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A contribution to the identification of vegetative Andean woody bamboos in southernmost America using leaf anatomy[1]

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Guerreiro C., Z. E. Rúgolo de Agrasar, and M. F. Rodríguez (Instituto de Botánica Darwinion, Labardén 200, CC 22, B1642HYD, San Isidro, Buenos Aires, Argentina). A contribution to the identification of vegetative Andean woody bamboos in southernmost America using leaf anatomy. J. Torrey Bot. Soc. 140: 259–268. 2013.—*Chusquea* Kunth and *Rhipidocladum* McClure species (Poaceae, Bambusoideae, Bambuseae) are the only two genera of woody bamboos whose distributions reach the southernmost portion of the Andes mountain range. The identification of woody bamboos relies mainly on vegetative characters. In the present work, foliage leaf blade anatomy of Andean woody bamboo species occurring in Argentina and neighboring areas is described. Eight species are surveyed: *Chusquea culeou* E. Desv., *C. deficiens* Parodi, *C. lorentziana* Griseb., *C. montana* Phil., *C. quila* Kunth, *C. valdiviensis* Phil., *Rhipidocladum neumannii* Sulekic, Rúgolo & L. G. Clark and *R. racemiflorum* (Steud.) McClure. Leaf blade abaxial epidermal and cross section characters of each species are described and an identification key based on anatomical characters is provided. Anatomical evidence that support the idea of *C. quila* and *C. valdiviensis* as different species is presented and information on useful characters to distinguish between them is provided. Also, taxonomic position of *R. neumannii* is determined based on anatomical features. Finally, the taxa studied are compared in tables based on leaf anatomical characters of taxonomic value.

Key words: abaxial epidermis, cross section characters, foliage leaf blade.

Bamboos occur naturally in tropical and temperate regions worldwide. Neotropical woody bamboos are distributed nearly continuously throughout Central and South America. In the Andean montane forest, bamboo is usually found along forest edges, steep ravines and "páramo" regions. Also, woody bamboos are well known as understory dominants in Andean-Patagonian beech forests of Argentina and Chile (Judziewicz et al. 1999).

Six genera of woody bamboos occur in the Andes: *Arthrostylidium* Rupr., *Aulonemia* Goudot, *Chusquea* Kunth, *Elytrostachys* McClure, *Guadua* Kunth and *Rhipidocladum* McClure, with an estimated 130 species. Three of these genera, *Aulonemia*, *Chusquea* and *Rhipidocladum,* are Andean-centered, in each case 40–75% of the species occur in the Andes (Clark 1995, Fisher et al. 2009). And only two, *Chusquea* and *Rhipidocladum*, reach the southernmost portion of the Andes. According to Renvoize (1998), Judziewicz et al. (2000), Morrone et al. (2008), Guerreiro and Rúgolo (2012) and Rúgolo and Vega (2012), approximately 18 species of woody bamboos occur in the austral Andes of Argentina, southern Bolivia and Chile, and all of them are endemic with a single exception (see below).

Chusquea Kunth is the most diverse bamboo genus in the world; it comprises an estimated 160 species (Bamboo Phylogeny Group 2012). The genus is defined by bipapillate subsidiary cells in the foliar stomatal complexes in addition to its uniform spikelet structure comprising four glumes, one female-fertile floret and the absence of a rachilla extension (Clark 1997, Fisher et al. 2009). Primarily montane, it is distributed from Mexico to Argentina and Chile, and from 0 to over 4000 m above sea level. The species of *Chusquea* are often significant, sometimes dominant, components of montane forest and high-altitude grassland vegetation, where they can be aggressive colonizers (Judziewicz et al. 1999).

Rhipidocladum McClure species grow from northeastern Mexico to northwestern Argentina, in humid forests or on forests margins at elevations from near sea level to 2900 m (Judziewicz et al. 1999). There are 19 described species. *Rhipidocladum racemiflorum* (Steud.) McClure is a widespread and somewhat

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polymorphic species that ranges from central Mexico down to northwestern Argentina but otherwise the species tend to have fairly restricted distributions (Clark 1995).

Parodi (1941) reviewed the species of *Chusquea* from Argentina, describing two new species, *C. deficiens* Parodi and *C. argentina* Parodi, which was later considered a synonym of *C. culeou* E. Desv. (Judziewicz et al. 1999). Sulekic et al. (1999) reviewed the genus *Rhipidocladum* for Argentina, describing a new species, *R. neumannii* Sulekic, Rúgolo & L. G. Clark, for northwestern Argentina and southern Bolivia.

In Argentina, Andean woody bamboo species occur in two distinct areas:

1- The high montane forest in northern Argentina known as ''Yungas''. This ecosystem forms the southern end of a strip of montane forest that runs along the Andes of South America. Here, *Chusquea deficiens* Parodi, *C. lorentziana* Griseb., *Rhipidocladum neumannii* Sulekic, Rúgolo & L. G. Clark and *R. racemiflorum* (Steud.) McClure occur (Guerreiro et al. 2011, Guerreiro and Rúgolo 2012, Rúgolo and Vega 2012).

2- The Andean-Patagonian beech forest of southern Argentina. The only genus present in this area is *Chusquea* with three species: *C. culeou* E. Desv., *C. montana* Phil. and *C. valdiviensis* Phil. (Guerreiro and Rúgolo 2012).

Foliar anatomy of woody bamboos from southern South America is barely known, despite the fact that identification of woody bamboos is mainly based on vegetative characters, since flowers are seldom available (Judziewicz et al. 1999). Freier (1941) studied leaf blade anatomy of six species of *Chusquea* from Argentina. Matthei (1997) described the foliar anatomical characters of six species of the genus *Chusquea* growing in the X Region of Chile. Regarding *Rhipidocladum*, the information available is only at the generic level (Soderstrom and Ellis 1987, Clark and Londoño 1991). Preliminary results of this work were presented in an international congress (Guerreiro et al. 2010).

In the present work, foliage leaf blade anatomy is described for the Andean woody bamboo species occurring in Argentina and neighboring areas: *Chusquea culeou* E. Desv., *C. deficiens* Parodi, *C. lorentziana* Griseb., *C. montana* Phil., *C. valdiviensis* Phil., *Rhipidocladum neumannii* Sulekic, Rúgolo & L. G. Clark and *R. racemiflorum* (Steud.) McClure. Epidermal and cross sections characters are described and illustrated in order to enhance the current descriptions of the species and identify characters of taxonomic value, to be used in the determination at genus and/or species level. In this study, we will also include *Chusquea quila* Kunth since its presence in Argentina is not clear (Parodi 1945, Zuloaga et al. 1994, Judziewicz et al. 2000, Morrone et al. 2008, Guerreiro and Rúgolo 2012).

Materials and Methods. For the study of leaf anatomical structure of woody bamboo species, herbarium material from SI (Thiers 2012) and material preserved in alcohol 70% were used. The middle portion of foliage leaf blades was used. For epidermal studies, small fragments of foliage leaves were placed in glass tubes with xylol and exposed to ultrasound for approximately 2 hours to eliminate superficial wax and impurities. The material was dehydrated and coated with gold-palladium. Photomicrographs of leaf abaxial epidermis were obtained using a scanning electron microscope Philips XL30 TMP at the Museo de Ciencias Naturales ''Bernardino Rivadavia'' in Buenos Aires, Argentina. The following superficial characters were observed: ribs and furrows, long cells, papillae, stomatal apparatus, silica bodies, prickle hairs, microhairs and macrohairs (Ellis 1979, Rúgolo de Agrasar and Rodríguez 2002).

In order to obtain foliage leaf cross sections, the herbarium material was boiled in water with commercial use detergent for several minutes before making the cuts. The applied methods included complete cross sections obtained manually. The histological sections were stained with safranin and mounted in glycerine-gelatine (D'Ambrosio de Argüeso 1986). Leaf cross sections were observed and photographed with a light microscope Nikon Microphot FXA. To describe these, the following characters were considered: ribs and furrows, midrib, epidermal cells, bulliform cells, fusoid cells and marginal sclerenchyma (Ellis 1976, López Soto et al. 2009).

SPECIMENS EXAMINED. *Chusquea culeou* E. Desv.: **ARGENTINA. Neuquén:** Los Lagos, Villa La Angostura, 23 Apr 2009, *Rúgolo 2332* (SI); 12 Sep 2009, *Rúgolo 2334* (SI).

Chusquea deficiens Parodi: **ARGENTINA. Jujuy:** Valle Grande, 15 Feb 1995, *Deginani*

et al. 835 (SI); **Salta**: Anta, Serranías de Maíz Gordo, 10 Jan 1939, *Devoto* et al. *1010* (SI).

Chusquea lorentziana Griseb.: **ARGENTINA. Salta:** Guachipas, Pampa Grande, 2 May 1942, *Hunziker 1548* (SI); **Tucumán**: Monteros, Quebrada de los Sosa, 26 Dec 1971, *Krapovickas & Cristóbal 20452* (SI).

Chusquea montana Phil.: **ARGENTINA. Neuquén:** Los Lagos, Villa La Angostura, Cerro Bayo, 8 Jan 2010, *Rúgolo 2343* (SI); **Río Negro**: Bariloche, Laguna Frías, 18 Apr 1977, *Rúgolo* et al. *752* (SI).

Chusquea quila Kunth: **CHILE. X Región:** Osorno, 24 Jan 1992, *Rúgolo 1370* (SI); **XI Región**: Aisén, valle del Río Palena, 28 Jan 1994, *Rúgolo 1980* (SI).

Chusquea valdiviensis E. Desv.: **ARGENTINA. Neuquén:** Los Lagos, Parque Nacional Nahuel Huapí, Isla Victoria, Feb 1946, *Peréz Moreau 58* (SI). **CHILE. XIV Región:** Valdivia, Paso Puyehue, 23 Feb 1978, *Rúgolo 749* (SI).

Rhipidocladum neumannii Sulekic, Rúgolo & L. G. Clark: **ARGENTINA. Salta:** José de San Martín, Yacimiento Río Pescado, 2 May 2003, *Morrone* et al. *4555* (SI). **BOLIVIA. Santa Cruz:** Andrés Ibañez, 27 Mar 1998, *Nee* et al. *48768* (SI).

Rhipidocladum racemiflorum (Steud.) McClure: **ARGENTINA. Salta:** Santa Victoria, Parque Nacional Baritú, 22 Jun 1999, *Hilgert and Hill 2367* (SI). **BOLIVIA. La Paz:** Sur Yungas, Serranía de Marimonos, 25 Jul 1987, *Killeen 2628* (SI).

Results. Leaf Anatomy: Cross Section (FIG. 1, 2; TABLE 1). *Chusquea culeou:* Ribs and furrows not evident. Developed midrib with sclerenchyma strand not projecting abaxially. Outer walls thickened and covered by a distinct, thick cuticle continuous over the epidermal cells. Fan-shaped bulliform cells situated at level with the general epidermal surface. Fusoid cells present or absent; when present, successive, separated by numerous chlorenchyma cells. Well-developed, pointed cap of sclerenchyma at margin, not in contact with lateral bundle (Fig. 1 A, B).

This species shows a somewhat widespread distribution in southern Argentina and Chile. Some individuals inhabiting open areas outside *Nothofagus* forests show coriaceous leaf blades with sclerified margins. Currently, ecological anatomy of this species is being studied (Guerreiro C, unpublished data).

Chusquea lorentziana: Adaxial deep furrows. Prominent midrib, projecting abaxially due to size of bundle. Outer walls thickened and covered by a distinct, thick cuticle continuous over the epidermal cells. Fan-shaped groups of bulliform cells situated at bases of furrows occupying ¼ of the leaf thickness. Successive fusoid cells separated by numerous chlorenchyma cells. Well-developed, rounded cap of sclerenchyma at margin (Fig. 1 C).

Chusquea deficiens: Very noticeable adaxial ribs and deep furrows. Prominent midrib, not projecting abaxially. Outer walls thickened and covered by a distinct, thick cuticle continuous over the epidermal cells. Fan-shaped groups of bulliform cells situated at bases of furrows occupying ½ of the leaf thickness. Successive fusoid cells separated by numerous chlorenchyma cells. Well-developed, rounded cap of sclerenchyma at margin (Fig. 1 D; Guerreiro et al. 2011).

Chusquea montana: Adaxial, slight, shallow furrows. Prominent midrib with abaxial sclerenchyma strand, not projecting. Outer walls thickened and covered by a distinct, thick cuticle continuous over the epidermal cells. Fan-shaped groups of bulliform cells situated at level with the general epidermis. Fusoid cells absent. Well-developed, rounded cap of sclerenchyma at margin (Fig. 1 E, F).

Chusquea quila: Adaxial, slight, shallow furrows. Midrib with developed abaxial sclerenchyma strand, not projecting. Outer walls thickened and covered by a distinct, thick cuticle continuous over the epidermal cells. Fan-shaped groups of bulliform cells situated at level with the general epidermal surface. Successive fusoid cells, separated by numerous chlorenchyma cells. Well-developed, pointed cap of sclerenchyma at margin (Fig. 1 G, H).

Chusquea valdiviensis: Ribs and furrows not evident. Midrib with developed abaxial sclerenchyma strand, not projecting. Outer walls thickened and covered by a distinct, thick cuticle continuous over the epidermal cells. Fan-shaped groups of bulliform cells situated at level with the general epidermal surface. Successive fusoid cells separated by numerous chlorenchyma cells. Well-developed, pointed cap of sclerenchyma at margin (Fig. 1 I, J).

Rhipidocladum neumannii: Adaxial, slight, shallow furrows. Near the margins, 3 adaxial, prominent rounded ribs, situated over the vascular bundles. Distinct midrib, not projecting abaxially. Outer walls thickened and

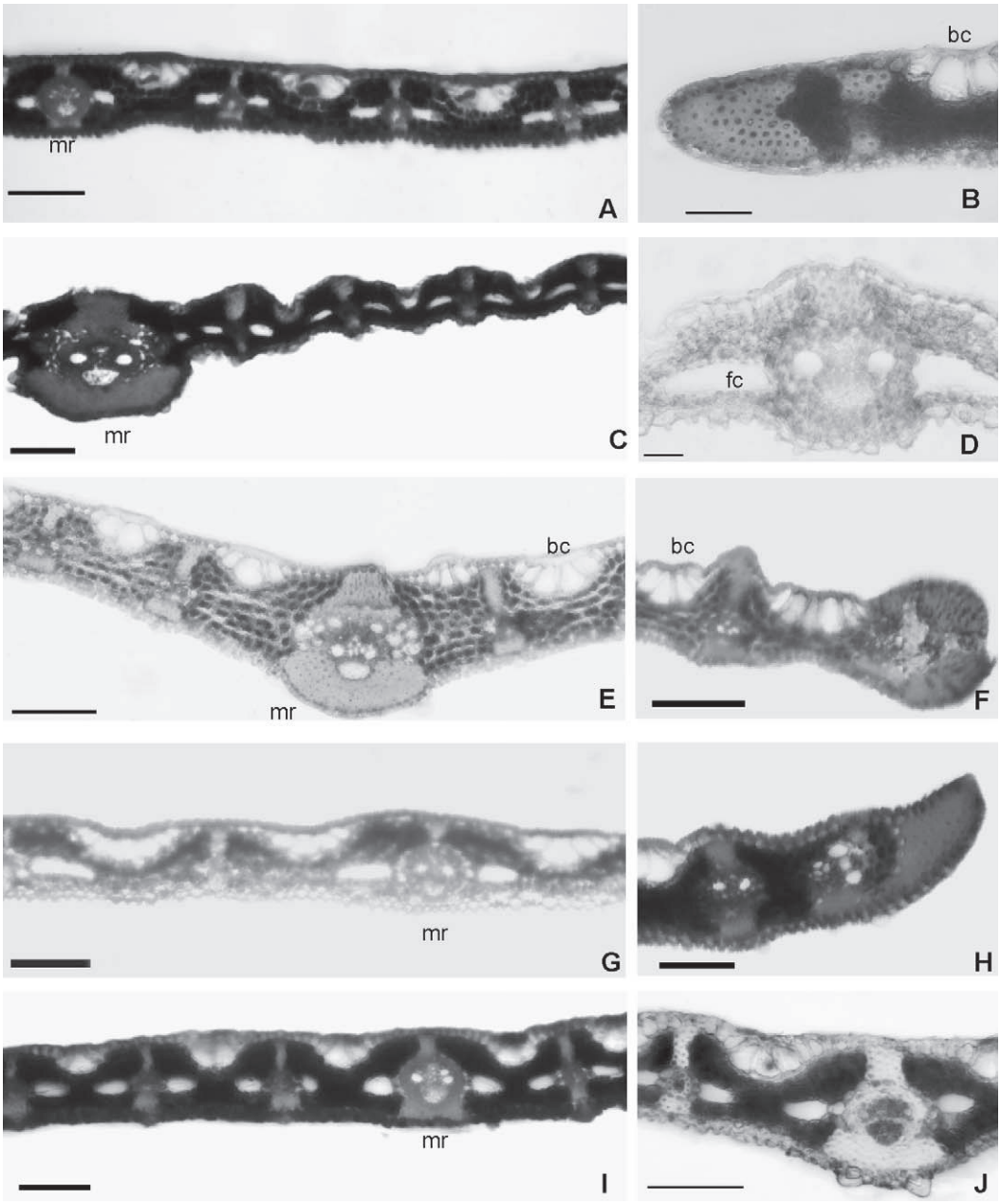

FIG. 1. Leaf blade cross section light microscope micrographs of *Chusquea* species. *C. culeou:* (A) general view with midrib, (B) leaf margin with pointed cap of sclerenchyma. (C) *C. lorentziana*, prominent midrib, adaxial deep furrows. (D) *C. deficiens,* midrib and fusoid cells. *C. montana* (E) general view with midrib, (F) leaf margin with rounded cap of sclerenchyma. *C. quila* (G) general view with midrib, (H) leaf margin with pointed cap of sclerenchyma. *C. valdiviensis* (I) general view, (J) midrib. Scale bars = 100 μm (A, C, E–J), 50 μm (B) and 20 μm (D). Abbreviations = bulliform cells (bc), fusoid cells (fc) and midrib (mr).

covered by a distinct, thick cuticle continuous over the epidermal cells. A single layer of intercostal sclerenchymatic cells just internal to the abaxial epidermis in between the vascular bundles and a small, inconspicuous adaxial group of sclerenchyma fibers below the bulliform cells. Fan-shaped groups of bulliform cells situated at level with the general epidermal surface, occupying ¼ of the leaf thickness. Fusoid cells absent. Small, rounded

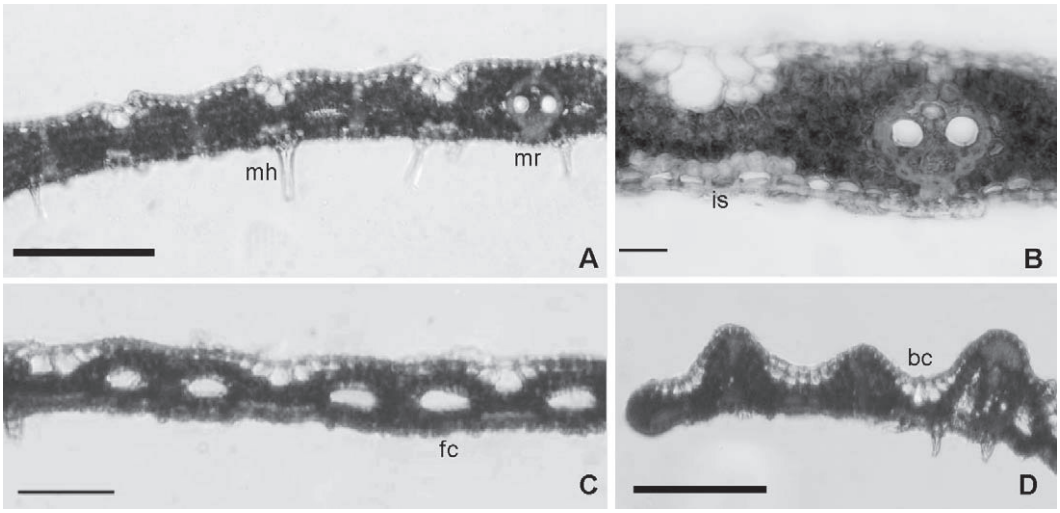

FIG. 2. Leaf blade cross section light microscope micrographs of *Rhipidocladum* species. *R. neumannii* (A) general view with midrib and abaxial macrohairs, (B) midrib and intercostal sclerenchyma. *R. racemiflorum* (C) general view showing fusoid cells, (D) leaf margin with small, rounded cap of sclerenchyma and adaxial ribs and furrows. Scale bars = 100 μm (A, C–D) and 20 μm (B). Abbreviations = bulliform cells (bc), fusoid cells (fc), macrohair (mh) and midrib (mr).

cap of sclerenchyma at margin. Abaxial epidermis with macrohairs (Fig. 2 A, B).

Rhipidocladum racemiflorum: Adaxial, slight, shallow furrows. Near the margins, 3 adaxial, prominent rounded ribs, situated over the vascular bundles. Distinct midrib, not projecting abaxially. Outer walls thickened and covered by a distinct, thick cuticle continuous over the epidermal cells. A single layer of intercostal sclerenchymatic cells just internal to the abaxial epidermis in between the vascular bundles and a small, inconspicuous adaxial group of sclerenchyma fibers below the bulliform cells. Fan-shaped groups of bulliform cells situated at level with the general epidermal surface. Successive fusoid cells separated by numerous chlorenchyma cells. Small, rounded cap of sclerenchyma at margin (Fig. 2 C, D).

LEAF ANATOMY: ABAXIAL EPIDERMIS (FIG. 3, 4; TABLE 2). *Chusquea culeou*: Long cells with slightly wavy walls and abundant rounded, large papillae. Stomatal complex long and narrow, 15 μm long and 5 μm wide, low dome-shaped subsidiary cells, with simple papillae. Rounded and saddle-shaped silica bodies only on midrib. Scarce, large prickle hairs irregularly arranged. Angular prickles on leaf margin. Infrequent elongated microhairs,

Table 1. Comparative leaf cross section characters among species of Andean woody bamboos.

Species	Adaxial ribs and furrows	Distinct midrib	Bulliform cells	Fusoid cells	Marginal sclerenchyma
C. culeou	Not evident	Not projecting	Epidermis level	Present or absent	Developed, pointed
C. deficiens	Very noticeable	Not projecting	Base of furrow	Present	Developed, rounded
C. lorentziana	Very noticeable	Projecting abaxially	Base of furrow	Present	Developed, rounded
C. montana	Not evident	Not projecting	Epidermis level	Absent	Developed, rounded
C. quila	Not evident	Not projecting	Epidermis level	Present	Developed, pointed
C. valdiviensis	Not evident	Not projecting	Epidermis level	Present	Developed, pointed
R. neumannii	Only on margins	Not projecting	Epidermis level	Absent	Small, rounded
R. racemiflorum	Only on margins	Not projecting	Epidermis level	Present	Small, rounded

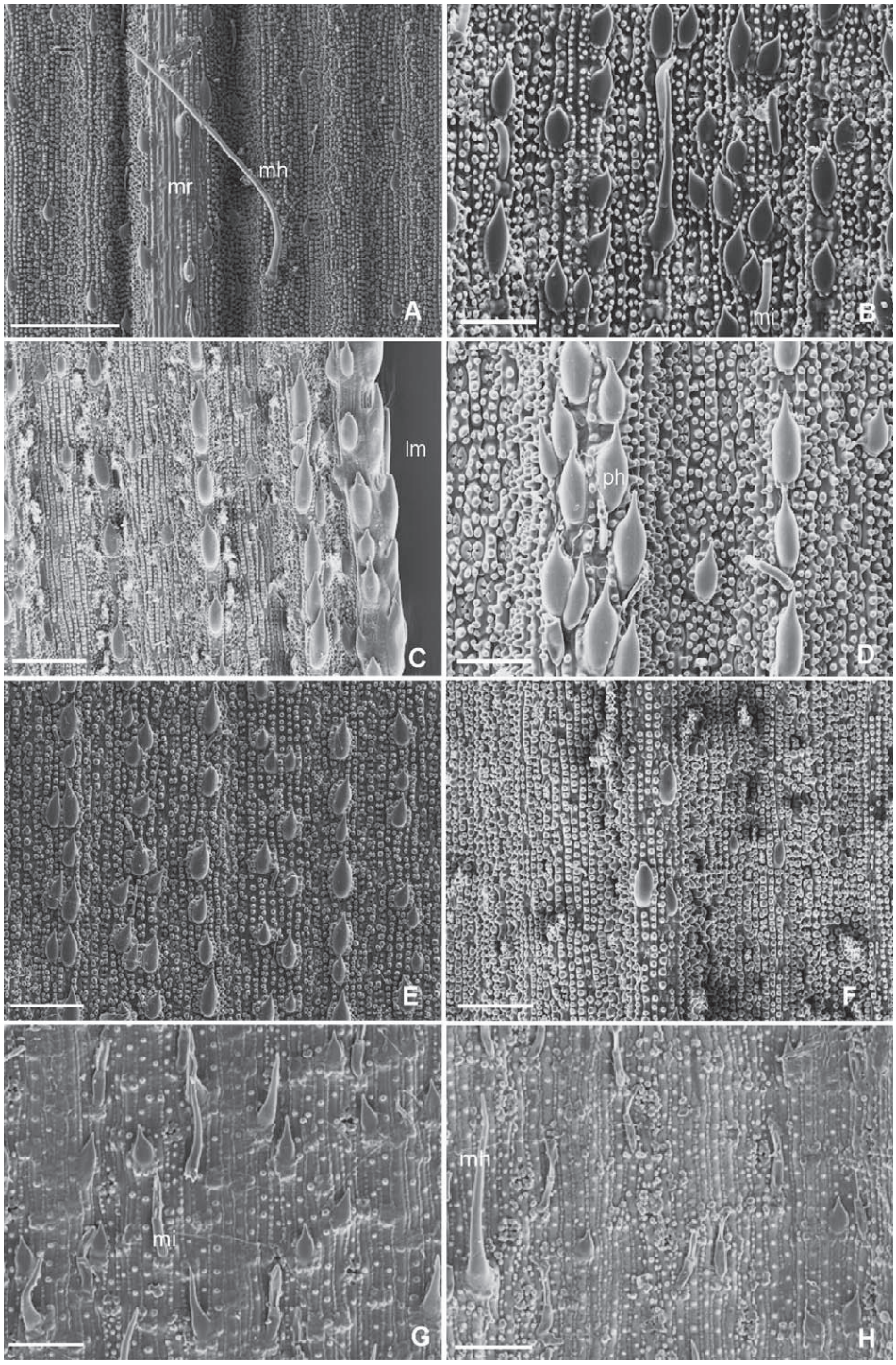

FIG. 3. Leaf blade abaxial epidermis scanning electron micrographs. (A) *Chusquea culeou,* macrohair and prickle hairs on midrib. (B) *C. deficiens,* macrohair, microhairs and prickle hairs. (C) *C. lorentziana,* prickle hair rows and angular prickle hairs on leaf margin. (D) *C. montana,* prickle hair rows and microhairs. (E) *C. quila,* prickle hairs arranged in rows. (F) *C. valdiviensis,* general view. (G) *Rhipidocladum neumannii,* microhairs and prickle hairs irregularly arranged. (H) *R. racemiflorum,* macrohairs and microhairs. Scale bars = 200 μm (A), 100 μm (C, E–F) and 50 μm (B, D, G–H). Abbreviations = leaf margin (lm), macrohair (mh), microhair (mi), midrib (mr) and prickle hair (ph).

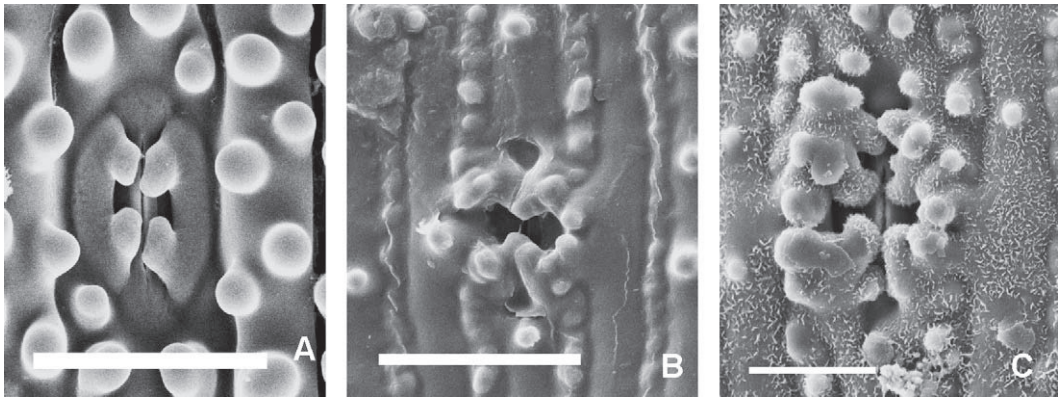

FIG. 4. Stomata scanning electron micrographs. (A) *Chusquea montana,* bipapillate subsidiary cells. (B) *Rhipidocladum neumannii*, overarching, angular papillae. (C) *R. racemiflorum,* overarching, angular papillae. Scale bars = 20 μm (A–B) and 10 μm (C).

apical cell with round apex. Scarce macrohairs with swollen base (Fig. 3 A).

Chusquea deficiens: Long cells with straight walls and abundant dome-shaped papillae. Stomatal apparatus slightly sunken, 12 μm long and 10 μm wide. Low dome-shaped subsidiary cells with simple papillae. Dumb-bell shaped silica bodies associated to prickle hair rows. Abundant prickle hairs, medium sized, arranged in rows. Leaf margin with one row of angular prickles. Infrequent microhairs and macrohairs (Fig. 3 B; Guerreiro et al. 2011).

Chusquea lorentziana: Long cells with wavy walls and abundant dome-shaped, large papillae. Stomatal apparatus 17 μm long and 7 μm wide, with low dome-shaped subsidiary cells with simple papillae, sunken, occluded by papillae from adjacent long cells. Saddle shaped silica bodies alternating with prickle hairs on costal zones. Abundant prickle hairs arranged in rows. Leaf margin with several rows of angular prickles. Infrequent microhairs in intercostal zones. Macrohairs absent (Fig. 3 C).

Chusquea montana: Long cells with straight walls and abundant rounded papillae, irregularly arranged. Stomatal apparatus 12 μm long and 6 μm wide, arranged in rows, with low dome-shaped subsidiary cells with simple papillae. Equidimensional saddle shaped silica bodies, scarce, associated to prickle hair rows in costal zones. Abundant, large prickle hairs arranged in rows with short barb. Leaf margin with one row of angular prickles of large base and long barb. Infrequent microhairs associated to prickle hairs. Macrohairs absent (Fig. 3 D, 4 A).

Chusquea quila: Long cells with slightly wavy walls and a single row of large, rounded papillae. Stomatal apparatus 14 μm long and 7 μm wide, arranged in rows, with low dome-shaped, ovoid subsidiary cells with simple papillae. Irregular, dumb-bell shaped silica bodies, scarce, associated to prickle hairs. Abundant prickle hairs of large base and short barb arranged in rows. Leaf margin with one row of angular prickles of large base and long barb. Infrequent microhairs associated to prickle hair rows. Macrohairs absent (Fig. 3 E).

Table 2. Comparative leaf abaxial epidermis characters among species of Andean woody bamboos.

Species	Long cell walls	Size of stomata (μm, long × wide)	Shape of silica bodies	Prickle hairs	Microhairs	Macrohairs
C. culeou	Slightly wavy	15 × 5	Rounded and saddle	Scarce	Scarce	Scarce
C. deficiens	Straight	12 × 10	Dumb-bell	Abundant	Scarce	Scarce
C. lorentziana	Wavy	17 × 7	Saddle	Abundant	Scarce	Absent
C. montana	Straight	12 × 6	Saddle	Abundant	Scarce	Absent
C. quila	Slightly wavy	14 × 7	Irregular dumb-bell	Abundant	Scarce	Absent
C. valdiviensis	Straight	12 × 8	Cross	Scarce	Scarce	Scarce
R. neumannii	Wavy	17 × 6	Not seen	Scarce	Frequent	Frequent
R. racemiflorum	Wavy	10 × 6	Not seen	Scarce	Abundant	Scarce

Chusquea valdiviensis: Long cells with straight walls and abundant, large, rounded papillae. Stomatal complex long and narrow, 12 μm long and 8 μm wide, slightly sunken, low dome-shaped subsidiary cells, with simple papillae. Cross-shaped silica bodies. Scarce prickle hairs of large base and short barb, irregularly arranged. Leaf margin with one row of angular prickles. Infrequent microhairs and macrohairs (Fig. 3 F).

Rhipidocladum neumannii: Long cells with wavy walls and frequent, small, simple papillae quite spaced. Stomatal apparatus 17 μm long and 6 μm wide, arranged in rows, occluded by four angular, overarching papillae from adjacent long cells. No silica bodies observed on surface examined. Scarce prickle hairs irregularly arranged with small base and short barb. Leaf margin with one row of angular prickles. Frequent microhairs and macrohairs, both irregularly arranged (Fig. 3 G, 4 B).

Rhipidocladum racemiflorum: Long cells with wavy walls and frequent, small, simple papillae quite spaced. Stomatal apparatus 10 μm long and 6 μm wide, arranged in rows, occluded by four angular overarching papillae from adjacent long cells. No silica bodies observed on surface examined. Infrequent prickle hairs of medium base and short barb. Leaf margin with one row of angular prickles. Abundant microhairs irregularly arranged and isolated macrohairs (Fig. 3 H, 4 C).

KEY BASED ON LEAF BLADE CHARACTERS (EPIDERMIS AND CROSS SECTION)

1- Adaxial, prominent ribs only observed near leaf margins. Intercostal sclerenchyma present. Subsidiary cells of stomata lacking papillae 2
1′- Adaxial ribs and furrows prominent or not, all over the blade. Intercostal sclerenchyma absent. Subsidiary cells of stomata with a pair of papillae 3
2- Fusoid cells absent. Frequent macrohairs and microhairs, irregularly arranged . . . . . *R. neumannii*
2′- Fusoid cells present. Infrequent macrohairs. Abundant microhairs irregularly arranged . . . . . *R. racemiflorum*
3- Macrohairs present on abaxial epidermis . . .4
3′- Macrohairs absent on abaxial epidermis . . .6
4- Developed midrib but not projecting. Infrequent prickle hairs on abaxial epidermis. Cross-shaped silica bodies . . . . . *C. valdiviensis*
4′- Midrib abaxially prominent, projecting or not. Abundant or infrequent prickle hairs on abaxial epidermis. Rounded, saddle or dumb-bell shaped silica bodies 5
5- Adaxial ribs and furrows not evident. Scarce prickle hairs irregularly arranged. Rounded and saddle-shaped silica bodies only found on midrib. . . . . *C. culeou*
5′- Very noticeable ribs and deep furrows on adaxial side. Abundant prickle hairs arranged in rows. Dumb-bell shaped silica bodies. . . . . *C. deficiens*
6- Leaf margin with several rows of angular prickles. Adaxial deep furrows. Prominent midrib, projecting abaxially . . . . . *C. lorentziana*
6′- Leaf margin with one row of angular prickles. Adaxial shallow furrows. Midrib with developed abaxial sclerenchyma strand, not projecting. 7
7- Fusoid cells absent. Rounded cap of sclerenchyma at margin. . . . . *C. montana*
7′- Fusoid cells present. Pointed cap of sclerenchyma at margin. . . . . *C. quila*

Discussion. In this paper, foliage leaf blade anatomical characters of taxonomic value found in Andean woody bamboo species from Argentina and neighboring areas were described. Thus, current descriptions of the species were enhanced and improved. Also, an identification key based on anatomical characters of foliage leaves was provided. Since most of the species studied here are monocarpic, with long vegetative periods, the identification of new anatomical characters bears a considerable taxonomic significance contributing to the determination of vegetative material.

Anatomically, leaf cross section of all the species studied here exhibit fan-shaped bulliform cells not associated with colorless parenchyma cells, situated at level with the general epidermal surface, as in *C. culeou, C. montana, C. quila, C. valdiviensis* and both *Rhipidocladum* species, or at bases of deep adaxial furrows, as in *C. deficiens* and *C. lorentziana,* occupying between ¼ and ½ of the blade thickness. Fusoid cells are especially characteristic of the Bambusoideae and when they occur in other genera, affinities between these

and the bamboos may be indicated (Ellis 1976). Fusoid cells were present in most cases but *C. montana* and *R. neumannii* lack fusoid cells. And in *C. culeou*, fusoid cells may be present or absent, it has been suggested that the occurrence of fusoid cells is related to anatomical variations between sun and shade leaves (March and Clark 2011). The woody bamboo species from northern Argentina showed very noticeable ribs and furrows, but in both species of *Rhipidocladum*, these were present only near the leaf margin. All the species showed a cap of sclerenchyma at leaf margin, this may be pointed, as in *C. culeou, C. quila* and *C. valdiviensis*, or rounded, as in *C. deficiens, C. lorentziana, C. montana, R. neumannii* and *R. racemiflorum*.

Papillate long cells are characteristically present on leaf abaxial epidermis of bamboo species (Judziewicz et al. 1999). In all the *Chusquea* species included in this study, these are abundant, large, adjacent and arranged in one or two rows. In both *Rhipidocladum* species, they are small, quite spaced and arranged in one row. Subsidiary cells of stomata also differ between genera, in *Rhipidocladum* species they lack papillae and in *Chusquea* species, they bear two simple papillae. Silica bodies were not seen in both *Rhipidocladum* species, while in *C. culeou*, they were only observed on the midrib. Particularly, in the case of *C. deficiens, C. lorentziana, C. montana* and *C. quila,* silica bodies were associated to prickle hair rows and cross-shaped silica bodies were only observed in *C. valdiviensis*. Prickle hairs and microhairs are present in every species studied. Also, a single row of angular prickles is present on the leaf margin of all species studied except in *C. lorentziana*, which shows several rows of angular prickles. Macrohairs are usually present on the abaxial epidermis but scattered, only in *R. neumannii* they are abundant. *Chusquea lorentziana, C. montana* and *C. quila* lack macrohairs.

Some authors have considered *Chusquea quila* and *C. valdiviensis* as synonyms (Parodi 1945, Nicora 1978) while others, as separate species (Matthei 1997, Judziweicz et al. 2000, Morrone et al. 2008). They occur sympatrically in the Andean-Patagonian beech forests of southern Argentina and Chile. However, a proper differentiation between these species was never presented. Only Matthei (1997) made a small comment on this matter using height and distribution as the main characters to distinguish between them. In the present work, anatomical evidence was presented that support the idea of *C. quila* and *C. valdiviensis* as different species. They can be distinguished by the shape of long cell walls, the shape of the silica bodies, the abundance and distribution of prickle hairs and the presence or absence of macrohairs (Table 2).

The distribution of intercostal sclerenchyma fibers and the distinct patterns of papillae overarching the stomata are useful in distinguishing among sections within the genus *Rhipidocladum* (Clark and Londoño 1991). Regarding these particular features, *R. neumannii* showed similar characters to those of *R. racemiflorum*, thus it is placed in *Rhipidocladum* Sect. *Racemiflorum* L. G. Clark & Londoño.

Literature Cited

Bamboo Phylogeny Group. 2012. An updated tribal and subtribal classification of the bamboos (Poaceae: Bambusoideae). Bamboo Sci. Cult. 25: 1–10.

Clark, L. G. 1995. Diversity and distribution of the Andean woody bamboos (Poaceae: Bambuseae), pp. 501–512. In S. P. Churchill, H. Balslev, E. Forero, and J. L. Luteyn [eds.], Biodiversity and conservation of neotropical montane forests. The New York Botanical Garden Press, New York, NY.

Clark, L. G. 1997. Diversity, biogeography and evolution of *Chusquea*, pp. 33–44. In G. P. Chapman [ed.], The bamboos. Academic Press, London, UK.

Clark, L. G. and X. Londoño. 1991. A new species and new sections of *Rhipidocladum* (Poaceae: Bambusoideae). Am. J. Bot. 78: 1260–1279.

D'Ambrosio de Argüeso, A. 1986. Manual de Técnicas en Histología Vegetal. Hemisferio Sur, Buenos Aires, Argentina. 84 p.

Ellis, R. P. 1976. A procedure for standardizing comparative leaf anatomy in the Poaceae. I. The leaf-blade as viewed in transverse section. Bothalia 12: 65–109.

Ellis, R. P. 1979. A procedure for standardizing comparative leaf anatomy in the Poaceae. II. The epidermis as seen in surface view. Bothalia 12: 641–671.

Freier, F. 1941. Contribución al estudio de la anatomía foliar de las especies del género *Chusquea* de la Flora Argentina. Rev. Argent. Agronom. 8: 364–379.

Fisher, A. E., J. K. Triplett, C. S. Ho, A. D. Schiller, K. A. Oltrogge, E. S. Schroder, S. A. Kelchner, and L. G. Clark. 2009. Paraphyly in the bamboo subtribe Chusqueinae (Poaceae: Bambusoideae) and a revised infrageneric classification for *Chusquea*. Syst. Bot. 34: 673–683.

Guerreiro, C., Z. E. Rúgolo de Agrasar, and M. F. Rodríguez. 2010. Estudios anatómico-estruc-

turales en especies andinas de *Chusquea* Kunth (Poaceae, Bambusoideae, Bambuseae) de la Argentina. X Congreso Latinoamericano de Botánica, La Serena, Chile.

GUERREIRO, C., Z. E. RÚGOLO DE AGRASAR, AND M. F. RODRÍGUEZ. 2011. Novedades en *Chusquea deficiens* (Poaceae, Bambusoideae, Bambuseae), un bambú leñoso muy poco conocido del noroeste argentino. Bol. Soc. Argent. Bot. 46: 177–185.

GUERREIRO, C. AND Z. E. RÚGOLO. 2012. *Chusquea* Kunth, pp. 52–58. *In* F. O. Zuloaga, Z. E. Rúgolo de Agrasar, and A. M. Anton [eds.], Flora Argentina. Plantas vasculares de la República Argentina. Monocotiledoneae: Poaceae: Aristidoideae - Pharoideae. Vol. 3 (I). Graficamente, Córdoba, Argentina.

JUDZIEWICZ, E. J., L. G. CLARK, X. LONDOÑO, AND M. J. STERN. 1999. American bamboos. Smithsonian Institution Press, Washington DC. 392 p.

JUDZIEWICZ, E. J., R. J. SORENG, G. DAVIDSE, P. M. PETERSON, T. S. FILGUEIRAS, AND F. O. ZULOAGA. 2000. Catalogue of new world grasses (Poaceae): I. Subfamilies Anomochlooideae, Bambusoideae, Ehrhartoideae, and Pharoideae. Contr. U. S. Natl. Herb. 39: 1–128.

LÓPEZ SOTO, M. M., S. D. KOCH, M. FLORES-CRUZ, AND E. M. ENGLEMAN. 2009. Anatomía comparada de la lámina foliar del género *Distichlis* (Poaceae). Acta Bot. Mex. 89: 1–23.

MARCH, R. H. AND L. G. CLARK. 2011. Sun-shade variation in bamboo (Poaceae: Bambusoideae) leaves. Telopea 13: 93–104.

MATTHEI, O. 1997. Las especies del género *Chusquea* Kunth (Poaceae: Bambusoideae), que crecen en la X Región, Chile. Gayana Bot. 54: 199–220.

MORRONE, O., F. O. ZULOAGA, H. M. LONGHI-WAGNER, P. IZAGUIRRE, R. BEYHAUT, A. M. CIALDELLA, L. GIUSSANI, S. S. DENHAM, A. GUGLIERI, I. BOLDRINI, A. ZANÍN, D. SALARIATO, AND D. DE GENNARO. 2008. Poaceae, pp. 609–967. *In* F. O. Zuloaga, O. Morrone, and M. J. Belgrano [eds.], Catálogo de las plantas vasculares del Cono Sur (Argentina, Sur de Brasil, Chile, Paraguay y Uruguay), Pteridophyta, Gymnospermae, Monocotyledoneae. Missouri Botanical Garden Press, St. Louis, MO.

NICORA, E. G. 1978. Gramineae, pp. 14–22. *In* M. N. Correa [ed.], Flora Patagónica (República Argentina). INTA, Buenos Aires, Argentina.

PARODI, L. R. 1941. Estudio preliminar sobre el género *Chusquea* en la Argentina. Rev. Argent. Agronom. 8: 331–344.

PARODI, L. R. 1945. Sinopsis de las gramíneas chilenas del género *Chusquea*. Rev. Universit. 30: 61–71.

RENVOIZE, S. A. 1998. Gramíneas de Bolivia. The Royal Botanic Garden, London, UK. 676 p.

RÚGOLO DE AGRASAR, Z. E. AND M. F. RODRÍGUEZ. 2002. Cauline anatomy of native woody bamboos in Argentina and neighbouring areas: Epidermis. Bot. J. Linn. Soc. 138: 45–55.

RÚGOLO, Z. E. AND A. S. VEGA. 2012. *Rhipidocladum* McClure, pp. 66–68. *In* F. O. Zuloaga, Z. E. Rúgolo de Agrasar, and A. M. Anton [eds.], Flora Argentina. Plantas vasculares de la República Argentina. Monocotiledoneae: Poaceae: Aristidoideae - Pharoideae. Vol. 3 (I). Graficamente, Córdoba, Argentina.

SODERSTROM, T. R. AND R. ELLIS. 1987. The position of bamboo genera and allies in a system of grass classification, pp. 225–238. *In* T. R. Soderstrom, K. W. Hilu, C. S. Campbell, and M. E. Barksworth [eds.], Grass systematics and evolution. Smithsonian Institution Press, Washington, DC.

SULEKIC, A. A., Z. E. RÚGOLO DE AGRASAR, AND L. G. CLARK. 1999. El género *Rhipidocladum* (Poaceae, Bambuseae) en la Argentina. Darwiniana 37: 315–322.

THIERS, B. 2012. Index herbariorum: A global directory of public herbaria and associated staff. Retrieved June 15, 2012 from The New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/ih>

ZULOAGA, F. O., E. G. NICORA, Z. E. RÚGOLO DE AGRASAR, O. MORRONE, J. PENSIERO, AND A. M. CIALDELLA. 1994. Catálogo de la familia Poaceae en la República Argentina. Monog. Syst. Botan. 47: 1–178.