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Platyspermic seeds from the Early Permian of Paraná Basin, Brazil

M.E. BERNARDES-DE-OLIVEIRA[1,2*], M.C. DE CASTRO-FERNANDES[1], RAJNI TEWARI[3] AND F. RICARDI-BRANCO[4]

[1] *Centro de Pós-Graduação, Pesquisa e Extensão, Guarulhos, SP, Brazil, maryeliz@usp.br*
[2] *Programa de Pós-Graduação em Geologia Sedimentar, IGc, São Paulo, SP, Brazil.*
[3] *Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226007, India.*
[4] *Depto. de Geologia e Recursos Minerais, IG, Campinas, SP, Brazil.*

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ABSTRACT

Bernardes-De-Oliveira ME, De Castro-Fernandes MC, Tewari R & Ricardi-Branco F 2007. Platyspermic seeds from the Early Permian of Paraná Basin, Brazil. The Palaeobotanist 56(1-3): 1-19.

This paper results from a taxonomic study of platyspermic seeds from taphofloristic assemblage of the "Toca do Índio Ranch", belonging to the upper portion of the Itararé Subgroup, Municipality of Cerquilho (SP) and a revision of material collected by Millan (1977) from the same area which is deposited in the National Museum of Rio de Janeiro. The assemblage comprises the Transitional Taphoflora (A-B) or the *Gangamopteris-Rubidgea-Stephanophyllites* association from the type-locality of Northeastern Paraná Basin. This taphoflora is Early Permian (Asselian- Early Sakmarian) in age and records the beginning of the colonization of the Paraná Basin by the proto-glossopterid and gangamopterid elements of the *Glossopteris* flora. It is, probably, correlated to the Argentinean "Lubeckense A" Floristic Stage or even a little older. The platyspermic seeds are assigned to the genera *Samaropsis* and *Cordaicarpus*. The assemblage is diversified and includes the taxa *Cordaicarpus brasilianus* n. sp., *Samaropsis dolianitii* Millan, *S. rigbyi* Millan, *S. tietensis* Millan, *S. cerquilhensis* (Millan) comb. nov., *S. moreirana* (White) Millan, *S. goraiensis* Surange & Lele, *S. rugata* sp. nov. and *S. rohnii* sp.nov. The record of *S. moreirana* (White) Millan in the present study is the oldest from the Paraná Basin and *S. goraiensis* Surange & Lele is recognized for the first time outside India. The wide variety of detached seeds reflect the diversification of the gymnosperms in this assemblage, putatively related to the last interglacial event of the Lower Gondwana glaciation in the Paraná Basin. Biostratigraphic correlation based on seeds is not possible due to apparent endemic nature of the assemblage and further work in this field is required.

Key-words—Platyspermic seeds, Paraná Basin, Early Permian, Lower Gondwana.

ब्राज़ील की पराना द्रोणी के प्रारंभिक पर्मियन से प्राप्त चिपिटबीजी अंकुर

एम.ई. बर्नार्डिस-डी-ऑलिवीरा, एम.सी. डी कैस्ट्रो-फर्नांडिज, रजनी तिवारी एवं एफ. रिकार्डि-ब्रैंको

सारांश

इस शोध-पत्र से सरकिल्हो (एस पी) की नगर पालिका के इटरारे उपसमूह के ऊपरी भाग से संबंधित "टोका डो इंडियो रॉच" के टफोपादपी समुच्चय से प्राप्त चिलिकीबीज अंकुरों के वर्गिकीय अध्ययन तथा उसी क्षेत्र से मिल्लन (1977) द्वारा एकत्रित

* Corresponding Author

सामग्री का परिशोधन जो कि रियो डी जनैरियो के राष्ट्रीय संग्रहालय में जमा है का निष्कर्ष निकलता है। इस समुच्चय में पूर्वोत्तर पराना द्रोणी के प्ररुप-स्थान से प्राप्त संक्रामी टेफोवनस्पतिजात (ए-बी) या *गंगेमोप्टेरिस-रुबीड्जीआ-स्टेफेनोफाईलाइटिज* संगुणन सम्मिलित है। यह टेफोवनस्पतिजात प्रारम्भिक पर्मियन युग की है तथा ग्लोसोप्टेरिस वनस्पतिजात के प्रोटोग्लोसोप्टेरिड एवं गंगेमोप्टेरिड तत्वों द्वारा पराना द्रोणी के उपनिवेशन की शुरुआत का संकेत देती हैं। संभवत यह अर्जेंटीना "ल्युबेकेन्स ए" पादप अवस्था अथवा इससे थोड़ी अधिक पुरानी से सहसंबंधित है। चिपिटबीजी अंकुर *सेमरोप्सिस* व *कोर्डाइकार्पस* वंश को निर्धारित करते हैं। यह समुच्चय विविधरुपायित है तथा इसमें *कोर्डाइकार्पस ब्रसिलिएनस* नवप्रजाति, *सेमरोप्सिस डोलिएनिट्याई* मिल्लन, एस. *रिबियाई* मिल्लन, एस. *टाइटेन्सिस* मिल्लन, एस. *सरकिलहेन्सिस* (मिल्लन) संयोजनजाति, एस. *मोरीरना* (वाईट) मिल्लन, एस. *गोराईएन्सिस* सुरंगे एवं लेले, एस. *रुगेटा* नवप्रजाति एवं एस. *रोहनी* नवप्रजाति, वर्गक निहित हैं। वर्तमान अध्ययन में पराना द्रोणी से प्राप्त एस. *मोरीरना* (वाईट) मिल्लन का अभिलेख सर्वाधिक प्राचीन है तथा भारत से बाहर एस. *गौरैन्सिस* सुरंगे व लेले की पहचान पहली बार की गई है। पृथक अंकुर के विस्तृत प्रकार इस समुच्चय में अनावृतबीजी के विविध रुपण दर्शाते हैं, अनुमानतः पराना द्रोणी में निम्न गोंडवाना हिमनदन की अंतिम अंतर हिमानी घटना से संबद्ध है। अंकुरों पर आधारित जैवस्तरिक सहसंबंध समुच्चय की आभासी स्थानिक प्रकृति के कारण संभव नहीं है तथा इस क्षेत्र में आगे कार्य करने की आवश्यकता है।

संकेत-शब्द—चिपिटबीजी अंकुर, पराना द्रोणी, प्रारंभिक पर्मियन, निम्न गोंडवाना।

INTRODUCTION

SINCE the beginning of the paleobotanical researches, the study of seeds was relegated to a secondary level of importance. However, they assume importance considering their potentiality in phytostratigraphical and possibly in evolutionary studies. The study of Gondwana platyspermic seeds gained momentum when Maithy (1965) proposed a scheme for their identification and classified them in groups. This scheme was later revised by Millan (1974a, 1994).

In the Paraná Basin, besides Millan (1965, 1969, 1974a, b, 1977, 1980, 1981, 1990, 1991, 1994, 1995), studies on Gondwana seeds have also been carried out by Bernardes-de-Oliveira & Pontes (1976), Bernardes-de-Oliveira (1977), Bernardes-de-Oliveira *et al.* (1978), Ricardi-Branco (1997) and Mune (2005).

The platyspermic seeds of the "Toca do Índio Taphoflora" are included here under the genera *Samaropsis* and *Cordaicarpus* and not under *Cornucarpus* as proposed by Millan (1977). The seed assemblage integrates the Transitional Taphoflora (A-B) of Rösler (1978), also designated as *Gangamopteris–Rubidgea-Stephanophyllites* association by Bernardes-de-Oliveira *et al.* (2005). This taphoflora, which is Early Permian in age, registers the arrival of the early Glossopteris flora (*Rubidgea*, *Gangamopteris* and allied taxa) in the Paraná Basin. It is probably correlated with the "Lubeckense A" Floristic Stage of Argentina, also known as *Gangamopteris* zone lower subunit (Archangelsky & Cúneo, 1991) because of common features like the first *Glossopteris* records, presence of equisetales and sphenophyllales. Besides, both the Brazilian and Argentinean floras mark the extintion of *Botrychiopsis plantiana*.

The seed assemblage of "Toca do Índio Taphoflora" is rich and diversified. In the present study, taxonomic revision of the species of the dispersed platyspermic seeds identified by Millan (1977, 1990, 1991, 1995) from the upper most level of the Itararé Subgroup, Cerquilho Municipality, São Paulo State, Brazil has been carried out. This is the first systematic study of dispersed Lower Gondwana seeds from the area. It comprises a new species of the genus *Cordaicarpus viz. C. brasilianus* sp. nov. and eight species of *Samaropsis* viz. *Samaropsis dolianitii, S. rigbyi, S. tietensis, S. cerquilhensis* comb. nov., *S. moreirana, S. goraiensis* and two new species viz. *S. rohnii* sp. nov. and *S. rugata* sp. nov. An updated classification scheme of seeds is also presented (Fig. 8).

MATERIAL AND METHOD

The material comprises about 115 specimens of platyspermic seeds which are preserved mainly in

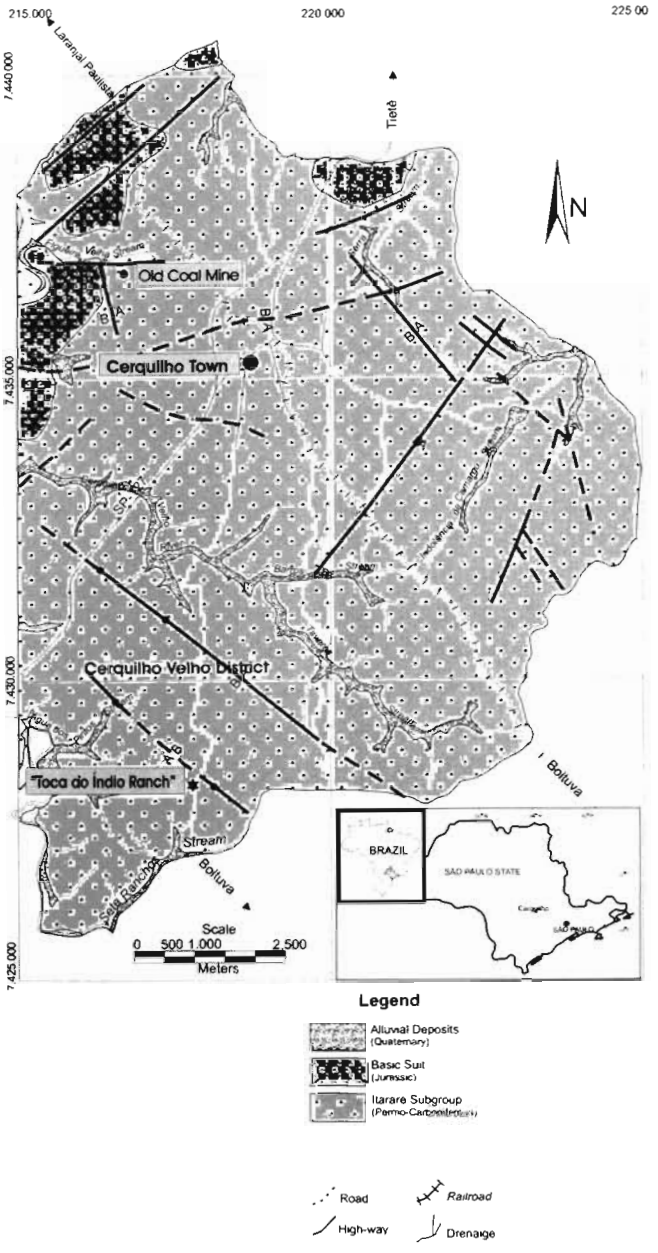


Fig. 1—Geological map of the Cerquilho region showing fossiliferous locality (modified from Santos *et al.* 1996).

siltstone collected from outcrops of the upper levels of Itararé Subgroup, in the "Toca do Índio Ranch", Cerquilho Velho District, Municipality of Cerquilho (SP) (Fig. 1). Majority of the seeds is preserved as impressions and is found dispersed in different beds of the outcrop. The seeds occur characteristically in three fossiliferous levels (Millan & Dolianiti, 1977) viz. the lower level where they are associated with *Gangamopteris*, the middle level where they are preferentially associated with cordaitalean and gangamopterid leaves and the upper level where they are associated with the predominant *Paracalamites*.

The studied material is kept in the scientific collection of the Geosciênces Institute of the University of São Paulo, under the numbers following the systematic descriptions. Besides, the material studied by Millan (1977, 1995) from the same taphoflora (deposited in the National Museum of the Federal University of Rio de Janeiro) was also examined.

The material was studied under the stereomicroscope and drawings were made with the help of camera lucida. The photographic documentation was made with Canon Camera EOS 300 with macro-lens and also with C. Zeiss Photo Stereomicroscope model Stemi SV6 and MC80 of the Paleobotany and Palynology Laboratory of IGc/USP. The specimens were compared with those described by earlier workers, using the classification scheme of Maithy (1965) and Millan (1974b, 1994).

LOCALITY

The samples were collected from the Itararé Subgroup outcrop located on the left margin of a Sorocaba river affluent brook, in the "Toca do Indio

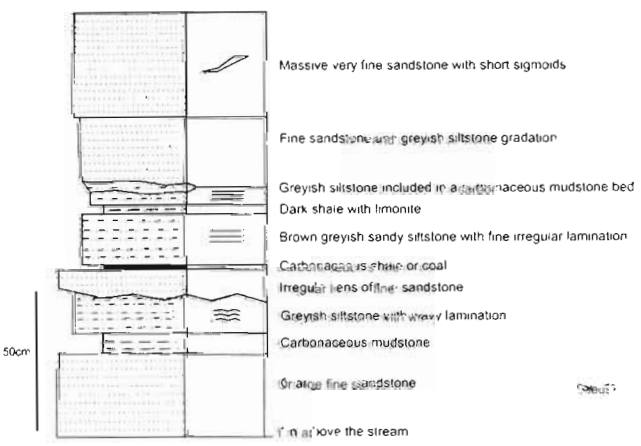


Fig. 2—Litholog of the "Toca do Índio Ranch" (Rohn & Lages, 2000).

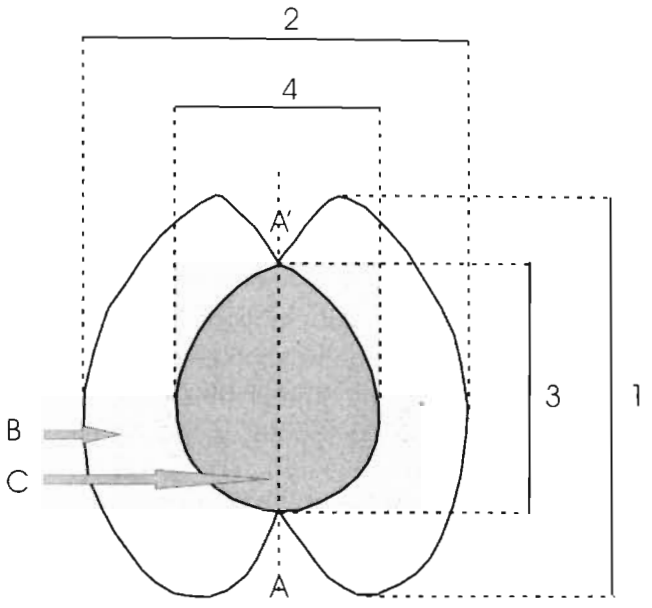


Fig. 3—Schematic diagram of a typical seed (modified after Leguizamón, 1971).

Legend:
1. Total length of the seed
2. Maximum width of the seed
3. Length of Nucule + Sclerotesta
4. maximum width of Nucule+Sclerotesta
A. Proximal extremity or base
A'. Distal extremity or apex
A-A'. Verticle middle axis
B. Sarcotesta
C. Nucule + Sclerotesta = Nucellus

Ranch", 9 km SW from the Cerquilho town, SP (latitude 23°13'52" S and longitude 47°25'24" W) (Fig.1).

The outcrop is 6 meters high and consists of light greyish siltstones, carbonaceous mudstone and carbonaceous shale. They are intercalated with lens and sigmoid bodies of fine grained light yellowish sandstones. The fossils are found in several levels of mudstones and siltstones and even in sandstones but occur more frequently above the carbonaceous mudstone (Bernardes-de-Oliveira, 2003; Fig. 2). This occurrence is associated with coal measures. It was discovered by Dolianiti and Millan (1973) and studied later by several workers (Millan, 1977, 1989a, 1991, 1995; Millan & Dolianiti, 1977, 1979, 1980a, b, 1981, 1982; Iannuzzi & Rohn, 1995; Rohn & Lages, 2000; Ricardi-Branco & Bernardes-de-Oliveira, 2000).

GEOLOGY OF ITARARE SUBGROUP

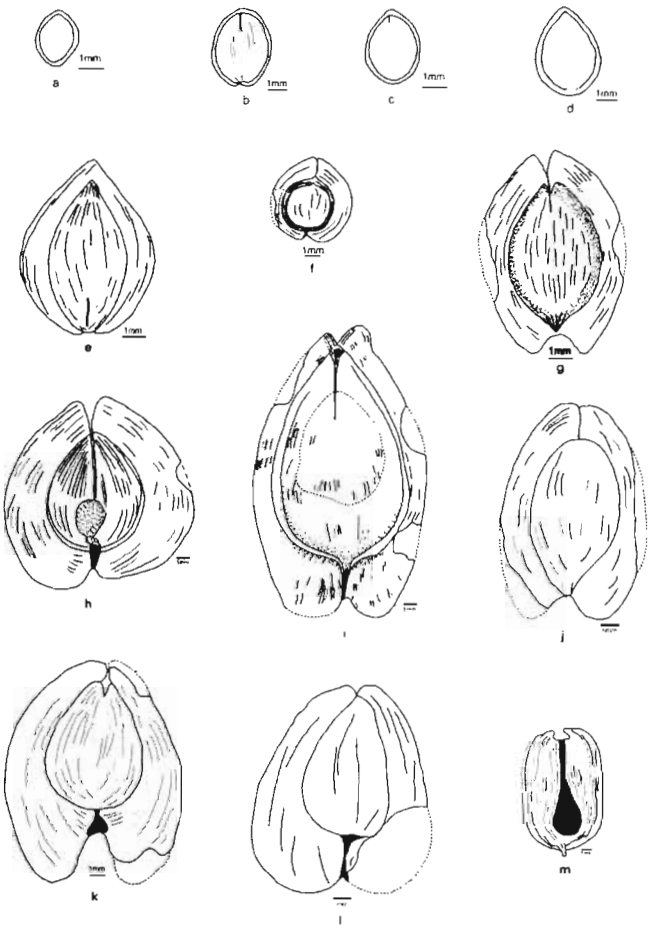
The Paraná Basin is a huge Paleozoic-Mesozoic intracratonic sedimentary basin, with a surface of nearly 1,600,000 square km, situated in the central-eastern portion of South America. It spreads from southern Brazil through Paraguai, Uruguai to northeastern Argentina, having connections in its south portion with the Chaco-Paraná Basin. It might have been interconnected with the South African Karroo Basin in the geological past. Its Brazilian area is about 1,000,000 square km.

Lithostratigraphy of the basin is presented by Milani *et al.* (1998). They classified it into six supersequences- Rio Ivaí (Ordovician-Silurian), Paraná (Devonian), Gondwana I (Upper Carboniferous-Lower Triassic), Gondwana II (Middle-Upper Triassic), Gondwana III (Upper Jurassic-Lower Cretaceous) and Bauru (Upper Cretaceous). The first three sequences are related to Palaeozoic big transgressive cycles. During the deposition of the Gondwana I Supersequence the Paraná Basin assumed the effective isolation in the continental interior.

Several progradations and retractions of the ice gave a complex association of facies to the Itararé Subgroup. They are diamictites and striated pavements (ice action indicators) at different stratigraphic levels, intercalated with big sandstone bodies and rhythmites with dropped clasts and shales deposited under fluvial, deltaic, costal marine or open sea environments under direct or indirect action of ice or even in interglacial phases. The depositional environment of the Cerquilho coal measures is interpreted as progradation shoreline and sometimes as fluvial in interglacial scenery of the final phase of sedimentary history of the Itararé Subgroup (Martini & Rocha-Campos, 1991; Santos *et al.*, 1996).

SYSTEMATICS

The Palaeozoic gymnospermous seeds were grouped under Radiospermae and Platyspermae, on the basis of their radial and bilateral symmetries, respectively (Brongniart, 1874). The platyspermic



seeds of Gondwana, according to original scheme of Maithy (1965), were attributed to the genera *Samaropsis, Cordaicarpus, Cornucarpus* and *Nummulospermum*, while the radiospermic seeds to the genus *Stereocarpus* (Surange, 1974 considered this genus as scale leaf) and *Rotundocarpus*.

Maithy (1965) established his classification scheme using the morphological characters of seeds. Schematic diagram of a typical seed with terminology used in description is provided in Fig. 3. In the present study, identification and classification of Gondwana seeds follow Maithy's (1965) scheme which was updated by Millan (1994).

Genus—CORDAICARPUS Geinitz, 1862

Type-species—*Cordaicarpus cordai* Geinitz, 1862

Cordaicarpus brasilianus sp. nov.

(Pl. 1.1, 2; Fig. 4a-d)

Diagnosis—Small platyspermic seeds, shape oval to elliptical, apex acute to acuminate, base rounded to

Fig. 4—(a) *Cordaicarpus brasilianus* sp. nov.— Specimen showing continuous, narrow sarcotesta, micropylar line and rounded base. SCGIUSP Specimen No. GP/3T 2358aB. (b) *C. brasilianus* sp. nov. — Specimen showing narrow sarcotesta, micropylar line and chordate base. SCGIUSP Specimen No. GP/3T 2357E. (c) *C. brasilianus* sp. nov. — Specimen showing narrow sarcotesta, micropylar line and rounded base. SCGIUSP Specimen No. GP/3T 2355E. (d) *C. brasilianus* sp. nov. — Specimen showing narrow sarcotesta and rounded base. SCGIUSP Specimen No. GP/3T 2356aA. (e) *Samaropsis dolianitii* Millan (1977)— Specimen without a sinus, with acute apex and wide truncate base. SCGIUSP Specimen No. GP/3T 2400. (f) *Samaropsis moreirana* (White) Millan (1977) —Seed small, almost rounded, showing wider sarcotesta at the apex, subcircular, acuminate nucellus and a well defined sclerotesta. SCGIUSP Specimen No.GP/3T 2359A. (g) *Samaropsis goraiensis* Surange & Lele (1956) —Specimen showing sinus and nucellus with acute extremeties. SCGIUSP Specimen No. GP/3T 2364C. (h) *Samaropsis rigbyi* Millan (1977) — Specimen showing a wide sarcotesta, oval nucellus with fine striations converging in the apical area and an embryo (?) in the basal region. SCGIUSP Specimen No. GP/3T 2360A. (i) *Samaropsis cerquilhensis* (Millan) comb. nov. — Specimen showing an ovate nucellus and a wide sarcotesta which tapers towards the apex and is detached in the basal region. Since the sarcotesta is not preserved in the apical region, apex apparently shows feature similar to two horns. SCGIUSP Specimen No.GP/3T 2386. (j) *Samaropsis rohnii* sp. nov. Specimen showing an elongated and striated nucellus with a rounded apex, acute base and a sarcotesta with sinus on both extremities. SCGIUSP Specimen No.GP/3T 2396B. Holotype. (k) *Samaropsis rugata* sp. nov. Specimen showing an ovate nucellus and a very wide sarcotesta in the basal area. The sarcotesta is roughly striated. SCGIUSP Specimen No. GP/3T 2364B. Holotype. (l) *S. rugata* sp. nov. Specimen showing an ovate nucellus and a very wide, roughly striated sarcotesta in the basal area. SCGIUSP Specimen No. GP/3T 2383B. (m) *Samaropsis tietensis* Millan (1977) —Seed platyspermic, showing oblong outline, sarcotesta, apical sinus, subparallel sides and an obtuse base. Nucellus lageniform with long and narrow apical region. SCGIUSP Specimen No. DGP-MN 1346 Pb. Holotype.

chordate; surface smooth to finely striated without median ridge, indistinct micropylar line; narrow and uniform sarcotesta, ratio of maximum width of sarcotesta to maximum width of nucellus 1:8 to 1:13.

Derivation of name—After Brazil, place of origin.

Holotype— Scientific Collection of Geosciences Institute, University of São Paulo. Specimen No. GP/3T 2353B. (Pl. 1.1)

Syntypes—GP/3T – 2354E, 2355E, 2356aA, 2357E, 2358aB and 2398a, b.

Age —Itararé Subgroup (upper portion), Lower Permian.

Locality— "Toca do Índio Ranch", Cerquilho, SP, Paraná Basin.

Floristic association—Gangamopteris–Rubidgea–Stephanophyllites association or Transitional Taphoflora.

Description—Very small platyspermic seeds, measuring 3.5 to 4 mm in length and 2.5 to 3 mm in width, oval to elliptic in shape with acute to acuminate apex and rounded base; surface without well-marked median ridge, striated, striations smooth to finely striated, divergent, narrow sarcotesta more or less uniformly wide, measuring 0.2 to 0.3 mm in width, sometimes apparently small sinus present at insertion point of funicle.

Comparison— *Cordaicarpus brasilianus* is comparable with a group of similar seeds *viz. C. chichariensis* Lele, *C. prolatus* Walkom, *C. mucronatus* Høeg & Bose, *C. irapuensis* Bernardes-de-Oliveira and *C. acuminatus* Gutierrez, Ganuza, Morel & Arrondo. However, *C. chichariensis* differs in having circular shape and *C. prolatus* differs in having pointed base. *C. mucronatus* is larger in size with an acute apex and wider sarcotesta. *C. irapuensis* is also bigger in size and has uniformly narrow sarcotesta. *C. acuminatus,* too, differs by being larger in size, more erohniited shape and less rounded base without a conical projection. Detail comparison is presented in Fig. 5.

Stratigraphic and geographic distribution—This form till date is recorded from the upper position of the Itararé Subgroup (Asselian- Sakmarian), "Toca do Índio Ranch", Cerquilho Municipality, SP.

Genus—SAMAROPSIS Göeppert, 1864

Type-species —*Samaropsis ulmiformis* Goëppert, 1864

Samaropsis dolianitii Millan, 1977

(Pl. 1.3; Fig. 4e)

Description—Platyspermic seeds of oval shape in vertical position, small, 3.5-4.5 mm in length and 2.5-3 mm in width; seed widest in the median region, without sinus; apex acute, base wide, truncate; apex of nucellus rounded to obtuse or acute, base truncate; surface striated.

PLATE 1
(Scale bar = 1mm)

1. *Cordaicarpus brasilianus* sp.nov. — Morphology of the seed. SCGIUSP Specimen No. GP/3T 2353B. Holotype.
2. *C. brasilianus* sp.nov. — Details of micropyle. SCGIUSP Specimen No. GP/3T 2356aA.
3. *Samaropsis dolianitii* Millan . SCGIUSP Specimen No. GP/3T 2357C.
4. *Samaropsis goraiensis* Surange & Lele— Morphology of the seed. SCGIUSP Specimen No. GP/3T 2363aA.
5. *S. goraiensis* Surange & Lele — Morphology of the seed. SCGIUSP Specimen No. 2369B.
6. *S. goraiensis* Surange & Lele — Details of apex and micropyle. SCGIUSP Specimen No.GP/3T 2369B.
7. *S. goraiensis* Surange & Lele — Details of the base. SCGIUSP Specimen No.GP/3T 2363aA.
8. *Samaropsis rigbyi* Millan — Morphology of the seed. SCGIUSP Specimen No. GP/3T 2360A
9. *S. rigbyi* Millan — Morphology of the seed. SCGIUSP Specimen No. 2384.
10. *Samaropsis moreirana* (White) Millan — Morphology of the seed. SCGIUSP Specimen No. GP/3T 2359A.

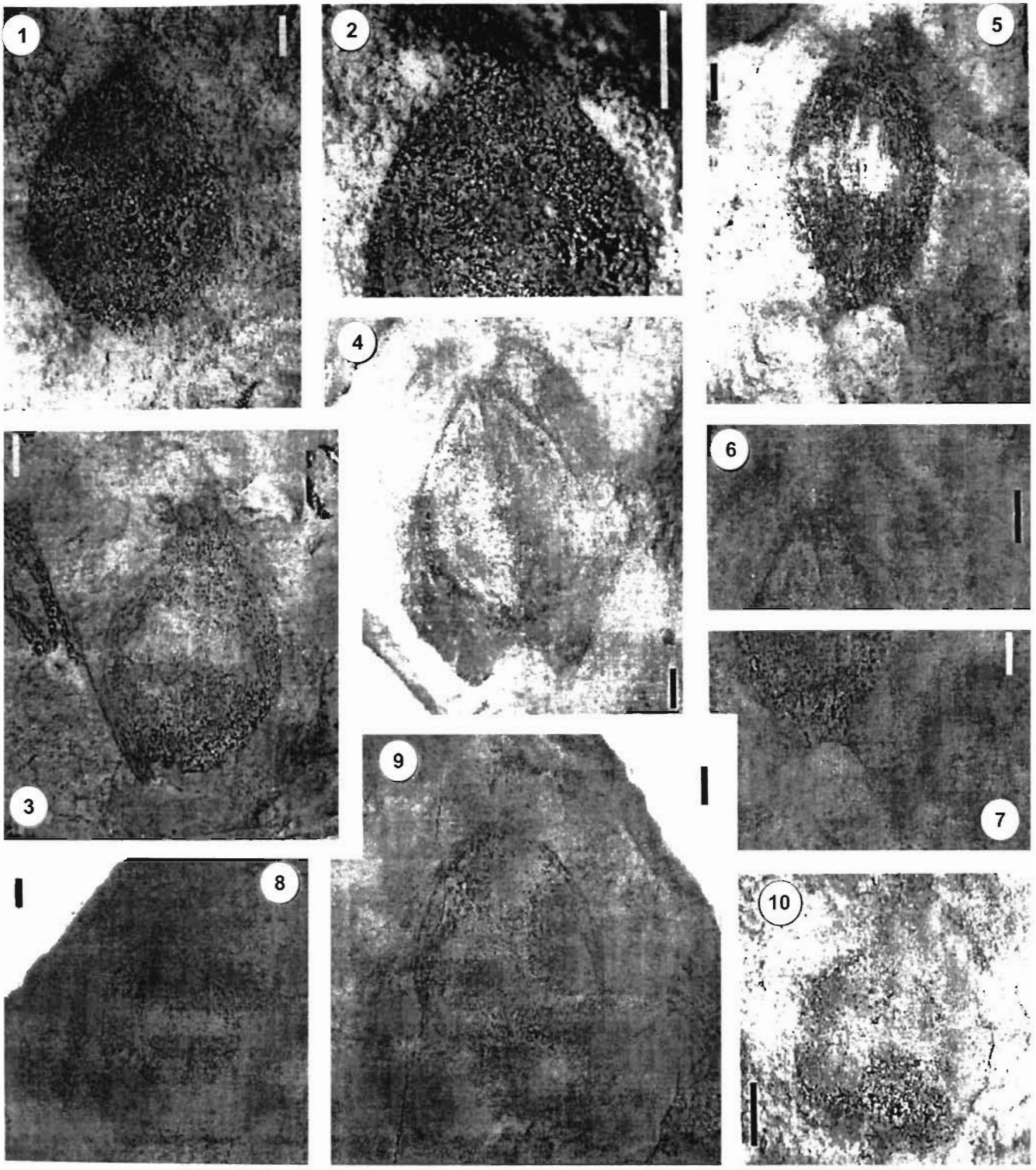


PLATE 1

Comparison—The specimens described here morphologically resemble the specimens described by Millan (1977).

Remarks—This species is not so frequent in the material of the IGc/USP Scientific Collection as in the material studied by Millan 1977 of the National Museum Collection.

Stratigraphic and geographic distribution—This form is restricted to the upper Itararé Subgroup (Asselian- Sakmarian), "Toca do Índio Ranch", Cerquilho Municipality, SP.

Samaropsis moreirana (White) Millan, 1967

(Pl. 1.10; Fig. 4f)

Description—Small platyspermic seeds, almost rounded, slightly apiculate with wide chalaza, finely striated, nucellus oval-rounded, measuring 5 mm in length and 4.7 mm in width; sclerotesta well defined, 0.37 mm in width in apical region and 0.13 mm in width at base; sarcotesta narrow, 0.63 mm wide in proximal area, 1.13 mm wide (maximum width) in apical area, apex slightly emarginate; nucellus subcircular, acuminate, measuring 2.75 mm in length and 2.63 mm in maximum width, ratio of maximum width of sarcotesta to maximum width of nucellus 1: 2.35.

Comparison—The two specimens studied here agree in shape and size with the descriptions made by White (1908, pl. 10.10) of specimens from the Barro Branco Coal, in Lauro Muller, SC (upper part of Siderópolis Member, Rio Bonito Formation, Artinskian).

Remarks—White (1908) circumscribed these seeds as *Cardiocarpon moreiranum*. Dolianiti (1952) made an informal new combination *Samaropsis moreiranum* White and later Millan (1967) formally made a new combination as *Samaropsis moreirana* (White) Millan 1967. Considering the ratio of maximum width of sarcotesta and maximum width of the nucellus which is 1:2.35, this form actually belongs to the genus *Samaropsis*.

Stratigraphical and geological distribution—The species extends in stratigraphical distribution from the upper portion of the Itararé Subgroup ("Toca do Índio Ranch") Cerquilho Municipality (SP) to the upper portion of the Rio Bonito Formation (Siderópolis Member, Lauro Miller, SC).

Samaropsis goraiensis Surange & Lele, 1956

(Pl. 1.4-7, Fig. 4g)

Description—Seeds platyspermic, elliptical in shape, small, 8.0 x 6.0 mm; sarcotesta with sinus on both extremities, 1.5 mm wide, slightly wider toward chordate base; nucellus acute on both extremities, micropyle marked at apex; surface finely striated; one specimen (GP/3T 2361E) along with three others found

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PLATE 2 ⟶

(Scale bar = 1mm unless otherwise stated)

1. *Samaropsis rohnii* sp. nov. — Morphology of the seed. SCGIUSP Specimen No.GP/3T2396B. Holotype.
2. *S. rohnii* sp. nov. — Details of the base. Scale bar = 10mm
3. *Samaropsis cerquilhensis* (Millan) nov. comb. — Morphology of the seed. SCGIUSP Specimen No. GP/3T 2390a.
4. *S. cerquilhensis* (Millan) comb.nov.— Morphology of the seed. SCGIUSP Specimen No. 2390b.
5. *S. cerquilhensis* (Millan) comb. nov. — Oval nucellus with acute apex and rounded base. SCGIUSP Specimen No. GP/3T 2386.
6. *S. cerquilhensis* (Millan) comb. nov. — Details of the apical portion of the sarcotesta. Distinct sinus in the apical area apparently forming two small horns. SCGIUSP Specimen No. GP/3T 2386.
7. *Samaropsis rugata* sp. nov. — Details of the acute apex. SCGIUSP Specimen No. GP/3T 2364B. Holotype.
8. *S. rugata* sp. nov. — Morphology of the seed. SCGIUSP Specimen No. GP/3T 2383B.
9. *S. rugata* sp. nov. —Morphology of the seed. SCGIUSP Specimen No. GP/3T 2364B. Holotype.

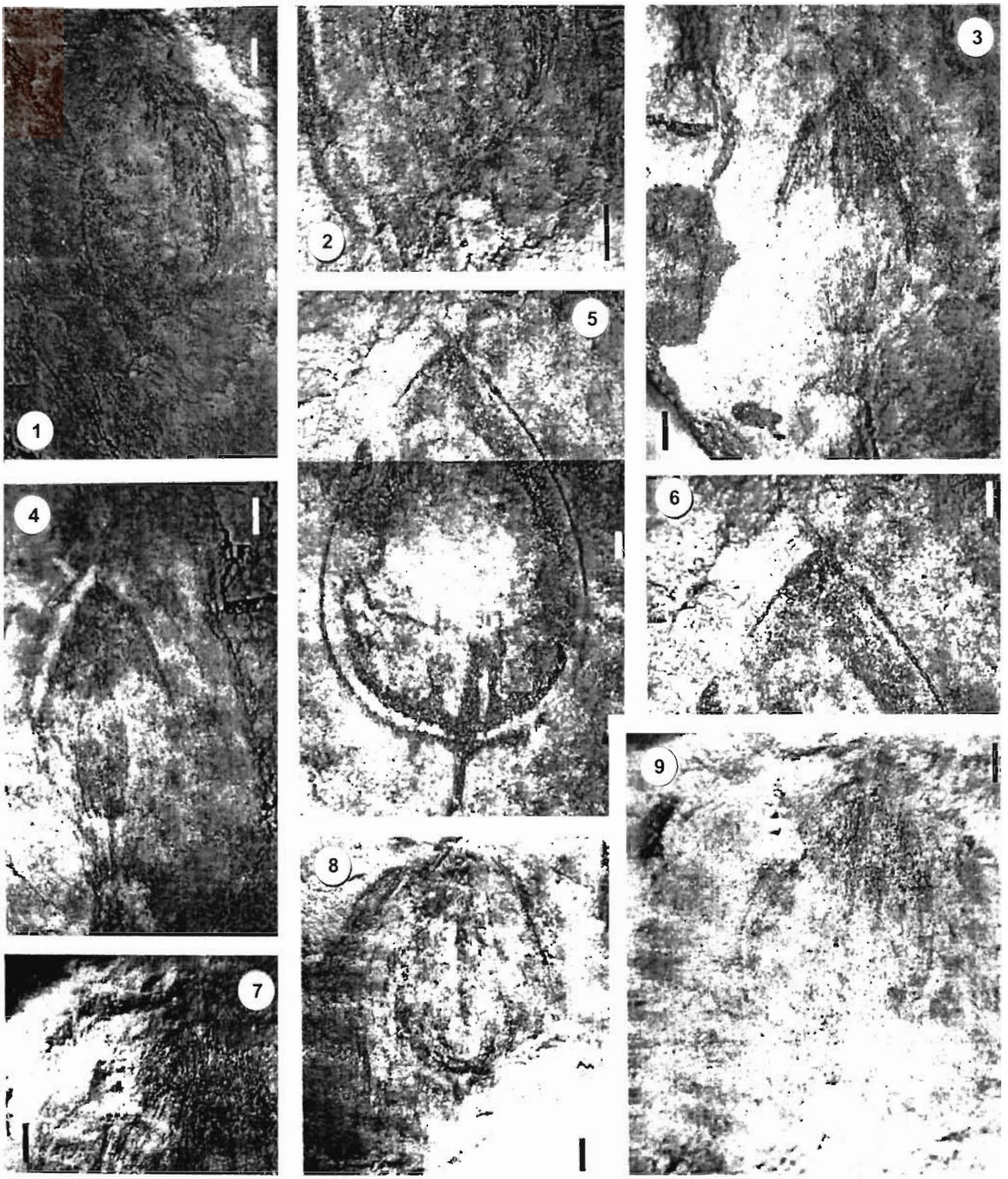

PLATE 2

Characteristics / Species	Shape	Sarcotesta	Size	Apex	Base	Sinus	Median Ridge	Micro-pyle	Striation	Age
C. mucronatus Høeg & Bose 1960	Oval	Very Narrow	10-20mm long x 7mm wide	Pointed	Rounded	Apical sinus absent	Absent	?	Present	Lower Permian
C. prolatus Walkom 1935	Oval	Narrow (1mm)	9mm long x 5mm wide	Pointed	Broad	Absent	Vascular bundle on the base	Short	Absent	Lower Permian
C. chichariensis Lele 1962	Circular	Short conical beak at the apex (2mm wide)	17mm long x 15mm wide	Acuminate	Rounded	Apical sinus absent	Absent	?	?	Triassic
C. irapuensis Bernardes-de-Oliveira & Pontes 1976	Oval	Narrower at the apex and base than at the laterals	5.7 – 8.8mm long x 5 – 7mm wide	Acuminate	Chordate	Apical sinus absent	Absent	Not well marked	Without or few striations	Lower Permian
C. acuminatus Gutierrez et al. 1992	Oval to suboval	Wider at the apex and the base than at the laterals (1-1.5mm)	12mm long x 7.5mm wide	Acuminate	Without Conical projection	Basal and apical sinus present	Absent	?	Fine striations present	Upper Carboniferous to Lower Permian
C. brasilianus sp. nov.	Ovate to elliptic	Uniform, narrow (0.2 – 0.3mm), ratio of maximum width of sarcotesta and nucellus is 1:8 to 1:13	3.5 – 4mm long x 2.5 – 3mm wide	Acute to Acuminate	Rounded to chordate without central vascular bundle	Sometimes short sinus at the insertions of funicle	Absent	In-distinct	Divergent striation, smooth to finely striated surface	Lower Permian

in a fructification like structure apparently attached to leaf similar to *Rubidgea* and though ill preserved resembles *Denkania.*

Comparison—The specimens are quite similar to *S. goraiensis* Surange & Lele (1956, pl. 1. 3, 4, 14; text-fig. 3) in all morphographic diagnostic characters *viz.* size, shape (pear-shaped) with pointed ends and nature of sarcotesta (about 1.5 mm wide), which narrows towards the apex with a fine micropyle and gradually widens towards the chordate base. Detail comparison with other species is presented in Fig. 6.

Stratigraphical and geographical distribution—Talchir Formation, Goraia Coalfield, Madhya Pradesh and Karharbari Formation, Giridih Coalfield, Bihar, India (Lower Permian); and upper portion of the Itararé Subgroup, Paraná Basin (Asselian-Sakmarian), "Toca do Índio Ranch", Cerquilho Municipality, SP.

Samaropsis rigbyi Millan, 1977

(Pl. 1.8, 9; Fig. 4h)

Description—Seeds platyspermic, oval in shape in vertical position, 10-14 mm in length and 8.0 to 14 mm in width, widest at median region with apical and basal sinuses; sarcotesta forms two wide wings measuring 2.75 mm in width in apical and middle regions and 3.75 mm in basal region; nucellus oval in shape with acute apex, 9 mm in length and 6.5 mm in width, ratio of maximum width of sarcotesta to maximum width of nucellus 1:1.8; surface of nucellus striated, striations converge in apical area; sometimes, in basal region, an oval embryo like structure with rounded apex projecting toward chalaza and sinus in basal region present, micropylar line visible from apex to base .

Comparison—Samaropsis rigbyi Millan 1977 is very similar to *S. goraiensis* Surange & Lele (1956) but differs in having wider sarcotesta, circular shape and oval nucellus bearing an embryo like structure.

Fig. 5—Table showing comparison of *Cordaicarpus brasilianus* sp. nov. with other related species.

Stratigraphical and geographical distribution—Restricted to the upper portion of the Itararé Subgroup, Paraná Basin (Lower Permian), "Toca do Índio Ranch", Cerquilho Municipality (SP).

Samaropsis cerquilhensis (Millan) comb. nov.

(Pl. 2.3-6; Fig. 4i)

Basionym —1977 *Cornucarpus cerquilhensis* Millan; *Anais Acad. brasil. Ciênc.* 49 (4): 583-587, pl. 1.1-7; pl. 2.1; pl. 3.1.

Description—Seeds oval in shape, 17-24 mm in length and 10-15 mm in maximum width, widest in median-basal region; sarcotesta widest in basal region, forms lobate, wings with small well developed sinus in basal area, tapers towards median portion and follows same width up to apex, 5.4 mm wide in basal region,1.4 mm wide in median region, apex emarginate, margins distinct in apical area, ratio of maximum width of sarcotesta to maximum width of nucellus 1:2; nucellus oval with acute apex and rounded base, protruded as small cone in the basal sinus towards the funicle, micropyle present in apical portion of nucellus.

Remarks—Observing specimens of "Toca do Índio Ranch" taphoflora in which the sarcotesta was not preserved, Millan (1977) considered this form as *Cornucarpus*. According to him, the apex was bifurcated into two structures similar to horns. However, re-examination of these specimens and study of other well preserved specimens (GP/3T 2386, Pl. 2.5, 6, Fig. 4i), help in detecting sarcotesta, which is apparently detached from the basal portion. The sarcotesta is a little reinforced in the apical sinus area giving appearance of two small horns, when detached. Hence, a new combination is proposed here. Some smaller specimens (GP/3T 2390a, b, Pl. 2.3, 4) have the same kind of sarcotesta and nucellus of same shape. This type of seed probably lost its sarcotesta while attaining a larger size e.g. *Samaropsis leslii* Seward 1917 of Lower Permian of South Africa and *Samaropsis milleri* (Feistmantel) Seward 1917 of Karharbari Formation (Lower Permian) of India.

Stratigraphical and geographical distribution—Till date this form is restricted to the upper portion of the Itararé Subgroup (Lower Permian), "Toca do Índio Ranch", Cerquilho Municipality (SP).

Samaropsis rohnii sp. nov.

(Pl. 2.1, 2; Fig. 4j)

Diagnosis— Platyspermic seeds, elliptical-elongate, apex rounded, retuse, base wide chordate, measure 12.5 mm in length and 8 mm in maximum width; sarcotesta uniformly wide in lateral and distal regions of seed, widening in proximal region where 2.8 mm wide, ratio of maximum width of sarcotesta and maximum width of nucellus 1:1.8; nucellus obovate with rounded apex and acuminate base which ends in acute cone, measures 8.75 mm in maximum length and 5 mm in maximum width, basal cone protrudes intersecting sarcotesta.

Derivation of name— After Rosemarie Rohn, an eminent Brazilian researcher of Paraná Basin.

Holotype— Scientific Collection of Geosciências Institute, University of São Paulo, Specimen No. GP/3T 2396B (Pl. 2.1, 2, Fig. 4j).

Age— Lower Permian (Asselian-Sakmarian).

Locality— "Toca do Índio Ranch", Cerquilho Municipality (SP).

Stratotype— Itararé Subgroup (upper portion), Lower Permian, Paraná Basin.

Floristic association— *Gangamopteris–Rubidgea–Stephanophyllites* association or Transitional Taphoflora.

Description— Elliptical, erohniite platyspermic seed, apex rounded, slightly retuse, base wide, chordate; sarcotesta more or less uniformly wide in distal and lateral regions of seed, slightly wider in proximal region, in apical region wings of sarcotesta closed forming a little emarginate sinus, in basal region sarcotesta wings form an open sinus; micropyle not marked; nucellus obovate, with rounded apex and acuminate base, tapering in form of acute cone intercepting sarcotesta, sarcotesta and nucellus finely striated.

Comparison— This form is represented by only one specimen. It is distinguished from other similar forms (Maithy, 1965, Millan, 1994 and other specimens

Characteristics / Species	Shape	Size	Sarcotesta	Nucellus Shape	M.W.S. x M.W.N.	Apex	Base	Sinus	Median rigde	Micropyle line	Striation	Age
S.tuerdae Gutierrez *et. al.*, 1992	Circular to sub-circular	10 - 11 mm long x 10.5 – 12 mm wide	Wide . 2-2. 5 mm at base and apex	Circular nucellus with emarginate apex and pointed base	1:4	Emar-ginate	Wide chordate	Present on both extre-mities	Well marked	Bifid or In "v" form at apex	Rough wrinkled sarcotesta	Upper Carboniferous
S. goraiensis Surange & Lele, 1956	Elliptical	8 mm long x 6 mm wide	Slightly wider at base 1.5 mm	Elliptical with both the ends pointed	1 2 5	Retuse	Wide chordate	Present on both extre-mities	Absent	Marked at Apex	Fine (?)	Lower Permian
S. kurtzii Leguizamón, 1971	Sub-circular	16.5 mm long x 14.5 mm wide	Large, wider at base, 3 mm	Subcircular pyriform with two well developed horns at apex and with conical basal projection	1:4.7	Emar-ginate	Wide chordate	Present on both extre-mities	Absent	In "v" form at apex	Fine on sarcotesta	Lower Permian
S. moravica (Helmh) Walkom, 1928	Unkown	8 mm long x 8 mm wide (?)	Wide extent	Pyriform nucellus with pointed ends	1 2	Rounded	Rounded	Present on both extre-mities	Absent	—	Fine on nucellus	Lower Permian
S. nuñezii Garcia, 1990	Oval	10-15 mm long x 9-11 mm wide	Wide at apex and lateral areas. 1 5 – 2 mm	Oval nucellus, acute apex with two projections, acuminate base	—	Acute – emar-ginate	Chordate	Present on both extre-mities	Well marked	Bifid or in "v" form at apex	Fine on sarcotesta (?)	Upper Carboniferous - Lower Permian
S. ovalis Walkom, 1935	Oval to circular	10 mm long x 7 mm wide	Wide wings 1.75 mm	Almost circular to ovate	1:2	Shallow-ly emar-ginate	Wide chodate	Present on both extre-mities	Absent	In "v" form at apex	—	Lower Permian
S. rigbyi Millan, 1977	Oval to sub-circular	10-14 mm long x 8-14 mm wide	Wide wings (2.75 mm) Wider near basal area 3 75 mm	Oval in shape with acute apex	1:1 8	Roundly lobed	Chordate with conic- al projectio n	Present on both extre-mities	Absent	Marked from apex to embryo (?)	Fine on sarcotesta and nucellus	Lower Permian
S. cerquilhensis (Millan) comb nov	Elliptical-elongate	17-24 mm long x 10-15 mm wide	Very wide near basal area. 5 4 mm	Oval with acute apex and rounded base with conical projection	1:2	Acute, emar-ginate reinforce d on micro-pyle area	Close chordate to lobate	Present on both extre-mities	Absent	Crossing nucellus in apical portion	Fine on sarcotesta and nucellus	Lower Permian
S. rugata sp.nov	Rounded triangular to oval	3.8-11 mm long x 9 8-10.5 mm wide	Very wide in basal region, 3 75 -5 mm	Triangular to oval nucellus	1.1.5	Acute, emar-ginate	Close – chordate	Chordate apex and base	Absent	Sometimes slightly open	Rough wrinkled sarcotesta	Lower Permian
S. rohnii sp nov	Elliptical-elongate	12.5 mm long x 8 mm wide	Slightly wider in basal region, 2.8 mm	Oboval shape, rounded apex, acuminate base with cone like projection	1:1 8	Retuse	Wide chordate	Closed at apex and open at base	Absent	Not marked	Fine on sarcotesta and nucellus	Lower Permian

Fig. 6—Comparative morphology of various species of *Samaropsis* with sinus on both the extremities
M.W.S. = Maximum Width Sarcotesta. M.W.N. = Maximum Width Nucellus.

studied here) in various morphological characters. From *Samaropsis cuerdae* (Gutierrez *et al.* 1992) it differs by its elliptical-elongate shape, emarginate base, retuse apex, width of sarcotesta, which is more or less uniformly wide from the apex to the median portion and wider in the basal region. It also differs by the elliptical to obovate nucellus which has an acuminate apex and is without a median crest. However, both the taxa are similar in having acuminate base ending in an acute cone that intercepts the sarcotesta. From *S. goraiensis* (Surange & Lele, 1956) it is distinct by larger size, obovate shape, acute base, absence of a distinct micropyle and nature and width of sarcotesta. Both the seeds, however, have a similar base which is more or less chordate. From *S. nuñeezii* Garcia, this form is distinct by its rounded acuminate, retuse apex, nucellus with an acuminate projection at the base and a well developed sarcotesta. From *S. kurtzii* (Leguizamón 1971) it distinguishes by the elliptical-elongate shape but is similar in having expanded sarcotesta in the proximal sector. From *S. rigbyi* (Millan, 1977), it distinguishes by more elongate shape of the nucellus with rounded apex and acute conical base and by wider sarcotesta on the extremities than on the laterals. *S. moravica* (Helmhacher) Walkom 1928 is distinct from this new species by its smaller size, huge wing-like borders and nucellus with both edges acute.. This specimen is distinct from *S. ovalis* (Walkom, 1935) by its more elongate vertical shape, more elongate and bigger nucellus with acute base, and by the absence of shallow emarginate apex.

Stratigraphical and geographical Distribution—Till date, *Samaropsis rohnii* sp. nov. is restricted to the upper portion of the Itararé Subgroup (Lower Permian) "Toca do Índio Ranch", Cerquilho Municipality (SP).

Samaropsis rugata sp. nov.

(Pl. 2.7-9; Fig. 4 k,l)

Diagnosis—Seeds platyspermic, rounded triangular to oval in shape, with sinus on both extremities, apex acute, emarginate, base wide chordate, sarcotesta narrow in distal area, widening towards base; nucellus triangular, rounded to oval in shape with acute apex, rounded, truncate base and putatively preserved chalaza; sarcotesta roughly striated.

Derivation of name—The specific epithet is derived from the characteristic rough wrinkled surface of the sarcotesta.

Holotype— Scientific Collection of Geosciences Institute, University of São Paulo, Specimen No. GP/3T 2364B (Pl. 2. 7, 9; Fig. 4 k,l).

Syntypes—Specimens GP/3T 2379A, 2383B and 2397A of the Scientific collection of the IGc/USP.

Age—Lower Permian (Asselian-Sakmarian).

Locality— "Toca do Índio Ranch", Cerquilho Municipality (SP).

Stratotype—Itararé Subgroup (upper portion), Lower Permian, Paraná Basin.

Floristic association— *Gangamopteris–Rubidgea–Stephanophyllites* association or Transitional Taphoflora.

Description— Seeds platyspermic, rounded to oval, triangular in shape with sinus on both extremities and measure 3.8 to 11 mm in length and 9.8 to 10.5 mm in width. Apex acute, emarginate and base wide chordate. Sarcotesta 0.9 to 1.25 mm wide in the apical region and 3.75 to 5 mm wide in the basal region. Nucellus rounded, triangular to oval, with flat to rounded base. Maximum length of the nucellus 7.5 to 7.75 mm and maximum width 4.75 to 5.75 mm. Basal cone or chalaza present, 1.5 mm long. The ratio of maximum width of the sarcotesta to maximum width of the nucellus 1-1.5 : 1-1.27. Sarcotesta roughly striated.

Comparison— This form is very similar to *Samaropsis rigbyi* (Millan, 1977) and *S. goraiensis* (Surange & Lele, 1956) but it can be distinguished from both by its more triangular shape and wide and strongly corrugated sarcotesta in the basal area. Comparison with other species is presented in fig. 6.

Stratigraphical and geographical distribution— Till date, *Samaropsis rugata* sp. nov. is restricted to the upper portion of the Itararé Subgroup (Lower Permian), "Toca do Índio Ranch" Taphoflora, Cerquilho Municipality (SP).

	Brazil				India	
Age	Upper Carboniferous	Lower Permian			Lower Permian	
	Itararé Subgroup	Guatá Subgroup			Talchir	Karharbari
Level/Formation	Upper	Rio Bonito Fm.		Palermo Fm.	Goraia Coalfield	Giridih Coalfield
Taphofloras	Cerquilho	L. Müller	Criciúma			
Cordaicarpus brasilianus sp. nov	+		N o	N o		
Samaropsis dolianitii Millan, 1977	+		t	t		
S. moreirana (White) Millan, 1977	+	+	r e	r e		
S. goraiensis Surange & Lele, 1956	+		c o	c o	+	+
S. rigbyi Millan, 1977	+		r	r		
S. cerquilhensis (Millan) comb. nov.	+		d e	d e		
S. rohnii sp. nov.	+		d	d		
S. rugaia sp. nov.	+					
S. tietensis Millan, 1995	+					

Fig. 7—Table showing stratigraphical and geographical distribution of platyspermic seeds species from "Toca do Índio Ranch" taphoflora.

Samaropsis tietensis Millan, 1995

(Fig. 4 m)

Description—Seeds platyspermic, shape oblong in a vertical position, small, measuring 8.0 x 6.0 mm in size; sarcotesta striated, lobate sinus present at apex, margins sub-parallel, base obtuse, forms wide wings in apical and median regions, narrows down in proximal region; nucellus lageniform, striated with long, narrow apical region and rounded base; striations diverge outwards from base and converge towards apex, median furrow crosses seed from apical sinus to base of nucellus, divides it into two symmetrical halves.

Remarks—This form is represented by only one specimen in Millan's collection and is again registered here.

Stratigraphical and geographical distribution—The form is restricted to the upper portion of the Itararé Subgroup, "Toca do Índio Ranch" Taphoflora, Cerquilho Municipality, SP.

DISCUSSION

The seed assemblage of "Toca do Indio Taphoflora" is rich and diversified and includes nine taxa of which three species of the genus *Samaropsis* viz. *S. dolianitii* Millan, *S. rigbyi* Millan and *S. tietensis* Millan have already been identified by Millan (1977, 1995). A new combination *viz. S. cerquilhe*nsis (Millan) comb. nov. is proposed here for the seeds earlier named as *Cornucarpus cerquilhensis* by Millan (1977). *S. moreirana* (White) Millan till date restricted to Artinskian (Rio Bonito Formation) but now extends down in the geological time to the Asselian-Sakmarian (upper part of Itararé Subgroup). Presence of *S. goraiensis* Surange & Lele in the upper portion of the Itararé Subgroup (Early Permian) of Brazil indicates its wider geographical distribution since it was earlier reported from India (Surange & Lele, 1956; Fig. 7) from the Talchir and Karharbari formations (Early Permian; Maithy, 1965). Additionally, two new species

CATEGORY A-RADIOSPERMIC SEEDS

GROUP A.I- WITHOUT A MEDIAN RIDGE
Type A.I.1 - Without striations
Rotundocarpus ovatus Maithy, 1965
Rotundocarpus striatus Maithy, 1965

CATEGORIA B- PLATYSPERMIC SEEDS

GROUP B.I-WITH OR WITHOUT A NARROW DIFFERENTIATED TESTA
Type B.I.1-With a median ridge
SubType B.I.1.1-Without other morphological characters
Cordaicarpus barbosanus Millan, 1977
Cordaicarpus karharbarensis Maithy, 1965
SubType B.I.1.2-Apex bifurcate with horn like processes
Buriadiospermum sewardii Pant, Nautiyal & Tiwari, 1985
Maheshwariella bicornuta Pant & Nautiyal,1963
Type B.I.2-Without a median ridge
SubType B.1.2.1-Apex obtuse/ acute
Cordaicarpus emarginatus Walkom, 1935
Cordaicarpus ovatus Walkom, 1935
Cordaicarpus rocha-camposii Bernardes-de-Oliveira, 1976 (*In* Bernardes-de-Oliveira & Pontes, 1976)
Cordaicarpus zeillerii Maithy, 1965
Karharbariospermum surangei Srivastava & Chandra 1982
Stephanostoma crystallinum Pant & Nautiyal,1960
Platycardia bengalensis Pant & Nautiyal,1960
Palispermum ovalis Pant, Nautiyal & Tiwari, 1985
Birsinghpuria indica Pant, Nautiyal & Tiwari, 1985
Palaeocarpus birsinghpurensis Pant, Nautiyal & Tiwari, 1985
Shivacarpus johillensis Pant, Nautiyal & Tiwari, 1985
SubType B.I.2.2-Apex acuminate
Cordaicarpus acuminatus Gutierrez et al. 1992
Cordaicarpus chichariensis Lele, 1962
Cordaicarpus irapuensis Bernardes-de-Oliveira, 1976 (*In* Bernardes-de-Oliveira & Pontes, 1976)
Cordaicarpus mucronatus Høeg & Bose, 1960
Cordaicarpus prolatus Walkom, 1935
Cordaicarpus brasilianus sp. nov.
Collospermum ovalis Pant, Nautiyal & Tiwari, 1985
Retortistoma crystallina Pant, Nautiyal & Tiwari, 1985
Bulbospermum surangei Pant, Nautiyal & Tiwari, 1985
SubType B.I.2.3-Apex with a sinus
Cordaicarpus cesarii Gutierrez et al. 1992
Cordaicarpus famatinensis Gutierrez et al. 1992
Cordaicarpus oliveiranus (White) Millan, 1965
SubType B.I.2.4-Apex bifurcated with horn-like processes
Cornucarpus patagonicus (Ferruglio) Correa da Silva & Arrondo, 1977
Cornucarpus striatus Walkom 1935
Feruglíocladus patagonicus (Ferruglio) Archangelsky & Cúneo, 1987 (sementes associadas)
Maheshwariella spinicornuta Maheshwari & Tewari 1986
Maheshwariella furcata(Surange & Lele) Maheshwari & Tewari 1986
SubType B.I.2.5-Apex not known
Talchirospermum indicum Srivastava & Chandra 1982
SubType B.I.2.6-Without other morphological characters
Walkomiellospermum indicum Pant & Srivastava,1963
Spermatites indicus Srivastava, 1954

GROUP B. II -WITH A WIDE AND DIFFERENTIATED TESTA
Type B.II.1 -With a median ridge
SubType B.II.1.1-With a sinus on one extremity
Eucerospermum opimum Ferruglio, 1946
Eucerospermum patagonium Ferruglio, 1946
Samaropsis intermedia Høeg & Bose, 1960
Samaropsis leslii Seward, 1917
Samaropsis mendesii Rigby, 1972
Samaropsis millerii (Feistimentel) Seward, 1917
Samaropsis sancti-marci Bernardes-de-Oliveira, 1976 (*In* Bernardes-de-Oliveira & Pontes, 1976)
SubType B.II.1.2 -With a sinus on both extremities
Samaropsis dawsonii (Shirley) Walkom, 1922
Samaropsis millaniana Bernardes-de-Oliveira, 1976 (*In* Bernardes-de-Oliveira & Pontes, 1976)
Samaropsis asymetrica Archangelsky, A.,1999
Otofeista millerii (Feistimentel) Pant, Nautiyal & Tiwari, 1985
Patagosperma lubeckense Archangelsky, A., 1995
SubType B.II.1.3-Without a sinus
Samaropsis indica (Zeiller) Seward, 1917
Samaropsis zambesicus Høeg & Bose, 1960
Cornuspermum pennatus Banerjee 1969
Type B.II.2-Without a median ridge
SubType B.II.2.1-Oval/ Elliptical in shape in a vertical position
Sub-SubType B.II.2.1.1-Sarcotesta without a sinus
Samaropsis dolianitii Millan, 1977
Samaropsis itapevensis Millan, 1995
Sub-SubType B.II.2.1.2-Sarcotesta with a sinus on one extremity
Nummulospermum bowenense Walkom, 1921
Samaropsis argentina Feruglio, 1951
Samaropsis bainhensis Millan, 1967
Samaropsis barcelosa (White) Seward, 1917
Samaropsis boutakoffii Høeg & Bose, 1960
Samaropsis criciumensis Millan, 1967
Samaropsis etheridgei Walkom, 1922
Samaropsis ganjrensis Saksena, 1956
Samaropsis longii, Schopf, 1962
Samaropsis moreirana (White) Millan, 1965
Samaropsis raniganjensis Seward & Sahni, 1920
Samaropsis srivastavae Lele, 1962
Samaropsis surangei Lele, 1962
Sub-SubType B.II.2.1.3-Sarcotesta with a sinus on both extremities
Samaropsis cuerdae Gutierrez et al. 1992
Samaropsis goraiensis Surange & Lele, 1956
Samaropsis kurtzii Leguizamón, 1971
Samaropsis moravica (Helmhacher) Walkom, 1928
Samaropsis nuñezii Garcia, 1990
Samaropsis ovalis Walkom, 1935
Samaropsis rigbyi Millan, 1977
Samaropsis cerquilhensis (Millan) *comb. nov.*
Samaropsis rohnii sp. nov.
Samaropsis rugata sp. nov.
SubType B.II.2.2-Vertically oblong shape
Sub-SubType B.II.2.2.1-Sarcotesta with a sinus on one extremity
Samaropsis tietensis Millan, 1995
SubType B.II.2.3-Oval/ elliptic shape in horizontal position
Sub-SubType B.II.2.3.1-Sarcotesta without a sinus
Samaropsis feistmantelii Maithy, 1965
Samaropsis thomasii Schopf, 1962
Pterygospermum raniganjense Pant & Nautiyal,1960
Sub-SubType B.II.2.3.2-Sarcotesta with a sinus
Alatocarpus indicus Lele, 1969
Alatocarpus johillensis Lele, 1969
Samaropsis menisca Lele, 1962
Samaropsis pincombei Walkom, 1928
Samaropsis seixasii (White) Seward, 1917

Fig. 8—Key for identification of Permian Gondwana seeds

viz. S. rohnii sp. nov. and *S. rugata* sp. nov. are erected.

Cordaicarpus chichariensis Lele (species similar to *C. brasilianus*) and many other species of *Cordaicarpus* are typical of the formations of the lower subunit of *Gangamopteris* Zone in Argentina. Many species of *Samaropsis* appear in the Argentinean Interval Zone but most of them are common only in the lower subunit of *Gangamopteris* zone (Archangelsky & Cúneo, 1991). This zone is somewhat comparable with the Cerquilho flora (top of Itararé Subgroup). However, a close comparison based only on seed species is not possible between the two floras. The variety of seeds in the assemblage points toward the diversity of gymnosperms in this taphoflora, which is probably related to the last interglacial event (with temperate climate) of the great Lower Gondwana Glaciation in the Paraná. Since most of the taxa are not, so far, reported elsewhere, biostratigraphic correlations are not possible. Besides, lack of finer morphographical features of the seeds also prevent precise comparisons. By and large, the assemblage is comparable with the Early Permian flora of India (Fig. 7). An endeavour for further comprehensive work in this direction is required for biostratigraphic studies. The presence of *S. goraiensis* Surange & Lele registered here confirms an Early Permian age attributed to this taphoflora. Based on the generated data from the present study the scheme of classification of seeds has been modified (Fig. 8).

The lithostratigraphic position of this occurrence is subject of different interpretations (Fúlfaro *et al.*, 1991; Santos *et al.*, 1996). The reason is that the position of the last glacial deposits is not well established since the outcrops in the Cerquilho area are rare and weathered. But it is not far from the boundary between the Glacial Itararé Subgroup and the Post-glacial Guatá Subgroup (Tubarão Group) and its position in the last interglacial phase of Itararé Subgroup seems to be the most probable considering its putative correlation with the Tietê area (SP), on the border of the Capivari River.

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