

AMARJOLIA DACTYLOTA (BOSE) COMB. NOV.,
A BENNETTITALEAN BISEXUAL FLOWER FROM THE
RAJMAHAL HILLS, INDIA

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ABSTRACT

Amarjolia dactylota (Bose) comb. nov. comprises spirally arranged bracts enclosing a whorl of microsporophylls and the female receptacle with immature seminiferous and interseminal scales. Microsporophylls in gross features resemble the microsporophylls of *Weltrichia santalensis* (Sitholey & Bose) Bose described by Sitholey and Bose (1971). Flower being protandrous, the details of seminiferous and interseminal scales are not known.

Key-words— *Amarjolia*, Bennettitales, Bisexual flower, Rajmahal Hills, Upper Jurassic (India).

सारांश

भारत में राजमहल पहाड़ियों से एक बेंनेटाइटेली उभयलिंगी पुष्पाणुम : अमरजोलिया डेक्टाइलोटा (बोस) नव संयोजन - महेन्द्र नाथ बोस, जयश्री बैनर्जी एवं पंकज कुमार पाल

अमरजोलिया डेक्टाइलोटा (बोस) नव संयोजन में लघुबीजाणुपर्णों के चक्र के चारों ओर सपिलाकार विन्यस्त सहपत्र तथा अपरिपक्व बीजघर शल्क एवं अन्तराबीजी शल्क विद्यमान हैं। लघुबीजाणुपर्ण सिथोले व बोस (1971) द्वारा वर्णित वैलट्राइकिया सॅन्तालेन्सिस (सिथोले व बोस) बोस से सभी लक्षणों में समानता प्रदर्शित करते हैं। यह पुष्प पुष्पकव है तथा इसके बीजघर एवं अन्तराबीजी शल्कों के विषय में विस्तृत जानकारी नहीं है।

INTRODUCTION

A BISEXUAL flower belonging to Bennettitales was described by Bose (1966) as *Cycadeoidea dactylota* from Amarjola (about 1.8 km NE of Amara-para Village), Rajmahal Hills, Bihar. His description was based on a well-preserved petrified specimen. Since then several visits were made to the same locality in search of new specimens, but without any success. However, a specimen having only the outer bracts enclosing an immature 'androecium' was collected by one of us (M.N.B.) from the same locality. The present paper describes the original specimen of Bose (1966) and the immature flower bud.

DESCRIPTION

Genus— *Amarjolia* n. gen.

Diagnosis— As for the only species *Amarjolia dactylota* (Bose) comb. nov.

Amarjolia dactylota (Bose) comb. nov.

Pl. 1, figs 1-4; Pl. 2, figs 7-10; Pl. 3, figs 13-15;
Pl. 4, figs 16-19; Text-figs 1-4

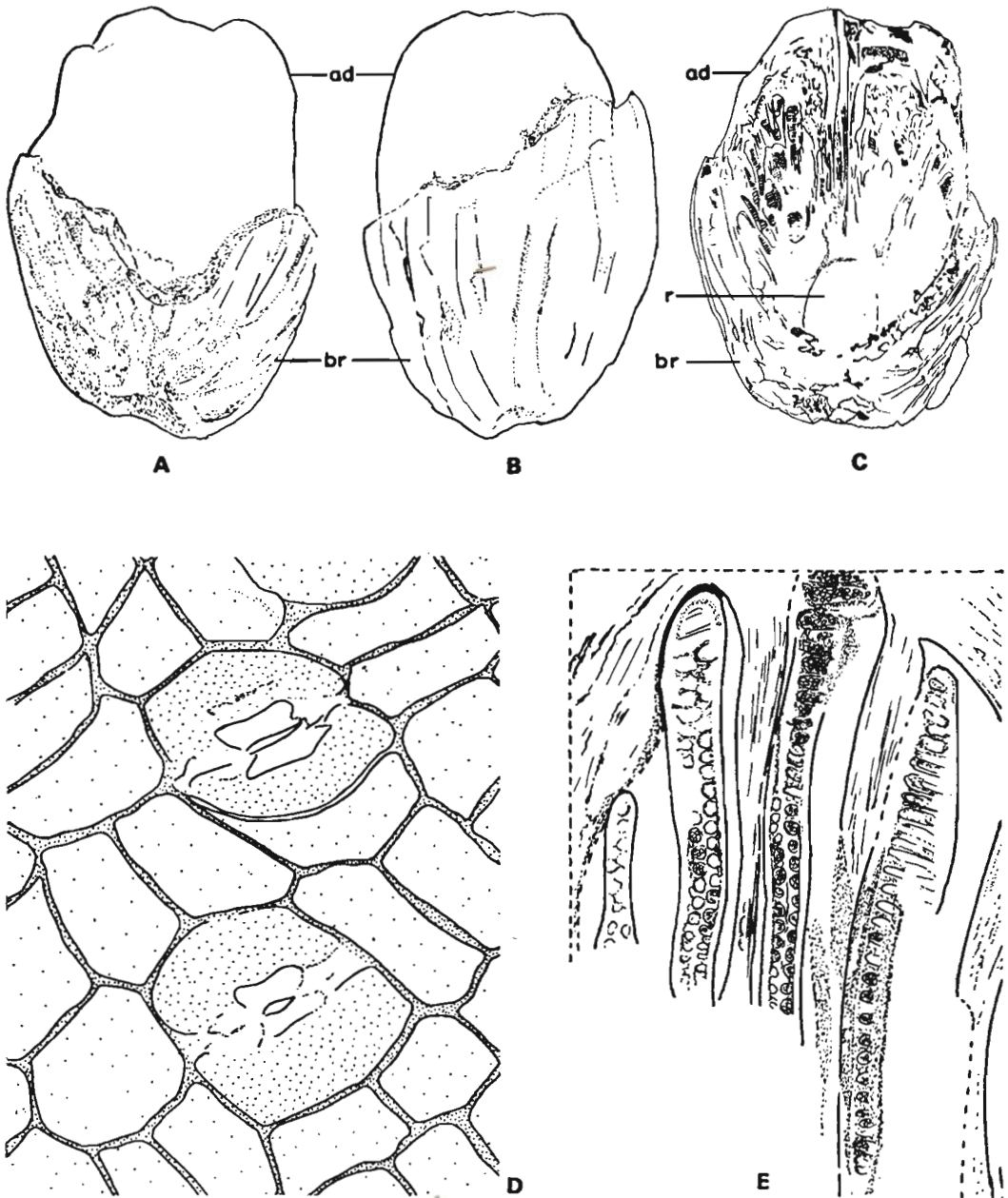
1966 *Cycadeoidea dactylota* Bose, p. 569, fig. 1 (description and text-figure of the holotype).

1971 *Cycadeoidea dactylota* Bose: Sitholey & Bose, pp. 153, 158, pl. 34, figs 19-21 (brief discussion and figures of microsporophylls).

1974 *Cycadeoidea dactylota* Bose: Bose, p. 194 (brief description and discussion).

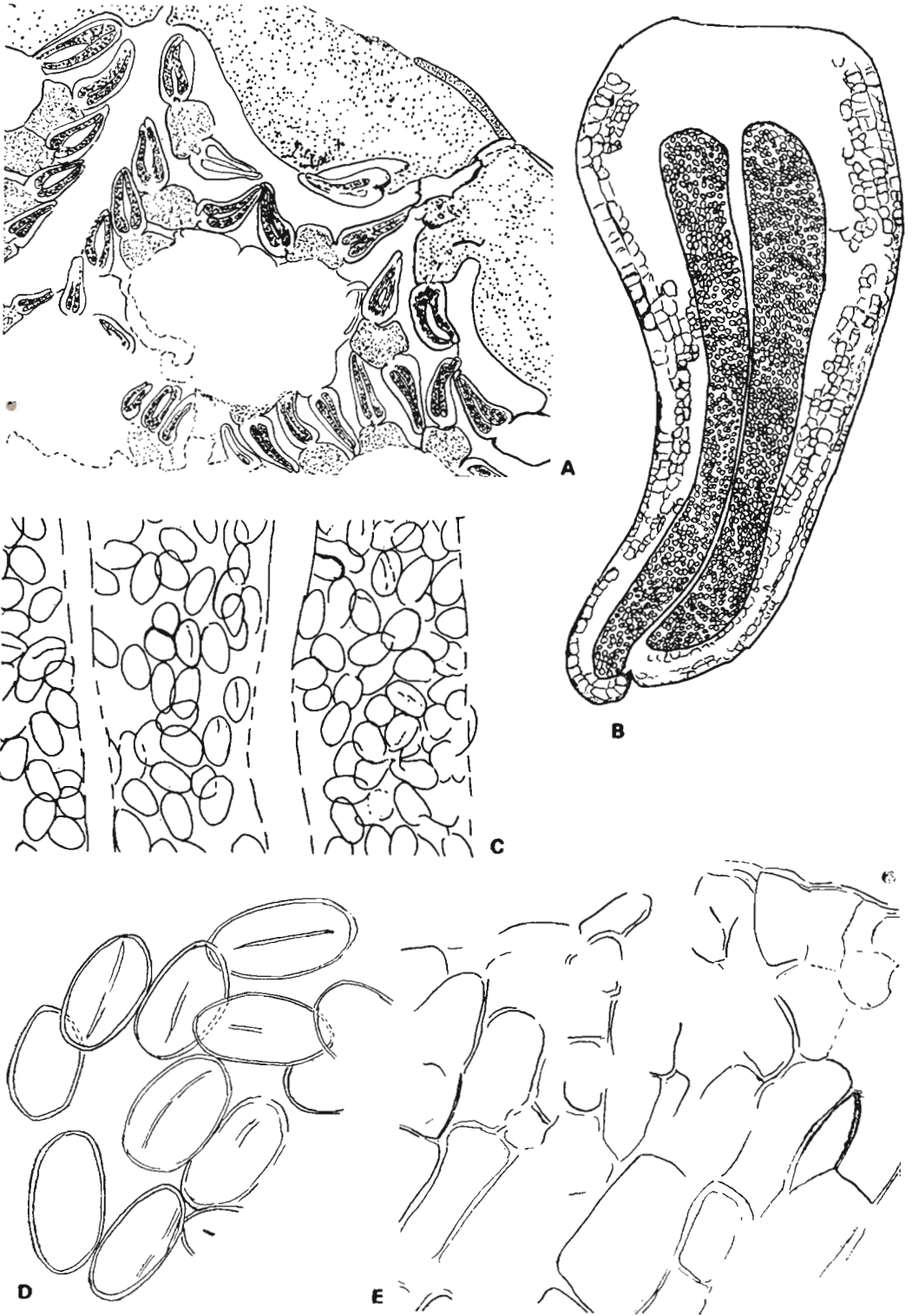
Diagnosis— Bisexual flower consisting of an axis bearing bracts, 'androecium' and female receptacle with immature seminiferous and interseminal scales.

Flower as a whole oval in shape, 6 cm long and 4.5 cm wide. Bracts spirally arranged, forming a perianth of more than two turns, exact number in each turn not known, lateral sides showing prominent



TEXT-FIG. 1A-E — *Amarjolia dactylota* (Bose) comb. nov.— A, B, the flower as seen from two different sides, B.S.I.P. specimen no. 24133, $\times 1$; C, median longitudinal section of the flower, B.S.I.P. slide no. 24133-1, $\times 1$; D, showing two stomata and epidermal cells of a bract, B.S.I.P. slide no. 24133-12, $\times 500$; E, longitudinal section of a few 'synangia', B.S.I.P. slide no. 24133-1, $\times 7$ (ad='androecium', br=bracts and r=receptacle).

TEXT-FIG. 2A-E — *Amarjolia dactylota* (Bose) comb. nov.— A, a part of 'androecium' in transverse section showing parts of microsporophylls and a few 'synangia', B.S.I.P. slide no. 24133-8, $\times 6$; B, a synangium showing two pollen masses, B.S.I.P. slide no. 24133-8, $\times 60$; C, parts of 'synangia' showing pollen grains, B.S.I.P. slide no. 24133-1, $\times 200$; D, a few pollen grains, B.S.I.P. slide no. 24133-1, $\times 500$; E, showing a few cells of seminiferous and interseminal scales in longitudinal section, B.S.I.P. slide no. 24133-1, $\times 500$.



TEXT-FIG. 2A-E

long hairs; hairs about 4-5 mm long. Surface cells of bracts on ventral side polygonal or rectangular; lateral- and end-walls straight or at places slightly wavy; surface-wall unspcialized. Cells on dorsal surface like those on ventral surface. Stomata confined to dorsal surface only, not so densely crowded, transversely orientated. Subsidiary cells smaller than ordinary epidermal cells, non-papillate. Guard cells crescent-shaped; aperture elliptical in shape.

Bracts in cross section showing a thick layer of cuticle followed by rectangular epidermal cells, an ill-defined zone of hypodermal cells and ground tissue of loosely connected isodiametric cells. Vascular bundles not well-marked, their number and arrangement not clear.

'Androecium' as a whole ovate in shape, entirely covering and concealing female receptacle, about 4.7 cm long and 3.5 cm wide near middle region; consisting of 12 microsporophylls in a whorl, microsporophylls compressed together but not fused with each other, externally showing 12 prominent ridges and grooves; each groove finely striated in longitudinal direction, at places somewhat rugose. Microsporophylls attached in a whorl just below base of female receptacle. In cross section microsporophylls showing a thick cuticle followed by a layer of rectangular epidermal cells and parenchymatous zone consisting of loosely connected isodiametric cells traversed by a large number of secretory canals. In some near centre a single vascular bundle is visible. In longitudinal section microsporophylls near apex showing a thick parenchymatous tissue, about 1.2 cm in height; lower down microsporophylls bending inwards and reaching close to the base of female receptacle and entirely encircling it from all sides so as to form a sort of "chamber" between walls of microsporophylls and receptacle. On adaxial side of microsporophylls a large number of finger-like 'synangia' are seen projecting out and almost filling the entire "chamber". 'Synangia' attached in two rows on adaxial sides of microsporophylls; about 1.7-2 cm long. Bases of 'synangia' swollen, gradually narrowing towards tip. Each 'synangium' in median longitudinal section showing two series of small chambers along its entire length; chambers of one series lying in contact with each other and alternating

with those of the other series. Each chamber full of numerous pollen grains. In cross section 'synangium' showing a central parenchymatous zone bearing on either side ovate pollen-bearing organ, each consisting of an outer layer of cuticle followed by a layer of rectangular epidermal cells and a 3-cell wide zone, cells within this zone rectangular in shape, enclosing somewhat two oval chambers full of pollen grains. The layer separating the two pollen bearing chambers not well-preserved.

Pollen grains oval with symmetrical ends, sometimes with asymmetrical ends, 16-24 × 24-36 μm. Monosulcate, sulcus long, usually narrow, ends ± tapering. Exine thin, about 1 μm thick, laevigate and infra-structured.

Female receptacle dome-shaped, internal tissue not well-preserved. In cross section at places isodiametric cells visible, numerous secretory canals are also present, xylem extremely poorly preserved. Semiferous and interseminal scales immature, visible only at places, represented by a few cells here and there.

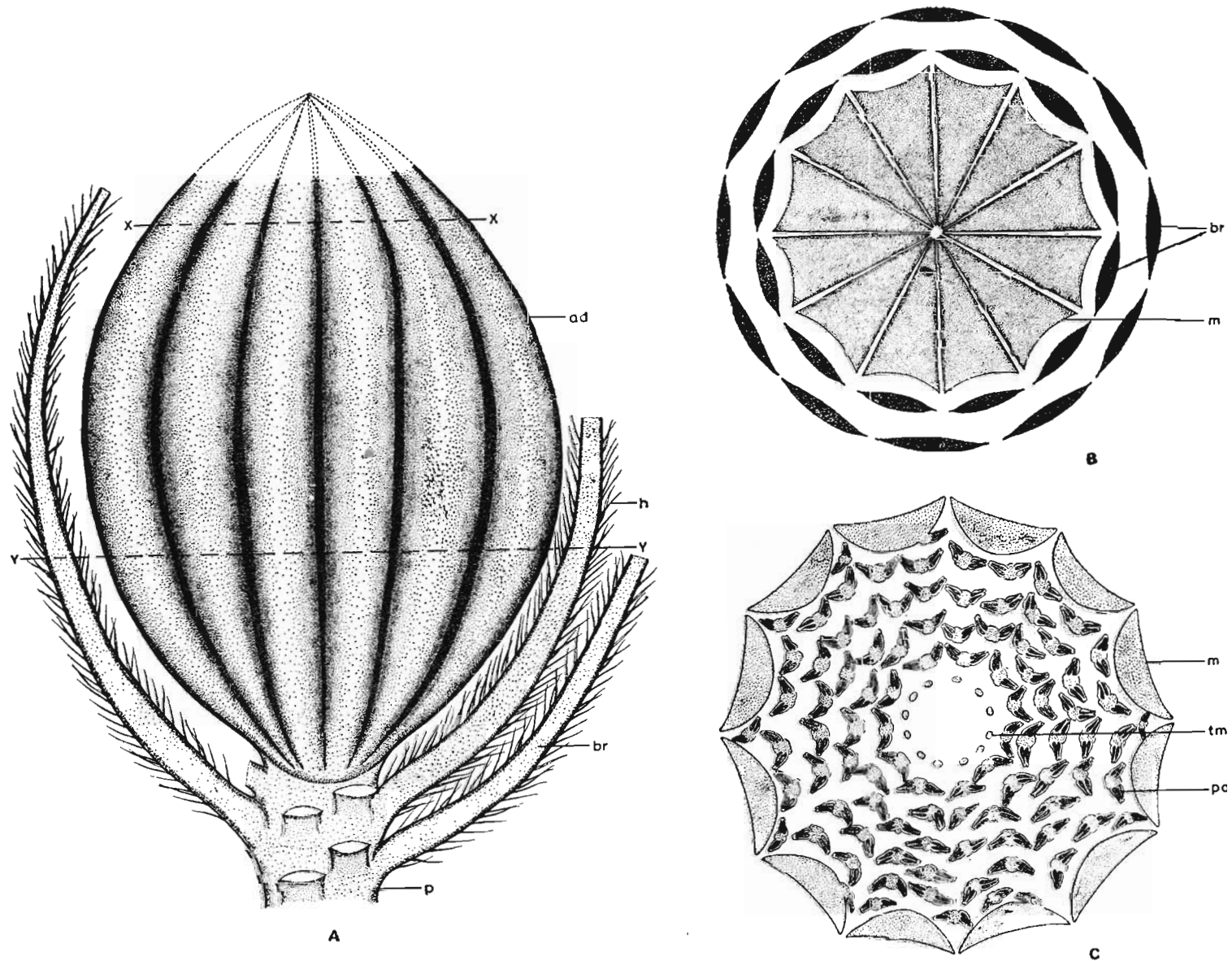
Holotype—Specimen no. 24133 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality—Amarjola, Rajmahal Hills, Bihar.

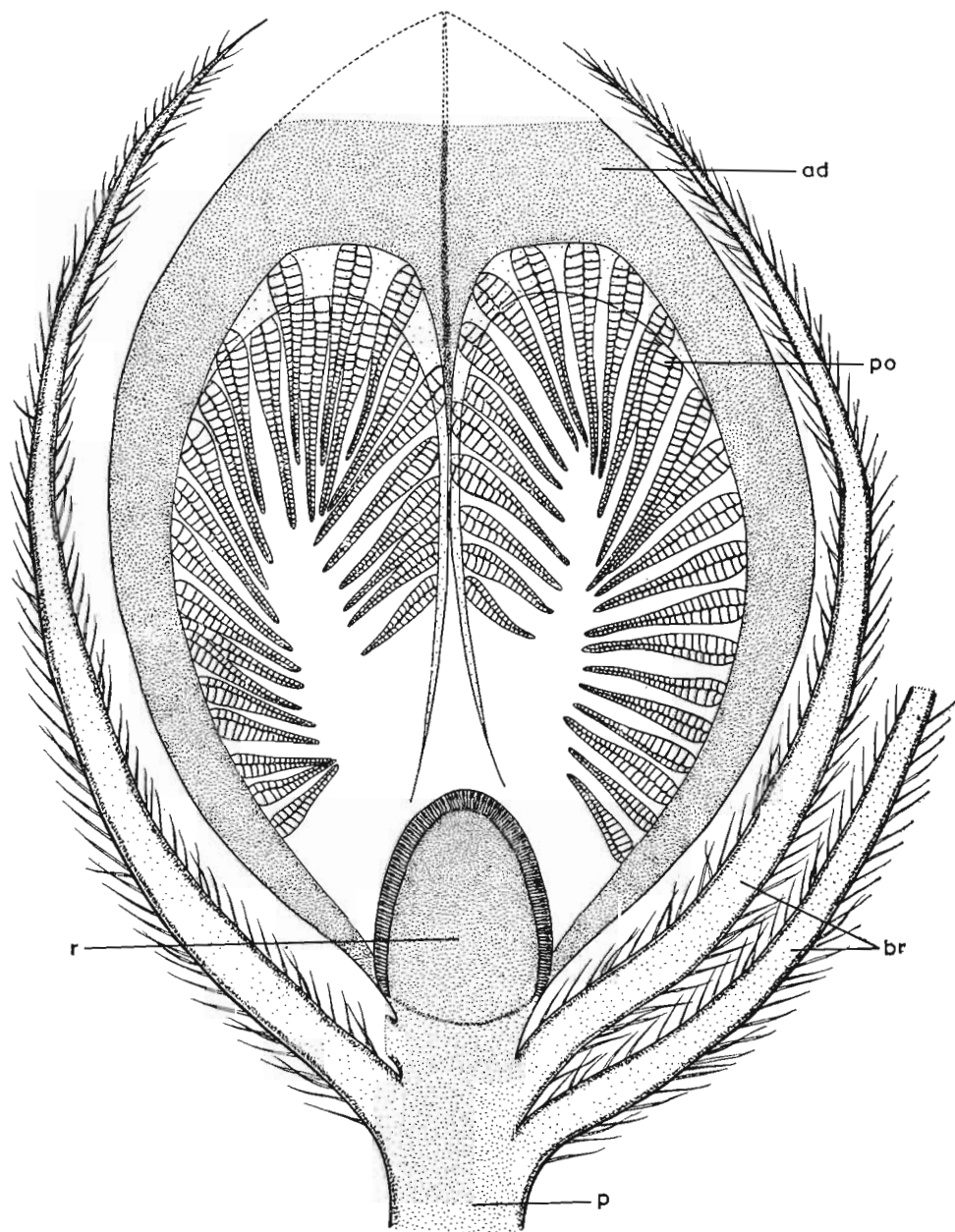
Horizon & age—Rajmahal Formation; Upper Jurassic.

Remarks & comparison—*Amarjolia dactylota* is the only Bennettitalean bisexual flower so far known from India. The above diagnosis is based on a petrified specimen whose bracts are incomplete towards distal end, exposing major part of 'androecium'. Unfortunately, except for the 'androecium' the anatomical details of the bracts, peduncle and the receptacle, together with semiferous and interseminal scales, are not so well-preserved. In none of the microsporophylls vascular supply is visible. In some of the transverse sections of the microsporophylls, where the finger-like 'synangia' are attached, a single vascular bundle is visible in the centre. In median longitudinal section some of them show, at places, scalariform tracheids.

The semiferous and the interseminal scales are in a very young stage of development. Except for a few cells their details are not clearly visible. From their stage of development it is clear that this flower was protandrous. Perhaps the ovules matured after the pollen grains were shed



TEXT-FIG. 3A-C— *Amarjolia dactylota* (Bose) comb. nov.— A, Idealized restoration of the flower, the majority of bracts (br) not shown in order to show the 'androecium' with ridges and grooves, \times ca 5; B, idealized restoration of the transverse section along the line x—x shown in fig. A (b=bracts and m=microsporophylls), \times ca 2.5; C, idealized restoration of transverse section of the flower along the line Y—Y shown in fig. A, showing proximal (outer) part of microsporophylls(m), syngangia attached to stalks (pc) and distal (inner) part of microsporophylls (tm) close to receptacle, \times ca 2.5 (bracts not shown).



TEXT-FIG. 4—The median longitudinal section of the flower—an idealized restoration, showing spirally arranged bracts (br), 'androecium' (ad) bearing fertile finger-like 'syngia' (po), female receptacle (r) bearing seminiferous and interseminal scales and the peduncle (p).

It is of course difficult to say and demonstrate whether the ovules were in the pollen receptive stage at the time of shedding of the pollen grains.

The microsporophylls of *A. dactylota* resembles most, in gross features, the micro-

sporophylls of *Weltrichia santalensis* (Sitholey & Bose) Bose described by Sitholey and Bose (1971). The details of pollen bearing organs of *W. santalensis* are not known. In general appearance *A. dactylota* somewhat resembles *Cycadeoidea dactotensis*

(Macbride) Ward and *Cycadeoidea* sp. described by Delevoryas (1963) and Crepet (1974). The microsporophylls of *C. dacotensis* and *C.* sp. are quite different from those of *A. dactylota*. The microsporophylls of *C. dacotensis* are more like *Weltrichia spectabilis* (Nathorst) Harris (1969). In *Cycadeoidea* the flowers are partially embedded within leaf bases. Unlike species of *Cycadeoidea*, it seems that *A. dactylota* was exposed and was attached to stems like *Williamsonia* Carruthers, *Wielandiella* Nathorst and *Williamsoniella* Thomas. Both *Williamsonia* and *Wielandiella* differ from *A. dactylota* in having unisexual flowers. Only *Williamsoniella* is bisexual, but its 'androecium' is entirely different from *A. dactylota*. The microsporophylls of *Williamsoniella* are wedge-shaped and on its adaxial surface usually there are two or three pairs of short fertile branches and each branch has a two valved pollen capsule.

A YOUNG FLOWER BUD WITH ANDROECIUM LIKE *AMARJOLIA DACTYLOTA*

Pl. 1, figs 5, 6; Pl. 2, fig. 1; Pl. 3, fig. 12

The flower bud consists of an axis covered with spirally arranged bracts enclosing the 'androecium'. The gynoecium is not preserved or perhaps was not formed when it was fossilized.

The bud measures 4.5 cm in length and 2 cm in width. The axis is about 1.7 cm in length and the details of its anatomy are not known. The bracts forming the perianth are in more than 2-3 turns, none of them are complete and their substance is fairly thick. At places fine lateral hairs of bracts are visible. In cross section, the bracts show an outer layer of cuticle followed by a layer of rectangular epidermal cells twice as long as broad. The epidermis is followed by a zone of hypodermis 5-6 cells thick. They are thick-walled and polygonal in shape. The cells of the hypodermis on the dorsal side are larger than those on the ventral side. The vascular bundles are collateral and mostly seven in number (two above and five forming an arc parallel to the lower surface). The ground tissue consists of loosely connected isodiametric cells.

'Androecium' is not well-preserved. In median longitudinal sections it seems to be like that of the 'androecium' of *Amarjolia dactylota*.

Because the specimen is imperfectly preserved so it has not been assigned to any species.

Collection — Specimen no. 32834 of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Amarjola, Rajmahal Hills, Bihar.

Horizon & age — Rajmahal Formation; Upper Jurassic.

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EXPLANATION OF PLATES

PLATE I

Amarjolia dactylota (Bose) comb. nov. (figs 1-4)

1, 2. Showing external features from two different directions; B.S.I.P. specimen no. 24133. × 1. (ad.= 'androecium' and br.=bracts).

3. Longitudinal section of a few cells of seminiferous and interseminal scales; B.S.I.P. slide no. 24133-1. × 500.

4. Showing two stomata of a bract as seen under reflected light; B.S.I.P. slide no. 24133-12. × 500.

5. A young flower bud having 'androecium' like *A. dactylota*; B.S.I.P. specimen no. 32834. $\times 1$.
6. Median longitudinal section of the above specimen; B.S.I.P. specimen no. 32834. $\times 2.5$ (m= microsporophyll).

PLATE 2

Amarjolia dactylota (Bose) comb. nov. (figs 7-10)

7. A part of 'androecium' in transverse section showing a finger-like 'synangia'; B.S.I.P. slide no. 24133-8. $\times 6$.
8. 'Synangia' in longitudinal section; B.S.I.P. slide no. 24133-1. $\times 7$.
9. 'Synangia' showing two rows of contiguous chambers; B.S.I.P. slide no. 24133-1. $\times 40$.
10. A part of figure 8 enlarged to show a portion of a 'synangium'. $\times 16$.
11. Transverse section of a bract of the young flower bud shown in Pl. 1, fig. 5; B.S.I.P. slide no. 32834-2. $\times 15$.

PLATE 3

Amarjolia dactylota (Bose) comb. nov. (figs 13-15)

12. A portion of the 'androecium' in median longitudinal section of the young flower bud

(Pl. 1, fig. 5) showing the finger-like 'synangia'; B.S.I.P. slide no. 32834-1. $\times 40$. (m= microsporophyll).

13. *A. dactylota*, showing 'synangia' in cross section with numerous pollen grains; B.S.I.P. slide no. 24133-8. $\times 60$.
14. *A. dactylota*, transverse section of 'androecium' showing 'synangia'. B.S.I.P. slide no. 24133-6. $\times 17$.
15. *A. dactylota*, median longitudinal section showing a portion of 'androecium' and the female receptacle. B.S.I.P. slide no. 24133-1. $\times 17$. (r=receptacle).

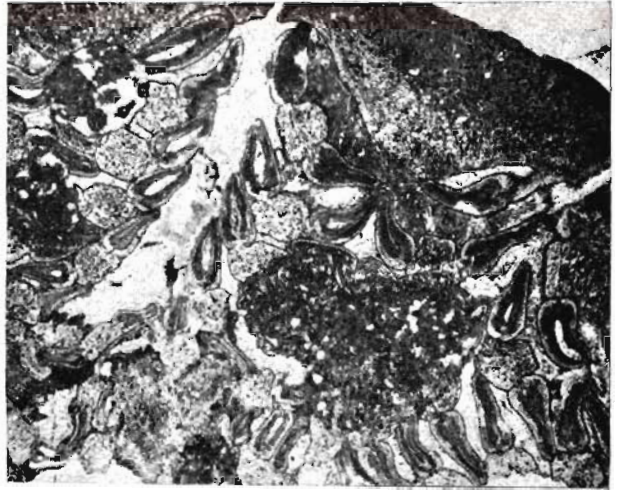
PLATE 4

Amarjolia dactylota (Bose) comb. nov.

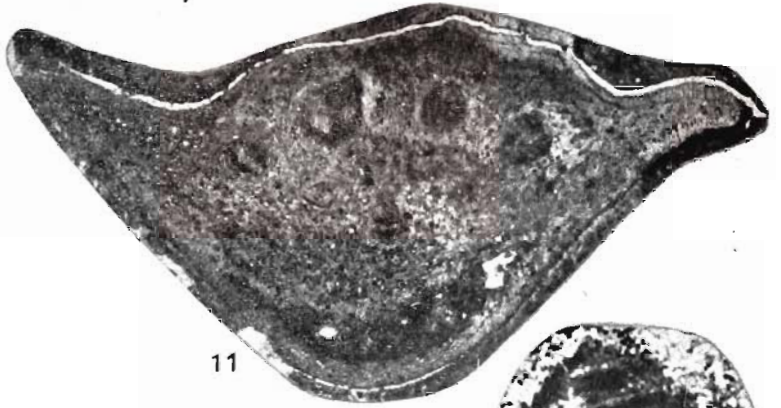
- 16, 17. Showing pollen grains; B.S.I.P. slide no. 24133-1. 16 $\times 200$; 17 $\times 500$.
18. Showing part of a receptacle with seminiferous and interseminal scales; B.S.I.P. slide no. 24133-1. $\times 50$.
19. Median longitudinal section of the flower, B.S.I.P. slide no. 24133-1. $\times 2.5$ (ad=androecium, po=pollen bearing 'synangia', and r=female receptacle).



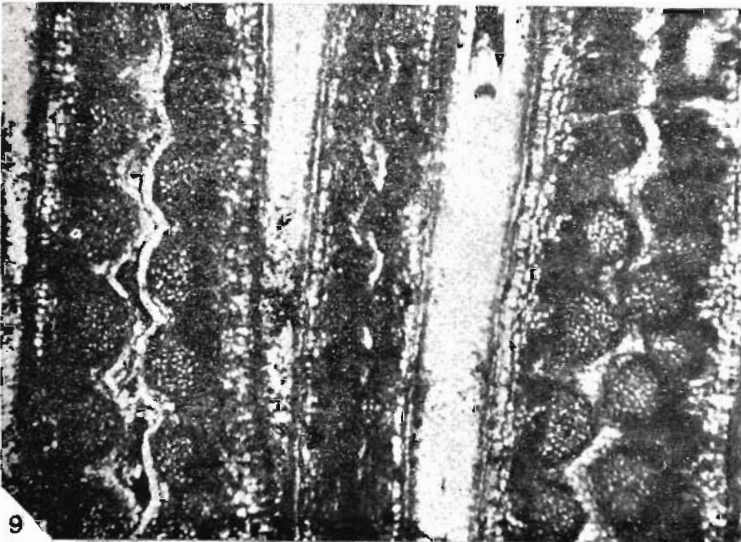
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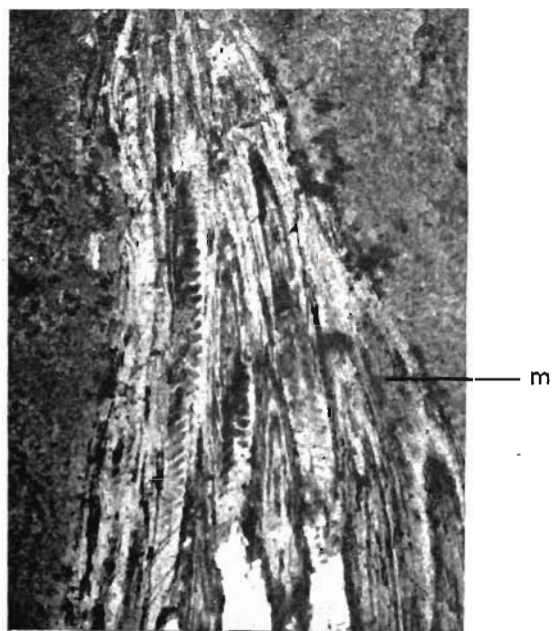
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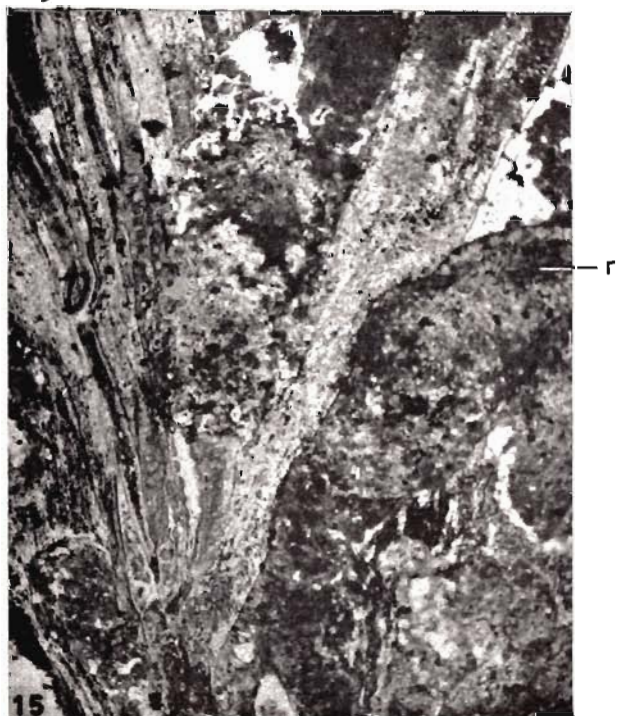
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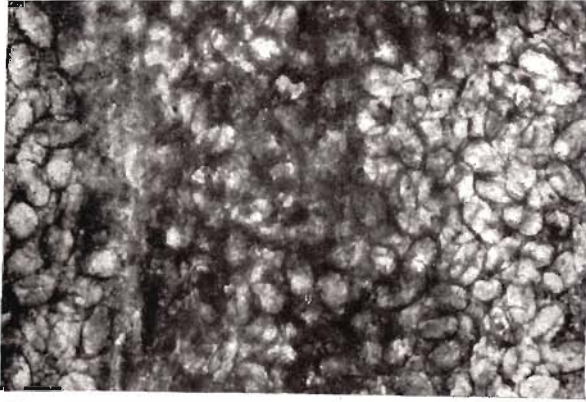


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15





16



17



ad

po

r

19



18