

THE GENUS *Dictyozamites* OLDHAM FROM INDIA

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ABSTRACT

All the existing species of *Dictyozamites* Oldham from India have been reinvestigated. Five distinct species (*D. falcatus* (Morris) Medlicott & Blanford, *D. indicus* Feistmantel, *D. hallei* Sahni & Rao, *D. sahnii* Gupta & Sharma, and *D. feistmantelii* n. sp.) have been recognized and two fragmentary specimens have been described as *Dictyozamites* sp. The new species, viz., *D. feistmantelii* is based on some of the earlier described specimens of *D. falcatus* from Vemavaram and other East Coast localities. Pinnae of *D. feistmantelii* are stalked and they have distinct auriculate bases. *D. bagjoriensis* Jacob has now been found to be the same as *D. hallei*.

INTRODUCTION

THE genus *Dictyozamites* was instituted by Oldham (in Oldham & Morris, 1863, p. 40) on two specimens described in the same paper by Morris (in Oldham & Morris, 1863, p. 38, pl. 24, figs. 1-2) as *Dictyopteris falcata* and *D. falcata* var. *obtusifolia*. Oldham's diagnosis of *Dictyozamites* was as follows:

"*Pinnis multinervis: basi subauriculatis; nervis dichotomis reticulatis*"

The above diagnosis was emended by Harris (1969). We have here accepted the diagnosis as suggested by Harris (1969) but to his original diagnosis, here a paragraph dealing with the anatomy of the rachis has been added.

DESCRIPTION

Genus — *Dictyozamites* Oldham (in Oldham & Morris, 1863)

Emended Diagnosis (partly from Harris)— "Leaf simply pinnate, pinnae attached near upper margin of rachis, base of pinna contracted and usually asymmetric. Veins diverging from point of attachment, forking and anastomosing frequently. Cuticle developed, lamina normally hypostomatic, cell walls normally sinuous; stomata syndetocheilic with a subsidiary cell opposite each guard cell".

Rachis, in transverse section, showing an outer layer of epidermis followed by 6-7 cells wide hypodermis. Within ground tissue about 25-30 vascular bundles arranged in double series in the form of 'U'. Vascular bundles collateral; xylem pointing inwards;

radial walls of tracheids showing scalariform thickening.

Type Species — *Dictyopteris falcata* Morris (in Oldham & Morris, p. 38).

Dictyozamites falcatus (Morris) Medlicott & Blanford.

Pl. 1, figs. 1-7; Pl. 2, figs. 9-14; Pl. 3, figs. 15-19; Text-fig. 1 A-F.

1863 *Dictyopteris falcata* Morris: In Oldham & Morris, p. 38, pl. 24, figs. 1, la.

1863 *Dictyopteris falcata* var. *obtusifolia* Morris: In Oldham & Morris, p. 38, pl. 24, figs. 2, 2a.

1877c *Dictyozamites indicus* Feistmantel, p. 18 (*partim*), pl. 5, figs. 1-2a.

1879 *Dictyozamites falcatus* (Morris) Medlicott & Blanford, p. 142, pl. 8, fig. 6.

1903 *Dictyozamites falcatus* (Morris): Seward, p. 222 (*partim*), pl. 15, figs. 5, 8.

1913 *Dictyozamites falcatus* (Morris): Bancroft, p. 74, pl. 8, figs. 6-8.

1917 *Dictyozamites falcatus* (Morris): Seward, p. 546 (*partim*).

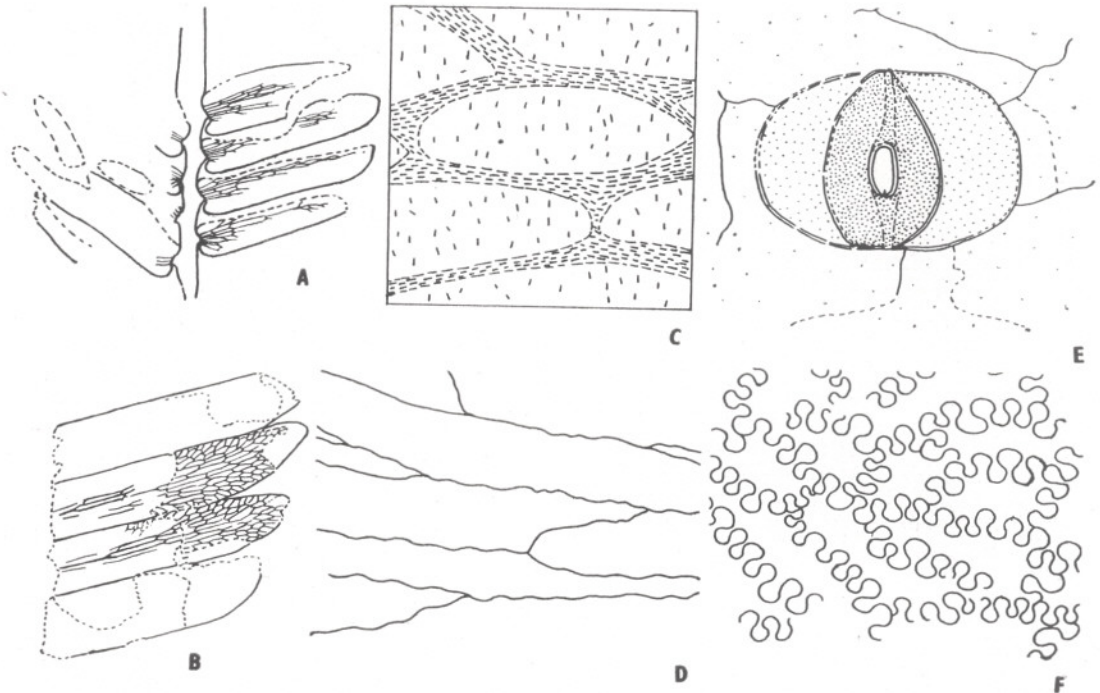
1951 *Dictyozamites falcatus* (Morris): Jacob, p. 8 (*partim*).

1959 *Dictyozamites falcatus* (Morris): Pascoe, p. 980, fig. 8.

1968 *Dictyozamites falcatus* Oldham: Gupta & Sharma, p. 25 (*partim*).

1968 *Dictyozamites indicus* Feistmantel: Gupta & Sharma, pl. 1, figs. 6, 7.

1972 *Dictyozamites* sp.: Bose & Kasat, p. 284, pl. 1, figs. 1-6; pl. 2, figs. 7-12; text-figs. 1-2.



TEXT-FIG. 1—*Dictyozamites falcatus* (Morris) Medlicott & Blandford—**A**, B.S.I.P. no. 33806 \times 1. **B**, B.S.I.P. no. 4452 \times 1.5. **C**, Lower surface showing distribution of stomata; B.S.I.P. slide no. 33806-4 \times 40. **D**, Lower surface showing cells along veins; B.S.I.P. slide no. 33806-7 \times 250. **E**, A stoma; B.S.I.P. slide no. 33806-7. **F**, Upper surface showing sinuous walled cells; B.S.I.P. slide no. 33806-3 \times 250. (Text-figs. **A**, **C**-**F** from Bose & Kasat, 1972).

1974 *Dictyozamites falcatus* (Morris) Medlicott & Blandford: Bose, p. 192.

1976 *Dictyozamites falcatus* (Morris): Kimura & Sekido, text-figs. 23-24.

Emended Diagnosis—Leaf pinnate, exceeding 15 cm in length and 4-5 cm wide. Rachis mostly concealed on upper side by pinnae bases, 3-5 mm wide. Pinnae alternate, arising at an angle of 60° - 70° , closely set, rarely overlapping, about 2-2.5 cm long and 0.5 cm broad at base, linear—lanceolate, sometimes falcate, towards middle region almost straight; apex obtuse or bluntly acute. Pinnae attached to rachis by a minute expanded portion of basal middle part of lamina only, basal median sinus situated slightly towards basicopic margin. Acroscopic basal margin slightly expanded, rarely weakly auriculate, basicopic margin extending beyond point of emergence of pinnae, forming asymmetrical bases, sometimes weakly auriculate. Margin entire. Venation reticulate, 2-3 prominent longitudinal veins arising from point of attachment and running almost upto apex, remaining veins radiating from base and curving towards margin; all veins

anastomosing. Meshes of middle region of pinnae elongated, rectangular, almost parallel, 2-4 mm long, towards margin and pinna base meshes smaller in size, oval or polygonal and less than 1 mm in length, 10-12 (rarely 14) areoles present across middle region of each pinna.

Upper surface showing irregularly arranged polygonal cells; lateral- and end-walls highly sinuous; loops deep and prominent. Surface wall unspecialized, devoid of papillae and trichomes. On lower surface veins clearly marked, about 4-5 cells wide; cells along veins serially arranged, rectangular, much longer than broad; lateral- and end-walls slightly wavy. Cells inside vein meshes polygonal; lateral- and end-walls wavy or slightly sinuous. Stomata numerous, confined to interveinal regions, crowded, irregularly distributed, transversely orientated, rarely obliquely placed. Subsidiary cells broad, with prominent walls, not sinuous; guard cells thick, crescent shaped. Aperture mostly oval.

Rachis in transverse section, showing an outer layer of rectangular epidermal cells, followed by 6-7 layered thick-walled

hypodermal cells. Ground tissue consisting of thin-walled isodiametric or oval cells, having intercellular spaces in between. Within ground tissue and in between vascular bundles sclereids visible. Vascular bundles about 25-30, collateral, arranged in double series in the form of 'U'; opening of 'U' facing upwards. Xylem pointing inwards; radial walls of tracheids showing scalariform thickening. Phloem cells obscure, polygonal in shape. Vascular bundles surrounded by an incomplete layer of thick-walled mechanical tissue.

Lectotype — G. S. I. no. 4441 (Oldham & Morris, 1863, pl. 24, fig. 1).

Distribution — Chilgojuri, Amarjola and Kasamu, Rajmahal Hills, Bihar.

Age — ?Upper Jurassic

Remarks — *Dictyozamites falcatus* was first described from Chilgojuri, Amrapara by Oldham and Morris (1863). Their both the figured specimens (Pl. 1, figs. 1, 3) are petrified and are preserved in cherts. Unfortunately, unlike Nipania cherts, the preservation in these cherts is rather unsatisfactory. From the same place a few cherts were studied by Bancroft (1913). Out of these she could describe, to some extent, the anatomy of petiole of *D. falcatus*. Many more specimens of *D. falcatus* were collected by us from the same locality. They, too, did not give much information. However, from a few specimens peel preparations could be made for cuticular study. One of the best preserved petrified specimen of *D. falcatus* was described by Bose and Kasat (1972) from Amarjola, a locality very close to Chilgojuri. This specimen, too, is petrified and extremely well preserved. From this specimen alone details of the rachis and surface features of pinna could be studied. As the specimen is rather fragile so thin sections of the pinna could not be prepared for anatomical details. The surface features of pinna and details of rachis anatomy, mentioned above in the diagnosis of *D. falcatus*, is mainly from the specimen from Amarjola and some of the specimens from Chilgojuri.

Comparison — Outside India, *Dictyozamites falcatus* has been described from Bahia Tekenika, Tierra del Fuego; Japan, Korea and Southern Primorye, U.S.S.R. Out of these, a detached pinna described and figured by Halle (1913, pl. 5, fig. 31 as *Dictyozamites* cf. *falcatus* (Morris) Oldham

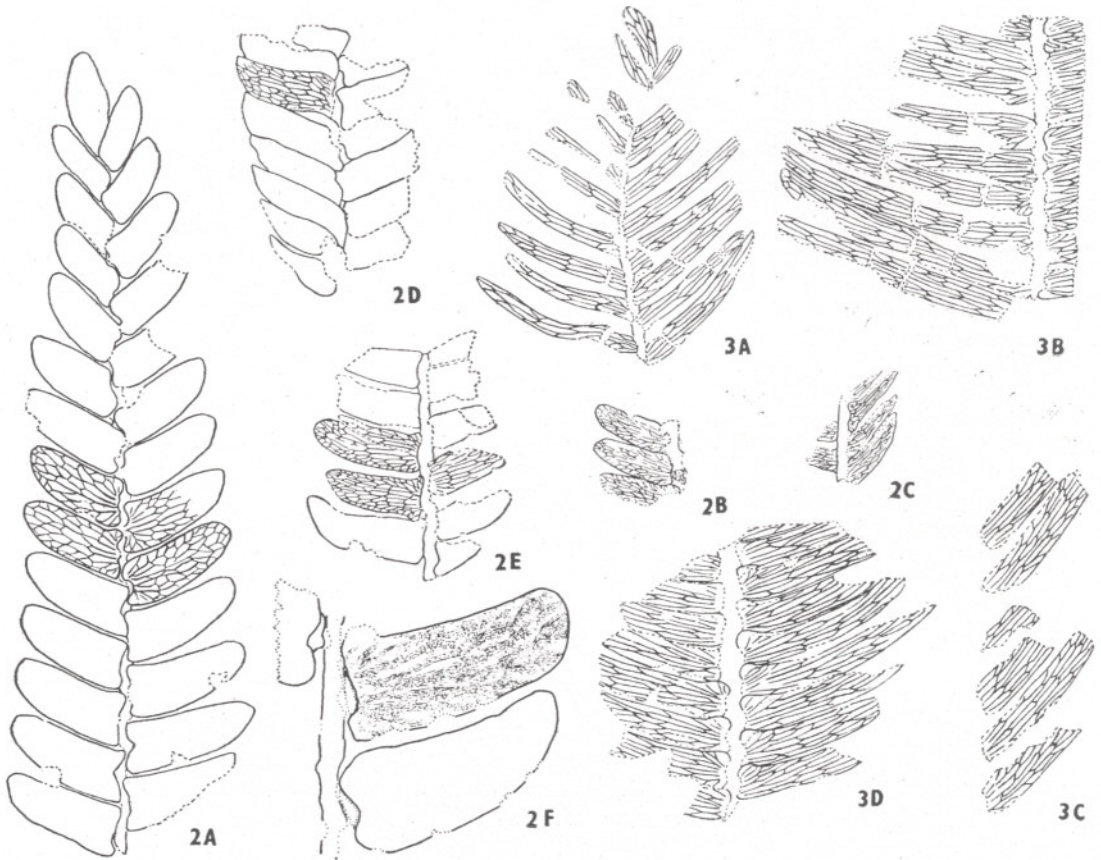
from Bahia Tekenika resembles most in overall shape and venation pattern of some of the pinnae of *D. falcatus* described from India. Halle's specimen, too, shows near middle three prominent veins running almost parallel from base to apex. The pinna from Bahia Tekenika is only slightly longer and broader than the pinnae of the Indian specimens. Halle's (1913, pl. 5, fig. 29) other specimen is almost double the size of the largest pinna of Indian specimens. His third figured specimen is incomplete, here only the pinnae bases are visible. All these specimens have already been transferred to *D. cazaubonii* Archangelsky & Baldoni by Kimura and Sekido (1976). The Japanese specimens of *D. falcatus* figured by Yabe (1905) have much larger pinnae (except near apex) also their venation pattern is different. None of the pinnae show prominent veins running along middle region as is seen in the Indian specimens. It is quite likely that the Japanese specimens, which have been assigned to *D. falcatus*, belong to a different species. Krasilov (1967, pl. 42, figs. 2-5) described a few detached pinnae of *D. falcatus* from the Southern Primorye of U.S.S.R. All the pinnae figured by him differ in overall shape and size. The pinnae are larger and their venation pattern is different.

D. falcatus differs from *D. hawelli* Seward, described by Harris (1969), in having smaller pinnae. The pinnae bases are also different. In *D. hawelli* pinnae bases are non-auriculate. Moreover, in the Yorkshire species the subsidiary cells are papillate.

Dictyozamites indicus Feistmantel, 1876

Pl. 1, fig. 8; Pl. 4, figs. 20-30; Text-fig. 2A-F

- 1876 *Dictyozamites indicus* Feistmantel, p. 37 (*partim*, specimens from Murrero).
 1877a *Dictyozamites indicus* Feistmantel, p. 70 (*partim*, p. 46, figs. 7-8).
 1877c *Dictyozamites indicus* Feistmantel, p. 18 (*partim*), pl. 6, figs. 4-5.
 1879 *Dictyozamites indicus* Feistmantel, p. 24 (*partim*), pl. 3, figs. 3-4.
 1903 *Dictyozamites falcatus* (Morris): Seward, p. 222 (*partim*), pl. 15, figs. 6-7.
 1933 *Dictyozamites indica* (Feistmantel) Sahni & Rao, p. 195, pls. 13-14, figs. 19-20.



TEXT-FIGS. 2-3 — 2, *Dictyozamites indicus* Feistmantel — A, G.S.I. no. 4621 from Vamavaram $\times 2$. B, B.S.I.P. no. 4481 from Maharajpur $\times 1.5$. C, B.S.I.P. no. 4472 from Maharajpur $\times 1.5$. D, Lectotype (G.S.I.) no. 4544 from Murrero $\times 2$. E, B.S.I.P. no. 23634 from Onthea $\times 2$. F, B.S.I.P. no. 4427 from Chilgojuri $\times 4$. 3, *Dictyozamites hallei* Sahni & Rao — A, B.S.I.P. no. 125/1268 from Basgo Bedo $\times 2$. B, B.S.I.P. no. 105/1268 from Basgo Bedo $\times 2$. C, A fragment in the same block from where lectotype has been figured; Botany Department, University of Lucknow no. F 15 from Onthea $\times 2$. D, Botany Department, University of Lucknow no. E 15, from near ruins at Sakrighat $\times 2$.

1963 *Dictyozamites indicus*: Sitholey, pl. 5, fig. 32.

1968 *Dictyozamites indicus* Feistmantel: Gupta & Sharma, p. 27.

1974 *Dictyozamites indicus* Feistmantel: Bose, p. 192.

1976 *Dictyozamites indicus* Feistmantel: Kimura & Sekido, text-fig. 10.

Emended Diagnosis — Leaf imparipinnate, linear-lanceolate, approximately 8.0-12.5 cm in length and 1-2 cm in width, uniformly broad along most of the length, tapering towards base and apex. Rachis 2-3 mm wide, partially or completely covered by pinnae bases, mostly concealed. Pinnae

closely set, either touching adjacent pinnae or slightly overlapping, rarely distant, attached slightly below middle or basal margin at an angle of about 60° - 80° , mostly at 70° . Pinnae typically 0.8-1.0 \times 0.25-0.4 cm in size, straight or slightly curved, bases asymmetrical, acroscopic and basiscopic margins auriculate; basiscopic margin sometimes slightly rounded, often basiscopic margin partially covered by acroscopic margin of pinna below. Margin entire; apex obtuse, rarely sub-acute. Veins diverging from base, forking and forming meshes, except near basiscopic margins and along margin meshes almost of equal

size, sometimes near middle meshes slightly larger; areoles 6-9 in crossing over middle region of pinna.

Lectotype — G.S.I. no. 4544 (Feistmantel, 1877a, p. 70, pl. 46, fig. 7).

Distribution — Murrero, Bindaban, Basgo Bedo, Maharajpur, Onthea, Kasamau and Chilgojuri in the Rajmahal Hills, Bihar; near Parsapani, district Hoshangabad, Madhya Pradesh and Vemavaram, district Guntur, Andhra Pradesh.

Age — ? Upper Jurassic.

Remarks — *Dictyozamites indicus* was founded on two fragmentary specimens (Feistmantel, 1877a, pl. 46, figs. 7, 8) collected from Murrero, Rajmahal Hills. While describing these specimens, Feistmantel (1876, 1877a) also included the previously described specimens of *D. falcatus* under his new species. The specimens from Murrero differ from the type species, *D. falcatus* in being smaller in size and in having different venation pattern. The pinnae bases in *D. indicus* are also markedly auriculate.

In most of the localities *D. indicus* is preserved in the form of impression. It is fairly common at Basgo Bedo, Maharajpur and Onthea. The specimens at Chilgojuri are present in cherts. From one specimen (Pl. 4, figs. 22, 30) it has been possible to study the surface features and anatomy of rachis to some extent. The preservation is not so good and because of lack of details their description has not been included in the diagnosis. The available data concerning the surface features and rachis anatomy are as follows:

Cells on both surfaces badly preserved; stomata confined to lower surface, irregularly distributed inside interveinal regions. Vein region 3-4 cell broad.

Rachis in transverse section almost spherical in shape, showing slight depression on upper side. Outer epidermal layer consisting of more or less squarish cells. Hypodermal cells not discernable. Cells of ground tissue oval or spherical, thin-walled, isodiametric, having intercellular spaces in between. Vascular bundle arranged in double row in the form of 'U' opening of 'U' facing upwards. Details of vascular bundle not visible.

Comparison — As mentioned earlier fronds of *Dictyozamites indicus* are much narrower than *D. falcatus*. In the latter species

the pinnae bases are either rounded or weakly auriculate. In *D. falcatus* near middle region, there are 2-3 prominent veins running parallel to each other from base to apex. No such veins are present in *D. indicus*. Also in *D. indicus* vein meshes are almost of equal sizes over the major part of the lamina. Amongst the foreign species, *D. indicus* resembles most *D. minusculus* Menendez (1966) in over all shape and size of pinnae. But the latter species has conspicuous parallel veins in middle region. Also in middle region the vein meshes are much larger than the rest. In the size of pinnae *D. indicus* may be compared with *D. yamazakii*. In the latter species the areoles are fewer in number and also bigger in size. Although, *D. krusinensis* Kon'no (1972) has smaller pinnae like *D. indicus*, the former species has pinnae with finer reticulation.

Dictyozamites hallei Sahni & Rao

Pl. 5, figs. 31-38; Pl. 6, figs. 42, 43; Text-fig. 3A-D

1933 *Dictyozamites hallei* Sahni & Rao, p. 196, pl. 14, figs. 23-25.

1946 *Dictyozamites hallei* Sahni & Rao: Ganju, p. 68, pl. 4, figs. 24, 25.

1951 *Dictyozamites hallei* Sahni & Rao: Jacob, p. 8, pl. 3, figs. 1, 2.

1951 *Dictyozamites bagjoriensis* Jacob, p. 7, pl. 3, figs. 3-5.

1963 *Dictyozamites bagjoriensis* Jacob: Sitholey, p. 68, pl. 6, fig. 42.

1968 *Dictyozamites hallei* Sahni & Rao: Gupta & Sharma, p. 25.

1974 *Dictyozamites hallei* Sahni & Rao: Bose, p. 192.

1976 *Dictyozamites hallei* Sahni & Rao: Kimura & Sekido, text-fig. 21.

1976 *Dictyozamites bagjoriensis* Jacob: Kimura & Sekido, text-fig. 22.

Description — Fronds imparipinnate available size 13.2 × 4.0 cm, lanceolate, gradually tapering towards apex and base. Rachis slender, flexuous, partly or completely concealed by pinnae bases. Pinnae alternate or sub-opposite, closely set in middle region, slightly distant towards apical region; majority arising at 75°-85°, angle of attachment becoming 55°-60° towards apical region. Pinnae narrow, elongated, falcate, gradually narrowing into bluntly pointed apex, largest pinna measuring 2.6 × 0.25 cm; margin

entire. Pinnae attached to rachis by a small portion of lamina slightly below middle of base; bases asymmetrical, acroscopic margin weakly auriculate or rounded, basiscopic margin extending toward the point of emergence. Veins coarse, 4-6 radiating from basal median sinus, in some middle veins parallel, forking and forming interconnections, areoles few, majority similar in size and shape, narrow and elongated, 1-3 mm or more in length, veins near base 4-8 (apical pinnae mostly 4), 4-8 veins met within crossing middle part of pinna (pinna near middle mostly with 6-8 areoles and near apex 4-5).

Lectotype — Botany Department, University of Lucknow no. F. 15 (Sahni & Rao, 1933, pl. 14, fig. 23).

Locality — Basgo Bedo, Onthea, ruins at Sakrigalighat and Bagjori in the Rajmahal Hills, Bihar.

Age — ?Upper Jurassic.

Remarks — *Dictyozamites hallei* was instituted by Sahni and Rao (1933) on some specimens from Onthea and ruins at Sakrigalighat. Out of the two specimens figured by them (Sahni & Rao, 1933, pl. 14, figs. 23, 24), the specimen no. F 143 (Sahni & Rao, 1933, pl. 14, fig. 24) is now misplaced. The other specimen, viz., no. F 15 (Sahni & Rao, 1933, pl. 14, fig. 23) is a small block and has impressions of a few fragmentary fronds. Since the specimen was first figured by Sahni and Rao (1933), at places a portion of the figured specimen is missing. We have here figured (Pl. 5, fig. 37) the best available specimen in the same block.

Jacob (1951) described a new species, *Dictyozamites bagjoriensis* from Bagjori, about 11.2 km south of Mirzachowki, Rajmahal Hills. According to Jacob (1951, pp. 7, 8) *D. bagjoriensis* differed from *D. hallei* in the following points:

"1. The frond is more slender with the pinnae generally shorter, and broader at the base.

2. The veins distinctly radiate from the base (cf. the parallel course of the middle veins in *D. hallei*).

3. Not more than five, or occasionally six veins are present at the base of the pinnae (cf. 8 or 9 in *D. hallei*).

4. Only 4 to 5 veins are present in the middle of each pinna (cf. 7 or 8 in *D. hallei*).

5. The number of veins reaching the lower margin of the pinnae is usually 6 (cf. about 18 or more in *D. hallei*)."

A re-examination of all the available specimens of *D. hallei* from Sahni and Rao's collection showed that some of the fronds had pinnae with venation pattern similar to those of *D. bagjoriensis*. They, too, have shorter pinnae, which are broader at the base (Pl. 5, fig. 35). Some of these have very few veins which are radiating from the base (Text-fig. 3C, D). Our observation was further confirmed by the specimens collected from Basgo Bedo, Rajmahal Hills. In one of the specimens (Pl. 5, figs. 31-33; Text-fig. 3A) pinnae along the major part, especially near middle have 6-8 (rarely 9) veins near base but pinnae (Pl. 6, fig. 43; Text-fig. 3A) near apex have 3-4 veins near base. Similarly number of veins vary in the middle of each pinna. In this particular specimen and in the other specimens from Basgo Bedo emergence of veins in different pinnae also vary, but the majority seem to radiate from the base. After having examined all the specimens of *D. hallei* from Sahni and Rao's (1933) collection and the specimens from Basgo Bedo we are convinced that *D. hallei* and *D. bagjoriensis* belong to the same species and as such we have merged the latter species with *D. hallei*.

Comparison — *Dictyozamites hallei* differs from *D. indicus* Feistmantel in having longer and narrower pinnae with acute or sub-acute apex. In the latter species the pinnae are shorter and broader and they have mostly obtuse apex. The vein meshes in *D. hallei* are narrower and larger than *D. indicus*. From the remaining species of *Dictyozamites*, *D. hallei* can readily be distinguished by their much narrower pinnae.

Dictyozamites sahnii Gupta & Sharma

Pl. 6, figs. 39-41; Pl. 7, fig. 49; Text-fig. 4A,B

1968 *Dictyozamites sahnii* Gupta & Sharma,
p. 21, pl. 1, figs. 1-4; text-figs. 2A-B,
3A-C,

1974 *Dictyozamites sahnii* Gupta & Sharma:
Bose, p. 192.

Emended Diagnosis — Frond imparipinnate, largest available specimen measuring 13.5 × 8.6 cm, gradually narrowing towards apex. Rachis almost completely

covered by pinnae bases; pinnae arising at an angle of 50°-70°, attached by a portion of lamina slightly below middle of base. Pinnae alternate, contiguous, much longer than broad, 4.0-5.0 cm long and 0.8-1 cm broad, apical and basal pinnae shorter, falcate, gradually narrowing towards apical region; apex acute; margin entire. Pinnae bases touching each other, sometimes interlocking, asymmetrical, both acroscopic and basiscopic margins auriculate, sometimes basiscopic margin rounded and extending beyond point of emergence. Veins anastomosing, radiating from base, along middle of lamina 3-5 veins running almost parallel upto 2/3 the length, then only 1 or 2 reaching upto apex, remaining veins diverging towards margin; vein meshes about 5-8 mm long, towards base and margin meshes smaller (1-2 mm long); number of veins running across broadest region of pinnae 14-16.

Holotype — K27/Raj.0., Dr K. M. Gupta's Collection, University of Jodhpur. (Gupta & Sharma, 1968, pl. 1, fig. 1).

Distribution — Onthea and Sakrighat in the Rajmahal Hills, Bihar.

Age — ? Upper Jurassic.

Comparison — *Dictyozamites sahnii* looks very much like *D. asseretoi* Barnard (1965). However, in the latter species acroscopic margin of pinnae is much expanded and auriculate. The acroscopic margin is also overlapping the rachis and adjacent pinna. The pinnae of *D. auriculatus* Kimura & Sekido (1976) are larger in size and they have markedly auriculate acroscopic basal angle.

Dictyozamites feistmantelii n. sp.

Pl. 7, figs. 44-48; Pl. 8, figs. 50-53; Text-figs. 5A-C, 6A,B,E,F

1877b *Dictyozamites indicus* Feistmantel: Feistmantel, p. 18 (*partim*), pl. 2, figs. 5, 6.

1877c *Dictyozamites indicus* Feistmantel: Feistmantel, p. 17 (*partim*), pl. 4, figs. 7, 7a; pl. 5, figs. 3-4a.

1879 *Dictyozamites indicus* Feistmantel: Feistmantel, p. 24 (*partim*), pl. 3, figs. 1-2, 5-6a; pl. 4, figs. 1-8; pl. 5, figs. 1-12.

1963 *Dictyozamites falcatus* Feistmantel: Sitholey, pl. 5, fig. 31.

1963 *Dictyozamites falcatus* (Morris) Medlicott & Blanford: Bakshi, p. 208, pl. 1, fig. 6a-b

Diagnosis — Leaves imparipinnate, shape as a whole lanceolate, estimated length 25-30 cm (maximum available length 17.8 cm), width in middle region 6-8 cm. Rachis exposed, from extreme base to about 3 cm rachis devoid of pinnae, 2-4 mm wide, gradually narrowing towards apex, longitudinally striated. Pinnae alternate, closely set or slightly sparse, never overlapping, 2-6 cm long (near middle mostly 4-6), 0.3-1.0 cm broad, apical pinnae falcate, upper margin of basal pinnae more or less straight; apex obtuse. Both acroscopic and basiscopic margins auriculate, near middle base constricted and forming a small stalk; about 1-1.5 mm long; stalk attached closer to lateral margins of rachis at an angle of 60°-80°.

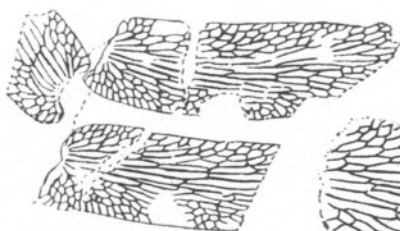
Pinnae veins numerous, radiating from base, forking and anastomosing, 4-6 veins along middle region forming longer (0.5-0.8 cm long) meshes from base to apex, remaining meshes (forming the bulk) smaller in size, near base and along margins meshes smallest in size. About 18-24 veins met within crossing middle part of pinnae.

Holotype — G.S.I. no 4620 (Feistmantel, 1879, pl. 3, fig. 2).

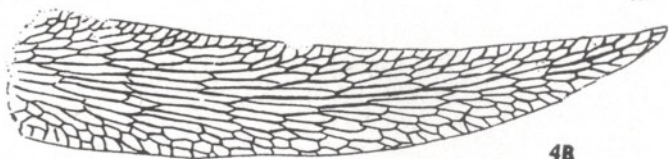
Distribution — Gollapalle, Raghavapuram, Vemavaram and Sriperumbudur, in the East Coast Gondwana and Parsapani and Jatamao in Hoshangabad District, Madhya Pradesh.

Age — ? Upper Jurassic-Lower Cretaceous

Remarks — *Dictyozamites feistmantelii* is abundant at Vemavaram. From the East Coast Gondwana its occurrence is also known from Gollapalle, Raghavapuram (north valley of Bara Konda) and Sriperumbudur. Some of the specimens (Pl. 7, fig. 44; Pl. 8, fig. 51) from Vemavaram clearly show the pinnae stalks and in other the stalks are compressed beneath the pinnae bases. Out of the two specimens figured by Feistmantel (1877b) from Gollapalle, the one figured in Pl. 2, fig. 5 (Feistmantel, 1877b) has rather broad pinnae. Unfortunately, the specimen is poorly preserved and in most of the pinnae the apical part is missing. In this specimen venation, too, is not discernable. The other specimen described by Feistmantel (1877b, pl. 2, fig. 6) has only one



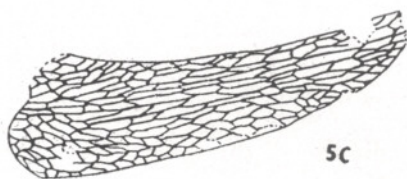
4A



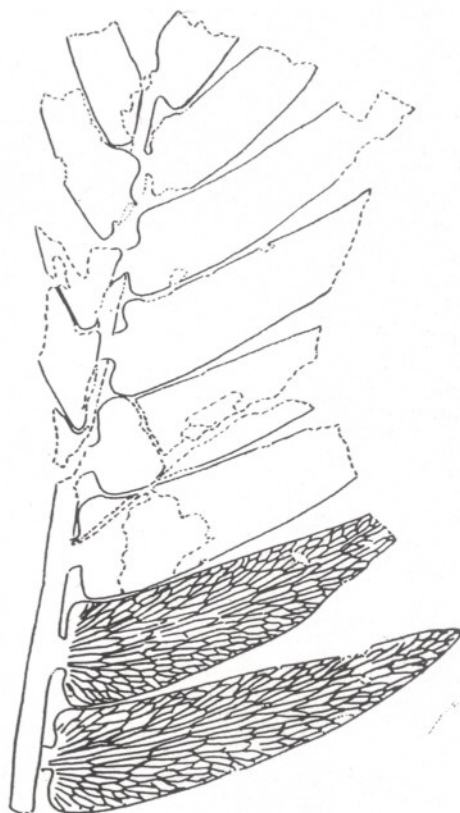
4B



5A



5C



5B

TEXT-FIGS. 4, 5

complete pinna and its rachis is missing. In this specimen the basal margins of pinnae and their venation pattern is similar to the ones described from Vemavaram. The specimens from Raghavapuram described by Baksi (1968, pl. 1, figs. 6a, b) match the specimens from the above locality. One of his specimens (Baksi, 1968, pl. 1, fig. 6b) shows pinnae with minute stalks. The specimens from Sriperumbudur do not show the pinnae stalk, otherwise they match with the other specimens. So far we have only two fragmentary specimens (Pl. 8, fig. 50) in our collection from Parsapani and only one from Jatamao. The specimen figured here from Parsapani closely agrees with the one figured by Feistmantel (1879, pls. 4, 5) from Sriperumbudur.

Comparison — *Dictyozamites feistmantelii* was earlier confused with *D. falcatus*. The former species differs from the latter in many ways. The fronds of *D. feistmantelii* are much larger and broader in size. The pinnae of *D. feistmantelii* have mostly acute apex and they have prominently auriculate basal margins. The vein meshes over the major part of pinna are smaller in size and they are much more in number. Unlike *D. falcatus*, the major part of rachis in *D. feistmantelii* is exposed and in the latter species the pinnae are mostly attached by a minute stalk.

D. sahnii Gupta & Sharma (1968) has longer pinnae and they are sessile. In this species, unlike *D. feistmantelii*, the vein meshes are bigger in size and their number is much less. *D. falcatus* described by Yabe (1905) resembles *D. feistmantelii* in having somewhat similar looking pinnae. The venation pattern (Yabe, 1905, pl. 2, fig. 5) is also more or less similar. The Japanese specimens differ in having sessile pinnae. *D. auriculatus* Kimura & Sekido (1976) has bigger pinnae and has different venation pattern. In having stalked pinnae, *D. feistmantelii* resembles *D. reniformis* Ôishi (1936). The latter species,

however, differs in having longer stalked reniform pinnae.

Dictyozamites sp.

Pl. 8, figs. 54-56; Text-fig. 6C, D

Description — Fragmentary pinnate frond, available size 6.8 × 3.5 cm. Rachis about 5 mm wide, stout, gradually tapering towards apex, partly covered by pinnae bases. Pinnae alternate, attached to upper surface of rachis at an angle of 60°-70° by a small protruding area from middle region of base. Pinnae 1-1.6 cm long and 0.8-1.0 cm broad at base, deltoid; margin entire, slightly thickened; apex obtuse. Both acroscopic and basicopic margins rounded or weakly auriculate, rarely basicopic margin overlapping the acroscopic margin of pinna lying just below. Veins prominent, numerous, radiating from point of attachment, 4-5 veins running almost parallel upto about 2/3 pinnae length, these veins forming longer and elongated meshes, remaining meshes smaller and occupying major pinna area, number of areoles across middle part of pinna 14-20.

Collection — Specimen no. N/7 of Botany Department, Lucknow University and no. 156/1268 of Birbal Sahni Institute of Palaeobotany.

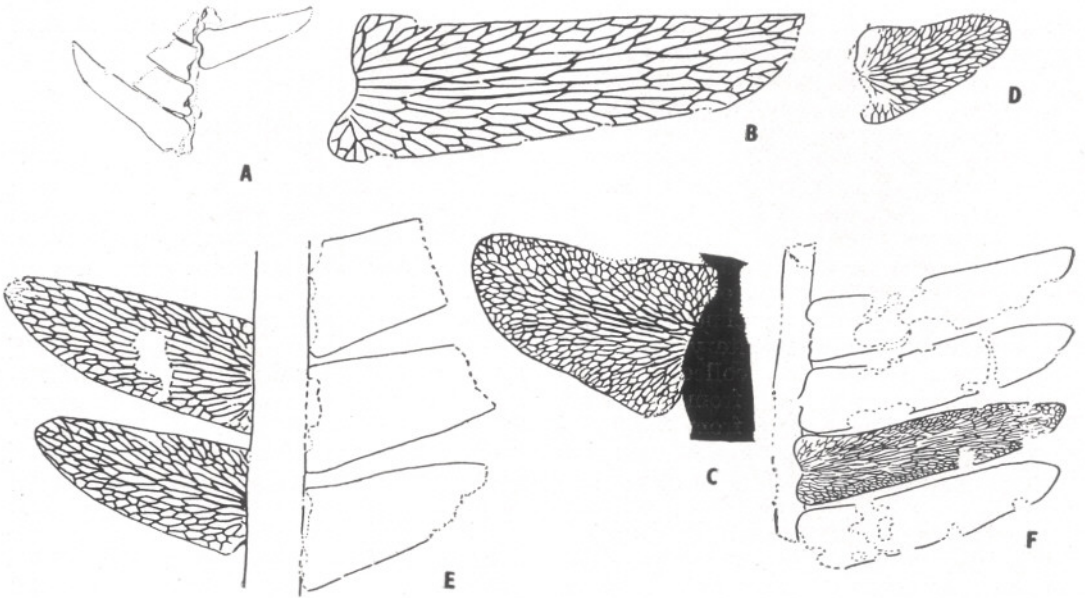
Locality — Basgo Bedo (B.S.I.P. no. 156/1268) and an unknown locality (no. N/7) in the Rajmahal Hills, Bihar.

Age — ? Upper Jurassic.

Remarks — The above description is based on two fragmentary specimens. One of them (Pl. 8, fig. 54), in counterparts, was collected from Basgo Bedo and the other (Pl. 8, fig. 55) belongs to the Botany Department, Lucknow University. The exact locality of the second specimen is not known. The label on the specimen only indicates that it was collected from the Rajmahal Hills, Bihar.

Both the specimens are fragmentary, so they have not been assigned to any of

TEXT-FIGS. 4, 5 — 4, *Dictyozamites sahnii* Gupta & Sharma — A, B.S.I.P. no. 4859 from Sakrigalighat × 2. B, Botany Department, University of Jodhpur no. K 28 RAJ/O from Onthea × 2. 5, *Dictyozamites feistmantelii* n. sp. — A-B, G.S.I. nos. 4619 and 4624 from Vemavaram × 2. C, G.S.I. no. 4565 from Golapili × 2.



TEXT-FIG. 6 — A, *Dictyozamites feistmantelii* n. sp., B.S.I.P. no. 38/1438 from Parsapani $\times 1$. B, A pinna magnified from specimen no. 38/1438 $\times 4$. C, *Dictyozamites* sp., Botany Department, University of Lucknow no. N/7 $\times 2$. D, *Dictyozamites* sp., B.S.I.P. no. 156/1268 from Basgobedo $\times 2$. E, *D. feistmantelii* n. sp., G.S.I. no. 4627 from Vemavaram $\times 2$. F, *D. feistmantelii* n. sp., G.S.I. no. 4620 from Vemavaram $\times 1$.

the existing species of *Dictyozamites*. They seem to be the basal parts of some larger variety of *Dictyozamites*.

Comparison — *Dictyozamites* sp. can be readily distinguished from all the other Indian species of *Dictyozamites* by the deltoid shape of the pinnae alone. However, it shows slight resemblance to some of the fronds belonging to the basal part of *D. feistmantelii* (Pl. 7, fig. 47). *Dictyozamites* sp. differs in having smaller pinnae which are attached to rachis at more oblique angle. In general shape of pinnae *Dictyozamites* sp. may be compared with *D. grossinervis* Yokoyama (1890) described from Shimamura, Japan. The pinnae in the latter species are, however, bigger in size and they have fewer vein meshes which are larger in size.

CONCLUDING REMARKS

The geographical and geological distribution of the genus *Dictyozamites* has been

discussed by Jacob (1951) and Kimura and Sekido (1976). According to Jacob (1951) *Dictyozamites* is a characteristic Middle Jurassic genus. Its occurrence from Liassic to Lower Cretaceous (Neocomian) is also known. It has been described by Barnard (1965) from the Liassic of Iran and a few species have been described from the Lower Cretaceous of U.S.S.R. (*D. cordatus* (Kryshstofovich) Prynada, *D. obliquus* Samylina, *D. grossinervis* Yokoyama, *D. kawasaki* Tateiwa etc.) and Argentina (*D. areolatus* Archangelsky & Baldoni). But the majority of the species have been reported from the Middle-Upper Jurassic.

In India the genus *Dictyozamites* is not so common. It is most common at Vemavaram but the largest number of species are known from the Rajmahal Hills. In the Rajmahal Hills it occurs mostly in the older beds, viz., Onthea, Basgo Bedo and Maharajpur. The genus is fairly common at Chilgojuri too. In the Jabalpur Formation (?) it is rather rare and the best

known specimens are from Parsapani. The genus is so far not known anywhere from Kutch and the undoubted Lower Cretaceous localities such as Bansa, Himmatnagar and Than (Kathiawar). Most of the beds from where Indian species of *Dictyozamites* have been described, are of doubtful age and in our opinion the presence of this genus alone does not help much in fixing the age of the beds from where they have been collected.

ACKNOWLEDGEMENT

We are grateful to Professors S. C. Agarwala and B. S. Trivedi of Botany

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EXPLANATION OF PLATES

PLATE 1

- 1-6. *Dictyozamites falcatus* (Morris) Medlicott & Blanford; 1, (Lectotype—G.S.I. no. 4441); 2, (B.S.I.P. no. 6235); 3, (G.S.I. no. 4442); 4, (B.S.I.P. no. 33806); 5, (B.S.I.P. no. 29772); 6, (B.S.I.P. no. 4432). × 1. (figs. 1-3 & 5-7 from Chilgojuri and fig. 4 from Amarjola earlier figured by Bose & Kasat, 1972).
7. *D. falcatus* Oldham; a portion of fig. 6 magnified showing venation; B.S.I.P. no. 4432. × 3.
8. *Dictyozamites indicus* Feistmantel from Murrero; Lectotype—G.S.I. no. 4544. × 1.

PLATE 2

Dictyozamites falcatus (Morris) Medlicott & Blanford

9. Lower side of a pinna showing distribution of stomata; B.S.I.P. slide no. 33806-4. × 40.
10. A portion from the above magnified. × 150.
11. A stoma; B.S.I.P. slide no. 33806-4. × 500.
12. Upper surface of a pinna showing surface cells; B.S.I.P. slide no. 33806-4. × 500.
13. Radial longitudinal section showing tracheids with scalariform thickening; B.S.I.P. slide no. 33806-2. × 500.
14. Transverse section of rachis showing sclereid(s); B.S.I.P. slide no. 33806-5. × 500.

(All figs. from Bose & Kasat, 1972)

PLATE 3

15. Transverse section of rachis showing the arrangement of vascular bundles; B.S.I.P. slide no. 33806-1. × 30.
16. A portion of rachis in transverse section; B.S.I.P. slide no. 33806-8. × 75.
17. Two vascular bundles of rachis in transverse section; B.S.I.P. slide no. 33806-5. × 150.
18. Transverse section of rachis showing pinna trace bundles; B.S.I.P. slide no. 33806-8. × 75.
19. Transverse section of rachis showing epidermal and hypodermal cells; B.S.I.P. slide no. 33806-1. × 500.

(figs. 15, 17 & 19 from Bose & Kasat, 1972)

PLATE 4

Dictyozamites indicus Feistmantel

- 20-21. From Basgo Bedo; B.S.I.P. nos. 111/1268, 78/1268. × 1.
22. From Chilgojuri; B.S.I.P. no. 4427. × 1.
23. The above magnified. × 3.
24. From Vomavaram; G.S.I. no. 4621. × 1.
25. From Onthea; B.S.I.P. no. 4393. × 1.
26. A portion from the above magnified. × 3.
27. From Onthea; B.S.I.P. no. 23634. × 4.
28. From Parsapani; B.S.I.P. no. 12/1438. × 1.
29. A portion from the above magnified. × 4.
30. Transverse section of rachis of specimen no. 4427 (fig. 22). × 75.

PLATE 5

Dictyozamites hallei Sahni & Rao

- 31-33. From Basgo Bedo; B.S.I.P. nos. 155/1268, 125/1268 and 105/1268 (figs. 32 & 33 are counter parts of fig. 31). × 1.
34. From Basgo Bedo; B.S.I.P. no. 66/1314. × 2.
35. From Onthea; Botany Department, University of Lucknow no. F 15. × 1.
36. From near ruins at Sakrigalighat; Botany Department, University of Lucknow no. E 15. × 1.
37. From Onthea; Botany Department, University of Lucknow no. F 15 (Lectotype). × 1.
38. A portion from the above magnified. × 4.

PLATE 6

39. *Dictyozamites sahnii* Gupta & Sharma; K. M. Gupta coll. no. K 28/Raj. 0 (counter part of specimen no. K 27/Raj. 0) from Onthea. × 1.
40. A pinna magnified from the above. × 2.
41. *D. sahnii* Gupta & Sharma; K. M. Gupta coll., Lectotype no. K 27/Raj. 0. × 1.
42. *Dictyozamites hallei* Sahni & Rao; Botany Department, University of Lucknow no. F 15. × 7. (From Sahni & Rao, 1933).
43. *D. hallei* Sahni & Rao; B.S.I.P. no. 125/1268. × 4.

PLATE 7

44, 46-48. *Dictyozamites feistmantelii* n. sp.; 44, (G.S.I. no. 4624); 46, (B.S.I.P. no. 1/1366); 47-48, (G.S.I. nos. 4627 & 4619) from Vemavaram. Fig. 46. $\times 2$ and rest. $\times 1$.

45. *D. feistmantelii* n. sp.; G.S.I. no. 4565 from Golapili. $\times 1$.

49. *Dictyozamites shanii* Gupta & Sharma; B.S.I.P. no. 4671 from Onthea. $\times 1$.

PLATE 8

50. *Dictyozamites feistmantelii* n. sp.; B.S.I.P. no. 38/1438 from Parsapani. $\times 1$.

51. *D. feistmantelii* n. sp.; Holotype, G.S.I. no. 4620 from Vemavaram. $\times 1$.

52. Two pinnae enlarged from the above. $\times 2$.

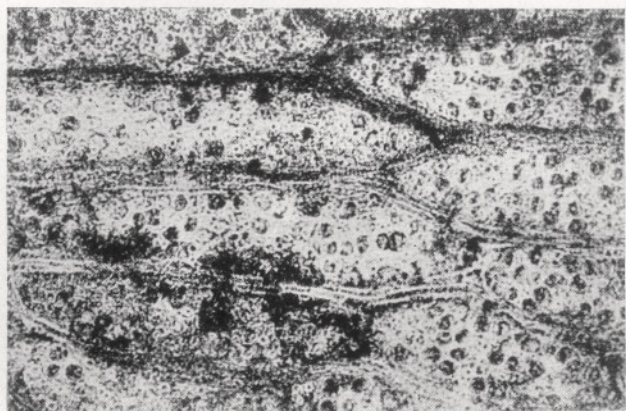
53. A pinna of *D. feistmantelii* n. sp.; B.S.I.P. no. 59/558 from Vemavaram. $\times 2$.

54-55. *Dictyozamites* sp.; 54, (B.S.I.P. no. 156/1268 from Basgo Bedo) and 55, (Botany Department, University of Lucknow no. N/7 from an unknown locality in the Rajmahal Hills). $\times 1$.

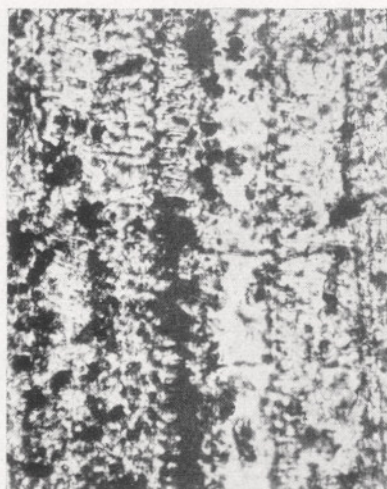
56. A pinna from the above enlarged. $\times 4$.



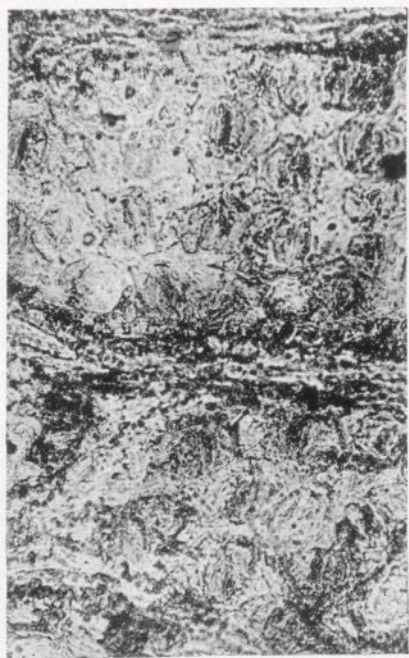
PLATE 1



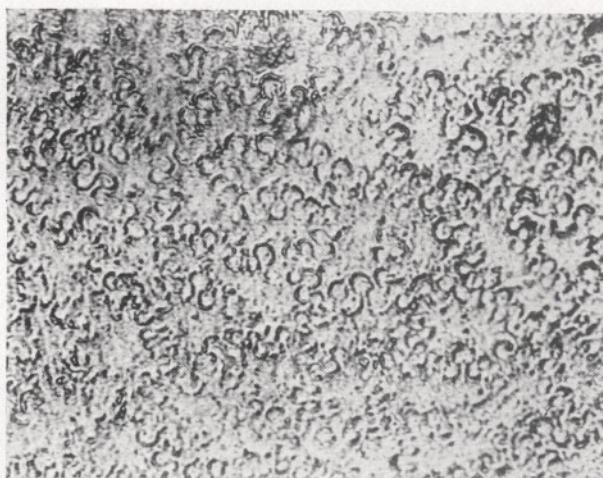
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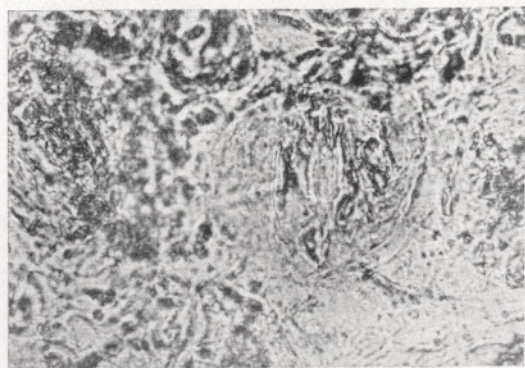
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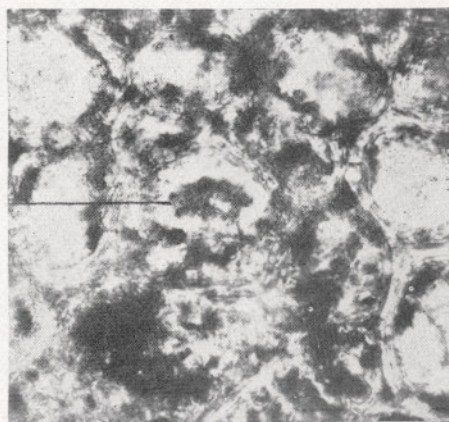
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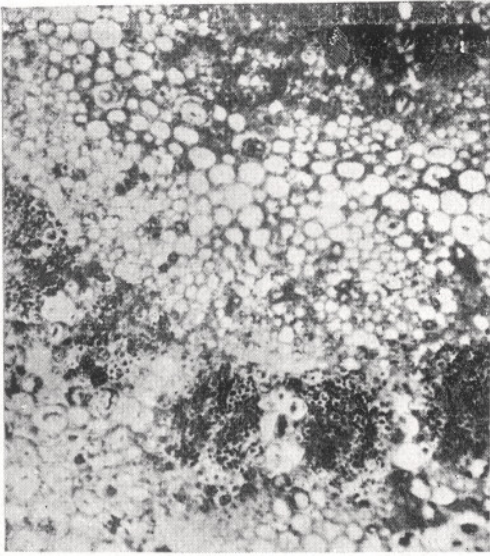


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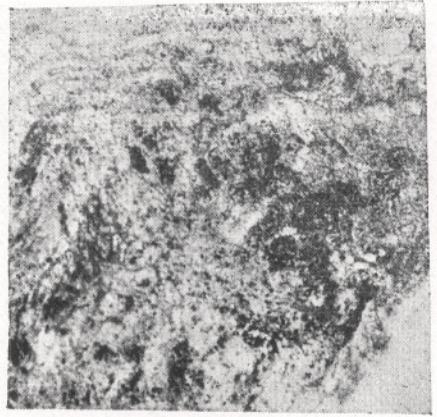


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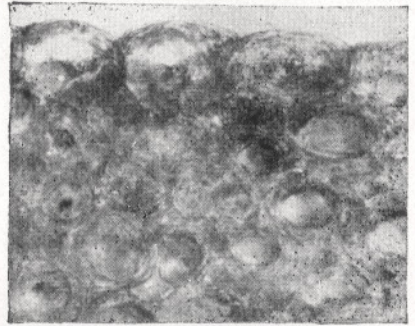




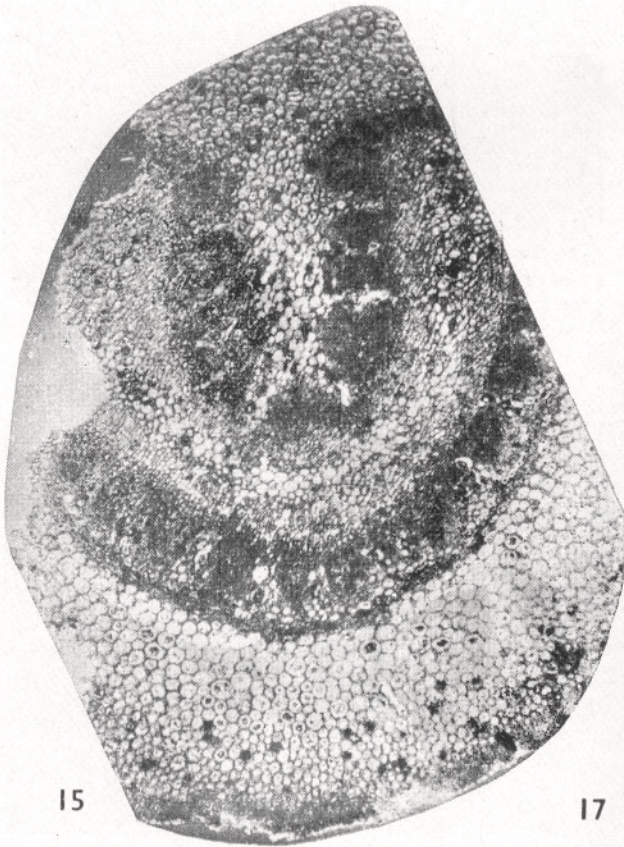
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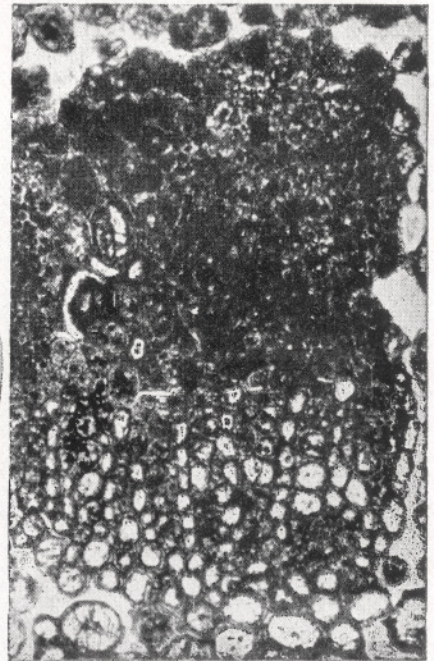
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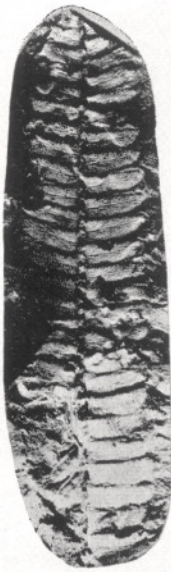
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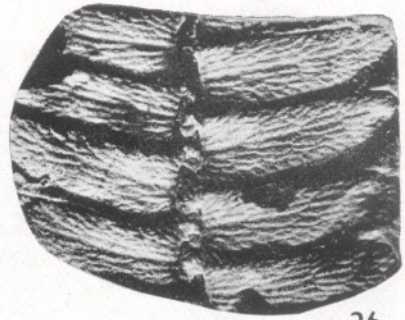
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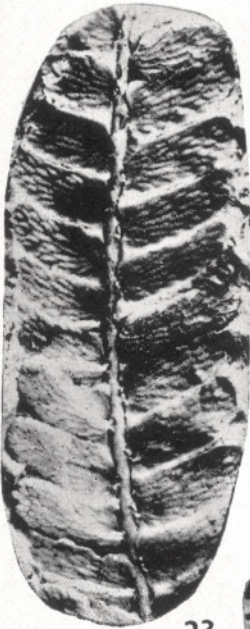
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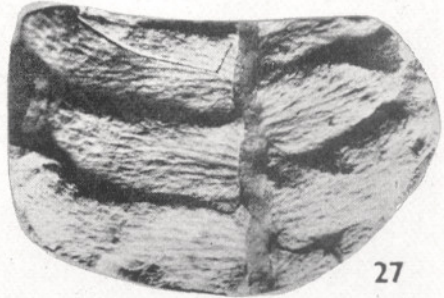
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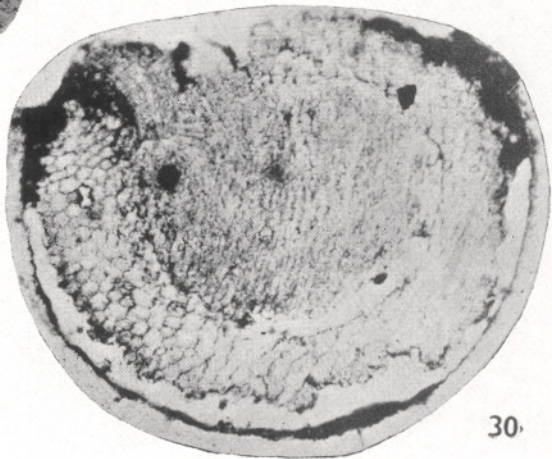
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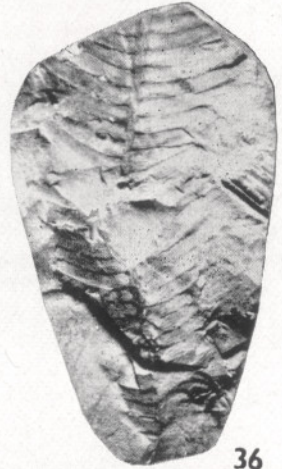
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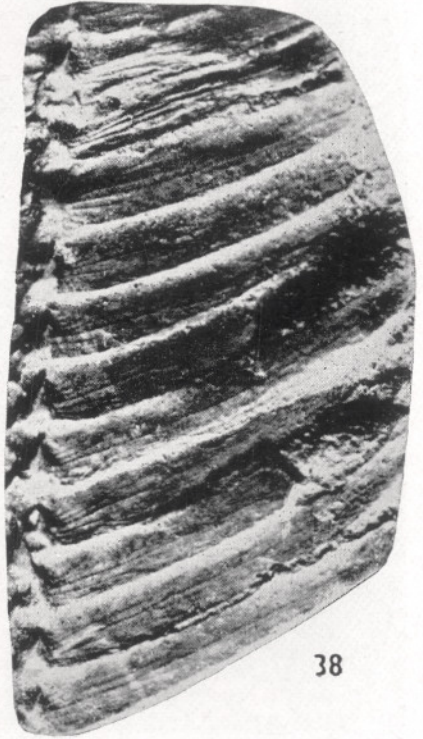
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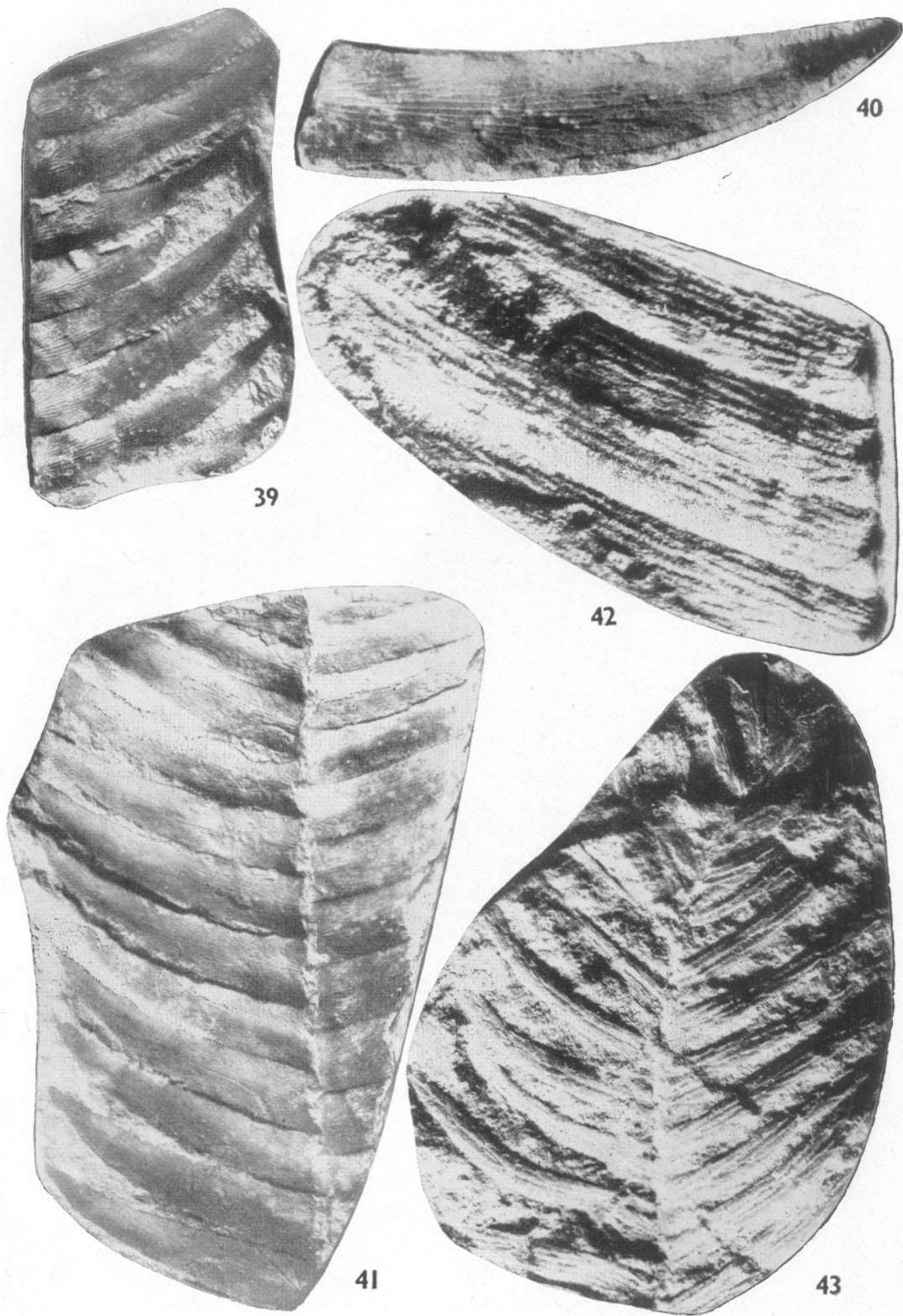


PLATE 6

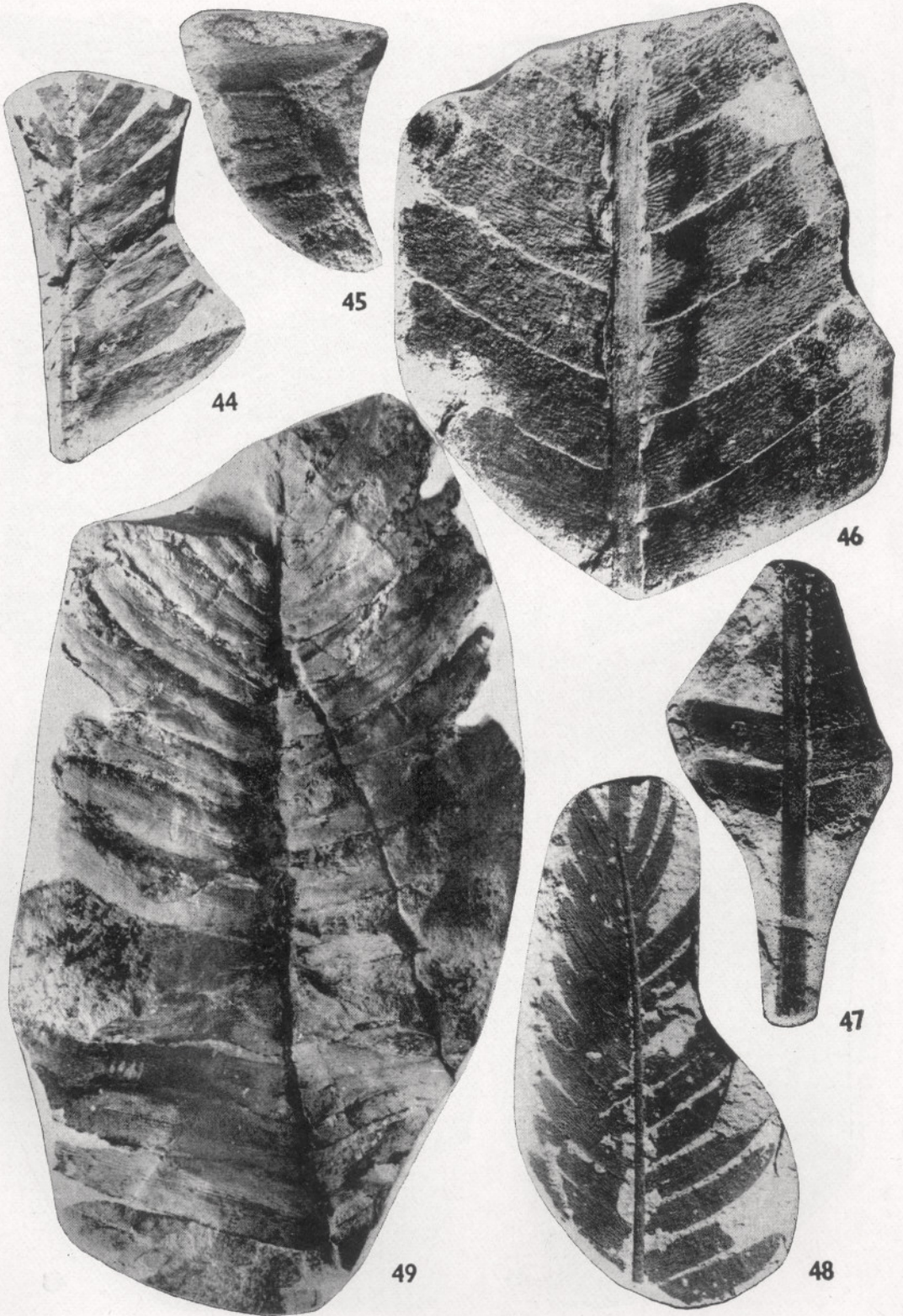


PLATE 7

