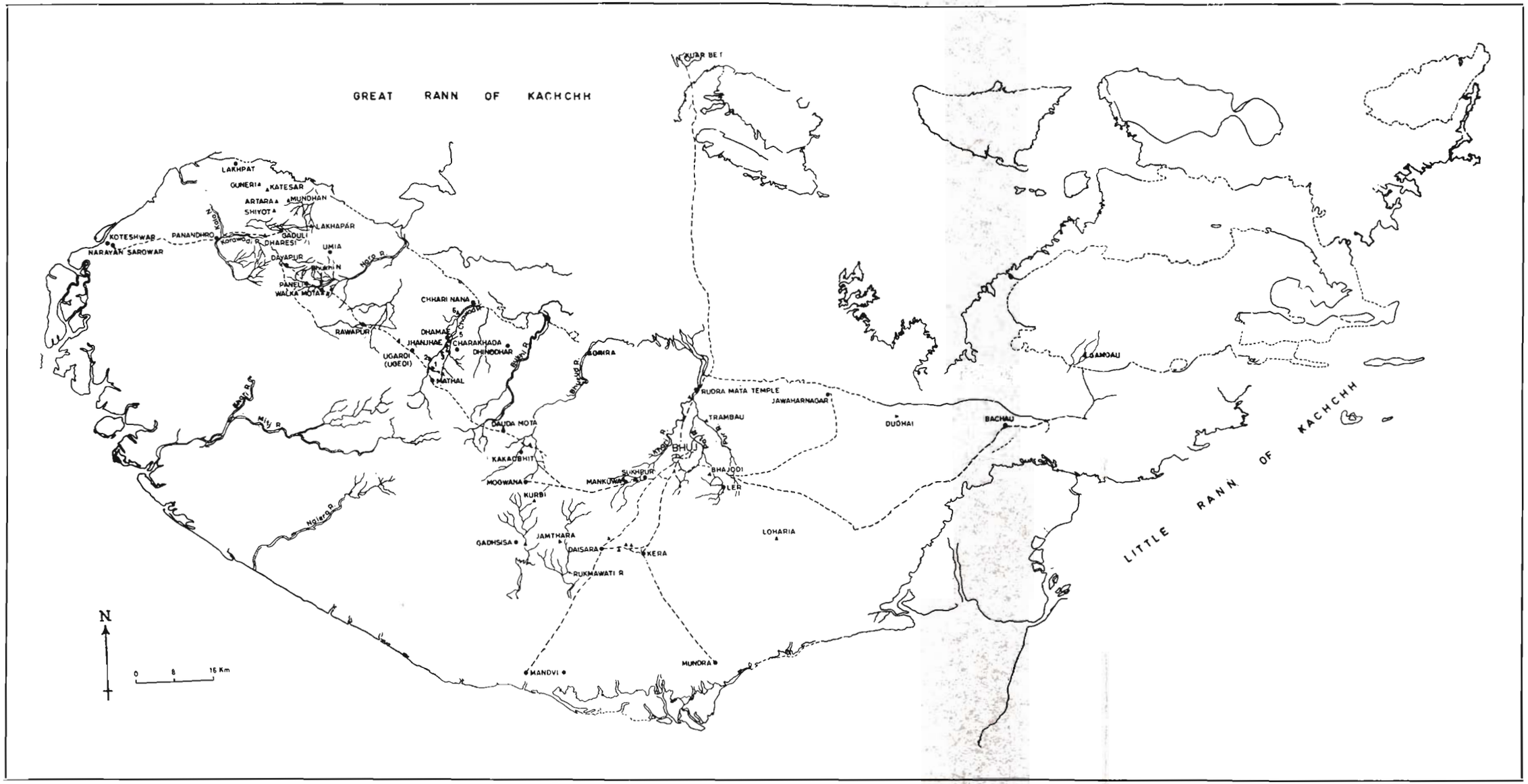
17. *Chawad River*

(i) '*Nala*" cutting (23°25′48″: 69°10′30″) — About 0.5 km from Chawad River Dam site (on right hand side along down stream).

(ii) About 1 km from (left bank) dam downstream (23°26′2″: 69°10′26″).

(iii) About 3.5 km upstream (left bank) from Dhamae Charkhara Road (23°27′37″: 69°12′21″).

(iv) About 1 km upstream (left bank) from Dhamae Charkhara Road (23°28′8″: 69°12′55″).



MAP 1 — Showing the various megafossil localities in Kachchh.

(v) About 0.5 km upstream (left side) from Dhamae Charkhara Road (23°28′26″: 69°13′00″).

(vi) About 500 metre downstream (left bank) from Muru-Chawad confluence (23°31′33″: 69°14′38″).

18. *Ugardi* (Ugedi; 23°27′46″: 69°8′26″) — Megafossils were collected from shale dumps lying close to a well (about 6 km north-west of Ugardi).

19. *Walka Mota* (23°34′52″: 68°59′48″) — The village Walka Mota is about 10 km south-west of Dayapar.

(i) This locality is about 2 km south-east of village Walka Mota. Plant megafossils here were preserved on white sandstone and exposed on the surface by the side of Rawapar-Paneli Road.

(ii) Megafossils were collected from shale dumps of about 1 km east south-east of village Walka Mota.

20. *Khari Nala near Walka Mota* (68°59′30″: 23°36′10″) — Fossiliferous rocks are exposed in a "*nala*" which is about 25 km north-west of Walka Mota close to Paneli-Walka Mota Road.

21. *Lakhapar* (23°41′30″: 68°57′) — The village Lakhapar is about 9 km east of village Gaduli. From here megafossils were collected from different spots along a "*nala*" close to the village.

22. *Shiyot* (23°43′36″: 68°54′4″) — The localities are about 1.5 km and 3.25 km from Shiyot close to Gaduli-Shiyot Road.

23. *Artara* (23°45′5″: 68°53′43″) — A few megafossils were collected from the bank of a water reservoir which is about 3 km from the village Artara on way to Mundhan.

24. *Katesar* (23°45′46″: 68°52′40″) — The fossiliferous bed is exposed about 1/2 km south of Katesar Temple.

25. *Ghuneri* (23°47′10″: 68°51′58″) — Fossils were collected from a "*nala*" which is about 200 m north of village Ghuneri.

26. *Dharesi* (23°41′19″: 68°51′16″) — Dharesi is about 120 km north-west of Bhuj and about 40 km south-west of Narain Sarowar. There are two main localities near Dharesi.

(i) About 0.5 km south of Dharesi Village near the temple.

(ii) Northern bank of Korawadi River, about 1.5 km from the village.

Out of the above mentioned localities the best preserved specimens were collected from Trambau, Sukhpur, Jamthara, Kurbi, Kakadbhit, Chawad River, Walka Mota and Dharesi. At Jamthara, Kurbi and Kakadbhit the fossils are preserved in the form of impressions, whereas the rest of the localities, viz., Trambau, Sukhpur, Chawad River, Walka Mota and Dharesi yielded specimens mostly with well-preserved cuticle.

All the type and figured specimens are preserved either at the Geological Survey of India, Calcutta (G.S.I.) or at the Birbal Sahni Institute of Palaeobotany, Lucknow (B.S.I.P.).

DESCRIPTION

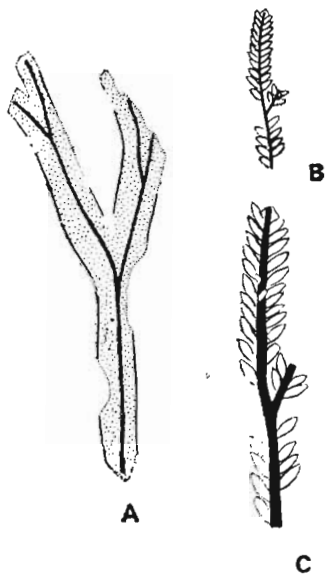
Genus — *Thallites* Walton, 1925

Thallites sp.

Pl. 1, fig. 2; Text-fig. 1A

Description — Thallus dichotomously branched, largest specimen about 2.7 cm in length and 2.5-4.5 mm in width, each branch further forking near apex, substance seems to be thick, margin entire, at places slightly undulated; midrib prominent, 0.5 mm broad.

Occurrence — Trambau, Jamthara and Gadhsisa.



TEXT-FIG. 1A-C — **A**, *Thallites* sp. from Trambau, B.S.I.P. specimen no. 22/2419, × 2; **B-C**, cf. *Selaginellites* sp. from Trambau, B.S.I.P. specimen no. 134/2677: B, × 1 and C, × 2.

Comparison — Like *Marchantites sewardii*, described by Berry (1920) from the Lower Cretaceous of Maryland, *Thallites* sp. too, has dichotomously branched thallus with a distinct midrib. In over all shape of thallus *M. jacutensis* Budanstev (1963) somewhat agrees with *Thallites* sp. The present species also resembles *Thallites* sp. described by Teslenko (1970) in gross features. In size and shape of thallus, *Thallites* sp. may be compared with *Hepaticites pantii* Bose & Pal (1983). However, in the absence of scales and rhizoids in *Thallites* sp. further comparison is not possible.

Genus — *Hepaticites* Walton, 1925

Hepaticites sukhpurensis n. sp.

Pl. 1, figs 1, 15; Text-fig. 2A, B

Diagnosis — Thalli forming rosettes, about 0.6-1.8 cm in diameter, usually 3-4 branches radiating from centre. Thallus dichotomously branched, each segment forking once, ultimate segment showing an apical notch. Thallus linear, 0.5-2 mm wide; margin straight or slightly undulated, substance of lamina nearer midrib thick, towards margin thin. Midrib present but ill-defined. Ventral scales and rhizoids not visible.

Holotype — B.S.I.P. specimen no. 26A/2235.

Occurrence — Sukhpur and Kera.

Remarks — The diagnosis is based on a specimen with part and counterpart. The specimen shows a number of thalli preserved as compression. Cells are not preserved and none of the specimens yielded ventral scales or rhizoids.

Comparison — *Hepaticites sukhpurensis* resembles most *Ricciopsis scanica* Lundblad (1954), described from the Liassic of Sweden, in general habit and size of thalli. Due to lack of details in the present species further comparison is not possible. Amongst the living species, *H. sukhpurensis* resembles most *Riccia natans*.

Genus — *Isoetites* Münster, 1842

Two species of *Isoetites*, viz., *I. serratifolius* and *I. indicus* were described by Bose and Roy (1964) from Ghuneri and Trambau respectively. *I. serratifolius* was based on detached leaves/sporophylls, whereas *I. indicus* was instituted on the basis of sporophylls arranged in a close spiral, forming a sort of rosette. From the latter, megaspores were isolated from several sporophylls.

During the last few years several specimens of *I. serratifolius* have been collected from various localities in Kachchh. The richest locality for this species is Dharesi. From Trambau a few more specimens of *I. indicus* have been collected. In the new specimens of *I. indicus*, too, the upper parts of sporophylls are not preserved. As we do not know anything about the upper part (lamina) of *I. indicus* and also do not have any information concerning the megaspores of *I. serratifolius*, so at present we are keeping them as two separate species.

Isoetites serratifolius Bose & Roy

Pl. 1, figs 3-8; Text-figs 2C-J, 3A, B

1964 *Isoetites serratifolius* Bose & Roy, p. 226, pl. 1, figs 1-5.

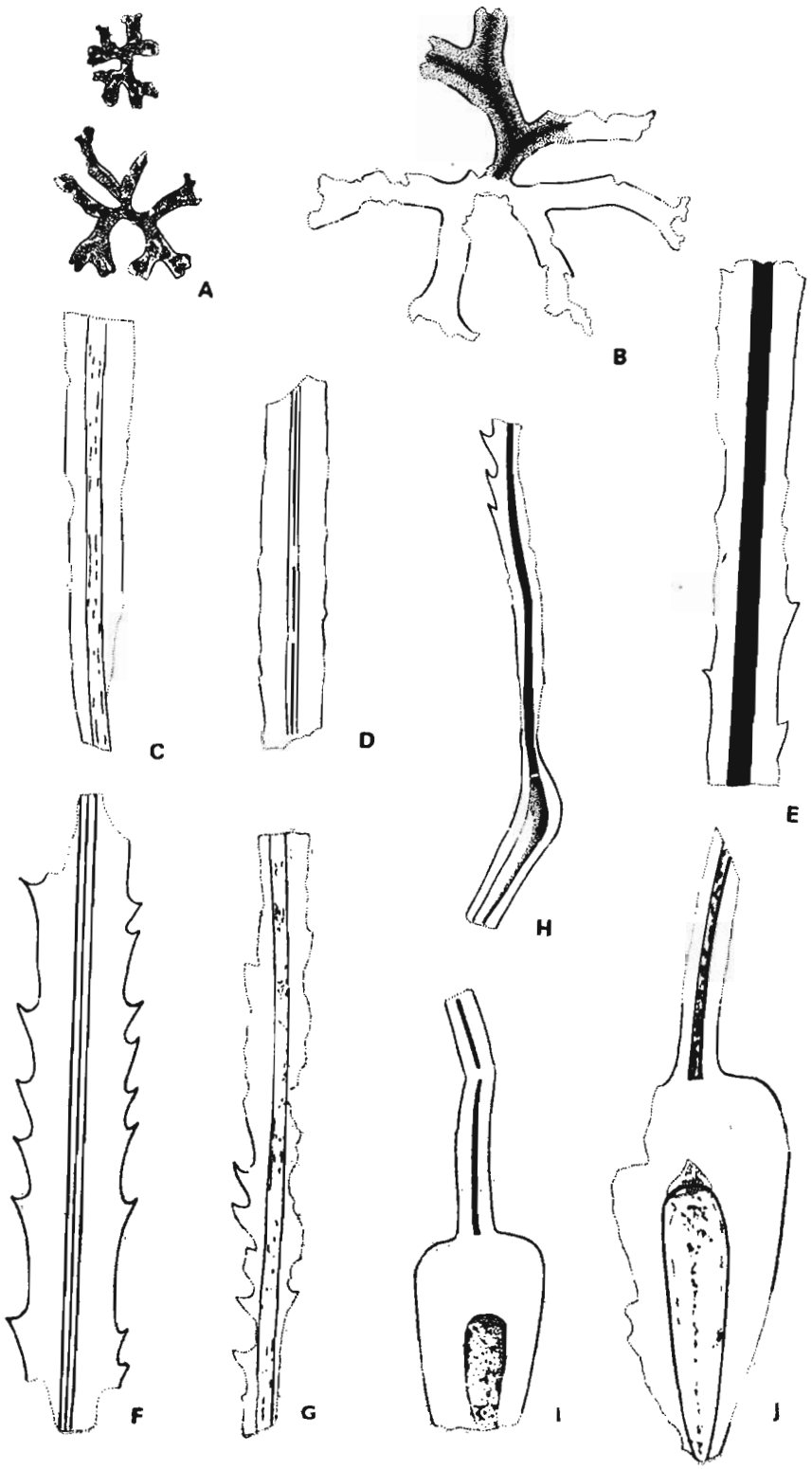
1966 *Isoetites serratifolius* Bose & Roy: Surange, p. 19, fig. 9D-F.

1974 *Isoetites serratifolius* Bose & Roy: Sukh Dev, p. 73.

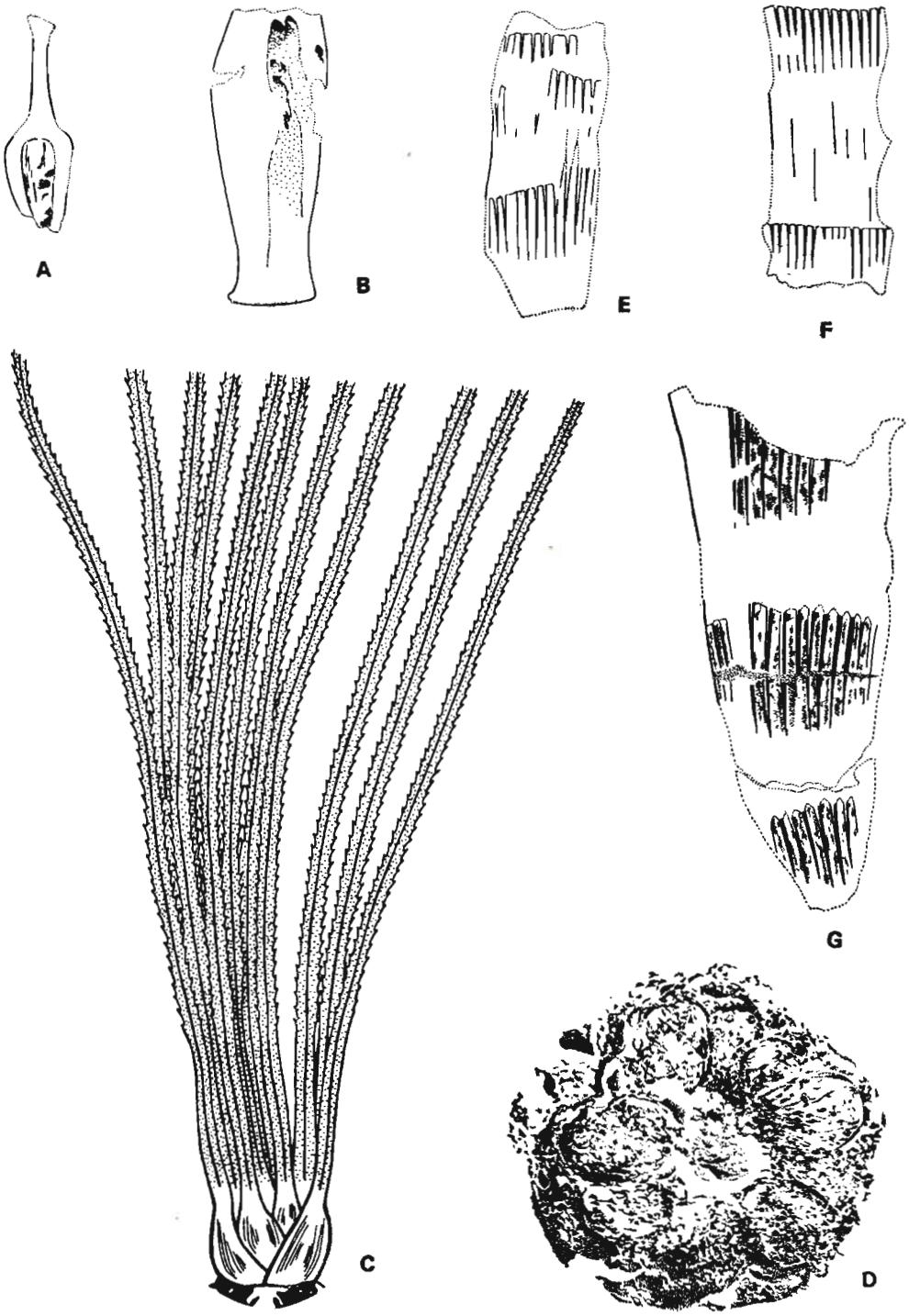
Emended Diagnosis — Detached leaves/sporophylls, 1.2-8.5 cm long, 0.3-0.7 cm broad near middle region; base somewhat spoon-shaped, showing an obovate depressed sporangial region, 1.1-1.9 cm long and

→

TEXT-FIG. 2A-J — **A, B,** *Hepaticites sukhpurensis* n. sp. from Sukhpur, B.S.I.P. specimen no. 26A/2235 (holotype): A × 2 and B × 4; **C-J,** *Isoetites serratifolius* Bose & Roy; **C-D,** parts of sporophylls showing entire and minutely toothed margins respectively, B.S.I.P. specimen nos. 8/2236 from Ghuneri and 14/2084 from Dharesi, × 2; **E-G,** portions of sporophylls showing deeply serrated margins, B.S.I.P. specimen nos. 14/2084A from Dharesi, 32723 from Ghuneri and 17/1727 from Dharesi, × 2; **H-J,** showing basal parts of sporophylls, B.S.I.P. specimen nos. 32717 (lectotype) from Ghuneri, 51/2004 from Dharesi and 5/389A from Ghuneri: H × 1, I × 2 and J × 3.



TEXT-FIG. 2



TEXT-FIG. 3

0.3-0.4 cm broad. Upper sterile part of leaf/sporophyll flattened, substance of lamina thin, margin nearer base entire, remaining portion with inwardly curved serrations, serrations of varied shape and size, mostly concave, about 1 mm long; rarely margin entire or minutely toothed. Lamina showing a prominent median vein, about 1-1.5 cm wide.

Lectotype — B.S.I.P. specimen no. 32717.

Occurrence — Khari River (Rudramata Dam site), Chawad River (locality no. 5), Ugardi, Lakhapar, Shiyot, Artara, Katesar, Ghuneri and Dharesi (locality no. 2).

Remarks — Detached leaves/sporophylls from Dharesi are slightly broader than those from Ghuneri and Katesar and in them serrations are deeply notched and rather distantly placed. In one specimen from Ghuneri at the upper portion of the sporangial chamber a faint, triangular impression is visible which perhaps represents a ligule (Text-fig. 2J).

Comparison — Except *Isoetites serratus* Brown (1939), *I. serratifolius* differs from all other species of *Isoetites* by its serrate margin. Unlike *I. serratifolius*, in *I. serratus* serrations are present only around the spatulate ends of the sporophylls. The basal portions of sporophylls of *I. choffatii* Saporta described by Teixiera (1948, 1952) are like *I. serratifolius*, but in the former the margin of the lamina is not serrate.

Isoetites indicus Bose & Roy

Pl. 1, figs 9-14; Text-fig. 3D

1964 *Isoetites indicus* Bose & Roy, p. 226, pl. 1, figs 6-17.

1966 *Isoetites indicus* Bose & Roy: Surange, p. 21, fig. 9G-J.

1974 *Isoetites indicus* Bose & Roy: Sukh-Dev, p. 73.

Diagnosis (slightly modified from Bose & Roy, 1963)— Sporophylls numerous, spirally arranged, forming a sort of rosette. Rosettes 2.5-4.5 cm in diameter. Bases of sporophylls mostly oval with entire margin, broadest region about 4-6 mm wide. Megaspores in each sporangium exceeding 1,500 in number. Megaspores trilete, amb triangular — sub-triangular, size 285-430 μm. Inner body ± oval, equatorial zone of flanze 30-45 μm broad, slightly broader at apical regions, membraneous; trilete laesurae membraneous, undulating, extending up to equatorial margin. Exine 4.5-7 μm thick, reticulate; muri about 6-10 μm wide; lumina ± polygonal, 16-26 μm in size, infragranulate.

Lectotype — B.S.I.P. specimen no. 32221.

Occurrence — Trambau.

Comparison — Bases of sporophylls of *Isoetites indicus* are somewhat like the sporophylls of *I. elegans* Walkom (1941-42). But *I. elegans* differs in having 40-55 megaspores in each sporangium and the megaspores are 0.5 mm in diameter. In *I. indicus* there are about 1,500 megaspores in each sporangium and they range in size from 285-430 μm.

Genus —*Selaginellites* Zeiller, 1906

cf. *Selaginellites* sp.

Pl. 2, figs 2, 3; Text-fig. 1B, C

Description — Branched leafy stem, about 2.2 cm long and 0.3 mm broad; branches slender, 8 mm in width. Ventral leaves spreading, delicate in texture, ovate or lanceolate in shape, measuring 1.5 mm in length and 1.0 mm in width; margins entire; apex acute; base broad; midrib rarely visible. Dorsal leaves mostly not clearly marked.

Occurrence — Trambau.

Comparison — In general appearance the present specimen resembles most *Selaginellites gracilis* (Oldham & Morris) Pal

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TEXT-FIG. 3A-G — **A-B,** *Isoetites serratifolius* Bose & Roy, showing basal portions of sporophylls, B.S.I.P. specimen nos. 54B/2084B from Dharesi and 1/2224 from Ghuneri: A × 1 and B × 2. **C,** restoration of a part of *I. serratifolius* (apical portions of sporophylls have not been shown, because in none of the sporophylls apex is preserved; *ca.* × 1; **D,** *I. indicus* Bose & Roy from Trambau, showing sporophyll bases, B.S.I.P. specimen no. 32219 from Trambau, × 2; **E-G,** *Equisetites rajmahalensis* Oldham & Morris from Kakadbhit (locality no. 1) showing nodes with appressed leaf-sheath, B.S.I.P. specimen nos. 24/2082B, 14/1725 and 327253: E-F × 1 and G × 1.5.

(1984). *Lycopodites victoriae* Seward (1904) somewhat resembles cf. *Selaginellites* sp. in having two rows of laterally disposed leaves, but in *L. victoriae* leaves are comparatively larger and variable in size. *L. scanicus* Nathorst ex. Halle described by Lundblad (1950) and *L. falcatus* Lindley & Hutton described by Harris (1961) from Yorkshire differ from cf. *Selaginellites* sp. in having leaves with denticulate margins.

Genus — *Equisetites* Sternberg, 1833

Equisetites rajmahalensis Oldham & Morris

Pl. 2, fig. 1; Text-fig. 3E-G

Specimen from Kachchh:

1968 *Equisetum rajmahalense* (Oldh. & Morr.) Feistm.: Roy, p. 108, pl. 1, figs 1, 2; Text-fig. 1.

Description — Stems articulated, 4-4.5 cm long, near nodal region 0.9-1.9 cm broad; internodes 1.4-3 cm long, about 0.9-1.8 cm broad, ± smooth, rarely at places showing faint striations. Nodes slightly swollen, with appressed leaf sheaths. Leaf sheaths with 25-30 (mostly 30) segments, free portion of leaf segments usually not preserved; leaf segments linear, gradually tapering towards tip; commissural region narrow near base, broader towards apex, usually 1 cm long.

Occurrence — Kakadbhit (locality no. 1), Chawad River (locality no. 3) and Dharesi (locality no. 2).

Remarks — In fossilized condition it is difficult to distinguish (see Sen & Sen, 1973) the stems of *Equisetum sensu stricto* and *Hippochaetae* Milde (1865). As such, here, we have preferred to use the generic name *Equisetites* Sternberg instead of *Equisetum* Linneaus.

Comparison—The specimens from Kachchh match with some of the specimens of *Equisetites rajmahalensis* figured by Oldham and Morris (1863, pl. 35, figs 3, 4), Sahni and Rao (1933) and Bose and Sah (described as *Equisetum rajmahalense* (Oldham & Morris) Feistmantel, 1968, pl. 1, figs 4-6) from the Rajmahal Hills. Both have smooth surfaced internodes and they have leaf sheaths with 25-30 segments. *Equisetites mobergii* Möller described by Möller and Halle (1913) and *E. minensis* Konńo (1962), too, have smooth internodes. *E. mobergii* differs in having leaf sheaths having 8-10 segments. In *E. minensis* Konńo (1962) leaf sheaths have 12-14 segments.

Genus — *Hausmannia* Dunker, 1846

Hausmannia dichotoma Dunker

Pl. 2, fig. 4; Text-fig. 4E, F

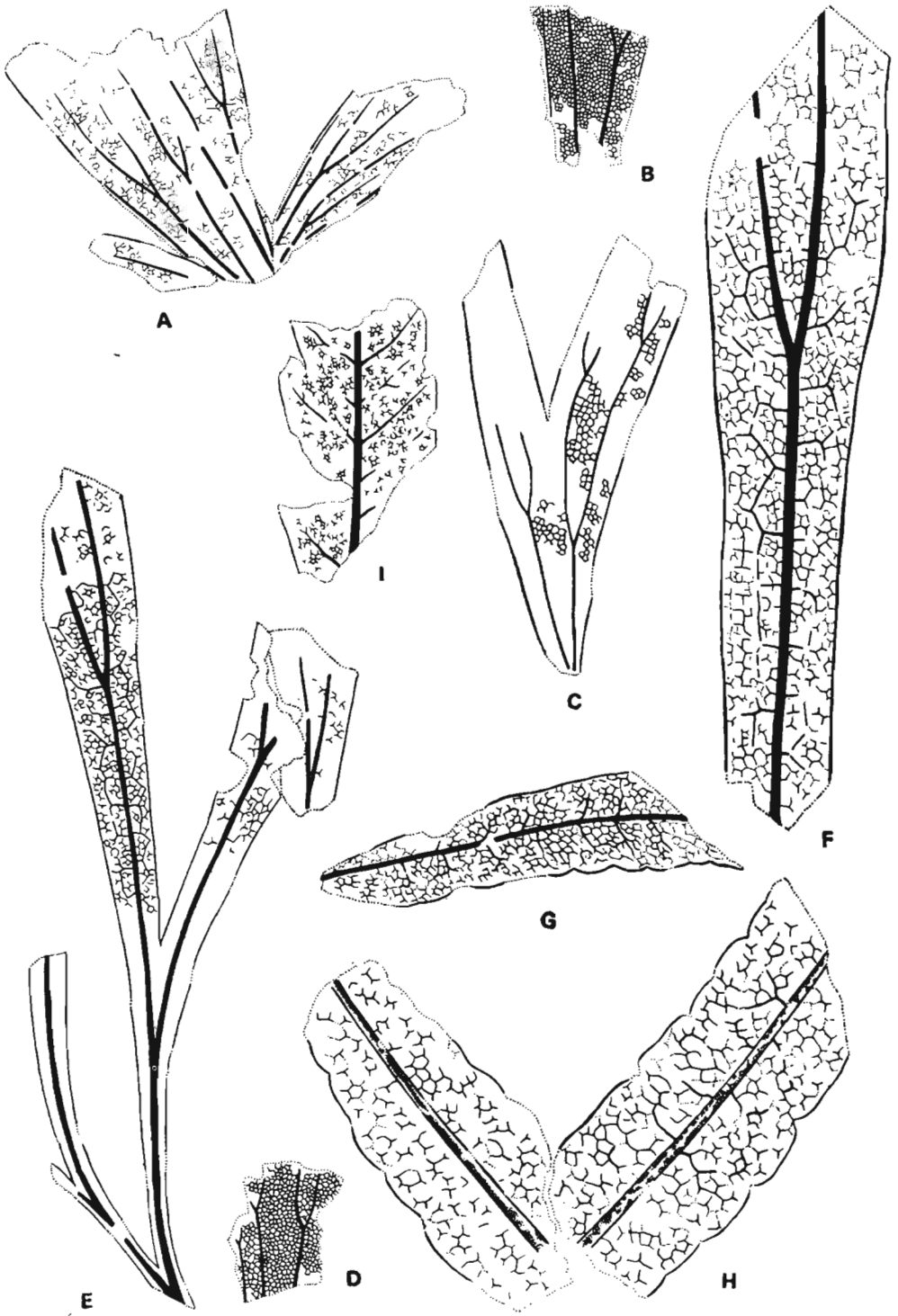
Description — Frond petiolate, 6.2 cm large. Petiole 5 mm long and 1.5 mm broad. Lamina as a whole obcuneate, dichotomising, each half further bifurcating into two segments, substance of lamina thick, apical region of segments incomplete, width of segment 6.5 mm, margins entire. Each primary segment with a distinct principal vein, about 0.7 mm wide, dividing further and entering each ultimate segment. Lateral veins arising at an angle of 80°-90°, bifurcating and anastomosing to form rectangular, squarish or polygonal meshes throughout the lamina. Marginal veins visible at places.

Occurrence — Chawad River (locality no. 3).

Comparison — The specimens from Kachchh matches with the specimens of *Hausmannia dichotoma* Dunker described by Zeba-Bano (1980) from Jatamao and Jana and Bose (1981) from Than in gross feature and venation pattern. It also resembles the specimens of *H. dichotoma* described by Richter (1906), Seward (1911) and Harris (1961). *H. dichotoma* described by Kilpper (1964) from the Rhaeto-Liassie bed of

→

TEXT-FIG. 4A-I — **A-D,** *Hausmannia* sp. from Dharesi, B.S.I.P. specimen nos. 5/2410, 22/1727A, 15/2004A and 16/1727A, × 1; **E-F,** *H. dichotoma* Dunker from Chawad River (locality no. 3), B.S.I.P. specimen nos. 44/2411B and 44/2411B: **E,** × 2 and **F,** × 4; **G-H,** *Dictyophyllum* sp. from Chawad River (locality no. 1), B.S.I.P. specimen nos. 7/2411A and 9/2411A: G × 2 and H × 4; **I,** ?*Dictyophyllum* sp./*Clathropteris* sp. from Kurbi, B.S.I.P. specimen no. 5/2680A, × 1.



TEXT-FIG. 4

northern Iran also agrees with the present specimen in general appearance.

Hausmannia sp.

Text-fig. 4A-D

Description — Largest specimen obcuneate, measuring 6.5 cm in length and 3.8 cm in width near apex. In the best preserved specimen (Text-fig. 4A) five prominent veins are visible, out of these three are forking at different levels. Each principal vein branching into finer lateral veins at an angle of 70°-90°, these are further branching and anastomosing to form squarish or polygonal meshes throughout lamina, marginal and penultimate veins not preserved.

Occurrence — Dharesi (locality no. 2).

Remarks — The above description is based on a few fragmentary specimens devoid of base and apex.

Comparison — In the nature of lateral veins *Hausmannia* sp. shows some similarity with *H. kohlmannii* Richter (1906), but the latter differs in having only three principal veins. Like *H. forchhammeri* Bartholin figured by Richter (1906), *Hausmannia* sp. has five principal veins. *H. forchhammeri* differs in having finer secondary and tertiary veins.

Genus — *Dictyophyllum* Lindley & Hutton, 1834

Dictyophyllum sp.

Pl. 2, figs 5, 6; Text-fig. 4G, H

Description — Largest available segment measuring 2.5 cm in length and 0.7 cm in width, in all the segments both base and apex missing, margin slightly wavy. Each segment with a distinct midrib, about 0.8 mm broad; secondary veins mostly arising at right angle to midrib, tertiaries further dividing and anastomosing to form small polygonal meshes enclosing the free endings of the ultimate veins.

Occurrence — Chawad River (locality no. 1).

Comparison — From Chawad River (locality no. 1) a large number of fragmentary sterile pinna segments of *Dictyophyllum* sp. have been collected. These fragments resemble the fragmentary segments of *?Dictyophyllum* sp. described by Bose *et al.* (1983) and *Dictyophyllum* sp. figured by Banerji *et al.* (1983) from Gardeshwar and Himmatnagar respectively. *Dictyophyllum* sp. also resembles the segments of *D. indicum* Bose & Jana (1979) described from Than, Gujarat. The narrower segments of *D. bartholinii* Möller (1902, pl. 4, fig. 10) are like the segments of *Dictyophyllum* sp.

Genus — *Phlebopteris* Brongniart, 1836

Phlebopteris minutifolius Banerji

Pl. 2, figs 7-14; Text-fig. 5A-H

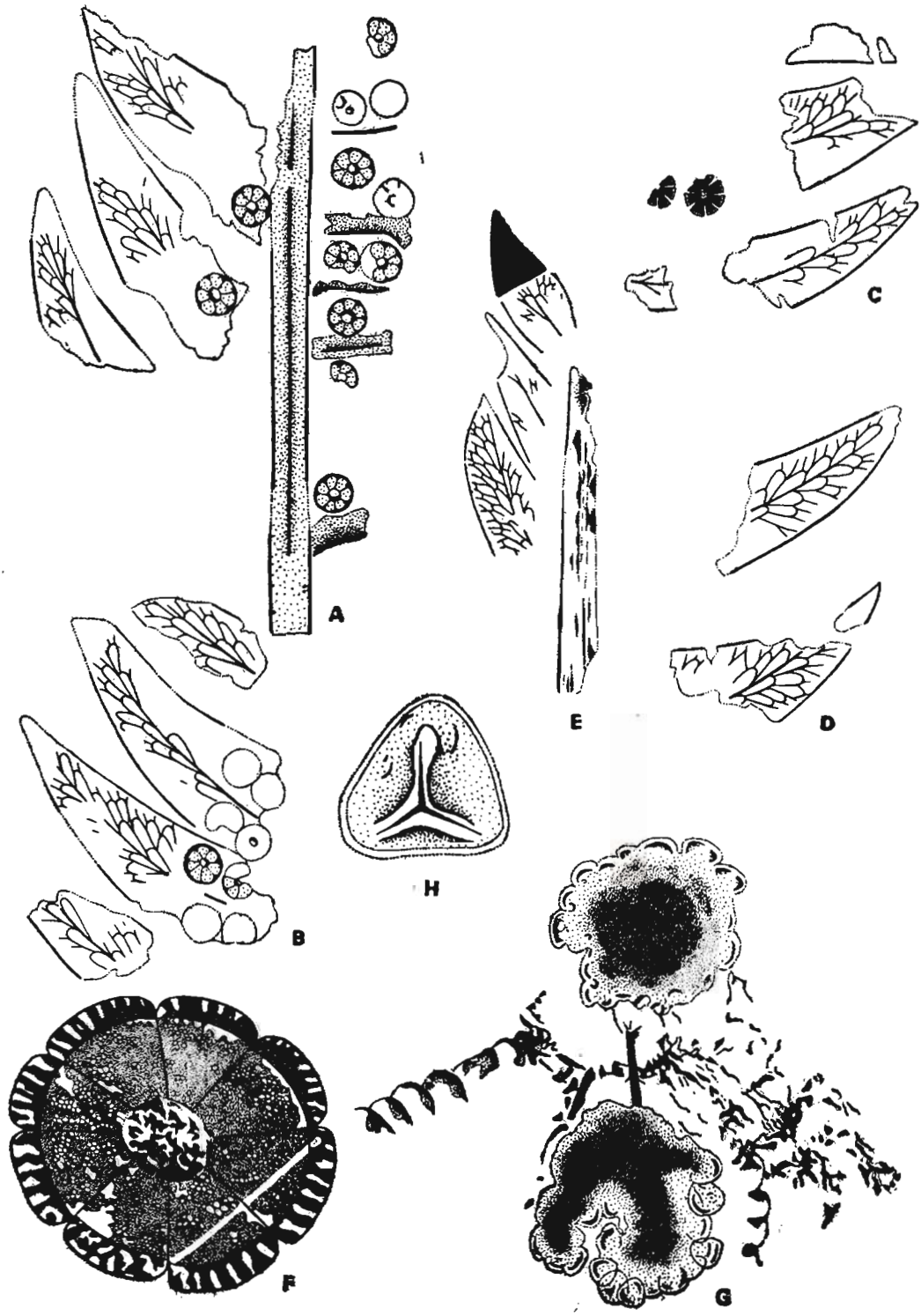
1981 *Matonidium cingulatum* Zeba-Bano & Bose, Text-fig. 1B.

1982 *Phlebopteris minutifolius* Banerji, p. 310, pl. 1, figs 1-11, text-fig. 2A-H.

Diagnosis (*based on diagnosis by Banerji*, 1982: *overall shape and size of frond unknown*)— Largest available specimen 2.3 cm long and 1.5 cm wide. Pinna rachis 1 mm wide, showing a distinct median groove. Pinnules attached to rachis by entire base at an angle of about 45°-50°, subopposite, falcate, 5-7 mm in length and 2.5-3 mm in width; margin entire; gradually tapering to an acute or subacute apex; base broad, both acroscopic and basiscopic margins straight. Midrib distinct, extending up to apex; lateral veins arising at an angle of 30°-35°, after emergence bifurcating and anastomosing with each other to form large

→

TEXT-FIG. 5A-H — *Phlebopteris minutifolius* Banerji from Walka Mota (locality no. 3)— **A-B,** part and counterpart showing fertile pinnules and their venation pattern, B.S.I.P. specimen no. 35409 (holotype) and 35410, × 7; **C,** part of a specimen showing two sori, B.S.I.P. specimen no. 35411, × 7; **D-E,** showing sterile pinnules, B.S.I.P. specimen nos. 35412 and 35413; D × 7, E × 6; **F,** a detached sorus from holotype, showing 8 sporangia, × 50; **G,** showing a macerated sporangia with released spore masses, B.S.I.P. slide no. 6444, × 100; **H,** showing an isolated spore with distinct interradial thickenings, B.S.I.P. slide no. 6444, × 500, (All the figures are from Banerji, 1982).



TEXT-FIG. 5

elongated meshes along midrib, from corners of these meshes veins again branching and joining to form a few more meshes towards margin, sometimes closer to apex veins merely forked, 3-4 veins per mm occurring towards margin.

Fertile pinnules on lower surface bearing a single row of two sori on either side of midrib. Sori circular, about 1 mm in diameter, from base almost covering 1/3 of pinnule, attachment indistinct (?sessile). Sporangia radially arranged around a central receptacle, 7-8 in number, about 0.5×0.3 mm, with a distinct vertical annulus; receptacle circular (as seen from above), 0.2 mm in diameter; indusium absent.

Approximately 64 trilete spores per sporangium, spore amb triangular to subtriangular, 38-50 μm; trilete distinct, rays usually extending up to 3/4th of spore radius; exine laevigate, about 1 μm thick, exine closer to trilete rays slightly more thickened, interradial region showing folds.

Epidermal cells of rachis rectangular, elongated, anticlinal walls straight or slightly wavy, periclinal wall smooth.

Holotype — B.S.I.P. specimen no. 35409.

Locality — Walka Mota (locality no. 3).

Comparison — All the Indian species of *Phlebopteris* differ from *P. minutifolius* in having pinnules which are larger in size. In none of them, so far, spores have been isolated. Both *P. athgarhensis* Jain (1968) and *P. polypodioides* Brongniart described by Sukh-Dev (1970) from Madhya Pradesh and Patra (1980) from Orissa have falcate pinnules like *P. minutifolius*, but *P. athgarhensis* and *P. polypodioides* differ in having larger number of sori. *P. polypodioides* described by Harris (1961) from Yorkshire differs from *P. minutifolius* in having pinnules with more concentrated veins and basal web connecting pinnules on the same side. *P. hirsuta* Sahni & Sitholey (1945) resembles *P. minutifolius* in size and falcate nature of pinnules, but it differs in having ramental hairs and spores with more thickened exine at the corners. In our opinion spores of *P. hirsuta* are more like *Matonidium*. *P. indica* Sahni & Sitholey (1945), too, resembles *P. minutifolius* in the nature of pinnules; it, however, differs in having once forked lateral veins and in the nature of sporangia and spores. The pinnules of *P. branneri* (White) described by Webber (1961) and *P. angustiloba* (Presl) Hirmer & Hörhammer reported by Tralau (1965) are bigger in size than those of *P. minutifolius*, but their spores are more like *P. minutifolius*.

Some of the spores of Matoniaceae described by Juhasz (1979) as *Phlebopterisporites equiexinus* and *P. harskutensis* are very close to the spores of *P. minutifolius*.

Genus — *Matonidium* Schenk, 1871

Matonidium cingulatum Zeba-Bano & Bose

Pl. 3, figs 6-9; Text-fig. 6A-E

1981 *Matonidium cingulatum* Zeba-Bano & Bose, p. 95, pl. 1, figs 1-11; text-figs 1A, C-D, 2A-F.

Diagnosis (from Zeba-Bano & Bose, 1981 with minor alterations)— Pinnae linear, gradually narrowing towards base and apex, largest available specimen 12.6×2.7 cm, substance of lamina thick. Pinna rachis about 2 mm wide, basal part (about 1.3-1.5 cm from base) devoid of pinnules, grooved. Sterile pinnules closely set, attached to rachis by their entire base at an angle of 55°-80°, bases of adjoining pinnules mostly joining each other, mostly subopposite, at places opposite or alternate. Basal pinnules deltoid, 2.5-4 mm long and 2.0-2.5 mm broad near base, pinnules of middle region linear, falcate, 1.5-2-3 cm long and 0.5-0.2 cm wide near base, gradually tapering towards apex; apical pinnules smaller in size, narrow, 4-6 mm in length and 1.5 mm in width. Apex acute, sometimes subacute; margins entire, thick. Midrib prominent, slightly depressed, traversing from base to

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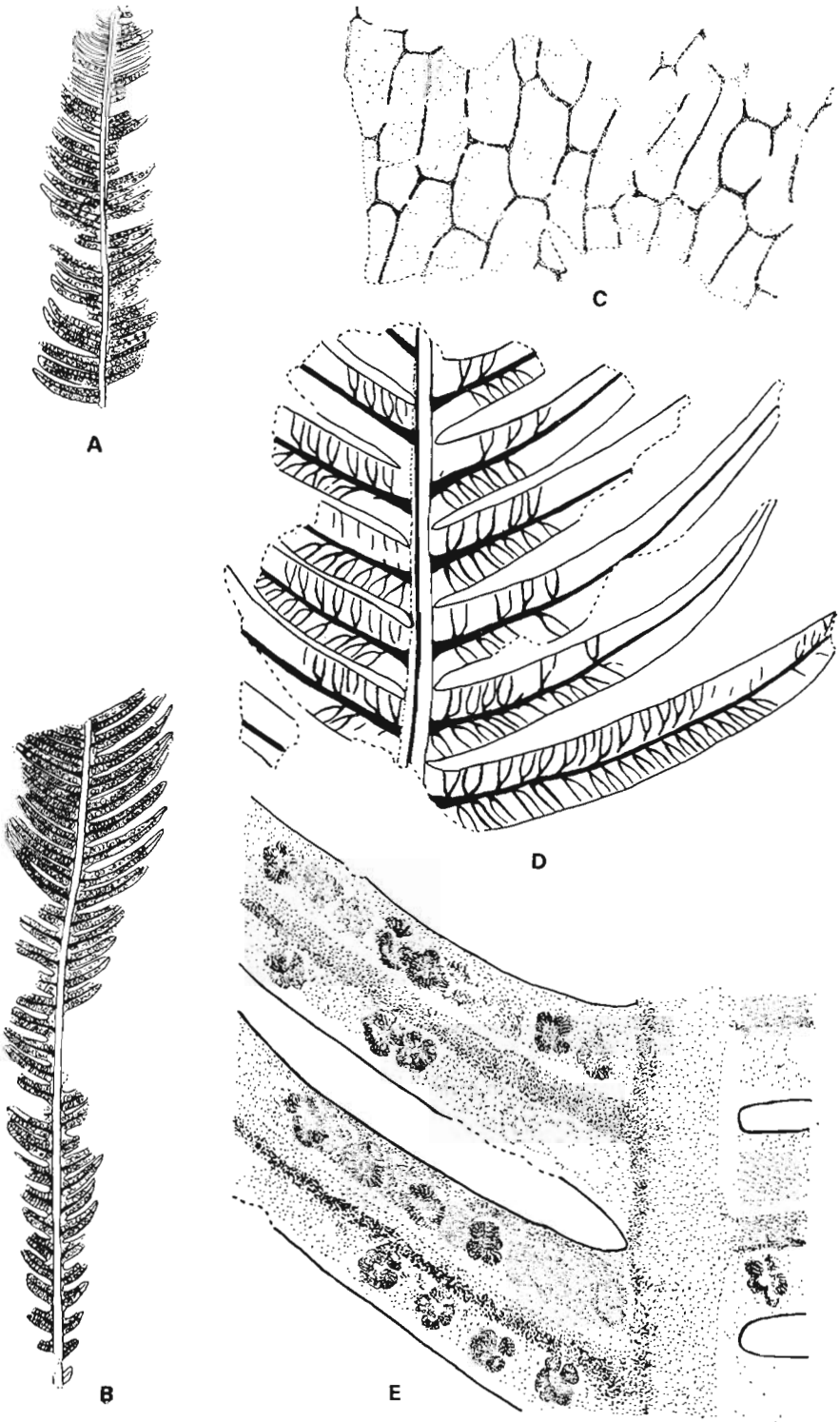
TEXT-FIG. 6A-E — *Matonidium cingulatum* Zeba-Bano & Bose from Trambau. **A-B,** showing detached fertile pinnae, B.S.I.P. specimen nos. 65/2001 (holotype) and 31/878,× 1; **C,** showing a few epidermal cells of rachis, B.S.I.P. slide no. 22/878(2),× 250; **D,** showing a detached sterile pinna, B.S.I.P. specimen no. 287/521,× 4; **E,** a part of a fertile pinna showing a few sori, B.S.I.P. specimen no. 112/2001,× 10. (All the figures are from Zeba-Bano & Bose, 1981).



TEXT-FIG. 6

apex, lateral veins arising at an angle of 85°-90° from midrib at a concentration of 2 per mm, mostly forking once either just after emergence or slightly away from midrib, each branch reaching up to margin.

Fertile pinnules having uniformly arranged sori on either side of midrib, covering almost entire length of pinnule. Sori about 8-10 in basal pinnules and 12-20 per pinnule near middle region, placed in between margin and midvein, circular to elliptical in shape, slightly bulging upwards from surface of lamina. Each sorus having about 4-5 sporangia with prominent annulus, arranged more or less in a ring, showing a central rounded scar probably of placenta. Each sporangium having a rounded tetrahedral spore mass, about 100 μm in size. Spores triangular-subtriangular, 45 μm in size, apices angular, interapical margins straight or convex. Trilete rays narrow, equal, extending up to three-fourth radius; commissure distinct. Cingulum narrow, slightly broader at apices; exine laevigate and intrapunctate, 2 μm thick.

Epidermal cells of rachis squarish to rectangular in shape, serially arranged; anticlinal walls straight or slightly wavy, unevenly thickened; periclinal wall smooth.

Holotype — B.S.I.P. specimen no. 65/2001.

Locality — Trambau and Dharesi (locality no. 2).

Comparison — The pinnae and pinnules of *Matonidium cingulatum*, in gross features, resemble *M. indicum* Sahni described by Banerji *et al.* (1983) from the Lower Cretaceous of Himmatnagar and Than, Gujarat and *M. goeppertii* (Ettingshausen) Schenk described by Harris (1961) from the Jurassic of Yorkshire and Appert (1973) from Madagascar. In *M. indicum* the details of the fertile pinnae are not known and in *M. cingulatum* the overall shape of the frond is unknown. *M. goeppertii* has typically about 10 sporangia in each sorus and its spores are devoid of cingulum. However, like *M. cingulatum* the fertile pinnules of *M. goeppertii* from Madagascar have occasionally five sporangia in each sorus. From the Madagascarian species, so far, no spore has been described.

Genus — *Coniopteris* Brongniart, 1849

Coniopteris cf. *hymenophylloides* (Brongniart) Seward

Pl. 3, figs 1-5; Text-fig. 7A-I

Specimens from Kachchh:

1968 *Sphenopteris* sp.: Roy, p. 113, pl. 2, figs 15,16; pl. 3, figs 20, 21; text-fig. 8.

Description — Detached pinnae; largest pinna about 4.0 cm long (range noted 0.9-4.0 cm), pinna as a whole linear-lanceolate in shape. Pinna rachis 0.4-0.8 mm wide, showing two longitudinally running parallel ridges. Majority of pinnules alternate, arising at an angle of 40°-45°. Basal pinnules generally 4-6 mm long and 3-4.5 mm broad, rhomboidal or wedge-shaped, mostly tri-lobed, margin of each lobe further notched at unequal distances; apex of apical lobe mostly subacute or obtuse, apices of lateral lobes rounded or broadly obtuse. Base constricted, acroscopic margin truncate, basiscopic margin decurrent. Apical pinnules 1-1.5 mm long and 0.5-1 mm broad, more or less ovate-lanceolate in shape, margin entire or segmented (mostly forming two incomplete lateral lobes), apex acute.

Fertile pinnae showing sub-oppositely arranged pinnules, measuring 3.5-5 mm in length and 2 mm in width, apices of pinnules representing a sorus with a cup-shaped indusium. Each indusium with a large number of sporangium. In some, annulus is clearly marked. Spores not preserved.

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TEXT-FIG. 7A-I — *Coniopteris* cf. *hymenophylloides* (Brongniart) Seward. **A-F, I,** showing parts of sterile fronds, B.S.I.P. specimen nos. 9/2085C from Walka Mota (locality no. 2), B/2076 from Bhajodi, 15/2005 from Walka Mota (locality no. 1), 59/2219 from Lakhapar, 4/2076 from Bhajodi, 45/2005 from Walka Mota (locality no. 1), 43/2891B from Chawad River (locality no. 4): A × 4, B × 2, C × 2, D × 2, E × 4, F × 4 and I × 1; **G,** showing part of a fertile frond, B.S.I.P. specimen no. A/2076 from Bhajodi, × 6; **H,** showing an indusial cup, B.S.I.P. specimen no. A/2076 from Bhajodi, × 50.

TEXT-FIG. 7

Occurrence — Bhajodi, Sukhpur, Gadhsisa, Chawad River (locality no. 4) and Khari Nala near Walka Mota.

Comparison — Among all the figured specimens of *Coniopteris hymenophylloides* (Brongniart) Seward, the present specimens of *C.* cf. *hymenophylloides* are closest to the specimens figured by Arber (1917, pl. 3, fig. 4) from New Zealand, Szé (1933, pl. 1, figs 1-10) from China, Vakhrameev and Doludenko (1961, pl. 3, figs 1-5) from Russia and Harris (1961, figs 53C-G & 54E, L) from Yorkshire.

UNCLASSIFIED FERNS

Genus — *Cladophlebis* Brongniart, 1849

Cladophlebis daradensis n. sp.

Pl. 3, figs 10-13; Pl. 4, fig. 5; Text-figs 8A-H, 11C

1968 *Cladophlebis* sp. cf. *C. longipennis* Seward: Roy, p. 112, pl. 2, fig. 17, text-fig. 6.

1970 *Cladophlebis* sp. cf. *C. longipennis* Seward: Kasat, p. 212, pl. 1, figs 3-5, text-fig. 2A, B.

1973 *Cladophlebis* sp.: Borkar and Chiplonkar, p. 274, pl. 1, fig. 8.

Diagnosis — Frond bipinnate, exceeding 14.5 cm in length and 6.5 cm in width. Rachis about 1 mm broad, showing a median longitudinal groove. Pinnae linear, alternate, more than 8 cm long, about 0.7 cm broad, arising at an angle of about 50°-55°, towards apex angle of divergence reduced to about 20°-30°. Pinna rachis showing a median groove. Pinnules subopposite to alternate, up to 9 mm long and 4 mm broad, somewhat ovate to rhomboidal, mostly separate, sometimes contiguous, arising at an angle of about 40°-55°. Acroscopic margin constricted at base, basiscopic margin slightly decurrent. Margin entire. Apex acute or obtuse. Basal basiscopic pinnule of each pinna larger than other pinnules, generally bi-trilobed, attached to rachis almost at right angle or slightly reflexed downwards. Midrib faintly marked, straight or somewhat undulate, secondary veins few, rarely visible, usually once forked, enlarged basal pinnule having a short midvein dividing into two branches, each branch further giving rise to a few forked or unforked veinlets.

Holotype — B.S.I.P. specimen no. 33879 (Kasat, 1970, pl. 1, fig. 3).

Type locality — Darad near Than, District Gujarat.

Occurrence in Kachchh — Trambau, Khari River (Rudra Mata Dam site), Sukhpur, Mankua, Daisara, Kurbi, Gadhsisa, Kakadbhit (locality nos. 1, 2), Dauda Mota, Chawad River (locality nos. 1, 2, 3, 5), Bhuki Nala near Meghpar, Walka Mota (locality no. 3), Lakhapar and Dharesi (locality no. 2).

Remarks — In Kachchh *Cladophlebis daradensis* is fairly wide spread. Unfortunately, all the Kachchh specimens are fragmentary and sterile. The largest specimen, so far, collected is about 8 cm long and 10 cm wide. In majority of the specimens secondary veins are indistinct. The best preserved specimens with veins are those from Kurbi and Trambau. Also some of the specimens from Kurbi have largest pinnules (9×4 mm). The specimens from Walka Mota and Trambau have smaller pinnules (1.5-2×1-1.5 mm).

Comparison — *Cladophlebis daradensis* shows apparent resemblance with *C. longipennis* Seward (1894). Their pinnules look somewhat similar in shape and size. Unfortunately, nature of the basal basiscopic pinnules in *C. longipennis* is not known. In gross features *C. daradensis* resembles *C. srivastavae* Gupta (1954), but the latter differs in having pinnules with bluntly pointed apices and uneven margin. *Cladophlebis* sp. cf. *C. longipennis* Seward described by Bose (1958) from Sehora resembles *C. daradensis* in general size and shape of pinnules. Other details in the former species are not known. *C.* (*Eboracia*) *lobifolia*

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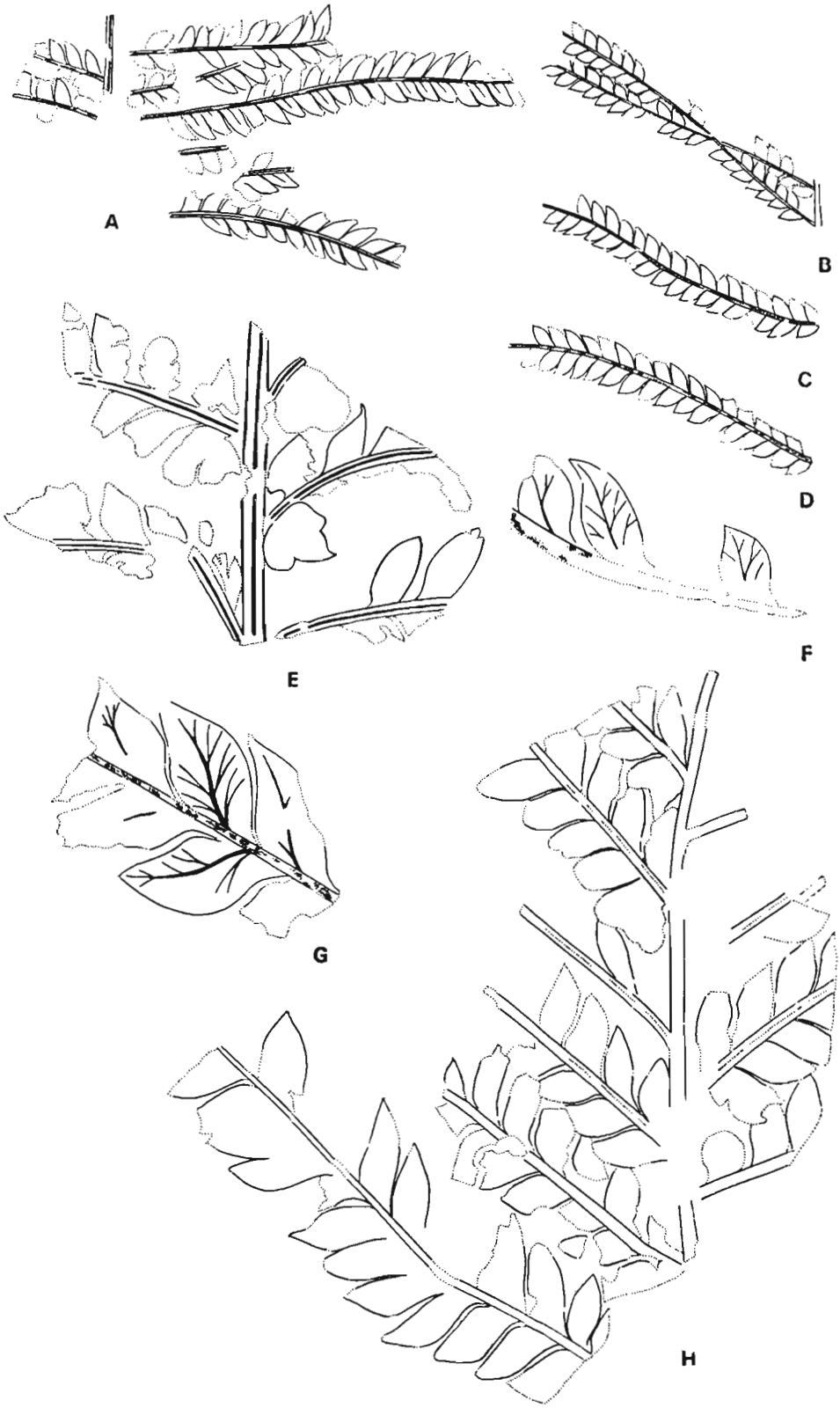
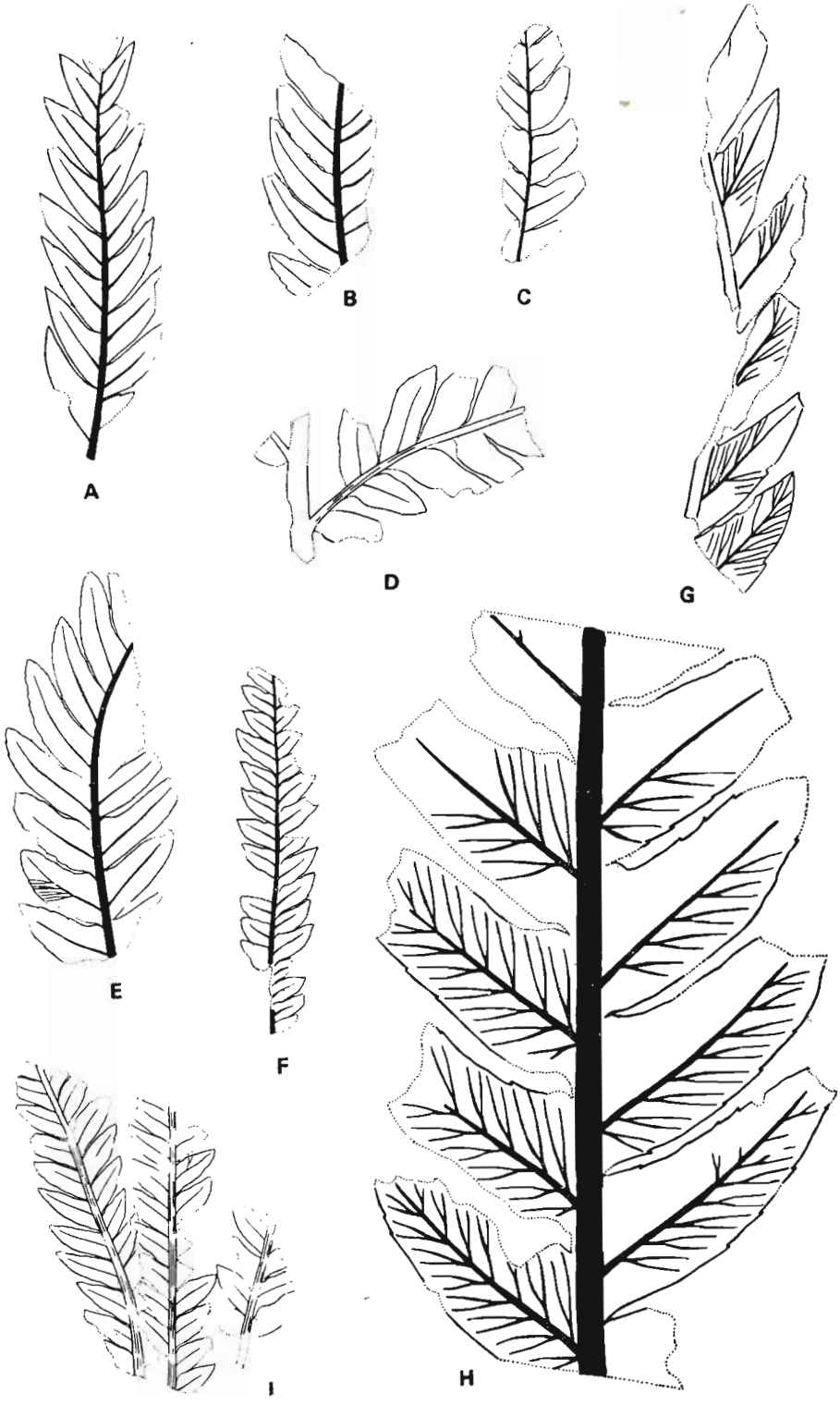
TEXT-FIG. 8A-H — *Cladophlebis daradensis* n. sp., B.S.I.P. nos. 246/2000A from Kakadbhit (locality no. 1), 66/2081 from Dauda Mota, 3/1212 from Kakadbhit (locality no. 2), 30/2083 from Trambau, 17/2204 from Kurbi, 33/2215 from Walka Mota (locality no. 3), 36A/2215 from Walka Mota (locality no. 3), 27/2204B from Kurbi: A-D × 1, E × 2, F-G × 6 and H × 2.



TEXT-FIG. 8



TEXT-FIG. 9

(Phillips) described by Yabe and Ôishi [1933, pl. 30(1), fig. 9] differs from *C. daradensis* in having deltoid-shaped pinnules. *C.* (*Gleichenites* ?) *takeyamae* Ôishi & Takahasi [1938, pl. 5(1), fig. 6] has a much thicker rachis and its pinnules are finger-shaped or elongate-ovate in shape. *C. kuzuryuensis* Kimura (1958) is tripinnate and its ultimate pinnules are slightly more elongated than the pinnules of *C. daradensis*.

Cladophlebis cf. *kathiawarensis* Roy

Pl. 4, fig. 10; Pl. 5, figs 1, 2; Text-figs 9A-H, 10A, B

Specimens from Kachchh:

1876a *Alethopteris whitbyensis*, Brgt. sp.: Feistmantel, p. 22, pl. 3, figs 1-4, 1a-3a; pl. 12, figs 3, 3a.

Description — Pinnae detached (only in one specimen a single pinna is attached to main rachis), overall shape linear-lanceolate, 1.7-5.2 cm in length and 1-2.2 cm in width (largest pinna, 10.3×1.2 cm). Rachis 0.5-1 mm wide, medianly grooved, sometimes showing faint striations. Pinnules closely set, sometimes connected with one another by decurrent bases, attached by whole base at an angle of 45°-80° (distal pinnules mostly at 45°, proximal at 60°-80°), alternate to subopposite, 0.6-1.6 cm long and 0.2-1.5 cm wide at base (apical pinnules 1.5-2×1.2-1.5 mm), falcate. Margin near base entire, little higher up slightly wavy, crenulate or dentate, near apex mostly dentate. Apex acute or sub-acute; acroscopic margin in majority somewhat auriculate, rarely truncate, basiscopic margin slightly decurrent. Midrib prominent, near apex faintly discernible; secondary veins emerging at an angle of about 45°-50°, usually once forked, rarely nearer apex one or two veins unforked.

Occurrence — Dudhai, Trambau, Sukhpur, Jamthara, Kakadbhit (locality nos. 1 & 2) and Kurbi.

Remarks — Feistmantel's (1876) specimens of *Alethopteris whitbyensis* described from Dudhai seem to be similar to the ones now collected from Kurbi and other localities in Kachchh. Due to rubbing over the majority of Feistmantel's specimens now do not show the veins clearly. The best preserved specimens of *Cladophlebis* cf. *kathiawarensis* are those from Kurbi and Jamthara. Except one specimen from Kurbi all are detached pinnae and in this specimen too, there is only one pinna which is attached to the main rachis. In none of these specimens the nature of the lowermost pinnule is clear. As such the Kachchh specimens have been tentatively referred to *C. kathiawarensis* Roy (1968).

Comparison — In gross features and venation pattern the pinnules of the specimens from Kachchh are like *Cladophlebis kathiawarensis* Roy (1968) described from Songad in Gujarat. *C.* cf. *kathiawarensis* resembles the sterile leaves of *Todites indicus* (Oldham & Morris) Bose & Sah (1968). In both, pinnules have dentate margin near apices. In *T. indicus*, unlike the present species, the basal pair of veins of the pinnules are mostly once or twice forked. In *C.* cf. *kathiawarensis* veins are only once forked. The pinnules of *C.* (*Todites*) *roessertii* (Presl), described by Seward (1908) from South Africa, are somewhat like the smaller pinnules of *C.* cf. *kathiawarensis*. Some of the pinnules of *C. fastuosa* Kimura (1959, pl. 3, fig. 4) show superficial resemblance with the pinnules of *C.* cf. *kathiawarensis*, but in *C. fastuosa* pinnules have mostly serrate margin. *C.* ex gr. *williamsonii* (Brongniart) Brongniart described by Kimura and Sekido (1978) shows only superficial resemblance with *C.* cf. *kathiawarensis*. In *C.* ex gr. *williamsonii* (Brongniart) Brongniart the lateral veins are forking twice.

Cladophlebis sp. A

Pl. 4, figs 1-3; Text-fig. 10C-E

Description (*description is based on incomplete, detached pinnae*) — Pinna 1.3-4.7 cm long, 1.7-2.2 cm broad, overall shape more or less lanceolate. Rachis distinct, 0.8 cm wide, at places slightly undulated, sometimes

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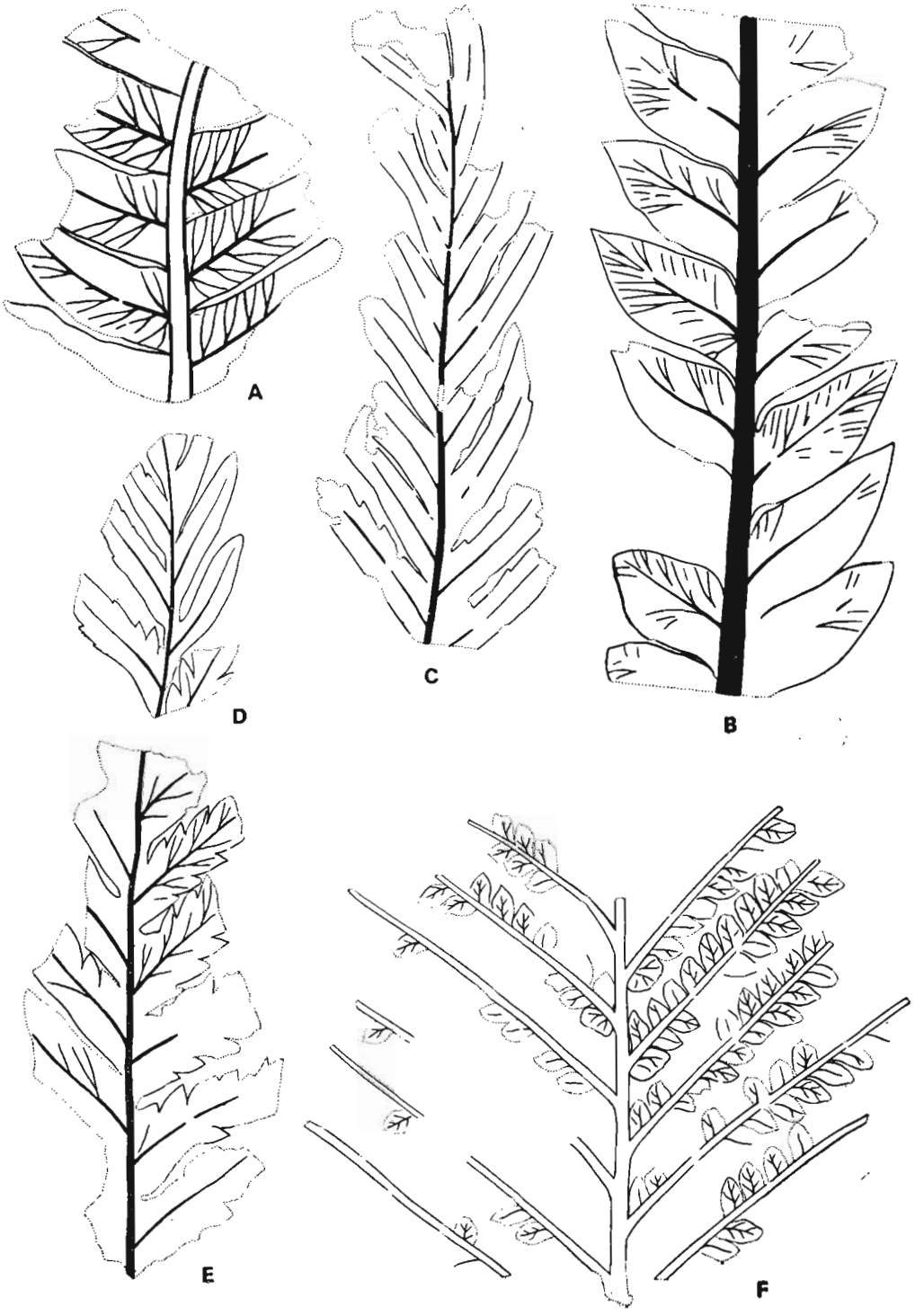
TEXT-FIG. 9A-I — A-H, *Cladophlebis* cf. *kathiawarensis* Roy, B.S.I.P. specimen nos. 7/2204, 13/2204, 5/2204, 3/2204, 9/2204, 175/2082, A/2204 and 18/2083 (A-G from Kurbi & H from Trambau): A-F × 1, G × 2 and H × 4; I, ?*Matonidium* sp. from Kakadbhit (locality no. 2), B.S.I.P. specimen no. 98/1212, × 1.



TEXT-FIG. 10

showing faint striations in longitudinal direction. Pinnules arising at an angle of 40°-50°, alternate or subopposite, lanceolate; margin entire to lobed, basal pinnules pinnatifid, margin of apical pinnules entire, wavy or dentate. Apex sub-acute; acroscopic margin truncate, basiscopic margin decurrent. Midrib prominent, lateral veins forking once, mostly obscure.

Occurrence — Khari River (Rudra Mata Dam Site).

Comparison — In gross features *Cladophlebis* sp. A agrees with *C. oerstedtii* (Heer) Seward described by Tanai (1979). *Cladophlebis* sp. A differs in having pinnules with both entire and lobed margins. Pinnules of *C. oblongifolia* Fontaine (1889) look like *Cladophlebis* sp. A, but they are broader than the latter species.

Cladophlebis sp. B

Pl. 4, fig. 9; Text-fig. 10F

Description — Frond bipinnate, 3 cm long; rachis 1 mm wide. Pinnae linear, alternate, arising at an angle of 45°-50°, largest specimen 2.5 cm long and 0.6 cm broad. Secondary rachis 0.5 mm wide, medianly grooved. Pinnules alternate or suboppositely arranged, attached at an angle of 60°-70°, somewhat ovate in shape, size 1.5-2.5×1.5-2 mm, attached by entire base; margin entire; acroscopic margin straight, basiscopic margin slightly decurrent; apex obtuse, rarely sub-acute. Midrib distinct, lateral veins usually two, unforked, arising at wide angles. Basal basiscopic pinnule of each pinna deltoid in shape, attached partially to the main rachis and partially to secondary rachis, 1.5×3 mm in size, veins few, arising from secondary rachis, mostly unforked rarely at places forking once.

Occurrence — Dharesi (locality no. 2) and Chawad River.

Comparison — *Cladophlebis* sp. B is comparable with *C. srivastavae* Gupta (1954) in general appearance. However, the present species differs in having pinnules which are smaller in size and the lateral veins are unforked, whereas in *C. srivastavae* the lateral veins are once forked. *C. daradensis* can be distinguished from *Cladophlebis* sp. B by its pinnules which are larger in size and by their venation pattern. Moreover, in *C. daradensis* basal basiscopic pinnules are bi- or trilobed.

Cladophlebis sp. C

Pl. 4, figs 4, 11; Pl. 5, fig. 4; Text-fig. 11A, B

The description is based on a detached pinnule preserved in the form of incrustation. The specimen has yielded a few minute pieces of cuticle. After maceration slides of only one surface (stomatiferous) could be prepared.

Description (for description frond assumed to be bipinnate)— Pinnule about 1.1 cm in length and 0.3 cm in width, falcate; extreme base and apex not preserved, upper half of margin minutely dentate. Midrib prominent, lateral veins once forked, mostly forking slightly away from midrib.

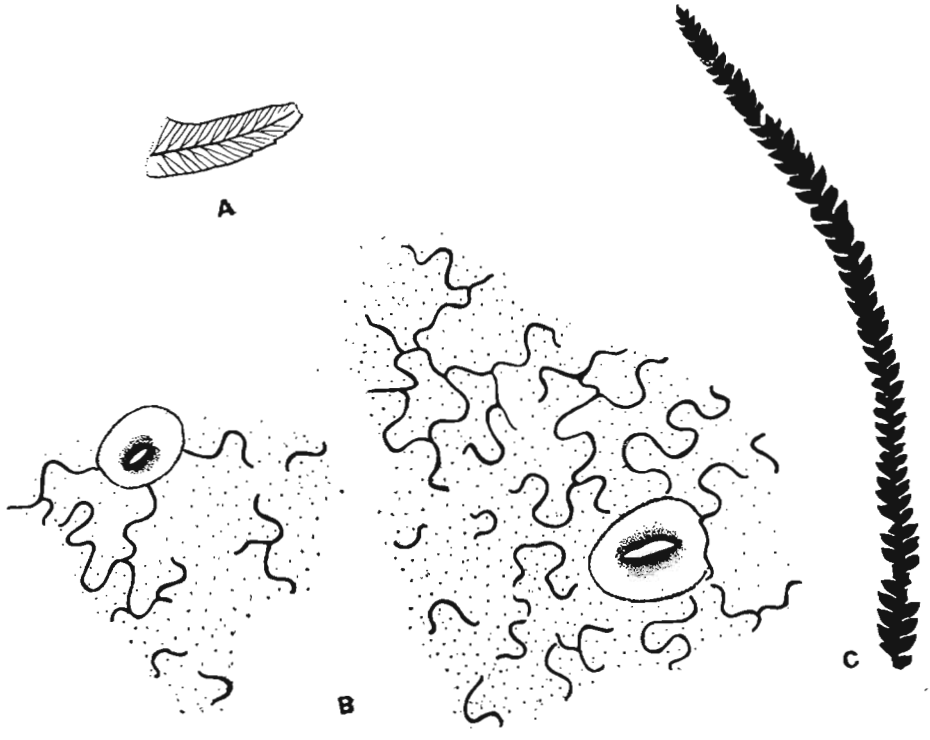
On one surface stomata irregularly distributed, mostly longitudinally orientated, closely spaced. Subsidiary cells indistinguishable from ordinary epidermal cells, stomatal pit broadly oval. Guard cells sunken, thinly cutinized, inner walls slightly more cutinized. Epidermal cells polygonal, thick-walled; lateral- and end-walls highly sinuous. Surface wall unspecialized.

Occurrence — Khari River (Rudra Mata Dam site).

Comparison — *Cladophlebis* sp. A resembles, in gross morphology, *C. kathiawarensis* Roy (1968) and *C.* cf. *kathiawarensis* (see p. 19). The specimen has been described here separately because it is only a detached fragmentary pinnule. Moreover, the cuticular structure of the former two species are not known. The cuticle of *Cladophlebis* sp. C is like *C. daughertyii* Ash (1969).

←

TEXT-FIG. 10A-G — **A, B,** *Cladophlebis* cf. *kathiawarensis* Roy, showing venation, B.S.I.P. specimen nos. 97/2089B from Sukhpur and 175/2082 from Kurbi, × 4; **C-E,** *Cladophlebis* sp. A from Khari River (Rudra Mata Dam Site), B.S.I.P. specimen nos. 27/2002B, 16/2204 and 17/2206A: C × 2, D × 1 and E × 2; **F,** *Cladophlebis* sp. B from Dharesi, B.S.I.P. specimen no. 11/2004, × 2.



TEXT-FIG. 11A-C — **A**, *Cladophlebis* sp. C from Khari River (Rudra Mata Dam Site), B.S.I.P. specimen no. 4/2206A, × 2; **B**, cuticle from the same specimen, B.S.I.P. slide no. 4/2206A-5 × 250; **C**, *C. daradensis* n. sp. from Khari River (Rudra Mata Dam Site), B.S.I.P. specimen no. 34/2398, × 1.

However, external features of the pinnules of *C. daughertyii* are quite different.

Form Genus — *Sphenopteris* Sternberg, 1825

Sphenopteris metzgerioides Harris

Pl. 4, figs 6-8; Text-fig. 12A, B

Description — Frond tripinnate-quadripinnate, largest specimen about 5.5 cm long and 5 cm broad; rachis 1 mm wide; primary, secondary and tertiary branches emerging alternately, secondary and tertiary branches arising at an angle of 30°-45° and 30°-35° respectively; ultimate segments linear in shape, sometimes showing nearly equal dichotomy, measuring 2-5 × 0.4-1.2 mm, with obtuse-acute apices, each segment with a median vein, substance of lamina thin and delicate.

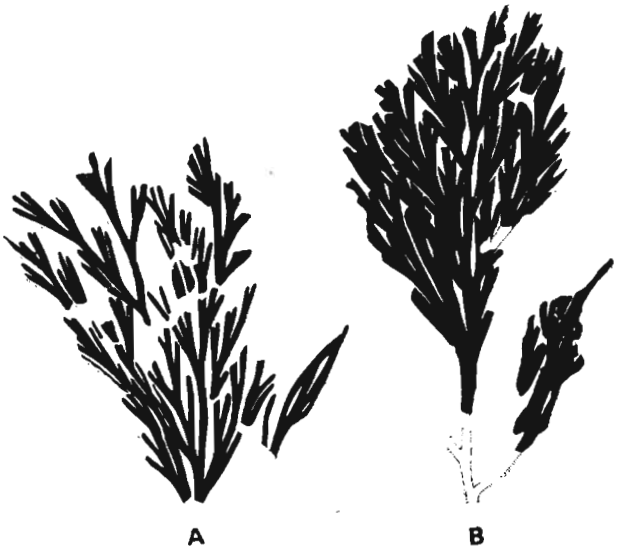
Occurrence — Gadhsisa and Chawad River (locality nos. 3 & 5).

Comparison — The present specimens match exactly with the specimen of *S. metzgerioides* figured by Harris (1961, fig. 71D) from Yorkshire. Besides, Harris's (1961) specimen of *S. metzgerioides*, the present specimens also resemble, in gross features, *S. tenuifissa* Saporta figured by Teixeira (1948, pl. 33, fig. 4). In *S. tenuifissa* branching habit of ultimate segments is different. *Raphaelia neuropteroides* Debey & Ettinghausen described by Berry (1928, pl. 11, fig. 6) shows only superficial resemblance. Its branching habit of ultimate segments is quite distinct from *S. metzgerioides*.

A FERTILE FROND SHOWING DENNSTAEDTOID AFFINITIES

Pl. 5, fig. 7; Pl. 6, fig. 10; Text-fig. 13A, B

Description — Bipinnate frond, about 5 cm in length and 5.2 cm in width. Primary



TEXT-FIG. 12A-B — *Sphenopteris metzgeroides* Harris, B.S.I.P. specimen nos. 27/2411 from Chawad River (locality no. 3) and 21/2676 from Gadhsisa, × 2.

rachis 0.8 mm wide, with distinct median ridge, pinnae arising alternately at an angle of 45°-50° and about 3-6 mm apart, lanceolate to narrowly deltoid in shape, 2.5-3 cm long and 0.7 cm wide. Secondary rachis 0.5 mm wide with a median ridge, slightly winged. Basal pinnules fertile (up to about half to two third distance), distal pinnules sterile, pinnules attached at an angle of 45°, alternate to subopposite, contiguous linear lanceolate, size 1-3×0.5-1 mm, base broad; basiscopic margin decurrent; acroscopic margin slightly constricted; margin mostly deeply lobed, sometimes notched; apex acute; veins indistinct, at places midvein discernible. Each fertile pinnule bearing a sorus at the basalmost lobe towards acroscopic margin, remaining portion sterile. Sorus superficial and resting at a vein-ending. Indusium pouch-shaped, attached below and at sides of the receptacle, apex truncate. A few sori showing circular scars of different sizes perhaps representing sporangia of mixed nature.

Occurrence — Bhajodi.

Remarks — The above description is based on a single specimen with part and counterpart. The specimen is preserved in the form of an impression. The specimen shows apparent resemblance with some of the fertile species of *Coniopteris* Brongniart. However, it differs from the species of *Coniopteris* in their soral character. In *Coniopteris* fertile pinnule bears more than one sorus, whereas in the present specimen ultimate leaflet has only one sorus, which is placed at the basalmost lobe towards the acroscopic margin and the remaining lobes are devoid of sorus.

Amongst the living ferns, the soral character as well as sterile parts of the pinnules of the specimen from Bhajodi are more like some of the Dennstaedtoid genera, i.e. *Leptolepia* Mettenius, Kuhn and *Microlepia* Presl. As the specimen lacks details of indusium, sorus and sporangium, so at present it has not been assigned to any family.

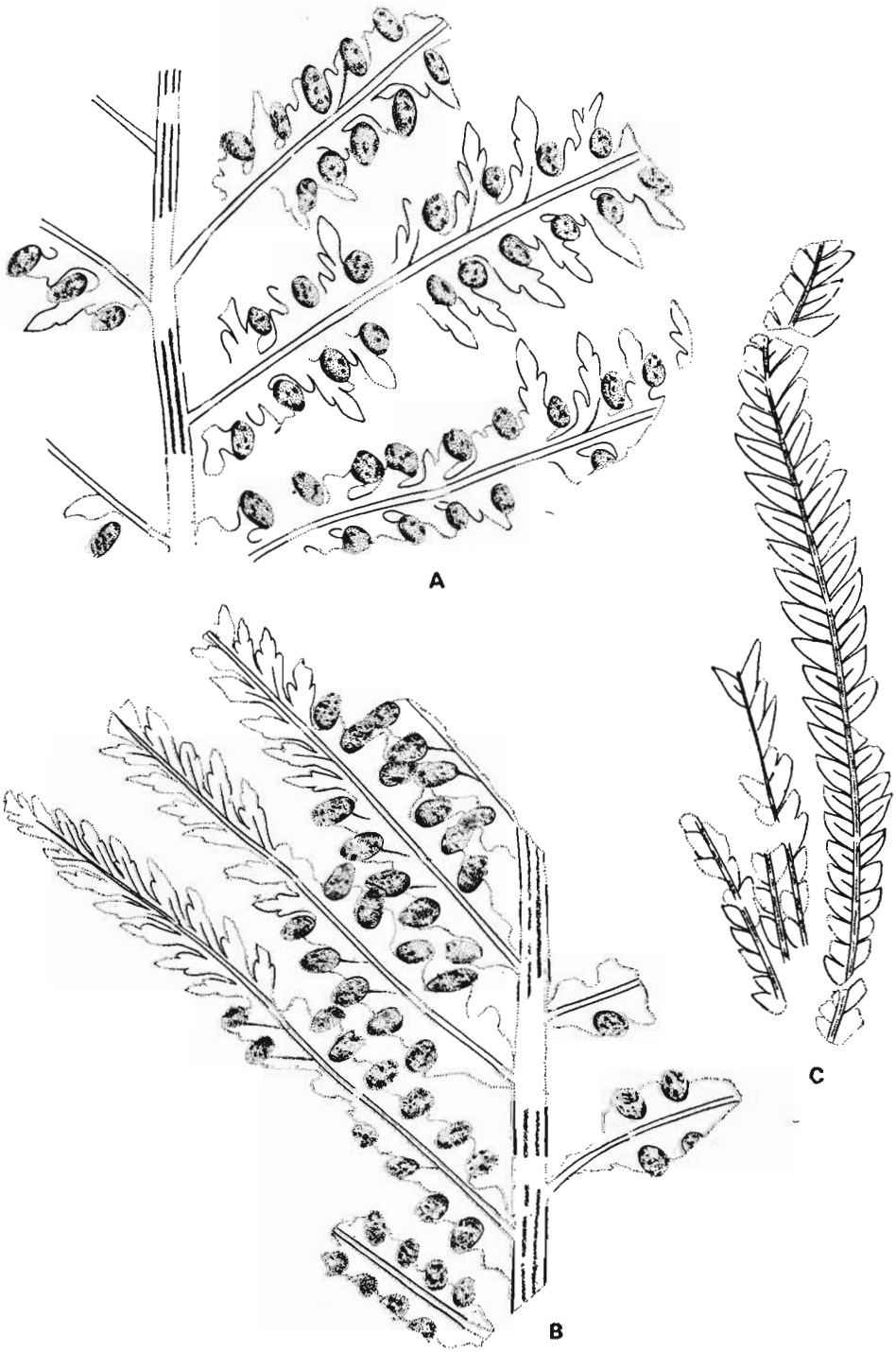
FERNS OF DOUBTFUL GENERIC AFFINITY

Genus — *Gleichenites* Göeppert, 1836

?Gleichenites sp.

Pl. 5, fig. 3

Description (for description assumed to be bipinnate)— Detached fragmentary pinna, 3 cm long and 0.4 cm wide. Rachis 1 mm wide. Pinnules arising at an angle of



TEXT-FIG. 13A-C — **A, B,** part and counterpart of a frond showing Dennstaedtoid affinities from Bhajodi, B.S.I.P. specimen nos. 19/2076 and 7/2076, × 4; **C,** ?*Matonidium* sp. from Kakadbhit (locality no. 2), B.S.I.P. specimen no. 103/1212, × 1.

70°-80°, alternately arranged on upper side of rachis, 2.2.5 mm long and about 1.5 mm wide, oblong-ovate, substance of lamina thick, margin entire, apex obtuse; basiscopic margin bulging out and covering about 3/4 of rachis, as compared to basiscopic margin acroscopic margin not so convex. Veins indistinct, only at places midrib faintly discernible.

Occurrence — Trambau.

Remarks — The affinities of this specimen are doubtful. The general form of pinnules and their mode of attachment is more like *Gleichenia nordenskiöldii* Heer described by Sukh-Dev (1970), Borkar and Chiplonkar (1973) and Bose *et al.* (1980).

?*Dictyophyllum* sp./*Clathropteris* sp.

Text-fig. 4I

Description — Fragmentary sterile pinna measuring 3.2 cm in length and 2.2 cm in width, shape as a whole unknown, margin lobed not deeply divided; midvein about 1 mm broad, secondary veins emerging at an angle of 60°-70° and usually 1.2 cm apart, subopposite, running up to lobed margin, tertiaries forming rectangular or polygonal meshes, at places vein endings also faintly visible within the polygonal meshes.

Occurrence — Kurbi.

Remarks — The above description is based on a single sterile specimen collected from Kurbi. In this specimen finer meshes are not well-preserved. As such it is difficult to make out whether the specimen belongs to *Dictyophyllum* Lindley & Hutton (1834) or *Clathropteris* Brongniart (1828). According to Ôishi and Yamasita (1936) and Harris (1961) in *Dictyophyllum* the meshes are polygonal, whereas in *Clathropteris* they are rectangular. In addition, in *Dictyophyllum* pinnae are deeply divided into lateral segments and in *Clathropteris* division is only half way to the midrib. In this latter character the present specimen resembles more *Clathropteris*. But as the preservation is not satisfactory, so for the time being we have preferred to keep its affinities open.

?*Matonidium* sp.

Pl. 6, fig. 9; Text-figs 9I, 13C

Description — Pinnae linear-lanceolate, largest pinna measuring 10.2 cm in length, 1.5 cm in width. Pinna rachis about 1 mm wide, showing a distinct median groove. Pinnules alternate, attached to rachis by entire base, arising at an angle of 45°-55°, more or less rhomboidal in shape, 5-8 mm long and 3-4 mm wide, margin entire sometimes near apex slightly wavy, apex acute-subacute; acroscopic margin slightly constricted; basiscopic margin decurrent. Veins mostly obscure. Midrib reaching up to apex, lateral veins once or twice forked.

Occurrence — Kakadbhit (locality no. 2).

Remarks — Collection includes two incomplete specimens in part and counterpart. In both the specimens pinna are radiating from base, as is commonly met with in *Matonidium* and *Phlebopteris*. In the absence of well-preserved veins, it is difficult to assign these specimens to any genus with certainty. Mostly in *Phlebopteris* veins form meshes along the midrib. Such meshes are not visible in the present specimens. In general form and habit the specimens resemble *Matonia mesozoica* Appert (1973). The latter, however, differs in having much smaller pinnules. The sterile pinnules of *M. americanum* Berry (1919) look like the smaller pinnules of ?*Matonidium* sp.

?*Coniopteris* cf. *minturensis* Brick

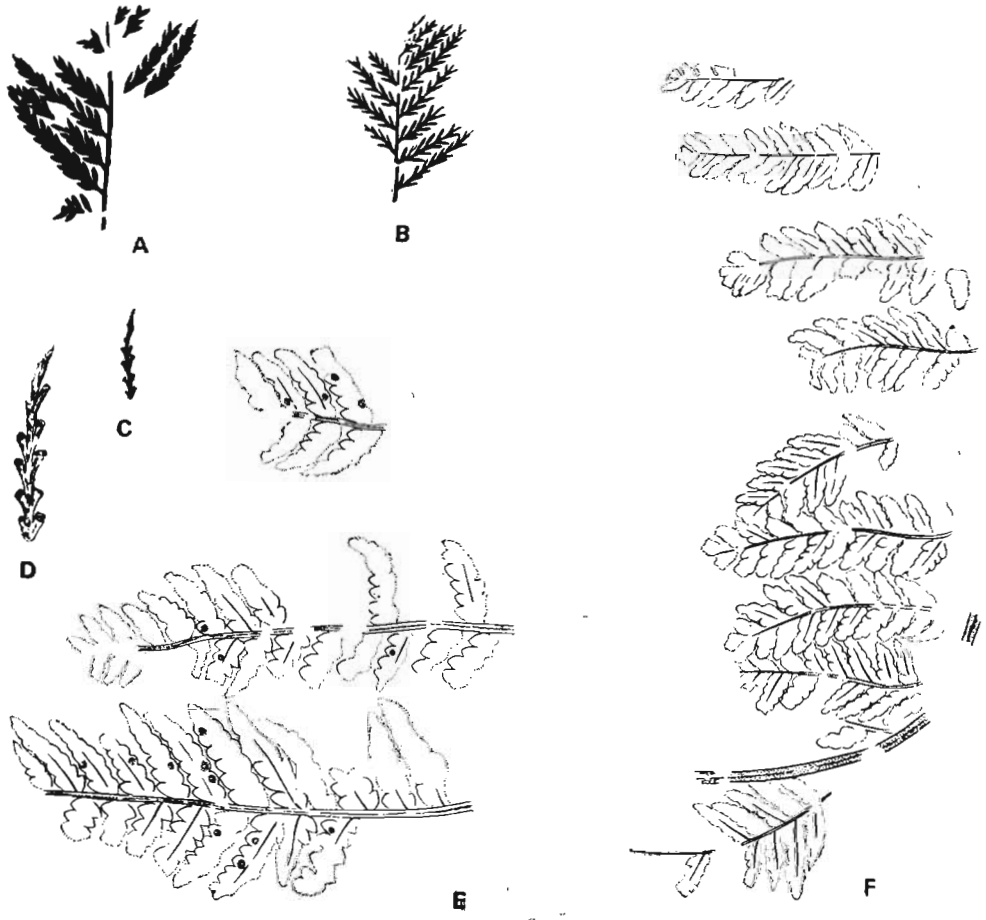
Pl. 5, figs 5, 6; Text-fig. 14A-D

Specimen from Kachchh:

1972 *Onychiopsis* sp. cf. *O. psilotoides* (Stokes & Webb) Ward: Mathur, p. 488, fig. 19.

1982 *Onychiopsis* sp. cf. *O. psilotoides* (Stokes & Webb) Ward: Bose *et al.*, p. 3 (under synonymy of *Pachypteris haburensis* Bose *et al.*).

Description — Largest frond 3.5 cm long and 2 cm wide; primary rachis 5-8 mm wide, showing a median groove. Pinnae linear attached at an angle of 40°-55°, closely set, alternate, towards apex sub-opposite, mostly 1.5-2.2 cm long and 0.2 cm wide, towards distal end gradually decreasing in size. Secondary rachis 2 mm wide, smooth. Pinnules alternate or sub-opposite, attached at an angle of 40°-60°, lanceolate or narrowly obcuneate in shape, typically 1.5-2×0.4-1 mm in size; margin entire or rarely near apex minutely dentate; apex



TEXT-FIG. 14A-F — **A, B,** ?*Coniopteris* cf. *minturensis* Brick from Trambau, B.S.I.P. specimen nos. 77/2677 and 80/2677, × 2; **C, D,** a portion of a fertile frond found in association with ?*Coniopteris* cf. *minturensis* from Chawad River (locality no. 5), B.S.I.P. specimen no. 14/2679: C × 1 and D × 2; **E, F,** *fern frond — Type* 1, B.S.I.P. specimen nos. 41/2419 from Trambau (this specimen seems to be a part of a fertile frond) and 22/2920 from Jamthara: E × 2 and F × 1.

sub-acute, obtuse or truncate, apical region of basal pinnules sometimes trilobed; bases of adjacent pinnules touching each other. Venation mostly obscure, principal vein after emergence giving of a lateral branch at low angle, then further forking once or twice.

Occurrence — Mardakh Bet, Trambau, Khari River (Rudra Mata Dam site), Chawad River (locality no. 5) and Lakhapar.

Remarks — All the specimens of ?*Coniopteris* cf. *minturensis* are sterile. In none of them attached fertile pinnae have been found. However, in Chawad River (locality 5) a detached fertile pinna has been collected in association with ?*Coniopteris* cf. *minturensis*. The preservation in this specimen (Text-fig. 14C, D) is extremely poor and it is not definite whether the specimen belongs to ?*Coniopteris* cf. *minturensis* or some other species of *Coniopteris*.

The sterile specimens resemble most *Coniopteris minturensis* Brick (1953, pl. 12, figs 5, 8).

FERN FROND — TYPE 1

Pl. 6, figs 7, 8; Text-fig. 14E, F

Description — Leaves tripinnate, shape as a whole unknown, largest specimen about

10 cm in length. Principal rachis 1.5 mm broad, smooth. Pinnae of first order arising at an angle of 50°-70°, mostly 1.3-1.5 cm apart, alternate, largest pinna measuring 3.8 cm in length and 1.6 cm in width, linear-lanceolate; rachis 0.5 mm wide, distinctly grooved. Pinnae of second order sub-opposite to alternate, attached at an angle of 50°-80°, measuring 8-9 mm in length and 1.5-2.5 mm in width, linear-lanceolate; secondary rachis 0.5 mm broad. Pinnules attached at an angle of about 45°, contiguous, typically 1.2-2 × 1 mm, ovate; margin entire; apex subacute-obtuse; venation indistinct, at places midrib faintly visible. Apical region of pinnae not forming distinct pinnules, only showing wavy margin.

Occurrence — Trambau and Jamthara.

Remarks — This type of frond is extremely rare in Kachchh. So far it has been collected only from Trambau and Jamthara. The specimen from both these localities are extremely badly preserved. The specimen from Jamthara is sterile and its ultimate segments at places show distinct midrib. The specimens from Trambau seem to be fertile. In some of the pinnules faint circular depressions on either sides of midrib are visible. These depressions are situated slightly away from margins and perhaps they represent the sori. No other details are visible. The poor condition of preservation does not allow them to be referred to any definite genus.

Comparison — The specimens resemble most *Cladophlebis* (*Teilhardia*?) *kanmerai* Kimura (1976, pl. 1, figs 2, 3) in overall shape and size of pinnules. Kachchh specimens also resemble in gross features *Osmundopsis plectrophora* Harris figured by Brick (1953, pl. 2, figs 2, 3), *Cladophlebis* sp. b described by Ôishi [1941, pl. 36(1), fig. 5] and *C. tripinnata* Archangelsky (1963, pl. 1, figs 1, 4).

GYMNOSPERMS

Genus — *Sagenopteris* Presl, 1838

Sagenopteris cf. *colpodes* Harris

Pl. 6, figs 1-6; Text-fig. 15A-K

Specimens from Kachchh:

1980 *Sagenopteris* sp. cf. *S. colpodes* Harris: Bose & Banerji, p. 226, pl. 1, figs 1-10; text-fig. 1A-J.

Description (from Bose & Banerji, 1980 with minor changes) — Detached leaflets, 2.8 × 1 to 10.5 × 2.3 cm, lamina inequilateral, ovate-lanceolate; margin entire; apex obtuse, sometimes sub-acute; base gradually tapering downwards. Petiole mostly about 2-3 mm long, smooth. Midrib prominent, evanescent towards apex, secondary veins arising at an angle of 10°-15°, branching and forming meshes, meshes 2-5 × 0.3-1.1 mm, marginal meshes smaller.

Occurrence — Kurbi, Kakadbhit (locality no. 1) and Chawad River (locality no. 3).

Remarks — *Sagenopteris* cf. *colpodes* is fairly common at Kurbi. In Chawad River some of the specimens have '*phytolemma*', but from none of them cuticular preparation could be made. At Kakadbhit *Sagenopteris* is extremely rare. From all these localities more than 75 specimens have been collected and out of them only one seems to be attached to the petiole along with another leaflet.

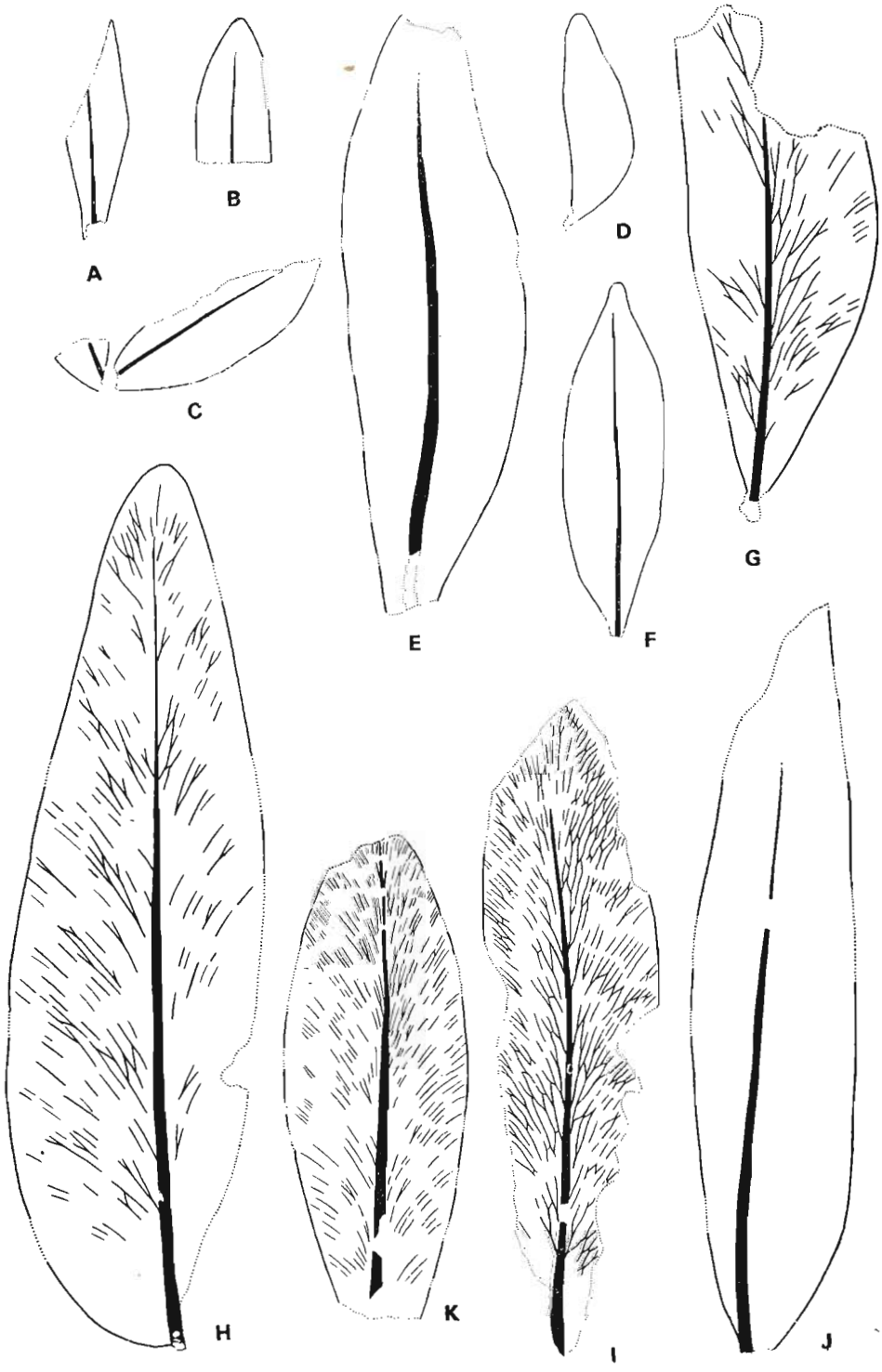
Comparison — The specimens from Kachchh resemble most *Sagenopteris colpodes* Harris (1940 & 1964) described from Yorkshire in gross features and in size range. Some of the leaflets of *Sagenopteris* cf. *colpodes* also resemble the smaller leaflets of *S. elliptica* Fontaine (1889), but in the latter species the leaflets are typically lanceolate in shape and they have acute apices. *S. nilssoniana* (Brongniart) Ward figured by Bonetti (1963, pl. 4, figs 1, 3 & 5) resemble in external features *S.* cf. *colpodes*. In *S. nilssoniana* the meshes are slightly broader. *S.* cf. *nilssoniana* (Brongn.) Ward described by Möller and Halle (1913) has broader and fewer meshes. *Anthrophyopsis grandis* Walkom reported by Flint and Gould (1975) approaches in size the larger leaflets of *S.* cf. *colpodes*. *A. grandis*, however, differs in having secondary veins which are arising at more wider angles.

Genus — *Caytonia* Thomas, 1925

Caytonia indica n. sp.

Pl. 7, figs 1-18; Text-fig. 16A-K

Diagnosis — 'Fruit' pedicellate; pedicel up to 5 mm long, usually 0.8-1 mm broad, covered with numerous trichomes. 'Fruit' globose or broadly elliptic (abortive 'fruits'



TEXT-FIG. 15

broadly elliptic, ovoid or reniform), maximum width 3 mm, lip distinct, curving backwards towards pedicel (in abortive 'fruits' lip indistinct, only a thickened, undulate zone visible).

Cells of pedicel elongate rectangular with oblique or straight end-walls, lateral-walls mostly straight, rarely at places slightly wavy; surface unspecialized; in mature 'fruit' cells generally covered with trichome bases; trichome bases irregular in shape, mostly broadly oval or circular. 'Fruit' cuticle thick, cells mostly polygonal, rarely squarish or rectangular. Lateral- and end-walls thick, usually straight, rarely at places slightly wavy; surface smooth; trichome bases absent. Cells surrounding lip thick-walled, obscure, giving a frill-like appearance all along the margin of lip.

Seed oval or rounded, 1-1.8×1.2 mm, orthotropous, outer cuticle delicate. Micropyle slightly sunken, lying almost opposite chalaza, cells minute, squarish or rectangular. Below micropyle a few layers of cells polygonal, more or less isodiametric, irregularly arranged, other cells rectangular, much longer than broad, somewhat serially arranged in longitudinal direction. Cells near chalaza smaller in size and converging towards base. Lateral- and end-walls straight, surface smooth. Entire surface showing prominent transverse wrinkles.

Holotype — B.S.I.P. slide no. 7049.

Occurrence — Chawad River (locality no. 4).

Remarks — 'Fruits' of *Caytonia indica* were isolated from matrix by bulk maceration. The majority of the 'fruits' are abortive and most of them are devoid of seeds. From only one 'fruit' a single seed could be taken out. Besides this seed, a few dispersed seeds have also been obtained which match with the one found *in situ*. All these dispersed seeds can conveniently be referred to the genus *Amphorispermum* Harris. Another specimen (Text-fig. 16D) shows seven oval depressions inside the 'fruit' probably representing the position of seeds.

Comparison — 'Fruits' of *C. thomasii* Harris (1933) reported from Scorseby Sound, East Greenland differ from the 'fruits' of *C. indica* in being broader than long. In *C. thomasii* the micropylar cells are longer than the micropylar cells of *C. indica*. Like *C. indica* the Yorkshire species of *Caytonia*, viz., *C. sewardii* Thomas, *C. nathorstii* (Thomas) Harris and *C. kendallii* Harris described by Harris (1964) have round fruits. *C. sewardii* can be distinguished from *C. indica* by its strongly jagged epidermal cells of 'fruit'. In *C. nathorstii* the epidermal cells of 'fruits' are straight-walled, but it differs from *C. indica* in having longer micropylar cells. *C. kendallii* has 'fruits' whose epidermal cells are weakly jagged, moreover, its micropylar cells, too, are longer than the micropylar cells of *C. indica*. The 'fruits' of *C. harrisii* Reymanówna (1973), described from Grojec, Poland, are covered with a large number of glandular hairs. The epidermal cells of 'fruits' are also papillate in *C. harrisii*.

Genus — *Pachypteris* Brongniart, 1828

Pachypteris indica (Oldham & Morris) Bose & Roy

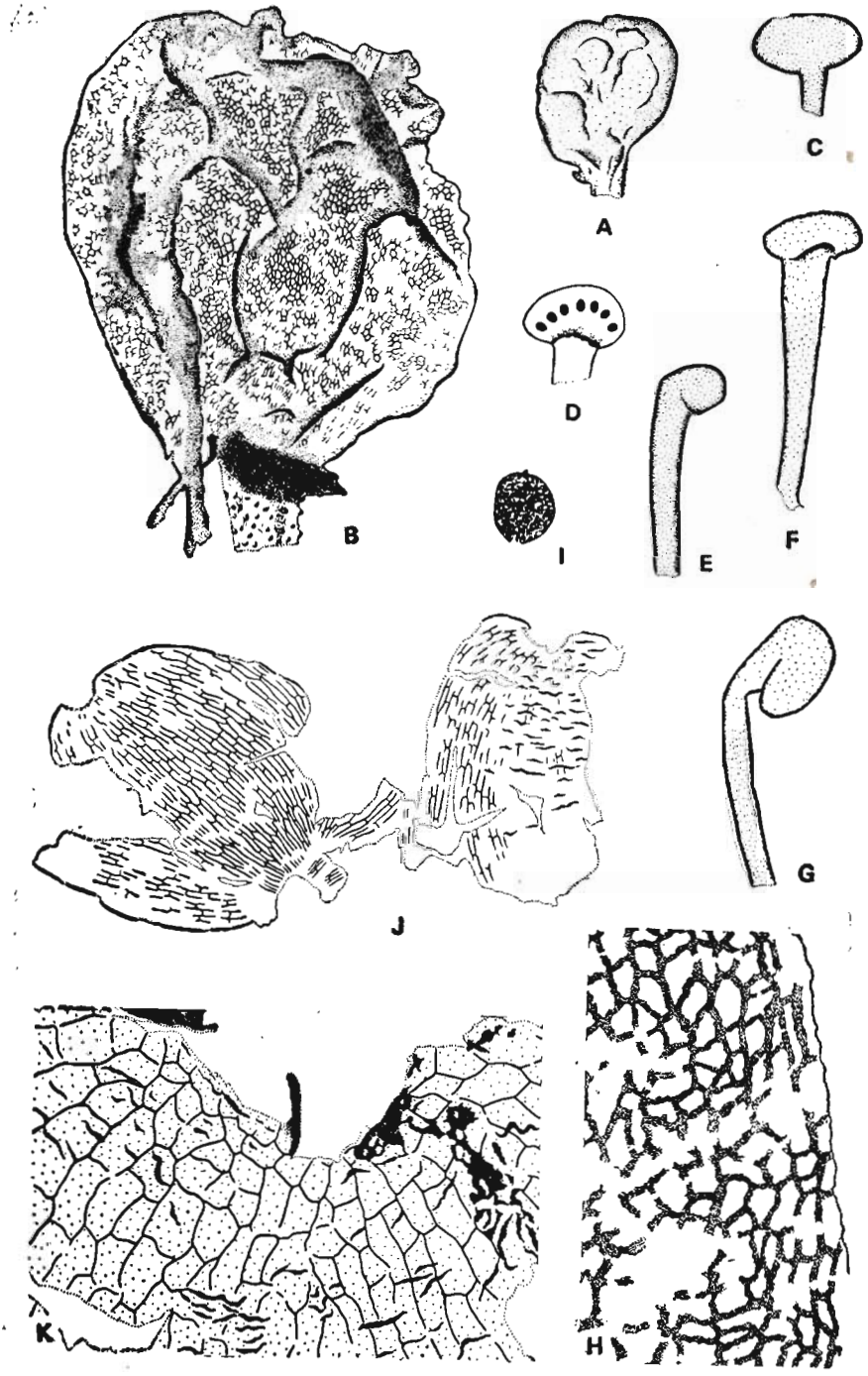
Pl. 8, figs 1-8; Pl. 9, figs 1, 5, 7-9; Pl. 10, figs 5, 6; Pl. 11, figs 8, 9; Text-figs 17, 18A-F, 19A-F, 20A-I, 21A-D

1863 *Taxodites ?indicus* Oldham & Morris, pl. 33, figs 5, 6.

1876 *Palissya bhoojoorensis* Feistmantel, p. 56, pl. 9, figs 4-5, 5a.
Palissya, like the species from the Rajmahal Group: Feistmantel, p. 57, pl. 11, figs 6, 6a.
Palissya resembling *Taxites laxus* Phillips: Feistmantel, p. 57, pl. 12, figs 8, 9.

←

TEXT-FIG. 15A-K — *Sagenopteris* cf. *colpodes* Harris. **A, B, D-J,** B.S.I.P. specimen nos. 27/2082A, 33/2420, 18/2420, 38/2082B, 68/2420, 23/2082B, A/2420, 179/2082 and 48/2420 from Kurbi; A, B, D, F and J × 1, E, G, H and I × 2; C and **K,** B.S.I.P. specimen nos. 105/2411B and 147/2411B from Chawad River (locality no. 3), × 1.



TEXT-FIG. 16A-K — *Caytonia indica* n. sp. from Chawad River (locality no. 4). **A, B,** mature 'fruit'. B.S.I.P. slide no. 7049: A × 10 and B × 25; **C, E-G,** abortive 'fruits', B.S.I.P. slide no. 7052, × 6; **D,** a young 'fruit' showing positions of seeds, B.S.I.P. slide no. 7050, × 6; **H,** cuticle of 'fruit' wall, B.S.I.P. slide no. 7049, × 150; **I,** a dispersed seed, B.S.I.P. slide no. 7051, × 6; **J,** seed cuticle recovered from the specimen figured in A, B.S.I.P. slide no. 7049, × 25; **K,** a portion of the above magnified showing a few cells adjacent to micropyle, B.S.I.P. slide no. 7049, × 150.

TEXT-FIG. 17 — *Pachypteris indica* (Oldham & Morris) Bose & Roy from Chawad River (locality no. 4), B.S.I.P specimen no. 88A/2411 D, × 1.

1877a *Palissya indica* (Feistm.) Oldh.: Feistmantel, p. 22, pl. 8, fig. 7.
1877b *Palissya indica* Oldh.: Feistmantel, p. 15, pl. 8, figs 1-5; pl. 10, figs 2, 3.
1879 *Dichopteris ellorensis* Feistmantel, p. 14, pl. 2, figs 8-10.
1879 *Dichopteris ellorensis* Feistmantel, p. 14, pl. 2, figs 8-10.
1915 *Retinosporites indica* Holden, p. 221, pl. 11, figs 1, 4, 9, 11.
1920 *Retinosporites indica* Feist.: Seward & Sahni, p. 36 (*partim*).
1928 *Retinosporites indica* (O. & M.): Sahni, p. 16 (*partim*).
1940 *Retinosporites indica*: Florin, p. 64.
1968 *Pachypteris indica* (Oldham & Morris) Bose & Roy, p. 2, pl. 1, figs 3-5; pl. 2, figs 10-14; pl. 3, figs 15, 16, 19, 20; text-figs 1A-C, 2A-H, 3A-C, 4A-D, 5A.
1968 *Pachypteris holdenii* Bose & Roy, p. 6, pl. 1, figs 1, 2, 8, 9, pl. 3, figs 17, 18; text-figs 5B-D, 6A, B.
1972 *Pachypteris indica* (Oldham & Morris) Bose & Roy: Bose & Kasat, p. 178, text-fig. 1A-F.
1974 *Pachypteris indica*: Srivastava, p. 183, text-fig. 3(1-8).
1981 *Pachypteris indica* (Oldham & Morris) Bose & Roy: Sukh-Dev & Zeba Bano, p. 1, pl. 1, figs 1-8, text-fig. 1A-G.

Emended Diagnosis — Leaf mostly bipinnate, rarely tripinnate, estimated length and breadth about 60×25 cm (largest available leaf measuring 45×21.5 cm), shape as a whole broadly ovate, substance of lamina thick and coriaceous. Proximal end of rachis distinctly pulvinus, 1.3-1.7 cm wide. Rachis surface smooth, gradually narrowing towards apex, major part of rachis 0.7-0.9 cm wide, sometimes showing a median groove. Pinna shape as a whole lanceolate, arising at an angle of 25°-75°, alternate, rarely sub-opposite, crowded or distantly placed, 1.7-13.5 cm in length and 0.4-3.2 cm in width, towards base and apex gradually diminishing in size. Pinna rachis on ventral side with a median groove, 1-2.5 mm wide. Pinnules closely or distantly placed, rarely touching each other, apical pinnules commonly pinnatifid. Pinnules arising at an angle of 20°-55°, near middle majority arising at an angle of 35°-40°, towards apex less than 30°; linear, lanceolate or obovate, typically 0.7-2.4 cm long, 1-3 mm wide, margin mostly entire, sometimes lobed (mostly trilobed) or tridentate near apex, rarely near apex microscopically dentate. Basiscopic margin distinctly decurrent; apex acute, mucronate or obtuse. In tripinnate fronds ultimate pinnules like normal pinnules in gross features, mostly 0.2-1 cm in length and 1-2 mm in width. Veins mostly concealed, rarely in some midrib with one or two lateral veins visible. Midrib when visible reaching almost up to apex; lateral veins arising at low angles. In case of tridentate pinnules, principal vein dividing and reaching base of each dentation. Sometimes in pinnatifid forms apical pinnules with a few more veins which are mostly forking once.

Cells of primary rachis similar on both sides, mostly rectangular, sometimes squarish or polygonal, occasionally fairly longer than broad; anticlinal walls usually straight or slightly wavy; periclinal wall smooth, devoid of papillae. Stomata present on both surfaces; upper surface with very few stomata, whereas lower surface having a large number of stomata. Stomata irregularly distributed, on lower surface very rarely forming discontinuous single files, longitudinally orientated. Subsidiary cells 5-8 in number, commonly 6 or 7, major part of subsidiary cells strongly cutinized, forming a thickened ring around stomatal pit. Stomatal pit mostly oval, sometimes stellate; guard cells sunken, thinly cutinized; aperture elliptical or slit-like.

On secondary and tertiary racheae stomatal distribution more or less similar to that of main rachis. Cells, on upper surface, usually narrow, much longer than broad; anticlinal walls mostly slightly sinuous (end walls oblique and less sinuous); periclinal wall smooth. Cells of lower surface rectangular, polygonal, elongated; anticlinal walls sinuous; periclinal wall unspecialized. Subsidiary cells 5-8 in number, usually 6, surface like that of primary rachis. Guard cells sunken, thinly cutinized.

Cuticle of pinnules of both bi- and tripinnate fronds more or less similar in nature, hypostomatic, stomata confined mostly on lower surface, rarely in some a few stomata also present on upper surface, about 6-8 μm thick on both surfaces. Upper surface having rectangular, elongated-rectangular or polygonal cells; anticlinal walls straight or slightly sinuous because of secondary

TEXT-FIG. 18

TEXT-FIG. 19A-F — *Pachypteris indica* (Oldham & Morris) Bose & Roy. **A-C,** portions of fronds showing pinnules with dentations, B.S.I.P. specimen nos. 82/2411C, 90/2411C and 20/2411C from Chawad River (locality no. 4): A, B × 1, C × 2; **D, E,** parts of fronds showing pinnules with entire margins, B.S.I.P. specimen nos. 42/2082B and 79/2079B from Kakadbhit, × 1; **F,** a part of a tripinnate frond, B.S.I.P. specimen no. 26/2411 from Chawad River (locality no. 4), × 1.

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TEXT-FIG. 18A-F — *Pachypteris indica* (Oldham & Morris) Bose & Roy, showing variations in shape and size of pinnules. **A, B,** showing tri-dentate pinnules; **C-E,** showing pinnules with entire margins; **F,** showing pinnules with lobed margin; B.S.I.P. specimen nos. 83/2411C, 83/2411C, 56/2411, 29/2411, 66/2411 and 100/2411B from Chawad River (locality no. 4), × 1.

TEXT-FIG. 20

thickening; periclinal wall smooth, sometimes having small circular thickening at corners. In some, upper surface showing elongated rectangular cells along veins (especially principal vein). Lower surface with longitudinally orientated, irregularly distribut.d and closely placed stomata, at places stomata tending to form discontinuous files, in some pinnules stomata avoiding veinal regions. Subsidiary cells 5-8 in number, mostly 6, inner wall of subsidiary cells considerably thickened, because of this at places stomatal pit partially concealed, in such cases stomatal pit giving a stellate appearance; stomatal pit usually squarish, oval or rounded in shape; having a cutinized thickening all around, rarely two stomata sharing a common subsidiary cell; inner wall of guard cells thinly cutinized, stomatal aperture elliptical or slit-like. Ordinary epidermal cells elongated rectangular or polygonal in shape; anticlinal walls straight or slightly sinuous; surface smooth.

Holotype — G.S.I. specimen no. 4909.

Occurrence — Trambau, Khari River (Rudra Mata Dam site), Sukhpur, Daisara, Kurbi, Gadhsisa, Kakadbhit (locality nos. 1 & 2), Dauda Mota, Chawad River (locality nos. 2, 3, 4, 5 & 6), Ugardi, Lakhapar and Dharesi (locality nos. 1 & 2).

Remarks — *Pachypteris indica* is extremely common in Chawad River (locality nos. 2 & 4). Pinnules in this species vary a good deal both in size and shape. In the same frond it may have pinnules with entire margins and pinnules having dentations near apices or with distinctly lobed pinnules.

Comparison — The majority of the specimens of *Pachypteris indica* externally look like *P. lanceolata* Brongniart described by Vakhrameev and Samylina (1958) from U.S.S.R. and Harris (1964) from Yorkshire. Some of the specimens of *P. lanceolata*, figured by Doludenko and Svanidze (1969, pl. 10, fig. 1) from Georgia, U.S.S.R., are like some of those fronds of *P. indica* which have pinnatifid apical pinnules. *P. lanceolata* differs from *P. indica* in having epidermal cells which have simple or branched thin strips over periclinal wall. Unlike, *P. indica* in *P. lanceolata* the stomata are mostly absent along margins and midrib and in largest pinnules they are even avoiding lateral veins. Moreover, in *P. lanceolata* the subsidiary cells are not so cutinized as in *P. indica*. *P. major* differs in having mostly oblong segments which have far too numerous veins than the pinnules of *P. indica*. The segments of *P. bendukidzei* Doludenko & Svanidze (1969) are broader than the pinnules of *P. indica* and its segments have thickened margins. In *P. austropapillosa* Douglas (1969) cells on the upper surface of lamina are often papillate. Some of the specimens of *P. desmomera* (de Saporta) Barale (1970, pl. 6, figs 2, 5, 7; 1981, pl. 4, fig. 1) resemble the specimens of *P. indica* which have pinnules with entire margin. In *P. desmomera* the subsidiary cells are mostly 7 in number and some of the epidermal cells have thin strips.

Pachypteris specifica Feistmantel

Pl. 9, figs 2-4, 6; Pl. 10, figs 1-4; Pl. 11, figs 1-7; Pl. 12, figs 4, 5; Text-figs 22A-I, 23A-E, 24A-I, 25A-K

1876 *Pachypteris specifica* Feistmantel, p. 32, pl. 3, figs 6, 6a.

1876 *Pachypteris brevipinnata* Feistmantel, p. 33, pl. 3, figs 7, 7a; pl. 4, figs 1-3; pl. 12, fig. 2.

1943 *Pachypteris specifica* Feistm. (=*P. brevipinnata* Feistm.): Frenguelli, p. 242.

1968 *Sphenopteris specifica* (Feistm.) Roy, p. 112, pl. 2, fig. 18; pl. 3, fig. 19; text-fig. 9.

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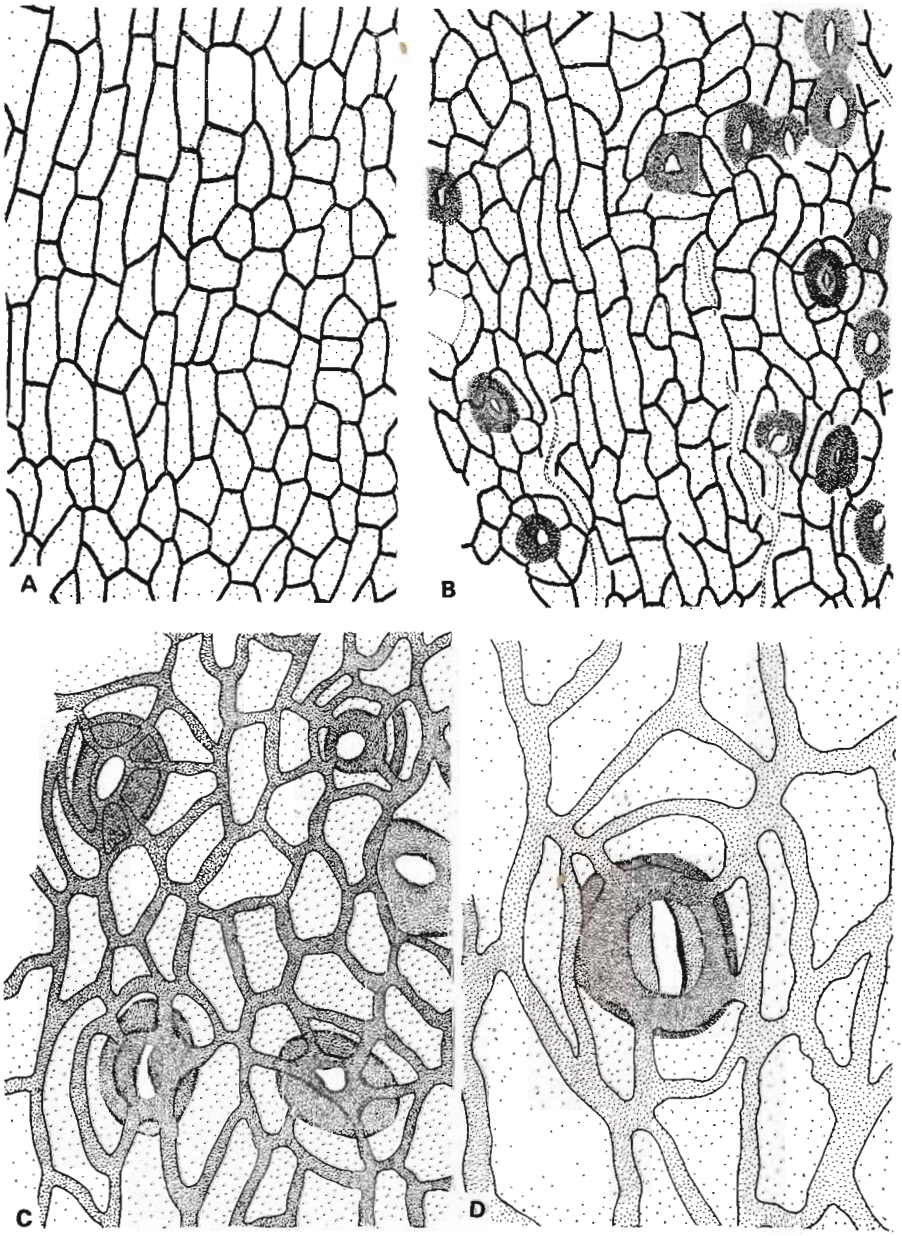
TEXT-FIG. 20A-I — *Pachypteris indica* (Oldham & Morris) Bose & Roy from Chawad River (locality no. 4). **A**, a pinnule with entire margin, B.S.I.P. specimen no. 29/2411 from Chawad River (locality no. 4), × 2; **B**, a pinnule with mucronate apex, B.S.I.P. specimen no. 56/2411, × 2; **C**, a pinnule with tri-dentate apex, B.S.I.P. specimen no. 90/2411C, × 2; **D**, a tri-lobed pinnule, B.S.I.P. specimen no. 100/2411B, × 2; **E**, a portion of a frond showing both entire margined and tri-dentate pinnules, B.S.I.P. specimen no. 74/2411C, × 1; **F**, showing a part of a tri-pinnate frond, B.S.I.P. specimen no. 26/2411, × 2; **G**, a bipinnate frond showing pinnules with dentate apex, B.S.I.P. specimen no. 2/2679C, × 1; **H**, showing a few petiole bases, B.S.I.P. specimen no. 84/2411C, × 1; **I**, lower surface of a pinnule, showing distribution of stomata, B.S.I.P. slide no. 90/2411-1, × 20.



TEXT-FIG. 21A-D — *Pachypteris indica* (Oldham & Morris) Bose & Roy from Chawad River (locality no. 4). **A,** cells of upper cuticle, B.S.I.P. slide no. 90/2411-1, × 100; **B,** lower cuticle showing stomatal distribution, B.S.I.P. slide no. 90/2411-1, × 100; **C,** lower cuticle showing a few stomata, B.S.I.P. slide no. 90/2411-1, × 200; **D,** a stoma, B.S.I.P. slide no. 90/2411-1, × 500.

1972 *Sphenopteris* sp.: Mathur, p. 488, fig. 20.

1974 *Pachypteris specifica* Feistmantel: Srivastava, p. 184.

1974 *Pachypteris brevipinnata* Feistmantel: Srivastava, p. 184.

Emended Diagnosis — Frond bipinnate with ultimate segments pinnatifid (nearly

TEXT-FIG. 22A-I — *Pachypteris specifica* Feistmantel, B.S.I.P. nos. 68/2082B (Kurbi), 36/2082 (Kurbi), 25/2000C (Kakadbhit locality no. 2), 2000A (Kakadbhit locality no. 1), 251/2000A (Kakadbhit locality no. 1), 98/2079 (Kakadbhit locality no. 2), 97/2079B (Kakadbhit locality no. 2), 40/2676 (Gadhsisa) and 44/2203 (Kakadbhit locality no. 1), × 1.

tripinnate), substance of lamina thick, shape as a whole probably lanceolate. Primary rachis 1-2 mm wide, showing a prominent median groove. Each pinna imparipinnate; pinna rachis 0.5-1 mm wide, having a median groove. Pinnae 0.4-4 cm long and 0.2-1.5 cm broad, lanceolate, emerging at an angle of 40°-50°, less towards apex, mostly alternate, rarely towards apex sub-opposite. Pinnules lanceolate or oval, attached at an angle of 45°-65°, gradually decreasing in size towards apex, alternate or sub-opposite, 0.15-1.5 cm long and 0.1-0.5 cm broad; margins entire, lobed or pinnatifid, when pinnatifid bases of lobes never touching rachis; acroscopic margin curving

TEXT-FIG. 23A-E — *Pachypteris specifica* Feistmantel from Kakadbhit (locality no. 2), B.S.I.P. specimen nos. 96/2203B, 94/2079B, 64/2079B, 155/2203B and 110/2203B: A-C × 1, D × 2 and E × 4; **D, E,** showing venation.

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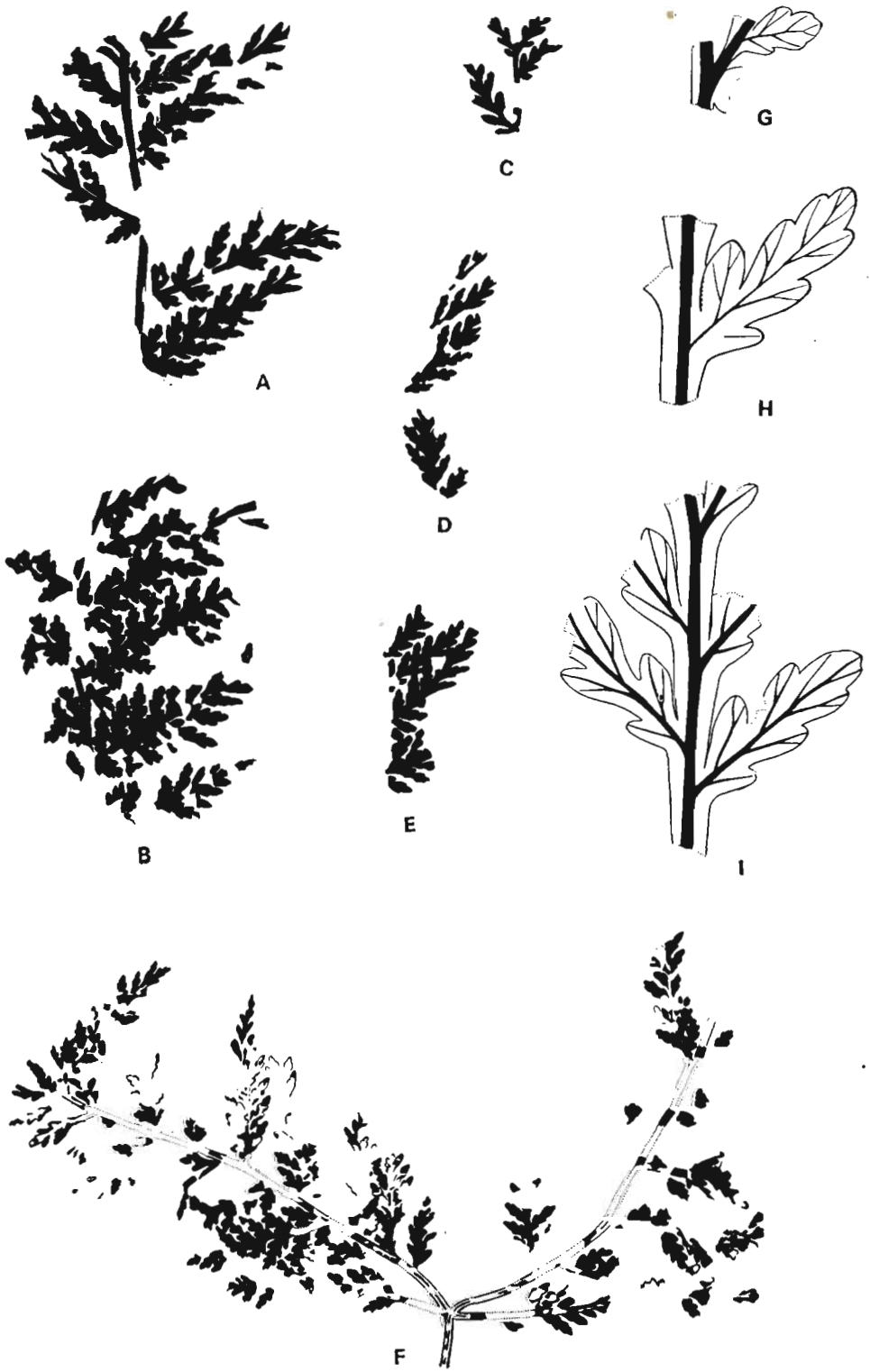
TEXT-FIG. 24A-I — *Pachypteris specifica* Feistmantel from Chawad River (locality no. 4). **A-E,** showing general habit of fronds, B.S.I.P. nos. 63/2411B, 41/2411, 60/2411, 82/2411 and 55/2411, × 1; **F,** a specimen showing four fronds attached to a stem, B.S.I.P. specimen no. 45/2411, × 1; **G-I,** showing venation, B.S.I.P. slide nos. 41/2411-1, 41/2411-2 and 41/2411-3 from Chawad River (locality no. 4): G × 4 and H, I × 6.



TEXT-FIG. 24

downwards or slightly constricted, basiscopic margin decurrent, sometimes bases of adjoining pinnules joining with each other; apex sub-acute or obtuse. Rarely a basiscopic pinnule of a pinna attached directly to main rachis. Midrib distinct; secondary veins arising at low angles, mostly simple or forking once, rarely twice or thrice forked.

Cells of rachis, on upper surface, square or rectangular, more or less serially arranged; anticlinal walls straight and thick, rarely slightly wavy; periclinal wall smooth. Cells on lower surface serially arranged, elongate-rectangular; anticlinal and periclinal walls similar to those of cells of upper surface, rarely at places finely striated. Trichomes absent.

Upper cuticle of lamina slightly thicker than lower, stomata confined to lower surface only. Cells of upper surface polygonal, rarely squarish or rectangular, irregularly arranged, at places along veins tending to be serially arranged; anticlinal walls straight or slightly wavy; periclinal wall smooth, at places finely striated. On lower surface cells along veins serially arranged, mostly rectangular, rarely polygonal; anticlinal walls thick, straight or slightly wavy at places; periclinal wall smooth, sometimes finely striated. Cells between veins polygonal, irregularly arranged; anticlinal walls mostly slightly undulated, rarely straight; periclinal wall smooth. Stomata monocyclic, irregularly distributed between veins, mostly obliquely orientated, occasionally transversely or longitudinally placed, not so crowded, sometimes at places two or three stomata lying close to each other, in such cases stomata sharing one or two common subsidiary cells. Subsidiary cells unspecialized 5-7 in number, mostly 7, not differentiated into polar and lateral subsidiary cells. Stomatal pit large, mostly broadly oval, rarely circular; guard cells slightly sunken, thinly cutinized, inner rim fairly well cutinized. Trichome bases absent.

Lectotype — G.S.I. specimen no. 4791 (Feistmantel, 1876, pl. 3, fig. 6).

Occurrence — Bhajodi, Khari River (Rudra Mata Dam site), Kuar Bet, Jamthara, Kurbi, Gadhsisa, Kakadbhit (locality nos. 1 & 2) and Chawad River (locality nos. 2, 3 & 4).

Remarks — Feistmantel (1876) had described two species of *Pachypteris* from Kachchh. They are *P. specifica* from Bhajodi and *P. brevipinnata* from Kakadbhit. While describing these species he never compared them with each other. On re-examination Feistmantel's specimens we have found them to be similar in gross morphology. In none of them veins are clear. In the lectotype (G.S.I. specimen no. 4791) outline of some of the pinnules are not at all clear. The best preserved specimen is the one figured by Feistmantel (1876, pl. 3, fig. 7) as *Pachypteris brevipinnata* (G.S.I. specimen no. 4792). The rest of the specimens of *P. brevipinnata* are not so well-preserved. The specimens figured by Feistmantel (1876) in pl. 4, figs 3 and 4 are part and counterpart. All these specimens and the specimens figured by Roy (1968, pl. 2, fig. 18; pl. 3, fig. 19; text-fig. 9) resemble our new specimens in gross features.

Pachypteris specifica is extremely common at Kurbi, Kakadbhit and Chawad River. Specimens with 'phytolemma' have been collected only from Gadhsisa and Chawad River. The specimens from Bhajodi, Khari River, Kuar Bet, Jamthara, Kurbi, Gadhsisa and Kakadbhit have also a few pinnules with lobed margins. In some of these fronds a pinna may have pinnules with either entire or lobed margins. The specimens from Chawad River have mostly segments which are pinnatifid and much smaller in

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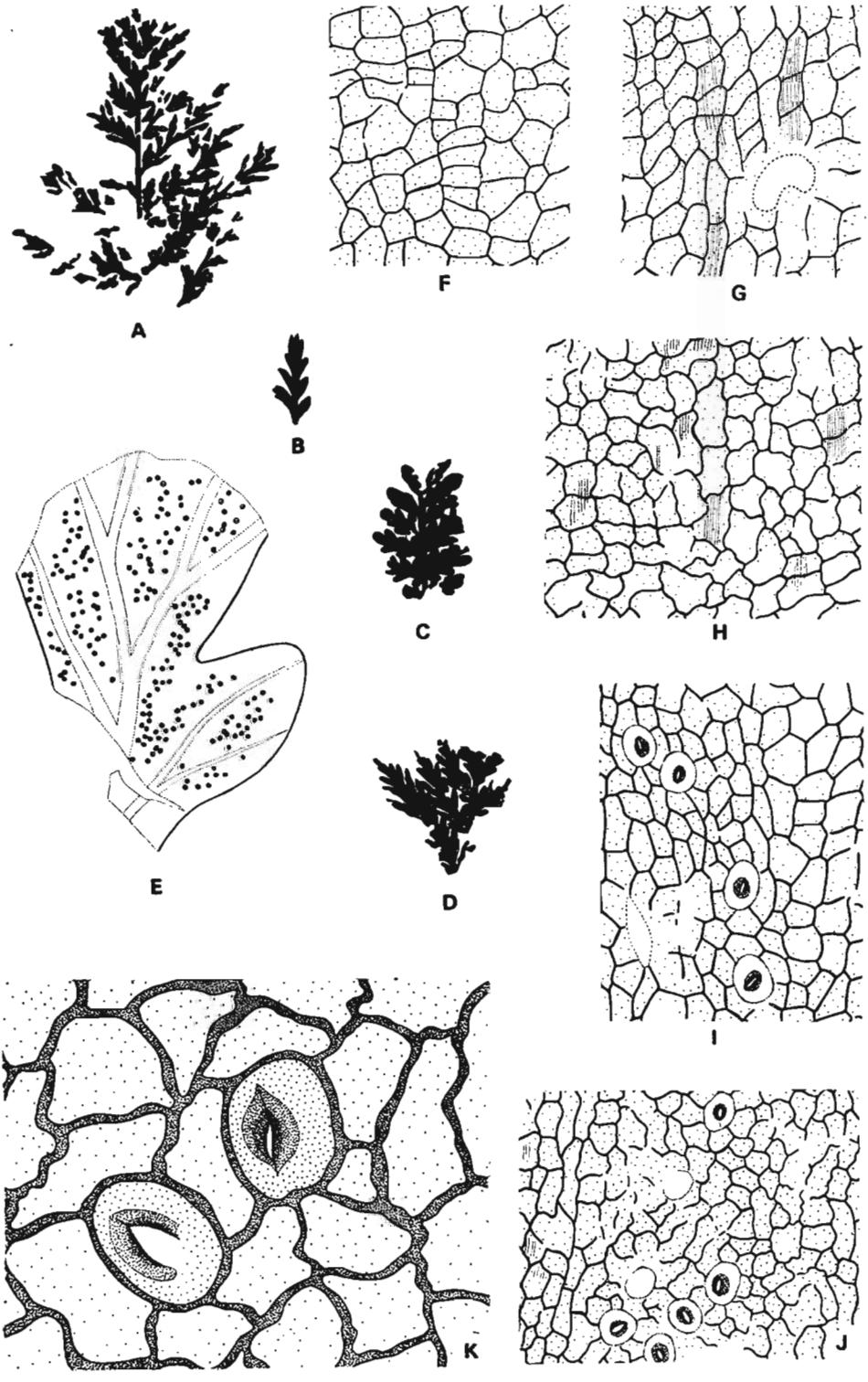
TEXT-FIG. 25A-K — *Pachypteris specifica* Feistmantel, **A-D,** showing parts of fronds, B.S.I.P. specimen no. 44/2411 (Chawad River, locality no. 4), 47/2404 (Gadhsisa), 35/2398 (Khari River, Rudra Mata Dam site) and 34/2411 (Chawad River, locality no. 4), × 1; **E,** showing distribution of stomata, B.S.I.P. slide no. 41/2411-3A (Chawad River, locality no. 4); × 20; **F,** upper cuticle of rachis, B.S.I.P. slide no. 52/2411-2 (Chawad River, locality no. 4), × 150; **G,** lower cuticle of rachis, B.S.I.P. slide no. 52/2411-2 (Chawad River, locality no. 4), × 150; **H,** upper cuticle of a pinnule, B.S.I.P. slide no. 25/2411-1 (Chawad River, locality no. 4), × 150; **I,** lower cuticle of a pinnule, showing a few stomata, B.S.I.P. slide no. 6/2404-1 (Gadhsisa), × 150; **J,** lower cuticle of a pinnule, showing a few stomata; B.S.I.P. slide no. 52/2411-1, × 150; **K,** showing two enlarged stomata, B.S.I.P. slide no. 55/2411-1, × 500.



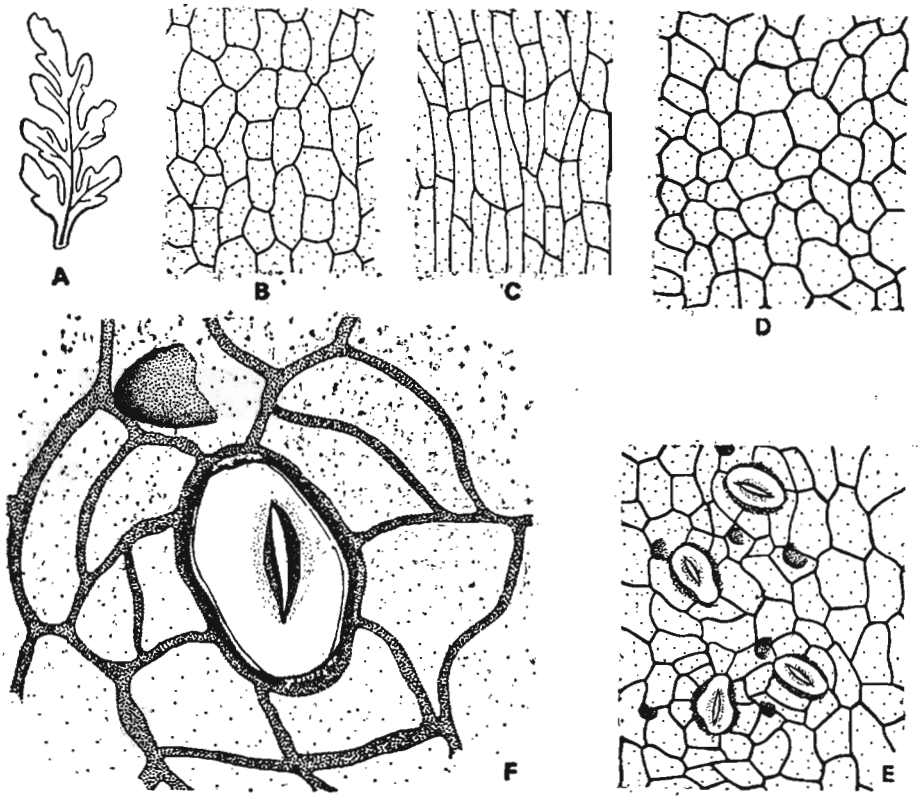
TEXT-FIG. 25

size. In some specimens both pinnatifid and entire margined segments are present. The larger pinnae of specimens from Chawad River approaches in size the smaller pinnae of fronds collected from Kurbi, Gadhsisa and Kakadbhit. The cuticle of all the specimens collected from Gadhsisa and Chawad River are similar.

In most specimens veins are obscure. The veins are more commonly visible in the specimens from Kakadbhit (locality no. 2). In some of these specimens from Kakadbhit (locality no. 2) veins are forking thrice (Text-fig. 23E). In the specimens from Gadhsisa and Chawad River, the veins are mostly not visible, however, after maceration most of the pinnules show the veins clearly (Text-fig. 24G-I).

One specimen from Chawad River (locality no. 4) is particularly interesting because in this specimen four leaves are attached at the apical end of a stem (Text-fig. 24F). A specimen with similar type of habit has been described as *Scleropteris furcata* by Halle (1913, pl. 4, figs 10, 11) from Graham Land.

Comparison — In gross features *Pachypteris specifica* resembles most *P. crassa* (Halle) Townrow (1965). *P. crassa* differs from *P. specifica* in having rachis with minute lumps and also it has papillate epidermal and subsidiary cells. *P. indica* differs in having narrower and longer pinnules, it has also got pinnules with dentate margins. Moreover, in *P. indica* the subsidiary cells are mostly 6 in number



TEXT-FIG. 26A-F — **A,** *Pachypteris* cf. *elegans* Archangelsky from Trambau, showing veins, B.S.I.P. slide no. 32129,× 2; **B,** cells of upper surface of rachis, B.S.I.P. slide no. 32129-3,× 150; **C,** cells of lower surface of rachis, B.S.I.P. slide no. 32129-3,× 150; **D,** cells of upper surface of lamina, B.S.I.P. slide no. 32129-2, × 150; **E,** lower cuticle showing a few stomata and trichome bases, B.S.I.P. slide no. 32129-2,× 150; **F,** a stoma, B.S.I.P. slide no. 32129-2,× 500.

and their inner walls are fairly well-cutinized. In *P. specifica* subsidiary cells are mostly 7 in number and their inner walls are not cutinized.

Pachypteris cf. *elegans* Archangelsky

Pl. 13, figs 1-6; Pl. 15, fig. 4; Text-fig. 26A-F

Description — Detached pinna, measuring 1.6 cm in length and 0.6 cm in width, substance of lamina thick; rachis about 1 mm wide. Pinnules 3.5 × 2 mm, alternate, arising at an angle of about 30°-40°, lobed, apical lobe sometimes notched near apex; acroscopic margin constricted, basiscopic margin markedly decurrent. Midrib emerging at an angle of 45°, forking and entering each lobe (lateral vein forking near apex).

Cells of rachis on upper surface polygonal; anticlinal walls thick, straight; periclinal wall smooth. On lower surface cells mostly elongate-rectangular; anticlinal walls thick straight; periclinal wall smooth or sometimes with a thin longitudinal strip. Trichome bases absent on upper surface, rare on lower surface.

Cuticle of pinnules on both surfaces about 7 μm thick, stomata confined to lower surface. Cells of upper surface polygonal, more or less isodiametric; anticlinal walls thick, straight; periclinal wall smooth or occasionally finely granulose. Cells along veins somewhat serially arranged in longitudinal direction, elongate polygonal or rectangular in shape; anticlinal walls straight or at places wavy, thick; periclinal wall smooth or finely granulose. Cells between veins polygonal and cells along margins slightly longer than cells between veins. Stomata irregularly scattered between veins, majority longitudinally orientated, rarely transverse or oblique, monocyclic or incompletely dicyclic. Subsidiary cells 6-9, mostly 7, rarely 5 or 9, inner walls of lateral subsidiary cells markedly thickened, rarely adjacent stomata sharing a common subsidiary cell. Guard cells thinly cutinized, not sunken, around aperture surface slightly more thickened forming a sort of ring; stomatal aperture elliptical. Trichome bases unicellular, oval or circular; trichomes cylindrical, dome or thumb-shaped.

Occurrence — Trambau.

Remarks — The cuticle of the specimens from Kachchh matches with the cuticle of *Pachypteris elegans* Archangelsky (1966) described from Argentina in most points. It only differs in having mostly longitudinally orientated stomata. In the specimens from Argentina stomata do not have any definite orientation. Besides cuticle, in the specimen from Kachchh the pinnules are lobed, whereas, in the specimens figured by Archangelsky (1966) the pinnules have entire margins. However, in the Argentinian specimens the lower catadromic pinnules are often once lobed.

Comparison — *Pachypteris* cf. *elegans* here described resembles most some of the lobed pinnules of *P. specifica*. The cuticle of *P. specifica* differs in having irregularly distributed stomata and the stomatal pit do not have lateral thickenings. Also in *P. specifica* there are no trichome bases. *P. crassa* Townrow (1965) differs from *P.* cf. *elegans* in having papillate epidermal and subsidiary cells.

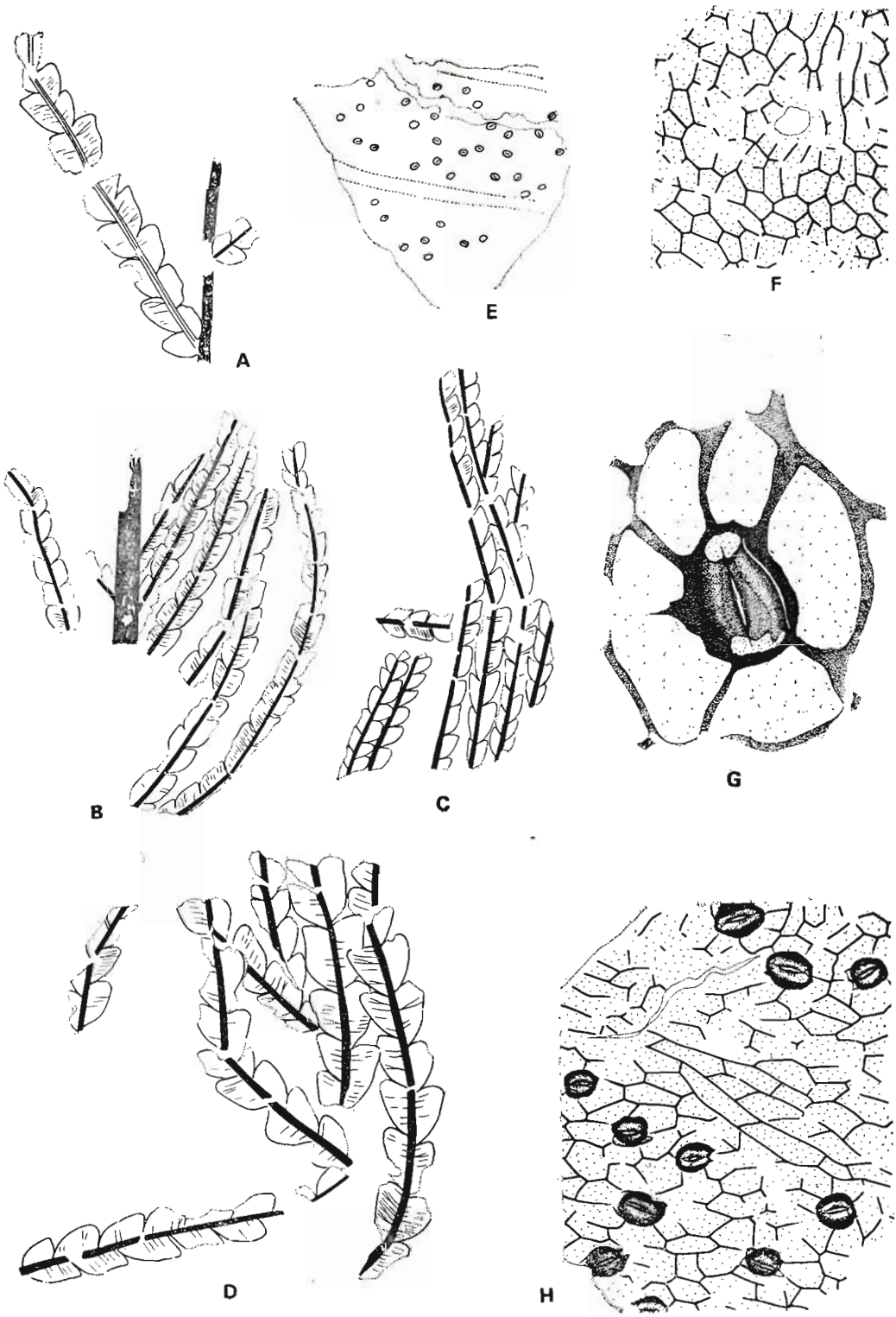
Genus — *Ctenozamites* Nathorst, 1886

Ctenozamites kachchhensis n. sp.

Pl. 12, figs 1-3; Pl. 14, figs 1-8; Text-fig. 27A-H

Diagnosis — Frond bipinnate, rachis 0.4 cm wide; pinnae alternate, arising at an angle of 35°-45°, exceeding 6.5 cm in length and 1.1 cm in width; pinna rachis 0.5-1 mm wide, smooth or faintly striated. Pinnules subopposite, attached by broad base at an angle of 60°-80°, generally broader than long, more or less contiguous, mostly rhomboidal in shape, sometimes somewhat triangular, measuring 2-6 × 2-10 mm in size; margins entire; apex obtuse, rarely truncate. Veins usually obscure, sometimes faintly visible at places, parallel, about 0.5 mm apart, simple or forked, majority unforked, forking at various levels.

Stomata confined to lower surface, stomatiferous surface thinner than nonstomatiferous surface. Cells of upper surface mostly polygonal, rarely rectangular; anticlinal walls straight; periclinal wall mostly unspecialized, sometimes minutely granulose or mottled. Cells along veins not so well marked, elongated rectangular or polygonal; anticlinal walls straight (sometimes end walls oblique); periclinal wall smooth, granulose or mottled. On lower surface venal region mostly well-demarcated by elongated



TEXT-FIG. 27

rectangular cells, rarely cells polygonal in shape; anticlinal walls straight (end-walls straight or oblique); periclinal wall smooth. Cells in between veins mostly like upper surface. Stomata confined to non-venal regions, irregularly scattered, transversely or obliquely orientated, very rarely longitudinally placed. Subsidiary cells 4-6, mostly 5, very rarely 4, inner wall of subsidiary cells well cutinized forming a somewhat raised ring around stomatal pit. Guard cells elongated, showing crescent-shaped thickenings on outer sides, stomatal aperture narrow, slit-like.

Holotype — B.S.I.P. specimen no. 32171.

Occurrence — Trambau, Kurbi, Kakadbhit (locality nos. 1 & 2) and Dauda Mota.

Remarks — *Ctenozamites kachchhensis* is most abundant at Kakadbhit (locality no. 2). The specimens with cuticle have been collected only from Trambau. Out of all the specimens collected only two specimens show the bipinnate nature of the fronds.

Comparison — Besides *Ctenozamites kachchhensis*, there is only one more species of *Ctenozamites*, so far, known from India. This species has been described by Sukh-Dev and Zeba-Bano (1981) as *C. surangei* from the Jabalpur Formation of India. *C. surangei* differs from *C. kachchhensis* in having pinnae which arise at wider angles (50°-80°) and their pinnules are almost twice as long as broad. The pinnules in the former species have truncate-obtuse apices and in each pinna the basal pair of pinnules are larger and obovate in shape. *C. kachchhensis* is somewhat comparable with *C. cycadea* (Berger) Schenk described by Harris (1964, fig. 41G) and Delle (1967) in gross features. But *C. cycadea* differs in having pinnules which are longer than broad, whereas in the present species pinnules are usually broader than long and unlike *C. cycadea* it lacks papillate cells on upper surface. *C. leckenbyii* (Leckenby) Nathorst described by Harris (1964) is distinguished by its much larger size and falcate shape of pinnules which have often a few small dentations. The pinnules of *C. megalostoma* Harris (1964), too, has minute teeth at their apical ends. *C. usnadzei* Doludenko & Svanidze (1969), described from the Jurassic of Georgia, can be readily distinguished by the size and falcate nature of pinnules. The lower cuticle of *C. usnadzei*, described by Barnard and Miller (1976) from Iran, has prominent trichome bases. The pinnules of *Ctenozamites* sp. described by Chuan, Yao and Ching (1976) from Yunnan resemble the pinnules of *C. kachchhensis* in general shape, but in *Ctenozamites* sp. the pinnules are much smaller in size.

Genus — *Pseudoctenis* Seward, 1911

Pseudoctenis fragilis n. sp.

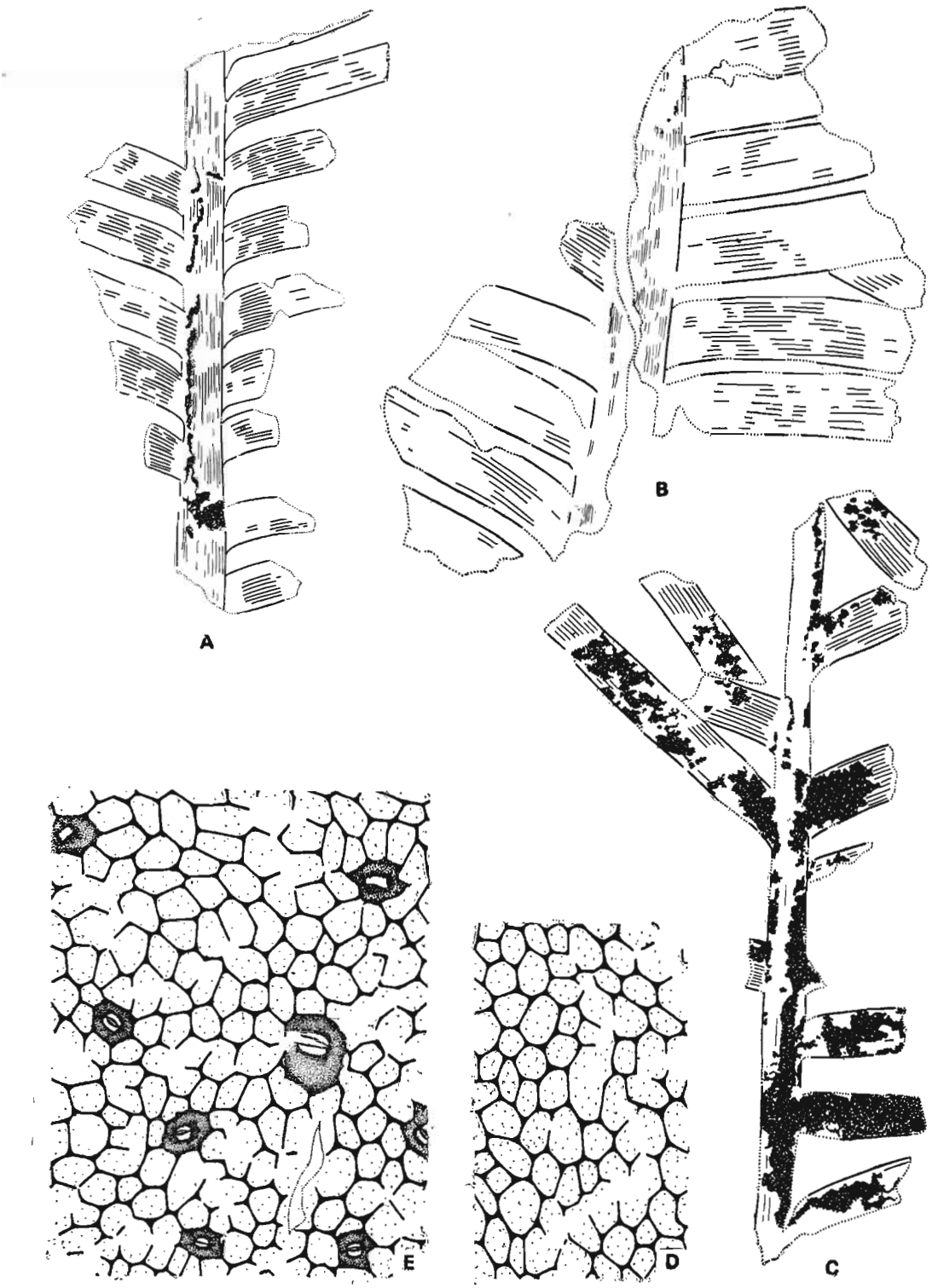
Pl. 15, figs 1-3; Pl. 16, figs 1, 3, 4; Pl. 17, fig. 3; Text-figs 28A-E, 29A-E

Diagnosis (*size and form of leaf unknown*) — Largest available leaf 14.6 cm long and 9.5 cm broad; rachis 0.7-1.3 cm wide, finely striated in longitudinal direction; pinnae attached at an angle of 70°-80°, subopposite or opposite, rarely alternate, linear, largest pinna 5 cm long (apical portion missing) and about 1.1 cm wide, pinnae usually 3-4 mm apart. Margins entire; acroscopic basal margin straight, sometimes slightly curving downwards; basal basiscopic margin decurrent, rarely somewhat constricted slightly away from the point of attachment; apex not preserved, veins 10-12, rarely 13, simple, parallel, unforked.

Cuticle 1.6 μm thick, hypostomatic, upper cuticle devoid of stomata, ordinary epidermal cells and cells along veins similar looking, polygonal, nearly isodiametric-irregular in shape; anticlinal walls straight, slightly more thickened at the corners,

←

TEXT-FIG. 27A-H — **A-D**, *Ctenozamites kachchhensis* n. sp., showing a few leaves, B.S.I.P. specimen nos. 67/2000C, 65/522, 100/2079 and 77/2079 from Kakadbhit, × 1; **E**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 181/521-7, × 40; **F**, upper cuticle, B.S.I.P. slide no. 181/521-1, × 150; **G**, showing a stoma, B.S.I.P. slide no. 181/521-1, × 500; **H**, lower cuticle showing a few stomata, B.S.I.P. slide no. 181/521-1, × 150.



TEXT-FIG. 28

due to thickenings around corners sometimes cells appearing to be somewhat rounded; periclinal wall smooth or mottled.

On lower surface stomata irregularly distributed, longitudinally or obliquely orientated, rarely transversely placed, marginal regions devoid of stomata. Subsidiary cells usually 8, rarely 7, inner wall of subsidiary cells conspicuously thickened forming an incomplete ring around stomatal pit. Guard cells sunken, thinly cutinized, aperture slit-like. Ordinary epidermal cells like those on upper surface. Only a few layers of cells along margins slightly more elongated.

Holotype — B.S.I.P. specimen no. 130/2411.

Occurrence — Trambau, Sukhpur and Chawad River (locality no. 3).

Comparison — About a dozen specimens have been recovered from Sukhpur and Chawad River. Unfortunately, none of the specimens is complete. The present specimens are closely comparable with *Pseudoctenis eathiensis* (Richard) Seward described by Seward (1911, pl. 10, fig. 45) and Doludenko and Svanidze (1969) in gross features. *P. eathiensis*, however, differs in having pinnae with forked veins. *P. crassinervis* Seward (1911) differs by its shorter pinnae which have coarser veins. *P. depressa* and *P. spectabilis* described by Harris (1932) from Greenland can be distinguished by their broader pinnae. In *P. depressa* cells on upper surface are papillate, whereas in *P. fragilis* cells are devoid of papillae. In *P. spectabilis* veins are branching near the rachis. In having 8-10 veins in each pinnae, *P. brevipennis* Öishi (1940) comes closer to the present specimens, but in the former the pinnae are smaller in size. *P. ensiformis* described by Halle (1913) from the Jurassic of Graham Land has coarser veins which are occasionally forking. All the species described from Yorkshire by Harris (1964) differ from *P. fragilis* either in gross morphological features or in details of cuticular structure. *P. herriesi* Harris (1964) differs in having pinnae with larger number of veins and in this species stomata are confined between veins. In *P. locusta* Harris (1964) pinnae are ovate-lanceolate and they have both simple and forked veins. *P. oleosa* Harris (1964), too, has simple and forked veins. *P. barulensis* Doludenko & Svanidze (1969) differs in having comparatively narrower pinnae and its cuticle has papillate epidermal cells.

Bose and Banerji (1981) have described a large number of species of *Pterophyllum* from India. Amongst them *P. morrisianum* Oldham, in general shape of pinnae, resembles most *P. fragilis*. However, *P. morrisianum* differs from *P. fragilis* in having both simple and forked veins.

Genus — *Pterophyllum* Brongniart, 1828

Pterophyllum distans Morris

Pl. 16, fig. 2; Pl. 17, fig. 6; Text-fig. 30D

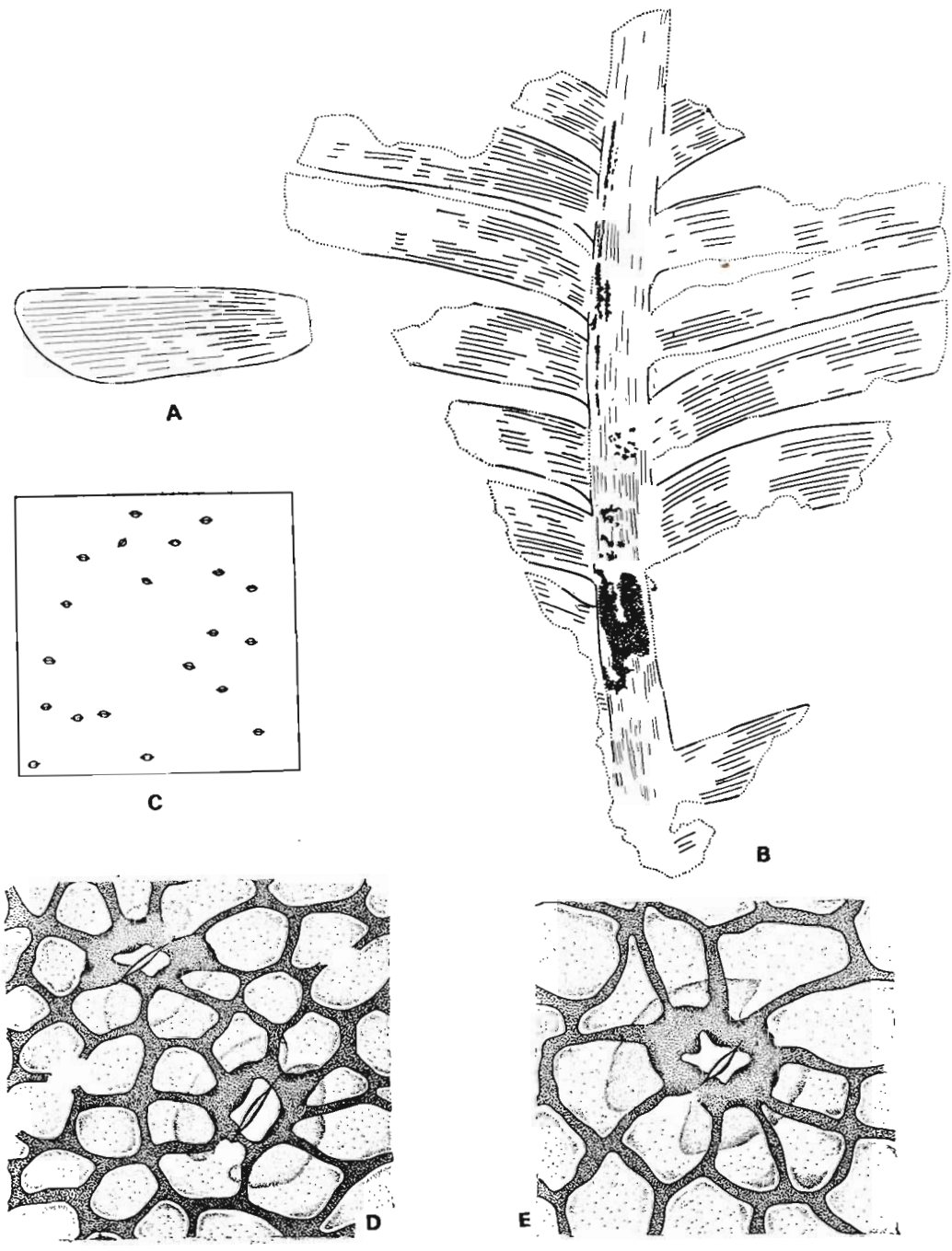
Kachchh Specimens:

1981 *Pterophyllum distans* Morris: Bose & Banerji, p. 253, pl. 5, fig. 27; text-figs 10C, 14A.

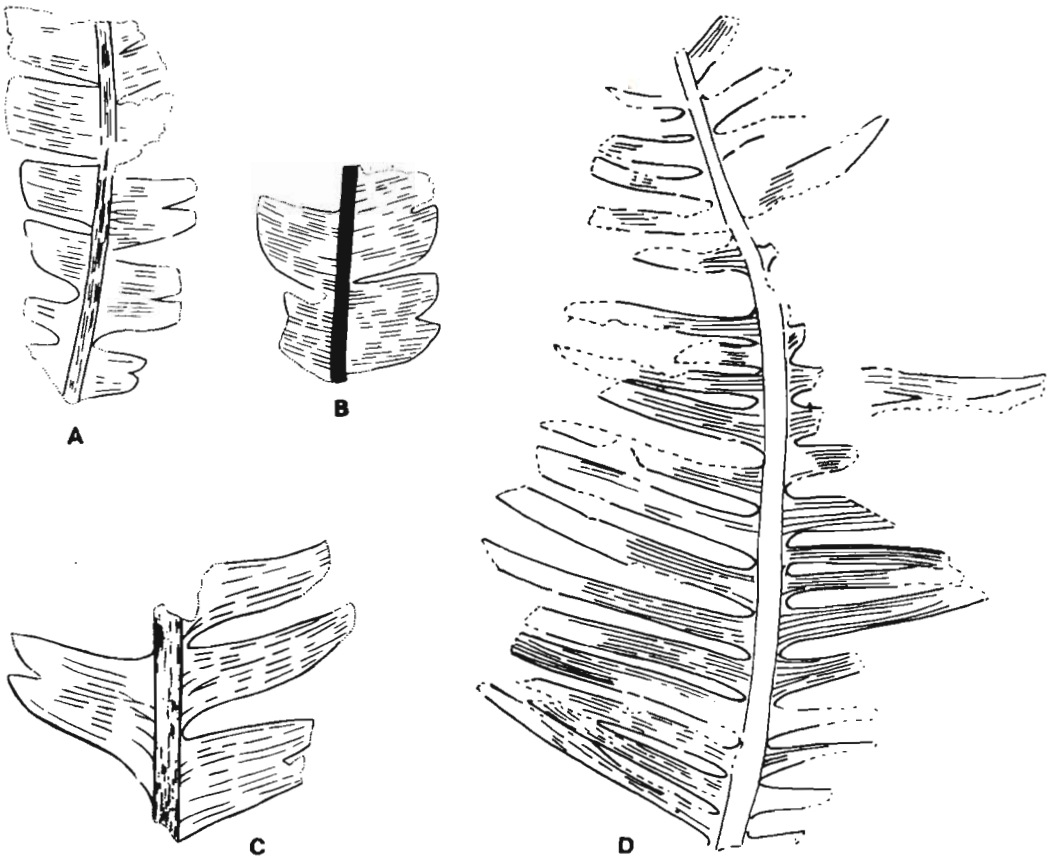
Description (from Bose & Banerji, 1981 with minor changes) — Largest specimen measuring 14.5 cm in length and 12 cm in width near middle region. Rachis 4-5 mm wide, gradually tapering towards apex, surface showing fine longitudinal striations. Pinnae laterally attached, opposite or subopposite, arising at an angle of about 80°-90° near middle region, angle of divergence less near apex and base. Pinnae linear, 5.2-6 cm long, 3-5 mm wide near base, gradually diminishing towards apex; apex acute or subacute; acroscopic and basiscopic margins slightly curved, bases of adjoining pinnae mostly touching or joining each other, distances between adjoining pinnae about 1-2 mm. Veins simple, 4-9 (depending on pinna width), mostly 5-6, rarely 4, parallel.

←

TEXT-FIG. 28A-E — *Pseudoctenis fragilis* n. sp., **A-C**, showing fragmentary specimens, B.S.I.P. specimen nos. 3/2417A (Sukhpur), 130/2411 (Chawad River, locality no. 3) and 26/2417A (Sukhpur); × 1; **D**, upper cuticle showing a few cells, B.S.I.P. slide no. 71/2417-1, × 150; **E**, lower cuticle showing a few stomata, B.S.I.P. slide no. 71/2417-1, × 150.



TEXT-FIG. 29A-E — *Pseudoctenis fragilis* n. sp. **A,** showing a detached pinna, B.S.I.P. specimen no. 104/2679C from Chawad River (locality no. 3), × 1; **B,** a specimen showing a few fragmentary pinnae, B.S.I.P. specimen no. 49/2411 from Chawad River (locality no. 3), × 1; **C,** lower cuticle showing distribution and orientation of stomata, B.S.I.P. slide no. 71/2417, × 40; **D, E,** showing stomata, B.S.I.P. slide no. 71/2417, × 300 and × 500.



TEXT-FIG. 30A-D — A-C, *Anomozamites* cf. *fissus* Feistmantel from Dharesi (locality no. 1), B.S.I.P. specimen nos. 5/2084A, 3/2004B and 3/2084A, × 2; D, *Pterophyllum distans* Morris from Kakadbhit (locality no. 2), B.S.I.P. specimen no. 105/1212, × 1. (Figure D from Bose & Banerji, 1981).

Occurrence — Kakadbhit (locality no. 2).

Comparison — In gross features and venation pattern the specimens from Kakadbhit match with the ones figured by Bose and Banerji (1981, text-fig. 10A, B) from the Rajmahal Hills. In some of the Kakadbhit specimens the number of veins may go up to 9, whereas in the Rajmahal specimens the veins are mostly 4-5 in number.

Genus — *Anomozamites* Schimper, 1870

Anomozamites cf. *fissus* Feistmantel

Pl. 17, figs 1, 2, 5; Text-fig. 30A-C

Description — Leaves devoid of apex and base, measuring 0.9-2.5 cm in length and 1-1.5 cm in width Rachis 0.8-1.0 mm wide, finely striated in longitudinal direction. Lamina divided into unequal segments, 0.4-0.7 cm long and 0.2-0.5 cm wide, distal margin of segments mostly notched, lateral margins entire. Bases of segments mostly joined with each other. Veins simple or forked, forking at different levels.

Occurrence — Dharesi (locality no. 1).

Comparison — In external form and to some extent in the nature of venation the Dharesi specimens resemble *Anomozamites fissus* described by Bose and Banerji (1981, text-fig. 8A, B) from the Rajmahal Hills. *A.* cf. *fissus* in external form resembles some of the specimens of *Taeniopteris*? sp. described by Douglas (1969, figs 66, 67). Externally *A.* cf. *fissus* also resembles *Nilssonia compta*? (Phill.) described by Arber (1917, pl. 8, fig. 3) from Mokoia,

New Zealand. The latter species, however, differs in having simple veins. In our opinion this species either belongs to *Anomozamites* or *Pterophyllum*.

Genus — *Nilssoniopteris* Nathorst, 1909

Nilssoniopteris pannuceus n. sp.

Pl. 17, figs 4, 7, 8; Pl. 18, figs 3, 5; Pl. 19, figs 1, 2; Text-fig. 31A-J

Diagnosis — Fronds exceeding 13.4 cm in length (largest specimen measuring 13.4 in length and 2.8 cm in width; maximum available width 3.3 cm), shape as a whole linear-lanceolate, substance of lamina thin, margin entire. Midrib distinct, 2-2.8 mm wide, gradually tapering towards apex, showing a median groove, sometimes finely striated in longitudinal direction; lateral veins arising at an angle of 75°-90°, straight, simple or forked, forking at different levels, about 0.5-0.8 mm apart, parallel.

Upper cuticle about 1.5 μm thick, lower slightly thinner; amphistomatic. On upper surface stomata sparse, mostly obliquely orientated, a few longitudinally or transversely placed. Subsidiary cells slightly more thickened than ordinary epidermal cells; guard cells fairly well-cutinized, slightly sunken. Cells between veins irregularly arranged, rectangular, polygonal or squarish; anticlinal walls highly sinuous, periclinal wall smooth. Cells along veins serially arranged, rectangular, mostly more than twice as long as broad, very rarely squarish or polygonal; anticlinal walls highly sinuous; periclinal wall flat.

Lower cuticle showing broad stomatal zones and narrow non-stomatal zones along veins. Cells along veins rectangular, much longer than broad, rarely square or polygonal. Cell walls sinuous, surface smooth. Occasionally showing circular or oval, unicellular trichome bases; outer wall of trichome bases thick and mostly sinuous. Cells between veins irregularly packed, polygonal; anticlinal walls highly sinuous; periclinal wall unspecialized. Trichome bases less frequent than along veins. Stomata irregularly distributed, mostly obliquely orientated, sometimes transverse, rarely longitudinally placed. Stomatal frequency about 50 per sq mm. Very rarely a few stomata present along veins. Stomata along veins mostly longitudinally placed. Subsidiary cells slightly more cutinized than ordinary epidermal cells, mostly showing prominent wrinkles radiating from outer walls of subsidiary cells; guard cells fairly well-cutinized, inner walls more thickened, sunken; aperture narrow, elliptical; stomatal pit rectangular or broadly oval.

Derivation of Name — Because of the radiating wrinkles from outer walls of subsidiary cells, latin word *pannuceus* has been used for the specific name.

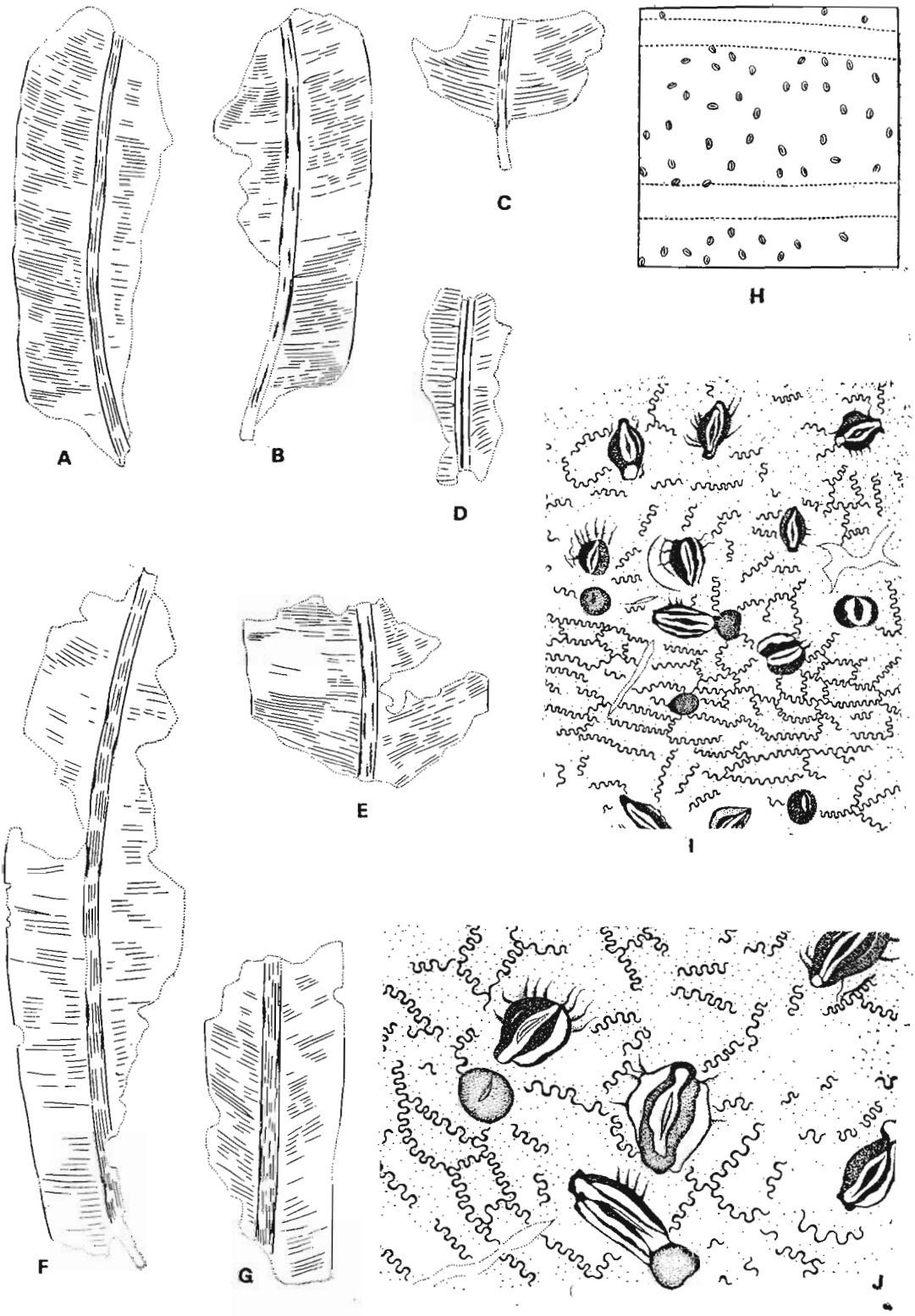
Holotype — B.S.I.P. specimen no. 11/2411 C.

Occurrence — Chawad River (locality no. 2).

Comparison — In being amphistomatic *Nilssoniopteris pannuceus* resembles most *N. ciniza* Ash (1978) described from Ciniza Lake beds in the upper part of the Monitor Butter Member of the Chinle Formation. *N. ciniza* differs from *N. pannuceus* in having papillate subsidiary cells and also in having ordinary epidermal cells which have slightly bulging surface or are with a small pointed papilla. The cuticle of *Nilssoniopteris* sp. described by Carpentier (1939) is somewhat like *N. pannuceus*, because both have non-papillate ordinary epidermal and subsidiary cells. They have also similar type of trichome bases. *Nilssoniopteris* sp., however, differs in being hypostomatic. In gross features, *N. taeniata* Samylina (1961) resembles *N. pannuceus*. *N. taeniata* differs from *N. pannuceus* in being hypostomatic and its subsidiary cells do not show the

→

TEXT-FIG. 31A-J — *Nilssoniopteris pannuceus* n. sp.— **A-G**, showing a few fragmentary fronds, B.S.I.P. specimen nos. 13/2411C, 2/2411C, 5/2411C, 7/2411C, 4/2411C, 9/2411C and 14/2411C, × 1; **H**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 11/2411C-1, × 40; **I**, lower cuticle showing a few stomata and trichome bases, B.S.I.P. slide no. 11/2411C, × 125; **J**, lower cuticle showing a few stomata, B.S.I.P. slide no. 11/2411C-1, × 250.



TEXT-FIG. 31

prominent radiating wrinkles as present in *N. pannuceus*. All the three species of *Nilssoniopteris* (*N. vittata* Brongniart, *N. major* (L. & H.) and *N. pristis* Harris) described by Harris (1969) from Yorkshire differ from *N. pannuceus* in being hypostomatic. *N. pannuceus* agrees with *N. muchlensis* Doludenko & Svanidze (1969) in external features, but it differs in being hypostomatic and its subsidiary cells are devoid of prominent radiating wrinkles as are seen in *N. pannuceus*.

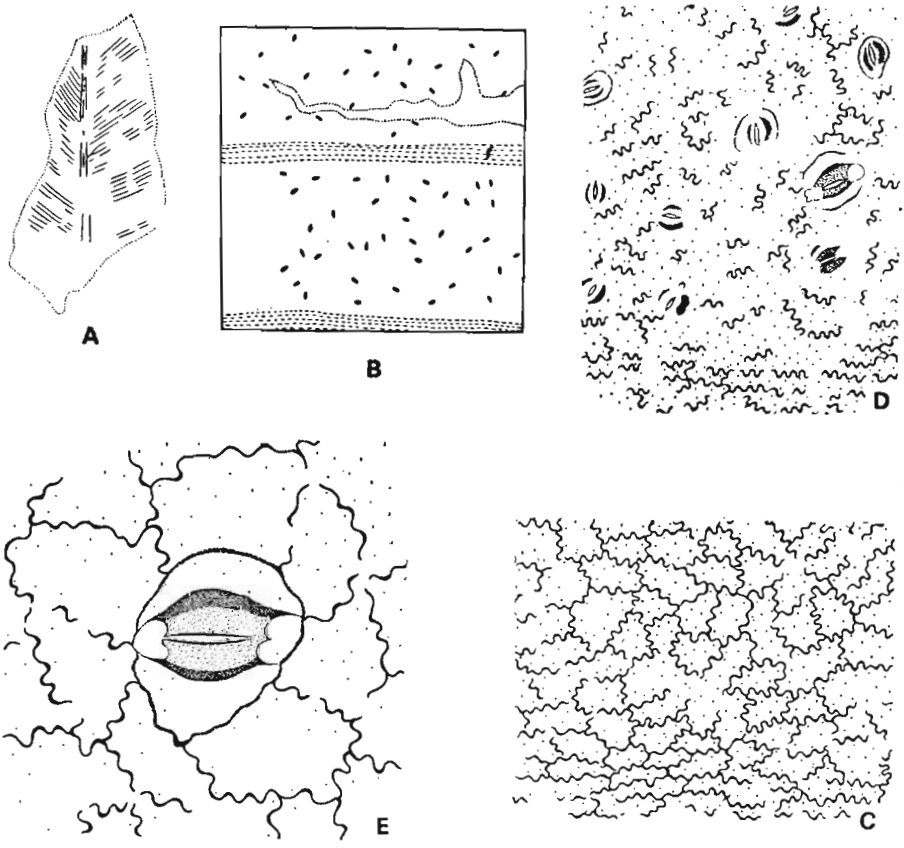
Nilssoniopteris variabilis n. sp.

Pl. 18, figs 1, 2, 4, 6; Pl. 19, figs 3-5; Text-fig. 32A-E

Diagnosis (*leaf size and shape as a whole unknown*) — Largest specimen 4 cm long and 1.5 cm broad. Margin entire (where visible). Midrib about 1 mm wide, secondary veins emerging at an angle of 40°-50°, parallel, usually unforked, rarely forking once.

Upper cuticle about 3 μm thick, showing more or less serially arranged rectangular cells along veins. Between veins, cells squarish or polygonal, irregularly arranged, forming much broader zones than those along veins. Lateral and end-walls highly sinuous; surface wall smooth, devoid of trichome bases.

Stomata confined to lower surface, irregularly orientated in strips between veins, but often nearly transverse. Subsidiary cells always smaller than epidermal cells, often very small, outer wall of subsidiary cells



TEXT-FIG. 32A-E — *Nilssoniopteris variabilis* n. sp.— **A,** holotype, B.S.I.P. specimen no. 32054, × 1; **B,** lower cuticle showing distribution of stomata, B.S.I.P. slide no. 32054-5, × 40; **C,** upper cuticle showing cells along veins and between veins, B.S.I.P. slide no. 32054-5, × 150; **D,** lower cuticle showing a few stomata, B.S.I.P. slide no. 32054-6, × 150; **E,** a stoma, B.S.I.P. slide no. 32054-6, × 500.

broad, entire or obscurely marked with outwardly directed sinuous extensions, inner wall not extending as a solid or hollow papilla over the guard cells; surface if exposed, thin. Epidermal cells next to subsidiary cells often smaller than other epidermal cells and forming a more or less definite ring around the stoma, and if subsidiary cells very small and surrounding cells ring well-marked then these cells appear like a ring of anomocytic subsidiary cells. Often one of these cells may lie opposite a subsidiary cell and be of the nature of an encircling cell. Guard cells moderately cutinized, not much sunken, aperture slit-like. Trichome bases extremely rare on veins consisting of an ordinary cell with a thickened surface showing a ring-shaped scar, cells around trichome bases sometimes forming a ring as with a stoma.

Derivation of Name — The specific name *variabilis* has been given, because of the the deceptive appearance of the stomatal apparatus.

Holotype — B.S.I.P. specimen no. 32054.

Occurrence — Trambau.

Comparison — *Nilssoniopteris variabilis* differs from *N. pannuceus* in having secondary veins which are arising at narrower angles (40°-50°). In *N. pannuceus*, the secondary veins emerge at an angle of 78°-90°. Moreover, *N. pannuceus* is amphistomatic. *N. variabilis* differs from all other species of *Nilssoniopteris* in having typically paracytic type of stomata as well as stomata which appear to be anomocytic, though they are in reality paracytic. *N. angustifolia* Doludenko & Svanidze (1969, pl. 37, figs 1-6) has narrow leaves like *N. variabilis*, but in *N. angustifolia* secondary veins are arising at wider angles. The leaves of *N. longifolia* Doludenko & Svanidze (1969, pl. 39, figs 1, 2) are also narrow like *N. variabilis*, but it differs from the latter both in venation pattern as well as in details of cuticular structure.

Genus — *Otozamites* Braun, 1843

Otozamites imbricatus Feistmantel

Pl. 20, figs 1, 2, 9, 10; Text-fig. 33A-F

1876 *Otozamites imbricatus* Feistmantel, p. 48, pl. 8, figs 1, 1a.

1873-85 *Otozamites imbricatus* Feistm.: Zigno, p. 71.

1963 *Otozamites bellus* Roy, p. 397.

1965 *Otozamites imbricatus* Feistmantel: Roy, p. 215, pl. 1, figs 1-5.

1974 *Otozamites imbricatus* Feistmantel: Bose, p. 100, pl. 46, figs 1, 2; text-fig 1A-F.

Diagnosis (from Bose, 1974) — Pinnate leaf, exceeding 17 cm in length, width 3-4 cm. Rachis 2-3 mm wide, upper surface partially concealed. Pinnae mostly attached at an angle of about 55°-70°, but near apex and base arising at a smaller angle. Pinnae attached to rachis near middle of base or by the lower half of base, alternate, closely set, sometimes imbricate, 1.5-2.5 cm long, 3-4.5 mm wide near auricle, falcate; base asymmetrical, auriculate, auricle developed near upper basal angle; lower basal margin of the pinna lying above partly covering auricle of the pinna lying below; apex acute or obtuse. Veins emerging from point of attachment and radiating into auricle and rest of pinna, 6-8 in number, dichotomizing at all levels.

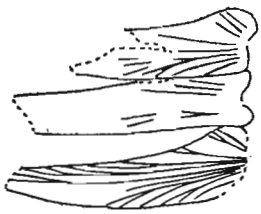
Cuticle moderately thick on both sides, upper cuticle slightly thicker than the lower. Upper cuticle showing rectangular cells along veins, mostly 2-3 cells wide, cells in between veins quadrangular or polygonal, serially arranged, at places irregularly packed; anticlinal walls sinuous, loops prominent; sometimes lateral-walls of cells along veins slightly more thickened; periclinal wall smooth.

Lower cuticle differentiated into wide stomatiferous and narrow non-stomatiferous zones. Cells along veins 2-4 cells wide; anticlinal walls sinuous, loops distinct; central part of cell surface slightly thickened, forming a sort of rudimentary papilla. Cells within stomatal bands like cells of upper cuticle, but periclinal wall mostly with a small circular thickening near the centre. Stomatal bands 2-4 stomata wide (mostly 3), stomata irregularly scattered, often closely set, mostly transversely orientated, sometimes obliquely placed. Subsidiary cells slightly more cutinized than ordinary epidermal cells, papillate. Guard cells well-cutinized, slightly sunken; aperture slit-like or oval.

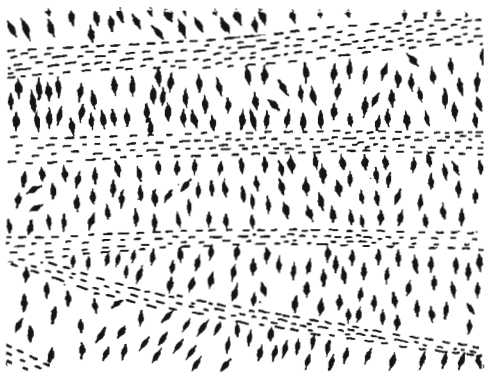
Lectotype — G.S.I. specimen no. 4812.

Occurrence — Loharia and Trambau.

Comparison — The upper cuticle of *Otozamites imbricatus* is markedly different from most species of *Otozamites*. It has



A



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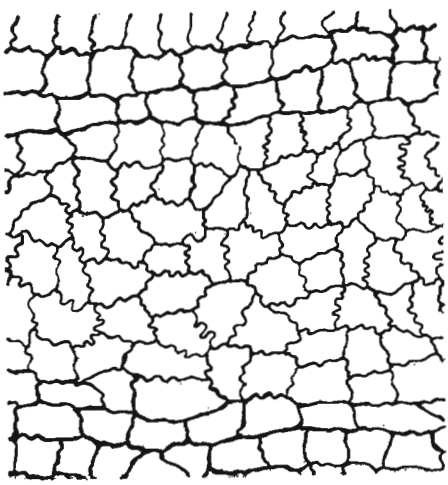

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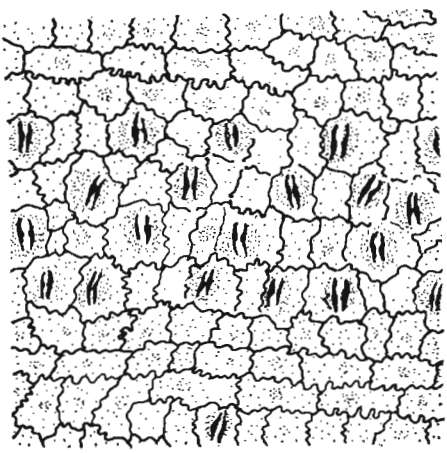

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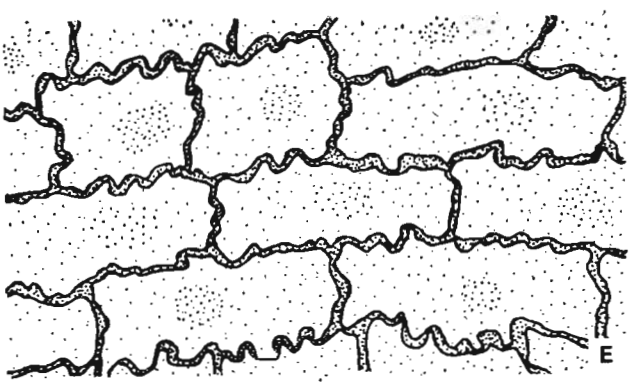
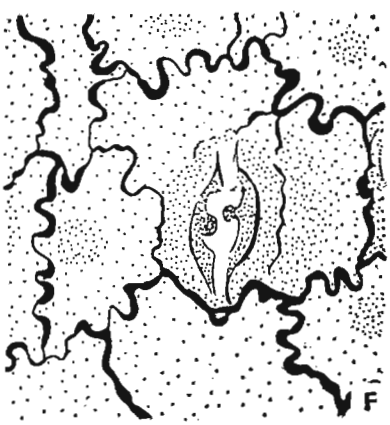


E



F

TEXT-FIG. 33A-F — *Otozamites imbricatus* Feistmantel from Trambau. **A,** showing three pinnae, B.S.I.P. specimen no. 31926,× 1; **B,** lower cuticle showing distribution of stomata, B.S.I.P. slide no. 31926-1,× 40; **C,** upper cuticle showing cells along veins and cells in between vein, B.S.I.P. slide no. 31926-1, × 150; **D,** lower cuticle showing cells along veins and stomata, B.S.I.P. slide no. 31926-1,× 150; **E,** lower cuticle showing a few cells along vein, B.S.I.P. slide no. 31926-1,× 500; **F,** a stoma, B.S.I.P. slide no. 31926-1, × 500. (All figures from Bose, 1974).

serially arranged rectangular cells along veins and quadrangular or polygonal cells between veins. *O. graphicus* (Leckenby), *O. leckenbyii* Harris and *O. gramineus*, (Phillips) described by Harris (1969) from Yorkshire show some superficial resemblance with *O. imbricatus*; however, *O. imbricatus* differs from the other three species in having fewer number of veins and its stomata are not sunken in pits. The position of stomata is more like *O. bechei* Brongniart described by Harris (1961) and *O. venosus* Harris (1969). *O. bechei* has slightly sunken stomata which are protected by large papillae of neighbouring cells. In *O. venosus* the pinnae are smaller in size. In external form *O. imbricatus* may be compared with *O. conimbricensis* Teixeira (1948).

Otozamites walkamotaensis Bose & Zeba-Bano

Pl. 20, figs 3-6; Pl. 21, figs 1-9; Text-fig. 34A-L

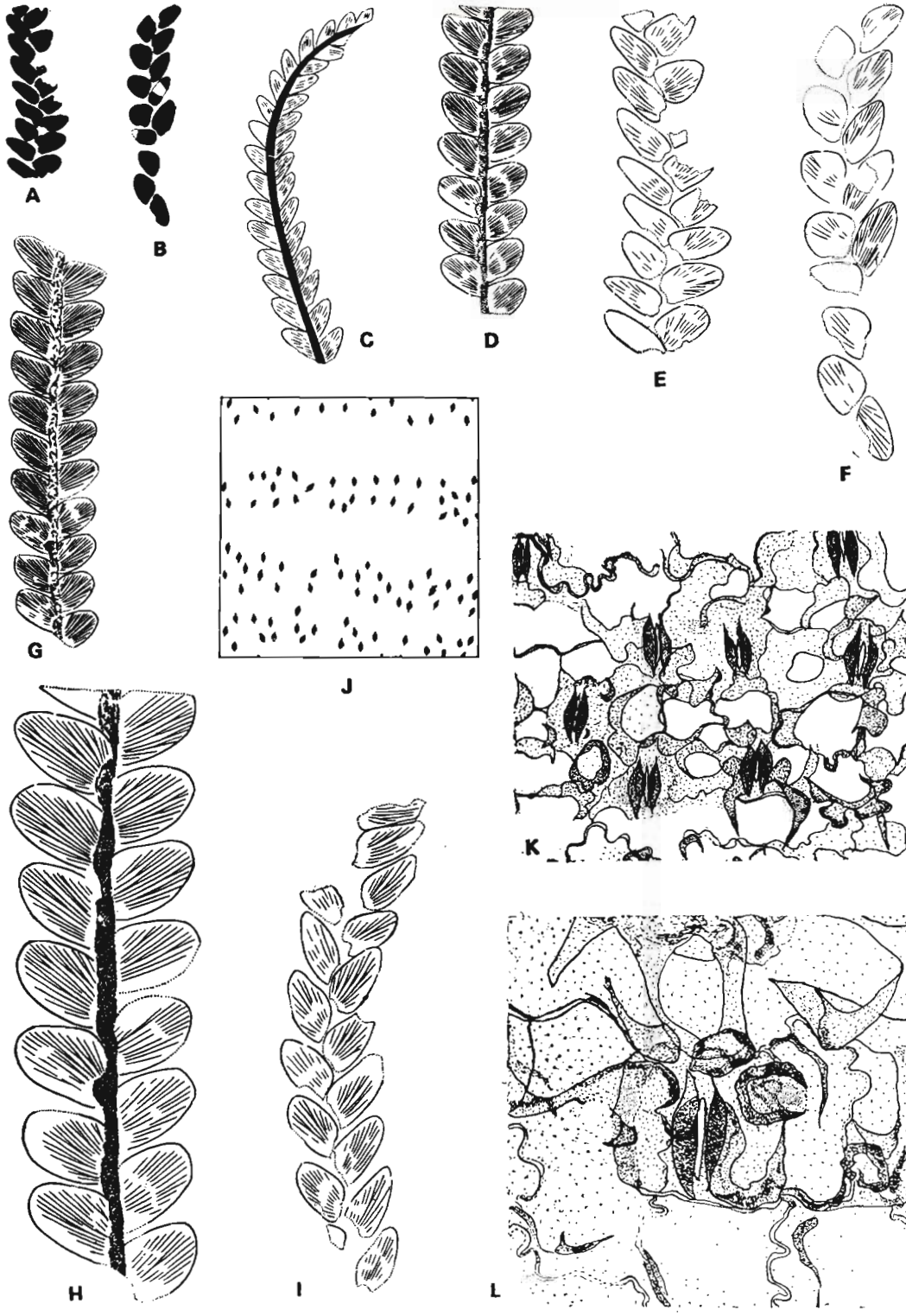
1981 *Otozamites walkamotaensis* Bose & Zeba-Bano, p. 227, pl. 1, figs 1-9; text-fig. 1 A-G.

Diagnosis (*from Bose & Zeba-Bano, 1981*) — Leaf as a whole linear, pinnate, exceeding 13 cm in length, 0.8-1.2 cm wide near middle region, narrower towards base and apex. Rachis slender, about 1 mm wide, mostly concealed by enlarged pinnae bases. Pinnae attached to rachis at an angle of 40°-80° by a small basal sinus formed by asymmetrical bases, closely set or contiguous, mostly cuneate, sometimes orbicular, gradually decreasing in size towards base and apex. Basal pinnae somewhat orbicular, about 3 mm in length and 2.5 mm in width, remaining pinnae mostly cuneate with obtuse or sub-acute apices and rounded base, rarely falcate, 0.3×0.25 mm-1×0.6 cm in size. Margin entire, thick, sometimes revolute. Acroscopic margin somewhat expanded, auricle feebly or scarcely developed; basiscopic margin contracted, partly covered by acroscopic margin of the pinna lying below; veins radiating from base, simple or forking at all levels, reaching up to margin, 8-14 in number across middle region of pinna, forking 1-2 times, very rarely thrice.

Cuticle moderately thick on both sides. Upper cuticle slightly thicker than lower cuticle. Cells of rachis on both surfaces mostly narrowly elongated, quadrangular, sometimes polygonal in shape, serially, arranged, at places groups of small polygonal cells visible on one surface; lateral-walls thick, parallel, straight or at places slightly wavy, end-walls oblique, slightly thinner than lateral-walls; surface smooth. Stomata mostly confined to lower side, transversely or obliquely placed; walls of subsidiary cells thinner than ordinary epidermal cells, at places slightly wavy, non-papillate. Guard cells crescent-shaped, thickening of guard cells well-defined.

Upper cuticle of pinna thicker towards extreme base, cells along this region smaller in size than remaining part of pinna, polygonal in shape, lateral- and end-walls thick, slightly wavy or sinuous; surface smooth. Cells of marginal region serially arranged, fairly longer than broad, rectangular, lateral- and end-walls sinuous with broad loops, surface mostly smooth, hair bases extremely rare, present over a few marginal cells. Cells of middle part of lamina broader than cells along margins, irregularly packed or at places tending to be serially arranged, mostly quadrangular in shape, sometimes polygonal; lateral- and end-walls sinuous with prominent dome-shaped loops, surface smooth.

Lower cuticle differentiated into three zones outer marginal region, broad stomatiferous and narrow non-stomatiferous bands. Marginal region 2-7 cells wide, cells rectangular, serially arranged; lateral- and end-walls sinuous with broad loops, surface unevenly cutinized, slightly more thickened towards centre but non-papillate. Cells near point of attachment of lamina much smaller in size and highly papillate. Non-stomatiferous bands 2-3 cells wide, cells serially arranged, rectangular to polygonal in shape; lateral- and end-walls unevenly thickened, sinuous or wavy; surface papillate. In each cell mostly a single papilla present, sometimes 2, rarely up to 4; papillae circular, ring-shaped or crescent-shaped, mostly hollow. Stomatal bands 2-5 stomata wide, cell walls wavy or sinuous, mostly obscure, covered by papillae of adjoining cells as well, sometimes papillae joining to form a frill-like structure with hollow central region, almost concealing epidermal cells and stomata. Stomata within stomatal bands transversely or obliquely orientated, stomatal apparatus somewhat



TEXT-FIG. 34

squarish in shape, surface of subsidiary cells occasionally covered by papillae of adjacent cells, outer walls of subsidiary cells thin, wavy; guard cells sunken, having well-defined crescent-shaped thickening; aperture lens-shaped.

Holotype — B.S.I.P. specimen no. 17/e 2085B.

Occurrence — Walka Mota (locality no. 3).

Remarks — *Otozamites walkamotaensis* shows great variation in shape and size of pinnae. The majority of the specimens have more or less triangular pinnae. Fronds with orbicular type of pinnae are less common. Rarely in some, in the same specimen (Text-fig. 34B, F) on one side of rachis pinnae are triangular in shape, whereas, on the other side it has somewhat orbicular-shaped pinnae (this is perhaps due to preservational factor).

Comparison — *Otozamites walkamotaensis*, in gross features, resembles most *O. barthianus* Kurtz (in Roth, Kurtz & Burckhardt, 1901, pl. 3, fig. 9 from Argentina), *Otozamites* sp. described by Edwards (1934, pl. 5, fig. 2 from New Zealand), *O. massalongianus* Zigno described by Wesley (1974, from Italy), *O. falsus* Harris described by Marcinkiewicz (1973, pl. 3, fig. 1) from Holy Cross Mts., Poland and the smaller fronds of *O. falsus* Harris (1969, fig. 2A from England). In the former three species the details of cuticular structures are not known. The lower cuticle of *O. falsus* is highly papillate and the stomata are sunken in pits which do not form definite files. *O. walkamotaensis* is somewhat similar to *O. obtusus* Lindley & Hutton described by Reymanowna (1963) from Poland. In both these species the cells of upper cuticle are more or less similar and their lower cuticle is highly papillate. *O. obtusus* differs from *O. walkamotaensis* in having stomata which are sunken in pits. The orbicular shaped pinnae of *O. walkamotaensis* are more like the pinnae of *O. pecten* Sahni & Sitholey (1943) described from the Salt Range, Pakistan. In *O. pecten* stomata are present along margins also. In gross features *O. walkamotaensis* resembles *O. kilpperiana* Barnard & Miller (1976), but in the latter species veins are more sparse. Also in *O. kilpperiana* periclinal walls of cells along venal region are non-papillate.

Otozamites kachchhensis n. sp.

Pl. 22, figs 1-10; Text-fig. 35A-K

Doubtful specimens from Kachchh:

1974 *Otozamites* sp.: Bose, p. 102, pl. 47, figs 7-10, text-figs 1G, 2A-B.

Diagnosis (*apical and basal regions not preserved*) — Leaf pinnate, linear, largest specimen 6.9 cm long and 1 cm wide. Rachis 0.8 cm wide, smooth, almost concealed by pinnae bases. Pinnae alternate, closely set at an angle of 70°-80°, sometimes upper margin of lower pinna overlapping lower margin of pinna lying immediately above, pinnae gradually becoming shorter and narrower towards apex, somewhat rhomboidal in shape, at places slightly falcate, measuring 3-5×2-3 mm, base asymmetrical; basiscopic margin near base slightly constricted, acroscopic margin somewhat auriculate; margin almost parallel near middle region, becoming slightly narrower towards apex; apex rounded or truncate-obtusely rounded, veins 4-6, diverging from base, forking once or twice at different levels, in some 2-3 simple veins entering auricle.

Lower cuticle of rachis slightly thicker than upper cuticle. Stomata confined to lower surface, slightly sunken. Both surfaces having rectangular cells, at places squarish or polygonal; lateral-walls usually slightly undulated or sinuous (sinuosity

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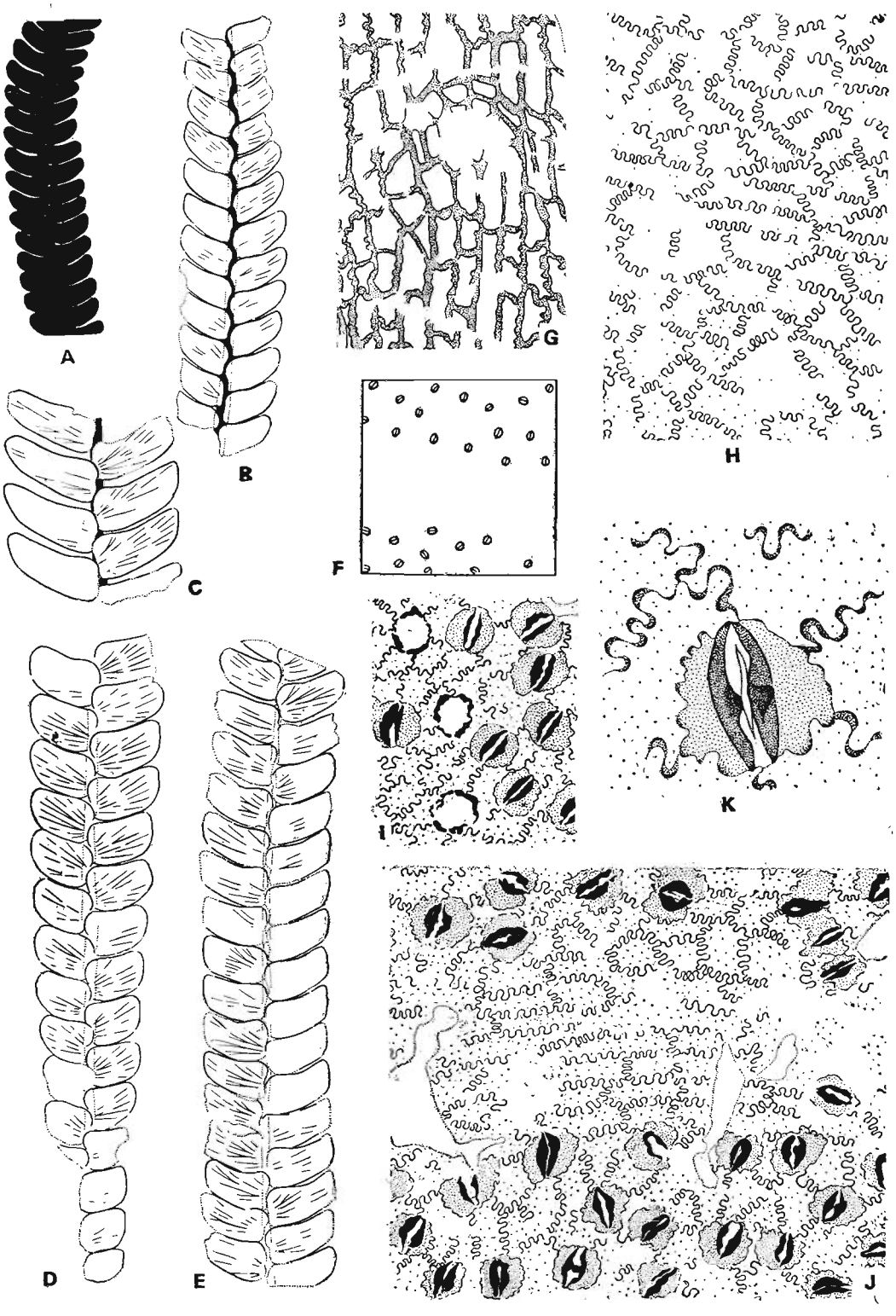
TEXT-FIG. 34A-L — *Otozamites walkamotaensis* Bose & Zeba-Bano. **A-I**, showing fragmentary fronds, B.S.I.P. specimen nos. 30/2215E (Walka Mota locality no. 2), 30A/2215E (Walka Mota locality no. 2), 39/2215A (Walka Mota locality no. 1), 52/2085 (Walka Mota locality no. 1), 30/2215E (Walka Mota locality no. 2), 30A/2215E (Walka Mota locality no. 2), 7/2085 (Walka-Mota locality no. 1), 7/2085A (Walka Mota locality no. 1), and 29/2215A (Walka Mota locality no. 2): **A-D** × 1 and **E-H** × 2; **J**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. WK-(1), × 40; **K**, lower cuticle showing a few stomata, B.S.I.P. slide no. 5/2085B-(1), × 250; **L**, a stoma, B.S.I.P. slide no. 5/2085B-(1), × 500. (Figures J-L from Bose & Zeba-Bano, 1981).



TEXT-FIG. 35

more pronounced in cells of lower surface), rarely at places straight; end-walls usually oblique, straight or at places wavy; surface wall smooth. Stomata transversely orientated; subsidiary cells crescent-shaped; guard cells slightly more cutinized than subsidiary cells; stomatal aperture slit-like.

Cuticle on both surfaces moderately thick, almost of same thickness on both surfaces. Cells of upper surface nearer margin usually quadrangular-polygonal, irregularly packed. Cells along veins slightly more elongated, 2-3 cells wide, mostly rectangular; cells between veins polygonal or rectangular. Anticlinal walls of all cells on upper surface deeply sinuous and marked by distinct rounded loops; periclinal wall smooth.

Lower cuticle showing 2-4 cells wide outer marginal zone and inner zone having stomatiferous and non-stomatiferous bands. Stomatiferous bands slightly broader than non-stomatiferous bands. Cells of marginal zone and stomatiferous bands irregularly packed, rectangular or polygonal, cells along stomatiferous bands (5-6 cells wide, rarely 7) serially arranged, rectangular. Anticlinal walls highly sinuous with distinct rounded loops; periclinal wall smooth. Stomata transversely or obliquely placed, very rarely longitudinally orientated; subsidiary cells slightly more cutinized than ordinary epidermal cells; papillate, rarely tips of papillae of opposite subsidiary cells touching each other, each papilla solid. Guard cells sunken, crescent-shaped, well cutinized; aperture elliptical or slit-like. Occasionally both stomatiferous and non-stomatiferous zones showing oval or circular trichome bases; margin of trichome base thickly cutinized.

Holotype — B.S.I.P. specimen no. 61/2679E.

Occurrence — Kakadbhit (locality no. 1) and Chawad River (locality no. 3).

Remarks — In overall shape and size of pinnae *Otozamites kachchhensis* resembles most *Otozamites* sp. described by Bose (1974, pl. 47, figs 7-10; text-fig. 2A, B) from Kakadbhit. Bose's specimens of *Otozamites* from Kakadbhit were later referred to *O. walkamotaensis* by Bose and Zeba-Bano (1981, p. 227). The pinnae of *Otozamites* sp., however, differ from those of *O. walkamotaensis* in gross features. The specimens from Kakadbhit have rhomboidal-shaped pinnae, whereas, in *O. walkamotaensis* pinnae are circular to triangular in shape. In the absence of " phyto-lemma " in the specimens of *Otozamites* sp. from Kakadbhit, they have been doubtfully referred to *O. kachchhensis*.

Comparison — *Otozamites kachchhensis* resembles most *O. bengalensis* described by Walkom (1921, pl. 10, fig. 6) from western Australia. The cuticle of the Australian species has not been described. In general shape of pinnae *O. kachchhensis* also resembles *O.* cf. *mandelslohii* Kurr. described by Walkom (1917, pl. 8, fig. 4) from Queensland, Australia, but in *O.* cf. *mandelslohii* the number of veins in each pinna is much more than in the pinnae of *O. kachchhensis*. The overall shape of pinnae of *O. reglei* (Brongniart) Saporta described by Barale and Contini (1973) is somewhat similar to *O. kachchhensis*. In *O. reglei* the stomata are sunken in a pit. In external features *O. kachchhensis* may be compared with *O. mimetes* Harris (1969) described from Yorkshire. In this species the ordinary epidermal cells on lower side are papillate and its stomata are sunken in pits. The cuticles of *O. obtusus* Lindley & Hutton and *O. raciborskii* Reymanowna described by Reymanowna (1963) from Grojec near Cracow in Poland differ in having papillae on lower surface and in having sunken stomata. The lower

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TEXT-FIG. 35A-K — *Otozamites kachchhensis* n. sp. from Chawad River (locality no. 3). **A-E,** showing a few fragmentary fronds, B.S.I.P. nos. 52/2411, 61/2679E, 12/2679B, 31/2891A and 24/2679B: A × 1, B-E × 2; **F,** showing distribution of stomata, B.S.I.P. slide no. 61/2679B-1, × 30; **G,** lower cuticle of rachis, B.S.I.P. slide no. 61/2679B-1, × 150; **H,** cells of upper cuticle, B.S.I.P. slide no. 61/2679B-1, × 150; **I,** lower cuticle showing a few stomata and trichome bases, B.S.I.P. slide no. 24/2679B-1, × 150; **J,** lower cuticle showing distribution of stomata, B.S.I.P. slide no. 61/2679B-1, × 150; **K,** a stoma, B.S.I.P. slide no. 61/2679B-1, × 500.

cuticle of *O. walkamotaensis* Bose & Zeba-Bano is also highly papillate.

Genus — *Dictyozamites* Oldham, 1863

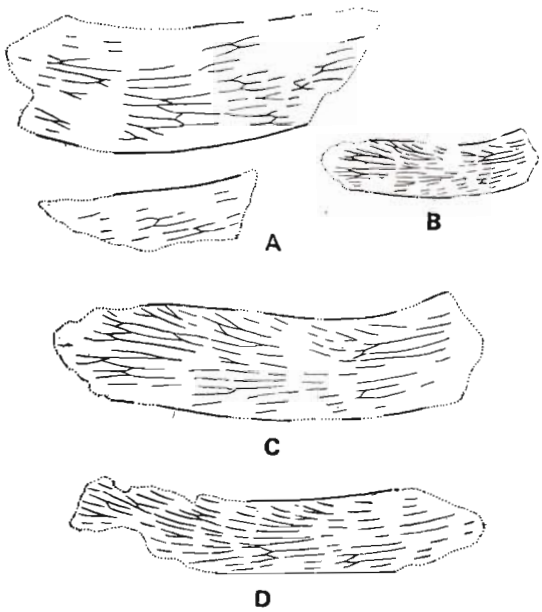
Dictyozamites sp.

Pl. 20, figs 7, 8; Text-fig. 36A-D

Description (*based on three detached fragmentary pinnae whose bases and apices are incomplete*) — Largest pinna fragment 3.2 cm long and 0.7 cm wide. Margins entire. Veins prominent, reticulate, meshes in middle region more elongated than meshes towards margins, meshes of midle region measuring 5-7×0.6-1 mm, marginal meshes measuring 3-5×0.5-0.8 mm, mostly elongated-polygonal in shape.

Occurrence — Kakadbhit (locality no. 2).

Comparison — The specimens are too fragmentary and therefore do not permit detail comparison with any of the existing species of *Dictyozamites*. In general outlook and venation pattern the above pinnae fragments are somewhat comparable with *Dictyozamites falcatus* (Morris) Medlicott & Blanford described by Bose and Zeba-Bano (1978) and *D. feistmantelii* Bose & Zeba-Bano (1978).



TEXT-FIG. 36A-D — *Dictyozamites* sp. from Kakadbhit (locality no. 2), B.S.I.P. specimen nos. 51/2203B, 88/2203B, 88/2203B and 91/2079: A, C and D × 2 and B × 1.

Genus — *Ptilophyllum* Morris, 1840

All the Kachchh specimens of *Ptilophyllum*, found in the form of impressions, have been described either under *P. cutchense* Morris or *P. acutifolium* Morris. The specimens with 'phytolemma' have been described separately under different species.

Ptilophyllum cutchense Morris

Pl. 23, figs 1-7; Pl. 24, fig. 1; Pl. 47, fig. 4

Specimens from Kachchh

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

1841 *Ptilophyllum cutchense* Morris, p. 117.

1870-72 *Ptilophyllum cutchense* Morris: Schimper, p. 167 (*partim*).

1872 *Palaeozamia cutchensis* Morris: Wynne, p. 173.

1876 *Ptilophyllum cutchense* Morris: Feistmantel, p. 42, pl. 4, figs 6, 7; pl. 5, figs 1, 2a, 3; pl. 6, fig. a; pl. 7, fig. 2; pl. 12, fig. 4.

1876 *Ptilophyllum acutifolium* Morris: Feistmantel, p. 44 (*partim*), pl. 5, figs 4, 4a.

1876 *Ptilophyllum cutchense*, var. *distans* Feistmantel, p. 43, pl. 5, fig. 2b; pl. 6, fig. b.

1876 *Ptilophyllum cutchense* var. *curvifolium* Feistmantel, p. 44, pl. 6, fig. c.

1876 *Ptilophyllum cutchense* var. *minimum* Feistmantel, p. 44, pl. 7, figs 1, 1a.

1876 *Ptilophyllum brachyphyllum* Feistmantel, p. 45, pl. 7, figs 3, 3a.

1876 *Otozamites contiguus* Feistmantel, p. 48, pl. 7, figs 4, 4a.

1917 *Ptilophyllum* (*Williamsonia*) *pecten* (Phillips): Seward, p. 522 (*partim*) fig. 588C.

1917 *Ptilophyllum cutchense* Morris: Seward, p. 518, fig. 591.

1920 *Ptilophyllum acutifolium* Morris: Seward & Sahni, p. 20 (*partim*), pl. 5, fig. 50.

1972 *Ptilophyllum cutchense* Morris: Bose & Kasat, p. 118, pl. 1, figs 7, 8, 10; pl. 2, fig. 14; pl. 13, fig. 114.

Diagnosis (from Bose & Kasat, 1972) — Lamina as a whole linear-lanceolate, pinnate, exceeding 30 cm in length, width 0.5-3 cm, attenuate towards base and apex. Rachis partially exposed, sometimes concealed, about 1-3.5 mm wide. Pinnae attached on upper surface of rachis, closely set or imbricate, mostly attached by entire base, arising at an angle of about 50°-70°. Pinnae as a whole linear, rhomboidal, subulate or ovate, margin straight or sometimes slightly falcate. Apex obtuse or obtusely acuminate, sometimes apiculate. Acroscopic margin mostly rounded; basiscopic margin straight, slightly decurrent. Veins arising from entire base, more or less parallel, forked or unforked, forking at all levels.

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

Occurrence —Loharia, Trambau, Bhajodi, Kera, Sukhpur, Jamthara, Kurbi, Gadhsisa, Manzal, Kakadbhit (locality nos. 1-3), Dauda Mota, Chawad River (locality nos. 2, 3, 6), Walka Mota, Lakhapar, Ghuneri and Dharesi (locality no. 2)

Remarks — P. cutchense type of leaves are extremely common at Kakadbhit and Kurbi. The exact locality of the lectotype is not known. In Grant's memoir (1840) it has been mentioned as "South of the Charwar range".

At Kurbi, besides the usual *P. cutchense* type of leaves, there are some leaves which have extremely minute pinnae. Some of these resemble in external features *P. elongatum* Douglas (1969) and *Ptilophyllum* sp. "b" also described by Douglas (1969). Unfortunately, in none of them veins are preserved. Their description is as follows:

TYPE 1

Pl. 23, fig. 1

Leaves fragmentary, imparipinnate, 2.8 cm long and 0.4 cm wide. Rachis about 0.8-1 mm wide. Pinnae attached on upper surface of rachis at an angle of 50°-60°, almost concealing it, closely set, upper margin overlapping part of lower margins of pinna lying above, oval-elongate, slightly falcate, 1-2 mm long and 0.8-1 mm wide, gradually becoming smaller and narrower towards distal ends; apex acute; acroscopic basal margin curving downwards, basiscopic basal margin slightly decurrent, veins not visible. In overall shape the specimen resembles more *Ptilophyllum elongatum* Douglas (1969).

TYPE 2

Pl. 23, figs 2, 3, 7

Leaf imparipinnate, linear, largest specimen measuring 3 cm in length and 0.8 cm in width (range noted 4.5-8 mm). Rachis 0.5-1 mm wide, almost concealed by pinnae. Pinnae subopposite or alternate, contiguous attached at an angle of 55°-60°, linear, slightly falcate. Margin entire, apex acute or obtuse; upper basal angle constricted, lower basal angle decurrent. Veins obscure.

The specimens resemble in goss features, *Ptilophyllum* sp. "b" described by Douglas (1969) from Australia and *Ptilophyllum* sp. B figured by Kimura and Tsujii (1982, pl. 41, fig. 7; text-figs 6, 9a) from Japan.

Ptilophyllum acutifolium Morris

Pl. 23, figs 8-11

Specimens from Kachchh:

1840 *Ptilophyllum acutifolium* Morris: in Grant, p. 327, pl. 21, figs 1a-3.
1941 *Ptilophyllum acutifolium* Morris, p. 117.
1876 *Ptilophyllum acutifolium* Morris: Feistmantel, p. 44 (*partim*).
1876 *Otozamites conf. goldiaei* Brongniart: Feistmantel, p. 49, pl. 11, figs 3, 4.
1972 *Ptilophyllum acutifolium* Morris: Bose & Kasat, p. 117, pl. 1, figs 1-5.

Diagnosis (slightly modified from Bose & Kasat, 1972) — Leaves pinnate, measuring more than 42 cm in length, width 4-10.5 cm, lamina as a whole broadly lanceolate. Rachis fully or partially concealed, about 2-5 mm broad, sometimes with fine longitudinal striations. Pinnae attached on upper surface of rachis, arising at an angle of about 53°-72°, sometimes at right angles, closely set, often touching each other, mostly attached by entire base, rarely upper basal angle free. Pinnae as a whole linear, elon-

gate, narrow; margin straight or falcate; apex acute. Upper basal angle slightly rounded, lower basal angle decurrent. Veins arising from entire base, more or less parallel, forked or unforked, when forking mostly once.

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

Occurrence — Loharia, Bhajodi, Manzal and Kakadbhit (locality nos. 1 & 2).

Remarks — Like *Ptilophyllum cutchense* the exact locality of the lectotype of *P. acutifolium* is not known. Its locality has also been reported as, "South of the Charwar Range" (Grant, 1840).

Ptilophyllum oldhamii Jacob & Jacob

Pl. 25, figs 4-7, 9-11; Text-fig. 37A-G

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

1972 *Ptilophyllum oldhamii* Jacob & Jacob: Bose & Kasat, p. 121, pl. 3, figs 19, 20, 24, 26, 27, 29; text-fig. 1A-G.

Diagnosis (from Bose & Kasat, 1972 with minor change) — Leaves 2.2-3.5 cm long and 0.6-0.8 cm wide. Rachis concealed by pinnae. Pinnae closely set, imbricate or contiguous, alternate or subopposite, arising at an angle of about 45°-57°. Pinnae 5-9 mm long, 2-3 mm wide near base; apex apiculate; margins entire; upper basal angle somewhat rounded, lower basal angle slightly decurrent. Veins obscure.

Cells of rachis on both surfaces squarish or rectangular; anticlinal walls thick, slightly wavy at places, sometimes a few cells with sinuous walls; periclinal wall unspecialized.

Upper cuticle of lamina thin. Cells rectangular, squarish or polygonal, irregularly arranged; anticlinal walls sinuous; periclinal wall smooth. Lower cuticle showing an outer marginal zone without stomata and an inner zone with stomata. Marginal zone about 5-6 cells wide, near apex up to 10 or more. Cells along margins mostly rectangular, sometimes polygonal or squarish; anticlinal walls sinuous; periclinal wall unspecialized. Within stomatal zone stomata crowded, tending to form one stoma wide files, files discontinuous and irregular, occasionally a few stomata lying slightly oblique. Guard cells sunken, crescent shaped, mostly concealed by overhanging papillae. Subsidiary cells slightly more cutinized than ordinary epidermal cells, usually papillate; papillae solid or dome shaped. Epidermal cells within stomatal zones papillate. Papillae 1-3 or more, crescent, dome or mushroom-shaped, sometimes forming circular to oval rings.

Neotype — B.S.I.P. specimen no. 3376.

Occurrence — Trambau.

Comparison — *Ptilophyllum oldhamii* resembles most *P. nipanica* Vishnu-Mittre described by Bose and Kasat (1972). *P. boreale* (Heer) Seward described by Thomas (1930) and *P. pecten* (Phillips) described by Harris (1969). In all these species there is a marginal non-stomatic zone and an inner zone with stomata. *P. nipanica* differs in having non-papillate cells within the stomatal zone. In *P. boreale* the lower cuticle is devoid of papillae. Pinnae apices in *P. pecten* are obtuse and in this species stomata are usually confined to strips between veins.

Ptilophyllum indicum Jacob & Jacob

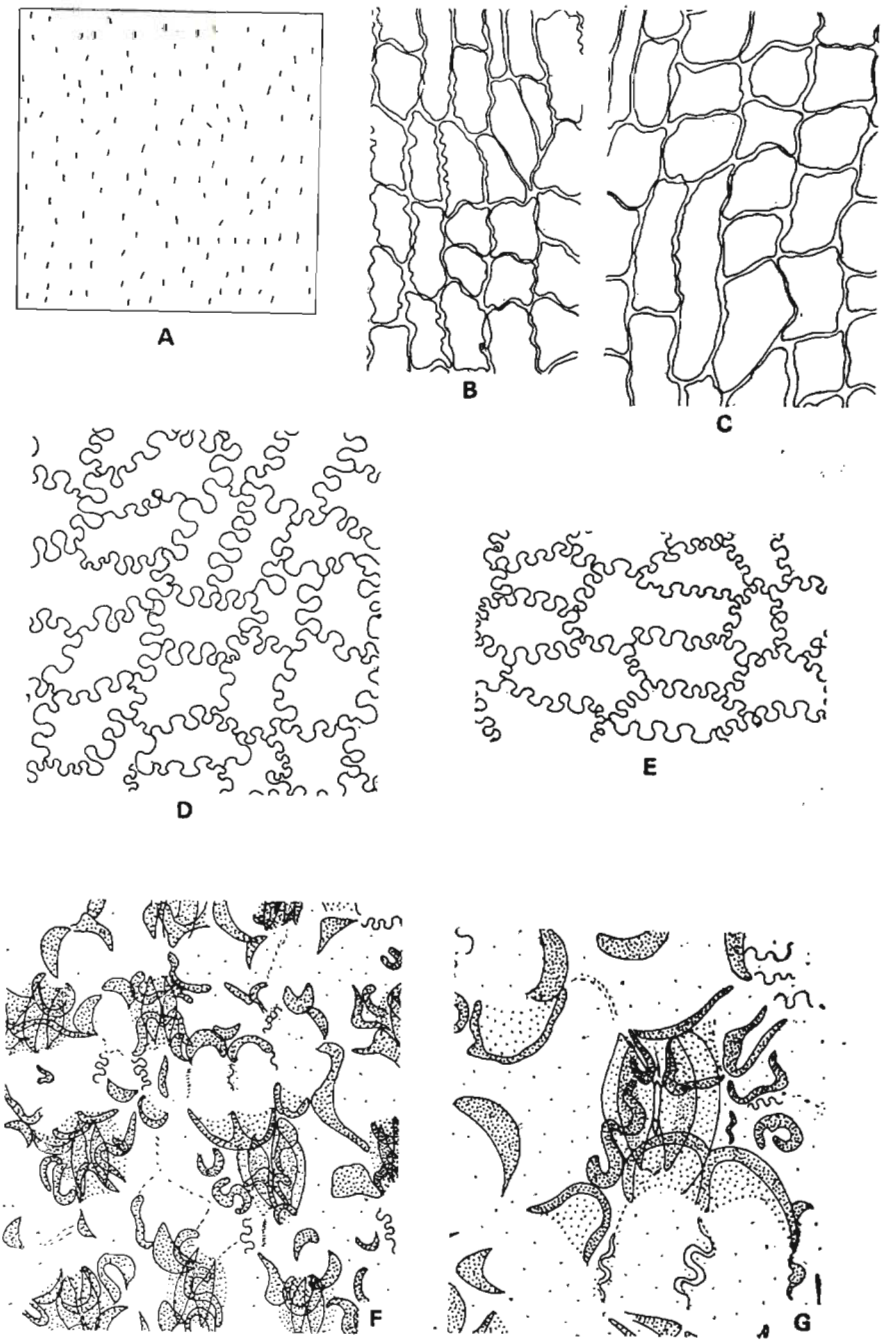
Pl. 25, figs 1-3, 5, 8; Pl. 26, figs 3-5; Text-figs 38A-39A-F

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

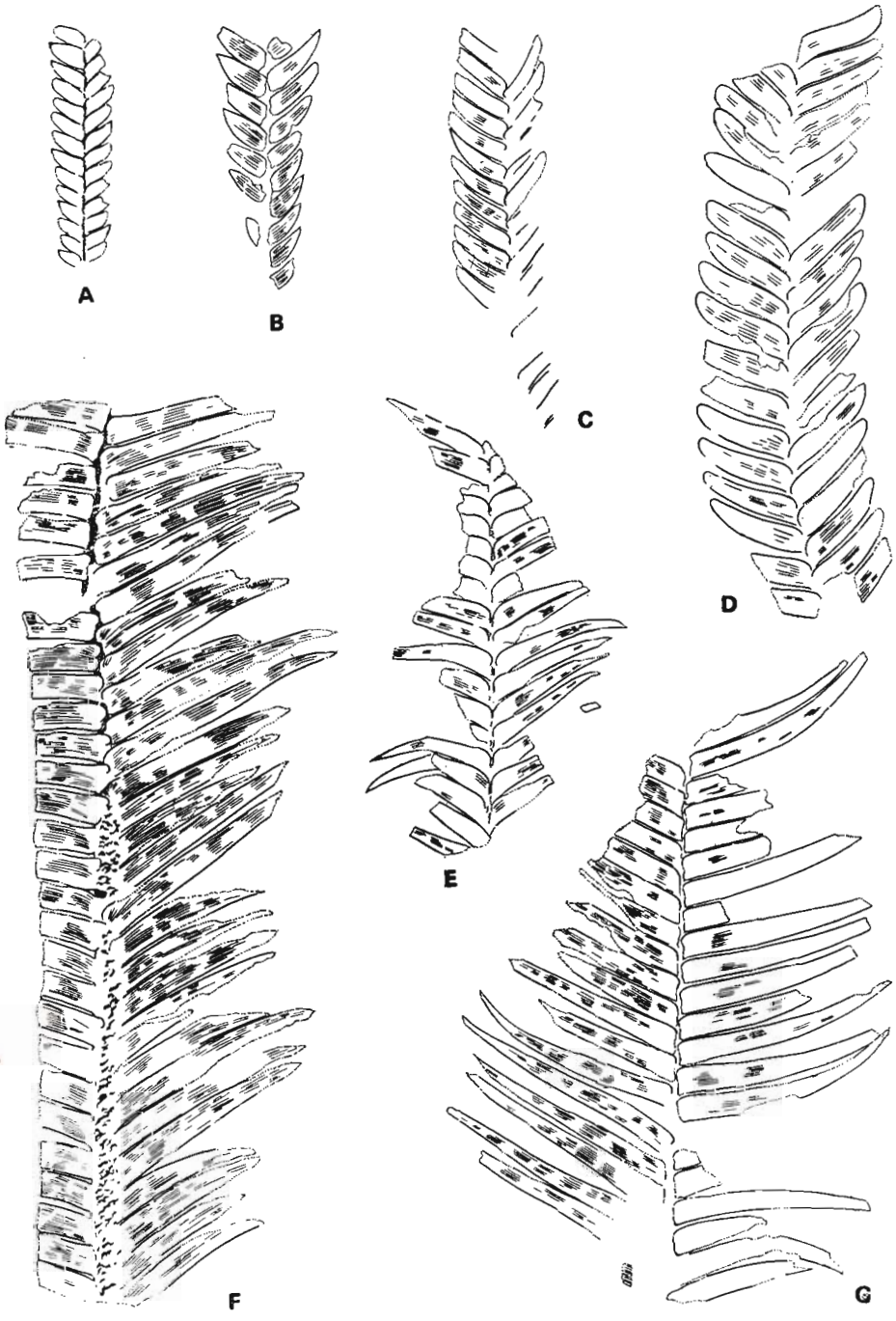
1972 *Ptilophyllum indicum* Jacob & Jacob: Bose & Kasat, p. 123, pl. 3, figs 21-23, 25, 28; pl. 4, figs 39, 40; text-fig. 2 A-F.

Diagnosis (slightly modified from Bose & Kasat, 1972) — Leaves pinnate, exceeding 7 cm in length, width near middle 0.4-0.6 cm. Lamina as a whole of even width, gradually tapering towards base and apex. Rachis completely covered by pinnae, 0.8-1 mm wide. Pinnae somewhat lanceolate, alternate, closely set, sometimes imbricate, arising at an angle of about 60°-65°. Apex apiculate, rarely acute. Acroscopic basal margin gradually curving downwards, basiscopic basal margin straight or slightly decurrent. Veins mostly obscure, forked or unforked.

Upper cuticle of rachis thick, cells serially arranged, rectangular, a few much large-



TEXT-FIG. 37A-G — *Ptilophyllum oldhamii* Jacob & Jacob from Trambau. **A,** lower cuticle show distribution of stomata, B.S.I.P. slide no. 33767-3, × 40; **B,** lower cuticle of rachis, B.S.I.P. slide no. 3376 × 250; **C,** upper cuticle of rachis, B.S.I.P. slide no. 33767-2, × 250; **D,** upper cuticle of pinna, B.S.I.P. s no. 33767-1, × 250; **E,** lower cuticle showing marginal cells, B.S.I.P. slide no. 33767-1, × 250; **F,** lo cuticle showing a few stomata, B.S.I.P. slide no. 33767-1, × 250; **G,** a stoma, B.S.I.P. slide no. 33767-1, × (All figures from Bose & Kasat, 1972).



TEXT-FIG. 38

than broad. Anticlinal walls wavy or sometimes slightly sinuous but without any prominent loops; periclinal wall devoid of papillae or hairs. Cells of lower cuticle similar to those of the upper cuticle.

Upper cuticle of lamina thinner than the lower, devoid of stomata, papillae and trichome bases. Cells more or less regularly arranged, mostly rectangular, a few squarish or polygonal. Anticlinal walls sinuous, loops distinct, adjacent loops not touching each other. Lower cuticle differentiated into broad stomatal bands and narrow non-stomatal bands along veins. Marginal non-stomatic area 4-6 cells wide, near tip more than 6 cells wide. Marginal cells rectangular with sinuous anticlinal walls, loops slightly less in number than upper cuticle; periclinal wall unspecialized. Non-stomatal bands 2-5 cells wide (mostly 3), cells mostly rectangular, sometimes a few polygonal; anticlinal walls sinuous, loops like those of marginal cells, loops of end-walls smaller than lateral-walls, sometimes walls near corners more thickened than marginal cells; periclinal wall smooth or slightly thickened, sometimes papillate. Papillae varying in shape, circular or crescent-shaped. Cells of stomatal bands smaller than non-stomatal bands, rectangular or polygonal; anticlinal walls sinuous, mostly walls thicker than non-stomatal bands. Cells mostly papillate; papillae, circular, hollow or crescent-shaped, often cells with one or two papillae. Stomatal bands 2-6 stomata wide, mostly 5. Stomata transversely orientated, rarely slightly oblique. Subsidiary cells more cutinized than ordinary epidermal cells, occasionally with two solid circular or rounded, raised papillae. Mostly subsidiary cells and guard cells covered by papillae of adjacent cells, each stomatal apparatus covered by about 4-5 papillae near the guard cells. Guard cells sunken, crescent-shaped.

Neotype — B.S.I.P. specimen no. 33770.

Occurrence — Trambau and Sukhpur.

Comparison — In external features *Ptilophyllum indicum* resembles *P. oldhamii* Jacob & Jacob described by Bose and Kasat (1972). *P. indicum* differs in having stomatal and non-stomatal bands. Both *P. sokalense* Doludenko (1963) and *P. okribense* Doludenko & Svanidze (1964) resemble *P. indicum* in having papillate cells on lower surface. Unlike *P. indicum* in *P. sokalense* stomata are not covered by papillae of the adjacent ordinary cells. *P. okribense* can be distinguished by its mere shape of pinnae.

Ptilophyllum sakrigaliensis Sah

Pl. 26, figs 1, 2; Pl. 27, figs 1-5; Text-figs 38F, G, 40A-F

Specimens from Kachchh:

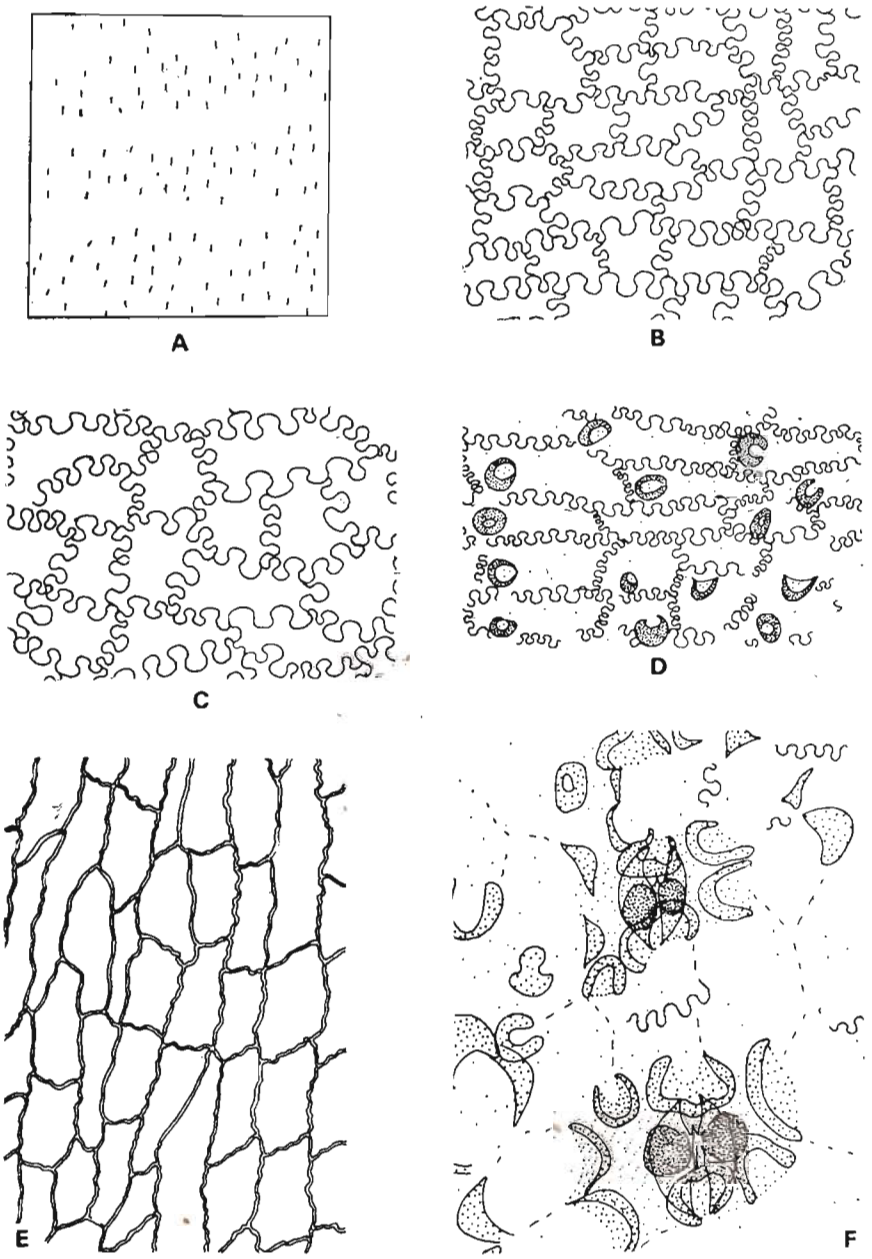
1972 *Ptilophyllum sakrigaliensis* Sah: Bose & Kasat, p. 127, pl. 5, figs 41, 50; pl. 6, figs 56, 57; text-fig. 4A-F.

Diagnosis (*from Bose & Kasat, 1972 with minor alterations*) — Leaves pinnate, exceeding 20 cm in length, 6-7.6 cm wide. Rachis 3-5 mm wide, partially or completely concealed by pinnae. Pinnae linear, sometimes slightly falcate arising at an angle of about 60°-90°, closely set or slightly imbricate, 3-3.8 cm long, 2-4 mm wide near base. Apex acute; acroscopic basal margin straight or slightly curved; basiscopic basal margin straight or slightly decurrent, sometimes covered by upper basal angle of pinna lying below. Veins arising from entire base, simple or forked, mostly forking once, rarely more than once.

Upper cuticle devoid of stomata, hairs or papillae. Cells closer to margins rectangular, a few squarish or polygonal, arranged in regular rows; anticlinal walls sinuous, loops small but prominent. Cells

←

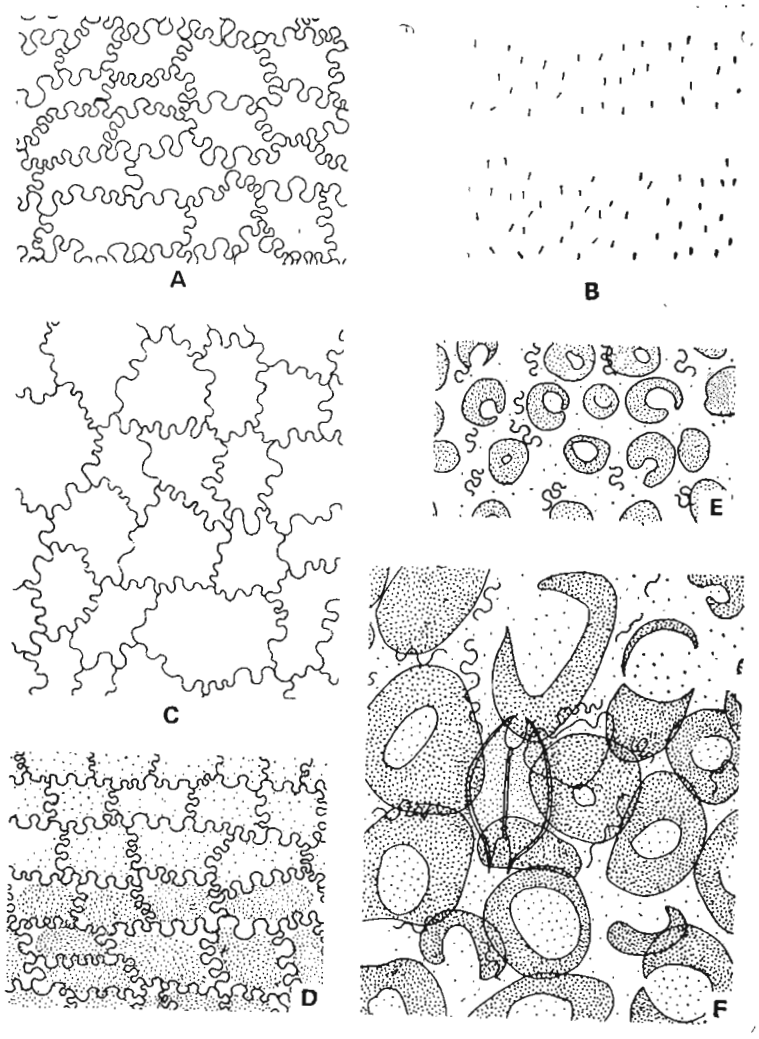
TEXT-FIG. 38A-G — **A**, *Ptilophyllum indicum* Jacob & Jacob from Sukhpur, B.S.I.P. specimen no. 36/2417, × 1; **B**, *Ptilophyllum* sp. from Walka Mota (locality no. 3), B.S.I.P. specimen no. 32/2215E, × 1; **C-D**, *Ptilophyllum institacallum* Bose, B.S.I.P. specimen nos. 13/2424 (from Chawad River locality no. 6) and 17/2891A (from Chawad River locality no. 3), × 1; **E**, *Ptilophyllum* cf. *amarjolense* Bose from Chawad River (locality no. 3), B.S.I.P. specimen no. 16/2891A, × 1; **F-G**, *Ptilophyllum sakrigaliensis* Sah from Chawad River (locality no. 2), B.S.I.P. specimen nos. 26/2411C and 29/2411C, × 1.



TEXT-FIG. 39A-F — *Ptilophyllum indicum* Jacob & Jacob from Trambau. **A**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 31884-1, × 40; **B**, upper cuticle, B.S.I.P. slide no. 31884-3, × 250; **C**, lower cuticle showing marginal cells, B.S.I.P. slide no. 31884-4, × 250; **D**, lower cuticle showing cells of non-stomatal zone, B.S.I.P. slide no. 33771-2, × 250; **E**, rachis cells, B.S.I.P. slide no. 33771-1, × 250; **F**, two stomata, B.S.I.P. slide no. 32422, × 500. (All figures from Bose & Kasat, 1972).

in central region polygonal, a few squarish, irregularly arranged; anticlinal walls sinuous loops less prominent as compared to marginal cells. Cells near base polygonal, with wavy anticlinal walls. Lower cuticle differentiated into stomatiferous and non-

stomatiferous bands, often bands indistinct due to papillae; near base because of papillae bands indistinct. Stomatiferous bands broader than non-stomatiferous bands. Marginal non-stomatiferous bands 9-10 cells wide, less towards base and apex. Cells rectangular, a few polygonal, arranged in regular series; anticlinal walls sinuous, loops more prominent near margin; periclinal wall of cells near margin (about 1-5 cells wide) either unspecialized or showing faint thickening, while remaining cells showing a single, solid papilla. Other non-stomatiferous bands 2-4 cells wide, cells mostly polygonal; anticlinal walls obscure, when visible sinuous with less prominent loops than marginal cells, periclinal wall mostly with a hollow ring-shaped papilla, a few with solid circular or dome-shaped papillae, sometimes papillae dividing into unequal domes or the ring



TEXT-FIG. 40A-F — *Ptilophyllum sakrigaliensis* Sah from Khari River. **A**, upper cuticle showing marginal cells, B.S.I.P. slide no. 31872-3, × 250; **B**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 31872-1, × 40; **C**, upper cuticle showing cells near middle region, B.S.I.P. slide no. 31872-3, × 250; **D**, marginal cell of lower cuticle, B.S.I.P. slide no. 31872-4 × 250; **E**, lower cuticle showing cells of a non-stomatal band, B.S.I.P. slide no. 31872-4, × 250; **F**, a stoma, B.S.I.P. slide no. 31872-1, × 500. (All figures from Bose & Kasat, 1972).

having 3-4 notches. Within stomatal bands, cells somewhat similar to those of non-stomatal bands, cell outline very rarely visible; periclinal wall of each cell bearing papillae like those of cells of non-stomatal bands but near base cells mostly with a solid papilla rarely a few with a semicircular papilla. Stomatal bands 2-5 stomata wide, mostly 3-4, within bands stomata irregularly scattered. Stomata transversely orientated, a few slightly oblique, concealed by papillae of adjacent cells. Subsidiary cells non-papillate. Guard cells well cutinized, crescent-shaped.

Lectotype — B.S.I.P. specimen no. 4923.

Occurrence — Khari River near Bhuj and Chawad River (locality no. 2).

Remarks — The specimens from Chawad River (locality no. 2) in gross features match exactly with the lectotype (see Pl. 23, figs 8-11) and other specimens of *Ptilophyllum acutifolium* Morris so far collected from Kachchh. When similar specimens with 'phyto-lemma', matching the cuticle of the present specimens, will be found from other localities, then it will perhaps be better that these specimens are put under *P. acutifolium*.

Comparison — In general outlook *Ptilophyllum longipinnatum* Menéndez (1966) is like *P. sakrigaliensis*, but its lower cuticle is not so papillate as *P. sakrigaliensis*. Moreover, the subsidiary cells of *P. longipinnatum* are papillate. The cuticle of *P. hirsutum* Thomas & Bancroft, described by Harris (1969), is like *P. sakrigaliensis*. In *P. sakrigaliensis* the pinnae are larger and narrower than *P. hirsutum*. *P. ukrainense* Doludenko (1963) has pinnae with obtuse apex, but its lower cuticle somewhat resembles the lower cuticle of *P. sakrigaliensis*. The cells of *P. sakrigaliensis* have bigger and more crowded papillae.

Ptilophyllum distans (Feistmantel) Jacob & Jacob

Pl. 28, figs 1, 2, 8-10; Text-fig. 41A-E

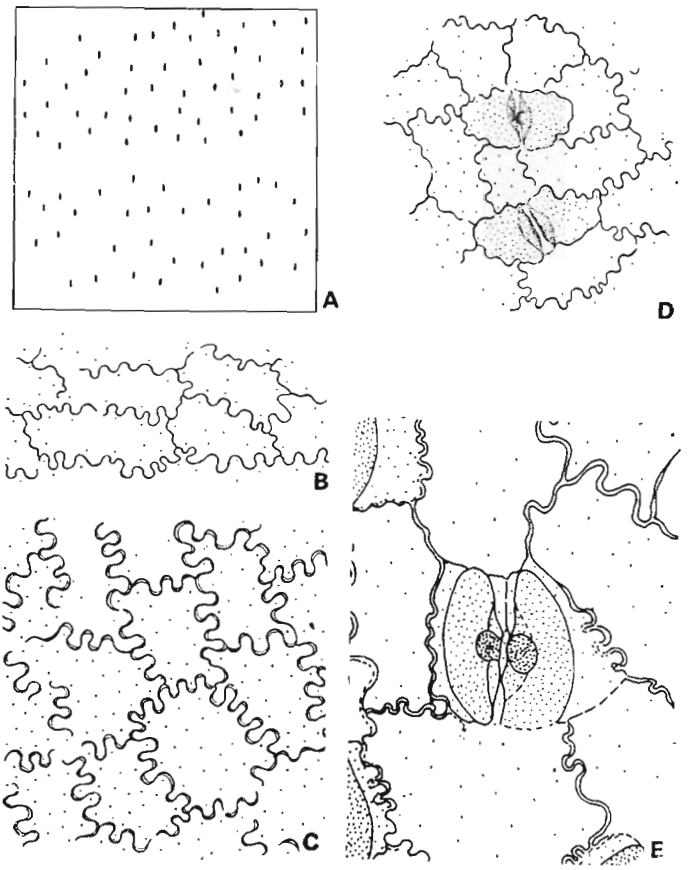
Specimens from Kachchh:

1972 *Ptilophyllum distans* (Feistmantel) Jacob & Jacob: Bose & Kasat, p. 129, pl. 8, figs 66-67, 74, 77; text-fig. 5H.

Diagnosis (from Bose & Kasat, 1972 with minor changes) — Frond imparipinnate, length exceeding 8.5 cm, width 1.5-3.5 cm near middle region, gradually narrowing towards base and apex. Rachis partially or completely concealed by pinnae. Pinnae linear oblong, 0.5-2 cm in length, 0.2-0.3 cm in width, mostly 1.5 cm long and 0.2 cm wide, closely set or imbricate, arising at an angle of about 50°-85°, attached on upper surface of rachis. Pinna apex subacute or acute, sometimes apiculate; acroscopic basal margin rounded, rarely very slightly auriculate; basiscopic basal margin decurrent, mostly concealed by acroscopic margin of pinna below. Veins arising from entire base, forking once or twice, rarely thrice.

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

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



TEXT-FIG. 41A-E — *Ptilophyllum distans* (Feistmantel) Jacob & Jacob, **A-D** (from Sukhpur) and **E** (from Trambau). **A**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 31918-1, × 40; **B**, lower cuticle showing cells along veins, B.S.I.P. slide no. 31918-1, × 150; **C**, showing cells of upper cuticle, B.S.I.P. slide no. 31918-1, × 250; **D**, lower cuticle showing two stomata, B.S.I.P. slide no. 31918-1, × 150; **E**, a stoma, B.S.I.P. slide no. 31930-2, × 500.

circular area, but without any distinct papilla. Within stomatal bands stomata irregularly scattered, sometimes forming discontinuous longitudinal files, very rarely a few stomata occurring over non-stomatal bands. Stomata transversely orientated, rarely slightly oblique, crowded or sparse. Subsidiary cells more cutinized than ordinary cells; anticlinal walls sinuous, or wavy; periclinal wall with or without papilla; papillae rounded, solid. Guard cells slightly sunken, crescent-shaped, well-cutinized, inner walls around the pore more cutinized.

Holotype — G.S.I. specimen no. 4905.

Occurrence — Trambau and Sukhpur.

Comparison — The cuticle of *Ptilophyllum distans* resembles very much the cuticle of *P. cantherifera* Douglas (1969). In both the species ordinary epidermal cells of the lower cuticle are devoid of papilla and the subsidiary cells are papillate. In *P. cantherifera* the pinnae are falcate. In *P. longipinnatum* Menéndez (1966) like *P. distans*, the subsidiary cells are papillate, but in the former species the papillae are hollow. Moreover, its ordinary epidermal cells are also sometimes papillate. The cuticle of *P. pectinoides* (Phillips) described by Harris (1969) looks very much like the cuticle of *P. distans*. In *P. pectinoides*, on lower

surface, some of the ordinary epidermal cells have bulging surfaces. In *P. distans* the cells have smooth surface.

Ptilophyllum horridum Roy

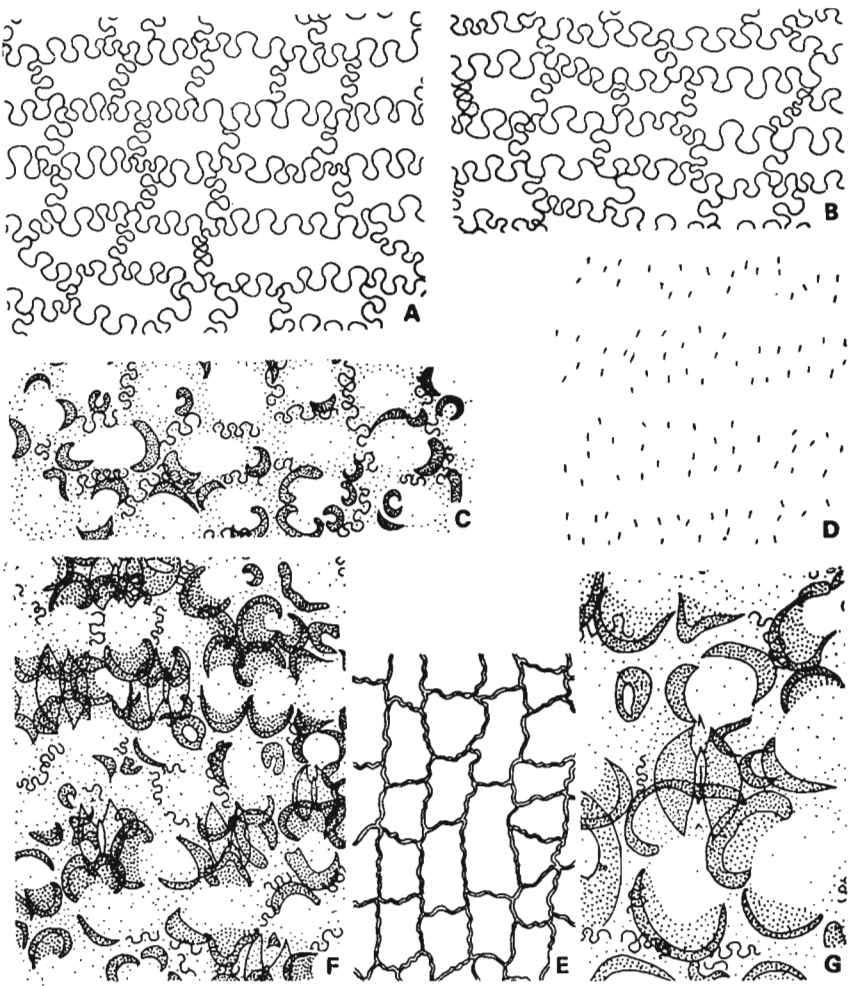
Pl. 28, figs 3-7; Text-fig. 42A-G

Specimens from Kachchh:

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

1972 *Ptilophyllum horridum* Roy: Bose & Kasat, p. 125, pl. 4, figs 30-38; pl. 5, figs 47-49; text-fig. 3A-G.

Diagnosis (from Bose & Kasat, 1972)— Leaf pinnate, exceeding 19.5 cm in length, uniformly broad, gradually tapering towards base and apex, width near middle 0.9-2 cm. Rachis concealed by pinnae, 1-2 mm wide. Pinnae closely set, almost touching each other, sometimes imbricate, mostly alternate, occasionally sub-opposite, arising



TEXT-FIG. 42A-G — *Ptilophyllum horridum* Roy from Trambau. **A**, upper cuticle, B.S.I.P. slide no. 31940-1, × 250; **B**, lower cuticle showing marginal cells, B.S.I.P. slide no. 31935, × 250; **C**, lower cuticle showing cells of a non-stomatal band, B.S.I.P. slide no. 33762, × 250; **D**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 31889-1, × 40; **E**, rachis cells, B.S.I.P. slide no. 31952, × 250; **F**, lower cuticle showing a few stomata, B.S.I.P. slide no. 33762, × 250; **G**, a stoma, B.S.I.P. slide no. 33762, × 500. (All figures from Bose & Kasat, 1972).

s an angle of about 55°-68°. Pinnae 4-11 dm long, 1.3 mm wide near base, linear or near-lanceolate; apex apiculate, sometimes cute or obtuse, acroscopic basal margin unded, basiscopic basal margin decurrent. eins faintly marked, forked or unforked, rking at different levels.

Rachis cells rectangular or squarish, very rely polygonal; anticlinal walls thick, avy, sometimes sinuous with less prominent ops; periclinal wall unspecialized.

Cells of lamina on upper surface mostly ctangular, a few squarish or polygonal, ore or less regular in arrangement; anti-inal wall sinuous, loops wide, head of ops rounded; periclinal wall smooth or ottled. Lower cuticle differentiated into omatiferous and non-stomatiferous bands. omatiferous bands broader than non-omatiferous bands. Marginal non-omatiferous bands without any hair or pilla, 5-6 cells wide, cells mostly rectan-lar or squarish, a few polygonal, generally rially arranged; anticlinal walls sinuous, ops prominent with rounded heads. Other n-stomatiferous bands 3-4 cells wide; lls rectangular, a few squarish or polygonal, ranged in regular rows; anticlinal walls uous, fairly thick-walled, mostly cell alls obscured by papillae, surface with 3 papillae, mostly 2 or 3, papillae rounded, escent, arch or mushroom-shaped. Some-nes 2-3 papillae of same cell joining gether, and completely obscuring cell wall. omatiferous bands 2-6 stomata wide, ostly 3-4, rarely 2 (near margin). Ordinary idermal cells with 2-3 papillae, nature of pillae same as those of cells of non-omatiferous bands. In each cell, papillae sed together forming a sort of ring over ll wall and completely obscuring it. Cells naller in size than those of non-stomati-rous bands, rectangular or polygonal; nticlinal walls when visible sinuous, rarely avy. Subsidiary cells non-papillate, slight-more cutinized than those of ordinary idermal cells. Guard cells thickly cuti-zed, crescent-shaped, sunken. Stomatal pparatus covered by papillae of adjacent lls.

Holotype — B.S.I.P. specimen no. 31889.

Localities — Trambau, Sukhpur and haresi (locality no. 1).

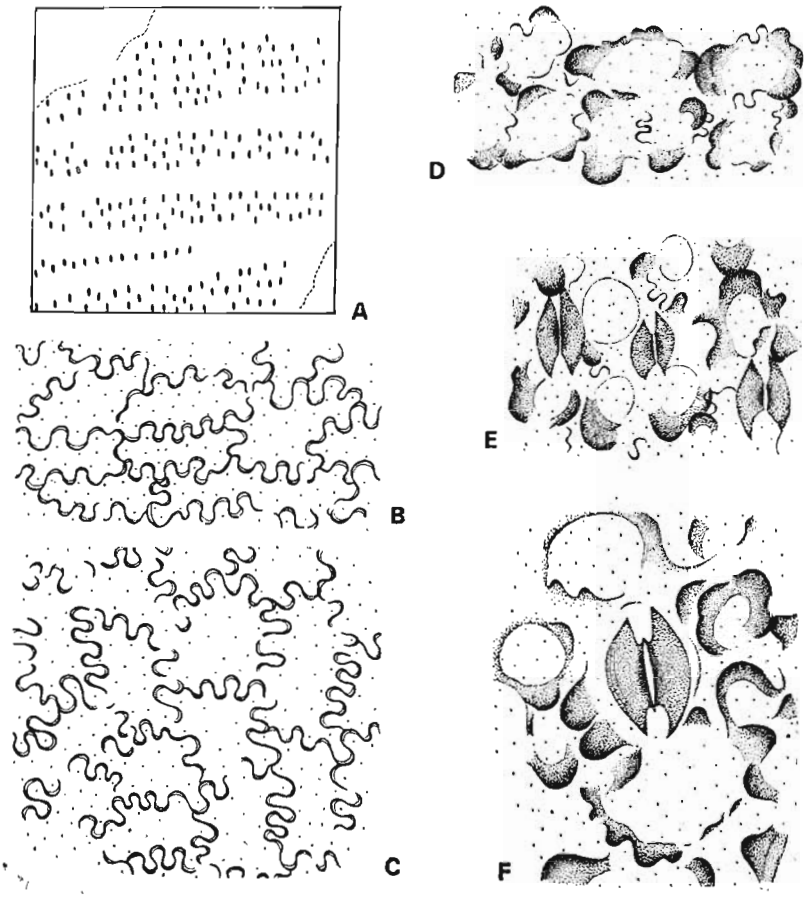
Comparison — The pinnae apices of *P. rridum* are like *P. indicum* Jacob & Jacob d *P. oldhamii* Jacob & Jacob described by Bose and Kasat (1972). *P. horridum* can easily be distinguished from both these species by its lower cuticle which is highly papillate. In the nature of papillae *P. horridum* comes closest to *P. caucasicum* Doludenko & Svanidze (1964). On lower surface they have almost similar type of papillae. In *P. caucasicum* stomatal bands are narrower than *P. horridum* and in the former species pinnae apices are also different from the latter species. *P. sakrigaliensis* Sah described by Bose and Kasat (1972) differs from *P. horridum* in having pinnae with acute apices, also on lower surface the cells have only one papilla.

Ptilophyllum institacallum Bose

Pl. 29, figs 1, 5-7; Text-figs 38C, D, 43A-F

Description — Largest specimen 11 cm long and 1.6-2.2 cm wide. Rachis mostly concealed by pinnae bases, up to 3 mm wide, smooth or finely striated. Pinnae alternate, closely set, attached at an angle of 60°-80°, linear, sometimes slightly falcate, 0.9-1.4 cm in length, 0.4-2.4 cm in width; acroscopic basal margin rounded, basiscopic basal margin somewhat rounded, constricted or slightly decurrent; apex acute, obtuse or apiculate; margin entire. Veins arising from entire base, slightly diverging towards distal side, simple, sometimes forked.

Upper cuticle having mostly rectangular cells, sometimes polygonal; anticlinal walls highly sinuous, loops prominent and deep; periclinal wall smooth. Occasionally cells along veins narrower than remaining cells. Lower cuticle showing a distinct marginal zone all round; marginal zone 8-10 cells wide, cells rectangular or polygonal; anticlinal walls highly sinuous, loops like those of cells on upper surface; periclinal wall unspecialized. Inner zone having papillate cells and stomata, with or without distinct stomatal and non-stomatal bands. When differentiated into stomatal and non-stomatal bands, the outer two stomatal bands slightly broader than the remaining stomatal bands, rarely a few stomata occurring along non-stomatal bands. Stomata rarely distributed over entire surface, avoiding the marginal non-stomatal zone. Anticlinal walls of cells of stomatal and non-stomatal bands sinuous, completely obscured by papillae, periclinal wall having one or more hollow papillae;



TEXT-FIG. 43A-F — *Ptilophyllum institacallum* Bose from Chawad River (locality no. 6). **A**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 13/2424, × 40; **B**, lower cuticle showing cells along margin, B.S.I.P. slide no. 13/2424, × 150; **C**, upper cuticle showing a few cells, B.S.I.P. slide no. 13/2424, × 150; **D**, lower cuticle showing cells along vein, B.S.I.P. slide no. 13/2424, × 150; **E**, lower cuticle showing a few stomata, B.S.I.P. slide no. 13/2424, × 150; **F**, a stoma, B.S.I.P. slide no. 13/2424, × 500.

papillae variously shaped, mostly crescent-shaped or semi-lunar, papillae of individual cell and adjacent cells joining each other in order to form a sort of "frill-like" structure. Stomata mostly concealed by papillae of adjacent cells, slightly sunken. Inner wall of subsidiary cells slightly more thickened; guard cells crescent-shaped, fairly well cutinized.

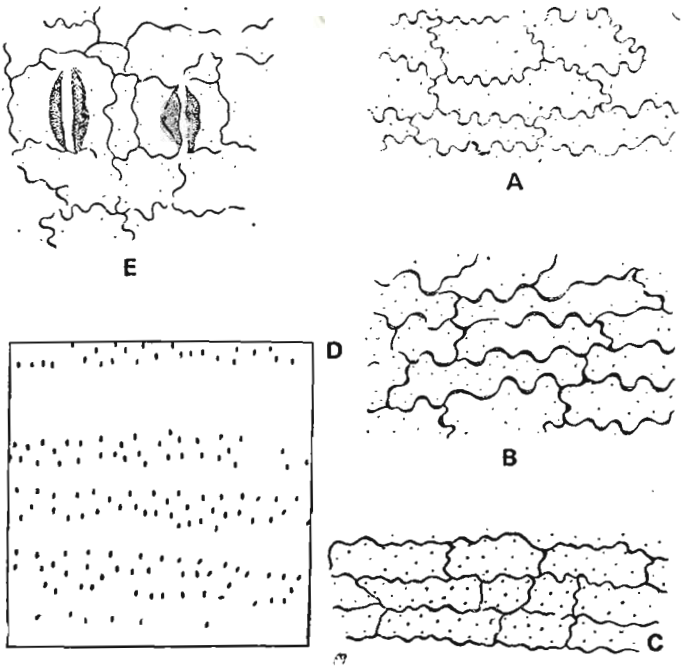
Occurrence — Trambau, Sukhpur and Chawad River (locality no. 3).

Remarks — The cuticle of specimens from Kachchh resembles the cuticle of the specimens of *P. institacallum* Bose described by Bose and Kasat (1972). In the specimens from Kachchh pinnae apices are rather variable. They have acute, obtuse or apiculate apices. In the specimens, described by Bose and Kasat (1972), the pinnae have sub-acute or acute apices.

Ptilophyllum cf. *amarjolense* Bose

Pl. 29, figs 3, 4; Pl. 30, figs 1, 2; Text-figs 44A-F, 38E

Description — Pinnate leaf measuring about 6 cm in length and 3 cm in width; rachis 1.5-2 mm wide, upper surface completely concealed by pinnae. Pinnae sub-opposite attached at an angle of about 80°-85°, 3-4 mm wide near base, acroscopic



TEXT-FIG. 44A-E — *Ptilophyllum* cf. *amarjolense* Bose from Chawad River (locality no. 3). **A**, upper cuticle showing a few cells, B.S.I.P. slide no. 16/2891-1 A, × 150; **B**, lower cuticle showing a few cells along margin, B.S.I.P. slide no. 16/2891A-1, × 150; **C**, lower cuticle showing cells along a vein, B.S.I.P. slide no. 16/2891A-1, × 150; **D**, lower cuticle showing distribution of stomata, B.S.I.P. slide no. 16/2891A-1, × 40; **E**, lower cuticle showing two stomata, B.S.I.P. slide no. 16/2891A, × 150.

basal margin curving downwards; basiscopic basal margin slightly decurrent concealed by acroscopic basal margin of pinna lying below; apex acute. Veins obscure, visible only at places.

Cells on upper surface rectangular, close to margin more or less serially arranged; anticlinal walls sinuous loops slightly more cutinized; periclinal wall smooth or mottled. Lower surface showing distinct non-stomatal and stomatal bands. Marginal bands 8-9 cells wide, cells rectangular, somewhat serially arranged; anticlinal walls sinuous loops long but not so deep; periclinal wall smooth. Other non-stomatal bands 4-5 cells wide, mostly 4; cells like the cells of marginal bands; periclinal wall mostly thickened towards centre but never forming a definite papilla. Cells within stomatal bands rectangular or polygonal irregularly arranged; anticlinal walls less sinuous; periclinal wall leaving a small area all around margin mostly more cutinized but never forming a definite papilla. Stomatal bands 2-3 stomata wide, mostly 3, very rarely 1 or 4. Stomatal band next to the marginal non-stomatal band, single stomata wide. Stomata transversely orientated, sometimes slightly oblique, irregularly distributed. Inner walls of subsidiary cells slightly more cutinized, but without any papilla. Guard cells crescent-shaped, fairly well cutinized.

Occurrence — Chawad River (locality no. 3).

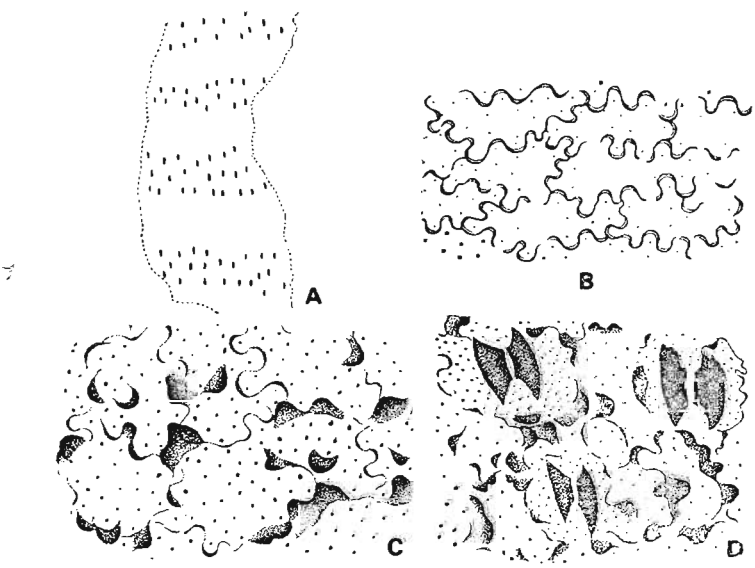
Comparison — The cuticle of *Ptilophyllum* cf. *amarjolense* matches most the cuticle of *P. amarjolense* Bose described by Bose and Kasat (1972). In the former species the stomatal bands are 2-3 stomata wide, whereas, in the latter species stomatal bands are 4-5 stomata wide. Also, in *P.* cf. *amarjolense* the cells on lower surface have slightly thickened periclinal wall. *Ptilophyllum* sp. described by Menéndez (1966) have cells with thickened periclinal wall, but it differs from *P.* cf. *amarjolense* in having papillae above the guard cells.

Ptilophyllum sp.

Pl. 29, fig. 2; Pl. 30, figs 3, 4; Text-figs 38B, 45A-D

Description — Leaf 3 cm long and 1.3 cm wide; rachis about 1 mm wide, partially or completely concealed by pinnae bases. Pinnae alternate or sub-opposite, attached at an angle of 65°-70°, linear, slightly falcate, measuring 4-9× 2-2.5 mm, gradually reducing in size towards base; apex acute, margin entire; acroscopic basal margin rounded, basiscopic basal margin constricted, slightly decurrent. Veins more or less parallel, simple or forked.

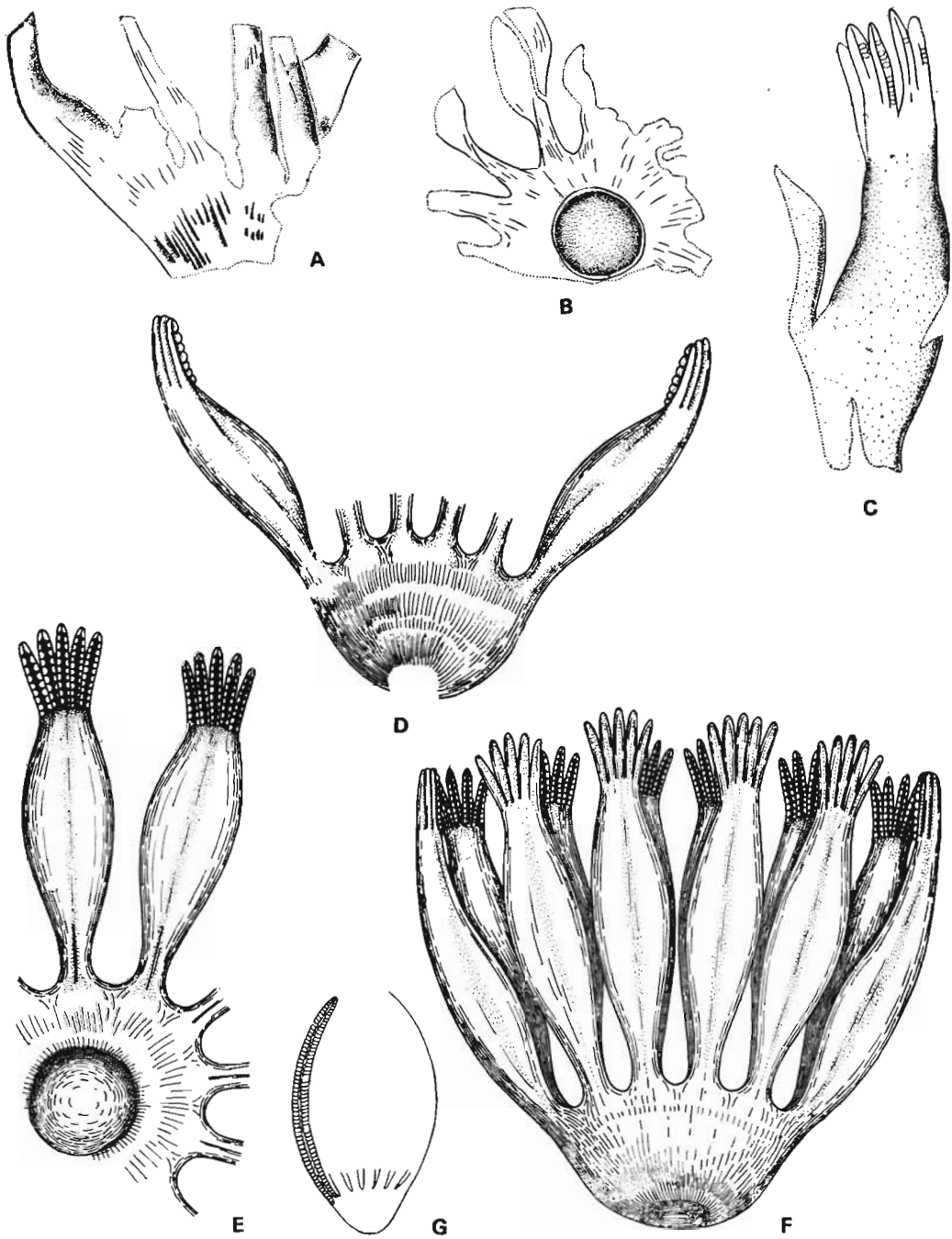
Cells of upper cuticle rectangular or polygonal, showing somewhat regular arrangement; anticlinal walls sinuous, loops prominent, periclinal walls smooth. Lower cuticle having broad stomatal and narrow non-stomatal bands. Non-stomatal bands 3-4 cells wide, cells serially arranged, rectangular; cell outline mostly indistinct; anticlinal walls less sinuous than the cells on upper surface; periclinal wall with 1-4 arch or crescent-shaped papillae, rarely semi-lunar or circular. Papillae usually placed closer to overlapping lateral- and end-walls. Stomatal bands 3-4 stomata wide, rarely a few stomata also placed along non-stomatal bands. Within stomatal bands, at places, stomata tending to form longitudinal files, stomata transversely orientated. Subsidiary cells slightly more cutinized than ordinary epidermal cells, devoid of papilla. Guard



TEXT-FIG. 45A-D — *Ptilophyllum* sp. from Walka Mota (locality no. 3). **A**, showing distribution of stomata, B.S.I.P. slide no. 32/2215E-2,× 40; **B**, lower cuticle showing cells along margin, B.S.I.P. slide no. 32/2215E-1,× 150; **C**, lower cuticle showing cells along a vein, B.S.I.P. slide no. 32/2215E-1,× 150; **D**, lower cuticle showing a few stomata, B.S.I.P. slide no. 32/2215E-1,× 150.

→

TEXT-FIG. 46A-G — **A-F**, *Weltrichia harrisiana* n. sp. **A**, showing a part of a laterally compressed specimen, B.S.I.P. no. 182/2082 (from Kurbi),× 1; **B**, showing a part of the upper surface of a 'flower' with the central cavity, B.S.I.P. specimen no. 10/1725 (from Kakadbhit — locality no. 1),× 1; **C**, showing distal part of a microsporophyll with finger-like appendages, B.S.I.P. specimen no. 19/2204 (from Kurbi), × 2; **D**, restoration of a flower showing lateral view of two microsporophylls; **E**, restoration of part of a flower showing proximal view of two microsporophylls and the central cavity; **F**, showing restoration of a complete flower; **G**, *Weltrichia* sp., showing restoration of a microsporophyll with two rows of (?) polliniferous chambers.



TEXT-FIG. 46

cells crescent-shaped, slightly sunken. Cell walls of ordinary epidermal cells within stomatal bands concealed by papillae, each cell having more than one papilla, papillae placed closed to lateral- and end-walls, joining together and obscuring the walls. Trichome bases absent.

Occurrence — Walka Mota (locality no. 3).

Comparison — *Ptilophyllum* sp. resembles most *P. rewaensis* Sukh-Dev & Zeba Bano (1977). The cuticle of both the species are more or less similar in nature. *P. rewaensis* can be distinguished by its pinnae which have apiculate apices. Also in *P. rewaensis*, on lower surface, the non-stomatal bands have mostly 2 papillae. Papillae are also commonly circular in shape, they are hollow, sometimes two or three papillae joining together and forming 'frill-like' structure.

Genus — *Weltrichia* Braun, 1847

Weltrichia harrisiana n. sp.

Pl. 31, figs 1, 2, 7; Text-fig. 46A-F

Diagnosis — Estimated diameter of male flower about 12-15 cm; microsporophylls (?) 12-14 in number, coalescent towards base, forming a circular depression of about 2 cm in diameter. Microsporophylls coriaceous, showing prominent longitudinal striations, near the point of attachment adaxial surface showing a prominent ridge, about 2/3 distal end expanded. Each microsporophyll near apex terminating into 5 uniformly broad fertile appendages; fertile appendages measuring 0.7-0.9 cm in length and about 1·5 mm in width, each appendage having a double row of polleniferous chambers.

Specific name — The specific name is after the Late Professor Thomas Maxwell Harris.

Holotype — B.S.I.P. specimen no. 10/1725.

Occurrence — Kurbi and Kakadbhit (locality nos. 1 & 2).

Remarks — The above diagnosis is based on 5 fragmentary specimens. From the specimen no. 10/1725 (Pl. 31, fig. 7) from Kakadbhit (locality no. 1), which shows the adaxial surface, it has been estimated that *Weltrichia harrisiana* probably had 12-14 microsporophylls. This specimen shows bases of about 8 microsporophylls. In this specimen the circular depression shows a broad rim all round. This rim is about 0.7 cm wide and has been formed due to the joining of the bases of microsporophylls. The specimen clearly shows that the microsporophylls were arranged in a whorl.

The holotype (Pl. 31, fig. 7; Text-fig. 64B) is laterally compressed and was collected from Kurbi. In this specimen, one of the microsporophylls at its margin gives a faint idea of hair bases, but they are not so clear. From this locality apical regions of two microsporophylls were also collected. Both these specimens (Pl. 31, figs 1, 2) clearly show the fertile appendages attached at the apical end. In each appendage a median groove is visible. The polleniferous chambers are not so distinct.

Comparison — Like *Weltrichia hirsuta* Schweitzer (1977, text-figs 12D, 13a, b), described from Iran, *W. harrisiana* too, has fertile appendages at the apical end of microsporophylls. In *W. hirsuta* the microsporophylls are highly hirsute. Moreover, in *W. hirsuta* the arrangement of microsporophylls is different from that of *W. harrisiana*.

Weltrichia sp.

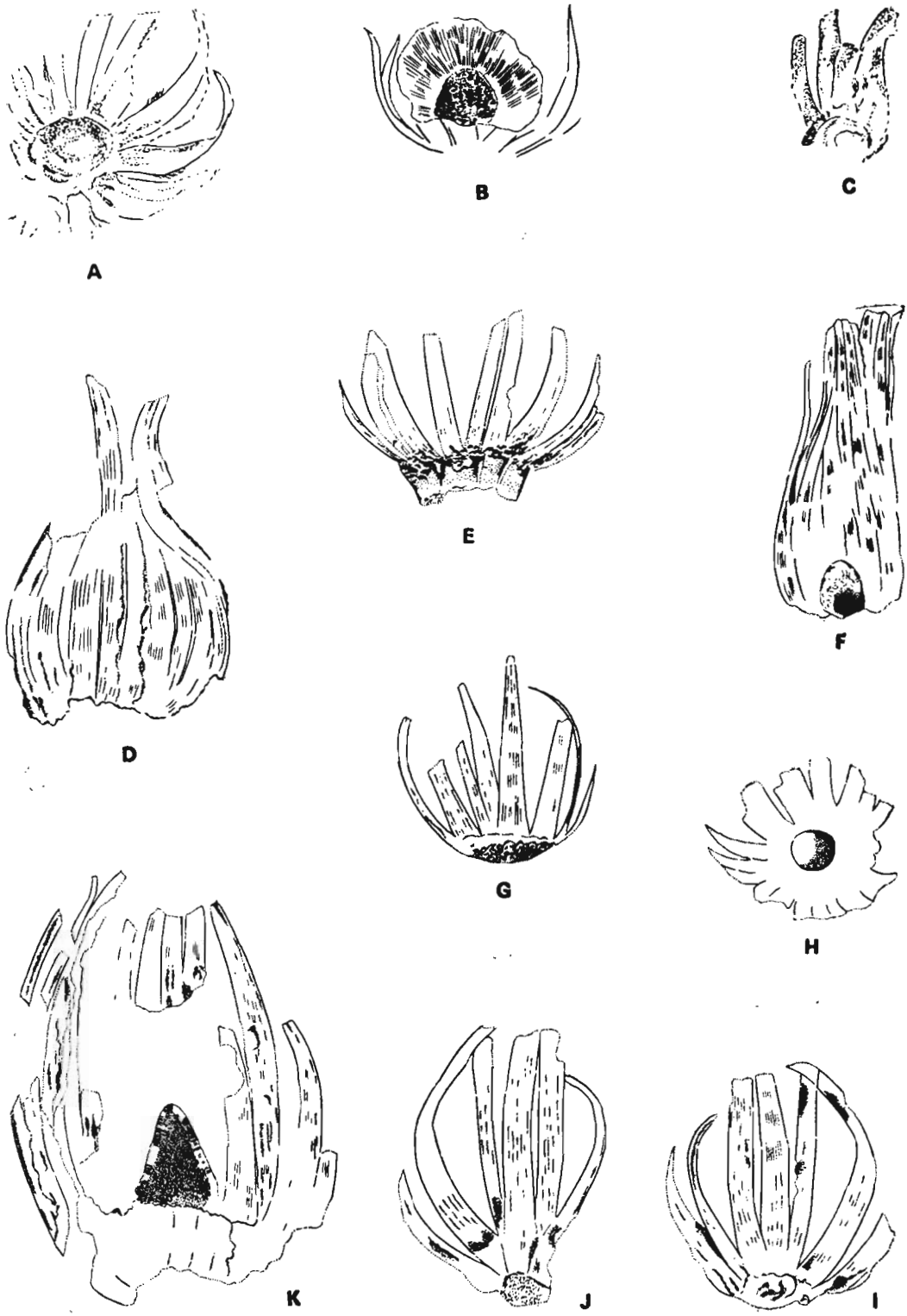
Pl. 31, figs 3-6; Text-fig. 46G

1971 *Weltrichia* sp.: Sitholey & Bose, p. 157, pl. 4, figs 22-25.

Description — Flowers 3-2.8 cm long and 1.9 to 2 cm wide. Microsporophylls 8-10

→

TEXT-FIG. 47A-K — **A-J**, *Williamsonia blanfordi* Feistmantel, G.S.I. specimen no. 4/844 (from Kakadbhit locality no. 1), B.S.I.P. specimen no. 84/2678 (from Kakadbhit locality no. 1), G.S.I. specimen no. 4/845 (from Kakadbhit locality no. 1), B.S.I.P. specimen nos. 32/2203B (from Kakadbhit locality no. 2), D/2000A (from Kakadbhit locality no. 1), 78/2079 (from Kakadbhit locality no. 2), 43/2407 (from Kakadbhit locality no. 1), 79/2678 (from Kakadbhit locality no. 1), 90/2678 (from Kakadbhit locality no. 1) and 74/2678 (from Kakadbhit locality no. 1); all × 1; **K**, *Williamsonia kakadbhitensis* n. sp. from Kakadbhit (locality no. 2), B.S.I.P. specimen no. 92/2079, × 1.



TEXT-FIG. 47

in number, coalescent towards base (?forming a whorl), exceeding 4 cm in length, having a double row of (?) polleniferous chambers. Each(?) polleniferous chamber rectangular or squarish, contiguous.

Occurrence — Kakadbhit (locality no. 1).

Remarks — The above description is based on two incomplete specimens. It seems that this species had about 12 microsporophylls. The nature of microsporophylls, i.e. the (?)polleniferous chambers situated directly on the microsporophylls, is rather characteristic. In this respect the flowers resemble most *Weltrichia* sp. described by Weber (1980) from the Santa Clara Formation, Mexico.

Genus — *Williamsonia* Carruthers, 1870

The collection from Kachchh includes more than 50 specimens of *Williamsonia*. The specimens are preserved as impressions, incrustations, cast and mould. There are only four specimens which have 'phytolemma' preserved in them and they have yielded two distinct types of cuticle. The 'flowers' are either closed or open. Some of them are preserved upside down, often showing the base of the receptacle alongwith a few complete or incomplete bracts. The specimens show a good deal of variation in shape and size. The receptacles, wherever preserved, also show variation. They are either conical or dome-shaped. We have here identified only four species. Two of them are based on the nature of cuticle and the remaining two are based mainly on the presence or absence of hairs on the bracts and the shape of receptacle. While describing these species we are quite aware that at some later date when more specimens with 'phytolemma' will be available, a few more species may turn up or the two species based on the nature of hairs and receptacle may prove to be the same, because the ones without distinct hairs may have lost their hairs, during preservation.

Williamsonia blanfordii Feistmantel

Pl. 31, figs 8-10; Pl. 32, figs 2, 4; Text-fig. 47A-J

1876 *Williamsonia blanfordi* Feistmantel, p. 52, pl. 12, figs 5-7.
1877*c* *Williamsonia blanfordi* Feistmantel, p. 29, pl. 1, figs 4, 5; pl. 2, fig. 6.
1917 *Williamsonia blanfordi* Feistmantel: Seward, p. 445, fig. 558.
1920 *Williamsonia blanfordi* Feistmantel: Seward & Sahni, p. 27, pl. 6, fig. 58.
1963 *Williamsonia blanfordi* Feistmantel: Sitholey, p. 13, pl. 2, fig. 13.
1974 *Williamsonia blanfordi* Feistmantel: Bose, p. 193.

Diagnosis — Female 'flower', shape as a whole onion-like, sometimes slightly prolonged towards apical end, 2.8-5.2 cm long and 1.4-4 cm wide. Bracts forming a perianth of more than one turn, linear, about 2.8-5.2 cm long and 0.3-0.5 cm wide near base, gradually tapering towards apex, rarely at places showing fine striations. Receptacle dome-shaped, 0.6-1.4 cm wide, slightly constricted near base. Seminiferous and interseminal scales visible as fine tubular markings, about 0.9 cm in length.

Lectotype — G.S.I. specimen no. 4/844.

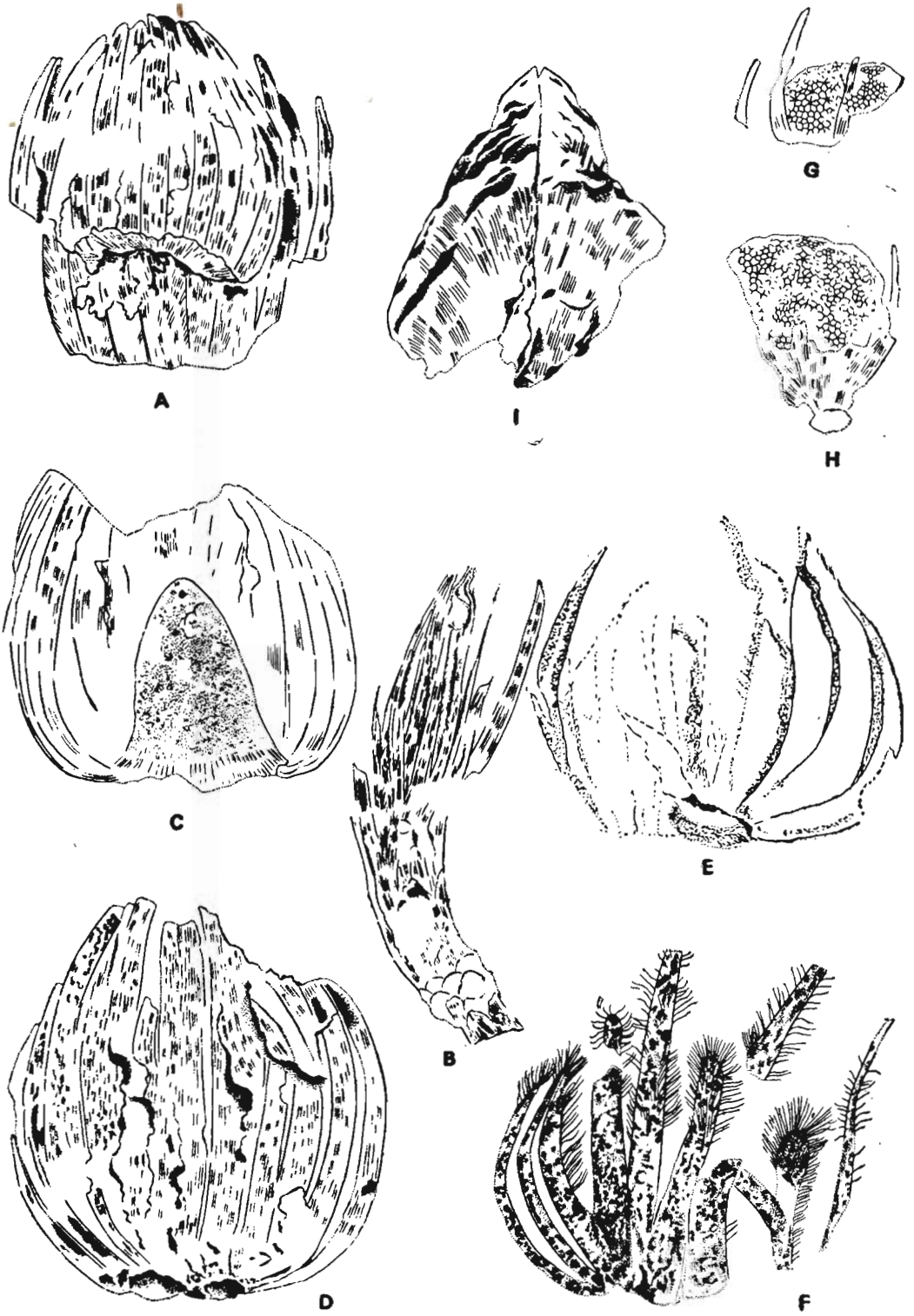
Occurrence — Kera (locality no. 1) and Kakadbhit (locality nos. 1 & 2).

Remarks — Feistmantel's (1876) description was based on three specimens collected from Kakadbhit. Out of these, his specimen number 4/843 (Feistmantel, 1876, pl. 12, fig. 5) is now not available.

The above diagnosis is based on the original specimens of Feistmantel (1876) and a few new specimens mostly collected from Kakadbhit. Only one specimen is from Kera. Feistmantel's (1876) original specimens are preserved in the form of impressions, whereas, the new collection includes

→

TEXT-FIG. 48A-I — **A-F**, *Williamsonia kakadbhitensis* n. sp. (figures A-D from Kakadbhit — locality no. 2, **E**, from Walka Mota — locality no. 1 and **F**, from Kurbi), B.S.I.P. specimen nos. 33/2203, 1/2091B, 32226, 32226A, 3/7085A and 176/2082, × 1; **G-H**, *Bennetticarpus* sp. from Kakadbhit (locality no. 1), B.S.I.P. specimen nos. 45/2407 and 46/2407, × 1; **I**, *Cycadolepis* sp. from Kakadbhit (locality no. 2), B.S.I.P. no. 35/2203, × 1.



TEXT-FIG. 48

specimens preserved as impression, cast and mould.

Comparison — The overall shape of *Williamsonia blanfordii* is like *W. harrisiana* Bose (1968). Its receptacle, too, looks like *W. harrisiana*. Both the species have long seminal and interseminal scales. *W. harrisiana* differs in having bracts with long hairs. In *W. diquiyui* described by Delevoryas and Gould (1973) and Person and Delevoryas (1982) the seminal and interseminal scales are almost of the same size as in *W. blanfordii*, but in the former species the receptacle is conical in shape. Some of the specimens of *W. blanfordii* look like *W. asseretoi* Barnard & Miller (1976). In *W. asseretoi* the receptacle is conical in shape. One of the specimens of *W. blanfordii* (Pl. 31, fig. 10) resembles *W. prynadae* Turutanova-Ketova (1963) in the overall shape of its gynoecium. The details of the gynoecium of the latter species are not known.

Williamsonia kakadbhitensis n. sp.

Pl. 32, figs 1, 3, 5, 9, 10; Pl. 33, figs 3-5; Text-figs 47K, 48A-F

Diagnosis — 'Flower' mostly onion-shaped, rarely ovate, 5.3-6.5 cm in length and 2.2-5.5 cm in width. Number of bracts variable, spirally arranged, forming a perianth of more than one turn, linear, 5.3-6.5 cm long and 2.5-6 cm wide, gradually tapering towards apex, sometimes apex obtuse, surface covered with fine hairs; hairs more prominent along lateral margins; hairs 1.5-6 mm in length. Receptacle cone-shaped, measuring 1.5-3 cm in length and 1.3-2.7 cm in width near base. Seminiferous and interseminal scales inconspicuous, about 1.5 mm long.

Holotype — B.S.I.P. specimen no. 32226.

Occurrence — Kurbi, Kakadbhit (locality nos. 1 & 2) and Walka Mota (locality no. 2).

Remarks — *Williamsonia kakadbhitensis* is most common at Kakadbhit (locality no. 2). Out of the specimens collected, three specimens are somewhat ovate in shape. One of the specimens (Pl. 32. fig. 5; Text-fig. 48B) is attached to a *Bucklandia*-type of stem.

Comparison — *Williamsonia kakadbhitensis* differs from *W. blanfordii* Feistmantel in having bracts with long hairs. Unlike *W. blanfordii*, which has dome-shaped receptacle, *W. kakadbhitensis* has conical receptacle. Some of the specimens of *W. kakadbhitensis* look more like *W. sewardiana* Sahni (1932) in gross features as well as in the shape of receptacle. In both, bracts have prominent hairs, but in *W. kakadbhitensis* hairs are more prominent. In *W. guptai* Sharma (1968) the bracts do not show the hairs, but its receptacle is more like that of *W. kakadbhitensis*. However, in *W. guptai* the seminiferous and interseminal scales are slightly larger in size. The bracts of *W.* cf. *haydenii* Seward, described by Boureau (1950) and Jacob and Shukla (1955), show transverse striations. In. *W. sahnii* Gupta (1943) the bracts have prominent hairs and its receptacle seems to be conical in shape, but the 'flower' of *W. sahnii* is much larger in size than the 'flowers' of *W. kakadbhitensis*.

Williamsonia trambauensis n. sp.

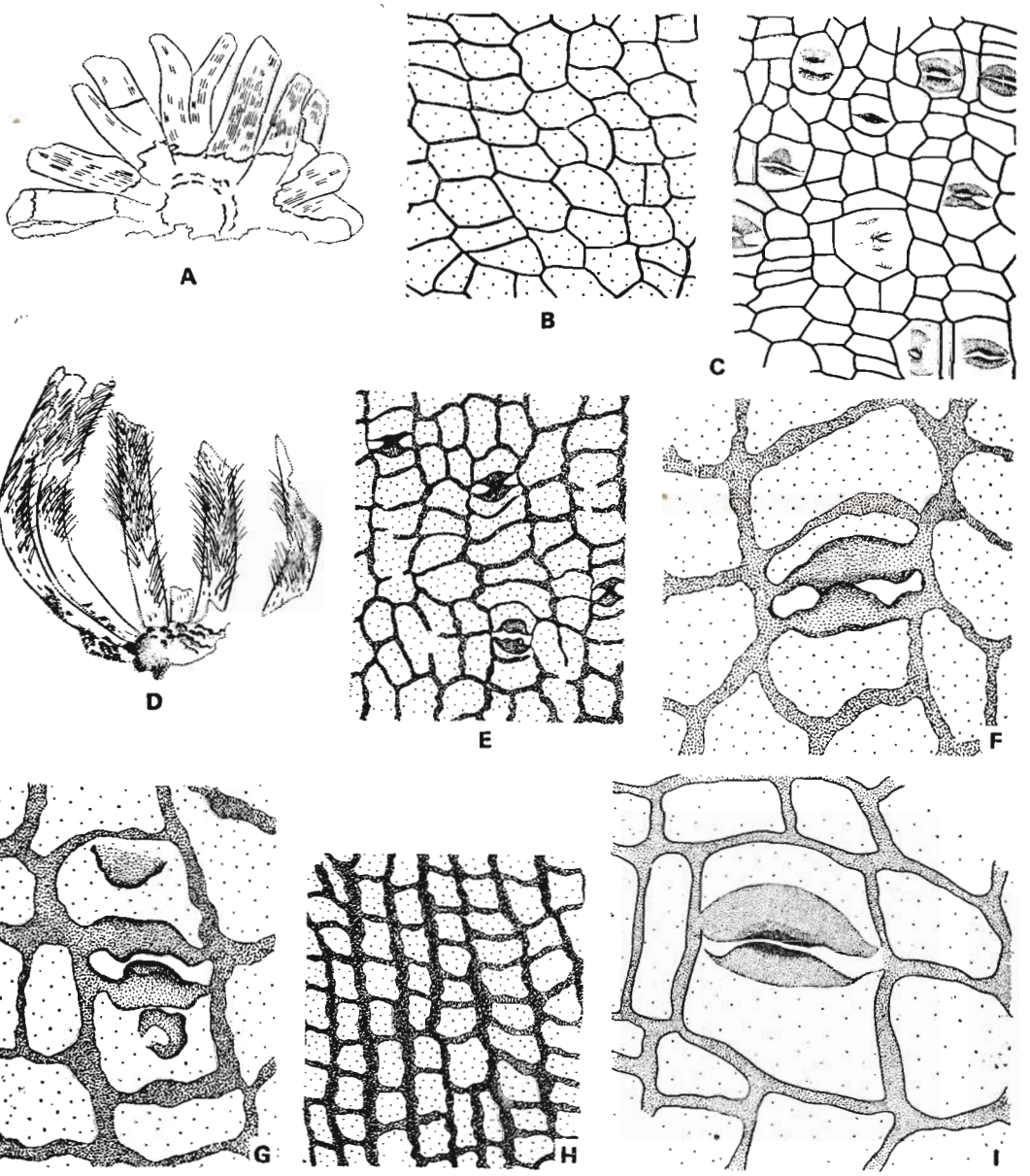
Pl. 33, fig. 1; Pl. 34, figs 1-3; Text-fig. 49A-C, I

Diagnosis — Bracts spirally arranged, thick, surface showing longitudinal striations, hairs not visible. Receptacle 1.1 cm in diameter.

Cuticle on both surfaces almost of same thickness. Stomata confined to lower surface. Upper surface showing irregularly arranged rectangular cells, mostly cells elongated in transverse direction; cells towards base broader than cells near middle and apical regions; anticlinal walls straight or slightly wavy at places. Very rarely minutely sinuous; periclinal wall mostly unspecialized, sometimes with circular or oval trichome bases. Entire upper surface covered with distantly placed ramentum bases, near base both trichome and ramentum bases rare. Cells on lower surface like those of upper surface, also having both trichome as well as ramentum bases. Stomata irregularly distributed, transversely orientated, fairly closely placed. Subsidiary cells slightly less cutinized than ordinary epidermal cells. Guard cells somewhat crescent-shaped, rarely inner wall of a cell bulging and covering a part of the cell lying opposite.

Holotype — B.S.I.P. specimen no. 34/2887.

Occurrence — Trambau.



TEXT-FIG. 49A-I — **A**, *Williamsonia trambauensis* n. sp. from Trambau, B.S.I.P. specimen no. 34A/2887, × 1; **B-C**, upper and lower surfaces of *W. trambauensis* respectively, B.S.I.P. slide no. 34/2887-1, × 150; **D**, *Williamsonia sukhpurensis* n. sp. from Sukhpur, B.S.I.P. specimen no. 44/2089; × 1; **E**, lower surface of *W. sukhpurensis* n. sp. showing a few stomata, B.S.I.P. slide no. 44/2089-1, × 150; **F-G**, *W. sukhpurensis* n. sp. showing two stomata, B.S.I.P. slide nos. 44/2089-1 and 30/2089-1, × 500; **H**, *W. sukhpurensis* n. sp. showing a few cells of upper surface, B.S.I.P. slide no. 44/2089-2, × 150; **I**, a stoma of *W. trambauensis* n. sp., B.S.I.P. slide no. 34/2887-1, × 500.

Remarks — The above diagnosis is based on a single specimen which is preserved upside down. It only shows parts of a few bracts and the base of the receptacle. Although the bracts do not show any hairs, but the cuticle shows nume-

rous trichome and prominent ramentum bases.

Comparison — The bracts and the basal diameter of the receptacle of *Williamsonia trambauensis* are more like *W. blanfordii* Feistmantel (1876). In *W. seniana* Bose & Kasat (1969) the epidermal cells have much larger dimensions and some of them show transverse striations. Also in *W. seniana* the subsidiary cells are slightly more cutinized than the ordinary epidermal cells and their inner walls are mostly papillate. Both *W. guptai* Sharma (1968) and *W. amarjolense* Sharma (1968) differ from *W. trambauensis* in having smooth-walled cells which are devoid of papilla. In *W. harrisiana* Bose (1968) the bracts have prominent hairs on lateral sides. Moreover, in *W. harrisiana* cells of the bracts are non-papillate. The bracts of *W. bulbiformis* Menéndez (1966) are like the bracts of *W. trambauensis*, both lack hairs on their lateral sides. *W. bulbiformis* differs from *W. trambauensis* in having fewer number of stomata and larger epidermal cells. In *W. bulbiformis* ramentum bases are absent. In *W. nizhonia* Ash (1968) trichome bases are rare but it has no ramentum bases.

Williamsonia sukhpurensis n. sp.

Pl. 33, figs 2, 8; Pl. 34, figs 4, 5; Pl. 35, figs 1-4; Text-fig. 49D-H

Diagnosis—'Flower' onion-shaped, having a perianth of more than one turn. Bracts 4-4.7 cm long and 5.6 mm wide, surface at places showing discontinuous and somewhat oval longitudinal scars; lateral sides showing prominent long hairs, sometimes at places abaxial and adaxial surfaces also showing hairs; hairs about 3-5 mm long.

Cells on upper surface mostly rectangular, sometimes squarish, rhomboidal or polygonal, somewhat serially arranged; lateral- and end-walls thick, at places showing jagged thickening or rarely broken by pits; surface wall smooth or mottled. Ramentum bases sparsely placed. Trichome bases absent. Cells on lower surface like those on upper surface, but less regularly arranged. Stomata irregularly distributed, transversely orientated. Subsidiary cells almost of same size and thickness as of ordinary epidermal cells; sometimes near centre showing a circular thickening, rarely papillate; papillae circular or semicircular in shape. Guard cells slightly more cutinized than subsidiary cells. Ramentum bases more frequent than on upper surface. Trichome bases absent.

Holotype — B.S.I.P. specimen no. 44/2089.

Occurrence — Sukhpur.

Remarks — Although the bracts of the specimens of *Williamsonia sukhpurensis* are covered with hairs, yet the ramentum bases in this species are not so common as in *W. trambauensis*.

Comparison — Like *Williamsonia kakadbhitensis* the present species has bracts with prominent hairs. *W. sukhpurensis* differs from *W. trambauensis* in having bracts with long hairs on lateral sides. Also in the latter species, both upper and lower cuticles have numerous trichome bases. The ramentum bases are smaller and fewer in number in *W. sukhpurensis*. In *W. harrisiana* Bose (1968) the bracts have prominent hairs like *W. sukhpurensis*, however, the latter species differs in lacking ramentum bases and it has much more closely placed stomata. The anticlinal walls of the epidermal cells in *W. feneonis* Barale (1981) and *Williamsonia* sp. described by Barale (1981) are sinuous in nature. In *W. feneonis* the epidermal cells are papillate which are long and conical in shape, whereas in *W. sukhpurensis* papillae are missing. *W. himas* Harris (1953, 1969) differs from *W. sukhpurensis* in having stomata on both the surfaces.

Genus — *Cycadolepis* Saporta, 1874

Cycadolepis pilosa Feistmantel

Pl. 32, fig. 6

Specimen from Kachchh:

1876 *Cycadolepis pilosa* Feistmantel, p. 51 pl. 7, fig. 5.

Diagnosis — Substance of scale leaf thick, linear-lanceolate in shape, about 2.8-3.6 cm long and 0.6-1 cm wide; apex obtuse. Surface showing fine striations in longitudinal direction, lateral edges with prominent hairs; hairs 0.2-0.7 cm in length.

Holotype — G.S.I. specimen no. 4/809 (Feistmantel, 1876, pl. 7, fig. 5).

Occurrence — Bhajodi, Kurbi, Kakadbhit (locality no. 2) and Walka Mota (locality no. 1).

Comparison — *Cycadolepis pilosa* resembles most the smaller scale leaves of *C. mexicana* Wieland described by Person and Delevoryas (1982), *C. lanceolata* Menéndez (1966) and *C. oblonga* Menéndez (1966). Unlike the latter three species the cuticle of *C. pilosa* is not known.

Cycadolepis sp.

Text-fig. 48I

Description — Specimen incomplete at base, available length 5.5 cm, width at widest region 3.3 cm, apex acute; margin entire. Middle part showing a longitudinal groove along which 5-6 veins running in longitudinal direction, in the remaining part veins curving out to meet margins, veins simple or forked.

Occurrence — Kakadbhit (locality no. 2).

Comparison — *Cycadolepis* sp., in gross features, looks like *C. involuta* Menéndez (1966). In *C. involuta* veins are forking and anastomosing, but in *Cycadolepis* sp. veins are not anastomosing. In general appearance *Cycadolepis* sp. also resembles *C. oldhamii* (Feistmantel) Bose & Jain (1964). In *C. oldhamii* the median groove is absent. In *C. hallei* Harris (1969) the middle region is much thickened, otherwise the lateral veins are more like *Cycadolepis* sp.

Genus — *Bennetticarpus* Harris, 1932

Bennetticarpus sp.

Pl. 32, figs 7, 8; Text-fig. 48G, H

Description — Specimen incomplete, showing a part of the gynoecium and apical part of a few bracts. Surface of gynoecium showing slightly projecting seed micropyles which are surrounded by 5-6 interseminal scales; surface of interseminal scales flattened, polygonal in shape.

Occurrence — Kakadbhit (locality no. 1).

Remarks — The specimen was found in association with a large number of specimens of *Williamsonia blanfordii* Feistmantel. The bracts surrounding the gynoecium of *Bennetticarpus* sp. do not show any hairs. It is quite likely that *Bennetticarpus* sp. is a mature 'fruit' of *W. blanfordii* Feistmantel.

Genus — *Elatocladus* Halle, 1913

Elatocladus confertus (Oldham & Morris) Halle

Pl. 36, figs 1-5; Text-fig. 50A-D

Specimen from Kachchh:

1876 *Palissya*?: Feistmantel, p. 56, pl. 10, fig. 5.

Description — Largest specimen about 7 cm long, branching irregularly at an angle of 45°-55°; leaves spirally disposed, generally attached at an angle of 50°-70°, very rarely at places attached at an angle of 80°-90°. Leaves linear-lanceolate or oblong in shape, typically about 3-4 mm long and 0.8-1 mm wide, towards distal end gradually reducing in size; margins entire, apex acute-subacute, rarely obtuse; base usually slightly constricted rarely decurrent; midrib distinct, running from base to apex. Often basal region of lateral branches having comparatively smaller and narrower leaves, rarely even scale-like.

Occurrence—Kurbi, Gadhsisa and Kakadbhit (locality nos. 1 & 2).

Remarks — *Elatocladus confertus* is extremely common at Kurbi. The specimens from Kachchh, in gross features, resemble most the specimens described from Peninsular India (see, Feistmantel, 1877b; Sahni, 1928; Bose *et al.*, 1982 etc.) and from Graham Land by Halle (1913).

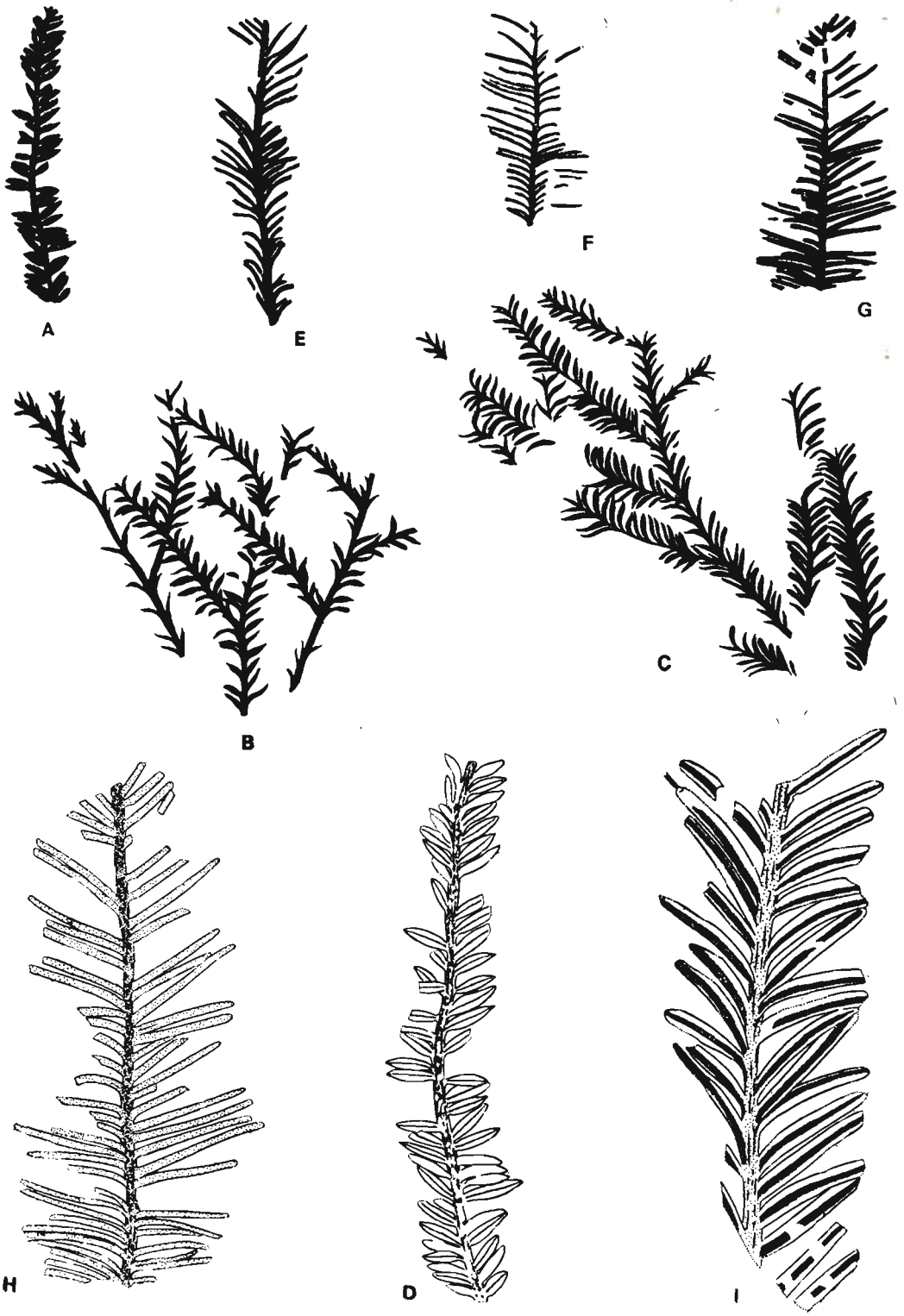
Elatocladus cf. *tenerrimus* (Feistmantel) Sahni

Pl. 33, figs 6, 7; Pl. 36, figs 6, 7; Text-fig. 50E-H

Specimen from Kachchh:

1876 Fragment of a coniferous (?) branch with long narrow leaves: Feistmantel, pl. 10, fig. 6.

Description — Branched leafy shoots, stem 0.8-1 mm wide, leaves spirally arranged but in compressed state spreading on lateral sides, attached by broad decurrent bases. Leaves narrow elongate or linear in shape, typically measuring 0.8-1.1 cm in length



TEXT-FIG. 50

and 0.5-0.8 mm in width; margins entire; apex mostly obtuse, rarely at places somewhat acute; midrib usually indistinct.

Occurrence — Jamthara, Kakadbhit (locality nos. 1 & 2).

Remarks — The specimens from Kachchh match with the specimens of *E. tenerrimus* figured by Sahni (1928, pl. 1, figs 11, 12) from Satpura Basin and Bose *et al.* (1983, pl. 1, fig. 21) from Gardeshwar.

Elatocladus jabalpurensis (Feistmantel) Sahni

Pl. 37, figs 1-3; Text-figs 50I, 51H-J

Description — Shoots irregularly branching, stem usually 1-3 mm wide, lateral branches quite robust, arising at an angle of 45°-55°. Leaves spirally arranged at an angle of 55°-75°, leaves typically 0.9-1.3 cm long and 1.5-2.5 mm wide, linear-lanceolate or oblong in shape; margin entire; apex subacute or obtuse; base constricted, slightly decurrent. Midvein distinct running from base to apex.

Occurrence — Chawad River (locality no. 3).

Remarks — Specimens from Chawad River (locality no. 3) are comparable with the specimens figured by Feistmantel (1877b, pl. 9, figs 1-6; pl. 10, fig. 1) and Sahni (1928, pl. 5, fig. 73) from India, Ganesan and Bose (1982, pl. 1, fig. 7; pl. 2, figs 11, 12) from Bhutan and Halle (1913, pl. 9, fig. 8) from Graham Land.

Elatocladus chawadensis n. sp.

Pl. 37, figs 4-8; Text-fig. 51A-G

Diagnosis — Twigs slender, largest specimen measuring 8 cm in length; stem 1 cm wide. Leaves spirally arranged, spreading in horizontal plane, linear-lanceolate, 0.6-0.8 cm long and 0.8-1 cm wide, gradually becoming smaller and narrower towards distal end, usually attached at an angle of 70°-80°; base slightly constricted, at places twisted; apex acute-subacute; margin entire: midrib conspicuous.

Cuticle on both surfaces almost of same thickness, hypostomatic. Upper surface devoid of stomata, cells more or less uniformly arranged, mostly rectangular, sometimes at places polygonal; cells along midrib mostly elongate-rectangular; anticlinal walls straight or at places slightly wavy; rarely broken by pits; periclinal wall unspecialized, smooth, rarely mottled. On lower surface cells mostly irregularly arranged, polygonal, rarely rectangular or squarish; anticlinal walls straight or slightly wavy at places, corners somewhat rounded; periclinal wall like upper surface. Stomata few, irregularly distributed over entire surface, at places tending to form discontinuous single files, longitudinally orientated, monocyclic. Subsidiary cells 4-6 (2+2, 2+3 or 2+4), mostly 4 or 6, almost of same thickness as ordinary epidermal cells. Stomatal pit oval. Guard cells slightly sunken, thinly cutinized; aperture slit-like.

Holotype — B.S.I.P. specimen No. 47/2891B.

Occurrence—Chawad River (locality no. 4).

Comparison — In gross features *Elatocladus chawadensis* resembles most *E. confertus* (Oldham & Morris) Halle (1913) and the specimens of *E. confertus* described in this paper from Kurbi. It also resembles *E. tenerrimus* (Feistmantel) Sahni (1928), *E. pseudotenerrimus* Maheshwari & Kumaran (1976), *E. sehoraensi* Maheshwari & Kumaran (1976) and *E. bosei* Maheshwari & Kumaran (1976). *E. tenerrimus* differs from *E. chawadensis* in being amphistomatic. In *pseudotenerrimus* the stomata are present in two distinct bands and its subsidiary cells are 4-5 in number. Like *E. tenerrimus* both *E. sehoraensis* and *E. bosei* are amphistomatic. Some of the leaves of *E. kingianus* Bose *et al.* (1982) look like

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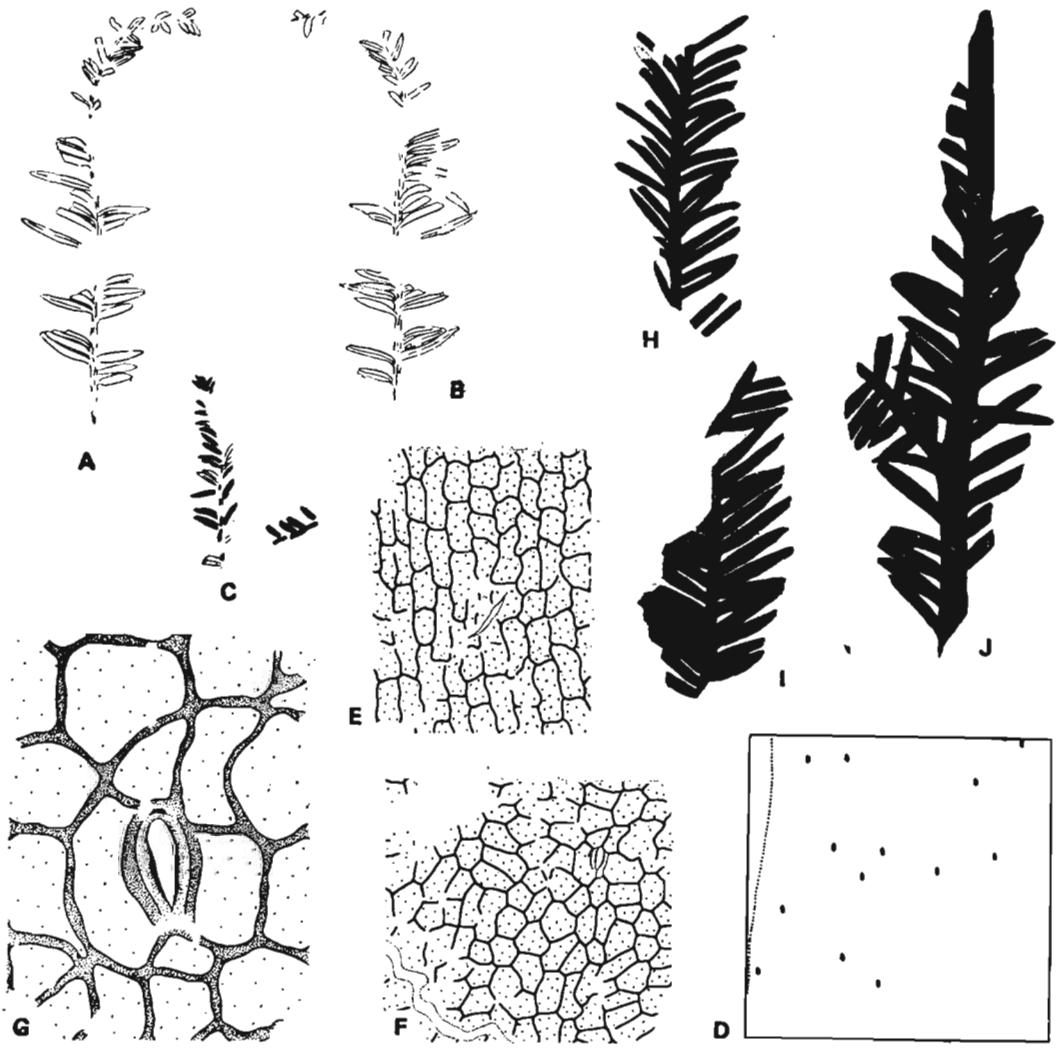
TEXT-FIG. 50A-I — **A-D**, *Elatocladus confertus* (Oldham & Morris) Halle, B.S.I.P. specimen nos. 44/2000C (from Kakadbhit — locality no. 2), 71/2082 (from Kurbi), 152/2082 (from Kurbi) and 44/2000C (from Kakadbhit — locality no. 2): A-C × 1 and D × 2; **E-H**, *Elatocladus* cf. *tenerrimus* (Feistmantel) Sahni from Kakadbhit (locality no. 2), B.S.I.P. nos. A2/2203B, 39/2079B, 123/2263 and 123/2263: E-G × 1 and H × 2; **I**, *Elatocladus jabalpurensis* (Feistmantel) Halle, B.S.I.P. specimen no. 5/2679B (from Chawad River — locality no. 3), × 2.



TEXT-FIG. 51A-J — **A-G**, *Elatocladus chawadensis* n. sp. from Chawad River (locality no. 4): **A-C**, showing detached twigs, B.S.I.P. specimen nos. 49/2891B, 47/2891B and 45/2891B, × 1; **D**, showing distribution of stomata on lower surface, B.S.I.P. slide no. 47/2891B-1, × 40; **E**, upper surface showing a few cells, B.S.I.P. slide no. 47/2891B-1 × 150; **F**, lower surface showing a few cells and a stoma, B.S.I.P. slide no. 47/2891B-1, × 150; **G**, a stoma, B.S.I.P. slide no. 47/2891B-1, × 500; **H-J**, *Elatocladus jabalpurensis* (Feistmantel) Halle from Chawad River (locality no. 3), B.S.I.P. slide nos. 5/2679B, 1/2679 and 28/2411B, × 1.

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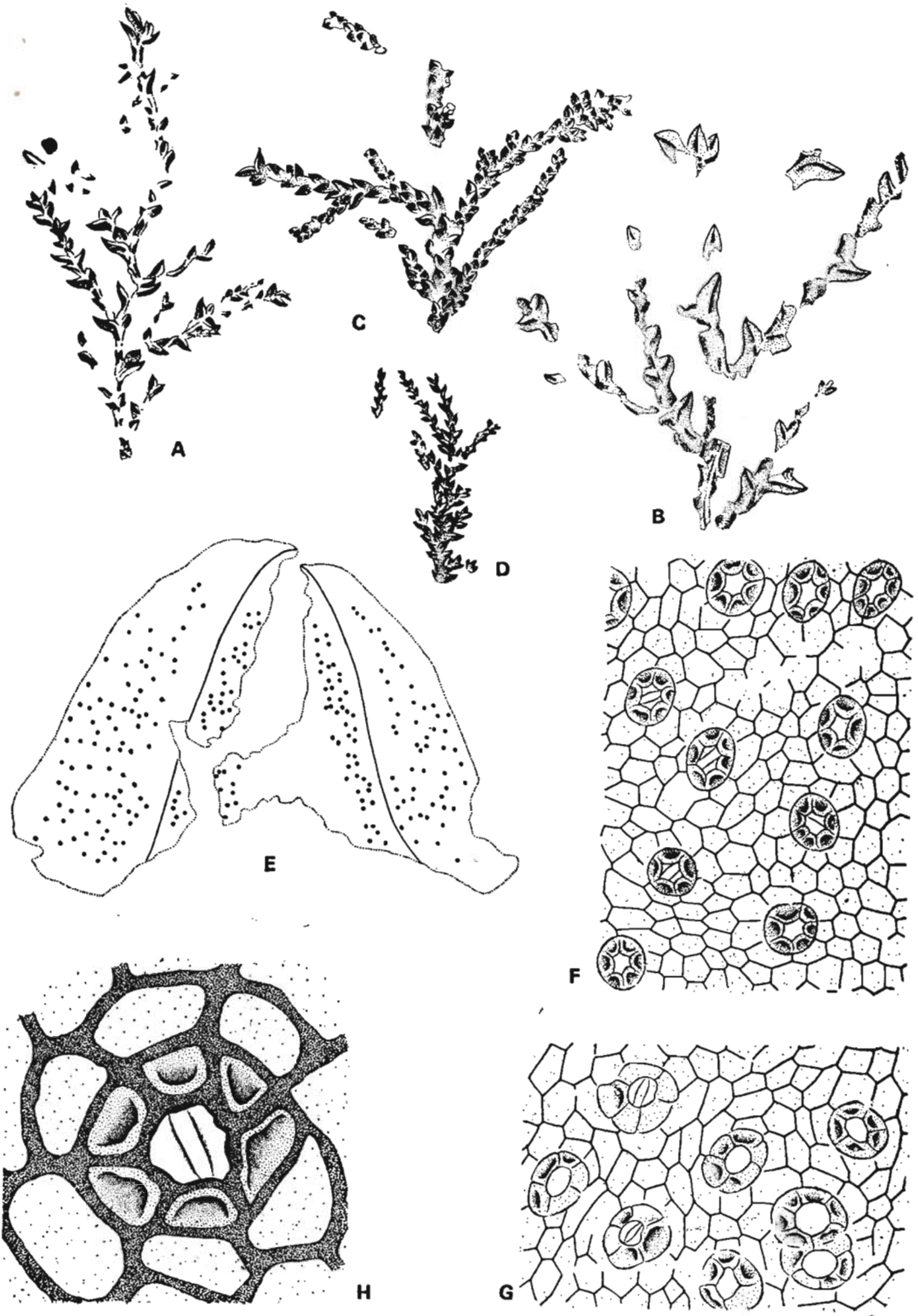
TEXT-FIG. 52A-H — **A-B**, *Pagiophyllum grantii* n. sp. from Trambau, B.S.I.P. specimen nos. 71/2677 and 84/2677: A × 1 and B × 2; **C-D**, *Pagiophyllum chawadensis* n. sp., B.S.I.P. specimen nos. 65/2411A (from Chawad River — locality no. 3) and 38/2676 (from Gadhsisa), × 1; **E**, upper and lower surfaces of *P. grantii* n. sp., showing distribution of stomata, B.S.I.P. slide no. 84/2677-1, × 20; **F**, lower surface of *P. grantii* n. sp., showing a few stomata, B.S.I.P. slide no. 84/2677-1, × 150; **G**, *P. grantii* n. sp., showing a few stomata of upper surface, B.S.I.P. slide no. 84/2677-1, × 150; **H**, *P. grantii* n. sp., showing a stoma of lower surface, B.S.I.P. slide no. 84/2677-1, × 500.



TEXT-FIG. 52

E. chawadensis, but in *E. kingianus* the stomata are arranged in a band running along the midrib. *E. patens* Harris (1935) shows some similarity with *E. chawadensis* in external features, but in *E. patens* stomata are distributed within two stomatal bands.

Genus — *Pagiophyllum* Heer, 1881

Pagiophyllum grantii n. sp.

Pl. 38, figs 1-5; Text-fig. 52A, B, E-H

The following specimens from Kachchh are doubtfully referred to *Pagiophyllum grantii*.

1876 *Pachyphyllum* (?)*divaricatum* Bunb. sp.: Feistmantel, p. 59, pl. 10, figs 1, 1a.

1928 *Pagiophyllum* cf. *P. divaricatum* (Bunbury): Sahni, p. 23, pl. 2, figs 30, 31.

Diagnosis — Shoots branching in all directions at an angle of 45°-65°. Leaves spirally arranged, spreading, arising at an angle of 45°-55°, typically about 1-2×0.8-1.2 mm, gradually becoming smaller in size towards distal end, falcate, mostly apical region inwardly curved; keeled; margin entire; apex acute; base markedly decurrent.

Cuticle moderately thick, amphistomatic, upper surface slightly thinner than lower surface. Upper surface showing two broad stomatic zones leaving a narrow central astomatic region. Stomatal bands broad at base, gradually narrowing towards apex. Stomata within stomatal bands unevenly distributed and irregularly orientated, majority obliquely placed, sometimes touching each other. Stomatal apparatus mostly ring-shaped, sometimes broadly oval in shape. Subsidiary cells mostly 5, rarely 6 or 4, major part of subsidiary cells much more cutinized than ordinary epidermal cells. Guard cells sunken, thinly cutinized; aperture oval or slit-like. Stomata amphicyclic or incompletely amphicyclic; encircling cells like ordinary epidermal cells. Ordinary epidermal cells within stomatal bands mostly polygonal, rarely rectangular; anticlinal walls thick and straight; periclinal wall smooth, rarely at places slightly thickened. Cells within non-stomatal zone rectangular or polygonal, as compared to cells within stomatal bands cells of non-stomatal zone much longer than broad; walls similar to those of cells within stomatal bands. On lower surface, except along margin, stomata irregularly distributed over entire surface, at places tending to form one stoma wide discontinuous files, stomata comparatively sparsely distributed. Stomata mostly obliquely placed; stomatal apparatus like those of upper surface. Ordinary epidermal cells like those within stomatal bands of upper surface; anticlinal walls slightly more thick.

The specific name is after C. M. Grant, Esq., Capt. Bombay Engineers.

Holotype — B.S.I.P. specimen no. 71/2677.

Occurrence — Trambau, Kurbi and Kakadbhit (locality no. 1).

Remarks — From Kakadbhit (locality no. 1) Feistmantel (1876, pl. 10, fig. 1) had described a coniferous branched twig as *Pachyphyllum* (?)*divaricatum* Buno. sp. (Feistm). Under the synonymy of this species he had placed the original specimens of *Cryptomerites divaricatus* described by Bunbury (1851, pl. 13, figs 4a, b). However, the original specimen of Bunbury (1851, pl. 13, fig. 4) has now been described as *Geinitzia divaricata* (Bunbury) by Harris (1979). The specimens of *G. divaricata* have straight leaves and the original specimen of Bunbury (1851, pl. 13, fig. 4) has much longer and more spreading leaves than *Pagiophyllum grantii*. Moreover, the cuticle of *G. divaricata* is quite different from *P. grantii*. In *G. divaricata* the stomata are situated within four flatter sides, and in this species subsidiary cells are mostly

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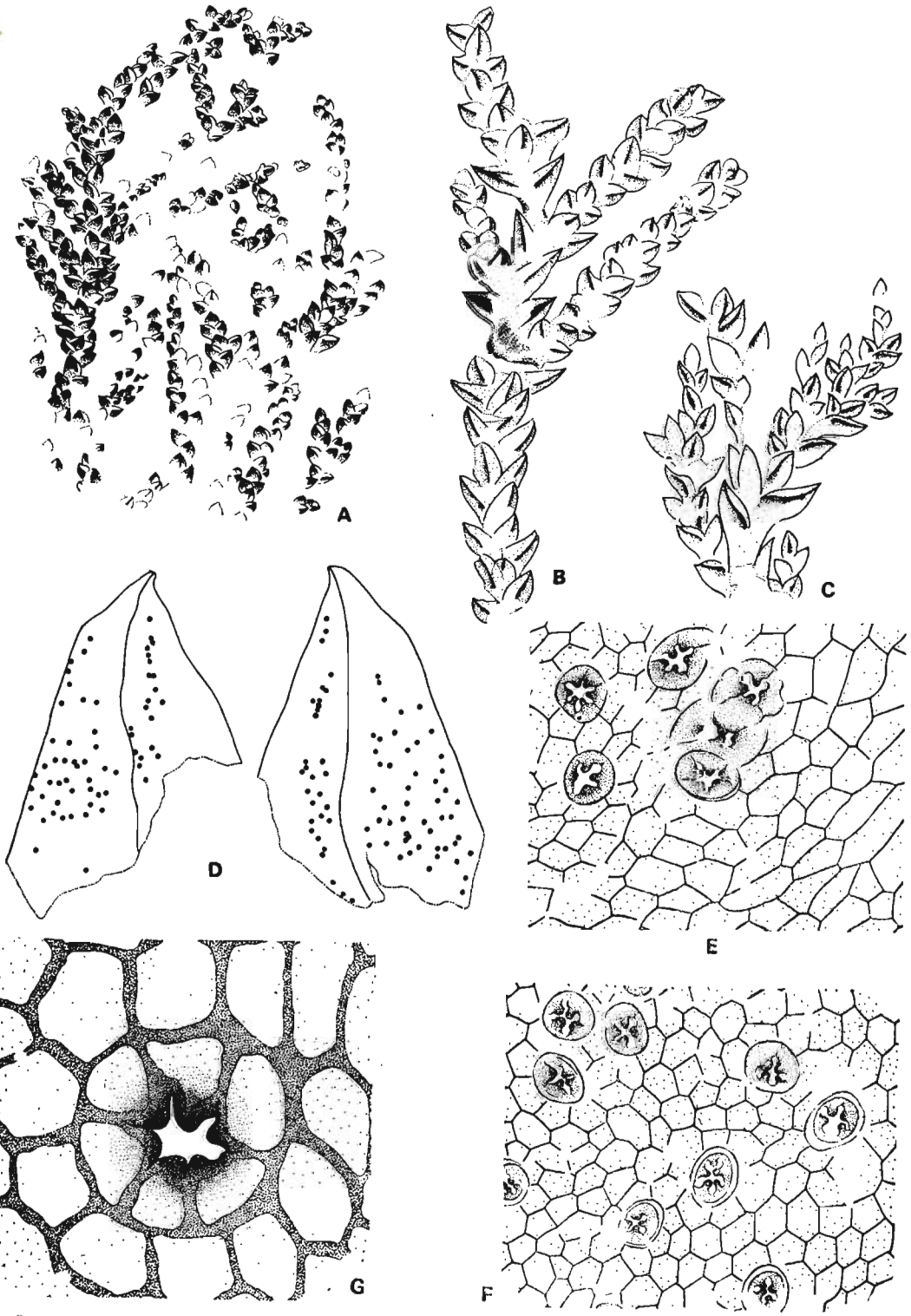
TEXT-FIG. 53A-G — *Pagiophyllum chawadensis* n. sp. **A-C**, B.S.I.P. specimen nos. 135/2411B (from Chawad River — locality no. 3), 6/2679 (from Chawad River — locality no. 3) and 31/2266A (from Rudra Mata Dam site): A × 1, B × 3 and C × 4; **D**, showing distribution of stomata on upper and lower surfaces, B.S.I.P. slide no. 44/2679B-1, × 20; **E**, upper surface showing a few stomata, B.S.I.P. slide no. 44/2679B-1, × 150; **F**, lower surface showing a few stomata, B.S.I.P. slide no. 44/2679B-1, × 150; **G**, a stoma, B.S.I.P. slide no. 38/2676-2, × 500.



TEXT-FIG. 53

four in number, often lateral subsidiary cells larger than the two polar cells.

Comparison — The twigs with small leaves of *Pagiophyllum grantii* look more like *Geinitzia rigida* (Phillips) Harris (1979). In *G. rigida* on abaxial surface stomata are mostly in longitudinal files, whereas on adaxial side they are in files if numerous, but scattered if few. Amongst the Indian species of *Pagiophyllum*, *P. grantii* resembles most *P. bansaensis* Bose & Sukh-Dev (1972) as far as the distribution of stomata is concerned. Unlike *P. grantii* in *P. bansaensis* the subsidiary cells are not so thickened. In gross features, too, the leaves in both the species are quite distinct from each other. *P. grantii* resembles somewhat *P. falcatum* Bartolin described by Knowlton (1916). The cuticular structure of the latter species is not known.

Pagiophyllum chawadensis n. sp.

Pl. 39, figs 1-5; Pl. 40, figs 1-3; Pl. 41, figs 1, 2; Text-figs 52C, D, 53A-G

Diagnosis — Shoots repeatedly branching in all directions, mostly at an angle of about 30°-45°. Leaves borne in a close helix, 1.5-2.5 mm long and 1-2 mm wide, mostly deltoid in shape, sometimes falcate, keeled, bases of leaves decurrent but mostly concealed by leaves lying below; margins entire; apex acute or somewhat mucronate. Distal parts of twigs mostly bearing smaller and slightly appressed leaves, proximal regions with more spreading leaves, leaves lying just below the point of bifurcation of twigs slightly bigger in size and attached almost at an angle of 80°-90°.

Cuticle moderately thick, upper surface slightly thinner than lower surface, amphistomatic. On upper surface, close to margins, stomata confined in two distinct zones leaving a central broader non-stomatic zone, stomatal zones about 2-3 stomata wide from base to near about middle of leaf, then onwards stomata in a single continuous or discontinuous files, stomatal zones of either sides converging towards apex. Within stomatal zones stomata rather sparsely place, rarely at places 2-3 stomata lying close together and some of their subsidiary cells touching each other, very rarely sharing a common subsidiary cell. Also within stomatal zones stomata irregularly distributed, mostly transversely or obliquely orientated. Stomatal apparatus mostly oval in shape, rarely circular, monocyclic or dicylic. Subsidiary cells 4-6, mostly 5, very rarely 7, inner wall of each subsidiary cell with a solid or hollow papilla, all the papillae overhanging the stomatal pit. Guard cells thinly cutinized, sunken; aperture slit-like. Ordinary epidermal cells over entire upper surface mostly polygonal, very rarely squarish or rectangular, cells within stomatal zones irregularly arranged and cells within non-stomatic region more regularly arranged in longitudinal direction; anticlinal walls thick, more or less straight; periclinal wall smooth or at places unevenly thickened. On lower surface, except for avoiding 4-5 cells wide region close to margin, stomata unevenly scattered over entire surface. Stomatal structure and epidermal cells like those of stomatal zones of upper surface.

Holotype — B.S.I.P. specimen no. 135/2411B.

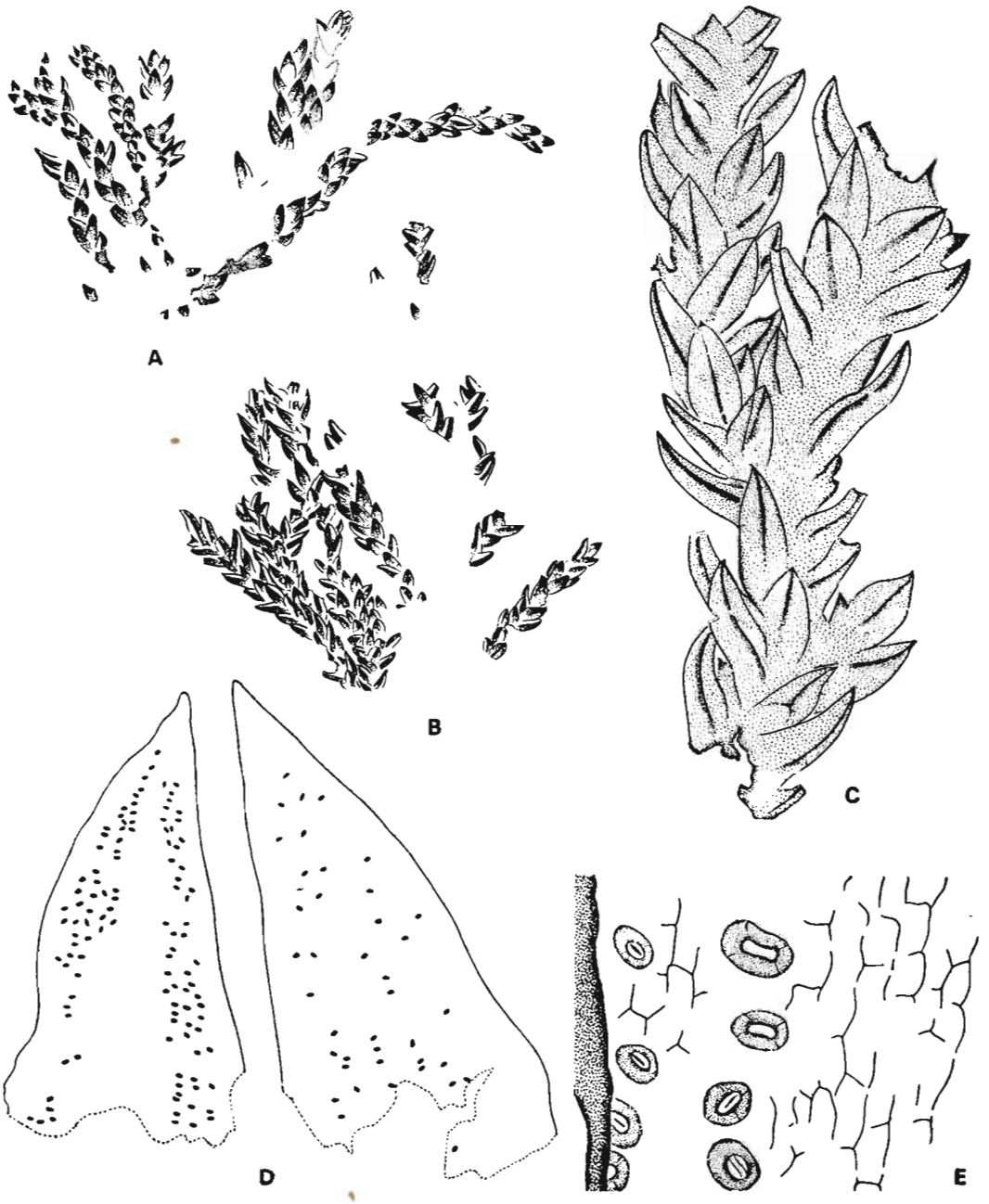
Occurrence — Khari River (Rudra Mata Dam site), Gadhsisa and Chawad River (locality no. 3).

Comparison — The distribution of stomata in *Pagiophyllum chawadensis* is more like *P. bansaensis* Bose & Sukh-Dev (1972) and *P. grantii* Bose & Banerji. In both, *P. bansaensis* and *P. grantii* the subsidiary cells are non-papillate. However, in *P. grantii* the periclinal wall of the subsidiary cells is highly cutinized. The stomatal apparatus of *P. astrachanense* Doludenko (1966) is more like *P. chawadensis*, both have mostly 5 subsidiary cells with overhanging papillae. *P. astrachanense* differs in having larger leaves and its stomata are in files. Like *P. chawadensis* in *P. simpsonii* Ash (1970), too, the subsidiary cells are 4-6 (usually 5) in number and are also papillate. *P. simpsonii* differs in its stomatal distribution and in having often papillate epidermal cells. *P. bosei* Pal (1984) has more spreading leaves and in this species central regions in both surfaces are devoid of stomata.

Pagiophyllum morrisii n. sp.

Pl. 40, figs 4, 5; Pl. 41, figs 3-6; Text-fig. 54A-E

Diagnosis — Twigs repeatedly branched, branching at an angle of 45°-65°, bearing spirally arranged leaves. Leaves measuring



TEXT-FIG. 54A-E — *Pagiophyllum morrisii* n. sp. from Chawad River (locality no. 3). **A-C**, B.S.I.P. specimen nos. 11/2679B, 79/2679B and 71/2679: A-B × 1, and C × 10; **D**, showing distribution of stomata on upper and lower surfaces, B.S I.P. slide no. 68/2679B-1, × 20; **E**, upper surface showing a few stomata, B.S.I.P. slide no. 71/2679B-2, × 150.

1.5-7 mm in length and 1-2.5 mm in width, triangular of somewhat rhomboidal in shape, larger leaves mostly falcate and spreading, leaves closer to apical region smaller in size and less spreading or appressed. All leaves keeled; margin entire; apex acute or sub-acute, rarely obtuse, bases mostly concealed by apices of leaves lying below.

Amphistomatic, both surfaces more or less of same thickness; frequency of stomata on lower surface more than on upper surface. Upper surface showing a broad, median non-stomatic zone and two stomatal bands towards margins. Cells of non-stomatic zone rectangular-polygonal, serially arranged in longitudinal direction; lateral- and end-walls straight, rarely at places slightly wavy; surface wall unevenly thickened, cells within stomatal bands rectangular or polygonal, shorter in length than those of non-stomatal zone; cell walls like those of cells along non-stomatic region. Width of stomatal bands variable from place to place, mostly 2-4 stomata wide, at places up to 5 stomata wide. Within stomatal bands stomata distantly placed, but at places lying close to each other and their subsidiary cells touching each other, mostly irregularly distributed, at places tending to form discontinuous one stoma wide files; majority transversely or obliquely orientated, very rarely longitudinally placed. Stomata mostly amphicyclic, subsidiary cells usually 4 (2+2), very rarely 5, lateral cells longer than polar cells, surface unevenly thickened. Guard cells sunken, thinly cutinized, aperture slit-like. On lower surface from base to little over middle region of leaf stomata irregularly scattered, higher up towards distal end stomata mostly avoiding central region and at places closer to margins tending to form one stoma wide discontinuous files, sometimes stomata also present along median region, majority obliquely orientated, a few longitudinally or transversely orientated. Structure of epidermal cells and stomatal apparatuses same as on upper surface.

Specific Name — After J. Morris Esq., who had first reported Mesozoic plants from Kachchh (in Grant, 1840).

Holotype — B.S.I.P. specimen no. 71/2679B.

Occurrence — Chawad River (locality no. 3).

Remarks — On lower surface leaves from the same twig show slight variation in the pattern of stomatal distribution.

Comparison — To some extent *Pagiophyllum rewaensis* Bose & Sukh-Dev (1972) resembles *P. morrisii* in the distribution of stomata, but in the former species stomata are mostly longitudinally orientated. However, the stomatal apparatuses of *P. rewaensis* are more like *P. morrisii*. Both have 4 (2+2), subsidiary cells and their lateral cells are much longer than the polar cells. *P. rewaensis* has larger and more spreading leaves. Leaves of *P. marwarensis* Bose & Sukh-Dev (1972) are also larger in size and are much more spreading. The stomata in *P. marwarensis* have 4-6 subsidiary cells. In gross features, *P. morrisii* looks more like *P. chawadensis* Bose & Banerji, but in the latter species the subsidiary cells are papillate. The smaller leaves of *P. morrisii* resemble somewhat the leaves of *P. sherensis* Maheshwari & Kumaran (1976), but *P. sherensis* differs in having stomata which have mostly 5 subsidiary cells. Some of the twigs of *P. morrisii* look like *P. papillatum* Orlovskaya described by Doludenko and Orlovskaya (1976), but *P. papillatum* differs in having papillate subsidiary cells.

Genus — *Brachyphyllum* Lindley & Hutton (1836) *ex* Brongniart, 1928

Brachyphyllum royii n. sp.

Pl. 42, figs 1-4; Pl. 55, figs 5, 8, 11, 15; Text-fig. 55A-L

The following specimens from Kachchh are doubtfully referred to *Brachyphyllum royii*.

1876 *Echinostrobus expansus*, Stbg. sp.: Feistmantel, p. 60, pl. 9, figs 6-9, 9a; pl. 10, figs 3, 4.

Diagnosis — Branched shoot, branches emerging at an angle of 60°-90°. Leaves spirally arranged, attached at an angle of 80°-90°, thick, mostly rhomboidal in shape, keeled, 1.2-4.5 mm long and 1.2-4.5 mm wide; margin entire; apex acute. Leaf-base cushion rhomboidal in shape; free part of leaf mostly directed upwards, rarely at places slightly spreading.

Cuticle of both surfaces about 8 μm thick, amphistomatic. On both surfaces stomata

irregularly distributed, but mostly placed slightly away from margins and apex, occasionally adjacent stomata touching each other but never sharing a common subsidiary cell; on upper surface, closer to base, concentration of stomata more than towards apical end; on lower surface at places stomata tending to form discontinuous files; files 3-8 stomata long. On upper surface stomata longitudinally, obliquely or transversely orientated and on lower surface stomata mostly longitudinally orientated, sometimes obliquely or transversely placed. Stomata monocyclic or incompletely dicyclic. Subsidiary cells 4-5 in number, rarely 6, slightly more cutinized than ordinary epidermal cells. Guard cells sunken; aperture slit-like. Ordinary epidermal cells similar on both surfaces, polygonal; anticlinal walls mostly thick and straight, rarely broken by pits or slightly wavy at places; periclinal wall smooth, rarely in some central region slightly more cutinized or very rarely showing a thin longitudinal strip.

Holotype — B.S.I.P. specimen no. 114/521.

Occurrence — Trambau, Sukhpur, Kera, (?)Kakadbhit (locality no. 1) and Chawad River (locality no. 3).

Remarks — Feistmantel (1876, pl. 9, figs 6-9, 9a; pl. 10, figs 3, 4) described a few specimens from Kakadbhit (locality no. 1) as *Echinostrobus expansus* Stbg. sp. These specimens were later referred to *Brachyphyllum expansum* (Sternb.) by Sahni (1928, p. 20). It seems Holden (1915) while describing *Echinostrobus expansus* managed to get the cuticle out of the specimen figured by Feistmantel (1876) in pl. 9, fig. 6. From Kakadbhit (locality no. 1) we have also collected several specimens like the ones figured by Feistmantel (1876, pl. 9, figs 6-9; pl. 10, figs 3, 4), but from none of them we could manage to get cuticular preparations. We also tried to get cuticular preparation, out of the original specimens of Feistmantel (1876) but without any success. In none of the specimens from Kakadbhit 'phyto-lemma' is preserved. Only the specimens collected from Trambau, Sukhpur and Kera have well-preserved 'phyto-lemma'.

Comparison—In external features, *Brachyphyllum royii* looks like *B. feistmanteli* (Halle) Sahni (1928, pl. 2, fig. 27). The details of epidermal structure of *B. feistmanteli* are not known. Externally *B. royii* resembles very much *B. brikae* Doludenko & Orlovskaya (1976), but in *B. brikae* the stomata are arranged in rows and their subsidiary cells are papillate. Like *B. royii* both *B. bansaensis* Sukh-Dev & Bose (1974) and *B. eikaiostomum* Sukh-Dev & Bose (1974), described from Bansa, are amphistomatic. In *B. bansaensis* stomata are in files and they are mostly transversely orientated. Also the subsidiary cells have a prominent thin slit. In *B. eikaiostomum* leaf margin is microscopically frilled, whereas in *B. royii* leaf margin is entire. *Brachyphyllum* sp. described by Sukh-Dev and Zeba-Bano (1981) from Sehora has fewer stomata on lower surface, whereas in *B. royii* on lower surface the number of stomata are more than those on the upper surface. *B. royii* resembles some of the specimens of *B. tropidimorphum* Wesley (1956) in goss features, but the latter species differs in having stomata which are arranged in longitudinal rows.

Genus — *Araucarites* Presl, 1838

Araucarites cutchensis Feistmantel

Pl. 43, figs 13, 14; Text-fig. 56W

1876 *Araucarites cutchensis* Feistmantel, p. 62, pl. 7, fig. 7; pl. 8, figs 2-6; pl. 9, figs 1-3; pl. 12, fig. 10.

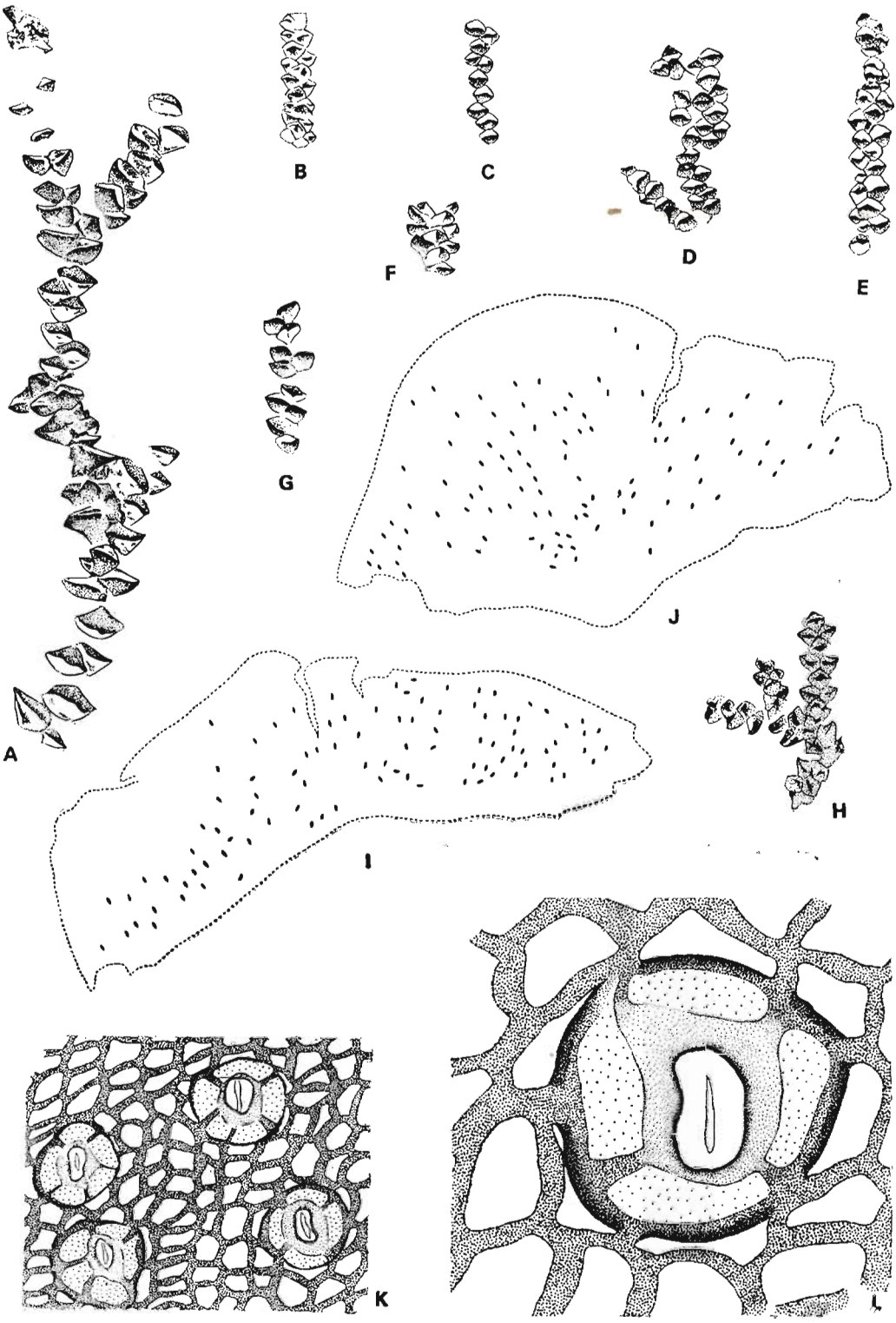
1877b *Araucarites cutchensis* Feistm.: Feistmantel, p. 16 (partim), pl. 4, fig. 4 (only the specimen figured on the upper left hand side and not the *Desmiophyllums*), pl. 10, figs 2, 3, 5-7, 10-12, 14-16 (in fig. 16 only the specimen figured on the right hand side).

1879 *Araucarites cutchensis* Feistm.: Feistmantel, p. 27 (*partim*), pl. 14. figs 6, 9; pl. 15, fig. 1; pl. 16, fig. 15.

1882 *Araucarites cutchensis* Feistm.: Feistmantel, p. 44 (*partim*), pl. 3, figs 12, 19.

1919 *Araucarites cutchensis* Feistm.: Seward, p. 264.

1920 *Araucarites cutchensis* Feistm.: Seward & Sahni, p. 34, pl. 6, figs 63, 64.



TEXT-FIG. 55

1928 *Araucarites cutchensis* Feistm.: Sahni, p. 31.
1932 *Araucarites macropterus* (Feist): Deb, p. 103, fig. 3.
1957 *Araucarites cutchensis* Feistm.: Ramanujam, p. 87, figs 2, 3.
1959 *Araucarites cutchensis* Feistm.: Pascoe, pp. 991, 994 — Jabalpur and Umia floras, fig. 13.
1963 *Araucarites cutchensis* Feistmantel: Sitholey, p. 48, pl. 14, fig. 100.
1963 *Araucarites* sp.: Adyalkar & Rao, p. 319, pl. 38, fig. 4.
1968 *Araucarites cutchensis* Feistm.: Baksi, p. 210, pl. 3, fig. A, B.
1973 *Araucarites cutchensis* Feistmantel: Bose & Maheshwari, pl. 1, figs 1-5, text-fig. 1A-E.
1974 *Araucarites cutchensis* Feistmantel: Bose & Maheshwari, p. 217
1981 *Araucarites cutchensis* Feistmantel: Sukh-Dev & Zeba-Bano, p. 6, pl. 3, figs 7-9; text-fig. 3G.
1983 *Araucarites* sp. cf. *A. cutchensis*, Feistmantel: Banerji *et al.*, p. 470, pl. 1, fig. 21; text-fig. 2E.

Diagnosis [from Bose & Maheshwari (1973) with minor alterations] — Mature cone about 5.5 cm in diameter, cone scales 1.5-3.5 cm long and 1.4-2.8 cm wide, more or less wedge-shaped with curved distal margins or sloping sides. Base of scale narrow, truncate; tip short, bluntly pointed or acute, measuring 3-8 mm in length and 2-4 mm in width at broadest point. Main body of scale on dorsal side finely striated in longitudinal direction; on ventral side having medianly placed obovate seed (in compressed state). Seed possibly embedded, 1.1 to 2 cm long and 0.5 to 0.9 cm wide at broadest point, surface often showing longitudinal striations. Ligule absent.

Lectotype — G.S.I. specimen no. 4848.

Occurrence — Bhajodi, Jamthara, Kurbi, Kakadbhit (locality nos. 1 & 2), Dauda Mota, Chawad River (locality no. 3) and Dharesi (localitiy no. 2).

Remarks — *Araucarites cutchensis* is most common at Kakadbhit (locality no. 1). In other localities, mentioned above, it is rather rare. From Kakadbhit (locality no. 1) we have got a specimen (in part and counterpart) which is preserved as a transverse section (Pl. 43, fig. 14; text-fig. 56W). All other specimens are detached cone scales.

Araucarites minutus Bose & Maheshwari

Pl. 43, figs 1-4; Text-fig. 56P-U

Description — Cone scales about 0.7-1.5 cm long and 0.6-1.1 cm wide, obcuneate, base truncate, distal end broad occasionally terminating in a small pointed tip (0.8-2 mm in length), rarely obtuse. Seed medianly placed, 0.5-1 cm long and 2.5-5 mm wide at broadest region, seed surface sometimes showing fine striations in longitudinal direction.

Occurrence — Gamdau, Trambau, Khari River (Rudra Mata Dam site), Kakadbhit (locality no. 1), Dauda Mota and Walka Mota.

Comparison — *Araucarites minutus* has a wide range of distribution in Kachchh. In size and shape the present specimens match with the specimens of *A. minutus* described by Bose and Maheshwari (1973) from Sher River, near Sehora. Some of the specimens collected from Kakadbhit, Dauda Mota and Walka Mota also resemble in size and shape with *A. minimus* described by Archangelsky (1966) from Tico, Argentina. But *A. minimus* differs from the present species in having ligule. In general shape and size *A. minutus* may be compared with some of the specimens of *A. cutchensis* Feistmantel described by

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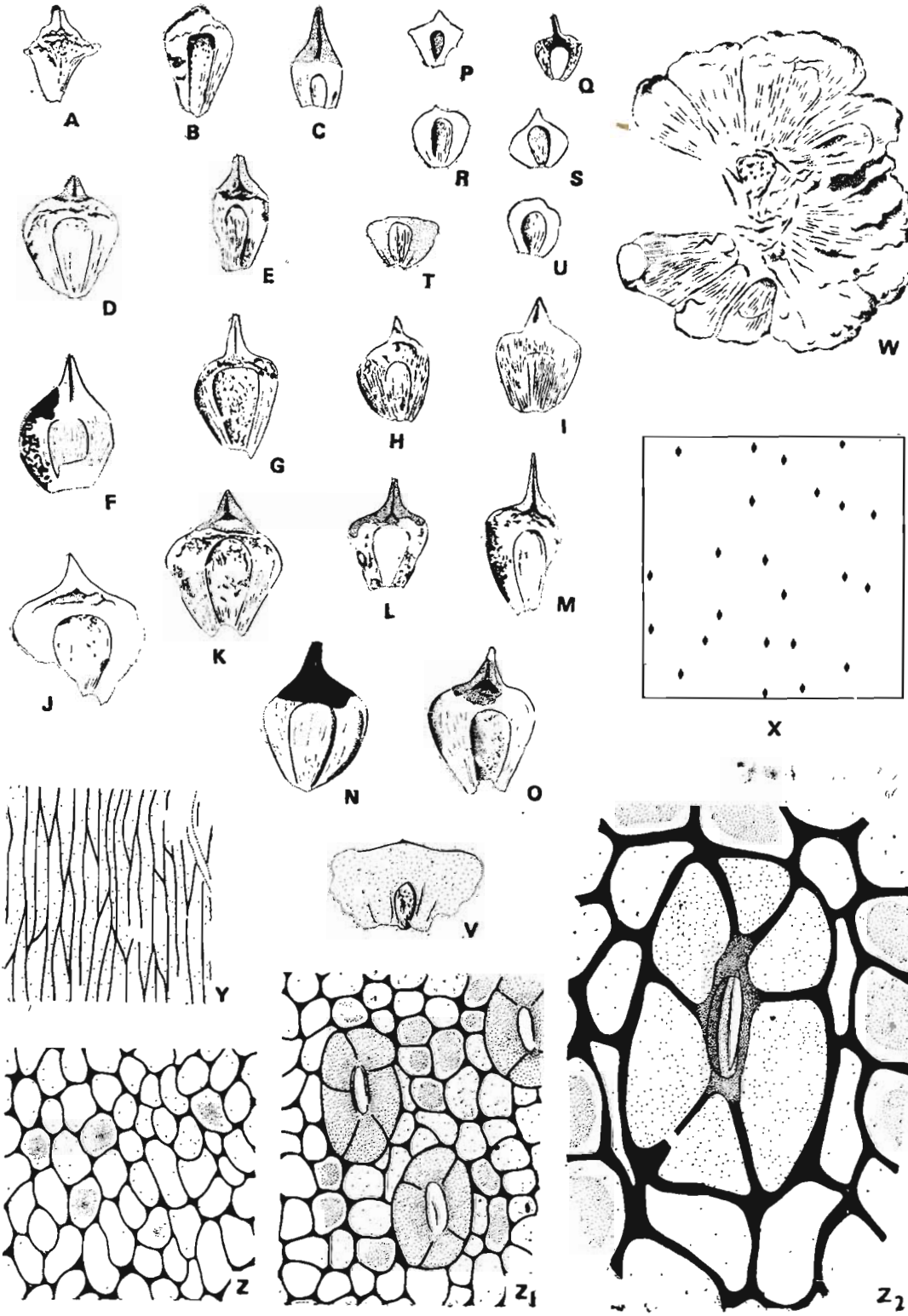
TEXT-FIG. 55A-L — *Brachyphyllum royii* n. sp. **A-H**, showing detached twigs, B.S.I.P. specimen nos. 1/2887 (from Trambau), 95/2677 (from Trambau), 31/2234C (from Kera), 1/2418 (from Kera), 84/2089C (from Trambau), 71/2887 (from Trambau), 76/2891A (from Chawad River — locality no. 3) and 83/2677 (from Trambau): A × 2 and B-H × 1; **I**, showing distribution of stomata on upper surface, B.S.I.P. slide no. 84/2089C-1, × 20; **J**, showing distribution of stomata on lower surface, B.S.I.P. slide no. 84/2089C-1, × 20; **K**, lower surface showing a few stomata, B.S.I.P. slide no. 84/2089C-1, × 150; **L**, lower surface showing a stoma, B.S.I.P. slide no. 84/2089C-1, × 500.



TEXT-FIG. 56

Halle (1913, pl. 8, fig. 10) and *A. falsanii* (Saporta) Barale (1970, pl. 13, figs 8, 9).

Araucarites janaianus n. sp.

Pl. 43, figs 6-12, 15, 16; Pl. 44, figs 1-4; Text-fig. 56A-O, X-Z_2

Diagnosis — Detached cone scales, about 1.5-2.6 cm long and 0.6-2 cm wide, obcuneate, distal end typically prolonged into an awn-like acicular tip; base truncate. Apical end (acicular tip) 3-8 mm long, showing a distinct median ridge, tip acute or subacute. Median region of scales occupied by an obovate seed, 0.5-1.4 cm in length and 0·3-0·9 cm in width. Exposed parts of scale and seed surface occasionally showing faint longitudinal striations. Scales commonly showing a triangular ligule between the prolonged tip and distal end of seed.

Cuticle of cone-scale moderately thick, amphistomatic, concentration of stomata much more towards tip, near base and on lateral sides stomata rare. Epidermal cells on both surfaces almost similar in shape and size, mostly polygonal with rounded corners; anticlinal walls thick, straight, rarely at places slightly wavy; periclinal wall smooth, sometimes central region slightly more thickened. Stomata comparatively less on one surface, but on both surfaces irregularly distributed, at places tending to form discontinuous files (single stoma wide), majority longitudinally orientated, sometimes obliquely placed, occasionally subsidiary cells of adjoining stomata touching each other. Stomatal apparatus broadly oval, rarely somewhat circular in shape, majority monocyclic, rarely incompletely dicyclic. Subsidiary cells 4-7 in number, mostly 4-5; when 4 polar and lateral subsidiary cells distinct, mostly polar subsidiary cells smaller in size. Subsidiary cells slightly more cutinized than ordinary epidermal cells. Guard cells sunken, thinly cutinized, aperture elliptical or slit-like. Seed cuticle devoid of stomata; cells elongated; anticlinal walls thin, straight or rarely at places broken by pits; periclinal wall unspecialized.

Holotype — B.S.I.P. specimen no. 70/2677.

Occurrence — Trambau and Chawad River (locality nos. 2, 3 & 4).

Derivation of Name — The specific name is after Dr B. N. Jana of the Birbal Sahni Institute of Palaeobotany, who had been a great help to us during our field trips to Kachchh.

Remarks — Well-preserved specimens of *Araucarites janaianus* have been collected mostly from Trambau and Chawad River (locality no. 3). In both these localities the specimens show a good deal of variation as far as distal end is concerned, but in majority of the specimens the tip is rather awn-like. However, specimens with shorter as well as longer tips have similar type of cuticle. In most cases when the cuticle is slightly over macerated the periclinal wall looks smooth, but the cells of cuticle pieces which are slightly under macerated show distinct thickening in the central region.

Comparison — In gross features *Araucarites janaianus* looks more like *Araucaria pantiana* Bose & Maheshwari (1973). *A. pantiana* differs in having stomata which are mostly arranged in single files and its stomata are commonly dicyclic. Moreover, in *A. pantiana* the subsidiary cells

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TEXT-FIG. 56A-Z_2 — **A-O**, *Araucarites janaianus* n. sp., showing cone scales; B.S.I.P. specimen nos. 26/2887, 79/2887, 8/2887, 9/2887, 80/2887, 34/2677, 11/2419, 39/2677, 85/2677, 29/2891, 72/2887, 42/2677, 41/2887, 70/2677 and 27/2001 (except fig. J, rest are from Trambau. Fig. J is from Chawad River — locality no. 3), × 1; **P-U**, *Araucarites minutus* Bose & Maheshwari, B.S.I.P. specimen nos. 5/2236 (from Walka Mota), KND (from Kakadbhit — locality no. 1), 1/2410 (from Dharesi), 5/2081 (from Dauda Mota), 6/2677 and 9/2419 (from Trambau), × 1; **V**, *Araucarites* cf. *nipaniensis* Singh, B.S.I.P. specimen no. 70/2677 (from Trambau), × 1; **W**, *Araucarites cutchensis* Feistmantel, B.S.I.P. specimen no. 33/3885 (from Kakadbhit — locality no. 1), × 1; **X-Z**, *Araucarites janaianus* n. sp., **X**, lower surface of cone scale showing distribution of stomata, B.S.I.P. slide no. 29/2891A-1 (Chawad River — locality no. 3), × 40; **Y**, showing cells from over seed, B.S.I.P. slide no. 29/2891-2, × 150; **Z**, cuticle of cone scale showing a few cells, B.S.I.P. slide no. 29/2891A-1, × 150; Z_1, cuticle of cone scale showing a few stomata, B.S.I.P. slide no. 29/2891A-1, × 150; Z_2, a stoma of a cone scale, B.S.I.P. slide no. 29/2891A-1, × 400.

are mostly 4 in number and they are slightly less cutinized than ordinary epidermal cells. In *Araucarites sehoraensis* Bose & Maheshwari (1973) apex is bluntly pointed and sometimes even the entire distal end is convex without having any distinct pointed tip. Also its stomata are mostly arranged in rows and within the rows stomata are obliquely placed. In *A. fibrosa* Sukh-Dev & Bose (1974) stomata are confined only to lower surface and are mostly transversely or obliquely orientated. The cone scales of *A. phillipsii* Carruthers described by Harris (1979) have short pointed apices and in this species stomata are scattered and variously orientated. Some of the specimens of *A. falsanii* (Saporta) Barale (see Barale, 1981, pl. 52, figs 2, 3) may be compared with such specimens of *A. janaianus* which have short pointed apices, but the former species differs in having stomata which are arranged in files.

The cuticle of *A. janaianus* matches with the cuticle of *Brachyphyllum royii* Bose & Banerji. Their epidermal cells and stomata are very similar, including distribution and orientation of stomata. Moreover, most of the specimens of *A. janaianus* have been collected in association with *B. royii*. It is quite likely that these two species may have belonged to the same plant.

Araucarites cf. *nipaniensis* Singh

Pl. 43, fig. 5; Text-fig. 56V

Description — Detached cone scales, somewhat trapezoidal in shape with rounded corners, 1-1.2 cm in length and 1.9-2.3 cm in width; margin entire, distal end near centre tapering and forming a minute projection; base mostly incomplete. Cone scale, closer to base, bearing an oval seed measuring 6-9 mm in length and 2.5-3 mm in width.

Occurrence — Trambau and Walka Mota (locality no. 1).

Comparison — *Araucarites* cf. *nipaniensis* Singh resembles most the specimen of *A. nipaniensis* figured by Singh (1956, pl. 1, fig. 1) from Nipania, Rajmahal Hills. The specimen from Nipania is petrified, whereas all the specimens of *A.* cf. *nipaniensis* from Kachchh are preserved in the form of impressions. *A.* cf. *nipaniensis* looks somewhat like some of the specimens of *A. macropterus* Feistmantel described by Sukh-Dev and Bose (1974, pl. 1, fig. 9), but the holotype of *A. macropterus* figured by Feistmantel (1877, pl. 8, fig. 9) and Sukh-Dev and Bose (1974, pl. 1, fig. 10) is much bigger in size than *A.* cf. *nipaniensis*.

GYMNOSPERM — INCERTAE SEDIS

Genus — *Linguifolium* Arber, 1913

Linguifolium curvatum n. sp.

Pl. 45, figs 5, 10; Text-fig. 57A-D

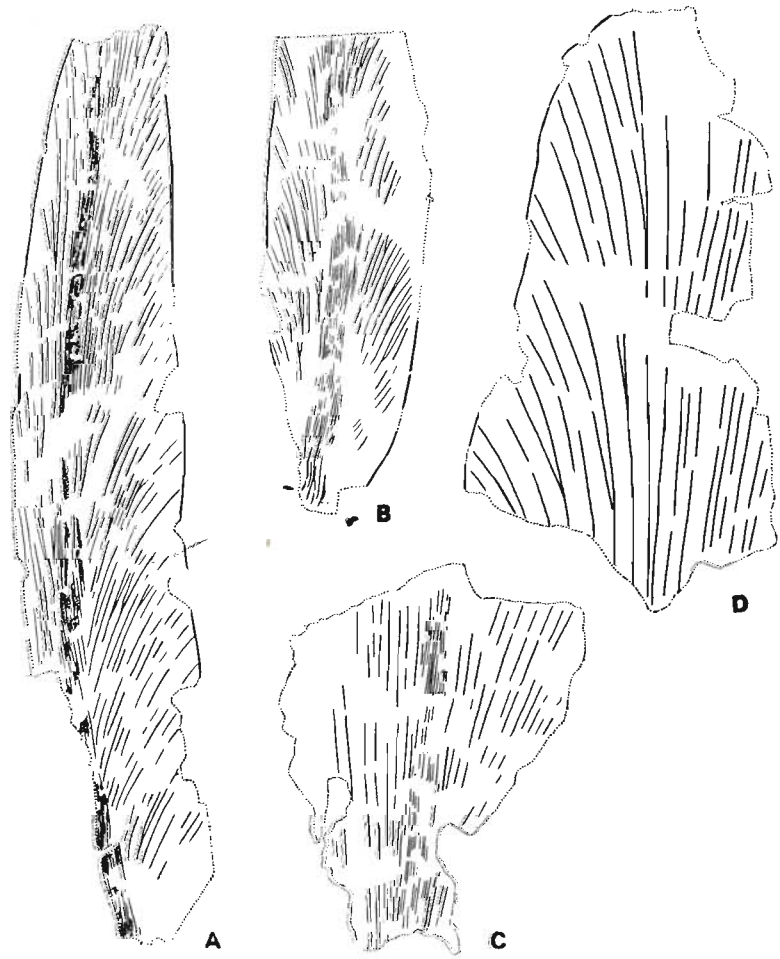
Description — Leaves fragmentary; simple largest specimen 11.4 cm long and 3 cm wide near broadest region, leaf as a whole tongue-shaped, slightly curved; margin entire; extreme base and apex not preserved. Midrib distinct, about 2-2.5 mm broad near base, gradually narrowing towards apex, striated; lateral veins arising at an angle of 10°-25°, running upwards, slightly arched, dicholomising 2-3 times, usually twice, veins 0.8-1 mm apart, never anastomosing.

Holotype — B.S.I.P. specimen no. 38/2000.

Occurrence — Kakadbhit (locality no. 2).

Remarks & Discussion — This is the first report of *Linguifolium* from India. Validity of this genus has been discussed by Berry (1945) in detail. In our opinion, too, *Linguifolium* is quite distinct from *Glossopteris* Brongniart (1828), *Palaeovittaria* Feistmantel (1876c), *Rubidgea* Tate (1869) and *Euryphyllum* Feistmantel (1879a). It differs from all these genera in having a distinct midrib which is running from base to apex and in having laterals which do not form any meshes. *Sagenopteris* Presl (1836) differs from *Linguifolium* in having asymmetrically placed midrib and secondary veins forming meshes. *Taeniopteris* Brongniart (1832) is ribbon-shaped and its lateral veins arise at much wider angles. Pinnae of *Morrisia* Bose (1959) and *Danaeopsis* Heer (1864) show similar type of venation pattern but both these differ from *Linguifolium* in being pinnate in nature.

Comparison — *Linguifolium curvatum* resembles most *L. lillianum* Arber (1913, 1917) in size, shape and venation pattern. But *L. curvatum* differs from *L. lillianum* in having finer secondary veins which are



TEXT-FIG. 57A-D — *Linguifolium curvatum* n. sp. from Kakadbhit (locality no. 2), B.S.I.P. specimen nos. 38/2000, 24/1212, 27/1212 and 6/2203B: A-C × 1, D × 2.

emerging at narrower angles. *L. kurtzii* Frenguelli (1941) is incompletely known and its veins are much finer than *L. curvatum*. *L. arctum* Menéndez (1951), *L. llantenense* Menéndez (1951) and *L. waitakiense* Bell described by Bell *et al.* (1956) are much narrower than *L. curvatum*.

Genus — *Taeniopteris* Brongniart, 1832

Taeniopteris kutchensis Bose & Banerji

Pl. 45, figs 7, 9; Text-figs 58A-D, 59D

1876a *Oleandridium vittatum* Brongn.: Feistmantel, p. 15, pl. 1, figs 1-3; pl. 2, figs 1-5; pl. 12, fig. 1.

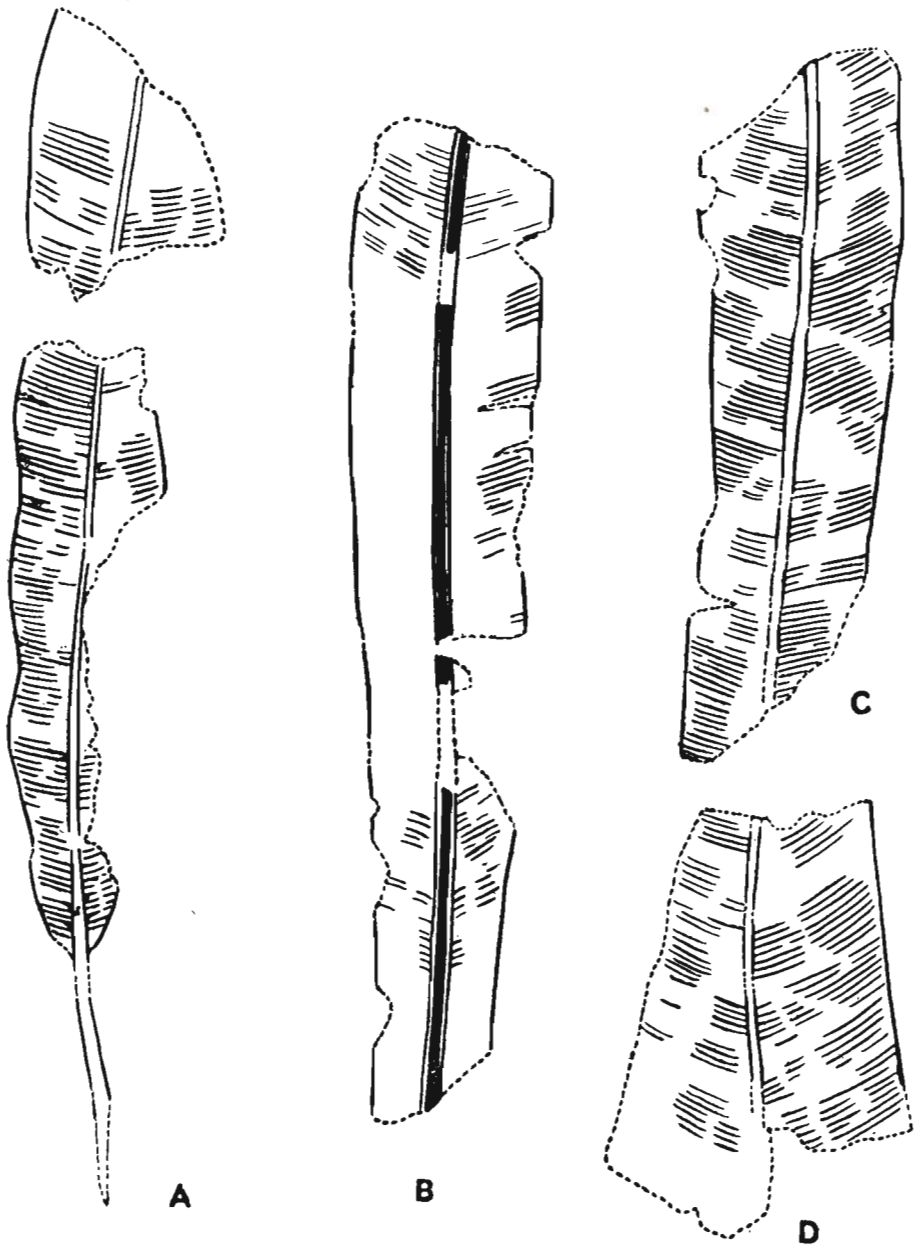
1876a *Taeniopteris densinervis* Feistmantel, p. 19, pl. 2, fig. 6.

1876b *Oleandridium vittatum* Schimper: Feistmantel, p. 30.

1963 *Taeniopteris vittata* Brongniart: Sitholey, p. 71.

1981 *Taeniopteris kutchensis* Bose & Banerji, p. 227, pl. 1, figs 7-9; pl. 5, fig. 26; Text-figs 2A-D, 9A.

Diagnosis (from Bose & Banerji, 1981) — Leaf simple, petiolate. Petiole 2.5-3 cm long, base of petiole swollen. Leaf 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



TEXT-FIG. 58A-D — *Taeniopteris kutchensis* n. sp. from Kakadbhit (locality no. 1), G.S.I. specimen nos. 4777, 4778, 4780 and 4785. × 1 (from Bose & Banerji, 1981).

of incomplete segmentation; apex obtuse. Midrib uniformly broad, 2-2.5 mm wide, near apex slightly narrower, longitudinally striated. Secondary veins arising at 80°-90°, near apex arising at 50°-65°, majority simple, once forked, forking 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 — G.S.I. specimen no. 4777.

Occurrence — Kakadbhit (locality no. 1) and Dauda Mota.

Remarks — *Taeniopteris kutchensis* matches exactly with the specimens of *Nilssoniopteris variabilis* and *N. pannuceus* described on pp. 52-55. In the absence of 'phytolemma' in the specimens of *T. kutchensis*, it is extremely difficult to determine whether the fronds belong to *N. variabilis* or *N. pannuceus*. As such they have been referred to the form genus *Taeniopteris*.

Comparison — *Taeniopteris kutchensis* has similar type of venation pattern as *T. fluctuous* Etheridge described by Chapman and Cookson (1926). *T. fluctuous* differs in having crumpled lamina. *T. elongata* Walkom (1918) shows only superficial resemblance with *T. kutchensis*, it differs from the latter in having a much tapering base and too frequently bifurcating lateral veins.

Taeniopteris cf. *spatulata* McClelland

Pl. 45, figs 2, 4, 6, 8; Text-fig. 59A-C

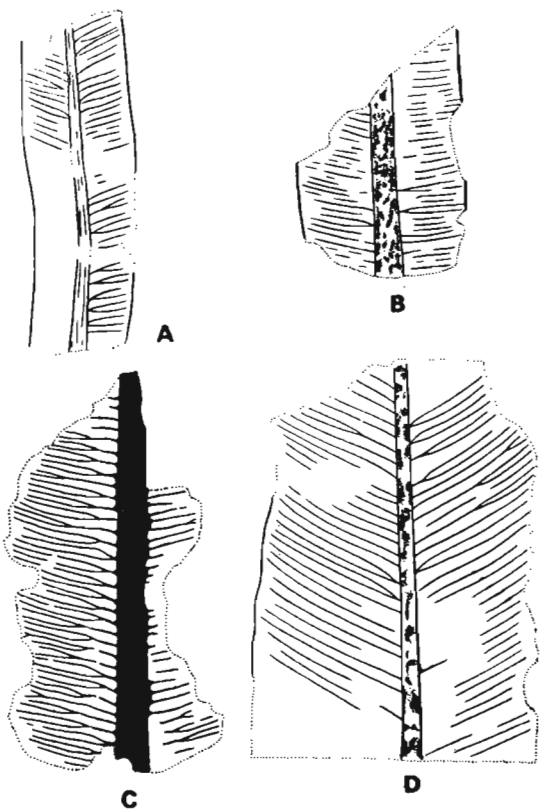
Specimens from Kachchh:

1981 *Taeniopteris spatulata* McClelland: Bose & Banerji, p. 219, pl. 5, figs 28, 29; text-figs 1B, 9B.

Description — Leaf simple, linear-spatulate, incomplete both at base and apex, 1-3.5 cm long, 0.3-1.2 cm broad; margin entire. Midrib 0.5-1 mm wide, showing a median groove, faintly striated along longitudinal direction; lateral veins arising at an angle of about 85°-90°, simple or forked, forking at all levels, majority forking just after emergence, 18-28 per cm.

Occurrence — Kakadbhit (locality no. 1), Dauda Mota, Chawad River (locality no. 1), Ugardi, Lakhapar, Artara and Dharesi (locality no. 1).

Remarks — All the specimens, so far collected from Kachchh, are devoid of apex and base. The specimens resemble the narrower leaves of *Taeniopteris spatulata* McClelland described by Bose and Banerji (1981, text-fig. 1A, C), but in the absence of apex and base they have here been described as *T.* cf. *spatulata*.



TEXT-FIG. 59A-D — **A-C**, *Taeniopteris* cf. *spatulata* McClelland, B.S.I.P. specimen nos. 2/2000A from Kakadbhit (locality no. 1), A/2004 (from Dharesi) and 69/2219A (from Lakhapar): A-B × 2, C × 4; **D**, *Taeniopteris kutchensis* n. sp. from Kakadbhit (locality no. 1): × 1.5. (Figure D from Bose & Banerji, 1981).

The venation pattern of the specimens (Text-fig. 59A) from Kakadbhit (locality no. 1) and Dharesi is more like the specimens figured by Bose and Banerji (1981, pl. 1, fig. 1; text-fig. 1A, F) from the Rajmahal Hills, Bihar. Most of the lateral veins of the specimen from Lakhapar (Text-fig. 59C) are forked and this specimen resembles more the specimen figured by Bose and Banerji (1981, text-fig. 1D) from Vemavaram and the basal portion of the leaf of *T. daintreei* McCoy figured by Douglas (1969, fig. 1, 1-Frontispiece). The venation of the middle portion of this leaf (Douglas, 1969, fig. 1, 1-Frontispiece) of *T. daintreei* is more like the leaves of the specimen of *T.* cf. *spatulata* from Kakadbhit and Dharesi.

Taeniopteris sp. A

Pl. 45, figs 1, 3; Pl. 46, figs 1-4; Pl. 47, figs 5, 6; Text-fig. 60A-L

Description (*leaf assumed to be simple and of Taeniopteris*; *shape, length, apex & base unknown*) — Leaf 0.8 mm wide; margins entire; midrib 1 mm wide; showing a median groove. Lateral veins arising at an angle of 45°-60°, mostly once forked, forking at various levels usually forking closer to midrib, reaching up to margins.

Cuticle about 2.5 μm thick; hypostomatic. Upper cuticle slightly thicker than lower, devoid of stomata. Cells along midrib more or less serially arranged, elongated-rectangular, thick-walled. Cells along lateral veins slightly shorter than cells along midrib, rectangular or polygonal in shape, 2-3 cells wide, serially arranged. Cells between veins mostly polygonal, irregularly packed; anticlinal walls straight, rarely at places slightly wavy; periclinal wall smooth. On lower surface cells along midrib similar to those on upper surface. Along margins and lateral veins cells serially arranged, longer than broad, mostly rectangular; anticlinal wall slightly thinner than those of upper surface, slightly wavy at places, periclinal wall unevenly thickened. Cells between veins irregularly packed, cell walls mostly obscure, polygonal; anticlinal wall usually straight, rarely slightly wavy at places, periclinal wall unspecialized. Stomata irregularly distributed between veins, not so crowded, mostly longitudinally orientated, sometimes obliquely or transversely orientated. Subsidiary cells 5-7 in number, at places, cell walls obscure straight walled; periclinal wall smooth, inner wall of lateral subsidiary cells thickened, sometimes inner wall of all the subsidiary cells thickened in order to form a circular or oval ring around the stomatal pit. Guard cells slightly sunken; surface slightly more cutinized than ordinary epidermal cells; aperture narrow, slit-like.

Occurrence — Trambau.

Remarks — Besides the specimen described above, there is one more (Text-fig. 60A) imperfectly preserved specimen. It also seems to be a portion of a *Taeniopteris* like leaf. Its lateral veins are obscure and it is not known whether they are forking or not. The lateral veins here seem to be slightly more closely placed than the one described above (Text-fig. 60F). In most points the cuticle of both the specimens agree with each other. Unlike the specimen described above, the epidermal cells of the present specimen (Text-fig. 60A-E) on both surfaces have cells with mostly, slightly wavy lateral- and end-walls and on lower surface the stomata are mostly obliquely or transversely placed. Also in this specimen the inner wall of most subsidiary cells are thickened so as to form an oval or circular ring around the pit.

Due to lack of better preserved specimens, this specimen (Text-fig. 60A) has not been described here separately under a new species.

Comparison — *Taeniopteris* sp. A (Text-fig. 60F) resembles in venation pattern the specimen of *Taeniopteris* cf. *spatulata* (Text-fig. 59C). The cuticle of *Taeniopteris* sp. A is more like the cuticle of *T. tenuinervis* Brauns described by Harris (1932). Both have straight-walled epidermal cells and six unspecialized subsidiary cells. In both, inner walls of subsidiary cells are thickened. *T. tenuinervis* differs from *Taeniopteris* sp. A in having more wider lamina and its lateral veins are not so commonly forking as in *Taeniopteris* sp. A. In *T. daintreei* McCoy described by Douglas (1969) the veins are commonly forking like *Taeniopteris* sp. A but the former differs in having papillate subsidiary cells. Moreover, in *T. daintreei* the ordinary epidermal cells are irregularly sinuous. The upper cuticle of *Taeniopteris* sp. A described by Douglas (1969) has papillate epidermal cells. *Taeniopteris* sp. 'b', described by Douglas (1969) differs from our *Taeniopteris* sp. A in having epidermal cells with sinuous walls and trichome bases over midrib.

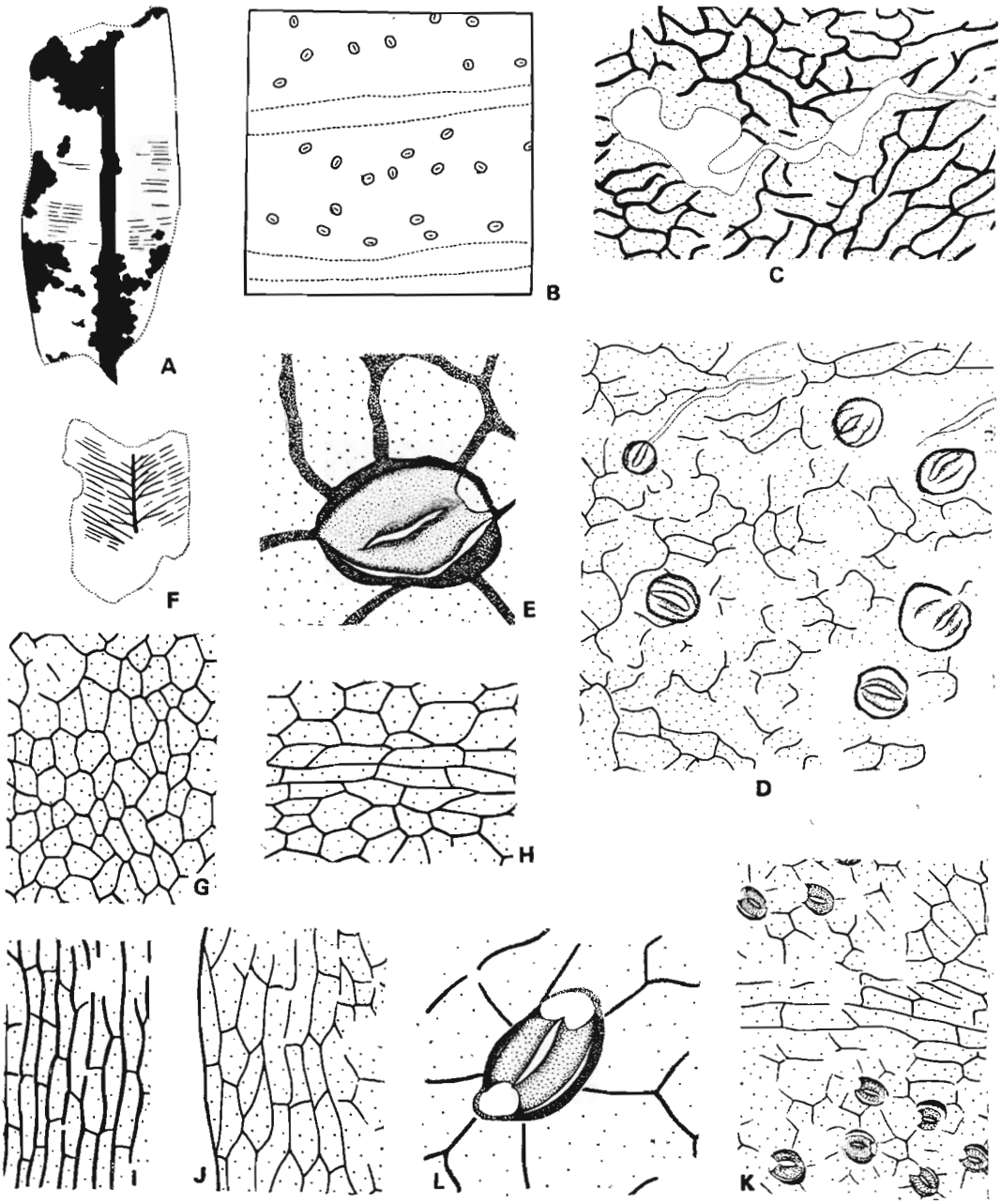
Genus — *Trambaua* n. gen.

Diagnosis — Same as type species.
Type species — *Trambaua apiculata* n. sp.

Trambaua apiculata n. gen., n. sp.

Pl. 48, figs 1-6; Text-fig. 61A-D

Diagnosis (*leaf assumed to be bipinnate, available fragment 3 cm long and 0.8 cm wide*; *rachis 0.8-1 mm wide*) — Pinnules oblong to ovate, alternate or subopposite,



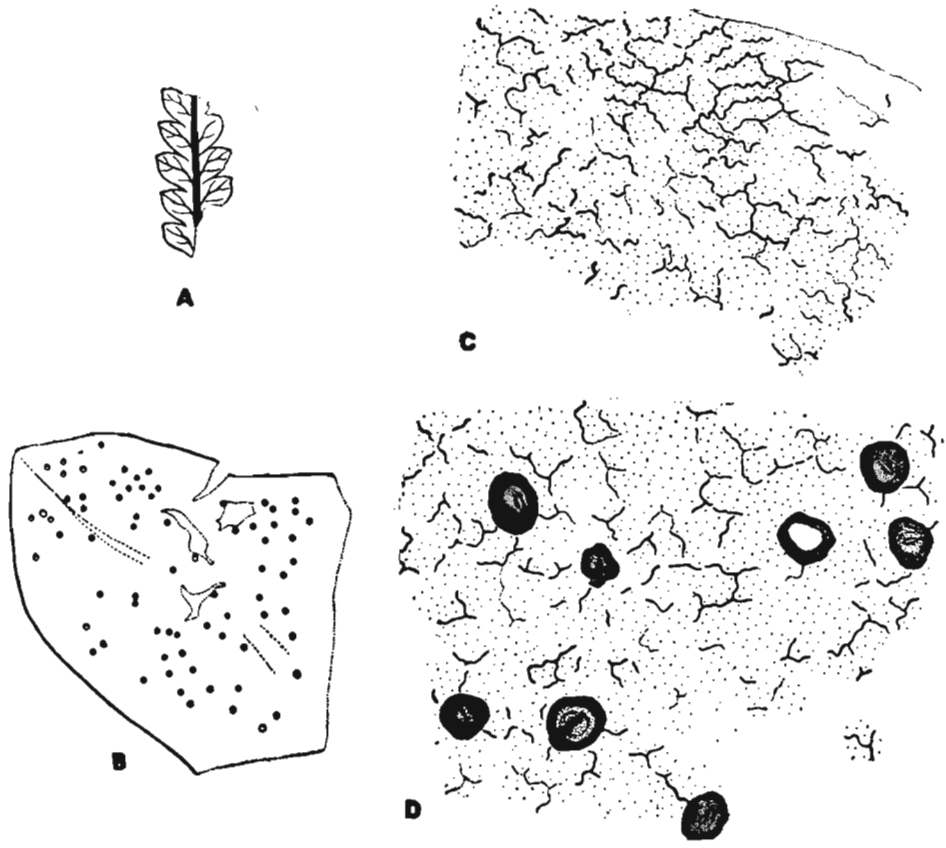
TEXT-FIG. 60A-L — **A-E**, a specimen of *Taeniopteris* resembling *Taeniopteris* sp. A from Trambau. **A**, showing gross morphology, B.S.I.P. specimen no. 35/2083, × 2; **B**, showing stomatal distribution, B.S.I.P. slide no. 35/2083, × 40; **C**, upper cuticle, B.S.I.P. slide no. 35/2083, × 150; **D**, lower cuticle showing a few stomata, B.S.I.P. slide no. 35/2083, × 150; **E**, a stoma, B.S.I.P. slide no. 35/2083, × 500; **F-K**, *Taeniopteris* sp. A from Trambau, F, showing venation, B.S.I.P. specimen no. 49/2420, × 2; **G**, upper cuticle showing cells between veins, B.S.I.P. slide no. 49/2420-4, × 150; **H**, upper cuticle showing cells along vein and between veins, B.S.I.P. slide no. 49/2420-7, × 150; **I**, lower cuticle showing cells along midrib, B.S.I.P. slide no. 49/2420-9, × 105; **J**, lower cuticle showing cells along margin, B.S.I.P. slide no. 49/2420-4, × 150; **K**, lower cuticle showing a few stomata, B.S.I.P. slide no. 49/2420-10, × 150; **L**, a stoma, B.S.I.P. slide no. 49/2420-1, × 500.

attached by entire base at an angle of 50°-55°, 1.5-2.5 mm long and 1.5-2 mm wide; margin entire, scarcely thickened; acroscopic basal margin straight; basiscopic basal margin mostly joining acroscopic basal margin of the pinnule lying below. Apex apiculate. Principal vein arising at an angle of 35°-40° after emergence giving rise to a lateral vein on lower side (catadromic) which do not reach the margin, thereafter forking 2-3 times, substance of lamina thick, dark but slightly translucent, showing darker veins and obscure separate minute round bodies.

Cells of rachis, on both surfaces, elongated rectangular; anticlinal walls slightly undulated; periclinal wall smooth. Lower surface showing a few sparsely placed stomata.

Cuticle fairly thick on both sides, at compressed margin measuring 3 μm thick. Upper cuticle without stomata, cells almost uniform, veins not shown, cell outlines indistinct but where seen cells polygonal or rectangular, anticlinal walls slightly undulated; periclinal wall smooth. No trichome present.

Lower cuticle showing almost evenly scattered stomata except near margin where there are none. Vein courses not recognizable, epidermal cells obscurely marked and like those of upper side. A very few possible trichome bases present consisting of a thin round area in a cell with an otherwise wide thicker surface. Guard cells surrounded by about five subsidiary cells, mostly like other epidermal cells but enormously thickened. On outer side thicken-



TEXT-FIG. 61A-D — *Trambaua apiculata* n. gen., n. sp. from Trambau. **A**, showing part of a frond, B.S.I.P. specimen no. 135/2677, × 2; **B**, showing distribution of stomata on lower surface, B.S.I.P. slide no. 135/2677-1, × 20; C, upper cuticle, B.S.I.P. slide no. 135/2677-1, × 150; **D**, lower cuticle showing a few stomata, B.S.I.P. slide no. 135/2677-1, × 150.

ing forming a ring, inner edge of ring slightly above general epidermal level; ring forming an oval or circular area; occasionally guard cell's (?) aperture visible over this oval or circular area.

Holotype — B.S.I.P. specimen no. 135/2677.

Occurrence — Trambau.

Remarks — Mostly pinnules on upper side having a few microthyriaceous bodies.

Discussion — This tiny fragment leaves the shape and therefore the affinities of the leaf are open. The whole leaf might be small and simple; it might be once or several times pinnate. The venation would fit *Pachypteris* and probably other genera. However, its cuticle is quite distinct from *Pachypteris* and other so-called Mesozoic Pteridosperms like: *Dicroidium*, *Lepidopteris*, *Cycadopteris*, etc. It is not *Ctenozamites* or *Ptilozamites* which have nearly parallel veins indicated on the cuticle. Clearly though it represents a species of Pteridosperm leaf so far unknown in the flora.

Genus — *Lorumformophyllum* n. gen.

Diagnosis — Leaf strap-shaped, substance of lamina thick; lateral margins having distantly placed dentations. Midrib evanescent towards apex; secondary veins arising at narrow angles, mostly dichotomizing. Stomata confined to lower surface, anomocytic, arranged in rows, longitudinally orientated or slightly obliquely placed; subsidiary cells 5-7 in number; a thickened rim present around stomatal aperture.

Derivation of name — The generic name is based on the strap-shaped nature of the leaves.

Type Species — *Lorumformophyllum dentatum* n. sp.

Discussion — In external features *Lorumformophyllum* n. gen. resembles most the leaflets of *Chankanella* Krassilov (1964). As the cuticular structure of *Chankanella* is not known and also as we do not know the true nature of *Lorumformophyllum*, viz., whether it is a simple or a compound leaf, so for the time being we have kept our specimens separate from *Chankanella*. The cuticle of *Lorumformophyllum* is very much like *Turketia angustifolia* Gomolitzky (1969). *Lorumformophyllum* has much broader leaves than *Turketia* and also in *Turketia* there is a faintly marked midrib. The genus *Ptilozamites*, too, has cuticle like *Lorumformophyllum*. In both, the inner walls of subsidiary cells form a ring. The former is, however, a pinnate leaf. The lamina of *Johnstonia* Walkom (1924), later transferred to *Dicroidium* by Townrow (1957), is forked, but each branch looks somewhat like *Lorumformophyllum*. While *Johnstonia* (Retallack, 1977 has maintained this as a separate genus) is amphistomatic, *Lorumformophyllum* is hypostomatic.

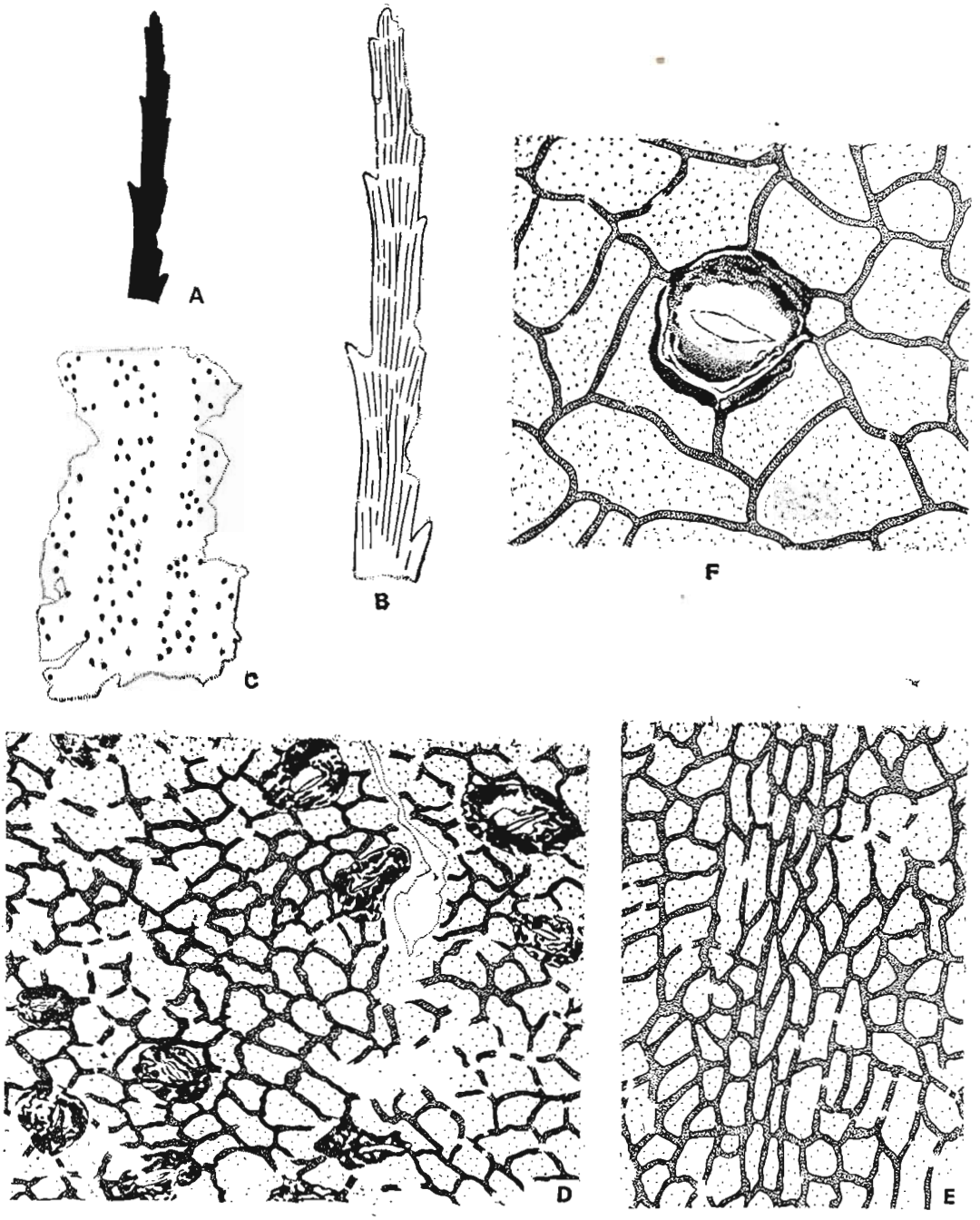
Lorumformophyllum dentatum n. sp.

Pl. 49, figs 1-7; Text-fig. 62A-F

Diagnosis — Leaf strap-shaped, 4.5-5 cm in length and maximum width 1.2 cm, substance of lamina thick, margins showing distantly (1-3 mm apart) placed prominent elongated projections or dentations; dentations 1.5-2 mm long with rounded apices. Median vein prominent near base, evanescent towards apex; secondary veins emerging at an angle of about 10°-15°, majority forking 1-3 times, mostly reaching up to margins.

Cuticle on both surfaces more or less of equal thickness, stomata confined to lower surface. On upper surface cells along veins almost 2-3 times larger than broad, more or less arranged in rows; lateral- and end-walls straight or, at places slightly wavy; surface devoid of papillae. Cells in between venal regions irregularly arranged, mostly polygonal, some with rounded corners; lateral- and end-walls slightly wavy; surface wall unspecialized at places slightly thickened. Trichome bases present, but not so common.

Lower surface showing stomatal and non-stomatal zones, rarely a few stomata lying outside stomatal zones. Cells along non-stomatal zones more or less regularly arranged in longitudinal direction, polygonal, slightly longer than broad; lateral- and end-walls straight or slightly wavy at places; surface wall smooth. Cells between stomatal zones irregularly arranged, polygonal but shape and size variable; lateral- and end-walls straight or slightly wavy; surface wall smooth or at places slightly thickened. Stomata longitudinally orientated, a few slightly obliquely placed. Subsidiary cells mostly 5-7, rarely 8, of unequal



TEXT-FIG. 62A-F — *Lorumformophyllum dentatum* n. gen., n. sp. from Trambau. **A**, showing part of a leaf, B.S.I.P. specimen no. 3/1723, × 1; **B**, showing venation, B.S.I.P. specimen no. 3/1723, × 2; **C**, showing distribution of stomata on lower surface, B.S.I.P. slide no. 3/1723a-1, × 20; **D**, lower surface showing a few stomata, B.S.I.P. slide no. 3/1723a-1, × 150; **E**, cells of lower cuticle, B.S.I.P. slide no. 3/1723a-1, × 150; **F**, a stoma, B.S.I.P. slide no. 3/1723a, × 500.

size; inner wall of subsidiary cells forming a circular to oval thick cutinized ring round the stomatal pit. Guard cells sunken, thinly cutinized; aperture slit-like or elliptical.

Holotype — B.S.I.P. specimen no. 3/1723.

Occurrence — Trambau.

Comparison — The leaflets of *Chankanella vachrameevii* Krassilov (1964) looks very much like *Lorumformophyllum dentatum*. Unfortunately, the cuticle of *C. vachrameevii* is not known and also it is not known whether *L. dentatum* is a simple leaf or a part of a compound leaf (?leaflet). The cuticle of *L. dentatum* resembles the cuticle of *Turketia angustifolia* Gomolitzky (1969). In both, stomata are confined to lower surface only and the stomata have cutinized rims around stomatal apertures. However, *T. angustifolia* possesses a comparatively narrower lamina with faintly marked midrib. Like *L. dentatum* the gaurd cells of *Ctenozamites* and *Ptilozamites* are placed at the base of a thickened rounded pit formed by the subsidiary cells, but the latter two genera have pinnate leaves whose pinnae have nearly parallel veins. Externally *Aphlebia nervosa* Óishi (1940) looks somewhat like *L. dentatum*, but the lateral segments of *A. nervosa* have acute tips.

Genus — *Allocladus* Townrow, 1967

Allocladus biswasianus n. sp.

Pl. 50, figs 1-8; Text-fig. 63A-M

Diagnosis — Twigs bearing leaves in a simple helix, maximum available width 5 mm. Leaves appressed, rhomboidal, up to 5 mm in length and 4 mm in width, abaxial side convex, occasionally showing a keel; margins scarious and scalloped; apex obtuse or subacute; bases often hidden by apical parts of adjoining leaves.

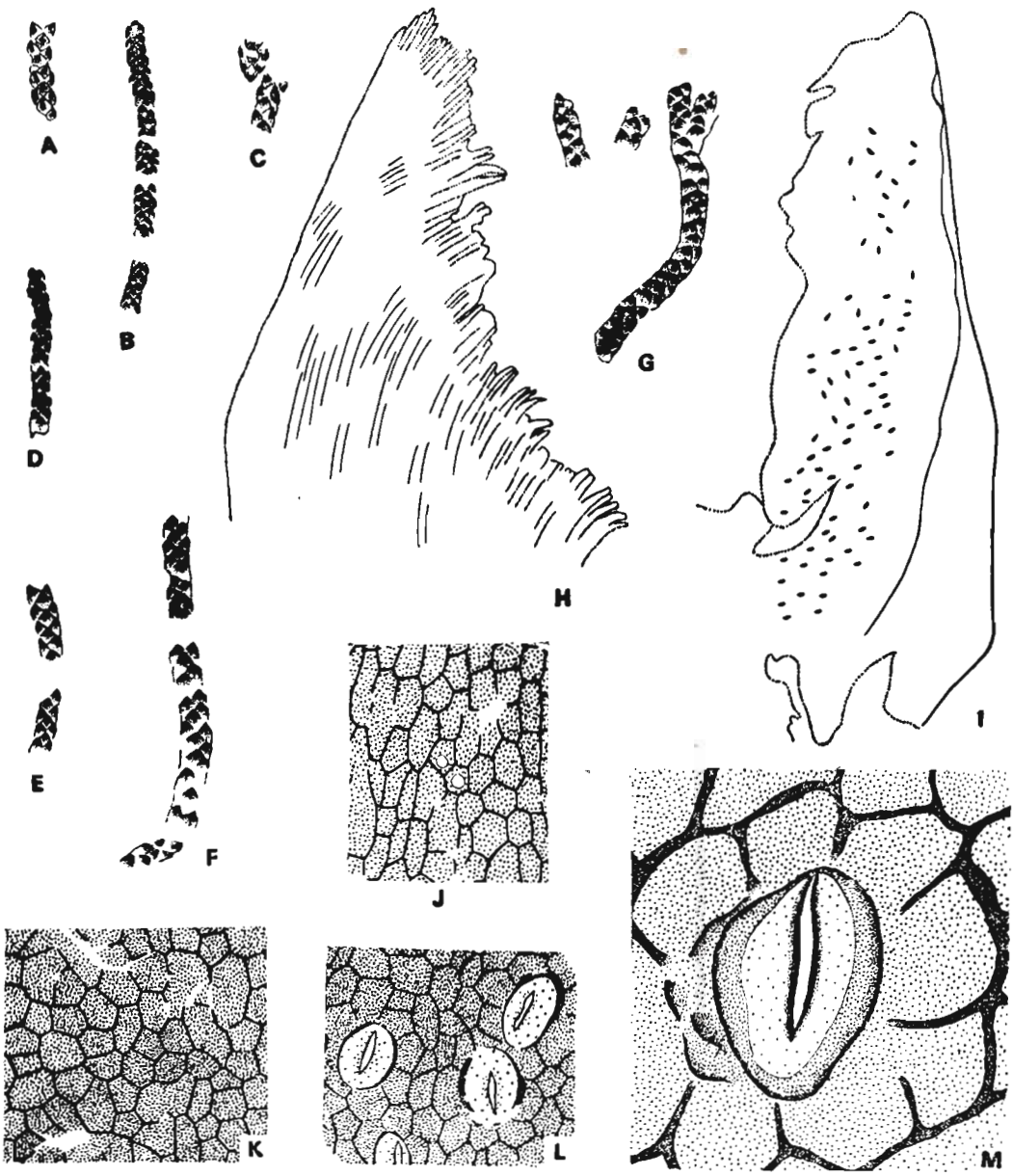
Leaves epistomatic. Upper surface slightly thinner than lower surface, stomata confined to two lateral zones lying about 3-5 cells away from margins, median region devoid of stomata. Within stomatal zones stomata irregularly distributed, obliquely orientated, rarely transversely placed, mostly stomata lying close to each other, rarely adjoining stomata sharing a common subsidiary cell; irregularly dicyclic. Subsidiary cells mostly 6-7 in number, rarely 4-5 or 8-9 in number; surface unevenly thickened, mostly inner walls slightly more thickened and forming a complete or an incomplete rim around stomatal pit. Guard cells slightly sunken inside an oval pit, thinly cutinized; aperture slit-like, rarely elliptic. Encircling cells like ordinary epidermal cells. Within stomatal zones cells irregularly arranged, polygonal; anticlinal walls thin, straight or slightly wavy at places, periclinal wall unevenly thickened, sometimes central region of cells showing a small circular and less cutinized area, rarely having a sort of rudimentary papilla. Cells along non-stomatic zone more regularly arranged in longitudinal direction, polygonal or rectangular in shape, slightly longer than broad; anticlinal and periclinal walls same as cells within stomatal zones. Cells of lower surface mostly like those of non-stomatic zone of upper surface.

The specific name is after Dr S. K. Biswas of Oil and Natural Gas Commission.

Holotype — B.S.I.P. specimen no. 65/2089C.

Occurrence — Trambau and Sukhpur.

Comparison — *Allocladus biswasianus* resembles *A. bansaensis* Sukh-Dev & Zeba-Bano (1979) and *A. townrowii* Sukh-Dev & Zeba-Bano (1979) in general appearance. In *A. bansaensis* stomata are distributed over the entire upper surface and are mostly longitudinally orientated. In *A. townrowii* sometimes a few stomata are also present on lower surface near the leaf base and the basal cells are papillate. *A. sehoraensis* Sukh-Dev & Zeba-Bano (1969) has smaller leaves than *A. biswasianus*, but the overall shape of leaves is somewhat similar in both the species. In *A. sehoraensis* stomata with in stomatal zones are in discontinuous files and they are longitudinally orientated. Moreover, in *A. sehoraensis* a few stomata are also present on lower surface which are confined to basal region. The leaves of *A. cribbii* Townrow (1967) are somewhat like *A. biswasianus*, but the former species differs in having papillate epidermal cells. In *A. cribbii* subsidiary cells are 3-6 in number. *A. milneanus* (Tension Woods) Townrow (1967) has longer as well as appressed and spreading leaves with acute



TEXT-FIG. 63A-M — *Allocladus biswasianus* n. sp. **A-G,** showing detached twigs, B.S.I.P. specimen nos. 49/2887 (from Trambau), 3/2285 (from Walka Mota), 70/2419 (from Trambau), 7/2235 (from Sukhpur), A/2235 (from Sukhpur), 158/2419 (from Trambau) and 11/2235 (from Sukhpur), × 1; **H,** margin of a leaf showing scarious projections, B.S.I.P. slide no. 65/2089-2, × 40; **I,** upper cuticle showing distribution of stomata, B.S.I.P. slide no. 68/2089C-1, × 30; **J,** upper surface showing a few cells, B.S.I.P. slide no. 65/2039C-1, × 150; **K,** showing cells of lower surface, B.S.I.P. slide no. 65/2089C-1, × 150; **L,** upper surface showing a few stomata, B.S.I.P. slide no. 65/2089C-1, × 150; **M,** a stoma, B.S.I.P. slide no. 65/2089C-1, × 500.

apices. Also in *A. milneanus* stomata within stomatal zones are in short rows of 2-5 stomata in length and are mostly longitudinally orientated.

FRAGMENTARY LEAVES WITH WELL-PRESERVED CUTICLE

A large number of fragmentary leaves with parallel veins have been collected from various localites in Kachchh. In all such fragments both bases and apices are missing. Some of these pieces have turned out to be fragments of pinnae of *Pseudoctenis fragilis* Bose & Banerji while others belong to the genus *Cycadolepis* Saporta (1873). Besides, there are two types which have rather characteristic cuticle, but can not be assigned to any definite genus. They may be parts of simple leaves like *Desmiophyllum* Lesquereux (1878), *Harrisophyllum* Pant *et al.* (1983), etc. or they may be portions from detached pinnate type of leaves. The cuticle of these two types are described below:

LEAF TYPE — 1

Pl. 51, fig. 2; Pl. 52, figs 1-3; Text-fig. 64A-E

Leaf fragment measuring 4.5×1 cm, apical and basal regions not preserved, substance of lamina thick; margin dentate; dentations about 1.5 cm apart. Apices incomplete. Veins conspicuous, parallel, about 12-14 in number at its broadest region.

Cuticle on both surfaces almost of same thickness, about 3-4 μm thick; stomata confined to one surface only. Non-stomatiferous surface mostly having much longer than broad cells, spindle or rhomboidal in shape, rarely polygonal or rectangular; anticlinal walls straight or slightly wavy at places; periclinal wall smooth, rarely in some surface slightly unevenly thickened. Cells arranged in longitudinal directions; veinal and intervenal regions not distinguishable.

Stomatiferous surface showing stomatal and non-stomatal bands; stomatal bands 3-5 stomata wide, within stomatal bands stomata irregularly scattered mostly longitudinally orientated, rarely obliquely placed. Subsidiary cells 6-8 in number, inner walls thickly cutinized forming an oval rim around stomatal pit. Guard cells sunken; aperture slit-like. Ordinary epidermal cells along stomatal bands polygonal, irregularly arranged; anticlinal walls thin and straight; periclinal wall smooth or rarely unevenly thickened. Very rarely within stomatal bands a large number of epidermal cells converging towards each other leaving a central ill-preserved region; surface of some of these cells having a circular or oval thickening (this type of arrangement of cells may have been formed due to some sort of injury or some other unnatural factor). Ordinary epidermal cells along non-stomatal zones like those of non-stomatiferous surface.

Occurrence — Chawad River (locality no. 6).

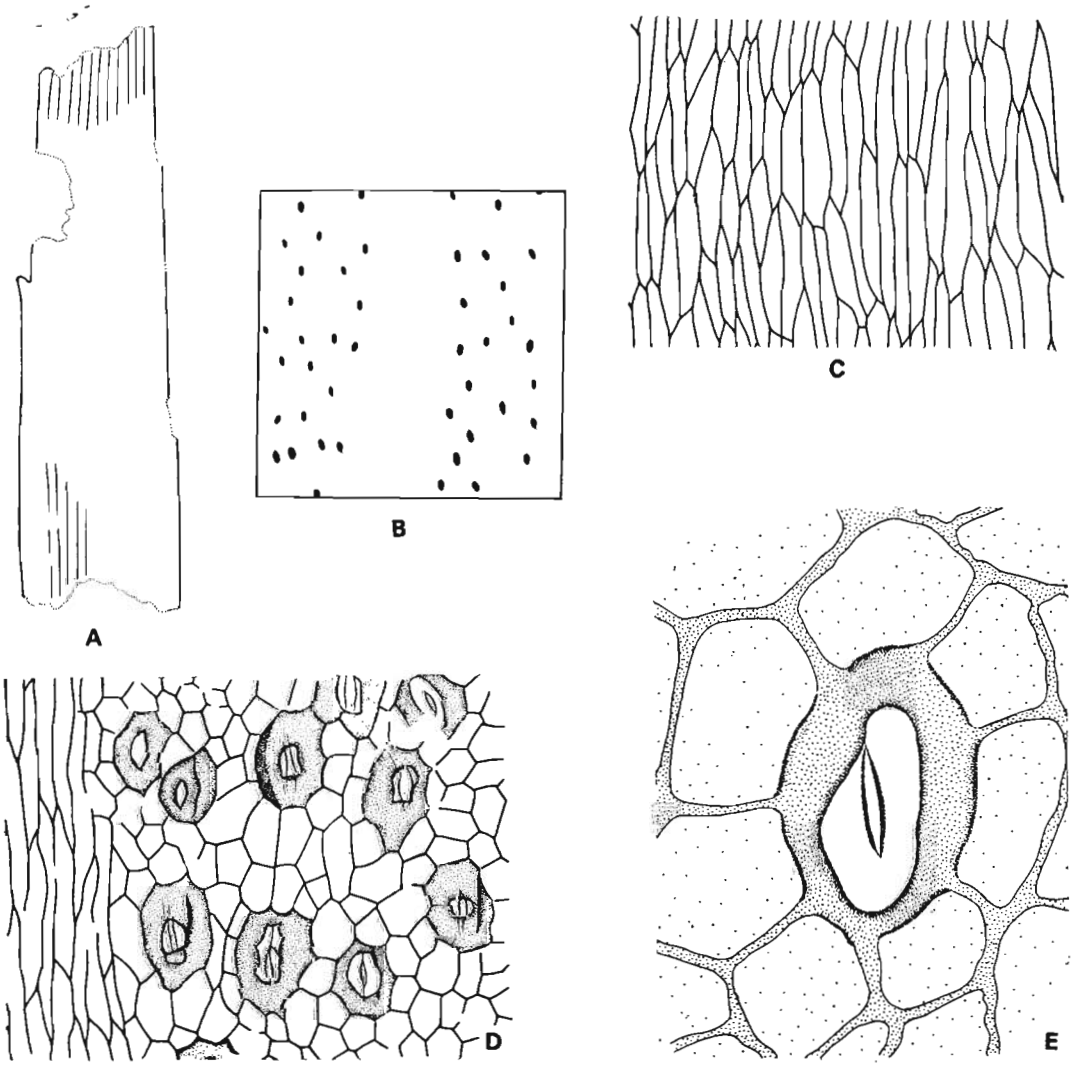
LEAF TYPE — 2

Pl. 51, figs 1, 3-5; Text-fig. 65A-F

Leaf fragment measuring 3.5 cm in length and 1.3 cm in width; margin entire; veins parallel, 12-15 in number.

Cuticle about 3 μm thick, hypostomatic. Cells of non-stomatiferous surface like those of *Leaf-type-1*. Trichome bases rare. Stomatiferous surface slightly thinner than non-stomatiferous surface, differentiated into stomatal and non-stomatal zones. Cells along non-stomatiferous zones elongated, usually 5-10 times longer than broad, rectangular, spindle-shaped or polygonal; anticlinal walls straight or at places slightly wavy; periclinal wall unspecialized. Trichome bases common. Stomatal bands 2-4 stomata wide, rarely single stoma wide; stomata irregularly scattered, at places tending to form short discontinuous files, within bands stomata longitudinally orientated. Stomatal apparatus oval in shape, completely covered by hair-like outgrowths from subsidiary and adjoining cells; hair-like out growths about 14-18 in number. Subsidiary cells slightly smaller than ordinary epidermal cells, inner walls more cutinized forming an oval rim around the stomatal pit. Guard cells mostly not visible, sunken; aperture narrow. Ordinary epidermal cells within stomatal bands slightly smaller in size than those along non-stomatal bands.

Occurrence — Ugardi,



TEXT-FIG. 64A-E— *Leaf type*-1 A from Chawad River (locality no. 6). **A**, fragment of a leaf, B.S.I.P. specimen no. 12/2424, × 2; **B**, showing distribution of stomata, B.S.I.P. slide no. 12/2424-1, × 40; **C**, showing cells of non-stomatiferous surface, B.S.I.P. slide no. 12/2424-1, × 150; **D**, stomatiferous surface showing a few stomata, B.S.I.P. slide no. 12/2424-1, × 150; **E**, a stoma, B.S.I.P. slide no. 12/2424-1, × 500.

Genus — *Bucklandia* Presl, 1825

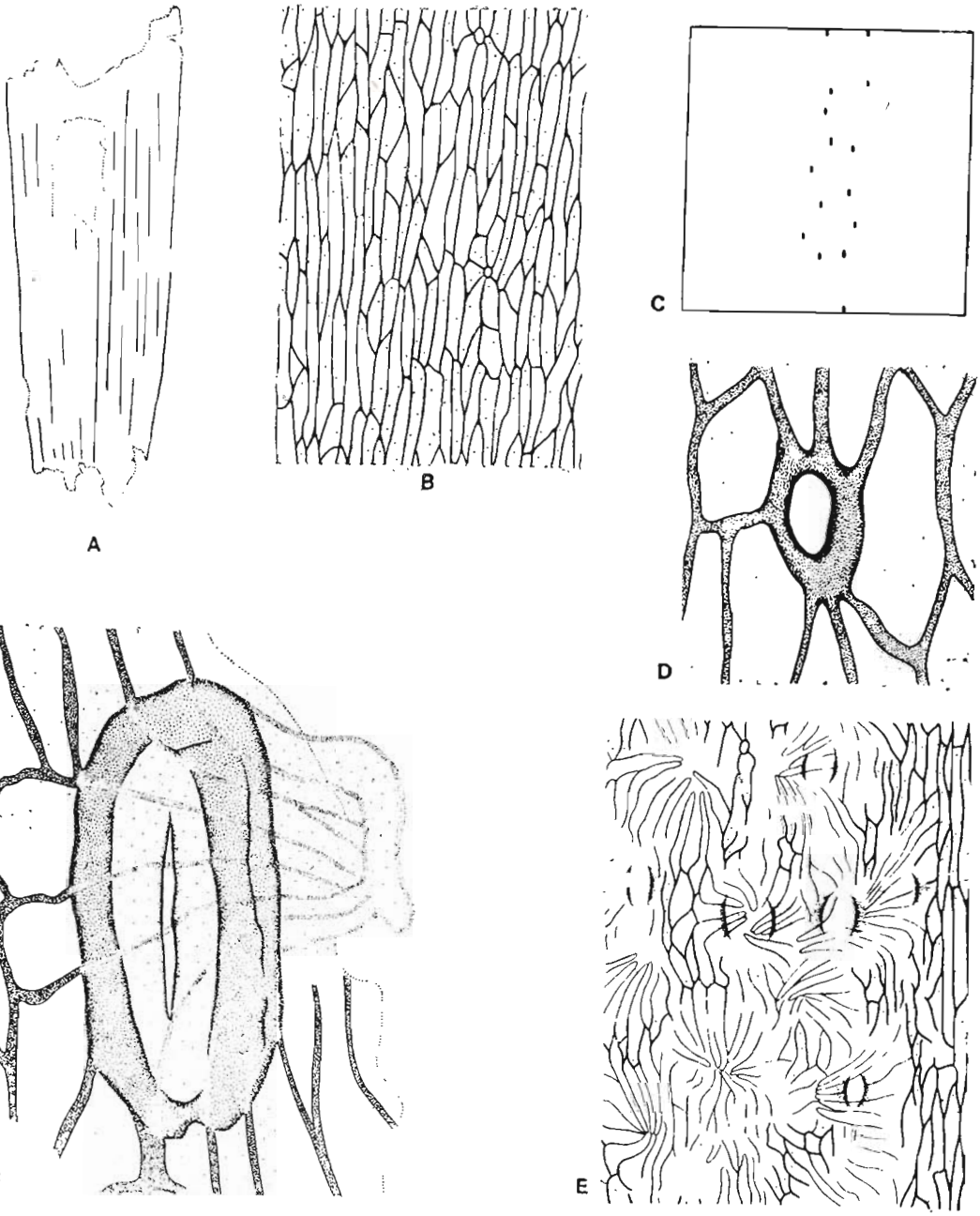
?*Bucklandia* sp.

Pl. 47, figs 1-3; Text-fig. 66A, B

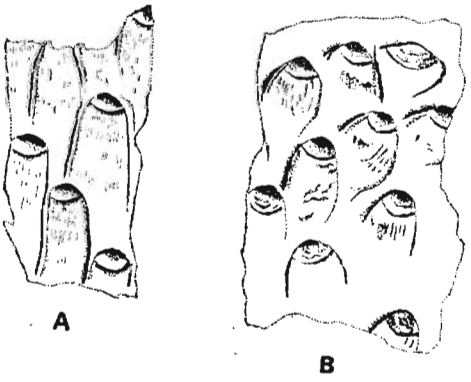
Description — All the specimens showing inner surface of a few fragmentary decorticated stems. Largest specimen is 5.2 cm long and 4.6 cm broad. Surface showing spirally arranged oval-oblong, rhomboidal or lorenze-shaped leaf bases, leaf bases usually 0.8-1.7 cm long and 0.8-1.6 cm wide. Leaf-scars obcuneate with concave apices, sometimes cuneate with rounded bases. Leaf-trace bundles not visible.

Occurrence — Kakadbhit (locality no. 1) and Chawad River (locality no. 3).

Comparison — In the absence of leaf-trace bundles it is difficult to compare the present specimens with any of the existing



TEXT-FIG. 65A-F — *Leaf type*-2 B from Ugardi. **A**, showing part of a leaf, B.S.I.P. specimen no. 6/2240, × 2; **B**, showing cells of non-stomatiferous surface, B.S.I.P. slide no. 6/2240-1, × 140; **C**, showing distribution of stomata, B.S.I.P. slide no. 6/2240-1, × 40; **D**, upper surface showing a trichome base, B.S.I.P. slide no. 6/2240-1, × 500; **E**, stomatiferous surface, B.S.I.P. slide no. 6/2240-1, × 150; **F**, a stoma, B.S.I.P. slide no. 6/2240-1, × 500.



TEXT-FIG. 66A-B — ?*Bucklandia* sp. from Kakadbhit (locality no. 1), B.S.I.P. slide nos. 11/2079A and 256/2000A, × 1.

species of *Bucklandia*. As such here they have doubtfully been referred to *Bucklandia*. The leaf-bases in general shape and size resemble the specimens described by Bose (1953, pl. 1, figs 1, 4 & 1959, pl. 1, fig. 3).

Genus — *Kachchhia* n. gen.

Diagnosis — Main rachis of microsporophylls branching in horizontal plane; branches alternate or sub-opposite, simple or forked. Each branch or ultimate branch terminating into a swollen head having ridges and grooves; each ridge on ventral side bearing a boat-shaped, bilocular sporangium close to margin, sporangium enclosing two distinct pollen masses.

Type Species — *Kachchhia navicula* n. sp.

Discussion — Some of the specimens of *Kachchhia* (Text-fig. 67B, F, E) externally show a striking resemblance with the species of *Caytonanthus* Harris figured by Harris (1964, fig. 7A-C). *Caytonanthus* differs from *Kachchhia* in having synangia which have usually 4 pollen sacs. *Townrovia petasata* (Townrow) Retallack (1981) shows only superficial similarity with *Kachchhia*. In *T. petasata* sporangia are unilocular like the species of *Pteruchus* Thomas and *Antevsia* Harris. Moreover, arrangement of pollen sacs in *Townrovia*, *Pteruchus* and *Antevsia* is quite different from *Kachchhia*. In having bilocular sporangia *Kachchhia* comes closer to *Crossotheca* Zeiller, but in the latter genus the sporangia are arranged radially on the underside of the expanded fertile branches whose tips are slightly expanded into a circular or paddle-shaped limb.

Kachchhia navicula n. sp.

Pl. 53, figs 1-9; Pl. 54, figs 1-4; Text-figs 67A-F, 68A-F, 69A-I

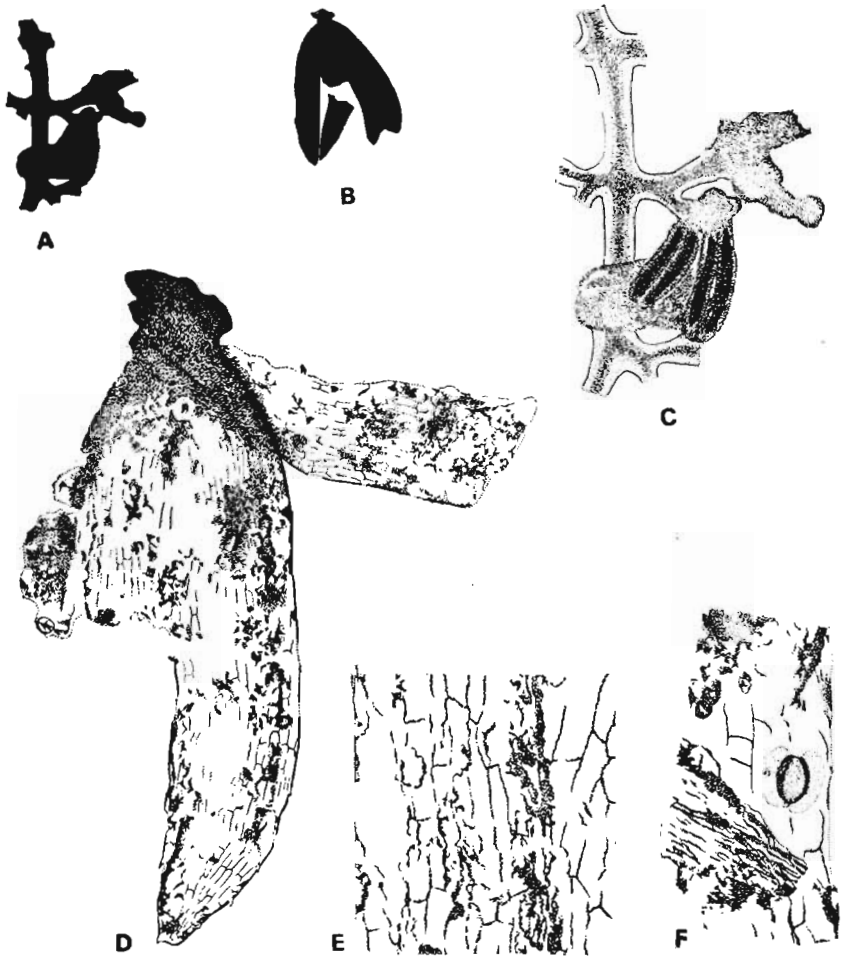
Diagnosis — Microsporophylls exceeding 4 cm in length, 1 cm in width. Principal rachis slender, about 0.8-1 mm wide, branching in horizontal plane, branches alternate or subopposite, simple or forked, majority forking once, rarely twice, arising at an angle of 75°-90°, 3-4 mm long and 0.8-1.2 mm wide, surface smooth. Each branch or ultimate branch terminating into a swollen head (about 1.5 mm in diameter), when laterally compressed apical end (head) club-shaped, whereas when dorsiventrally compressed circular in shape, but usually showing 8 ridges and grooves, towards distal end ultimate branches usually notched. Each ridge on ventral side bearing a bilocular sporangium close to the margin. Sporangia boat-shaped, 2-3.5 mm long and 1-1.5 mm wide, bilocular, having two somewhat elliptic masses of spores, dehiscence slit unknown.

Cells of principal rachis mostly polygonal, usually much longer than broad, rarely rectangular or squarish in shape; anticlinal walls straight or at places slightly wavy; periclinal wall mostly showing longitudinal striations.

→

TEXT-FIG. 67A-F — *Kachchhia navicula* n. gen., n. sp. **A-C,** fragments of microsporophylls, B.S.I.P. specimen nos. 110/2203B (from Kakadbhit — locality no. 2), 39/2404 (from Gadhsisa) and 183/2082 (from Kurbi): A × 10, B × 4, C × 2; **D,** a detached head having a few sporangia, B.S.I.P. specimen no. 110/2203B, × 12; **E, F,** part and counterpart of an apical portion of a microsporophyll, B.S.I.P. specimen nos. A/2203B and B/2203B, × 8.

TEXT-FIG. 67



TEXT-FIG. 68A-F — *Kachchhia navicula* n. gen., n. sp., specimens isolated by bulk maceration from shale samples collected from Chawad River (locality no. 4). **A**, a part of a microsporophyll, B.S.I.P. slide no. 7055, × 3; **B**, showing a sporangium, B.S.I.P. slide no. 7060, × 6; **C**, specimen shown in figure A enlarged after partial maceration; showing two sporangia each with two spore masses, B.S.I.P. slide no. 7055, × 6; **D**, a part of specimen shown in figure B, showing cells of sporangial wall, B.S.I.P. slide no. 7060, × 25; **E**, sporangial wall showing a few cells, B.S.I.P. slide no. 7060, × 150; **F**, a bisaccate pollen grain adhering to sporangial wall, B.S.I.P. slide no. 7061, × 150.

Cuticle of lateral branches and ultimate branches slightly thinner than rachis cuticle. Cells polygonal, isodiametric or slightly longer than broad; anticlinal walls straight; periclinal wall smooth. Stomata extremely rare, usually confined towards apical end, irregularly distributed and orientated. Subsidiary cells 5-7 in number; stomatal pit large, broadly oval. Guard cells slightly sunken, inner wall thinly cutinized; aperture elliptical in shape. Sporangial wall thinly cutinized; cells elongated polygonal or rectangular in shape; anticlinal walls mostly straight, very rarely at places slightly wavy; periclinal wall smooth. In compressed state lateral sides showing prominent trichomes.

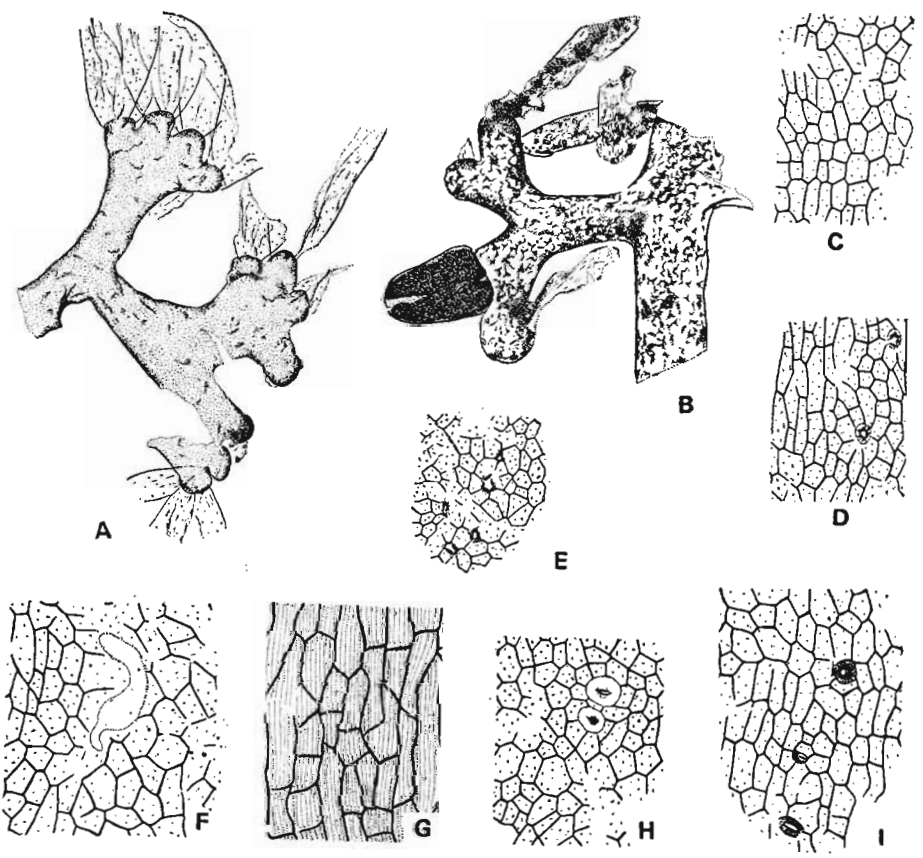
Holotype — B.S.I.P. specimen no. 110/2203B.

Occurrence — Kurbi, Gadhsisa, Kakadbhit (locality nos. 1 & 2) and Chawad River (locality no. 4).

Remarks — In all the above mentioned localities *Pachypteris specifica* Feistmantel is extremely common and most of the speci-

mens of *Kachchhia navicula* have been collected in close association with *Pachypteris specifica*. At Kurbi and Kakadbhit specimens of *K. navicula* are preserved in the form of impressions. At Gadhsisa the specimens have mostly badly preserved 'phyto-lemma'. The best specimens, with well-preserved cuticle, have been isolated by bulk maceration from the shale samples from Chawad River (locality no. 4). At this locality both *Pachypteris specifica* Feistmantel and *P. indica* (Oldham & Morris) Bose & Roy are extremely common. Next in abundance is *Pagiophyllum chawadensis* Bose & Banerji. The other species, viz., *Elatocladus chawadensis* Bose & Banerji and *Coniopteris* cf. *hymenophylloides* (Brongniart) Seward reported from the same locality are rare.

From some of the sporangia of *K. navicula* we have been able to get pollen masses but in almost all of them the grains are immature. Isolated mature pollen grains have been found sticking to some of the dissected sporangial walls. They are mostly bisaccate and nonstriate



TEXT-FIG. 69A-I — *Kachchhia navicula* n. gen., n. sp. **A-B,** showing two specimens isolated from shale samples from Chawad River (locality no. 4), B.S.I. P. slide nos. 7045 and 7062. Fig. **A** clearly shows the heads of the ultimate branches with ridges (each with a sporangium) and grooves and fig. **B,** shows a sporangium with two distinct spore masses, × 10; **C,** polygonal cells from over head, B.S.I.P. slide no. 7056, × 150; **D,** cuticle of an ultimate branch, B.S.I.P. slide no. 7056, × 150; **E,** showing a few stomata from over a terminal part of a lateral branch, B.S.I.P. slide no. 7056, × 150; **F,** showing cells of a main lateral branch, B.S.I.P. slide no. 7064, × 150; **G,** showing cells of the principal rachis of microsporophyll, B.S.I.P. slide no. 7065, × 150; **H,** two stomata from over apical end of a lateral branchlet, B.S.I.P. slide no. 7056, × 150; **I,** cuticle of a lateral branch, B.S.I.P. slide no. 7064, × 150.

(Pl. 53, fig. 9; Text-fig. 68F). It is of course difficult to say whether such grains really belong to *K. navicula*. The epidermal cells and the stomata of *K. navicula* are more like *Pachypteris specifica* Feistmantel.

The true nature of the pollen bearing organs is not known. In some of them we have seen two distinct pollen masses, but in none of them we have been able to see the septum separating the two pollen masses. As such we have described the pollen bearing organs as sporangia and not as synangia.

Genus — *Rajmahalia* Sahni & Rao, 1934

?Receptacle of *Rajmahalia* sp.

Pl. 55, figs 9, 10, 12; Text-fig. 70A, B

Description — The description is based on five incomplete receptacles which are all devoid of seeds. Two of the receptacles seem to be bell-shaped. The best preserved specimen (Text-fig. 70A) measures 2.8 cm in length and 1.6 cm in width near base. Apex obtusely rounded, base showing a rim which measures approximately 1 cm in width. Basal rim showing prominent wrinkles. Surface of receptacle showing oval or hexagonal slightly raised scars of fallen seeds, seed scars/cushions about 1.5-2 mm long and 1.2-2 mm wide, some of the seed-scars showing a minute circular depression perhaps representing the vascular strand.

Occurrence — Kakadbhit (locality no. 2).

Comparison — In overall shape the specimens resemble the receptacle of *Rajmahalia paradoxa* Sahni & Rao described by Ganju (1947, pl. 13, fig. 3) and Bose (1966, pl. 2, figs 10-12, 14). The present specimens differ in having more hexagonal markings over the receptacles. Also in *R. paradoxa* the base of receptacle seems to be rhomboidal in shape (Sahni & Rao, 1934, pl. 36, fig. 13; Bose, 1966, pl. 1, figs 1, 2), whereas in the present specimens the bases seem to be broadly oval.

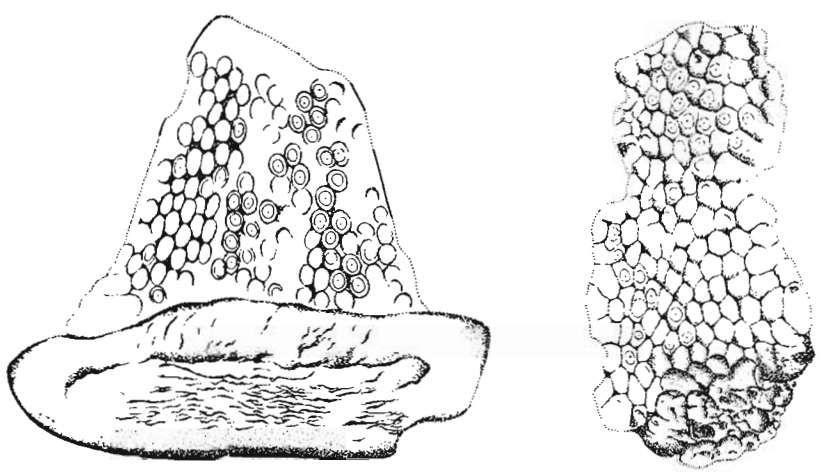
Genus — *Conites* Sternberg, 1823

Three distinct types of cones have been collected. They are all preserved in the form of impression and in most of them the details of cone-scales, etc. are missing.

Conites sp. A

Pl. 55, fig. 16; Text-fig. 71A

Cones broadly oval, 0.5-1 cm in length and 0.4-0.6 cm in width. Cone scales spirally arranged, mostly represented by rhomboidal scars.



TEXT-FIG. 70A, B — ?Receptacle of *Rajmahalia* sp., showing seed scars/cushions from Kakadbhit (locality no. 2), B.S.I.P. specimen nos. 101/2074 and 44/2203B, × 2.

Occurrence — Kakadbhit (locality no. 1) and Sukhpur.

Remarks — At Sukhpur the specimens of *Conites* sp. A have been collected in close association with specimens of *Brachyphyllum royii* Bose & Banerji. *Conites* sp. A resembles *Conites* sp. cf. *C.* sp. α Seward described by Sahni (1928, pl. 6, fig. 93). The present specimens also resemble the male cones of *Brachyphyllum speciosa* (Pomel) Saporta described by Barale (1981).

Conites sp. B

Text-fig. 71B-F

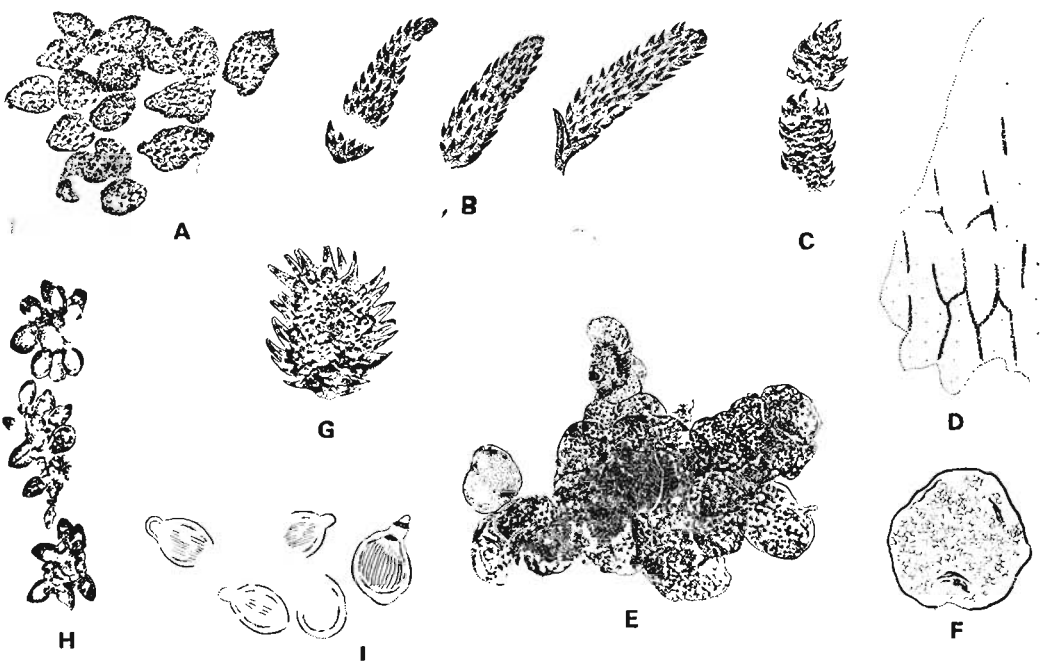
Male cones somewhat oblong in shape, base slightly broader than apical end, 1-1.3 cm long and 0.25-0.3 cm wide. Microsporophylls arranged helically, about 1 mm in length, more or less triangular in shape, slightly falcate.

Cuticle ill-preserved, at places showing serially arranged elongated rectangular or polygonal cells. Anticlinal walls of cells thin and straight; periclinal wall smooth. Pollen grains in compressed state rounded, 60-90 μm in diameter, alete, exine finely granulose, about 2 μm thick.

Occurrence — Trambau and Kakadbhit (locality no. 1).

Remarks — The above description is based on specimens collected from Trambau and Kakadbhit (locality no. 1). One of the specimens from Trambau has yielded minute pieces of cuticle of microsporophylls and isolated pollen masses. Cuticle pieces are ill-preserved and at places show only a few elongated cells. The pollen grains are mostly not fully matured.

Comparison — *Conites* sp. B differs from *Conites* sp. A in overall shape. The present species also looks like the specimens figured by Carpentier (1934, pl. 1, figs 4, 5). Carpentier's specimens are much



TEXT-FIG. 71A-I — **A,** *Conites* sp. A from Kakadbhit (locality no. 1), B.S.I.P. specimen no. 56/2885A, × 1; **B-C,** *Conites* sp. B, B.S.I.P. specimen nos. 91/2678 (from Kakadbhit — locality no. 1) and 22/2887 (from Trambau), × 2; **D,** *Conites* sp. B, showing a few cells of a microsporophyll, B.S.I.P. slide no. 22/2887-2, × 150; **E, F,** pollen grains isolated from the specimen figured in C (*Conites* sp. B), B.S.I.P. slide no. 22/2887-1, × 250; **G,** *Cone type*-1 from Kakadbhit (locality no. 1), B.S.I.P. specimen no. 35/2885, × 1; **H,** *Strobilites* cf. *sewardi* Sahni, showing seeds in groups, B.S.I.P. specimen no. 41/2420 (from Kurbi), × 1; **I,** isolated seeds of *Strobilites* cf. *sewardi* Sahni from Kakadbhit (locality no. 1), B.S.I.P. specimen no. 42/2885, × 2.

bigger in size. The shape of *Masculostrobus* sp. A of Barale (1970) is like *Conites* sp. B, however, in the former species pollen grains are comparatively smaller (38 μm) than those of *Conites* sp. B. Some of the pollen grains of *Brachyphyllum mamillare* Lindley & Hutton figured by Harris (1979) are almost of same size as the pollen grains of *Conites* sp. B. The cones of *B. mamillare* are more rounded or oval in shape.

Cone Type-1

Pl. 55, figs 1, 2; Text-fig. 71G

The collection includes a few conifer cones of doubtful nature, viz., whether they are male or female cones. Some of them have part and counterpart and give an appearance as if they have been sectioned longitudinally.

Cones measuring 1.4-3 cm in length and 0.8-1.4 cm in width. Cone-scales spirally disposed around an axis measuring about 1.5 mm in width, in compressed state tips of cone-scales spreading all along margins. Each cone-scale showing a prolonged tip having a prominent median ridge, main body of cone-scale somewhat obovate in shape, some of them showing an ill-defined oval depression slightly away from margins.

Occurrence — Kakadbhit (locality no. 1).

Remarks — From the overall shape of cones and cone-scales it seems that the cones may have belonged to the genus *Araucarites*. But in the absence of any definite seed we have preferred to keep the affinities of these cones open. Individual cone-scales look more like the smaller cone-scales of *Araucarites janaianus* Bose & Banerji. However, even the smallest cone-scale of *A. janaianus* is bigger than the cone-scale of the present specimens.

Genus — *Carpolithes* Schlotheim, 1820

Carpolithes sp. A

Pl. 55, figs 3, 4

Description — Seed incomplete on one side, 2.7×1.8 cm, ovate. Central body (?nucellus & endotesta) about 1.8 cm in diameter, enclosed by about 3 mm thick seed coat (sarcotesta). Micropyle is represented by a distinct groove.

Occurrence — Kakadbhit (locality no. 2).

Comparison — The specimen has both part and counterpart. One of them shows a central groove, whereas the other shows a central convex region (?nucellus & endotesta).

Carpolithes sp. A resembles most *Carpolithus* sp. B described by Barnard and Miller (1969, pl. 15, fig. 13) from the Shemshak Formation of Iran.

Carpolithes sp. B

Pl. 55, figs 13, 14

Description — The description is based on a few seeds ranging in size from 0.9×0.5 to 2.6×1.4 cm. Seeds are somewhat ovate in shape with rather narrow micropylar end. The micropylar end of one of the seeds (Pl. 55, fig. 13) is slightly curved on one side and its apical end is notched. Surface of all these seeds are either smooth or faintly striated in longitudinal direction. No other details are visible.

Occurrence — Trambau and Kakadbhit (locality no. 1).

Genus — *Strobilites* Lindley & Hutton, 1833

Strobilites cf. *sewardii* Sahni

Pl. 55, figs 6, 7; Text-fig. 71H, I

Description — Sessile seeds, mostly in groups of 2-7, sometimes a few even lying isolated, when in groups, usually pointing towards a central axis(?). Seeds ovate or obovate, rarely elliptic, measuring 2.5-6 mm in length and 2.5-5 mm in width. Central body surrounded by about 1 mm wide seed coat (?sarcotesta), surface of seeds at places showing faint longitudinal striations. Micropylar ends of some of the seeds slightly tapering and showing a median groove.

Occurrence — Jamthara, Kurbi and Kakadbhit (locality no. 1).

Remarks — The exact nature of the fructifications is not known. It is difficult to say whether they are fruits or seeds. Some of them have been found in close association with species of *Elatocladus* Halle. It

is interesting to note that Sahni (1928, pl. 5, figs 71-75) too, found his specimens of *Strobilites sewardii* in association with *E. Jabalpurensis*. The present specimen of *S.* cf. *sewardii* looks very much like the specimens of *S. sewardii* Sahni (1928).

CONCLUDING REMARKS

During our field trips to Kachchh we visited a large number of localities belonging to the Jhuran and Bhuj formations of Biswas and Deshpande (1983). The majority of the shale beds belonging to the Jhuran Formation were found to contain indeterminable plant debris. Only the Khari River Section near Rudra Mata Dam Site, besides indeterminable plant fragments, yielded a few identifiable plant remains. They are: *Cladophlebis daradensis*, *Cladophlebis* sp. A, *Cladophlebis* sp. C. *Pachypteris indica*, *P. specifica* and *Pagiophyllum chawadensis*. Out of these, except for *Cladophlebis* sp. A and *Cladophlebis* sp. C. the rest are all known from different localities belonging to the Bhuj Formation; especially they are fairly common at Kurbi, Gadhsisa, Kakadbhit and Chawad River (Biswas, 1977 mapped this region under Jhuran Formation).

In the Bhuj Formation we have found two distinct types of assemblages one of which is dominated by species of *Pachypteris*. In this assemblage the other important plant remains are a few species belonging to Pteridophyta, *Linguifolium* (only from Kakadbhit locality no. 2), *Sagenopteris* cf. *colpodes*, species of *Taeniopteris*, *Nilssoniopteris*, *Pterophyllum*, *Otozamites*, *Ptilophyllum*, *Elatocladus*, *Pagiophyllum* and *Brachyphyllum*. Out of these, except at Kakadbhit, *Brachyphyllum* is rather rare. The overall assemblage is more like the ones commonly met within the Middle Jurassic of other parts of the world, viz., Graham Land (see Halle, 1913) and Yorkshire. Only *Linguifolium* is more common in the Liassic. From none of the Jurassic-Lower Cretaceous formations of India, *Linguifolium*, *Sagenopteris* and *Nilssoniopteris* have been reported so far. In fact, the types of assemblages met with at Kurbi, Kakadbhit, etc. are quite distinct from the assemblages known anywhere from the Jurassic-Lower Cretaceous formations of India.

At Trambau, Sukhpur and Dharesi, which are supposed to belong to the Bhuj Formation, the plant assemblages are quite distinct from the ones mentioned from Kurbi, Gadhsisa, etc. In these localities *Ptilophyllum*, *Brachyphyllum* and *Allocladus* dominate. In addition, *Isoetites* and *Pagiophyllum* are also common. However, *Isoetites* is so far not known from Sukhpur. Because of the presence of *Isoetites* in these localities some of the deposits belonging to Bhuj Formation were most likely of fresh water origin. Besides, at many places especially at Trambau, Bhajodi, Kakadbhit and Dharesi root markings were seen in the shale beds. This too suggests that at least some of the plants were actually growing there and not drifted from else where. Except for the presence of *Isoetites* (which is so far known in India only from Kachchh) the assemblages at Trambau, Dharesi, etc. are more like the ones met within some of the localities belonging to the Jabalpur Formation, viz., Sehora, Hasnapur, etc. (see crookshank, 1936). The dominance of *Ptilophyllum* is also known from the various localities belonging to the Rajmahal Formation (Bindaban, Onthea, Amarjola, etc.), but at Bindaban, Onthea and Amarjola the conifers are rather rare. In the Rajmahal Hills, the conifers are more common only at Nipania, where bennettitalean remains are extremely rare. Most of these localities belonging to the Jabalpur and Rajmahal formations have been assigned an Upper Jurassic or Lower Cretaceous age.

From the three types of assemblages found within the Jhuran and Bhuj formations of Kachchh it is difficult to say much about the age of the Mesozoic fossiliferous beds of Kachchh. They may range is age from Middle to Upper Jurassic. Such differences in assemblages can also be due to geographical and ecological factors. It is quite possible that at Rudra Mata Dam Site the plant fossils were brought from somewhere else and they were perhaps deposited close to the shore line. The assemblages at Kurbi, Kakadbhit etc. are more suggestive of a halophytic type of vegetation as is known from some of the Middle Jurassic localities of Yorkshire and the ones known from Trambau, Sukhpur, Dharesi, etc. were perhaps further away from the sea. As such it is possible that the assemblages from the shale of Jhuran

and Bhuj formations were isochronous, controlled by facies variation, rather than belonging to widely different ages as thought earlier.

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EXPLANATION OF PLATES

PLATE 1

1. *Hepaticites sukhpurensis* n. sp. from Kera; B.S.I.P. specimen no. 11/2418. × 1.
2. *Thallites* sp. from Trambau; B.S.I.P. specimen no. 22/2419. × 1.
3-8. *Isoetites serratifolius* Bose & Roy; B.S.I.P. specimen nos. 56/2004 (from Dharesi), 51/2004 (from Dharesi), 32718 (from Ghuneri), 32717 (from Ghuneri), 32723 (from Ghuneri) and 32723 (from Ghuneri); 3-6, showing basal part of sporophyll and 7-8 showing upper part of sporophylls with serrations. 3-7. × 1, 8. × 2.
9-10, 14 *Isoetites indicus* Bose & Roy from Trambau; B.S.I.P. specimen nos. 30/2887, 32221 and 12/2887. × 1.
11-13. Megaspores isolated from *I. indicus* Bose & Roy; B.S.I.P. slide nos. 32221/17-4, 32220/19-9 and 32220/19-7. × 100.
15. *Hepaticites sukhpurensis* n. sp. from Sukhpur; B.S.I.P. specimen no. 26A/2235. × 1. (Figures 5-8 and 10-13 are from Bose & Roy, 1964).

PLATE 2

1. *Equisetites rajmahalensis* Oldham & Morris from Kakadbhit (locality no. 1); B.S.I.P. specimen no. 32725. × 1.
2, 3. cf. *Selaginellites* sp. from Trambau; B.S.I.P. specimen no. 70/2887. 2.× 2, 3.× 4.
4. *Hausmannia dichotoma* Dunker from Chawad River (locality no. 3); B.S.I.P. specimen no. 44/2411B. × 1.
5, 6. *Dictyophyllum* sp. from Chawad River (locality no. 1); B.S.I.P. specimen nos. 16/2411A and 7/2411A.× 1.
7-9. *Phlebopteris minutifolius* Banerji from Walka Mota (locality no. 3); B.S.I.P. specimen nos. 35412, 35414 and 35409; 7-8, showing fragments of sterile fronds and 9, a part of a fertile frond showing sori. 7.× 6, 8.× 4, 9. × 6.
10. A sorus of *P. minutifolius* Banerji showing 8 sporangia with distinct annulus.× 50 (Specimen consumed while isolating spores).
11-14. Isolated spores of *P. minutifolius* Banerji; B.S.I.P. slide nos. 6444 (figs. 11 & 14) and 6445 (figs. 12 & 13). × 500. (Figures 7-14 from Banerji, 1982).

PLATE 3

1-5. *Coniopteris* cf. *hymenophylloides* (Brongn.) Seward; B.S.I.P. specimen nos. 9/2085C (from Walka Mota), 43/2891B (from Chawad River-locality no. 3), 4/2076 (from Bhajodi), 23A/2891B (from Chawad River-locality no. 4) and A/2076 (from Bhajodi); 1-4 sterile fronds; 5, part of a fertile frond showing sori. 1 & 3.× 1, 2 & 4.× 2, 5.× 4.
6, 7. *Matonidium cingulatum* Zeba-Bano & Bose (parts of fertile specimens) from Trambau; B.S.I.P. specimen nos. 65/2001 and 98/878. 6.× 1, 7.× 4.
8, 9. Isolated spores of *M. cingulatum* Zeba-Bano & Bose; B.S.I.P. slide no. 22/878-2. × 500.
10-13. *Cladophlebis daradensis* n. sp.; B.S.I.P. specimen nos. 10/2679 (from Chawad River-locality no. 1), 17/2204 (from Kurbi), 34/2398 (from Rudra Mata Dam site) and 103/2677 (from Trambau).× 1. (Figures 6-9 from Zeba-Bano & Bose, 1981).

PLATE 4

1-3. *Cladophlebis* sp. A; B.S.I.P. specimen nos. 17/2206 (from Rudra Mata Dam site), 27/2002B (from Kurbi), 16/2204 (from Kurbi). × 1.
4. *Cladophlebis* sp. C from Khari River (Rudra Mata Dam Site); B.S.I.P. specimen no. 4/2206A. × 1.
5. *Cladophlebis daradensis* n. sp. from Trambau; B.S.I.P. specimen no. 78/2677. × 1.
6-8. *Sphenopteris metzgerioides* Harris; B.S.I.P. specimen nos. 76/2679B (from Chawad River-locality no. 3), 18/2676 (from Gadhsisa) and 21/2676A (from Gadhsisa). 6.× 1, 7.× 2, 8.× 1.
9. *Cladophlebis* sp. B. from Dharesi; B.S.I.P. specimen no. 11/2004. × 1.
10. *Cladophlebis* cf. *kathiawarensis* Roy from Kurbi; B.S.I.P. specimen no. 9/2204. × 1.
11. A piece of cuticle of *Cladophlebis* sp. C, showing a few stomata; B.S.I.P. slide no. 4/2206A-3 × 150.

PLATE 5

1, 2. *Cladophlebis* cf. *kathiawarensis* Roy from Jamthara; B.S.I.P. specimen nos. 30/2920 and 31/2920. × 1.
3. ? *Gleichenites* sp. from Trambau; B.S.I.P. specimen no. 16/2001. × 1.
4. *Cladophlebis* sp. C, showing two stomata; B.S.I.P. slide no. 4/2206-4. × 500.
5. ? *Coniopteris* cf. *minturensis* Brick from Trambau; B.S.I.P. specimen no. 80/2677. × 1.
6. A part of a fertile frond found in association with ?*Coniopteris* cf. *minturensis* Brick; B.S.I.P. specimen no. 14/2679. × 2.
7. Part of a fertile frond showing Dennstaedtoid affinities from Bhajodi; B.S.I.P. specimen no. 7/2076. × 1.

PLATE 6

1-6. *Sagenopteris* cf. *colpodes* Harris; B.S.I.P. specimen nos. A/2420 (from Kurbi), 18/2420 (from Kurbi), 179/2082 (from Kurbi), 105/2411B (from Chawad River — locality no. 3), 23/2082B (from Kurbi) and 38/2082 (from Kurbi). 1-2 and 4-6.× 1, 3.× 2.
7, 8. Fern frond — Type 1; B.S.I.P. specimen nos. 41/2419 (from Trambau) and 22/2920 (from Jamthara). 7.× 2, 8.× 1.
9. ? *Matonidium* sp. from Kakadbhit (locality no. 2); B.S.I.P. specimen no. 103/1212.× 1.
10. Counter part of a fertile frond showing Dennstaedtoid affinitie from Bhajodi; B.S.I.P. specimen no. 19/2076. × 4

PLATE 7

1-7. *Caytonia indica* n. sp. from Chawad River (locality no. 4); B.S.I.P. slide nos. 7052, 7052A, 7052B, 7052C, 7050, 7052D and 7049. × 1.
8. Figure 5 enlarged. × 12.
9. *C. indica* n. sp. from Chawad River (locality no. 4); B.S.I.P. slide no. 7052 E. × 6.
10. Figure no. 7 enlarged showing the lip; B.S.I.P. slide no. 7049. × 6.
11. Figure 1 enlarged. × 6.
12. Figure 2 enlarged. × 6.
13. An isolated seed of *C. indica* n. sp.; B.S.I.P. slide no. 7051. × 6.
14. Figure 7 enlarged showing the lip and the wrinkled outer wall; B.S.I.P. slide no. 7049. × 30.
15, 16. Showing seed cuticle with rectangular cells; B.S.I.P. slide no. 7049. × 60, and × 150.
17. Showing cells of the outer wall of 'fruit'; B.S.I.P. slide no. 7049. × 150.
18. showing micropylar end of a seed; B.S.I.P. slide no. 7051. × 150.

PLATE 8

1-5. *Pachypteris indica* (Oldham & Morris) Bose & Roy; B.S.I.P. specimen nos. 2/2679C (from Chawad River — locality no. 2), 56/2411 (from Chawad River — locality no. 4), 3/2411 (from Chawad River — locality no. 4), 100/2411B (from Chawad River — locality no. 3) and 66/2411 (from Chawad River — locality no. 4). × 1.
6-8. *P. indica* showing venation of a few pinnules; B.S.I.P. specimen nos. 1/2679C (from Chawad River — locality no. 2), 1/2679C (from Chawad River — locality no. 2) and 4/2679 (from Chawad River — locality no. 2). × 4.

PLATE 9

1. *Pachypteris indica* (Oldham & Morris) Bose & Roy from Chawad River (locality no. 2); B.S.I.P. specimen no. 74/2411C. × 1.
2-4. *Pachypteris specifica* Feistmantel; B.S.I.P. specimen nos. 35/2398 (from Rudra Mata Dam site), 19/2676 (from Gadhsisa) and 22/2679A (from Chawad River — locality no. 3). × 1.
5. *P. indica* (Oldham & Morris) Bose & Roy from Chawad River (locality no. 3); B.S.I.P. specimen no. 26/2411. × 1.
6. *P. specifica* Feistmantel showing venation of a few pinnules from Chawad River (locality no. 4); B.S.I.P. specimen no. 41/2411. × 8.
7, 8. *P. indica* (Oldham & Morris) Bose & Roy from Chawad River (locality no. 2); B.S.I.P. specimen nos. 1/2679C and 1/2679C. 7- × 4, 8- × 4.
9. *P. indica* (Oldham & Morris) Bose & Roy, showing cells of upper cuticle; B.S.I.P. slide no. 90/2411-1. × 150.

PLATE 10

1-4. *Pachypteris specifica* Feistmantel; B.S.I.P. specimen nos. 125/2203B (from Kakadbhit — locality no. 2), 25/2000C (from Kakadbhit — locality no. 2), 63/2411B (from Chawad River — locality no. 4) and 97/2079B (from Kakadbhit — locality no. 2). × 1.
5, 6. *P. indica* (Oldham & Morris) Bose & Roy showing distribution of stomata on lower surface; B.S.I.P. slide nos. 90/2411-1 and 74/2411C. × 150.

PLATE 11

1-7. *Pachypteris specifica* Feistmantel; B.S.I.P. specimen nos. 36/2082 (from Kurbi), 41/2411 (from Chawad River — locality no. 4), G.S.I. specimen no. 4/792 (from Kakadbhit — locality no. 1), 15/2404 (from Gadhsisa), 44/2203 (from Kakadbhit — locality no. 1), 40/2676 (from Gadhsisa) and 2000A (from Kakadbhit—locality no. 1). × 1.
8, 9. *Pachypteris indica* (Oldham & Morris) Bose & Roy showing two stomata; B.S.I.P. slide nos. 90/2411-1 and 100/2411. × 500.

PLATE 12

1-3. *Ctenozamites kachchhensis* n. sp. from Kakadbhit (locality no. 2); B.S.I.P. specimen nos. 65/522, 100/2079B and 77/2079B. × 1.
4. *Pachypteris specifica* Feistmantel, lower cuticle showing distribution of stomata; B.S.I.P. slide no. 6/2404-1. × 150.
5. *P. specifica* Feistmantel, showing a stoma; B.S.I.P. slide no. 6/2404-1. × 500.

PLATE 13

1. *Pachypteris* cf. *elegans* Archangelsky from Trambau; B.S.I.P. slide no. 32129. × 1.
2. The above magnified. × 4.
3. A portion from the above magnified, showing distribtion of stomata; B.S.I.P. slide no. 32129-2. × 15.
4. *P.* cf. *elegans* Archangelsky, showing distribution of stomata on lower surface; B.S.I.P. slide no. 32129-2. × 150.
5. *P.* cf. *elegans* Archangelsky, showing a few cells on upper surface; B.S.I.P. slide no. 32129-1. × 150.
6. *P.* cf. *elegans* Archangelsky, showing two stomata; B.S.I.P. slide no. 32129-2. × 500.

PLATE 14

1-5. *Ctenozamites kachchhensis* n. sp. from Trambau; B.S.I.P. specimen nos. 32171 (figs 1 & 5), 32178 (figs 2 & 3) and 32174. 1-2, 4. × 1, 3. × 4, 5. × 2.
6. *C. kachchhensis* n. sp., showing upper surface; B.S.I.P. slide no. 32174-1. × 150.
7. *C. kachchhensis* n. sp., showing distribution of stomata in lower surface; B.S.I.P. slide no. 32174-1. × 150.
8. *C. kachchhensis* n. sp., showing two stomata; B.S.I.P. slide no. 32174-1. × 500.

PLATE 15

1, 2. *Pseudoctenis fragilis* n. sp.; B.S.I.P. specimen nos. 3/2417A (from Sukhpur) and 49/2411 (from Chawad River — locality no. 3). × 1.

3. *P. fragilis* n. sp., showing upper cuticle; B.S.I.P. specimen no. 71/2417-1. × 150.
4. A stoma of *Pachypteris* cf. *elegans* Archangelsky; B.S.I.P. slide no. 32129-2. × 500.

PLATE 16

1. *Pseudoctenis fragilis* n. sp. from Chawad River (locality no. 3); B.S.I.P. specimen no. 130/2411. × 1.
2. *Pterophyllum distans* Morris from Kakadbhit (locality no. 2); B.S.I.P. specimen no. 62/1212. × 1.
3. Lower cuticle of *Pseudoctenis fragilis* n. sp., showing a few stomata; B.S.I.P. no. 71/2417-1. × 150.
4. A stoma of *P. fragilis* n. sp.; B.S.I.P. specimen no. 71/2417-1. × 500.

PLATE 17

1, 2, 5. *Anomozamites* cf. *fissus* Feistmantel from Dharesi (locality no. 1); B.S.I.P. specimen nos. 3/2004B, 5/2084 and 3/2084A. × 1.
3. A detached pinna of *Pseudoctenis fragilis* n. sp. from Trambau; B.S.I.P. specimen no. 4/1723a. × 1.
4. *Nilssoniopteris pannuceus* n. sp. from Chawad River (locality no. 2); B.S.I.P. specimen no. 2/2411C. × 1.
6. *Pterophyllum distans* Morris from Kakadbhit (locality no. 2); B.S.I.P. specimen no. 111/1212. × 1.
7, 8. *Nilssoniopteris pannuceus* n. sp. from Chawad River (locality no. 2); B.S.I.P. specimen nos. 7/2411 and 4/2411C. × 1. (Figure 6 from Bose & Banerji, 1981).

PLATE 18

1, 2. *Nilssoniopteris variabilis* n. sp. from Trambau; B.S.I.P. specimen nos. 32054 and 32054A. × 1.
3. *Nilssoniopteris pannuceus* n. sp. from Chawad River (locality no. 2); B.S.I.P. specimen no. 9/2411C. × 1.
4. Upper cuticle of *N. variabilis* n. sp.; B.S.I.P. slide no. 32054-5. × 150.
5. Upper cuticle of *N. pannuceus* n. sp.; B.S.I.P. slide no. 11/2411C-1. × 150.
6. Lower cuticle of *N. variabilis* n. sp., B.S.I.P. slide no. 32054-5. × 150.

PLATE 19

1. A stoma of *Nilssoniopteris pannuceus* n. sp.; B.S.I.P. slide no. 11/2411C. × 500.
2. *N. pannuceus* n. sp., showing distribution of stomata on lower surface; B.S.I.P. slide no. 11/2411C. × 150.
3. A stoma of *Nilssoniopteris variabilis* n. sp. giving a false impression of being anomocytic in nature; B.S.I.P. slide no. 32054-5. × 500.
4. A stoma of *Nilssoniopteris variabilis* n. sp.; B.S.I.P. slide no. 32054-6. × 500.
5. A typical paracytic type of stoma of *N. variabilis* n. sp.; B.S.I.P. slide no. 32054-5. × 500.

PLATE 20

1, 2. *Otozamites imbricatus* Feistmantel from Loharia; B.S.I.P. specimen no. 4812 (both the specimens are preserved in the same block). × 1.
3-6. *Otozamites walkamotaensis* Bose & Zeba-Bano; B.S.I.P. specimen nos. 7/2085A (Walka Mota—locality no. 1), 29/2215E, 30/2215E and 29/2215E (Walka Mota—locality no. 2), 3, 5 and 6. × 1, 4. × 2.
7, 8. *Dictyozamites* sp. from Kakadbhit (locality no. 2); B.S.I.P. nos. 88/2203B and 91/2079. 7. × 1, 8. × 2.
9. Lower cuticle of *Otozamites imbricatus* Feistmantel; B.S.I.P. slide no. 3926-1. × 150.
10. *O. imbricatus* Feistmantel, showing two stomata; B.S.I.P. slide no. 3926-1. × 500. (Figures 1, 2 and 9, 10 from Bose, 1974).

PLATE 21

1-3. *Otozamites walkamotaensis* Bose & Zeba-Bano from Walka Mota (locality no. 2); B.S.I.P. specimen nos. 18/2085B, 17/2085B and 8/2085B. × 1.
4. *O. walkamotaensis* Bose & Zeba-Bano, showing a stoma and a few rachis cells; B.S.I.P. slide no. 8/2085B-1. × 500.
5. Upper cuticle of *O. walkamotaensis* Bose & Zeba-Bano; B.S.I.P. slide no. 16/2085B-1. × 250.
6. *O. walkamotaensis* Bose & Zeba-Bano, showing a few papillae along a non-stomatal band; B.S.I.P. slide no. A1/2085-2. × 500.
7. Stomatal and non-stomatal bands of lower surface of *O. walkamotaensis* Bose & Zeba-Bano; B.S.I.P. slide no. B1/2085B-1. × 60.
8. *O. walkamotaensis* Bose & Zeba-Bano, showing a stoma; B.S.I.P. slide no. 5/2085B-1. × 500.
9. *O. walkamotaensis* Bose & Zeba-Bano, showing a few stomata on lower surface of lamina; B.S.I.P. slide no. A1/2085B-2. × 150. (All figures from Bose & Zeba-Bano, 1981).

PLATE 22

1-7. *Otozamites kachchhensis* n. sp., figures 1-2 and 4-7 from Chawad River (locality no. 3) and figure 3 from Kakadbhit (locality no. 1); B.S.I.P. specimen nos. 31/2891A, 24/2679B, 52/2411, 61/2679B, 2/2891A, 31/2891A and 24/2679B. 1.5. × 1, 6.7. × 2.
8. Upper surface of *O. kachchhensis* n. sp.; B.S.I.P. slide no. 61/2679B-1. × 150.
9. *O. kachchhensis* n. sp., showing a stoma; B.S.I.P. slide no. 61/2679B-1. × 500.
10. Lower surface of *O. kachchhensis* n. sp.; B.S.I.P. slide no. 61/2679B-1. × 150.

PLATE 23

1. *Ptilophyllum cutchense* Morris — Type 1 from Kurbi; B.S.I.P. specimen no. 7/2420. × 1.
2, 3, 7. *P. cutchense* Morris — Type 2 from Kurbi; B.S.I.P. specimen nos. 60/2082B, 111/2420 and 90/2420. × 1.
4-6. *P. cutchense* Morris, figures 4-5 from Kakadbhit (locality no. 1) and figure 6 from south of Charwar

range; G.S.I. specimen nos. 4/808 and 4/804 and Br. Mus. specimen no. V 20191 (9943). × 1.

8-11. *Ptilophyllum acutifolium* Morris, figures 8-9 from south of Charwar range and figures 10-11 from Kakadbhit (locality no. 1); Br. Mus. specimen nos. V 21330 (9942) and V 20190 (9941) and B.S.I.P. specimen nos. 33765 and 33766. × 1. (Figures 4-6 and 8-11 from Bose & Kasat, 1972).

PLATE 24

1. *Ptilophyllum cutchense* Morris, a few leaves attached to *Bucklandia* type of stem from Kurbi; B.S.I.P. specimen no. 34094. × 1.
2. *Ptilophyllum horridum* Roy from Trambau; B.S.I.P. specimen no. 33875. × 1. (Both the figures from Bose & Kasat, 1972).

PLATE 25

1-3, 5. *Ptilophyllum indicum* Jacob & Jacob, figures 1, 3 and 5 from Trambau and figure 2 from Sukhpur; B.S.I.P. specimen nos. 33771, 36/2417A, 31884 and 33770. × 1.

4, 6. *Ptilophyllum oldhamii* Jacob & Jacob from Trambau; B.S.I.P. specimen nos. 33767 and 32415. × 1.

7. *P. oldhamii* Jacob & Jacob, showing 3 enlarged pinnae; B.S.I.P. specimen no. 33767. × 10.
8. *P. indicum* Jacob & Jacob, a few pinnae enlarged; B.S.I.P. specimen no. 33770. × 10.
9. *P. oldhamii* Jacob & Jacob, lower cuticle; B.S.I.P. slide no. 32415-1. × 150.
10. *P. oldhamii* Jacob & Jacob, showing a few stomata; B.S.I.P. slide no. 33737-1. × 500.
11. *P. oldhamii* Jacob & Jacob, showing distribution of stomata on lower surface; B.S.I.P. slide no. 32415-2. × 40.

PLATE 26

1,2. *Ptilophyllum sakrigaliensis* Sah, figure 1 from Khari River and figure 2 from Chawad River (locality no. 2); B.S.I.P. specimen nos. 31872 and 46/2411C. × 1.

3. *Ptilophyllum indicum* Jacob & Jacob, showing lower cuticle; B.S.I.P. slide no. 33768. × 150.
4. A stoma of *P. indicum* Jacob & Jacob; B.S.I.P. slide no. 33768. × 500.
5. *P. indicum*, showing distribution of stomata on lower surface; B.S.I.P. slide no. 33768. × 40. (Except figure 2, the rest are from Bose & Kasat, 1972).

PLATE 27

1, 5. *Ptilophyllum sakrigaliensis* Sah from Chawad River (locality no. 2); B.S.I.P. specimen nos. 26/2411C and 29/2411C. × 1.

2. *P. sakrigaliensis* Sah, upper cuticle; B.S.I.P. slide no. 29/2411C. × 150.
3. *P. sakrigaliensis*, lower cuticle; B.S.I.P. slide no. 31872-4. × 150.
4. *P. sakrigaliensis*, showing two stomata; B.S.I.P. slide no. 31872-1. × 500. (Figures 3 & 4 from Bose & Kasat, 1972).

PLATE 28

1, 2, 8. *Ptilophyllum distans* (Feistmantel) Jacob & Jacob, figures 1-2 from Trambau and figure 8 from Sukhpur; B.S.I.P. specimen nos. 31918, 31930 and 14/2417. × 1.

3-6. *Ptilophyllum horridum* Roy from Trambau; B.S.I.P. specimen nos. 33874, 31889, 31937 and 33873. × 1.

7. *P. horridum* Roy, a few pinnae enlarged; B.S.I.P. specimen no. 31911. × 5.
9. *P. distans* (Feistmantel) Jacob & Jacob, showing two stomata; B.S.I.P. slide no. 31918. × 500.
10. *P. distans* (Feistmantel) Jacob & Jacob, showing stomatal distribution; B.S.I.P. slide no. 31918. × 40. (Except figure 8, all are from Bose & Kasat, 1972).

PLATE 29

1. *Ptilophyllum institacallum* Bose from Chawad River (locality no. 3); B.S.I.P. specimen no. 17/2891A. × 1.
2. *Ptilophyllum* sp. from Walka Mota (locality no. 2); B.S.I.P. specimen no. 32/2215E. × 1.

3-4. *Ptilophyllum* cf. *amarjolense* Bose from Chawad River (locality no. 3); B.S.I.P. specimen nos. 64/2891A and 16/2891A . × 1.

5. *P. institacallum* Bose, upper cuticle; B.S.I.P. slide no. 13/2424. × 150.
6. *P. institacallum* Bose, lower cuticle; B.S.I.P. slide no. 13/2424. × 150.
7. *P. institacallum* Bose, showing two stomata; B.S.I.P. slide no. 13/2424. × 500.

PLATE 30

1. *Ptilophyllum* cf. *amarjolense* Bose, showing distribution of stomata on lower surface; B.S.I.P. slide no. 16/2891A-2. × 150.
2. *P.* cf. *amarjolense* Bose, showing a few stomata; B.S.I.P. slide no. 16/2891-1. × 500.
3. *Ptilophyllum* sp., showing lower cuticle; B.S.I.P. slide no. 32/2215E-1. × 150.
4. *Ptilophyllum* sp., showing two stomata; B.S.I.P. slide no. 32/2215E-1. × 500.

PLATE 31

1-2, 7. *Weltrichia harrisiana* n. sp., figures 1 and 2 from Kurbi and figure 7 from Kakadbhit (locality no. 1); B.S.I.P. specimen nos. 20/2204, 19/2204 and 10/1725. 1, 7. × 1, 2. × 2.

3-6. *Weltrichia* sp. from Kakadbhit (locality no. 2); B.S.I.P. specimen nos. 32208, 32229, 32229 and 32208. 3-4. × 1, 5. × 3, 6. × 5.

8-10. *Williamsonia blandifordi* Feistmantel from Kakadbhit (locality no. 1); G.S.I. specimen no. 4/844, B.S.I.P. specimen nos. 95/2079 and 84/2678. × 1.

PLATE 32

1, 3, 5, 9, 10. *Williamsonia kakadbhitensis* n. sp., figures 1, 3, 5 and 10 from Kakadbhit (locality no. 2) and figure 9 from Kurbi; B.S.I.P. specimen

nos. 32228, 33/2203B, 1/2079B, 176/2082 and 92/2079. × 1.
2, 4. *Williamsonia blanfordii* Feistmantel from Kakadbhit (locality no. 2); B.S.I.P. specimen nos. 78/2079 and 32/2203B. × 1.
6. *Cycadolepis pilosa* Feistmantel from Kakadbhit (locality no. 2); B.S.I.P. specimen no. 71/522. × 1.
7, 8. *Bennetticarpus* sp. from Kakadbhit (locality no. 1); B.S.I.P. specimen nos. 45/2407 and 46/2407. × 1.

PLATE 33

1. *Williamsonia trambauensis* n. sp. from Trambau; B.S.I.P. specimen no. 34A/2887. × 1.
3-5. *Williamsonia kakadbhitensis* n. sp., figures 3-4 from Kakadbhit (locality no. 2) and figure 5 from Walka Mota (locality no. 1); B.S.I.P. specimen nos. 32232, 32226 and 3/2085. × 1.
6, 7. *Elatocladus* cf. *tennerimus* (Feistmantel) Sahni from Kakadbhit (locality no. 2); B.S.I.P. specimen nos. A/2203B and 123/2263. × 1.
2, 8. *Williamsonia sukhpurensis* n. sp. from Sukhpur; B.S.I.P. specimen nos. 44/2089 and 30/2089. × 1.

PLATE 34

1. Lower cuticle of *Williamsonia trambauensis* n. sp.; B.S.I.P. slide no. 34/2887-2. × 150.
2. Upper cuticle of *W. trambauensis* n. sp.; B.S.I.P. slide no. 34/2887-1. × 150.
3. *W. trambauensis* n. sp., showing two stomata; B.S.I.P. slide no. 34/2887B-2. × 500.
4. Lower cuticle of *Williamsonia sukhpurensis* n. sp.; B.S.I.P. slide no. 30/2089-1. × 150.
5. *W. sukhpurensis* n. sp., showing a stoma; B.S.I.P. slide no. 30/2089-1. × 500.

PLATE 35

1. Upper cuticle of *Williamsonia sukhpurensis* n. sp.; B.S.I.P. slide no. 44/2089-2. × 150.
2. Lower cuticle of *W. sukhpurensis* n. sp.; B.S.I.P. slide no. 44/2089-1. × 150.
3. Upper cuticle of *W. sukhpurensis* n. sp.; B.S.I.P. slide no. 30/2089-1. × 150.
4. *W. sukhpurensis* n. sp., showing a stoma; B.S.I.P. slide no. 44/2089-1. × 500.

PLATE 36

1-5. *Elatocladus confertus* (Oldham & Morris) Halle; B.S.I.P. specimen nos. 44/2000c (from Kakadbhit locality no. 2), 71/2082 (from Kurbi), 118/2420 (from Kurbi), 152/2082 (from Kurbi) and 159/2082 (from Kurbi). × 1.
6, 7. *Elatocladus* cf. *tenerrimus* (Feistmantel) Sahni; B.S.I.P. specimen nos. 39/2079 (from Kakadbhit locality no. 2) and 8/2920 (from Jamthara). × 1.

PLATE 37

1-3. *Elatocladus jabalpurensis* (Feistmantel) Sahni from Chawad River (locality no. 3); B.S.I.P. specimen nos. 1/2679, 28/2411B and 5/2679B. × 1.
4, 5. *Elatocladus chawadensis* n. sp. from Chawad River (locality no. 4); B.S.I.P. specimen nos. 45/2891B and 36/2891B. × 1.
6. Upper cuticle of *E. chawadensis* n. sp.; B.S.I.P. slide no. 47/2891B-1. × 150.
7. Lower cuticle of *E. chawadensis* n. sp.; B.S.I.P. slide no. 47/2891B-1. × 150.
8. A stoma of *E. chawadensis* n. sp.; B.S.I.P. slide no. 47/2891B-1. × 500.

PLATE 38

1, 2. *Pagiophyllum grantii* n. sp. from Trambau; B.S.I.P. specimen nos. 71/2677 and 84/2677. × 1.
3. *P. grantii* n. sp., showing upper surface; B.S.I.P. slide no. 84/2677-1. × 150.
4. *P. grantii* n. sp., showing lower surface; B.S.I.P. slide no. 84/2677-1. × 150.
5. *P. grantii* n. sp., showing two stomata of lower surface, B.S.I.P. slide no. 84/2677-1. × 500.

PLATE 39

1. *Pagiophyllum chawadensis* n. sp. from Chawad River (locality no. 3); B.S.I.P. slide no. 135/2411B. × 1.
2. Upper surface of *P. chawadensis* n. sp.; B.S.I.P. slide no. 38/2676-1. × 150.
3. Lower surface of *P. chawadensis* n. sp.; B.S.I.P. slide no. 38/2676-1. × 150.
4, 5. Showing stomata; B.S.I.P. slide nos. 38/2676-1 and 38/2676-1. × 500.

PLATE 40

1-3. *Pagiophyllum chawadensis* n. sp. from Chawad River (locality no. 3); B.S.I.P. specimen nos. 6/2679B, 44/2679 and 65/2411B. × 1.
4. Lower surface of *Pagiophyllum morrisii* n. sp.; B.S.I.P. slide no. 71/2679-1. × 150.
5. *P. morrisii* n. sp. lower surface showing two stomata; B.S.I.P. slide no. 71/2679B-1. × 500.

PLATE 41

1, 2. *Pagiophyllum chawadensis* n. sp.; B.S.I.P. specimen nos. 31/2266A (from Rudra Mata Dam site) and 38/2676 (from Gadhsisa). × 1.
3-5. *Pagiophyllum morrisii* n. sp. from Chawad River (locality no. 3); B.S.I.P. specimen nos. 71/2679B, 60/2679 and 11/2679B. × 1.
6. Upper surface of *P. morrisii* n. sp.; B.S.I.P. slide no. 71/2679-1. × 150.

PLATE 42

1. *Brachyphyllum royii* n. sp. from Trambau; B.S.I.P. specimen no. 11/2887. × 1.
2. Lower cuticle of *B. royii* n. sp.; B.S.I.P. slide no. 84/2089C. × 150.
3, 4. Two stomata from lower surface of *B. royii* n. sp.; B.S.I.P. slide no. 84/2089C. × 500.

PLATE 43

1-4. *Araucarites minutus* Bose & Maheshwari; B.S.I.P. specimen nos. 5/2081 (from Dauda Mota), 5/2236 (from Gamdau), 9/2419 (from Trambau) and 56/2085 (from Walka Mota). × 1.
5. *Araucarites* cf. *nipaniensis* Singh from Walka Mota; B.S.I.P. specimen no. 91/2085. × 1.
6-12. *Araucarites janaianus* n. sp.; B.S.I.P. specimen nos. 8/2887 (from Trambau), 41/2887 (from Trambau), 70/2677 (from Trambau), 27/2001 (from Trambau), 72/2887 (from Trambau), 29/2891A (from Chawad River — locality no. 3), 94/2411 (from Chawad River — locality no. 4). × 1.
13, 14. *Araucarites cutchensis* Feistmantel; G.S.I. specimen no. 4/848 and B.S.I.P. specimen no. 33/2885. × 1.
15. *A. janaianus* n. sp.; B.S.I.P. slide no. 70/2677-1. × 150.
16. *A. janaianus* n. sp. showing a stoma; B.S.I.P. slide no. 70/2677-1. × 500.

PLATE 44

1. *Araucarites janaianus* n. sp., showing a few cells and stomata from apical end of a cone-scale; B.S.I.P. slide no. 29/2891A-1. × 150.
2. Seed cuticle of *A. janaianus* n. sp., showing elongated cells of seed cuticle; B.S.I.P. slide no. 29/2891-2. × 150.
3. *A. janaianus* n. sp., showing a few stomata near apical end of a cone-scale; B.S.I.P. slide no. 29/2891A-1. × 150.
4. *A. janaianus* n. sp., showing a stoma; B.S.I.P. slide no. 29/2891A-1. × 500.

PLATE 45

1, 3. A specimen of *Taeniopteris* with part and counterpart resembling *Taeniopteris* sp. A from Trambau; B.S.I.P. specimen nos. 35/2083 and 25/2083. × 1.
2, 4, 6, 8. *Taeniopteris* cf. *spatulata* McClelland; B.S.I.P. specimen nos. 5/2240 (from Ugardi), 18/2004 (from Dharesi), 2/2000A (from Kakadbhit — locality no. 1). 2, 4, 6.× 1 and 8.× 2.
7, 9. *Taeniopteris kutchensis* Bose & Banerji from Kakadbhit (locality no. 1); G.S.I. specimen nos. 4778 and 4777. × 1.
5, 10. *Linguifolium curvatum* n. sp. from Kakadbhit (locality no. 2); B.S.I.P. specimen nos. 24/1212 and 38/2000C. × 1.

PLATE 46

1. *Taeniopteris* sp. A. from Trambau, showing a few stomata; B.S.I.P. slide no. 49/2420-1. × 500.
2. Single stoma of a specimen resembling *Taeniopteris* sp. A.; B.S.I.P. slide no. 35/2083. × 500.
3. Lower cuticle of a specimen resembling *Taeniopteris* sp. A., showing a few stomata; B.S.I.P slide no. 35/2083. × 150.
4. A specimen resembling *Taeniopteris* sp. A., showing cells of upper cuticle; B.S.I.P. slide no. 35/2083. × 150.

PLATE 47

1-3. ?*Bucklandia* sp. from Kakadbhit (locality no. 1); B.S.I.P. specimen nos. 256/2000A, 8/2079A and 11/2079A. × 1.
4. *Ptilophyllum cutchense* Morris from Jamthara; B.S.I.P. specimen no. 13/2920. × 1.
5. *Taeniopteris* sp. A. from Trambau, showing non-stomatiferous surface; B.S.I.P. slide no. 49/2420-1. × 150.
6. Stomatiferous surface of *Taeniopteris* sp. A.; B.S.I.P. slide no. 49/2420-1. × 150.

PLATE 48

1. *Trambaua apiculata* n. gen., n. sp. from Trambau; B.S.I.P. specimen no. 135/2677.× 1.
2. Above specimen enlarged. × 4.
3. Non-stomatiferous surface of *T. apiculata* n. gen., n. sp., showing microthyriaceous body (M); B.S.I.P. slide no. 135/2677. × 150.
4. *T. apiculata* n. gen., n. sp., showing a stoma; B.S.I.P. slide no. 135/2677. × 500.
5. Stomatiferous surface of *T. apiculata* n. gen., n. sp.; B.S.I.P. slide no. 135/2677. × 150.
6. *T. apiculata* n. gen., n. sp., showing a stoma; B.S.I.P. slide no. 135/2677. × 500.

PLATE 49

1-3. *Lorumformophyllum dentatum* n. gen., n. sp. from Trambau; B.S.I.P. specimen nos. 32161, 3/1723 and 32139. 1.× 1, 2.× 2, 3.× 2.
4. Fig. 3 enlarged. × 4.
5. Non-stomatiferous surface of *L. dentatum* n. gen., n. sp.; B.S.I.P. slide no. 32139-2. × 150.
6. Stomatiferous surface of *L. dentatum* n. gen., n. sp.; B.S.I.P. slide no. 32139-2. × 150.
7. *L. dentatum* n. gen., n. sp., showing a stoma; B.S.I.P. slide no. 32139-3. × 500.

PLATE 50

1-5. *Allocladus biswasianus* n. sp.; B.S.I.P. specimen nos. A/2235 (from Trambau), 65/2089 (from Sukhpur), 3/2235 (from Trambau), 74/2001 (from Trambau) and 11/2235 (from Trambau). × 1.
6. *A. biswasianus* n. sp., upper cuticle showing distribution of stomata; B.S.I.P. slide no. 65/2089-1. × 150.
7. *A. biswasianus* n. sp., showing cells of lower cuticle; B.S.I.P. slide no. 65/2089-1. × 150.
8. *A. biswasianus* n. sp., showing a stoma; B.S.I.P. slide no. 65/2089-1. × 500.

PLATE 51

1. *Leaf type* — 2 from Ugardi; B.S.I.P. specimen no. 6/2240. × 1.
2. *Leaf type* — 1 from Chawad River (locality no. 6); B.S.I.P. specimen no. 12/2424. × 1.
3. Non-stomatiferous surface of *Leaf type* — 2; B.S.I.P. slide no. 6/2240-2. × 150.
4. A stoma of *Leaf type* — 2; B.S.I.P. slide no. 6/2240-1. × 500.
5. Stomatiferous surface of *Leaf type* — 2, showing a stomatal band; B.S.I.P. slide no. 6/2240-1. × 150.

PLATE 52

1. *Leaf type*-1, showing non-stomatiferous surface; B. S.I.P. slide no. 12/2424-1. × 150.
2. Stomatiferous surface of *Leaf type* — 1, showing two stomatal bands; B.S.I.P. slide no. 12/2424-1. × 150.
3. A stoma of *Leaf type*-1; B.S.I.P. slide no. 12/2424-1. × 500.

PLATE 53

1-3. *Kachchhia navicula* n. gen., n. sp.; B.S.I.P. nos. A/2203B (from Kakadbhit — locality no. 2), 39/2404 (from Gadhsisa) and 110/2203B (from Kakadbhit — locality no. 2). 1.× 1, 2.× 1, 3. × 4.
4-6. *K. navicula* n. gen., n. sp., obtained by macerating shale samples in bulk from Chawad River (locality no. 4); B.S.I.P. slide nos. 7062, 7055 and 7045. × 6.
7. *K. navicula* n. gen., n. sp., showing a sporangium; B.S.I.P. slide no. 7060. × 6.
8, 9. *K. navicula* n. gen., n. sp., showing a few pollen grains (P) adhering to a sporangial wall; B.S.I.P. slide nos. 7063 and 7061. × 150.

PLATE 54

1. *Kachchhia navicula* n. gen., n. sp., showing cuticle near apical end of a lateral branch; B.S.I.P. slide no. 7056. × 150.
2. *K. navicula* n. gen., n. sp., showing rachis cells; B.S.I.P. slide no. 7065. × 150.
3. *K. navicula* n. gen., n. sp., showing cells of a lateral branch near apical end; B.S.I.P. slide no. 7056. × 150.
4. *K. navicula* n. gen., n. sp., showing two stomata of a lateral branch; B.S.I.P. slide no. 7056. × 500.

PLATE 55

1, 2. *Cone type*-1.; B.S.I.P. specimen nos. 3/2407 (from Kakadbhit — locality no. 1) and 35/2885 (from Kakadbhit — locality no. 1). × 1.
3, 4. *Carpolithes* sp. A., showing part and counterpart; B.S.I.P. specimen no. 38/1212. × 1.
5, 8, 11, 15. *Brachyphyllum royii* n. sp.; B.S.I.P. specmen nos. 4/2677 (from Trambau), 32262 (from Trambau), 95/2677 (from Trambau) and 1/2418 (from Kera). × 1.
6, 7. *Strobilites* cf. *sewardi* Sahni; B.S.I.P. specimen nos. 41/2420 (from Kurbi) and 42/2885 (from Kakadbhit — locality no. 1). × 1.
9, 10. ?Receptacle of *Rajmahalia* sp. from Kakadbhit (locality no. 2); B.S.I.P. specimen nos. 101/2079 and 44/2203. Figs. 9 and 10. × 1 and fig. 12, a part of fig. 10 enlarged two times.
13, 14. *Carpolithes* sp. B.; B.S.I.P. specimen nos. 49/2885 (from Kakadbhit — locality no. 1) and 25/2001 (from Trambau). × 1.
16. *Conites* sp. A. (from Kakadbhit — locality no. 1); B.S.I.P. specimen no. 56/2885A. × 1.

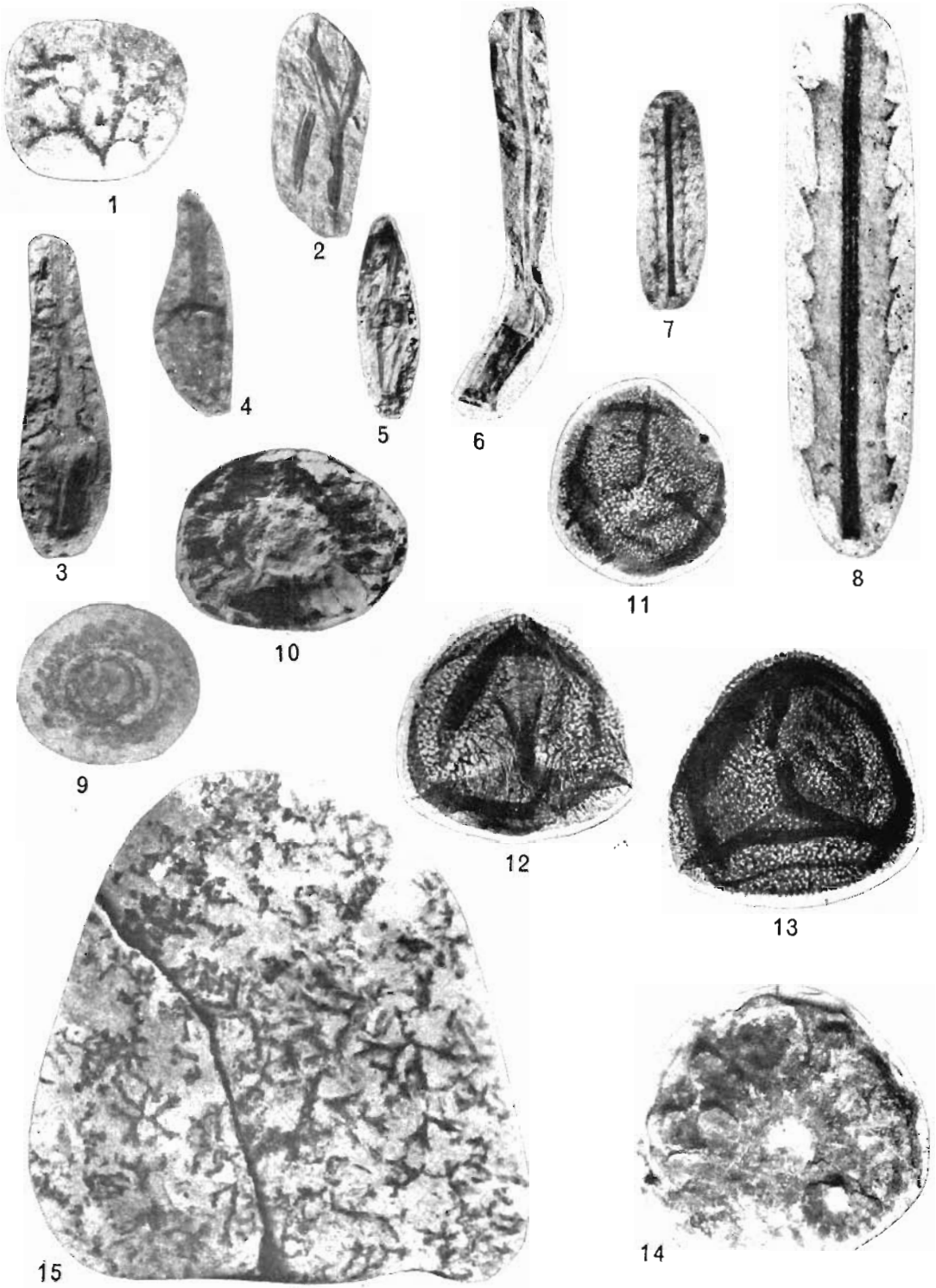

PLATE 1

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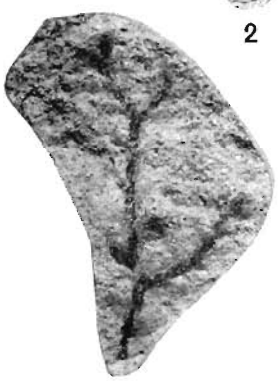

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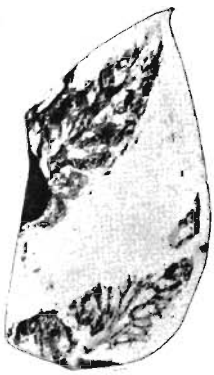

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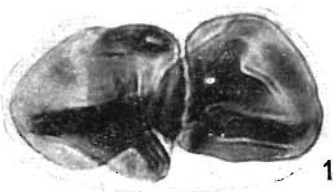

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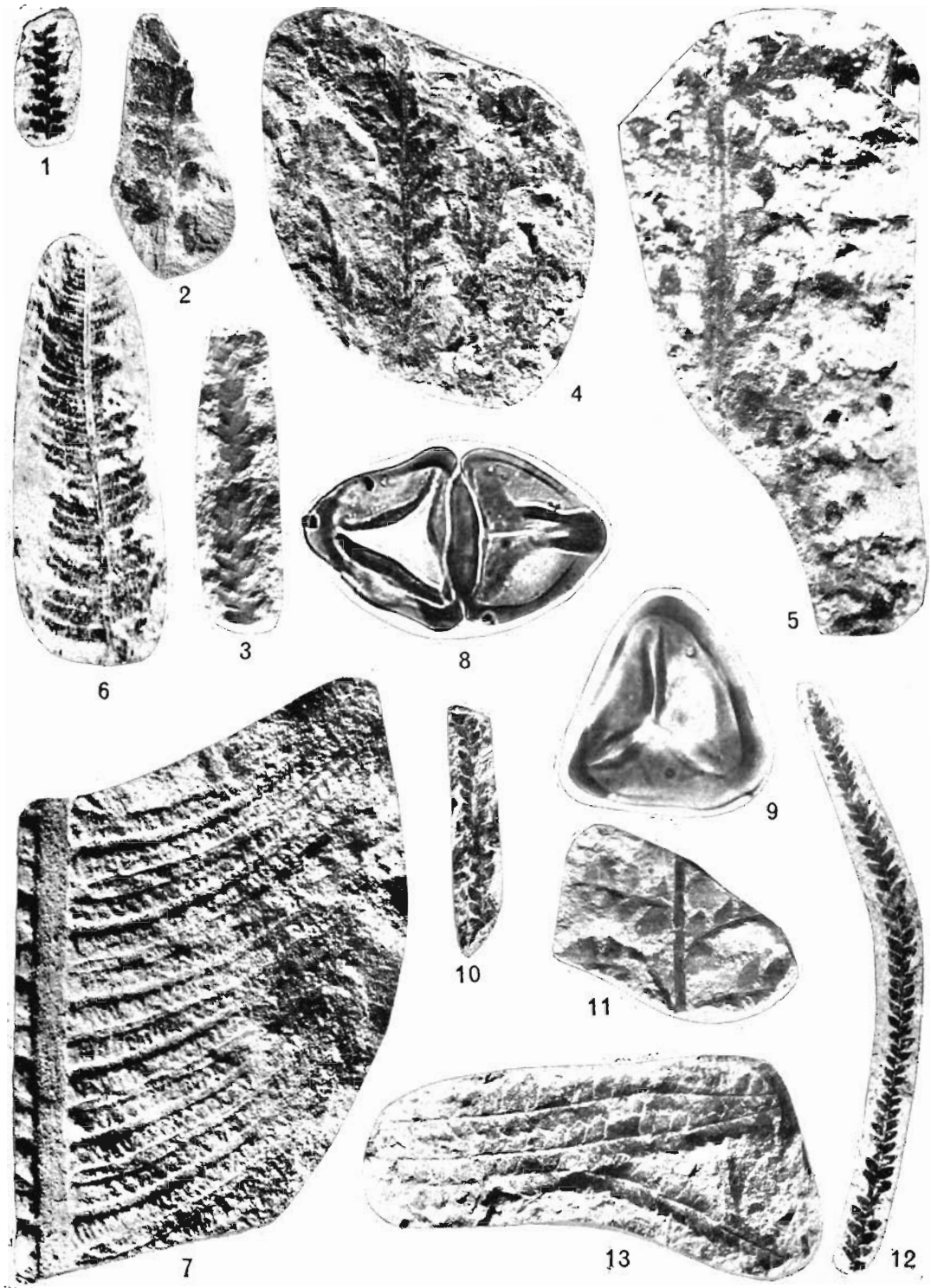
PLATE 2



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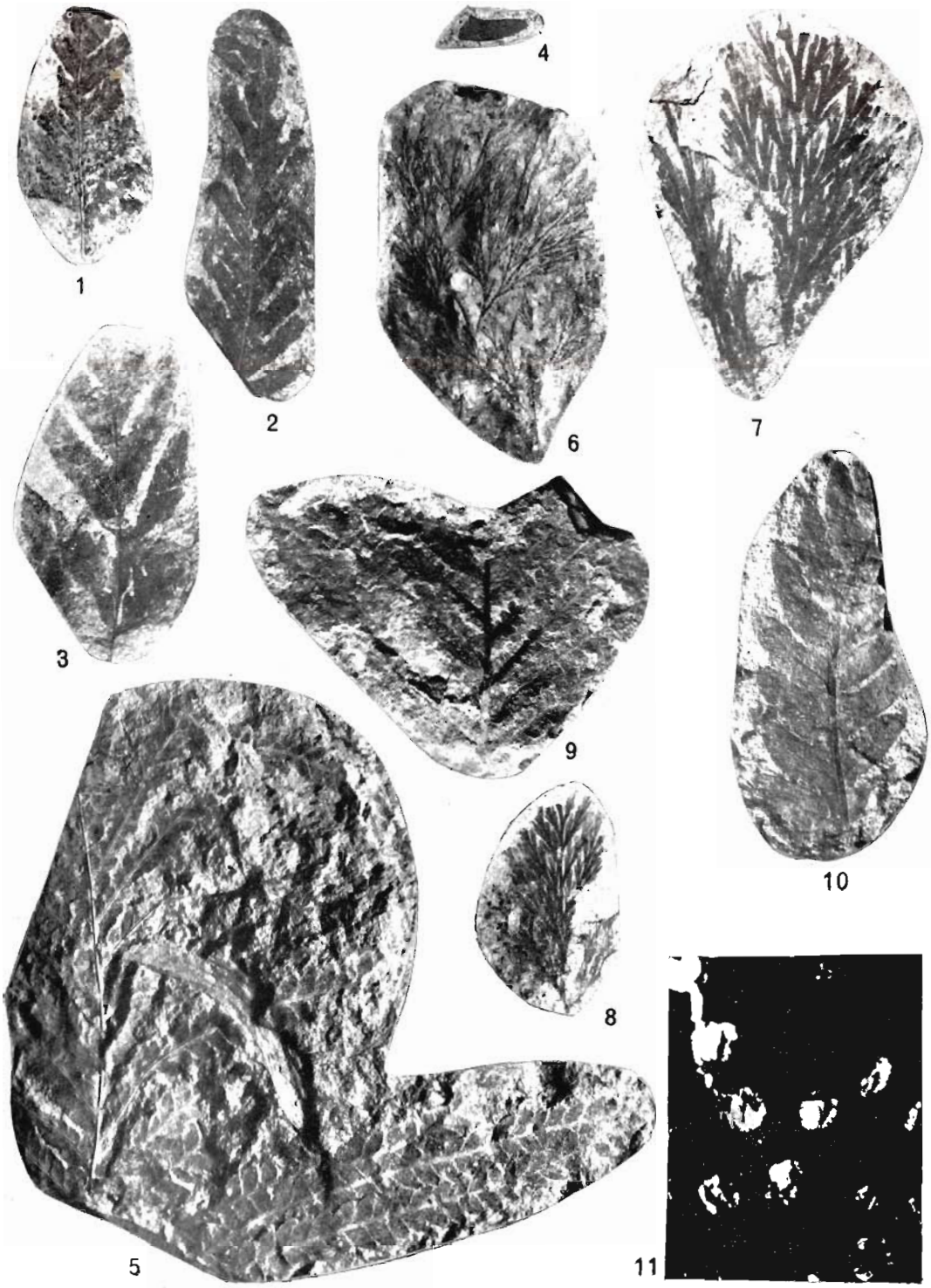

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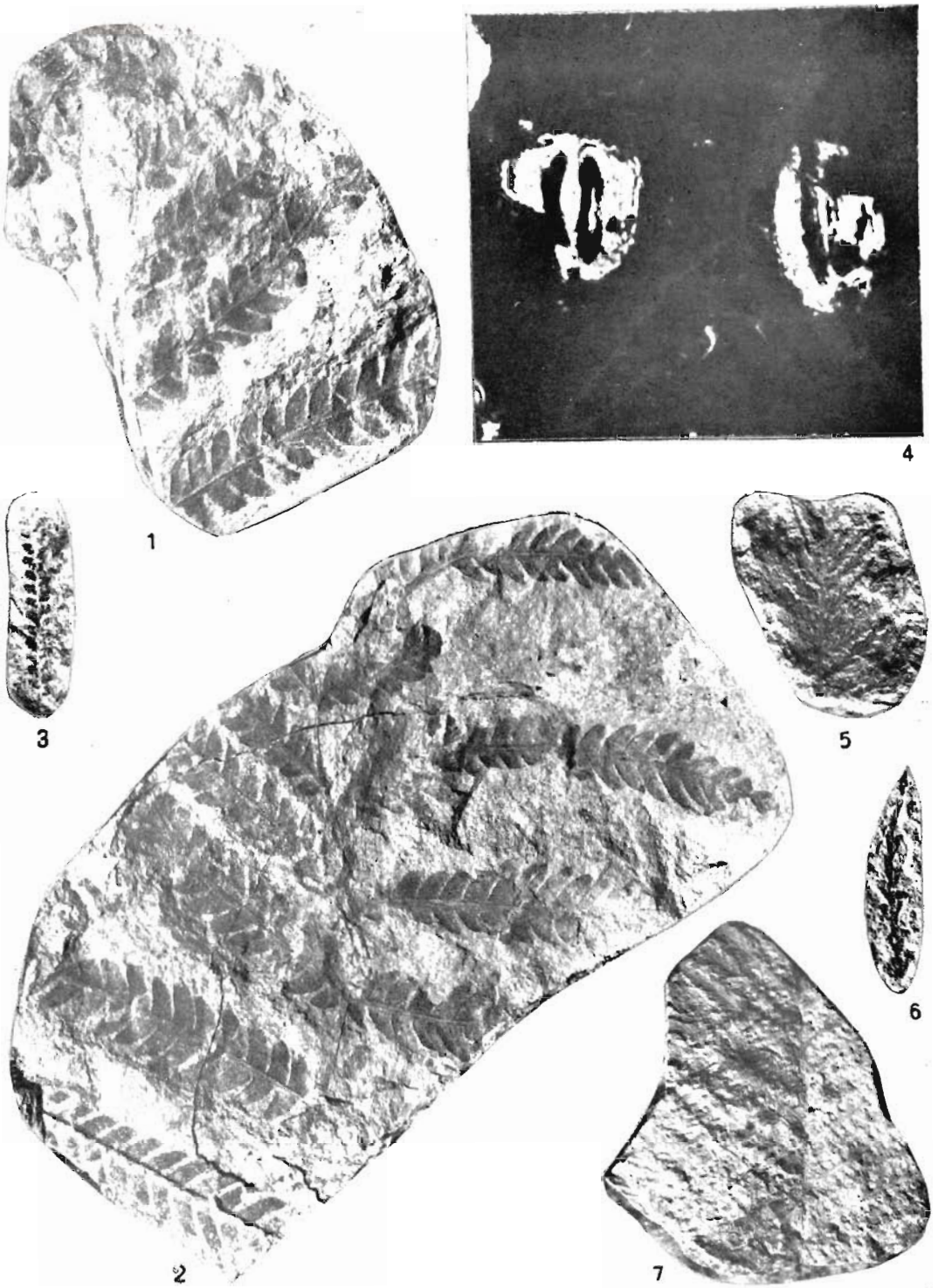

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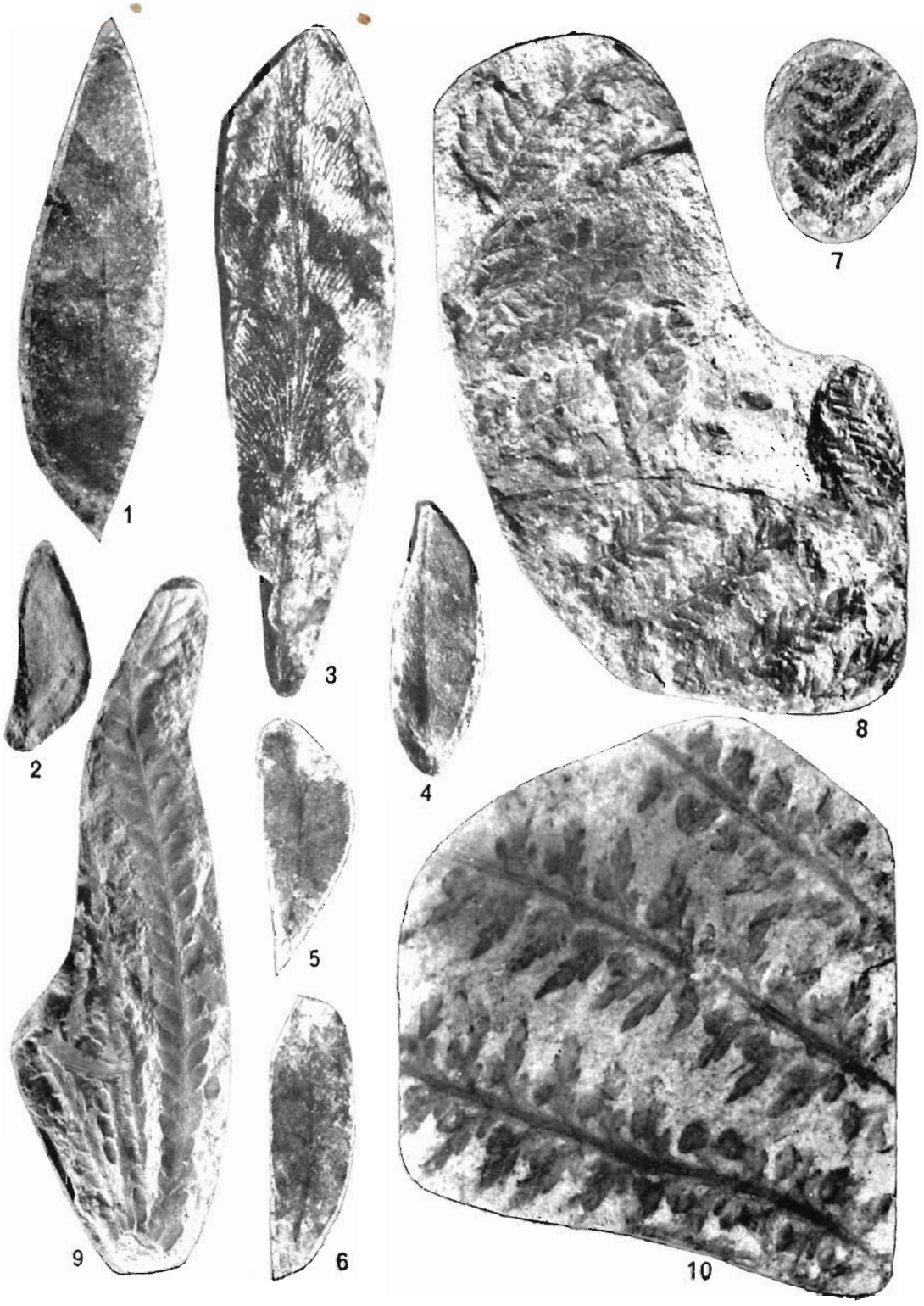

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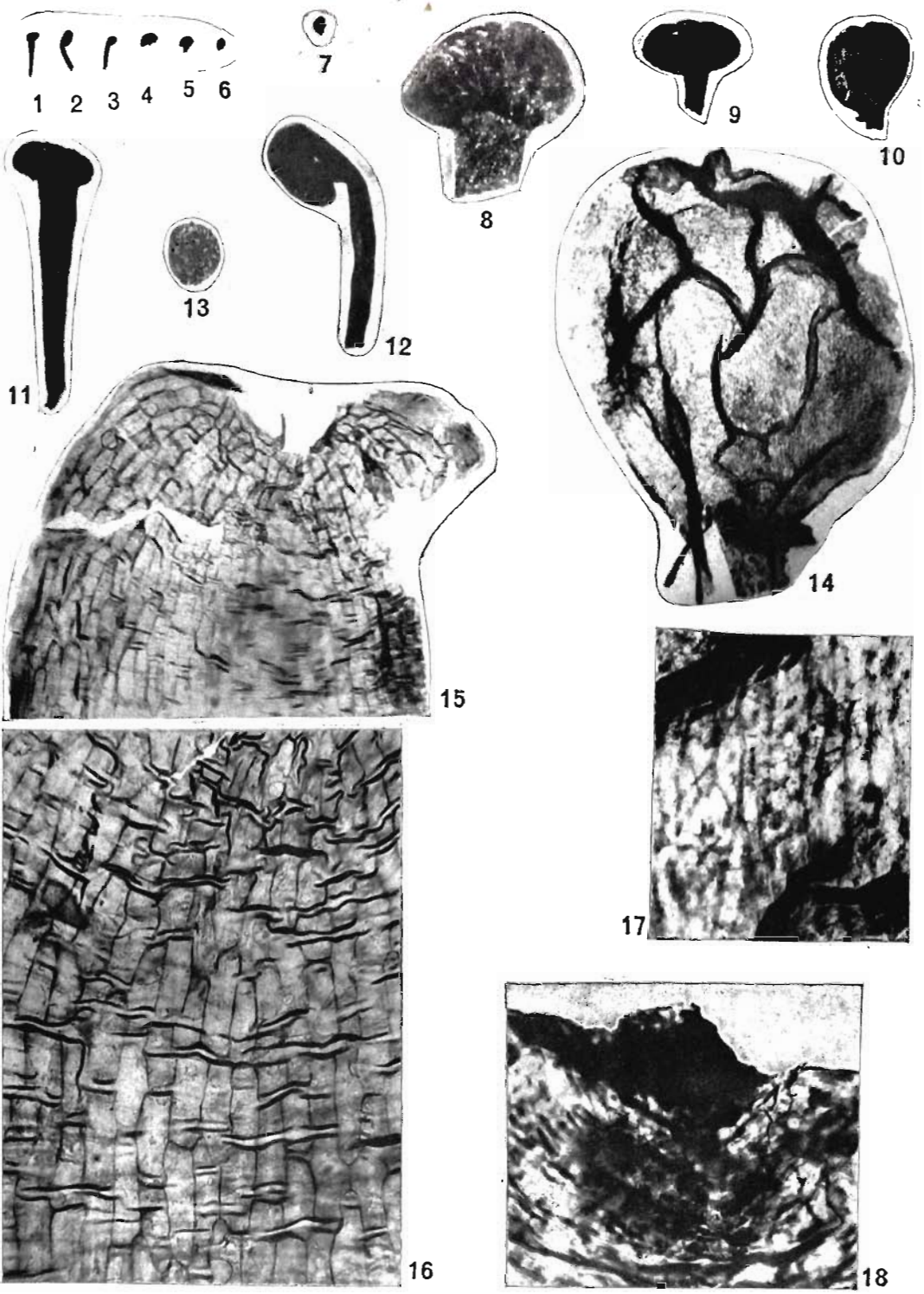

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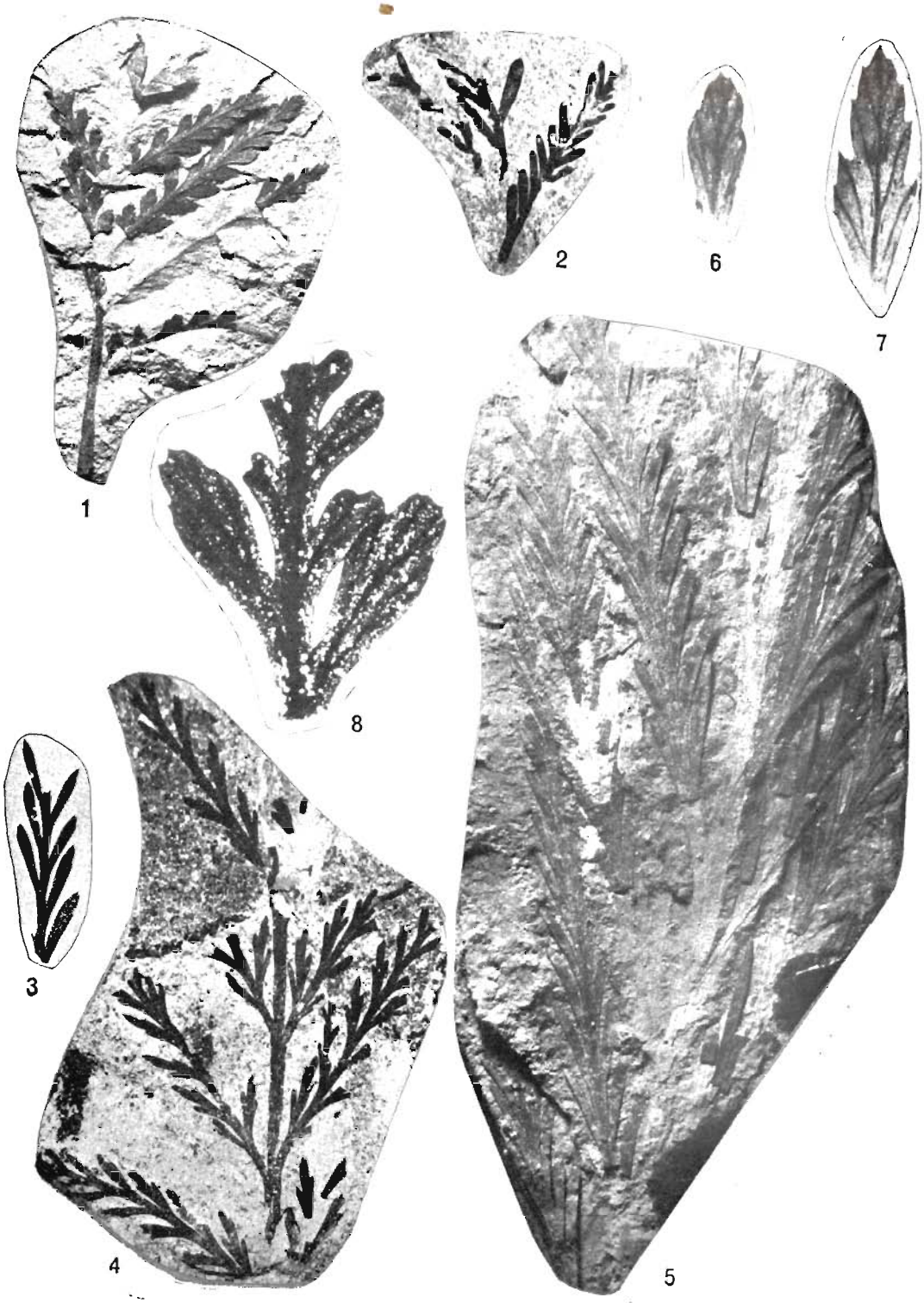
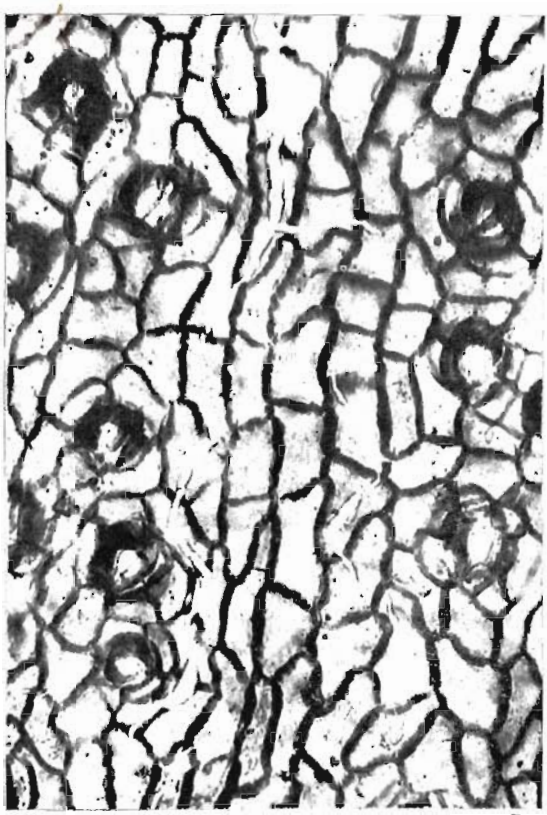


PLATE 8

PLATE 9



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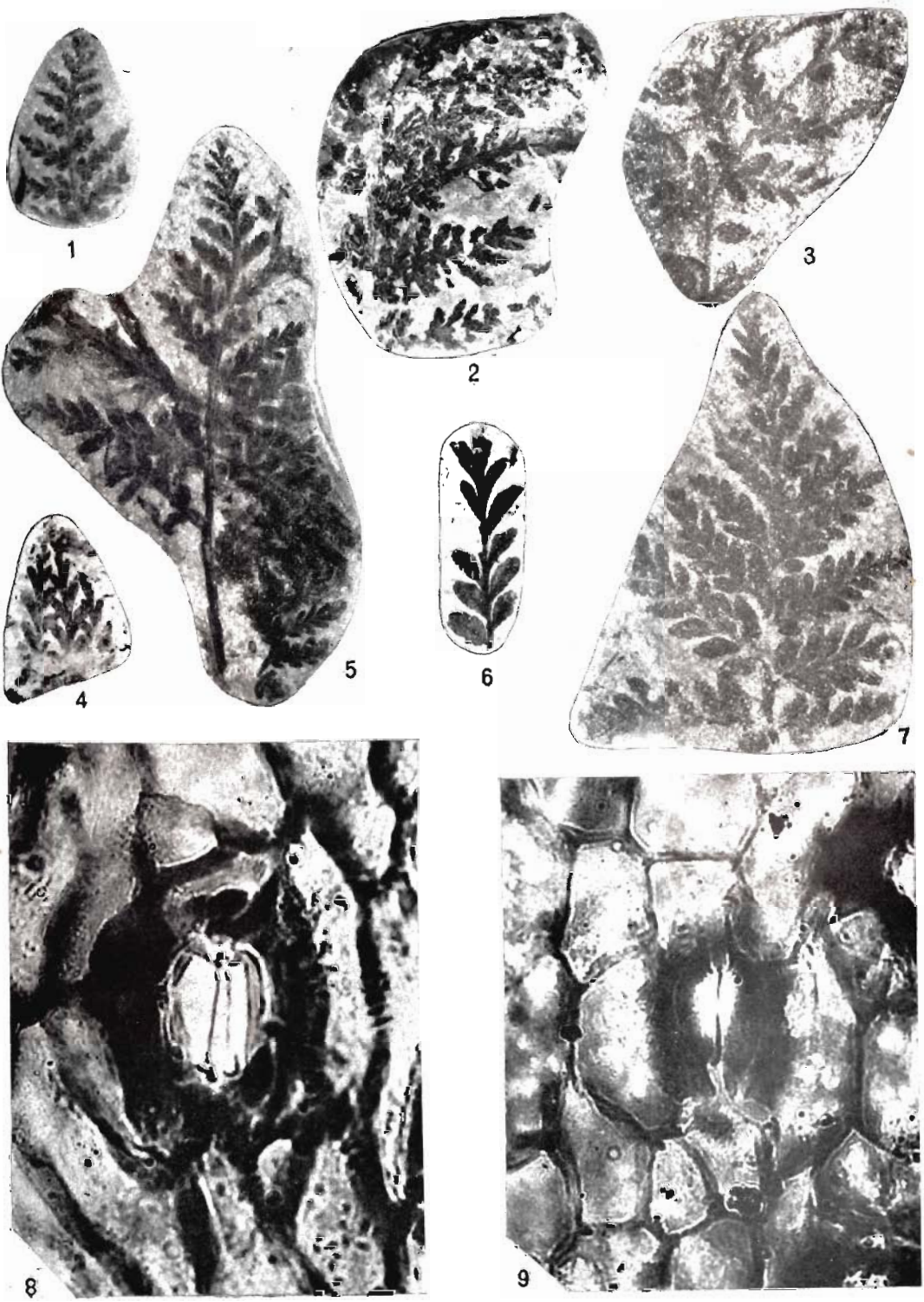

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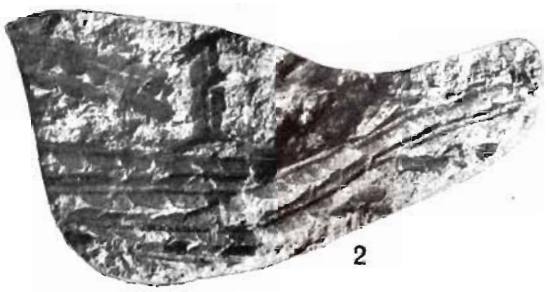

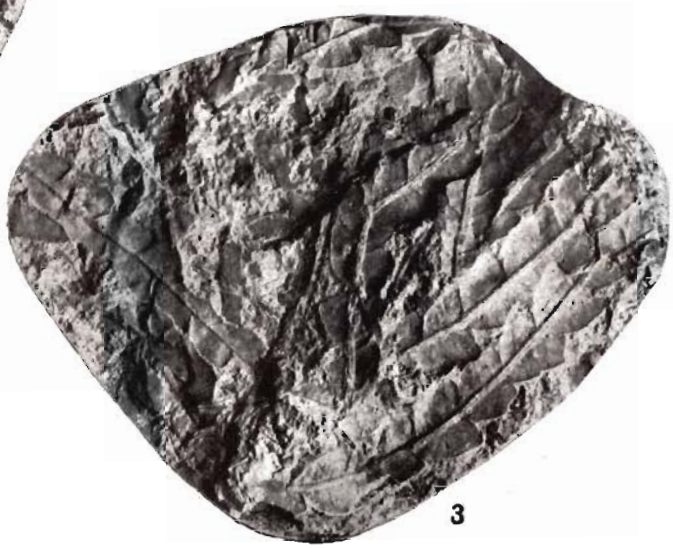

PLATE 12

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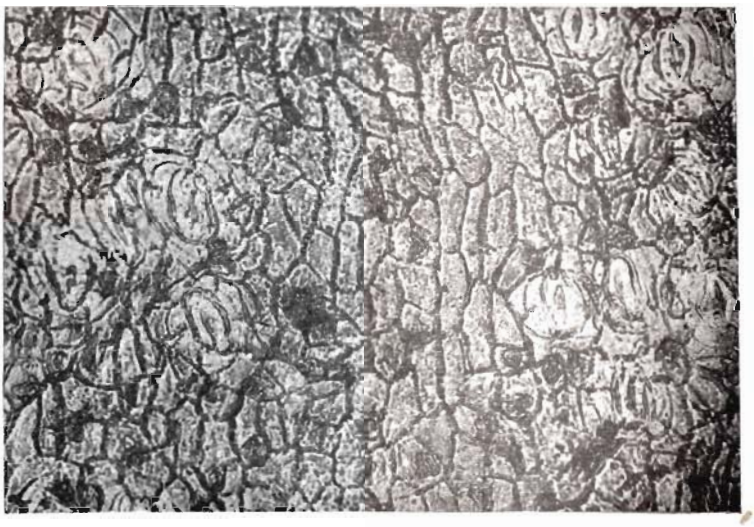

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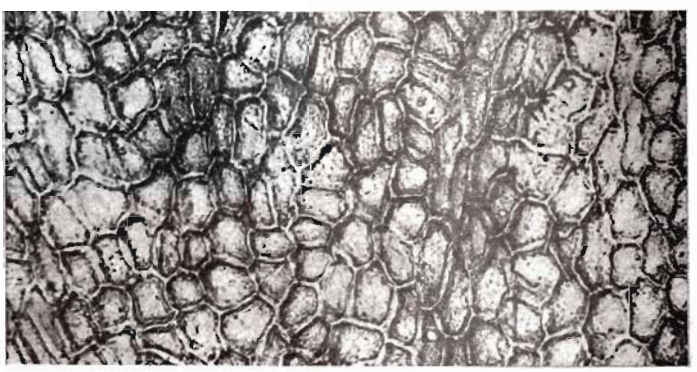

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PLATE 13

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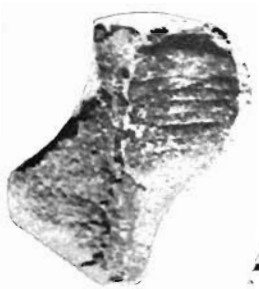

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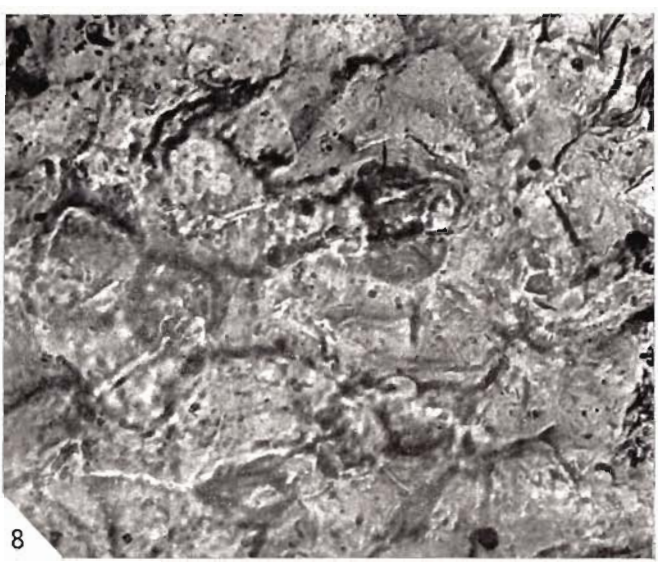

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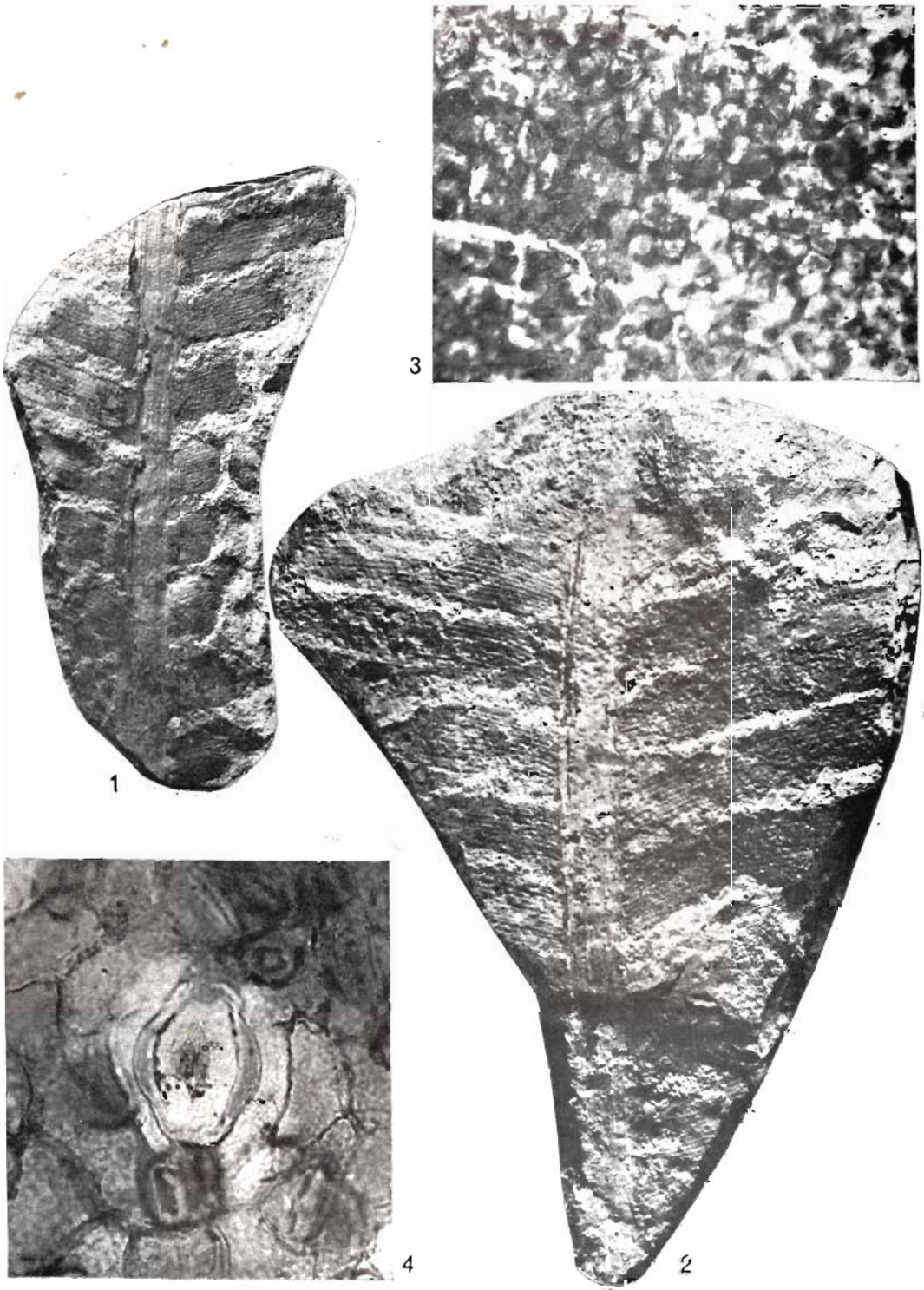

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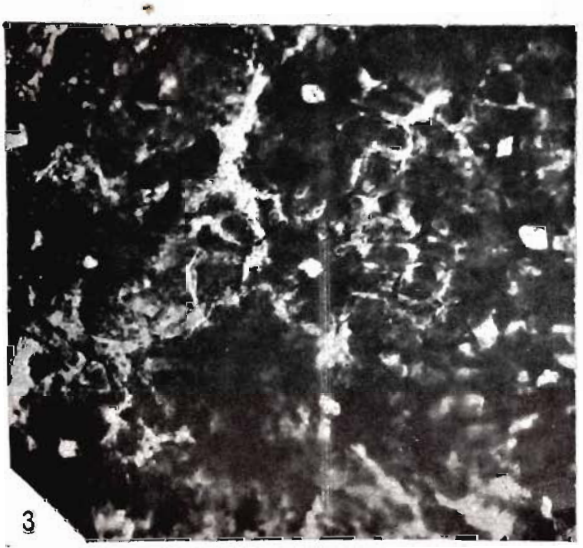

PLATE 16

PLATE 17

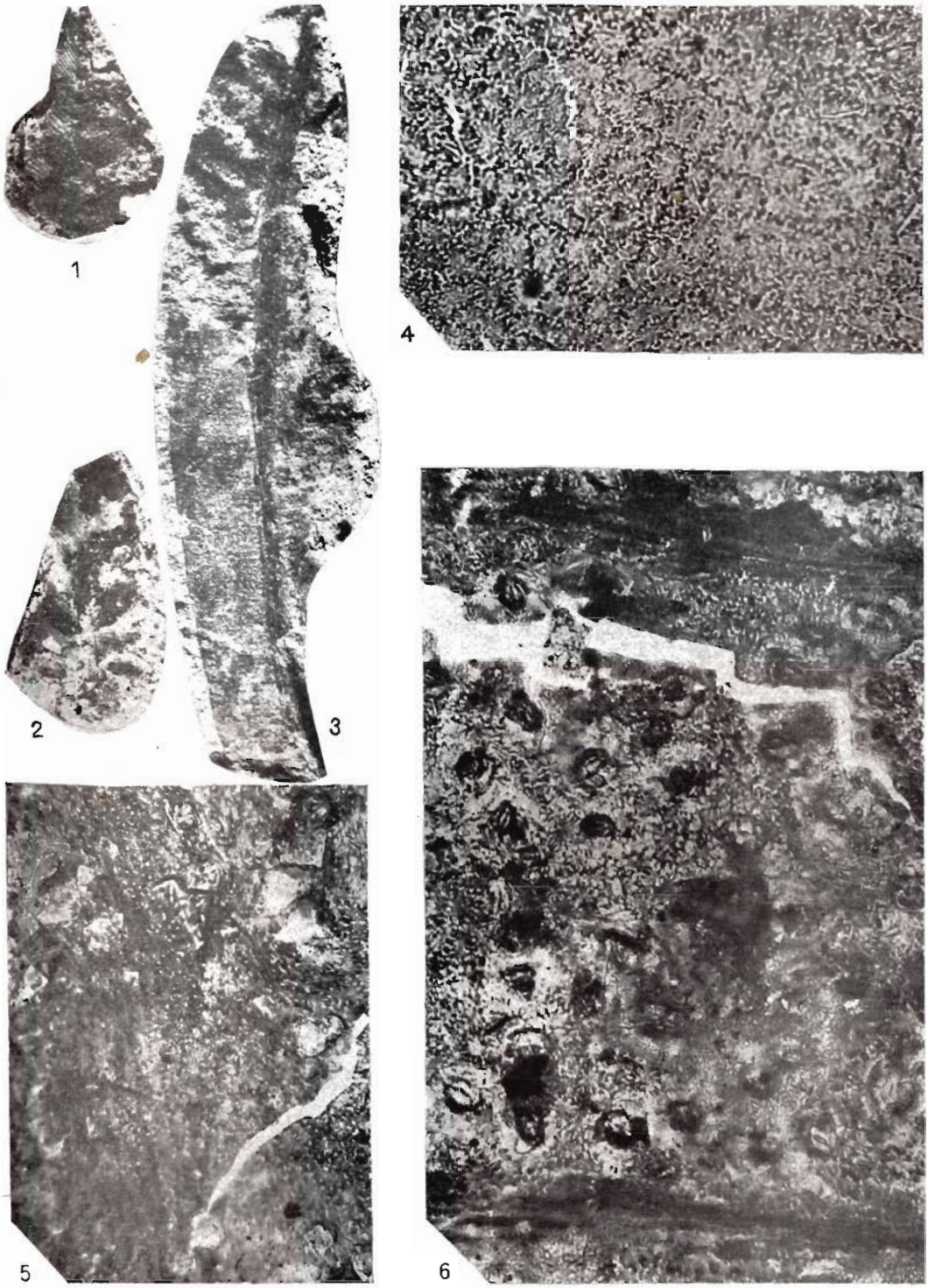

PLATE 18

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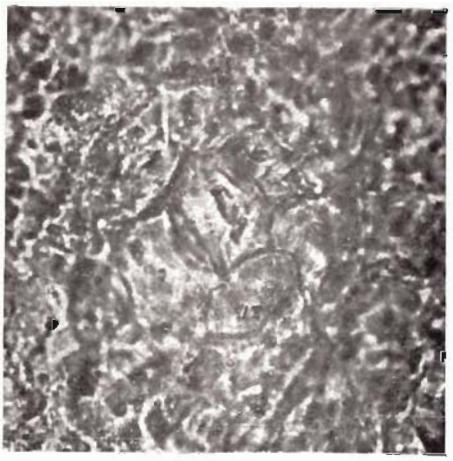

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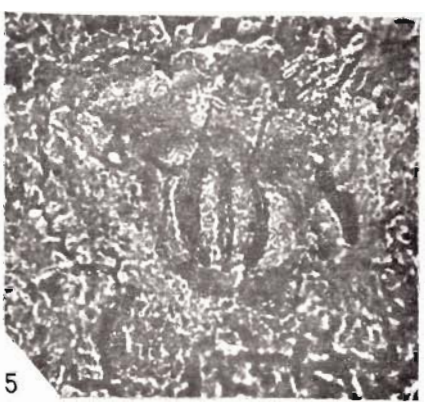

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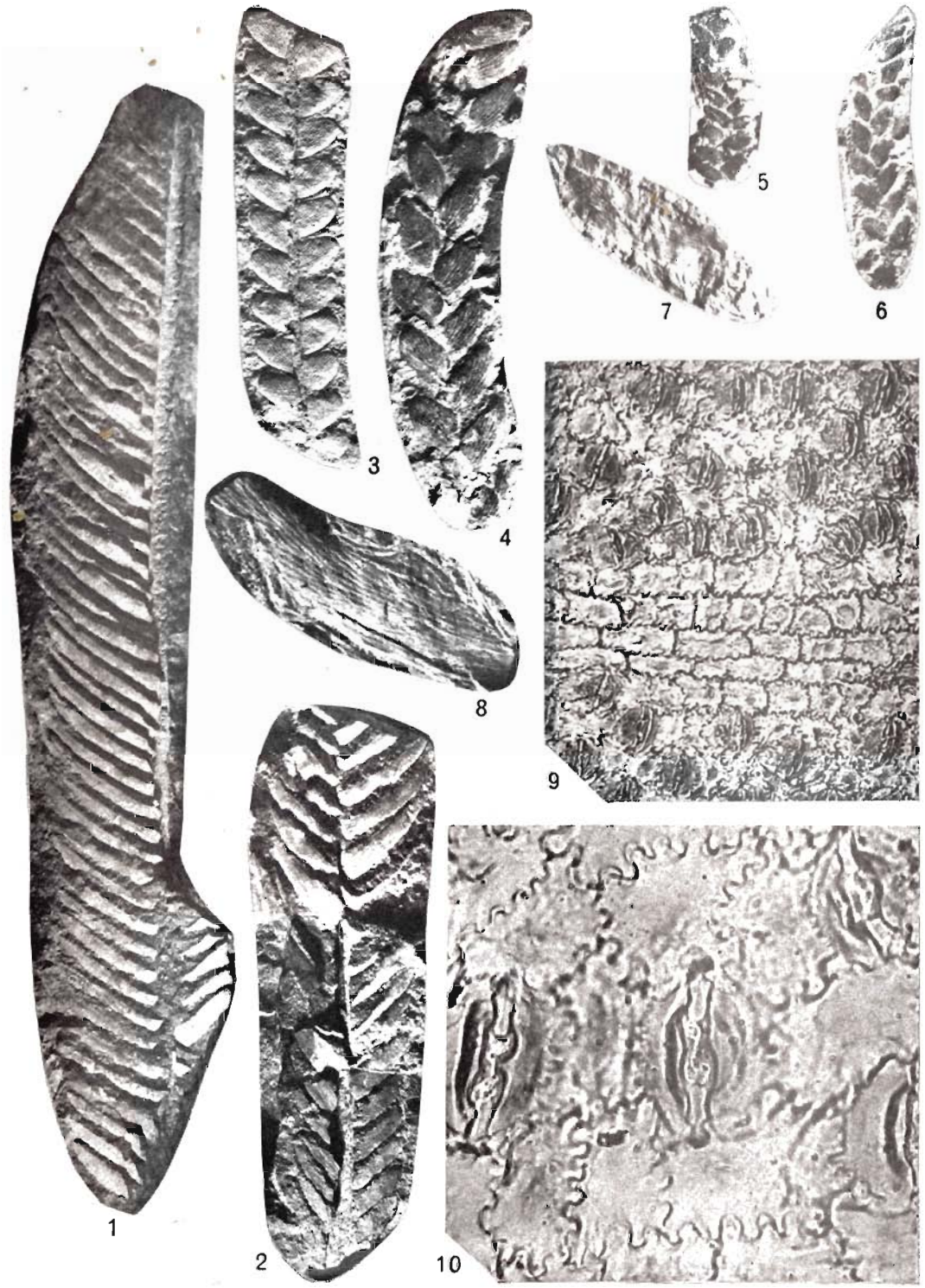

PLATE 20


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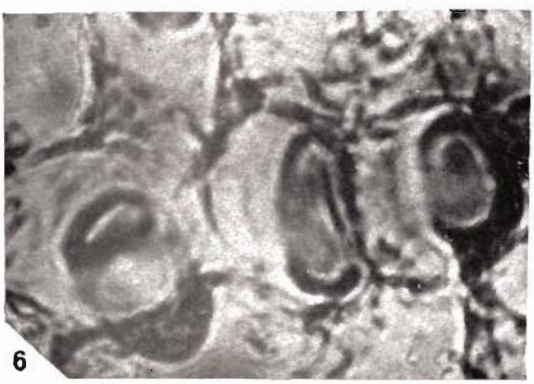
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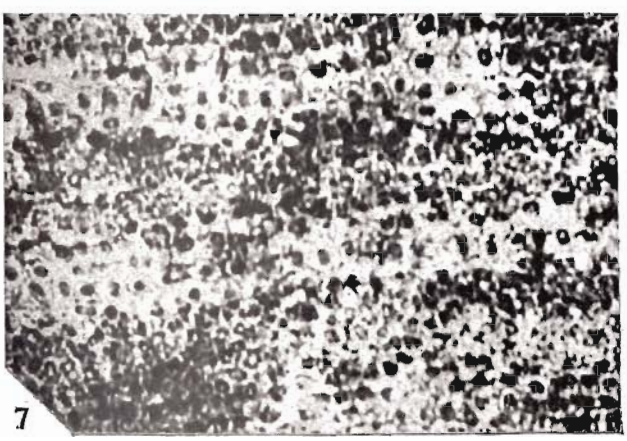
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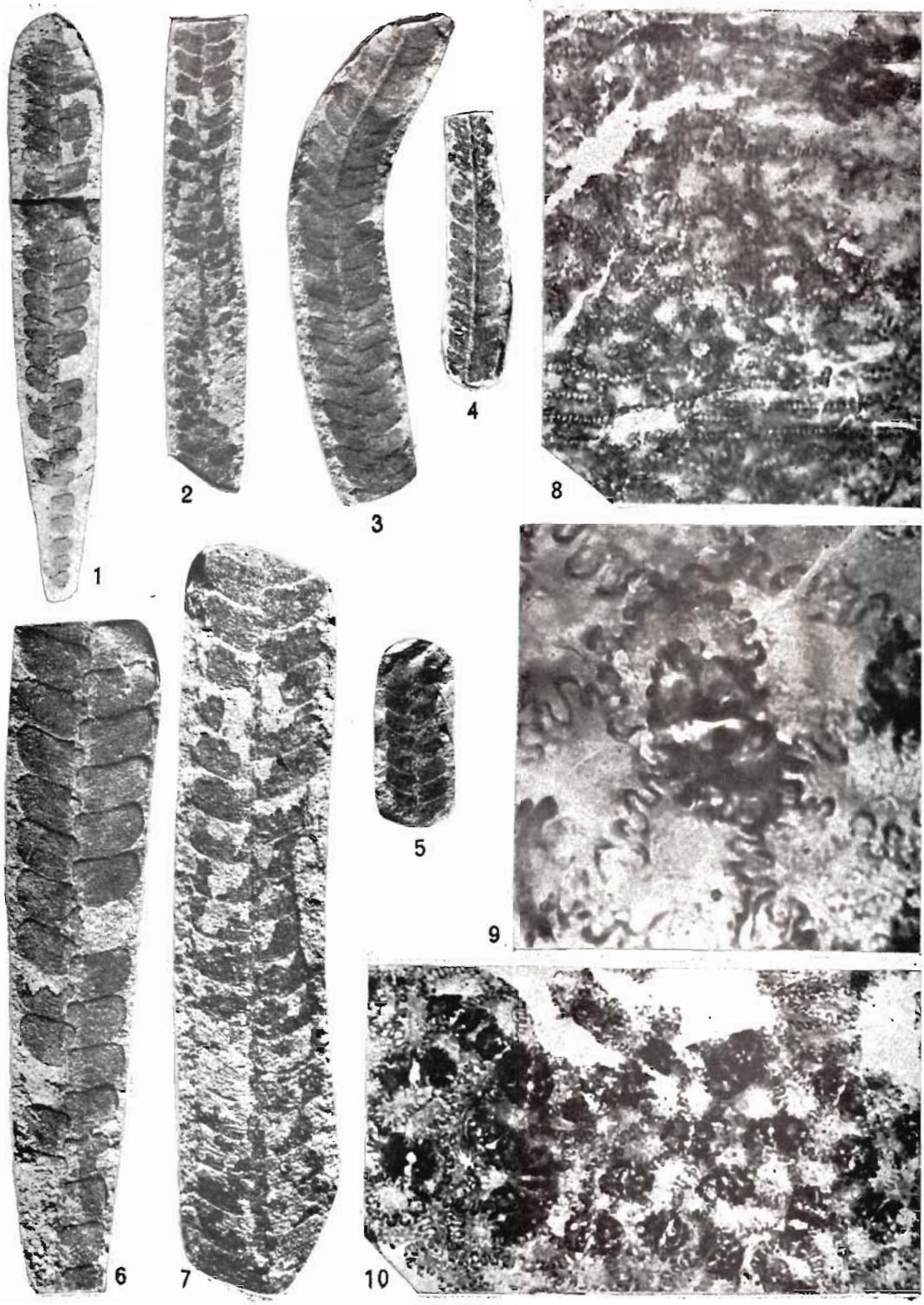

PLATE 22

PLATE 23

PLATE 24

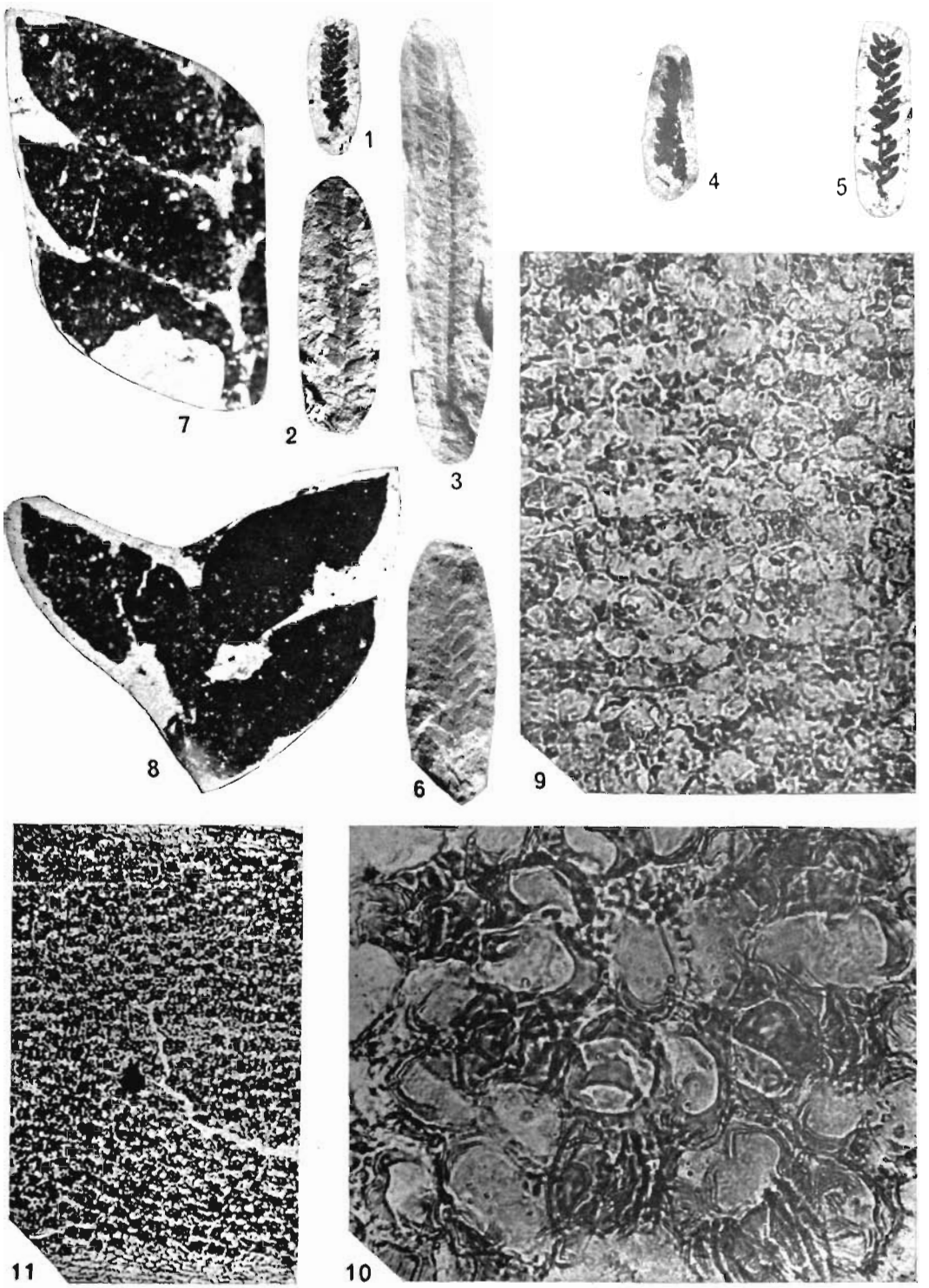

PLATE 25

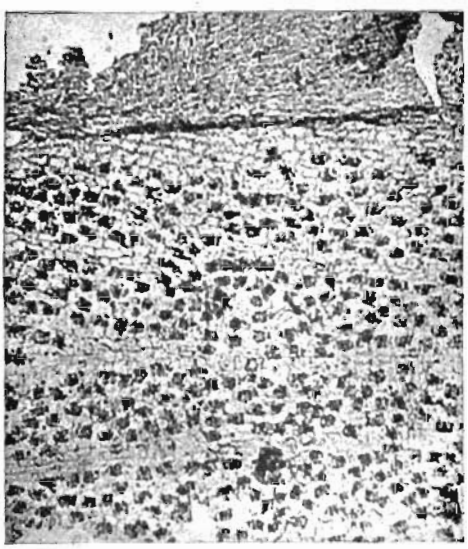

PLATE 26


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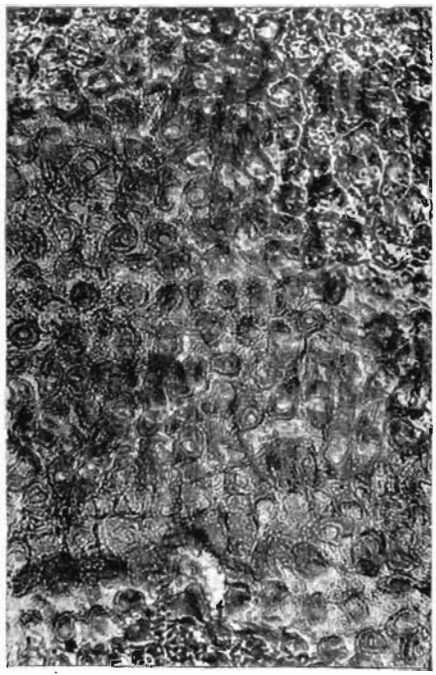
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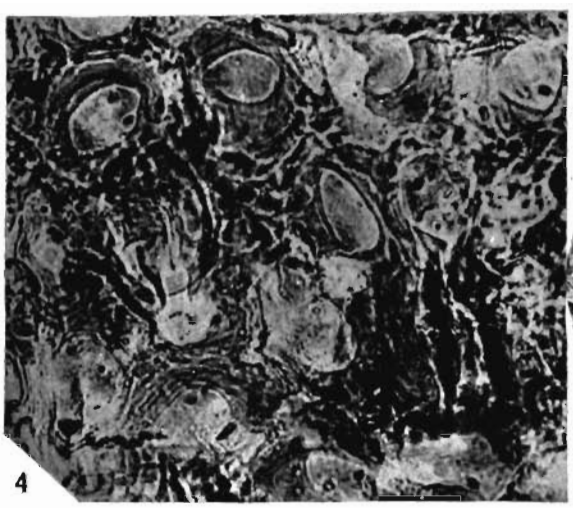
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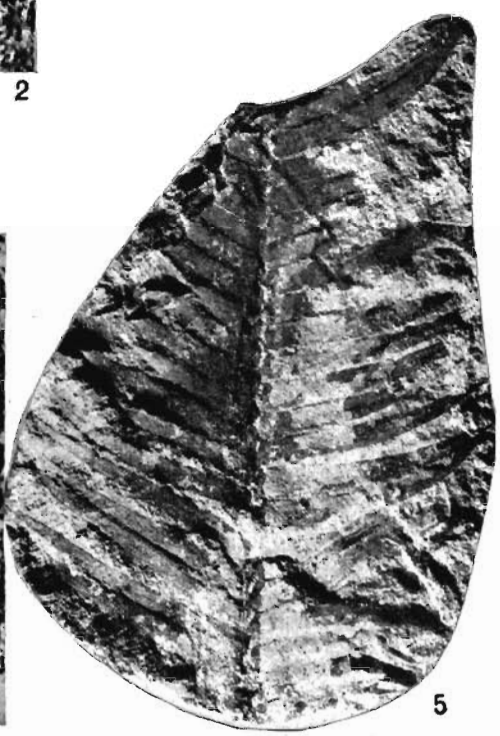
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PLATE 27

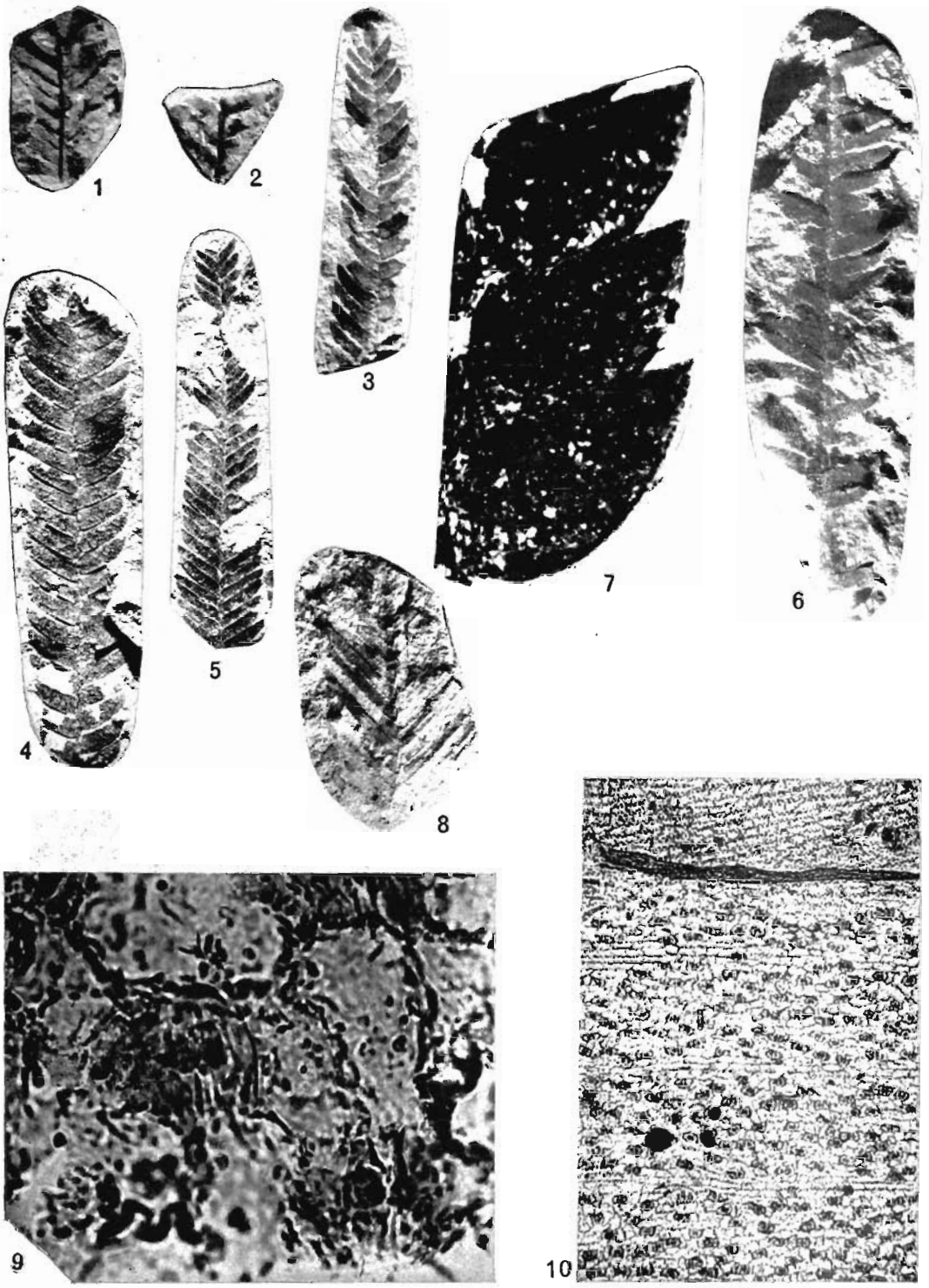

PLATE 28


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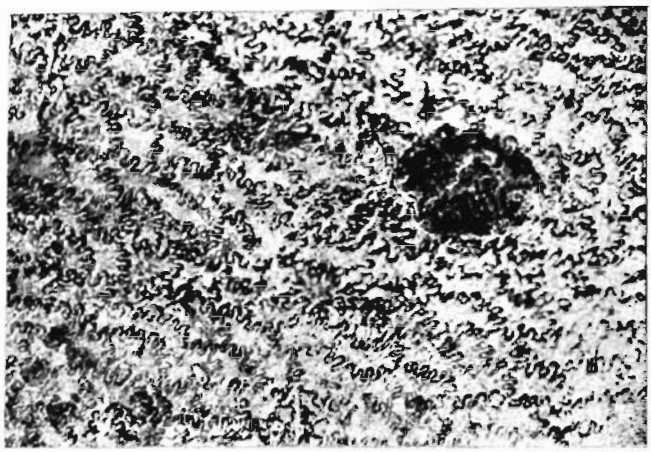
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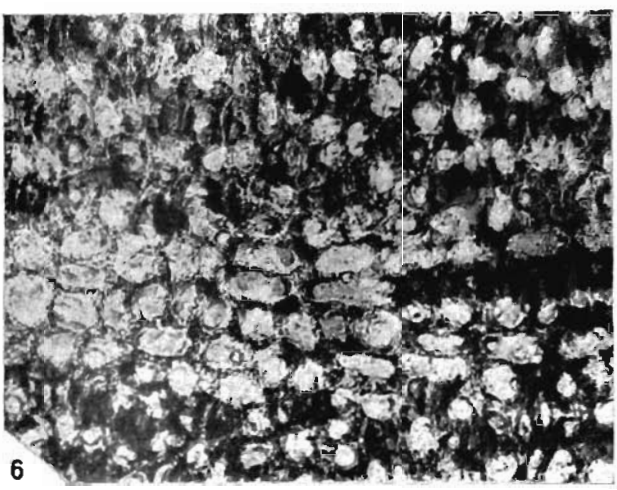
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PLATE 29

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PLATE 30

PLATE 31

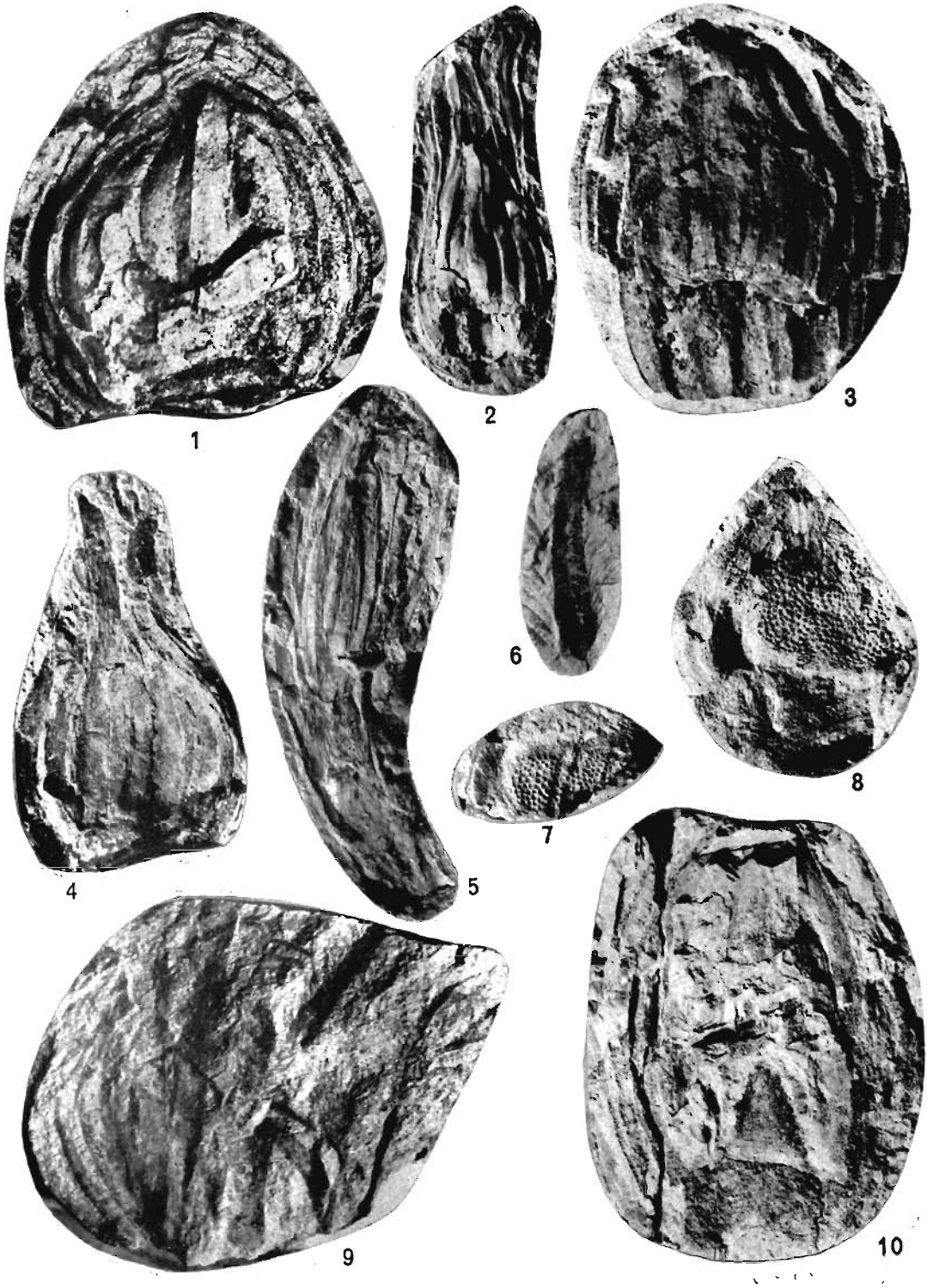

PLATE 32

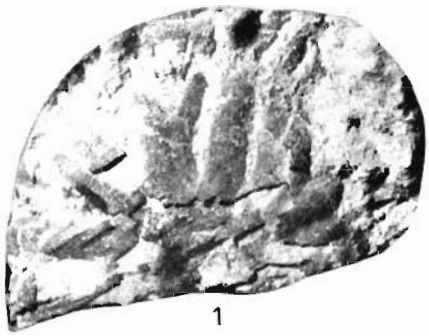
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PLATE 33


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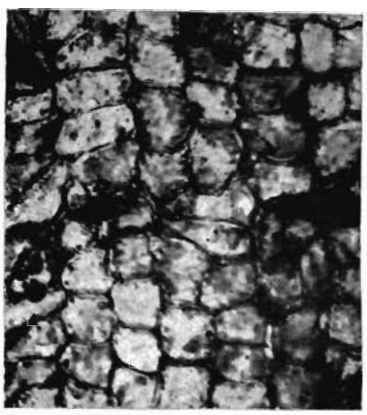
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PLATE 34

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PLATE 35

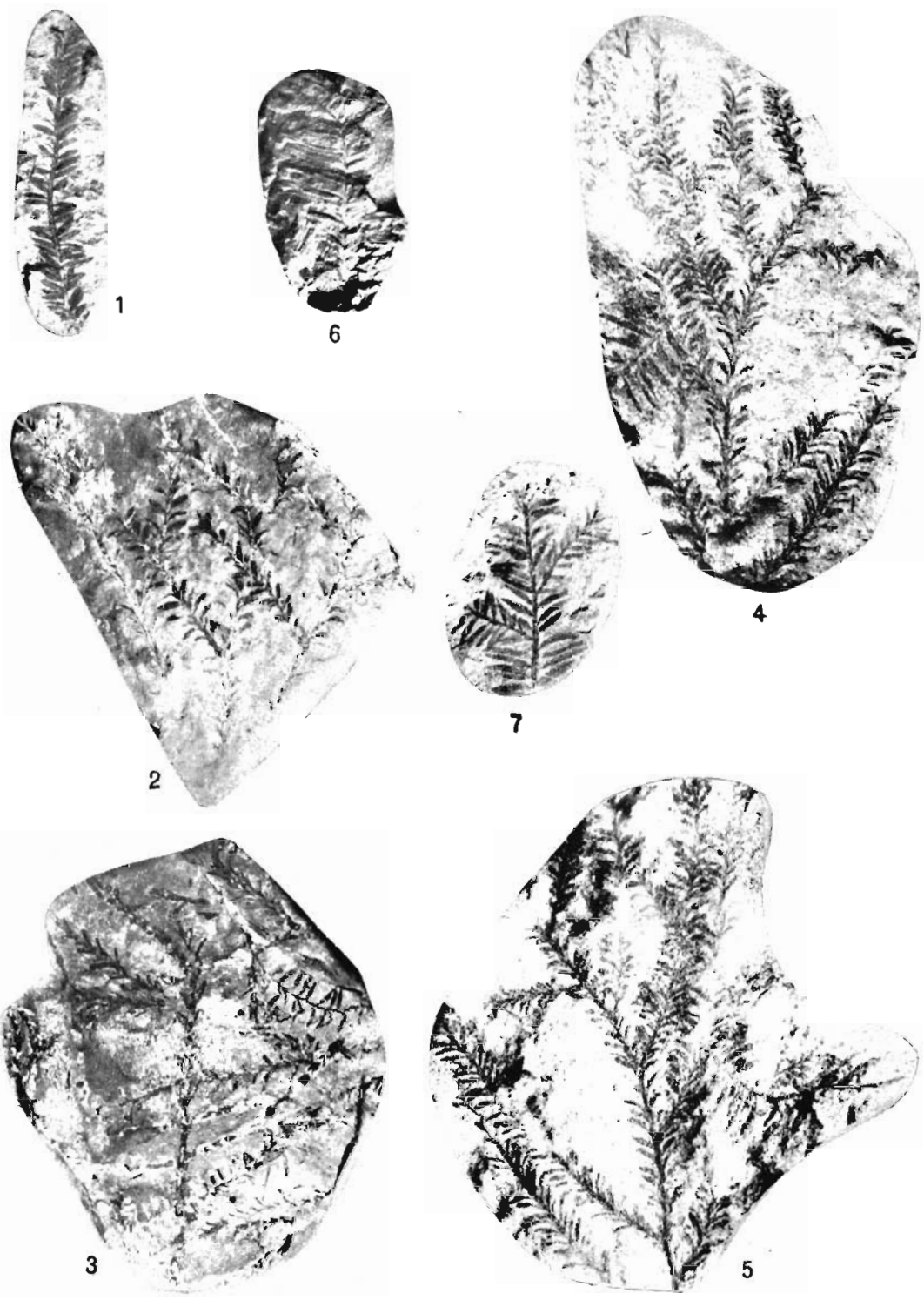

PLATE 36

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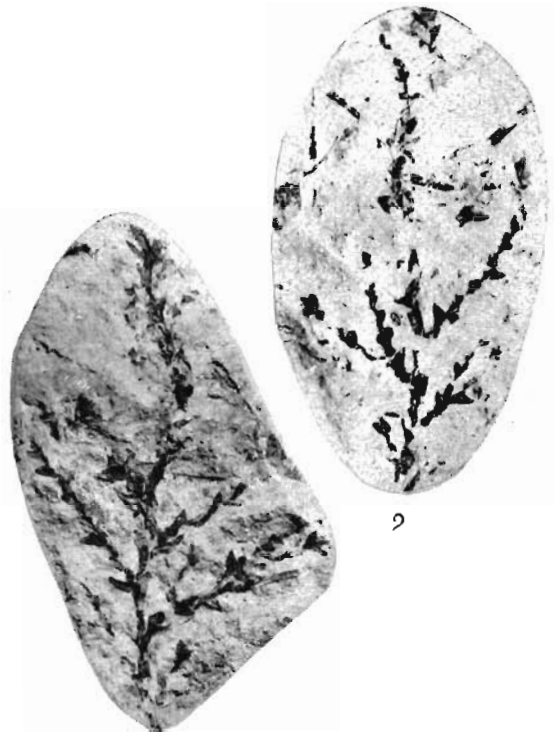
PLATE 37



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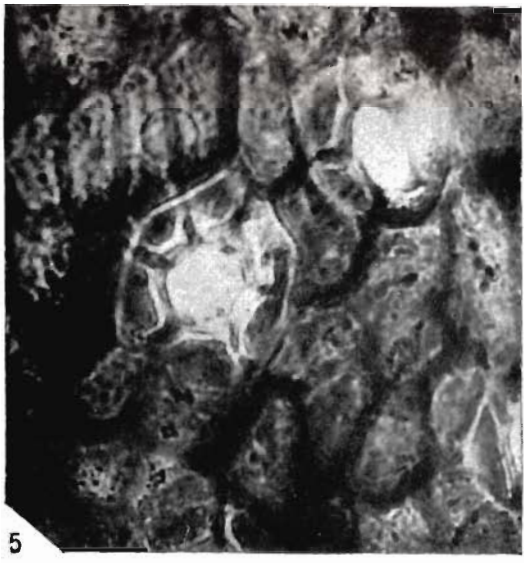

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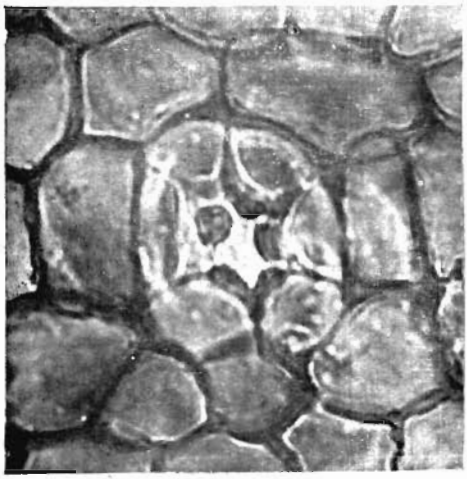
PLATE 38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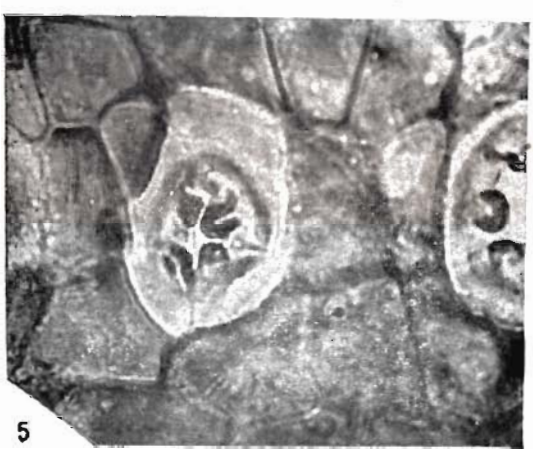
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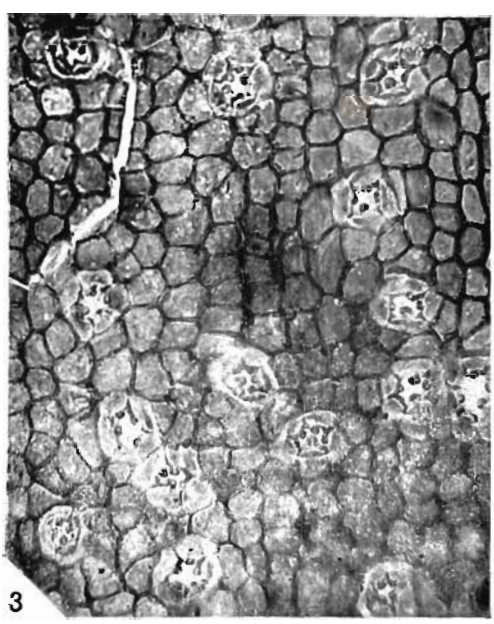
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PLATE 39

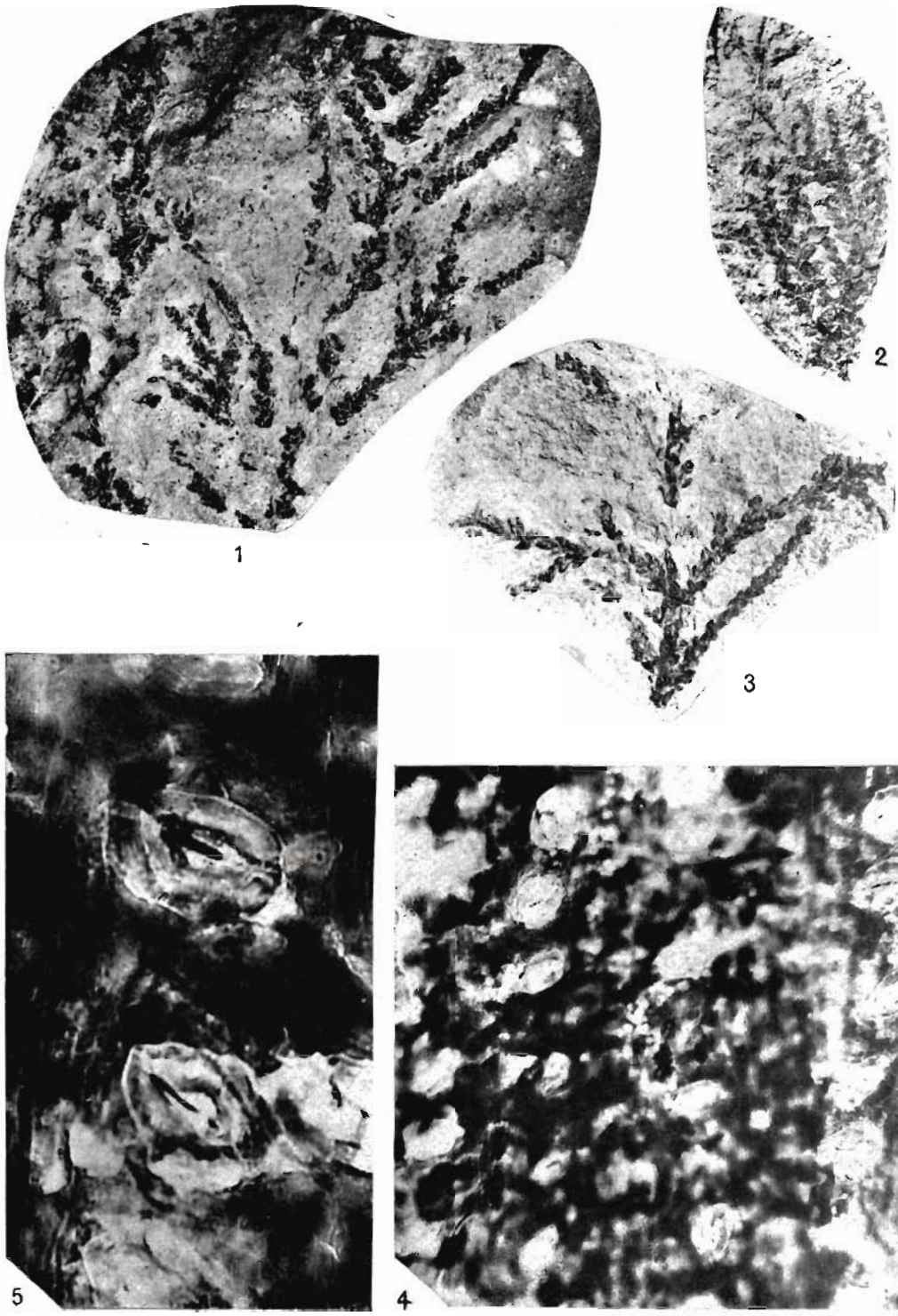

PLATE 40

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PLATE 41

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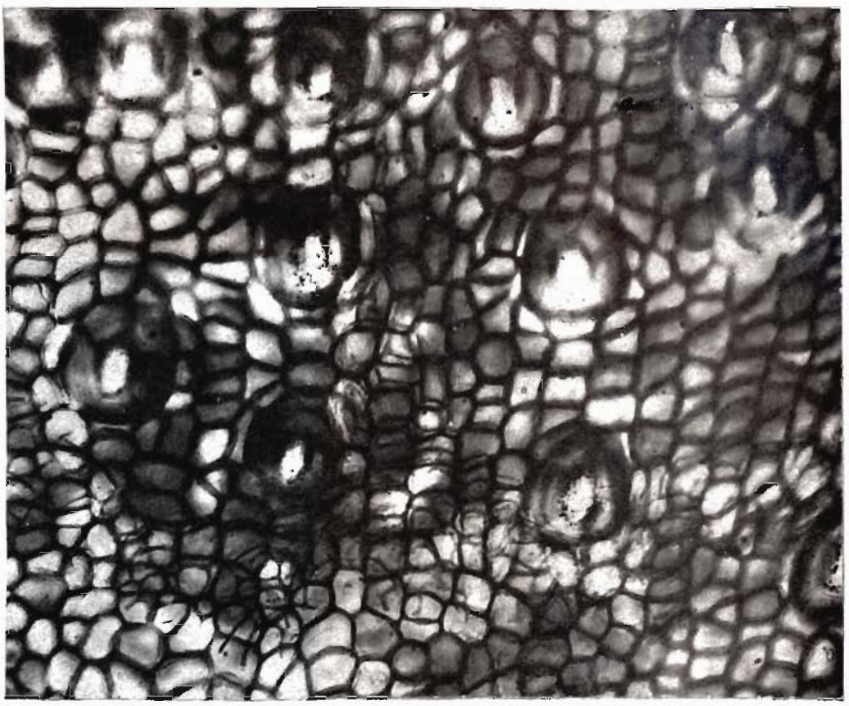

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PLATE 42

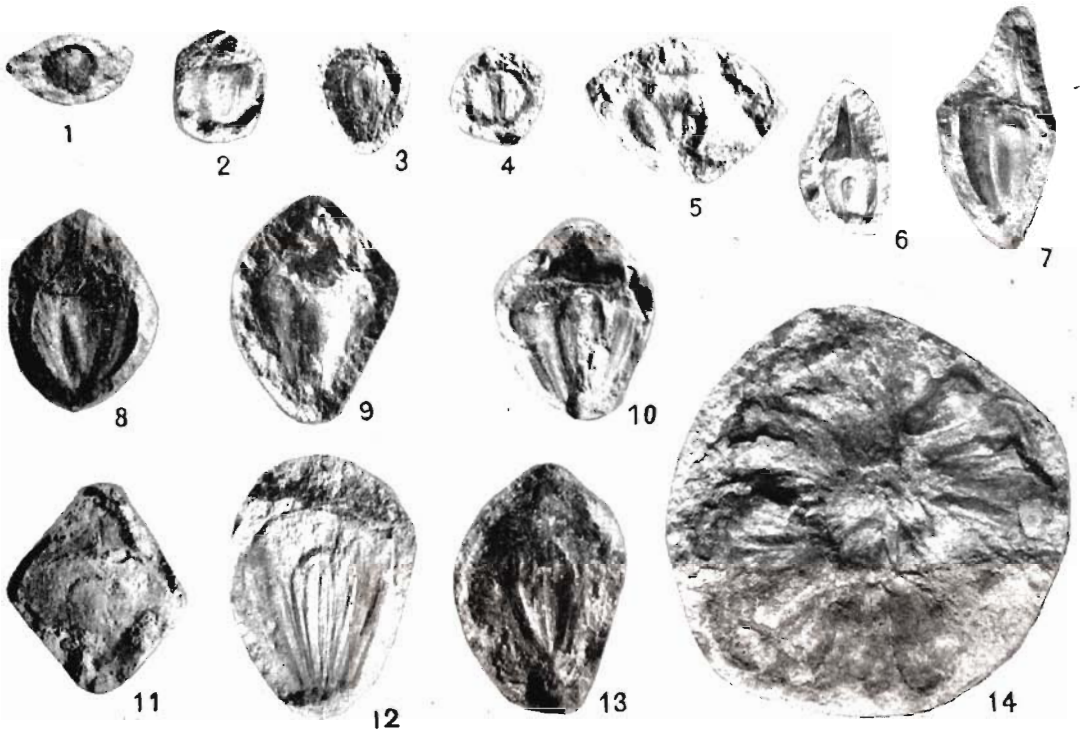
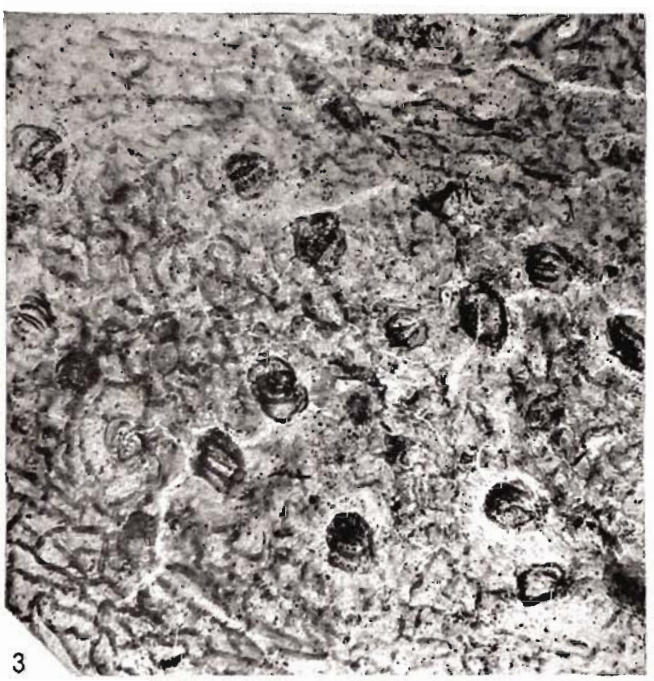


PLATE 43

PLATE 44

PLATE 45



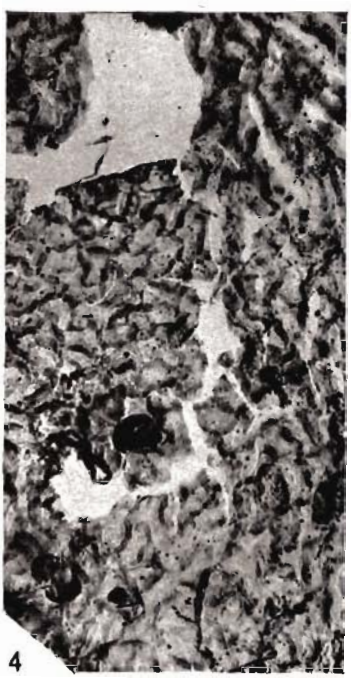


PLATE 46

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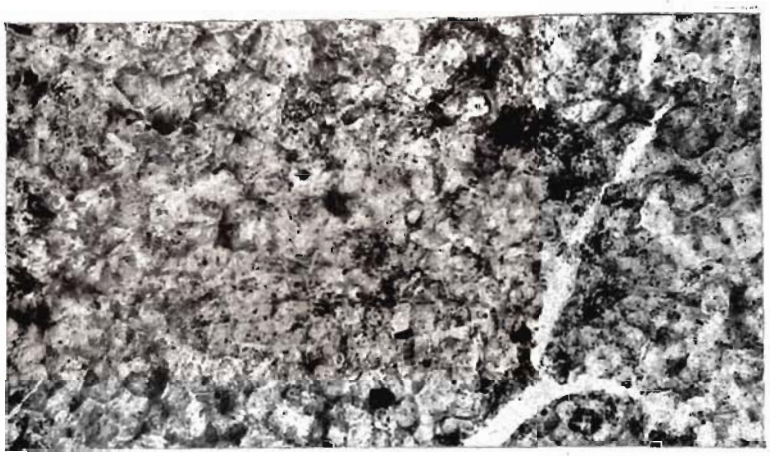

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PLATE 47

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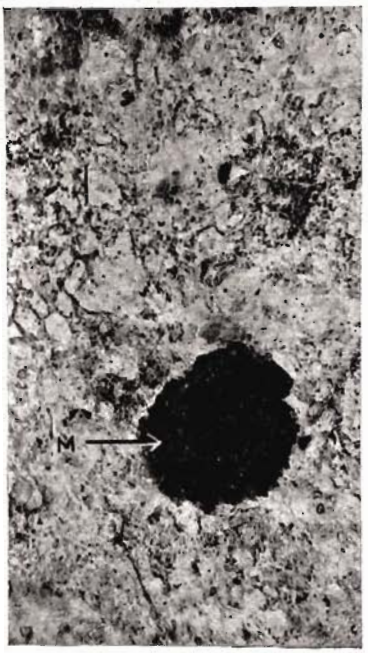

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PLATE 48

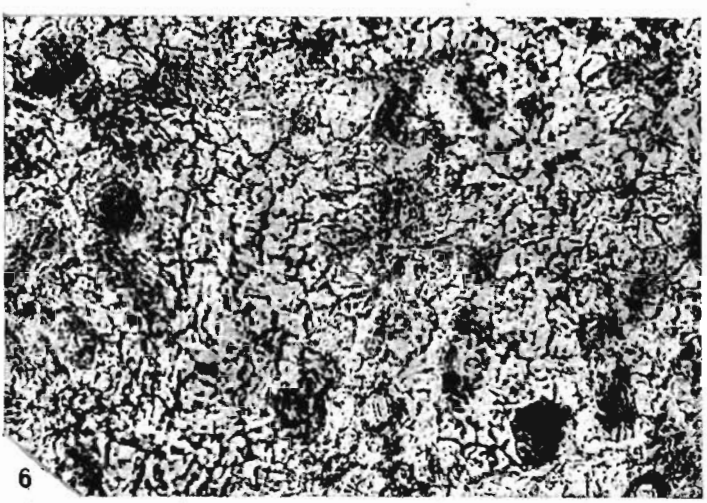

PLATE 49

PLATE 50


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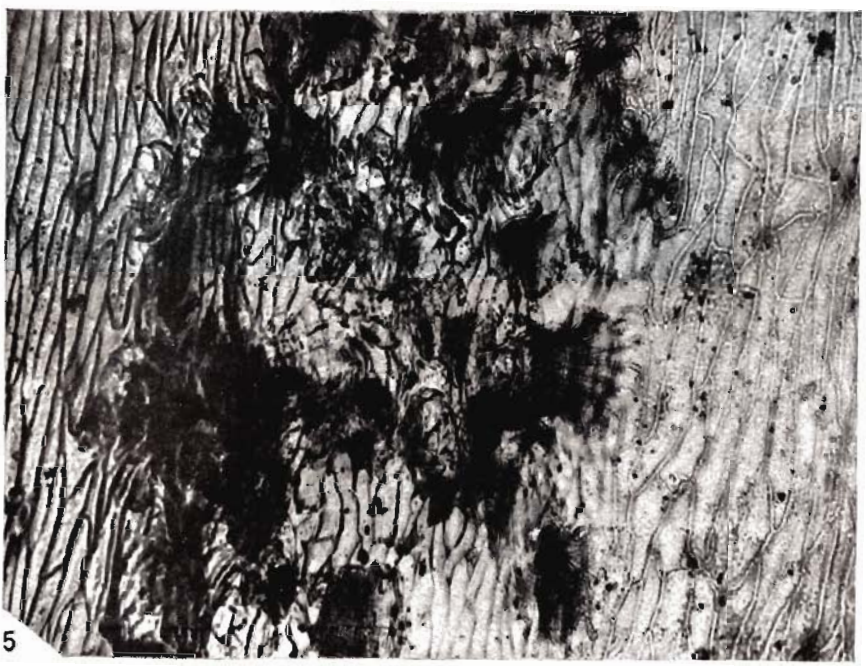
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PLATE 51

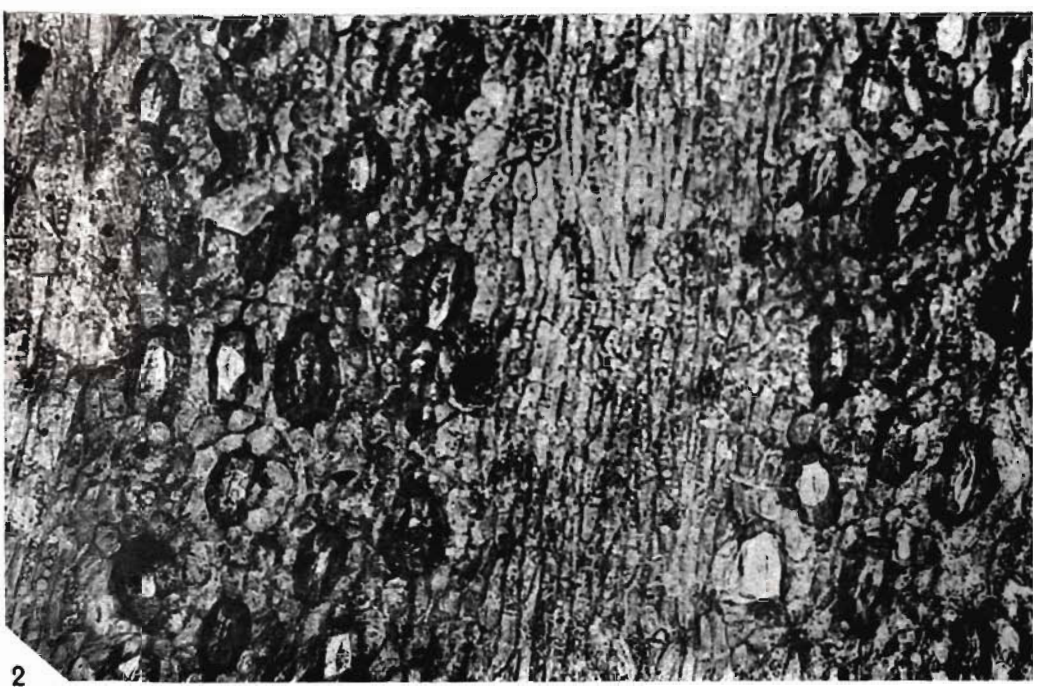

PLATE 52


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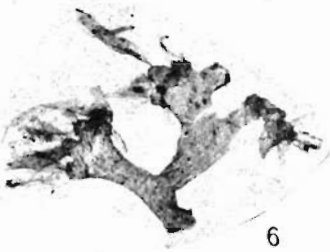
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PLATE 53

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PLATE 54

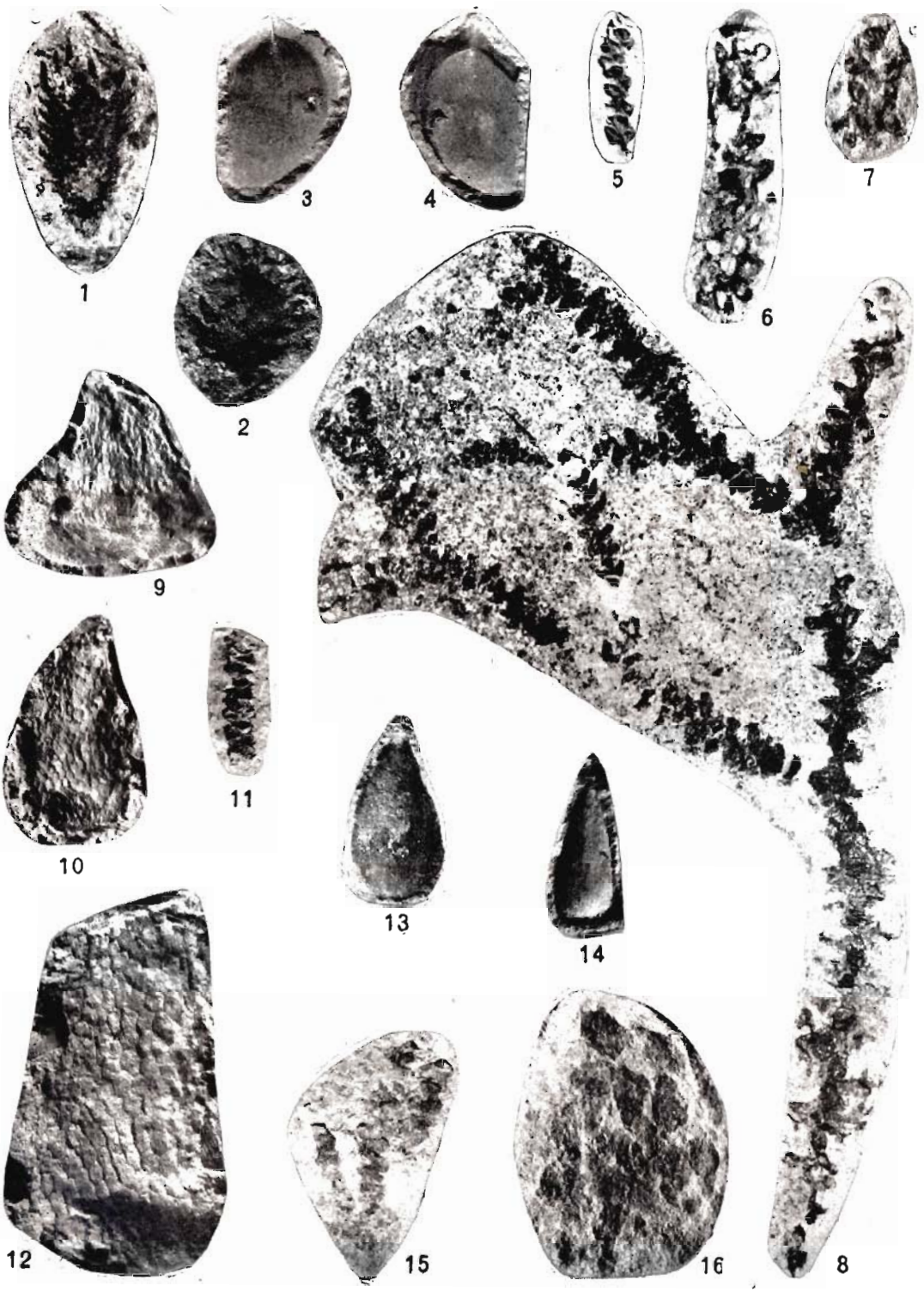

PLATE 55