On two enigmatic infructescences from Permian Gondwana of the Rajmahal Basin*

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Two new dichotomously branched infructescences, a gynoclad and an androclad, are reported from shales associated with the Lalmatia Coalseam in Hura Coalfield, Rajmahal Basin, Bihar. The branched infructescences though are found in association with ginkgophyte leaves, yet their affinities seem to be with the pteridospermous groups.

Key-words—Fructifications, Ginkgophytes, Glossopteris Flora, Gondwana, Pteridosperms (India).

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सारांश

राजमहल द्रोणी के परमी गोंडवाना से दो रहस्यपूर्ण फलन

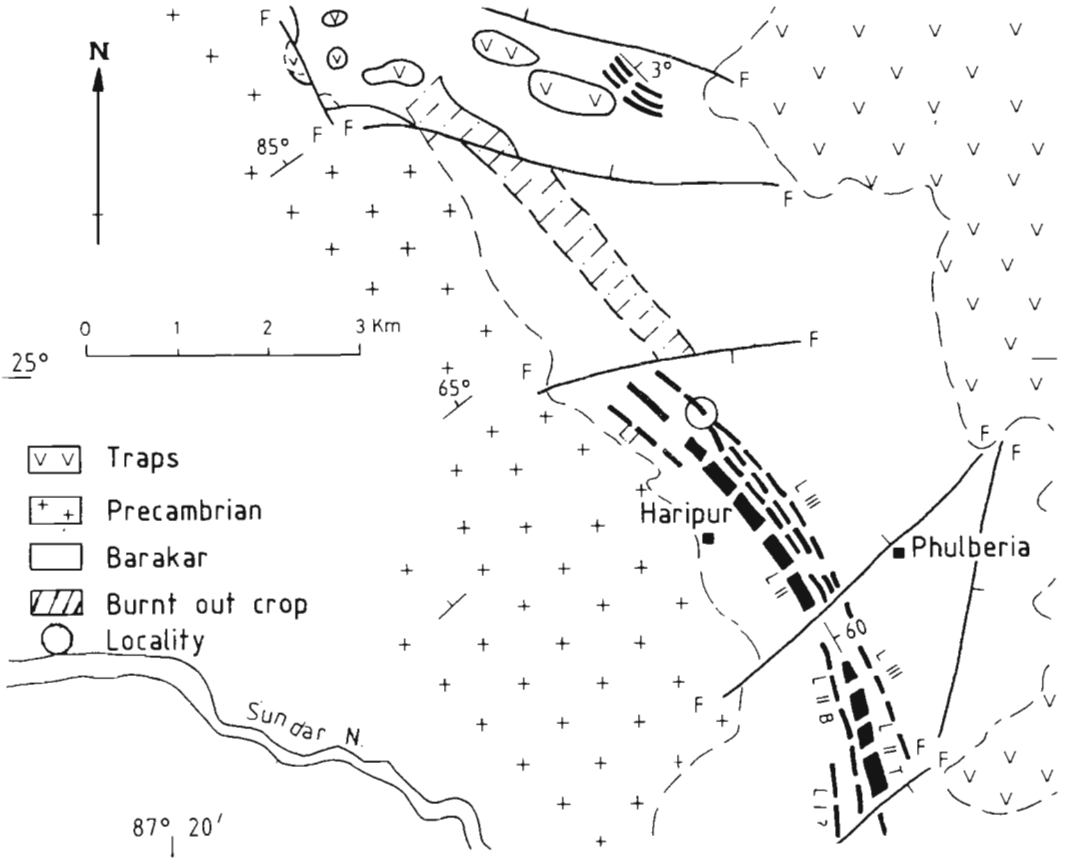
ऊषा बाजपेयी एवं हरिकृष्ण माहेश्वरी

राजमहल द्रोणी (बिहार) में हुरा कोयला-क्षेत्र में लालमटिया कोयला-सीम से सहयुक्त शैलों से प्राप्त दो नये शाखित फलन, एक गाइनोक्लेड तथा एक ऐन्ड्रोक्लेड का वर्णन किया गया है। ये शाखित फलन, हॉलाकि गिन्क्गोफ़ाइटी पत्तीयों के साहचर्य में पाये जाते हैं, तो भी टेरीडोस्पर्मी समूह के पौधों से इनकी सजातीयता प्रतीत होती है।

THE Hura Coalfield is the northernmost outlier of coal-bearing formations in the Rajmahal Basin. Coal is being exploited in the area since long (Ball, 1877) by the local people who intermittently dig shallow pits to collect coal for their use. Raja Rao (1987) reports the occurrence of a few coalseams in the Barakar Formation. Large scale mining is being done by the Rajmahal Open Cast Project in the Lalmatia bottom (L-II) and Lalmatia top (L-III) seams.

Plant fossils were reported from the Permian beds near Lohandia by Feistmantel (1880). These included a few leaves of the genus *Glossopteris*, scale leaves and seeds. Almost a hundred years later, Singh, Srivastava and Maheshwari (1986) recorded a heterophyllous sphenophyll—*Sphenophyllum gondwanensis*—and the equisetalean *Lelstotheca* from shales associated with the Lalmatia (II) top seam. In the same collection we have now observed the presence of *Neomariopteris hughesii* (Feistmantel) Maithy 1974, *Glossopteris communis* Feistmantel 1876, *Glossopteris lanceolatus* Pant & Singh 1971, *Glossopteris ampla* Dana 1849, *Glossopteris angustifolia* Brongniart 1831, *Glossopteris linearis* McCoy 1847, *Glossopteris retusa* Maheshwari 1965, *Glossopteris stricta* Bunbury 1861, *Glossopteris stenoneura* Feistmantel 1877, *Vertebraria indica* Royle 1839, Eretmonia-type leaf-scales and Arberiella-type sporangia. Recently Maheshwari and Bajpai (in Press) have reported several species of ginkgophyte leaves from shale intercalations between Lalmatia bottom and top seams, exposed far away from the main exposures of the II coalseam in the Lalmatia-Simra area. The bed is rich in plant fossils. Here we record two interesting types of fructifications from the same beds.

*Contribution to IGCP Project 237: Floras of Gondwanic Continents.



Map 1—General location of the pit from where the fossils were collected.

MATERIAL

Plant fossils were collected by our colleagues Shri H. N. Boral and late Dr V. K. Singh from an abandoned shallow pit, dug by local villagers for coal, near the village Haripur (Map 1), in the southern part of the Hura Coalfield. Subsequently we collected additional specimens from the locality and observed the following sequence in this particular pit (Text-fig. 1).

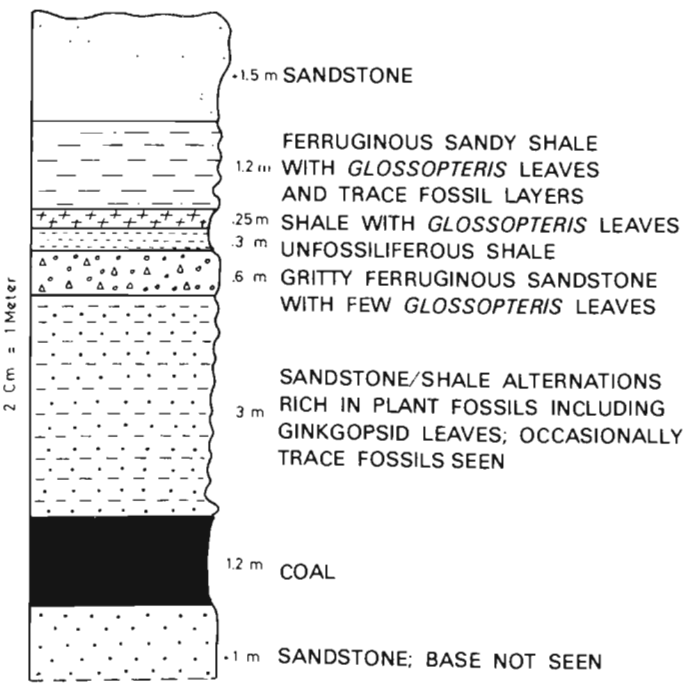
The type and figured specimens have been deposited in the Repository of Birbal Sahni Institute of Palaeobotany, Lucknow.

DESCRIPTION

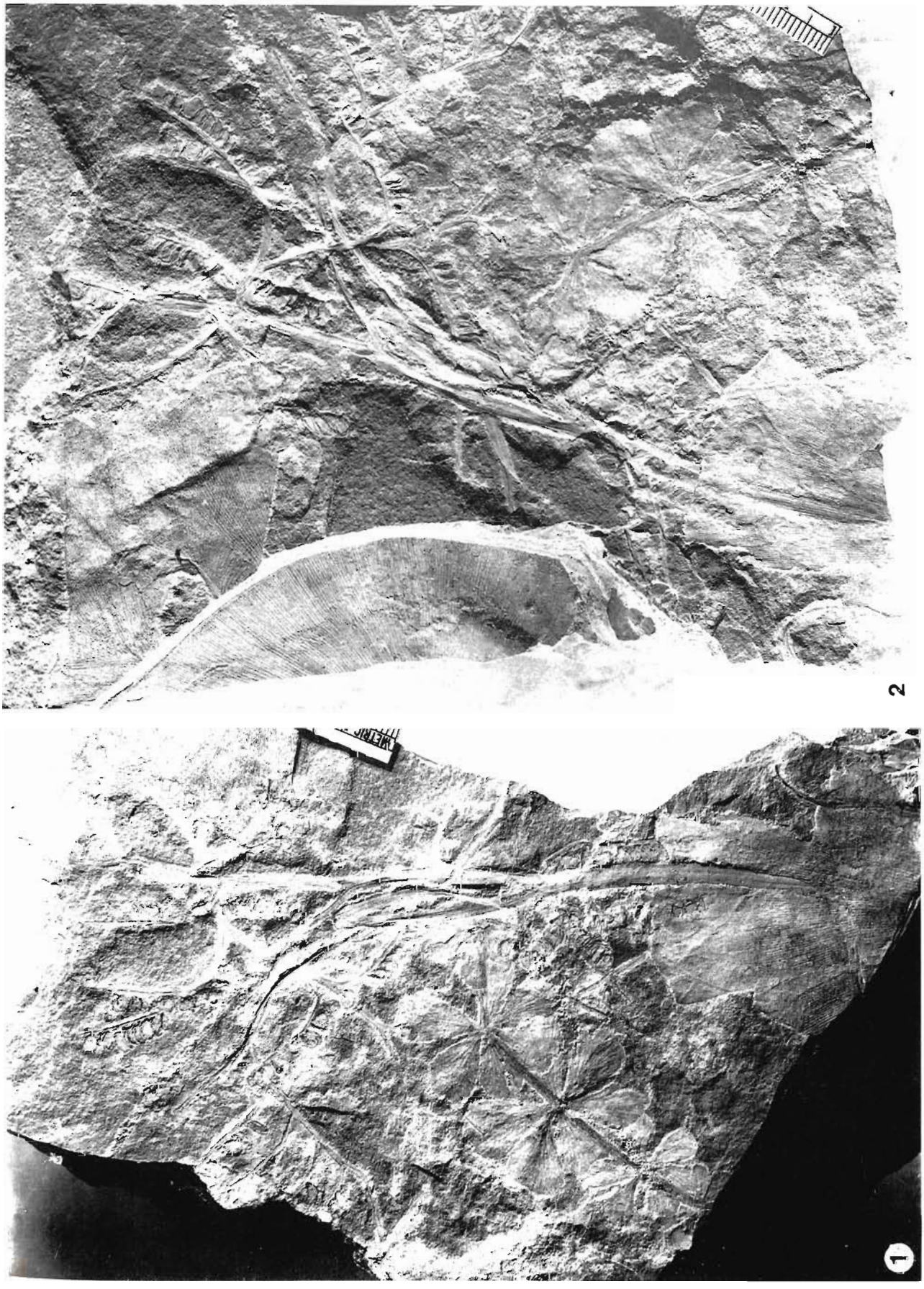
Veekaysinghia gen. nov.

Type species—*Veekaysinghia durgavatiae* sp. nov.

Diagnosis—Seed-bearing axis, repeatedly branched on a basic dichotomous pattern; ultimate branches sometimes apparently pinnate, bear aphyllous, orthotropous seeds, usually compactly arranged and only on one side of the axis.



Text-figure 1—A generalized litholog of the face of the pit from which the fossils have been collected.



Figures 1, 2—*Vekatasinghia durgaeae* gen. et sp. nov. **1.** Holotype specimen no. 36570, × 1; the lower part of the principal axis is overlapped by a ginkgopsid leaf. A twig of *Sphenophyllum* is also seen in lower left half. **2.** Holotype: counterpart, specimen no. 36571, × 1; apical part of a ginkgopsid leaf is seen on the far left.

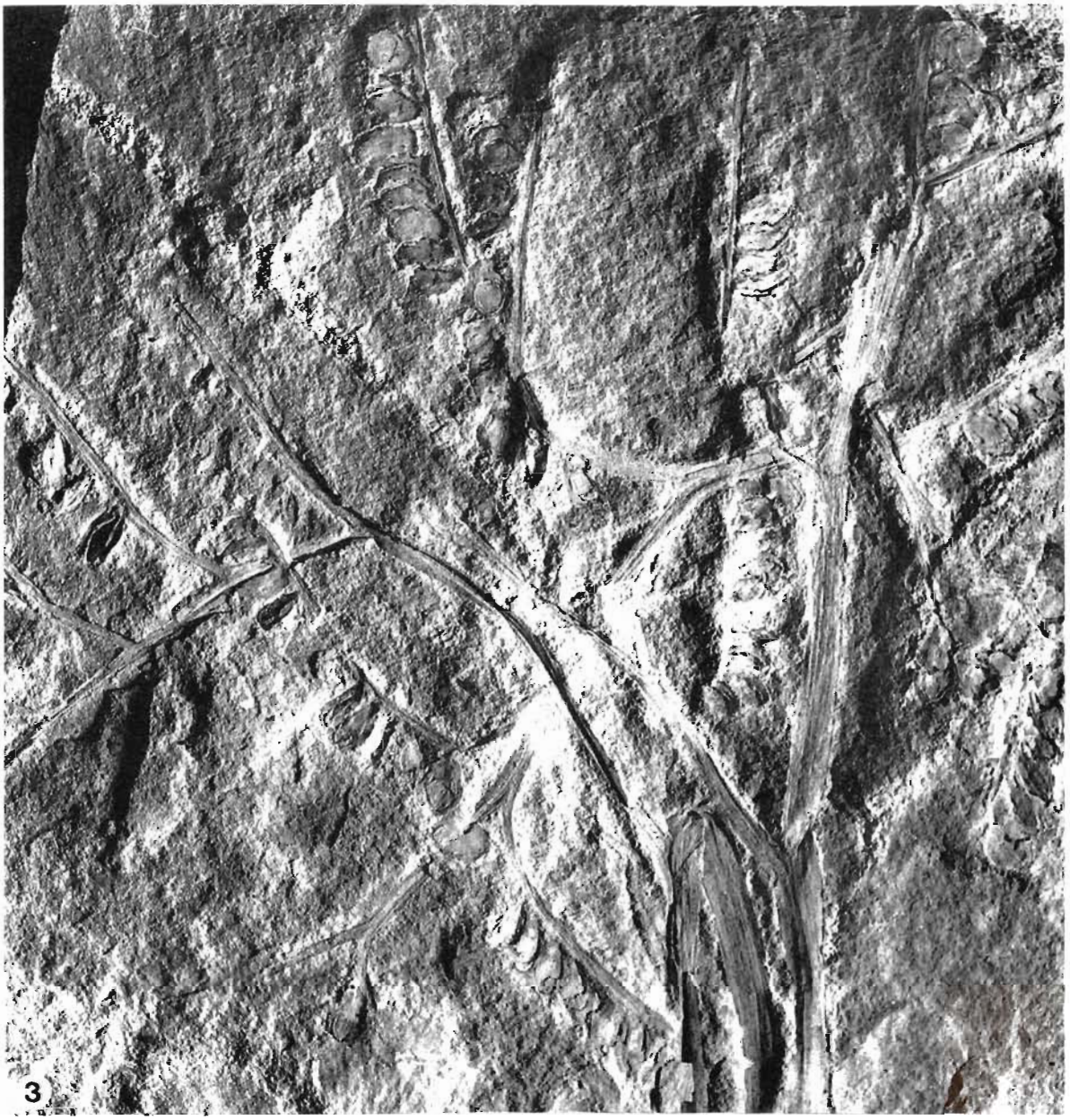


Figure 3— *Veekaysinghia durgavatiae* gen et sp nov.. a part of the holotype enlarged to show 'pinnate' ultimate branches bearing closely placed seeds on one side of the axis (upper left of the figure); specimen no. 36570, × 2.5.

Description—It is rather an unusual infructescence for the Gondwana. Most of the hand specimens show only portions of the infructescence. Only one specimen (Figure 1), and its counterpart (Figure 2), seem to represent almost the complete organ. The specimens are profusely branched on a basic dichotomous pattern. The ultimate branches seem to be lateral (Figure 3), probably due to suppressed dichotomy, i.e., helicoid branching.

The complete infructescence was atleast up to 18 cm long with first dichotomy of the axis occurring about 6 cm from the base. Up to five levels of dichotomy have been observed (Figures 3, 4). Fine striations run all along the axis (Figure 5). The infructescences are monogynons on which orthotropus seeds are compactly arranged (Figures 6-11). The seeds are aphyllous, in not being associated with a sporophyll or scale, sessile and almost invariably situated on one side of the axis, usually overlapping one another (Figures 8, 9).

Seeds are obovate in shape, 3.5-4 mm long and up to 2.5 mm broad at the widest, neither micropyle nor hilum is seen. As the seeds are preserved only as impressions, details of wall layers are not clearly

Figure 4—*Veekaysinghia durgavatiae* gen et sp nov a gynoclad associated with several ginkgopsid leaves A well preserved leaf of *Saportaea* is seen on the left side, specimen no 36574, × 1.

decipherable At some places one can see indications of two integuments and an almost rounded nucellus (Figures 12, 13), which is up to 2 mm in diametre Under incident light cellular outlines are faintly discernible The cells are rectanguloid and arranged end-to-end.

Diagnosis of species—As for the genus.

Derivation of generic name—After late Vinay Kumar Singh, our associate on the Rajmahal Basin studies.

Derivation of species name—After Durgavati, the valiant Queen of the principality of Gondwana, central India, circa 16th Century A.D. (Chopra, 1973).

Comparison—The striking features of the described gynoclad are a dichotomous branching pattern, and orthotropus seeds compactly arranged on ultimate branches. The infructescence compares with the gynoclad *Utkalia dichotoma* described from the Hinjir (=Kamthi) Formation exposed in the Hinjirida Ghati near Handapa, Mahanadi Basin (Chandra, 1984). In both the infructescences, the primary axis is dichotomously branched and the ultimate axes bear aphyllous seeds. However, in *Utkalia dichotoma* further branching is on an alternate pattern, and the ultimate branches are reported to bear a single terminal seed. An androclad organizationally similar to *Utkalia* has

Figure 5—*Veekaysinghia durgavatiae* gen. et sp. nov., a part of the gynoclad enlarged to show a dichotomy of the axis and partly exposed seeds, apparently attached on one side of the axis; specimen no. 36571, × 4.

been reported from the Upper Triassic Molteno Formation (Anderson & Anderson, 1983, pl. 26, fig. 1).

The corystospermaceous gynoclads referred to the genus *Umkomasia* Thomas 1933 are also profusely branched. However, the branches arise laterally in the axils of bracts and bear cupules in imparipinnate manner (Holmes, 1987). This gynoclad has been linked with *Dicroidium* leaves on the basis of constant association in the sediments.

Wankiea bondii, a gynoclad from the Early Permian of Zambia (Lacey & Huard-Moine, 1966), differs in having opposite/subopposite lateral branches and a terminal cluster of 4-6 'seeds'. It has been suggested that *Wankiea* may be a microsporangiate fructification of *Pecopteris arcuata* (Huard-Moine, 1964).

Seeds of *Amphorispermum ellipticum* Harris 1932 are arranged in a manner that simulates the arrangement in our specimens. However, in the former, the main axis and branches are unknown and the terminal branches have only been inferred (Harris, 1981).

Staphidiophora secunda Harris 1935 consists of an axis that bears a few sessile seeds in its upper part and only on one side as in *Veekaysinghia durgavatiae*. According to Harris (1935), the seeds were probably borne alternately but as a result of twisting of axis came to be located on one side. On the basis of similarity in cuticular features, *Staphidiophora* is attributed to the leaves of *Hartzia tenuis*.

Caytonia is a monogynon that bore 'fruits' oppositely or sub-oppositely on a dorsiventral rachis. It is attributed to the leaf *Sagenopteris* alongwith the androclad *Caytonanthus* on the basis of regular association (Sporne, 1965).

The ginkgoalean female 'cone' reported from Molteno Formation exposed at Matatiele in the Karoo Basin (Anderson & Anderson, 1983, pl. 24, fig. 1) superficially resembles our specimens in being a gynoclad. Details of the African fossil are, however, not yet known.

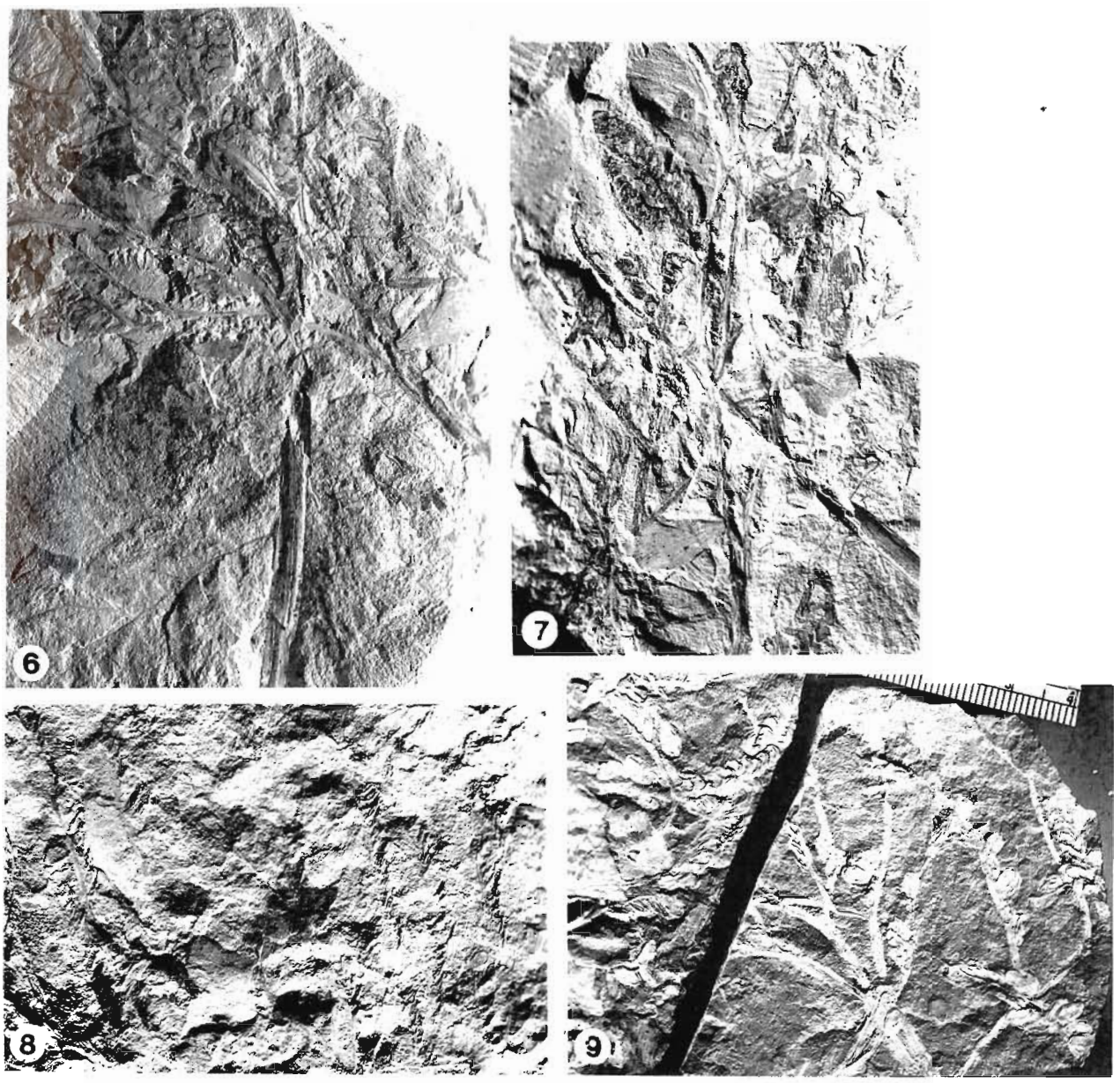
Holotype—Specimen no. 36570, Birbal Sahni Institute of Palaeobotany, Lucknow; Early Permian, Barakar Formation, shales associated with Lalmatia Coalseam, near village Haripur, Hura Coalfield, Rajmahal Basin, India.

***Birbalsahnia* gen. nov.**

Type species—*Birbalsahnia divyadarshanii* sp. nov.

Diagnosis—Androclad, main axis dichotomously branched, subsequent branches lateral, alternate to one another, ultimate branches thin, terminally bearing pollen-sacs, attachment of pollen-sacs on ultimate branches not discernible; pollen-sacs apparently tetra-locular.

Description—The incomplete pollen-sac-bearing organ (Figure 14) occurs in the same sediment layers that have yielded ginkgopsid leaves and the branched seed-bearing organ *Veekaysinghia*. The preserved length of the main axis is about 4 cm; width is 5-6 mm. However, it is not possible to determine whether the main axis is the principal axis of the androclad or it is a branch of the principal axis. The two-level dichotomy of the main branch gives an apparent decussate pattern (Figure 17). Subsequent and ultimate branches are alternate (Figure 15). Quite often ultimate branches are seen only on one side and that too at irregular intervals (Figure 17). Pollen-sacs could have been terminal to the ultimate branches; however, actual attachment is not seen. They are found either singly or in groups of 3-7 (Figures 15, 16). Pollen-sacs are oblong, probably tetra-locular. No pollen grain was recovered from the pollen-sacs. Probably all the pollen was shed before preservation. Scanning



Figures 6-9—*Veekaysinghia durgavatiae* gen. et sp. nov. **6,7** Part and counterpart of another gynoclad showing closely placed seeds, specimen nos. 36576, 36577, × 1. **8**. Disjointed axes showing seeds in lateral view; specimen no. 36575, × 1 **9** Disjointed axes, apparently bearing seeds only on one side, specimen no. 36573, × 1.

electron micrograph of broken surface of a pollen-sac shows that probably hyaline silica (chalcedony) has infiltrated the pollen-sac. At places, degradation of pollen-sac surface could be seen clearly A few minute rounded bodies and filaments (fungal) have also been observed. Another fertile axis is present which shows opposite to sub-opposite branches on both sides of the axis.

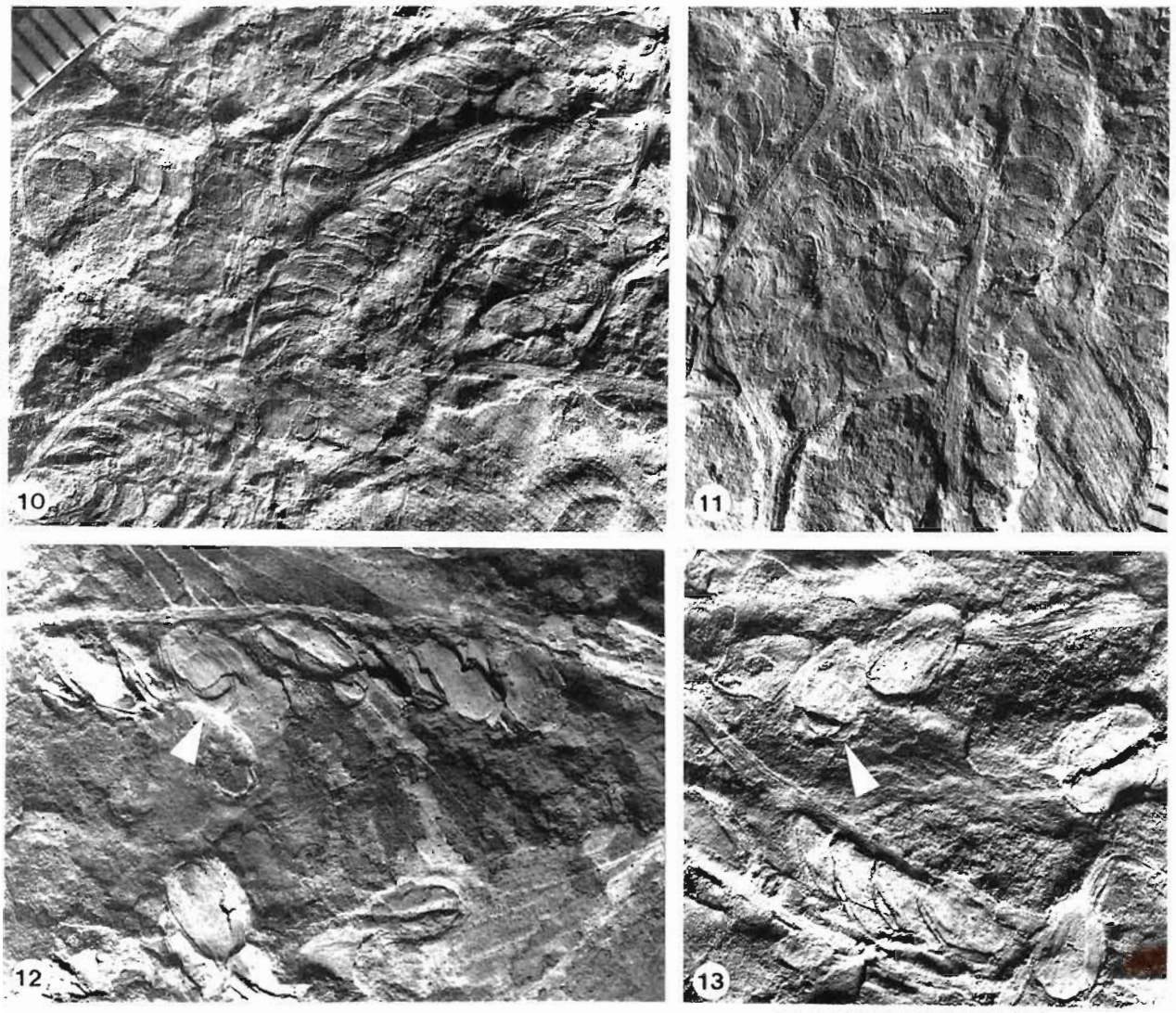
Diagnosis of species—As for the species.

Derivation of generic name—After Professor Birbal Sahni (1891-1949).

Derivation of species name—After Professor Divya Darshan Pant.

Comparison—The infructescence is comparable to the peltaspermaceous androclad *Antevsia* Harris 1937 from the Triassic. The latter, however, is bipinnate, with alternate primary branching, and less regularly arranged secondary branches. Pollen-sacs are with longitudinal line of dehiscence.

Pteruchus Thomas 1933, the androclad of the Corystospermaceae, known from the Triassic of the Gondwana Supercontinent differs in having a central



Figures 10-13—*Veekaysinghia durgavatiae* gen. et sp. nov. Portions of gynoclads enlarged to show attachment and nature of seeds. A nucellus is seen in one seed each in figures 12 and 13. **10,11**. Specimen no. 36574, × 3; **12,13.** specimen no. 36572, × 4.

axis which bears short lateral branches, generally in one plane The pollen-sacs are borne on the underside of peltate head. The dehiscence again is longitudinal

Caytonanthus Harris 1937 (Caytoniaceae), from the Jurassic, is a dorsiventral axis bearing opposite/sub-opposite pinnae. The pinnae are branched irregularly and each terminal branchlet bears a single 'anther' comprising four chambers, thus comparing closely with the pollen-sac of the present infructescence.

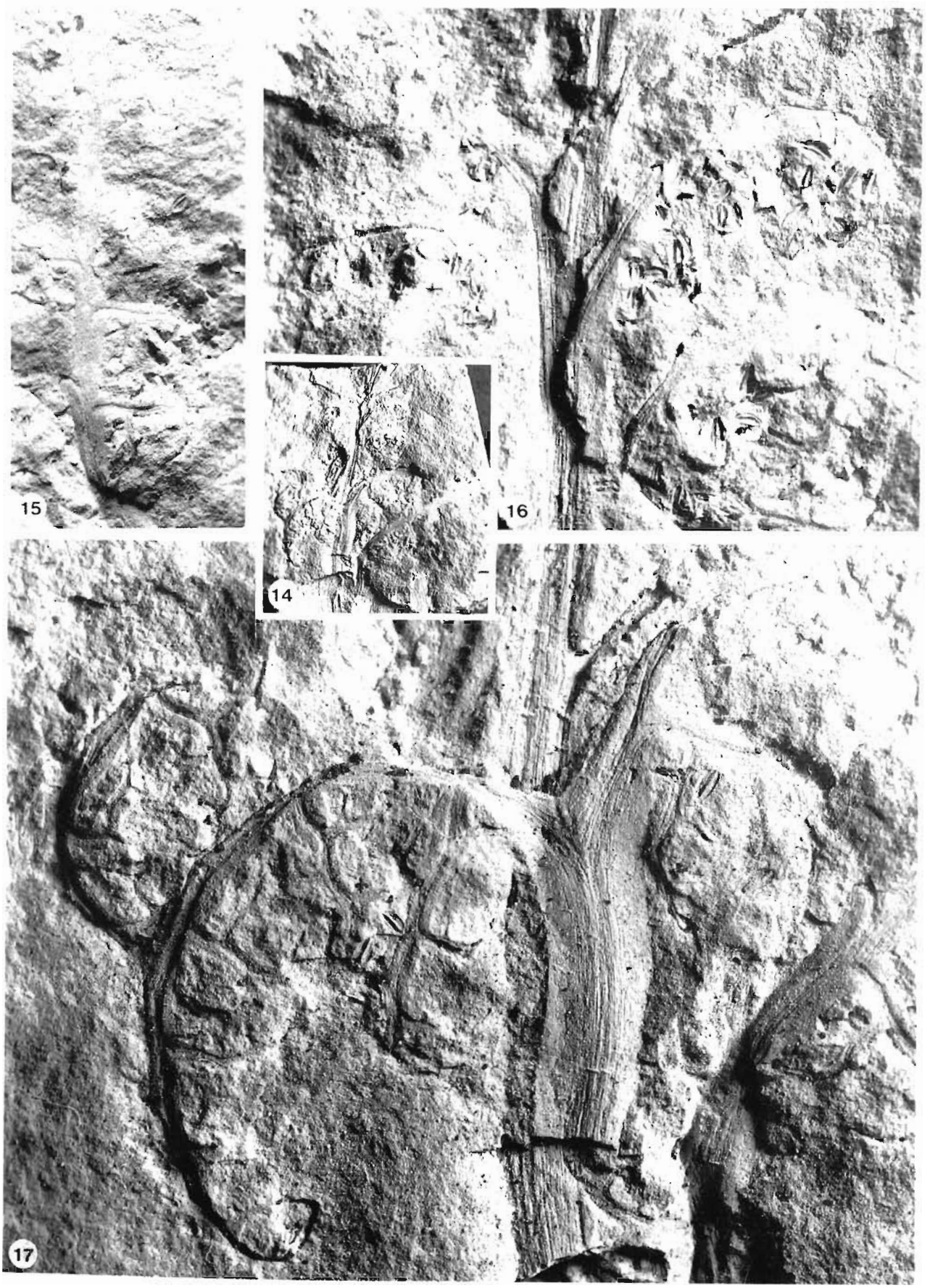
Antholithus Brongniart 1822 comprises a dichotomously branched axis, bearing terminal clusters of pollen-sacs. According to Nathorst (1908) the genus *Antholithus* is affiliated to a ginkgoalean or cycadalean group.

Holotype—Specimen no. 36578, Birbal Sahni Institute of Palaeobotany, Lucknow; Early Permian, Barakar Formation, shales associated with Lalmatia Coalseam, near village Haripur, Hura Coalfield, Rajmahal Basin, India.

AFFINITIES

Veekaysinghia is a very unusual type of fructification for the Gondwana. It is no doubt a

Figures 14-17—*Birbalsahnia divyadarshanii* gen. et sp. nov. **14.** Holotype: specimen no. 36578, × 1 **15**. The lower right portion of the holotype enlarged to show the 'foliose' nature of the branches, × 4. **16,17** Upper and lower portions, respectively of the holotype enlarged to show the branching pattern and clusters of pollen-sacs, × 7.5



Figures 14-17

gynoclad as each ultimate branch bears a number of compactly arranged obovate bodies—the seeds. The seeds have an sclerotesta surrounded by a flat border, the sarcotesta. Some of the specimens even show a third region, the nucellus (Figures 12, 13). No subtending bract or sporophyll has been observed so far. The arrangement of the seeds is also very peculiar as all the seeds are apparently on one side. There are two explanations. One, the seeds were spirally disposed but due to twisting of the axis now occupy same plane; second, the ultimate branches are fertile pinnules with reduced lamina, each bearing seeds in a linear row.

In the latter case, each gynoclad may be compared to a modified frond, thus indicating affinities with Pteridosperms. However, so far there is no supporting evidence, like the presence of a cupule, or a manoxylic wood, at this level except for the occurrence of Sphenopteris- and Callipteris-type of foliage. The Permian Gondwana *Sphenopteris* fronds are now known to be definite ferns (*Neomariopteris/Damudopteris*). Callipteris-type of frond is a new find and though its taxonomic status is yet to be ascertained, it does occur in the same horizon as *Veekaysinghia*.

The flora at this level is dominated by ginkgophyte leaves, such as *Rhipidopsis, Ginkgoites,* and *Saportaea*. Though the fructification has not been found in organic connection, yet a ginkgophyte affinity can also not be negated. The female ginkgoalean 'cone' recorded from Late Triassic Molteno Formation (Anderson & Anderson, 1983, pl. 24, fig. 1) also has a superficial resemblance. *Staphidiophora secunda* Harris 1935 from the Rhaetic of Greenland, which on the basis of association is believed to belong to ginkgoalean leaf *Hartzia* Harris, shows a comparable arrangement and organization of seeds.

So far only two fossil seed-bearing organs were definitely assigned to the ginkgophytes. Both are as removed from each other as are from *Veekaysinghia* or from extant *Ginkgo*. Florin (1949) reasoned in detail to regard the Palaeozoic taxon *Trichopitys heteromorpha* de Saporta 1875 as a ginkgophyte, albeit a primitive one. Meyen (1987, p. 148) does not agree with Florin's interpretation. According to him the Family Trichopityaceae should be placed under the Order Peltaspermales. Archangelsky (1965) suggests that the Early Cretaceous taxon *Karkenia incurva* "may well be an intermediate type of female structure ("flower") between *Trichopitys* and *Ginkgo*". In *Karkenia* the inverted, collar-less ovules/seeds are arranged compactly on the axis. Collar has been assumed to be a secondary feature of the *Ginkgo* ovule (Florin, 1949). Probably 'short shoot' habit was also a later feature (Archangelsky, 1965, p. 136). According to Meyen (1987, p. 155) independent status of the Family Karkeniaceae is still inopportune. Thus, it seems so far no fossil infructescence can definitely be assigned to the Ginkgoales.

The basic pinnate branching pattern and the flattened axis of *Birbalsahnia* suggest modified pinna in which the lamina got completely reduced. The faint impressions of cells seen over the flattened axis also indicate a modified pinna. The Early Permian androclad *Callipterianthus* also has modified pinnae with a completely reduced lamina (Meyen, 1987, p. 149).

Thus the data at hand seems to indicate the presence of a Pteridosperm-related group in the assemblage. This group does not have affinities with the true glossopterids, dominant elements of Permian vegetation of the Gondwana Supercontinent.

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