

Pteridophytic remains from Early Cretaceous succession

*A.K. Srivastava, **S.R. Manik, *R.R. Gawande and **G.V. Patil

*Geology Department, **Botany Department, Amravati University, Amravati-444 602

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The plant megafossils recovered from Upper Gondwana beds belonging to Early Cretaceous succession of Bairam—Belkher area exhibit beautifully preserved sterile and fertile specimens having pteridophytic affinities. The assemblage is represented by *Gleichenites*, *Sphenopteris*, *Matonidium*, *Cladophebis*, *Phlebopteris*, *Todites* and *Coniopteris*. The emphasis has been given to the morphotaxonomy and comparative distribution of ferns in Early Cretaceous succession of India.

Key-words—Pteridophyte, Bairam-Belkher area, Early Cretaceous, Upper Gondwana.

INTRODUCTION

PLANT megafossils from the Upper Gondwana succession (Early Cretaceous) of Bairam-Belkher area (Long. 77° 31'E, Lat. 21° 16'N) are discovered in recent times (Srivastava *et al.*, 1995, 1996, 1999, 2001a,b,c, 2003). Prior to this, the succession was considered to be devoid of plant megafossils and fixation of age was also debatable. The megafossils are well represented by the diverse and rich assemblages of gymnosperms and pteridophytic remains, which are preserved in the fine grained clayey unit in the form of impressions.

The Gondwana lithounit of the area is a part of Satpura basin showing an exposure of 90-100 metre areno-argillaceous sediments. The fossiliferous horizon i.e. light grey to dark grey clay makes interbedded and pocketed occurrences in the siltstone and sandstone horizon respectively.

Genus— *Coniopteris* Brongniart 1849

Coniopteris quinqueloba Phillips 1975

Pl. 1, Fig. 7

Description—A detached fertile frond bipinnately compound, 4.5 cm long x 1 cm broad, rachis distinct, stout 1mm broad, pinna linear to lanceolate attached to the rachis; the pinnules are arranged alternately to sub-opposite arising at an angle of 45°-50° ranging in size from 2 to 3mm; varying in shape from short linear to lobed struc-

ture; apices of pinnules possesses distinct sori at the tip. Sori oblong and round, located at the end of pinnules.

Comparison - The present specimen shows close resemblance with *Coniopteris quinqueloba* Phillips in general appearance and narrow ultimate pinnules; each fertile pinnule terminates as a distinct sori marked by elevated portion in part and concavity in counterpart. The specimen also resembles with *Coniopteris* cf. *minutensis* Brick (Bose & Banerji 1984) reported from Kachchh, in having pinnately compound frond and general shape. However, *Coniopteris* cf. *minutensis* is a sterile frond whereas, present specimen is fertile and identified as *Coniopteris quinqueloba*. It can also be compared with *Coniopteris* sp. described from Bouda near Athgarh. However, in *Coniopteris* sp. (Patra and Sahoo 1992) pinnules are rhomboidal or wedge-shaped in contrast to narrow linear pinnules.

Genus— *Gleichenites* Goeppert 1836

Gleichenites gleichenoides (Oldham & Morris)

Seward and Sahnii 1920

Pl. 2, Fig. 4; Pl. 4, Fig. 1

Description—A sterile frond bipinnate of about 7cm long and 2.5cm broad; rachis 0.8mm wide, secondary branches emerging alternately, arising at an angle of 45° to 50°; the pinnules oblique to the pinna axis, broadly linear measuring 4-5mm x 1.5-

2mm with acute apices; margin entire, midrib faintly marked; veins present but indistinct.

Comparison—The specimen shows close resemblance with *G. gleichenoides* (Surange 1964) in shape of pinnules; and attachment of rachis. It is distinct from *G. rewaensis* (Surange 1964) in absence of thick and ovately rounded pinnules. The genus *Gleichenites* sp. has been reported from Rajmahal Formation (Sharma 1971), Jabalpur Formation (Zeba-Bano 1979) and Bhuj Formation (Bose & Banerjee 1984). It can be distinguished from *Gleichenites nordenskioldii* (Sukh-Dev 1970) in shape and attachment of pinnules. It is also reported from Umia of Saurashtra (Borker & Chiplonker 1973) and forms an important component Jurassic-Cretaceous sediments.

Genus—*Todites* Seward 1900

Todites indicus (Oldham & Morris) Bose and Sah

Pl. 2, Fig. 6; Pl. 3, Fig. 1

Description - Frond pinnate, 6cm long x 1cm broad, with a strong stout rachis, 1mm in breadth having distinct median ridge, pinnules arising almost at right angles; closely set; attached by a broad base, 3-4mm x 2-3mm; the side towards the rachis strongly convex; margin entire, apex obtuse or rounded; fertile pinnule shows distinct sori arranged on either side of midrib.

Comparison : The specimen resembles in form and shape with the pinnules of *Cladophlebis*. It is distinct from the genus *Phlebopteris* in varying shape,

size and stout rachis. The specimens compare with *Todites indicus* (Bose & Sah 1968) in morphographic characters and presence of sori.

Genus—*Phlebopteris* Brongniart 1836

Phlebopteris athgarhensis (Jain) Prakash and Sukh-Dev 1994

Pl. 1, Fig. 2

Description—A leafy fertile shoot measuring 2cm x 1.5cm; rachis about 1mm broad showing distinct groove, pinnules falcate closely set; opposite to subopposite attached by a broad base at an angle of about 50°, 0.8mm long x 0.2mm broad, apex acute; margin entire; lateral veins indistinct because of poor preservation.

Fertile pinnules bear a single row of sori on either side of midrib. Sori circular or oval approximately 0.5mm in diameter, 7-9 sori in a row on either side of midrib, spores not preserved.

Comparison— The genus *Phlebopteris* is characterized by pinnate fronds, with ultimate segments linear, provided with a well-marked midrib giving off numerous dichomously branched, secondary veins, which may anastomose. Sori circular, forming a single row on each side of the midrib. It is clearly distinguished from *Phlebopteris hirsuta* in absence of stiff brown, multicellular hairs. It shows close resemblance with *Phlebopteris athgarhensis*, (Jana 1968) in shape, recurved margin with prominently developed oval to circular sori.

PLATE 1

1. *Matonidium indicum*, magnified view of frond exhibiting details of pinnules.
2. *Phlebopteris athgarhensis*, a fertile frond with rows of sori.
3. *Matonidium indicum*, specimen showing details of frond and pinnules.
4. Magnified view of *Cladophlebis medicottiana* exhibiting venation pattern.
5. *Matonidium indicum*, frond showing details of pinnules.
6. *Todites indicus*, a fertile frond showing details of morphographic features.
7. *Coniopteris quinqueloba*, fertile frond showing details of sori.
8. *Cladophlebis denticulata*, specimen showing attachment and shape of pinnules.
9. *Sphenopteris arguata*, showing morphographic details of pinna.

(Scale: 1 cm)

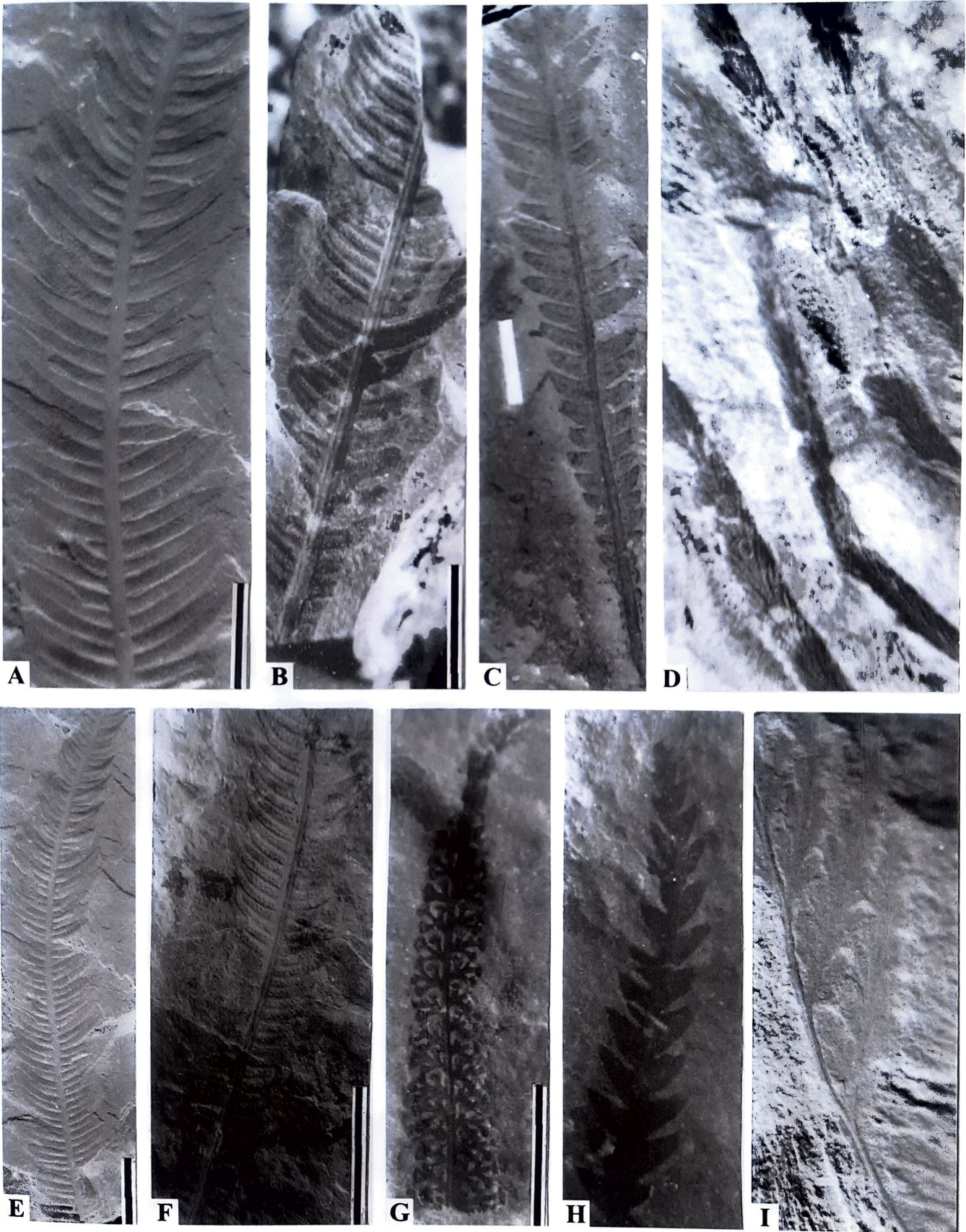


PLATE 1

Genus—*Cladophlebis* Brongniart 1849

Cladophlebis indica (Oldham & Morris) Sahni
and Rao 1934

Pl. 2, Fig 2; Pl. 3, Fig. 2; Pl. 4, Fig. 2

Description—Pinna fragmentary, measuring 3.5cm in length and 1.5cm in width, rachis about 1mm broad, showing a distinct median longitudinal groove, pinnules linear, alternate, attached laterally by whole base, 1.4cm long and 0.5cm broad, arising at an angle of 40°, midrib of pinnules prominent, traversing the entire length, venation distinct, secondary veins oblique and fork at least once after its emergence, the margin of pinnules is either entire or slightly wavy, basiscopic margin slightly decurrent.

Comparison—In gross morphological feature and venation pattern the pinnae recovered from Bairam-Belkher locality resemble most to *C. indica* (Oldham & Morris) Sahni and Rao reported from Rajmahal (1934) and Sriperumbadure beds, (Venkatchala 1977, Venkatachala Rajnikanth 1987) in having the pinnules attached by their whole base to the rachis, lanceolate shape, prominent midrib. The present specimen also resembles with *Cladophlebis* sp. A (Bose & Banerji 1984) described from Kachchh in overall shape and attachment of pinnules.

Cladophlebis denticulata (Oldham) Pascoe 1959

Pl. 1, Fig. 8; Pl. 2, Fig. 5; Pl. 4, Fig. 3.

Description—Detached pinna, measuring 5.5cm x 1.7cm. Rachis slender 1mm broad, with faintly marked longitudinal groove, the pinnules are alternate to sub-opposite, closely set, somewhat overlapping, ovate to lanceolate, broader at the base, narrowing

towards the apex measuring 0.8cm x 0.4cm, attached to the rachis by entire base, pinnules becoming smaller near the apex, secondary veins present but faintly marked, forking once before reaching the margin. Pinnules becoming smaller in size near apical region.

Comparison—The specimen is a sterile pinna resembling *Cladophlebis denticulata* (Venkatachala & Rajnikanth 1987, Benerji 1995) in shape, attachment and venation pattern. The present form also shows resemblance with *Cladophlebis daradensis* (Bose & Banerjee 1984) reported from Kachchh. However, Kachchh specimens are completely bipinnate fronds. *Cladophlebis kathiawarensis* (Bose & Banerji 1984) resembles in size of pinnules and attachment but it differs in uniform width of pinnules from the present species.

Cladophlebis medlicottiana (Oldham) Pascoe 1959

Pl. 1, Fig. D; Pl. 3, Fig. E.

Description—Single, incomplete leafy shoot 8cm long and 6cm broad attached by whole base, 1mm wide rachis forming an angle of about 30°-35° while the pinnae are 4cm x 2mm, linear-lanceolate, margin slightly dentate, apex sub-acute to obtuse with clearly marked midrib and venation.

Comparison—The specimen is comparable with *C. medlicottiana* described from Athgarh Formation (Sukh-Dev 1970, Prakash and Sukh-Dev 1994) and from Jabalpur Formation (Zeba-Bano 1979).

Genus—*Matonidium* Schenk 1871

Matonidium indicum Sahni, 1936

PLATE 2



1. *Matonidium indicum*, specimen showing details of frond and venation pattern.
 2. *Cladophlebis indica*, showing shape and attachment of pinnules.
 3. *Sphenopteris hislopii*, specimen showing lobing, attachment and venation.
 4. *Gleichenites gleichenoides*, a sterile specimen showing details of shape, size and attachment of pinnules.
 5. *Cladophlebis denticulata*, showing details of venation pattern.
- (Scale: 1 cm)



PLATE 2

Pl. 1, Fig. 1, 3, 5; Pl. 2, Fig. 1

Description— Detached pinnae linear, gradually narrowing towards base and apex; ranges in size from 5-12cm x 1-2.5cm; pinna rachis distinctly marked, 1mm wide, with a distinct groove, pinnules closely set, attached to the rachis laterally by their entire base at an angle of 35°-50°, bases of adjoining pinnules joining with each other and arranged in opposite to subopposite fashion. Basal pinnules small, deltoid, measuring 1mm; pinnules of middle region linear, lanceolate 1.5cm in size and tapering towards apex. Apex acute; margin entire, prominent midrib, lateral veins not distinctly marked, sometimes show forking.

Fertile pinnules possess uniformly arranged sori on either side of midrib covering almost entire length of pinnule; number of sori varies from 10-20 per pinnule placed between margin and midrib; sori circular to oval or elliptical in shape; slightly bulging upward from the lamina.

Comparison—The pinnae and pinnules in gross morphology resembles *Matonidium indicum* Sahni (1936). The species *Matonidium indicum* is also described from Lower Cretaceous of Himmatnagar and Gujarat (Benerjee *et al.* 1983). It is also comparable to *M. goeppertii*, (Ettingshausen) Schenk in its shape and size of pinnules. However, *M. goeppertii* possesses typically 10 sporangia in its sorus; in contrast present species shows 10-12 sori. *Matonidium cingulatum* (Zeba-Bano and Bose 1981) is distinct in absence of cingulate spores.

Genus—*Sphenopteris* Sternberg 1825

Sphenopteris hislopii Oldham and Morris 1863

Pl. 2, Fig. 3; Pl. 3, Figs 3, 4

Description—Four incomplete specimens rang-

ing in size from 2-7cm in length and 1.5-5cm in width present in the collection; rachis 1mm wide, pinnae suboppositely arranged with an angle of 45°-50°. Pinnae lobed and contracted towards apex, pinnule oval alternately disposed, decurrent with rounded apex; margin entire measuring 5-6mm wide at base, veins arising from the base and diverging to its apex, forked at least once.

Comparison— The present specimens show resemblance with *Sphenopteris hislopii* (Surange 1964).

Sphenopteris metzgerioides Harris 1961

Pl. 4, Fig. 4

Description— A branched leafy shoot approximately 4cm in length, 3.5cm in width, dissected dichotomously and ultimate branches form broad spatulate pinnule, dissected, margin entire, venation indistinct.

Comparison—The specimen compares with *S. metzgerioides* is showing characteristic dichotomous branching and the lamina being fan shaped/spatulate, divided into small segments.

Sphenopteris arguata Lindley and Hutton 1834

Pl. 1, Fig. 9

Description— Frond with strong stout rachis measuring 4cm in length and 1.5cm in width. Pinnae arranged on the rachis preserved only on one side and measures 2.5cm in length and 1cm in breadth. The lamina lobed and sometimes lobe reaches upto the base, midrib not distinctly marked, secondary veins fork at an acute angle.

Comparison—The frond in its gross morphology, comes closer to *Sphenopteris*. However, it is typically

PLATE 3

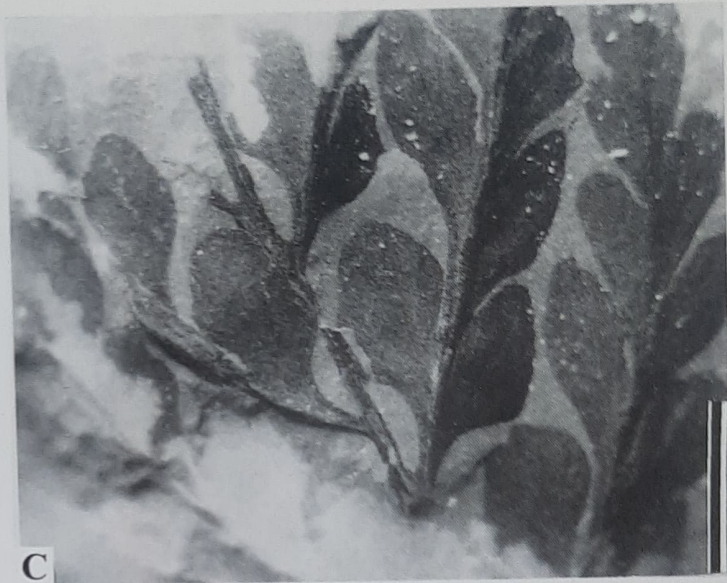
1. *Todites indicus*, showing details of fertile structure.
2. *Cladophlebis indica*, showing shape and attachment of pinnules.
3. *Sphenopteris hislopii*, exhibiting details of venation pattern.

4. *Sphenopteris hislopii*, specimen showing lobing, attachment and venation.
5. *Cladophlebis medicottiana*, showing shape, size and attachment of pinnules.

(Scale: 1 cm)



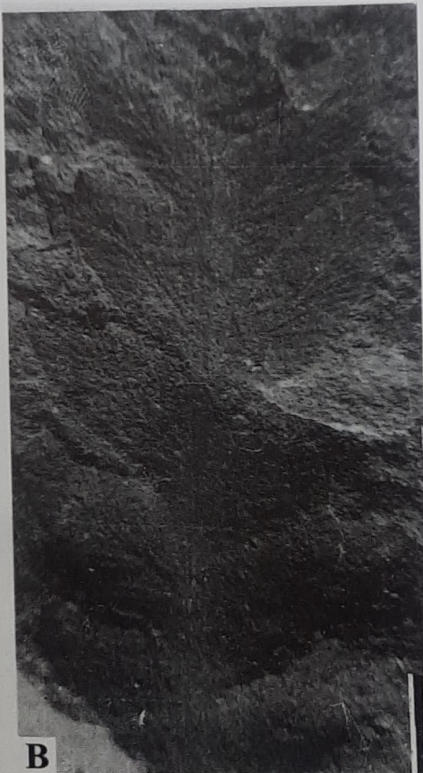
A



C



D



B



E

different from *S. affinis* in shape and shows resemblance with *S. arguata* (Surange 1964) in rhomboid shape, attachment and arrangement of pinnules.

DISCUSSION

The analysis of pteridophytic flora represented by *Coniopteris quenqueloba*, *Gleichenites gleichenoides*, *Todites indicus*, *Phlebopteris athgarhensis*, *Cladophlebis indica*, *C. medicottiana*, *C. denticulata*, *Matonidium indicum*, *Sphenopteris hislopii*, *S. arguata* and *S. metzgerioides* indicates that the genus *Coniopteris* is most characteristic and represents the fertile frond of Dicksoniaceae. The family Osmundaceae is represented by *Cladophlebis indica*, *C. meddicottiana*, *C. denticulate* and *Todites indicus*. The genera *Matonidium indicum*, *Phlebopteris athgarhensis* indicate the occurrence of family Matoniaceae and *Gleichenites gleichenoides* represents the family Gleicheniaceae. Three species of *Sphenopteris* viz., *Sphenopteris hislopii*, *S. arguata*, *S. metzgerioides* represents the diversity of ferns in the area. From the foregoing account it is evident that fern-like Dicksoniaceae, Dipteridaceae, Matoniaceae and Gleicheniaceae were well established and abundantly represented in India. These families are also represented in Dubrajpur (Banerji 1990), Gardeshwar (Bose *et al.* 1983), Gangapur (Sukh-Dev & Rajnikanth 1988), Gollapalle (Pandya & Sukh-Dev 1990), Himmatnagar (Benerji *et al.* 1983), Jabalpur Formation (Maheshwari & Kumaran 1976, Zeba-Bano 1979, Pandya & Sukh-Dev 1990), Tarnetar, Umia (Shah *et al.* 1991), Athgarh (Prakash & Sukh-Dev 1994, Patra 1971, Patra & Sahoo 1992) and Rajmahal Hills, Bihar (Sahni & Rao 1934, Bose & Sah 1968, Sharma 1991, Benerji 1995). It is noteworthy that these ferns survived in association with the gymnospermous plants; as evidenced by the dominance of Bennettiales and Coniferales in the area

(Srivastava *et al.*, 1999, 2001).

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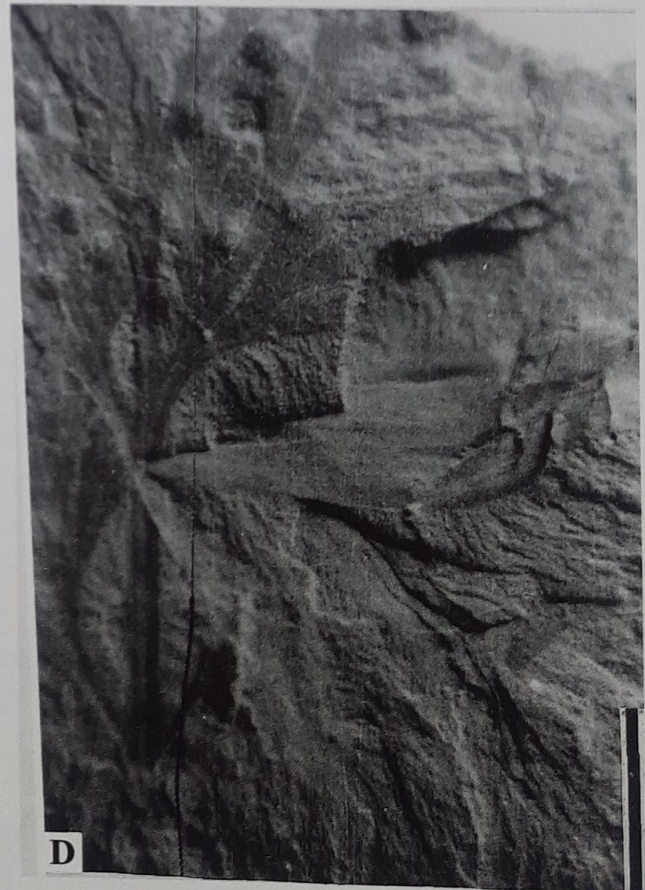
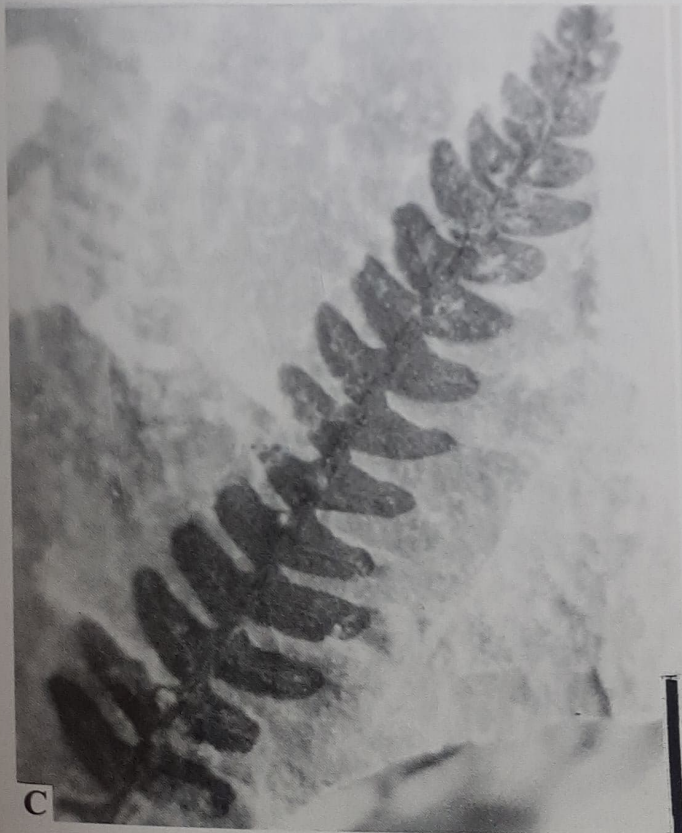
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PLATE 4

1. *Gleichenites gleichenoides*, a sterile frond exhibiting morphographic features.
 2. *Cladophlebis indica*, showing details of ventation pattern.
 3. *Cladophlebis denticulata*, specimen showing details of pinna.
 4. *Sphenopteris metzgerioides*, showing morphographic features.
- (Scale: 1 cm)



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