Seed coat micromorphology of some Asiatic Spermacoceae (Rubiaceae)

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Abstract. Thirteen species of four tropical genera of Spermacoceae (Rubiaceae) in Asia: Richardia L. (1 sp.), Diosia L. (1 sp.), Mitracarpus Zucc. (1 sp.) and Spermacoce L. (10 spp.), were studied as to their seed coat surface patterns, using SEM. In Richardia scabra, the seed is fused with the mericarp and the surface pattern of the mericarp is distinctive with conspicuously striated papillae. The seeds of Diosia virginiana are unique in having baculate testa. In Mitracarpus and Spermacoce, the seed coats are basically reticulate, but differ in size, shape and nature of the meshes of the reticulum. Seed coat patterns may not be of great taxonomic value in the generic delimitation, which is far from clear in the Spermacoceae. Yet, they might lend some support for the recognition of species in genera like Spermacoce when taken along with other morphological attributes.

Key words: Diosia; Mitracarpus; Richardia; Seed-coat pattern; Spermacoce; Spermacoceae.

Introduction

The tribe Spermacoceae with about 18 genera distributed in the tropical and temperate regions of the world excluding New Zealand (Verdcourt, 1958), is characterized by a herbaceous habit, setiferous stipules, solitary ovules attached to the middle of the septum in each cell, valvate corolla lobes, dry fruits which are valvular capsules or separating into one-seeded cocci and pluriloculate pollen grains (Verdcourt, 1958; Brenekamp, 1966; Dwyer, 1980; Chaw and Peng, 1987). Four of these genera, namely, Spermacoce L. (including Borreria G. F. W. Meyer), Diosia L., Richardia L. and Mitracarpus Zucc. that are usually weedy and widespread in tropical Asia have been often confused in the herbaria. Their general morphology and taxonomy have been elucidated recently by Chaw and Peng (1987) and Sivarajan et al. (1987). This paper deals with the seed coat patterns of the 10 species of Spermacoce and one species each of Diosia, Richardia and Mitracarpus, available in tropical part of Asia.

Even as there is no difference of opinion as to the generic status of Richardia and Mitracarpus, the delimitation and circumscription of Spermacoce and Diosia is still inconclusive. Spermacoce L. and Borreria G. F. W. Meyer are considered to be distinct genera by many authors, based on the dehiscence of the capsule: both cocci dehiscent at apex in Borreria; one coccus indehiscent and adherent to the septum in Spermacoce (Meyer, 1818; Hepper and Keay, 1963; Backer and Bakhuizen van den Brink, Jr., 1965; Steyermark, 1972). Brenekamp (1934)
concedes that this character is too small and insufficient for generic delimitation, but retains the two genera for the "purely opportunistic reason" that it is easily recognizable. Most others, however, prefer to combine the two taxa under the generic name *Spermacoce* (Hooker, 1881; Verdcourt, 1975, 1976; Deb and Dutta, 1984; Sivarajan *et al.* 1987; Chaw and Peng, 1987).

After examining the African materials of *Spermacoce* (*sensu lato*) and *Dodia*, Verdcourt (1975) opined that he would have put them together, because their close relationship is very apparent. However, the New World materials have persuaded him to keep *Dodia* as a distinct genus. "Certainly the type species of *Dodia*, *D. virginiana* L., differs widely in its fruit structure from other species included in the genus" (Verdcourt, 1975). Lewis and Oliver (1974) have also acknowledged the fact that the circumscription of the genus *Dodia* is far from conclusive, but consider it to be more closely related to *Richardia* by their fruits which separate into indehiscent cocci. The number of carpels by which these genera are usually distinguished are variable and there are species of *Richardia* having two to four carpels, leading to confusion in the taxonomy of the group. However, the terminal capituli subtended by two to four involucral leaves and the deciduous calyx demarcate *Richardia* from *Dodia* fairly well.

Verdcourt (1975: 317–322) has concluded that the species of *Mitracarpus* widespread in tropical Africa, S. America and Asia are all conspecific and that the correct name of the species is *M. villosus* (Sw.) DC. Consequently the name *M. verticillatus* (Schum. & Thonn.) Vatke, by which this species is invariably referred to in Indian floras, becomes a synonym of *M. villosus*.

These above-mentioned genera can easily be distinguished as follows:

1a. Infl. of terminal capituli subtended by 2–4 invol. leaves; calyx deciduous. .... *Richardia*

1b. Infl. axillary and also terminal, invol. leaves absent; calyx persistent .... 2

2a. Flowers often axillary, solitary; fruits splitting into two indehiscent cocci .................................... *Dodia*

2b. Flowers several per axil; fruit with 1 or both cocci dehiscent .......... 3

3a. Capsules circumscissile .......... *Mitracarpus*

3b. Capsules 2-valved ............ *Spermacoce*

The present study is aimed at examining whether seed coat surface patterns would provide any reliable taxonomic parameter for generic delimitation or species recognition.

**Materials and Methods**

Seeds prepared for scanning electron microscopy (SEM) were collected from herbarium sheets using a dissecting light microscope (LM). After cleaning with a fine Chinese brush dipped in distilled water, the seeds were dehydrated through an ethanol series and acetone, critical-point dried with CO₂, coated with gold, and examined with a Zeiss 950 SEM at an accelerating voltage of 15 KV.

Three to eighteen seeds of each sample were mounted and examined. Little variation within samples was obvious. The seed photographed was in all cases judged to be typical for the sample. All voucher numbers of specimens examined are listed after the description of each species. Voucher numbers are given in the legends of Figs. 1–39 only when more than one collection was observed.

**Observations**

*Richardia scabra* L.     Figs. 1–3.

Here the seeds are inseparable from the mericarp as they enlarge and fuse with the latter. The mericarps or cocci are obovoid or ellipsoid, 2.5–3.5×1.5–2 mm, and the surface is papillose. The papillae occur in various sizes
and shapes, some of them appearing as buckled protuberances on the mericarp surface; under higher magnifications, the entire surface is seen to be covered by conspicuous, thick, sinuate striations.

Specimen examined: Chaw 221 (HAST).

Diodia virginiana L.  
Figs. 4-6.

Fruits separating into 2 indehiscent cocci, but unlike in Richardia seeds are fused with the mericarp. Seed much larger than in other taxa, 4.3-5.0×2-3 mm, with a longitudinal ventral groove; surface reticulate under LM, but densely baculate under SEM, the bacula characterized by striations.

Specimen examined: Hsieh & Chaw 1501 (HAST).

Mitracarpus villosus (Sw.) DC. [=M. verticillatus (Schum. & Thonn.) Vatke]  
Figs. 7-9.

Seeds rhomdoid or squarish, with almost truncate ends, brownish, 0.8-1.0×0.4-0.6 mm with 4 short ventral grooves from the angles connecting the central, longitudinal groove; surface almost smooth under LM, but distinctly reticulate under SEM; meshes not in regular rows, polygonal, isodiamic and depressed, granulate or with closely parallel, faint striations; walls of the reticulum thick and raised.

Specimen examined: Nair 26799 (CALI).

Spermacoce pusilla Wall. [=Borreria pusilla (Wall.) DC.]  
Figs. 10-11.

Seeds oblong-ellipsoid with rounded ends, dark brown, or brownish black, 1.18-0.5-0.7 mm, with longitudinal ventral groove; surface smooth under LM, but faintly reticulate under SEM; meshes not in regular rows, polygonal, flat or slightly depressed, isodiamic or longish, smooth without granules or striations; walls thin, faint and a little raised.

Specimen examined: Joseph 2799, Sivarajan 68 (CALI).

S. tamamii Sivar. & Nair [=Borreria stricta auct. non (L. f.) K. Schum.]  
Figs. 12-13.

Seeds oblong-ellipsoid, light brown with rounded ends, ca. 1.5×0.8 mm, with a longitudinal, ventral groove; surface smooth under lower magnifications, faintly reticulate at higher magnification; meshes polygonal, not in regular rows, irregularly shaped, not depressed, smooth without granules or striations, walls raised, thin, but more conspicuous than in S. pusilla.

Specimen examined: Sivarajan 625 (CALI).

S. malabarica (Sivar. & Mani) Sivar. et al.  
[Borreria malabarica Sivar. & Mani.] Figs. 14-16.

Seeds brownish, ellipsoid with rounded ends, ca. 2.4×1.2 mm, with a ventral groove; seed surface minutely reticulate, meshes polygonal, not in regular rows, isodiamic or longish, depressed and with closely parallel, faint striations. Walls fairly thick and raised.

Specimen examined: Sivarajan 36428 (CALI).

S. articulatis L. f. [=Borreria articulatis (L. f.) Williams]  
TYPE I.  
Figs. 17-18.

Seeds ellipsoid with rounded ends and a longitudinal ventral groove, brownish, ca. 2.5-3.5×1.4-1.8 mm, smooth under LM, reticulate under SEM; meshes polygonal, not in regular rows, isodiamic or longish, deeply depressed, almost smooth; walls raised, thick, merging with the mesh.

Specimens examined: Chaw & Peng 321, Chaw 403, 469, 481 (HAST); Sivarajan 1484 (CALI).

TYPE II.  
Figs. 19-21.

Seeds oblong-ellipsoid with rounded ends, light brown, ca. 2-2.5×1-1.3 mm, surface smooth under LM, but reticulate under SEM; meshes depressed, polygonal, not in regular rows, isodiamic or longish, often with conspicuous, radiating striations from the centre; walls
Figs. 1-12. Scanning electron micrographs of seeds of Spermacoceae. 1-3, Richardia scabra; 4-6, Diodia virginiana; 7-9, Mitracarpus villosus; 10-11, Spermacoce pusilla, from Joseph 2772; 12, S. ramani. Scale bars equal 100 μm except that those of 3, 6, 9 and 11 are 10 μm.
thick, raised and not merging with meshes.

Specimens examined: Sowmini 1087, Meenabai 4818, Mohanan 11590 (CALI).


Seeds ovoid or ellipsoid with rounded ends, dark brown or blackish, reticulate under LM and SEM with a longitudinal ventral groove, ca. 2.3–3.2×1.6–1.8 mm. Meshes not in regular rows, polygonal, isodiametric or longish, deeply depressed, occasionally with faint, radiating striations; walls thick, raised and distinct from meshes.

Specimens examined: Sivarajan 318, CU 24657 (CALI).


Seeds ellipsoid or ovoid with rounded ends, brownish with a longitudinal, ventral groove, 1.7–2.7×1–1.5 mm; surface reticulate, meshes polygonal, not in regular rows, deeply depressed, smooth with granules or striations inside; walls thick, raised, often flexuous resulting in meshes of various shapes.

Specimens examined: Chaw 220, Chaw & Peng 255 (HAST); Sivarajan 464 (CALI).

*S. mauritiana* Gideon ex Verdc. [=*Borreria repens* DC.] Figs. 28–30.

Seeds oblong-ellipsoid with rounded ends, brownish, 0.9–1.1×0.4–0.6 mm, smooth under LM, distinctly reticulate under SEM; meshes in regular, longitudinal rows, rectangular or polygonal, broader than long, deeply depressed inside with granulate or bullate protuberances; walls thick, raised and distinct.

Specimens examined: Chaw & Peng 257 (HAST); Sivarajan 320, CU 15904 (CALI).

*S. ocymoides* Burm. f. [=*Borreria ocymoides* (Burm. f.) DC.] Figs. 31–33.

Seeds brownish, oblong-ellipsoid with rounded ends, ca. 1.7×0.7 mm, with a longitudinal, ventral groove; testa appear reticulate at lower magnifications, but as areolate under higher magnifications; meshes or areoles polygonal, not in regular rows, isodiametric or longish, smooth or with fine striations, flat or deeply depressed; walls thick, merging with the meshes.

Specimen examined: Sowmini 1272 (CALI).

*S. assurgens* Ruiz & Pavon [=*Borreria laevis* sensu auct. permult.] Figs. 34–36.

Seeds oblong-ellipsoid with rounded ends, brownish with a longitudinal ventral groove;

Figs. 37–39. Scanning electron micrographs of seeds of *Spermacoce verticillata*. Scale bars of 37 and 38 equal 100 μm, 39 equals 10 μm.
seed surface prominently reticulate with transverse grooves; meshes polygonal, mostly isodiamic, deeply depressed with fine striaions inside; walls thick, raised and distinct from the mesh.

Specimens examined: Chaw & Peng 260 (HAST). TUA 1698 (CALI).


Seeds oblong-ellipsoid, ends rounded, 1.8-2×0.8 mm, brownish, ca. 1×0.5 mm; surface distinctly reticulate; meshes in almost regular, vertical rows, polygonal, mostly isodiamic, deeply depressed with very faint striaions inside; walls thick, raised and distinct from the mesh.

Specimen examined: Francis 1046 (CALI).

**Discussion**

SEM studies on the seed coat patterns of these four Asiatic genera show that not much light can be shed on "generic boundaries (which) are far from clear in the Spermacoceae" (Lewis and Oliver, 1974). The genus *Richardia* stands apart from all others in regards to the surface patterns of the mericarp. Lewis and Oliver (1974) described the mericarps as "densely papillose and vertically striatillose". Observations at higher magnifications have now contributed another interesting aspect: the papilae themselves are beautifully ornamented by conspicuous, sinuate striaions.

Both *Mitracarpus* and *Spermacoe*, the seeds of which were studied, displayed basically similar, reticulate seed coat patterns. At the species level, however, this may be useful along with other characteristics. The seed surface reticula in different species vary in terms of shape of cells: they are either isodiamic, transversely or longitudinally elongated, depressed or flat, striated, granulate or smooth meshed. Walls can be thick or thin, straight, curved or flexuous; they can rise abruptly from the seed surface or merge with the mesh, becoming structurally indistinct.

The genus *Diodia* L. has only a single representative in Asia, i.e. *D. virginiana*, the type species of the genus. While reporting this species from Taiwan, Hsieh and Chaw (1987) have described its seeds as reticulate. However, the present study reveals that the largest seeds of *D. virginiana* are unique among the four Asiatic genera in their baculate surface cells. Verdcourt (1975, pl. 42) has provided SEM micrographs of the seed coat patterns of another species of the genus *D. aulacosperma*. This closely resembles the tranverse groove pattern of *S. assurgens*. However these grooves are regularly spaced and extended all around the seed except for the ventral groove, whereas the grooves of *S. assurgens* are not regular nor do they completely encircle the seed.

In *Spermacoe*, the linear-lanceolate-leaved *S. pusilla* and *S. ramanii* have a distinctive type of reticulum with very faint walls, rising abruptly from an otherwise smooth seed surface. While the rest, i.e. the broad-leaved species, the walls are thick and meshes depressed to varying degrees. *S. malabarica*, however, agrees more with the broad-leaved species rather than the linear-lanceolate-leaved ones. *Spermacoe articulata* L. f. is a variable species, even after the exclusion of *S. hispida* L. It displays almost continous variations from an erect or prostrate form with non-flexuous leaves and long tubular flowers (*Meenabai 4818*, CALI) to a sub-erect or prostrate form with slightly flexuous leaves and short, campanulate flowers (*Sivarajan 1464*, CALI). The present study also points to a possible high degree of infraspecific variability. The former form has testa cells almost isodiamic and the meshes of the reticulum are often beset with radiating striae (Figs. 19-21), while the latter has fairly
elongated meshes without such striae (Figs. 17 and 18). Perhaps more extensive sampling and analysis of the intermediate populations might reveal more of variations in seed-coat patterns also.

Spermacoce hispida and S. articulatits are closely related and have been even considered conspecific, until Sivarajan and Nair (1986) segregated them. In external morphology one may relate the two species through the flexuous-leaved form with short campanulate flowers. However, the seed-coat pattern studied shows otherwise, i.e., the prostrate form with non-flexuous leaves and long tubular flowers, display a more closely related seed-coat pattern to S. hispida, rather than the other form which is otherwise more similar to the latter.

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Literature Cited


亞洲薊草科鴨舌蕨族植物之種皮微細形態

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薊草科的鴨舌蕨族（Spermacoecae）約有18屬，除紐西蘭外，廣佈於世界的熱帶和亞熱帶地區。本文以掃描式電子顯微鏡觀察亞洲地區的4屬13種該族植物——鴨舌蕨屬（Richardia L.）1種，鈕扣蕨屬（Diodia L.）1種，Mitracarpus Zucc. 屬1種，鴨舌蕨屬（Spermacoec L.）10種等的種皮形態，以探討本族內的屬和種之間的界定。

鴨舌蕨的種子和分果序結合，且果皮的乳頭狀突起有明顯的條紋而別於其他的3屬。大鈕扣草（D. virginiana L.）的種皮細胞呈腫柱狀，相當特別。其他2屬，基本上種皮細胞呈腫狀，但不同種之間縫格的大小和形狀則有所差異。Mitracarpus 屬的種子具長方柱形，其縱面的四個頂角有溝槽和中心的縱溝混合。以種皮的性狀配合其他形態特徵可以容易的區分鴨舌蕨類屬內的種類。鴨舌蕨屬（S. articulare L. f.）的種子有2型，是否另有一變種存在，須作進一步的研究。