

# Bryophytes and lichens in peatlands and *Tepualia stipularis* swamp forests of Isla Grande de Chiloé (Chile)

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## Abstract

León, C.A., Oliván, G., Larraín, J., Vargas, R. & Fuertes, E. 2014. Bryophytes and lichens in peatlands and *Tepualia stipularis* swamp forests of Isla Grande de Chiloé (Chile). *Anales Jard. Bot. Madrid* 71(1): e003.

One hundred and twenty-nine taxa of bryophytes and lichens were found in peatlands (*Sphagnum* bogs) and swamp forests of *Tepualia stipularis* of Isla Grande de Chiloé (Chile) (41°-43°S, 73°-74°W). Forty eight percent of these species are endemic to southern South America. The range of most species spans from Los Rios Region to Magallanes Region. Fifty mosses, 52 liverworts, and 27 macrolichens were reported. Global and national distributions and habitat preferences are given for each species.

**Keywords:** mosses, liverworts, lichens, peatlands, geographic distribution, southern South America.

## Resumen

León, C.A., Oliván, G., Larraín, J., Vargas, R. & Fuertes, E. 2014. Briófitos y líquenes de turberas y tepuales de la Isla Grande de Chiloé (Chile). *Anales Jard. Bot. Madrid* 71(1): e003.

Se han encontrado un total de 129 taxones de briófitos y líquenes en turberas esfagnosas y bosques pantanosos de *Tepualia stipularis* de la Isla Grande de Chiloé (Chile) (41°-43°S, 73°-74°W). El 48% de las especies reportadas son endémicas del sur de Sudamérica. La distribución más frecuente entre las especies encontradas comprende desde la Región de Los Ríos hasta la Región de Magallanes y Antártica Chilena. Se registraron 50 musgos, 52 hepáticas y 27 macrolíquenes. Se reportan además las distribuciones globales y nacionales, y preferencias de hábitats para las distintas especies.

**Palabras clave:** musgos, hepáticas, macrolíquenes, turberas, distribución geográfica, sur de Sudamérica.

## INTRODUCTION

Bryophytes and lichens play a key role in peatlands. They participate directly in the constitution of peat and in the maintenance of these ecosystems (Vitt & Belland, 1995). In some types of peatlands, mosses, like *Sphagnum* L., cover almost completely the surface (Gignac & al., 1991). Due to wetness levels and the often meager vascular plant cover, peatlands bring favorable conditions to bryophytes and contribute to a large extent to the diversity of moss and liverwort species, particularly in regions where peatlands are abundant (Minayeva, 2008). Also, in the Northern Hemisphere, the role of peatlands in the upkeep of lichenic diversity is very important (Lang & al., 2009). Nevertheless, Minayeva (2008) reported that the species number of lichens present is quite low compared to the non-peatland lichen flora for any given region. Thus, the role of peatlands in maintaining lichen biodiversity is unclear.

Europe and North America have completed inventories of peatland floras (Malmer, 1962; Vitt & Belland, 1995; Wheeler, 1993), and this has permitted them, among other things, to determine the species that indicate the type of peatland, to study their ecological niches and to assess its relations with environmental parameters (Vitt & al., 1975, 1990; Gignac & Vitt, 1990; Gignac & al., 1991). Unfortunately, this is not the situation in southern cone South America. In Chile, studies on the floristic diversity of peatlands are scarce (San Martín & al., 1999; Schlatter & Schlatter, 2004; Teneb & Dollenz, 2004; Teneb & al.,

2008; Kleinebecker & al., 2010) and even scarcer are the studies on the bryophytes and macro-lichens (Díaz & al., 2005, 2008; Villagra & al., 2009).

In Chile, peatlands are widely distributed in the southern part of the country (Zegers & al., 2006), and are important ecosystems from an ecological and economic point of view. In particular, in Isla Grande de Chiloé, located in insular Patagonia, large extensions of different types of these ecosystems can be found (Díaz & al., 2008).

Our study focused on peatlands dominated by *Sphagnum* spp., of the Isla Grande de Chiloé and on swamp forests of *Tepualia stipularis* (Hook. & Arn.) Griseb., aka "tepuales", which are strongly linked to these peatlands. In Chiloé, based on their origin, it is possible to find two types of *Sphagnum* peatlands: those originated after the retreat of glaciers, referred to in this paper as glaciogenic peatlands, and those originated after 1850 following the burning or cutting down of forests typical to flooded areas, locally known as "pomponales" (Zegers & al., 2006), referred to as secondary or anthropogenic peatlands in here.

Tepuales are dominated by *Tepualia stipularis* ("Tepú", Myrtaceae), which sometimes can be accompanied by *Podocarpus nubigenus* Lindl. ("Maño Macho", Podocarpaceae), *Pilgerodendron wiferum* (D. Don.) Florin. ("Guaytecas Cypress", Cupressaceae) and/or *Drimys winteri* J.R. Forst. & G. Forst. ("Canelo", Winteraceae). These forests develop in swampy water-saturated areas (García & Ormazabal, 2008) and may accumulate organic material (Veblen & Schlegel, 1982). As has been pointed out, cutting

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down these forests could have resulted in the aforementioned anthropogenic peatlands (Zegers & al., 2006). Thus, the origin is a relevant factor for its floristic characterization. In addition, there are studies that show that the vascular and bryophytic floras of peatlands and tepuales are the same (Villagrán & Barrera, 2002; Villagrán & al., 2002, 2003, 2005), and therefore we think that stating the differences and similarities between both ecosystems is relevant.

This study contributes to the knowledge of the bryolichenic flora through achieving three central objectives: i) a floristic inventory of the mosses, liverworts and macro-lichens present in glaciogenic and anthropogenic peatlands and tepuales of Isla Grande de Chiloé; ii) an evaluation of floristic differences and similarities among these three closely related communities, and iii) the study of the main ecological and biogeographical features of this flora, assessing the habitats, micro-habitats and patterns of geographical distribution of the species found. Being our main aim to establish the basis necessary to understand the ecological relations between the vegetation of these wetlands and its environment.

## MATERIALS AND METHODS

Isla Grande de Chiloé, Los Lagos Region, Chile, is our study area (42°-43°S; 73°-75°W). Chiloé's climate is wet temperate with a strong oceanic influence (di Castri & Hajek, 1976). Mean summer temperature is 10.2 °C and mean winter temperature is 6.2 °C (Pérez & al., 2003). Annual rainfall fluctuates between 1,900 and 2,300 mm (CONAF, 2009), reaching 5,000-6,000 mm in montane areas (Pérez & al., 2003).

Ten sites located in the northern and central parts of the island were selected (Fig. 1). Three study areas represented glaciogenic peatlands: Río Negro (RN), Los Caulles (CA) and Púlpito (PL); five studied areas represented anthropogenic peatlands: Senda Darwin (SD), Lecam (LC), Pumanzano (PM), Río Chepu (CH) and Tegel (TG); and two study areas represented tepuales: Senda Darwin (SD) and Chiloé National Park (CU).

Specimens were carefully determined according to morphological characters, and their characteristics were compared with the literature and herbarium specimens (including types). For lichens, chemical characters were also used. Lichen substances were identified using thin layer chromatography (TLC) following the protocol of White & James (1985). Specimens were deposited in MACB and CONC and in Carolina León's personal collection. Detailed information on studied specimens and their localities is listed in the supplementary material.

The nomenclature follows Müller (2009) for mosses, except for *Racomitrium geronticum* Müll. Hal. (Larraín, 2012), and *Hymenodontopsis mnioides* (Hook.) N.E. Bell, A.E. Newton & D. Quandt (Bell & al., 2007); Hässel de Menéndez & Rubies (2009) for liverworts, and Galloway & Quilhot (1998), Feuerer (2012), and Index Fungorum (CABI Bioscience & al., 2012) for lichens. The list of species has been arranged taxonomically in families following the criteria of Goffinet & al. (2008, 2011) for mosses, except for the species *Rhaphidorrhynchium callidum* (Mont.) Broth., which follows the Tropicos database (Missouri Botanical Garden, 2014). For liverworts, the classification proposed

by Crandall-Stotler & al. (2009) and Stotler & Crandall-Stotler (2011) was followed. For macro-lichens, we used the classification suggested by the Index Fungorum (CABI Bioscience & al., 2012).

To establish the patterns of the global distribution of each of these species, an adaptation of the patterns proposed by Villagrán & al. (2005) and Seki (1974) was done. The distributional ranges used are: Austral-Antarctic (A), which is equivalent to the pattern type of *Nothofagus* of Seki (1974) ranging from southern South America, to southern Australia (including Tasmania) and New Zealand; American (AM), limited to the American continent; Bipolar (B) species that are widely distributed in the circumboreal region and disjunct with southern South America and Antarctica; Circum-Subantarctic (C), which includes the Austral-Antarctic continental and insular territory between latitudes 40° and 84° S; Cosmopolitan (COS), species which are widely distributed around the world; Endemic (E), their ranges cover southern Chile and Argentina, mainly restricted to temperate rainforests of southern South America, including Tierra del Fuego, Falkland Islands, South Georgia and the Antarctic peninsula; African (F), species which cover South America and Africa; Neotropical (N), the species under this pattern are disjunct with distant territories of tropical America, like the oriental Andes of Peru and Bolivia, southern Brazil, northern Andes; Pantropical-type *Podocarpus* (PAN), their ranges cover temperate and tropical areas of the world, like South America, southern Africa, Australasia and Indo-Malaysia.

The patterns of distribution in Chile followed those laid down by Villagrán & al. (2005) with some modifications. The patterns used were: Xeromorphic (X), from the northern border of the country to the interfluvial area of Choapa (Coquimbo Region) -Petorca (Valparaíso Region) (17°-33°S); Mediterranean (M), which expands from the interfluvial areas of Choapa-Petorca to the Biobío river (33°-37°S); Valdivian (V), from Biobío to Chiloé (37°-43°S); Nord-Patagonian (N), from Chiloé to Aysén (43°-49°S); and Subantarctic (S), from Aysén to Cape Horn (49°-56°S). In addition, ranges disjunct with Central Chile (CCCh), Easter Island (EI), Juan Fernández Archipelago (JF), Fray Jorge and Talinay Forests (R), and Magallanes (Ma) are indicated. Species for which Chiloé represents their northernmost limit (NL) are also highlighted.

## RESULTS

In total, 129 species have been identified, of which 50 were mosses, 52 liverworts, and 27 macro-lichens (Table 1). The anthropogenic peatlands are the most species rich habitat, adding up to 73 species. In second place come the glaciogenic peatlands, where 70 species were reported. Finally, the tepuales present 59 species in total.

Liverworts and mosses were found with similar frequencies in glaciogenic peatlands, whereas mosses were slightly more frequent in anthropogenic peatlands, and liverworts dominated tepuales (Fig. 2).

From a worldwide distribution perspective, the majority of taxa identified are endemic (48%) and restricted to southern South American temperate rainforests. Secondly come species with bipolar distribution, followed by Austral-Antarctic species and cosmopolitan ones respectively. The remaining species are found in other cold-temperate areas



**Fig. 1.** Map of Chiloé, showing the studied localities. Glaciogenic peatlands: PL, Púlpito; RN, Rio Negro; CA, Caulles. Anthropogenic peatlands: SD, Senda Darwin; CH, Chepu; PM, Pumanzano; LC, Lecam; TG, Teguel. Tepuales: SD, Senda Darwin; CU, Chiloé National Park.

and in tropical belts throughout the world (Fig. 3A). When a more detailed analysis of habitat preference by organism type is done, the dominance of species endemic to southern South America reappears as a pattern.

The analysis of the distribution patterns in Chile of all studied species evidences that the majority of the taxa have a Valdivian-Nord Patagonic-Subantarctic distribution (VNS) (Fig. 3B). With regards to the analysis of habitat preference by organism type, the same trend can be seen, though with different degrees of dominance. Liverworts show the more distinct VNS pattern, and the species of this group do not show xeromorphic or Mediterranean patterns, in contrast with macrolichens, for which xeromorphic or Mediterranean taxa exist. Mosses on average have wider distribution patterns: 13% of its species are widely distributed in Chile. It is worth highlighting that seven of the studied species have at Isla Grande de Chiloé their northern-most distribution limit.

Different dominant species were registered in each of the habitats. There is a large proportion of rare species: sixty nine

taxa were found only in one type of habitat. Nevertheless, common species were registered in at least two of the three habitat types sampled, and sixteen of them were common to the three types of habitats, e.g., *Dicranoloma billardierei*, *Jamesoniella colorata* and *Cladonia squamosa*. Even though the type of habitat with the largest number of species was the anthropogenic peatland, the tepuales presented the greatest amount of exclusive species.

## DISCUSSION

Peatlands are vitally important to the biodiversity of the planet and provide a haven for a wealth of unusual and specially adapted organisms (Charman, 2002). According to our results, the number of species registered in this study clearly shows the relevance of these ecosystems in the conservation of biodiversity, especially in Chiloé, where peatlands and tepuales represent a low percentage of the area of the island.

**Table 1.** Bryophyte and macro-lichen distribution in peatlands and tepuales of Chiloé. Global distribution patterns: Austral-Antarctic (A), American (AM), Bipolar (B), circum-Subantarctic (C), Cosmopolitan (COS), Endemic to southern South America (E), shared with Africa (F), Neotropical (N), Pantropical (PAN). Local (Chilean) distribution patterns: disjunct with Central Chile (CCh), disjunct with Easter Island (EI), disjunct with the Juan Fernández Archipelago (JF), Mediterranean (M), disjunct with Magallanes Region (Ma), Nord-Patagonian (N), north-most limit (NL), disjunct with Fray Jorge Forest (R), Subantarctic (S), Valdivian (V), Xeromorphic (X). Preferred habitats: anthropogenic peatland (AP), tepuales (TF), glaciogenic peatland (GP). Preferred microhabitats: tree base (BA), bryophyte carpet (CB), corticolous (Co), epiphyllous (EP), semi-submerged in pool (PP), completely submerged in pool (PS), forest floor (SB), peatland floor (herbarium material with no other specification; ST), peatland water-saturated floor (STA), on feces in peatland floor (STF), on bonfire rests in peatland floor (STFo), humid peatland floor (STH), dry peatland floor (STS).

Group	Family	Taxon	Distribution		Habitat			
			Global	Local	Macro	Micro		
Mosses	Sphagnaceae	<i>Sphagnum</i> cf. <i>capillifolium</i> (Ehrh.) Hedw.	COS	V	AP	ST		
		<i>Sphagnum falcatulum</i> Besch.	A	VNS	GP-AP-TF	STA, PS, SB		
		<i>Sphagnum fimbriatum</i> Wilson	B	VNS	GP-AP-TF	STS, SB		
		<i>Sphagnum magellanicum</i> Brid.	COS	VNS	GP-AP-TF	STA, SB		
		<i>Sphagnum</i> cf. <i>subsecundum</i> Nees	B	V	AP	STA		
	Polytrichaceae	<i>Polytrichastrum longisetum</i> (Sw. ex Brid.) G.L. Sm.	B	VNS	GP-AP	STA		
	Grimmiaceae	<i>Racomitrium geronticum</i> Müll. Hal.	B	VNS - JF	GP	STS		
Dicranaceae		<i>Campylopus aureonitens</i> subsp. <i>recurvifolius</i> (Dusén) J.-P. Frahm	E	MV	GP	PP		
		<i>Campylopus acuminatus</i> Mitt.	A	VNS	GP-AP	STS, PS		
		<i>Campylopus incrassatus</i> Müll. Hal.	A	MVNS	AP	STS		
		<i>Campylopus clavatus</i> (R. Br.) Wilson	C	MVNS-JF, EI	TF	SB		
		<i>Campylopus introflexus</i> (Hedw.) Brid.	COS	XMVNS-JF	GP-AP	STS		
		<i>Campylopus pyriformis</i> (Schultz) Brid.	B	XMVNS-JF	GP-AP	STS		
		<i>Chorisodontium aciphyllum</i> (Hook. f. & Wilson) Broth.	A	VNS-JF	GP	ST		
		<i>Dicranella circinata</i> Herzog	E	V	GP-AP	STA		
		<i>Dicranoloma billardierei</i> (Brid. ex Anon.) Paris	PAN	MVNS-JF	GP-AP-TF	STS		
		<i>Dicranoloma imponens</i> (Mont.) Renauld	A	VNS	GP-AP	STS		
		<i>Dicranoloma robustum</i> (Hook. f. & Wilson) Paris	A	VNS	GP-AP	Co		
		<i>Eucamptodon perichaetialis</i> (Mont.) Mont.	E	MVNS-JF	GP-AP	Co		
		Pottiaceae		<i>Leptodontium longicaule</i> var. <i>microruncinatum</i> (Dusén) R.H. Zander	AM	MVNS-JF	AP	STS
		Splachnaceae		<i>Tayloria stenophysata</i> (Herzog) A.K. Kop.	E	VNS	GP	STF
<i>Tetraplodon mnioides</i> (Sw. ex Hedw.) Bruch & Schimp.	B			VNS	GP	STF		
Meesiaceae		<i>Leptobryum pyriforme</i> (Hedw.) Wilson	COS	XMVNS	GP	STFo		
Bryaceae		<i>Bryum pseudotriquetrum</i> (Hedw.) P. Gaertn., B. Mey. & Scherb.	B	VNS-CCh	GP	STFo		
Mniaceae		<i>Pohlia nutans</i> (Hedw.) Lindb.	B	VNS	AP	STS		
Bartramiaceae		<i>Breutelia dumosa</i> Mitt.	E	VNS	GP-AP	STA		
		<i>Breutelia subplicata</i> Broth.	E	MVNS	GP-AP-TF	STH		
		<i>Conostomum pentastichum</i> (Brid.) Lindb.	C	VNS	AP	STS		
Orthotrichaceae		<i>Ulota</i> cf. <i>rufula</i> (Mitt.) A. Jaeger	E	VN-JF	GP	Co		
		<i>Zygodon hookeri</i> var. <i>leptobolax</i> (Müll. Hal.) Calabrese	E	MVNS	GP	Co		
		<i>Zygodon pentastichus</i> (Mont.) Müll. Hal.	E	MVNS-JF	GP	Co		
Rhizogoniaceae		<i>Hymenodontopsis mnioides</i> (Hook.) N.E. Bell, A.E. Newton & D. Quandt	B	MVNS-JF	TF	SB		
Ptychomniaceae		<i>Ptychomniella ptychocarpa</i> (Schwägr.) W.R. Buck & al.	E	MVNS-JF	GP-TF	SB		
		<i>Ptychomnion cygnisetum</i> (Müll. Hal.) Kindb.	E	XMEVNS-JF	GP-AP-TF	STS, SB		
		<i>Ptychomnion densifolium</i> (Brid.) A. Jaeger	C	VNS	GP-AP	STS		
Hypopterygiaceae		<i>Dendrohypopterygium arbuscula</i> (Brid.) Kruijer	E	MVNS-JF	TF	SB		

Table 1. (Continuation)

Group	Family	Taxon	Distribution		Habitat	
			Global	Local	Macro	Micro
		<i>Hypopterygium didictyon</i> Müll. Hal.	PAN	MVNS	TF	SB
	Daltoniaceae	<i>Daltonia gracilis</i> Mitt.	N	VNS-JF	AP	Co
		<i>Distichophyllum dicksonii</i> (Hook. & Grev.) Mitt.	E	VNS	TF	Co
	Amblystegiaceae	<i>Sanionia uncinata</i> (Hedw.) Loeske	B	VNS	AP	STA
	Thuidiaceae	<i>Thuidiopsis furfurosa</i> (Hook. f. & Wilson) M. Fleisch.	PAN	VNS-JF	AP	STS
	Brachytheciaceae	<i>Kindbergia praelonga</i> (Hedw.) Ochyra	B	MVNS	AP	STA
	Hypnaceae	<i>Calliergonella cuspidata</i> (Hedw.) Loeske	COS	V	AP	STA
		<i>Hypnum chrysogaster</i> Müll. Hal.	C	VNS- JF	GP-AP	Co
		<i>Hypnum cupressiforme</i> var. <i>mossmanianum</i> (Müll. Hal.) Ando	C	VNS	GP-TF	ST, SB
	Sematophyllaceae	<i>Rhaphidorrhynchium callidum</i> (Mont.) Broth.	E	XMVNS	AP-TF	Co
	Lepyrodontaceae	<i>Lepyrodon patagonicus</i> (Cardot & Broth.) B.H. Allen	E	MVNS	GP	Co
	Lembophyllaceae	<i>Acrocladium auriculatum</i> (Mont.) Mitt.	C	VNS	TF	SB
		<i>Rigodium pseudothuidium</i> Dusén	E	XMVNS-JF	AP-TF	STS, SB
		<i>Rigodium brachypodium</i> (Müll. Hal.) Paris	E	XMVNS-JF	TF	SB
Liverworts	Aneuraceae	<i>Riccardia alcicornis</i> (Hook. f. & Taylor) Trevis	E	VNS	AP	STA
		<i>Riccardia amnicola</i> Hässel	E	VNS-Ma	AP	STA
		<i>Riccardia floribunda</i> (Steph.) A. Evans	E	VNS	GP-AP-TF	STA
		<i>Riccardia hyalitricha</i> Hässel	E	VNS	TF	SB, CB
		<i>Riccardia prehensilis</i> (Hook. & Taylor) C. Massal.	E	VNS	GP-AP-TF	Co, SB, CB, BA
		<i>Riccardia rivularis</i> Hässel	E	VNS-NL	GP-AP-TF	Co, SB, CB
		<i>Riccardia spinulifera</i> C. Massal.	E	VNS	TF	SB, CB
	Porellaceae	<i>Porella subsquarrosa</i> (Nees & Mont.) Trevis.	E	VNS-CCh, JF	GP-AP	Co
	Lepidolaenaceae	<i>Gackstroemia magellanica</i> (Lam.) Trevis.	E	VNS-CCh, JF	GP	SB, CB
		<i>Lepidogyna menziesii</i> (Hook.) R.M. Schust.	E	VNS-JF	GP-TF	SB, CB
	Radulaceae	<i>Radula decora</i> Gottsche ex Steph.	N	VNS-R, JF	TF	Co
	Frullaniaceae	<i>Frullania</i> cf. <i>boveana</i> C. Massal.	E	VNS	GP-AP-TF	Co
	Lejeuneaceae	<i>Cheilelejeunea</i> cf. <i>obtruncata</i> (Mont.) Solari	E	VNS	AP-TF	SB, CB
	Schistochilaceae	<i>Schistochila lamellata</i> (Hook.) Dumort.	E	VNS- CCh, JF	TF	SB, CB
	Trichocoleaceae	<i>Leiomitraelegans</i> (Lehm.) Hässel	E	VNS-JF	GP-AP	SB, CB
	Herbertaceae	<i>Herbertus runcinatus</i> (Taylor) Kuhnem.	E	VNS-CCh, JF	GP-TF	Co, SB, CB
	Lepicoleaceae	<i>Lepicolea ochroleuca</i> (L. f. ex Spreng.) Spruce	F	VNS-CCh, JF	GP-AP-TF	STA, Co
	Lepidoziaceae	<i>Bazzania peruviana</i> (Nees) Trevis.	N	VNS- JF	GP-AP-TF	Co, SB, CB, BA
		<i>Hyalolepidozia bicuspidata</i> (C. Massal.) S.W. Arnell ex Grolle	F	VNS- R, JF	GP-AP	EP
		<i>Kurzia setiformis</i> (De Not.) J.J. Engel & R.M. Schust.	A	VNS-CCh	GP-AP	EP
		<i>Lepidozia chiloensis</i> Steph.	A	VNS-NL	GP	PP
		<i>Lepidozia chordulifera</i> Taylor	E	VNS-CCh, JF	GP-AP-TF	BA, CB, Co
		<i>Lepidozia fuegiensis</i> Steph.	E	VNS-R	TF	SB, CB
		<i>Lepidozia laevifolia</i> (Hook. f. & Taylor) Gottsche, Lindenb. & Nees	A	VNS-R, JF	GP-AP	ST
		<i>Telaranea blepharostoma</i> (Steph.) Fulford	E	VNS-CCh, JF	AP-TF	ST, EP
		<i>Telaranea plumulosa</i> (Lehm. & Lindenb.) Fulford	E	VNS- JF	AP-TF	EP
		<i>Acromastigum anisostomum</i> (Lehm. & Lindenb.) A. Evans	A	VNS	GP	ST

Table 1. (Continuation)

Group	Family	Taxon	Distribution		Habitat			
			Global	Local	Macro	Micro		
Lophocoleaceae		<i>Chiloscyphus attenuatus</i> (Steph.) J.J. Engel & R.M. Schust.	E	VNS-JF	TF	SB, CP		
		<i>Chiloscyphus breutelii</i> (Gottsche) J.J. Engel & R.M. Schust.	N	V	TF	SB, CP		
		<i>Chiloscyphus horizontalis</i> (Hook.) Nees	E	VNS	TF	SB, CP		
		<i>Chiloscyphus humilis</i> (Hook. f. & Taylor) Hässel	C	VNS-JF	GP	PP, BA		
		<i>Chiloscyphus magellanicus</i> Steph.	E	VNS-JF	GP-TF	SB, BA, CB		
		<i>Chiloscyphus striatellus</i> C. Massal.	E	VNS	GP-TF	SB, CP		
		<i>Chiloscyphus subviridis</i> (Hook. f. & Taylor) J.J. Engel & R.M. Schust.	E	VNS-CCh, JF	GP	SB, CP		
		<i>Leptoscyphus huidobroanus</i> (Mont.) Gottsche	E	VNS	GP-AP-TF	SB, CP		
		Plagiochilaceae		<i>Plagiochila chonotica</i> Taylor	E	VNS	TF	SB, CP
				<i>Plagiochila hookeriana</i> Lindenb.	E	VNS-JF	TF	SB, CP
				<i>Plagiochila lechleri</i> Gottsche	E	VNS-Ma	AP	SB, CP
				<i>Plagiochila lophocoleoides</i> Mont.	E	VNS	TF	SB, CP
				<i>Plagiochila rubescens</i> (Lehm. & Lindenb.) Lindenb.	E	VN-CCh, JF	TF	SB, CP
<i>Plagiochila stictaecola</i> Mont. & Gottsche	E			VNS	GP	BA		
<i>Plagiochila subpectinata</i> Besch. & C. Massal.	E			VNS-R	AP-TF	SB, CP		
Jamesoniellaceae		<i>Cryptochila grandiflora</i> (Lindenb. & Gottsche) Grolle	PAN	VNS-JF	GP	ST		
		<i>Jamesoniella colorata</i> (Lehm.) Steph.	C	VNS-CCh, JF	GP-AP-TF	STS, Co, CB		
		<i>Nothostrepta bifida</i> (Steph.) R.M. Schust.	E	VNS-JF	AP	CB		
Cephaloziaceae		<i>Cephalozia skottsbergii</i> Steph.	E	VNS-Ma-NL	GP-AP	ST, EP		
Scapaniaceae		<i>Anastrophyllum schismoides</i> (Mont.) Steph.	A	VNS	GP	STH		
Balantiopsisaceae		<i>Balantiopsis asymmetrica</i> (Herzog) J.J. Engel	E	VNS-JF	AP-TF	CB, BA		
		<i>Balantiopsis cancellata</i> (Nees) Steph.	E	VNS-CCh, JF	GP-AP	BA, CB		
		<i>Isotachis madida</i> (Hook. f. & Taylor) Mitt.	E	VNS-CCh	AP	STS		
Calypogeiaceae		<i>Calypogeia sphagnicola</i> (Arnell & J. Perss.) Warnst. & Loeske	B	VNS-Ma-NL	GP-AP	ST, EP		
Geocalycaceae		<i>Saccogynidium australe</i> (Mitt.) Grolle	A	VNS-JF	AP	ST, EP		
Lichens	Cladoniaceae	<i>Cladia aggregata</i> (Sw.) Nyl.	PAN	VNS-JF	GP-AP	STH, BA		
		<i>Cladonia arbuscula</i> (Wallr.) Flot.	B	VNS	GP-AP	ST		
		<i>Cladonia bellidiflora</i> (Ach.) Schaer.	B	VNS-NL	GP-AP	ST		
		<i>Cladonia cenotea</i> (Ach.) Schaer.	B	VNS-Ma-NL	GP	ST		
		<i>Cladonia chlorophaea</i> (Flörke ex Sommerf.) Spreng.	COS	VNS-JF	TF	Co		
		<i>Cladonia gracilis</i> subsp. <i>elongata</i> (Wulfen) Vain.	B	VNS-JF	AP-TF	ST		
		<i>Cladonialepidophora</i> Ahti & Kashiw.	E	VNS-JF	GP-AP	ST		
		<i>Cladonia macilenta</i> Hoffm.	COS	VNS-JF	AP-TF	Co		
		<i>Cladonia mitis</i> Sandst.	B	VNS	GP-AP	ST		
		<i>Cladonia pycnoclada</i> (Pers.) Nyl.	E	MVNS-JF	GP-AP	ST		
		<i>Cladonia scabriuscula</i> (Delise) Leight.	COS	VNS-JF	AP	ST		
		<i>Cladonia squamosa</i> (Scop.) Hoffm.	COS	VNS-JF	GP-AP-TF	ST		
		<i>Cladonia subsubulata</i> Nyl.	B	VNS-JF-NL	AP	STH		
		Lobariaceae		<i>Pseudocyphellaria berberina</i> (G. Forst.) D.J. Galloway & P. James	E	VNS-JF-R	GP-TF	Co
				<i>Pseudocyphellaria crocata</i> (L.) Vain.	COS	MVNS-JF, R	TF	Co

Table 1. (Continuation)

Group	Family	Taxon	Distribution		Habitat	
			Global	Local	Macro	Micro
		<i>Pseudocyphellaria divulsa</i> (Taylor) Imshaug	E	VNS	AP	Co
		<i>Pseudocyphellaria faveolata</i> (Delise) Malme	A	VNS	TF	Co
		<i>Pseudocyphellaria flavicans</i> (Hook. f. & Taylor) Vain.	E	VNS-JF	GP-TF	Co
		<i>Pseudocyphellaria valdiviana</i> (Nyl.) Follmann	E	VSN	TF	Co
		<i>Sticta caulescens</i> De Not.	E	VSN	TF	Co
		<i>Sticta hypochra</i> Vain.	E	VSN	TF	Co
	Parmeliaceae	<i>Hypogymnia subphysodes</i> (Kremp.) Filson	A	MVNS	GP-AP	Co
		<i>Parmotrema reticulatum</i> (Taylor) M. Choisy	COS	XMVNS-JF, R, EI	AP	Co
	Peltigeraceae	<i>Peltigera didactyla</i> (With.) J. R. Laundon	COS	VNS	AP	STS
		<i>Peltigera polydactylon</i> (Neck.) Hoffm.	COS	VNS-R	AP	STS
	Sphaerophoraceae	<i>Bunodoporon patagonicum</i> (C.W. Dodge) Wedin	A	VNS	TF	Co

In a study complementing the one presented here we have reported three species and one sub-species new to Chiloé Province, five species new to los Lagos Region and one species new to Chile; thus highlighting the importance of these wetlands in the context of Chilean biodiversity (León & al., 2013).

On the other hand, a high number of species shown in this work could have been influenced by environmental elements—including the presence of rare or vagrant species—and the heterogeneity of the landscape (Halfpeter & Moreno, 2005). Sixty of the mentioned species were documented just for one place, which could result from community structural complexity, as previously seen in tropical forests (Halfpeter & Moreno, 2005).

The heterogeneity of the landscape and, in particular, the heterogeneity of the microhabitat, has an important effect on the species registered in each habitat type, especially in the case of glaciogenic and anthropogenic peatlands. The vertical gradient, which translates into a microtopographic or microstructural division, embraces from pools and water saturated depressions to dry hummocks. This is one of the most relevant factors when assessing the specific richness

and the floristic composition (Andrus & al., 1983; Wheeler, 1993; Wheeler & Proctor, 2000; Rydin & Jeglum, 2006). The latter is not applicable to tepuales, where the bryophytic carpet is homogeneous.

In addition, there are environmental factors that may also heavily influence the composition of the bryophyte and lichen species in these ecosystems. León (2012) established that the chemical composition of water affects significantly the occurrence of the species of the cryptogamic groups under study.

After comparing the floristic results obtained here with results already published for ombrotrophic peatlands in the Northern Hemisphere, the low number of *Sphagnum* species in the studied area stands out: only six, a number much lower than that established for Canada (Vitt & Belland, 1995) or Great Britain (Wheeler, 1993). It is important to note that in Chile no taxonomical review of the genus *Sphagnum* has been carried out, so the number of reported species could vary after further studies.

Another contrasting result is the high number of species of liverworts present in the peatlands of Chiloé in comparison to those in the Northern Hemisphere. For instance, Vitt & Belland (1995) reported 20 species of liverworts in Canadian peatlands, and Wheeler (1993) pointed out 17 species of liverworts in British bogs. The specific richness of both is significantly surpassed by the 30 taxa found in Chiloé. Nevertheless, the low number of liverworts that has been historically documented could be partially explained by the generalized lack of knowledge of this group. Although the Boreal peatlands are very well characterized, studies that include liverworts are scarce (Kleinebecker & al., 2008).

Vitt & Belland (1995) have stated that in the Canadian peatlands an important percentage of species have a high fidelity to a certain type of peatland. These authors refer to the utility of bryophytes as indicator species for the classification of these ecosystems. In the case of Chiloé, despite having observed the fidelity of some species to a type of habitat, further studies are necessary to identify with certainty the species that can serve as indicators for the classification of peatlands.

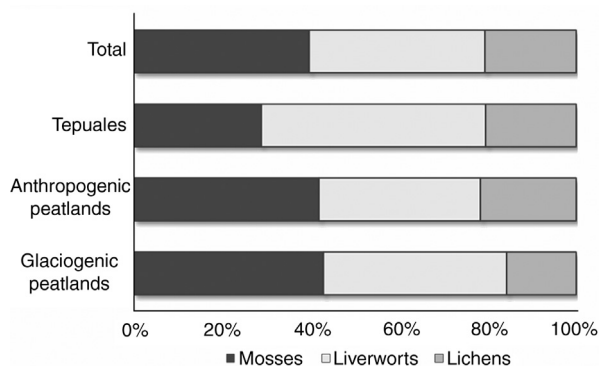
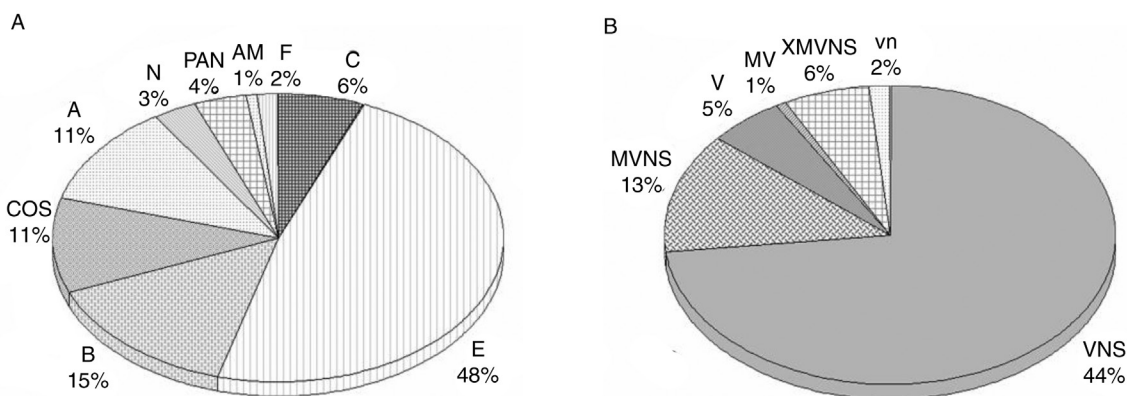


Fig. 2. Percentage of mosses, liverworts, and macro-lichens in total and in each of the types of habitats.



**Fig. 3.** Distribution patterns: **A**, global for all the species (A, Austral-Antarctic; AM, American; B, Bipolar; C, Circumsubantarctic; COS, Cosmopolitan; E, Endemic; F, African; N, Neotropical; PAN, Pantropical). **B**, national for all the species (M, Mediterranean; N, Nord-Patagonic; S, Subantarctic; V, Valdivian; X, Xeromorphic).

The dominant bryo-lichenic flora of peatlands and tepuales coincides in distribution with that of the Valdivian temperate rainforests endemic to southern South America. This suggests a prolonged isolation of the flora (Villagrán & al., 2003). For example, the Neotropics are one of the areas showing the highest endemicity of bryophytes worldwide—the percentage of endemic species reaches 48% (Tan & Pócs, 2000). Consequently, taking as reference the cited study, the 48% endemic taxa we find in our study places the assessed ecosystems in the range of highest bryophyte endemicity.

The majority of species studied shows a wide distribution in southern Chile; extending along regions X and XII in southern Chile and reaching, in certain cases, region VII in central Chile. This distribution pattern is repeated for most of the bryophytic flora of the archipelago of Chiloé (Villagrán & al., 2005). This range of distribution, associated with temperate rainforests of southern South America, is considered favorable for the development of groups of cryptogams like the ones studied, due to the conditions that exist there, such as the very humid oceanic climate, the diversity of habitats, and the temperatures moderated by the influence of the sea (Barrera & Osorio, 2008).

Another relevant issue to highlight is the important number of species that exhibit discontinuity in their national distributional ranges. An important number of disjunct species shows a gap between Chiloé and the forests of Fray Jorge, located in the semi-arid coast of northern Chile. This distributional pattern has been associated with tectonic and climatic events that affected the Chilean territory during the Tertiary and Quaternary, that transformed Fray Jorge into a glacial refuge (Villagrán & al., 2004).

Finally, measuring the biological diversity, as well as shedding light on ecological theory, provides decision makers with new parameters for issuing recommendations on the conservation of taxa or endangered areas, as well as monitoring the effects of perturbations on the environment (Moreno, 2001). The Convention on Biological Diversity requires that the signatory nations establish an inventory of its biodiversity, monitor changes in the biodiversity, and lay out plans on how biodiversity can be preserved (ONU, 1992). However, Chile is still far from meeting these objectives with regards to bryophytes and macro-lichens, groups that show a lack of basic and descriptive research, which should be tackled in order to establish

and adequately manage the natural heritage. Thus, the present study is our contribution towards meeting these requirements.

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