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PACHYPTERIS HABURENSIS N. SP. AND OTHER PLANT FOSSILS FROM THE PARIWAR FORMATION

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ABSTRACT

Fossil plant remains collected from the Pariwar Formation, exposed about 1 km east of Habur Village, are described here. The floral assemblage at Habur is dominated by a new species of *Pachypteris* (*P. haburensis*). Besides, the assemblage comprises a fertile species of *Gleichenia*, *Pachypteris* sp., *Taeniopteris spatulata* McClelland, *Ginkgo* sp., *Elatocladus tenerrima* (Feistmantel) Sahni, *Pagiophyllum* spp., *Araucarites* sp. cf. *A. cutchensis* Feistmantel, *Coniferocaulon rajmahalense* Gupta and a 'flower'-like organ.

Key-words — *Pachypteris*, Megafossils, Pariwar Formation, ?Upper Jurassic-Lower Cretaceous (India).

सारांश

परिवार शैल-समूह से पेकिप्टेरिस हाबुरेन्सिस नव जाति एवं अन्य पादपाश्म – महेन्द्रनाथ बोस, के० पी० नवनीथ कुमारन एवं जयश्री बैनर्जी

हाबुर गाँव के पूर्व में लगभग एक किलोमीटर की दूरी पर विगोपित परिवार शैल-समूह से पादपावशेषों का वर्णन किया गया है। हाबुर में वनस्पति जातीय समुच्चय पेकिप्टेरिस की एक नई जाति (पे० हाबुरेन्सिस) से प्रभावी है। इसके अतिरिक्त इस समुच्चय में ग्लाइकीनिआ की बन्ध्य जातियाँ, पेकिप्टेरिस जा०, टीनिआप्टेरिस स्पेटुलेटा मैक्क्लीलैंड, गिन्कगो जा०, इलेटोक्लेडस टेंनेरिमा (फ़ाइस्टमॅन्टेॅल) साहनी, पेजियोफ़िल्लम् जा०, अॅराकेराइटिस जा० सजातीय अॅ० कच्छेन्सिस फ़ाइस्टमॅन्टेॅल, कोनिफ़ेरोकोलॉन राजमहलेन्से गुप्ता तथा एक 'पुष्प'-सदृश अवयव हैं।

INTRODUCTION

THE exposed Mesozoic sediments in the Jaisalmer basin are mostly of post-Triassic age and have been classified into Lathi, Jaisalmer, Baisakhi, Bedesar, Pariwar and Abur formations. According to Das Gupta (1974) they range in age from Liassic to Aptian. Out of these formations, until recently, plant fossils (petrified woods) were known to occur only in the Lathi Formation. Das Gupta *et al.* for the first time discovered plant impressions from the Pariwar Formation in 1975. Later a part of this collection was described in detail by Maheshwari and Singh (1976). During our recent trips (1978 and 1979) to Jaisalmer we have also collected plant remains from the same locality. Besides, we have collected fossil wood pieces from Lathi, Baisakhi, Bedesar and Pariwar formations. The wood pieces are rather badly preserved so in the present paper only the plant impressions have been described.

The fossiliferous bed, having plant impressions, is situated approximately 1 km east of Habur Village (27°10′: 70°33′) which is about 60 km from Jaisalmer. The exposures are seen along the eastern fringe of a water reservoir ("*Seraliya ka toba*" — except for the rainy season, lying dry throughout the year). The succession at this place from bottom to top is as follows:

Rock types	from to	Thickness	Fossil Occurrence
Variegated shales	—	A thin layer	Indeterminable fragmentary plant remains.
Dirty white, yellowish or brownish cross bedded, fine grained, highly friable sandstone with ferruginous shale partings.	00 m-0·90 m	0·90 m (P_1)*	Ferruginous fossil woods.
Yellowish shale (commonly arenaceous), seems to be marly in nature with remains of rich plant fossils. At places ferruginous partings visible.	0·90-1·40 m	0·50 m (P_2)	Fossiliferous bed with fairly well preserved plant impressions, dominated by *Pachypteris haburensis* n. sp.
Yellowish to brownish coloured. At places thinly laminated, fine to medium grained micaceous soft sandstones (?feldspathic in nature) also containing thin ferruginous intercalations.	1·40-2·10 m	0·70 m (P_3)	Fragments of fossil woods, rare occurrence of *Pagiophyllum* sp. and *Taeniopteris spatulata* McClelland.
Silty to sandy white laminated shales with fine grained sandstone intercalations. Shale calcareous in nature; in upper part at places, light purplish in colour showing rain prints-like markings.	2·10-3·50 m	1·40 m (P_4)	Rarely with indeterminable fragmentary plant remains.
Dirty brown, slightly micaceous, ferruginous, soft, somewhat fine grained sandstone with thin ferruginous partings particularly in the upper part, also at places concretionary.	3·50-4·30 m	0·80 m (P_5)	Fossil wood fragments.

*P_1 — P_5 indicate the different beds from where rock samples have been collected.

DESCRIPTION

Gleichenia sp.

Pl. 1, figs 5,6; Text-fig. 1C-D

1976 ?*Gleichenites* sp.: Maheshwari & Singh, p. 116, pl. 1, fig. 2.

A detached fragmentary pinna of ?*Gleichenites* sp. was described by Maheshwari and Singh (1976). The present collection includes a few detached pinnae with both sterile and fertile pinnules.

Description — Pinnae 0.4-1.1 cm long and 0.2-0.3 cm wide. Pinna rachis 0.5 mm wide, striated or with a median ridge. Pinnules alternate, attached at 40°-45°, deltoid in shape, rarely somewhat falcate, 1-1.5 mm long and 0.5-1.5 mm broad at base, margin entire, slightly revolute; apex obtuse, acroscopic margin straight; basiscopic margin slightly decurrent, touching acroscopic margin of the pinnule lying below. Substance of lamina thick. Veins obscure, only in some mid-vein visible, secondaries not preserved. Fertile pinnule with a single sorus placed near upper margin but closer to base. Sorus circular or oval with a central oval or circular depression. The number of sporangia not discernible.

Collection — Nos. 21/2095 and 28/2095 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Comparison — The fertile pinnules of *Gleichenia* sp. are more like the fertile pinnules of *G. gleichenoides* (Oldham & Morris) Bose & Sah (1968, pl. 4, fig. 26). In both the species the shape of pinnules is more or less similar and each pinnule has a single sorus which is placed closer to the upper margin. *G. gleichenoides* has 12-15 sporangia. In the present specimens sporangia are not preserved. In *G. bosahii* Pant & Srivastava (1977), too, each fertile pinnule has a single sorus which is placed near base. *G. bosahii* differs in having closely set pinnules which have more obtuse

apices. In *G. yuasensis* Kimura & Kansha (1978) the sterile pinnules are more like the pinnules of the present species but the pinnules in the former species have acuminate apex.

Pachypteris haburensis n. sp.

Pl. 1, figs 11, 12; Text-figs 1A-B, 2A-C

1972 *Onychiopsis* sp. cf. *O. psilotoides* (Stokes & Webb) Ward: Mathur, p. 488, fig. 19.
1975 *Cladophlebis* sp. (?): Das Gupta *et al.*, p. 236, fig. 3.
1976 Frond Type-1: Maheshwari & Singh, p. 117, pl. 1, fig. 8.

Diagnosis — Frond bipinnate, shape as a whole broadly lanceolate, up to 13 cm long and 7 cm wide. Main rachis 2-5 mm wide, with faint longitudinal striations, at times with a prominent median ridge. Pinnae closely set, alternate, rarely near apex sub-opposite, touching each other or at places even overlapping, arising at 30°-35°. Pinna rachis 0.5 mm wide, extremely delicate and slightly raised. Pinnules arising near base at 25°-30°, near apex at 15°-20°; crowded, touching each other or overlapping adjacent pinnules, lanceolate, apical pinnules sometimes pinnatifid, 2-4 mm long and about 1 mm broad, basal pinnules 5-7 mm long, 1-1.5 mm broad, apex acute-subacute; margin entire; acroscopic margin constricted or slightly decurrent; basiscopic margin decurrent, decurrent base of the lowermost pinnule running almost parallel to main rachis and touching the basiscopic margin of the pinnule belonging to pinnae lying below. Veins obscure, only at places principal vein visible, secondary veins few, rarely preserved, making narrow angle with the primary vein.

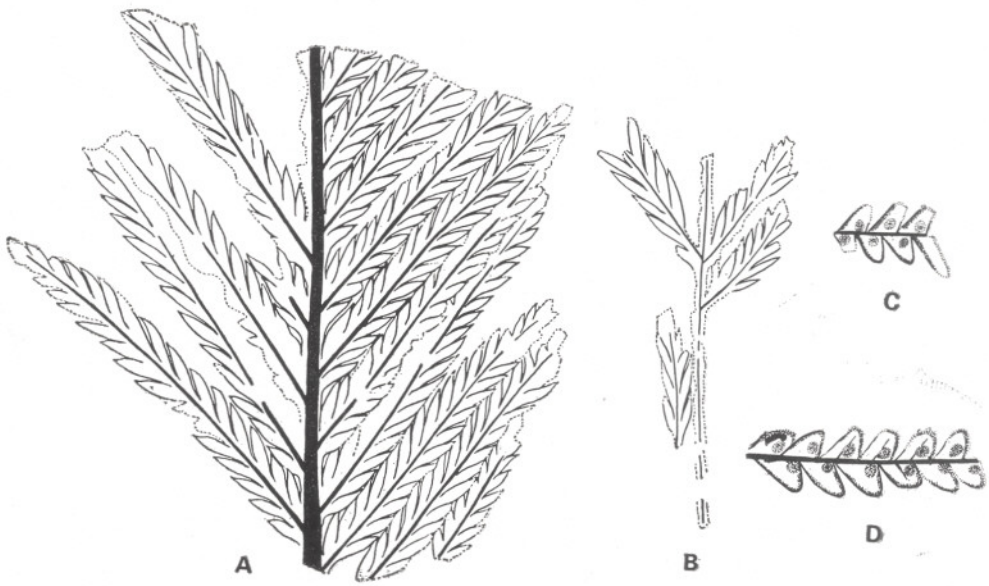
Holotype — Specimen no. 18/2011 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Locality — 1 km east of Habur Village.

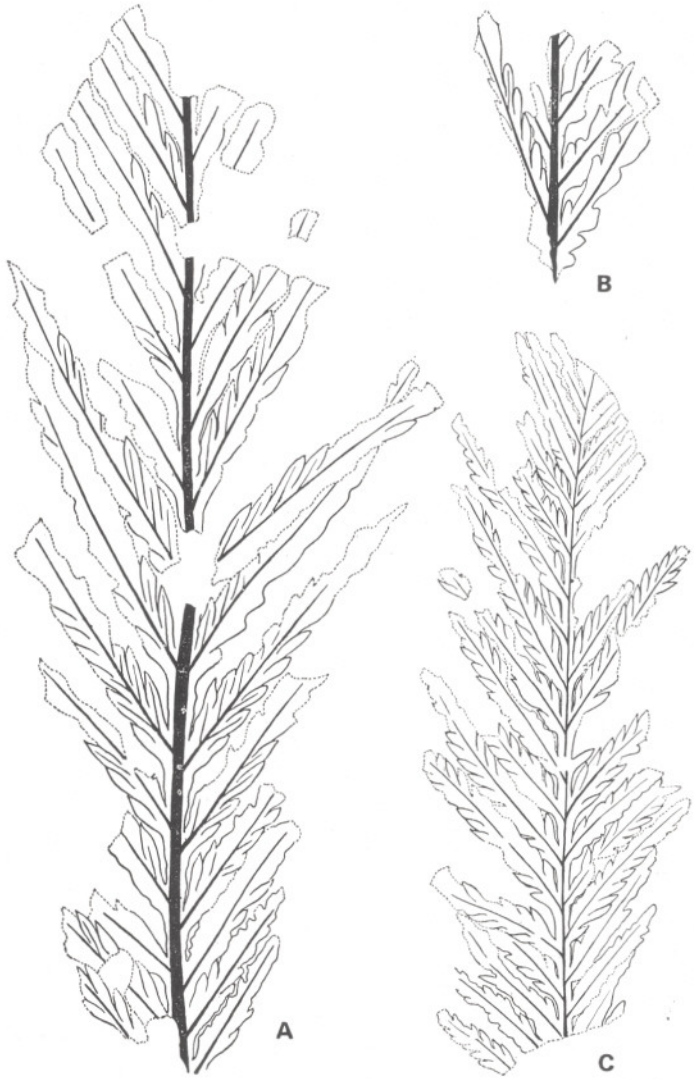
Horizon & Age — Pariwar Formation; ?Upper Jurassic-Lower Cretaceous.

Comparison — At Habur *Pachypteris haburensis* is the commonest species. Associated with these leaves quite a few branched specimens (Text-fig. 3F) have been collected. They seem to be the basal parts of main rachis of large fronds (probably of *P. haburensis*). The branches are 4-6.4 cm long.

The smaller fronds of *P. haburensis* resemble *Scleropteris ceassa* Halle (1913, pl. 4, fig. 4a) described from Graham Land.



TEXT-FIG. 1 — **A-B,** *Pachypteris haburensis* n. sp., B.S.I.P. nos. 12/2011, 21/2011, × 1; **C-D,** *Gleichenia* sp., B.S.I.P. nos. 21/2095 and 28/2095, × 3.



TEXT-FIG. 2 — **A-C,** *Pachypteris haburensis* n. sp., B.S.I.P. nos. 26/2011, × 2, 1/2011 and 20/2011, × 1.

The Graham Land specimens have smaller pinnae and pinnules, also the pinnae are slightly more distantly placed. In general habit of fronds *P. haburensis* resembles *S. pomelii* Saporta (1873, pl. 46, fig. 1; pl. 47, fig. 1). *P. haburensis* differs in having pinnatifid apical pinnules. The basal pinnules of *P. haburensis* are like the smaller pinnules of *Pachypteris indica* (Oldham & Morris) Bose & Roy (1968). In the latter species pinnae are much more distantly placed and the majority of pinnules is bigger in size. *P. holdenii* Bose & Roy (1968) is based on a detached pinna with well-preserved cuticle. The pinnules of this species are bigger in size than those of *P. haburensis*. *P. lanceolata* Brongniart described by Harris (1964) from Yorkshire has larger and broader pinnules. However, a small leaf, figured by Harris (1964, fig. 56c), somewhat resembles the apical part of leaves of *P. haburensis*. The former specimen has distantly placed pinnae and broader pinnules.

Pachypteris sp.

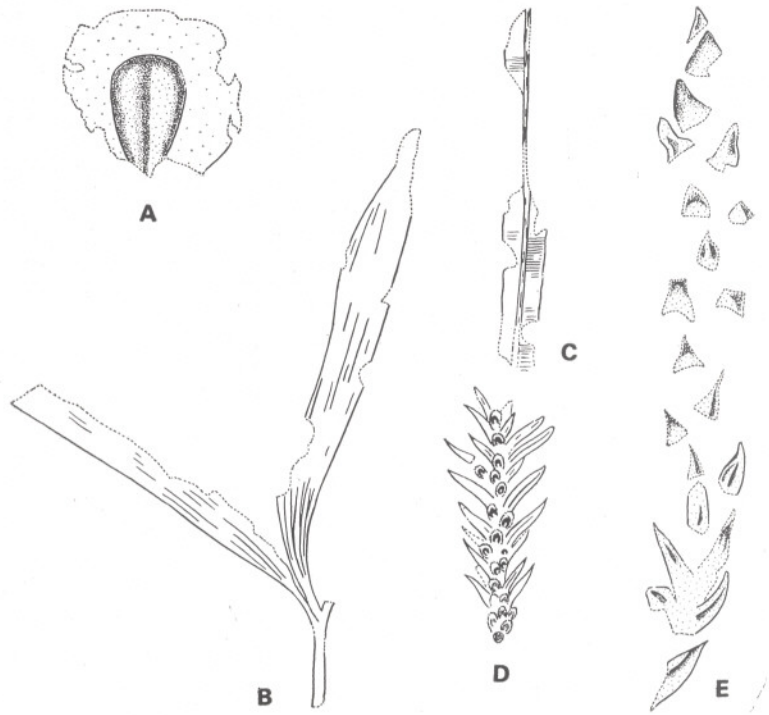
Pl. 1, fig. 9; Text-fig. 3E

Description — Detached pinna, 6×1.8 cm; rachis prominent, about 1 mm wide, showing a median ridge. Pinnules alternate or subopposite, arising at 25°-30°, lanceolate, 1-1.6 cm long, 0.2 cm broad; margin entire; apex acute, rarely sub-acute; acroscopic margin gradually curving down; basiscopic margin distinctly decurrent. In some, mid-vein faintly marked, secondary veins not visible.

Collection — No. 5/2011 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Comparison — The specimen resembles both *Pachypteris holdenii* Bose & Roy (1968, pl. 1, fig. 1) and *P. indica* (Oldham & Morris) Bose & Roy (1968, pl. 2, fig. 13). However, the pinnules of the present specimen are more like the ones in *P. holdenii*. Since cuticular details are not available so the specimen has not been referred to any of these species.

TEXT-FIG. 3 — **A-D,** *Ginkgo* sp., B.S.I.P. nos. 50/2095, 51/2095, 46/2095 and 27/2095; A, B, × 2; C, D, × 1; **E,** *Pachypteris* sp., B.S.I.P. no. 5/2011, × 1; **F,** basal portion (?) rachis, B.S.I.P. no. 19/2011, × 1.



TEXT-FIG. 4 — **A,** *Araucarites* sp. cf. *A. cutchensis* Feistmantel B.S.I.P. no. 15/2011, × 2; **B,** *Ginkgo* sp. B.S.I.P. no. 9/2011, × 2; **C,** *Taeniopteris spatulata* McClelland, B.S.I.P. no. 25/2011, × 1; **D,** *Pagiophyllum* sp. B, B.S.I.P. no. 25/2011, × 2; **E,** *Pagiophyllum* sp. A, B.S.I.P. no. 17/2011, × 2.

**Taeniopteris haburensis* Bose & Banerji

Remarks — The new collections include a large number of leaves of *Taeniopteris haburensis*. At Habur, after *Pachypteris haburensis* they are next in abundance. The largest specimen so far collected measures 23.8 cm in length and 2.4 cm in breadth. The specimen is incomplete both at base and apex. It seems that the length must have exceeded more than 25 cm. The largest specimen of Maheshwari and Singh (1976) did not exceed 14 cm in length.

*This species was originally described by us as *Taeniopteris vittata* Brongniart, which was expected to have been published in 1980. However, due to unavoidable circumstances the publication of this paper was delayed. In the meantime Bose & Banerji (1981) assigned our specimens of *T. vittata* to a new species, *Taeniopteris haburensis* and referred them under the synonymy of this new species.

Taeniopteris spatulata McClelland

Pl. 1, fig. 4; Text-fig. 4C

This species has already been described by Maheshwari and Singh (1976). In addition to new specimens from the main fossiliferous bed (P_2) we have also collected a specimen from the ferruginous shale partings from the underlying bed (P_3). The description of the specimen is given below.

Description — Leaf fragmentary, simple, narrow, strap-shaped, 4 × 0.5 cm; margin entire, base and apex not preserved. Midvein prominent, about 0.5 mm wide; lateral veins arising almost at right angle, simple or forked.

Collection — No. 25/2011 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Comparison — In general shape and venation pattern the present specimen resembles most the specimen of *T. spatulata*

described by Maheshwari & Singh (1976, pl. 2, fig. 13; text-fig. 5). It may also be compared with the specimens of *T. spatulata* figured by Feistmantel (1879, pl. 1, figs 8, 9), from Vemavaram. In the Vemavaram specimens the secondary veins bifurcate just after emergence. Here the secondary veins are mostly not well-preserved near the point of emergence, so their exact nature is not clear.

Ginkgo sp.

Pl. 1, fig. 10; Text-figs 3A-D, 4B

Description — Leaf petiolate, maximum available length of petiole 0.9 cm, finely striated. Lamina as a whole obcuneate, deeply divided into segments. Central division reaching almost up to apical part of petiole. Segments simple or forked, when forked segment dividing once, more than 9 in number. Unforked segments somewhat lanceolate in shape, with obtuse apices. Near base veins about 2-3 per segment, higher up due to forking approximately 4-6, parallel.

Collection — Nos. 51/2095, 50/2095, 46/2045 and 27/2095 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Comparison — *Ginkgo* sp. resembles most the smaller leaves of *Ginkgo* sp. cf. *sibrica* Heer described by Harris and Millington (in Harris, Millington & Miller 1974, text-fig. 5E, F) from Petrad Point, Yorkshire. *Ginkgo* sp., however, differs in having lobes which are much closely set or even overlapping at places. *G. rajmahalensis* (Sah & Jain) Zeba-Bano *et al.* (1979) has mostly broader lobes and they are not so deeply dissected. Das Gupta *et al.* (1975) had described a specimen as *Actinopteris* sp. It is quite likely that this specimen is same as *Ginkgo* sp. described here. The specimen seems to be more complete than the ones present in our collection.

Elatocladus tenerrima (Feistmantel) Sahni

Pl. 1, fig. 9

1976 ?*Elatocladus* sp.: Maheshwari & Singh, p. 121, pl. 2, figs 16a, 17.

Amongst the several specimens of *Elatocladus conferta* (Oldham & Morris) Halle collected from Habur one specimen proved to be *E. tenerrima* (Feistmantel) Sahni (Pl. 1, fig. 7). The specimen is rather fragmentary and it matches exactly the specimens of *E. tenerrima* earlier described by Sahni (1928, pl. 1, figs 10-12) and *E. sehoraensis* Maheshwari & Kumaran (1976).

Description — Leafy twig, 2.2 cm long and 0.9 cm broad; leaves biseriately arranged, linear, rarely slightly falcate, 9 mm in length and 6 mm in width, margin entire, apex rounded; acroscopic margin constricted; basiscopic margin markedly decurrent. Midvein clearly marked.

Collection — No. 37/2095 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Pagiophyllum sp. A

Pl. 1, fig. 13; Text-fig. 4E

Description — Shoot about 5.4 cm long, with spirally arranged leaves, leaves at base more divergent than apical leaves. Basal leaves narrower and longer than apical leaves, about 4 mm long and 2 mm broad; apical leaves triangular, about 3 mm long and 2 mm broad. Apex acute, margin entire.

Collection — No. 17/2011 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Comparison — The apical leaves are somewhat like *Pagiophyllum bansaensis* Bose & Sukh-Dev (1972, pl. 2, fig. 10) and the apical leaves of *P. marwarensis* Bose & Sukh-Dev (1972, pl. 1, fig. 3). *Pagiophyllum* sp. A also resembles, to some extent, some of the twigs of *P. connivens* Kendall (1948) in general shape of leaves.

Pagiophyllum sp. B

Pl. 1, figs 1, 2; Text-fig. 4D

Description — Unbranched leafy twig, approximately 2 cm long. Leaves crowded, spirally arranged, diverging, 2-3 mm long and 0.5 mm broad, falcate, lower surface keeled; margin entire; apex acute; base decurrent, concealed by leaves below.

Collection — No. 25/2011 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Comparison — The specimen described above was collected from the ferruginous shale partings of the bed (P_3) which is overlain by the main fossiliferous plant bed (P_2). *Pagiophyllum* sp. described by Maheshwari and Singh (1976, pl. 2, fig. 16b) from Habur matches with the present specimen. In general form of leaves *Pagiophyllum* sp. B resembles *P. rewaensis* Bose & Sukh-Dev (1972, pl. 1, fig. 6). However, the present specimen has smaller leaves. In leaf size *Pagiophyllum* sp. B is more like *P. marwarensis* Bose & Sukh Dev (1972) but the latter has more broader and divergent leaves. *Pagiophyllum* sp. B also resembles one of the shoots of *Elatocladus heterophylla* Halle (1913, pl. 8, fig. 20). However, *E. heterophylla* differs in having more spreading leaves.

Araucarites sp. cf. *A. cutchensis* Feistmantel

Pl. 1, fig. 3; Text-fig. 4A

Description — Detached seed-scale, both base and apex missing, approximately 1.1 cm long and 1.4 cm broad at broadest region. Seed obovate, 0.7 cm long and 0.5 cm broad, showing a prominent median ridge.

Collection — No. 15/2011 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Comparison — The specimen is too fragmentary and bigger in size than *Araucarites minutus* Bose & Maheshwari (1973). In general shape and size it is more like *A. cutchensis* Feistmantel described by Bose & Maheshwari (1973, pl. 1, figs 3, 4; text-fig. 1C). But in the absence of base and apex it is difficult to assign the present specimen to any of the known species with certainty.

Coniferocaulon rajmahalense Gupta

Pl. 1, fig. 14

Description — The collection includes three specimens resembling *Coniferocaulon rajmahalense* Gupta (1954). They are 3.3 cm to 11 cm in width and are characterized by narrow transverse grooves. Within the grooves lense-shaped protuberances are present, these range in size from 4-5 mm in length and 1-1.5 mm in breadth.

Collection — No. 11/2011 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Comparison — The genus *Coniferocaulon* was previously described from India by Bancroft (1913), Sahni (1931), Gupta (1954), Bose (1959), and Bose *et al.* (1979). Amongst these, the present specimens resemble most the specimen described by Bose *et al.* (1979) from Gardeshwar.

SPECIMEN TYPE A

Pl. 1, fig. 8

Description — A small 'flower' like organ, about 1.1 cm long and 0.9 cm broad at broadest region, more or less inverted bell-shaped. Bracts spirally arranged; 1.1 cm in length and 1-1.5 mm in width, near apex bracts slightly spreading and curving downwards; margin entire.

Collection — No. 35/2095 of the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Remarks — The specimen is rather small in size. It could be a small Bennettitalean " flower ".

DISCUSSION

From the Pariwar Formation, exposed near Habur, Maheshwari and Singh (1976) had described *?Gleichenites* sp., *Phlebopteris* sp., Frond Type-1, *Taeniopteris vittata* Brongniart, *T. densinervis* Feistmantel, *T. spatulata* McClelland, *Pterophyllum* sp., *Otozamites imbricatus* Feistmantel, *Ptilophyllum acutifolium* Morris, *Elatocladus conferta* (Oldham & Morris) Halle, *?Elatocladus* sp. and *Pagiophyllum* sp. Except *Otozamites imbricatus* and *Ptilophyllum acutifolium* the present collection includes all these species. In addition, it has *Pachypteris* sp., *Ginkgo* sp., *Elatocladus tenerrima* (Feistmantel) Sahni, *Pagiophyllum* sp. A, *Araucarites* sp. cf. *A. cutchensis* Feistmantel and *Coniferocaulon rajmahalense* Gupta.

The mega-plant assemblage at Habur is dominated by the presence of *Pachypteris haburensis* n. sp. The next in abundance are *Taeniopteris haburensis* Bose & Banerji, *Elatocladus conferta* (Oldham & Morris) Halle and *Pterophyllum* sp. respectively. The species belonging to *Pagiophyllum* is extremely rare and so far the genus *Brachyphyllum* has not been found at Habur. So the mega-plant assemblage at Habur really does not fit in the sub-zone *Pagiophyllum-*

Brachyphyllum of Sah, Singh and Sastry (1971, table III) as was suggested by Maheshwari and Singh (1976). The assemblage is more like the one known from Kakadbhit in Kachchh. At Kakadbhit the flora has a fair representation of *Pachypteris*, *Taeniopteris* (*T. haburensis*) and *Otozamites*. The Habur assemblage differs in having *Gleichenia* which is more common in the Lower Cretaceous though it is also known from the Upper Jurassic. So far the genus *Gleichenia* has not been found anywhere in Kachchh. In the presence of *Gleichenia* and in having *Pachypteris*, *Taeniopteris spatulata* and *Ptilophyllum* the assemblage from Parsapani, Satpura basin is somewhat like the one met with at Habur. However, at Habur *T. spatulata* and *Ptilophyllum* are rare, whereas, both these are quite common at Parsapani. Because of the presence of *Gleichenia* it is likely that the fossiliferous bed exposed near Habur is somewhat younger in age than the fossiliferous plant bearing beds of Kachchh.

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EXPLANATION OF PLATE

1, 2. *Pagiophyllum* sp. B., B.S.I.P. No. 25/2011, fig. 1 (× 1), fig. 2 (× 2).
3. *Araucarites* sp. cf. *A. cutchensis* Feistmantel, B.S.I.P. No. 15/2011.× 1.
4. *Taeniopteris spatulata* McClelland, B.S.I.P. No. 25/2011.× 1.
5, 6. *Gleichenia* sp. showing fertile pinnules, B.S.I.P. Nos. 21/2095 and 28/1095.× 2.
7. *Elatocladus tenerrima* (Feistmantel) Sahni, B.S.I.P. No. 37/2095.× 1.
8. Specimen Type-A, B.S.I.P. No. 35/2095. × 2.
9. *Pachypteris* sp., B.S.I.P. No. 5/2011.× 1.
10. *Ginkgo* sp., B.S.I.P. No. 51/2095.× 1.
11,12. *Pachypteris haburensis* n. sp., B.S.I.P. Nos. 18/2011 (Holotype) and 20/2011.× 1.
13. *Pagiophyllum* sp. A., B.S.I.P. No. 17/2011. × 1.
14. *Coniferocaulon rajmahalense* Gupta, B.S.I.P. No. 11/2011.× 1.

PLATE 1