STUDIES IN THE GLOSSOPTERIS FLORA OF INDIA — 18. GYMNOSPERMIC SEEDS AND SEED-BEARING ORGANS FROM THE KARHARBARI BEDS OF THE GIRIDIH COALFIELD, BIHAR

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ABSTRACT

Gymnospermic seeds and seed-bearing organs are described from the Karharbari beds, Giridih Coalfield. The seeds have been assigned to *Cordaicarpus, Samaropsis, Cornucarpus, Nummulospermum* and *Rotundocarpus* gen. nov. Two species of *Cordaicarpus* and one species of *Samaropsis* are new. The seed-bearing organs belong to *Arberia* White and *Palmatophyllites* gen. nov.

INTRODUCTION

THE Indian Lower Gondwana formations are known to contain remains of platyspermic and radiospermic seeds. Feistmantel (1879, 1881) has recorded number of seeds from the Talchir-Karharbari beds, Raniganj group and Panchet strata. Zeiller (1902) recorded from the Karharbari stage and Seward & Sahni (1920) from the Karharbari and Raniganj Stage. In recent years Saksena (1955) described two species of *Samaropsis* from the Ganjra nalla beds of the South Rewa Gondwana basin and Surange & Lele (1956) from the Talchirs of the South Rewa. Surange (1958) described a new genus of seed from the New Kenda Colliery, Raniganj stage. These seed records have been assigned to the following genera:

Cordaicarpus Geinitz
Samaropsis Göppert
Stereocarpus Surange

Recently Pant & Nautyial (1960) brought to the light three new genera viz., *Stephanostoma, Pterigospermum* and *Platycardia* from an unknown horizon of the Raniganj Coalfield. Besides, there are few Lower Gondwana records of seeds obtained from coal maceration (SURANGE, *et. al.* 1953, SRIVASTAVA, 1954). Seeds have also been described by Lele (1963) from strata believed to be of Middle Gondwana age.

DESCRIPTION

The collection described below comes from the Karharbari stage of the Giridih Coalfield. The material has been collected from the shale dumps lying outside the collieries and also from shale outcrops. The localities are:

1. *Srirampur* open quarry, near Chunka Village.
2. 16 *A pit*, 1 mile north of Chunka Village.
3. 16 *B pit*, near 16 A pit.
4. *Central pit*, 4 miles south of Giridih town.
5. *Kandia pit*, nearly 200 yds. south of central pit.
6. *Deep pit*, at the foot of southern part of Komaljore hill.
7. *Jubille pit*, near Buriadih, at the southern part of Bhaddra hill.
8. *Jogtiabad pit*, between Bhaddua and Komaljore hills, along the Komaljore nalla.
9. *Puthrodiha nalla*, Puthrodiha, 2 miles south of Giridih town.
10. *Domahni ghat*, 6 mile S.E. of Giridih town.

The specimens are preserved as impressions. Most of them have a carbonized crust, which crumples into pieces during the course of maceration for the recovery of cuticle. However, in few cases an examination of the carbodized crust of the seed coat reveals the epidermal structures to a certain extent.

(A) GYMNOSPERMIC SEEDS

Cordaicarpus Geinitz

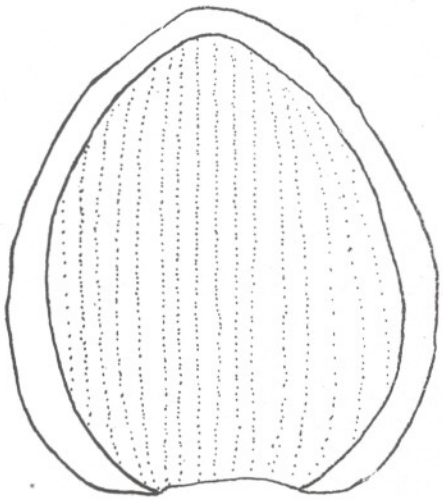
Cordaicarpus zeilleri sp. nov.

Pl. 1, Figs. 1-3; Text-figs. 1, 2

1902 — *Cordaicarpus* sp. Zeiller
1920 — *Cordaicarpus* cf. *C. cordai* (Geinitz) Seward

Diagnosis — Platyspermic seed, pear-shape, cordate base and rounded apex or

roundly acute. A narrow border (? Sarcotesta) encircles the sclerotesta, nearly uniform in width.



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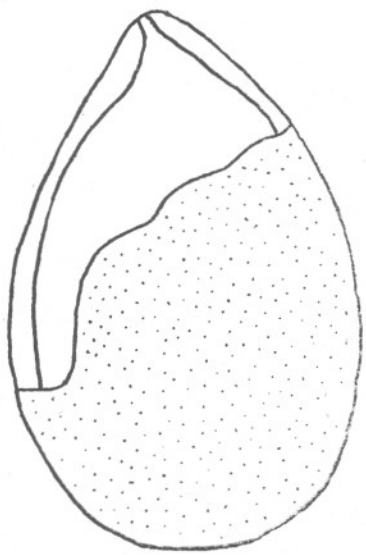

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TEXT-FIGS. 1, 2 — *Cordaicarpus zeilleri* sp. nov. × 10.

Holotype — 32794/424, Birbal Sahni Institute of Palaeobotany collection.

Locality — Central pit, Srirampur Colliery.

Horizon — Karharbari Stage (Lower Permian).

Description — There are about fifty well preserved impressions of seeds. Seeds vary in size from 4-8 × 3-7 mm. Seeds are mostly pear-shaped with cordate base and rounded apex; sometimes they are oval with pointed apex (PL. 1, FIG. 2). A narrow border (1 mm., sarcotesta ?) surrounds the sclerotesta. Usually several striations are present on the sclerotesta (PL. 1, FIGS. 1, 2), but sometimes a faint median ridge is perceptible from apex to base (PL. 1, FIG. 3). Usually a thin carbonized crust is preserved on the seeds which on maceration, crumples into pieces, but under incident light shows elongated rectangular cells.

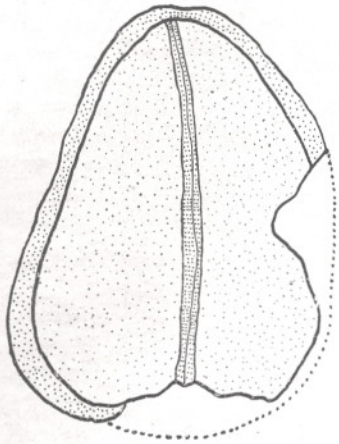
Comparison — So far this species is only known from the Karharbari stage, Giridih Coalfield. The seed agrees closely in its shape and size to *Cordaicarpus* sp. (ZEILLER, 1902; PL. 2, FIG. 11).

The seeds were earlier described by Zeiller (1902) under *Cordaicarpus* sp. Later Seward and Sahni (1920) described them as *Cordaicarpus* cf. *C. cordai* (Gein.) on the basis of external morphological resemblance with the northern species. However, the carbonized seed coat of the northern species shows reticulate meshes which are absent in the Southern forms. On the contrary the Indian Lower Gondwana seeds possess vertical striations. The morphological differences merits consideration especially when the relationship if any between the members of the Northern and Southern floras is not clearly understood. A new specific name is, therefore, proposed to accomodate these Lower Gondwana forms. Arber's (1905 : 20) *Cordaicarpus* sp. from the New Castle series of New South Wales, Australia seems to be identical to the present species. But nothing can be said definitely till the original specimen is examined.

Cordaicarpus karharbarense sp. nov.

Pl. 1, Fig. 4; Text-fig. 3

Diagnosis — Seed Platyspermic, cordate shape, apex bluntly rounded. A prominent ridge is present on the median region of the seed. A thin border sarcotesta ? surrounds



TEXT-FIG. 3 — *Cordaicarpus karharbarense* sp. nov. × 2½.

the seed, which is little wider towards the base.

Holotype — 31340/424, Birbal Sahni Institute of Palaeobotany collection.

Locality — Central pit.

Horizon — Karharbari Stage (Lower Permian).

Description — Only twenty impression of platyspermic seeds are on sandy micaceous shales. Seed cordate, apex bluntly rounded. Seed 2·7 -3 × 1·3 -2 cm. A prominent ridge is present on the median region of the seed. A thin border (sarcotesta?) surrounds the seeds, 1·5-2 mm wide. The border is little wider towards the base.

Comparison — A good number of *Cordaicarpus* seeds are known from the Lower Gondwanas but the present specimen is easily distinguished by its large size and the presence of a distinct median ridge. Among the specimens of *Cordaicarpus; Cordaicarpus emerginatus* Walkom (1935, PL. 19, FIG. 11), *Cordaicarpus* (?) *ovatus* Walkom (loc. cit. PL. 19, FIG. 8), *Cordaicarpus prolatus* Walkom (loc. cit., PL. 19, FIG. 6) and *Cordaicarpus mucronatus* Hφeg & Bose (1960, PL. 11, FIGS. 2, 3) are characterized by an acute apex and therefore do not compare. *Cordaicarpus zeillerii* sp. nov. is distinguished by its pear shape and acute apex. Thus, the present specimen is incomparable to any of the known species of *Cordaicarpus*, therefore, a new name *Cordaicarpus karharbarense* is attributed to the present seeds.

Cornucarpus Arber

Cornucarpus furcata (Surange & Lele) n. comb.

Pl. 1, Fig. 5; Text-fig. 4

1956 — *Cordaicarpus furcata* Surange & Lele

Description — Impression of small unwinged seed; oval, somewhat flattened at the base and with bifid apex. A small depression is seen at the base which perhaps marks the position of its attachment with the megasporophyll or stalk. The size of the seed is 4 × 3 mm. A uniformly wide but very narrow border is visible (sarcotesta). A few lines are seen running all round the border of the seed. The sarcotesta ? is drawn out for about 2 mm. at the apex and is bifid. These beak like projections are delicate and the precise function is not known. It may be that a micropylar tube has bifurcated into two for an advanced mechanism for catching pollen or it was probably a somewhat funnel shaped structure.

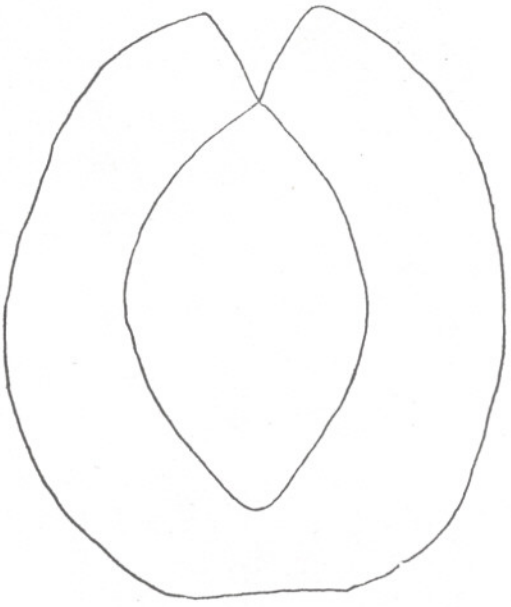
Locality — Central pit, Jubille pit and Srirampur open quarry.

Comparison — The present collection contains about ten seeds which agree with the description and figures of Surange & Lele (1956, PL. 1, FIGS. 9-10; TEXT-FIG. 1). A similar seed has been described by duToit (1927: 405, PL. XLI, FIG. 11) from the Gondwana beds of Uganda (Lower Permian) as *Cornucarpus* sp.

TEXT-FIG. 4 — *Cornucarpus furcata* n. comb. × 10.

Cornucarpus furcata was so far known in India from older horizons (Talchir stage, South Rewa Gondwana Basin). This is the first record of the species from the Karharbari stage.

The generic name *Cornucarpus* Arber was adopted by Halle (1927) as a general designation for platyspermic wingless seeds with two acute projecting horns. Later this name has been adopted by Walkom (1935) and duToit (1927). The specimen of Surange & Lele (1956) which is identical with those of the present collection, show similar pointed horns and are, therefore, transferred from *Cordaicarpus* to *Cornucarpus*. Recently Pant & Nautyial (1960) have described in detail the anatomy of a seed, *Stephanostoma* which possesses a funnel-like structure at the apical end. It is probable that *Cornucarpus* furcata had a mechanism comparable to *Stephanostoma*,



TEXT-FIG. 5 — *Samaropsis ganjrensis* Saksena. × 10.

Samaropsis Göppert

Samaropsis millerii (Feistm.) Seward

Pl. 1, Fig. 6

1879 — *Carpolithus milleri* Feistmantel
1905 — *Cardiocarpus* (?) *milleri* Arber

Description — Imperfectly preserved seeds on sandy micaceous shale, all of them are incomplete. Seed as a whole oval, its apical region is evidently emarginate. About 3 cm. long and 2 cm. broad. Sarcotesta narrower at the sides and broader at base (5 mm.). Sclerotesta ovate cordate.

Locality — Central pit and Srirampur open quarry.

Comparison — The specimens from the Karharbari beds agree well with those described by Seward & Sahni (1920) and Feistmantel (1879). *S. millerii* has also been recorded from Belgian Congo (HΨEG & BOSE, 1960).

Samaropsis ganjrensis Saksena

Pl. 1, Figs. 7, 8; Text-fig. 5

Description — Only six carbonized impressions of platyspermic seeds, oval or subcircular; the size varies from 6-12 × 4-9 mm. Sclerotesta 4-6 × 2·5-4 mm., somewhat convex and pear shaped with bluntly rounded base and slightly pointed apex. The sarcotesta is thin, surrounds the sclerotesta except at the apical end, where it is notched into a V-shaped sinus. The ends of the sarcotesta are bluntly rounded. Sometimes one of the notch end of the sarcotesta is comparatively wider and pointed than the other; this causes the seed to become asymmetrical. The sarcotesta is wider at the apical end and measures 3 mm. and is 2 mm. at the narrowest basal end.

Locality — Jubille pit and Deep pit.

Comparison — The specimens agree with the holotype of *S. ganjrensis* Saksena preserved at the Institute of Palaeobotany and the other specimens figured by him (1955: 74-75, TEXT-FIGS. 5-11). The Ganjara nalla beds (South Rewa basin) from where this species was originally recorded are believed to be either Barakar or Karharbari in age (SAKSENA, 1952: 10). The present finding furnishes the first record of this species from the typical Karharbari beds.

In many impressions of detached seeds as in this case the orientation of the seed with reference to its apex and base may become confusing; especially in the absence of any evidence as to the position of attachment. However, judged from the description of numerous platyspermic seeds and also from morphological point of view, it

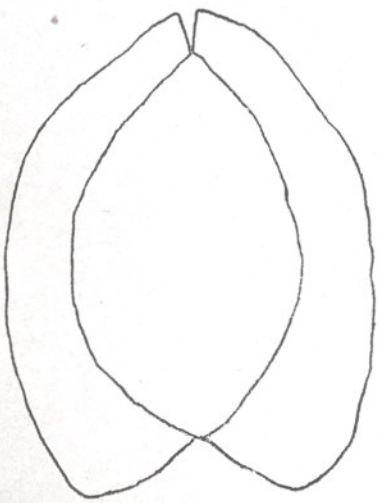
seems that when a sinus is present only on one side of the sarcotesta that side should probably represent the apical end of the seed. If, this is true, then Saksena's specimen would have to be orientated upside down.

Samaropsis goraiensis Surange & Lele

Pl. 1, Figs. 9, 10; Text-fig. 6

Description — Only Four impressions are in the collection. The seeds are incompletely preserved. They vary in size from 8-10 × 5-8 mm. The sclerotesta measures 5-6 × 3·5 mm. It is pear shaped and both the ends are bluntly pointed. The sarcotesta is 2 mm. wide, encircles the sclerotesta and has a median sinus at the apex and a broad V-shape notch at the base, which appears cordate. The sarcotesta is symmetrical, wider at the base, and the ends are bluntly rounded.

Locality — Central pit and Deep pit.



TEXT-FIG. 6 — *Samaropsis goraiensis* Surange & Lele. × 10.

Comparison — The specimens agree in shape and size with *S. goraiensis* Surange & Lele (1956, PL. 1, FIGS. 3, 4, 14), described from the Talchir Stage of the South Rewa Gondwana Basin. So far this species was known only from the Goraia beds of the Talchir stage of South Rewa Gondwana basin, the present record suggest its continuation in the younger beds.

Samaropsis feistmantelii sp. nov.

Pl. 1, Fig. 11; Text-fig. 7

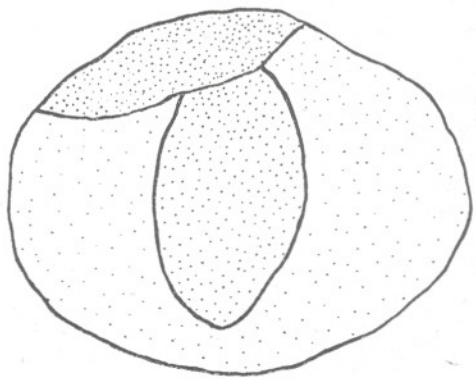
Diagnosis — Seed more or less circular, sclerotesta oval, longer than broad with both the ends pointed; sarcotesta encircles the sclerotesta which is broadest at the sides and narrow towards the apex and base.

Holotype — 32801/499, Birbal Sahni Institute of Palaeobotany collection.

Locality — Central pit, Srirampur Colliery.

Horizon — Karharbari stage (Lower Permian).

Description — Only two cast of platyspermic winged seeds on a sandy micaceous shale; seed small more or less circular, measuring 5 × 6 mm.; sclerotesta oval, longer than broad, 4 × 2·5 mm. with pointed ends; sclerotesta surrounded by a well marked sarcotesta which is broadest on two sides, where it is 1·5 mm. wide and gradually narrows down towards apex and base. A thin crust is preserved on the seed which under strong incident light shows small rectangular cells.



TEXT-FIG. 7 — *Samaropsis feistmantelii* sp. nov. × 10.

Comparison — *Samaropsis seixasi* (White) Seward (1917) compares with the present seed but differs in having a notched apex. *Samaropsis thomasii* Schopf (1962) agrees with the present seed in its organization, but differs in its very small size. *Samaropsis menisca* Lele (1963) differs in having the sarcotesta notched at both the ends and striations over the sclerotesta. Besides, it is known from considerably younger strata. Seeds having similar construction have been recorded by Feistmantel from the

Raniganj Stage of Karanpura coalfield (1886, PL. 5A, FIGS. 8a-e).

Samaropsis sp.

Pl. 1, Fig. 12; Text-fig. 8

Description — Single specimen of small platyspermic oval seed measuring 5 × 3·5 mm., sclerotesta oval, apical end wider and more round than the basal end and devoid of striations or ridges; sarcotesta surrounds the sclerotesta except at the apical end where it is deeply notched into a oval sinus. The notched ends of the sarcotesta are hook-like.

Locality — Jubille pit.

Comparison — The present specimen agrees somewhat with *S. ganjrensis* Saksena (1955, TEXT-FIG. 5) but differs by its symmetrical oval shape and hook-like ends of the sarcotesta. *S. raniganjensis* Seward & Sahni (1920, PL. 2, FIG. 12) agrees in shape but differs in presence of broad V-shaped sinus; besides it is known from a younger horizon. Thus, the present specimens seem to combine characters of *S. ganjrensis* as well as *S. raniganjensis*, and its assignment to either species is difficult. Since only a single specimen is found it is kept separate but no specific name has been assigned.

TEXT-FIG. 8 — *Samaropsis* sp. × 10.

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***Nummulospermum* Walkom**

Nummulosperuum cf. *bowense* Walkom

Pl. 2, Fig. 13

Description — There are only three specimens in the collection. Seed 1-1·4 × 0·6-0·8 cm., ± circular-oval sclerotesta circular with a prominent beak like structure projecting into a narrow micropyle like structure. Sarcotesta encircles the sclerotesta, wider at the apical and lateral regions than the basal portion. The sarcotesta is slightly emarginate at the apex.

Locality — Central pit, Srirampur Colliery.

Comparison — Inspite of the unsatisfactory preservation the specimens compare well with the *N. bowense* Walkom (1921). So far *Nummulospermum* was known only from the Permian beds of Australia and Belgian-Congo, it is for the first time recorded from India.

***Rotundocarpus* gen. nov.**

Diagnosis — Small radiospermic wingless seeds, oval or spindle shaped, strongly convex surface with or without vertical striations.

Genotype — *Rotundocarpus striatus* sp. nov.

Comparison — These seeds are comparable with *Stereocarpus* Surange (1957, PL. 1, FIGS. 1, 2) in being radiospermic and wingless, but do not possess the characteristic ribs of *Stereocarpus*. Cridland (1963: 191) remarked that *Stereocarpus* to be a radiospermic scale leaf on the basis of examination of a plaster cast. This interpretation of Cridland has no justification because *Stereocarpus* does not show on its epidermal surface the characteristic of scale leaves, i.e., the presence of veins on the leaf surface and the stomata on the epidermal surface. *Cordaicarpus* Geinitz and *Cornucarpus* Arber differs in the presence of a distinct but narrow border and in being platyspermic. The other two genera, i.e., *Samaropsis* Göppert and *Nummulospermum* Walkom possess distinct wing and are also platyspermic. Thus the present seed does not compare to any of the known genera of, seeds from the Lower Gondwanas and therefore, constitutes a new type of seed. A generic name *Rotundocarpus* is, therefore, proposed for such seeds.

Rotundocarpus striatus sp. nov.

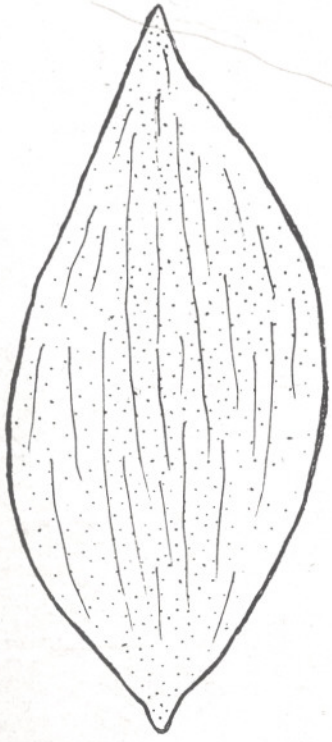
Pl. 2, Fig. 14; Text-fig. 9

Diagnosis — Small radiospermic wingless seeds, strongly convex, spindle shaped with pointed apex and base, on the surface of the seeds numerous fine vertical striations are present running from apex to base.

Holotype — 32803/504, Birbal Sahni Institute of Palaeobotany collection.

Locality — Jogtiabad pit, Karharbari Colliery, Giridih.

Horizon — Karharbari stage, Lower Permian.



TEXT-FIG. 9 — *Rotundocarpus striatus* sp. nov. × 10.

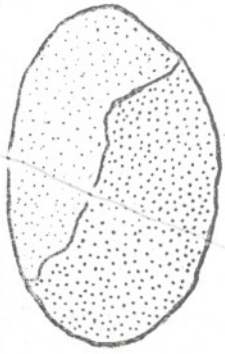
Description — Impression of small radiospermic wingless seeds, measuring 6-10 × 3-4 mm. Seeds are spindle shaped, strongly convex and bulge out of the rock surface; apex pointed and the base also pointed or slightly rounded. On its surface numerous fine vertical striations are present from apex to base. Most of the seeds have a carbonized crust which crumpless into pieces during maceration. Under incident light, however, the carbonized crust shows rectangular, elongate cells placed end to end.

Remarks — The radiospermic seed *Carpolithus striatus* Walkom (1935) from upper Kuttung Series of Weire basin appears to be a *Rotundocarpus* from its description and photograph.

Rotundocarpus ovatus sp. nov.

Pl. 2, Fig. 15; Text-fig. 10

Diagnosis — Radiospermic wingless seeds, thick, strongly convex, almond shaped or more or less oval with rounded apex and base; striations or ribs absent.



TEXT-FIG. 10 — *Rotundocarpus ovatus* sp. nov. × 10.

Holotype — 32804/499, Birbal Sahni Institute of Palaeobotany collection.

Locality — Central pit, Srirampur Colliery.

Horizon — Karharbari stage, Lower Permian.

Description — About ten seeds are in the collection. The size varis from 5-6 × 3-4 mm. Seeds are thick, almond shaped or more or less oval with rounded apex and base. The seeds are devoid of border, ribs or striations.

Comparison — *Rotundocarpus ovatus* is distinguished from *R. striatus* by its almond shape, distinct rounded apex and the absence of striations.

(B) SEED-BEARING ORGANS

Our knowledge of the seed-bearing organs from the Lower Gondwana of Southern hemisphere is very meagre in comparison to the records of a large number of isolated

Gymnospermic seeds. The only definite seed bearing organ known is *Arberia brasiliensis* White (1908) from Brazil. It is to be said that it bears Cordiacarpus type of seed. *Arberia* has been recorded in recent years from India (SURANGE & LELE, 1956), Africa PLUMSTEAD, 1961) and Antartica (PLUMSTEAD, 1962).

Palmatophyllites gen. nov.

Palmatophyllites lacerata n. comb.

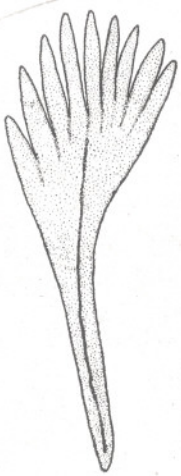
Pl. 2, Figs. 16-20; Text-figs. 11, 12

1882 — *Noeggerathiopsis lacerata* Feistmantel, Pls. 15, 17, Figs. 1-3, 4a; 2, 3.

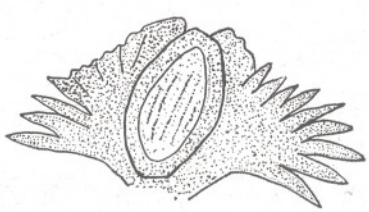
1902 — *Noeggerathiopsis* (?) *lacerata* Zeiller, Pl. 7, Figs. 2, 3.

1905 — (*Noeggerathiopsis* ?) *lacerata* Arber, Fig. 39.

1920 — *Squamae lacerata*, Seward & Sahni, Pl. 2, Fig. 16.



TEXT-FIG. 11 — *Palamatophyllites lacerata* n. comb. × 2.



TEXT-FIG. 12 — *Palamatophyllites lacerata* n. comb., incomplete bract with a seed of *Samaropsis* type. × 2.

Diagnosis — Megasporophyll, broadly spathulate, apical margin deeply lobed; lobes narrow and acuminate showing fanlike arrangement; bract convex, tapering towards the base with a median longitudinal fold. From the basal region a median vein arises, dichotomising repeatedly; each lobe has a single vein. A platyspermic seed (*Samaropsis*) is present near the middle of the bract in a median position, the micropylar end of the seed is towards the slash.

Holotype — 31395/425, Birbal Sahni Institute of Palaeobotany collection.

Isotype — 32805/499, Birbal Sahni Institute of Palaeobotany collection.

Locality — 16 B pit and Central pit, Srirampur Colliery.

Horizon — Karharbari Stage, Lower Permian.

Description — There are twenty specimens preserved on sandy micaceous shales. No carbonized crust is present and the rock matrix is rather unfavourable for showing details of the preserved parts. The biggest specimen (PT. 2, FIG. 16; TEXT-FIG. 11) is 6 × 2 cm. and is nearly complete, showing a broadly spathulate bract with a fairly drawn out narrow base. A median ridge-like structure is evident in all the specimens (present in the specimens of ZEILLER, 1902; FEISTMANTEL, 1882; SEWARD & SAHNI, 1920). The veins mostly start dichotomising near the upper end of the long drawn basal part; they are fairly apart and each apical lobe is supplied by a single veinlet. No seeds are seen on this bract which is quite like those known so far.

The other specimen which bears the seed (PL. 2, FIGS. 19, 20; TEXT-FIG. 12) is unfortunately incomplete measuring 1·5 × 2·2 cm. but the presence of a few lobes seen particularly on the sides suggest that this specimen was a part of the apical portion of the bract. The width of this specimen is nearly the same as that of the above one. A platyspermic seed attributable to *Samaropsis* is present in the middle of this specimen and would appear to be lying in a median position. The seed measures 10 × 7 mm. and has a pear shaped sclerotesta surrounded by a uniformly broad sarcotesta (2 mm. wide). Faint longitudinal striations are observed on the sclerotesta. The apical side of this seed is towards the lobes. This seed appears like *S. ganjrensis* Saksena which is found in detached state in the material. Although an organic connection

between the seed and the scale cannot be demonstrated, the position of the seed on the scale strongly suggests that it was originally attached by a short stock apparently to the median ridge of the scale near the apex.

Discussion — Similar specimens were first recorded by Feistmantel from the Karharbari stage of South Rewah Gondwana Basin and placed under *Noeggerathiopsis* viz. *Noeggerathiopsis lacerata*, inspite of the fact that the specimens were deeply incised at the apical margin, convex in shape and with a distinct median groove. Zeiller (1902) and Arber (1905) later expressed doubts about its inclusion under *Noeggerathiopsis*. Zeiller pointed out that the specimens appeared to resemble *Cycadospadix* or megasporophyll of *Cycas*. Seward & Sahni (1920) remarked that the convex appearance of the specimens was suggestive of a protective bract, and they were probably borne by some cordaitean reproductive shoot. This suggestion was based upon their discovery of a scale bearing the seed of *Samaropsis milleri* (Feistm.) Seward. The present finding of *Samaropsis* seed on *Noeggerathiopsis lacerata* supports the contention of Seward and Sahni (1920), that these specimens represent a megasporophyll or a protective bract. The species *N. lacerata* is, therefore, placed under a new genus *Palmatophyllites*. Another megasporophyll *Arberia*, recorded from the Karharbari and Talchir stages is also known to have borne *Cordaicarpus*-like seeds (SEWARD, 1917; SURANGE & LELE, 1956).

Arberia White

Arberia cf. *umbellata* Surange & Lele

Pl. 2, Fig. 21

Description — The collection includes a megasporophyll-like organ. The incomplete specimen measures 4·5 cm. in length and 1·4 cm. in in width at the broadest part. It has a slender stalk, about 4 mm. in width which expands upwards into a flattened head bearing recurved processes. No seed is preserved on this specimen.

Locality — Central pit, Srirampur Colliery.

Horizon — Karharbari stage (Lower Permain).

Comparison — The specimen shows closest resemblance to *A. umbellata* Surange & Lele (1956), but due to the imperfect preservation of the specimen a detailed comparison is not possible.

A. umbellata was previously known only from the Talchir stage of the South Rewah Gondwana Basin.

DISCUSSION

Gymnospermic seeds from the Lower Gondwanas of Southern hemisphere have been recorded from Brazil, South Africa, Uganda, Belgian Congo, Zambesi basin, Antartica, Australia and India. The seeds have been assigned to the following genera:

Cordaicarpus Geinitz
Cornucarpus Arber
Samaropsis Göppert
Nummulospermum Walkom
Stereocarpus Surange
Rotundocarpus gen. nov.

The Gondwana seeds show nearly analogus character, however, still they show divergence in their structure and shape. The seeds are commonly platyspermic, except for the few recent records of the radiospermic seeds. From the study of literature of the Lower Gondwana seeds, it has become evident that under the genera *Cordaicarpus* and *Samaropsis*, seeds showing a wide range of variation in characters have been placed. The *Cordaicarpus* Geinitz was originally proposed to accomodate platyspermic seed with a narrow border enclosing an ovate or cordate nucule; the base being either rounded or cordate. However, the seeds placed under it possess distinct beak like apex (*C. mucronatus* HØEG & BOSE, 1960; *C. prolatus* WALKOM, 1935) or with a prominent median ridge (*C. karharbarense* sp. nov.). The seeds placed under *Samaropsis* show a range of variation in shape and structure. The shape ranges from vertically oval (*S. ganjrensis* Saksena), circular (*S. barcellosa* White) to horizontally oval (*S. seiaxsi* White); sinus may be present on one side (*S. ganjrensis* Saksena) or both the sides (*S. goraiensis* Surange & Lele). In some a prominent median ridge is also present [*S. milleri* (Feistm.) Seward].

It is thus obvious that these two genera incorporate seeds showing a wide range of variation in their shape and structure with result that these genera have become much unwieldy. In view of this a tentative scheme for further delimitation is proposed here on the basis of seed morphology. The

characters taken into consideration are as follows:

1. Overall shape of the seed, i.e. platyspermic or radiospermic.
2. Presence of a narrow or wide sarcotesta.
3. Presence or the absence of a ridge or groove.
4. Shape of the apex and base.

The scheme for classification is as follows:

A. *Seed Radiospermic*

Group. 1. With distinct ridge — *Stereocarpus* Surange (1957)

Group. 2. Without ridge — *Rotundocarpus* gen. nov.

B. *Seed Platyspermic*

(I) With narrow border

a. With a median ridge

Group. 3. — *Cordaicarpus karharbarense* sp. nov.

b. Without a median ridge

Group. 4. Apex obtuse or roundly acute

Cordaicarpus zeilleri sp. nov.
Cordaicarpus ovatus Lele (1963)
Cordaicarpus emarginatus Walkom (1935)

Group. 5. Apex pointed (acuminate)

Cordaicarpus mucronatus Hφeg & Bose (1960)
Cordaicarpus prolatus Walkom (1935)
Cordaicarpus chichariensis Lele (1960)

Group. 6. Apex bifurcated into two horn-like processes

Cornucarpus furcata (Surange & Lele) n. comb.
Cornucarpus striatus Walkom (1935)
Cornucarpus sp. duToit (1932)

(II) Seed with a wide border (Sclerotesta)

a. Seeds with a ridge

Group. 7. — *Samaropsis milleri* (Feistm.) Sew (1920)
Samaropsis indica (Zeill.) Sew. (1917)
Samaropsis dowsoni (Shirley) Walkom (1922)
Samaropsis intermedia Hφeg & Bose (1960)
Samaropsis leslii Seward (1917)

b. Seeds without a ridge

Vertically oval or circular in shape

Group. 8. Without any sinus — *Nummulosperm bowense* Walkom (1921)

Group. 9. Sinus on one side — *Samaropsis ganjrensis* Saksena (1954)
Samaropsis raniganjensis Sew. & Sahni (1920)
Samaropsis barcellosa White (1908)
Samaropsis bautkofi Hφeg & Bose (1960)
Samaropsis longii Schopf. (1961)

Group. 10. Sinus on both the sides

Samaropsis goraiensis Surange & Lele (1956)

Horizontally oval in shape

Group. 11. Sclerotesta without any sinus

Samaropsis thomasii Schopf (1961)
Samaropsis feistmantelii sp. nov.

Group. 12. Sclerotesta with sinus — *Samaropsis seixasi* (White) Sew. (1917)
Samaropsis menisca Lele (1963)
Samaropsis pincombei Walkom (1928)
Samaropsis johillensis Saksena (1954)

The scheme for classification proposed here is a tentative one and can be modified when more evidences come up. Each group has been considered in the classification as a distinct separate entity.

It should be mentioned here that Walkom (1935) assigned few seed impressions from the Upper Kutung Series of Weire basin, New South Wales to *Trignocarpus* Brongn. *Trignocarpus* was originally proposed to accommodate Northern radiospermic seeds with distinct ridges and known internal anatomy. The Australian specimens are preserved in form of impressions and their assignment to *Trignocarpus* is not justifiable. From the description it appears that it will be more appropriate if these seeds are referred to *Stereocarpus* Surange, which has been enunciated to accomodate impression of radiospermic seeds with ridges.

The affinities and relationship of these gymnospermic seeds still remains a palaeobotanical puzzle. The seeds are recorded in dispersed state in association with the leaves belonging to the Glossopteridales, Coniferales, Cordaitales etc. But so far no leaf genera have been recorded in organic connection with these seeds. In past few authors considered platyspermic seeds to be Cordaitean in affinity and tempting hypothesis were postulated for a possible relationship with *Noeggerathiopsis*, which is believed to be a Cordaitean plant. White (1908) suggested that *Samaropsis* seeds were borne on the leaves of *Gangamopteris*. The records of seed-bearing organs are very meagre. The only definite record is *Arberia* (?) *brasilensis* Lundquist (1919) bearing *Cordaicarpus* from the Rio Grande do Sul, Brazil. Plumstead (1963) considered some of them to be Angiospermic. The question will remain unsettled till a definite organic connection is proved. At any rate from the divergent characters exhibited by the seeds, it becomes obvious that these seeds belong to different genera and perhaps even different groups of plants.

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REFERENCES

ARBER, E. A. N. (1902). The clarke collection of fossil plants from New South Wales. *Quart. J. Geol. Soc.* **58**: 1-26.

Idem (1905). The Glossopteris Flora. *London.*

CRIDLAND, A. A. (1963). A Glossopteris flora from the Ohio Range, Antartica. *Amer. J. Bot.* **50**: 186-195.

DU-TOIT, A. L. (1927). Some fossil plants from the Gondwana beds of Uganda. *Ann. S. Afr. Mus.* **28** : 395-407

FEISTMANTEL, O. (1879). The fossil flora of Gondwana system: flora of the Talchir Karharbari beds. *Palaeont. indica.* Ser. 12, **3**: 1-48.

FEISTMANTEL, O. (1882). The fossil flora of Gondwana system: flora of the Damuda and Panchet divisions. *ibid.* Ser. 12, **3**(2): 1-149

Idem (1886). The fossil flora of Gondwana system: Flora of some of the coalfields of Western Bengal. *ibid.* Ser. 12, **4**(2): 1-66.

HALLE, T. G. (1927). Palaeozoic plants from Central Shansi. *Palaeont. Sinica*, Ser. A. **2**, (1): 1-316

HØEG, O. A. & BOSE, M. N. (1960). The Glossopteries flora of the Belgian Congo with a note on some fossil plants from Zambesi basin (Mozambique). *Ann. Mus. Roy. Congo. Belge.* Série in-8° Sciences geologiques. **32**: 1-106

LELE, K. M. (1963). Studies in the middle Gondwana flora: 3. Platyspermic seeds and megaspore impressions from the South Rewa Gondwana Basin. *Palaeobotanist*, **11**: 13-18.

LUNDQUIST, G. (1919). Fossil Pflanzen der Glossopteris — Flora aus Brasilen. *K. Sv. Vet. Handl.* **40**(3): 1-36.

PANT, D. D. (1958). The structure of some leaves and fructifications of the Glossopteris flora of Tanganyika. *Bull. Brit. Mus. Nat. Hist. geol* **3**(4): 127-175.

PANT, D. D. & NAUTIYAL, D. C. (1960). Some seeds and sporangia of Glossopteris flora from the Raniganj Coalfield, India. *Palaeontographica* B. **107**: 41-64.

PLUMSTEAD, E. P. (1962). Fossil floras of Antartica. Trans-Antartic Exped. 1955-58. Scientific Rep. 9. Geology. *Trans. Antartic. Expedition Committee.* 1-154.

Idem (1963). The influence of plants and environments on the developing animal life of Karoo times. *S. Afr. J. Sci.* **69**(5): 147-152.

SAKSENA, S. D. (1952). Correlation of the Gondwanas based on the evidence of plant fossils. *Agra Univ. J. Res.* **1**: 1-13.

Idem (1954). On two new species of *Samaropsis* from the South Rewa Gondwana basin, Central India. *Palaeobotanist*, **4**: 73-76.

SCHOPF, J. M. (1961). A preliminary report on plant remains and coal of the sedimentary section in the Central range of the Horlick

Mountains, Antartica. *Institute of Polar Studies*, Report 2. *Ohio*: 1-61.

SEWARD, A. C. (1917). Fossil plants. **3**. *Cambridge*.

SEWARD, A. C. & SAHNI, B. (1920). Indian Gondwana plants: A Revision. *Mem. geol. Surv. India. Pal. Indica*. N.S. **7**(1): 1-54.

SURANGE, K. R. (1957). Studies in the Glossopteris Flora of India — 8. *Stereocarpus emarginatus* gen. et. sp. nov. a seed from the Lower Gondwanas of India. *Palaeobotanist*,. **6**(1): 29-30.

SURANGE, K. R. & LELE, K. M. (1956). Studies in the Glossopteris Flora of India-6. Plant fossil from Talchir beds of South Rewa Gondwana basin. *Ibid*. **5**(2): 82-90.

SURANGE, K. R., SRIVASTAVA, P. N. & PREM SINGH (1953). Microfossil analysis of some Lower Gondwana Coal seams of West Bokaro, Bihar. *Bull. Nat. Inst. Sci. India*. No. 2: 111-127.

WALKOM, A. B. (1921). *Nummulospermum bowense* gen et. sp. nov. *Quart. J. geol. Soc*. **77**(4): 289-295.

Idem (1922). Palaeozoic flora of Queensland, Pt. I. The flora of the Lower and Upper Bowen Series. *Queensland Geol. Surv*. Publication No. 270: 1-45.

Idem (1928). Notes on some additions to the Glossopteries Flora in New South Wales. *Proc. Lin. Soc. N.S.W*. **53**(5): 555-564.

Idem (1935). Some fossil seeds from the Upper Palaeozoic Rocks of the Werrie basin, N.S.W. *Ibid*. **60**(5-6): 459-463.

WHITE, D. C. (1908). Fossil flora of the Coal measures of Brazil. I.C. Commisao estudos das Minas de Carood de. *Pedra do Brazil*. Rio-de-Janeiro: 337-617.

ZEILLER, R. (1902). Observations sur quelques plantes fossiles des Lower Gondwanas. *Mem. geol. Surv. India. Pal. Indica*. N.S. **2**(1): 1-40.

EXPLANATION OF PLATES

PLATE 1

1. *Cordaicarpus zeilleri* sp. nov., Holotype, Specimen No. 32794/499, Central pit. × 4.

2. *Cordaicarpus zeilleri* sp. nov., A somewhat narrow specimen with many vertical striations. Specimen No. 32795/499, Central pit. × 4.

3. *Cordaicarpus zeilleri* sp. nov., Another specimen showing a faint median ridge. Specimen No. 31312/424, Central pit. × 6.

4. *Cordaicarpus karharbarense* sp. nov., Holotype, Specimen No. 31340/424, Central pit. × Nat. size.

5. *Cornucarpus furcata* n. comb. Specimen No. 32796/499, Central pit. × 4.

6. *Samaropsis milleri* (Feist.) Seward, Specimen No. 20026, Central pit. × Nat. size.

7. *Samaropsis ganjrensis* Saksena, Specimen No. 32797/502, Deep pit. × 4.

8. *Samaropsis ganjrensis* Saksena, Specimen No. 32798/502, Deep pit. × 4.

9. *Samaropsis goraiensis* Surange & Lele, Specimen No. 32799/499, Central pit. × 4.

10. *Samaropsis goraiensis* Surange & Lele, another specimen ± circular — triangular in outline. Specimen No. 32800/503, Jubille pit. × 4.

11. *Samaropsis feistmantelii* sp. nov. Holotype, Speimen No. 32801/499, Central pit. × 4.

12. *Samaropsis* sp. Specimen No. 32809/503, Jubille pit. × 4.

PLATE 2

13. *Nummulospermum* cf. *bowense* Walkom. Specimen No. 31301/424, Central pit. × 4.

14. *Rotundocarpus striatus* gen. et sp. nov. Holotype, Specimen No. 32803/504, Jogtiabad pit. × 4.

15. *Rotundocarpus ovatus* sp. nov. Holotype, Specimen No. 32804/499, Central pit. × 4.

16. *Palmatophyllites lacerata* gen. et n. comb. Holotype, Specimen No. 31393/425, 16A pit. × Nat. size.

17. The figure 16 enlarged to show the median groove. × 2.

18. *Palamatophyllites lacerata* gen. et n. comb. Another specimen, Specimen No. 31395/425, 16A pit. × Nat. size.

19. *Palamatophyllites lacerata* gen. et n. comb. Isotype. Showing bract with seed, Specimen No. 32805/499, Central pit. × Nat. size.

20. Fig. 19 magnified to show the characters of the seed. × 4.

21. *Arberia* cf. *umbellata* Surange & Lele, Specimen No. 32806/499, Central pit. × 3.

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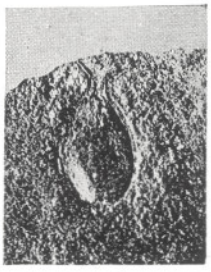

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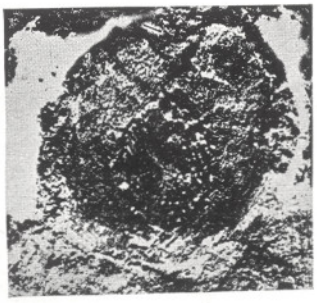

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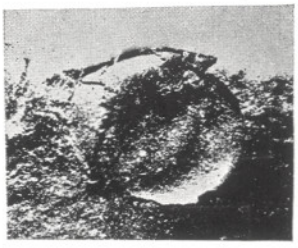

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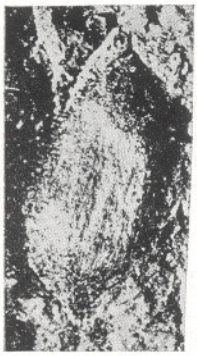

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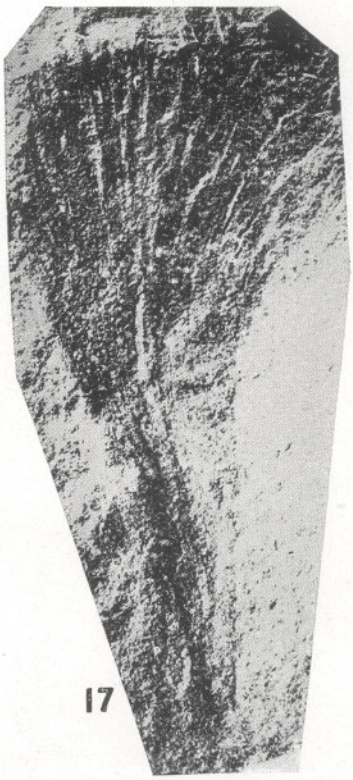

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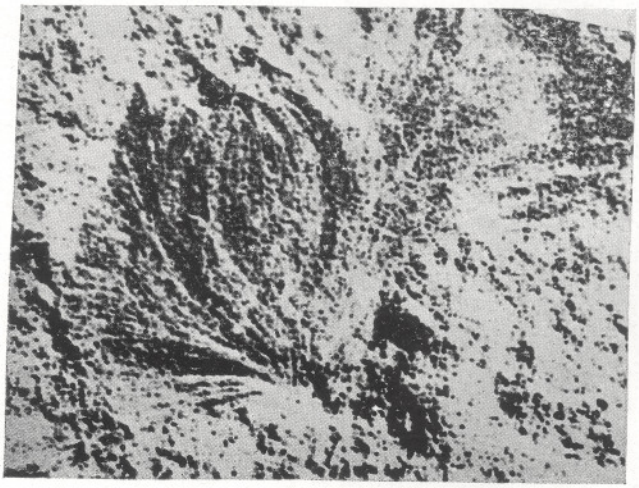

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