THREE SPECIES OF *PTILOPHYLLUM* FROM BANSA, MADHYA PRADESH

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ABSTRACT

Ptilophyllum rewaensis n. sp., *Ptilophyllum* sp. cf. *P. horridum* Roy and *Ptilophyllum* sp. are described from the Lower Cretaceous of Bansa, Madhya Pradesh. In addition, a classification based on morphological and epidermal characters of most of the Ptilophyllums known from India and other countries is also prepared. In all 24 species are considered here — Argentina 1 (*P. longipinnatum*), Egypt 1 (*P. khargaense*), India 14, Italy 1 (*P. triangulare*), U.K. 3 (*P. hirsutum, P. pecten, P. pectinoides*) and U.S.S.R. 4 (*P. caucasicum, P. okribense, P. sokalense, P. ukrainense*).

INTRODUCTION

BENNETTITALEAN leaves are of rare occurrence in the Lower Cretaceous flora of the South Rewa Gondwana Basin, Madhya Pradesh. So far only two species of *Ptilophyllum* have been reported from this area, viz., *P. cutchense* Morris (Feistmantel, 1882, p. 3, 4, 40, not described or figured) and *P. gladiatum* Bose & Sukh-Dev (1958). The former species is known by two specimens and the latter by a single specimen.

In 1958 and 1959-60, three more specimens of *Ptilophyllum* were collected by one of us (Sukh-Dev) from near Bansa, which are described here as *P. rewaensis* n. sp., *Ptilophyllum* sp. cf. *P. horridum* Roy and *Ptilophyllum* sp.

In 1966, Kilpper briefly discussed 22 species of *Ptilophyllum* known from the world over. Later, Sharma (1967) partially classified the Indian species on the basis of lower epidermal characters. Both the works now need revision. Bose and Kasat (1972) re-investigated the Indian ptilophyllums. In the present paper 24 species of this genus known from India and other countries are classified up to the individual species on the basis of morphological and epidermal characters of their leaves in the form of a key.

DESCRIPTION

Genus — *Ptilophyllum* Morris, 1840

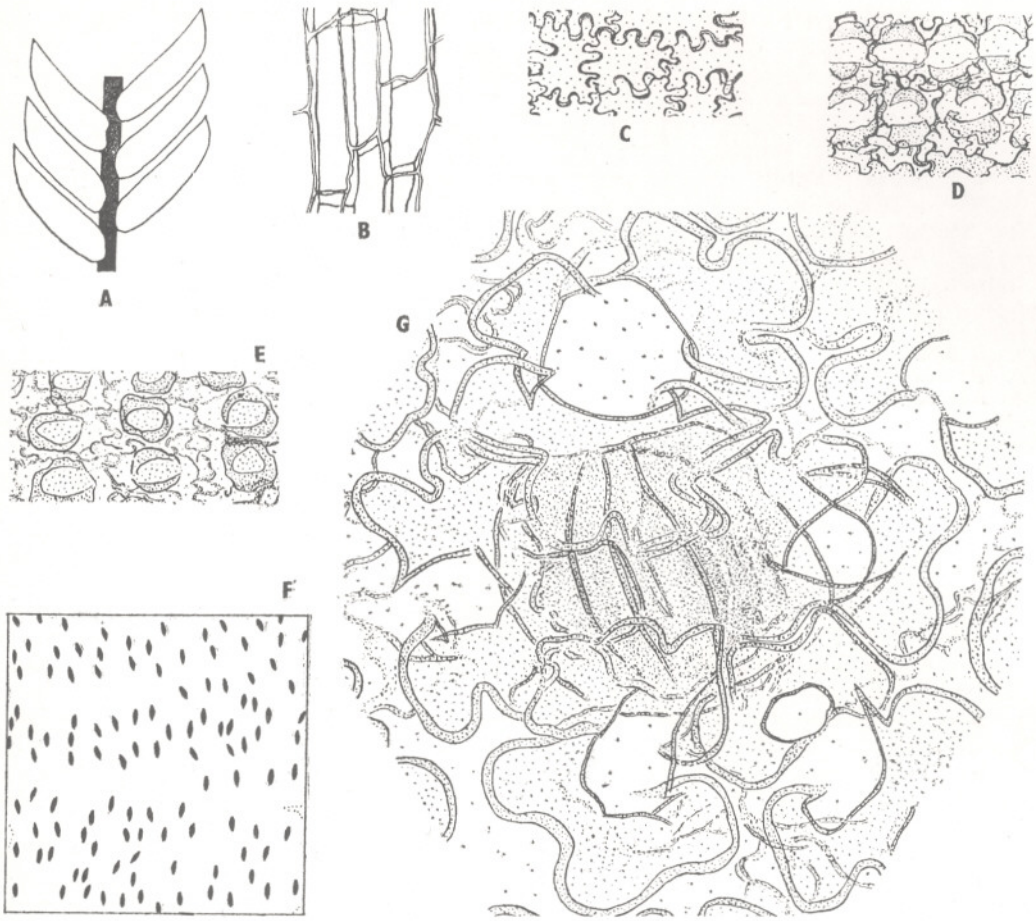
Ptilophyllum rewaensis n. sp.

Pl. 1, fig. 1; Pl. 2, figs. 11-13; Text-fig.1A-G

Diagnosis — Leaf imparipinnate, more than 5 cm in length. Rachis longitudinally striated, completely covered over by pinnae. Pinnae linear, almost parallel-sided, slightly falcate, typically $8 \times 1{\cdot}5$ mm, alternate, closely attached at an angle of about 40°-50°. Margin entire. Acroscopic basal margin rounded, basiscopic margin also rounded. Distal end abruptly obliquely-truncate and forming an apiculate apex. Lamina thick, concealing veins, veins almost parallel and forked.

Rachis cuticle slightly thick. Cells on both surfaces rectangular, sometimes squarish or polygonal. Anticlinal walls slightly thick, straight, frequently undulate. Hypodermis present under both surfaces.

Upper cuticle of lamina slightly thick, cells rectangular, sometimes squarish or polygonal. Anticlinal walls thick, greatly sinuous. Periclinal wall smooth except marginal cells where trichomes rarely present. Stomata absent. Lower cuticle differentiated into broader stomatal bands alternating with narrow vein bands and a non-stomatal marginal region. Margin about 5-10 cells wide, cells and occasional trichomes as on upper cuticle. Cells near stomatal band showing papillae at various stages of formation. Vein bands generally 2-4 cells wide, cells rectangular or polygonal, anticlinal walls sinuous. Papillae mostly 2 on a cell, large, crescent-shaped, commonly more or less circular when single or lobed, hollow, sometimes papillae of the cells of a row coectnned with one another by a longitudinal cuticular ridge. Stomatiferous



TEXT-FIG. 1 — *Ptilophyllum rewaensis* n. sp. — A, a few pinnae enlarged showing apiculate apex, specimen no. 19/469 × 3. B, cuticle of rachis, slide no. 19/469-2 × 250. C, upper cuticle showing marginal cells, slide no. 19/469-4 × 250. D, E, lower cuticle showing papillae over the vein bands, slide nos. 19/469-3, 19/469-1 × 250. F, showing orientation and distribution of stomata in 1 sq mm of lower cuticle, slide no. 19/469-1 × 40. G, lower cuticle showing stoma and papillae, slide no. 19/469-4 × 800.

bands generally 2-6 stomata wide, cells heavily papillate, anticlinal walls wherever visible sinuous. Papillae usually larger, thickly cutinized, hollow, variously lobed, eccentrically developed or more or less circular and forming a frill-like structure. Papillae covering most of the cell surface and stomatal apparatus where their lobes fitting into one another or overlapping. Stomata scattered in stomatal bands, transversely orientated, sometimes slightly oblique. Stomatal apparatus (stoma + subsidiary cells) more or less circular, oval or rectangular (average size 43×52 μ, of 30 stomata taken at random). Subsidiary cells more cutinized than ordinary epidermal cells, papillate, outer wall of subsidiary cells rather wavy. Rarely lateral encircling cells present. Guard cells sunken, crescent-shaped thickenings well-developed.

Holotype — Specimen no. 19/469 (Pl. 1, fig. 1), Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Locality — Machrar River, about 3/4 km NNW of Bansa, Shahdol District, Madhya Pradesh.

Horizon & Age — Jabalpur Series, Lower Cretaceous.

Comparison — *Ptilophyllum rewaensis* show some resemblance with *P. sakrigaliensis* Sah (Bose & Kasat, 1972). In both, the lower cuticle is differentiated into stomatal and non-stomatal bands. Sometimes papillae of nonstomatal bands of *P. rewaensis* are found undivided and hollow as in *P. sakrigaliensis*. But in *P. sakrigaliensis* the papillae are comparatively massive, solid or hollow with thick walls or sometimes divided into two, rarely more lobed over the stomatal and non-stomatal bands. But in *P. rewaensis* the papillae over the veins are generally two per cell, while over the stomatal bands papillae are much more lobed. The stomatal apparatus in *P. rewaensis* is broader (average size 43×52 μ) than that of *P. sakrigaliensis* (average size $41{\cdot}5 \times 36$ μ). Moreover, the apice of the pinnae in *P. rewaensis* are apiculate but in *P. sakrigaliensis* these are acute. *P. rewaensis* shows close resemblance in general form of the pinnae with one of the specimens of *P. horridum* Roy figured by Bose and Kasat (1972, pl. 4, fig. 31). In both the species stomata are also arranged in bands on lower surface, but they are quite different in the form and distribution of papillae. *P. rewaensis*, which is similar to *Ptilophyllum* sp. and *Ptilophyllum* sp. cf. *P. horridum* (both described here later) in the stomatal arrangement, is differentiated from both by the apiculate apices of the pinnae and by the presence of usually two or one large papilla per cell over the veins. The bases of the pinnae are much less asymmetrical and its stomatal apparatus (average size 43×52 μ) is also larger than that of *Ptilophyllum* sp. (average size $36{\cdot}5 \times 43{\cdot}5$ μ). The stomatal apparatus in *P. rewaensis* is slightly broader than that of *P.* sp. cf. *P. horridum* (average size $46{\cdot}5 \times 45$ μ).

Ptilophyllum sp. cf. *P. horridum* Roy

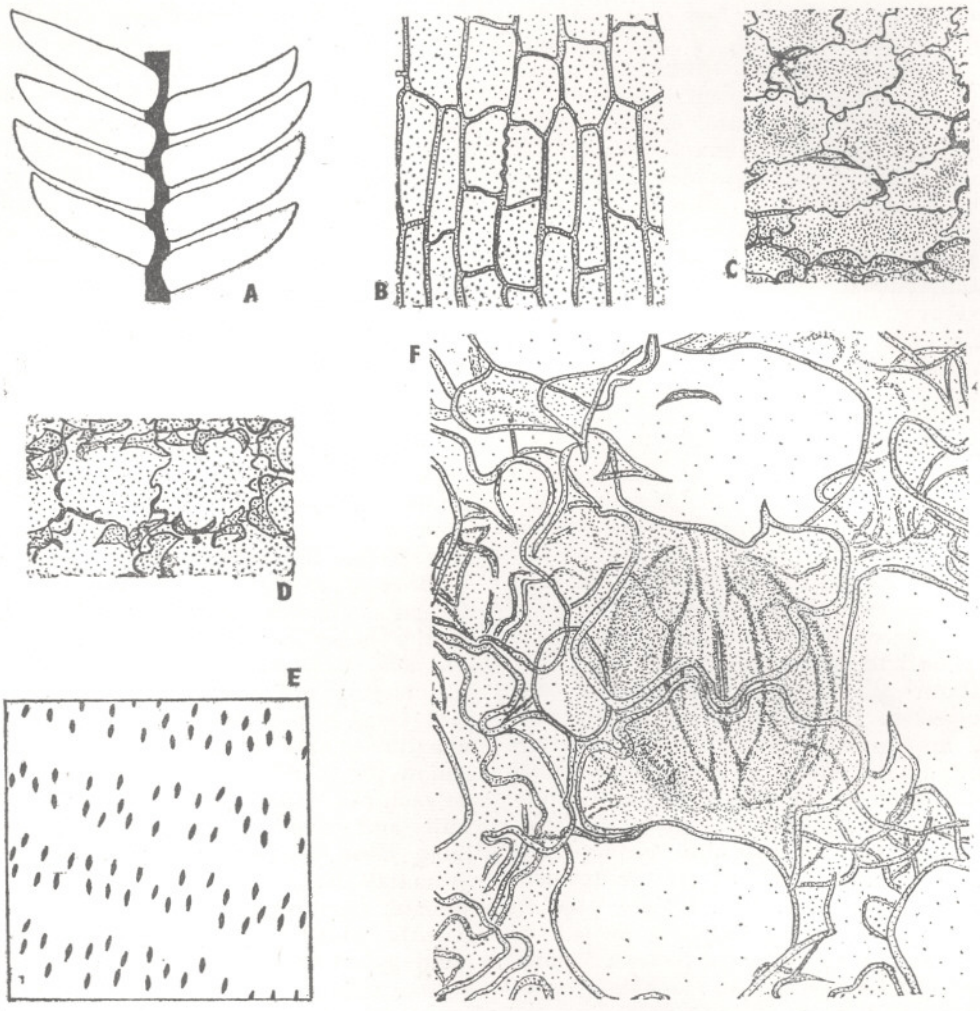
Pl. 1, figs. 4-7; Text-figs. 2A-F

Description — Leaf more than 19 cm in length. Lower greater part of lamina showing gradual increase in width from base upwards. Petiole slender. Pinnae linear, almost parallel-sided, typically 8 to 9 mm in length and 2·5 mm in breadth, alternate, closely set, covering rachis partially and making an angle of about 60°-70°. Margin entire. Apex acute. Acroscopic basal margin rounded, sometimes straight or slightly enlarged, basiscopic margin rounded or straight. Distal end rather abruptly obliquely-truncate. Veins not clear, almost parallel but uppermost diverging towards margin, forking at different intervals.

Epidermal cells of rachis rectangular, elongate, sometimes squarish or polygonal. Anticlinal walls slightly thick, entire, sometimes slightly undulate. Periclinal wall smooth.

Upper cuticle of lamina thinner than the lower one. Cells squarish, rectangular or polygonal. Anticlinal walls slightly thick, sinuous. Periclinal wall smooth. Lower cuticle differentiated into margin of 2-8 cells width (fragments seen) without stomata and inner stomatiferous region further differentiated into stomatiferous bands alternating with non-stomatiferous vein bands of variable width, sometimes stomata occurring over the latter as well. Margin composed of cells similar to those of the upper cuticle. Vein bands about 2-6 cells wide, cells rectangular, squarish or polygonal, arranged serially. Papillae over veins small, usually crescent-shaped, sometimes dome-shaped, rounded or conical, hollow, about 3-5 or more papillae occurring on each cell, usually present along anticlinal walls and covering them, papillae may be lying close or joining together or lobed. Stomatal bands more heavily papillate, stomata transversely orientated, sometimes slightly oblique. Papillae over stomatal bands small to massive, forming a frill-like structure, usually much eccentrically developed and variously lobed, crowded over anticlinal walls, leaving more or less circular or irregularly shaped area over the cells, covering the stomatal apparatus where their lobes overlapping or fitting into one another. Epidermal cells in the stomatal and vein bands not clearly marked, anticlinal walls sinuous to undulate. Stomatal apparatus (stoma + subsidiary cells) more or less squarish or rectangular (average size $46{\cdot}5 \times 45$ μ, of 30 stomata taken at random), subsidiary cells more cutinized than ordinary epidermal cells, papillate, outer margin straight or wavy. Guard cells sunken with well-developed crescent-shaped thickenings.

Collection — Specimen no. 63/470 (Pl. 1, fig. 4), Birbal Sahni Institute of Palaeobotany Museum, Lucknow.



TEXT-FIG. 2 — *Ptilophyllum* sp. cf. *P. horridum* Roy — A, a few pinnae enlarged, specimen no. 63/470 × 3. B, cuticle of rachis, slide no. 63/470-4 × 250. C, lower cuticle showing marginal cells near the stomatal band, slide no. 63/470-5 × 250. D, lower cuticle showing papillae over the vein band, slide no. 63/470-1 × 250. E, showing orientation and distribution of stomata in 1 sq mm of lower cuticle, slide no. 63/470-1 × 40. F, lower cuticle showing stoma and papillae, slide no. 63/470-1 × 800.

Locality — Machrar River, about 1/2 km NNW of Bansa, Shahdol District, Madhya Pradesh.

Horizon & Age — Jabalpur Series, Lower Cretaceous.

Comparison — The present specimen shows some resemblance with *P. horridum* Roy (Bose & Kasat, 1972) in the form of the leaves and in the presence of stomatiferous bands on the papillate lower surface. However, both the species show the following differences. In the present specimen, as compared to *P. horridum*, the papillae are comparatively profuse, mucl. lobed, massive and larger, and the stomatal apparatus on the whole is also larger (average size 46·5×45 μ, in *P. horridum* average size 33·5×35 μ). Unlike the former species, the cells over veins in *P. horridum* are slightly smaller and sometimes non-

papillate. Moreover, the apices of pinnae are acute in the present specimen, whereas these are apiculate in *P. horridum*. In *Ptilophyllum* sp. cf. *P. horridum* and *Ptilophyllum* sp. (described here later) stomata are arranged in bands. But in the former papillae on the veins are mostly smaller and crescent-shaped, stomatal apparatus is larger and bases of the pinnae are only slightly asymmetrical. *P.* sp. cf. *P. horridum* resembles to some extent in the form of the leaf with one of the illustrations of *P. cutchense* Morris given by Bose and Kasat (1972, pl. 1, fig. 10), but the cuticular structure of the latter is not known. *P. jabalpurense* Jacob & Jacob may be compared to some extent in the form of the leaves (Bose & Kasat, 1972, pl. 9, fig. 80), but *P.* sp. cf. *P. horridum* differs markedly from *P. jabalpurense* in the nature and distribution of papillae.

Ptilophyllum sp.

Pl. 1, figs. 2, 3; Pl. 2, figs. 8-10; Text-fig 3A-I

Description — Leaf over 7·5 cm in length. Rachis stout, longitudinally striated. Pinnae linear-lanceolate, falcate, typically measuring 10·5×2·5 mm, slightly broader at the base, alternate, closely attached at an angle of about 40°-55° and covering the rachis completely on its upper side. Margin entire. Apex acute. Pinnae bases asymmetrical, upper basal margin rounded, slightly enlarged, lower basal margin running straight to rachis. Distal end obliquely truncate. Pinnae generally overlapping the pinna in front. Veins, arising from the basal attached portion, forking at different intervals, traversing the lamina almost parallel but uppermost diverging towards margin.

Rachis cells on both the surfaces rectangular, sometimes squarish or polygonal. Anticlinal walls straight or slightly undulate. Hypodermis present. Rarely trichomes present. Stomata rarely present on lower surface.

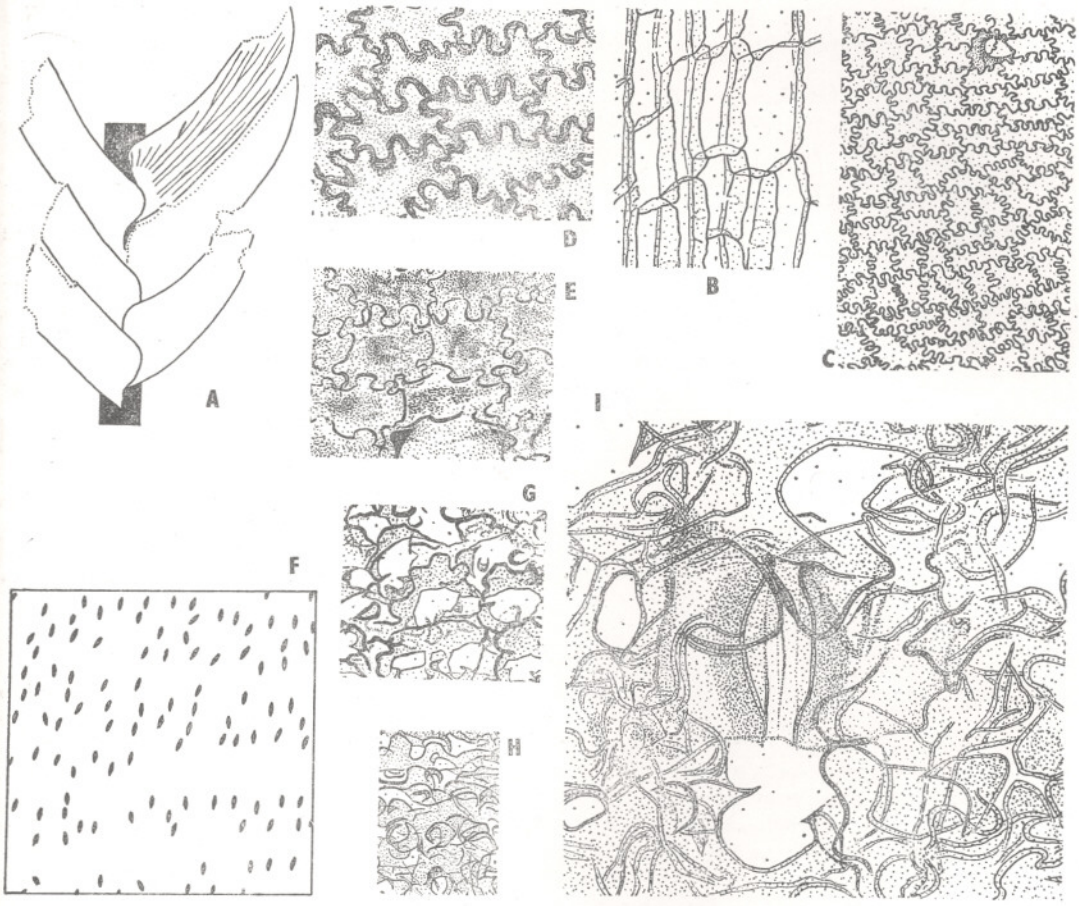
Upper cuticle of lamina thicker than the lower, composed of squarish, rectangular and polygonal cells. Anticlinal walls slightly thick, greatly sinuous. Periclinal wall unevenly cutinized, generally much less thickened at places along the anticlinal walls. Sometimes trichomes present, each occurring over one to a few marginal cells. Stomata absent. Lower surface differentiated into stomatal and non-stomatal vein bands and marginal region without stomata. Often stomata present in the vein bands and the bands then become ill-defined. Stomatal bands broader than vein bands. Marginal region about 4-11 cells wide, composed of cells similar to those of the upper cuticle, sometimes bearing trichomes also like the upper cuticle. Cells near stomatal band showing papillae at various stages of formation. Outline of cells in the stomatal and vein bands sinuous, but generally ill-defined due to presence of papillae. Both stomatal and vein bands heavily papillate; papillae thickly cutinized, hollow, more or less circular, crescent-shaped, conical, dome-shaped, eccentrically developed or irregularly lobed and irregularly distributed. Papillae of the same cell or the adjoining cells overlap each other or join to form a superficial sheath over the cuticle and leave more or less circular, oval or irregularly shaped uncovered area over the cell. Papillae over the stomatal bands much more developed and crowded, their lobes fitting into one another or overlapping over the stomatal apparatus. Stomata in stomatal bands transversely orientated, sometimes slightly oblique, usually somewhat distant, sometimes arranged in short rows. Stomatal apparatus (stoma + subsidiary cells) broadly oval, sometimes more or less circular (average size 36·5×43·5 μ, of 30 stomata taken at random), overhung by adjoining and subsidiary cells' papillae. Outer walls of subsidiary cells rather wavy, surface wall heavily cutinized. Lateral encircling cells sometimes present. Guard cells sunken, forming well-developed crescent-shaped thickenings.

Collection — Specimen no. 30326 (Pl. 1, fig. 2, counter part no. 30325, fig. 3), Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Locality — Machrar River, about 1/2 km NNW of Bansa, Shahdol District, Madhya Pradesh.

Horizon & Age — Jabalpur Series, Lower Cretaceous.

Comparison — *Ptilophyllum* sp. resembles *P. institacallum* Bose (Bose & Kasat, 1972) in the arrangement of stomata in bands. In both, papillae form a frill-like



TEXT-FIG. 3 — *Ptilophyllum* sp. — A, a few pinnae enlarged showing their bases and venation, specimen no. 30326 × 3. B, cuticle of rachis, slide no. 30326-3 × 250. C, upper cuticle showing marginal cells to wards the top, slide no. 30326-1 × 100. D, a few cells of upper cuticle enlarged, slide no. 30326-1 × 250. E, lower cuticle showing marginal cells near the stomatal band, slide no. 30326-1 × 250. F, showing orientation and distribution of stomata in 1 sq mm of lower cuticle, slide no. 30 326-1 × 40. G, lower cuticle showing papillae over the vein band, slide no. 30326-1 × 250. H, lower cuticle showing papillae over the vein band, slide no. 30326-2 × 250. I, lower cuticle showing stoma and papillae, slide no. 30326-1 × 800.

structure over the lower cuticle. But both the species differ in the shape of pinnae and in the details of cuticular features. In *Ptilophyllum* sp. the bases of the pinnae are asymmetrical; upper basal margin is enlarged and rounded, lower basal margin runs straight to rachis. Whereas in *P. institacallum* the sides of pinnae are comparatively parallel and both the basal margins are only slightly rounded, not asymmetrical like *Ptilophyllum* sp. In cuticular details, the stomata in *P. institacallum* are sometimes distributed irregularly over entire lower surface, but this feature is absent in *Ptilophyllum* sp. Moreover, the stomatal apparatus in *Ptilophyllum* sp. is on the whole smaller (average size 36·5×43·5 μ) than *P. institacallum* (average size 48·5×52 μ). The papillae over the veins are irregular in shape and distribution in *Ptilophyllum* sp. whereas in *P. institacallum* they are usually regular in shape and distribution. *P. caucasicum* Doludenko & Svanidze (1964), from the Jurassic of Georgia (U.S.S.R.), shows some apparent resemblance with *Ptilophyllum* sp. in the structure of lower

TABLE 1 — CLASSIFICATION OF INDIAN *PTILOPHYLLUM* SPECIES

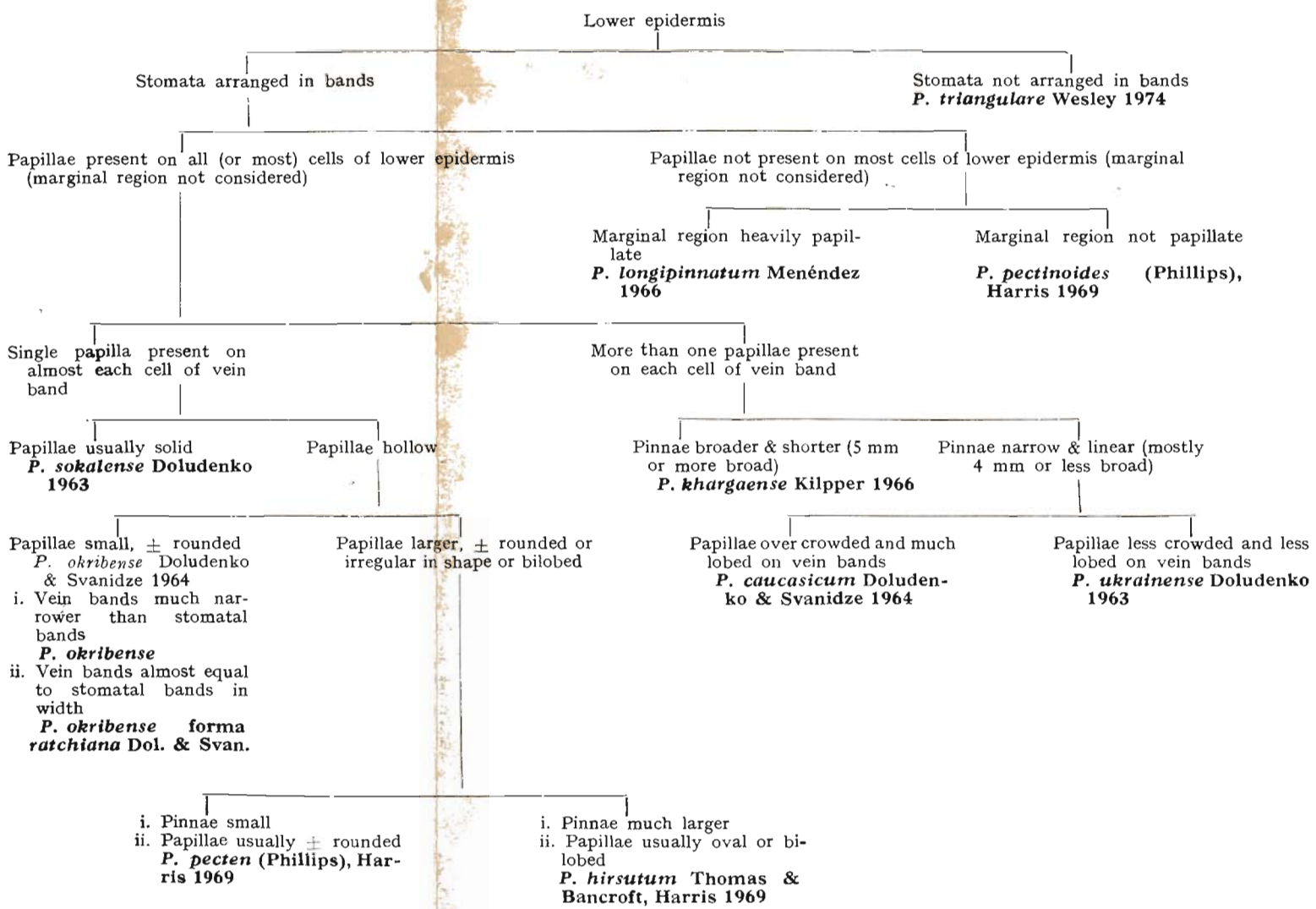
PTILOPHYLLUM (Indian species)

(Based on Bose & Kasat, 1972 and present work)

Lower Epidermis

- Papillae present
  - *Stomata arranged in bands
    - Distinct papillae present on ordinary epidermal cells
      - **Papillae present on each epidermal cell of vein band
        - Usually one or two papillae present on each epidermal cell of vein band
          - i. Pinnae apices acute
            ii. Stomatal apparatus narrower (average size 41·5 × 36 μ)
            P. sakrigaliensis
        - Usually two or more papillae present on each epidermal cell of vein band
          - i. Pinnae apices apiculate
            ii. Stomatal apparatus broader (average size 43 × 52 μ)
            P. rewaensis
      - Papillae not present on each epidermal cell of vein band
        - Papillae forming a frill-like structure over stomatal and vein bands
          - Stomatal apparatus smaller (average size 36·5 × 43·5 μ)
            ***Ptilophyllum* sp.**
          - Stomatal apparatus larger (average size 48·5 × 52 μ)
            P. institacallum
            *(less commonly stomata distributed irregularly over entire surface)
        - Papillae not forming a frill-like structure over vein bands
          - i. Papillae abundant over vein bands, much lobed & massive over stomatal bands
            ii. Stomatal apparatus larger (average size 46·5 × 45 μ)
            Ptilophyllum* sp. cf. *P. horridum
          - i. Papillae scanty over vein bands, less lobed & smaller over stomatal bands
            ii. Stomatal apparatus smaller (average size 33·5 × 35 μ)
            ****P. horridum***
            (in certain cases some cells of vein band non-papillate)
    - Distinct papillae not present on ordinary epidermal cells (rarely slightly more cutinized circular areas or hair-bases present
      P. distans
  - Stomata not arranged in bands
    P. oldhamii
- Papillae not present
  - Stomata arranged in bands
    - i. Leaves narrow (0·6-1·9 cm wide in middle)
      ii. Stomatal bands mostly 2-3 stomata wide
      P. sahnii
    - i. Leaves broad (3-5 cm wide in middle)
      ii. Stomatal bands 4-5 stomata wide
      P. amarjolense
  - Stomata not arranged in bands
    P. nipanica
    - Subsidiary cells papillate
      - i. Leaves broad (2-3·5 cm wide)
        ii. Hair-bases present over vein bands
        P. jabalpurense
      - i. Leaves narrow (0·4-0·9 cm wide in middle)
        ii. Hair-bases not present over vein bands
        P. indicum
    - Subsidiary cells non-papillate
      P. gladiatum

TABLE 2 — CLASSIFICATION OF *PTILOPHYLLUM* SPECIES FROM OTHER COUNTRIES



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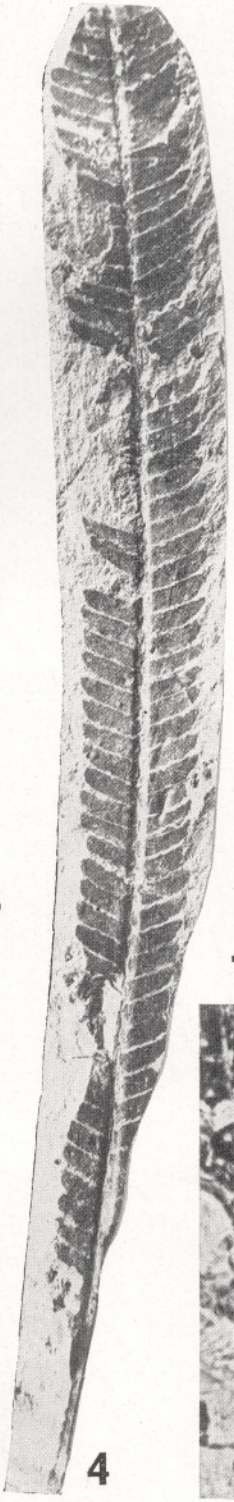

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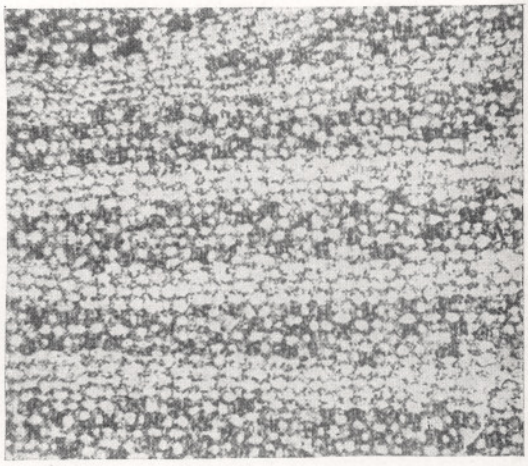

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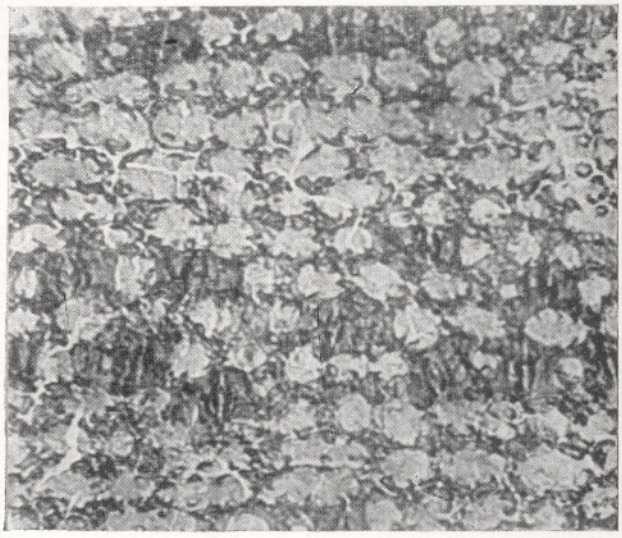

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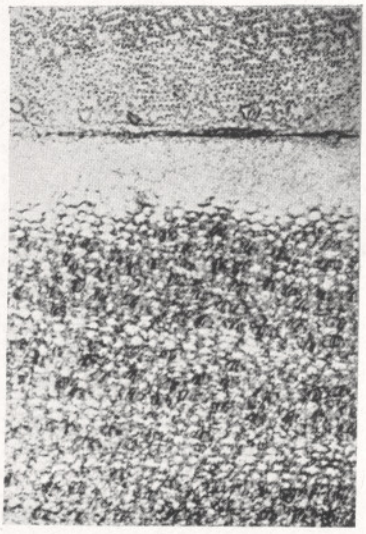
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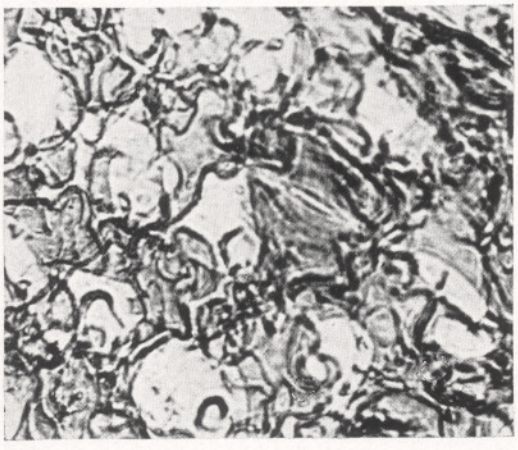
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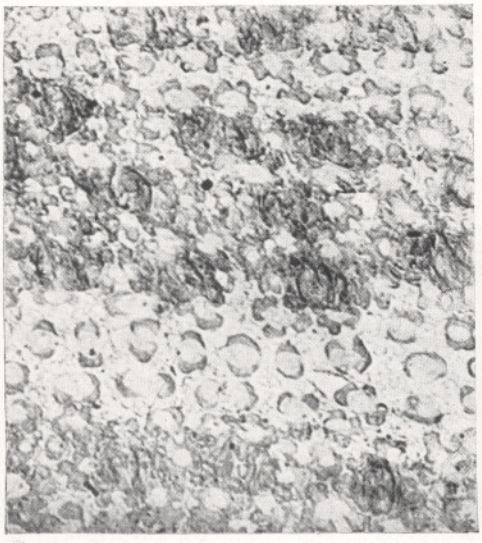
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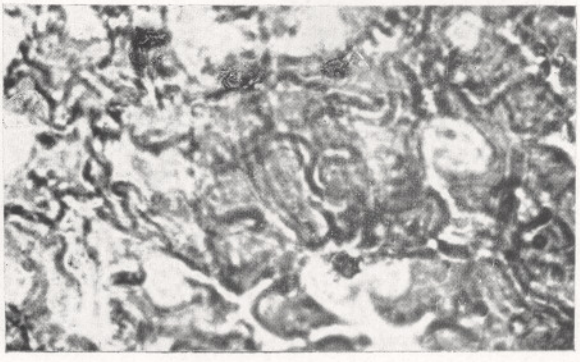
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cuticle. But the stomatal bands in *Ptilophyllum* sp. are generally 2-5 stomata wide, whereas in the Georgian species these are generally 2-3 stomata wide. Both the species further differ in the form of the bases of pinnae.

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EXPLANATION OF PLATES

Plate 1

1. *Ptilophyllum rewaensis* n. sp., holotype, specimen no. 19/469. × 1.

2(-3). *Ptilophyllum* sp., specimen no. 30326. × 1.

3. Specimen no. 30325, counter part of fig. 2. × 1.

4(-7). *Ptilophyllum* sp. cf. *P. horridum* Roy, specimen no. 63/470. × 1.

5. Lower cuticle showing stomatal and non-stomatal vein bands, slide no. 63/470-1. × 40.

6. Lower cuticle, slide no. 63/470-2. × 150.

7. Lower cuticle showing stomata and papillae, slide no. 63/470-3. × 500.

Plate 2

8(-10). *Ptilophyllum* sp. showing upper cuticle (marked U) and lower cuticle (marked L) differentiated into stomatal and non-stomatal vein bands, slide no. 30326-1. × 40.

9. Lower cuticle, slide no. 30326-1. × 150.

10. Lower cuticle showing stomata and papillae, slide no. 30326-1. × 500.

11(-13). *Ptilophyllum rewaensis* n. sp., lower cuticle showing stomatal and non-stomatal vein bands, slide no. 19/469-1. × 40.

12. Lower cuticle, slide no. 19/469-1. × 150.

13. Lower cuticle showing stoma and papillae, slide no. 19/469-1. × 500.