

UPPER GONDWANA PLANT FOSSILS FROM EAST GODAVARI DISTRICT IN ANDHRA PRADESH, INDIA*

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ABSTRACT

On the eastern bank of the River Godavari (East Godavari District), about 26 kms north of Rajahmundry town in Andhra Pradesh, several Jurassic plant fossils were collected for the first time. They all are impressions on ferruginous sandstone. These plant fossils include Filicales, Cycadales and Coniferales. But the present paper deals with species of *Ptilophyllum*; *Dictyozamites*, *Taeniopteris*, *Bucklandia*, *Elatocladus* and *Brachyphyllum*.

An attempt to prepare polygrams has been made for the specimens of *Ptilophyllum* spp. These polygrams represent various characters in a simplified polygonal drawings.

INTRODUCTION

Several Upper Gondwana localities are known all along the East Coast of India. In Andhra Pradesh they mainly occur near Vemavaram in Guntur District and Raghavapuram, Gollapalli in West Godavari District and Ayaparaj Kotapalli in Visakhapatnam District. These formations according to KING (1880) were identified as three stages namely Tirupati Sandstones, Raghavapuram shales and Gollapalli Sandstones (Table 1).

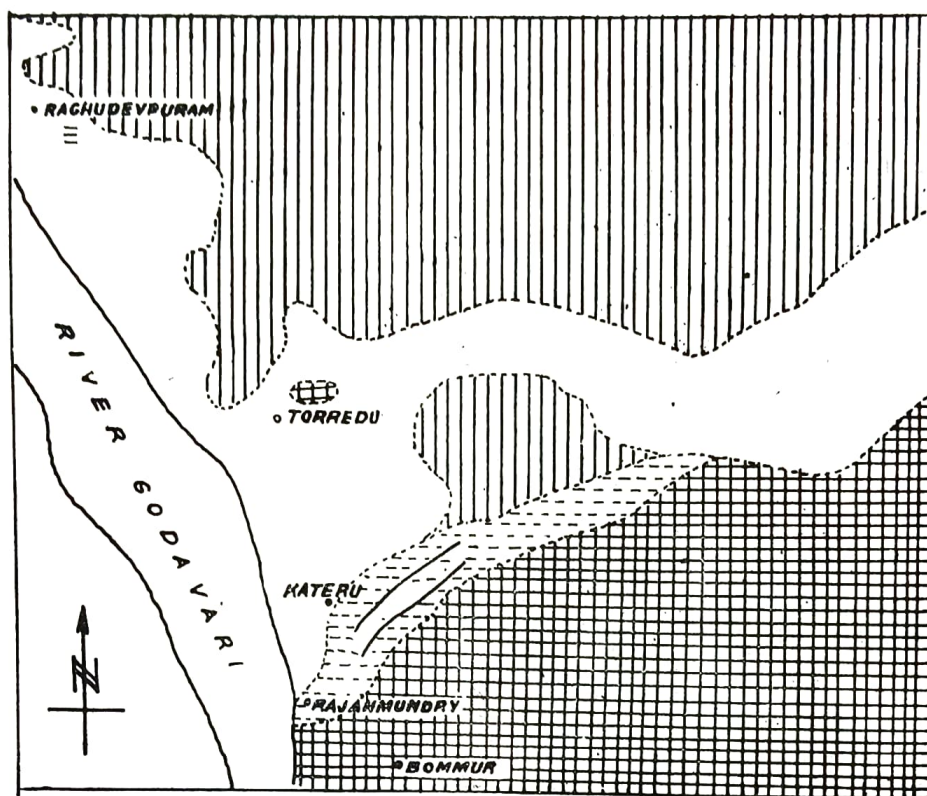
Table 1—Table showing Upper Gondwana Correlations in East Coast, India (Adapted from Lexique Stratigraphique International, 1956)

Standard Scale	Gondwana Division	East Coast			
		Godavari	Guntur	Madras	Ramnad
Lower Cretaceous	Jabalpur Series	Umia			
		Jabalpur	Tirupati	Pavalaur	Satyavedu
Middle-Upper Jurassic	Rajmahal Series	Kota	Raghavapuram	Vemavaram	Sriperumbudur Sivaganga
		Rajmahal	Gollapalle	Budavada	

Not much work has been done on the Gondwana localities of the Godavari District except by FEISTMANTEL (1877, 1879) and recently by BAKSI (1969), and BHALLA (1967). But all these reports are only from West Godavari District. From East Godavari District occurrence of Jurassic plant fossils has been brought to light by SATYANARAYANA (1976), SATYANARAYANA AND MAHABALE (1976).

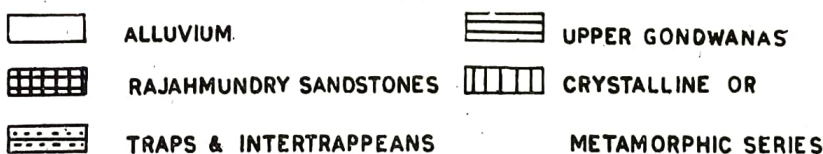
*Paper presented at the Second Indian Geophytological Conference, Lucknow, March 11-12, 1978.

While investigating for palaeobotanical material in the East Godavari District one of the authors (TSN) found a small hillock with numerous plant fossils, locally known as "Sudda Metta" ($17^{\circ} 8' 30'' : 81^{\circ} 44' 30''$). This hillock is in the South-East direction of the village Raghudevapuram, at a distance of one mile along the road leading to Korukonda, on the Eastern bank of the River Godavari, 26 kms North of Rajahmundry town (Map 1).



After King (1880)

Scale $\pm 1'' = 7$ miles



Map 1. Geological Formations of East Godavari District, Andhra Pradesh.

This isolated small hillock, "Sudda Metta" is 4 meters in height consisting of pale yellow and reddish brown to purple coloured sandstones. More or less in the middle of its height, a thin ferruginous sandstone band, nearly a meter in thickness, has yielded several Jurassic plant impressions. No carbonised material was found in any of the specimens. Pale yellow sandstone, present on either side of the ferruginous band also yielded a few ill-preserved plant impressions.

RAMASWAMY (1950) in the Reports of the Geological Survey of India has referred this small hillock as belonging to Tirupati Stage of Jabalpur Series. He has made no mention about the availability of plant fossils from this place.

MATERIAL AND METHODS

All the specimens described here were collected from a single locality "Sudda Metta". Since they are merely impressions, they were studied with the help of reflected light. While assigning the specimens to the respective species of *Ptilophyllum*, the emended diagnoses

by BOSE AND KASAT (1972) were followed. Many of the specimens though lacking cuticular or anatomical details, they resemble very much in all external morphology with the reported species. Hence, the identifications here are given as specimens comparable to those reported species. In case of *Ptilophyllum deodikarii* and *P. raghudevapurens*, the variations exhibited by them are adequate to refer them as new species.

Polygrams—Polygonal graphic representations of the morphological features called as polygrams, have been made for the specimens of *Ptilophyllum*. They were prepared on the basis of fundamental plan given by HUTCHINSON (1936) and LÖVE AND NODEAU (1961). Here eight common characters of the *Ptilophyllum* specimens were chosen and converted into quantitative values. The minimum and maximum range of each character was taken and the ranges were divided into five alphabetically represented Scores as shown below :

Character 1. Frond width	Score value
upto 2.0 cm	A
2.1 to 4.0 cm	B
4.1 to 6.0 cm	C
6.1 to 8.0 cm	D
8.1 to 10.0 cm	E
Character 2. Length/Width ratio of pinnae	
up to 5.0 cm	A
5.1 to 10.0 cm	B
10.1 to 15.0 cm	C
15.1 to 20.0 cm	D
20.1 to 25.0 cm	E
Character 3. Number of pinnae per unit length of rachis (5.0 cm)	
up to 5	A
6 to 10	B
11 to 15	C
16 to 20	D
21 to 25	E
Character 4. Rachis thickness	
up to 0.1 cm	A
0.11 to 0.2 cm	B
0.21 to 0.3 cm	C
0.31 to 0.4 cm	D
0.41 to 0.5 cm	E
Character 5. Angle made by the pinnae to rachis	
30 to 40°	A
41 to 50°	B
51 to 60°	C
61 to 70°	D
71 to 80°	E

Character 6.	Angle made by pinna margins near the apex (nature of apex)	Score value
	up to 20°	A
	21 to 40°	B
	41 to 60°	C
	61 to 80°	D
	81 to 100°	E
Character 7.	Width between pinna margins near the base (nature of attachment)	
	up to 0.1 cm	A
	0.11 to 0.2 cm	B
	0.21 to 0.3 cm	C
	0.31 to 0.4 cm	D
	0.41 to 0.5 cm	E
Character 8.	Number of veins in the middle of the pinna	
	up to 3	A
	4 to 6	B
	7 to 9	C
	10 to 12	D
	13 to 15	E

Depending on the character values of the specimen, the respective scores were fixed. A diagram with eight (as many as the characters chosen) radiating spokes having equal

MODEL POLYGRAM WITH EXAMPLE SCORE VALUES C C B D C C-B C

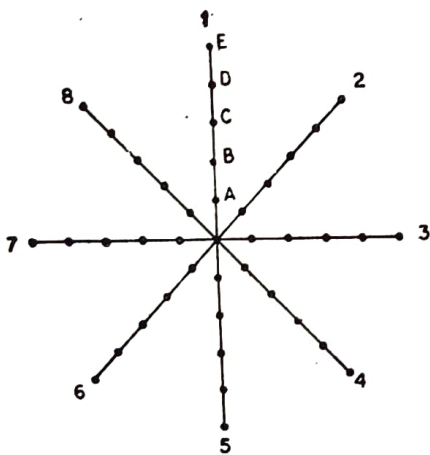


FIG. 1A

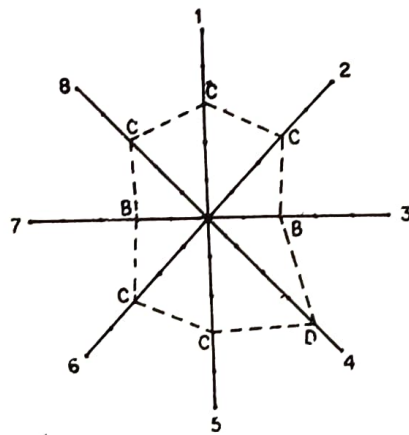


FIG. 1B

INDEX FOR SPOKE NUMBERS IN FIG. 1 & 2

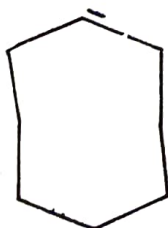


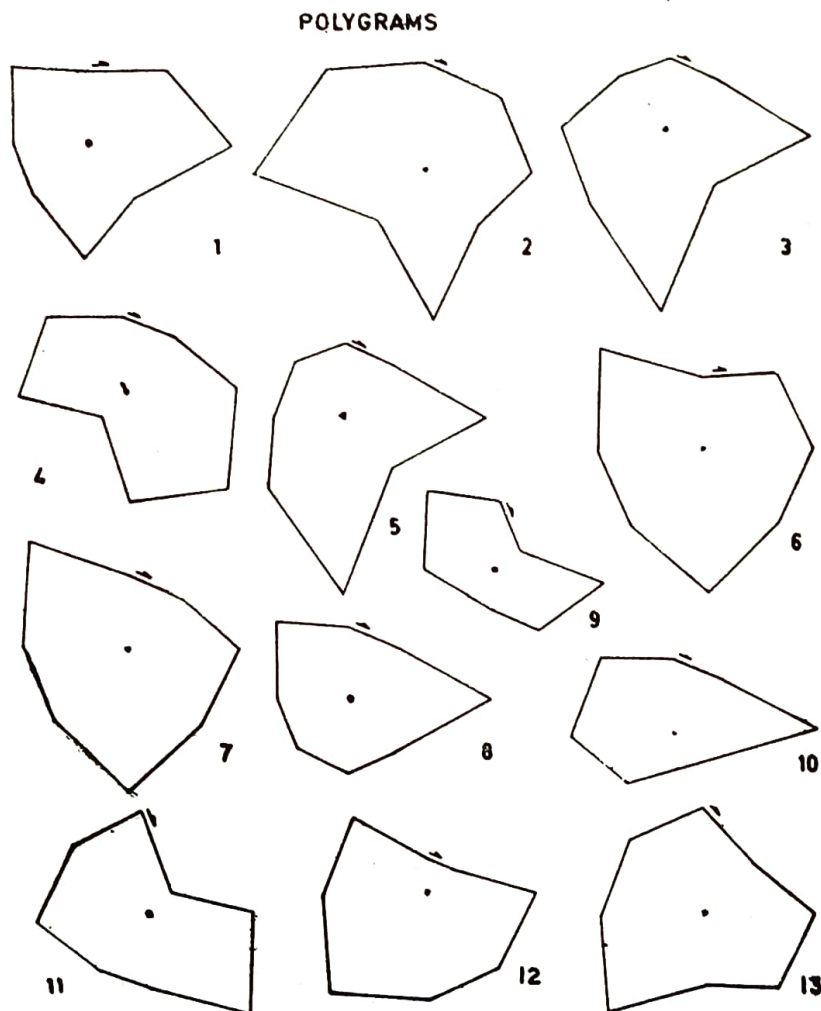
FIG. 1C

- 1 FROND WIDTH
- 2 LENGTH WIDTH RATIO OF PINNA
- 3 NUMBER OF PINNAE PER UNIT LENGTH OF RACHIS
- 4 RACHIS THICKNESS
- 5 ANGLE OF PINNAE TO RACHIS
- 6 ANGLE BETWEEN TWO MARGINS AT APEX
- 7 WIDTH BETWEEN TWO MARGINS AT BASE
- 8 NUMBER OF VEINS IN THE MIDDLE OF THE PINNA

length and angle of divergence was prepared. Each spoke was divided into five equal bits (as many as the scores for each character) and for convenience each score position was marked with alphabets (Fig. 1 A). Based on the quantitative value of each character respective scores were determined for each specimen (Table 2). The scores were marked on the respective spokes and they are joined by straight lines to obtain a polygram (Fig. 1 B, C). Score values were decided on average individual character, when the specimens were available in more than one for a species.

In the preparation of these polygrams, the angle of divergence between the spokes (45°), the order of spokes for each character and the length between each score point on the spoke (1.0 cm) were maintained constant in the original preparation. The preparation of polygrams will be more useful when the material is abundant for each species and also when the specimens are preserved with more characters. It is given here as a technique to study fossil material quantitatively.

Since all the specimens described here are from one locality (Raghudevapuram), a separate mention of the locality and horizon has not been made for each species.



Figs. 1-13 Polygrams for *Ptilophyllum* spp; 1. *P. acutifolium*; 2. *P. cutchense*; 3. *P. tenerimum*
 4. *P. rarinervis*; 5. *P. raghudevapurense*; 6. *P. deodikarii*; 7. *P. sp. cf. P. distans*; 8. *P. sp. cf. P. institacallum*
 9. *P. sp. cf. P. horridum*; 10. *P. sp. cf. P. jabalpurensis*; 11. *P. sp. cf. P. gladiatum*; 12. *P. sp. cf. P. sahnii*
 13. *P. sp. cf. P. amarjolense*

DESCRIPTION

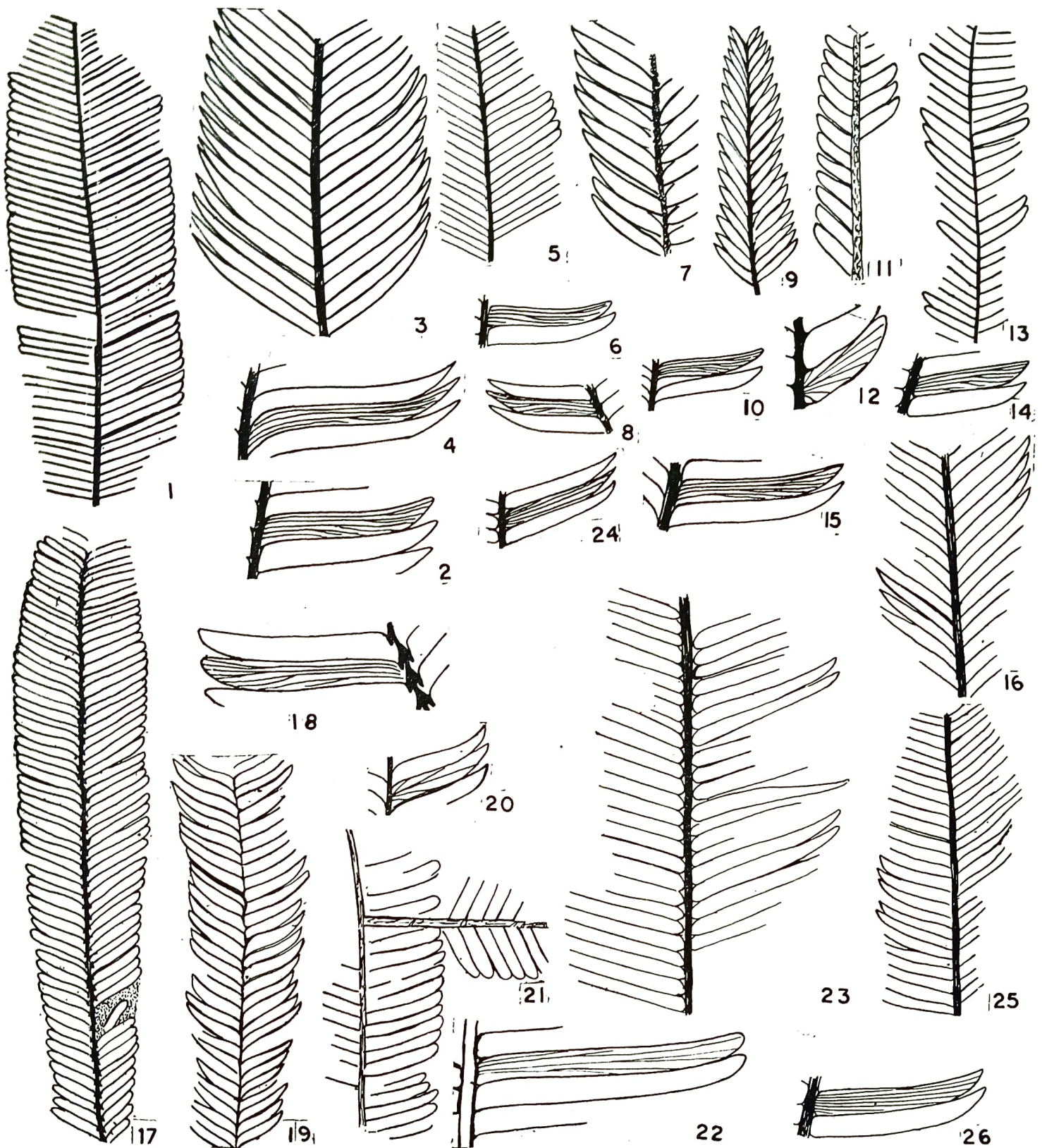
CYCADALES

Genus—**Ptilophyllum** Morris 1840

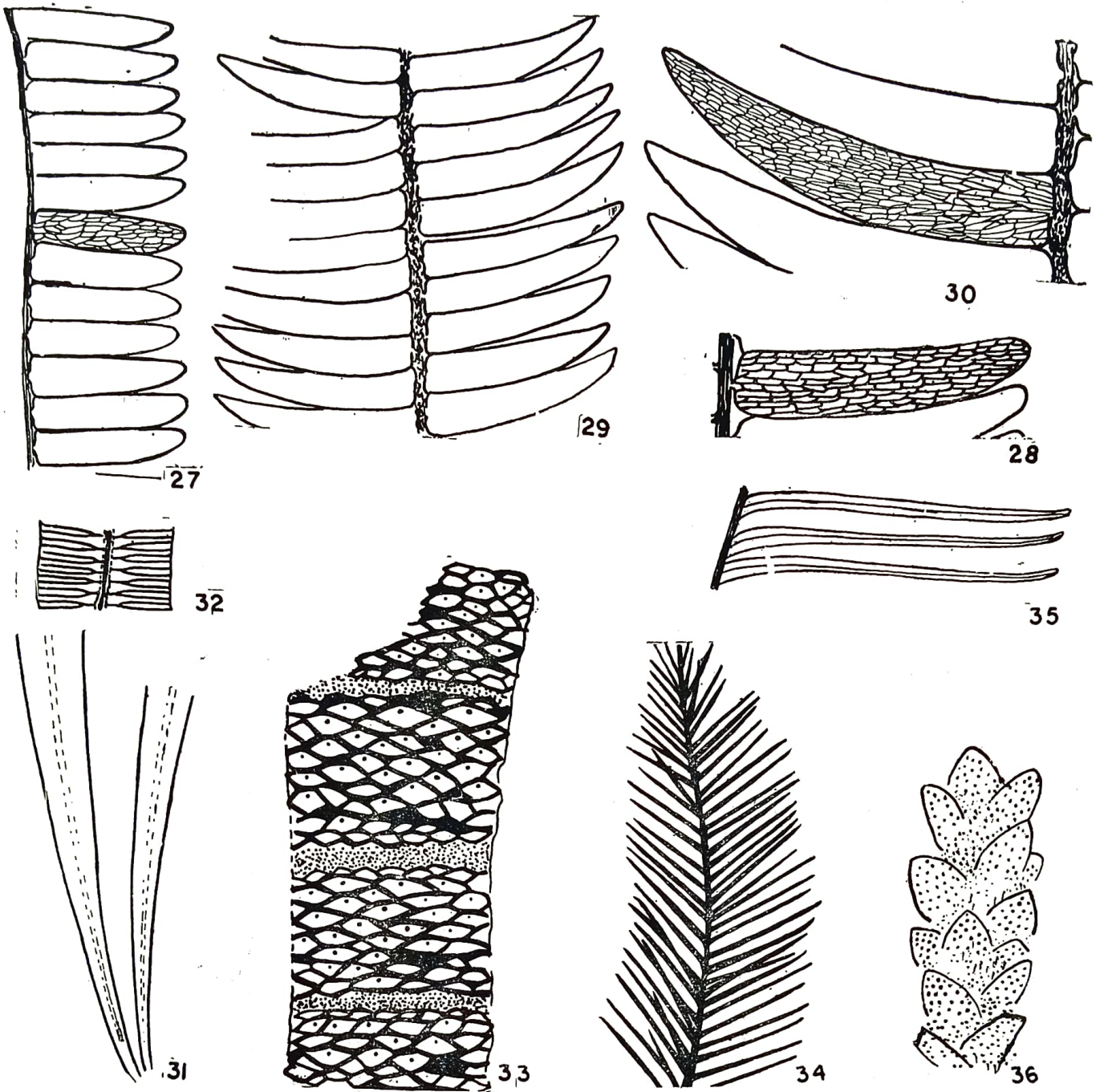
Ptilophyllum cutchense Morris 1840

Table 2—Morphological data of *Ptilophyllum* spp. and their Score Values used in the preparation of Polygrams

Serial no.	Name of the Species	Poly-gram no.	Character 1		Character 2		Character 3		Character 4		Character 5		Character 6		Character 7		Character 8	
			Read- ing	Score	Read- ing	Score	Read- ing	Score	Read- ing	Score	Read- ing	Score	Read- ing	Score	Read- ing	Score	Read- ing	Score
1.	<i>P. cutchense</i>	2	5.6	C	7.9	B	18	D	0.16	P	75	E	64	D	0.25	C	8.8	C
2.	<i>P. acutifolium</i>	1	4.0	B	10.2	C	16	D	0.17	B	5.3	C	26	B	0.2	B	8	C
3.	<i>P. tenerrimum</i>	3	3.4	B	6.0	B	20	D	0.13	B	71	E	60	C	0.25	C	6	B
4.	<i>P. rarinervis</i>	4	3.6	B	6.0	B	15	C	0.14	D	60	C	18	A	0.25	C	7	C
5.	<i>P. raghudevapurensis</i>	6	3.0	B	6.0	B	20	D	0.13	B	71	E	60	C	0.2	D	6	B
6.	<i>P. deodharii</i>	7	4.0	B	10.6	C	14	C	0.3	C	70	D	53	C	0.25	C	11	D
7.	<i>P. sp. cf. P. distans</i>	7	3.4	B	6.3	B	12	C	0.3	C	61	D	45	C	0.3	C	11	D
8.	<i>P. sp. cf. P. institaallum</i>	8	2.8	B	8.0	B	20	D	0.15	B	46	B	21	B	0.17	B	7.5	C
9.	<i>P. sp. cf. P. horridum</i>	9	3.0	B	3.5	A	15	C	0.15	B	25	A	18	A	0.15	B	8	C
10.	<i>P. sp. cf. P. jabalpurensis</i>	10	2.7	B	6.4	B	17	D	0.25	C	39	A	22	B	0.30	C	6.6	C
11.	<i>P. sp. cf. P. gladiatum</i>	11	3.2	R	5.3	B	12	C	0.28	C	0.55	C	13	A	0.25	C	10	D
12.	<i>P. sp. cf. P. sahnii</i>	12	2.0	A	3.1	A	12	C	0.3	C	60	C	74	D	0.3	C	8	C
13.	<i>P. sp. cf. P. amarjolensis</i>	13	3.3	B	5.6	B	14.5	C	0.18	B	65	D	60	C	0.22	B	9	C



Text-figs. 1-26—*Ptilophyllum* sp.—1. *P. cutchense*, $\times \frac{1}{2}$; 2. *P. cutchense* pinnae, $\times 1\frac{1}{2}$; 3. *P. acutifolium*, $\times \frac{1}{3}$; 4. *P. acutifolium*, $\times \frac{2}{3}$; 5. *P. tenerrimum*, $\times \frac{2}{3}$; 6. *P. tenerimum* pinnae, $\times 1$; 7. *P. sp. cf. P. gladiatum*, $\times \frac{2}{3}$; 8. *P. sp. cf. P. gladiatum* pinnae, $\times 1$; 9. *P. sp. cf. P. horridum*, $\times \frac{2}{3}$; 10. *P. sp. cf. P. horridum* pinnae, $\times 1\frac{1}{2}$; 11. *P. sp. cf. P. sahnii*, $\times \frac{2}{3}$; 12. *P. sp. cf. P. sahnii* pinnae, $\times 1\frac{1}{2}$; 13. *P. institacallum*, $\times \frac{2}{3}$; 14. *P. institacallum* pinnae, $\times 1$; 15. *P. sp. cf. P. distans*, $\times \frac{2}{3}$; 16. *P. sp. cf. P. distans* pinnae $\times 1$; 17. *P. raghudevapurensis* sp. nov., $\times \frac{1}{2}$; 18. *P. raghudevapurensis* pinnae, $\times 3$; 19. *P. rarinervis*, $\times \frac{2}{3}$; 20. *P. rarinervis* pinnae, $\times 2$; 21. *P. sp. cf. P. amarjolense*, $\times \frac{2}{3}$; 22. *P. sp. cf. P. amarjolense* pinnae, $\times 1$; 23. *P. deodikarii* sp. nov., $\times \frac{2}{3}$; 24. *P. deodikarii* pinnae, $\times \frac{2}{3}$; 25. *P. sp. cf. P. jabalpurensis*, $\times \frac{2}{3}$; 26. *P. sp. cf. P. jabalpurensis* pinnae, $\times 1$,



Text-figs. 27-36— 27. *Dictyozamites falcatus*, $\times 2/3$; 28. *D. falcatus*, $\times 1$; 29. *D. sahnii*, $\times 2/3$; 30. *D. sahnii* pinnae, $\times 1$; 31. *Taeniopteris spatulata*, $\times 2/3$; 32. *T. spatulata* venation $\times 1$; 33. *Bucklandia* sp., $\times 5\frac{1}{2}$; 34. *Elatocladus plana*, $\times 2/3$; 35. *E. plana* leaves, $\times 2$; 36. *Brachyphyllum expansum*, $\times 4.5$.

Pl. 1, Fig. 1 ; Text-figs. 1, 2 ; Polygram 2

Figured specimen 20—S/R—1972

Biseriately pinnate fragmentary fronds (6—S/R—1972, 14—S/R—1972, 18b—S/R—1972, 20—S/R—1972 and 407—S/R—1972) measuring 3.4 to 16.7 cm long, 1.4 to 5.8 cm broad, tapering towards base and apex. Rachis partly concealed or free, 0.1 to 0.2 cm thick. Pinnae linear, 1.8 to 4.0 cm long, 0.25 to 0.35 cm broad, attached to the rachis on the upper side by the whole base at an angle of $50-84^\circ$ with basal imbrication. Margins slightly falcate or straight. Upper basal angle free, rounded. lower basal angle generally decurrent. Apex obtuse or sub-acute. Veins 10-11 across the width of the pinnae in the middle, developed from the whole base, forked once or twice.

Comparison—Specimens 407—S/R—1972 resembles in all respects *P. cutchense* Morris (1840) in having upper basal angle rounded and lower basal angle \pm straight. Asymmetrical

basal lobes of specimen 18b—S/R—1972, and auriculate base in specimen 20—S/R—1972 resemble *P. gladiatum* Bose & Sukh Dev (1958). Specimen 14—S/R—1972 resembles *P. institacallum* Bose (1959), in having \pm basal angles.

Identification—Nature of pinnae, apex and base in all the specimens resemble the gross features of *P. catchense* Morris (1840), and hence all the above specimens were identified as *P. catchense*.

Ptilophyllum acutifolium Morris 1840

Pl. 1, Fig. 2 ; Text-figs. 3, 4 ; Polygram 2

Figured specimen—312—S/R—1972

Fragmentary fronds (23—S/R—1972, 55—S/R—1972 and 312—S/R—1972) measuring 4.4 to 10.0 cm long and 3.7-4.2 cm broad, attenuate towards apex and base, lamina as a whole broadly lanceolate. Rachis fully or partly concealed, 0.1 to 0.25 cm thick. Pinnae linear, sometimes lanceolate, attached to the upper side of the rachis by entire decurrent base at an angle of 40—56°, closely set or with little imbrication. Pinnae margins straight or little falcate ; apex acute or sub-acute, upper basal angle generally rounded and free, lower basal angle little decurrent. Veins 8-10 across the pinna in the middle, developed from entire base, forked once or twice.

Identification—All the specimens resemble *P. acutifolium* Morris (1840), in having linear long pinnae attached to the rachis at an angle of 40—70° by entire decurrent base, apex \pm acute and upper basal angle decurrent. Hence, these specimens were identified as belonging to *P. acutifolium* Morris.

Ptilophyllum tenerrimum Feistm. 1877

Pl. 1, Fig. 3 ; Text-figs. 5, 6 ; Polygram 3

Figured specimen—46—S/R—1972

Biseriately pinnate fragmentary frond measuring 6.5 cm long and 3.5 cm broad in the middle. Rachis 0.2 cm thick, free. Pinnae approximate, alternate, linear, elongated, placed obliquely on the upper side of the rachis at an angle of 60-65°, measuring 2.0 cm long and 0.3 cm broad in the middle. Apex obtuse, base as a whole truncate, acroscopic and basisopic margins straight, upper basal angle little rounded and lower basal angle straight, imbricate near the base. Veins 6-7 in the middle across the pinnae, developed from the whole base.

Comparison—The present specimen resembles with *P. catchense* Morris (1840), *P. amarjolense* Bose (1953), *P. horridum* Roy (1967) and *P. sahnii* Gupta & Sharma (1968b) in having obtuse apex. In having decurrent lower basal angle and 6-7 veins it differs from *P. acutifolium* Morris and *P. rarinervis* Feistm., respectively.

Identification—The present specimen resembles *P. tenerrimum* Feistm. (1877) in having elongated pinnae attached to the rachis at an angle of 60-65° by a truncate base, straight margins, obtuse apex and rounded upper and lower basal angles. Based on these features, the present specimen is assigned to *P. tenerrimum* Feistm.

Ptilophyllum rarinervis (Feistm.) Bose & Kasat 1972

Figured specimen—437—S/R—1972

Pl. 2, Fig. 11 ; Text-figs. 19, 20 ; Polygram 4

Biseriately pinnate frond measuring 4.5 cm long and 1.3 cm broad, gently tapering towards the base. Rachis slender, 0-15 cm thick, fully concealed by pinnae on the upper

side. Pinnae short, linear, alternate, or sub-opposite, sometimes opposite, measuring 1.4-1.6 cm long and 0.3 cm broad, attached by narrow decurrent base at an angle of 65°; apex sub-acute, pointed towards the upper part of the frond. Pinnae margins falcate showing imbricate nature, upper basal angle rounded and lower basal angle highly decurrent, bases of opposite pinnae touch each other. Base as a whole narrow and decurrent. Veins 3-4 developed from entire base generally fork near the apex. They run sub-parallel.

Identification—The present specimen resembles *P. rarinervis* (Feistm.) Bose & Kasat in having short pinnae attached to rachis at an angle of 65° with sub-acute apex, falcate margins, decurrent base and 3-4 veins. Hence, it is identified as *P. rarinervis* (Feistm.) Bose & Kasat.

***Ptilophyllum raghudevapureense* sp. nov.**

Pl. 1, Figs. 4, 5 ; Text-figs. 17, 18 ; Polygram 5

Figured specimen—424—S/R—1972

Biseriately pinnate fronds (specimens 424—S/R—1972, 28—S/RW1972, 21—S/R—1972) measuring 17.0 cm long and 2.2-3.2 cm broad, attenuate towards both apex and base. Rachis slender, 0.13 cm thick, fully concealed by pinnae. Pinnae linear, oblong, attached on the upper side of the rachis by whole base at an angle of 68-74°. Pinnae 1.0-2.1 cm long and 0.3-0.35 cm broad, apex obtuse. Pinnae slender and stumpy near base, linear and long in the middle and apex of the frond, margins falcate or straight, basal angle rounded and lower basal angle decurrent forming a spur-like extension, triangular in shape, extending over the upper basal angle of the pinnae below. Base as a whole convex. Veins 5-7 across the pinna margins in the middle, running parallel, forked once or twice, developed from the entire base.

Remarks—The specimens apparently look similar to *P. catchense* Morris (1840) in pinnae margins, apex and base. But the spur-like extension from the lower basal angle is the unique feature of these specimens.

Diagnosis—Specimens measuring upto 17 cm long and 3.2 cm broad, attenuate towards both apex and base. Rachis slender, ± concealed by pinnae bases. Pinnae 1.0-2.1 cm long, 0.3-0.35 cm broad, approximate, attached on the upper side of the rachis by a convex base at an angle of 68-74°; margins straight or falcate, upper basal angle rounded, lower basal angle decurrent forming a spur-like appendage, ± triangular, 0.1 cm long, extending over the upper basal angle of the pinnae below, apex obtuse. Veins 5-7 across the pinnae in the middle.

***Ptilophyllum deodikarii* sp. nov.**

Pl. 1, Figs. 6, 7 ; Text-figs. 23, 24 ; Polygram 6

Figured specimen—777—S/R—1972

Biseriately pinnate fragmentary frond measuring 9.2 cm long and 4.0 cm broad. Rachis almost concealed, 0.3 cm thick, pinnae long and linear, opposite, 3.7 cm long and 0.35 cm broad, attached to rachis on the upper side by the central part of the founded base at an angle of 64-76°, apex sub-acute, turned towards the apex of the frond ; acroscopic and basisopic margins straight and run ± parallel, upper and lower basal angles rounded. Veins 7-8 across the width of the pinnae in the middle, developing from a common central point, running parallel, forked once or twice.

Remarks—The specimen resembles *P. institacallum* Bose (1959) in having rounded base, but the general shape and nature of the frond, pinnae and pinnae apex differ from *P.*

institacallum Bose. The present specimen also resembles *Zamites gigas* Seward (1917) in having the veins developed from the central part of the pinnae base. But in rest of the characters it differs from *Zamites* sp. On the basis of the following characters the present specimen can be considered as a new species : (i) Pinna apex sub-acute, turns towards the apex of the frond at its sub-apex region abruptly at an angle of 75° ; (ii) Pinna base swollen, rounded and attached to the rachis by the central part at an angle of $64-74^\circ$ and (iii) veins developed from a common central point of the base.

Diagnosis—Biseriate fronds measuring more than 9.2 cm long and 4.0 cm broad, rachis 0.3 cm thick, \pm concealed by the pinnae bases. Pinnae long and linear measuring more than 3.7 cm and 0.35 cm broad, attached to rachis by a central part of the rounded base at an angle of $64-76^\circ$, apex sub-acute, turned towards the upper part of the frond ; basal angles rounded. Veins 7-8 across the width of the pinnae in the middle, developed from the central part of the base.

Ptilophyllum sp. cf. **P. distans** (Feistm.) Jacob & Jacob 1954

Figured specimen—80S/R—1972

Pl. 2, Fig. 13 ; Text-figs. 15, 16 ; Polygram 7

Biseriately pinnate frond measuring 5.5-9.0 cm long and 2.3-4.0 cm broad, tapering towards apex and base. Rachis partly or fully concealed by pinnae bases. Pinnae linear, measuring 1.9-3.3 cm long and 0.35-0.4 cm broad, \pm closely set at an angle of $64-80^\circ$ on the upper side of the rachis, margins falcate, upper basal angle rounded and lower basal angle straight or a little decurrent. Apex acute, veins 11-12 across the pinnae in the middle, fork once or twice, running parallel, developed from the whole base.

Comparison—The present specimen has been compared with *Ptilophyllum distans* (Feistm.) Jacob & Jacob (1954) taking into account the morphological features given in their emended diagnosis by BOSE AND KASAT (1972). The following are the common salient features between the present specimen and *P. distans* :—(i) Pinnae linear and long, (ii) attached to the rachis at an angle of $64-80^\circ$ by the lower part of the base, (iii) Pinnae with falcate margins, (iv) Upper basal angle free and rounded, and (v) lower basal angle little decurrent.

Ptilophyllum sp. cf. **P. institacallum** Bose 1959

Pl. 1, Fig. 8 ; Text-figs. 13, 14 ; Polygram 8

Figured specimen—11a—S/R—1972

Biseriately pinnate fronds (11 a—S/R—1972; 5—S/R—1972³ and 63b—S/R—1972) measuring 3.5 to 10.0 cm long and 1.8 to 2.5 cm broad, tapering towards apex. Rachis partly or fully concealed by bases of pinnae, 0.1 to 0.2 cm thick. Pinnae linear or narrowly ovate, attached on the upper side of the rachis, measuring 1.2-3.4 cm long and 0.12-0.3 cm broad, placed obliquely at an angle of $45-55^\circ$, closely set or with basal imbrication, attached by entire constricted base, sometimes base auriculate or truncate. Acroscopic and basisopic margins \pm falcate or straight, upper and lower basal angles rounded. Apex mostly sub-acute. Veins 7-9 arising from the centre of the base or from the whole base, forking once or twice at all levels.

Comparison—As regards to the external morphology the present specimen resembles *P. institacallum* Bose in the angle of the pinnae, basal imbrication, and attachment by a constricted base.

Ptilophyllum sp. cf. **P. horridum** Roy 1967

Pl. 1, Fig. 9 ; Text-figs. 9, 10 ; Polygram 9

Figured specimen—63b—S/R—1972

Biseriately pinnate frond, 7.8 cm long, 0.8 to 1.5 cm broad, tapering towards apex. Rachis slender, 0.1 cm, partly concealed. Pinnae linear, short, 0.9-1.2 cm long and 0.2 cm broad, alternate, attached on the upper side of the rachis by entire broad base at an angle of 45°, apex acute or apiculate, acroscopic margin straight, basispic margin convex, upper basal angle round and free, lower basal angle decurrent. Veins 4-5 across the pinnae in the middle, developed mostly from the lower part of the base, running parallel, forked once or twice at all levels.

Comparison—According to the emended diagnosis given by BOSE AND KASAT (1972) the present specimen resembles with *P. horridum* Roy in the following morphological features: (i) shape of the frond, (ii) attachment of the pinnae to the rachis, (iii) apex of the pinnae and (iv) decurrent lower basal angle of the base.

Ptilophyllum sp. cf. **P. jabalpureense** Jacob & Jacob 1954

Pl. 2, Fig. 10 ; Text-figs. 25, 26 ; Polygram 10

Figured specimen—53—S/R—1972

Biseriately pinnate fronds (7—S/R—1972, 53—S/R—1972, 333b—S/R—1972, 446—S/R—1972), measuring 5.3—16.6 cm long and 2.1-3.6 cm broad, tapering towards base and apex. Rachis 0.1-0.4 cm thick, longitudinally and transversely striated. Pinnae closely set on the upper side of the rachis, linear, long, 1.1-1.8 cm long and 0.3 cm broad, attached to rachis by an entire base at an angle of 38-67° with basal imbrication; acroscopic and basispic margins \pm falcate; upper basal angle free and rounded and lower basal angle invariably decurrent. Veins 5-9 developing from the entire or from the lower part of the base, forked once or twice running sub-parallel.

Comparison—In the external morphology the present specimen resembles *P. jabalpureense* Jacob & Jacob (1954) emended by BOSE AND KASAT (1972), in the following features: (i) rachis with transverse and longitudinal striations, (ii) pinnae attached at an angle of 38-67° by entire base, (iii) pinnae with falcate margins, (iv) upper basal angle rounded and lower basal angle decurrent.

Ptilophyllum sp. cf. **P. gladiatum** Bose & Sukh Dev 1958

Pl. 2, Fig. 12 ; Text-figs. 7, 8 ; Polygram 11

Figured specimen—888—S/R—1972

Biseriately pinnate fragmentary fronds (61—S/R—1972, 888—S/R—1972) measuring 4.8-7.8 cm long and 3.0 cm broad, tapering towards base and apex. Rachis partly concealed, 0.2 cm thick. Pinnae broadly lanceolate, attached on the upper side of the rachis by broad \pm auriculate base at an angle of 54-60°, measuring 2.0-2.1 cm long and 0.35-0.4 cm broad, closely set. Acroscopic margin straight and basispic margin little convex, upper basal angles rounded and lower basal angle \pm straight, base as a whole auriculate with asymmetrical lobes where the upper one is conspicuous. Veins nearly 10 across the pinnae margins in the middle, running almost parallel or sub-parallel, forking once or twice.

Comparison—In the following external morphological features given by BOSE AND KASAT (1972) for *P. gladiatum* Bose & Sukh Dev the present specimen resembles *P. gladiatum* in : (i) frond tapering towards apex, (ii) pinnae with highly pointed apex, (iii) attachment

by broad base to the rachis at an angle of 54-60°, (iv) upper basal angle rounded and lower basal angle straight.

Ptilophyllum sp. cf. **P. sahnii** Gupta & Sharma

Pl. 2, Fig. 14 ; Text-figs. 11, 12 ; Polygram 12

Figured specimen—15—S/R—1972

Biseriately pinnate fragmentary frond measuring 6.5 cm long and 2.0 cm broad, tapering towards the base. Rachis almost concealed by pinnae on the upper part, 0.3 cm thick. Pinnae short, oblong-ovate, arranged sub-opposite on the upper side of the rachis, measuring 1.1 cm long and 0.35 cm broad, attached to the rachis by entire base at an angle of $\pm 50^\circ$; acroscopic margin slightly convex, upper basal angle free and rounded, lower basal angle little decurrent. Veins 4-5 across the pinnae in the middle, developed from whole base, running sub-parallel, forked once or twice at all levels.

Comparison—The specimens resemble *P. sahnii* Gupta & Sharma (1968b) in the following morphological features given by BOSE & KASAT (1972) in their emended diagnosis: (i) shape of the frond, (ii) shape of the pinnae, (iii) attachment of the pinnae by entire base at an angle of $\pm 50^\circ$, (iv) upper basal angle decurrent and (v) veins 4-5 developed from whole base.

Ptilophyllum sp. cf. **P. amarjolense** Bose 1953

Pl. 2, Fig. 15 ; Text-figs. 21, 22 ; Polygram 13

Figured specimen—372b—S/R—1972

Biseriately pinnate fronds (62—S/R—1972, 116—S/R—1972, 372—S/R—1972, 701—S/R—1972) measuring 3.2-11.5 cm long and 2.5-3.6 cm broad, narrowing towards apex. Rachis 0.1 to 0.2 cm thick with longitudinal and transverse striations ; free or partly concealed by pinnae bases on the upper side. Pinnae linear oblong, measuring 1.5-2.0 cm long and 0.3-0.35 cm broad, placed alternate or sub-opposite, closely set or imbricate, attached by a truncate base at an angle of 58—86°. Acroscopic and basispic margins are \pm straight or a little falcate ; upper basal angle rounded and lower basal angle \pm decurrent. Apex obtuse. Veins 6-8 across the pinnae in the middle, forked once or twice and running sub-parallel.

Comparison—Though the petiolar part is not preserved in the specimens, the present specimens resemble in other morphological features given by BOSE AND KASAT (1972) for *P. amarjolense* Bose (1953) in the following features : (i) pinnae attached by truncate base, (ii) margins straight, (iii) upper basal angle rounded and lower basal angle slightly decurrent and (iv) pinnae apex obtuse.

Genus **Dictyozamites** (Oldham) Medlicott & Blanford 1879

Dictyozamites falcatus (Morris) Medli. & Bland. 1879

Pl. 2, Fig. 16 ; Text-figs. 27, 28

Figured specimen—1—S/R—1972

Biseriately pinnate fronds measuring up to 17.0 cm long and 4.5 cm broad on one side. Rachis 0.2 cm thick, free, pinnae ovate, measuring 4.5 cm long and 0.8-0.9 cm broad, attached to rachis by a central part at an angle of 87°, alternate. Pinnae margins straight, entire, episcopic margin and basispic margins abruptly rounded near base, forming an auriculate base and rounded basal angles. Apex obtusely rounded. Veins developed from the central part of the base, profusely forked to form meshes. Meshes in the middle are elongated than those in the margins, 17-19 across the pinnae in the middle.

Dictyozamites sahnii Gupta & Sharma 1968

Pl. 2, Figs. 17, 18; Text-figs. 29, 30

Figured specimen—3—S/R—1972

Biseriately pinnate frond, measuring upto 12.0 cm long and 9.2 cm width. Rachis 0.1 cm thick, partly concealed. Pinnae broadly linear, alternate, laterally attached to the rachis, measuring 5.2 cm long and 0.9 cm broad near base, attenuate towards apex. Pinnae attached by a central point of the auriculate base at an angle of 80°. Margins entire, falcate, apex acute, pointed towards the upper part of the frond. Veins developed from the central part of the pinnae base and anastomose to form angular meshes. Median and marginal meshes are much elongated.

Identification—In having pointed apex, falcate margins and auriculate base the present specimen resembles with *Dictyozamites sahnii* Gupta & Sharma (1968a). But the marginal meshes in the present specimen are equally elongated as the median ones whereas in *D. sahnii* Gupta & Sharma they are more or less oval in shape. This may be due to the age factor which does not help in recognizing the specimen as a new species.

Genus **Taeniopteris** Bronghniart 1832

Taeniopteris spatulata McCl. 1850

Pl. 3, Fig. 19 ; Text-figs. 31, 32

Sessile, broadly linear leaves, measuring upto 6.7 cm long and 0.9cm broad near sub-apex region, coriaceous texture, margins entire, narrowing towards base, apex \pm obtuse (?), mid-rib conspicuous, 0.15 cm thick, probably grooved on the dorsal side ; veins developed along the length of mid-rib laterally, \pm at right angles to the mid-rib, run parallel, fork once near the base, 32-34 veins in 1.0 cm length of the leaf.

Genus **Bucklandia** Presl 1825

Bucklandia sp.

Pl. 3, Fig. 19 ; Text-fig. 33

Figured specimen—117/—S/R—1972

A small fragment, probably an impression of a branch, 0.3 cm long and 1.2 cm broad. Leaf scars continuous, rhomboidal to elliptical, 0.1 cm long and 0.1 cm broad, 10-11 in one centimeter of the vertical length and 3-4 across the total width of the specimen. A small sub-terminal elevated spot is present in each scar, may be the rudiments of the vasculature to the young leaves.

CONIFERALES

Genus **Elatocladus** Halle 1913

Elatocladus plana (Feistm.) Seward 1919

Pl. 3, Fig. 20 ; Text-figs. 34, 35

Figured specimen—45—S/R—1972

Leaves measuring up to 11.5 cm long and 3.6 cm broad near the base, tapering towards the apex. Rachis slender, 0.1 cm thick with 3-5 longitudinal striations; pinnae linear, narrowly lanceolate, measuring 2.2 cm long and 0.15 cm broad, attached spirally to the rachis by a broad decurrent base at an angle of 52°. Apiscopic and basispic margins straight, upper basal angle free and rounded, lower basal angle decurrent. Apex sub-acute. Veins probably two on either side of the mid-rib, running parallel to it.

Table 3—Showing Upper Gondwana plant fossils reported from Raghudevapuram and other Indian localities.

Serial num-ber	Occurrence at Raghudevapuram spp. & spp. compared	Umia	Jabalpur	Rajmahals	East Coast	Remarks on age and Correlation
1	<i>Psilophyton cutchense</i> Morris.	+	+	+	+	Upper Jurassic and Lower Cretaceous (Rajmahal Series).
2	<i>P. acutifolium</i> Morris	+	+	+	+	—do—
3	<i>P. rarivervis</i> (Feistm.) Bose & Kasat	—	+	—	—	Upper Jurassic and Lower Cretaceous (Jabalpur Series).
4	<i>P. tenerumum</i> Feistm.	—	—	+	—	Upper Jurassic and Lower Cretaceous (Rajmahal Series).
5	<i>P. raghudevapurense</i> sp. nov.	—	—	—	—	—do—
6	<i>F. deoikarii</i> sp. nov.	—	—	—	—	—do—
7	<i>P. horridum</i> Roy	+	+	—	—	Upper Jurassic and Lower Cretaceous.
8	<i>P. distans</i> (Feistm.) Jacob & Jacob	+	+	—	—	Upper Jurassic and Lower Cretaceous.
9	<i>P. insitacellum</i> Kose	—	+	—	—	Upper Jurassic and Lower Cretaceous (Jabalpur Series).
10	<i>P. jabaipurensis</i> Jacob & Jacob	—	+	—	—	Upper Jurassic and Lower Cretaceous (Rajmahal Series).
11	<i>P. glabratum</i> Kose & Sukh Dev	—	+	—	—	—do—
12	<i>P. amarjalsense</i> Rose	—	—	+	—	Upper Jurassic and Lower Cretaceous (Jabalpur Series).
13	<i>P. sahnii</i> Gupta & Sharma	—	—	+	—	Upper Jurassic and Lower Cretaceous (Rajmahal Series).
14	<i>Bucklandia</i> sp. Seward	+	+	+	+	—do—
15	<i>Dictyozamites sahnii</i> Gupta & Sharma	—	—	+	—	—do—
16	<i>D. falcatus</i> (Old.) Medl. & Bland.	+	+	—	+	Upper Jurassic and Lower Cretaceous (Jabalpur Series).
17	<i>Taeniopteris spatulata</i>	+	+	+	+	Upper Jurassic
18	<i>Brachyphylloids expansum</i> (Brong.) Seward	—	—	+	+	Upper Jurassic and Lower Cretaceous (Jabalpur Series).
19	<i>Elatocladus plana</i> (Feistm.) Seward	—	+	+	+	—do—

+ = Presence, — = Absence

Genus **Brachyphyllum** Brongn. 1828

Brachyphyllum expansum (Brongn.) Seward 1917

Pl. 3, Fig. 21; Text-fig. 36

Figured specimen—316—S/R—1972

Thin, sterile specimen dorsiventrally compressed, measuring 2.0—4.0 cm long with irregularly preserved branchlets, each measuring \pm 2.0 cm long and 0.15 cm broad, probably developed from the leaf axes. Leaves suppressed, minute, \pm triangular in shape, measuring 0.1 cm long, succulent, sessile, arranged alternately and spirally (?); apex sub-acute.

Remarks—The gross morphological features such as shape, arrangement, apex of the leaves, margins and their attachment resemble *B. expansum* (Brongn.) Seward (1917). But in the present specimen numerous circular elevated spots are irregularly distributed on the leaves. They may either represent stomatal complex or scars of the trichome like outgrowths.

DISCUSSION

The assemblage here is rather interesting (Table 3). The dominance of *Ptilophyllum* basically suggests the Upper Jurassic age to the present locality. This genus is also known from several other localities in India. Among other Bennettitalean leaves *Dictyozamites* here is very important. It is not abundantly known from Indian Jurassic beds. JACOB (1951) while describing the geographical distribution of the genus referred this as a characteristic Middle Jurassic genus, but it is known to have been occurring from Liassic to Lower Cretaceous. However, it is abundant in Upper Jurassic beds. From East Coast Gondwanas, Vemavaram beds have yielded several specimens of *Dictyozamites*. From Rajmahal Group also this genus is well known. All other genera described here are equally well known from Jabalpur and Rajmahal Series both. *Taeniopteris* specimens in the present locality are quite abundant and are found in association with almost all the genera described. Richness of *Taeniopteris* and *Dictyozamites* indicates its closeness to Rajmahal flora. RAMASWAMY (1950) only on the basis of lithological data identified "Sudda Metta" as Tirupati Stage, equivalent to Jabalpur Stage of Jabalpur Series. But considering the flora belonging to here the present hillock definitely belongs to Gollapalli Stage (=Rajmahal Stage) of Rajmahal Series. Total absence of any flora in Tirupati Sandstones (PASCOE, 1963; p. 1002) make them distinguishable from other older formations belonging to East Coast Gondwanas. A detailed investigation of this area both palaeobotanically and geologically may further help in correlative studies.

ACKNOWLEDGEMENTS

We record our sincere thanks to Dr. G. B. Deodikar, Director, M.A.C.S. Research Institute, Poona for the laboratory and library facilities. One of the authors (TSN) is grateful to Shri M. Ramaiah, for his help in tracing the locality and while collecting the material from there.

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EXPLANATION OF PLATES

PLATE 1 :

1. *Ptilophyllum cutchence*, $\times \frac{1}{2}$
2. *P. acutifolium*, $\times \frac{2}{3}$
3. *P. tenerrimum*, $\times \frac{2}{3}$
4. *P. raghudevapurensis* sp. nov., $\times \frac{2}{3}$
5. *P. raghudevapurensis* pinnae, $\times 2\frac{1}{2}$
6. *P. deodikarii* sp. nov., $\times \frac{2}{3}$
7. *P. deodikarii* pinnae, $\times 1$

8. *P. institocallum*, $\times 2/3$
9. *P. sp. cf. P. horridum* $\times 2/3$

PLATE 2

10. *Ptilophyllum sp. cf. P. jabalpureense*, $\times 2/3$
11. *P. sp. cf. P. rarinervis*, $\times 2/3$
12. *P. sp. cf. P. gladiatum*, $\times 2/3$
13. *P. sp. cf. P. distans*, $\times 2/3$
14. *P. sp. cf. P. sahnii*, $\times 2/3$
15. *P. sp. cf. P. amarjolense*, $\times 2/3$
16. *Dictyozamitas falcatus*, $\times 2/3$
17. *D. sahnii*, $\times \frac{1}{2}$

PLATE 3

18. *Taeniopteris spatulata*, $\times 1$
19. *Bucklandia sp.* $\times 3$
20. *Flatocladus plana*, $\times 1/2$
21. *Brachyphyllum expansum*, $\times 4\frac{1}{2}$

