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TRIASSIC PLANT MEGAFOSSILS FROM THE TIKI FORMATION, SOUTH REWA GONDWANA BASIN, INDIA

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ABSTRACT

Plant megafossils are for the first time described from the Tiki Formation. The specimens are from two regions, Janar River Section, near Harai and Son River Section, near Giar, Shahdol District, Madhya Pradesh.

From the Janar River Section *Lepidopteris madagascariensis* Carpentier, *Dicroidium hughesii* (Feistmantel) Gothan, *D. zuberi* (Szajnocha) Archangelsky, *D.* sp., *Xylopteris* sp., *Sphenobaiera janarensis* Pal sp. nov. and *Baiera* sp. have been described. On the basis of this assemblage an Early Upper Triassic age has been suggested for Janar River beds.

Son River Section, near Giar has yielded *Lepidopteris stormbergensis* (Seward) Townrow, *Dicroidium giarensis* Pal sp. nov., *D. coriaceum* (Johnston) Townrow, *D. zuberi* (Szajnocha) Archangelsky, *D.* sp. cf. *D. odontopteroides* (Morris) Gothan, *Elatocladus denticulatus* Pal sp. nov., *E. raoi* Pal sp. nov., *Pagiophyllum bosei* Pal sp. nov., *Yabiella indica* Pal sp. nov. and *Desmiophyllum singhii* Pal sp. nov. Beside these, a few impressions of equisetaceous stem, leaf-sheath and nodal diaphragm have also been described. A Late Upper Triassic age has been proposed for the beds exposed in the Son River.

Key-words — Megafossils, Sphenopsida, Peltaspermales, Corystospermales, Ginkgoales, Coniferales, Tiki Formation, Upper Triassic (India).

सारांश

दक्षिण रीवा गोंडवाना द्रोणी (भारत) में स्थित टिकी शैल-समूह से त्रिसंधी कालीन गुरुपादपाश्म – पंकज कुमार पाल

इस शोध-पत्र में टिकी शैल-समूह से प्राप्त गुरुपादपाश्मों का पहली बार वर्णन किया गया है। ये प्रादर्श मध्य प्रदेश के शहदोल जनपद में हराई के समीप जनार नदी खंड तथा गियार के पास सोन नदी खंड से एकत्र किये गये थे।

जनार नदी खंड से लैपिडॉप्टेरिस मेडागास्करेन्सिस कारपेन्टियर, डाइक्रोइडियम् हयूजेसाई (फ़ाइस्टमॅन्टेॅल) गोथान, डा० जुबेराई (स्ज़ाजनोचा) आरचेन्जेल्सकी, डा० जाति, जाइलॉप्टेरिस जाति, स्फ़ीनोबेयरा जनारेन्सिस पाल नव जाति एवं बेयरा जाति वर्णित की गई हैं। इस समुच्चय के आधार पर जनार नदी संस्तरों की आयु प्रारम्भिक उपरि त्रिसंधी प्रस्तावित की गई है।

गियार के समीपस्थ सोन नदी खंड से लैपिडॉप्टेरिस स्ट्रोमबर्जेन्सिस (सिवर्ड) टाउनरॉ, डाइक्रोइडियम् गियारेन्सिस पाल नव जाति, डा० कोरिएसियम् (जॉहन्सटन) टाउनरॉ, डा० जुबेराई (स्ज़ाजनोचा) आरचेन्जेल्सकी, डा० जाति सजातीय डा० ओडोन्टॉप्टेरॉयडिस (मौरिस) गोथान, इलेटोक्लेडस डेन्टीकुलेटस पाल नव जाति, इ० रावई पाल नव जाति, पेजियोफ़िल्लम् बोसाई पाल नव जाति, याबियॅल्ला इन्डिका पाल नव जाति एवं डेस्मिओफ़िल्लम् सिंघाई पाल नव जाति उपलब्ध हुए हैं। इनके अतिरिक्त इक्वीसिटेली तनों, पर्ण आच्छद एवं पर्वसंधीय तनुच्छद के कुछ छापाश्मों का भी वर्णन किया गया है। सोन नदी में अनाच्छादित इन संस्तरों की आयु प्रारम्भिक उपरि त्रिसंधी प्रस्तावित की गई है।

INTRODUCTION

IN South Rewa Gondwana Basin the Tiki Formation comprises huge sedimentary strata distributed in the low lying vast tract from Neosi (23°35′53″N: 81°11′39″E) to Tiki (23°56′2″N: 81°21′59″E). Excepting the reports by Rao (in Krishnan, 1958, p. 12) and Singh (in Sastry *et al.*, 1977, p. 73) no plant megafossil has so far been described from this region. During the last four years I collected fairly well-preserved plant remains mostly with 'phytolemma' from Janar River Section near

Harai (23°40′53″N: 81°12′40″E) and Son River Section near Giar (locally spelled as Ghiyar; 23°49′58″N: 81°16′14″E), Shahdol District, Madhya Pradesh.

MEGAFLORA FROM JANAR RIVER SECTION

Recently, fairly well-diversified mega- and microspore assemblages have been described from the Janar River Section by Banerji, Kumaran and Maheshwari (1978); Sundaram, Maithy and Singh (1979) and Kumaran and Maheshwari (1980). On the basis of palynoflora Maheshwari, Kumaran and Bose (1978) have suggested the age of these beds as Norian. Unlike the miofloral assemblages from this region megafloral record is rather poor. Rao (in Krishnan, 1958, p. 12) reported the occurrence of *Thinnfeldia hughesii* (*Dicroidium hughesii*) and *Thinnfeldia* sp. (*Dicroidium* sp.) from South bank of Janar River about 0.75 km north-east of Harai Village. He, however, did not give any description or figure of his specimens. The specimens described in this paper were collected from grey micaceous sandy shales exposed on the east bank of Janar River about 1.25 km south-south-west of Harai and on the north bank of Janar River about 0.75 km north-north-east of Harai (Map 1).

DESCRIPTION

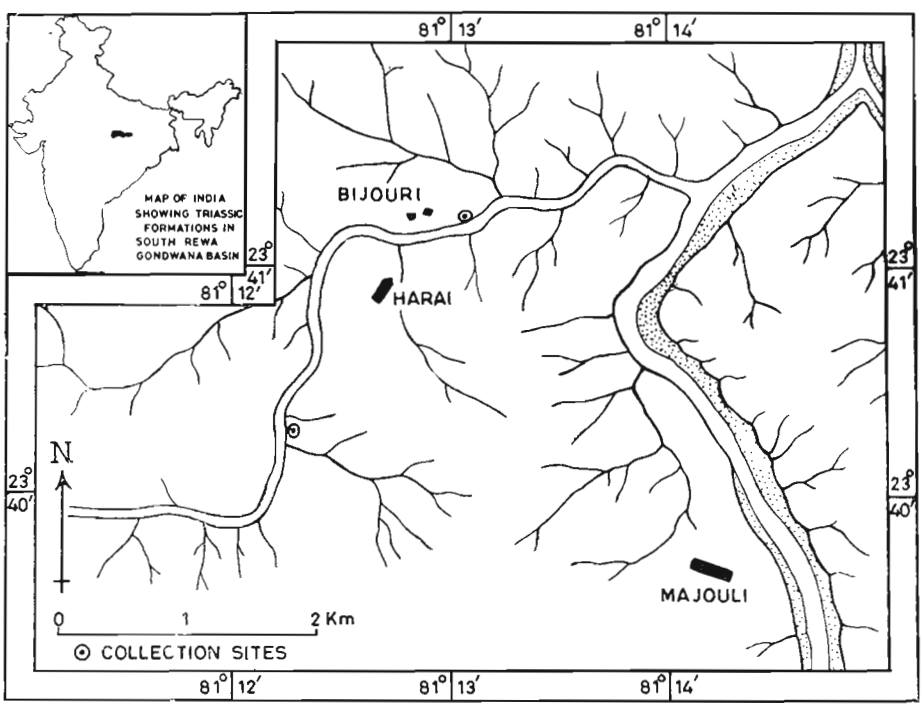
Class — Pteridospermopsida
Order — Peltaspermales
Family — Peltaspermaceae

Genus — *Lepidopteris* Schimper, 1869

Lepidopteris madagascariensis Carpentier

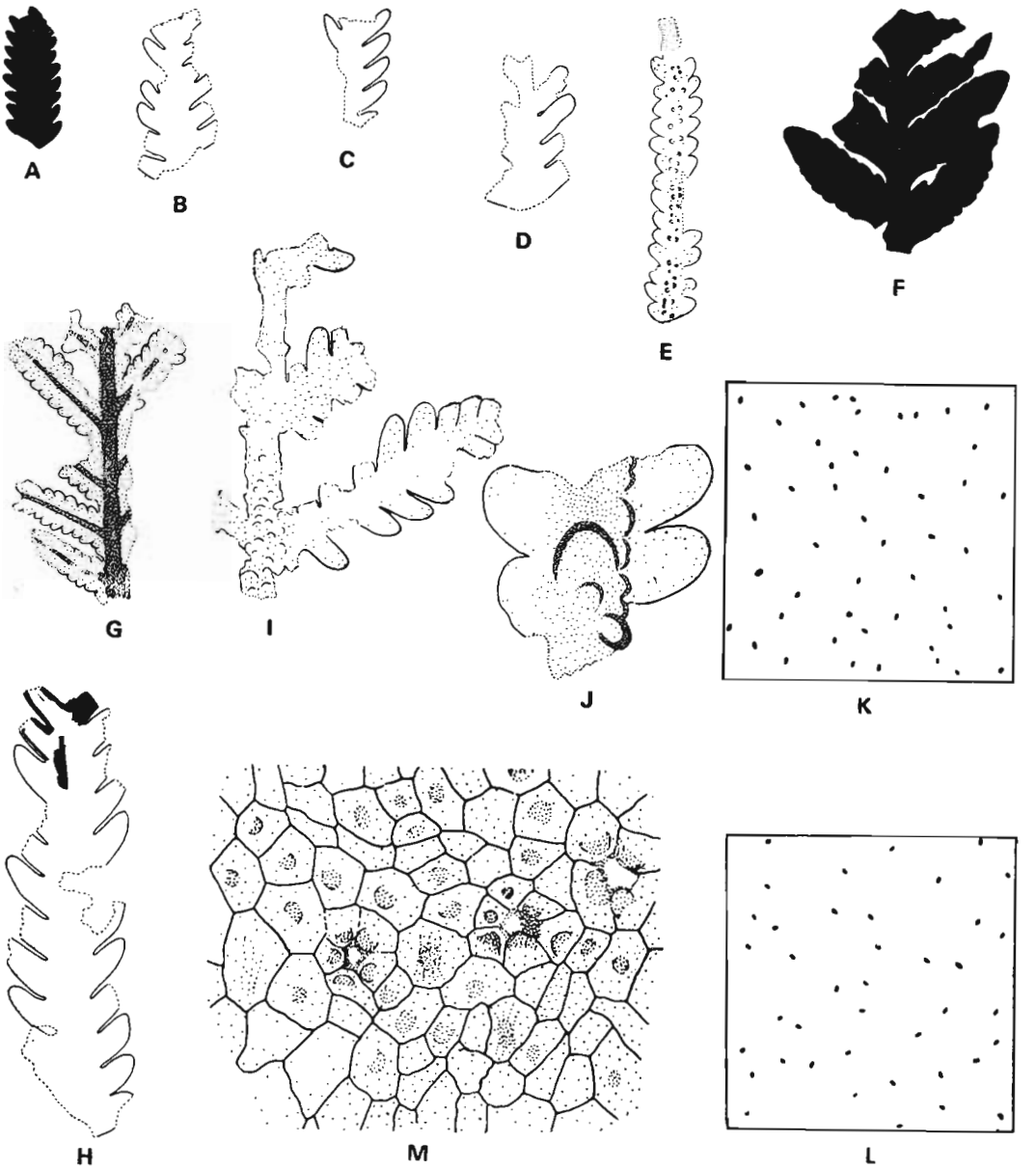
Pl. 1, figs 1-12; Text-fig. 1A-M

Description — Leaf bipinnate, incomplete at base and apex, largest specimen measuring 5 cm in length. Substance of lamina thick. Rachis 5 mm wide, covered with about 1 mm wide lumps. Lumps low, compressed edges of lumps raised on all sides. Pinnae subopposite, arising at an angle of about 60°, ±2 cm apart, largest available pinna 6 cm long, pinnules of adjacent pinna not touching each other. 'Zwischerfiedern'



MAP 1 — Showing the fossiliferous localities near Harai, Shahdol District, Madhya Pradesh, India.

more or less triangular in shape, about 1 mm long and 1 mm wide, attached by entire base, margins entire, apex obtuse, rarely subacute. Pinna rachis 4 mm wide, near base with minute lumps, remaining part smooth. Pinnules subopposite, arising at an angle of about 60°, usually lying slightly away from one another, rarely at places lateral margins of adjacent pinnules touching or overlapping each other. Pinnules typically oblong, 4-8 mm long and 2-4 mm wide, rarely slightly falcate, attached by

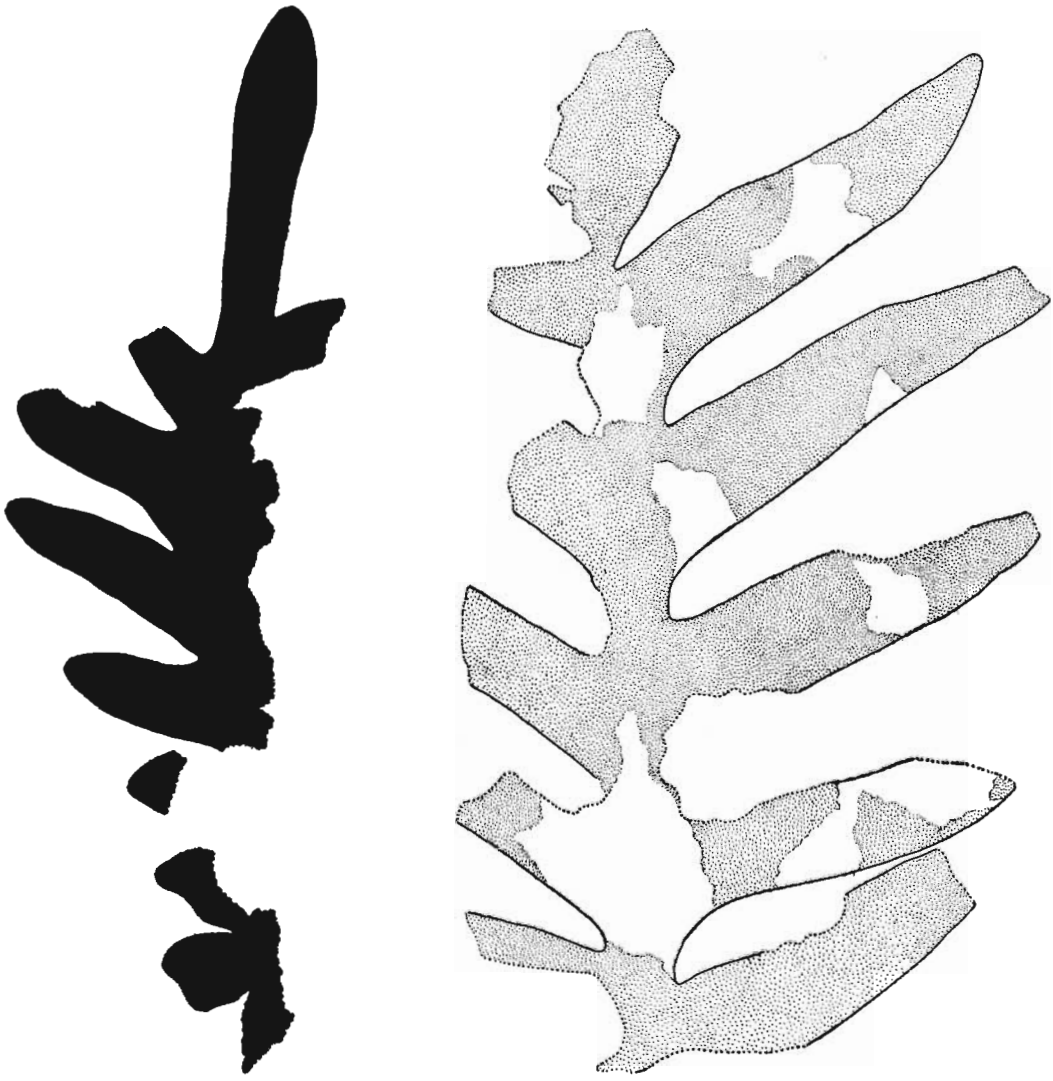


TEXT-FIG. 1 — *Lepidopteris madagascariensis* Carpentier. **A-I**, B.S.I.P. nos. 35610, 35614, 35606, 35615, 35611, 35607, 35612 35613, 35690: all, × 1; **J**, part of specimen in fig. E magnified showing detail of lumps over the rachis, B.S.I.P. slide no: 35611-1, × 4; **K, L**, distribution of stomata on two surfaces of lamina. B.S.I.P. slide no. 35609-3, × 40; **M**, cuticle of lamina showing epidermal cells and a few stomata, B.S.I.P. slide no. 35609-2, × 250.

entire base, margins entire or slightly lobed, apex obtuse or subacute. Midrib distinct, running up to apex; lateral veins scarcely visible, subopposite, forked or unforked.

Cuticle of rachis about 3 μm thick, amphistomatic; cells polygonal, somewhat isodiametric, often slightly elongated along middle region of rachis; anticlinal walls straight, at places slightly sinuous or with minute projections, often pitted; periclinal wall usually with a well-developed solid papilla. Stomatal frequency more or less similar on both surfaces. Subsidiary cells 4-7 in number, usually 5 or 6, each with a solid well-cutinized papilla overhanging the stomatal pit; stomatal pit round to oval, inner wall of subsidiary cells forming stomatal pit strongly thickened; guard cells sunken; aperture slit-like.

Cuticle of lamina about 2.5 μm thick. Cells polygonal, more or less isodiametric; sometimes cells along veins slightly



TEXT-FIG. 2 — *Dicroidium hughesii* (Feistmantel) Gothan. **A, B,** B.S.I.P. nos. 35618 and 35619, both, × 1.

elongated; anticlinal walls 2-5 μm thick, usually straight sometimes minutely undulated, at places broken by pits; periclinal wall mostly with a low solid papilla, at places papilla indistinct or absent, cell surface occasionally showing faint radiating striations. Stomatal frequency in both surfaces almost similar, irregularly distributed, typically monocyclic. Subsidiary cells usually 5-6, rarely 4, each with a cutinized solid lappet overhanging stomatal pit; stomatal pit round or oval. Guard cells sunken; aperture slit-like.

Occurrence — East bank of Janar River, 1.25 km south-south-west of Harai.

Comparison & Discussion — The specimens from Janar River agree with *Lepidopteris medagascariensis*, described by Townrow (1966), from Lower to Middle Triassic of Australia, Madagascar and South Africa, in size, shape and venation pattern of pinnules as well as in cuticular features. Like the specimens earlier described from Australia and other localities the present specimens, too, show variations in shape and size of the pinnules.

Order — Corystospermales
Family — Corystospermaceae

Genus — *Dicroidium* Gothan, 1912

Dicroidium hughesii (Feistmantel) Gothan

Pl. 2, figs 13-19; Text-figs 2A, B; 3A-E

Description — Leaf imparipinnate, maximum available length 14 cm. Rachis up to 18 mm wide. Pinnae opposite or subopposite, oblong to linear lanceolate, often slightly curving towards the pinna lying below, typically 6×1.5 cm, closer to base pinnae gradually decreasing in size, finally at extreme base becoming almost orbicular in shape. Pinna attached to rachis by entire base; basiscopic margin decurrent; lateral margins mostly entire, at places slightly wavy; apex obtuse or subacute. Typically each pinna with a distinct midvein, besides midvein a few veins arising directly from rachis. They are mostly confined below the midvein. Secondary veins arising from the midvein at an angle of ±40°, slightly arching, mostly once forked, towards apex lateral veins may be unforked.

Cuticle of rachis about 6 μm thick, slightly thinner on one side; amphistomatic. Cells usually squarish or rectangular in shape, sometimes polygonal, tending to be in rows; anticlinal walls straight; periclinal wall on thinner side smooth but often papillate on thicker side. Stomata sparse, about 15 per sq mm, mostly transversely or obliquely orientated.

Cuticle of lamina about 4 μm thick, one surface slightly thicker than the other; amphistomatic. Cells along veins often elongated arranged in rows, other epidermal cells mostly isodiametric-polygonal. Cells of thinner side mostly with somewhat rounded corners and also larger in size than those on the thicker surface. On both surfaces 4-6 rows of elongated cells present along lamina margins. Anticlinal walls of cells usually straight, at places slightly undulated; periclinal wall unspecialized or with a low, solid papilla. Papillae rare on thinner side but very common and comparatively distinct on the thicker side. Stomata slightly more in number on thicker surface, irregularly distributed and orientated, monocyclic or imperfectly dicyclic. Subsidiary cells usually 4 (2+2), sometimes 5, on thinner side rarely with a low papilla, on thicker surface subsidiary cells often papillate and sometimes papilla overhanging the stomatal pit. Stomatal pit typically rectangular, guard cells thinly cutinized, moderately sunken on thinner surface but relatively more sunken or thicker surface. Aperture slit-like or narrowly elliptical, lateral subsidiary cells frequently accompanied by encircling cells.

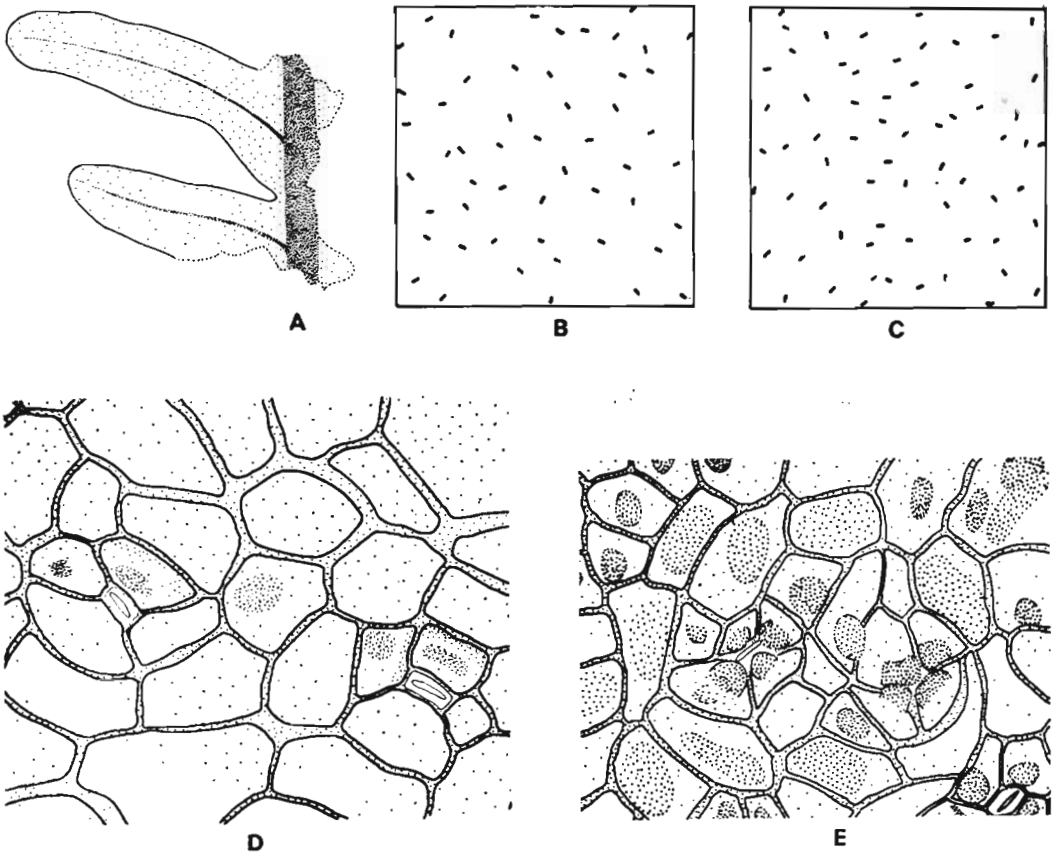
Occurrence — East bank of Janar River, 1.25 km south-south-west of Harai.

Comparison & discussion — The present specimens in their gross features and cuticular characters resemble *Dicroidium hughesii* described by Lele (1962a) from the Parsora Formation.

Dicroidium zuberi (Szajnocha) Archangelsky

Pl. 3, figs 20-32; Text-figs 4A-M, 5A-D

Description (for description assumed to be bipinnate) — Detached pinnae, imparipinnate, largest available pinna 8 cm long and 3 cm wide. Pinna rachis 2-5 mm wide, having a distinct median ridge. Pinnules closely spaced, often touching or overlapping each other; rhomboidal or broadly oval, 4×3 mm to 18×16 mm in size; usually

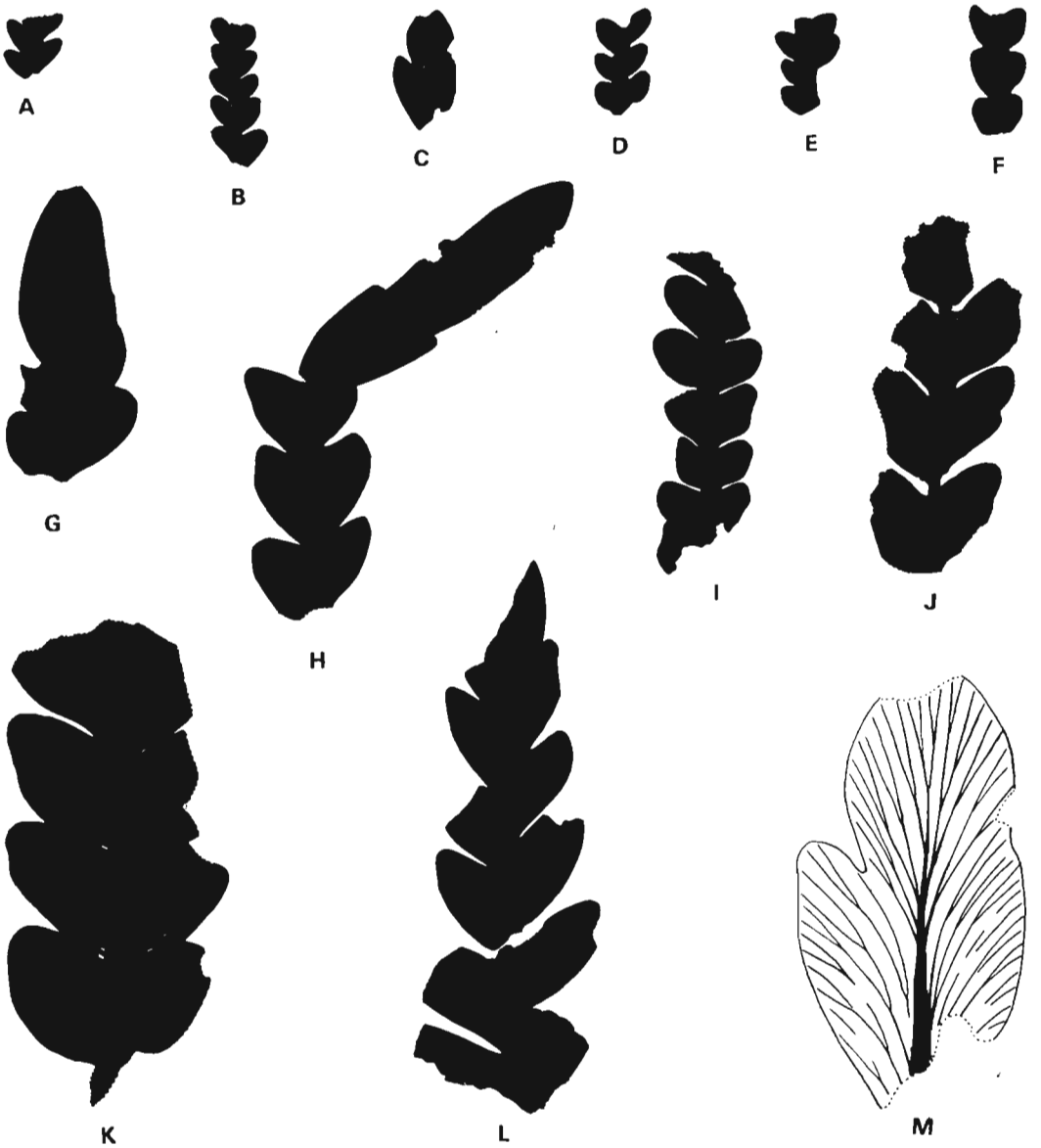


TEXT-FIG. 3 — *Dicroidium hughesii* (Feistmantel) Gothan. **A**, B.S.I.P. no. 35617, × 1; **B**, distribution of stomata over thinner side of lamina cuticle, B.S.I.P. slide no. 35618-2, × 40; **C**, distribution of stomata over thicker side of lamina cuticle, B.S.I.P. slide no. 35618-2, × 40; **D**, cuticle of lamina, thinner side, showing epidermal cells and two stomata, B.S.I.P. slide no. 35619-1, × 250; **E**, cuticle of lamina, thicker side, showing two stomata and epidermal cells, B.S.I.P. slide no. 35619-1, × 250.

slightly contracted at base; margins entire or slightly lobed; apex obtuse. Terminal pinnule oval or oblong. Three to four veins arising close to basiscopic side of pinnule base, each of these veins forking 1-3 times and arching towards margins. Substance of lamina thick.

Cuticle of pinnule on both surfaces more or less similar, rarely one surface slightly thinner, 6 μm thick, amphistomatic. Epidermal cells mostly isodiametric-polygonal, rarely at places slightly elongated, anticlinal walls 3-4 μm thick, usually straight, sometimes slightly undulated, rarely cell outlines with about 2 μm high cutin processes; periclinal wall usually having a low solid papilla, papilla often relatively more distinct on thicker surface. Stomatal frequency almost similar on both surfaces, evenly distributed over entire surface, irregularly orientated. Subsidiary cells 4-6 in number, mostly 5, occasionally differentiated into polar and lateral subsidiary cells, very rarely papillate. Rarely subsidiary cells of adjacent stomata touching each other. Stomatal pit typically rectangular, thickly cutinized on lateral sides; guard cells sunken, thinly cutinized, aperture slit-like. Encircling cells absent.

Rachis cuticle about 8 μm thick (one surface slightly thicker than the other), amphistomatic. On thicker side cells usually longitudinally elongated, at places isodiametric-polygonal. Stomata mostly transversely or obliquely orientated, sometimes longitudinally placed. Other details similar



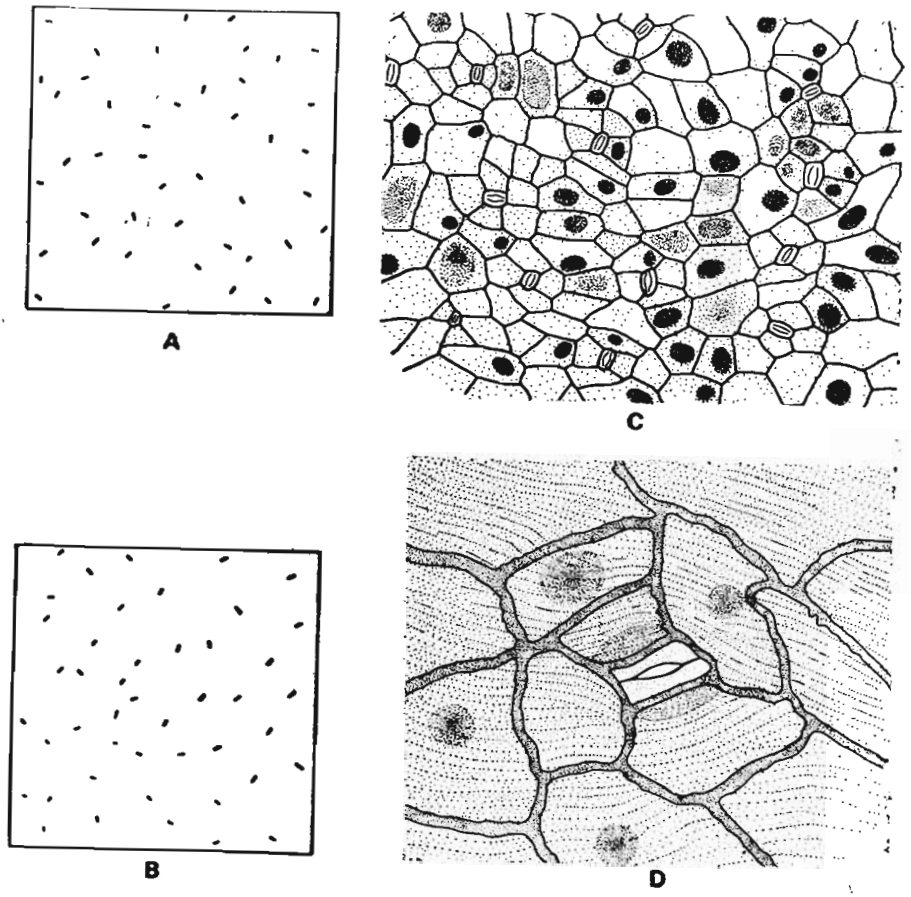
TEXT-FIG. 4 — *Dicroidium zuberi* (Szajnocha) Archangelsky. A-L, B.S.I.P. nos. 35630, 35621, 35631, 35632, 35633, 35620, 35636, 35623, 35635, 35628, 35627 and 5634, all × 1; M, specimen in fig. C magnified showing venation, B.S.I.P. slide no. 35631-1, × 4.

to the ones occurring over the pinnule surfaces.

Occurrence — East Bank of Janar River, about 1.25 km south-south-west of Harai and north bank of Janar River about 0.75 km east-north-east of Harai.

Remarks — In some of the specimens epidermal cells show parallel striations. Striations usually continuous along adjacent cells, often converging towards the cell papilla. In some specimens striations are quite distinct, whereas, in others they are very faint or even absent.

Discussion & Comparison — The Janar River assemblage is dominated by *Dicroidium zuberi*, however, so far no bipinnate frond



TEXT-FIG. 5 — *Dicroidium zuberi* (Szajnocha) Archangelsky. **A, B**, Distribution of stomatan on two surfaces of lamina, B.S.I.P. slide no. 35627-1, × 40; **C**, cuticle of lamina showing epidermal cells and stomata, B.S.I.P. slide no. 35634-1, × 125; **D**, a stoma and the surrounding epidermal cells with striations over the surface, B.S.I.P. slide no. 35634-2, × 500.

have been collected from this region. In gross features; thickness of cuticle; size, shape and outlines of epidermal cells and nature of stomatal apparatus the present specimens agree with those of *D. zuberi* described by Archangelsky (1968) from Middle to Upper Triassic of Argentina.

Dicroidium sp.

Pl. 4, figs 33-40; Text-fig. 6A-F

Description (based on fragmentary specimens, largest specimen 2.3 cm in length)— Leaf at least once pinnate. Pinna subopposite, elliptic or linear lanceolate, 4-11 mm long and 2-3 mm wide, attached by whole base, basiscopic margin decurrent, lateral margins entire, apex obtuse. Midvein distinct in the basal half of the pinna, evanescent towards apex. Lateral veins arising at an acute angle, once or twice forked.

Cuticle of lamina about 2.5 μm thick, one surface slightly thicker than the other. Epidermal cells mostly polygonal, ±isodiametric, on thicker side veins marked by rows of elongated cells, on both surfaces few rows of elongated cells present along lamina margin. Anticlinal walls of epidermal cells straight, often faintly sinuous, periclinal wall with a low solid papilla. Stomata more or less equally numerous on both surfaces of lamina, evenly distri-

buted and irregularly orientated. Subsidiary cells mostly 4 (2+2) in number, sometimes 5; often subsidiary cell bearing a low papilla on its surface. Stomatal pit rectangular, guard cells sunken, common wall between guard cells and lateral subsidiary cells thickened, aperture slit-like or narrowly elliptic. Frequently lateral subsidiary cell accompanied by an encircling cell outside it.

Rachis cuticle about 3 μm thick, one surface slightly thicker than the other. Cells of median region rectangular or square, serially arranged, more distinct on thicker side. Cells of marginal region polygonal, ± isodiametric. Anticlinal walls of epidermal cells straight or minutely sinuous, periclinal wall with a papilla. Stomata sparse, irregularly distributed and orientated.

Locality — East Bank of Janar River, about 1.25 km south-south-west of Harai.

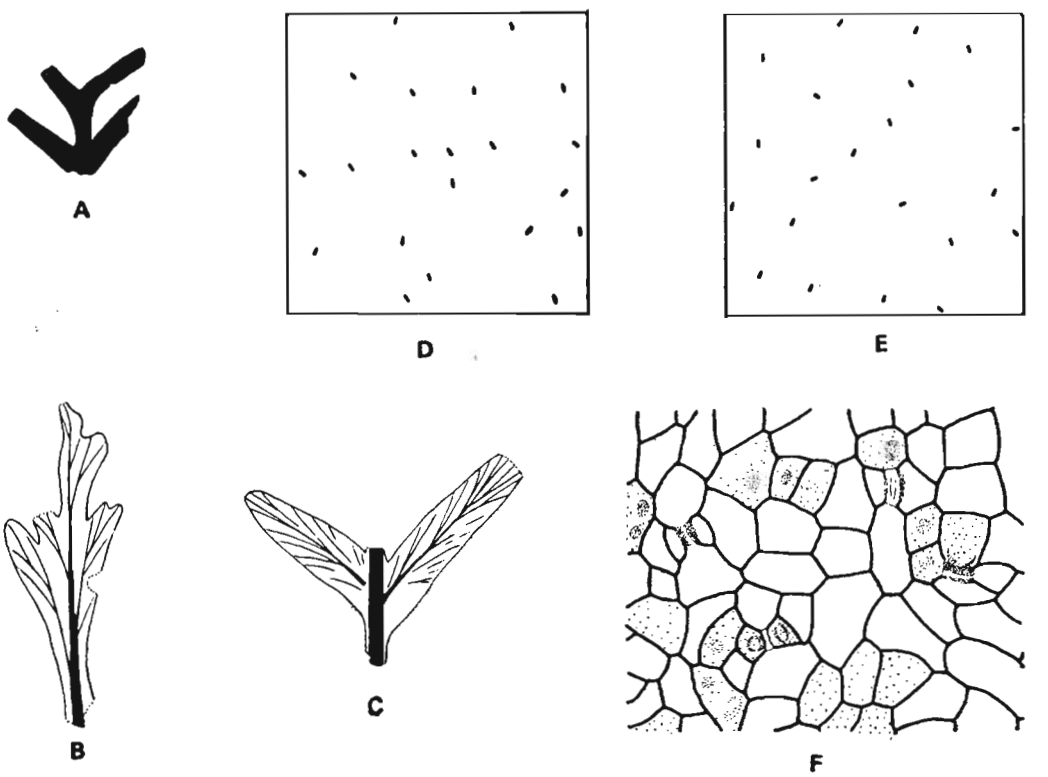
Comparison — *Dicroidium* sp. resembles some specimens of *D. coriaceum* (Johnston) Townrow described by Archangelsky (1968) from the Middle-Upper Triassic of Argentina in gross features and cuticular characters. But assignment of the present specimens to any particular species has been avoided due to their fragmentary nature.

Genus — *Xylopteris* Frenguelli, 1943

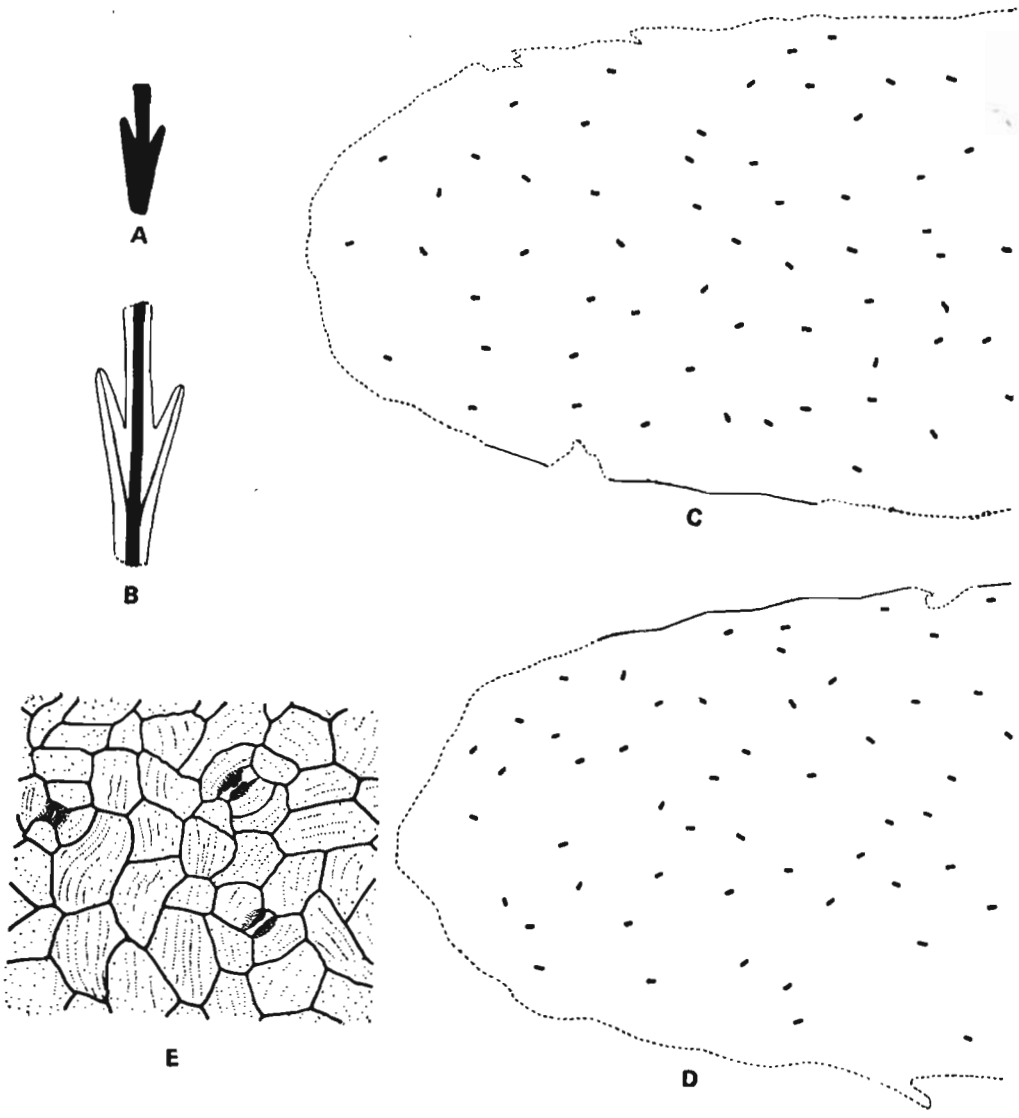
Xylopteris sp.

Pl. 4, figs 41-43; Text-fig. 7A-E

Description (based on single fragment, 1.6 cm in length, broken at both ends)— Leaf at least once pinnate. Rachis 1.5-2 mm wide, winged. Lamina segments subopposite, arising at an angle of about 20°, linear, 5 mm long, 1-1.5 mm wide, attached by entire base, basiscopic margin decurrent lateral margins entire, apex rounded,



TEXT-FIG. 6 — *Dicroidium* sp. A, B.S.I.P. no. 35639, × 1; B, C, B.S.I.P. slide nos. 35641-1 and 35640-1, both, × 2; D, E, distribution of stomata in thinner and thicker cuticle surfaces, B.S.I.P. slide no. 35640-2, × 40; F, thinner cuticle surface of lamina showing epidermal cells and a few stomata, B.S.I.P. slide no. 35640-2, × 150.



TEXT-FIG. 7 — *Xylopteris* sp. **A**, B.S.I.P. no. 35642, × 1; **B**, same, × 2, showing venation; **C**, **D**, distribution of stomata on thinner and thicker surfaces of lamina cuticle, B.S.I.P. slide no. 35642-2, × 50; **E**, thicker cuticle surface of lamina showing epidermal cells and stomata, B.S.I.P. slide no. 35642-2, × 150.

single median vein running from base to apex.

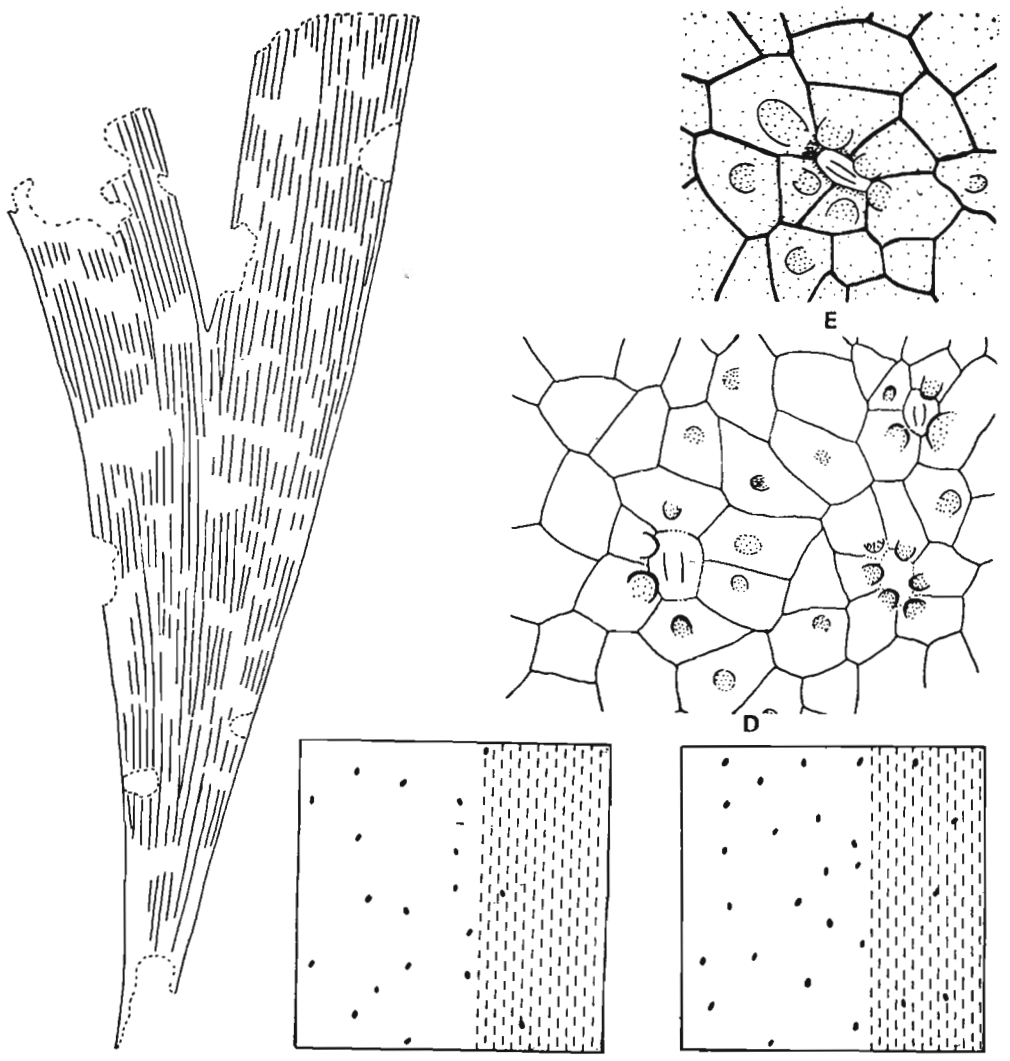
Rachis cuticle about 3 μm thick, one side thicker than the other. On thicker side cells along the middle region longitudinally elongated, serially arranged, along the wing cells polygonal, ±isodiametric or slightly elongated. On thinner side cells polygonal, mostly isodiametric, sometimes elongated. Anticlinal walls of epidermal cells straight, at places slightly undulated, periclinal wall with faint longitudinal striations, rarely with an indistinct papilla. Stomata ± equally numerous on two surfaces, irregularly distributed, longitudinally or obliquely placed.

Lamina cuticle about 2.5 μm thick, one surface slightly thicker than the other. On thicker side cells rectangular, ±serially

arranged, over the vein cells narrower and more regularly arranged. On thinner side cells polygonal, ± isodiametric, sometimes squarish. Anticlinal walls of epidermal cells mostly straight, at places minutely wavy or sinuous. Periclinal wall smooth or mottled. Stomata almost equal in frequency on both surfaces, evenly distributed mostly longitudinally or obliquely orientated, rarely transversely placed. Subsidiary cells 4 in number, two polar and two lateral, sometimes five. Guard cells ± sunken, common wall between guard cells and lateral subsidiary cell moderately thickened. Stomatal pit typically rectangular. Lateral subsidiary cell occassionally with an encircling cell outside it.

Occurrence — East bank of Jarar River, about 1.25 km south-south-west of Harai.

Comparison — In size, shape and disposition of lamina segments and in cuticular details the present specimen resembles



TEXT-FIG. 8 — *Sphenobaiera janarensis* Pal sp. nov., **A**, holotype, B.S.I.P. no. 35637, × 1; **B**, **C**, distribution of stomata on thicker and thinner sides of lamina cuticle, dotted areas represent venal region, B.S.I.P. slide no. 35637-1, × 40; **D**, three stomata and epidermal cells in the intervenal region of thinner side of lamina cuticle, B.S.I.P. slide no. 35637-1, × 250; **E**, a stoma, B.S.I.P. slide no. 35637-2, × 500.

Xylopteris spinifolia (Tenison-Woods) Frenguelli described from Middle-Upper Triassic of Australia by Frenguelli (1943) and Jones and de Jersey (1947, as *Stenopteris spinifolia*).

Class — Coniferopsida
Order — Ginkgoales

Genus — *Sphenobaiera* Florin, 1936

Sphenobaiera janarensis Pal sp. nov.

Pl. 5, figs 44-48; Text-fig. 8A-E

Diagnosis — Leaf as a whole obcuneate, lamina deeply dissected, forming two distinct lobes, exceeding 14 cm in length, lamina below the point of bifurcation more than 9 cm long and 4 cm wide, gradually tapering towards base, lobes diverging at an angle of about 30°, each lobe about 2.2 cm wide near middle, up to atleast 4 cm long. Leaf margin entire. Veins 10-12 per cm.

Cuticle moderately thick, amphistomatic, one surface slightly thicker than the other. On thicker side cells along veins and margins serially arranged, elongated, 4-6 times longer than broad with oblique end-walls; cells between veins shorter in dimension, less regularly arranged. On thinner side cells along veins and margins serially arranged, 4-6 times longer than broad, end-walls oblique, interveinal cells polygonal, ±isodiametric. Anticlinal walls of cells distinct, ±straight; periclinal walls of cells on both surfaces usually with a distinct papilla, at places papilla indistinct. Stomata mostly confined to intervenal region, sometimes occurring along veins, irregularly distributed, longitudinally or obliquely orientated. Subsidiary cells 4-6, usually 5 in number, each with a papilla overhanging stomatal pit. Stomatal pit round or oval. Guard cells sunken, thinly cutinized; aperture slit-like.

Holotype — Specimen no. 35637 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — East bank of Janar River, about 1.25 km south-south-west of Harai.

Comparison — *Sphenobaiera janarensis* resembles *S. argentinae* described from the Middle Triassic of Argentina (Frenguelli, 1946; Jain & Delevoryas, 1967) and Australia (Retallack, Gould & Runnegar, 1977) in gross features as well as in venation pattern, but *S. janarensis* differs from *S. argentinae* in having more closely spaced veins and wider segments. Moreover, cuticular features of *S. argentinae* are not known so far. *S. janarensis* resembles the specimens of *S. spectabilis* (Nathorst) Florin (1936) in general shape and size. Its cuticle, however, resembles more the cuticle of *Baiera spectabilis* described by Harris (1926, 1935) from the Upper Triassic of Greenland (Harris' specimens of *B. spectabilis* were later described by Florin, 1936 as *Sphenobaiera spectabilis*). The present species differs from *S. spectabilis* in having leaf segments which are two times wider than the largest Greenland specimens. Also in the Greenland specimens the veins are more closely spaced which are forking more frequently.

Genus — *Baiera* Braun, 1843

Baiera sp.

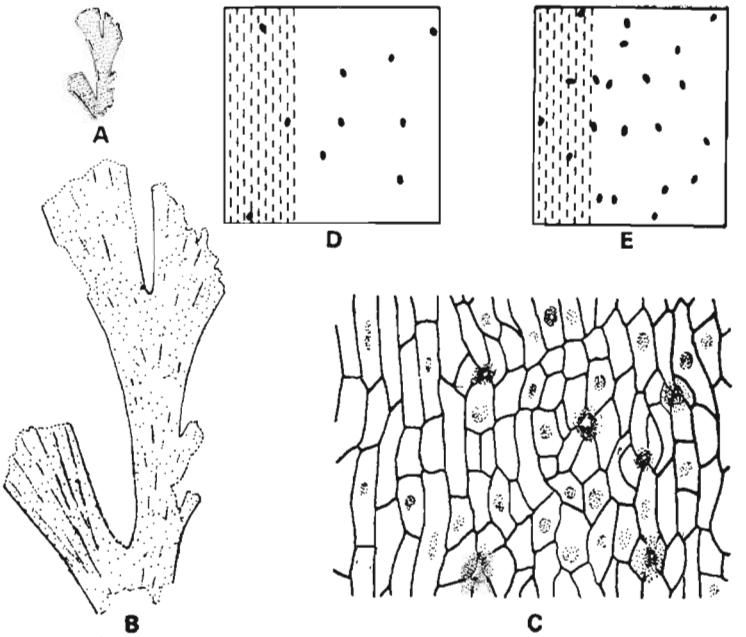
Pl. 6, figs 49-52; Text-fig. 9A-E

Description — Leaf fragment 1.5 cm long, divided by two successive dichotomies at angles of 35-40°. Segments about 2 mm wide at base gradually growing broader towards apex. Venation dichotomous.

Cuticle about 2 μm thick, amphistomatic. Epidermal cells along veins and margins narrowly elongated, rectangular or polygonal, serially arranged. In between veins cells wider and shorter, less regularly arranged. Anticlinal walls ± straight, at places broken by pits. Periclinal wall usually smooth, sometimes with faint striations, rarely with a low papilla. Stomata more numerous on one surface than on the other, mostly occurring in between veins with irregular distribution, at places forming ill-defined files of 3-4 stomata, mostly longitudinal or oblique in orientation, rarely transversely placed. Subsidiary cells 4-7 in number, usually 4 or 5. Inner walls of subsidiary cells heavily cutinized forming a crator-like stomatal pit. Frequently subsidiary cell bearing a cutin lappet overhanging the stomatal pit. Stomatal pit round to oval, sometimes elliptical. Guard cells deeply sunken, aperture slit-like.

Occurrence — East bank of Janar River, about 1.25 km south-south-west of Harai.

Comparison — In its available gross features *Baiera* sp. resembles *B. munsteriana* (Presl) Heer described by Harris (1926) from the Upper Triassic of Greenland. But



TEXT-FIG. 9 — *Baiera* sp. **A**, B.S.I.P. no. 35638, × 1; **B**, same, × 4; showing venation; **C**, **D**, distribution of stomata over two surfaces of lamina, dotted areas represent venal region, B.S.I.P. slide no. 35638-2, × 50; **E**, lamina cuticle showing epidermal cells and few stomata, on left note the elongated cells along vein, B.S.I.P. slide no. 35638-2, × 150.

it differs from the Greenland specimens in having more number of veins per segment. Also the cells outlines of *B. munsteriana* are distinctly sinuous. The Janar River specimen in having narrow segments and in cuticular features resembles *B. leptophylla* Harris (1935) from the Upper Triassic of Greenland, but differs from *B. leptophylla* in having more frequent dichotomies and more number of veins per segment.

MEGAFLORA FROM SON RIVER SECTION NEAR GIAR

Rao (in Krishnan, 1958, p. 12) for the first time reported the occurrence of *Thinnfeldia* sp. (*Dicroidium* sp.) and *Taeniopteris* sp. from east bank of Son River, north-west of Giar. Singh (in Sastry *et al.*, 1977, p. 73) reported *Dicroidium*, *Pachypteris*, *Noeggerathiopsis* and *Taeniopteris* from the Giar beds. Unfortunately both these authors have not given any description or figure of their specimens. According to Maheshwari, Kumaran and Bose (1978) *Gondwanoxylon ghiarii* Saksena (1962), a dicotyledonous wood described from Giar, is probably derived from the younger beds. Beside these, no other plant megafossils have so far been described from the Son River Section near Giar. However, a detailed description of miospores has been given by Maheshwari and Kumaran (1979).

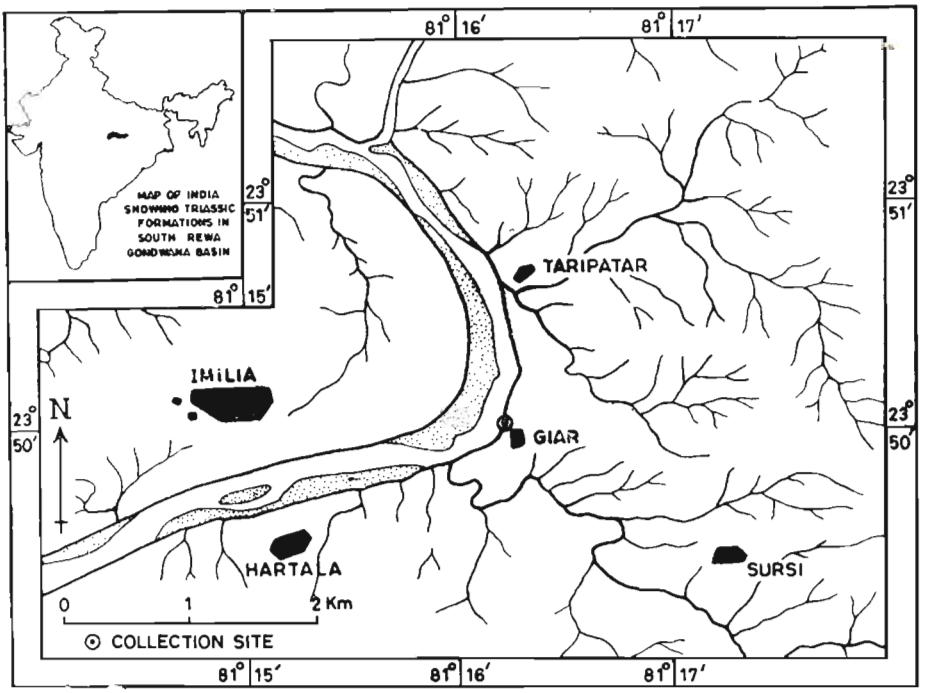
Plant megafossils described here were recovered from the greenish sandy shales exposed on the east bank of Son River about 150 m north-west of Giar (Map 2).

CLASS — SPHENOPSIDA

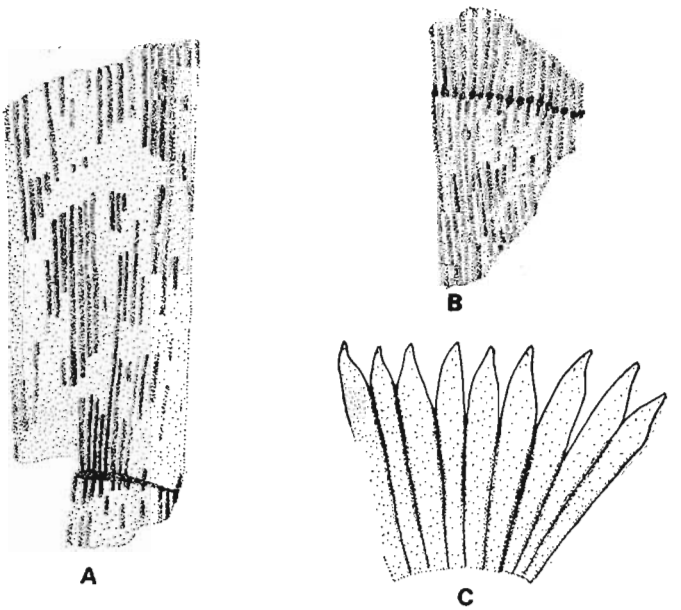
STEM

Pl. 6, figs 56-58; Text-fig. 10A, B

Description — Stem differentiated into nodes and internodes, ± 1.5 cm in diameter. Internodes characterized by alternately arranged parallel ridges and furrows in longitudinal direction, ridges and furrows continuous between internodes, 32-40 per cm. Node showing ± rounded scars, presumably representing leaf bases. Internodal region showing rectangular cells arranged in longitudinal rows.



MAP 2 — Showing fossiliferous locality near Giar, Shahdol District, Madhya Pradesh, India.



TEXT-FIG. 10 — **A**, **B**, equisetaceous stems, B.S.I.P. nos. 35646 and 35645, both × 2; **C**, equisetaceous leaf-sheath, B.S.I.P. no. 35643, × 8.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

Remarks — The specimens are preserved in the form of impression and cast. All the specimens are fragmentary, in none of them the internode region is complete. In the number of ridges per cm the present specimens resemble *Neocalamites foxii* Lele (1956) from the Parsora Formation. But the identity of *N. foxii* has been doubted by Bose (1974), continuous ridges between successive internodes occur not only in the genus *Neocalamites* but also in *Schizoneura* and *Phyllotheca*. Therefore, such leafless stems can not undoubtedly be assigned to any particular genus.

Leaf Sheath

Pl. 6, figs 53, 54; Text-fig. 10C

Description — Leaf sheath 4.5 mm long; divided segments; commisural flanges depressed, extending about 2-2.5 mm below the free tips. Segments linear-lanceolate, 0.5 mm wide, margin entire, apex acuminate.

Occurrence — East bank of Son River, 150 m north-west of Giar.

Nodal Diaphragm

Pl. 6, fig. 55

Description — Nodal diaphragm 12 mm in diameter. Margin fimbriated. At the centre a circular scar present. Other details obscure.

Occurrence — East bank of Son River, 150 m north-west of Giar.

Class — Pteridospermopsida
Order — Peltaspermales
Family — Peltaspermaceae

Genus — *Lepidopteris* Schimper, 1869

Lepidopteris stormbergensis (Seward) Townrow

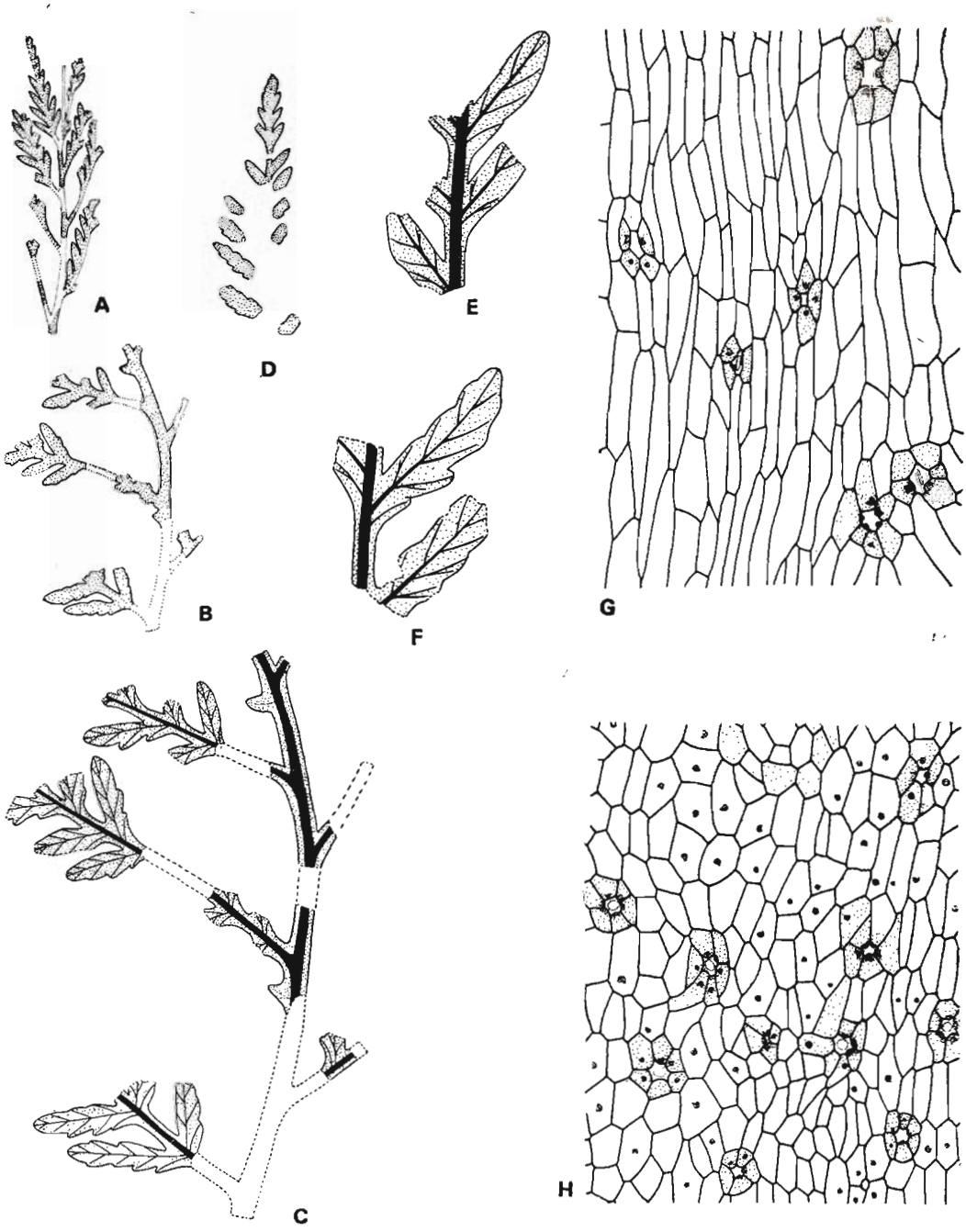
Pl. 7, figs 59-66; Pl. 8, figs 67-74; Text-figs 11A-H, 12A-G, 13A-I

Description — Leaf bipinnate, gradually tapering towards apex; principal rachis 1.5 mm wide, smooth, winged; 'zwischerfiedern' laterally borne, ovate, attached by entire base, margin entire, apex obtuse. Pinnae lanceolate, alternate, 0.5-1.0 cm apart, emerging at an angle of about 70° in midregion, gradually diminishing to about 30° near apex, ±4 cm long. Pinna rachis 0.5-0.7 mm wide, winged. Pinnules subopposite, arising at angle of 50°-60°, lanceolate, slightly falcate, typically 9 mm long and 2 mm wide near middle region, attached by broad base; acroscopic margin constricted, basiscopic margin decurrent extending downwards along rachis to pinnules lying below; lateral margins of basal pinnules mostly deeply lobed and their basiscopic margins more incised than acroscopic margin, distal pinnules becoming entire; pinnules apex subacute. Midrib in each pinnule running assymmetrically up to apex; lateral veins alternate or subopposite, mostly unforked, sometimes once forked. Lowermost pinnule lobe of the basiscopic side having a direct vascular supply from the pinna rachis.

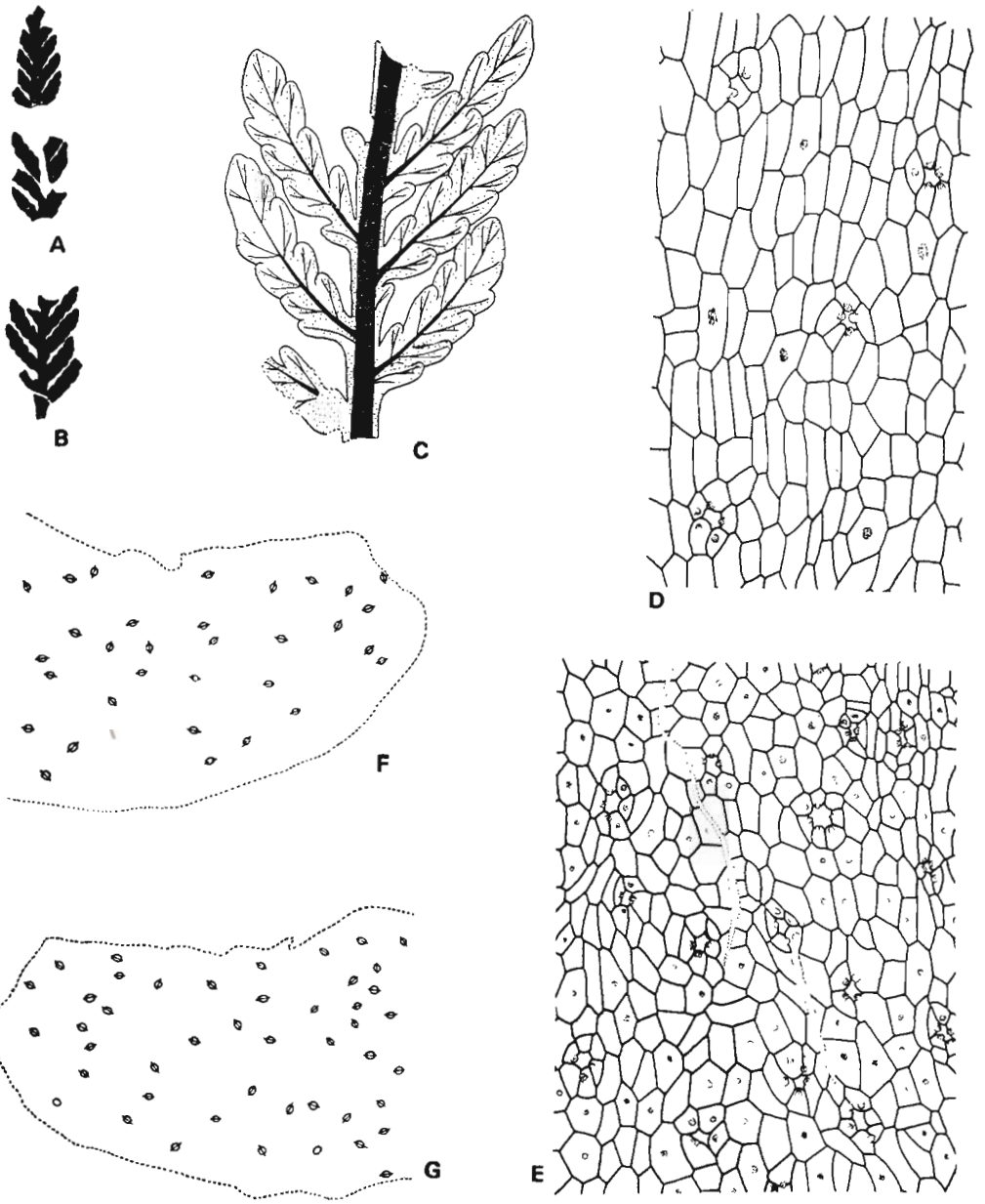
Cuticle of main rachis about 2.0 μm thick, one side slightly thicker than other, amphistomatic, stomata more numerous on thicker side. Epidermal cells on thicker surface polygonal, sometimes much longer than broad, cells of thinner surface much longer than broad, tending to be serially arranged. Anticlinal walls of epidermal cells straight, periclinal wall with a hollow papilla of about 5 μm in diameter or smooth. Stomata irregularly distributed, longitudinally or obliquely orientated. Subsidiary cells 4-6 in number (usually 5 or 6), very rarely 7, each with a papilla overhanging the stomatal pit, sometimes papilla placed little away from inner margin, papilla usually hollow, rarely subsidiary cells devoid of papillae. Stomatal pit round or broadly oval, guard cells sunken, aperture slit-like. Occasionally encircling cells present.

Cuticle of pinna rachis more or less similar to that of main rachis.

Cuticle of laminaa bout 1.5 μm thick, usually one surface slightly thicker than the other, amphistomatic, frequency of stomata more on thicker side more or less equally numerous on both surfaces of lamina. Veins faintly marked by few rows of elongated cells, other epidermal cells polygonal, mostly longer than broad, sometimes isodiametric; anticlinal walls sinuous or wavy, at places with 2-3 μm high cutin projections; periclinal wall with a hollow papilla, about 8 μm in diameter, sometimes periclinal walls devoid of papillae. Stomata irregularly

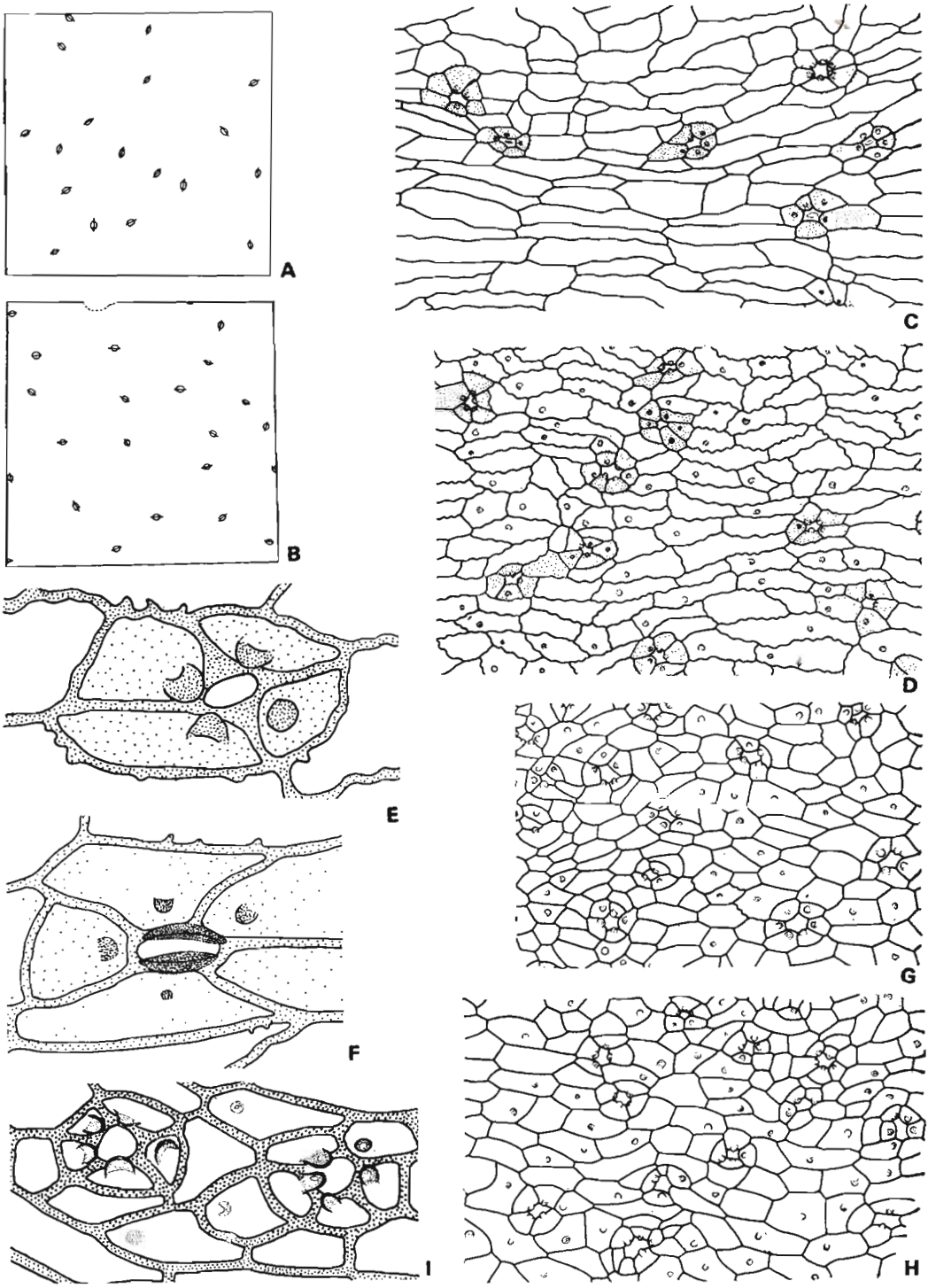


TEXT-FIG. 11 — *Lepidopteris stormbergensis* (Seward) Townrow. **A**, drawing of the part and counterpart of a specimen superimposed on each other, B.S.I.P. nos. 35653 and 35653 (CP), × 1; **B**, B.S.I.P. no. 35652, × 1; **C**, specimen in fig. B, × 2, showing venation of the pinnules; **D**, B.S.I.P. no. 35648, × 1; **E**, **F**, pinna fragments, recovered by bulk maceration, showing venation, B.S.I.P. slide no. 8140, both × 4; **G**, **H**, thinner and thicker surfaces of rachis cuticle, B.S.I.P. slide no. 35652-3, × 100.



TEXT-FIG. 12 — *Lepidopteris stormbergensis* (Seward) Townrow. **A**, **B**, B.S.I.P. nos. 35651 and 35650, both × 1; **C**, specimen in fig. B, showing venation, × 4; **D**, **E**, thinner and thicker cuticle surfaces of pinna rachis, B.S.I.P. slide no. 35650-4, × 100; **F**, **G**, distribution of stomata on thinner and thicker cuticle surfaces of a lamina segment, B.S.I.P. slide no. 35650-2, × 40.

distributed and orientated, mostly distantly placed, rarely subsidiary cells of adjacent stomata touching each other, subsidiary cells 5-7 in number, usually 5 or 6, each with a hollow papilla, usually overhanging the stomatal pit, sometimes papilla placed away from stomatal pit, anticlinal wall of subsidiary cell often with brush-like cutin



TEXT-FIG. 13

projections. Subsidiary cells sometimes more cutinized than ordinary epidermal cells. Stomatal pit round to oval, guard cells sunken, thinly cutinized, aperture slit-like. Subsidiary cells sometimes with encircling cells, usually forming incomplete ring.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

Remarks — *Lepidopteris stormbergensis* (Seward) Townrow is fairly common at Giar. The present specimens fall in two distinct groups. In one group pinnules are smaller in size with relatively less incised margins; ordinary epidermal cells ± elongated, only the cells of the thicker side of lamina cuticle are papillate, those on thinner side are smooth, cell outlines are distinctly sinuous or wavy and with cutin processes; stomatal frequency is unequal on two surfaces of lamina and subsidiary cells are more cutinized than ordinary epidermal cells (Pl. 7, figs 59, 62-66; Pl. 8, figs 68, 71, 72; Text-figs 11A-H, 13A-F). In the second group pinnules are larger in size and deeply lobed (almost becoming pinnate again); ordinary epidermal cells ± isodiametric, cells of both surfaces of lamina are papillate, cell outlines almost straight; stomata ± equally numerous on both surfaces of lamina and subsidiary cells and ordinary epidermal cells are of similar thickness (Pl. 7, figs 60, 61; Pl. 8, figs 67, 69, 70, 73, 74; Text-figs 12A-E, 13G-I). Specimens of first group are relatively more abundant than those of the second group. Similar variations in gross features as well as in cuticular details of this species have already been noticed by Townrow (1956, 1960) in the specimens from the Triassic of South Africa, Australia and Argentina. In all the specimens the rachises are entirely smooth excepting that in Pl. 7, fig. 60 (a pinna fragment) which shows small lumps over the rachis. Townrow (1960) also has mentioned about some specimens of *Lepidopteris stormbergensis* in which the rachises are smooth.

Order — Corystospermales
Family — Corystospermaceae

Genus — *Dicroidium* Gothan, 1912

Dicroidium giarensis Pal sp. nov.

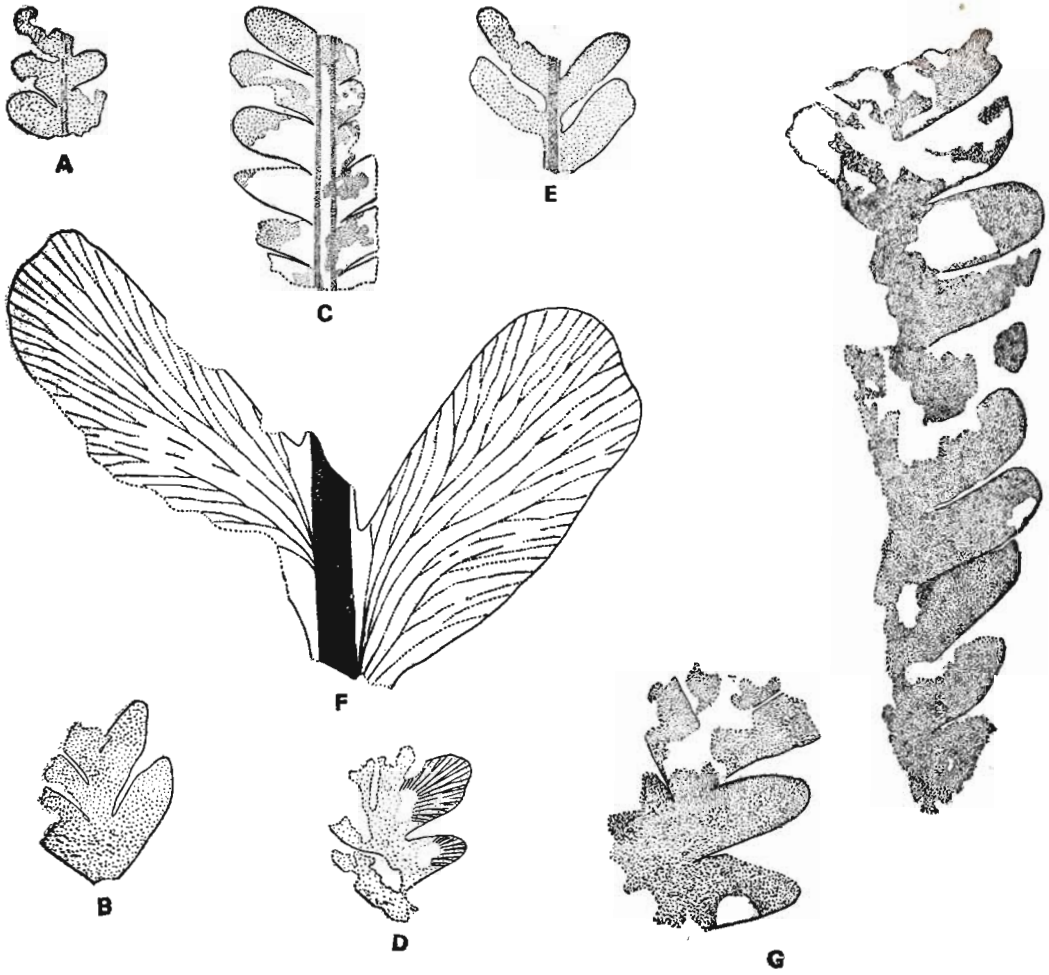
Pl. 9, figs 75-81; Text-figs 14A-G, 15A-F

Diagnosis — Pinnate frond; rachis 3-5 mm wide. Pinnae alternate, opposite or subopposite, arising at angle of 50°-60°, elliptic-oblong, 1-1.5 cm long and 5-8 mm broad, attached by broad base, acroscopic margin constricted, basiscopic margin decurrent, lateral margins entire or at places wavy. Venation consisting of 2-3 veins, tending to concentrate in one basiscopic point, uppermost vein strongest forking 3-5 times and supplying major part of lamina, lower veins forking once or twice.

Rachis cuticle about 2 μm thick, amphistomatic, frequency of stomata slightly more on lower side. Epidermal cells at places tending to be serially arranged, squarish, rectangular or polygonal, cells towards margin slightly more elongated; anticlinal walls undulated or rarely at places straight; periclinal wall unspecialized or with a faintly marked papilla (15 μm in diameter). Stomata irregularly distributed, transversely or obliquely orientated, rarely longitudinally placed. Subsidiary cells 4-6 in number, when 4 (2+2); rarely two adjacent stomata sharing a common subsidiary cell, surface wall mottled or papillate. Stomatal pit mostly rectangular, sometimes broadly oval; guard cells sunken, thinly cutinized, aperture narrowly elliptic. Lateral subsidiary cells sometimes with one or rarely with two encircling cells.

←

TEXT-FIG. 13 — *Lepidopteris stormbergensis* (Seward) Townrow: **A, B**, distribution and orientation of stomata over thinner and thicker sides of pinnule cuticle, B.S.I.P. slide no. 35652-2, × 40; **C, D**, thinner and thicker side of pinnule cuticle showing epidermal cells and stomata. note the epidermal cells of thinner side are not papillate but those of thicker surface are papillate, B.S.I.P. slide no. 35652-2, × 100; **E**, a stoma having four subsidiary cells with well developed papillae close to the stromatal pit, B.S.I.P. slide no. 35653-1, × 500; **F**, a stoma with five subsidiary cells, papillae over subsidiary cells are relatively small and away from the stomatal pit, B.S.I.P. slide no. 35654-1, × 500; **G, H**, cuticle of two surfaces of lamina, note the epidermal cells of both surfaces are papillate, B.S.I.P., slide no. 35650-2, × 100; **I**, two stomata, B.S.I.P. slide no. 35650-2, × 250.

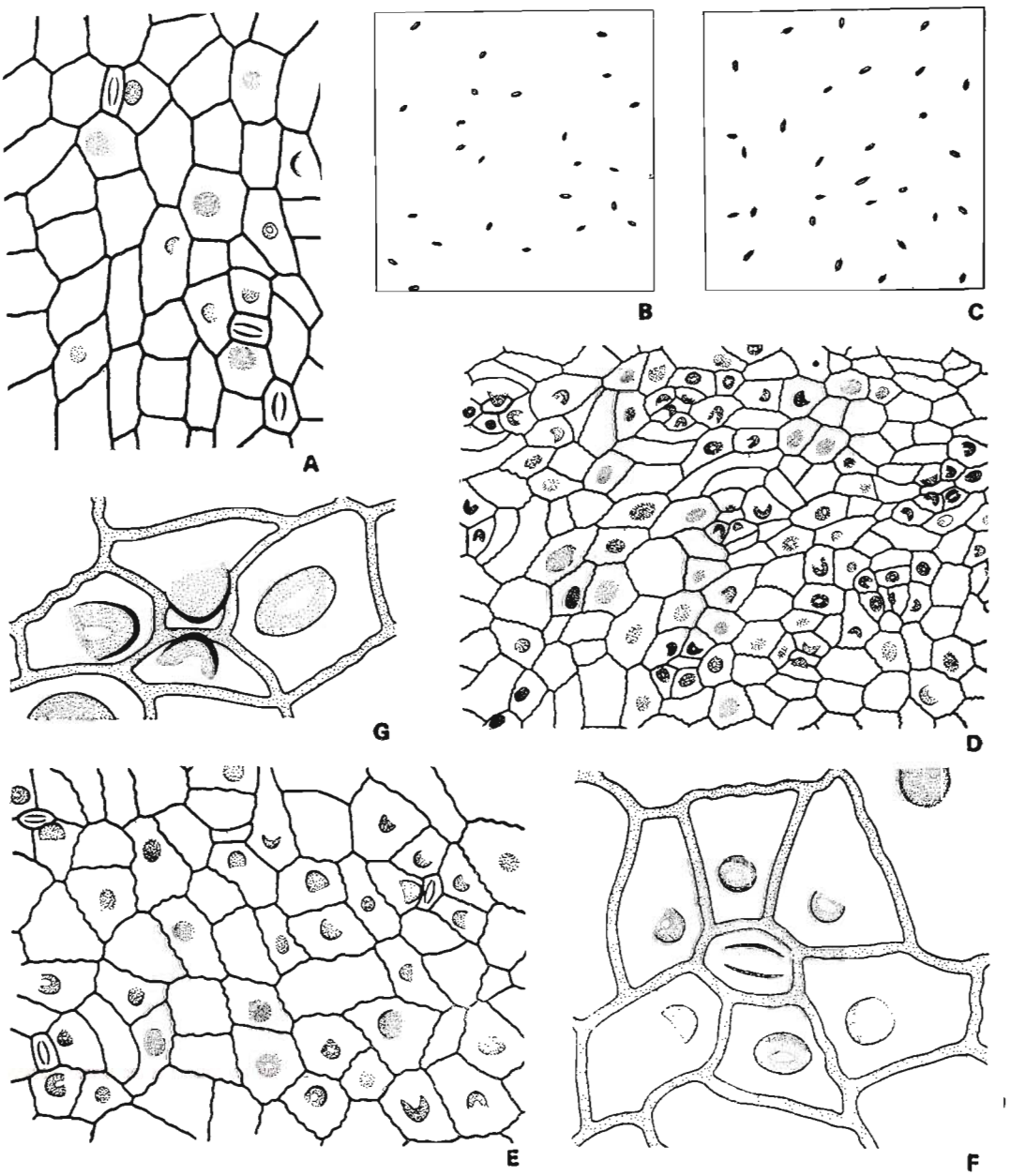


TEXT-FIG. 14 — *Dicroidium giarensis* Pal sp. nov.: **A-E**, B.S.I.P. nos. 35655, 35656, 35658, 35660 and 35661, all × 1; **F**, part of specimen in fig. E showing venation, × 4; **G**, holotype, B.S.I.P. no. 35659, × 1.

Cuticle of lamina about 1.5 μm thick, one surface slightly thicker than the other, amphistomatic with more or less similar frequency of stomata on both surfaces. On thicker surface cells along veins often rectangular, tending to be serially arranged. Ordinary epidermal cells on both surfaces polygonal. Cell outlines sinuous, surface usually papillate, papillae hollow, more distinct on thicker side of lamina cuticle, sometimes cells devoid of papillae. Stomata irregularly distributed and orientated. Stomata ± exposed or with exposed poles and sunken apperture. Subsidiary cells 4-7 in number, usually 4 or 5, on thicker side subsidiary cells mostly papillate, sometimes papillae overhanging the stomatal pit, on thinner side subsidiary cells usually devoid of papillae. Stomatal pit broadly oval or rectangular, guard cells thinly cutinized, aperture narrowly elliptic. Common wall between guard cell and lateral subsidiary cell little more cutinized in stomata with sunken apperture. Lateral subsidiary cell with one or two encircling cells outside it.

Holotype — Specimen no. 35659 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — East bank of Son River, about 150 m north-west of Giar.



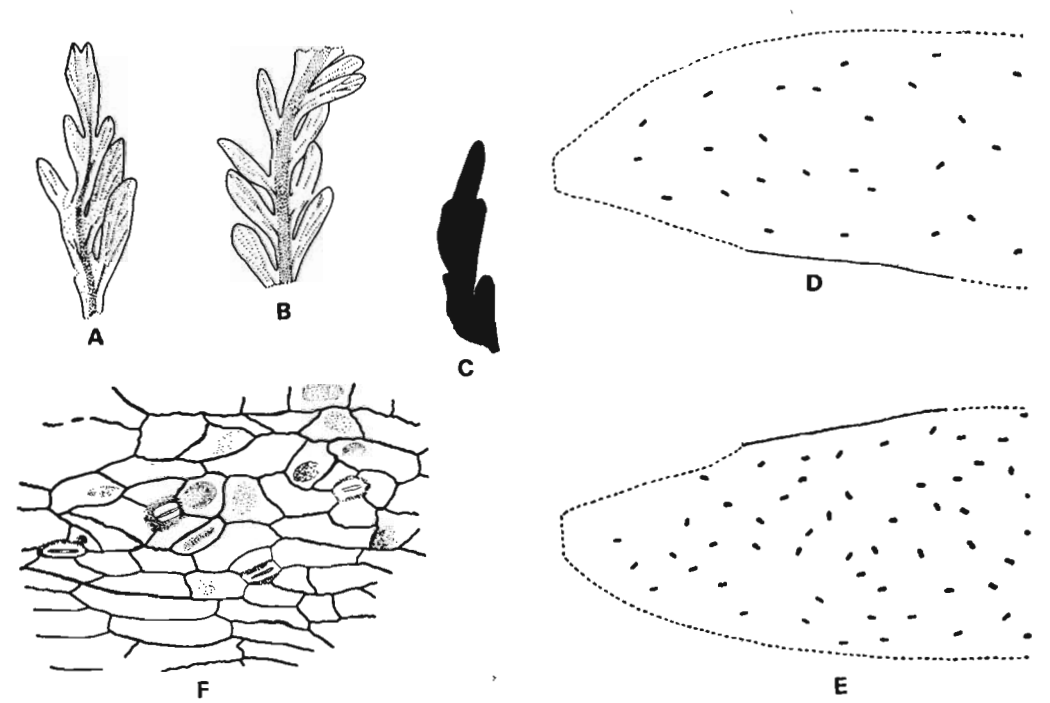
TEXT-FIG. 15 — *Dicroidium giarensis* Pal sp. nov.: **A**, rachis cuticle showing epidermal cells and a few stomata, B.S.I.P. slide no. 35661-2, × 200; **B**, **C**, distribution and orientation of stomata over thicker and thinner surface of lamina cuticle, B.S.I.P. slide no. 35659-1, ×40; **D**, cuticle of lamina, thinner side, B.S.I.P. slide no. 35659-1, × 100; **E**, epidermal cells and a few stomata of lamina cuticle, B.S.I.P. slide no. 35659-1, × 200; **F**, a stoma with six subsidiary cells, note the subsidiary cell papillae away from the stomatal pit, B.S.I.P. slide no. 35659-1, × 500; **G**, a stoma with four subsidiary cells, papillae over two lateral subsidiary cells overhanging the stomatal pit, B.S.I.P. slide no. 35659-1, × 500.

Comparison — *Dicroidium giarensis* is fairly common at Giar. In gross features it resembles some specimens of *D. odontopteroides* (Morris) Gothan and *D. feistmantelii* described by Townrow (1957) from the Triassic of South Africa, Australia and Argentina. But *D. giarensis* could be distinguished from *D. odontopteroides* and *D. feistmantelii* in venation pattern of pinnae and having mostly papillate subsidiary cells. In *D. odontopteroides* all the veins have a common point of origin whereas in *D. giarensis* 2-3 veins arise independently at the basiscopic side of the pinna base. Papillate subsidiary cells have been noted by Townrow (1957) in some exceptional specimens of *D. odontopteroides* but in *D. giarensis* it is a constant feature. In the shape of lamina segments and venation pattern *D. giarensis* could be compared with *D. feistmantelii* (Johnston) Gothan and *D. zuberi* (Szajnocha) Archangelsky, but *D. giarensis* could readily be distinguished from *D. feistmantelii* by its papillate subsidiary cells and from *D. zuberi* by its relatively thin lamina substance and much thinner cuticle. In having papillate subsidiary cells *D. giarensis* resembles *D. papillosum* Bose & Srivastava (1971) described from the Triassic of Nidpur, India. But in contrast to *D. giarensis*, papilla of a subsidiary cell in *D. papillosum* never overhangs the stomatal pit.

Dicroidium coriaceum (Johnston) Townrow

Pl. 10, figs 82-89; Text-fig. 16A-E

Description — Leaf pinnate, segments incipiently or fully developed. Rachis ± 1 mm wide. Pinnae alternate or subopposite, arising at an angle of 30°-40°, typically oblanceolate, 3-6 mm long and 1-1.5 mm wide, slightly contracted at base, acroscopic margin constricted, basiscopic margin decurrent, lateral margins entire, apex obtuse or subacute. Venation rather obscure, visible only in transmitted light, single vein entering each segment, forks twice or thrice. Leaf substance moderately thick, lamina



TEXT-FIG. 16 — *Dicroidium coriaceum* (Johnston) Townrow: **A-C**, B.S.I.P. slide nos. 8143, 8142 and 8166 all, × 4; **D, E**, distribution and orientation of stomata in two surfaces of lamina cuticle, B.S.I.P. slide no. 8142-1, × 50; **E**, cuticle of lamina showing epidermal cells and a few stomata, B.S.I.P. slide no. 8142-1, × 200.

shows a marginal rim of cutin in transmitted light.

Lamina cuticle about 2.5 μm thick, amphistomatic, stomata more numerous on one surface than on other. Epidermal cells usually isodiametric polygonal, sometimes elongated. Cells along lamina margin often narrowly rectangular. Anticlinal walls of epidermal cells minutely sinuous, often with cutin projections, at places broken by pits; periclinal wall with a papilla, sometimes papilla indistinct or absent. Stomata irregularly distributed and obliquely or longitudinally placed. Imperfectly dicyclic. Subsidiary cells basically four in number, two polar and two lateral, very often lateral subsidiary cells radially divided. Subsidiary cells usually with a papilla over its surface, rarely papillae overhanging the stomatal pit. Usually stomata well-seperated, very rarely subsidiary cells of adjacent stomata touching each other. Stomatal pit typically rectangular. Guard cells thinly cutinized, aperture usually exposed, at places slightly sunken.

Rachis cuticle about 3 μm thick, amphistomatic. Cells rectangular, ± serially arranged, more distinct on one surface than on the other, sometimes cells isodiametric, cell outlines straight or minutely sinuous, frequently with cutin projections, surface smooth or with a faint papilla. Stomata sparse, irregularly orientated.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

Discussion & Comparison — The description is based on a good number of leaf fragments mostly recovered from the shale samples macerated in bulk. However, in none of the specimen the forked portion of rachis has been found. The present material shows some variations in the extent of differentiation of leaf-segments but in venation as well as in cuticular features they all are essentially similar. In this species transition from slightly incised lamina to well-differentiated pinnae has already been noted by Archangelsky (1968) in materials from Argentine Triassic. The present specimens agree in gross features as well as in cuticular structures with the specimens of *D. coriaceum* (Johnston) Townrow described by Archangelsky (1966) from Middle to Upper Triassic of Argentina.

Dicroidium zuberi (Sazajnocha) Archangelsky

Pl. 10, figs 90, 91; Pl. 11, figs 92, 93; Text-fig. 17A-E

Description — Pinnate leaf (for description assumed to be bipinnate), pinnules subopposite, closely spaced, rhomboidal to oval, about 2.5×2 mm in size, attached by broad base, margin entire, apex obtuse. Venation obscure, only visible by transmitted light, 2 or 3 veins arise independently from the basiscopic side of pinnule base, each forking 2-4 times. Substance of lamina thick.

Pinnule cuticle about 5 μm thick, amphistomatic. Epidermal cells polygonal, mostly isodiametric, at places slightly longer than broad. Cell outlines ± straight, at places slightly sinuous, surface usually with a papilla. Stomata irregularly distributed and orientated. Subsidiary cells 4-6 in number, usually 4 or 5, often with a papilla on surface, rarely papilla overhanging the stomatal pit. Stomatal pit rectangular or broadly oval. Guard cells sunken, common wall between guard cells and subsidiary cells sometimes thickly cutinized, aperture slit-like or narrowly elliptical.

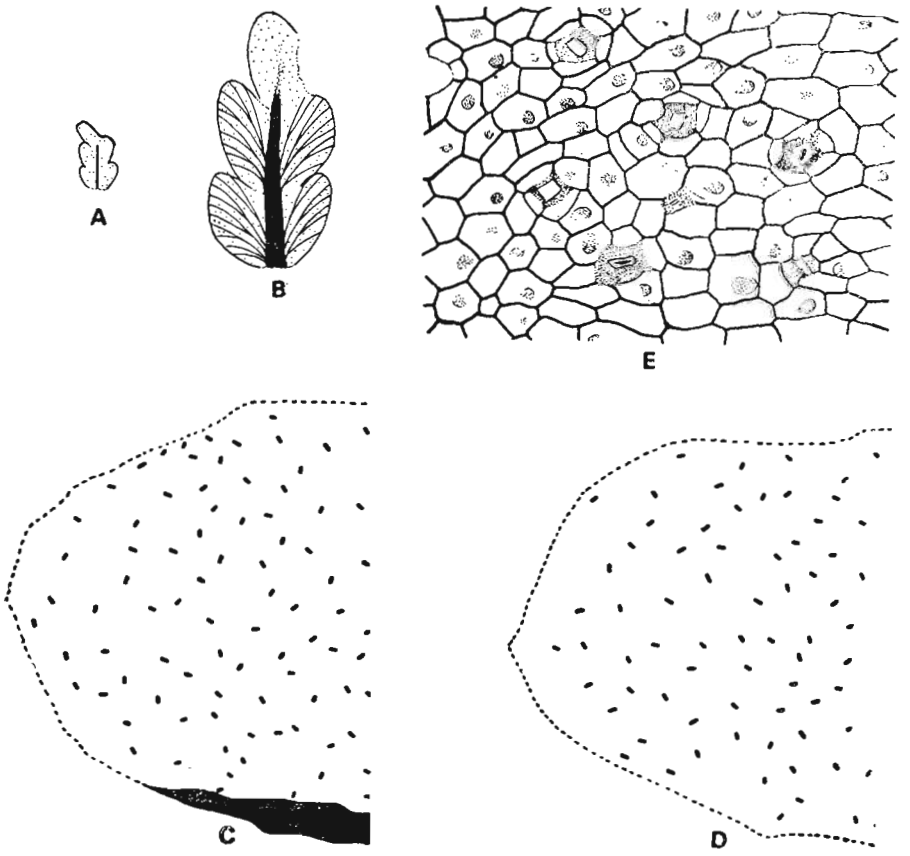
Occurrence — East bank of Son River, about 150 m north-west of Giar.

Comparison — *Dicroidium zuberi* (Sazajnocha) Archangelsky is very rare at Giar. The above description is based on a single pinna fragment. In shape, size and venation pattern of pinnules and also in cuticular details the specimen agrees with some specimens of *D. zuberi* described by Archangelsky (1968) from the Triassic of Argentina and also described in this paper from Janar River Section near Harai.

Dicroidium sp. cf. *D. odontopteroides* (Morris) Gothan

Pl. 11, figs 94-98; Text-fig. 18A-J

Description — Pinnate leaf. Rachis 1.5 mm wide. Pinnules more or less opposite, attached at an angle of about 45°, somewhat deltoid in shape, 5-6 mm long and 5-6 mm wide at base; margin entire; apex subacute; acroscopic margin slightly constricted; basiscopic margin decurrent joining acroscopic margin of the pinnule lying below. Venation odontopteroid type, veins arising at an angle of about 50°, mostly forked.



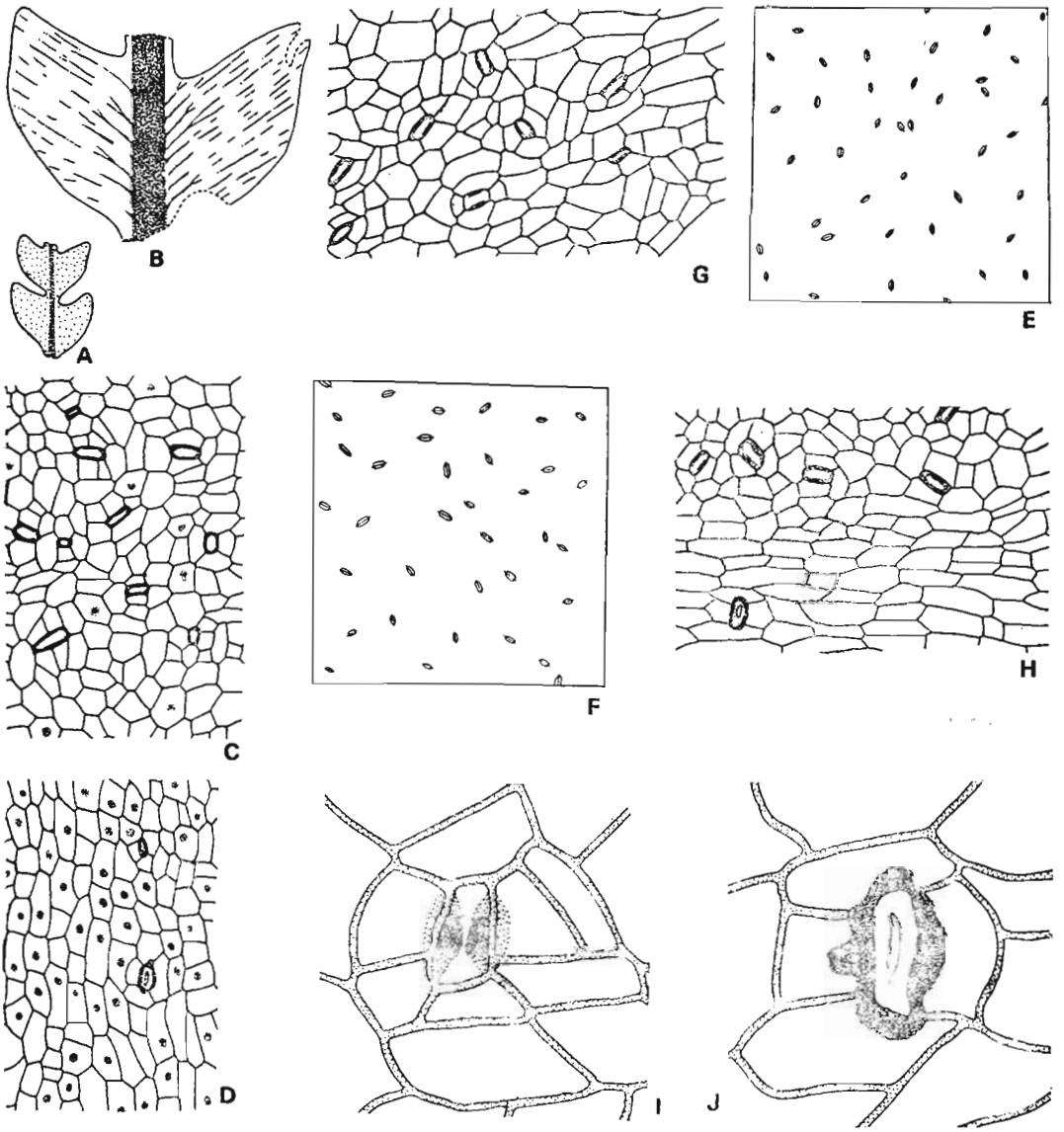
TEXT-FIG. 17 — *Dicroidium zuberi* (Szajnocha) Archangelsky. **A**, B.S.I.P. no. 35662, × 1; **B**, same, showing venation, × 3.25; **C, D**, distribution and orientation of stomata in two surfaces of lamina cuticle, B.S.I.P. slide no. 35662-2, × 50; **E**, cuticle of lamina showing epidermal cells and stomata, B.S.I.P. slide no. 35662-2, × 150.

Cuticle about 1 μm thick, amphistomatic, with more or less equal number of stomata on both surfaces. On lower surface cells along veins somewhat serially arranged, on upper surface cells along vein faintly marked by rows of squarish or rectangular cells. Ordinary epidermal cells on both surfaces isodiametric, polygonal or squarish in shape, cells along margin rectangular or squarish. Anticlinal walls straight at places, slightly wavy; periclinal wall smooth. Stomata irregularly distributed and orientated. Subsidiary cells 4-6; when 4 (2+2); often slightly less cutinized than ordinary epidermal cells. Stomatal pit typically oval, common wall between guard cells and lateral subsidiary cell thickened. Guard cells thinly cutinized; aperture narrowly elliptic.

Rachis cuticle about 1.5 μm thick, amphistomatic. Epidermal cells squarish or rectangular, at places polygonal, tending to be serially arranged; anticlinal walls straight; periclinal wall of cells smooth or mottled. Stomata irregularly distributed, mostly transversely orientated, sometimes obliquely or longitudinally placed.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

Remarks — In shape and size of lamina segments as well as in cuticular features the present specimen resembles *Dicroidium odontopteroides* (Morris) Gothan described by Townrow (1957) from the Triassic of South Africa, Australia and Argentina. But the Giar specimen differs from *D. odontopteroides* in having veins arising independently rather



TEXT-FIG. 18 — *Dicroidium* sp. cf. *D. odontopteroides* (Morris) Gothan: **A**, B.S.I.P. no. 35663, × 1; **B**, part of specimen in fig. A, showing venation, × 4; **C**, **D**, two surfaces of rachis cuticle showing epidermal cells and stomata, B.S.I.P. slide no. 35663-1, × 100; **E**, **F**, distribution and orientation of stomata in two surfaces of lamina cuticle, B.S.I.P. slide no. 35663-2, × 40; **G**, **H**, two surfaces of lamina cuticle, note the elongated cells along vein in fig. H, B.S.I.P. slide no 35663-2, × 100; **I**, a typical stoma from lamina cuticle B.S.I.P. slide no. 35663-2, × 500; **J**, a stoma with cutinization around stomatal pit, B.S.I.P. slide no. 35663-2, × 500.

than from a common point of origin. Moreover, the description is based on a single fragmentary specimen. Therefore, it has been described as *Dicroidium* sp. cf. *D. odontopteroides* (Morris) Gothan.

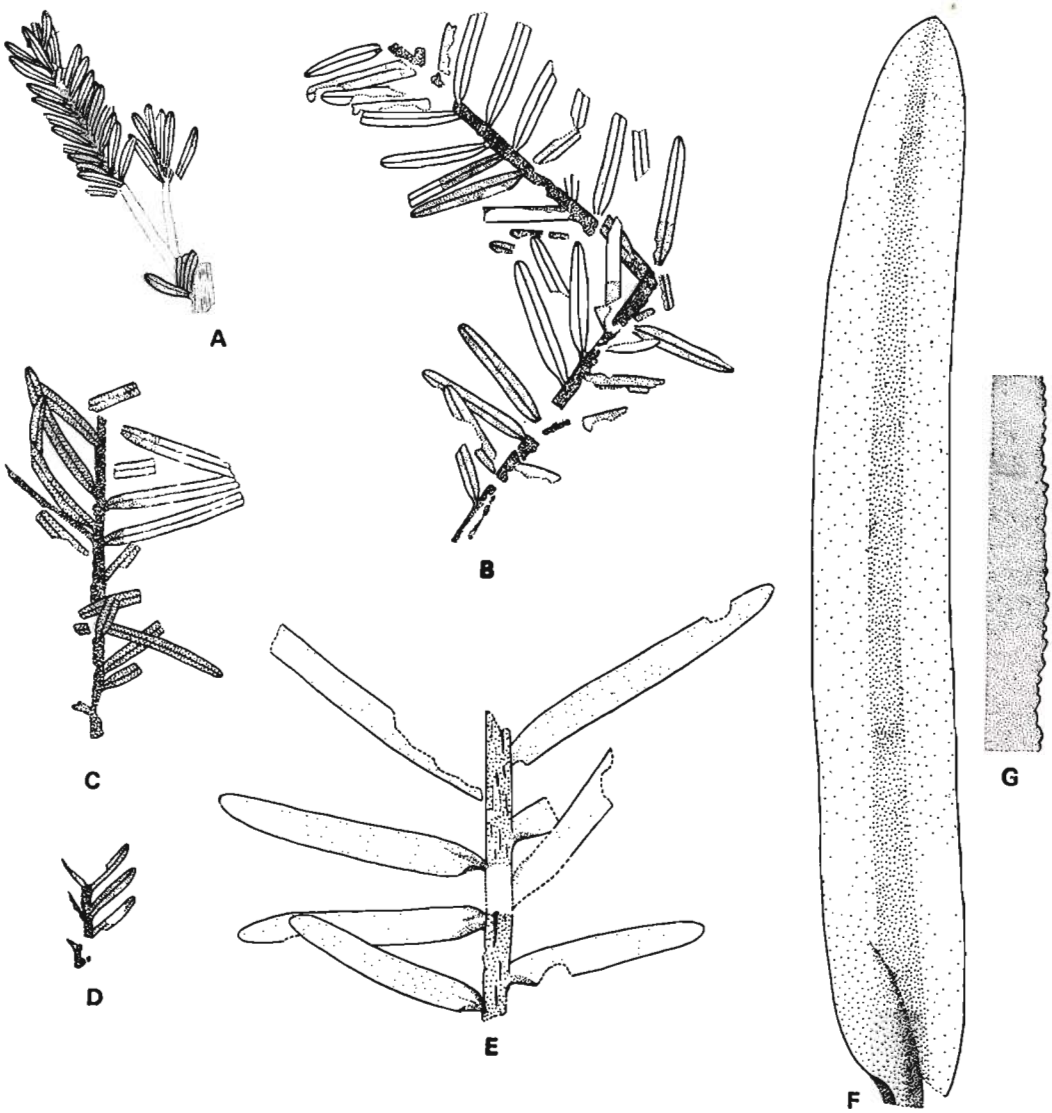
Class — Coniferopsida
Order — Coniferales

Genus — *Elatocladus* Halle, 1913

Elatocladus denticulatus Pal sp. nov.

Pl. 12, figs 99-104; Pl. 13, figs 105, 106; Text-figs 19A-G; 20A-D

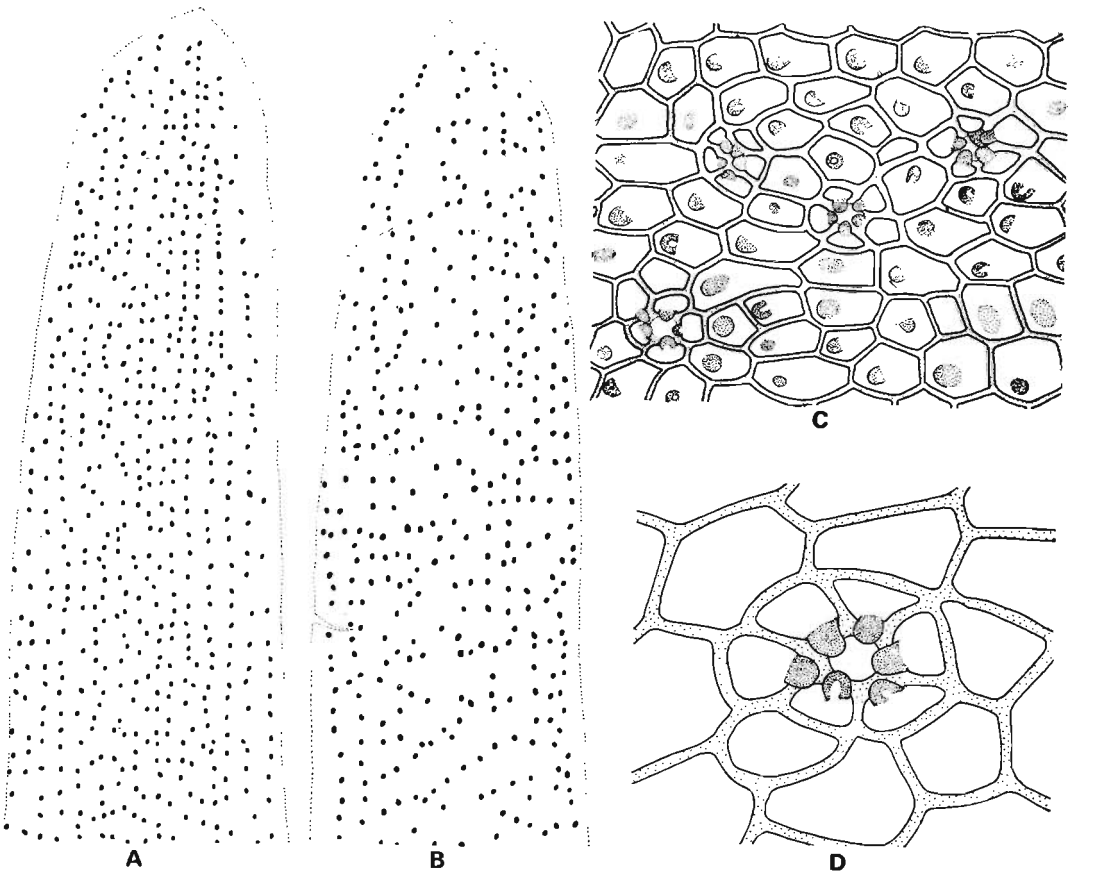
Diagnosis — Branched leafy-shoot, branching at an angle of 30°. Axis about 2 mm thick; near apex diminishing to about 1 mm.



TEXT-FIG. 19 — *Elatocladus denticulatus* Pal sp. nov.: **A**, B.S.I.P. no. 35664, × 1; **B**, holotype, B.S.I.P. no. 35665, × 1; **C, D**, B.S.I.P. nos. 35666 and 35667, both × 1; **E**, a part of the counterpart of holotype enlarged showing disposition of leaves, × 2; **F**, a leaf from the holotype enlarged, B.S.I.P. slide no. 35665-1, × 1; **G**, a portion of leaf in fig. F magnified showing minute dentation of margin, × 50.

Leaves about 2 mm apart, spirally arranged, (with 1/5 phyllotaxy), but all appear in one plane due to bending and twisting at their bases, near shoot apex leaves closely spaced and overlapping; usually arising at angle of 70°-80°, but towards apex angle of divergence less. Leaves dorsiventrally flattened, linear, 7-20 mm long and 2-2.5 mm wide, near base and apex of shoot leaves markedly reduced in size; base slightly constricted; margins almost parallel to each other, minutely dentate; apex obtuse; surface somewhat scabrous. Midrib prominent, traversing from base to apex.

Cuticle about 2 μm thick, amphistomatic with almost equal number of stomata on both surfaces. Stomata fairly crowded, irregularly distributed over entire surface,



TEXT-FIG. 20 — *Elatocladus denticulatus* Pal sp. nov.: **A**, **B**, distribution and orientation of stomata in two surfaces of leaf, B.S.I.P. slide no. 35665-2, × 20; **C**, leaf cuticle showing epidermal cells and a few stomata, B.S.I.P. slide no. 35665-1, × 250; **D**, a stoma magnified, B.S.I.P. slide no. 35665-1, × 500.

at places tending to form discontinuous files, 2-4 cells apart; usually longitudinally orientated, sometimes obliquely, or rarely transversely placed. On lower surface cells along vein arranged in longitudinal rows, elongated, with straight lateral walls and straight or oblique end walls. Other epidermal cells usually polygonal or rarely rectangular in shape, slightly shorter than cells along vein, at times isodiametric. On upper surface cells polygonal, more or less isodiametric, at places elongated, rarely squarish. On both surfaces close to margin 2-3 rows of rectagular cells present. Anticlinal walls of ordinary epidermal cells straight or very rarely at places slightly wavy; periclinal wall with a solid well-cutinized papilla. Stomata radially symmetrical, mostly amphicyclic, sometimes monocyclic; subsidiary cells 4-7, usually 5, rarely 7, each subsidiary cell with a overhanging papilla mostly concealing stomatal pit, rarely two adjacent stomata sharing a common subsidiary cell. Stomatal pit round to oval; guard cells rarely preserved, sunken.

Holotype — Specimen no. 35665 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

Remarks — The above species is based on four specimens and a large number of detached leaves isolated by bulk maceration. Two of the specimens belong to apical part of twigs and only one specimen shows branching habit. The holotype exhibits

transition in leaf size from base to apex. At its proximal part the leaves are 15 mm long and then gradually attain maximum length (20 mm) near middle region. Thereafter again gradually decreasing in size towards apical end.

The specific name refers to the minutely dentate margin of the leaves.

Comparison — *Elatocladus denticulatus* resembles shoots of *Rissikia media* (Tenison-Wood) Townrow (1967) described from the Upper Triassic of South Africa in shape and size of leaves and in the papillate nature of cuticle. But *E. denticulatus* differs from *R. media* in having leaves whose margins are microscopically dentate. In both the taxa leaves are amphistomatic, but in *E. denticulatus* stomata are relatively crowded and distributed all over the leaf surfaces, whereas in *R. media* stomata are relatively sparse and distributed in four diffused zones, a zone per flank. In *R. media*, subsidiary cells are 4 (2+2) in number, more or less similar to ordinary epidermal cells, whereas in *E. denticulatus* subsidiary cells are 4-7 in number, and their shape and size are different from those of ordinary epidermal cells. Moreover, in *E. denticulatus* each subsidiary cell has a well-developed papilla, whereas in *R. media* papillae over subsidiary cells are comparatively ill-developed and they are sometimes even absent. Also the epidermal cells of *E. denticulatus* are papillate but those of *R. media* are usually smooth.

E. denticulatus resembles *E. nitidus* Harris (1935) described from the Rhaetic of Greenland having cuticle with papillate epidermal cells, but the former differs from the latter in its amphistomatic nature of leaf. *E. denticulatus* resembles *E. ramosus* (Florin) Harris (1979) and *E. zamoides* (Leckenby) Harris (1979), reported from the Jurassic of Yorkshire, in shape and size of leaves, but the former can readily be distinguished by its amphistomatic nature of leaves.

Elatocladus raoi Pal sp. nov.

Pl. 13, figs 107-111; Text-fig. 21A-G

Diagnosis — Leafy shoot. Axis entirely concealed by sheathing leaf-bases. Leaves spirally inserted but in compressed state seem to be in one plane, typically 20 mm long, 1-1.5 mm broad at base and sheathing up to 2.5 mm in length, afterwards abruptly spreading out and forming an angle of 70°-80° with axis; towards distal part of shoot leaves gradually reducing in size and forming narrower angle with axis. Leaves dorsiventrally flattened, linear, widest at base; margin entire; apex obtuse or subacute. Single median vein traversing from base to apex.

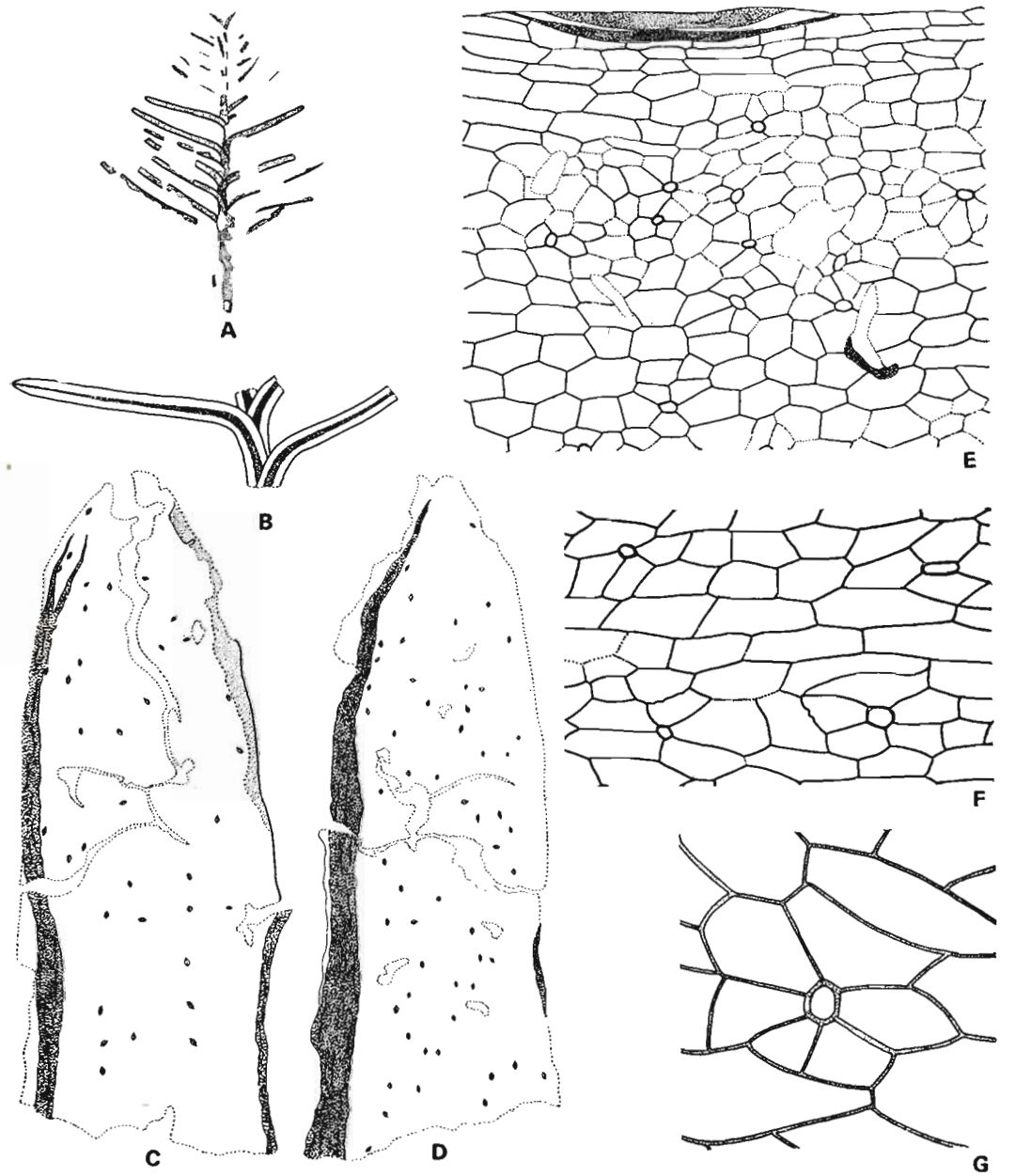
Cuticle about 1.5 μm thick, amphistomatic, frequency of stomata slightly more on one surface. Stomata sparsely placed, irregularly distributed over entire surface, at place forming 3-5 stomata having discontinuous files mostly longitudinally or obliquely orientated, rarely transversely placed. Cells along vein arranged in longitudinal rows, elongated, with straight lateral and usually oblique end-walls; ordinary epidermal cells polygonal, sometimes slightly longer than broad with more or less straight anticlinal walls; cells along margin elongated, narrower than cells along vein, with straight lateral- and usually oblique end-walls; all the cells having and smooth periclinal wall. Stomata monocyclic, subsidiary cells 4-6 in number, usually 5, shape varied, unspecialized, sometimes subsidiary cells of adjacent stomata touching each other, rarely two stomata sharing a common subsidiary cell; pit oval or elliptic, at times polygonal. Guard cells rarely preserved, sunken.

Specific name is after C. Nageswara Rao, Director, Geological Survey of India, who for the first time recorded plant megafossils from the Giar beds.

Holotype — Specimen no. 35668 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

Comparison — *Elatocladus raoi* could readily be distinguished from *E. denticulatus* described in this paper from the same bed by its narrower leaves and absence of cuticular papillae. *E. raoi* in gross features somewhat resembles *E. plana* (Feistmantel) Seward, described by Sahni (1928) from the Jurassic Lower Cretaceous formations of India. But the former differs in having leaves which are smaller and linear in shape. In *E. plana* leaves are acicular, near base of twigs reduced scale leaves are present, a feature which is missing in all the Giar specimens. *E. raoi* may also be compared with *E. zignoi* Wesley (1956) reported from



TEXT-FIG. 21 — *Elatocladus raoi* Pal sp. nov.: **A**, holotype, B.S.I.P. no. 35668, × 1; **B**, part of holotype enlarged, showing disposition of leaves, × 3; **C, D**, distribution and orientation of stomata in two surfaces of lamina cuticle, shaded areas represent folds in the cuticle where no stomata could be seen, B.S.I.P. slide no. 35668-2, × 40; **E**, cuticle of lamina, on top note the rows of elongated cells along vein, B.S.I.P. slide no. 35668-2, × 100; **F**, lamina cuticle showing a few stomata and epidermal cells, B.S.I.P. slide no. 35668-1, × 200; **G**, a stoma magnified, B.S.I.P. slide no. 35668-1, × 500.

the Jurassic of Italy in size and form of leaves, but the latter differs in having leaves which are spirally disposed as compared to *E. singhii* where all the leaves appear to be in one plane.

In the amphistomatic nature of leaves, *E. raoi* resembles *E. sehorensis* Maheshwari & Kumaran (1976) and *E. bosei* Maheshwari & Kumaran (1976) described from the Jurassic of Jabalpur Formation, India. But the latter two species have much shorter leaves with constricted bases, whereas in *E. raoi* leaves are much longer and their maximum width is at their bases. Moreover, in *E. sehorensis* stomata are distributed in two lateral bands on one surface and on the other surface a stomatic band is confined to central region only, whereas in *E. raoi* stomata are irregularly scattered on both the surfaces. Also in *E. sehorensis* subsidiary cells are mostly 4 in number. In *E. bosei* too, subsidiary cells are usually 4 in number which are less cutinized than ordinary epidermal cells. *E. raoi* resembles *E. polystictus* Harris (1935) which is based on dispersed leaves, because the leaves in both are amphistomatic, but they differ from each other in the details of cuticular structure. In *E. polystictus* stomata are distributed either in two broad bands on under side and two narrow bands on the upper side or stomata scattered in lower surface and on upper surface being rare. Also in *E. polystictus* surface of subsidiary cells and epidermal cells is thickened as compared to *E. raoi*. Both *E. setosus* (Phillips) Harris (1979) and *E. sideriticus* (Bose) Harris (1979) described from the Jurassic of Yorkshire are amphistomatic like *E. raoi*, but they differ from *E. raoi* in size, and shape of leaves is quite different and also in the pattern of stomatal distribution.

Genus — *Pagiophyllum* Heer, 1881

Pagiophyllum bosei Pal sp. nov.

Pl. 14, figs 113-120; Text-fig. 22A-O

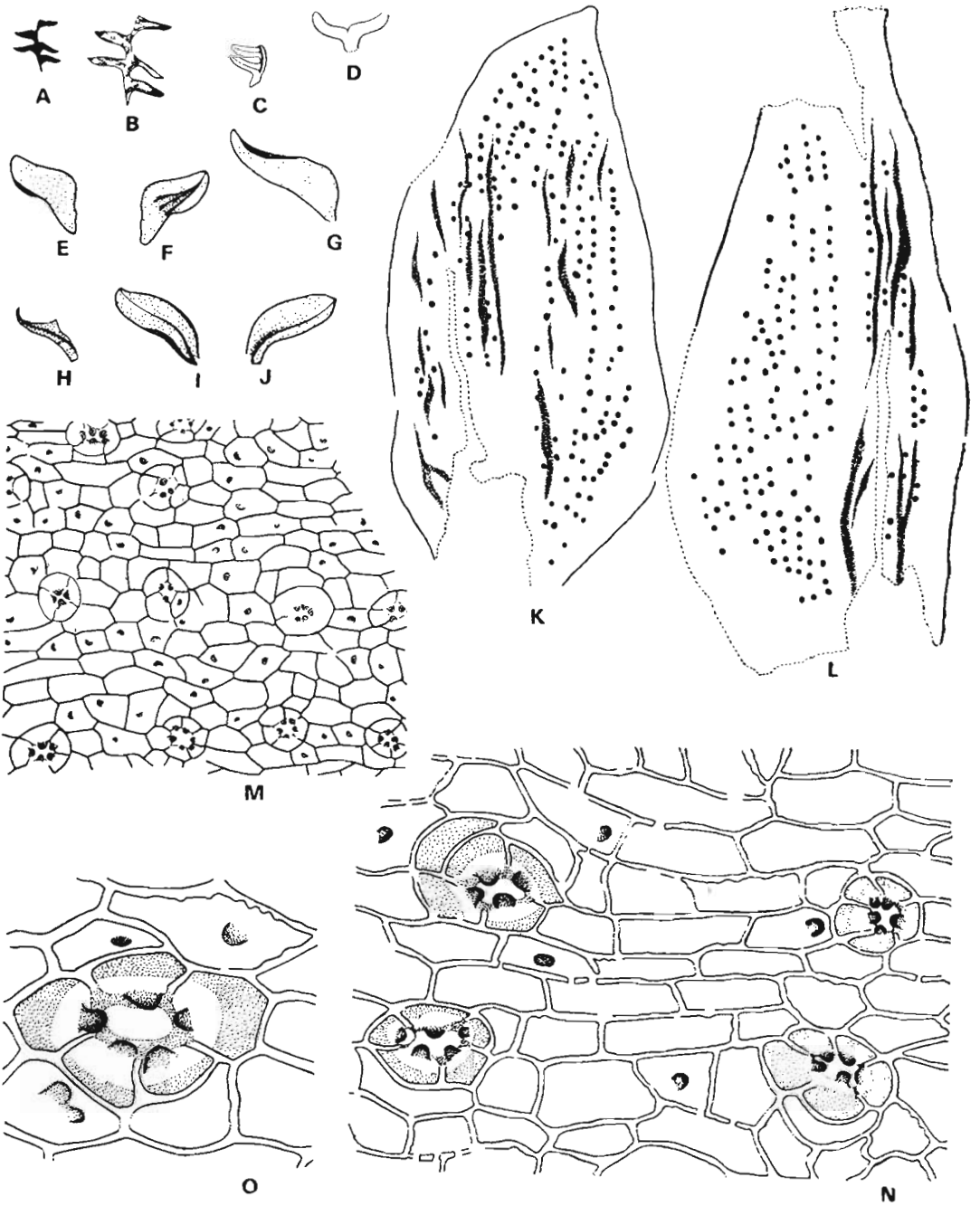
Diagnosis — Leafy twig, ±6 mm wide. Leaves spirally arranged, spreading, base distinctly decurrent, free part projecting radially at an angle of about 80° to axis. Leaf-blade lanceolate, 4 mm long and 1.8 mm wide near middle, slightly curving upwards, contracted to about 0.8 mm near base; margin entire, near apex rarely minutely dentate; apex sharply pointed or somewhat apiculate. Upper surface concave; lower surface convex, keeled.

Leaf cuticle about 2.5 μm thick, amphistomatic. Stomata on both surfaces occurring in two triangular but ill defined zones avoiding central and peripheral regions. Stomatal zones converging towards apex, within stomatal zones stomata arranged in discontinuous files, stomatal files commonly 3-6 cells apart. Cells along non-stomatiferous region mostly rectangular, 2-4 times longer than broad, more or less arranged in longitudinal rows. Cells along stomatal files and between stomata often polygonal or squarish. Anticlinal walls straight or slightly undulated, sometimes broken by pits. Periclinal wall with a solid well-cutinized papilla, typically 8 μm in diameter, sometimes papilla indistinct or absent. Stomatal apparatus monocyclic or incompletely dicyclic. Subsidiary cells 4-7 in number (usually 5); forming a ring; slightly more cutinized than ordinary cells, each subsidiary cell with a well-developed papilla overhanging stomatal pit. Stomatal pit round to oval; guard cells mostly not preserved, sunken; aperture slit-like. The species is named after Dr M. N. Bose, Director, Birbal Sahni Institute of Palaeobotany, Lucknow.

Holotype — Slide no. 8144 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

Comparison — *Pagiophyllum bosei* shows close similarity with *P. simpsonii* Ash (1970) described from the Chinle Formation (Upper Triassic), Arizona. Both the species agree in shape and size of leaves and in the presence of papillae over epidermal cells as well as subsidiary cells. But *P. bosei* differs from *P. simpsonii* in the absence of acutely pointed trichomes on leaves and in the pattern of stomatal distribution. In *P. simpsonii* stomata are scattered all over the leaf surfaces. The present species resembles *P. kurrii* (Schimper) Salfeld, described by Harris (1979) from the Jurassic of Yorkshire in having subsidiary cells with papillae overarching the stomatal pit, but they differ from each others as far as leaf size and shape are concerned. Moreover, in *P. kurrii* stomata are evenly distributed all over the surfaces and its epidermal cells are devoid of papillae.



TEXT-FIG. 22 — *Pagiophyllum bosei* Pal sp. nov.: **A**, holotype, B.S.I.P. slide no. 8144, × 1; **B**, holotype, × 2; **C, D**, fragmentary twigs, B.S.I.P. slide nos. 8147 and 8145, both × 3; **E, F**, ventral and dorsal view of a detached leaf, B.S.I.P. slide no. 8148, × 3; **G, H**, detached leaves, lateral view, B.S.I.P. nos. 8149 and 8167, G × 3, H, × 2; **I, J**, ventral and dorsal view of a detached leaf, B.S.I.P. no. 8146, both × 3; **K, L**, distribution and orientation of stomata in upper and lower cuticles of a dorsiventrally compressed leaf, B.S.I.P. slide no. 8146-1, × 40; **M**, cuticle of lamina, B.S.I.P. slide no. 8144-1, × 125; **N**, lamina cuticle showing epidermal cells and a few stomata, B.S.I.P. slide no. 8144-1, × 250; **O**, a stoma, B.S.I.P. slide no. 8144-1, × 500.

Among the Indian species of *Pagiophyllum*, in its external features *P. bosei* resembles *P. peragrinum* (L & H) Schnek described by Sahni (1928) from the Jurassic-Lower Cretaceous beds of India, *P. bansaensis* Bose & Sukh-Dev (1972) described from the Lower Cretaceous beds of Bansa and *P. sherensis* Maheshwari & Kumaran (1976) described from Jabalpur Series. But *P. bosei* can easily be distinguished from all those species by the manner in which the stomata are distributed and by its papillate nature of cuticle.

UNCLASSIFIED GYMNOSPERMS

Genus — *Yabiella* Oishi, 1931

Oishi (1931a) instituted the genus *Yabiella* based on specimens collected from the Triassic of Argentina and South Africa. He also provisionally included the specimens of *Macrotaeniopteris crassinervis* Feistmantel (1877) from the Jurassic of Rajmahal Hills, India in his genus *Yabiella*. But recently Bose and Banerji (1981) have identified the specimens of *Macroteniopteris crasinervis* Feistmantel (1877) as *Taeniopteris buskoghatensis* Bose & Banerji. Sukh-Dev (1980) described *Yabiella hirsuta* (Bose & Sukh-Dev) Sukh-Dev from the Lower Cretaceous of Bansa, India. As his specimens yielded cuticle and as the cuticular structure of the genus *Yabiella* was unknown at that time Sukh-Dev (1980) emended the generic diagnosis of *Yabiella*. But except Sukh-Dev's specimens all the other specimens of *Yabiella* are restricted to Triassic and its occurrence in the Lower Cretaceous without any representation in the intervening strata, viz., Jurassic, is quite unusual. Moreover, in the specimen of *Yabiella hirsuta* (B.S.I.P. no. 33759, figured by Sukh-Dev, 1980) the marginal vein is not clear, rather the leaf exhibits a thickened margin. Similar type of leaf margin is sometimes met with in taeniopteroid leaves due to the presence of fibrous bundle or slight curvation of lamina margin.

In my collection from Giar there is a specimen of *Yabiella* with well-preserved cuticle. In contrast to the specimens from Bansa (Sukh-Dev, 1980) the cuticle of Giar specimen is amphistomatic. In my opinion *Y. hirsuta* (Bose & Sukh-Dev) Sukh-Dev belongs to a different genus altogether. The venation of *Y. hirsuta* (Bose & Sukh-Dev) Sukh-Dev (1980, text-fig. 1C) is like that of *Macrotaeniopteris buskoghatensis* Bose & Banerji. Based on the present specimen from Giar as well as other specimens of *Yabiella*, the diagnosis of the genus is further emended here.

Emended diagnosis — Leaf spathulate to lanceolate, gradually tapering towards base, petiole short. Lamina attached laterally to the midrib. Midrib strong, distinct from base to apex; lateral veins simple or forked, sometimes uniting with adjacent veins at varying distances from the midrib; close to the lamina margin lateral veins join a marginal vein. Stomata evenly distributed on both the surfaces of lamina. Subsidiary cells 4-6 (2+2 or 2+4). Guard cells little sunken.

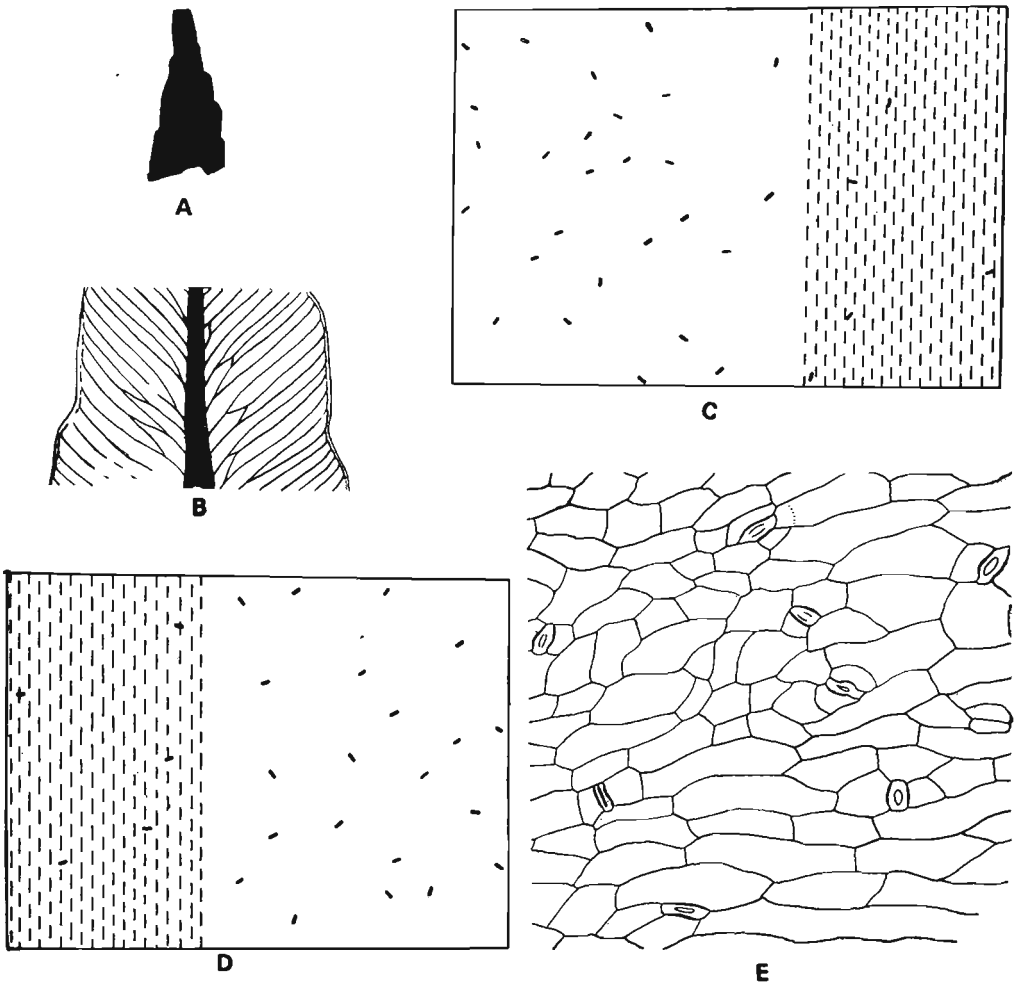
Type Species — *Taeniopteris mareyesiaca* Geinitz, 1876.

Yabiella indica sp. nov.

Pl. 15, figs 121-128; Text-fig. 23A-E

Diagnosis (leaf incomplete at base)— Leaf lanceolate, available length 2.2 cm; 1 cm wide, gradually narrowing to an acute apex; margin distantly lobed. Substance of lamina moderately thick. Midrib distinct, resembling up to apex, ±1 mm wide at the broadest part of lamina; lateral veins forming an angle of about 50° with the midrib, simple or once forked, at places away from the midrib uniting with adjacent vein at different levels; close to the leaf margin veins about 20 per cm, slightly curving upwards and finally joining a marginal vein. Marginal vein prominent all along leaf margin.

Cuticle 3 μm thick, amphistomatic. Epidermal cells along the midrib mostly squarish, at places polygonal, rarely slightly elongated; cells along lamina margin ± isodiametric, polygonal or squarish; other epidermal cells usually polygonal, elongated along the direction of lateral veins, sometimes isodiametric. Anticlinal walls of epidermal cells ± straight, in the midrib region cell outlines sometimes with nodular thickenings. Periclinal wall usually unspecialized, rarely with a papilla. Stomata ± equally numerous on two surfaces of lamina, evenly distributed and irregularly orientated. Subsidiary cells 4-6 in number (2+2 or 2+4), inner wall of subsidiary



TEXT-FIG. 23 — *Yabiella indica* Pal sp. nov.: **A**, holotype, B.S.I.P. no. 35670, × 1; **B**, part of holotype showing venation, × 4; **C, D**, distribution and orientation of stomata in thinner and thicker cuticle surfaces, dotted areas represent the portion of midrib, B.S.I.P. slide no. 35670-2, × 50; **E**, lamina cuticle showing epidermal cells and stomata, B.S.I.P. slide no. 35670-2, × 100.

cells forming stomatal pit often thickened. Stomatal pit rectangular or oval. Guard cells slightly sunken, aperture slit-like, thickly cutinized. Sometimes subsidiary cells accompanied by encircling cells.

Holotype — Specimen no. 35670 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

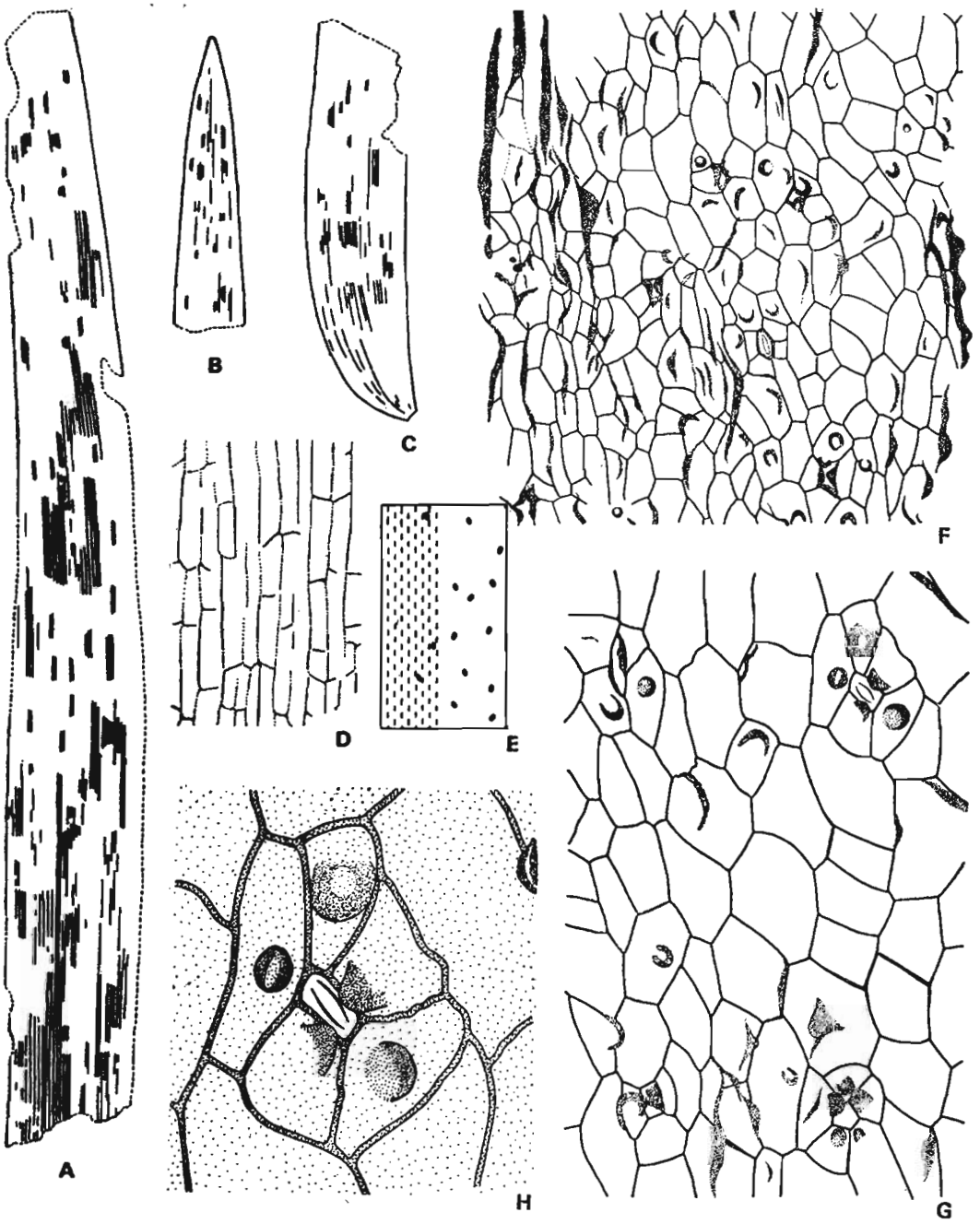
Comparison & discussion — In size, shape and venation pattern *Yabiella indica* resembles closely *Y. brackebushiana* (Kurtz) Oishi described from the Triassic of Argentina (Kurtz, 1921; Jain & Delevoryas, 1967). But their detail comparison is not possible because the cuticular structure of *Y. brackebushiana* is so far not known.

Genus — *Desmiophyllum* Lesquereux, 1878

Desmiophyllum singhii sp. nov.

Pl. 16, figs 129-132; Pl. 17, figs 133-136; Text-fig. 24A-H

Diagnosis — Leaves elongated lanceolate, often slightly falcate, ±2 cm wide, base constricted, margin entire, apex acute.



TEXT-FIG. 24 — *Desmiophyllum singhii* Pal sp. nov.: **A**, holotpye, B.S.I.P. no. 35671, × 1; **B**, fragment showing leaf apex, B.S.I.P. no. 35674, × 1; **C**, basal portion of the lamina, B.S.I.P. no. 35672, × 1; **D**, upper cuticle, B.S.I.P. slide no. 35671-2, × 125; **E**, orientation and distribution of stomata in lower cuticle surface, dotted area represents the venal region, B.S.I.P. slide no. 35671-2, × 20; **F**, lower cuticle showing epidermal cells and stomata, B.S.I.P. slide no. 35671-2, × 125; **G**, a few stomata and epidermal cells, B.S.I.P. slide no. 35671-2, × 250; **H**, a stoma magnified, B.S.I.P. slide no. 35671-2, × 500.

Veins numerous, unbranched, parallel, diverging at leaf base, converging towards apex. Near middle region of lamina concentration of veins about 20 per cm. Interstitial dark strands present between pairs of veins.

Cuticle thin and fragile. Upper surface devoid of stomata, divided into venal and intervenal bands. Cells along vein arranged in longitudinal files, rectangular. Cells between veins squarish or polygonal, nearly isodiametric; surface wall of cells mostly unspecialized, sometimes at places slightly thickened or mottled; lateral- and end-walls straight. Lower cuticle thinner than upper, divided into veinal and intervenal bands. Stomata mainly confined to intervenal bands but at places one or two stomata occurring on a vein. Cells along veins rectangular or elongated polygonal, arranged in longitudinal rows, lateral- and end-walls straight, surface bulging, centrally thickened and forming a low papilla. Cells of intervenal regions polygonal, usually isodiametric, sometimes elongated, outlines straight, surface varied, cells in some flat while in others convex and in still others conspicuously thickened forming a flat hollow papilla. Stomata rather sparsely distributed but more or less evenly scattered in intervenal regions, longitudinally or obliquely orientated. Subsidiary cells 4-6 usually 5, mostly with a distinct hollow papilla either close to stomatal pit or overhanging it but sometimes, medianly placed. Stomatal pit rectangular; guard cells sunken, thinly cutinized; apperture slit-like.

Holotype — Specimen no. 35671 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — East bank of Son River, about 150 m north-west of Giar.

Remarks — Ribbon-shaped leaves found in detached condition are sometimes described as *Phoenicopsis* (Seward, 1903; Retallack, Gould Runnegar, 1977) or *Podozamites* (Anderson, 1978). The affinities of such isolated leaves are uncertain, they may be ginkgoalean (cf. *Phoenicopsis*) or coniferous (cf. *Podozamites*) or even may be cycadalean (cf. detached pinna of *Pseudoctenis*). Therefore, the comprehensive generic name *Desmiophyllum* has been used here to accommodate the Giar specimens.

Desmiophyllum singhii is fairly common in Giar and frequently occurs in bundles. However, no complete leaf has so far been collected. The largest fragment is 17 cm long and is incomplete at both ends. It is considerably narrowed above and slightly narrowed below. I estimate its original length at about 30 cm. Other fragments show bases and apices. The only specimen exhibiting the very base is assymmetrically constricted. The origin of veins at the leaf base could not be seen but as soon as they are visible they are diverging and then running parallel and nowhere could branches be seen. There is no evidence whether the interstitial dark strands are ducts or bundles of fibres. In most of the specimens the lamina are slightly curved, but in a few are straight.

The specific name is after Mr Gopal Singh, Geological Survey of India, who reported plant megafossils from the Giar beds.

Comparison — Ribbon-shaped isolated leaf fragments resembling *Desmiophyllum singhii* have been described from the Middle — Upper Triassic of Australia (as *Phoenicopsis elongatus* by Retallack, 1977) and South Africa (as *Podozamites elongatus* by Anderson, 1978). But the Giar specimens differ from the Australian and South African specimens in having densely spaced veins and in the presence of interstitial strands. The cuticular features of the South African specimens have been described by Anderson (1978). The cuticle of *D. singhii* resembles the cuticle of *Podozamites elongatus* in being hypostomatic and in having papillate cells on lower cuticle. But in the former the surface wall of epidermal cells on lower side are strongly convex in contrast to those of the South African specimens. *D. singhii* resembles *D. gothanii* described from Rhaeto-Liassic of Nürnberg (Gothan, 1914; Florin, 1936) in gross features but the former differs from the latter in having papillate epidermal cells.

GENERAL DISCUSSION

Megafloral assemblage recovered from Janar River Section near Harai is represented by *Lepidopteris madagascariensis* Carpentier, *Dicroidium hughesii* (Feistmantel) Gothan, *D. zuberi* (Szajnocha) Archangelsky, *Dicroidium* sp., *Xylopteris* sp., *Sphenobaiera janarensis* Pal sp. nov. and *Baiera* sp. Out of these *Lepidopteris madagascariensis* and *Dicroidium zuberi* are most common. *D. hughesii* and *D.* sp. are next in abundance;

Xylopteris sp., *Sphenobaiera janarensis* and *Baiera* sp. are rather rare. In having the dominance of *Lepidopteris madagascariensis* and *Dicroidium zuberi* the Harai assemblage resembles the Late Triassic assemblage from the Upper Narrabeen Group of Australia (Townrow, 1966; Betallack *et al.*, 1977) and the Middle Triassic assemblages known from the Upper Beaufort beds of South Africa, Nymboida Coal Measures and Hawkesbury Sandstone of Australia and Esk Trough of Queensland (Townrow, 1966; Anderson & Anderson, 1974; Retallacket *et al.*, 1977; Flint & Gould, 1975). Because of the presence of *Xylopteris* and *Sphenobaiera* the Harai flora may be slightly younger in age. Thus on the basis of megafloral contents the Janar River beds, exposed near Harai, appear to be of Early Upper Triassic age. Among the known Indian Triassic floras, the Harai assemblage resembles the flora known from the Parsora Formation (Lele, 1969; Bose, 1974) in having common occurrence of *Dicroidium hughesii*. Besides *D. hughesii*, no other element is common to these floras. The genus *Glossopteris*, which is dominant in the Upper Permian, has been described from the Parsora Formation (Lele, 1962b), but it is totally missing at Harai. Therefore, the Harai assemblage seems to be relatively younger than the Parsora assemblage.

From Son River Section near Giar, *Lepidopteris stormbergensis* (Seward) Townrow, *Dicroidium giarensis* Pal sp. nov., *D. coriaceum* (Johnston) Townrow, *D. zuberi* (Szajnocha) Archangelsky, *D.* sp. cf. *D. odontopteroides* (Morris) Gothan, *Elatocladus denticulatus* Pal sp. nov., *E. raoi* Pal sp. nov., *Pagiophyllum bosei* Pal sp. nov., *Yabiella indica* Pal sp. nov. and *Desmiophyllum singhii* Pal sp. nov. have been described. Among these *Lepidopteris stormbergensis*, *Dicroidium giarensis* and *Elatocladus denticulatus* are most common. *Dicroidium coriaceum*, *Pagiophyllum bosei* and *Desmiophyllum singhii* are next in abundance. *Dicroidium zuberi*, *D.* sp. cf. *D. odontopteroides*, *Elatocladus raoi* and *Yabiella indica* are rather rare. Singh (in Sastry *et al.*, 1977) reported the occurrence of *Dicroidium*, *Pachypteris*, *Noeggerathiopsis* and *Taeniopteris* from Giar. Unfortunately, at present his collection is not traceable in the Geological Survey of India, Calcutta. But I had the opportunity to show my collection from Giar to Mr Gopal Singh of the Geological Survey of India, Northern Circle, Palaeontology Division and he agreed with me that *Dicroidium*, *Pachypteris*, *Noeggerathiopsis* and *Taeniopteris* identified by him were infact *Dicroidium giarensis*, *Lepidopteris stormbergensis*, *Desiophyllum singhii* and *Yabiella indica*.

The only common element at Harai and Giar is *Dicroidium zuberi*. However, *D. zuberi* is most common at Harai, whereas at Giar it is rather rare. *Lepidopteris* is represented by *L. madagascariensis* at Harai and by *L. stormbergensis* at Giar. *L. madagascariensis* mostly occur in older rocks whereas *L. stormbergensis* is present in the beds of younger age (Townrow, 1960). *Elatocladus* and *Pagiophyllum* which are commonly met with at Giar are totally absent at Harai. Thus as far as the megaflora is concerned the Giar beds seem to be younger in age than the beds exposed in Janar River near Harai. However, a just reverse view was proposed by Maheshwari *et al.* (1973). According to them the Harai beds are younger than the Giar beds. While assigning the Carnian age to the Giar beds and Norian age to Harai beds their conclusion was based on palynological data and they gave the emphasis on the occurrence of the megaspore taxa *Banksisporites pinguis* (Harris) Dettmann, *Horstisporites areolatus* (Harris) Potonié and *Nathorstisporites hopliticus* Jung. So far no megaspore has been described from Giar. However, I have recovered some megaspores from the Giar beds (which are yet to be described), majority of which are similar to *Banksisporites pinguis* (Harris) Dettmann described by Banerji *et al.* (1978) from Harai.

Lepidopteris stormbergensis, *Dicroidium coriaceum* and *D. odontopteroides* are known to occur in the Middle-Upper Triassic of South Africa, Argentina and Australia (Townrow, 1960; Archangelsky, 1968; Anderson & Anderson, 1974; Retallack *et al.*,1977). The genus *Yabiella* is a characteristic Upper Triassic form (Oishi, 1931a, 1931b; Jain & Delevoryas, 1967; Retallack, 1977). *Elatocladus* and *Pagiophyllum* which are commonly met with at Giar are more prevalent in the Indian Jurassic-Lower Cretaceous strata. Thus the megaflora indicates a Late Upper Triassic age for the beds exposed in Son River near Giar.

Pagiophyllum bosei and *Desmiophyllum singhii* from Giar in gross features look

similar respectively to *Pagiophyllum* sp. and *Desmiophyllum* sp. described from the Rhaeto-Liassic beds of the Hartala Hill, South Rewa Basin, India (Pal, 1984). The Hartala fossiliferous bed is younger in age than the Giar beds. It has *Brachyphyllum* and lacks the characteris ic Triassic forms like *Lepidopteris* and *Dicroidium*.

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EXPLANATION OF PLATES

PLATE 1

1-12. *Lepidopteris madagascariensis* Carpentier.

1. B.S.I.P. specimen no. 35606.× 1.
2. B.S.I.P. specimen no. 35607.× 1.
3. Specimen showing lumpy rachis, B.S.I.P. specimen no. 35608.× 1.
4. Specimen showing bipinnate nature of the frond, rachis with low lumps near base (see also text-fig. 1I), B.S.I.P. specimen no. 35609.× 1.
5. B.S.I.P. specimen no. 35610.× 1.
6. Specimen showing paired small lumps over the rachis (see also text-fig. 1D), B.S.I.P. specimen no. 356111.× 1.
7. Bipinnate specimen, B.S.I.P. specimen no. 35612.× 1.
8. B.S.I.P. no. 35613.× 1.
9. A part of specimen in fig. 8 showing venation, photographed in transmitted light after preparing transfer, B.S.I.P. slide no. 35613-1.× 4.
10. Cuticle of lamina showing epidermal cells and some stomata, B.S.I.P.slide no. 35609-1.× 150.
11. Single stoma of lamina, B.S.I.P. slide no. 35609-1.× 400.
12. Single stoma of lamina, showing much well-developed cutin lappets, B.S.I.P. slide no. 35607-1.× 400.

PLATE 2

13-19. *Dicroidium hughesii* (Feistmantel) Gothan.

13-15. B.S.I.P. specimen nos. 35616, 35617 and 35618. all.× 1.

16. Cuticle of lamina, thinner surface, B.S.I.P. slide no. 35618-1.× 150.
17. Cuticle of lamina, thicker surface, B.S.I.P. slide no. 35618-1.× 150.
18. A stoma from the thinner side of lamina cuticle, B.S.I.P. slide no. 35619-1.× 400.
19. A stoma from the thicker side of the lamina cuticle, subsidiary cells with well-developed papillae overhanging the stomatal pit, B.S.I.P. slide no. 35619-1.× 400.

PLATE 3

20-32. *Dicroidium zuberi* (Szajnocha) Archangelsky. Specimen in fig. 5 from Janar River, ENE of Harai; rest of the specimens from Janar River, SSW of Harai.

20-28. B.S.I.P. specimen nos. 35620, 25621, 35622, 35623, 35624, 35625, 35626, 35627 and 35628. all × 1.

29. Specimen photographed in transmitted light after preparing transfer, showing venation of the pinnules, B.S.I.P. slide no. 35629-1.× 4.
30. Cuticle of lamina showing epidermal cells and stomata, B.S.I.P. slide no. 35627-1.× 150.
31. Cuticle of lamina showing distinct striations over epidermal cells, B.S.I.P. slide no. 35643-2. × 200.
32. Cuticle of lamina showing two stomata magnified, B.S.I.P. slide no. 35634-3.× 400.

PLATE 4

33-40. *Dicroidium* sp.

3. B.S.I.P. no 35639.× 1.
34 BS.I.P. no. 35640.× 1.
35. Transfer of the specimen in fig. 34 showing venation, B.S.I.P. slide no. 35640-1.× 2.
36. B.S.I.P. no. 35641.× 1.
37. Transfer of the specimen in fig. 35 showing venation, B.S.I.P. slide no. 35641-1.× 2.
38. Cuticle of lamina, thinner side, B.S.I.P. slide no. 35641-2.× 100.
39. Cuticle of lamina, thicker side, B.S.I.P. slide no. 35641-2.× 100.
40. A stoma from lamina cuticle magnified, B.S.I.P. slide no. 35641-2.× 400.

41-43. *Xylopteris* sp.

41. B.S.I.P. no. 35642.× 1.
42. Specimen in fig. 41 in transfer showing venation, B.S.I.P. slide no. 35642-1.× 2.
43. Epidemal cells and a stoma of the lamina cuticle, B.S.I.P. slide no. 35642-2.× 400.

PLATE 5

44-48. *Sphenobaiera janarensis* Pal sp. nov.

44. Holotype, B.S.I.P. specimen no. 35637.× 1.
45. Cuticle from tne marginal region of leaf, thicker side, on right hand side of the photograph files marginal cells are visible, B.S.I.P. slide no. 35637-1.× 150.
46. Thinner side of the cuticle from the marginal region of leaf, files of elongated cells along lamina margin visible on right hand side of the photograph, B.S.I.P. slide no. 35637-1.× 150
47. Thinner side of the cuticle from middle region of lamina, showing elongated cells along vein and ±isodiametric cells in the interveinal region, B.S.I.P. slide no. 35637-2.× 150.
48. A stoma magnified, B.S.I.P. slide no. 35637-2. × 500.

PLATE 6

49-52. *Baiera* sp.

49. B.S.I.P. slide no. 35638-1.× 2.
50, 51. Cuticle of the two surfaces of lamina, B.S.I.P. slide no. 35638-2.× 100.
52. Cuticle of lamina showing epidermal cells and two stomata magnified, B.S.I.P. slide no. 35638-2.× 400.

53, 54. Equisetaceous leaf-sheath.

53. B.S.I.P. no. 35643.× 1.
54. Same.× 2.
55. Equisetaceous nodal diaphragm, B.S.I.P. no. 35644.× 1.
56-58. Equisetaceous stems.
56. B.S.I.P. no. 35645, note the rounded scars in the nodal region.× 1.
57. B.S.I.P. no. 35646.× 1.
58. B.S.I.P. no. 35647.× 2.

PLATE 7

59-66. *Lepidopteris stormbergensis* (Seward) Townrow.

59. Apical portion of a pinna, B.S.I.P. no. 35648.× 1.
60. Pinna fragment showing minute lumps over the rachis, B.S.I.P. no. 35649.× 1.
61. Pinna fragment showing larger pinnules with deeply lobed margins, B.S.I.P. no. 35650.× 1.
62. Specimen showing bipinnate nature of leaf, B.S.I.P. no. 35652.× 1.
63. Specimen showing the apical portion of the bipinnate leaf, B.S.I.P. no. 35653.× 2.
64. Specimen in fig. 62 photographed under liquid paraffin.× 2.
65, 66. Cuticle of the two surfaces of lamina, B.S.I.P. slide no. 8141, fig. 65 representing the thicker side of the cuticle with papillate epidermal cells, fig 66 is the thinner side of cuticle having ordinary epidermal cells devoid of papillae.× 100.

PLATE 8

67-74. *Lepidopteris stormbergensis* (Seward) Townrow

67. Transfer of the specimen in pl. 7, fig. 61, photographed in transmitted light, showing venation of the pinnules, B.S.I.P. slide no. 35650-1.× 1.5.
68. Transfer of a pinna apex from the counterpart of the specimen in pl. 7, fig. 62, photographed intransmitted light showing venation in pinnules, B.S.I.P. slide no. 35652(cp)-1.× 2.
69, 70. Cuticle of the two surfaces of pinnules, ordinary epidermal cells of both surface papillate, B.S.I.P. slide no. 35650-2.× 100.
71. Cuticle of lamina showing epidermal cells and two stomata, B.S.I.P. slide no. 35652-1.× 200.
72. A stoma from lamina cuticle showing six subsidiary cells, note the cut in projections from the subsidiary cell outline, B.S.I.P. slide no. 8141.× 400.
73. Cuticle of lamina showing two stomata with their subsidiary cells in contact, B.S.I.P. slide no. 35650-3.× 400.
74. A stoma, B.S.I.P. slide no. 35650-3.× 400.

PLATE 9

75-81. *Dicroidium giarensis* Pal sp. nov.

75. B.S.I.P. no. 35657.× 1.
76. Specimen photographed in transmitted light after preparing transfer, showing the venation, B.S.I.P. slide no. 35661-1.× 2.
77, 78. B.S.I.P. nos. 35656 and 35658. both × 1.
79. Holotype, B.S.I.P. no. 35659.× 1.
80. Cuticle of the lamina, thicker side, note the elongated cells along a vein, B.S.I.P. slide no. 35659-1.× 100.
81. Cuticle of lamina, thinner side, B.S.I.P. slide no. 35659-1.× 100.

PLATE 10

82-89. *Dicroidium coriaceum* (Johnston) Townrow

82, 83. B.S.I.P. slide nos. 8142 and 8143. Both × 1.
84. B.S.I.P. slide no. 8144.× 4.
85. Specimen in fig. 83 magnified.× 4.
86. Specimen in fig. 82 magnified.× 4.
87, 88. Cuticle of two surfaces of lamina, B.S.I.P. slide no. 8142-1.× 150.
89. A stoma of lamina cuticle magnified, B.S.I.P. slide no. 8142-1.× 500.
90, 91. *Dicroidium zuberi* (Szajnocha) Archangelsky.
90. B.S.I.P. no. 35662.× 1.
91. Cuticle of lamina, B.S.I.P. slide no. 35662-1. × 100.

PLATE 11

92, 93. *Dicroidium zuberi* (Szajnocha) Archangelsky.

92. Transfer of the specimen in pl. 10, fig. 90, photographed in transmitted light, showing the venation, B.S.I.P. slide no. 35662-1.× 6.
93. Cuticle of lamina showing epidermal cells and two stomata, B.S.I.P. slide no. 35662-2.× 400.

94-98. *Dicroidium* sp. cf. *D. odontopteroides* (Morris) Gothan.

94. B.S.I.P. no. 35663.× 2.
95, 96. Cuticle of two surfaces of lamina respectively, B.S.I.P. slide no. 35663-2.× 100.
97. A typical stoma, B.S.I.P. slide no. 356632.× 400.
98. An unusual stoma showing cutinization around the stomatal pit, B.S.I.P. slide no. 35663-3. × 400.

PLATE 12

99-104. *Elatocladus denticulatus* Pal sp. nov.

99. Specimen showing distal portion of a branched twig, B.S.I.P. no. 35664.× 1.
100. Holotype, B.S.I.P. no. 35665.× 1.
101, 102. Cuticles of the two surfaces of leaf, B.S.I.P. slide no. 35664-1.× 50.
103. Cuticle of leaf showing epidermal cells and some stomata, B.S.I.P. slide no. 35665-1.× 100.
104. A stoma with 7 subsidiary cells, B.S.I.P. slide no. 35665-1.× 400.

PLATE 13

105, 106. *Elatocladus denticulatus* Pal sp. nov.

105. B.S.I.P. no. 35667.× 2.
106. Cuticle of leaf showing three stomata with their subsidiary cells in contact, B.S.I.P. slide no. 35665-2.× 400.

107-108. *Elatocladus raoi* Pal sp. nov.

107. Holotype, B.S.I.P. no. 35668.× 1.
108. Same.× 2.
109. Cuticle of lamina, B.S.I.P. slide no. 35668-1. × 150.
110. A stoma with rectangular stomatal pit surrounded by four subsidiary cells, B.S.I.P. slide no. 35668-1.× 500.
111. A stoma showing five subsidiary cells surrounding the polygonal stomatal pit, B.S.I.P. slide no. 35668-1.× 500.

PLATE 14

112. *Pagiophyllum* sp. from East Bank of Son River, NW of Giar, preserved as impression, B.S.I.P. no. 35669.× 1.

113-120. *Pagiophyllum bosei* Pal sp. nov.

113. Holotype, a small fragment of a twig with four spirally borne leaves, B.S.I.P. slide no. 8144.× 1.
114. Twig fragment with two leaves, B.S.I.P. slide no. 8145.× 2.
115. A detached leaf, dorsal view, B.S.I.P. slide no. 8146.× 4.
116. Fragmentary twig bearing two leaves, B.S.I.P. slide no. 8147.× 4.
117. Holotype.× 4.
118. Cuticle of two surfaces of a laterally compressed leaf showing distribution of stomata, B.S.I.P. slide no. 8144-1.× 50.
119. Cuticle of lamina showing epidermal cells and stomata, B.S.I.P. slide no. 8144-1.× 100.
120 A stoma magnified, B.S.I.P. slide no. 8144-2. × 500.

PLATE 15

121-128. *Yabiella indica* Pal sp. nov.

121. Holotype, B.S.I.P. no. 35670.× 1.
122. Holotype, photographed in transmitted light after preparing transfer showing venation, B.S.I.P. slide no. 35670-1.× 2.5.
123. Part of the transfer of the holotype magnified, B.S.I.P. slide no. 35670-1.× 6.
124, 125. Cuticle of the midrib region of the leaf, thicker and thinner sides respectively, B.S.I.P. slide no. 35670-2.× 100.
126, 127. Cuticle of lamina, thicker and thinner sides respectively, B.S.I.P. slide no. 35670-2. × 100.
128. A stoma, photographed before maceration, showing the guard cells, B.S.I.P. slide no. 35670-2.× 400.

PLATE 16

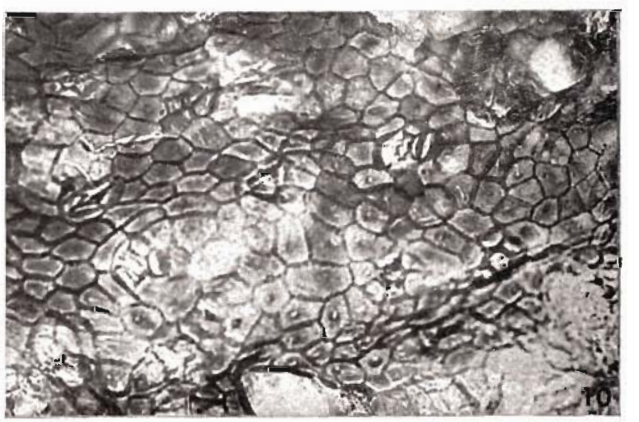
129-132. *Desmiophyllum singhii* Pal sp. nov.

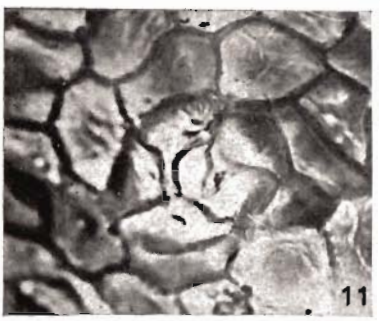
129. Basal portion of the leaf, B.S.I.P. no. 35672.× 1.
130. B.S.I.P. no. 35673.× 1.
131. Holotype, showing the fragments of leaves preserved ± parallelly, B.S.I.P. no. 35671.× 1.
132. Transfer of a leaf fragment, photographed in transmitted light showing details of venation and interveinal strands, B.S.I.P. slide no. 35671-1.× 15.

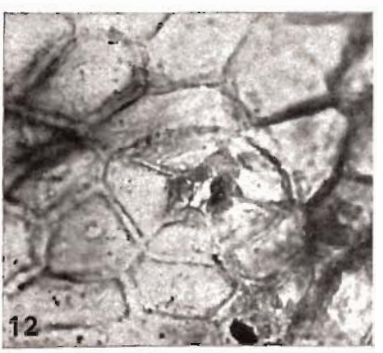
PLATE 17

133-136. *Desmiophyllum singhii* Pal sp. nov.

133. Upper cuticle of the leaf, B.S.I.P. slide no. 35671-2.× 150.
134. Lower cuticle of leaf, veinal area, B.S.I.P. slide no. 35671-2.× 150.
135. Lower cuticle of leaf, interveinal region, B.S.I.P. slide no. 35671-2.× 150.
136. A stoma magnified, B.S.I.P. slide no. 35671-2. × 500.







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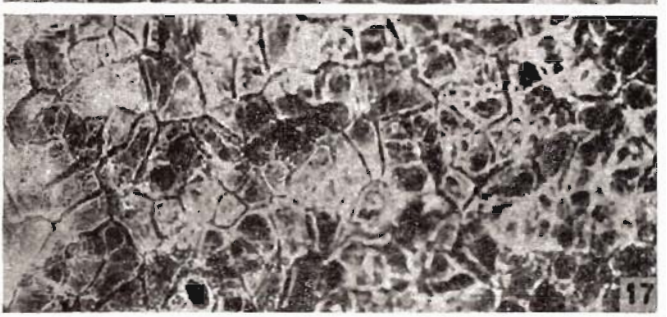

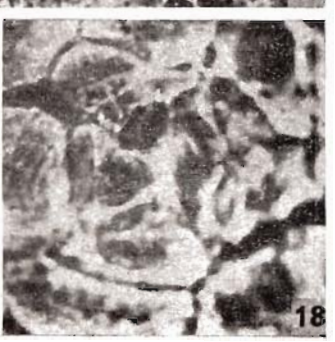

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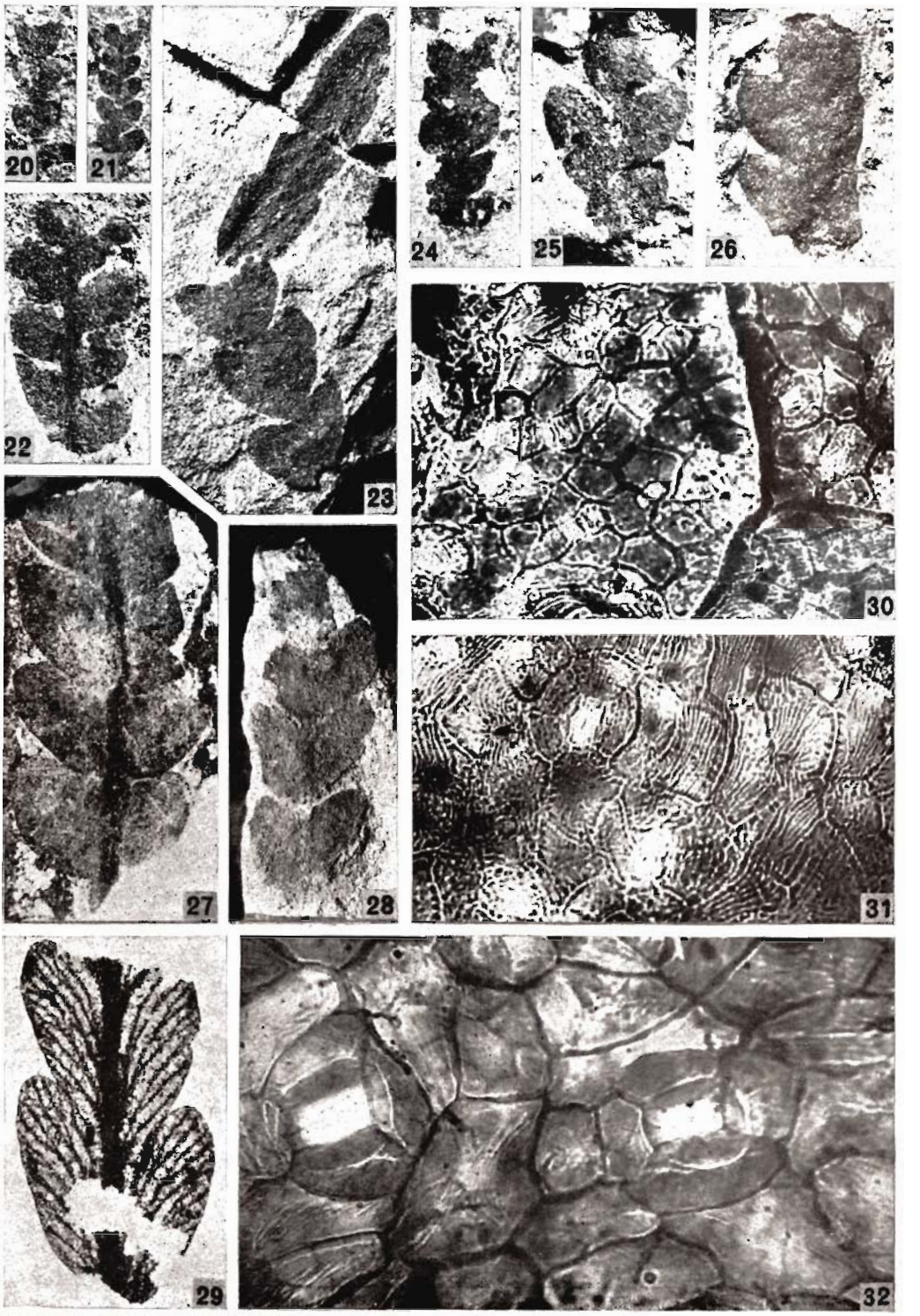

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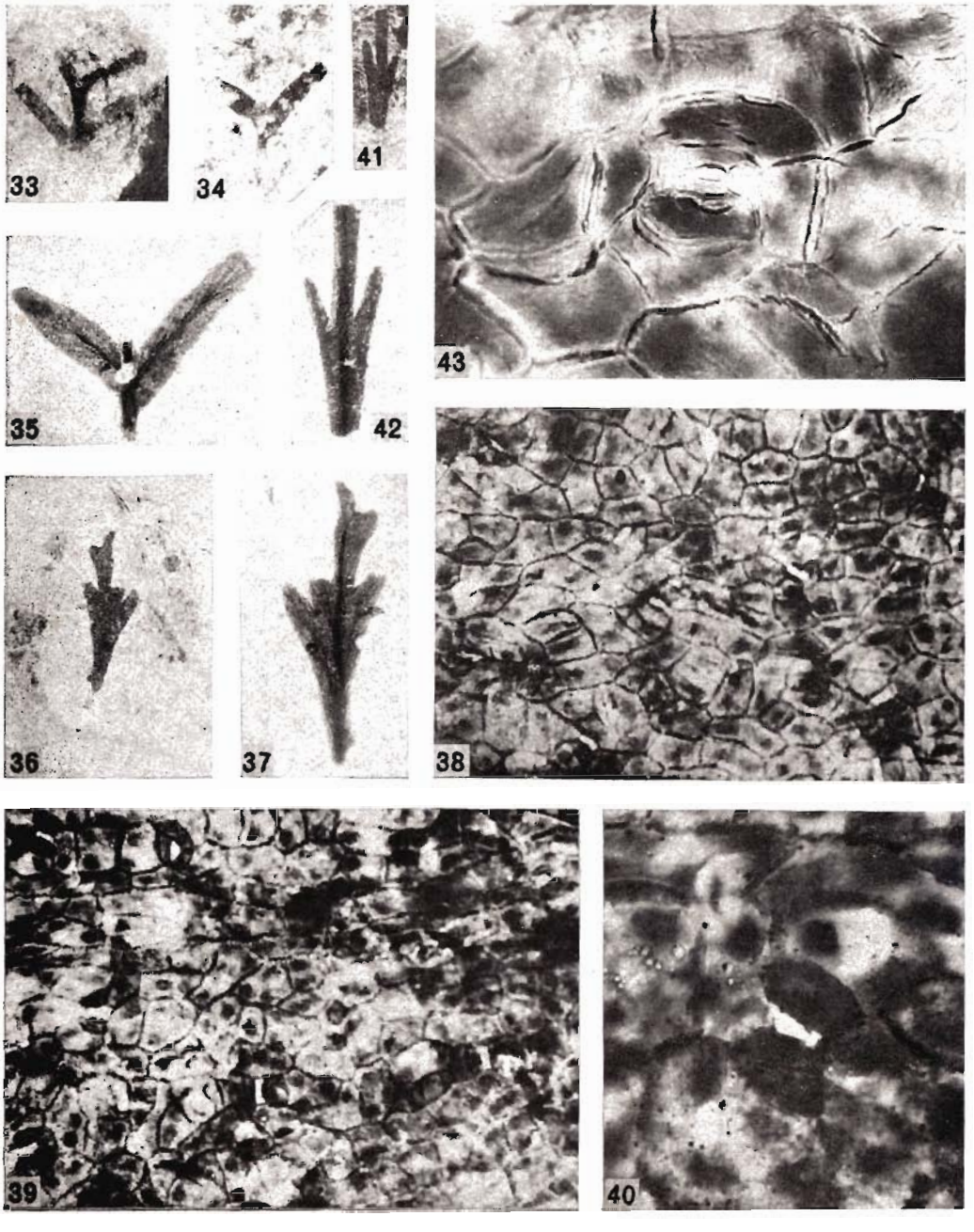

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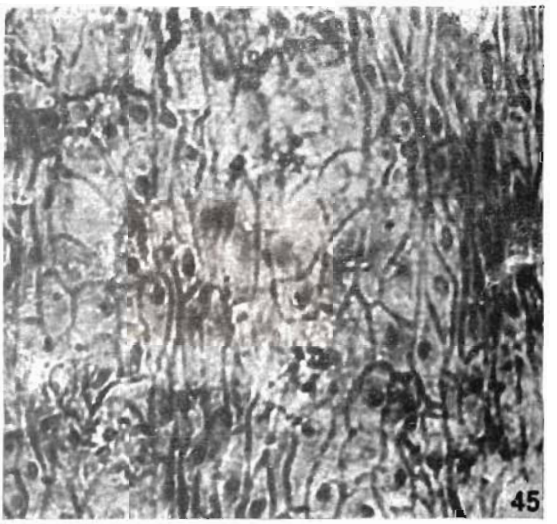


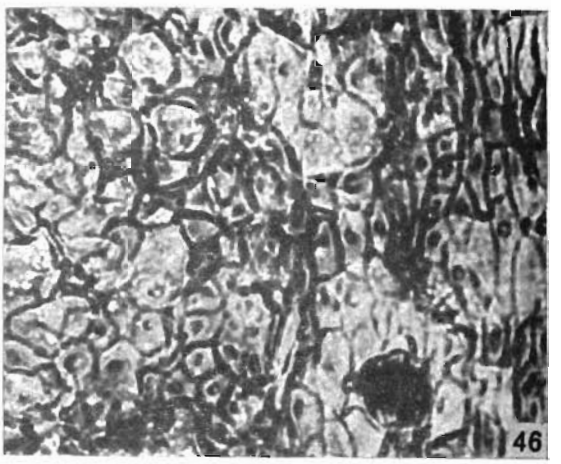
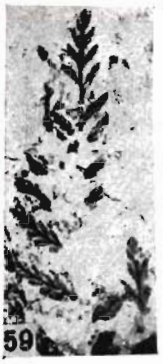


PLATE 5

PLATE 6



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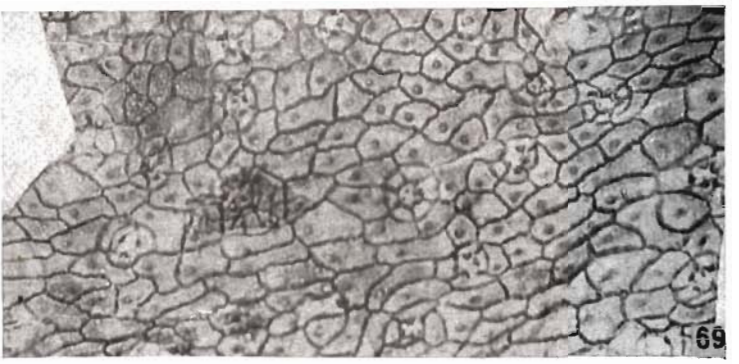

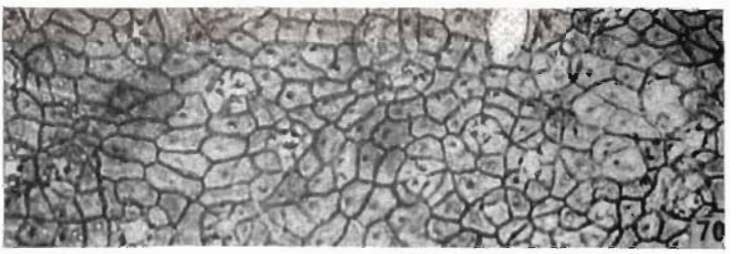

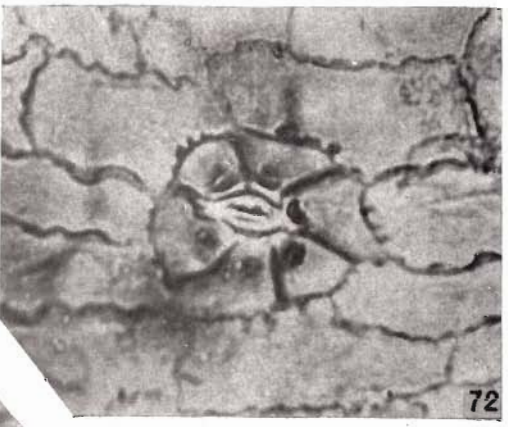

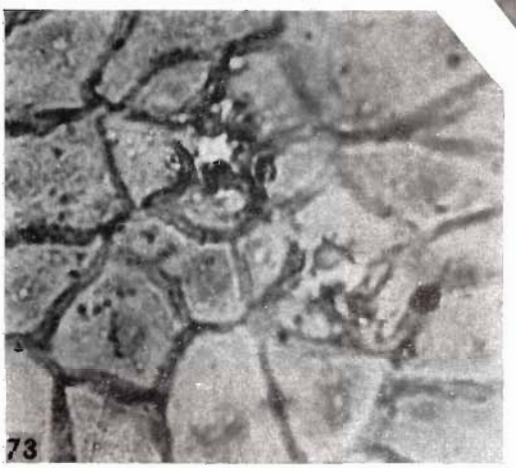

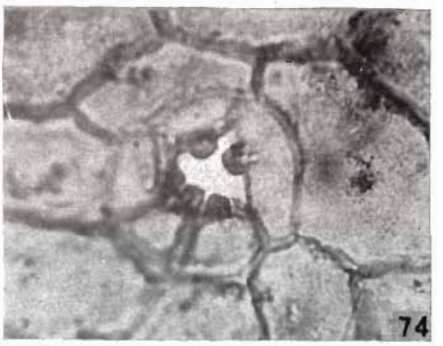

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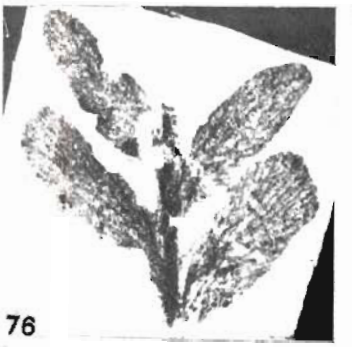

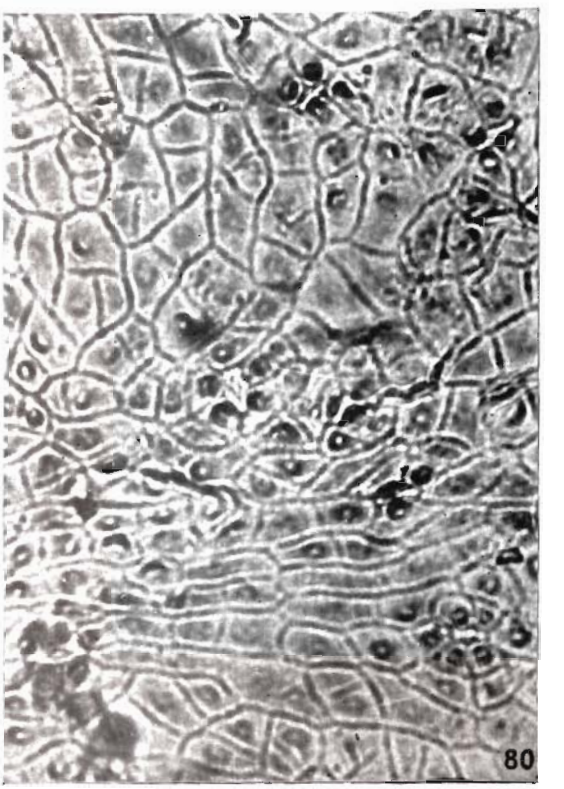

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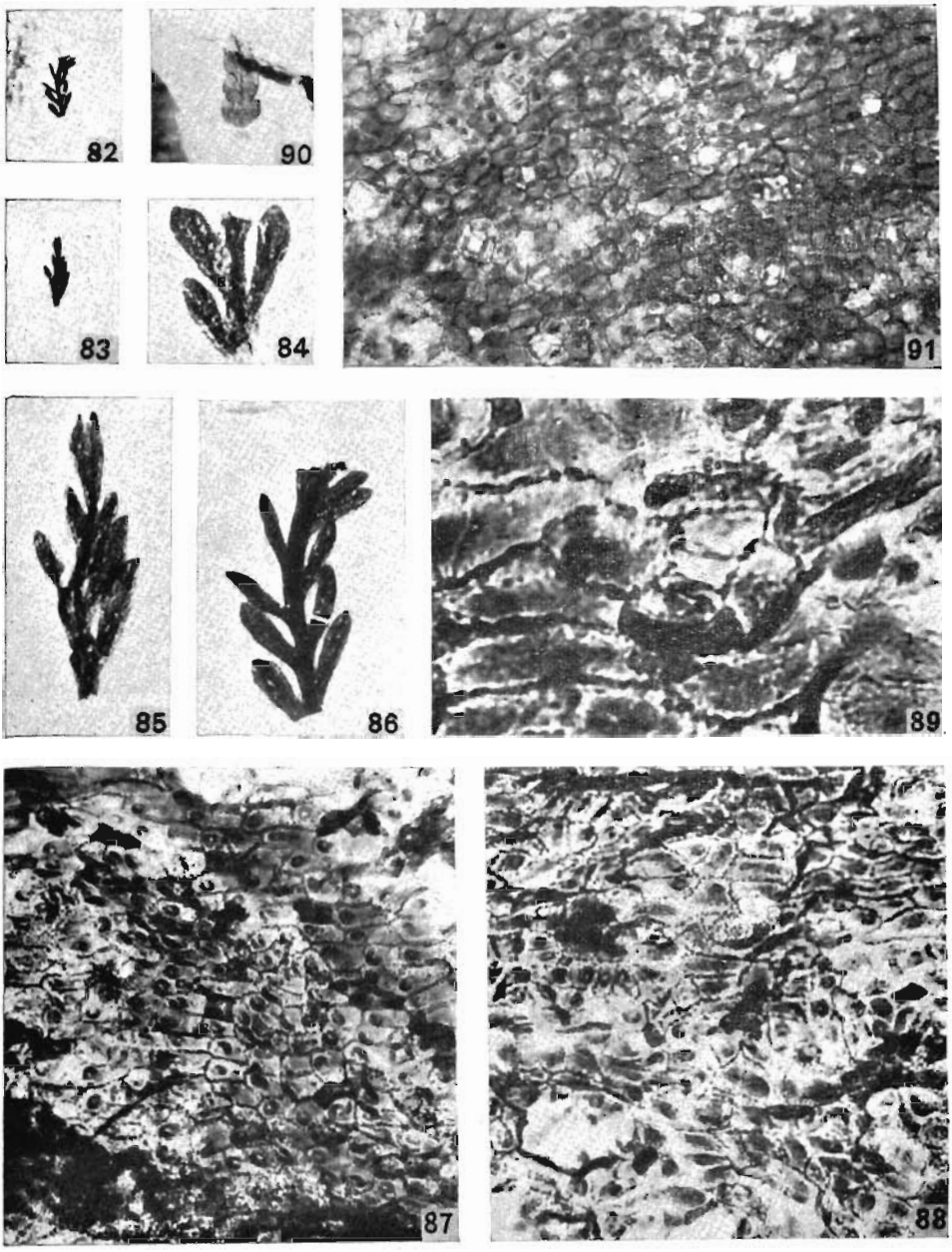

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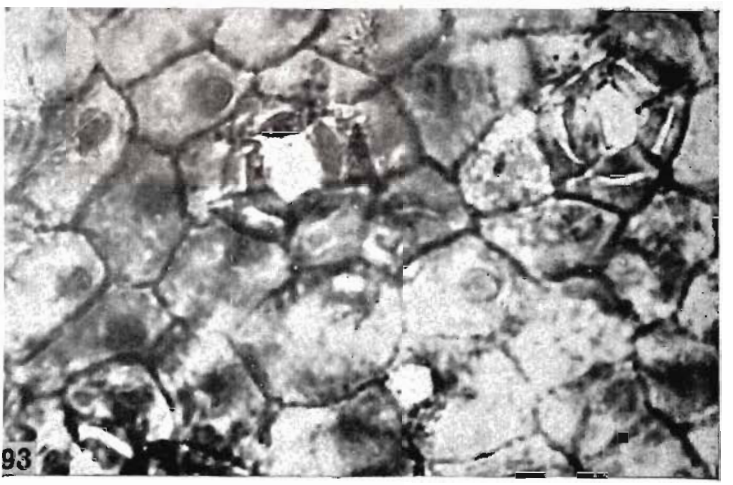

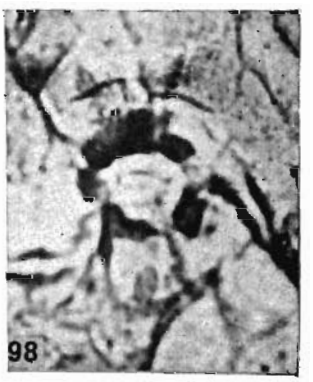

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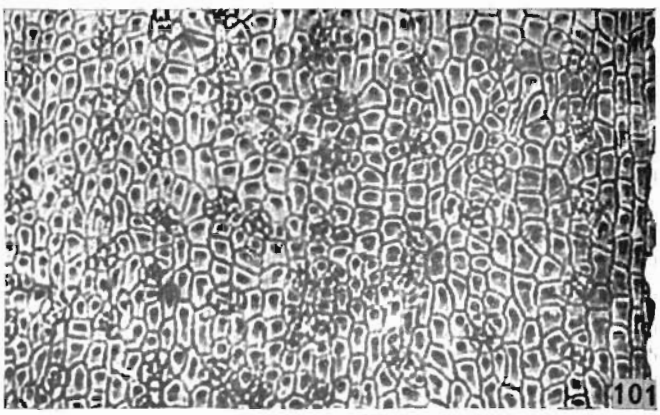

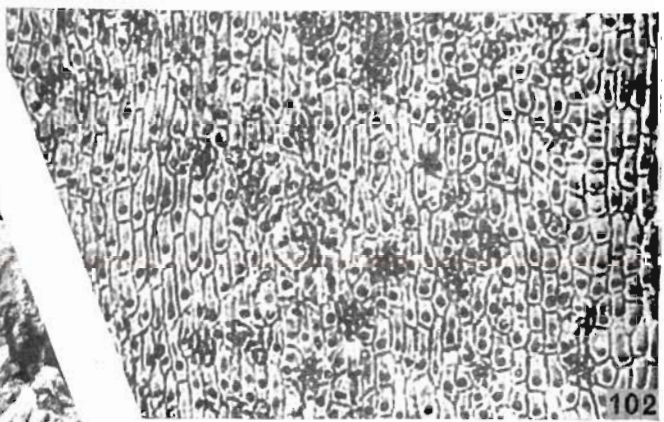

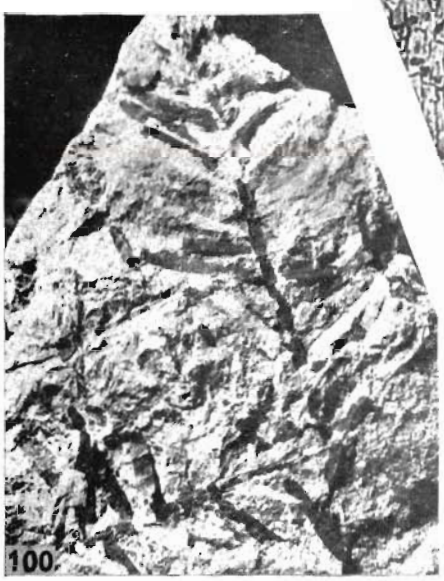

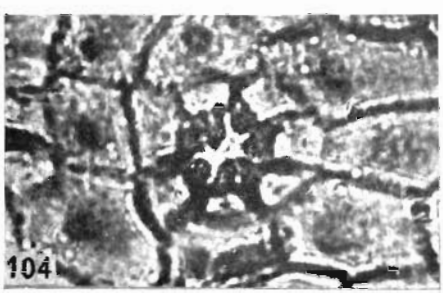

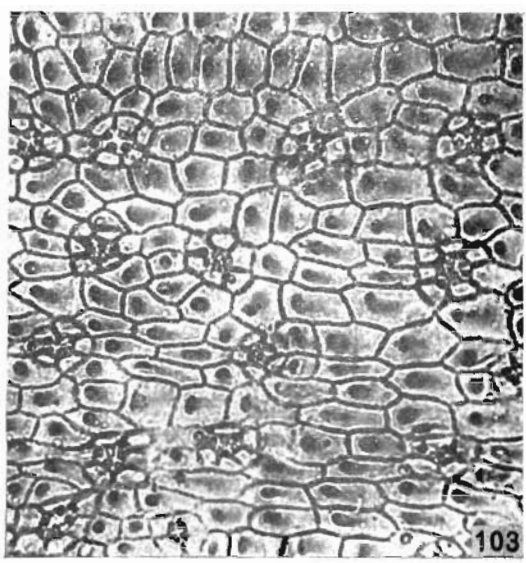

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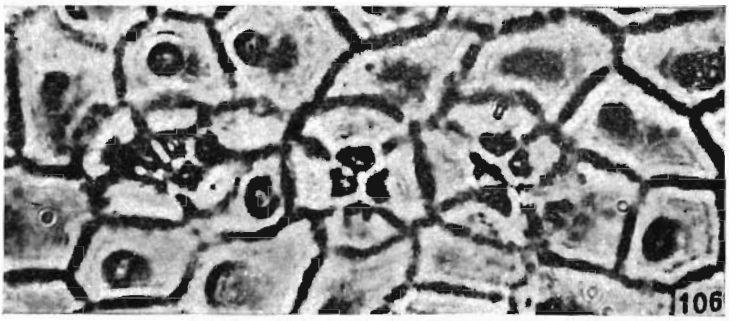

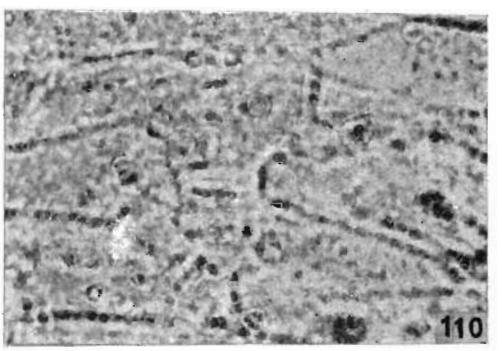

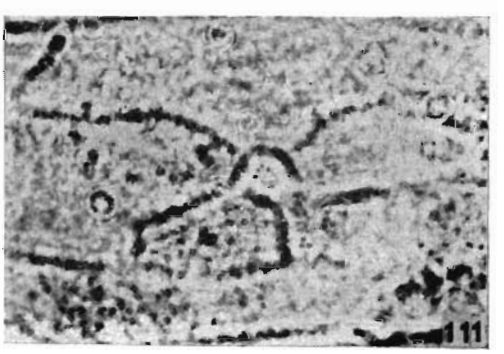

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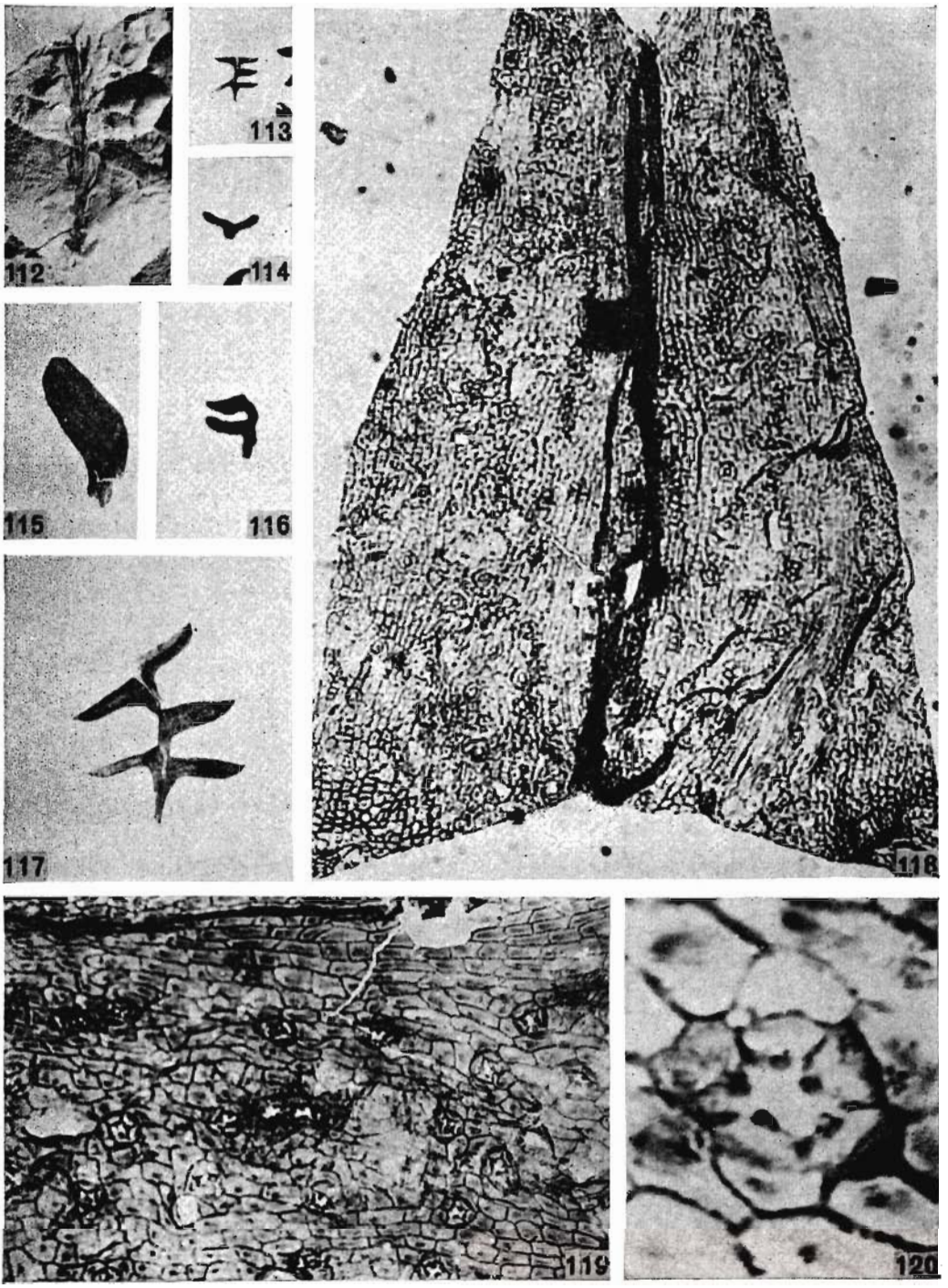

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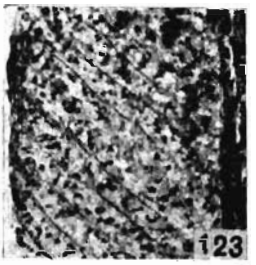

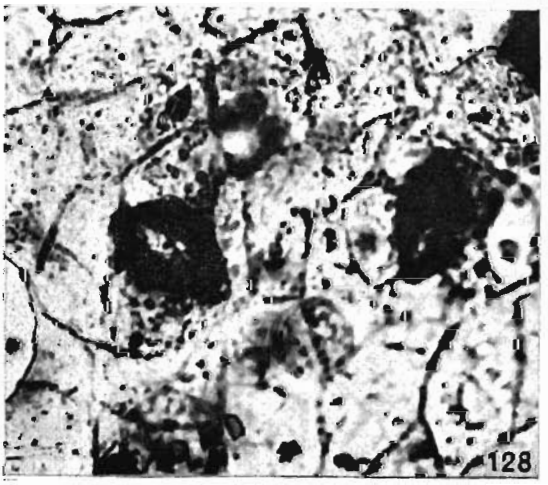

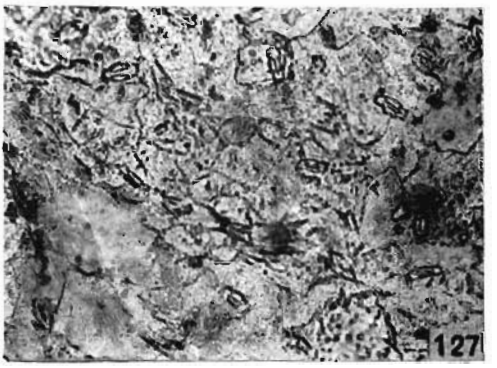

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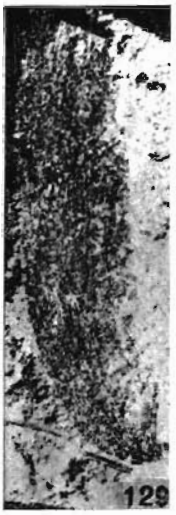

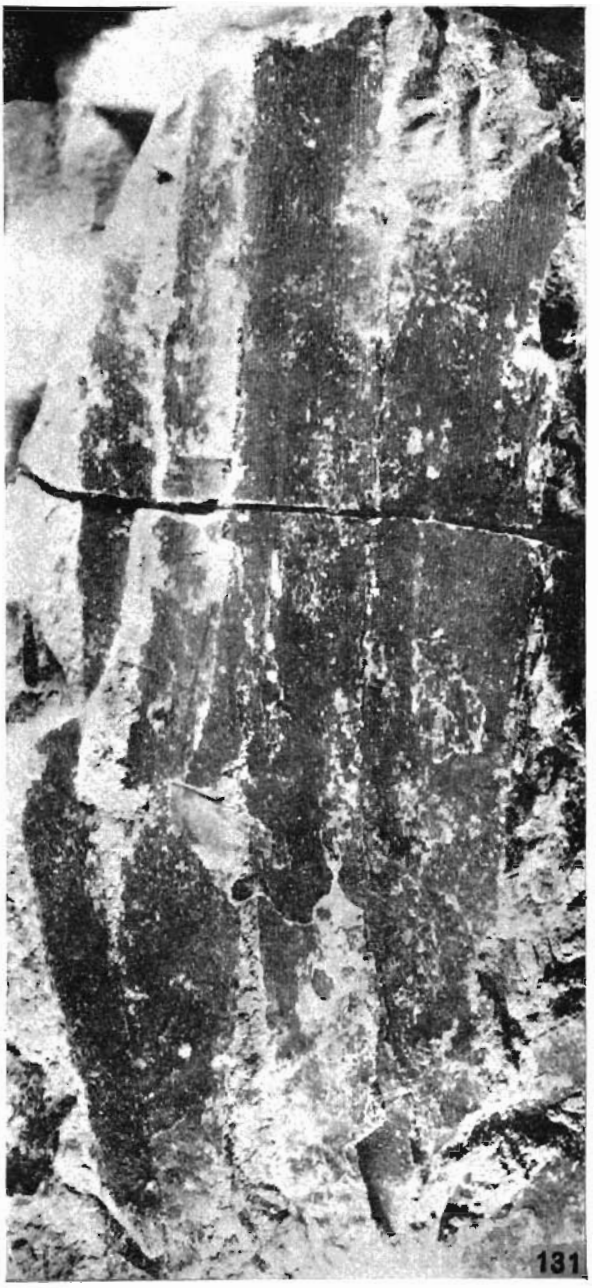

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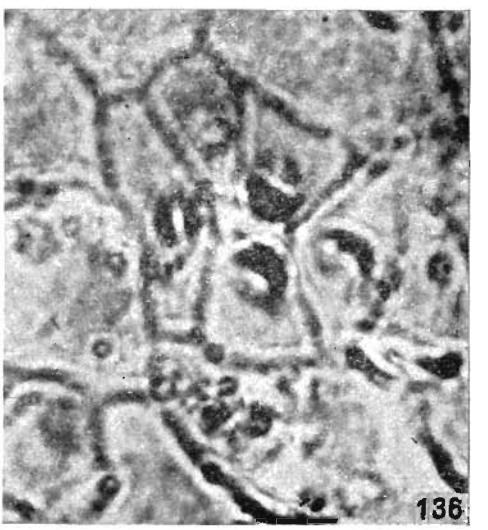

PLATE 17