

Fossil flora of Athgarh Formation, Orissa, India

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The paper includes a well diversified plant megafossil assemblage from Athgarh Formation, Orissa. It contains *Equisetites*, *Marattiopsis*, *Todites*, *Phlebopteris*, *Cycadopteris*, *Taeniopteris*, *Ptilophyllum*, *Anomozamites*, *Elatocladus*, *Pagiophyllum*, *Brachyphyllum* and *Araucarites*. The dominance of conifers and pteridophytes is noteworthy. Cycadophytes are scanty and so also *Thinnfeldia* and *Baiera*. The Athgarh flora is in its overall assemblage comparable with those of Bansa and Gangapur floras of Central India.

Key-words – Fossil Flora, Athgarh Formation, Early Cretaceous, Mahanadi Basin, India.

INTRODUCTION

THE plant megafossils from the Athgarh Formation have earlier been reported by Feistmantel (1877), Adyalkar and Rao (1960, 1963), Jain (1968), Patra (1973a,b, 1980, 1987, 1989), Patra and Patnaik (1974) and Patra and Sahoo (1992). Palynological study has been carried out by Maheswari (1975) and Jana and Tiwari (1986).

The Athgarh Formation is named after the village Athgarh (20°30' 85°41') in Mahanadi Basin, Cuttack and Puri districts of Orissa. It covers an area of about 124 km from north to south and about 112 km from east to west lying west to south-west of Cuttack city, small hillocks on both sides of the river Mahanadi.

Impression of plant megafossils on pinkish white or yellowish brown shales were collected in 1983 from Ghantikhal (20°10' 50": 85°44'30"), Naraj (20°28'10": 85°45'47") and Talbast areas (20°20'27": 85°35'17").

DESCRIPTION

Equisetites sp.

Pl.1, figs 1-3

Description: Stem fragments unbranched, 6.2-15.0 cm long and 0.5-0.8 cm wide. Nodes slightly broader than internodes. Internodes length range from 3.5-5.5 cm with ridges and furrows. Leaf-sheath has 12-16 leaves, ranging 4-10 mm x 1mm in size with apex acute or obtuse.

Comparison: *Equisetites* sp. is distinguished from *E. rajmahalense* emend. Trivedi & Sukh-Dev (1982) in having half the number of leaves in a leaf sheath. *Equisetites* sp. closely resembles to *E. möbergii* Moller (in Moller & Halle, 1913) from Scania in the shape of leaf-sheath but *E. möbergii* differs as the internodes are smooth and the number of segments in a leaf-sheath is comparatively more (16-20). *E. frenguelli* Orlando (1946) is comparable in having ridges and grooves in internodes, but it has lesser number of leaves in a leaf-sheath.

Todites indicus (Oldham & Morris) Bose & Sah, 1968

Pl. 1, figs. 4,6

Remarks: The specimens described by Patra (1973a) morphologically resemble *Todites indicus* (Oldham & Morris) Bose & Sah (1968).

Phlebopteris athgarhensis Jain, 1968

Pl. 1, fig. 17; Pl.2, figs. 2, 3, 4

1968 *Phlebopteris athgarhensis* Jain, p. 151, pl.1, figs. 1-5.

1980 *Phlebopteris polypodioides* Brongniart, Patra, p.64, pl.2, figs. 4-a.

Emended Diagnosis: Pinnae linear-lanceolate, 2.0-9.6 cm long and 1.6-3.4 cm wide. Apical eight pinnae radiate out in a palmate form. Pinna rachis about 1.5 mm in width. Pinnules falcate, sometimes straight, closely set, alternate to subopposite, upto 4 cm long and 0.4 cm wide, attached by entire base at an angle 60°-70°. Apex acute, margin entire, at times slightly undulate, curved downwards. Midrib prominent, persistent upto apex. Secondary veins form polygonal meshes on either side

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of midrib. From corner of these meshes arise forked or unforked veins, which at places show anastomoses. In fertile pinnules, lateral veins in between two sori are prominently developed and form a compartment. Sori oval or circular, 10-17, in a row on either side of midrib; sporangia 6-7 per sorus, oblong and annulate.

Comparison: The venation pattern in the present specimens is better preserved than the specimens described by Jain (1968). In the present specimens, the vein meshes in the fertile region have thicker lateral veins between the sori and they form compartments. The lateral veins which arise from the corner of meshes lead towards sori, a character not seen earlier.

Onychiopsis psilotoides (Stokes & Webb) Ward, 1905

Pl. 1, figs 8,9; Pl.2, figs 5,6; Pl.3, fig. 1

1973 *Onychiopsis paradoxes* Bose & Sukh-Dev; Patra, p. 327, pl.1, figs 4,5

Onychiopsis psilotoides has been reported for the first time from Athgarh Formation. Patra's (1973) specimens have been incorporated due to their likeness.

Cladophlebis acutipennis Oishi, 1940

Pl.1, fig. 10

The specimen is closely comparable to *Cladophlebis acutipennis* Oishi (1940) described from Japan in gross features. However, the present specimen is comparatively smaller in size.

Cladophlebis medlicottiana (Oldham) Pascoe, 1959

Pl. 1, fig.11; Pl.3, fig.4

The specimens match with those of *Cladophlebis medlicottiana* (Oldham) Pascoe described by Sukh-Dev (1970) and Zeba-Bano (1981) from the Jabalpur Formation.

Sphenopteris sp. A

Pl. 1, fig. 12

Description: Pinnae fragmentary, 6 cm in length and 1.3 cm in width. Rachis about 1 mm wide. Pinnules alternate, small, ovate, typically 6-9 x 3-5 mm in size,

attached at an angle of 40°-70°. Pinnule-lobes small, cuneate upto 3 mm long and 2 mm wide, united at base 2-3 lobes in lower pinnules, higher up lobes becoming less clear, margin entire, apex acute or obtuse. Midvein giving rise few lateral veins.

Comparison: *Sphenopteris* sp. A is characteristically distinct, but only few specimens have been found. It is comparable to *Sphenopteris* sp. described by Roy (1968) from Kuch and Kathiawar, in general shape and size of pinnae. It also resembles to some extent to the sterile pinnae of *Coniopteris hymenophylloides* (Brongniart) Seward described by Sze (1933) from China.

Sphenopteris sp. B

Pl. 3, figs. 2,3

Description: Frond bipinnate, fragmentary, 1.0-1.5 cm in size. Rachis less than 1 mm wide. Pinnae lanceolate, alternate, 0.5-1.2 cm long and 0.2-0.5 cm wide. Pinnules alternate, cuneate or obovate, 1-3 mm long, 1.0-1.5 mm wide. Margin entire or lobed, basisopic margin decurrent, joining the acroscopic margin of lower pinnule. Apex subacute or broad and minutely incised. Midvein giving rise to a few lateral veins.

Comparison: *Sphenopteris* sp. B is comparable to *Sphenopteris specifica* (Feistm.) Roy (1968) reported from Kutch, but in the present specimens the pinnules are comparatively smaller and attached at a wide angle.

Rhizomopteris ballii Feistmantel, 1877

Pl. 3, figs. 5,6

The xylem elements are discernible in the present specimens. preserved scars appear spirally arranged at irregular distances.

Taeniopteris spatulata McClelland, 1850

Pl.1, fig. 13

Occurrence of *Taeniopteris spatulata* is very rare, only a single specimen from Naraj has been reported. *Taeniopteris spatulata* is based on impressions only and thus differ from *Nipaniophyllum raoii* which has anatomical details.

PLATE 1

1. *Equisetites* sp., specimen No. B.S.I.P. 36307 x 1.
2. A part of above specimen enlarged, x 6.
3. *Equisetites* sp., specimen No. B.S.I.P. 36308, x 1.
4. *Todites indicus* (Oldham & Morris) Bose & Sah, a few pinnules enlarged, specimen no. B.S.I.P. 36309 x 4.
5. *T. indicus*, pinnules enlarged, specimen no. B.S.I.P. 36348 x 4.
6. *T. indicus*, specimen no. B.S.I.P. 36310 x 1
7. *Phlebopteris athgarhensis* Jain, fertile pinnae, Specimen no. B.S.I.P. 36317 x 1.
8. *Onychiopsis psilotoides* (Stokes & Webb) Ward, specimen No. B.S.I.P., 36320 x 1.
9. Above specimen enlarged x 2.
10. *Cladophlebis acutipennis* Oishi, specimen no. B.S.I.P. 36323 x 1
11. *Cladophlebis medlicottiana* (Oldham) Pascoe, specimen no. B.S.I.P. 36324 x 1.
12. *Sphenopteris* sp. A., specimen no. B.S.I.P. 36321 x 1
13. *Taeniopteris spatulata* McClelland, specimen no. B.S.I.P. 36329 x 1.
14. *Ptilophyllum acutifolium*, Morris, specimen no. B.S.I.P. 36334 x 4
15. *Ptilophyllum sahmii* Gupta & Sharma, specimen no. B.S.I.P. 36334 x 4.
16. *Pagiophyllum* sp., specimen no. B.S.I.P. 36336 x 1.
17. *Phlebopteris athgarhensis*, Jain, Sterile pinnae, specimen no. B.S.I.P. 36312 x 1.

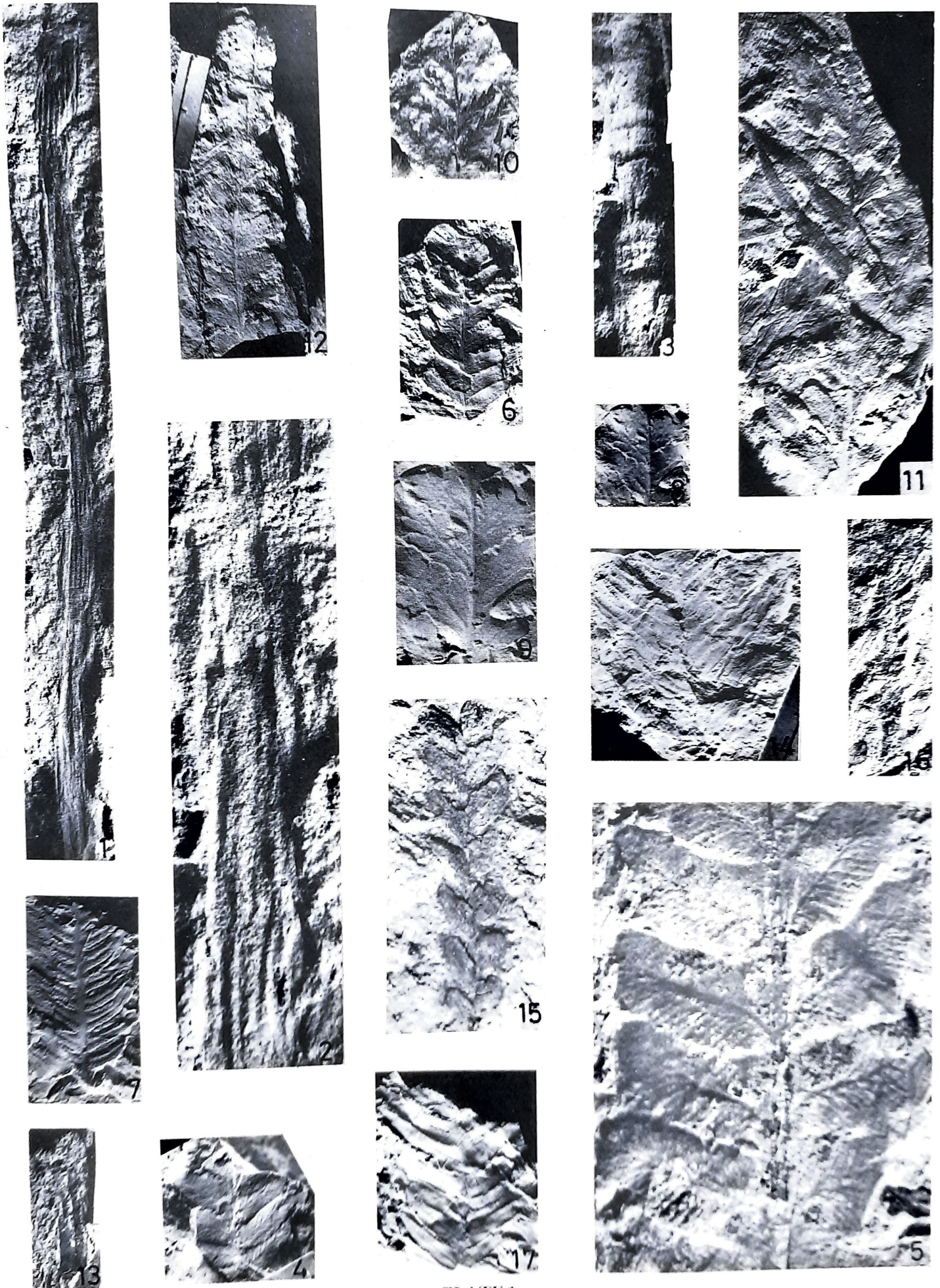


PLATE I

Table 1. Distribution of plant fossils in Athgarh Formation from Cuttack, Orissa.

Taxa \ Area	Ghantikhal	Naraj	Talbast	Dhurusia	Jagannath Prasad	Sidheswar Hill	Chakleshwar	Jagatia-Mundia
<i>Equisetites</i> sp.	+	-	-	-	-	-	-	-
<i>Todites indicus</i>	+	+	+	-	-	-	-	-
<i>Marattiopsis macrocarpa</i>	+	-	-	-	-	-	-	-
<i>Phlebopteris athgarhensis</i>	+	-	+	-	-	-	-	-
<i>Hausmannia</i> sp.	-	-	-	-	-	-	+	-
<i>Onychiopsis psilotoides</i>	+	-	+	-	-	-	-	-
<i>Gleichenia gleichenoides</i>	+	-	-	-	-	-	-	-
<i>G. nördenskioldii</i>	-	-	-	-	-	-	+	-
<i>Gleichenia</i> sp.	-	-	-	-	-	+	-	-
<i>Cladophlebis acutipennis</i>	+	-	-	-	-	-	-	-
<i>C. medicottiana</i>	+	+	-	-	-	-	-	-
<i>Cladophlebis</i> sp.	+	+	-	-	-	-	-	-
<i>Sphenopteris</i> sp. A.	+	-	+	-	-	-	-	-
<i>Sphenopteris</i> sp. B.	-	-	+	-	-	-	-	-
<i>Rhizomopteris ballii</i>	+	-	-	-	-	-	-	-
<i>Thinnfeldia</i> sp.	+	-	-	-	-	-	-	-
<i>Cycadopteris</i> sp.	-	-	+	-	-	-	-	-
<i>Sagenopteris</i> sp.	-	-	-	-	-	-	-	+
<i>Taeniopteris spatulata</i>	+	+	-	-	-	-	-	-
<i>Anomozamites</i> sp.	-	-	-	-	-	-	-	-
<i>Otozamites</i> sp.	-	+	-	-	-	-	-	-
<i>Ptilophyllum acutifolium</i>	+	-	+	-	+	-	-	-
<i>P. cutchense</i>	-	+	-	-	-	-	-	-
<i>P. indicum</i>	-	-	-	-	+	-	-	-
<i>P. oldhamii</i>	-	-	-	-	+	-	-	-
<i>P. sahnii</i>	-	+	-	-	-	-	-	-
<i>Elatocladus tenerrimus</i>	-	-	+	-	-	-	-	-
<i>Elatocladus</i> sp.	-	+	-	-	-	-	-	-
<i>Pagiophyllum</i> sp.	-	+	-	-	-	-	-	-
<i>Brachyphyllum regularis</i>	-	-	+	-	-	-	-	-
<i>Araucarites cutchensis</i>	-	-	+	-	-	-	-	-
<i>A. cf. macropterus</i>	-	-	-	-	-	+	-	-
<i>A. minutus</i>	-	+	+	-	-	-	-	-
<i>Araucarites</i> sp.	+	-	-	-	-	-	-	-
<i>Coniferocaulon rajmahalense</i>	-	-	+	-	-	-	-	-
<i>Podozamites lanceolatus</i>	-	-	-	-	-	+	-	-
<i>Baiera</i> sp.	+	-	-	-	-	-	-	-

* Recently Patra & Sahoo (1992) reported *Equisetites rajmahalensis* Oldh. & Morr., *Coniopteris* sp., *Cladophlebis kathiawarensis* (Roy) Bose & Banerji, *Brachyphyllum rhombicum* (Feistm.) Sahnii, *Pagiophyllum* sp., *Araucarites cutchensis* Feistmantel and *Coniferocaulon rajmahalense* Gupta from Bonda, near Athgarh, Cuttack District.

PLATE 2

- Ptilophyllum cutchense*, Morris, specimen no. B.S.I.P. 36331 x 1.
- Phlebopteris athgarhensis*, Jain fertile pinnae, specimen no. B.S.I.P. 36315 x 1.
- P. athgarhensis*, few sterile pinnules enlarged, showing venation pattern, specimen no. B.S.I.P. 36316 x 10.
- P. athgarhensis* fertile pinna enlarged showing sori and venation pattern, specimen no. B.S.I.P. 36314 x 4.
- Onychiopsis psilotoides*, (Stokes & Webb) Ward, specimen no. B.S.I.P. 36318 x 1.
- Above specimen enlarged x 2.
- Ptilophyllum sahnii* Gupta & Sharma, specimen no. B.S.I.P. 36334 x 1.
- Cycadopteris* sp., specimen no. B.S.I.P., 36325 x 6.

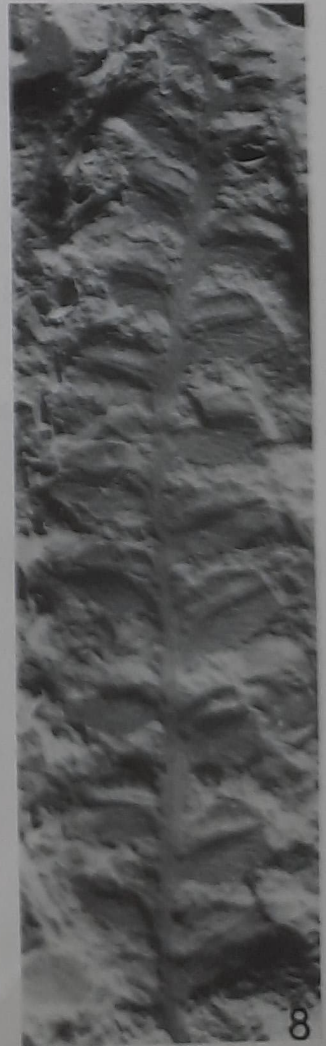
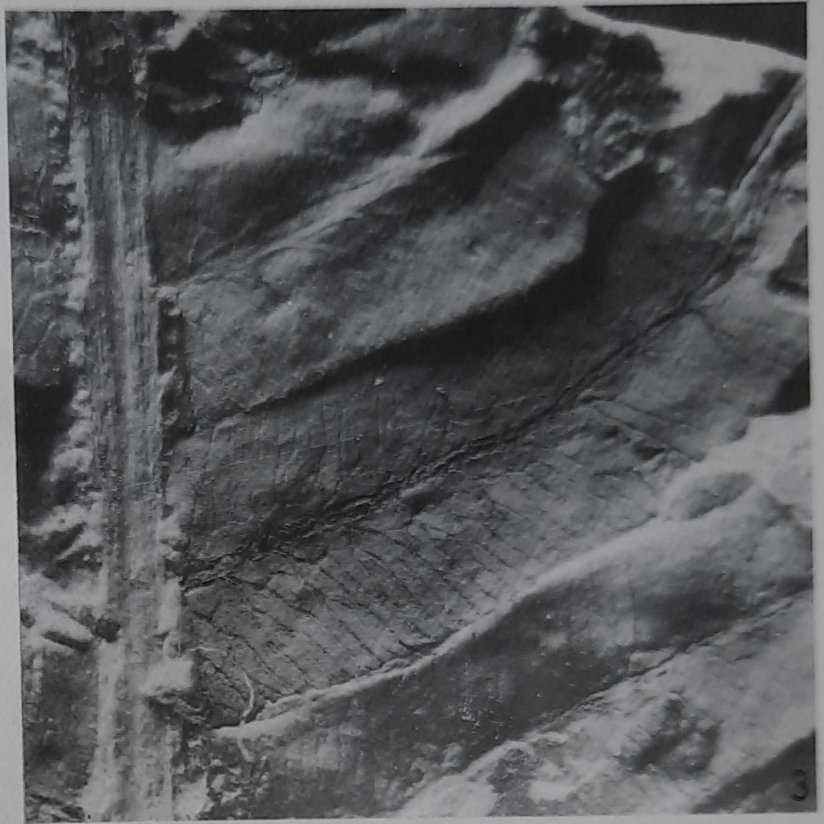


PLATE 2

Ptilophyllum acutifolium Morris, 1840

Pl.1, fig. 14

Ptilophyllum acutifolium is infrequently found at Talbast.

Ptilophyllum cutchense Morris, 1840

Pl. 2, fig. 1; Pl. 3, fig. 7,8

Leaves of *P. cutchense* are occurring more frequently than that of *P. acutifolium*.

Ptilophyllum cf. *P. sahnii* Gupta & Sharma, 1968

Pl.1, fig.15; Pl.2, fig.7

The present specimens though lack anatomical details are identified as *Ptilophyllum sahnii* on the basis of characteristic morphological features. The species was so far known only from Rajmahal Hills, Bihar.

Elatocladus tenerrimus (Feistmantel) Sahnii, 1929

Pl.3, fig.9

Leafy-twigs from Talbast match *E. tenerrimus* (Feistmantel) Sahnii (1928) in morphological features. In one of the specimens, the base of leaves appear narrow and decurrent, while in others they are mostly unstricted.

Pagiophyllum sp. A.

Pl.1, fig. 16

Leafy-twigs, fragmentary, 4.1-4.4 cm x 0.2-0.5 cm in size. Leaves spirally borne, falcate, 2-5 mm. long and 0.5 - 1.5 mm wide, forwardly or laterally directed, keeled, arising from a rhomboidal leaf-base cushion. Margin entire; apex acute and mucronate.

Due to lack of cuticular details its comparison is not possible.

Araucarites cutchensis Feistmantel, 1876

Pl. 3, fig. 16

The seed-scales closely resemble with *Araucarites cutchensis* Feistmantel described by Bose and Maheshwari (1973) in shape and size.

Araucarites minutus Bose & Maheshwari 1973

(Pl. 3, figs. 11-15)

The seed scales of *Araucarites minutus* have been reported from the first time from Athgarh Formation. The seed-scales lack cuticular details and are preserved as impressions, but they match in shape and size with those described by Bose and Maheshwari (1973) from Sehora, Jabalpur Formation and Bose and Banerji (1984) from Kutch.

Brachyphyllum regularis Borker & Chiplonkar, 1973

Pl.3, fig. 10

Brachyphyllum regularis is the commonest species in the Talbast area. These leafy-twigs are comparatively much larger in size and branched more than those reported from Songad by Borker and Chiplonkar (1973).

Coniferoaulon rajmahalense Gupta, 1954

Pl.3, figs. 17, 18

Description: Fragmentary stems, measuring 2.7-7.2 cm in length and 1.4-5.2 cm in width, marked with irregular transverse ridges and grooves, having at places circular to elliptical protuberances.

Specimens resemble with *C. rajmahalense* described from Rajmahal Hills (Gupta, 1954) and from Narsinghpur District (Bose, 1959).

DISCUSSION

The fossils flora of Athgarh Formation (Table 1) is dominated by pteridophytes and conifers with meager representation of cycadophytes other than *Ptilophyllum* and rare occurrence of pteridosperms and ginkgophytes. Amongst these *Todites indicus*, *Onychiopsis psilotoides*, *Cladophlebis acutipennis*, *C. medlicottiana*, *Ptilophyllum* P. cf. *sahnii*, and *Elatocladus tenerrimus* are the first record from this horizon.

In its characteristic composition and in the presence of fern viz., *Phlebopteris*, *Gleichenia nördenskioldii*, *Hausmannia* and *Onychiopsis*, this flora closely resembles that of Bansa flora of Jabalpur Formation (Assemblage Zone

PLATE 3

1. *Onychiopsis psilotoides* (Stokes & Webb) Ward, specimen no. B.S.I.P. 363319 x 4.
2. *Sphenopteris* sp. B, specimen no. B.S.I.P. 36322 x 1.
3. Above specimen enlarged x 4.
4. *Cladophlebis medlicottiana* (Oldham) Pascoe, specimen no. B.S.I.P., 36325 x 1.
5. *Rhizopteris ballii* Feistmantel, specimen no. B.S.I.P. 36327 x 1.
6. *R. ballii*, a petiole - scar enlarged, specimen no. B.S.I.P. 36328 x 12.
7. *Ptilophyllum cutchense* Morris, specimen no. B.S.I.P. no. 36331 x 1.
8. *P. cutchense*, specimen no. B.S.I.P. 36333 x 4.
9. *Elatocladus tenerrimus* (Feistmantel) Sahnii, specimen no. B.S.I.P. 36335 x 1.
10. *Brachyphyllum regularis*, Borker & Chiplonkar, specimen no. B.S.I.P. 36337 x 1.
11. *Araucarites minutus* Bose & Maheshwari, specimen no. B.S.I.P. 36337 x 1.
12. *A. minutus*, specimen no. B.S.I.P. 36344, x 1.
13. *A. minutus*, specimen no. B.S.I.P. 36342, x 1.
14. *A. minutus*, specimen no. B.S.I.P. 36441 x 1.
15. *A. minutus*, specimen no. B.S.I.P. 36343 x 1.
16. *Araucarites cutchensis* Feistmantel, specimen no. B.S.I.P. 36339 x 1.
17. *Coniferoaulon rajmahalense* Gupta, specimen no. B.S.I.P. 36345 x 1.
18. *C. rajmahalense*, specimen no. B.S.I.P. 36347, x 1.

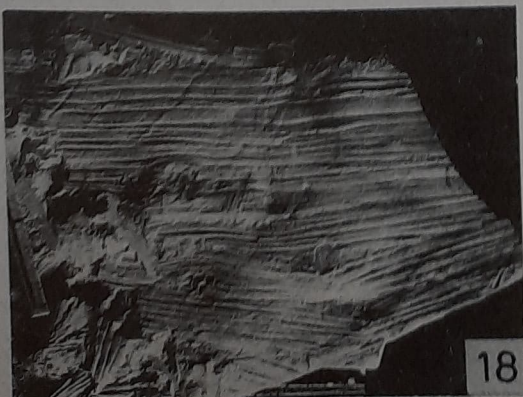
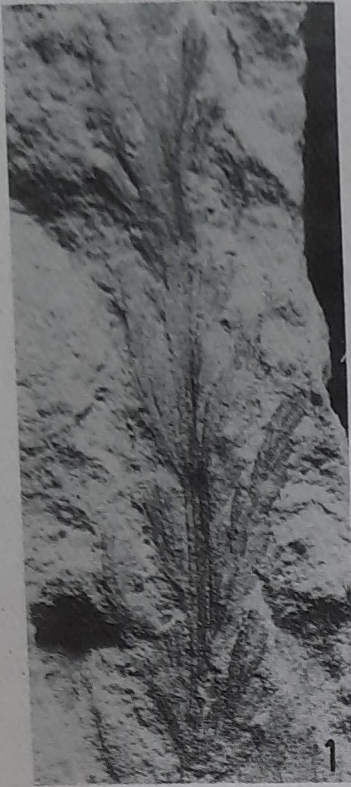


PLATE 3

10, Sukh-Dev 1988) of Early Cretaceous age. In this flora, *Weichselia* and *Allocladus* are absent. However, there is probability of finding *Weichselia* in the Athgarh Formation. The presence of *Lametriletes indicus* in dispersed spores are now known from the Athgarh Formation which are comparable to the *in situ* spores of *W. reticulata* (Singh & Venkatachala, 1988). The Athgarh Flora contains few fragmentary leaves of *Otozamites* and *Anomozamites*, probably this is due to local variation.

The Gangapur Assemblage-2 (Sukh Dev, 1988) and the Athgarh flora have common elements viz., *Equisetites*, *Gleichenia nördenskioldii*, *Hausmannia*, *Taeniopteris*, *Ptilophyllum*, *Araucarites*, *Elatocladus*, *Pagiophyllum* and *Coniferocaulon*. The genera *Allocladus*, *Athrotexites* and *Torreyites* of Gangapur assemblage are yet not found. The flora of Himmatnagar, Gardeswar and Dhrangadhra formations show some resemblance with the Athgarh flora in having *Gleichenia nördenskioldii* and *Brachyphyllum regularis*.

The Athgarh flora is comparable to older Sehora flora (Assemblage zone 9, Sukh-Dev, 1988) of Early Cretaceous age in having *Onychiopsis*, *Ptilophyllum*, *Taeniopteris*, *Brachyphyllum* and *Pagiophyllum*. But Sehora flora is comparatively less developed as there is paucity of ferns but cycadophytes and pteridosperms are present in abundance. In the Sehora flora *Phlebopteris*, *Gleichenia*, *Hausmannia* and *Cycadopteris* are absent, instead *Doratophyllum*, *Psychopteris*, *Allocladus* and *Saturia* are present.

The detailed comparison of the Athgarh flora with the Sonajuri and Nipania flora from Rajmahal Hills is not possible as the forms are not common.

Recently Singh and Venkatachala (1988) reassessed the *sporae dispersae* from the Athgarh Formation earlier studied by Maheshwari (1975) and Jana and Tiwari (1986), and assigned them to the Early Cretaceous age.

In conclusion, the Athgarh fossil flora appears to be the eastern extension of the Bansa flora therefore, it is considered of the same age i.e. Early Cretaceous.

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