Leaf structural characters of *Leandra* and *Miconia* (Miconieae: Melastomataceae): taxonomic and ecological significance

Caracteres estruturais foliares de *Leandra* e *Miconia* (Miconieae: Melastomataceae): importância taxonômica e ecológica

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Abstract: Leaves of six species of *Leandra* and *Miconia* were investigated to find structural characters of interest for the classification of species and genera, as well as those that may be related to water stress. Specimens were collected in Guartelá State Park, Brazil, and described morphologically. Anatomical studies were performed on leaf samples embedded in historesin and sectioned through a rotating microtome. Scanning electron microscopy was done on material fixed in glutaraldehyde. *Leandra* leaves are lanceolate-ovate, while *Miconia* leaves have oblong-lanceolate and lanceolate blades. Both genera have a vascular system of the petiole composed of collateral, bicolateral, and anficrials bundles. The leaves are hypoestomatic and dorsiventral, varying in the number of strata of the parenchyma. The midrib consists of concentric collateral bundles (U-shaped, V-shaped or circular) or concentric bundles. The morphology of the indument, the structure of the mesophyll, and the vascularization of the midrib are characteristics of interest for the diagnosis of species. They are probably species that avoid drought and consist of plants capable of reducing or compensating for water loss.

Keywords: Leaf blade anatomy. Indumentum. Leaf anatomy. Midrib vasculature. Petiole vasculature.

Resumo: Folhas de seis espécies de *Leandra* e *Miconia* foram investigadas estruturalmente, com atenção aos caracteres de interesse para separação das espécies e dos gêneros, bem como àqueles que podem estar relacionados ao estresse hídrico. Os espécimes foram coletados no Parque Estadual do Guartelá, Brasil, e descritos morfologicamente. Estudos anatômicos foram realizados em amostras foliares embebidas em historesina e seccionadas em micrótomo rotativo. A microscopia eletrônica de varredura foi feita em material fixado em glutaraldeído. As folhas de *Leandra* têm forma lanceolada-ovada, enquanto as folhas de *Miconia* possuem as lâminas oblongo-lanceoladas e lanceoladas. Ambos os gêneros possuem a vascularização do pecíolo composta de feixes colaterais, bicolaterais e anficrivais. As folhas são hipoestomáticas e dorsiventrais, variando no número de estratos dos parênquimas. A nervura central consiste em feixes concêntricos colaterais (em forma de U, em V ou circulares) ou concêntricos. A morfologia do indumento, a estrutura do mesofilo e a vascularização da nervura central são características de interesse para o diagnóstico de espécies. Provavelmente, são espécies que evitam a seca e consistem em plantas capazes de reduzir ou compensar a perda de água.

Palavras-chave: Anatomia foliar. Indumento. Anatomia da lâmina. Vascularização da nervura central. Vascularização de pecíolos.

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INTRODUCTION

Within the Melastomataceae family *Miconieae* Triana is the large tribe, with approximately 2,200 species. This tribe includes genera with numerous species, such as *Leandra* Raddi and *Miconia* Ruiz & Pav. which are well represented in Brazilian savanna landscapes. Savannas have high environmental importance though low protection with under 0.3% in protected areas (Cervi *et al*., 2007). The *Miconieae* circumscription has recently changed, and Goldenberg *et al*. (2012) emphasize that these rearrangements need the support of morphological studies.

The leaf structure and its indumentum have been used as prominent features in the taxonomy of the Melastomataceae (Metcalfe & Chalk, 1957; Wurdack, 1986; Guimarães *et al*., 1999; Reis *et al*., 2005; Oliveira, 2007; Donato *et al*., 2018). In a comprehensive study of the leaf structure of the Melastomataceae, Reis *et al*. (2005) discussed that these characters are key elements for identification of *Leandra* and *Miconia*. These authors gave a valuable description of both genera, characterizing the leaves of *Leandra* species with ornamented cuticle, epidermis with emergences and non-glandular trichomes, palisade parenchyma little developed, and vascular bundle of arch-like shape (almost closed); the leaves of *Miconia*, on the other hand, differ about its palisade parenchyma, that are more developed, occuping 70% of the mesophyll, and the vascular bundle is an open arch.

The xeromorphic foliar structure may be correlated with either water stress or the absence of certain nutrients in the soil. In dry environments, leaves of some Eudicots may show an increase of cutinization and lignification, dense venation, trichome density, hypodermis, increase the quantity of sclerified cells and extensive development of palisade parenchyma (Dickison, 2000; Appezzato-da-Glória & Carmello-Guerreiro, 2013).

The species of *Leandra* and *Miconia* selected for study include plants that live in dry microhabitats. In this scope, the aims of this work were: (1) to summarize information about the leaf structural characters important for determination of species and genera; and (2) to identify leaf structural characters that prevent the loss of water to the environment.

MATERIAL AND METHODS

Three species of each genus (*Leandra* and *Miconia*), were selected for this investigation (Table 1). The species were collected in the Guartelá State Park, located in Tibagi, in the state of Paraná, Brazil (24° 34' South latitude, and 50° 14' West longitude) (IAP, 2002). The vegetation in the sampled areas is composed of woody grassy savanna, arboreous savanna and Araucaria forestry (Carmo, 2006). The vouchers were deposited at the Herbarium of Maringá State University (HUEM) (Table 1). Herbarium acronyms cited in the text follows Thiers (2019), continuously updated.

Leaves from the third to the seventh node were described morphologically, following Rizzini (1977)'s terminology. Leaf samples (petiole, and blade fragments - apical, middle and basal regions) were fixed in FAA_{50} and stored in 70% ethanol solution (Johansen, 1940). The material was imbibed in Leica historesin (following the manufacturer's instructions), and cross-sectioned (8 μm thick) on a rotary microtome according to the standard protocol of Guerrits & Horobin (1991). In addition, some sections were made manually, using a razor blade. The slides were stained in toluidine blue (O'Brien *et al*., 1964), and enclosed with coverslips and Entellan synthetic resin. Light microscope photographs were taken on Leica ICC50 digital camera, and subsequently processed using the software LAS 50. The presence of phenolic compounds in the leaf blade was evaluated with a solution of 3% ferric chloride (Kraus & Arduin, 1997), tested in the manual and microtomy cross sections.

The clearing technique for the study of venation (Foster, 1950) consisted of clearing in 5% NaOH, dehydration in successive grades of alcohol, and staining in safranin 1%.; photographs were taken on Leica Microscope

Table 1. Selected listing of species of *Leandra* Raddi and *Miconia* Ruiz & Pav. by genera (alphabetical order) with geographical location, plant habitat and vegetation type. Legends: HUEM= Maringá State University Herbarium; * = species identified by Dr. Renato Goldenberg of the Federal University of Paraná.

Species*	Access number	Geographical location	Habit	Vegetation
Leandra aurea (Cham.) Cogn.	HUEM 24939	24° 33' 56.8" S 50° 15' 27.2" W	Undershrub	Woody grassy savanna
L. polystachya (Naudin) Cogn.	HUEM 24944	24° 33' 48.2" S 50° 15' 18.1" W	Undershrub	Woody grassy savanna
L. sericea DC.	HUEM 24949	25° 13' 23.6" S 50° 02' 19.9" W	Undershrub	Close to shrubs and surrounding forest
Miconia albicans (Sw.) Triana.	HUEM 24943	24° 33' 43.0" S 50° 15' 26.5" W	Undershrub	Rocky outcrop (rupestrian vegetation refuge)
M. hyemalis A. St.-Hill. & Naudin	HUEM 24941	24° 33' 43.1" S 50° 15' 29.0" W	Undershrub	Woody grassy savanna
M. ligustroides (DC.) Naudin.	HUEM 24927	24° 34' 09.1" S 50° 15' 37.9" W	Shrubby	Close to other shrubs and riparian forest

Stereo EZ4D, and the venation pattern followed the Hickey (1979)'s terminology.

The scanning electron microscope (SEM) analysis was performed with glutaraldehyde 5% fixed material. After washing in 0.1 M sodium cacodylate buffer, leaf fragments were dehydrated in graded ethanol series, critical point drying with CO_2, mounted on aluminum stubs, coated with gold (Horridge & Tamm, 1969), and then analyzed under a Quanta 250 FEI. Blade indumentum were described according to Wurdack (1986)'s atlas of hairs.

RESULTS

We present morpho-and anatomical data of six species of the Miconieae tribe from the *Leandra* and *Miconia* genera. Selected morphological features such as leaf blade shape and venation are shown in Table 2. The main findings concerning the leaf anatomy of these Miconieae species have potential significance for the taxonomy inter and intra *Leandra* and *Miconia* genera. For example, the micromorphology of the indumentum, and the anatomy pattern of the petiole and the leaf blade are summarized in Table 3.

Table 2. Leaf morphological characters of the six Miconieae species.

Species	Leaf blade shape	Leaf margin	Leaf base	Venation	Areole
Leandra aurea	Lanceolate-ovate	Serrate	Cordate	Acrodromous basal perfect	Closed pentagonal/quadrangular
L. polystachia	Lanceolate-ovate	Crenate	Obtuse	Acrodromous basal perfect	Closed pentagonal/quadrangular
L. sericea	Lanceolate-ovate	Serrate	Cuneate	Acrodromous suprabasal perfect/imperfect	Closed triangular/quadrangular
Miconia albicans	Oblong-lanceolate	Crenate	Cordate	Acrodromous basal perfect	Closed pentagonal/quadrangular
M. hyemalis	Oblong-lanceolate	Toothed	Obtuse	Acrodromous basal perfect	Closed pentagonal/polygonal
M. ligustroides	Lanceolate	Entire	Cuneate	Acrodromous basal perfect	Closed quadrangular/pentagonal/ polygonal

Table 3. Leaf structural characters with taxonomic significance for *Leandra* and *Miconia*.

Characters	*L. aurea*	*L. polystachia*	*L. sericea*	*M. albicans*	*M. hyemalis*	*M. ligustroides*
Indumentum (adaxial face)	Hairy	Hairy	Hairy	Glabrescent	Glabrescent	Glabrous
Indumentum (abaxial face)	Hairy	Hairy	Hairy	Hairy	Hairy	Glabrous
Trichome density	Few dense	Few dense	Few dense	Dense	Dense	Glabrous
Trichome type	Conic non-glandular Dendritic	Conic non-glandular Mixed	Conic non-glandular	Vermiform	Vermiform	Absent
Non-glandular trichome types	Conic/Mixed/ Dendritic	Conic/Mixed/ Dendritic	Conic/Mixed/ Dendritic	Vermiform/Biseriate	Vermiform/Biseriate	Glabrous
Petiole						
Epidermis	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate
Cuticle	Thickened	Thin	Thickened	Thickened	Thickened	Thickened
Leaf blade structure						
Epidermis	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate
Cuticle	Relatively thin	Relatively thin	Thin	Thick	Thick	Thick
Palisade parenchyma	2-4 layers	2-3 layers	1-2 layers	2-3 layers	2 layers	3 layers
Number of vascular bundles of the midrib	Two bundles: a central of larger caliber, and 1-2 bundles of smaller dimension	Two bundles: a central of larger caliber, and 1-2 bundles of smaller dimension	Three bundles: wider central bundle and two smaller bundles	Single bundle	Single bundle	Two bundles: a central of larger caliber, and 1-2 bundles of smaller dimension
Venation	Dense	Dense	Few dense	Dense	Dense	Dense
Vein saliency	Well developed	Well developed	Comparatively less salient	Well developed	Well developed	Well developed
Presence of pores	No observed	No observed	No observed	Present	Present	Present

LEAF MORPHOLOGY

Leandra leaves have lanceolate-ovate shape (Figure 1A) while the *Miconia* leaves show slight variation among the species, with blade oblong-lanceolate in *M. albicans* (Figure 1B) and *M. hyemalis*, and lanceolate lamina in *M. ligustroides* (Figure 1C). In both genera the leaf apex is acute (Figures 1A-1C), but the margin is variable (Table 2). The venation type is acrodromous basal perfect in *Leandra* and *Miconia* (Figures 1A, 1B), but *L. sericea* has acrodromous suprabasal perfect/imperfect venation (Figures 1D, 1E). This type of venation consists of at least two primary or strongly developed secondary veins that form convergent arches toward the leaf apex and originate at the leaf basis (Figures 1A, 1B) or above it (Figures 1D, 1E) and the areoles are closed (Figure 1F) exhibiting quadrangular, polygonal and pentagonal shapes.

LEAF ANATOMY

Indumentum

The adaxial epidermis is hairy in *Leandra* species, glabrescent in *M. albicans* and *M. hyemalis*, and glabrous in *M. ligustroides* (Table 3). In the abaxial epidermis surface, all species have distinct types of trichomes, except the *M. ligustroides* leaf that is devoid of trichomes (Table 3).

Conic elongated roughened multicellular non-glandular trichomes occur in the three species of *Leandra* (Figures 2A, 2B, and 2D), with a rounded or slender prominent apex. These appendices are longer and more flexible in *L. sericea* leaves. Both glandular and non-glandular trichomes are found on the surface of *Leandra* leaves (Figure 2C); they are short- or long-stalked (*L. sericea*) with pointed thick-walled branches, and thin-walled glandular branches which may be multicellular (*L. aurea* and *L. polystachia*) or multicellular/unicellular (*L. sericea*) with a spatulate apex. Dendritic trichomes (Figures 2A, 3B) were also seen in the three species of *Leandra*, with glandular or non-glandular arms.

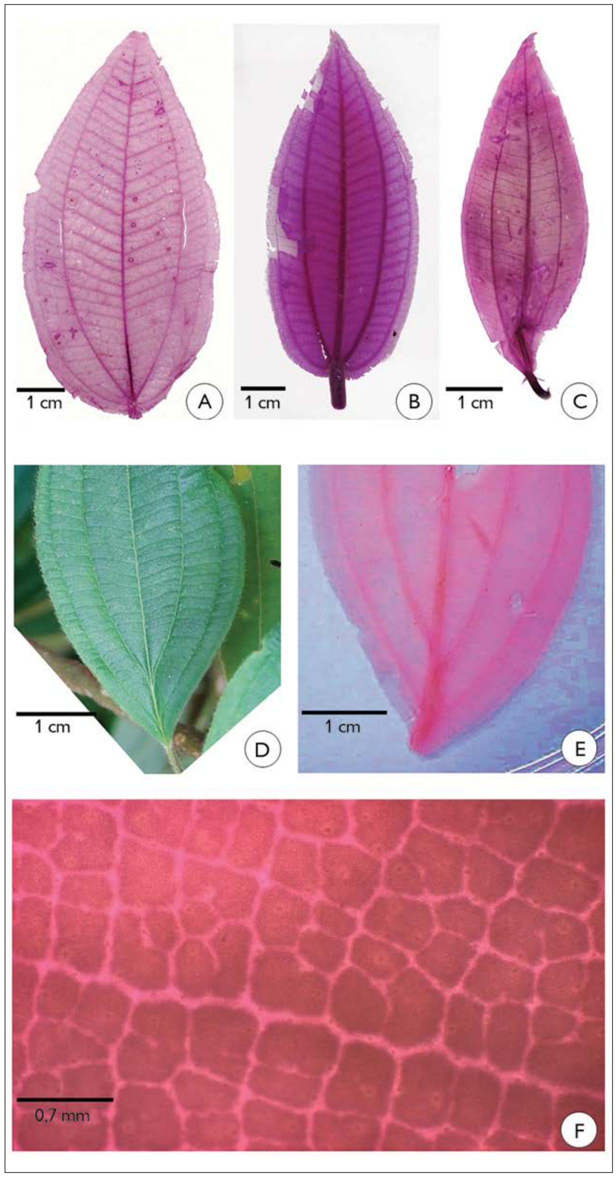

Figure 1. Leaf morphology of *Leandra polystachia* (A), *Miconia albicans* (B), *Miconia ligustroides* (C), *Leandra sericea* (D-E), and *Miconia hyemalis* (F), illustrating blade shape, apex, base and margin of the leaf, and venation/areole pattern. A-C) Leaves lanceolate-ovate, oblong-lanceolate and lanceolate, respectively, with acute apex; D-E) details of venation types, acrodromous suprabasal perfect and acrodromous suprabasal imperfect, respectively; F) quadrangular, polygonal and pentagonal closed areoles.

Vermiform trichomes (Figures 2E, 2F), that consist of four long and flexible tubular filaments, are common in the abaxial epidermis of *M. albicans* and *M. hyemalis*.

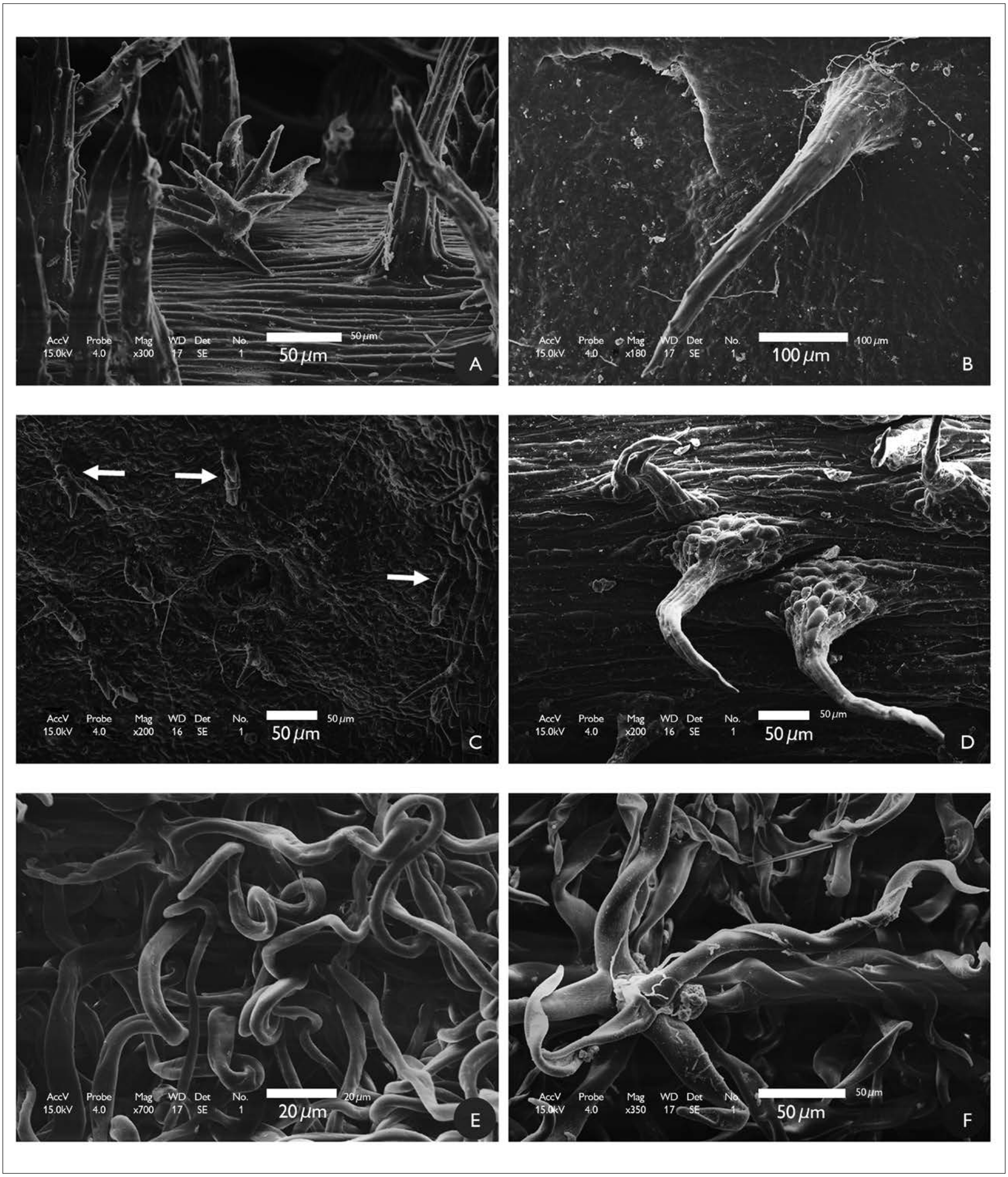

Figure 2. Scanning electron micrographs of the leaf epidermis of *Leandra aurea* (A), *Leandra polystachia* (B-C), *Leandra sericea* (D), *Miconia albicans* (E), and *Miconia hyemalis* (F), showing the different types of trichomes. A, B, D) Dendritic and conic elongated roughened multicellular non-glandular trichomes; C) trichomes of mixed structure (glandular and non-glandular) (arrows); and E-F) vermiform trichomes.

Petiole structure

The petiole consists of a uniseriate epidermis with a thickened cuticle (Figure 3A) unlike *L. polystachia* that has a thin cuticle (Figure 3B). All studied species exhibit trichomes (Figure 3B) except *M. ligustroides*. In *Miconia albicans* and *M. hyemalis* the petiole is densely pubescent (Figures 2E, 2F). The cortex, pith and interfascicular region of the petiole are conspicuously collenchymatized, but the parenchyma also occurs surrounding the vascular tissue (Figure 3B-3H). Sclereids and cells with druses are interspersed among the pith cells (see details in the Figures 3D-3F).

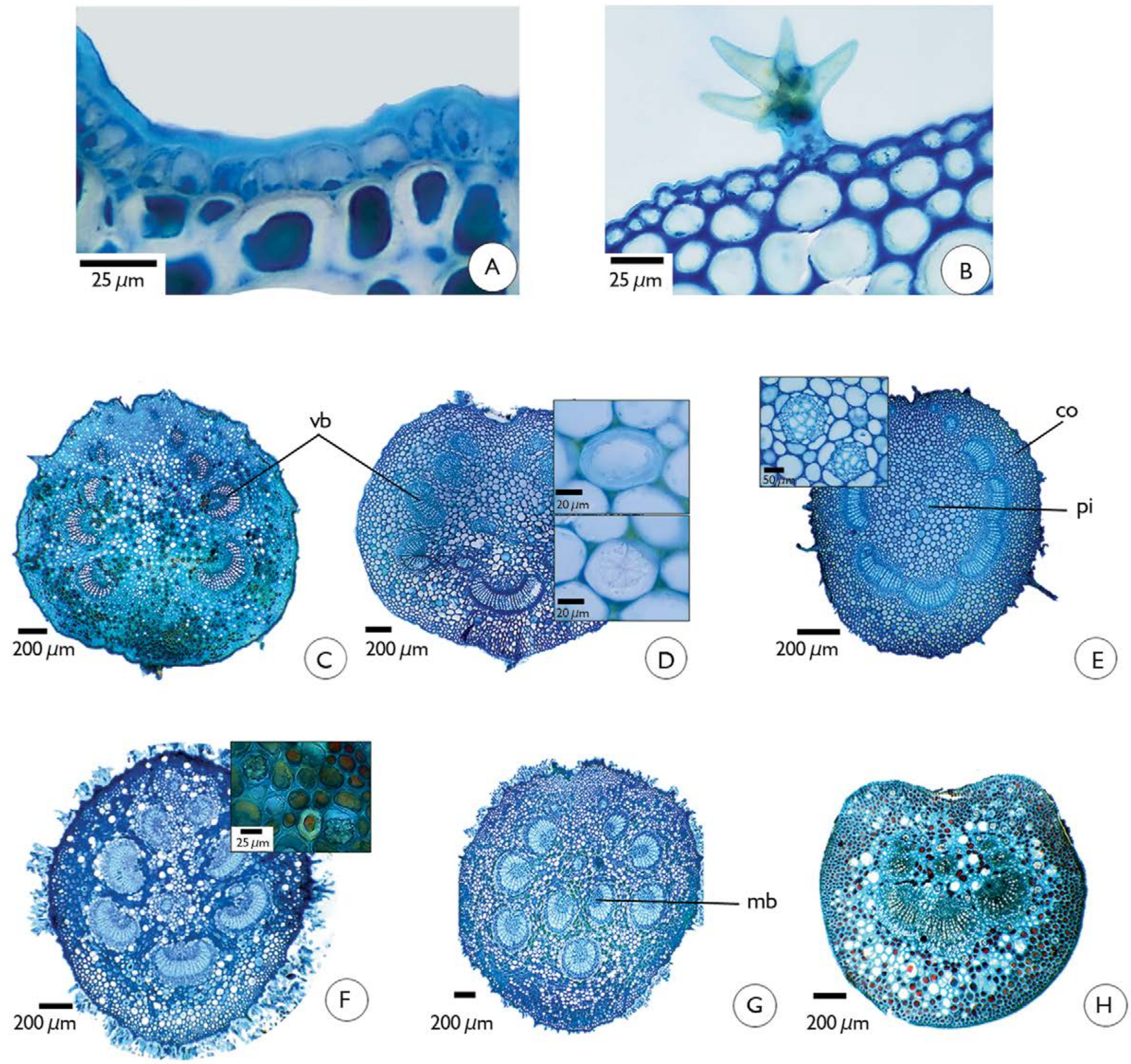

Figure 3. Petiole structure of *Miconia ligustroides* (A, H), *Leandra polystachia* (B, D), *Leandra aurea* (C), *Leandra sericea* (E), *Miconia hyemalis* (F), and *Miconia albicans* (G), in cross-sections. A, B) Shows details of the epidermis with thick and thin cuticles, respectively, and subepidermal collenchyma; C-H) petioles showing different number of vascular bundles; D-F) showing details of the pith with sclereids, druses and medullary bundles. Legends: co = cortex; mb = medullary bundles; pi = pith; vb = vascular bundle.

Both *Leandra* and *Miconia* species have a petiole vasculature composed of amphicribral bundles. The quantity and diameter of the vascular bundles varies among the six species (Figure 3). It is worth mention that one to four bundles were found in the pith tissue in both genera (Figures 3E, 3G).

Leaf blade structure

The leaf blade is made up of a uniseriate epidermis with a thin cuticle in *Leandra* (Figures 4A, 4B, 4H). In *Miconia* (Figures 4D, 4G) the epidermis has a thick cuticle. The leaves are hypostomatic in both genera. In *M. ligustroides,* the abaxial hypodermis is composed of one or two layers of parenchymatous cells with phenolic content (Figure 4D). The mesophyll is dorsiventral (Figure 4), with a varying number of palisade and spongy parenchyma strata. The palisade parenchyma consists of two to four thick cell-layers (Figures 4A, 4D-4H). However, *L. sericea* has only one single thick cell-layer (Figure 4B). The spongy parenchyma (Figure 4) also vary the number of layers of cells (from two to six), in which *L. polystachia* (Figure 4A) and *M. ligustroides* (Figure 4D) have more layers. Phenolic substances are common in the mesophyll of *Miconia* (Figures 4D-4G). Idioblasts with druses (Figures 4A, 4B, 4C, 4G) were observed in *Leandra* and *Miconia*'s mesophyll. The leaf margin is made up of parenchymatous cells with a rounded outline, except in *L. polystachia* and *M. ligustroides* (Figures 4G-4H) that also have collenchyma. The apical and middle regions of the leaf blade have a similar structural pattern for all species, varying in the palisade cells, that are wider in the *L. sericea* apex, and in the mesophyll of *M. albicans*, that is more homogeneous. Whereas significative structural variations were found in the basis of the blade, there are some differences: *L. aurea* has fewer layers of palisade parenchyma with wider cells; *L. sericea* has wider palisade cells; and *M. ligustroides* is devoid of the palisade and spongy parenchyma, with collenchyma and fundamental parenchyma.

Phenolic compounds

The search for phenolic compounds was performed in the leaves of the six studied species. The results were positive for the *Miconia* species and negative for *Leandra* ones. *Miconia hyemalis* showed high concentrations of phenolic compounds in the parenchyma, veins, and the extension of the bundle sheath (Figure 4I); *M. ligustroides* had higher concentrations of these compounds in the parenchyma layers close to epidermis (Figure 4J); and in the *M. albicans* leaf blade phenoloic compounds occurred in the palisade parenchyma and the veins (Figure 4K).

Veins

The midrib (Figures 5A-5F) consists of the epidermis, subepidermical collenchyma, parenchyma interspersed with druse idioblasts and fibers, and vascular bundles which may be either collateral (U-shaped, V-shaped or circular) or amphicribral concentric. Significant structural features in the midrib (middle region of the blade) are the quantity and the diameter of the vascular bundles, namely a single bundle (*M. albicans* and *M. hyemalis*) (Figure 5C). *Leandra aurea*, *L. polystachia* and *M. ligustroides* were characterized by two-three bundles. The central bundle was of larger diameter with one-two smaller bundles located in the adaxial face of the midrib (Figure 5A). *Leandra sericea* had three vascular bundles: a wider central bundle and two smaller bundles in the adaxial face of the midrib (Figure 5B). In addition, for all species, the basis of midrib (Figure 5E) consists of several vascular bundles that have about the same structural pattern of the petiole. All species have a single bundle in the apex of the midrib (Figure 5F). Veins of smaller diameter may show the bundle-sheath extension on the adaxial side, as seen in *Miconia ligustroides* (Figure 4E).

Xeromorphic leaf structure

The analysis of the six Miconieae species, including chiefly woody grassy savanna specimens, exhibits some characters that may be related to water stress. The analyzed characters of *Leandra* and *Miconia* that may be related to the xeromorphy (Table 3) are the trichome density (Figures 6A, 6B), a hypodermis with one or two layers of cells in *M. ligustroides* leaf (Figure 4C), and the extensive development of palisade parenchyma (2-4 layers) in almost all analyzed species. Among these characters, it is worth noting that the pores in the adaxial surface (Figures 6C, 6D) may be associated to hygroscopic properties because they are surrounded by thick-walled and non-lignified cells that maintain contact with veins and bundle-sheath extensions (Figure 4E).

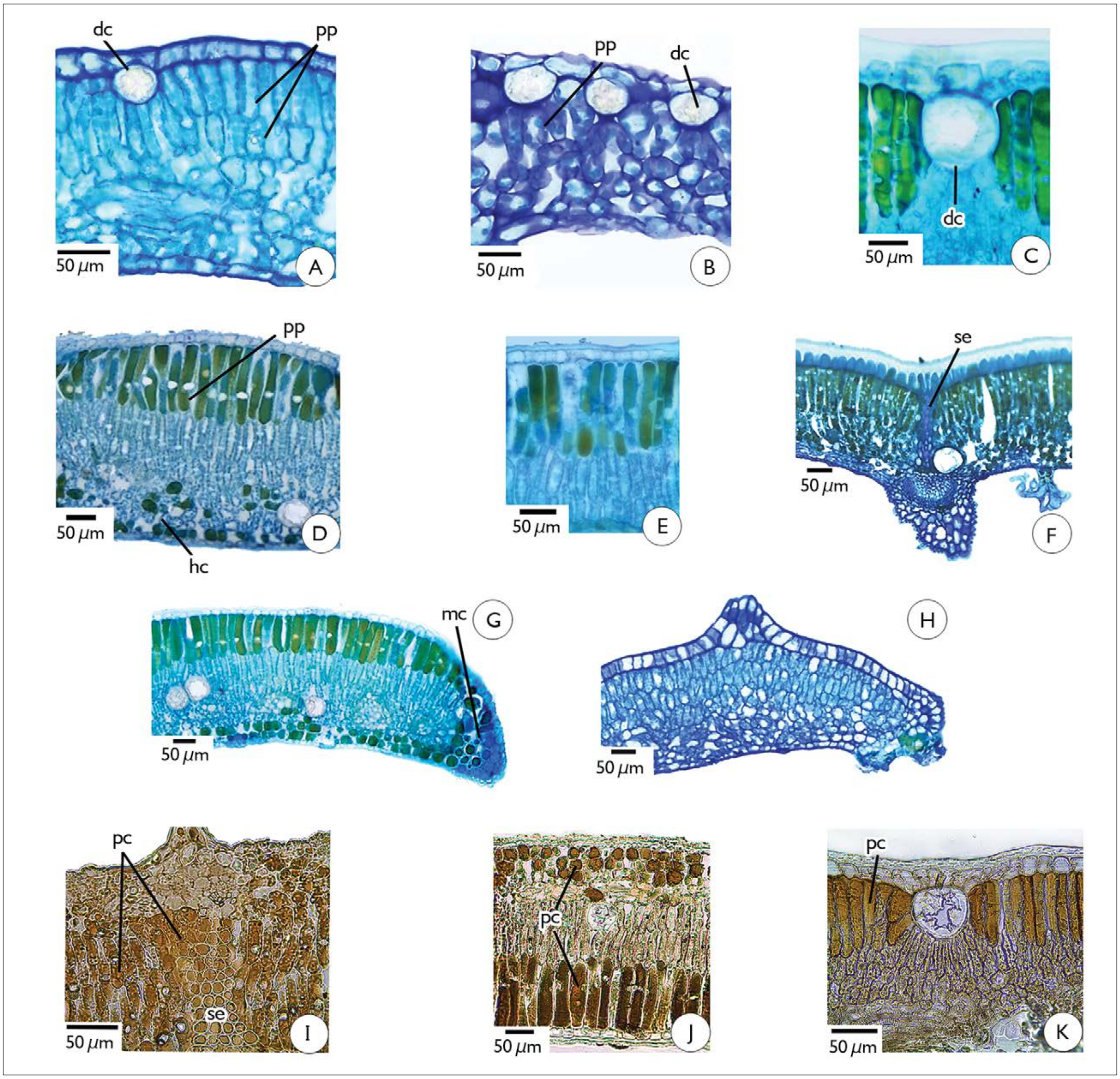

Figure 4. Leaf blade structure of *Leandra polystachia* (A, H), *Leandra sericea* (B), *Miconia albicans* (C), *Miconia ligustroides* (D, G), and *Miconia hyemalis* (E) in cross-sections showing dorsiventral mesophyll, hypodermis, bundle-sheath extension, and leaf margin with collenchymatous cells. Cross sections of leaf blades of *M. hyemalis* (I), *M. ligustroides* (J), and *M. albicans* (K) show the phenolic compounds stained in dark brown. Legends: dc = druse cells; hc = hypodermal cells; mc = leaf margin with collenchyma; pc = phenolic content; se =bundle-sheath extension.

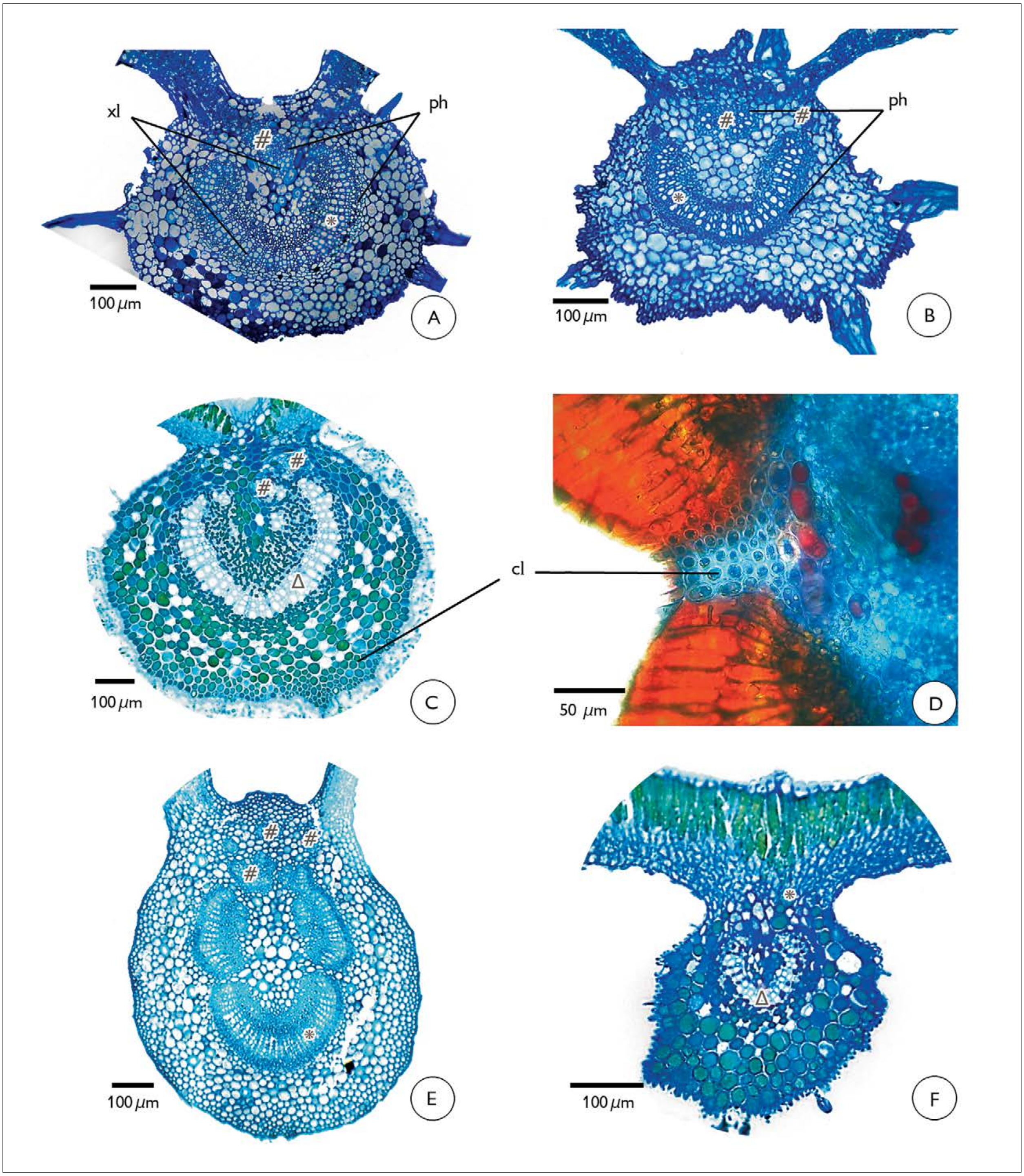

Figure 5. Midrib structure of *Leandra aurea* (A, E), *Leandra sericea* (B), *Miconia albicans* (C, F), and *Miconia hyemalis* (D) in cross-sections. A-C) Middle region of the blade; D) detail of the collenchyma in the adaxial surface of the midrib; E-F) sections made in the base and apex of the midrib, respectively. Legends: cl = collenchyma; ph = phloem; xl = xylem; **#** = circular vascular bundles; * = U-shaped vascular bundles; Δ = V-shaped vascular bundles.

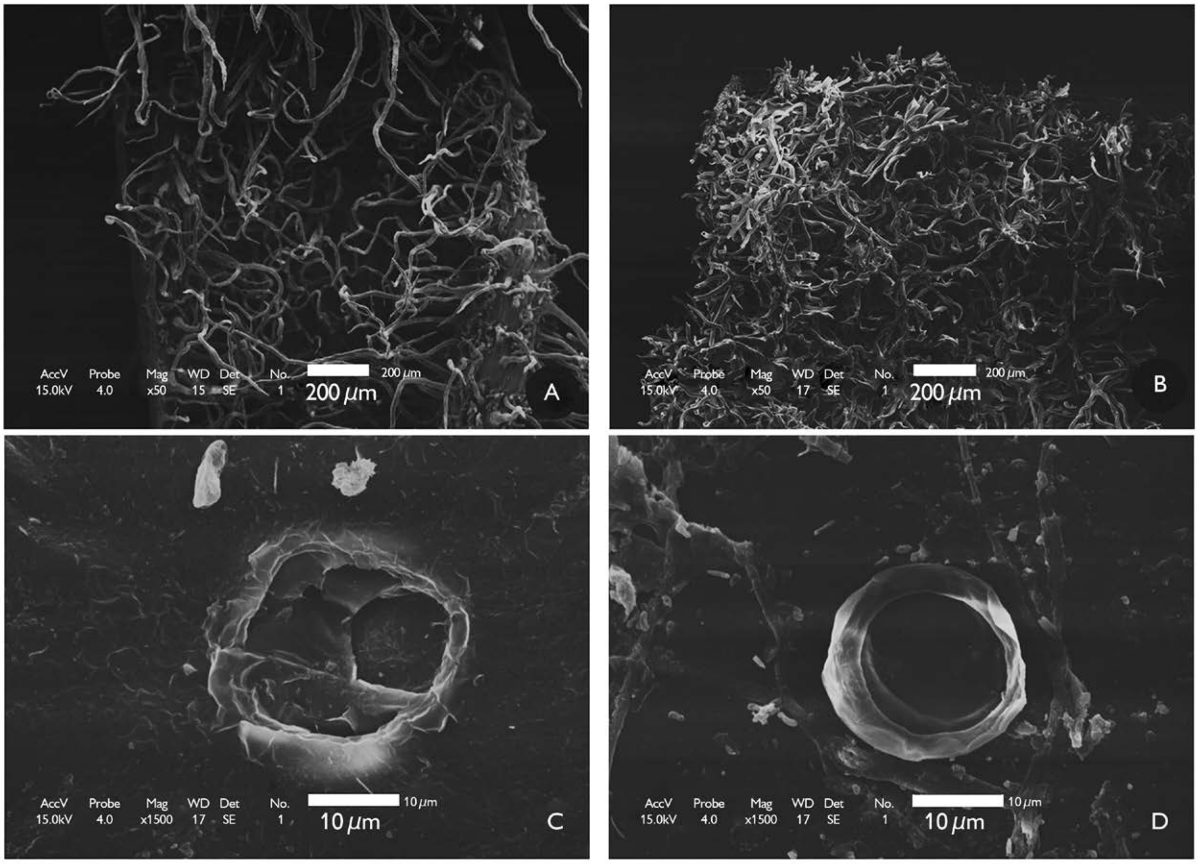

Figure 6. Scanning electron micrographs of the leaf epidermis of *Leandra aurea* (A), *Miconia hyemalis* (B, C), and *Miconia albicans* (D), evidencing trichome density (A, B) and adaxial surface pores (C, D).

DISCUSSION

Almost all the species of *Leandra* and *Miconia* investigated herein have leaf indumentum. The conic multicellular non-glandular trichome-like structures of *Leandra* were described by Wurdack (1986) as a trichome or hair. However, Uphof (1962) and Evert (2013) gave a valuable distinction between trichomes (hairs) and emergences according to their origins. Trichomes originate exclusively from epidermal cells while emergences arise from both epidermal and subepidermal cells. In the *Leandra* trichomes, mainly in *L. sericea*, the presence of collenchyma was observed in the base of the trichome, suggesting that this tissue arises from cells immediately subjacent to the epidermis. On the other hand, Evert (2013) states that the distinction between trichomes and emergences is not sharp, because some trichomes are elevated upon a base consisting of subepidermal cells. Therefore, an ontogenetic study is necessary to determine whether the mentioned structures are epidermal in origin or they are originated from both epidermis and cells beneath the epidermis.

Melastomataceae indumentum is of interest for species classification (Wurdack, 1986). Conic elongated roughened multicellular non-glandular trichomes were found in the three *Leandra* species. Vermiform trichomes were only seen in the *Miconia* species. Other trichomes, less frequent in the analyzed species, may be important for species separation within the genera, for instance, the trichome morphology of mixed structure seen in *Leandra* species.

All species herein investigated have petioles consisting of an arc of several vascular bundles. The arrangement of these bundles may be used for species identification in both genera. Metcalfe & Chalk (1957) stated that the petiolar vascular structure would be of considerable diagnostic value if better known. Stem medullary bundles, for instance, which occur in 71 genera of Melastomataceae (Metcalfe & Chalk, 1957), are also recorded in the petioles of *Miconia* and *Leandra*, with a variable number of bundles. Despite the different numbers of medullary bundles found in the genera studied herein, this condition seems to us an unreliable taxonomic character. Further analysis in more species of the family is necessary to determine its classification value.

The leaf structural features are of interest for separating species in the *Leandra* and *Miconia* genera. The characters related to the indumentum morphology, presence or absence of pores in the leaf surface, mesophyll structure and vascular tissue of midrib are of particular interest. Differentiation between the *Leandra* and *Miconia* genera based on certain leaf anatomical features has already been discussed by Reis *et al*. (2005). These authors concluded that the *Leandra* species have emergences, little developed palisade parenchyma, and a midrib with the main vascular bundle of an almost closed-arch shape. Conversely, the *Miconia* are devoid of emergences, the palisade parenchyma is usually well developed, and the vascular bundles are arranged in open-arch shape. Our results confirm that the main anatomical differences between genera are related to the occurrence of emergences in *Leandra*.

In *Leandra* and *Miconia* species herein examined, we found some leaf structural features that may be considered xeromorphic, such as strongly cutinized outer epidermal walls, adaxial surface pores, dense venation, trichome density, extensive development of palisade parenchyma, and depressions in the blade surface. We noted that the *Leandra* and *Miconia* species that live in woody grassy savanna are species with divergent specializations. The *Leandra* species have a smaller number of specialized structures for reduction or compensation of water loss while the *Miconia* species, except for *M. ligustroides* (that has shade leaves or lives near the riparian forest), have a larger diversity of adaptation strategies for survival in *habitats* where the supply of available water is deficient. *Leandra* and *Miconia* are probably drought-evading species, plants able to reduce or compensate for water loss, according to the Dickison (2000)'s classification, with one specialized structural feature or a set of features.

CONCLUSION

Leaf indumentum and petiole structure features are important evidence for separation of species of *Leandra* and *Miconia*. These genera include species (except the riparian *M. ligustroides* which have leaves exposed to shade) that exhibit some specialized leaf features that may be able to reduce water loss.

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Extração e caracterização de amido de espécies de *Dioscorea* cultivadas na Amazônia

Extraction and characterization of starch from *Dioscorea* species cultivated in the Amazon

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Resumo: Considerando-se o desenvolvimento de produtos utilizando matéria-prima regional, foram extraídos e caracterizados os amidos de *Dioscorea alata* L. e *D. altissima* Lam. Os parâmetros analisados foram rendimento, composição, morfologia e tamanho dos grânulos, composição físico-química, propriedades tecnológicas, toxicidade *in vitro* e análise microbiológica. Rendimento significativo (8,57%) foi observado em *D. altissima*. Amido disponível (75,02%), total (84,63%) e amilose (19,15%) foram maiores em *D. alata*. Amido resistente (10,10%) e amilopectina (82,09%) foram superiores em *D. altissima*. O pH e a acidez não variaram entre as amostras. A atividade de água foi menor em *D. alata*. Baixos teores de umidade, cinzas, lipídios, proteínas, fibras e alto conteúdo de carboidratos foram determinados. Os amidos não apresentaram citotoxicidade e nem contaminação microbiana. Os grânulos do amido de *D. altissima* são esféricos e significativamente maiores. Nos amidos de *D. alata* e de *D. altissima*, predominam, respectivamente, macro e microminerais. Absorção de água (85,73 g 100g^{-1}), óleo (67,13 g 100g^{-1}), estabilidade da espuma (100%) e claridade da pasta (2,87%) foram maiores em *D. alata*. A capacidade de inchamento (4,07 g g^{-1}) e a densidade aparente (0,87g mL^{-1}) foram superiores em *D. altissima*. Os amidos estudados possuem propriedades tecnológicas com potencial para a indústria de alimentos e para a produção de embalagens.

Palavras-chave: Grânulos. Inhame. Propriedades tecnológicas. Tubérculos.

Abstract: Considering the development of products using regional raw materials, the starches of *Dioscorea alata* L. and *D. altissima* Lam. were extracted and characterized. The parameters analyzed were: yield, composition, morphology and size of the granules, physicochemical composition, technological properties, *in vitro* toxicity, and microbiological analysis. A significant yield (8.57%) was observed in *D. altissima*. Available starch (75.02%), total (84.63%) and amylose (19.15%) were higher in *D. alata*. Starch resistant (10.10%) and amylopectin (82.09%) were superior in *D. altissima*. pH and acidity did not vary between samples. Water activity was lower in *D. alata*. Low moisture, ash, lipid, protein, fiber, and high carbohydrate contents were observed. The starches did not present cytotoxicity or microbial contamination. The granules of *D. altissima* starch are spherical and significantly larger. In *D. alata* and *D. altissima* starches, macro- and microminerals are predominant, respectively. Water absorption (85.73 g 100 g^{-1}), oil (67.13 g 100 g^{-1}), foam stability (100%), and pulp clarity (2.87%) were higher in *D. alata*. The swelling capacity (4.07 g g^{-1}) and bulk density (0.87 g mL^{-1}) were higher in *D. altissima*. The studied starches have technological properties with potential for the food industry, medicines and packaging.

Keywords: Granules. Yams. Technological properties. Tubers.

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