

Biometrics of the sporangia and spores of the *Parablechnum cordatum* complex (Blechnaceae, Polypodiopsida)

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Abstract. *Parablechnum* is the most diverse genus of Blechnaceae (ca. 65 species), with a pantropical distribution and two centers of diversity, in America and in the Austro-Pacific region. The species are dimorphic, with often erect rhizomes and rhizomatic scales, 1-pinnate fronds, with truncate blade at base, conform apex and stalked pinnae. This group presents many taxonomic problems, needing more detailed studies to resolve these conflicts of separation between species. This work deals with the American complex of *P. cordatum* in which the species *P. cordatum*, *P. schiedeanum*, *P. chilense*, *P. falciforme* and *Blechnum varians* are included. A biometric analysis of sporangia and spores, important taxonomic structures in the distinction of ferns, has been carried out. The data were subjected to an ANOVA and a discriminant analysis. In addition, the spores were observed under a scanning electron microscope to study their ornamentation. Of the characters we have studied thickness of the arcus, number of cells in the arcus, number of cells in the hypostome and major equatorial diameter of the spore have statistically supported taxonomic significance and are therefore useful for species separation.

Keywords: *Blechnum*, fern, morphology, pantropical, taxonomy.

[es] Biometría de los esporangios y esporas del complejo *Parablechnum cordatum* (Blechnaceae, Polypodiopsida)

Resumen. *Parablechnum* es el género más diverso de las Blechnaceae (ca. 65 especies), con una distribución pantropical y dos centros de diversidad, en América y en la región austro-pacífica. Las especies son dimorfas, con rizomas normalmente erguidos y escamas rizomáticas, frondas pinnadas, con hoja truncada en la base, de ápice conforme y pinnas pecioluladas. Este grupo presenta muchos problemas taxonómicos, por lo que se necesitan estudios más detallados para resolver conflictos de separación entre especies. Este trabajo trata del complejo americano de *P. cordatum* en el que se incluyen las especies *P. cordatum*, *P. schiedeanum*, *P. chilense*, *P. falciforme* y *Blechnum varians*. Se ha llevado a cabo un análisis biométrico de los esporangios y las esporas, estructuras taxonómicamente importantes en la distinción de los helechos. Los datos se sometieron a un ANOVA y a un análisis discriminante. Además, las esporas se observaron bajo un microscopio electrónico de barrido para estudiar su ornamentación. De los caracteres que hemos estudiado, el grosor del arco, el número de células en el arco, el número de células en el hipostomio y el diámetro mayor ecuatorial de la espora han apoyado estadísticamente su importancia taxonómica y, por lo tanto, son útiles para la separación de especies.

Palabras clave: *Blechnum*, helecho, morfología, pantropical, taxonomía.

Introduction

Blechnaceae is a subcosmopolitan fern family, with about 265 species (PPG I 2016). The family consists of 25 genera (Gasper et al. 2016, 2017; Molino et al. 2019). Among these, *Parablechnum* is the most diverse, comprising approximately 65 species

with a pan-tropical distribution (Fig. 1), predominantly in the southern hemisphere (Gasper et al. 2017).

The genus *Parablechnum* is one of the most complex genera of the Blechnaceae in terms of taxonomy; one of the groups of species that has received the most attention is the *P. cordatum* (Desv.) Gasper &

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Salino complex, including *Parablechnum cordatum*, *P. schiedeanum* (Schltdl. ex C.Presl) Gasper & Salino, *P. chilense* (Kaulf.) Gasper & Salino and *P. falciforme* (Liebm.) Gasper & Salino. In addition, there is another related taxon, *Blechnum varians* (E. Fourn.) C. Chr., which, because it is considered synonymous with *P. schiedeanum* (Moran 1995), has not been recombined with *Parablechnum*.

In the case of *P. cordatum*, *P. schiedeanum*, and *P. chilense*, there has been disagreement about whether they were co-specific (Tryon & Stolze 1993), or whether they were distinct species (De la Sota 1972; Moran 1995; Rodríguez 2015; Gasper et al. 2017), so several authors have indicated the need for a monographic study of the group (Dittrich et al. 2017; Moran 1995; Tryon & Stolze 1993). Recent molecular phylogenetic studies suggest that they could correspond to three different species (Vicent 2017).

Tryon & Stolze (1993) included *P. chilense* under the synonymy of *P. cordatum*, and this same criterion is adopted by Prada et al. (2008). There are authors who support the separation of both species based on morphological characteristics, such as Rodríguez (2015) who argues that *P. cordatum* and *P. chilense* differ in the shape and distribution of the scales of the petiole and rachis, the aerophores, and the sporal morphology.

As for *P. falciforme*, Moran (1995) maintains that it may be co-specific with *P. schiedeanum*. On the other hand, *Blechnum varians* appears as a synonym for *Parablechnum schiedeanum* according to Tropicos (2020), following the criteria of Mickel & Smith (2004), who believe that it is the same species. According to Moran (1995) *Blechnum varians* apparently differs from *P. schiedeanum* only by its dark axes and flattened or very sparse and irregular pinna margins, suggesting that it could be the same species since there is not so much difference.

To clarify the taxonomy of this group, a more extensive study of the genus is necessary, and among the characters that have been revealed to be of taxonomic importance, spores and sporangia are of special interest.

Spores have been widely used as a taxonomical character in ferns (Tryon & Lugardon 1991; Tryon & Tryon 1982). In particular, ornamentation, wall structure, size and shape of the spores are of high taxonomic value characters, since they are relatively constant for each species (Barrington et al. 1986, 2020; Lugardon 1974; Tryon & Lugardon 1991).

Particularly, spores have come out as important characters within the family Blechnaceae, and so do the sporangia (Melo da Silva et al. 2019; Molino et al. 2020; Moran et al. 2018; Prada et al. 2016; Passarelli et al. 2010).

Thus, the aim of this work is to provide new data that help to elucidate the infra-generic taxonomy of the species complex *Parablechnum cordatum* through the biometry of spores and sporangia.

Material and methods

Biometric Analysis

A biometric analysis of the five taxa was carried out, using at least two individuals from each of them. The specimens analysed can be found in the Appendix.

For the optical microscopy observations, the samples were mounted directly in water and photographed with a Nikon Eclipse Ci microscope with a Nikon DS-Fi2 camera. From the photographs taken, the desired characters were measured with the *Piximètre* software.

At least 15 measurements of the following sporangial characters were taken on each individual: height and width of the capsule; number of cells and thickness of the arcus; number of hypo and epistomial cells; width of the cells of the upper and lower lip and length of the pedicel and rosette. All the terms used regarding the sporangia follows what is stated in Molino et al. (2020). For the length of the rosette, a minimum of 10 measurements were taken per individual.

Spores were studied by optical microscopy to establish their dimensions in a total of 11 individuals, mounted in water without previous treatment. In every individual, 15 measurements of the polar and equatorial major diameter were taken, excluding the perispore.

From the same individuals, sporal ornamentation was studied by scanning electron microscopy. The samples were mounted in a sample holder with carbon adhesive, metallized and observed in a scanning electron microscope (SEM) JSM 6400 JEOL operating at 20 kv. The observations were made at the National Center of Electronic Microscopy (CNME) of the Universidad Complutense de Madrid. Two variables were chosen in relation to ornamentation: small (< 10 µm) or large (>10 µm) areolae, and presence or absence of filamentous processes.

Statistical analysis

A biometric data matrix has been constructed using the measurements of individuals for each character. Using the *SPSS* software, the normality of the data was checked, doing a K-S test, followed by a Lilliefors' significance correction. Once the normal distribution of the variables was checked, in the following statistical analyses, parametric tools were used. In all cases, $\alpha=0.05$ has been used as a criterion.

With the same software an ANOVA was made for each one of the mentioned characters with a Tukey's Post-Hoc HSD test to check if the difference between the means of the variables was significant.

Using the *Statgraphics* software, a discriminant function analysis was performed in 2 phases, first, using two dichotomous variables (small or large areolae, presence of filaments or not) that allowed us to differentiate 100% between 3 groups. In a second

phase, the discriminant analysis uses the continuous morphological variables producing a discriminant function that allows separating the species of each group according to the most explanatory variables.

Results

Morphological analysis of spores

In all species the spores are monolet, flat-convex in longitudinal equatorial view and elliptical in polar view. The perispodium is folded forming walls that delimit more or less regular areolae. The dimensions obtained (equatorial diameter x polar diameter) have been approximately *Blechnum varians* (46) 55 (65) x (37) 42 (50) μm ; *Parablechnum chilense* (44) 51 (57) x (33) 37 (40) μm ; *P. cordatum* (52) 66 (75) x (41) 52 (62) μm ; *P. falciforme* (43) 56 (67) x (34) 42 (52) μm and *P. schiedeanum* (47) 59 (74) x (37) 44 (55) μm . These are rounded values, the exact values with their standard deviation can be found in Table 1.

According to the ornamentation of the spores of each species, 3 groups could be distinguished: Group 1, formed by spores with small areolae, up to 10 μm and with filaments on the areolae surface, corresponding to *P. chilense* and *P. falciforme*; Group 2, which includes spores with large areolae, up to 30 μm and without filaments, corresponding to *P. cordatum* and *P. schiedeanum*, and Group 3, composed by spores with large areolae and with filaments in their central area, where only *B. varians* is found (Fig. 2).

These dichotomous variables have made it possible to differentiate one of the species in the complex, *B. varians*. In order to separate the taxa of groups 1 and 2, the analysis of the continuous variables was used.

Biometric analysis of characters

The biometric data for the characterization of the sample are shown in Table 1. With the discriminant analysis carried out in groups 1 and 2 resulting from the morphological analysis of the spores, the standardized coefficients of the discriminant function have been obtained for each group, which indicate the most important variables to separate *P. chilense* and *P. falciforme* in the first case, and *P. cordatum* and *P. schiedeanum* in the second. The results of the analysis are shown in Table 2, which highlights the most explanatory variables for the function in each group.

The continuous variables used to separate Group 1 species showed significant differences in the discriminant analysis (P-Value<10⁻⁴; Wilk's Lambda=0.0535403; gl=13), as did those in Group 2 (P-Value<10⁻⁴; Wilk's Lambda=0.128511; gl=13).

Of the five most significant variables to separate both species (Table 2), the three with higher absolute

values were chosen for Group 1 to make the separation of *P. chilense* and *P. falciforme* easier. The width of the upper lip, the number of hypostomial cells and the thickness of the arcus showed a percentage of cases correctly separated of 100%, that is, with these three variables and their respective measures, there was no confusion between the mentioned taxa because these measures were sufficiently different so that none of them was confused, allowing the total separation of them. This is shown in the scatter plot in Fig. 3, where the separation of both species is seen with two of the most explanatory variables (width of the upper lip and thickness of the arcus).

For Group 2, of the five most explanatory variables (Table 2), the three with the highest absolute values were chosen to facilitate the distinction of *P. cordatum* and *P. schiedeanum*. The number of cells in the arcus (Fig. 4), the equatorial diameter of the spores, and the length of the rosette (Fig. 6) showed a percentage of well separated cases of 92.98% (4 of 57 measurements were not correctly separated). This can be seen in the scatter plot of Fig. 5, in which certain overlaps between individuals of both species are seen with the two most explanatory variables (equatorial spore diameter and number of cells in the sporangial arcus).

To homogenize the distinction of the species in this complex, the discriminant function has been calculated for both groups using the same variables, that is, the two most explanatory variables of Group 1 (the width of the upper lip and the number of cells in the hypostome) and Group 2 (the number of cells in the arcus and the equatorial diameter of the spores) have been chosen.

For Group 1 the percentage of well separated cases is 98.67% (1 out of 75 measurements have not been correctly classified), while for Group 2 the percentage is 90.74% (5 out of 54 measurements have not been correctly classified).

From the previous analyses, it is clear that the combination of sporal and sporangial characteristics that make each one of the species unique is the following: *Blechnum varians*: spores of (46) 55 (65) x (37) 42 (50) μm , with large areolae and with filaments; *Parablechnum chilense*: spores of (44) 51 (57) x (33) 37 (40) μm , small areolae and with filaments. The width of the upper lip is (11) 15 (20) μm , the number of hypostomial cells is (3) 4 (5) and the thickness of the arcus is (49) 58 (67) μm ; *P. falciforme*: spores of (43) 56 (67) x (34) 42 (52) μm , with small areolae and with filaments. The width of the upper lip is (15) 24 (32) μm , the number of cells in the hypostomy is (2) 3 (4) and the thickness of the arcus is (59) 71 (85) μm ; *P. cordatum*: spores of (52) 66 (75) x (41) 52 (62) μm , with large areolae and without filaments. The number of cells in the arcus is (17) 21 (26) and the length of the rosette is (29) 77 (109) μm ; *P. schiedeanum*: spores of (47) 59 (74) x (37) 44 (55) μm , with large areolae and without

filaments. The number of cells in the arcus is (17) 22 (30) and the length of the rosette is (41) 58 (76) μm .

Discussion

Spores are a character of great importance when making taxonomic classifications in ferns (Barrington et al. 1986, 2020; Tryon & Lugardon 1991; Tryon & Tryon 1982). Specifically, in the case of the family Blechnaceae several studies have been made concerning the spores (Melo da Silva et al. 2019; Moran et al. 2018; Passarelli et al. 2010), and recently others that allow us to discriminate species and genera within this family using, in addition to the spores, the information concerning the sporangia (Molino et al. 2020).

The differences in spore ornamentation, in terms of areolae and filaments, have been mentioned in both *Parablechnum schiedeanum* (Moran et al. 2018) and *P. falciforme* (Passarelli et al. 2010), coinciding our results with those presented in these publications. As for *P. cordatum*, its ornamentation was described by Prada et al. (2008) and Melo da Silva et al. (2019), who indicated that the areas between ridges present filaments or that they present discrete filaments dispersed throughout the surface, respectively. Rodríguez (1970) described the spores of *P. chilense*, with perforations and evident laesura. Later this same author (Rodríguez 2015) highlighted that *P. chilense* and *P. cordatum* differ in the scales of the petiole, aerophores and palynology, but did not specify what the differences are. In our work we have been able to verify that *P. cordatum* does not present filaments on the surface of its spores and, therefore, the presence of filaments in *P. chilense* and its absence in *P. cordatum* is one of the most evident characteristics that allows differentiating both species.

It is not registered in any previous work the ornamentation of the spores of *B. varians* probably because it has been considered as a synonym of *P. schiedeanum* (Mickel & Smith 2004), however, according to our results *B. varians* presents big areolae and filaments in the surface of its spores, unlike the observed in those of *P. schiedeanum*.

In this work, it has been provided a statistical support related to the biometry of certain characters such as the width of the cells of the lip or the thickness of the arcus of the sporangia that has not been documented before. Likewise, it has been possible to separate the five taxa inside the complex, through the statistical comparisons of the means among the species with a discrimination of more than 90% in all the cases.

Despite having made a homogenization to facilitate the separation of taxa belonging to this complex, it is important to highlight the eight variables that most explain the separation between groups and within groups, because they provide much information about each taxon. Even so, for a simple identi-

fication, using only the four variables chosen we can do it in a correct way in more than 90% of the occasions.

Respecting the species that we treat in this work, only the sporangia of *Parablechnum cordatum* have been described before (Prada et al. 2016), where it is indicated that they are sporangia with (16) 17 (20) cells in the arcus, 4-6 in the epistomium, 3-5 in the hypostomium and 2-4 in the stomium (lips), wide pedicel that narrows abruptly in the rosette, whose cells are narrower, 1600 μm long and 160 μm wide. In our work, we have been able to verify that clear differences are observed in the number of cells in the epistomium and in the length of the pedicel, which are 3-4 and 264-488 μm respectively. The mentioned differences perhaps are due to that these authors treated *P. chilense* like synonym of *P. cordatum*, reason why the values that offer are nearer to which here we have obtained for *P. chilense*.

Spore biometry is also an extremely important character when making taxonomic classifications in ferns (Tryon et al. 1991). Prada et al. (2008) described the spores of *P. cordatum* as monolete, yellowish-brown, ellipsoidal, (60) 62 (74) x (44) 47 (57) μm , which shows a slight difference with our results [(52) 66 (75) x (41) 52 (62) μm]. As for *P. falciforme*, the sizes recorded in Passarelli et al. (2010) coincide with what has been observed in this work.

The sporal size values of *P. chilense* presented by Rodríguez (1970) are higher than those obtained in our work, and from them it is deduced that spores would tend to have a contour that would tend more to be circular than ellipsoidal in polar view; probably these differences are explained because in the measurements provided by that author the perisporium is included. The data of the spores and sporangia make clear that *P. chilense* presents differences with respect to *P. cordatum*, which agrees with the molecular data of Vicent (2017) and the morphological observations of Rodríguez (2015).

The rest of the biometric characters that have been studied in this work have shown to have an interesting diagnostic value, for which they should be considered in future studies, which was already shown by Prada et al. (2016) in relation to the number of cells in the arcus, among other characters.

Blechnum varians has been treated as a synonym of *P. schiedeanum* by different authors such as Mickel & Smith (2004), Rolleri & Prada (2006) and Gasper et al. (2016), although morphological differences had been previously pointed out between these two species, characterizing *B. varians* for having the petiole and rachis often of dark purple colour and the margins of the pinnae twisted, entire and occasionally serrated (Mickel & Beitel 1988). In our work we have found that there are also clear differences between them, both in the ornamentation of the spores and at the biometric level of sporangia.

Therefore, when recognizing these taxa as distinct species, their recombination to *Parablechnum* is necessary:

Parablechnum varians (C. Chr.) A. Wal, S. Molino & Gabriel y Galán **comb. nov.** \equiv *Lomaria varians* Fourn. Mex. pl. 1. 113. 1872. 1872. \equiv *Blechnum varians* (Fourn.) C. Christ Index filic. 161. 1905. SYNTYPES – Mexico, Veracruz; Orizaba, *Botteri 1420* in Herb- Van Heurck (AWH); “In Valle Cordovensi,” *Bourgeau 1826* (P-6 sheets; NY-2 sheets).

It differs from *Parablechnum schiedeanaum* in its atropurpureous petiole and rachis, crisped pinna margins and spores with filamentous micromentation.

With the results obtained, we elaborated a dichotomous key using the most significant characters of the statistical analysis that allows to distinguish in a simple way the species of this complex.

Key to the species within *P. cordatum* complex

1. Perisporium without filaments on the areolae surface 2
Perisporium with filaments on the areolae surface 3
2. Rosette length and equatorial spore diameter < 60 μm *P. schiedeanaum*
Rosette length and equatorial spore diameter > 60 μm *P. cordatum*
3. Perisporium with large areolae, up to 30 μm *P. varians*
Perisporium with small areolae, up to 10 μm 4
4. Rosette length and ring thickness < 60 μm *P. chilense*
Rosette length and ring thickness > 60 μm *P. falcifome*

Acknowledgements

We thank the herbarium of the Smithsonian National Museum of Natural History (US) for the Cuatrecasas grant that allowed us to obtain some of the material, as well as the herbarium of the New York Botanical Garden (NY), which also offered funding for the visit to its facilities. The Universidad Complutense de Madrid and Santander partially supported this research through the founding of a project (PR87/19-22616).

Thanks also to Myriam González, technician of the CNME, for the beautiful photos taken at the SEM.

And to Jose María Gabriel y Galán, precursor of this work and so many others, who will always be in our researches, thoughts and hearts.

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Appendix

This appendix indicates the specimens used in this study. It is marked with an asterisk (*) those used in the SEM.

***Blechnum varians* (E.Fourn.) C.Chr.:** HONDURAS: El Achote, *T.G. Yuncker 5936*, 17-07-1936 (US1637799); PANAMÁ: Chiriqui, Rio Caldera, *E.P. Killip 5074*, 2-06-1918 (US1843362*). ***Parablechnum chilense* (Kaulf.) Gasper & Salino:** CHILE: Región Bío-Bío, Concepción, Hualpén, *Gabriel y Galán s.n.*, 11-07-2014 (MACB109257); Región de los Lagos, Osorno, Puyehue, *Gabriel y Galán s.n.*, 08-2014 (MACB109256). ***Parablechnum cordatum* (Desv.) Gasper & Salino:** PERÚ: Cajamarca, Chota, Skillman et al. 12893, 14-09-1985 (NY); Cajamarca, Jaén, El Páramo, *J. Campos et al. 5060*, 23-06-1998 (NY); Pasco, Oxapampa, *H. van der Werff et al. 18201*, 9-07-2003 (NY). ***Parablechnum falciforme* (Liebm.) Gasper & Salino:** GUATEMALA: Chimaltenango, Volcán de Acatenago, *W.A. Kellerman 6481*, 8-02-1907 (US575495*). MÉXICO: Chiapas, Cerro del Boquerón, *C.A. Purpus 6739*, 09-1913 (NY); Oaxaca, Sola de Vega, Santiago de Textitlán, *A. Zarate Marcos 638*, 29-09-2006 (NY). ***Parablechnum schiedeanum* (Schltdl. ex C.Presl) Gasper & Salino:** COSTA RICA: Guanacaste, *Gabriel y Galán s.n.*, 17-07-2013 (MACB109260); San José, Vázquez de Coronado, *A. Rojas & Gabriel y Galán 10418*, 17/7/2013 (MACB109259*). MÉXICO: Veracruz, Jalapa, C.L. *Smith 2180*, 1894 (UC995564*).

Tables

Table 1. Characterization of the variables number of cells in the arcus (ANI), thickness of the archs (GRO), size of the sporangia capsule (CAP; length x width), number of cells forming the lip of the stomium (LAB), upper lip cells width (SUP), lower lip cells width (INF), number of cells of the epistomium (EPI), number of cells of the hypostomium (HIP), pedicel length (PED), rosette length (ROS) and size of the spore (ESP, equatorial diameter x polar diameter), indicating in each case the mean and the standard deviation, in the species of *Parablechnum cordatum* (COR), *P. chilense* (CHI), *P. schiedeanum* (SCH), *P. falciforme* (FAL) and *Blechnum varians* (VAR).

Tabla 1. Caracterización de las variables número de células del arco (ANI), grosor del arco (GRO), tamaño de la cápsula del esporangio (CAP; largo x ancho), número de células del estomio (LAB), anchura de las células del labio superior (SUP), anchura de las células del labio inferior (INF), número de células del epistomio (EPI), número de células del hipostomio (HIP), longitud del pedicelo (PED), longitud de la roseta (ROS) y tamaño de la espóra (ESP, diámetro ecuatorial x diámetro polar), indicando en cada caso la media y la desviación típica, en las especies de *Parablechnum cordatum* (COR), *P. chilense* (CHI), *P. schiedeanum* (SCH), *P. falciforme* (FAL) y *Blechnum varians* (VAR).

	ANI	GRO µm	CAP µm	LAB	SUP µm	INF µm	EPI	HIP	PED µm	ROS µm	ESP µm
CHI	19,51,9	58,34	329,524 x 367,720,6	3,80,4	15,11,8	13,72,3	4,10,6	3,90,5	985,3246,6	51,89,3	51,23,2 x 36,53,2
FAL	21,61,7	70,9,6	363,629,2 x 475,764,1	3,50,7	24,34,4	27,74,4	3,60,8	3,10,6	517,6116,1	68,116,1	56,34,5 x 42,43,2
COR	21,1±1,9	74,5±11	371,5±59,3 x 494±59,1	2,9±0,9	23,1±5,1	23,6±5,3	3,5±0,7	3,3±0,8	376,1±112,3	76,7±16,3	65,9±5,5 x 51,84,4
SCH	22,44,1	67,25,8	349,737,5 x 475,938,9	3,70,8	24,14,9	28,24,2	4,21,2	3,60,8	400,285,8	58,27,4	58,85 x 44,13,8
VAR	20,51,6	74,76,7	351,722,4 x 438,436,7	3,60,6	28,23,9	24,93,7	3,20,5	2,90,7	429,688	65,513,7	55,45,1 x 42,23,4

Table 2. Standardized coefficients of the discriminant function for both groups. The green shaded boxes are the most explanatory variables for the function.

Tabla 2. Coeficientes estandarizados de la función discriminante para ambos grupos. Las casillas sombreadas en verde son las variables más explicativas para la función.

Variables	Group 1	Group 2
Pedicel length	0.222035	-0.502921
Number of arcus cells	-0.212399	0.932363
Arcus thickness	-0.534215	-0.533924
Capsule width	-0.104907	-0.44576
Capsule length	-0.381633	0.0287873
Number of lip cells	0.294531	0.460275
Upper lip width	-0.745713	-0.293443
Lower lip length	-0.205091	0.126922
Number of epistomium cells	0.376523	0.241837
Number of hypostomium cells	0.728353	-0.039939
Rosette length	-0.452317	-0.695613
Spore polar diameter	-0.289928	-0.00322015
Spore equatorial diameter	-0.1594	-0.752393

Figures

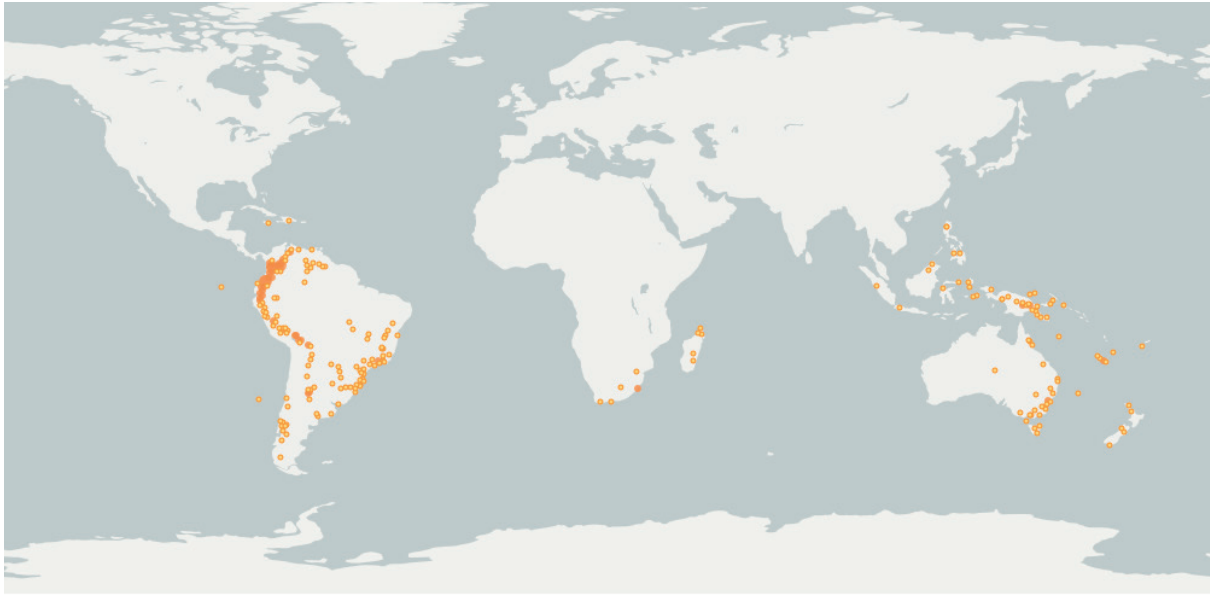


Fig 1. Distribution map of the genus *Parablechnum*.
Fig. 1. Mapa de distribución del género *Parablechnum*.

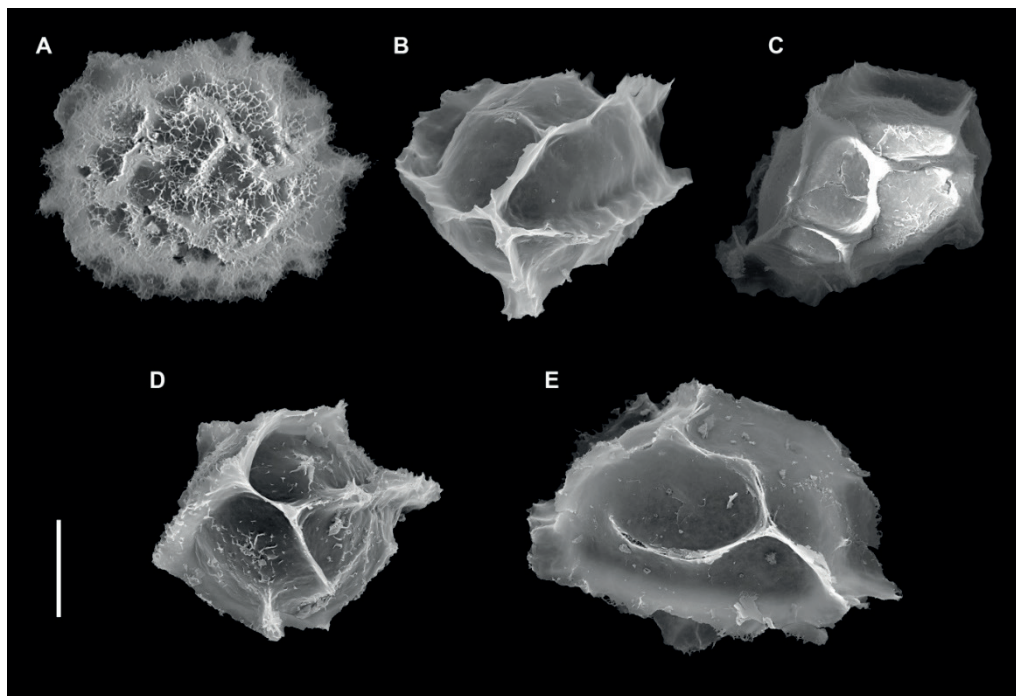


Fig. 2. Spores of the *Parablechnum cordatum* group seen under SEM. A. *P. chilense* (MACB109257); B. *P. cordatum* (Skillman et al. 12893, NY). C. *P. falciforme* (A. Zarate Marcos 638, NY); D. *Blechnum varians* (US1843362); E. *P. schiedeanum* (MACB109259). A, polar distal view; B and D, equatorial transverse view; C and E, equatorial longitudinal view. Bar = 15 μm in A; 25 μm in B-E.

Fig. 2. Esporas del grupo *Parablechnum cordatum* vistas al microscopio electrónico. A) *P. chilense* (MACB109257). B) *P. cordatum* (Skillman et al. 12893, NY). C) *P. falciforme* (A. Zarate Marcos 638, NY). D) *B. varians* (US1843362). E) *P. schiedeanum* (MACB109259). A, vista polar; B y C, vista ecuatorial transversal; C y E, vista ecuatorial longitudinal. Barra = 15 μm en A; 25 μm en B-E.

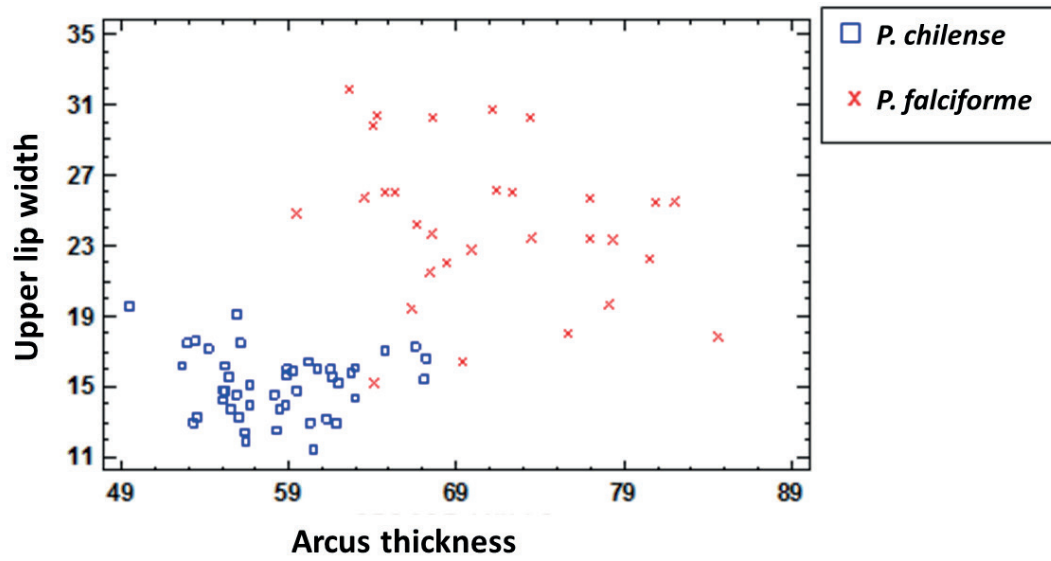


Fig. 3. Dispersion plot resulting from the analysis of the discriminant function with two of the most explanatory variables within Group 1.

Fig. 3. Gráfico de dispersión resultado del análisis de la función discriminante con dos de las variables más explicativas dentro del Grupo 1.

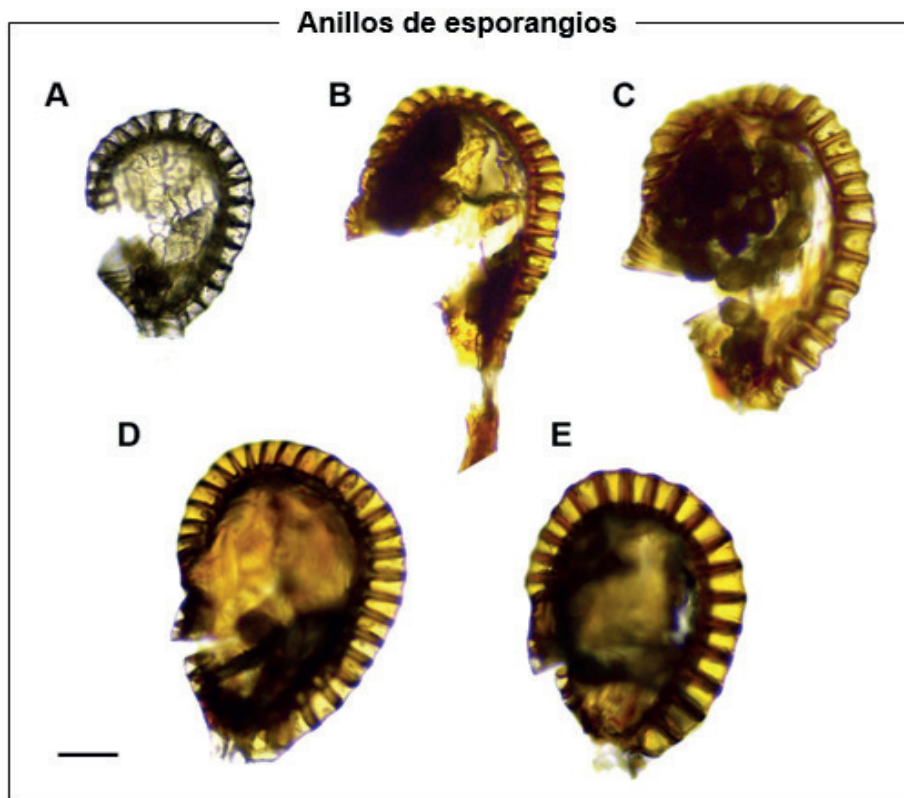


Fig. 4. Sporangia. A. *Parablechnum chilense* (MACB109257); B. *P. cordatum* (van Der Werff et al. 18201, NY); C. *P. falciforme* (C.A. Purpus 6739, NY); D. *P. schiedeanum* (MACB109259); E. *B. varians* (US1843362). Bar = 100 μ m in all.

Fig. 4. Esporangios. A. *Parablechnum chilense* (MACB109257); B. *P. cordatum* (van Der Werff et al. 18201, NY); C. *P. falciforme* (C.A. Purpus 6739, NY); D. *P. schiedeanum* (MACB109259); E. *B. varians* (US1843362). Barra = 100 μ m en todas.

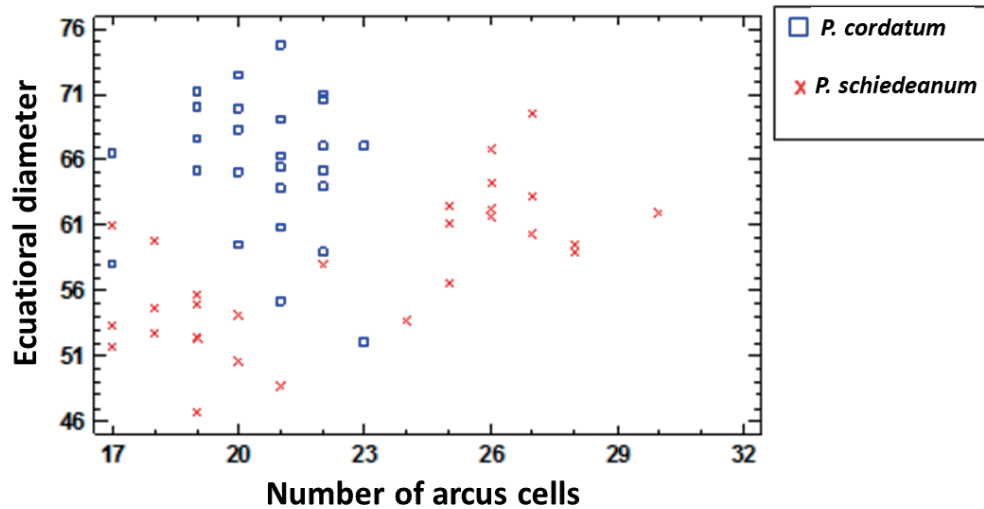


Fig. 5. Dispersion graph resulting from the analysis of the discriminant function with two of the most explanatory variables within Group 2.

Fig. 5. Gráfico de dispersión resultado del análisis de la función discriminante con dos de las variables más explicativas dentro del Grupo 2.

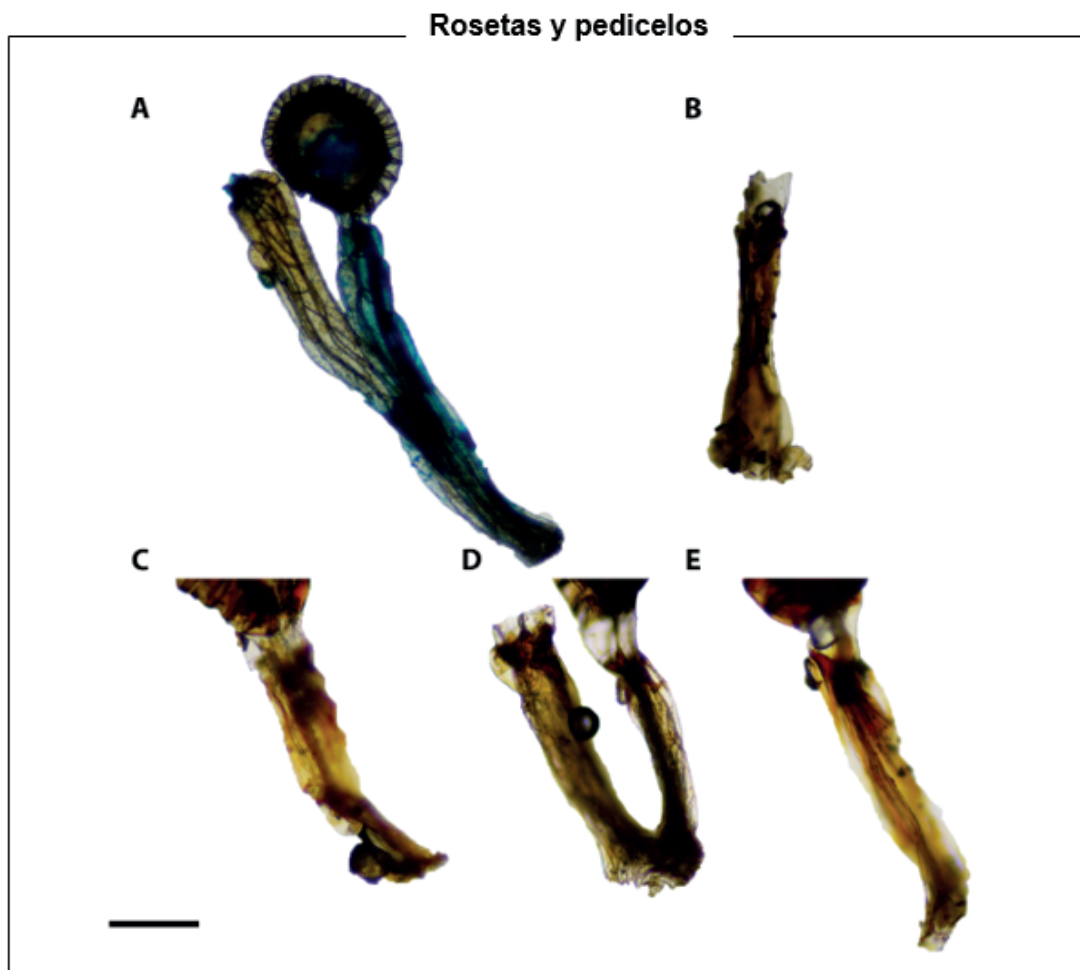


Fig. 6. Pedicels of the taxa within the *Parablechnum cordatum* complex. A. *P. chilense* (MACB109257); B. *P. cordatum* (*J. Campos et al.* 5060, NY); C. *P. falciforme* (*C.A. Purpus* 6739, NY); D. *P. schideanum* (MACB109259); E. *Blechnum varians* (US1637799).
Bar: 200 μ m in A; 100 μ m in B-E.

Fig. 6. Pedicelos de los taxones del complejo *Parablechnum cordatum*. A. *P. chilense* (MACB109257); B. *P. cordatum* (*J. Campos et al.* 5060, NY); C. *P. falciforme* (*C.A. Purpus* 6739, NY); D. *P. schideanum* (MACB109259); E. *Blechnum varians* (US1637799).
Barra: 200 μ m en A; 100 μ m en B-E.