A MALE FLOWER OF THE PENTOXYLEAE WITH REMARKS ON THE STRUCTURE OF THE FEMALE CONES OF THE GROUP

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ABSTRACT

Under the name of *Sahnia nipaniensis* gen. et sp. nov. the author describes some specimens which he believes to be the male flowers of the Pentoxyleae. These were borne apically on dwarf shoots closely resembling those of *Pentoxylon Sahnii* Srivastava. The flower consists of filiform spirally branched microsporophylls, fused proximally to form a disc which surrounds a broad and conical receptacle. The unilocular sporangia are borne at the ends of short branches of the sporophylls. Pollen grains are monocolpate and boat-shaped. In young flower the microsporophylls are surrounded by a whorl of deciduous bracts.

The infructescence of *Carnoconites laxum* and several specimens (showing longitudinal section) of the infructescence of *C. compactum* have also been discovered. The infructescence of *C. laxum* differs from that of *C. compactum* in having much shorter pedicels and much longer female cones. The infructescence of *C. compactum* differs from the reconstruction made by Professor Sahni in the absence of bifurcation of the pedicels and in the arrangement of the cones.

INTRODUCTION

THE Pentoxyleae, a new group of Jurassic gymnosperms, was instituted by Sahni (1948). Our knowledge of this group is based on the collective researches by Sahni (1932, 1938, 1948), A. R. Rao (1943) and B. P. Srivastava (1935, 1937, 1946). The Pentoxyleae comprises a number of organ genera: leaves known as *Nipaniophyllum Raoi* Sahni; two types of stem, viz. *Pentoxylon Sahnii* Srivastava and *Nipanioxylon Guptai* Srivastava; and female cones known as *Carnoconites compactum* Srivastava and *C. laxum* Srivastava. No organic connection among these genera has been yet discovered, but they have been correlated on the indirect evidence provided by anatomical structure. The present paper[1] contains an account of some more material of the *Pentoxyleae* from Nipania. It describes for the first time what is believed to be the male flower of *Pentoxylon Sahnii*; also described are some new specimens of the cones of *Carnoconites*, together with the infructescences of both the species of the genus. The infructescence of *C. laxum* is being described for the first time.

MATERIAL AND METHODS

The material is in the form of highly fossiliferous blocks of chert and was collected from Nipania in 1948 by a party consisting of the late Professor B. Sahni, Professor S. R. N. Rao, Dr. Jen Hsü and Dr. R. V. Sitholey. A part of it was kindly entrusted to me by Dr. R. V. Sitholey in July 1951 for investigation. For preliminary examination the blocks were cut both along and across the bedding plane. The sections were stained with aqueous safranin which helped in bringing out the obscure details of anatomy. For more complete study, the surface of selected specimens was ground carefully by stages and serial sketches and/or photographs made of the stages. Though the material is highly silicified, the organic remains took the stain readily. Of the different stains (safranin, gentian violet, aniline blue, Bismarck brown, erythrosin, Congo red and methylene blue) used by previous workers on the chert, safranin and methylene blue were found by them to be most useful (RAO, 1943, p. 355; SRIVASTAVA, 1946, pp. 190-192). I found aqueous safranin better than methylene blue. The preservation of the same type of organic remains in some blocks is different from that in the other blocks. In certain blocks the fossils have already acquired a red or brown stain from the presence of iron oxide in the chert. In these cases no artificial stain is required. In some of the sections the anatomical details are very clear whether they are kept uncovered or mounted in Canada balsam, while the other sections require to be

1. Paper read in the Botany Section of the 40th Session of the Indian Science Congress Association held at Lucknow (VISHNU-MITTRE, 1953, p. 112).

examined uncovered for seeing the structure properly. Glycerine jelly was found to be quite useful for examining sections of both the kinds. For preliminary examination glycerine alone was also used.

DESCRIPTION

Sahnia nipaniensis gen. et sp. nov.

Diagnosis — Male flower, terminating a "short shoot" of the type of *Pentoxylon Sahnii* and in young stage enveloped by bracts. The axis of the shoot is covered with an armour of close-fitting leaf-cushions. Leaf-cushions rhomboid with 4-9 mesarch vascular bundles. Space between leaf-cushions packed with unbranched unicellular hairs which arise from the cushions. Microsporophylls filiform, about 24 in number, attached in a whorl round a broad conical receptacle. Receptacle 4-5 mm. wide at the base and 2-3 mm. in height. Microsporophylls 1-1·5 cm. in length with short branches borne spirally. Sporangia stalked, borne at the end of branches, singly or in groups of 2 to 4; unilocular, pyriform, measuring 100 to 120 μ by 60 to 70 μ; wall thick. Pollen boat-shaped and monocolpate, 25-26 × 10-25 μ.

Sahnia nipaniensis gen. et sp. nov. is the only species so far known of the genus. It derives its generic name after the late Professor B. Sahni; the specific name is after the locality.

Locality — Nipania near Dimurchir in the District Amrapara, Santhal Parganas.

Horizon — Upper Gondwana. Rajmahal Stage, Rajmahal Series.

So far eight specimens of the male flower have been discovered. Specimen No. 3226 (Pl. 1, Fig. 3 & Pl. 2, Fig. 1) is regarded as the holotype. The four best preserved specimens are shown in Pl. 1, Figs. 1-4 and Pl. 2, Fig. 1. The flower was borne apically on the dwarf shoots. It consists of about twenty-four branched sporophylls fused proximally to form a disc which surrounds a broad receptacle. The specimen shown in Pl. 1, Fig. 3 and Pl. 2, Fig. 1 measures 2 by 1·5 cm. No bracts or scale-like structures enclose the mature flower, but in its young condition the microsporophylls were protected by a whorl of deciduous bracts (Pl. 1, Fig. 4).

The Dwarf Shoot — The dwarf shoot measures about 1-2 cm. in length and 1-1·5 cm. in diameter. It bears an armour of close-fitting, rhomboid, leaf-base cushions. The space between the leaf-base cushions is packed with unbranched unicellular hairs (Text-fig. 1). A row of 5 to 9 vascular bundles is seen towards the adaxial side of the leaf-bases (Pl. 1, Figs. 1, 2; Text-fig. 2). Each vascular bundle is enclosed in a sclerenchymatous sheath. The vascular bundle (Text-fig. 3) consists of centripetal xylem towards the adaxial side and centrifugal xylem forming an arc towards the abaxial side of the leaf-base. Protoxylem elements are not distinctly observable. The adaxial surface of the leaf-base also shows several layers of cells forming an abscission layer.

The pith and the cortex are broad. There is some amount of secondary growth which, however, is not eccentric. The vascular supply to the leaf-base consists of a single strand (Text-fig. 4), which curves up giving off 5 to 9 branches. The tracheids in the leaf trace bear exclusively scalariform thickening, while the tracheids of the main vascular bundle have, besides scalariform thickening, uniseriate and multiseriate bordered pits (Text-figs. 5, 5a). The bordered pits are contiguous, circular and compressed. The wide tracheids bear 3 to 4 rows of the alternate bordered pits. The pore is round and broad. The medullary rays are uniseriate.

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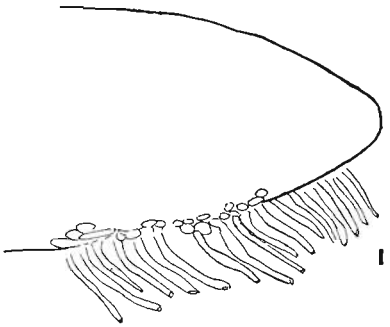
Text-figs. 1-9—*Sahnia nipaniensis*. 1., part of a leaf-base, showing unicellular hairs. × 80. 2, cross-section of leaf-bases showing the arrangement of the vascular bundles. CPX, centripetal xylem; CFX, centrifugal xylem; PH, phloem. × 12·5. 3, details of a vascular bundle of leaf-base. × 240. 4, longitudinal section of a dwarf shoot showing the vascular supply to the leaf-bases. × 10. 5, L.S. tracheids of the dwarf shoots with multiseriate, contiguous bordered pits. × 225. 5a, L.S. tracheids of the dwarf shoot with scalariform pitting. × 225. 6, a part of the disc showing the attachment of the microsporophylls and one microsporophyll, showing the mode of attachment of the microsporangia and the vascular supply. The number of the vascular bundles entering each microsporophyll is not exactly known. × 15 (cf. Pl. 3, Figs. 1-3). 7, tracheids of the microsporophyll showing the multiseriate pits. × 300. 7a, tracheids of the microsporophyll showing the scalariform pitting. × 300 (cf. Pl. 3, Fig. 4). 8, wall of the microsporangium in optical view. × 120. 8a, surface view of the microsporangium showing elongated rectangular cells. 9, microspores. × 300 (cf. Pl. 3, Figs. 5, 6).

Text-fig. 10 — *Pentoxylon* stem and dwarf shoot in organic connection. × 20 (cf. Pl. 4, Fig. 5).



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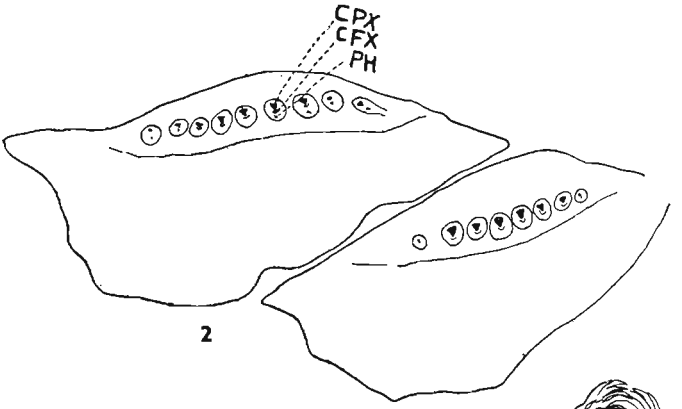

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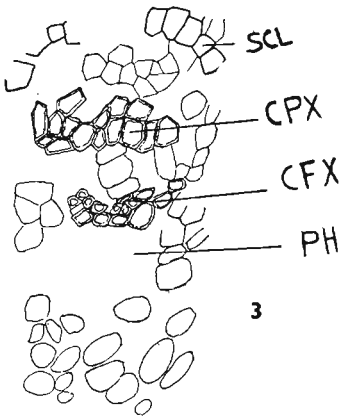

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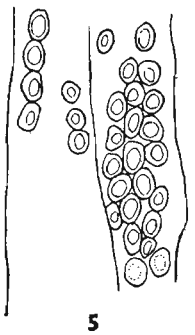

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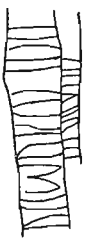

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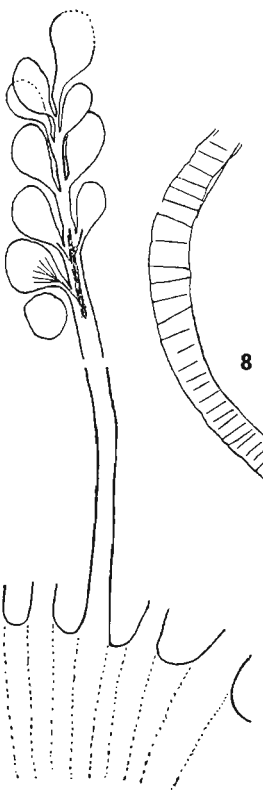

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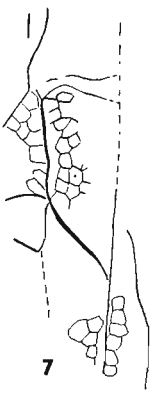

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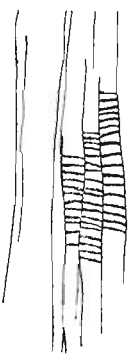

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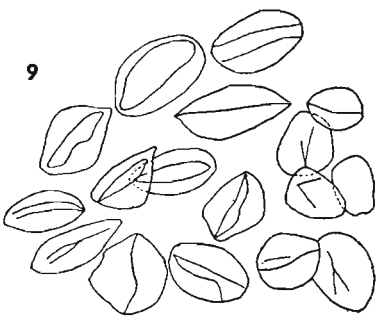

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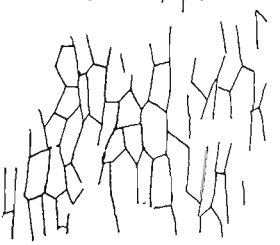

TEXT-FIGS. 1-10

The pith and cortex contain sclerotid nests. Some dwarf shoots of the same structure but as long as 5·5 cm. have been found in the blocks, but these do not bear any male flowers. The dwarf shoots of *Sahnia* may have been much longer than so far noticed.

The Receptacle — The receptacle is a conical body. The pith of the dwarf shoot is confined into the receptacle, which seems to be made of parenchymatous cells only. The vascular supply in the receptacle has not been seen.

The Microsporophyll — The microsporophylls (PL. 3, FIGS. 2, 3) are branched filiform structures measuring 1-1·5 cm. in length. They are fused below into a disc-like structure (PL. 3, FIG. 1; TEXT-FIG. 6) which surrounds the receptacle at its base. The disc persists on the flower till after maturity (PL. 1, FIGS. 1, 2). The microsporophylls are fused for 4-5 mm. of their length from the proximal end. The number of the vascular strands in the sporophyll is not known; the tracheids of the vascular strands show multiseriate bordered pits as well as scalariform pitting (PL. 3, FIG. 4; TEXT-FIGS. 7, 7a).

The Microsporangium — The microsporangia are attached at the end of short branches which arise spirally. They are unilocular, pear-shaped bodies and are borne on thick stalks which seem to be attached to a pad or cushion-like end of the branches. The microsporangium measures 100-120 μ by 60-80 μ. The wall consists of a layer of elongated thin-walled rectangular cells; near the edge of the sporangium the cells have their lateral walls slightly radially thickened as in the annulus of the ferns (TEXT-FIGS. 8, 8a). The stalk of the sporangium also consists of elongated rectangular cells. The vascular supply to the sporangium enters at its base and after a little distance divides into a large number of radiating branches. The tracheids in these branches bear, besides multiseriate bordered pits, scalariform pitting also.

The Microspores — The microspores (PL. 3, FIGS. 5, 6; TEXT-FIG. 9) are 25-26 μ long by 10-25 μ broad. They are boat-shaped and have a single longitudinal furrow. The furrow is wide open at its middle and narrows towards the end. The wall of the microspores is quite smooth.

Reconstruction of Male Flower — While reconstructing the vegetative parts and the female reproductive organs of Pentoxyleae, Sahni (1948, p. 77) presumed that the flowers of Pentoxyleae were unisexual and were borne at the ends of lateral dwarf shoots. The material described in the present paper supports this. Text-fig. 11 shows the reconstruction of a male flower borne apically on the dwarf shoot. The receptacle is surrounded by a disc formed by the fusion of the basal regions of the microsporophylls. Each microsporophyll is shown to be long, filiform structure bearing sac-like sporangia on all sides except the basal region which is sterile.

AFFINITIES OF THE MALE FLOWER

The flower is believed to belong to the Pentoxyleae on the basis of the similarity between the dwarf shoots bearing it and the dwarf shoots of *Pentoxylon Sahnii*.

The male flower is Bennettitalean in its general plan. It should be regarded unisexual, for there is no trace of female organs on the receptacle. The apical position of the flower on the "short shoot" recalls the terminal position of the *Williamsonia* flowers on lateral branches as in *W. Sewardiana*. In both the axis of the flower is a stem. In young condition the male flower described here is protected by deciduous bracts. The disc is persistent and does not fall off at maturity as in the Bennettitales. It occupies a hypogynous position. The microsporophylls are branched, filiform and fused proximally to form the disc, as in the bennettitalean flowers. Unlike the Bennettitales the microsporophylls remain erect from the very beginning and do not show circinate

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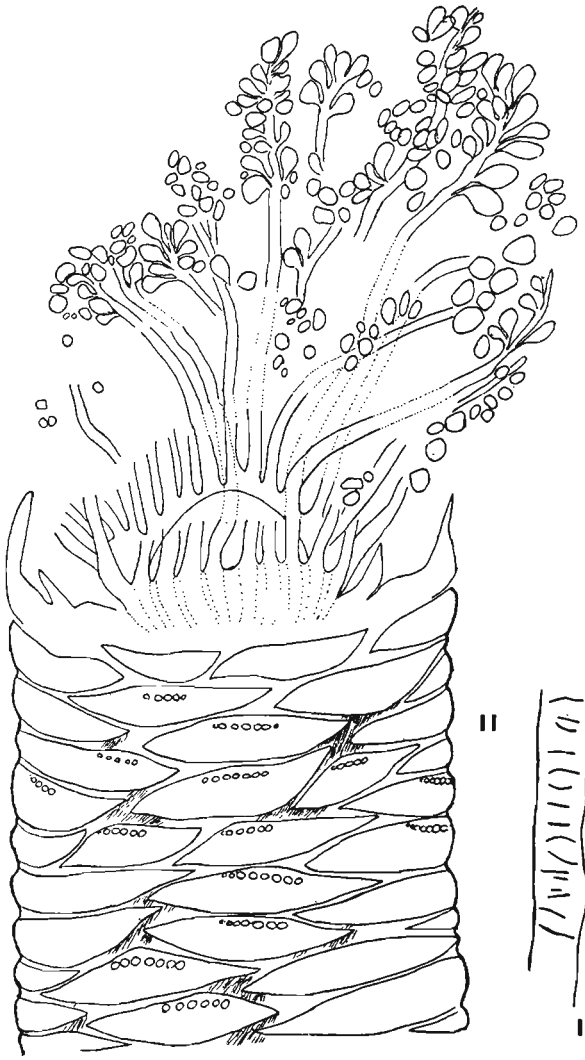
TEXT-FIGS. 11-16. 11, *Sahnia nipaniensis*. Reconstruction of male flower. × 5. 12, reconstruction of the infructescence of *Carnoconites compactum*. × 2. 13, infructescence of *C. compactum*. AA′, BB′ indicate the planes in which the cross-sections of the peduncle have been cut. × 2 (cf. PL. 4, FIG. 1). 14, *Carnoconites compactum*. Cross-section of the peduncle along the planes AA′, BB′ shown in Text-fig. 13. CFX, centrifugal xylem; PTR, pedicel-trace. × 60 (cf. PL. 4, FIG. 3). 15, *Carnoconites compactum*. Cross-section of one of the vascular bundles in the peduncle. CPX, centripetal xylem; CFX, centrifugal xylem; PH, phloem. × 165. 16, *Carnoconites compactum*. L.S. of tracheids from the peduncle showing multiseriate bordered pits. × 275. 16a, *Carnoconites compactum*. L.S. of tracheids from the peduncle showing scalariform pitting. × 275 (cf. PL. 4, FIG. 4).



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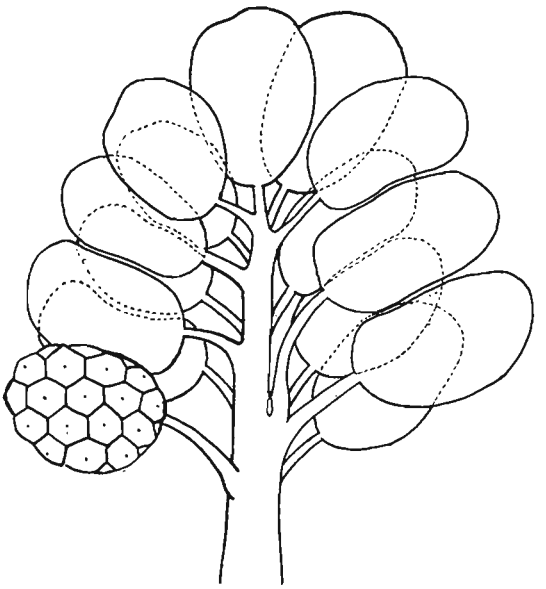

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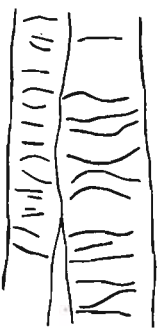

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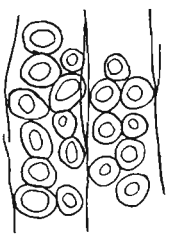

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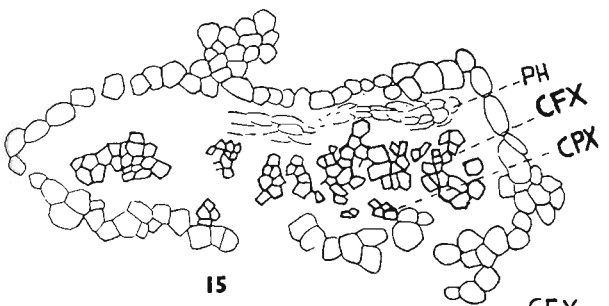

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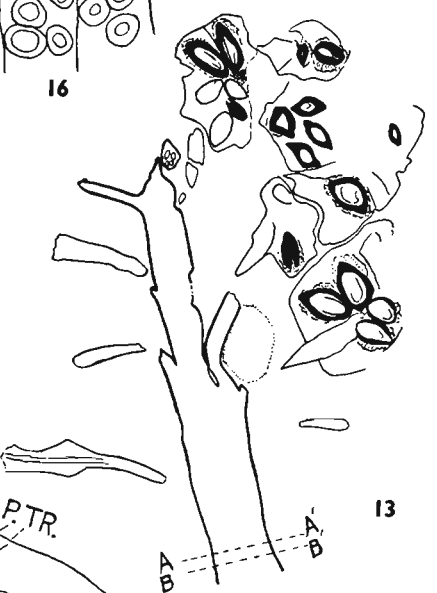

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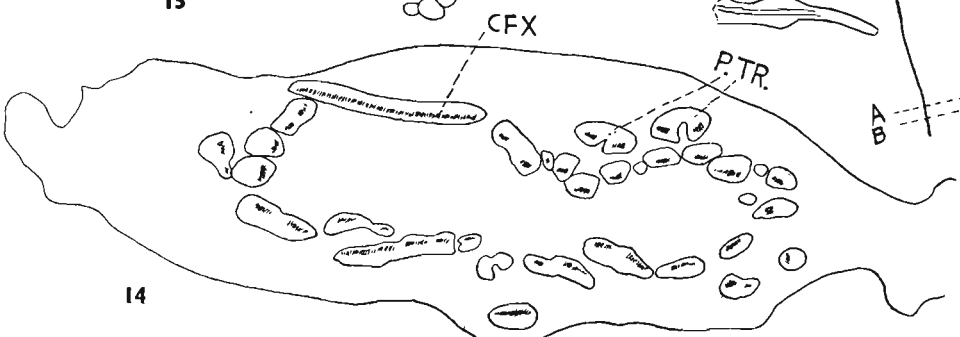

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TEXT-FIGS. 11-16

ptyxis; also the apices of the microsporophylls do not show any sterile portion, but bear microsporangia to the tip.

The mode of branching of the microsporophylls is spiral and the branches are borne all round the main axis. The pinnate structure of the microsporophylls characteristic of the Bennettitalean male flowers is not present. The microsporangia are sac-like and unilocular quite unlike the synangia of the Bennettitales, but resembling those of modern cycads. The pollen grains are boat-shaped with a single furrow. In this character and in size they approach the modern cycads.

While in general plan *Sahnia nipaniensis* seems Bennettitalean, it differs widely from this group in the nature of the microsporophylls and the unilocular microsporangia. There is no other group of plants, living or fossil, with which the specimens allow any comparison.

The shoot bearing the male flower, clothed in an armour of closely fitting leaf-base cushions, presents the same general appearance as in the stems of recent cycads and the Bennettitales. The leaf-traces pursuing a direct radial course to the cylinder find parallel in Bennettitales, in the seedlings of *Cycas* and in the sporophyll traces of other modern cycads (WORSDELL, 1906, p. 153). Besides, the exclusive presence of scalariform tracheids in the vascular supply of the leaf-trace is also as in modern cycads and the Bennettitales. In the presence of unicellular hairs on the leaf-base cushions our specimens approach the modern cycads. Unicellular hairs are, however, also found in the Bennettitales as in *Cycadeoidea micromyela* (*see* SEWARD, 1917, p. 374). The collateral mesarch type of vascular bundle in the leaf-bases of the shoot of *Sahnia* is a cycadean character, though shared by cordaitalean leaves and *Bennettites Gibsonianus* (SCOTT, 1923, p. 325) and also by the petiolar bundle of *Nipaniophyllum Raoi* (RAO, 1943, pp. 342, 343). The leaf-bases of *Sahnia* also approach the crescent-shaped leaf-bases of *Bowenia spectabilis* Hook. f. in possessing 4 to 7 vascular bundles in an arc (PEARSON, 1898, p. 477).

The male flower of *Sahnia nipaniensis* is borne apically on the dwarf shoots similar to those of *Pentoxylon Sahnii*. This fact lends strong support to the idea that the flower belongs to the Pentoxyleae. The presence of 5 to 6 curved vascular bundles devoid of eccentric secondary growth, the wide pith and wide cortex, the presence of the bordered pits in the tracheids of the shoots and the nature of the vascular supply to the leaf-bases are the characters of the shoots of *Sahnia nipaniensis* which resemble those described in the dwarf shoots of *Pentoxylon Sahnii* (SRIVASTAVA, 1946, p. 200; SAHNI, 1948, p. 58). The fact that the collateral mesarch nature of the vascular bundles on the leaf-cushions of *Sahnia nipaniensis* is exactly similar to petiolar bundles of *Nipaniophyllum Raoi* (RAO, 1943, pp. 342, 343) further increases the similarity with the Pentoxyleae. The radial pitting of the tracheids of the shoots of *Sahnia nipaniensis*, consisting of uni- and multiseriate circular, contiguous and compressed bordered pits, resembles the tracheidal pitting of the stem of *Pentoxylon Sahnii* (SRIVASTAVA, 1946, p. 198; SAHNI, 1948, p. 57).

There are, however, certain differences between the short shoots of *Pentoxylon* and those of *Sahnia nipaniensis*. The short shoots of *Pentoxylon* have not been described to bear any hairs on the leaf-base cushion, while this is a very conspicuous character of the dwarf shoots of *Sahnia nipaniensis*. Another difference noted by me is the occurrence of scalariform thickening in the tracheids of the dwarf shoots of *Sahnia*, a feature not yet reported in the dwarf shoots of *P. Sahnii*.

The close resemblance, in the majority of characters, between the dwarf shoots of *Pentoxylon* and those bearing the male flowers necessitated a re-examination of the slides of Srivastava (K 2/1, K 30/51, K 4/1, K 12/1, K 30, K 16, K 19/4, K 19/9). The presence of the hairs was not noted in his sections, maybe because of the less well-preserved condition of his specimens. In some of his sections, however, the scalariform thickening in the tracheids of the leaf-traces is observable, a feature which seems to have escaped the notice of the previous workers.

The vascular supply to the leaf in the dwarf shoots of *P. Sahnii* was studied (SRIVASTAVA, 1946, p. 200; SAHNI, 1948, p. 58) in a single cross-section of the short shoot. In my specimens it has been satisfactorily elucidated from a study of the serial longitudinal sections of the dwarf shoot; it is essentially the same as described by the previous workers. The radial pitting of the tracheids of the dwarf shoots of *Sahnia nipaniensis* consists both of multiseriate and uniseriate

bordered pits. No multiseriate pitting has been reported from the dwarf shoots of *Pentoxylon Sahnii*. However, both multiseriate and uniseriate pitting are met with in the stems of *P. Sahnii* and it is possible that this feature was also present in the dwarf shoots described by Srivastava, but could not be seen due, perhaps, to bad preservation.

Srivastava (1946, p. 200) showed that the dwarf shoots were borne on the *Pentoxylon* stems. Besides the anatomical resemblance between the two shown above, the specimen figured in Pl. 4, Fig. 5, Text-fig. 10 shows what appears to be the organic connection between a dwarf shoot and the *Pentoxylon* stem. The *Pentoxylon* stem in the specimen seems to be cut across at its nodal region. The number and the orientation of the vascular bundles and the dividing central bundles indicate the origin of a lateral branch of *Pentoxylon* stem. Another lateral branch, a dwarf shoot in its longitudinal section, is already in organic connection with the *Pentoxylon* stem. It appears that the dwarf shoots arose more or less at right angle to the *Pentoxylon* stem.

FURTHER OBSERVATIONS ON THE FEMALE CONES OF THE PENTOXYLEAE

In the present collection the female cones, belonging to *Carnoconites laxum* and *C. compactum*, have been found in various sizes, the smallest being 7 × 4 mm. and the largest 30 × 5 mm. (*vide* TABLE I). The range in form in the two species can be stated as follows:

1. Oblong — broadly oval — spherical (*C. compactum*).
2. Cylindrical — narrowly oval — oval (*C. laxum*).

The two forms predominating are the oblong and the cylindrical. That the intergrading forms are not the younger stages of these two predominating types is evident from the fact that the seeds in all of them are fully mature. They may be different varieties or subspecies of one or the other of the two species. Incidentally, it may be mentioned that *Nipaniophyllum* also shows a good deal of variation in the leaf-size; Sahni (1948, p. 52) has suggested that the leaves with a broader lamina and midrib may be a species different from *Nipaniophyllum Raoi*, and perhaps belonged to another species of *Pentoxylon* which had the female cones known as *C. laxum*.

It may be possible in future to correlate the different forms met with in *Carnoconites* with the variations in the leaves of *Nipaniophyllum*. Sufficient data for this are lacking at present.

So far there are two known species of the genus *Carnoconites*, *C. compactum* and *C. laxum*, both created by Srivastava. The fully mature cones bear compactly arranged seeds borne spirally on the axis. A loose or lax arrangement of the ovules, as the name *C. laxum* indicates, is not seen either in Srivastava's specimens or the ones now discovered. The inappropriateness of the specific epithet, *laxum*, has also been pointed out by Sahni (1948, p. 73). The compact nature of these cones probably resulted from the growth of the seeds after fertilization;

TABLE I — VARIATIONS IN THE CONES OF *CARNOCONITES* SRIVASTAVA

Specimen	Cone			Seed		Breadth of fleshy tissue	Number of seeds in each row	Pedicel of the cone
	Form	Length	Breadth	Length	Breadth			
A. *Carnoconites compactum* Srivastava								
Srivastava	Compact	2 cm.	1 cm.	...	...	1-2 mm.	5-6	Long
Nos. 3214, 3215	Spherical	1 cm.	7 mm.	3 mm.	1 mm.	0·1-0·5 mm.	5-6	Unknown
No. 3224	do	2 cm.	1·1 cm.	4 mm.	2·5 mm.	0·5 mm.	5-6	do
No. 3216	Oblong	1·5 cm.	8 mm.	4 mm.	1 mm.	1 mm.	4-5	do
B. *Carnoconites laxum* Srivastava								
Srivastava	Lax	3 cm.	5 mm.	...	...	...	Up to 20	Unknown
Nos. 3219, 3220	Cylindrical	3 cm.	5-6 mm.	1·1·5 mm.	1 mm.	0·1-0·2 mm.	Up to 25	do
No. 3217	Oblong	1·5 cm.	5 mm.	2 mm.	1 mm.	0·1-0·2 mm.	8-9	2-3 mm.
No. 3218	Cylindrical	1·8 cm.	3 mm.	1 mm.	1 mm.	0·1-0·2 mm.	14-15	Unknown
C. Intermediate Forms								
No. 3221	Oval	1·3 cm.	5 mm.	1·5 mm.	0·7-0·8 mm.	0·1-0·2 mm.	7-8	Unknown
No. 3222	do	7 mm.	4 mm.	1·5 mm.	1 mm.	0·1 mm.	5-6	do
No. 3223	Club-shaped	2 cm.	5 mm.	2 mm.	1 mm.	0·1-0·2 mm.	20-22	do
No. 3225	Oval	1 cm.	6 mm.	2 mm.	0·5 mm.	0·1 mm.	5-6	do

before this perhaps the cone in both the species was lax. The 5- to 6-angled shape of the central axis seems to have been acquired by pressure exerted by the post-fertilization growth of the seeds both distally and proximally. Due to invagination of the axis by the seeds, an arm of tissue from the central axis extends between two adjacent seeds, a feature which in longitudinal or cross-sections sometimes gives the misleading appearance of a subtending bract or scale of a seed.

Infructescence of Carnoconites compactum Srivastava — The infructescence (PL. 4, FIGS. 1, 2; TEXT-FIG. 13) measures 4·5 cm. in length and 4·7 cm. in breadth and not more than 1 cm. in thickness. The peduncle bears 4 pedicels on one side and 5 on the other, three of which bear the cones. The pedicels are attached spirally. The cones are more or less circular in cross-section; in longitudinal section they are 1-1·8 cm. long and 6 mm.-1·4 cm. broad. The fleshy layer is 1-1·5 cm. wide. The ovules in each longitudinal row do not exceed 6-7 in number. The cone axis is pentangular and 2 mm. across. The seeds are sessile, spirally arranged with their micropyles facing outwards. No subtending organs are present.

The pedicels are 1 cm. long and 1 mm. broad and arise at a small angle from the peduncle; they run along the peduncle for a little distance and then diverge abruptly. They become broader and fleshy at their distal ends. The bifurcation of the pedicels at their distal ends is not seen anywhere. The pedicels in cross-section have three bundles, viz. two lateral larger ones surrounding the central smaller one.

The peduncle is 6·5 mm. broad and 2 mm. thick and 3·5 cm. long; it is oval in cross-section, flattened dorsiventrally and extended laterally with a more or less wavy outline all round.

The vascular bundles of the peduncle are arranged in a ring (PL. 4, FIG. 3; TEXT-FIG. 14). Their number from base to apex is variable. The cross-sections cut by the author from the basal region AA', BB' (TEXT-FIGS. 13, 14) show as many as 30-40 bundles. The vascular supply from the base to the apex of the peduncle was studied in serial cross-sections of another specimen of an infructescence of *Carnoconites compactum*. In this specimen a length of 3·5 cm. of the peduncle is preserved. A cross-section at the lower extremity of the peduncle shows about 36 vascular bundles in a slightly irregular ring and seven pedicel-traces each with 2, 3 or 4 vascular bundles. The number of the vascular bundles about 2 mm. higher is reduced to about 25. As we go up, the number becomes reduced to 23, 15, 10 at intervals of about 2-3 mm. The number is reduced to about 5 at the level where the peduncle passes into a pedicel; in the pedicel itself the number of vascular bundles is seen to be three.

Professor Sahni (1948, p. 76) described the number of the vascular bundles in the peduncle to be 10. Srivastava (1946, p. 20) reported 8-9 vascular bundles in the uppermost region. In my specimen 7-9 bundles are found in the region 6-7 mm. below the apex of the peduncle.

The number of the vascular bundles in the peduncle thus on the whole shows a steady decrease distally. The vascular ring is very regular in the basal region of the peduncle, but loses its regularity in the upper region; in the uppermost region it again regains its regularity.

The vascular bundles in the peduncle are collateral and in some of them (TEXT-FIG. 15) few scattered elements of centrifugal xylem are also present. They are anastomosing and several of them are fused in a linear series forming a continuity of their xylem and phloem. Besides uniseriate contiguous and biseriate contiguous and compressed bordered pits, several of the tracheids of the vascular bundles bear scalariform thickening also (PL. 4, FIG. 4; TEXT-FIGS. 16, 16a).

Interspersed with the scalariform tracheids are bands of parenchyma. Annular and spiral tracheids are, however, found crushed by the growth of parenchyma cells. The phloem in cross-section is well developed, but the sieve-tubes are not recognizable in longitudinal section. The pedicel-trace at the point of its origin resembles the cortical strand. While passing out of the cortex, it is wedged into 2 with the concavity towards the centre of the peduncle. A little distance away it divides into 2 and then emerges out of the cortex bearing 3 unequal bundles, one smaller surrounded by two larger lateral ones. Some of the cortical bundles are concentric. The xylem in all forms a curve opening inwards with the phloem on the convex side. As seen in cross-section the fusion of the bundles takes place at the region of xylem or phloem, while the other

region remains separate to both. In the cortex and pith are noticed scattered stone cells.

Infructescence of Carnoconites laxum Srivastava — The specimen (PL. 5, FIG. 1) is incomplete and consists of 3 elongated cones attached by short pedicels to the peduncle. The three cones radiate outwards making an angle of 45° with one another. The cones are 2·5 cm. long and 5-6 mm. broad, cylindrical, bearing as seen in exact longitudinal section three rows of the seeds. The seeds are 2 × 1 mm.; the micropyles face towards the outside; the fleshy layer is thin and less developed than in *C. compactum*. Number of the seeds in each row is not more than 20-22.

The pedicel is fairly short, 2-3 mm. in length and unbranched. The 3 pedicels are seen arising from the apical portion of the peduncle which is 3 mm. broad. The incomplete portion of the peduncle in the specimen is not more than 5 mm. long. The pedicels do not thicken at the distal ends where they join the base of the cone as is the case with the pedicels of *C. compactum*. The peduncle appears to be slightly laterally flattened just as the peduncle of *C. compactum* Srivastava. In an oblique longitudinal section the peduncle seems to contain a number of vascular bundles, more or less grouped to form the pedicel-traces. The pedicels show quite clearly three vascular bundles in each. From the only available longitudinal section it appears that the bundles were of equal size, quite unlike those of the pedicels of *C. compactum* Srivastava. In the absence of the cross-section it is not possible to ascertain if it is so.

Scalariform thickening in the tracheids of the peduncle and pedicels as well as the central axis of the cones is a very prominent feature, closely resembling that of *C. compactum* Srivastava.

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EXPLANATION OF PLATES

The figured specimens are preserved at the Birbal Sahni Institute of Palaeobotany

PLATE 1

Sahnia nipaniensis gen. et sp. nov.

1. Male flower borne apically on dwarf shoot. Slide No. 3236. × 4½.

2. Another male flower. Slide No. 3235. × 4½.

3. Fully mature flower with the filiform sporophylls bearing sporangia. Slide No. 3226. × 4½.

4. Young male flower showing sporophylls enclosed by deciduous bracts. Slide No. 3227. × 5.

PLATE 2

Sahnia nipaniensis gen. et sp. nov.

1. Specimen in Pl. 1, Fig. 3 further enlarged. Slide No. 3227. × 10.

PLATE 3

Sahnia nipaniensis gen. et sp. nov.

1. Part of the receptacle with the microsporophylls from flower shown in Pl. 1, Fig. 3 (cf. TEXT-FIG. 6). × 20.
2. Distal part of some of the microsporophylls belonging to flower in Pl. 1, Fig. 3. × 20.
3. A microsporophyll from specimen in Pl. 1, Fig. 3 enlarged showing the sporangia and their mode of attachment. × 30.
4. Scalariform thickening in the tracheids of the microsporophylls from specimen in Pl. 1, Fig. 3 (cf. TEXT-FIG. 7a). × 150.
5, 6. Pollen with a single furrow. × 150 (cf. TEXT-FIG. 9).

PLATE 4

Carnoconites compactum Srivastava

1. Infructescences cut more or less lengthwise showing the peduncle, pedicels and the cones. Specimen No. 3243. × 2 (cf. TEXT-FIG. 13).
2. Counterpart of the above. Specimen No. 3243A. × 2.
3. Cross-section of the peduncle of specimen shown in Fig. 1 (Slide No. 3231). × 18 (cf. TEXT-FIG. 14).
4. Tracheids from the vascular bundles of the peduncle showing scalariform pitting. Slide No. 3230. × 150 (cf. TEXT-FIG. 16a).
5. *Pentoxylon* stem and a dwarf shoot in organic connection. × 40 (cf. TEXT-FIG. 10).

PLATE 5

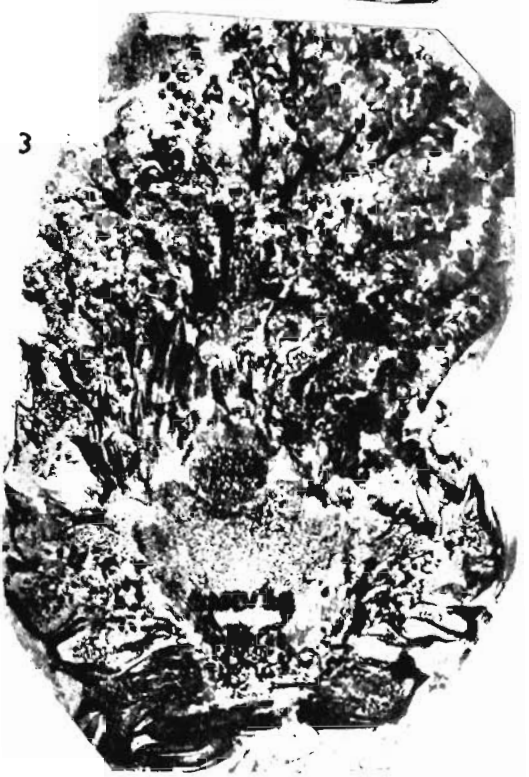
Carnoconites laxum Srivastava

1. Apical part of the infructescence (Slide No. 3242). × 4.

1

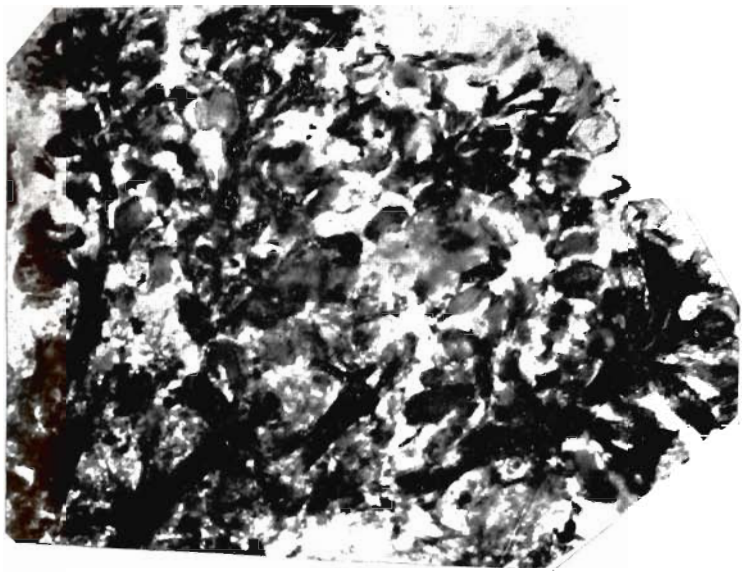
2

4



3

1

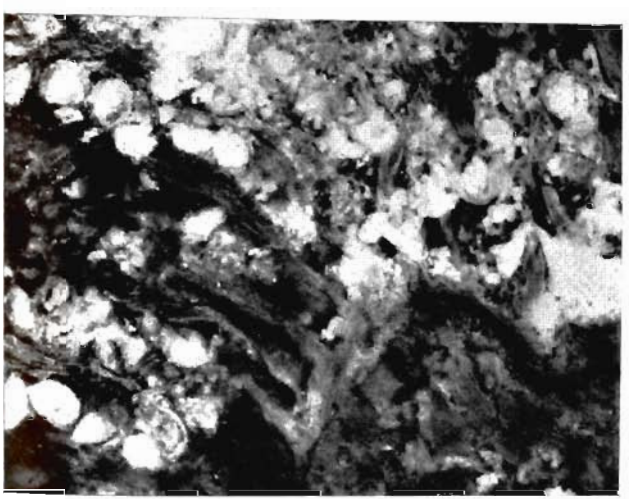


2

6

5

4

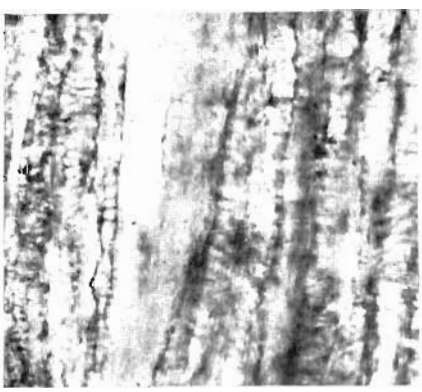


1

3

1

5



4

2

3