

ARAUCARITES BINDRABUNENSIS SP. NOV., A PETRIFIED MEGASTROBILUS FROM THE JURASSIC OF RAJMAHAL HILLS, BIHAR

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ABSTRACT

Under the name *Araucarites bindrabunensis* sp. nov. two specimens of petrified araucarian megastrobili are described from the Rajmahal Hills, Bihar. The megastrobili are ellipsoid in form and bear closely arranged, numerous, single-seeded scales. The scales are ligulate, winged and woody. Vascular supply of the cone-scales is probably double. Sclereids are absent from the pith of the cone axis and resin cells from below the vascular bundles both in the scale and the ligule. Stomata are absent from the upper surface of the seed-scale. Epidermal cells vary in size and shape according to their position on the scale.

In several respects the Rajmahal specimens resemble the fossil species *Araucaria mirabilis* (Speg.) Calder and the living species *A. Bidwillii* Hook.

INTRODUCTION

IN India the fossil plants belonging to Araucariaceae have so far been known only from impressions. The vegetative remains have been described under the name *Araucarites latifolius* Fst. by Feistmantel (1882) from Bansa near Chandia (S. Rewah), Jabalpur stage. The fertile remains are represented by detached cone-scales described as *Araucarites cutchensis*, *A. macropteris*, and *Araucarites* sp. and a cone known as *Ontheodendron Florini*. *A. cutchensis* was first described by Feistmantel (1876, p. 62) from Kukurbit in Kach (Umia stage). He also described *A. macropteris* (FEISTMANTEL, 1877, p. 24) from Golapili near Ellore in Madras (Rajmahal stage). Both these species were later reported from Kota stage (FEISTMANTEL, 1879, pp. 197-98, 218) and Jabalpur stage (idem, 1877a). *Araucarites* sp. and *Ontheodendron Florini* were the first araucarian remains described from the Rajmahal Hills by Sahni and Rao in 1933.

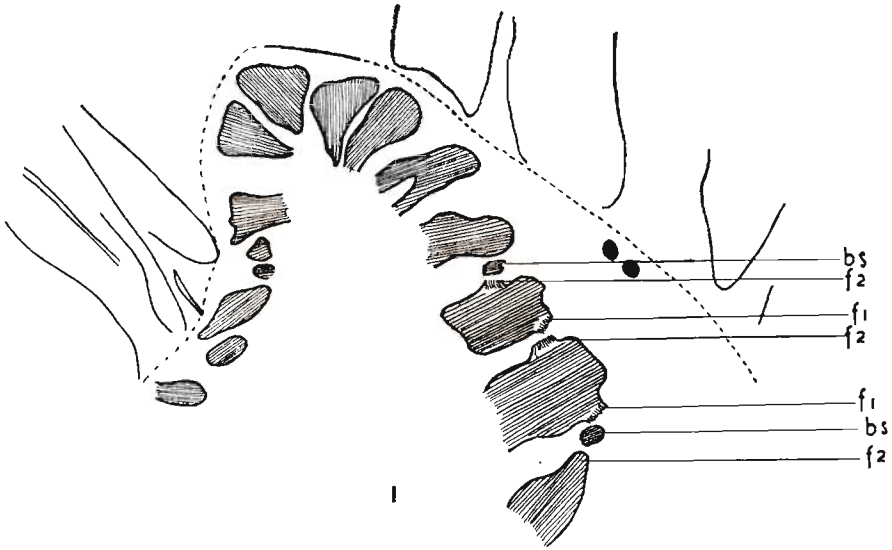
The only other Indian araucarian fossils known to the author are well-preserved impressions of cone-scales (unpublished) collected by Dr. K. R. Mehta and Mr. C. G. K. Ramanujam and by Mr. S. C. D. Sah from the Rajmahal Hills.

Silicified araucarian remains comprising seed-cones, seed-scales, twigs and multi-nerved leaves have been discovered from India for the first time by the author. Only the seed-cones and seed-scales are described in this paper. To start with the fossil cone was thought to be a mere cast and was described as such in a brief report on the material already published (VISHNUMITRE, 1953).

Locality — The material described in this paper was discovered by the author in 1950 from a cherty boulder from recently discovered Bindrabun (Brindabun), 4 miles north of Tinpahar, in the Rajmahal Hills. The boulder was found lying astray near the foot of the southern face of the hill at Bindrabun (Brindabun). This locality is different from Bindrabun, the famous locality from which Oldham and Morris (see FEISTMANTEL, 1880, p. x) described most of the plant remains.

The locality Bindrabun abounds in silicified wood and leaf impressions. Huge logs of wood several feet in length and 15-20 ft. in girth occur in groups at several places. Numerous fossil stumps are still seen standing there *in situ*. Cherty boulders either greyish white or reddish brown in colour are also very common. Fossil twigs predominate in these cherts. Other plant organs, i.e. leaves, shoots, fruits and seeds, are scarcely noticed.

Preservation and Technique — The fossil cone embedded in the chert is completely silicified. Maceration with hydrofluoric acid to recover cuticles or preparation of peel sections did not meet with any success. The specimen was sliced and microscopic sections prepared to study the anatomical details. On the whole preservation of tissues is good. The sections were stained with safranin but the response of the tissues to the stain was very poor. The sections have been mounted in dilute glycerine because the organic remains become transparent when mounted in Canada balsam.



TEXT-FIG. 1 — Longitudinal section of the cone-axis showing the vascular supply to the bract scale (bs) and fertile scales (f1 × f2). × 10.

DESCRIPTION

CLASS — CONIFERALES

FAMILY — ARAUCARIACEAE

GENUS — *Araucarites* Presl.

Araucarites bindrabunensis sp. nov.

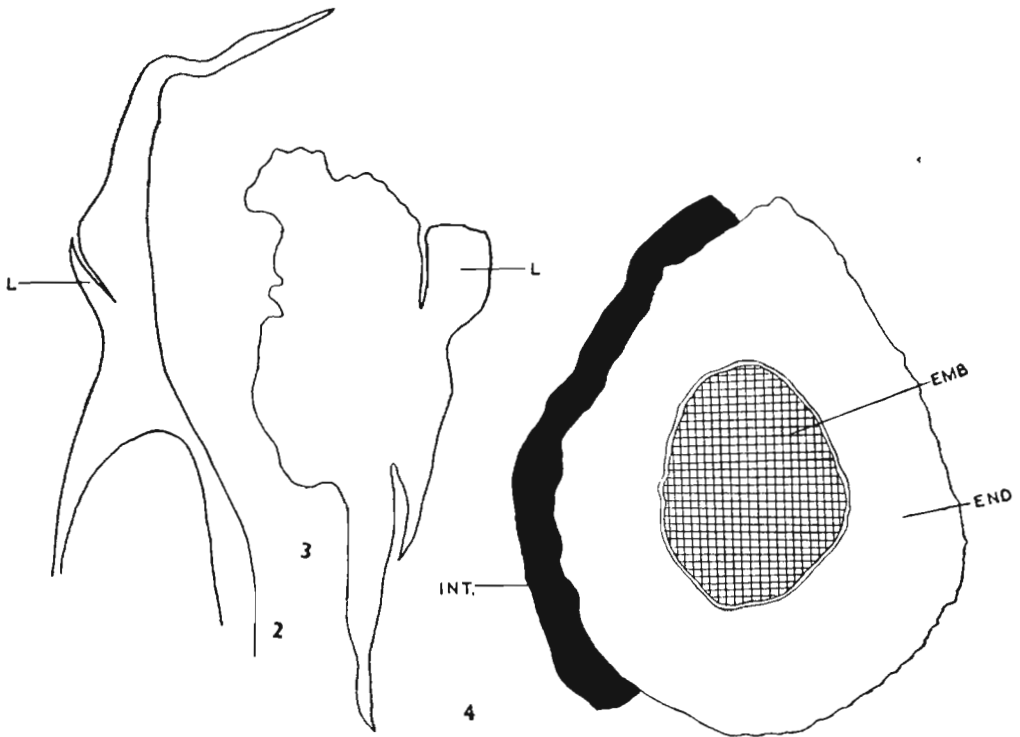
The species is based on two specimens of cones, one fairly complete (PL. 1, FIG. 1A) and the other a small portion (PL. 1, FIG. 1B), and some stray cone-scales. The specimens are embedded in the rock matrix of greyish colour and are silicified. The complete megastrobilus measures 7.5 cm. in length and 4.4 cm. in breadth. It seems to have been silicified before the shedding of its scales. The other cone (PL. 1, FIG. 1B) consists of a small portion of an axis bearing three scales. Examination from the other side of the block shows that this axis is attached to a small twig. It appears that these three scales borne by the axis are the remnants of a dehiscent cone.

The cone-axis — The cone axis (PL. 1, FIG. 5a; TEXT-FIG. 1) is about 1 cm. in diameter. In longitudinal section it shows a fairly wide pith, about 5-6 mm. in diameter. The pith is surrounded by a ring of separate vascular bundles (PL. 2, FIG. 8; TEXT-FIG. 1). The pith does not contain any sclereids, branched or unbranched, but a mucilage duct (PL. 2, FIG. 8, md) is present.

The vascular bundles in the cone-axis in the only longitudinal section available (TEXT-FIG. 1) are more or less obliquely cut. The primary xylem is not seen. Phloem is not preserved. In between the vascular bundles the medullary rays are very well preserved.

The pitting in the tracheids is not well preserved. However, at some places scalariform pitting is visible. Pits in the radial walls of the tracheids are rather obscure and appear to be uniseriate or biseriate and contiguous.

It is not possible to trace the vascular supply of the seed-scale complex for want of more material. Comparing the longitudinal section of the cone-axis of our specimen (TEXT-FIG. 1) with the figures of the cone-axis of *Araucaria mirabilis* as given by Miss Calder (CALDER, 1953, p. 113; TEXT-FIG. 2 A-F) it is possible to make out something of the nature of the vascular supply in the Rajmahal specimen. Fertile scale supply seems to arise by the fusion of the two strands, f1 and f2 (TEXT-FIG. 1), one from each vascular bundle coming off separately from each side of the leaf gap. Nothing beyond this is traceable of the vascular supply. If the observation made here is correct, then the seed-scale complex receives two vascular bundles. The cross-sections of the seed-scales from base to apex



TEXT-FIGS. 2-4 — 2, L.S. of a scale showing the ligule (L) and the prolonged tip. $\times 10$. 3, L.S. of a scale showing the attachment of the ligule (L). $\times 10$. 4, cross-section of a seed showing the integument (INT), endosperm (END) and embryo (EMB). $\times 25$.

were cut but the vascular bundles were not found preserved.

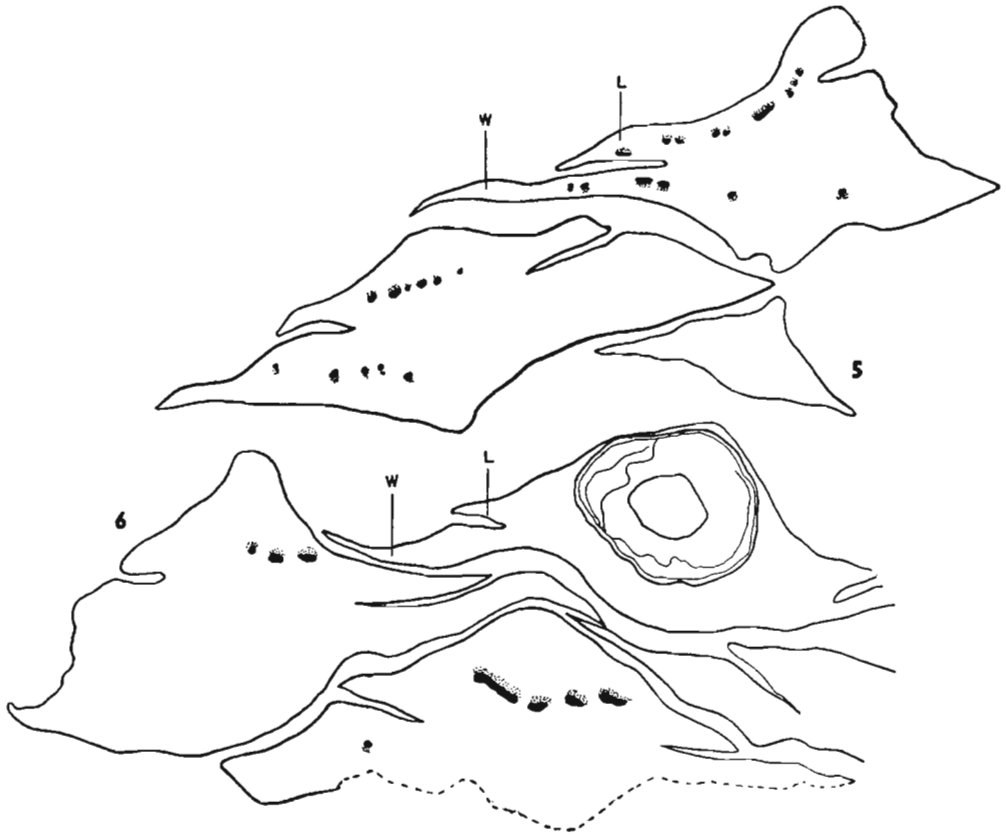
The Cone-scales — The scales (PL. 1, FIG. 4), measuring 0.18×0.9 cm. in the broadest part, are borne closely and spirally on the cone-axis. The scales are woody and wedge-shaped. The expanded distal part ends in a tip 3-5 mm. long (PL. 1, FIG. 7; TEXT-FIG. 2); proximally the scale gradually tapers towards its junction with the axis. The scales bear on their surface faint rib-like markings extending from the base towards the distal margin (PL. 1, FIG. 1). The margin on either side of the scale is expanded in the form of thin wings (PL. 1, FIG. 6). The expanse of the wings narrows down towards the proximal end of the scale. The cone-scales are ligulate (PL. 1, FIGS. 6, 7; TEXT-FIGS. 2, 3).

The epidermis of the scale and of ligule (PL. 2, FIG. 9) is made up of thick cross-walls and in section where the epidermis is imperfectly preserved these thick cross-

walls show as if the edge of the scale was spiny. The epidermis of the ligule in several sections seems to be very closely fused with the epidermis of the scale and the thick cross-walls of one are interlocked into those of the other and alternate with one another.

The hypodermis (PL. 2, FIG. 9) consists of 2-3 layers of rounded cells. In between the upper and lower hypodermal layers the cells are very small and indistinctly preserved. The anatomy of the wing (PL. 2, FIG. 10) is exactly similar to that of the scale. The vascular bundles in the scale as well as in the wing are not underlain by resin cells.

The Ligule — The ligule, like the scale, is also woody. The ligule is attached (PL. 1, FIG. 6; TEXT-FIG. 3) only in its middle to the adaxial surface of the scale and is freely prolonged both towards the distal and the proximal ends of the scale. It is undivided at its distal end. The ligule, like the scale, receives the vascular supply.



TEXT-FIGS. 5, 6 — Cross-sections through cone-scales showing the vascular supply in the ligule (L) and scale. W = wing. $\times 5$.

The vascular bundles in the ligule are inverted and like those of the scales are not underlain by any resin cells (PL. 2, FIG. 9; TEXT-FIGS. 5, 6).

The Seed — There is a single seed (PL. 1, FIG. 4) per scale. It is embedded on the adaxial face of the scale and in the fossil lies free in its cavity. The seed is cylindrical and measures 1.3-0.35 cm. It is inverted and gradually tapers towards the micropylar end. On breaking the specimen in the field several seeds were detached and fell off. A seed was later removed from one of the scales and ground from its distal end to study its anatomy.

The integument (TEXT-FIG. 4) of the seed is probably three-layered — thin outer and inner layers and a stony middle layer. The inner thin layer is followed by the endosperm which encloses the embryo.

The Cuticle — It has only been possible to study the cuticle from the upper surface

of the seed-scale. Attempts to study the cuticle from the lower surface of the scales by serial grinding and examining the material and also by macerating the scale-bearing material with hydrofluoric acid did not meet with success.

The cuticle from the upper surface of the seed-scale is devoid of stomata.

The epidermal cells from the upper surface of the distal portion of the scale are several times longer than broad, quadrangular, arranged in regular rows with the long axis parallel to the length of the scale.

The epidermal cells on the upper surface of the wing (PL. 2, FIG. 11) are irregular in shape and variously orientated. There also occur groups of similarly orientated cells lying more or less obliquely or at right angles to the neighbouring cells. The cells on the periphery of the wing are larger and in regular rows (PL. 2, FIG. 12).

Diagnosis—Megastrobilus ellipsoid, 7.5 cm. long, 4.4 cm. in diameter. Cone-scales, 1.8×0.9 cm., numerous, closely arranged round the axis; woody, winged, produced into a tip 3.5 mm. long. Ligule 6-7 mm. long and woody. Seed single, cylindrical, 1.3×0.35 cm., inverted, detachable. Integument probably three-layered, middle stony and the outer and inner thin. Cone-axis 1 cm. thick with a pith 5-6 mm. wide, no sclereids. Mucilage ducts present; vascular supply of the cone-scale probably double; the bract trace single, the fertile scale supply made up of two strands, each arising from either side of the leaf gap. Resin cells absent from below the vascular bundles in the scale and ligule. Stomata absent from the upper surface of the seed-scale. Epidermal cells on the distal portion of the upper surface of the scale longer and arranged in parallel rows along the length of the scale. Epidermal cells on the wing irregularly shaped and variously orientated.

DISCUSSION

The chief interest of the present paper lies in the fact that it serves as the first record of araucarian remains from India of which the anatomy has been studied. So far our knowledge of the araucarian remains from India was limited to impressions only. The structural details of the megastrobilus have helped a great deal in tracing its affinities.

The specimens described here have nothing whatsoever to compare with the impressions of *Ontheodendron Florini*, the only other fossil araucarian cone known from India.

In size and general outline the cone-scales of the present material approach *Araucarites cutchensis* more than *A. macropteris*. These comparisons cannot be stretched any further since the anatomy of *A. cutchensis* is not known.

Petrified megastrobili have been described from the petrified forest in Patagonia by Spegazzini (1924), Gothan (1925), Wieland (1935), Darrow (1936) and Calder (1953). Calder (1953, p. 110) described under the name *Araucaria mirabilis* (Spegazzini) the petrified araucarian cones which were previously described under different names such as *Araucarites mirabilis* Spegazzini, *Araucaria Windhausenii* Gothan, *Proaraucaria mirabilis* (Speg.) Wieland, *Proaraucaria patagonica* Wieland, *P. elongata* Wieland,

P. mirabilis var. *minima* Wieland and *Araucaria mirabilis* (Speg.) Windhausen.

In the origin of the vascular supply of the cone-scale from the axial stele, the size and nature of the wing of cone-scale and that of the ligule and its vascularization, etc., the silicified specimen described here resembles the cones of *Araucaria mirabilis*,

However, it differs from *A. mirabilis* in the longer scales and seeds, in the absence of sclereids and the presence of mucilage ducts in the pith and the absence of the resin cells from below the vascular bundles of the scales and the ligules. Another point of difference noted from *A. mirabilis* is the dehiscence of the individual scales and the seeds in *A. bindrabunensis* which according to Calder (1953, p. 112) may not be a distinct feature, but "may well be explained in term of the season in which the forest was overwhelmed". Further, the cuticle of the cone-scales of *A. mirabilis* is unknown.

The cuticle of fossil araucarian cone-scales is known only in three cases, viz. a Jurassic species *Araucarites phillipsi* Carr. (KENDALL, 1949, pp. 154-58) and two Tertiary species *Araucaria lignitici* Cookson and Duigan and *Agathis Yellourensensis* (COOKSON & DUIGAN, 1951, pp. 428-41). In the absence of the complete knowledge of the cuticle from both the upper and the lower surfaces of the seed-scale in *A. bindrabunensis*, it is futile to make cuticular comparisons with any of the fossil and living species of *Araucaria*. However, it is interesting to note that the epidermal cells on the distal region and on the wing of the cone-scales of *A. bindrabunensis* are very much comparable to the epidermal cells of the corresponding regions on the cone-scales of *A. lignitici* (COOKSON & DUIGAN, loc. cit., p. 429, PL. 3, FIG. 24).

Calder (1953, pp. 116, 118) compares *A. mirabilis* with the living species of *A. Bidwillii* which belongs to the newly created section *Bunya* (WILDE & EAMES, 1952, p. 44). Resemblance of *A. bindrabunensis* is also noted with this living species in the presence of woody wings, the dehiscence nature of the scales and seeds and in the vascular supply of the ligule. The vascular supply of the ligule is not found in any other living or fossil species of *Araucaria* except *A. Bidwillii* (WILDE & EAMES, 1948, p. 322) and *A. mirabilis* (CALDER, loc. cit.). The nearest living relation of *Araucaria bindrabunensis* is the Queensland 'bunya bunya', *A. Bidwillii*. *A. bindrabunensis* may,

therefore, be an extinct species of the section *Bunya* to which *A. Bidwillii* belongs.

There are no araucarias to be found growing wild in India today; *Agathis loranthifolia* has, however, been reported by Hooker (BISWAS, 1933, p. 43) from Malaya Peninsula. The present investigation shows that the Jurassic vegetation of India had a fair representation of Araucariaceae which has become extinct now.

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EXPLANATION OF PLATES

All photographs from untouched negatives.

PLATE 1

1. The block of the chert with two cones (A) and (B). Nat. size.
- 2 & 3. Counterparts of the cone in Fig. 1(A). Nat. size.
4. Cone-scales with embedded seed in one scale enlarged from Fig. 3. $\times 4$.
5. A piece of the block showing a part of the megastrobilus cut in oblique longitudinal section and a part of another megastrobilus; a = cone-axis. \times Nat. size.
6. Cross-section through a scale showing ligule (l) and wings (w). $\times 6$.
7. L.S. of the cone-scale showing the ligule (l) and the prolonged apex of another scale shown

in the lower left-hand corner of the photograph. $\times 5$.

PLATE 2

8. Cross-section through a part of the cone-axis showing the vascular bundles and a mucilage duct (md). $\times 25$.
9. A part of the cross-section of a scale showing anatomy of the scale and the ligule and the vascular bundles in the ligule (vb). $\times 40$.
10. A cross-section of a part of the wing showing the anatomy. $\times 30$.
11. Cuticle of the lateral wing. $\times 62$.
12. Cuticle from the upper surface of the seed, showing long, narrow epidermal cells. $\times 62$.



