INTRODUCTION

Galactia P. Browne, is a cosmopolitan genus, comprises about 50 species, distributed in tropical, subtropical and warm temperate zones especially in America, also Asia and Africa (Burkart, 1952). The plants vary in habit from perennial herbaceous climbing plants to shrubs (Burkart, 1971) and occupy a diversity of habitats: forests, savannas, hilly environments with poorly developed soils and rocks.

The genus Galactia is divided into 3 Sections: Odonia, Galactia and Coliaearia (Burkart, 1971), the differences were established by the following characters: the habit, the number of leaflets per leaf, the underground organs (roots, rhizomes and xylopodia), and flowers characters like: the flower...
size, the petals' width, the degree of stamens cohesion, etc.

Torres et al. (1983) described some anatomical characters (epidermal cells and stomata number/leaf surface, trichomes, palisade and spongy parenchyma, areoles, etc.) indicating that those characters are of taxonomic importance in Galactia species of Venezuela (G. dubia, G. latisiliqua).


It is extremely difficult to distinguish some of the species because they are morphologically very similar.

In Argentina, a study of leaf anatomy (G. latisiliqua, G. marginalis and G. glaucophylla) as a complement to growth form studies (Bacsonuelo et al., 1997), focused only on xeromorphic features, was recorded.

The present paper provides a description of anatomical characters in Argentine Galactia species as well as an assessment of their taxonomic and ecological significance.

**MATERIAL AND METHODS**

The samples (adult leaves) were collected from plants (10 species) within their distribution areas and from living plants obtained from seeds and grown at “Lucien Hauman” Botanical Garden, Faculty of Agronomy, Buenos Aires (34° 35’S, 58° 29’W), Argentina, since 1995 to 2000. Field material was fixed and stored in FAA. No material was available from four species: G. dubia, G. longifolia, G. martioides and G. pretiosa var. pretiosa.

Whenever possible, at least three specimens were sampled for each taxon. Mature terminal leaflets were selected for clearing and terminal-lateral leaflets for micromtome sectioning.

Samples for permanent slides were dehydrated in ethyl series, embedded in paraffin wax, serially sectioned with a rotary microtome. The 10-15 µm thick transverse sections (median region of the leaflets) were stained with a safranine-fast green combination (D’Ambrogio, 1986) and mounted in Canada balsam.

To study epidermal tissues and venation, leaves were cleared in 5% NaOH and alcohol 96° solution (1:1, v/v) for 5 min at 90°C, bleached in sodium hypochlorite (50%, v/v) for 10 min, washed with distilled water and stored in Chloral hydrate (25%, w/v) until needed, and then were mounted in glycerin-jelly (Dizeo de Strittmatter, 1973). The leaves architecture was described following Hickey (1973).

The material was observed and drawn with a Wild M20 microscope. Photomicrographs and respective scales were taken on a Zeiss photomicroscope.

Supplementary studies were carried out on herbaria vouchers (BAA, SI, M, CITES).

The specimens marked with*, represent herbaria vouchers (BAA) of cultivated plants at the Faculty of Agronomy (See Appendix). The herbaria are cited sensu Holmgren et al., 1990 (Index Herbariorum).

**RESULTS**

**General leaf morphology**

Phyllotaxis is generally alternate. The leaves are trifoliolate, except in G. benthamiana, G. marginalis and G. boavista, where the absence of the two basal leaflets determines a pseudo-single leaf.

**Venation**

The leaves venation is brochdodromous with pentagonal areoles and linear veinlets (Fig. 2 A).

**Leaf anatomy -mesophyll and veins structure-**

In general the dorsiventral mesophyll formed by 1-3 rows of palisade parenchyma and 1-2 spongy parenchyma cell layers with abundance of chloroplasts (Fig. 1 A & C). Central layers of mesophyll occupied by cells containing less chlorophyll, and often filled with tanniferous contents (Fig. 1 C), which are coloured brown in dried material. The palisade cells sometimes present crystals, mostly solitary, rhomboedral or styloid (rod-shaped crystals) in shape.

The midveins of all species –except G. boavista (Fig 1 B)-consisting of a single vascular strand (Fig.
1 C & D) with a non-photosynthetic parenchymatic tissue and a group of fibers (sclerenchyma). This parenchyma often presents cells with rhomboedral (Fig. 1 D) or styloid crystals. A group of a few cells of collenchyma is present in the vein rib on both sides of the vein beneath the epidermis (Fig. 1 D).

The leaves of *G. glaucophylla* (Fig. 1 C), *G. marginalis* (Fig. 1 A) and *G. texana* (Fig. 1 D) present abundant fibers surrounding the midvein and the small vascular bundles. *G. marginalis* presents conspicuous sclerenchyma at the marginal vein (Fig. 1 A).

An annular arrangement of opposite bundles surrounding a pith-like tissue occurs in the midvein of *G. boavista* (Fig. 1 B). The ground tissue has mucilaginous-tanniferous idioblasts (Fig. 1 B). An important hypodermis is observed at the main vein beneath the epidermis, at both sides of the leaf (Fig. 1 B).

**Epidermis and stomata**

**Epidermal cells**

*Transverse section.* Cuticle well developed, variable in thickness (4.2 µm to 1.05 µm). *G. marginalis* (Fig. 1 A) and *G. texana* show the most thick ones (Fig. 1 D).

Cells uniseriate, irregularly shaped. Vacuoles often containing tanniferous substances (Fig. 1 B), specially observed in voucher materials.

*Surface view.* Amphistomatic leaf, with lower density of stomata at upper surface. Cells polygonal, 4-many sided, straight-walled (adaxial) and undulate-walled (abaxial) (Fig. 2 B & C).

**Stomatal complex**

*Transverse section.* Stomata dispersed randomly over adaxial surface, at same level of other epidermal cells (Fig. 1 C).

*Surface view.* Stomata anisocytic surrounded by 2-3 subsidiary cells (Fig. 2 C).

**Foliar trichome types and lithocysts**

Both epidermis present non glandular uniseriate trichomes with a variable (1-2) number of short basal cells and an elongated terminal cell (Fig. 2 C) and glandular trichomes (club-shaped) formed by 8-12 cells with a short stalk (Fig. 2 B). Abaxial surface trichomes often conspicuous (Fig. 2 B).

Our results are useful to prepare a key to the species, mainly based on the midrib structure.

**Key to the species**

A. Unifoliolate leaves

B. Midvein with an annular arrangement of several bundles surrounding a pith-like tissue. Perivascular fibers present.

   BB. Midvein with a single collateral vascular bundle

   C. Midvein with a non-photosynthetic parenchyma around the bundle.

   CC. Midvein with sclerenchymatic tissue well developed (inner) and paren-chyma (outer) around the bundle.

AA. Trifoliolate leaves

D. Midvein with a layer of no photosynthetic parenchyma (endo-dermis)

   E. With perivascular fibers

   F. Perivascular fibres borde-ring phloem tissue, paren-chyma tissue bordering xylem

   FF. Perivascular and xylary fibers

   G. With no-photosynthetic parenchyma extension

   GG. Without parenchymatic extension. *G. texana* (Fig. 3 F)
EE. without perivascular fibers

**G. latisiliqua** (Fig. 3 G)

DD. Midvein with sclerenchymatic tissue well developed (inner) and parenchyma (outer) around the bundle.

H. Midvein with narrow parenchymatic tissue without extensions. With perivascular fibers

**G. striata** (Fig. 3 H)

HH. Midvein with sclerenchymatic tissue well developed and extension to adaxial epidermis

I. Parenchyma tissue with idioblasts cells absents.

**G. neesi** (Fig 3 I)

II. Parenchyma tissue with idioblastic cells present

**G. glaucophilla** (Fig. 3 J)

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**DISCUSSION**

The foliage leaves of the following species, *G. benthamiana*, *G. boavista*, *G. fiebrigiana*, *G. glaucophylla*, *G. latisiliqua*, *G. marginalis* and *G. texana*, present epidermal cells with thin cuticle, and abundant trichomes, most fibers and clear dorsiventral mesophyll with high accumulation of crystals. (Fahn & Cutler, 1992). Most of these anatomical leaf features are associated with xeromorphy, and represent a defense against herbivory (Solbrig & Orians, 1977).

Basconsuelo *et al.* 1997, remarked these xeromorphic characters in *G. glaucophylla*, *G. latisiliqua*, *G. marginalis* and *G. texana*, and a reduction of the leaf blade. The leaf blade reduction is more important in *G. glaucophylla* and *G. marginalis*. The latter species occur in hilly environments, in rock fissures or in poorly developed sandy to gravel soils.

The anatomical features are not useful to define the Section Odonia species. All species have dorsiventral mesophyll, with subepidermal chlorenchyma, dense palisade below the adaxial epidermis and spongy one over the abaxial one. A single collateral bundle (midrib) surrounded by a parenchyma tissue and fibers, connecting the parenchyma with less collenchyma to the adaxial epidermis.

**G. boavista**, from Section Collaearia presents differences with the otherspecies midribs. An annular arrangement of opposite bundles surrounding a pith-like tissue occurs in the midvein of *G. boavista*. This structure was cited by (Metcalfe & Chalk, 1950), in other tribes of Fabaceae.

Further studies must be performed in other members of the same section.

Most leaves in tribe *Phaseoleae* are pinnately trifoliolate. The lateral leaflets are sometimes absent, producing an unifoliolate leaf, in what seems a random selection across the spectrum of the tribe (Lackey, 1978, 1983). Occasional specimens or species in genera which are essentially trifoliolate have more or less than three leaflets (eg. *Handerbergia*, *Rynchosia* including *Galactia* (Lackey, 1983; Burkart, 1971).

In the monography about genus *Galactia* (Burkart, 1971), specimens with reduced basal leaflets are mentioned (eg. *G. benthamiana* Pedersen 5463, *G. dubia* Burkart 13.126) and *G. martii* with more than three leaflets.

The development of leaves (simple or compounds) is defined by the activity of several meristems provided by the shoot meristem. A group of genes is expressed to define the leaf morphology (Hofer & Ellis, 1998; Sinha, 1999; Chen *et al.*, 1997). These genes and their interactions, rule the variation rate from simple to compound leaves (Hofer & Ellis, 1998; Marx, 1987).
**Fig. 1.** A-D: Leaf and leaflets transverse section of *Galactia* species.


**Fig. 2.** A-C: Clarified leaves of *Galactia* species.

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CONCLUSIONS

We exhibit the importance of the transverse sections of main vascular bundles, due to their anatomical characters can be considered of taxonomic diagnostic value in the Galactia argentine species. We identified main vein 10 types, each for every species analyzed.

The blade reduction, the increase of sclerenchymatous tissue (sheath fibers, fibers by collenchyma as supporting tissue, perivascular fibers) are interpreted as a sequential increase in xeromorphism. These adaptive strategies associated with geographical distribution, can clearly be illustrated at species level (G. glaucophylla, G. neesi, G. boavista).

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APPENDIX