

Anatomy of the Pericarp and Seed-coat of *Lithraea molleoides* (Vell.) Engl. (Anacardiaceae) with Taxonomic Notes

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ABSTRACT

The aim of the present work was to record anatomical data for the fruit and seed of *Lithraea molleoides* (Vell.) Engl, and compare the results with those for *L. brasiliensis* and the genera *Schinus* and *Rhus*. The *L. molleoides* fruit was a drupe with a friable and lignified exocarp. The mesocarp was parenchymatous with large secretory canals associated with vascular bundles. The endocarp consisted of four layers: an outer layer of polyhedral cells with prismatic crystals of calcium oxalate, and three inner layers of sclereids in a palisade arrangement. The ovule was anatropous, unitegmic, and crassinucelate. In the chalazal region, a cup-like zone of tanniferous parenchymal cells formed the hypostase. The developing seed had a circinotropous-like shape, that originated through curvature of the long, coarse funicle that surrounded the tegument and embryo sac. The ripe seed was endotestal with bar-like thickenings or pittings in the cell walls.

Key words: Anacardiaceae, anatomy, pericarp, seed-coat

INTRODUCTION

The Anacardiaceae was currently divided into five tribes (Anacardiaceae, Spondiadeae, Rhoeeae, Dobineae and Semecarpeae), but this supra-generic classification was still controversial. Morphological, anatomical and *rbcL* sequence analyses by Terrazas and Chase (1996) suggested that two large clades should be recognized. One of these was monophyletic and contained members of the Spondiadeae group, while the second contained Anacardiaceae and Rhoeeae. Although floral features had been used extensively to separate the taxa within the Anacardiaceae, Terrazas and Chase (1996)

suggested that anatomical features of the endocarp and wood characters were more useful.

The tribe Rhoeeae contained the genera *Rhus*, *Schinus*, *Pistacia*, *Astronium*, *Schinopsis*, *Lithraea*, *Myracrodruon* and others. Based on an analysis of the structure of the pericarp in 29 genera, Wannan and Quinn (1990) identified two basic types of endocarp- *Spondias-type* and *Anacardium-type* - in the Anacardiaceae. The tribe Rhoeeae could be divided into three groups A, B and C based on endocarp structure. Groups A and B were classified as *Anacardium-type* and group C as *Spondias-type*. The genera *Rhus*, *Schinus*, *Schinopsis*, *Lithraea* and *Myracrodruon* were classified in group A, in which the endocarp consists of four layers of cells. The three internal layers were formed from sclereids

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organized in a palisade arrangement while the external layer was crystalliferous layer.

The external morphology of the fruit and the structure of the endocarp and seeds were very similar in *Rhus*, *Schinus* and *Lithraea*. Based on an analysis of the anatomical features of the fruit and seeds of *Lithraea brasiliensis*, Pienaar and Von Teichman (1998) concluded that this species ought to be included in the genus *Rhus* under the name *Rhus brasiliensis*, a combination that, until publication of the foregoing article, was not valid.

In this report, we describe new anatomical data for the fruit and seed of a Brazilian species of *Lithraea*, *L. molleoides*, and compare the results with those for *L. brasiliensis* and the genera *Schinus* and *Rhus*. Currently, only four species of *Lithraea* were known worldwide, with *L. molleoides* and *L. brasiliensis* being native to Brazil (Engler, 1876; Barkley, 1962).

MATERIALS AND METHODS

Fruits of *Lithraea molleoides* (Vell.) Engl. at different stages of development were collected from specimens grown in the Botanical Garden of the Instituto de Biociências, UNESP, Botucatu, SP, Brazil. The morphological and anatomical studies were done using fresh material and material fixed in FAA (Johansen, 1940). The morphological characteristics of the fruits were described and illustrated using fruits sampled from at least five trees. The nomenclature used here was based on Radford et al. (1974) for the form of the fruits, Spjut (1994) for the type of the fruit, and Roth (1977) for the pericarp layers.

Permanent slides were prepared from fixed samples embedded in plastic resin (Historesin, Leica) using the technique described by Gerrits (1991). The embedded material was glued to blocks of wood with epoxy-glue. Sections were cut on a rotary microtome with type C steel knives. The sections were stained with 0.05% toluidine blue in acetate buffer with pH 4.7 (O'Brien et al., 1964) and mounted in synthetic resin.

For histochemical tests, the sections of fresh material were treated with a) an aqueous solution of FeCl_3 to detect phenolic compounds, b) phloroglucinol-HCL for lignified walls (Sass,

1951), c) Sudan IV for lipids, chloridric and d) sulphuric acids for crystals (Johansen, 1940).

RESULTS

Morphology of the fruit and seed

The fruit was a white-greyish, smooth globose drupe 4-8mm in diameter, with a friable exocarp when ripe. The secretory mesocarp was dark and joined to the stone endocarp. The seed, one per fruit, was laterally compressed (Fig. 7) and derived from an anatropous ovule (Fig. 1) inserted on the basal-lateral side of the ovary. The seed-coat was membranaceous, smooth, and light yellow with a dark brown patch. As the seed grew, the long, curved, coarse funicle stick to the tegument of the seed (Figs. 2-7). The chalazal region and the funicle were seen externally as a dark brown patch in the ripe seed.

Ovary

The ovary was uniloculate with only one ovule (Fig. 1). The outer epidermis, which was uniseriate was covered with a cuticle and has stomata. The epidermal cells were radially elongated, with evident nuclei (Figs. 8 and 9). The ovarian mesophyll was formed by parenchyma cells and secretory canals associated with vascular bundles. The parenchyma cells close to the canals contained phenolic compounds (Figs. 8 and 9)

The inner epidermis of the ovary was multilayered with periclinal divisions that formed a pluristratified endocarp (*sensu stricto*) (Figs. 10-12). The layer of cells covering the locule had a cuticle and was the first to elongate radially (Fig. 12).

The structure of the pericarp

Longitudinal and transversal sections of young fruits showed the following anatomical features:

- a) An outer epidermis with radially-elongated cells (Fig. 13);
- b) A parenchymatous central zone characterized by secretory canals associated with vascular bundles arranged compactly, next to the other, in one layer, and a large number of parenchyma cells with phenolic compounds surrounding the secretory canals (Fig. 13); and
- c) A multilayered inner epidermis with three layers of radially-elongated cells and one with crystals (Fig. 13)

The outer epidermis form the exocarp (*sensu stricto*) which, in the ripe fruit, lignified and became friable (Figs. 13 and 14).

During the development of the fruit, the mesocarp consisted of a parenchymatous zone, secretory canals and vascular bundles and underwent very few changes, most of which involved an increase in the number of cells and in the size of the secretory canals (Figs. 15-17). The presence of parenchyma cells with phenolic compounds (Figs. 16 and 17) and canals with an amber colored secretion (Fig. 17) was characteristic in this species. In the ripe fruit, the mesocarp was secretory, became black and detaches from the exocarp. The separation of the exocarp and mesocarp occurred between the epidermis and the first layer of mesocarp cells (Fig. 14).

The endocarp consisted of four layers of cells, that were fully derived from the inner epidermis of the ovary wall and formed the endocarp *sensu stricto* (Figs. 10-12). In ripe fruit, the endocarp consisted of an outer layer of small polyhedral cells with prismatic crystals of calcium oxalate followed by three layers of sclereids in palisade in which the second layer had smaller cells than the first and third layers (Figs. 18-20). In ripe fruit, the four layers of cells that formed the endocarp became thicker and the walls became lignified (Figs. 19 and 20).

The seed

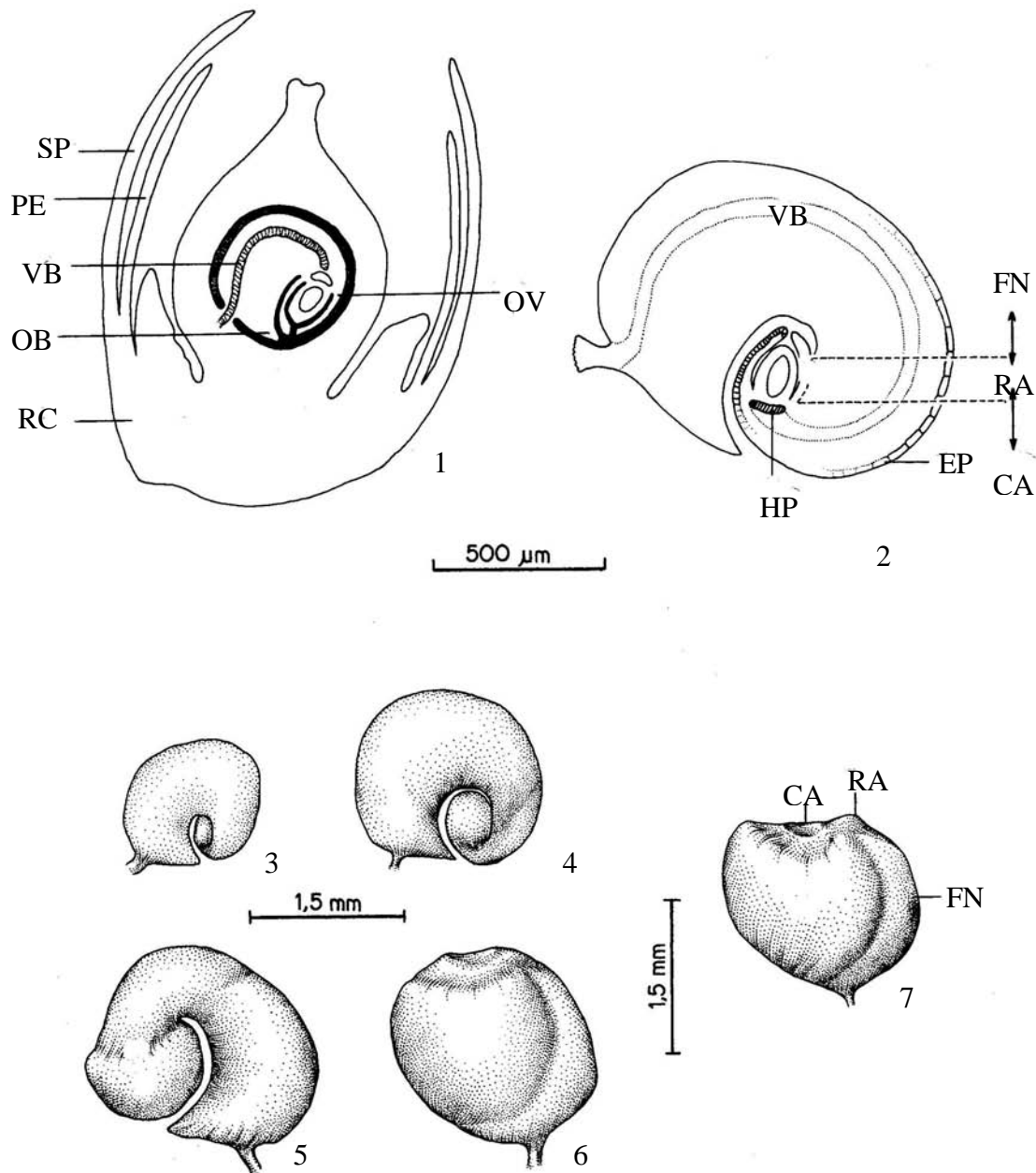
The ovule was anatropous, unitegmic and crassinucelate, with an evident dorsal raphe and a coarse funicle inserted in a basal-lateral position in the ovary wall (Figs. 1 and 8). The developing seed had a circinotropous-like shape originates through the curvature of the long, coarse funicle that surrounded the tegument and embryo sac (Figs. 2-7, 21 and 26)

In the micropyle region, the tegument was formed by 5-12 layers of cells (Figs. 22 and 23). Tanniferous deposits were present in the outer epidermis (Fig. 23). In the inner epidermis the cells were small, with a dense cytoplasm and were arranged compactly (Fig. 23). In the anti-raphe region, the tegument was formed by 4-5 layers of cells (Figs. 24 and 25). The outer epidermis cells were radially elongated and those of the inner epidermis were small and cubic, with a dense cytoplasm, and were arranged compactly. In the chalazal region, a very characteristic cup-like zone of tanniferous parenchyma cells partially surrounded the nucellus and the embryo sac to formed the hypostase (*sensu lato*) (Figs. 21, 24, 26 and 27). The funicle was coarse, with a vascular bundle that was surrounded by a sheath of phenolic compound cells (Fig. 27) and grew towards the micropyle to formed a funicular obturator (Fig. 21 and 26).

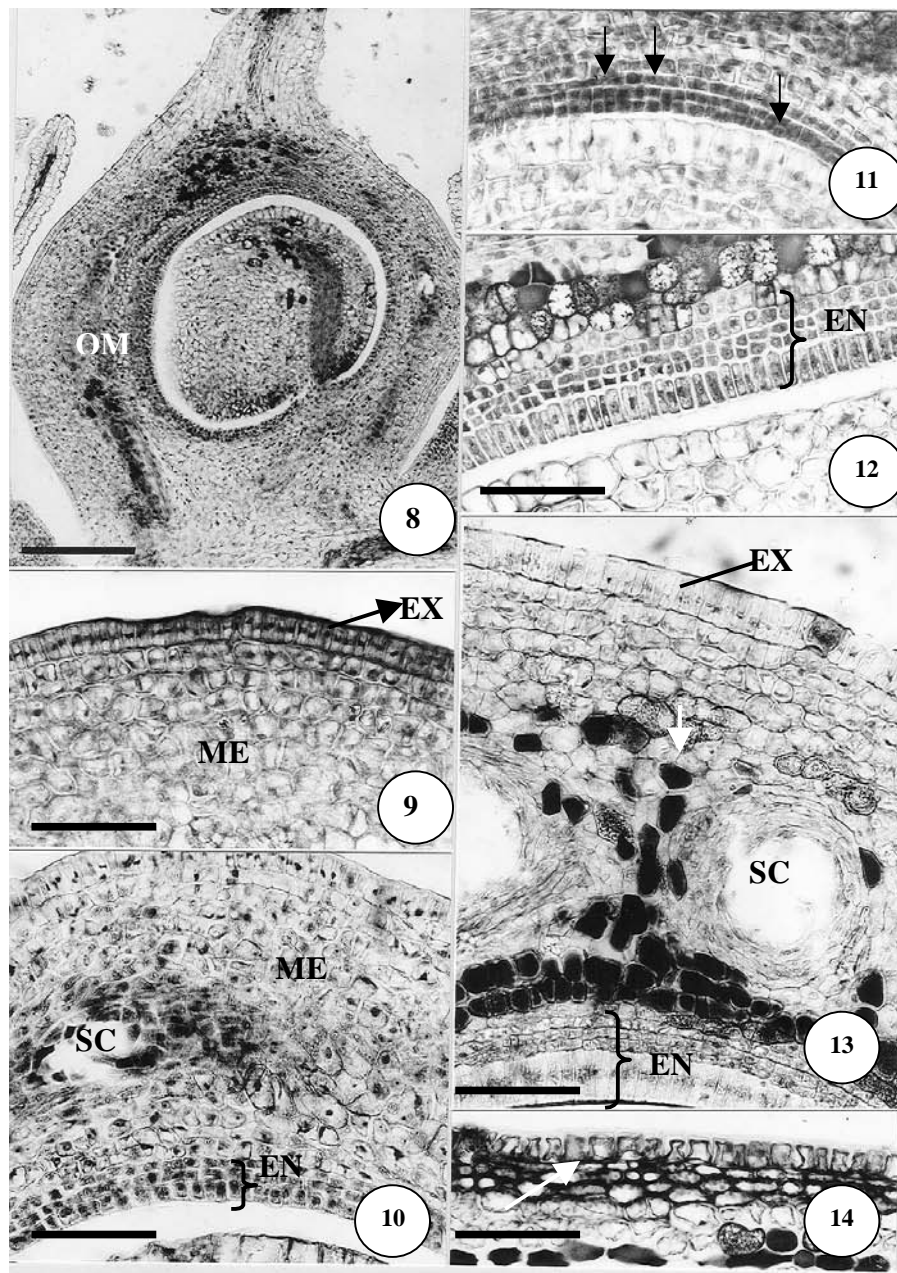
In a further stage of development, the single tegument or testa in the micropyle and anti-raphe region had 4-12 layers of cells. The outer epidermis of the testa was formed by large polyhedral radially elongated cells containing phenolic compounds (Fig. 28). The inner epidermis of the testa has small, cubic cells with evident nuclei and a dense cytoplasm (Fig. 28). The mesophyll had a loose fitting and were compressed in some places. Immediately below the tegument, a few cell layers of the nucellus were compressed. The endosperm had several layers of cells with an evident nucleus and dense cytoplasm in the peripheral embryo sac (Figs. 25, 27 and 28) and was quite vacuolated in the center. The ripe seed was exalbuminous, but showed the remainder of the nucellus and endosperm.

In the raphe-chalazal region, the hypostase contained cells with phenolic compounds and druses of calcium oxalate (Fig. 30).

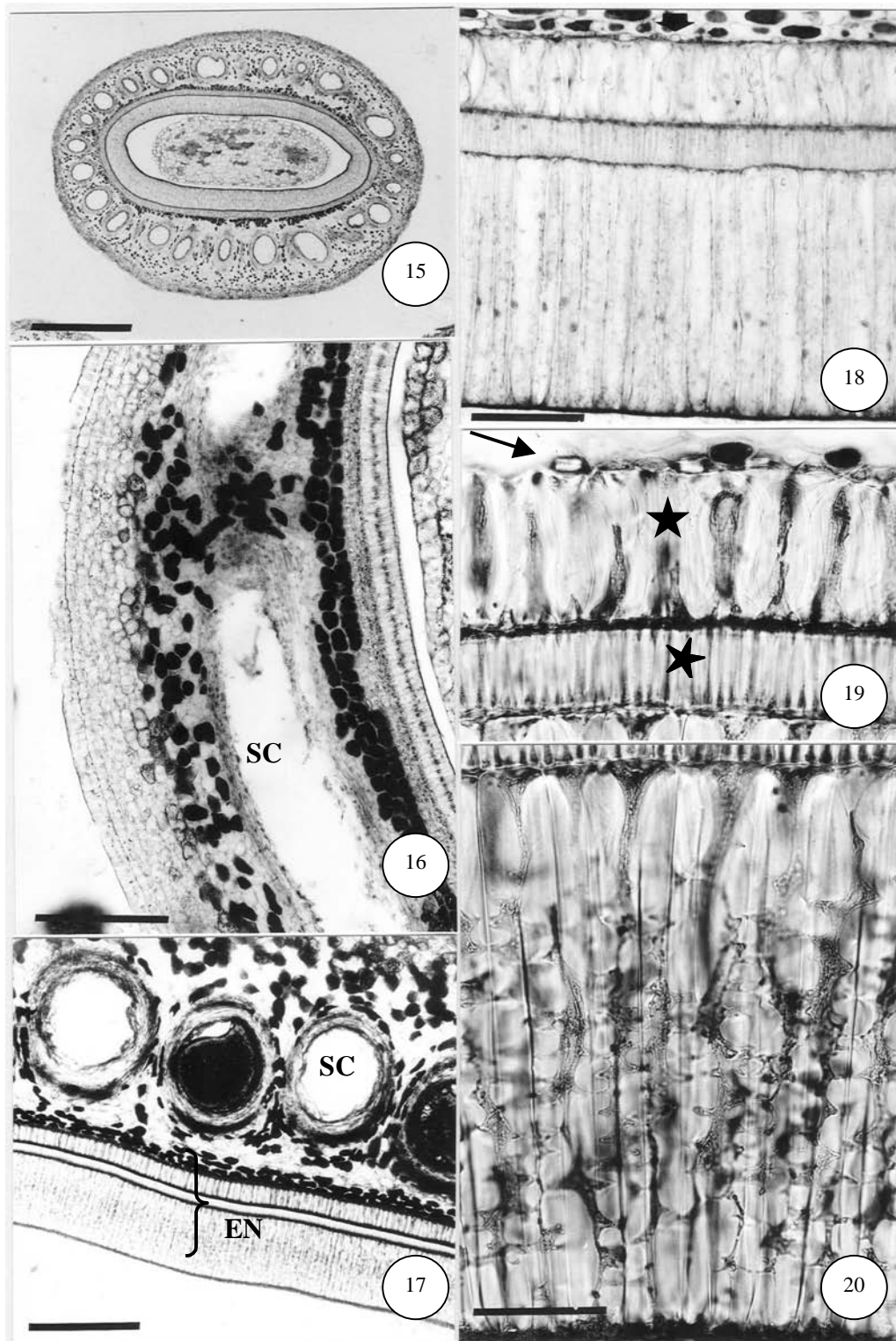
The growth of the funicle was not proportional to seed development and ripe seeds show only remnants of the funicle (Figs. 29 and 31).



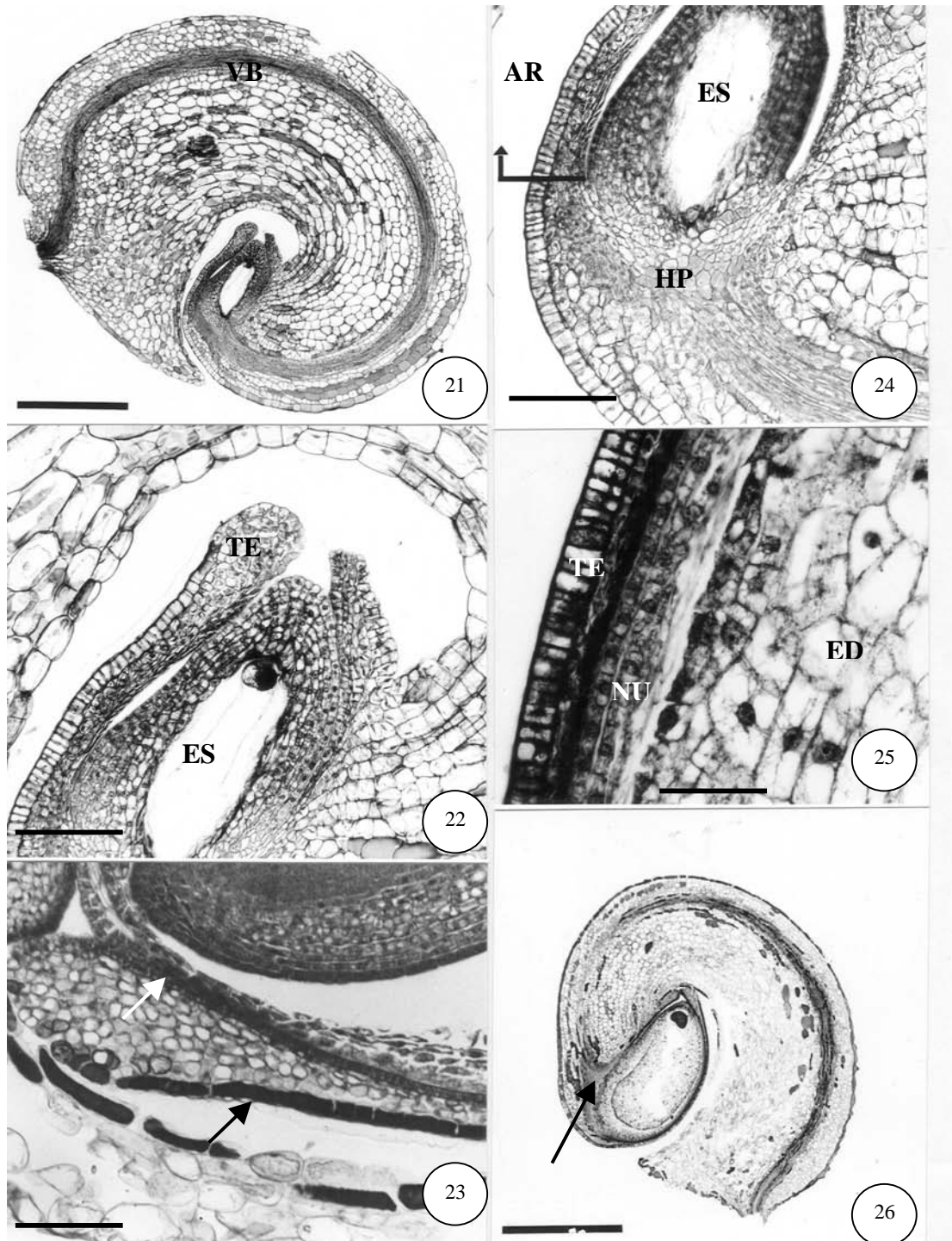
Figures 1-7 - 1. Longitudinal section of a flower with an anatropous ovule inserted on the basal-lateral side of the ovary. 2. Longitudinal section of a very young seed. 3-7. Stages of seed development. (CA=chalaza; EP=epidermis; FN=funicle; HP=hypostase; RA=raphe; TE=testa; SP=sepal; PE=petal; OV=ovule; OB=obturator; VB=vascular bundle; RC=receptacle)



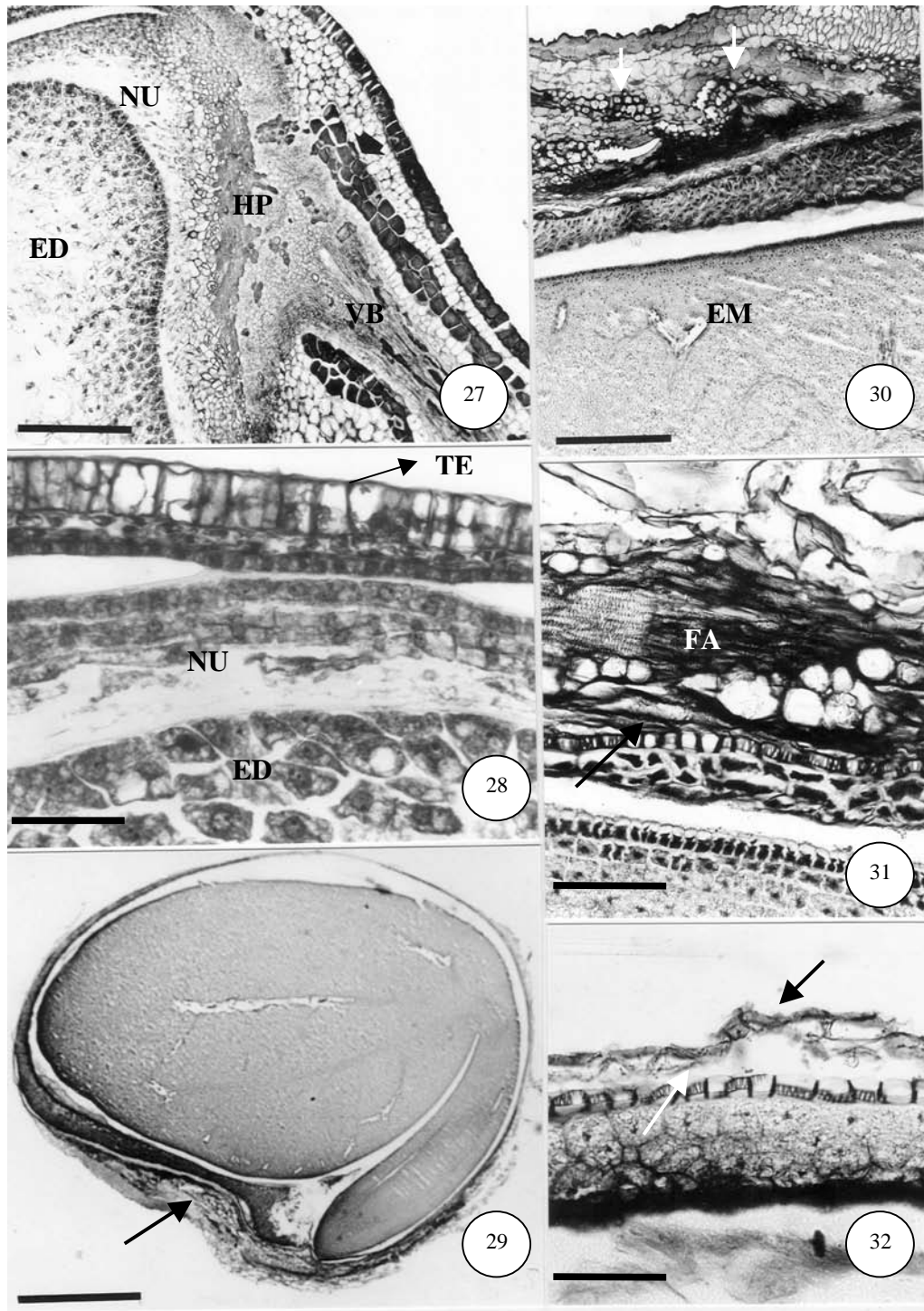
Figures 8-14 - 8. Longitudinal section of an ovary. (OM=ovarian mesophyll) (scale bar=250 μ m). 9-13. Transversal section of a young fruit. 9. Uniseriate exocarp (EX) and mesocarp (ME) (scale bar= 50 μ m). 10. Mesocarp (ME) with secretory canals (SC) and the multilayered endocarp (EN) (scale bar=50 μ m). 11. Endocarp in division (arrows) (scale bar=50 μ m). 12. Multilayered young endocarp (EN) (scale bar=50 μ m). 13. Pericarp. (SC=secretory canal; EN=endocarp; EX=exocarp; short arrow=stoma; white arrows=phenolic compounds) (scale bar=50 μ m). 14. Detail of the mature exocarp. White arrow showed the region of separation between the exocarp and mesocarp (scale bar= 125 μ m).



Figures 15-20 - 15. Transversal section of a ripe fruit (scale bar=1000µm). 16. Pericarp in longitudinal section (scale bar=150µm). 17. Mesocarp with phenolic compounds and secretory canals with dense secretion and multilayered endocarp (scale bar=500µm). 18. Four layers of endocarp without lignification (scale bar=125µm). 19. Three outer layers of ripe endocarp. The arrow showed the crystalliferous layer and two palisade lignified layers (★ and ★) (scale bar=50µm). 20. Lignified inner layer of ripe endocarp (scale bar=50µm). EN=endocarp; SC=secretory canal.



Figures 21-26 - 21. Longitudinal section of the circinotropous-like shape of a young seed. (VB=vascular bundle) (scale bar=500 μ m). 22. Detail of the micropyle region of a young seed. (TE=testa; ES=Embryo sac) (scale bar=125 μ m). 23. Testa in the micropyle region. The black arrow showed the outer epidermis of the testa with phenolic compounds and the white arrow showed the inner epidermis of the testa (scale bar=80 μ m). 24. The anti-raphe (AR) region indicated with arrow; hypostase (HP) and embryo sac (ES)(scale bar=125 μ m). 25. Detail of the layers of the anti-raphe region. (TE=testa; NU=nucellus; ED=endosperm) (scale bar=50 μ m). 26. Longitudinal section of a young seed showing a well-developed hypostase (arrow); endosperm (ED) and heart-shaped embryo (scale bar=100 μ m).



Figures 27-32 - 27. Chalazal region showing the endosperm (ED), nucellus (NU), hypostase (HP), vascular bundle (VB) (scale bar=250 μ m). 28. Longitudinal section of the anti-raphe region (TE=testa, NU=nucellus; ED=endosperm) (scale bar=40 μ m). 29. Longitudinal section of the ripe seed. The arrow indicates the vestigial funicular aril (scale bar=100 μ m). 30. Raphe-chalazal region of the ripe seed. Arrows show druses (EM=embryo) (scale bar=50 μ m). 31. Anti-raphe region. The arrow indicates secondarily thickened, lignified and abundantly pitted walls. (FA=vestigial funicular aril; EM=embryo) (scale bar=250 μ m). 32. Remains of the testa (black arrow) and pitted walls (white arrow) of the inner epidermis of the testa (scale bar=50 μ m).

The seed-coat was formed by waste from the testa, funicle, raphe-chalazal region and the hypostase (Fig. 30), with the testa cells appearing as flattered, non specialized cells (Figs. 30 and 32). The cells of the inner epidermis of the testa were small, secondarily thickened, lignified and had extensively pitted walls (Figs. 31 and 32), indicating an endostestal status. In some parts of the anti-raphae, only the endotesta covered the embryo (Fig.32).

In the ripe seeds, the only multiplicative region was the raphe-chalazal, with the micropyle and the anti-raphae regions showing little stratification (Figs. 29-32).

DISCUSSION

In the Anacardiaceae, the structure of the pericarp was an important diagnostic character, especially at the generic level. According to Wannan and Quinn (1990), the endocarp of the Anacardiaceae could be divided into two basic types: the *Spondias*-type, in which the sclereids were irregularly guided, and the *Anacardium*-type, in which they were regularly guided. *Lithraea*, *Rhus* and *Schinus* all had an *Anacardium*-type endocarp.

The structures of the exo-, meso- and endocarp of *Rhus*, *Schinus* and *Lithraea* showed many resemblances and were summarized in Table 1. The exocarp in *L. molleoides* and in *L. brasiliensis* (Pienaar and Von Teichman, 1998) were formed only by the outer epidermis. In ripe fruit, the cells had a thick non-lignified but very strongly cutinized wall that was separated at the mesocarp, which made it friable. In some species of *Schinus*, such as *S. terebinthifolius* (Carmello-Guerreiro and Paoli, 2002) and *S. molle* (Soos and Hausknot, 1951), the exocarp was formed by the epidermis plus the hypoderm, and became lignified, friable and separated from the mesocarp. In *Rhus lancea* (Von Teichman and Robbertse, 1986; Von Teichman, 1989) and in *R. prolematodes* (Von Teichman and Van Wyk, 1991), the exocarp consisted of the outer epidermis, the hypoderm and a variable number of mesocarp layers. In *R. lancea*, the hypoderm showed cells with thick, lignified walls, while in *Rhus prolematodes* they were not lignified. In *Rhus (Toxicodendron) diversiloba* (Copeland and Doyel, 1940), the exocarp was papery, but its was unclear how many layers constitute the

exocarp. The exocarp of *Rhus aromatica* and *R. glabra* was formed by the outer epidermis (Li *et al.*, 1999).

Schinus and *Lithraea* had a friable exocarp that separated from the mesocarp. In *Rhus glabra* and *R. aromatica*, the single-layered exocarp and the outer mesocarp (with parenchyma cells) were considered as "papery fruit peel" that separated from the rest of the fruit (vascular bundles and inner mesocarp) (Li *et al.*, 1999). It was unclear whether other *Rhus* species had a the presence of friable exocarp and if this separated from the mesocarp.

In all of the species studied in these three genera, the mesocarp was formed largely by parenchyma cells, tannic idioblasts and secretory canals associated with the vascular bundle. However, in *Rhus lancea* (Von Teichman and Robbertse, 1986; Von Teichman, 1989), *R. prolematodes* (Von Teichman and Van Wyk, 1991), *R. glabra* and *R. verniciflua* (Brizicky, 1963; Li *et al.*, 1999), the inner part of the mesocarp was sclerified and could be a part of the endocarp. In *Lithraea molleoides*, *L. brasiliensis* (Pienaar and Von Teichman, 1998), *Schinus terebinthifolius* (Carmello-Guerreiro and Paoli, 2002) and *S. molle* (Soos and Hausknot, 1951), no sclerification of the inner part of the mesocarp was observed.

The endocarp could be formed by the inner epidermis of the ovary and its immediate derivatives, in which case it was referred to as *sensu stricto*; if the endocarp also include layers of the mesocarp then it was referred to as *sensu lato* (Roth, 1977). In *Lithraea molleoides*, *L. brasiliensis* (Pienaar and Von Teichman, 1998) and *Schinus terebinthifolius* (Carmello-Guerreiro and Paoli, 2002) the endocarp was of the *sensu stricto* type since was formed by four layers fully derived from the inner epidermis and consisted of an outermost crystalliferous layer and three inner layers formed by sclereids in palisad; the latter layers covered the locule.

In *Rhus lancea* (Von Teichman and Robbertse, 1986; Von Teichman, 1989), *R. prolematodes* (Von Teichman and Van Wyk, 1991), *R. glabra* and *R. verniciflua* (Brizicky, 1963; Li *et al.*, 1999), the endocarp was *sensu lato* since the sclerified portion of the mesocarp was part of the endocarp. Only in *R. aromatica* was the inner mesocarp parenchymatous and the endocarp was defined as *sensu stricto* (Li *et al.*, 1999).

The inner part of the endocarp, or endocarp *sensu stricto*, developed from the inner epidermis of the ovary and its four-layered structure was very similar among species of *Lithraea* and *Schinus* (Carmello-Guerreiro and Paoli, 2002; Pienaar and Von

Teichman, 1998; Soos and Hausknost, 1951). In almost all species of *Rhus* studied by Copeland and Doyel (1940), Brizicky (1963), Von Teichman and Robbertse (1986), Von Teichman (1989), Wannan and Quinn (1990) and Von Teichman and Van Wyk (1991), the layer of macrosclereids in contact with the locule had wavy radial walls, except in *R. glabra* and *R. aromatica* (Li et al., 1999). This feature was not observed in any species of *Lithraea* or *Schinus* studied so far.

The seeds of *Rhus*, *Schinus* and *Lithraea* were considered to be partially pachychalazal (Von Teichman, 1991; Carmello-Guerreiro and Paoli, 1999) since the chalazal part of the seed-coat was smaller than the tegument part, and was characterized by an endotegmen with a thickened, lignified cell wall and bar-like or pitted thickenings that prevent the collapse of the cells (Piennar and von Teichman 1998). The partial pachychalaza observed in these genera was easily distinguished externally by that dark-brown color seen in the seed-coat. A tanniferous hypostase

was also a common feature of these three genera and of the Anacardiaceae in general (Von Teichman and Van Wyk, 1994), as was the amphicribal vascular bundle and crystalliferous cells of the raphe (Piennar and Von Teichman, 1998 and Carmello-Guerreiro and Paoli, 1999).

The ovules of *L. molleoides* and *R. problematodes* were basal but in *Schinus* they were apical (Carmello-Guerreiro and Paoli, 1999). *Rhus* and *Schinus* had an anatropous ovule (McNair, 1921; Kelkar, 1958; Von Teichman, 1991; Von Teichman and Van Wyk, 1991). *L. molleoides* also has an anatropous ovule, but after fertilization the funicle grew, curves and surrounded the tegument and embryo sac to give the young seed a circinotropous-like shape. In addition, the ovule of *L. molleoides* was unitegmic whereas in the species of *Rhus* and *Schinus* mentioned above the ovule was bitegmic. Piennar and Von Teichman (1998) described the ovule of *L. brasiliensis* as bitegmic.

Table 1 - Comparison of the anatomical characters of the exo-, meso- and endocarp in *Lithraea*, *Schinus* and *Rhus* species.

	Exocarp		Mesocarp		Endocarp			
	Epi	Hyp	OM	IM	CL	OL	ML	IL
<i>Lithraea molleoides</i>	Lig*	—	ParSC-t	Par	Par	Scl	Scl	Scl
<i>Lithraea brasiliensis</i> (Piennar and Von Teichman, 1998)	TW	—	ParSC-t	Par	Par	Scl	Scl	Scl
<i>Schinus terebinthifolius</i> (Carmello-Guerreiro and Paoli, 1999)	Lig	Lig*	ParSC-t/c	Par	Par	Scl	Scl	Scl
<i>Schinus molle</i> (Soos and Houknost, 1951)	Lig	Lig*	ParSC-t/c	Par	Par	Scl	Scl	Scl
<i>Rhus glabra</i> (Li, Baskin and Baskin, 1999)	Pa	?	ParSC-t/c*	Scl-t	Par	Scl	Scl	Scl(w?)
<i>Rhus aromatica</i> (Li, Baskin and Baskin, 1999)	Pa	?	ParSC-t/c*	Par	Par	Scl	Scl	Scl(w?)
<i>Rhus problematodes</i> (Von Teichman and Van Wyk, 1991)	TWt	TWt	ParSC-scl	Scl-t	Par	Scl	Scl	Scl-w
<i>Rhus lancea</i> (Von Teichman and Robbertse, 1986; Von Teichman, 1989)	TWt	TWt	ParSC-scl	Scl-t	Par	Scl	Scl	Scl-w
<i>Rhus diversiloba</i> (Copeland and Doyel, 1940)	Pa*	?	ParSC-scl	Par	Par	Scl	Scl	Scl-w

Legend: (---) absent. (?) uncertain. (*) Exocarp detaches from the mesocarp. Exocarp: Epi=epidermis; Hyp=hypoderm; Lig=lignified; Pa=papyriferous; TW=thickened wall; TW-t=thickened wall tanniferous. Mesocarp: OM=outer mesocarp; IM=inner mesocarp; Par=parenchyma; SC-t/c/scl=tanniferous cells (t), crystalliferous cells (c), sclerenchyma cells (scl) encircling the secretory canals. Endocarp: CL= crystalliferous layer; OL=outer layer; ML=median layer; IL=inner layer; Scl=palisade sclerenchyma cells; Scl-w=palisade sclerenchyma cells with wavy walls.

As shown for several species of *Rhus* (McNair, 1921; Kelkar, 1958; Von Teichman, 1991; Von Teichman and Van Wyk, 1991) and for *S. molle* (Soos and Hausknot, 1951; Copeland, 1959) and *S. terebinthifolius* (Carmello-Guerreiro and Paoli, 1999), the ovules of *Rhus* and *Schinus* showed greater similarity among themselves than do those of *Rhus* compared to *Lithraea*. In *Schinus*, as in *Rhus*, the ovule was bitegmic, with the outer tegument being much longer than the inner one.

In *L. molleoides*, the bar-like thickenings or pittings on the cell walls of the inner epidermis of the testa characterized it as an endotestal seed, as indicated by Corner (1976). This type of thickening has been a very common feature of different species of Anacardiaceae, in the endotesta and endotegmen.

CONCLUSION

Lithraea and *Schinus* differed *Rhus* in the structure of their endocarp. In the first two genera, the endocarp was of the *sensu stricto* type and consists of four layers of sclereids derived from the inner epidermis of the ovary. In *Rhus*, the endocarp was *sensu lato* type since it had layers of the mesocarp as well as the four layers from the inner epidermis. In addition to these differences, the sclereids in contact with the locule had wavy walls in *Rhus* and straight walls in *Schinus* and *Lithraea*.

Further anatomical and taxonomic studies were needed to solve persisting problems regarding the generic limits in this family. In particular the types of the ovules and the number of teguments need to be studied in detail in the three genera. Based on the findings of this study, it was concluded that *L. brasiliensis* should not be included in the genus *Rhus*, contrary to the suggestion of Piennar and Von Teichman (1998).

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RESUMO

O fruto de *Lithraea molleoides* (Vell.) Engl. é uma drupa globosa, branca-acinzentada, lisa, com exocarpo friável e lignificado quando maduro. O mesocarpo é parenquimático com grandes canais secretores associados aos feixes vasculares. O endocarpo é composto de quatro camadas: na camada mais externa as células são poliédricas, com cristais prismáticos de oxalato de cálcio, e nas três camadas internas as células são esclereides em paliçada. O envoltório da semente é membranáceo, liso, amarelo-pálido com uma mancha marrom escura. O óvulo é anátropo, unitegumentado, crassinucelado, inserido em posição basal-lateral. O funículo é crasso e cresce em direção à micrópila formando o obturador funicular. Na região calazal uma zona com células parenquimáticas de conteúdo tanífero formam a hipóstase. A semente em desenvolvimento apresenta uma forma circinótrona, originada a partir da curvatura do funículo crasso e longo que circunda o tegumento e o saco embrionário. A semente madura é endotestal com as paredes das células da endotesta espessadas e lignificadas em forma de barras ou pontuações.

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