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ADDITIONS TO THE JURASSIC FLORA OF DHOKUTI IN THE RAJMAHAL HILLS, INDIA

Przyczynek do jurajskiej flory z Dhokuti, Rajmahal Hills, Indie

ABSTRACT

Descriptions are given of the recently collected fossil plants from Dhokuti in the Rajmahal Hills, Bihar. These include new genera and species in addition to the previously described materials from this locality. Among the pteridophytes the dominating plants are *Selaginella, Cladophlebis, Gleichenia, Dicksonia, Sphenopteris* etc., and in gymnosperms the cycads and *Bennettitales* which occur abundantly in this locality. *Ginkgoites* and taxads are also known but not found frequently. The palaeoecological conditions of this flora are discussed and its correlations with other localities in the Rajmahal Hills are considered.

INTRODUCTION

The fossiliferous locality of Dhokuti is rich in fossil ferns, cycads and *Bennettitales* (S h a r m a 1969, 1971, 1972). Recently the author collected more fossil plants from this locality obtaining very interesting materials; some of these are described in the present paper. Fossil pteridophytic fronds occur both in fertile and sterile forms. In the former sori are found well-preserved but not sporangia and spores. Among gymnosperms, male as well as female fructifications of the bennettitalean plant *Williamsonia* are known but the fertile parts of cycads, *Ginkgoites* and taxads have not so far been reported.

All these plants are found preserved as impressions except the wood pieces of *Taxaceoxylon cupressoides* Sharma (S h a r m a 1970) which are found in a petrified state, but occur rarely.

DESCRIPTION

Pteridophytes: Commonly occurring pteridophytes in the locality of Dhokuti are *Selaginella, Cladophlebis, Gleichenia, Dicksonia, Klukia, Haydenia and Sphenopteris.* In addition of these types there are also others which are, however, rare e.g. *Equisetum, Todites* etc. In the present paper only those types are included which are new or recorded for the first time or which have previously been described on insufficient material, and better specimens now being available in author's collection.

Selaginella

A large number of beautifully preserved specimens of *Selaginella* are present in the author's collection. These are of two types as described elsewhere by the author (Sharma 1971). Plants resembling *Selaginellites* sp. A. (Sharma 1971) occur more frequently than those of *Selaginellites* sp. B. (Sharma 1971). Preserved fertile spikes belonging to the former have been found but similar parts of the latter have yet to be reported. The author does not think it proper to establish any new species on the basis of the present collection as the details of sporangia and spores still remain unknown.

In *Selaginella (Selaginellites)* sp. A. plants are large and monopodially branched (Pl. I, fig. 1). Branches are sparse in the vegetative part of the plant but the fertile spikes are produced in clusters of four or five (Pl. I, fig. 2). Similarly, leaves are distantly placed on the vegetative branches while sporophylls are closely and compactly disposed in the fertile spikes. Both leaves as well as sporophylls are heterophyllous, sessile and arranged in four rows. Lateral leaves /sporophylls are larger than the two rows of the dorsal leaves/ sporophylls.

Equisetites rajmahalensis O. and M. (1863)

The present author's collection contains a small specimen and its counterpart. It measures 2·2 × 0·8 cm and represents a small portion of stem (Pl. I, fig. 3). The nodal portion is smooth while in the internodal part alternating ridges and furrows are seen.

The specimen resembles closely the one reported by Bose and Sah (1968), (Pl. I, fig. 6) and described as *Equisetites rajmahalensis* Oldham and Morris (1863).

Cladophlebis denticulata Brongn.

Sterile fronds of osmundaceous nature are found in abundance in the fossiliferous locality of Dhokuti, but fertile specimens are rare. However, in a recent collection the author was able to gather quite a large number

Text-fig. 1. × 5·2; 1 — *Dennstaedia rajmahalensis* sp. nov.: Pinnules with sori; 2 — *Gleichenia dhokutense* sp. nov.: Pinnules with naked sori; 3 — *Cladophlebis denticulata* Brongn.: 8—12 sporangia in each sorus; 4 — *Dicsonia speciosa* sp. nov.: Large, inverted boat-shaped sori with slit-like openings; 5 — *Dryopteris cladophleboides* sp. nov.: A fertile pinnule; 6 — *Haydenia thyrsopteroides* Sew.: Pinnules with circular sori; 7 — *Dryopteris indica* Sharma.: Fertile pinnules.

of beautifully preserved fertile specimens with their counterparts. The following description is based on the study of these specimens.

Frond bipinnate; pinnae 10—14 cm long; pinnules linear, 1·9—2·4 × × 0·4—0·5 cm in size, apex acute or obtuse, margins smooth wavy or dentate; unicostate, secondary veins present, forking not observed in the proximal fertile pinnules but visible in the distal sterile ones. Sori large, 1·0 × 0·8 mm in size, naked, present on the abaxial side of the lamina on either side of the midrib. Concentration of sori is greater in the proximal pinnules and gradually decreases towards the upper side, so that the distal pinnules are sterile (Pl. I, fig. 10), and show the typical characters of the vegetative frond of *Cladophlebis denticulata* Brongn. Each sorus is made up of 8—12 sporangia which are arranged more or less in lines (Text-fig. 1. 3). However, details of sporangia and spores are not preserved.

The vegetative as well as sterile fronds present in the author's collection resemble closely those of *Cladophlebis denticulata* (S e w a r d 1910, Fig. 258, p. 345). The occurrence of fertile and sterile pinnules in the same pinna leaves no doubt that the Indian material does not differ from *C. denticulata* Brongn. However, comparison is also made with the Palaeozoic form *Chansitheca argentina* Herbst (1963) in which the arrangement, position and nature of sori resemble the present material. The former may possibly be phylogenetically related to *C. denticulata.*

Gleichenia

Like the sterile fronds of *Cladophlebis denticulata,* the vegetative leaves of *Gleichenia gleichenoides* are also commonly found in the fossiliferous locality of Dhokuti (S h a r m a 1969). In addition of this species there are also sterile and fertile fronds resembling gleichenias in the author's collection; but for want of definite characteristics the vegetative fronds cannot be assigned to any specific taxonomic rank, while the fertile ones are described below and classified as a new species.

Gleichenia dhokutense sp. nov. Sharma

D i a g n o s i s. Frond tripinnate; pinnae gradually tapering towards the apex; pinnules arise at right angles to rachis of pinna, alternate, linear, 1·0—2·0 × 0·4—0·5 cm in size, with 6—8 pairs of ultimate pinnules or lobes. Ultimate pinnules ovate with obtuse or blunt apices, 1·5—2·2 × × 1—2 mm in size, each is provided with a vein which bifurcates, the anterior bifurcation terminating in a large, circular, naked sorus. Sorus

is 0·6—0·7 mm in diameter having 6—8 rounded, closely placed sporangia. Details of sporangia and spores remain unknown.

The type specimen No. BD 152/Raj. DHO. is preserved with its counterpart. The specimen contains three pinnae of one side of the rachis. Each pinna possesses nearly 15 pairs of secondary pinnae. 6—8 pairs of pinnules are produced on a secondary pinna. Sori are clearly seen in the type specimen (Text-fig. 1.2) as well as in specimen No. BD 83/Raj. DHO. (Pl. I, fig. 6). They are naked and abaxial.

The present material shows the typical characteristics of gleichenias in the shape, size, venation and soral structures. It differs from *Gleichenia gleichenoides* (B o s e and S a h 1968) in vegetative as well as fertile character. In the latter there are 4—5 sporangia in a sorus and secondary pinnules are comparatively more linear and longer than the new species. Comparison is also made with the allied species of gleichenias (H e r b s t 1962) but the present species differs from all others in the size of pinnules and soral character.

Dicksonia

This genus was reported for the first time from the Rajmahal Hills by F e i s t m a n t e l (1877) and described as the species *D. bundrabunensis* Fst. But in 1968, B o s e and S a h transferred it to *Sphenopteris bindrabunensis* (Fst.) Bose and Sah. In 1971, the present author described another species of *Dicksonia, D. rajmahalensis* from Dhokuti in the Rajmahal Hills, which is characterised by the kidney shaped marginal sori. In author's collection there are a number of sterile as well as fertile specimens resembling dicksonias; some of these are grouped into a new species *Dicksonia speciosa* described below.

Dicksonia speciosa sp. nov. Sharma

D i a g n o s i s. Frond large, tripinnate; pinnae 5—12 or more cm long with 12—18 pairs of secondary pinnae. Secondary pinnae are 2·1—2·8 cm long with 6—8 alternate or subopposite pairs of pinnules. Pinnules small, 1·2 × 1·0 mm in size, triangular with obtuse apices. Each pinnule receives a vein which bifurcates and diverges. In fertile pinnules sorus covers almost the entire abaxial area of pinnule, measuring 0·9 × 0·7 mm in size. The indusium is made up of two unequal flaps opening by a slit like aperture on the posterior side of sorus.

There are a large number of specimens in author's collection representing this species. The type specimen No. BD 89/Raj. DHO. (Pl. I, fig. 8) represents a small part of the frond showing sori on the abaxial surfaces

of pinnules. The sori are large and inverted, boat-shaped in appearance (Pl. II, fig. 12). In the sterile fronds which occur comparatively less frequently than the fertile ones, each pinnule receives a single vein which bifurcates. In the fertile frond, venation is not visible as the sorus covers almost the entire surface of pinnule (Text-fig 1. 4).

The new material resembles the living species of *Dicksonia, D. navarrensis* in the nature of sori with slit-like openings (Bierhorst 1971, Fig. 15—30 F, p. 284), but differs in other details. *Dicksonia speciosa* sp. nov. is also compared with the known species of fossil dicksonias (Seward 1910, Harris 1961) but differs from all others in its characteristic shape and size of sori.

Dennstaedia rajmahalensis sp. nov. Sharma

Diagnosis. Frond tripinnate, pinnae linear, 7—9 cm long with gradually reducing secondary pinnae. Secondary pinnae 2—2·5 cm long with 8—10 pairs of subopposite or alternate pairs of pinnules. Pinnules ovate, slightly falcate with obtuse apices and measuring 2·5—3·0 × 1·2—1·5 mm in size. They are unicostate with secondary veins. The first secondary vein of the anterior side terminates in a large, circular, 0·6—0·7 mm in diameter, more or less marginal sorus. Details of sporangia and spores not clear.

The author possesses a beautifully preserved type specimen No. BD 3/Raj. DHO. (Pl. I, fig. 4) representing this species. It contains four fertile pinnae with sori on pinnules (Pl. II, fig. 13; Text-fig. 1.1). Sori are large with circular aperture. In the proximal part of pinna, even two sori are present per pinnule.

The material resembles closely the living species of *Dennstaedia, D. adaintoides* in shape and venation of pinnules as well as in the position of sori (Bierhorst 1971, Fig. 15—30 C, p. 284). Comparison is also made with *Sphenopteris (Dicksonia) bindrabunensis* (Fst.) Bose and Sah (1968), but in the latter sori are kidney-shaped while in the new material they are circular.

Dryopteris

The occurrence of *Dryopteris* in Mesozoic rocks was reported for the first time by the author in an earlier paper (Sharma 1971) and described the species *D. indica* Sharma from Dhokuti in the Rajmahal Hills. In author's collection there are several specimens representing this genus. In addition to the description of *D. indica* given below on the basis of comparatively better preserved specimens, a new species is also described in the present paper.

Dryopteris indica Sharma

There are a number of specimens in author's collection representing this species. They show variations in shape and size of pinnules i. e. either the pinnules are entire with wavy margin or deeply lobed, but they are similar as to venation and soral characters. The midrib of pinnule branches to the side lamina or lobes, which further divide into opposite or alternate veinlets (Pl. II, fig. 19; Text-fig. 1.7). It is on some of these ultimate nerves that the kidney-shaped sori are produced on the abaxial surfaces of pinnules.

In the present collection there are specimens which resembe closely in vegetative character, i. e. shape, size and venation of pinnules, *Sphenopteris* cf. *S. lobifolia* (S h a r m a 1971), but they have sori like *Dryopteris indica* Sharma. It is possible that the former represents the vegetative form of the latter.

**Dryopteris cladophleboides* sp. nov. Sharma

D i a g n o s i s. Frond bipinnate, large of unknown size; pinnae opposite or subopposite, 4—12 cm long; pinnules linear, oblong, 1·2—1·8 × 0·3—0·4 cm in size, margin entire, apex obtuse or blunt, unicostate with secondary veins showing simple dichotomy. Sori abaxial and produced on the anterior veinlets.

There are a number of specimens in author's collection representing this species. They are of various sizes and shapes and represent different portions of the frond, but all are similar in general morphology. The type specimen No. BD 23/Raj. DHO. (Pl. I, fig. 5; Text-fig. 1.5) and its counterpart preserve impressions of two fertile pinnae. The lamina of pinnules is thick and leathery. Veins as well as sori are very distinct, details of sporangia and spores are not, however, clear.

The new species resembles *Dryopteris indica* in the nature and position of sorii but differs in other characteristics like the shape, size and venation of pinnules. In these characteristics it resembles *Cladophlebis denticulata,* but the sori are very different from those of the latter. In *Dryopteris cladophleboides* sp. nov. sori are aspidiaceous, covered, and kidney-shaped, while in *Cladophlebis denticulata* they are osmundaceous, naked and oblong. The specific name is suggested by the venation pattern which is *Cladophlebis* type.

Haydenia thyrsopteroides Sew.

The occurrence of this species in the Jurassic rocks of Rajmahal Hills was reported for the first time by the author in an earlier paper (S h a r m a 1969). There are now a large number of beautifully preserved fertile

specimens of this species in author's collection. It is a large, tripinnate frond, size unknown. Secondary pinnae arise opposite or subopposite, 8—15 cm long with 10—14 pairs of pinnules (Pl. II, fig. 11). Proximal pinnules are lobed, 0·8—0·9 × 0·3—0·4 cm in size, while the distal ones are simple with obtuse apices. The sori are cup-shaped and are produced on either side of midrib, one in each lobe of pinnule (Tex-fig. 1. 6).

On the basis of the study of the present collection the author is convinced that this species is certainly related to the tree fern family *Cyatheaceae.*

Sphenopteris

It is a complex genus occurring in various forms. When found in association with seeds and microsporangia, it is described as a pteridospermous frond otherwise, a leaf of filicales. In the locality of Dhokuti different types of sterile fronds of *Sphenopteris* are found e.g. *S. hislopii* O. and M. (1863), *S. rajmahalensis* Sahni and Rao (1934), *S. imbricata* Sharma (1969) and the new forms described in the present paper.

Sphenopteris cf. *S. imbricata*

Frond large, bipinnate, pinnae 7—10 cm long, each provided with 6—9 pairs of subopposite or alternate pinnules. Pinnules trilobed (Text--fig. 2. 10), proximal lateral lobes small, 2·5 × 1·1 mm in size and bifurcated, central lobe large, rounded or elongated, 9—12 × 4—5 mm in size, margin dentate, veins diverging and dichotomised (Text-fig. 2. 9).

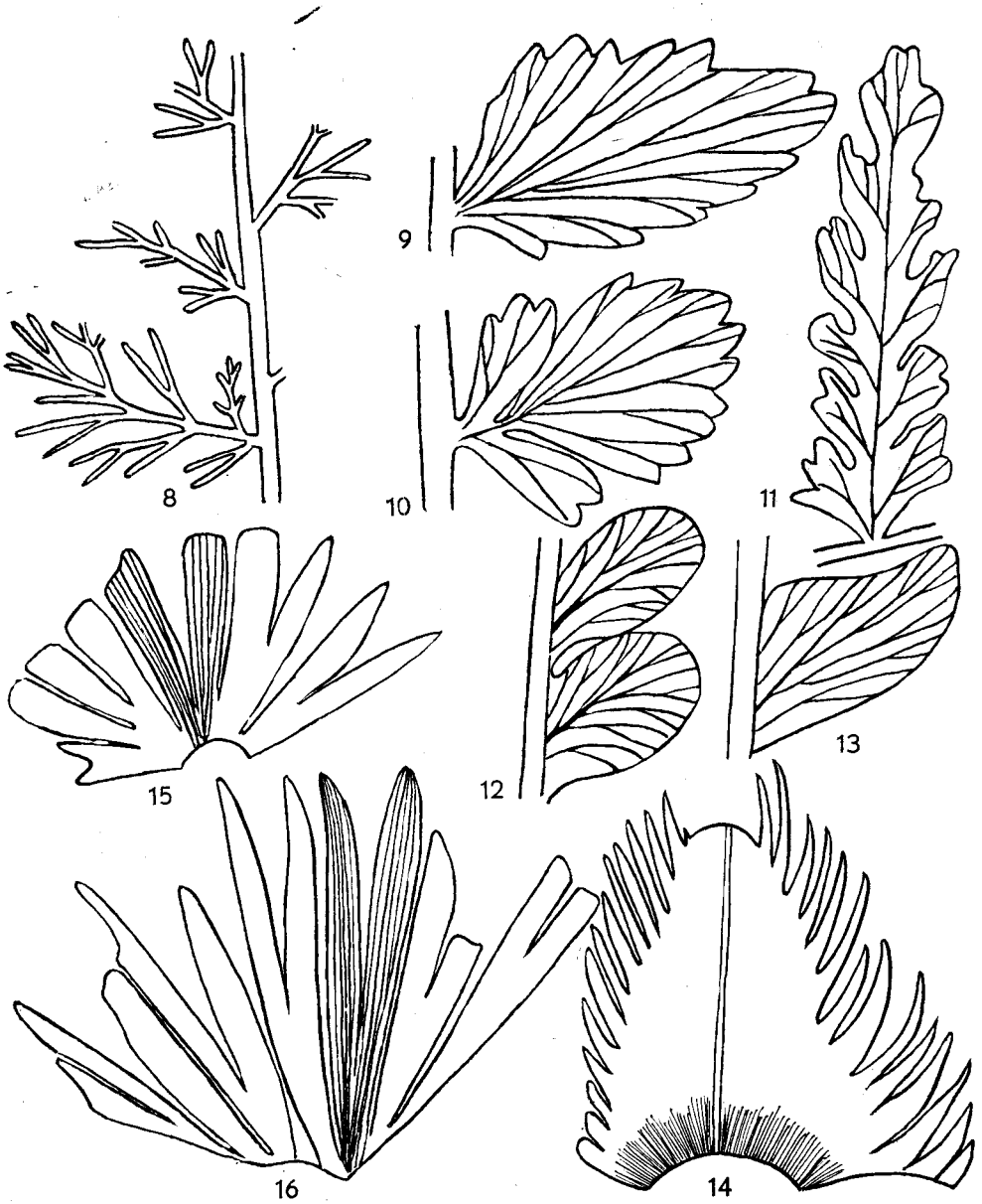
This frond (Specimen No. BD 98/Raj. DHO.; Pl. II, fig. 15) resembles *S. imbricata* Sharma (1969) in the arrangement and venation of pinnules, but the structure of pinnules is very unusual in the present frond and differs from all the known species of *Sphenopteris.*

Sphenopteris elaminata sp. nov. Sharma

Diagnosis. Frond non-laminated; branched, 30 × 14 mm in size; midrib 1·5 mm thick, monopodially branched, branches alternate, 4—6 mm long, secondary and tertiary branches dichotomously forked, 0·6—0·7 mm thick.

The type specimen No. BD 130/Raj. DHO. (Pl. I, fig. 7; Text-fig. 2. 8) is preserved with its counterpart. Leaf is a brown coloured impression of ash gray rock. The lamina is absent. The midrib and its branches are well preserved.

The specimen is comparable with *Sphenopteris tyrmensis* Seward



Text-fig. 2. × 4·6; 8 — *Sphenopteris elaminata* sp. nov.: Non-laminated leaf and its branches; 9, 10 — *Sphenopteris* cf. *S. imbricata*: Two fan-shaped, trilobed pinnules; 11 — *Sphenopteris* sp.: A pinnule with irregular lobes; 12 — *Thinnfeldia* cf. *T. amarjolense*: Two pinnules showing shape and venation; 13 — *Dicroidium* sp.: A pinnule showing shape and venation; 14 — *Cycadolepis* (?): Organ with lateral appendages and central midrib; 15, 16 — *Ginkgoites* sp.: Dissected lamina with parallel, dichotomised veins.

(1926) in general appearance but differs in details. It also resembles *Coniopteris setacea* (Pyrnada) Vakhrameev in non laminated nature and mode of branching, but differs in size and other details.

This kind of leaf has been reported for the first time from Indian rocks and as it is devoid of lamina the specific name *S. elaminata* is suggested.

Sphenopteris sp.

Frond bi or tripinnate, size unknown; pinnae 8—12 cm long, pinnules alternate or subopposite, 16—20 × 4—5 mm in size, deeply incised forming lobes of different sizes and shapes, with bifid truncate or obtuse apices. Pinnules unicostate with secondary veins which further bifurcate once or twice into the lamina or lobes.

There are a number of specimens in author's collection. Specimen No. BD 95/Raj. DHO. is best preserved. Venation is clear in pinnules (Text-fig. 2. 11).

The frond shows the general characters of *Sphenopteris* as well as of *Coniopteris* in having very much dissected lamina forming irregular lobes. Until the fertile parts are discovered, the author seems it proper to describe such specimens under the genus *Sphenopteris.*

Gymnosperms: These are represented by pteridosperms, cycads, *Bennettitales, Ginkgoales,* and taxads. The majority of them are represented by fronds except the bennettitalean fructification of *Williamsonia* and the petrified pieces of taxanean wood *Taxaceoxylon.* Some of the interesting forms collected recently from Dhokuti are described below.

Thinnfeldia cf. *T. amarjolense*

Frond small, pinnate or bipinnate; pinnae narrow, slender, 9—10 mm wide; pinnules opposite or subopposite, close, measuring 4·2 × 3·5 mm in size, margin entire, apex rounded, lower basal angle little decurrent; veins 3—4, diverging and dichotomously divided. Central vein is stronger than others (Text-fig. 2. 12).

There is a single specimen No. BD 156/Raj. DHO. in the author's collection representing this species. This specimen resembles *Thinnfeldia amarjolense* Sharma et al. (1971) in shape, size and venation of pinnules, but differs in the arrangement of pinnules. Comparison is also made with *T. odonotopteroides* (Morr.) Fst., *T. lancifolia* (Morr.) Walkam and *T. feistmanteli* Johnston but differs on the same points as *T. amarjolense.* The present material also resembles in external appearance with *Cladophlebis* sp. described by Bose and Sah (1968) from the Rajmahal Hills. However, venation is not distinct in their specimen. It may also be a *Thinnfeldia* similar to the present type.

Dicroidium sp.

Frond large, size unknown, rachis repeatedly dichotomised; pinnae linear, 8—10 × 1·5 cm in size; pinnules opposite or subopposite, thick, ovate, 0·7—0·8 × 0·4—0·5 cm in size, apex obtuse, upper basal angle round, lower decurrent, veins 5—6, diverging and dichotomously divided.

The specimen No. BD 185/Raj. DHO. (Pl. I, fig. 9) is preserved with its counterparts. Rachis is repeatedly dichotomised. Pinnules are thick, leathery, and veins are clear (Text-fig. 2. 13). The central vein is stronger than others. It divides twice or thrice while others fork only once.

Comparison is made with *Dicroidium obtusifolium* (Johnston) Townrow (1966). There is a resemblance in the shape, size and nature of pinnules but the mode of branching of rachis and venation is different. In *D. obtusifolium* rachis forks only once and veins are simple or dichotomised whereas, in the present frond, rachis divides repeatedly and all veins show dichotomy.

Cycadolepis (?)

It is a triangular organ measuring 4·1 × 3·2 cm in size; the basal part is little, narrow but thick and provided with radiating striations in addition to the midrib (Text-fig. 2. 14). From the lateral sides arise linear 0·7—1·2 × 0·2—0·4 cm thick, curved appendages with pointed apices. There are 16—18 such appendages along each margin. They gradually decrease in size towards the distal end of the organ (Pl. II, fig. 17), which is not clear.

This specimen No. BD 110/Raj. DHO. is comparable with *Cycadolepis indica* Gupta (1954) and *C. oldhami* (Fst.) Bose and Jain (1963) in size and shape but differs in others characters like the presence of lateral appendages; the basal part is thick and curved and there is a midrib besides radiating veins.

The specimen may also be compared with the distal part of the megasporophyll of *Cycas revoluta;* but differs in the absence of radial stalk and ramenta.

Williamsonia sp.

This is an impression of the tangential view of a bractless, seed bearing receptacle, 3·6 cm in diameter, and possesses the markings of seminiferous and interseminal scales (Pl. II, fig. 14). Surrounding a circular fertile scale there are 5—8 polygonal sterile scales.

The present specimen shows the general structure of a seed bearing *Williamsonia* and cannot be assigned to any definite species, till it is discovered with the bracts which enclose the receptacle.

Ginkgoites sp.

Though the occurrence of the genus *Ginkgoites* has been reported from many localities in the Rajmahal Hills (S a h and J a i n 1965), it has not been found frequently. Recently, S a h and J a i n (1965) described a new species of *Ginkgoites, G. rajmahalensis* and included in it all those specimens described thus far from the Rajmahal Hills. The author was able to collect a number of nicely preserved specimens of *Ginkgoites* from Dhokuti. They are all similar except for minor differences in the size and shape of leaf segments. The leaf is petiolate, petiole thin, lamina is divided into two halves, each half is further dissected into linear, 3·6—4·5×0·4—0·8 cm in size segments with acute apices (Pl. II, figs, 16, 19; Text-figs. 2. 15, 16). Each segment receives 3—5 parallel veins in the proximal part. The veins dichotomise at all levels and converge in the distal parts of segments.

The specimen resembles *Ginkgoites rajmahalensis* Sah and Jain as well as *G. huttoni* Seward in the segmentation of lamina and nature of venation. More investigation is needed to determine the definite taxonomic rank of the present material.

DISCUSSION

It has already been said that the fossiliferous locality of Dhokuti is rich in ferns, cycads and *Bennettitales* (S h a r m a 1972). However, the present collection has further increased our knowledge of the fossil flora of this locality. In addition to the new species described in the present paper, some of the plants have been reported for the first time from Dhokuti e. g. *Equisetites, Dicroidium, Ginkgoites* etc. A large number of beautifully preserved fertile ferns were also collected, study of which might help in tracing the line of phylogeny of leptosporangiate ferns.

Plants resembling living *Selaginella* are found frequently in Dhokuti. Fertile parts are produced in compact, terminal spikes, but details of sporangia and spores have not yet been reported. *Equisetites* is found rarely and in the form of an impression of stem part. Until the cones are discovered, it is difficult to make correlations with the well established species of *Equisetites* or living *Equisetum.*

Among the leptosporangiate ferns the most common representatives are the fronds of *Osmundaceae, Gleicheniaceae, Dicksoniaceae, Cyatheaceae* and *Aspidiaceae.* Osmundaceous fronds are described under two genera similar in appearance, *Cladophlebis* and *Todites.* S e w a r d (1910) distinguished these two genera on the characteristics of their fertile parts. In the

former sori are linear and found parallel to the secondary veins e. g. *Cladophlebis denticulata* (S e w a r d 1910, Fig. 258, p. 345), whereas in the latter sori are found either scattered (S e w a r d 1910, Fig. 256 B, p. 340) as in *Todites williamsoni* Sew. or along the veins on the abaxial surface of pinnule (H a r r i s 1961). S a h n i and R a o (1931) suggested the name *Cladophlebis indica* for the Indian material resembling *Cladophlebis denticulata* in vegetative characters. B o s e and S a h (1968) changed it to *Todites indica* and considered that the vegetative and fertile fronds were produced separately in this plant. In the present collection there are several specimens with their counterparts preserved showing fertile as well as sterile pinnules in the same pinna. The sori are large, oblong and arranged parallel to the secondary veins. The present study confirms the author's previous assumption (S h a r m a 1971) that the Indian material of the osmundaceous frond *Todites (Cladophlebis) indica* is not different from *C. denticulata* and is to be included in the latter species.

In *Gleicheniaceae* vegetative characteristics differ even in the same frond. whereas soral structures were found to be comparatively constant. The new species described in the present paper differs from the most commonly occurring species of *Gleichenia, G. gleichenoides* in vegetative as well as fertile characteristicts.

The majority of fronds of the *Dicksoniaceae* and *Caytheaceae* families collected from Dhokuti are in fertile forms. In the former sori are characterised by the unequal, bilipped indusium with circular or slit-like opening, while in the latter sori are cup-shaped with a circular opening. In *Dicksonia speciosa* sp. nov. sori are so large that they cover almost the entire abaxial surfaces of pinnules. This is due to unequal growth of the two flaps of indusium. The outer flap is much larger than the inner one and the opening is slit-like. *Dennstaedia* resembles *Dicksonia* in the marginal position of sori and biflapped nature of indusium, but the growth of flaps is not so unequal and thus the sori produced are rounded with circular openings.

Aspidiaceae are represented by the genus *Dryopteris* which resembles the living plants in vegetative as well as fertile structures. *Dryopteris cladophleboides* sp. nov. possesses sori like that of *Dryopteris* but the nature of its venation resembles *Cladophlebis*. Thus the identification of new species is mainly on soral characteristics.

The fronds of *Thinnfeldia, Dicroidium* and *Ginkgoites* have been reported for the first time from Dhokuti and arouse interest in the discovery of their associated fertile parts.

From the above description it is clear that during the Jurassic period the fossiliferous locality of Dhokuti had an assemblage of pteridophytes and gymnosperms, which were represented by lycopods, sphenopsids, ferns, pteridosperms, cycads, *Bennettitales, Ginkgoales* and taxads. This confirms the earlier assumption (S h a r m a 1971) that tall trees were absent in

Dhokuti during the Jurassic period and the vegetation consisted of herbs and shrubs.

This locality is exposed at a number of sites within an area of one kilometer. The rock is similar in all places but plant remains occur in different combinations, for example, in association with the fertile fronds of *Dicksonia, Haydenia* and *Dennstaedia* large sized nilssonias are found but bennettitalean frond *Ptilophyllum* is completely absent. *Ginkgoites, Dicroidium* and *Equisetites* were also collected from this site. Similarly, the rock with vegetative fronds of *Gleichenia gleichenoides* and *Cladophlebis denticulata* has *Ptilophyllum* as well as *Nilssonia.*

In comparison to other localities in the Rajmahal Hills (G u p t a 1966, map of Rajmahal Hills), Dhokuti has yielded the maximum number of fertile ferns including *Marattiopsis, Cladophlebis, Gleichenia, Klukia, Haydenia, Dicksonia, Dennstaedia, Dryopteris* etc. Also, majority of the species of *Nilssonia* known from India (S h a r m a 1971a) occur in this locality. Dhokuti possesses the maximum assemblage of plant groups belonging to pteridophytes and gymnosperms. But the plant fossils are found as impressions and so anatomical structures and details of sporangia and spores remain unknown.

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STRESZCZENIE

PRZYCZYNEK DO JURAJSKIEJ FLORY Z DHOKUTI, RAJMAHAL HILLS, INDIE

Podano opisy ostatnio zebranego materiału kopalnych roślin z Dhokuti w Rajmahal Hills, Bihar. Zawierają one nowe rodzaje i gatunki, wzbogacające listę roślin opisanych poprzednio z tego stanowiska. Wśród paprot-

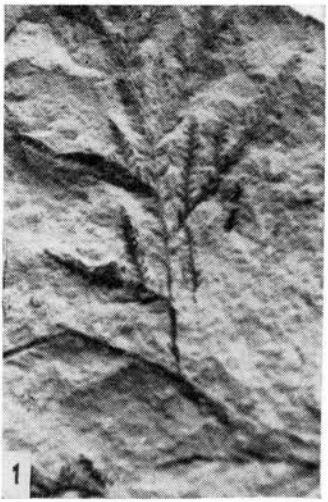
ników dominują: *Selaginella, Cladophlebis, Gleichenia, Dicksonia, Sphenopteris,* a wśród nagonasiennych sagowce i bennetyty, występujące obficie na tym stanowisku. *Ginkgoites* i cisowe są również znane, lecz niezbyt częste. Dyskutowane są warunki paleoekologiczne tej flory oraz ich korelacja z innymi stanowiskami w Rajmahal Hills.

PLATES

Plate I

× 1

1. *Selaginella* sp. A. Monopodially branched stem covered with leaves.
2. Same. A cluster of fertile spikes.
3. *Equisetites rajmahalensis* O. and M. A portion of stem. Nodal portion smooth while internodal part is differentiated into ridges and furrows.
4. *Dennstaedia rajmahalensis* sp. nov. Two fertile pinnae.
5. *Dryopteris cladophleboides* sp. nov. Pinnules with aspidiaceous sori.
6. *Gleichenia dhokutense* sp. nov. A small portion of frond with sori.
7. *Sphenopteris elaminata* sp. nov. Non-laminated leaf and its branches.
8. *Dicsonia speciosa* sp. nov. A portion of fertile frond.
9. *Dicroidium* sp. Branched rachis with pinnules.
10. *Cladophlebis denticulata* Brongn. Proximal (lower) pinnules fertile while distal (upper) ones sterile.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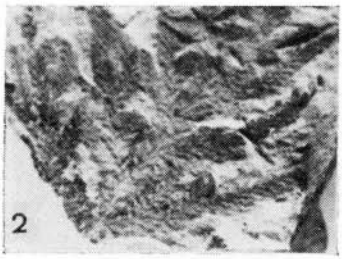
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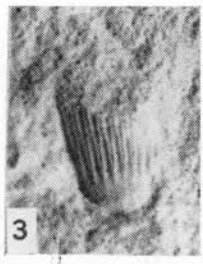
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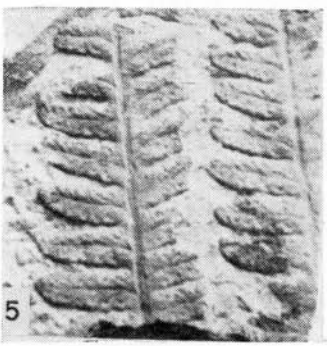
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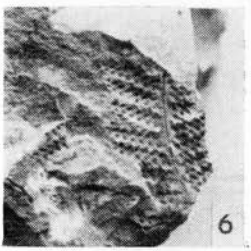
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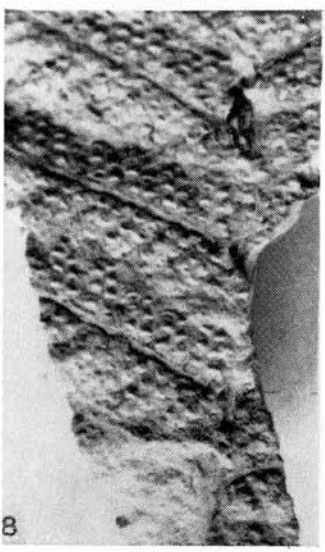
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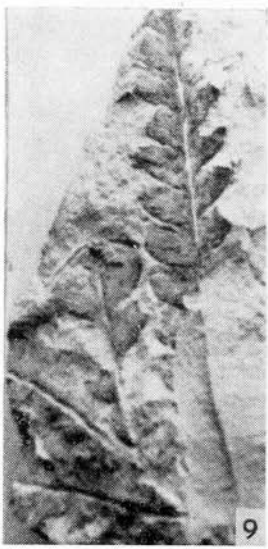
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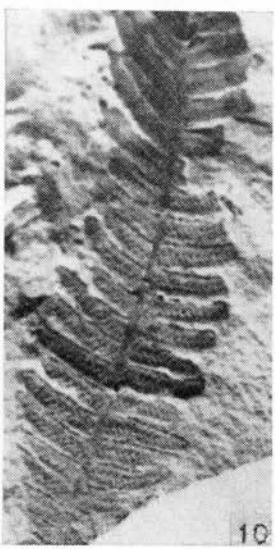
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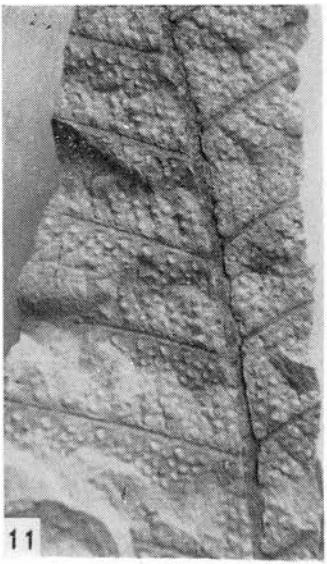
Plate II

11. *Haydenia thyrsopteroides* Sew. A portion on frond with cup-shaped sori on pinnules; × 1.
12. *Dicsonia speciosa* sp. nov. Pinnules with large sori having slit-like openings; × 2.
13. *Dennstaedia rajmahalensis* sp. nov. Pinnules with large, circular, more or less marginal sori; × 2.
14. *Williamsonia* sp. Seed. Bearing receptacle with markings of seminiferous and interseminal scales; × 1.
15. *Sphenopteris* cf. *S. imbricata*. Fan-shaped pinnules on a pinna; × 1.
16. *Ginkgoites* sp. Lamina dissected into linnear segments; × 1.
17. *Cycadolepis* (?). Organ with lateral appendages; × 3/4.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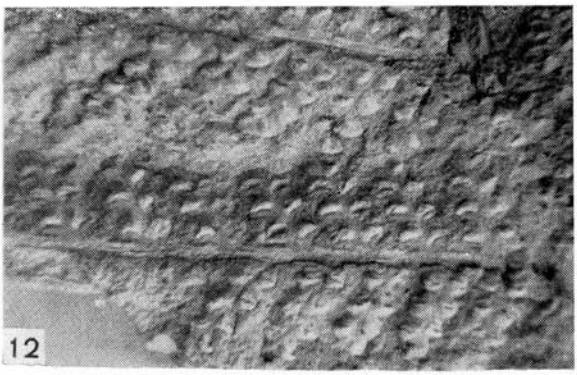
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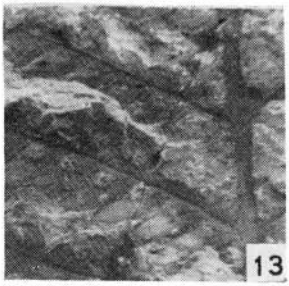
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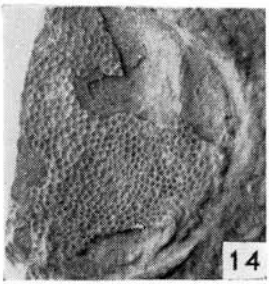
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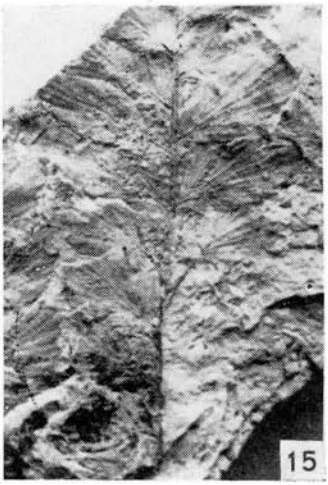
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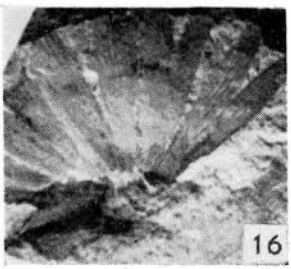
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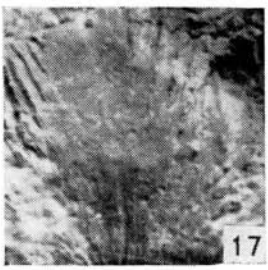
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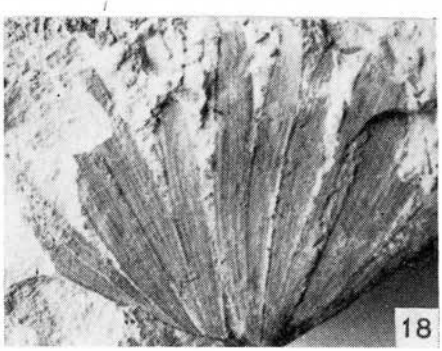
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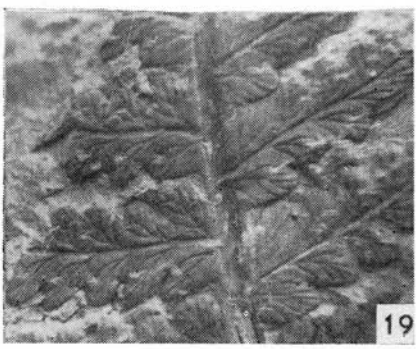
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