

## Confirmation of a continental-scale disjunction for the fern *Campyloneurum decurrens* (Polypodiaceae)

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#### Correspondencia:

1 Departamento de Briología y Pteridología, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru

2 Department of Geography and the Environment, University of Texas at Austin, Austin, TX 78712, U.S.A.

3 University Herbarium, 1001 Valley Life Sciences Bldg. #2465, University of California, Berkeley, CA 94720-2465, U.S.A.

\*Corresponding author

Email BL: [leon@austin.utexas.edu](mailto:leon@austin.utexas.edu)  
BL: (ORCID 0000-0001-6307-8639)  
Email E.H: [elluz91@gmail.com](mailto:elluz91@gmail.com)  
Email ARS: [arsmith@berkeley.edu](mailto:arsmith@berkeley.edu)

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**Keywords:** ferns; Atlantic Forest; western Amazon; Ecuadorean Choco; once-pinnate *Campyloneurum*.

### Confirmación de una disyunción a escala continental del helecho *Campyloneurum decurrens* (Polypodiaceae)

Blanca León\* <sup>1,2</sup>, Elluz Huamán <sup>1</sup>, and Alan R. Smith <sup>3</sup>

1 Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Peru.

2 Department of Geography and the Environment, University of Texas at Austin, U.S.A.

3 University Herbarium, University of California, U.S.A.

#### Abstract

We confirm the presence of *Campyloneurum decurrens* in the western side of South America based on herbarium collections. Specifically, we report three additional localities for its geographical range, two in Peru and one in Ecuador, and provide additional morphological information on this species. This report confirms a disjunction for this species between the Atlantic Forest in southeastern Brazil and the lowland forests in the Peruvian Amazon, and in the Ecuadorean Choco.

#### Resumen

Se confirma la presencia de *Campyloneurum decurrens* en el occidente de América del Sur en base a colecciones de herbario. Se reporta tres localidades adicionales para su distribución geográfica, dos en Perú y una en Ecuador y se provee de información morfológica adicional. Este reporte confirma también el patrón de disyunción entre la región del Bosque Atlántico en el sureste del Brasil y la de los bosques bajos de la amazonia peruana y del Chocó ecuatoriano.

The fern genus *Campyloneurum* includes mostly simple-leaved species, with a few having pinnate fronds (León 1992; Moran & Labiak 2017; Labiak & Moran 2018). A recent phylogenetic analysis by Labiak & Moran (2018) demonstrated that the once-pinnate species (*Campyloneurum decurrens* (Raddi) C. Presl, *C. magnificum* T. Moore and *C. pentaphyllum* (Willd.) Pic. Serm.) represent a basal lineage and proposed the subgenus *Decurrentia* to include them. These species all share, besides the laminar division, open primary areoles, with non-costal areoles including two or more excurrent veinlets, and sori in a terminal position on the veinlets.

A single once-pinnate *Campyloneurum*, either as *C. magnificum* (León 1992, León 1999) or *Polypodium fendleri* (Tryon & Stolze 1993), has been treated for Peru and Ecuador. However, Moran & Labiak (2017) discussed a single Peruvian specimen at the herbarium BR that they recognized to belong to the mainly Brazilian *Campyloneurum decurrens* (<http://www.br.fgov.br/RESEARCH/COLLECTIONS/HERBARIUM/zoomifyimaging.php?filename=000005906161&herbarium=BR>). This collection was made by Richard Spruce in Tarapoto,

San Martín, and considered as doubtfully from Peru by Moran & Labiak (2017), who suggested that the specimen (*Spruce 3963*) at BR could be a mislabeled collection made in Brazil by Martius. Additional material of *Spruce 3963* is also at BM and K, where those specimens were earlier identified by León as *C. decurrens*, and both images are available online at the Natural History Museum of London (<http://www.nhm.ac.uk/our-science/data/spruce/>). On this website, Spruce's notebook is also available, and as noted by León et al. (2003), Spruce included drawings of the venation pattern for many of his fern collections, as is the case for this collection. In addition his notebooks have field observations on habitat and habit. Spruce made his plant collections in Peru in 1855 and 1856, and his field notes allow for establishing July of 1855 as the date of this collection number. This material was found growing on wet rocks "in saxis inunds" (see Fig. 1A). However, there had not been new records or more detailed observations on recent material of *Campyloneurum decurrens* to confirm this species in western South America.

### Material and methods

We identified specimens using morphology-based keys and floristic treatments. Comparisons were made of available Brazilian material with the new collections from western South America. A map of all localities incorporates Brazilian localities from Moran & Labiak (2017), since older specimens recorded by León (1992) lack coordinates.

All microscopic observations were based on impressions obtained by nail polish applied to dry pinnae and mounted on microslides; pictures were taken with a Sony Cybershot camera using an Olympus compound microscope at 400X. Hair measurements were made for 10 different hair samples in each field.

### Results

*Campyloneurum decurrens* is mostly terrestrial, rheophytic or rarely a low epiphyte. Rhizome width varies between (3–) 4–6 (– 8) mm, and rhizome scales are slightly clathrate, with bi-auriculate bases. Fronds are long-petiolate, with stramineous petioles as long or longer than the lamina; indument of simple hairs 0.1–0.15 mm long; laminae have (2–) 4–7 (–11) pairs of lateral ascending pinnae, pinnae are narrow-lanceolate, 3–4.5 cm wide, with acuminate apices and bases gradually attenuate, asymmetric, decurrent on the basiscopic side (Figure 1 A and B), with 5–7 areoles at the middle of lateral pinnae. Apical pinnae and other distant pairs have an abruptly cuneate, long-decurrent bases, similar in shape and size to proximal pinnae. Sori are apical on the excurrent veinlets and without paraphyses.

Lateral pinnae of *C. decurrens* vary at their bases, from narrowly attenuate to abruptly cuneate, but all are decurrent basiscopically (Figures 1 A-C). All western South America specimens have lax fronds with well-spaced pinnae (Figs. 1A-B), while most Brazilian specimens have more numerous, slightly overlapping pinnae (Fig. 1C).

Specimens examined: Ecuador: Pichincha, Reserva Ecológica Los Illinizas, hacienda del Sr. Segundo Veracucha, por el camino que de la casa va al oeste, 18 Aug 2003, 400 m, *J. E. Ramos, J. Contreras & L. Ramos 7373* (MO, UC). Peru: San Martín, Ahuashiyacu waterfall, Cerro Escalera, along road to Yurimaguas, 6°28'S, 76°18'W, 4 Aug 2002, 850 m, *M. Christenhusz et al. 1989* (UC); San Martín, Prov. Bellavista, Distrito Alto Biavo, alrededores de la comunidad San Miguel, montane cloud forest with abundant moss and epiphytes, 8°28'17.4"S, 75°15'34.7"W, 750–800 m, July 2018, *R. Soplín s.n.* (USM); San Martín, Prov. San Martín, prope Tarapoto, July 1855, *R. Spruce 3963* (BM, K). Brazil (not cited by Moran & Labiak 2017): Espírito Santo, Santa Bárbara de Caparaó, 5 Dec 1929, *Mexia*



**Figure 1.** *Campyloneurum decurrens* from Peru. A- *Spruce 3963* (BM). B- New Collection, *Soplín s.n.* (USM), C- *Prado et al. 1512* (UC) from Brazil.

4093a (UC); Minas Gerais, Viçosa, 22 Jul 1930, *Mexia* 4892 (B, P, S, UC); Rio de Janeiro, Corcovado, Apr 1913, *Brade* 6461 (UC); Itatiaia, Apr 1913, *Brade* 6461 (UC); Itatiaia, 4–10 Jun 1913, *Brak (Brade?)* 6461 (S); Itatiaia, 23 Jul 1902, *Dusen* 743 (S); Tijuca, 3 Sep 1904, *Dusen* 5144 (S); Rio de Janeiro, *Gaudichaud* 2a (F); Rio de Janeiro, *Gaudichaud* 20 (P); Nova Friburgo, 22 Sep 1947, *Leite* 4204 (F); Organ mountains, Jul. 1871, *Luessen* 1237 (F); Corcovado, 1911, *Lutzburg* 363 (UC); Corcovado, 17 Jul 1873, *Mosen* 63 (P, S); Corcovado, 10 Sep 1874, *Mosen* 2683 (B, S); trail between Sylvestre and Paineiras, 14 Apr 1929, *Smith* 2251 (S, UC); São Paulo, Alto da Serra, *Wacket* 134 (S); São Paulo, 25 Dec 1873, *Mosen* 2224 (S); Alto da Serra, 1905, *Wacket* 134 (UC); Parana, Porto de Cima, 24 Jul 1914, *Jonsson* 717a (S). Without precise locality. 1842, *Claussen* 149 (P).

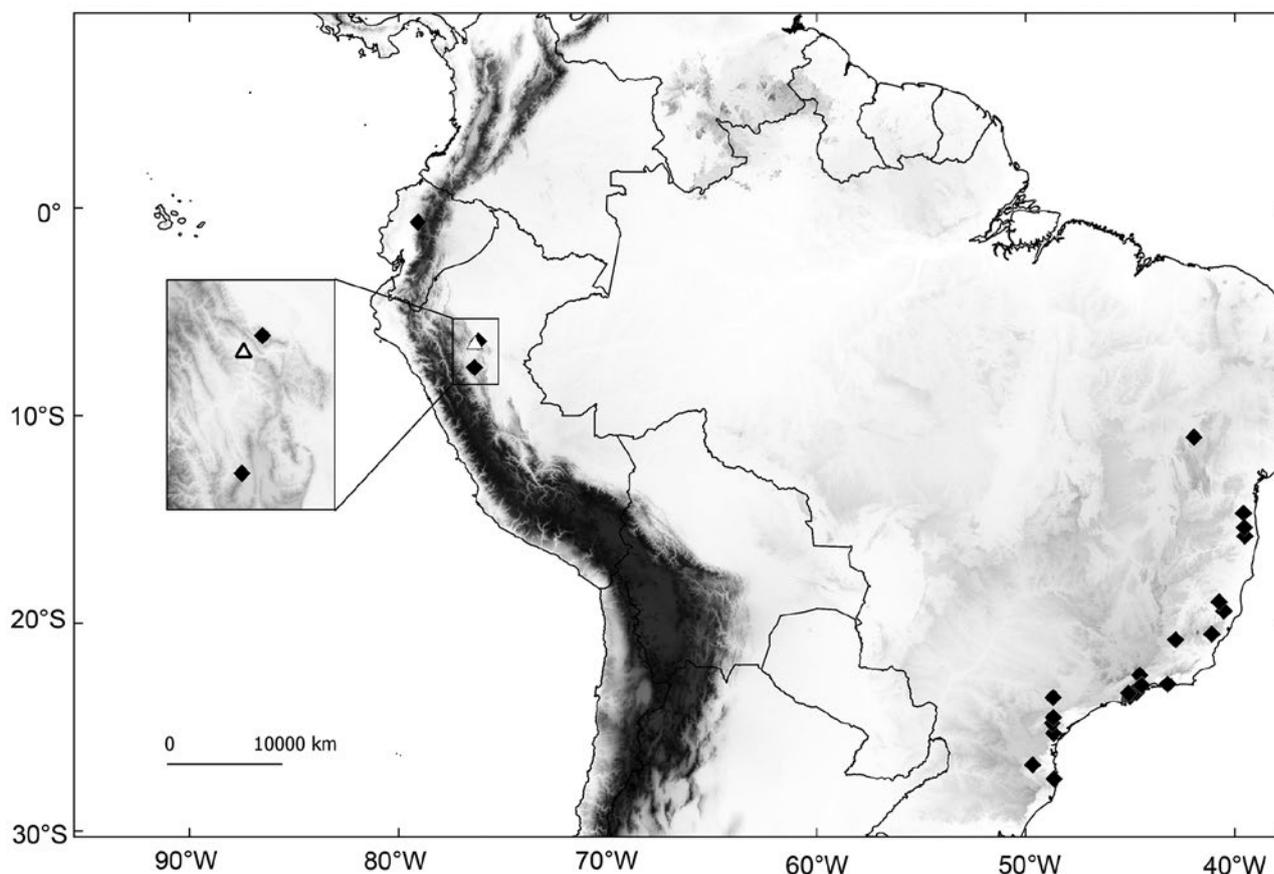
## Discussion

*Campyloneurum pentaphyllum* (Willd.) Pic. Serm. Is a related species from northern South America species, but it is unknown from Peru and Ecuador and differs from *C. decurrens* by having a sessile terminal pinna, with a broad cuneate base, and lateral spreading pinnae with over 8 areoles between the costae and pinna margins. *Campyloneurum decurrens* can be distinguished from *C. magnificum* by the latter species having pinnae more than 6 cm wide.

There is variation in pinnae shape between Andean specimens of *C. decurrens* and typical Brazilian specimens. Moran & Labiak (2017) illustrated leaf variation in *C. decurrens* in their Figure 4, showing that specimens with a smaller number of lateral pinnae have a more open, lax form (Fig. 4 C-E). These plants also show apical pinnae with bases abruptly attenuate and not as decurrent as the western South America collections (Figs. 1 A-B). Additional Andean collections are needed to illuminate variation within *C. decurrens* over its now broader range.

We confirm the presence of *C. decurrens* based on three new collections from the western side of South America. Two of the new collections were made in Peru, in the department of San Martín, the same department as Spruce's collection of the 19<sup>th</sup> century, while the third collection was made in northwestern Ecuador. One of the new *C. decurrens* specimens sent for identification at the Museo de Historia Natural in Lima (USM) was collected 175 km south of Spruce's collection. The second Peruvian specimen was collected less than 50 km northeast of the Spruce site. The specimen from NW Ecuador was collected more than 450 km north of the Spruce locality (Fig. 2), and on the western side of the Andean Cordillera.

*Campyloneurum decurrens* was described from material collected in Brazil, where it grows mostly on rocky



**Figure 2.** *Campyloneurum decurrens* distribution in South America. Inset map shows distribution records for eastern Peru. Triangle indicates the site of the 19<sup>th</sup> century Spruce collection in Peru. Diamonds represent all other collection sites.

humid sites in the Atlantic forest biome. Its current occurrence in the western lowlands of the continent represents a disjunction of more than 4000 km from its eastern Atlantic forest distribution. Disjunctions between eastern Brazil and the western Amazon are known for other vascular plants, for example in epiphytes (Freitas et al. 2016) and bromeliads (Maciel et al. 2017); these disjunctions have been explained in terms of past tectonics, recent forest connections and changes in climate (e.g. Sobral-Souza et al. 2015, Ledo & Colli 2017). Here we add the Choco region to these complex geographical patterns of a spore-dispersed organism that may also show long-distance dispersal.

The apparent disjunction (Fig. 2) between the Brazilian collections and Peruvian-Ecuadorean material may reflect the need to explore additional sites. At the same time, habitat specificity and past connections may still help to predict potential sites for prioritizing plant collecting, especially along the forests neighboring the Andean piedmont -- an important geographical link among the lowland forests of South America.

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#### Roles:

BL, EH and ARS wrote the manuscript and identified specimens from Peru and Ecuador, BL and ARS reviewed Brazilian material; EH and ARS revised and approved the manuscript.

#### Competing interests

The authors declare that they have no competing interests.

#### Aspectos éticos / legales:

This work did not incur any ethical or legal problems.

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