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Investigating seeds of *Araceae* from the Late Cretaceous sedimentary beds of Central India.

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ABSTRACT

The number of specimens of monocotyledonous fossil seeds has been recovered from the fossiliferous locality of Singpur, Madhya Pradesh, India (Lat. 19°58.141'N, Long. 78°40.838'E). From the reconstruction based on slide by slide observation it had been concluded that the petrified structures under consideration is a small sized monocotyledonous seeds of family *Araceae*. The seeds are ellipsoidal and oval differentiated into seed coat and large embryo. All the features described made it possible to assign it to a family of its closest resemblance. The fruits of *Araceae* are typically juicy berries, although rarely drier and leathery. The study of the fossil seeds represents an oldest and first record from the sites of Deccan Intertrappean Cretaceous-Palaeocene of central India. Numbers of fruits with seeds, both dicotyledonous and monocotyledonous are reported from the Intertrappean beds of India. But the report of isolated monocot seed is very rare. Hence the present report of a new seeds of *Araceae* from locality of Singpur is a noteworthy contribution to our knowledge of fossil seed.

Key words- Aroid seeds, Late Cretaceous, *Araceae*, Singpur etc.

INTRODUCTION

The diverse fossil flora from the Upper Cretaceous period of central India has been extensively studied in the past 50 years. This exceptional site contains a wide variety of well-preserved silicified plants, including pteridophytes, conifers, angiosperms, and their associated fungi (Chitaley S.D. 1950, Prakash U. 1956). Monocots are often not well preserved in the fossil record, partially because of their primarily herbaceous habit.The *Araceae*, or aroids, are plants which are very familiar to everyone but paradoxically little known. About 105 genera, over 3300 species distributed subcosmopolitan and most diverse in tropical latitudes.
The fruits of *Araceae* are typically juicy berries, although rarely drier and leathery. The seeds are many per berry; testa thick to thin, smooth,

Fig. 1 Modified map of Decan trap of Central India Showing fossil Locality

roughened, embryos sometimes decaying at maturity or lacking altogether. sometimes arillate, embryo usually straight, sometimes curved usually undifferentiated, rarely with highly developed plumule and then endosperm lacking and outer cell layers of embryo chlorophyllous; endosperm copious or absent, with all intermediate states occurring.

The specimens of monocotyledonous fossil seeds of *Araceae* has been described from the locality Singpur, Madhya Pradesh, India (Lat. 19°58.141'N, Long. 78°40.838'E). From the reconstruction based on slide by slide observation it had been concluded that the petrified structures under consideration is a small sized, ovate monocotyledonous seeds. Number of seeds has been reported from the different fossiliferous localities of the Deccan Intertrappean beds of central India. (Kumar 1984) reported fossil seed under the name *Clusiocarpus arilatus* from the Intertrappean beds of central India. *Clusiocarpus indicum* was reported (Kolhe and Wazalwar, 1998) from the same beds. *Mahabaleyspermum minutum* and *Deccanosperm arillata* are the seeds reported (Juneja 1993), *Unonaspermum corneri* (Bonde, 1993), *Ramakonospermus chitaleyensus* (Matin *et al.,* 2009), *Capparicocarpous nagpurii* (Konde and Kolhe, 2012), *Sahniospermum trapii* (Pundkar, 2017) from the Intertrappean beds of central India. (Bhowal 2000) reported fossil seeds under the name *Ramaconospermus singapuri* from Singpur beds of M.P, India. In addition to these, some workers have studied fruits of *Viracarpon hexaspermum* (Chitaley, 1958) and structure of embryo in the seeds of *Enigmocarpon parijai* Sahni (Biradar and Mahabale, 1974), *Phoenicoid* seed (Ambawani and Dutta, 2005). Numbers of fruits with seeds, both dicotyledonous and monocotyledonous are reported from the Intertrappean beds of India. But the report of isolated monocot seed is very rare. Hence the present report of a new seeds of *Araceae* from locality of Singpur (Fig1.) is a noteworthy contribution to our knowledge of fossil seeds from the Deccan Beds.

MATERIALS AND METHODS

The present fossil specimens are a nicely preserved monocotyledonous seeds exposed in its transverse and longitudinal plane collected during the field visits to the fossil locality. Present fossil seeds were preserved in the silicified chert in the petrified form. After breaking the chert, seeds were exposed in transverse and longitudinal sections. The anatomical details were studied by peel sections taken after etching with hydrofluoric acid and thoroughly washed with water (Darrah, 1936;Joy *et al*., 1956; Stewart and Tylor, 1965; Holmes and Lopez, 1986). The slides are prepared by mounting peels using xylene soluble DPX as a mountant and observed under research microscope and photographed for detailed study.

DESCRIPTION

The collected seed specimens are ellipsoidal and other two are oval differentiated into seed coat and large embryo (Pl.1, figs.1, 2, 3, 4). The detailed description of each part of the seed is given below as seed-coat, testa, tegmen, seed cavity, embryo and endosperm.

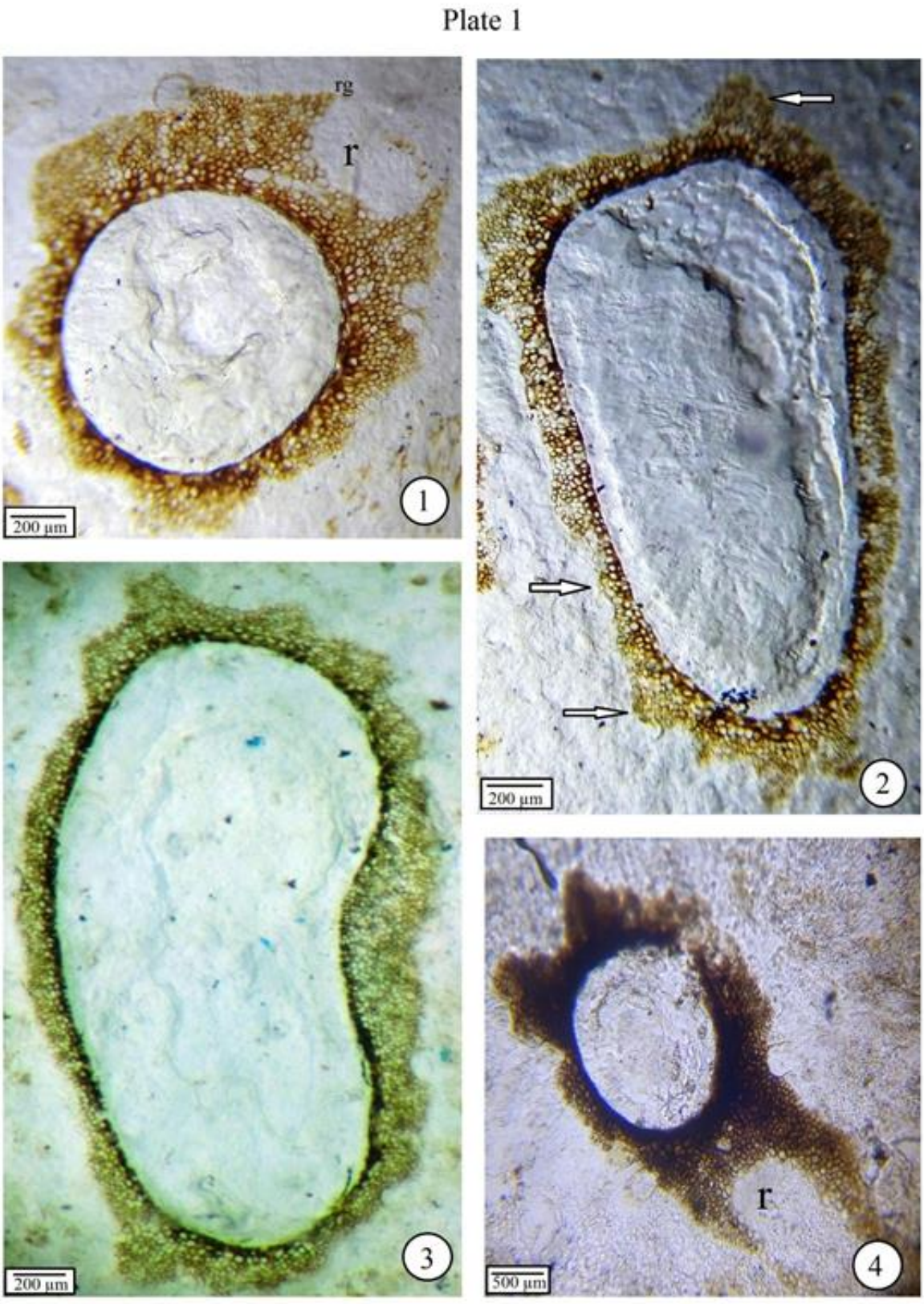

Fig. 2 : ***Arecospermum indicus*** **gen . et sp. nov.**
1.Transverse section of specimen 1 showing large ridge (rg) and raphe (r). 2. Longitudinal section of specimen 2 showing many small crests (arrows). 3. Longitudinal section of specimen 3. 4.Transverse section of specimen 4 showing raphe (r).

Seed Morphology

The seeds are small and ovate with a large ridge along the antiraphal side that extends from the micropyle to the hypostase area (Pl.1, fig.1). On either side of this are smaller, more irregular ridges. Broad at one end and tapering at the other, orthotropous, monocotyledonous, bitegmic having hypocotyl at one end measured 2.1-2.8 mm in length and 0.9-1.9 mm in width. The width of the seed at the micropylar end is 350 µm; and 200 µm at chalazal end. Vascular tissue is often not preserved.

Seed Coat

The seeds have a hard seed coat with crests measured about 100-500 µm in thickness. Exotesta is compressed. The seed coat is bitegmic and differentiated into testa and tegmen. In section, the seed coat is formed by isodiametric cells that are more thickened to the inside of the seed and slowly grade into thinner-walled cells. The remaining seed coat is warty. The raphe is enclosed by the testa (Pl.1, figs.1, 4).

Testa

It is 3 to 15 celled layered with oval to elongated cells having crests at outside. It showed variation in thickness, i.e. 30-160 µm thick. It has ridges and furrows with ridge up to 0.6 mm high. The seed coat is composed of isodiametric, pitted sclereids (Pl.2, figs.1, 3). These cells protrude from the testa or are found a few cells from the outside edge of the testa.

Tegmen

It is 2 to 5 celled, sclerified and thick walled 35-60 µm in thickness (Pl.2, figs. 1, 2, 3). Sclerenchymatous cells are compactly arranged without intercellular spaces. They are rectangular in shape and measured 20-30 µm (Pl.2, fig.2).

Seed cavity

The area occupied by the seed cavity is 0.6-1.2 mm at the central region.

Embryo

Embryo is large in size occupies maximum space of the seed cavity. In between wall of the embryo, there is a narrow space all around (Pl.1, figs.2, 3). However some thin walled parenchymatous cells are still preserved in this nucellar region (Pl.2, figs.4). The wall of embryo is made up of thin parenchymatous cells which are irregular in shape (Pl.2, figs.5). Embryo length is less than ¾ of the seed length. And width is about ¼ of seed width. Few circular embryonic cells are preserved at chalazal end. Embryo seen preserved and measures 0.4 mm-1.5 mm. The embryo measures 30 µm in thickness. Hypocotyl region is differentiated into radical at outside and plumule at inside of the seed cavity. Hypocotyl region was about 110 µm in length and 130 µm wide. Few cells in hypocotyl can be seen which were hexagonal measured about 10-25 µm in dimensions. Cells of radicle are 15-25 µm in size. Wall of embryo is 7-20 µm in thickness.

Nucellus

Around the embryo, a narrow empty space is seen which represents the nucellus. Nucellar tissue is preserved at some places and is parenchymatous (Pl.2 figs.4).

Endosperm

Remnants of endospermous tissue were seen at chalazal as well as mycropylar end. It measured 30-90 µm in thickness.

DISCUSSION

All the features described above made it possible to assign it to a family of its closest resemblance. On the basis of the seed coat characters it appears that the seed belonged to the monocotyledonous family.

Comparison with the already known fossil seeds

Many workers worked on monocot fruits but isolated monocot seed is not cited from the Deccan Intertrappean beds of central India.

Comparison with modern taxa

For assigning the fossil seed to proper family, it was also compared with living genera of modern monocot families. The available literature was thoroughly searched for the anatomical and embryological characters, Goebel (1905), Rendle (1971), Eames and Mac Daniels (1947), Maheshwari (1950), Hutchinson (1959), Porter (1959), Esau (1960-65), Eames (1961), Fahn (1974), Metcalfe C.R. (1960), Metcalfe C.R. and Chalk L. (1950) and most useful of all, by Corner (1976).

In monocotyledons there is much less diversity there are exotestal and endotestal seeds (Corner 1976). The account of seeds of monocotyledons was immensely useful. He stressed that the structure of the seed, especially of the seed coat, is very much helpful in tracing the affinity.

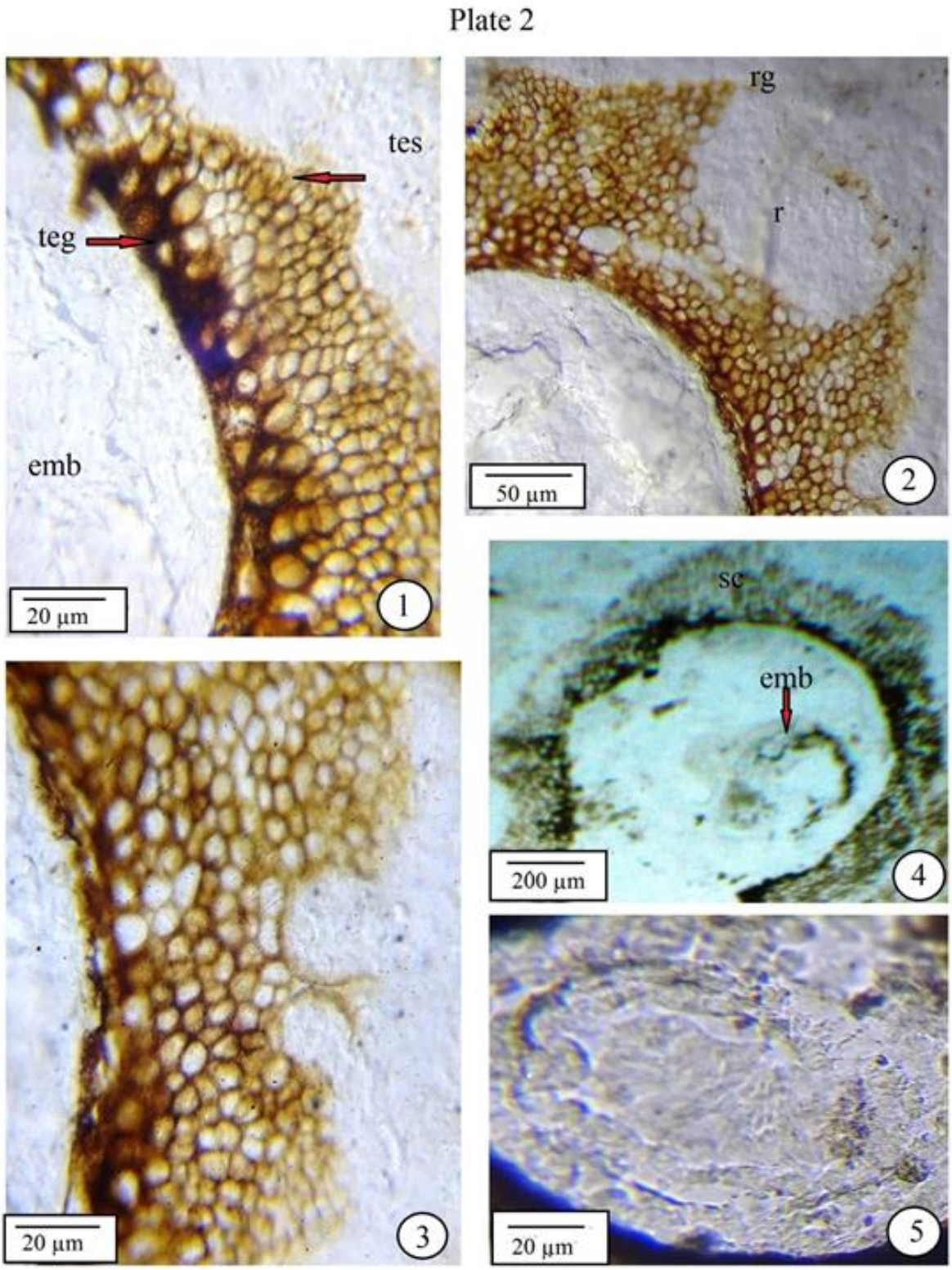

Fig. 3 : ***Arecospermum*** gen. nov.

1. L.S. of specimen 2 showing seed coat, testa (tes), tegmen (teg) and embryo (emb). 2. Magnified view of T.S. of specimen 1 showing details of large ridge (rg) and raphe (r). 3. Magnified view of T.S. of specimen 3 showing details of seed coat. 4. Magnified view of specimen 4 showing seed coat (sc) and embryo (emb).5. Magnified view of specimen 4 showing embryo.

The fossil seed is compared with the modern seeds of monocotyledonous families, namely Alismaceae, Potamogetonaceae, Hydrocharitaceae, Gramineae, Palmae and Araceae (Metcalfe & Chalk, 1950). The seeds of these families resemble the present fossil in having general characters of monocot seeds, such as solitary seed, single cotyledon, hard seed coat with crest, isodiametric cells of integument and large sized embryo. Family Alismaceae differs in having seeds with no endosperm and a curved or folded embryo. The slightly recurred outline of the embryo lends a U-shaped form to the seed. Family Potamogetonaceae differs in seeds non-endospermic, seeds with starch, embryo achlorophyllous, slightly curved, testa without phytomelan, membranous. Family Hydrocharitaceae differs in having straight embryo and no endosperm. Family Gramineae differs in having the seed coat to fused fruit wall. Family Palmae differs in having a thin seed coat with 3-4 cells thick; endosperm forms an outer peripheral thick mass with central cavity.

From the above discussion, it is very clear that the present fossil seed did not resemble with any already reported fossil seed. Mainly it differs in size and in the structure of integuments. When it is discussed with the extant family of monocotyledons, it shows affinities with the some genera from family *Araceae.* It resembles with *Urospatha, Anaphyllopsis, Dracontium* and *Keratosperma* in the structure of the seed. *Urospatha seeds* are curved and have prominent spines usually in four rows. Very strongly thickened isodiametric cells are found to the inside of the outer integument, while the cells to the outside are thin walled. The two zones are separated by an area of cells with dark staining contents, probably tannins (Seubert 1993). Seeds of *Anaphyllopsis* are somewhat reniform, with two thick dorsal (antiraphal) ridges that merge into one at the micropylar end of the seed and with a lateral ridge on either side. In *Dracontium* seeds are rounded and C-shaped, with smooth lateral surfaces and a rugose dorsal side. Seubert (1993) examined the integuments of several lasioid seeds, illustrating strongly differentiated inner and outer zones to the outer integument in species of all lasioid genera except *Anaphyllum*, which has a fairly uniform cell wall thickness throughout the outer integument. This is unlike the gradually thinning outer integument seen in *Keratosperma*. The fossil seed coat shows a gradual thickening of cell walls toward the inside. On the basis of these anatomical and morphological comparisons, it appears that present fossil seed closely resembles with family Araceae but needs further investigation hence present fossil seed is given a name *Araceospermum indicus* gen. et. sp. nov. generic name is after the family and specific name is after the location of Deccan Trap in central India.

RESULTS

The study of the fossil seeds represents an oldest and first record from the sites of Deccan Intertrappean Cretaceous- Palaeocene of central India. The seeds are often embedded in mucilaginous pulp among a wealth of other interesting new observations, shows that endosperm may be present in mature seeds of some groups as only a very thin layer. Many intermediate conditions exist between the presence of copious endosperm and absence of endosperm. Absence of endosperm is often correlated with the presence of a well-developed plumule and the largest seeds of *Araceae* are of this type, the seeds are usually straight, or often curved. The plumule is also highly developed. Seeds with a well developed plumule usually lack endosperm and have only a very thin, papery testa. Such large embryos generally contain chlorophyll at maturity and are only viable for a short time.

Systematics

Class-Lliopsida
Order- Alesmatales
Family- Araceae
Genus- Araceospermum
Species- Araceospermum indicus

Holotype - DDR/Seed/ Deccan Flora Museum and Research Center, Sakoli, India.
Horizon - Deccan Intertrappean Series of India.
Locality - Singpur, Madhya Pradesh, India.
Age - Late Cretaceous.

DIAGNOSIS

Araceospermum gen. nov.
Small, ovate, orthotropous, monocotyledonous, bitegmic seed, large ridge along the antiraphal side, smaller irregular ridges on either side. Seed coat hard with crests, formed by isodiametric cells, thickened to the inside and thinner to the outside, remaining seed coat is warty. Embryo thin walled parenchymatous, embryo length is less than ¾ of the seed length and width is about ¼ of seed width.

Araceospermum indicus gen. et sp. nov.

Small, ovate, orthotropous, monocotyledonous seed measuring 2.1-2.8 mm in length and 0.9-1.9 mm in width. The width of the seed at the micropylar end is 350 µm and 200 µm at chalazal end. Hard seed coat with crests measured about 100-500 µm in thickness, formed of isodiametric cells, more thickened to the inside of the seed and slowly grade into thinner-walled cells. Testa 3 to 15 celled measuring 30-160 µm in thickness having crests at outside. It has ridges and furrows with ridge up to 0.6 mm high. Tegmen 2 to 5 celled, sclerified, thick walled 35-60 µm in thickness. Embryo large, thin walled, parenchymatous measuring 0.4-1.5 mm. Hypocotyl region is differentiated into radical and plumule. Hypocotyl region was about 110 µm in length and 130 µm wide. Cells of radicle are 15-25 µm in size. Wall of embryo is 7-20 µm in thickness. Endosperm 30-90 µm in thickness.

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