



Polypodium s.s. (Polypodiaceae) in Brazil

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Abstract

Polypodium s.s. is a fern genus with currently about 40 species, and still with a controversial circumscription. The Flora of Brazil online reports just one *Polypodium* species in Brazil. Here we confirm the occurrence of a second species of the genus in Brazil, and present a taxonomic treatment of *Polypodium* from this country; this includes descriptions, an identification key, diagnostic illustrations, and comments on the species. The genus is represented in Brazil by two species: *Polypodium flagellare* and *P. kunzeanum*. In addition, a lectotypification is proposed.

Keywords: Ferns, taxonomy, Brazilian Amazon, disjunct distribution

Introduction

Polypodium Linnaeus (1753: 1082) s.s. is a fern genus with currently about 40 species (PPG I 2016), with a still controversial circumscription. According to the results of Otto *et al.* (2009), Sigel *et al.* (2014) and Assis *et al.* (2016), *Polypodium* s.s. comprises two well supported main clades, one Neotropical that includes species in the *Polypodium plesiosorum* group, and another clade with a north-temperate distribution that includes species of the *Polypodium vulgare* complex. Our knowledge about the phylogenetic relationships among the neotropical species of *Polypodium* is still incomplete, and previously mentioned studies included only a few species of the groups of *Polypodium plesiosorum* and *P. dulce*.

Species of the *Polypodium dulce* group that were included in the phylogenetic studies by Ranker *et al.* (2004), Otto *et al.* (2009), and Assis *et al.* (2016) are nested with the genus *Pecluma* Price (1983: 109), and four species were combined in this genus by Assis *et al.* (2016). Based on morphological evidence, we believe that other species of *Polypodium dulce* group also belong to *Pecluma*; however, additional phylogenetic studies that include other Neotropical species are needed.

According to Moran (1995), the *P. plesiosorum* group is polyphyletic and comprises about 15 species whose taxonomic delimitation is still unsatisfactory. In the most recent study of this group of *Polypodium*, Tejero *et al.* (2010) include 12 species, including the two species treated here, *P. flagellare* Christ (1896: 660) and *P. kunzeanum* Christensen (1906: 536).

Assis & Almeida (2018) listed only one *Polypodium*, *P. flagellare*, in the Flora of Brazil online; this was previously reported by Almeida & Salino (2015). Here we confirm the occurrence of a second species in Brazil and present a taxonomic treatment that includes descriptions, key, diagnostic illustrations, and comments for the genus in this country.

Methods

Type material and several specimens were reviewed from following herbaria: B, BHCB, BM, BR, CR, K, PMA, RB, S, USM, and W (following Thiers 2018). The terminology used to describe species was based on Lellinger (2002).

Taxonomy

Key to the Brazilian species of *Polypodium*

1. Pinnae adnate, never overlapping the rachis; sori forming one row between costae and pinna margins.....*Polypodium flagellare*
- Pinnae articulate, petiolate, cordate and overlapping with the rachis; sori forming 2–3 rows between costae and pinna margins.....
.....*Polypodium kunzeanum*

Polypodium flagellare Christ, Bull. Herb. Boissier 4(10): 660. 1896.

Type:—COSTA RICA. Puntarenas: Plaines de Surubres au sud de Puntarenas, cotê du Pacifique, July 1890, *P. Biolley* 2671 (Holotype BR 697064!, image!; isotypes: CR, P00624573, image!).

Goniophlebium patens J. Smith (1854: 230). Type:—PANAMA. Panama: Hacienda Santa Rita, B.C. *Seemann* 25 (Holotype K000642075!).

Fig. 1

Epiphytic; rhizomes short-creeping, 3.3–5.8 mm diam., not pruinose, densely scaly, scales peltate, orangish or castaneous at the point of attachment, not clathrate, (3.5) 3.8–5.25 × (0.95) 1.1–1.60 (1.75) mm, lanceolate with filiform apex, margins entire to retrorsely denticulate; fronds monomorphic, erect to pendant, petioles sulcate adaxially, 6–9.5 cm long 0.75–1.95 mm diam., paleaceous, dull, and with very sparse catenate hairs of 2–3 cells and 0.05–0.2 mm long; laminae 17.5–29.5 cm long, 1-pinnate, ovate to oblong, apex conform to subconform with apical pinnae adnate with the pinnae just below; rachises paleaceous, dull, glabrous adaxially, abaxially with sparse catenate hairs like those of petioles; pinnae 6–7 pairs, subopposite to alternate, strongly ascending, adnate to the rachises, membranaceous, linear, bases totally adnate the rachises, apices acute to acuminate, margins entire to crenulate; costae paleaceous abaxially, dull, glabrous adaxially, abaxially with sparse catenate hairs like those of petioles; medial pinnae 6.5–15.5 × 0.8–1.5 cm; veins anastomosing and forming 1–2 rows of areoles between costae and margin; sori rounded, forming 1 row between costae and pinna margins; sporangia glabrous.

Specimens examined:—BRAZIL. Pará: Canaã dos Carajás, Serra Sul corpo C, 6°22'44"S, 50°22'38"W, 611 m, 16 February 2010, *T.E. Almeida et al.* 2219 (BHCB); Canaã dos Carajás, Serra Sul corpo C, 6°20'41"S, 50°27'5"W, 677 m, 21 May 2010, *D.T. Souza et al.* 1129 (BHCB).

Additional specimens examined:—PANAMA. Panama: near Madden Dam and along Azote Caballo road near Alahueta, 90–100 m, 27 November 1934, *C.W. Dodge* 16567 (K); 1847, *Jenman s.n.* (BM). Coclé: Valle de Antón and vicinity, 500–700 m, 23–27 July 1935, *R.J. Seibert* 457 (K); camino del Río Mata Ahogado, 03 July 1977, *I. Fuentes* 21 (PMA); Herrera: Distrito de Las Minas, alrededores del Primer Ciclo de Chepo, 900 m, 19 September 1994, *C. Galdames* 1748 (PMA).

Distribution and habitat:—Moran (1995), Tejero-Díez & Pacheco (2004), Tejero-Díez (2005) and Luna-Vega *et al.* (2012) suggested that this is a rare endemic species of Central America (Costa Rica and Panama); Almeida & Salino (2015) reported it in Brazil only from the Serra dos Carajás, an eastern Amazonian mountain range located in Pará State, where it is epiphytic in the canopy of rainforests between 600–700 m.

Notes:—*Polypodium flagellare* can be easily recognized by the pendant leaves, adnate pinnae their width or slightly more to rachises, and one row of sori between costae and pinna margins. In both Brazilian specimens there are sparse, small catenate hairs, but these hairs are not reported in specimens from other regions. Affinities of *P. flagellare* as well as the relationships among *Polypodium s.s.* species are still uncertain (Tejero-Díez 2005).

Polypodium kunzeanum C. Chr., Index Filicum 536. 1906. *Polypodium cordatum* Kunze (1834: 44), *nom. illeg., non* Desv., 1827. Lectotype (designated here):—PERU. Peruvia subandina, Cassapi, August 1829, *Poeppig s.n.* (W0052623, image!, isolectotype BM fragment!). Fig. 2.

Terrestrial; rhizomes short-creeping, 5.5–7.5 mm diam., not pruinose, densely scaly, scales peltate, not clathrate, orangish and brown at the point of attachment, 2–5.2 × 0.8–1.6 mm, lanceolate with acuminate to filiform apex, margins entire; fronds monomorphic, erect, petioles sulcate adaxially, 13.5–24.2 cm long × 2.7–5.4 mm diam., glabrous, reddish brown and bright; laminae 38–47 cm long, 1-pinnate, lanceolate to ovate, apex conform; rachises glabrous on both surfaces, reddish brown and shiny; pinnae (4–5) 10–11 (17) pairs, opposite to subopposite, ascending, clearly articulate at bases, membranaceous, linear, bases cordate and overlapping the rachises (except in apical ones), apices acuminate, margins entire; costae shiny, yellowish brown to reddish brown and glabrous on both surfaces; medial pinnae 11–16 (23) × 1.7–1.8 (2.5) cm; veins anastomosing and forming 2–3 areoles rows between costae and margin; sori rounded, forming 2–3 rows between costae and pinna margins; sporangia glabrous.

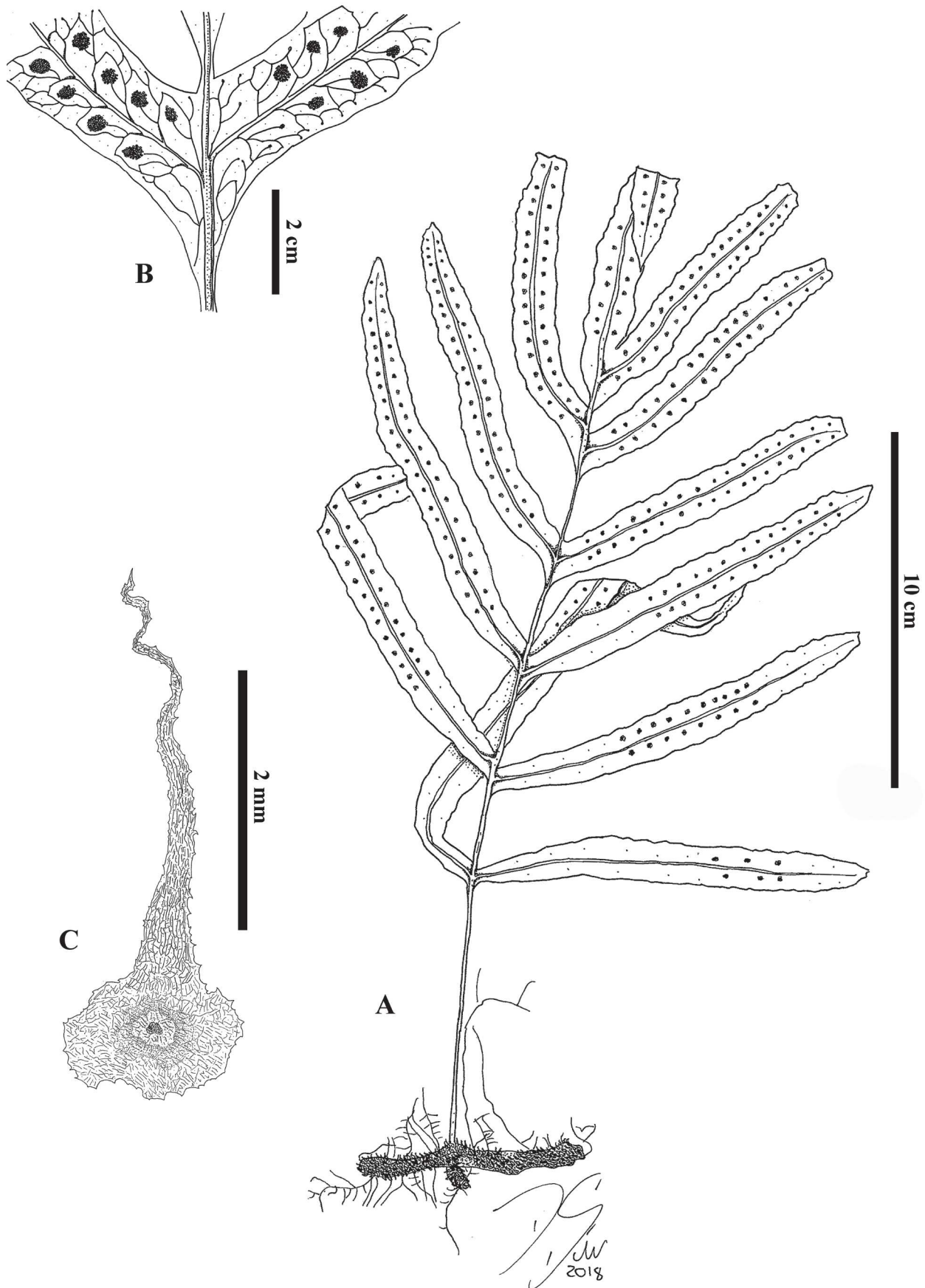


FIGURE 1. *Polypodium flagellare*. A. Habit. B. Detail of the pinnae base, veins and sori. C. Rhizome scale. (All from T.E. Almeida et al. 2219, BHCB).

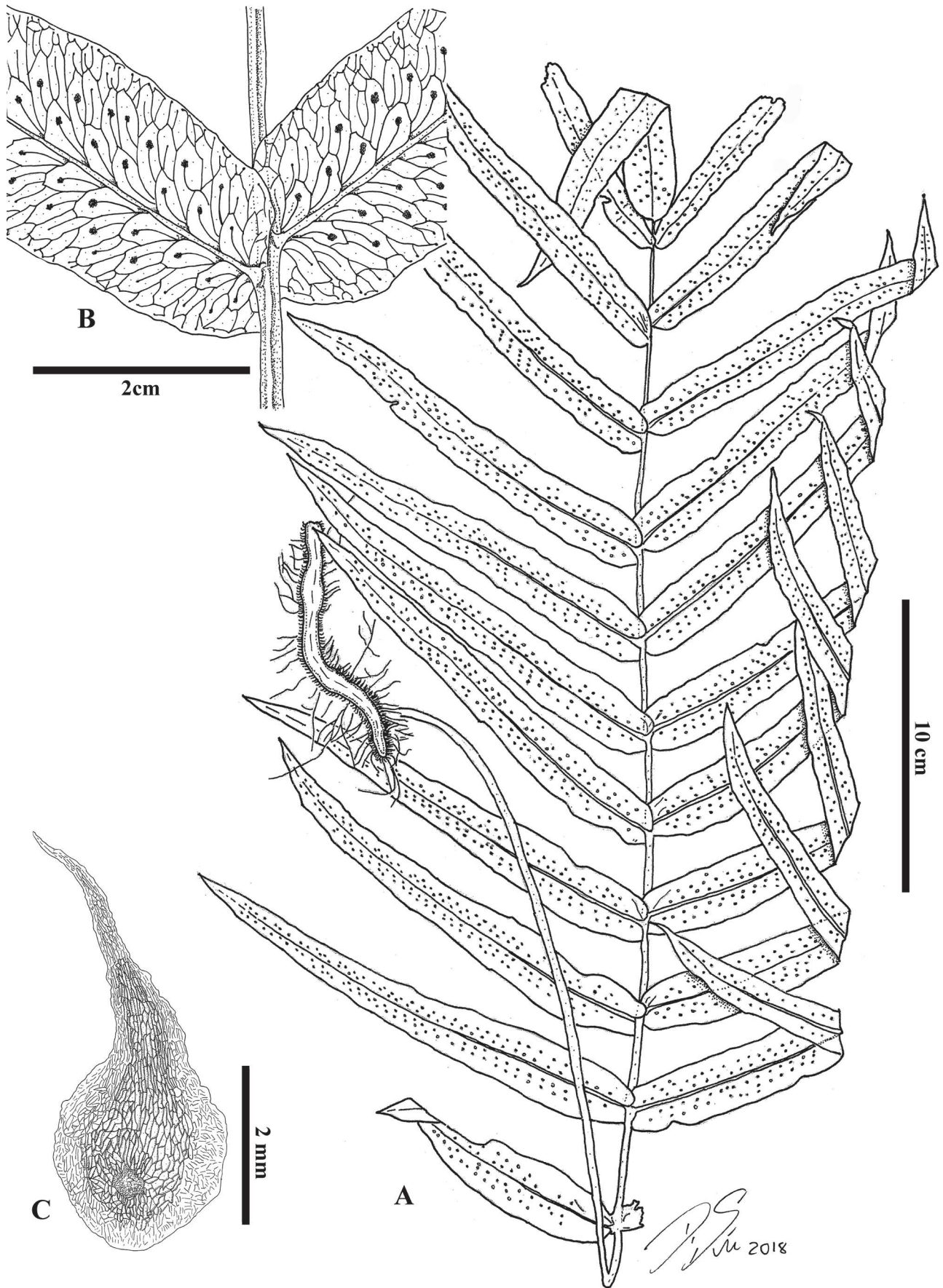


FIGURE 2. *Polypodium kunzeanum*. A. Habit. B. Detail of the pinnae base, veins and sori. C. Rhizome scale. (All from C.A.M. Lindman 2599, S).

Specimens examined:—BRAZIL. Mato Grosso: Cupim prope Palmeiras, Cascata, ad terram umbrosam inter saxa rupesque, 20 December 1893, *C.A.M. Lindman 2599* (BM, S); Itaúba, Resgate de Flora de UHE Colíder, lote G de supressão, 279 m, 13 May 2015, *M.E. Engels 3834* (RB); Pará: Redenção, Fazenda Bica d'água, 24 January 2003, *M.R. Pietrobom 5556* (RB).

Additional specimens examined:—COLOMBIA. Magdalena: Santa Marta, July 1903, *H.H. Smith 2564* (BM, K).—PERU. Amazonas: Bongará, Prov. Shillac, north by trail from Pedro Ruíz, 2300 m, 05°49'S, 78°01'W, 31 August 1983, *D.N. Smith & S. Vasquez 4945* (USM); San Martín: “In monte Campana prope Tarapoto”, August 1856, *R. Spruce 4772* (K, B); Province unknown: without locality, *Mathews 1835* (BM).

Distribution and habitat:—Brazil, Colombia, Costa Rica, Ecuador, Panama, and Peru (Lellinger 1989, Tejero-Díez 2005). In Brazil, this is known by only three collections from Mato Grosso and Pará States. This species is epiphytic (Lellinger 1989), terrestrial, rupicolous and between rocks in shaded places.

Notes:—*Polypodium kunzeanum* is characterized by the articulate pinnae, with cordate bases overlapping the rachises (except for the apical ones). *Polypodium kunzeanum* was cited by Tryon and Stolze (1993) as synonym of *P. sessilifolium* Desvaux (1827: 238) [*Serpocaulon sessilifolium* (Desv.) Smith (2006: 929)], but Smith *et al.* (2006) stated that they are not closely related because *P. kunzeanum* has much less regular venation, non-adnate pinnae with cordate bases (the basal ones with lobes overlapping the rachis), and non-clathrate rhizome scales. This is the unique species of *Polypodium* in the Neotropics with articulate pinnae, a character observed in the Asian genus *Goniophlebium* (Blume 1830: 132) Presl (1836: 185) (Tejero-Díez 2005, Tejero-Díez *et al.*, 2010). However, this species has not yet been included in any phylogenies to corroborate its placement.

Polypodium kunzeanum was recorded in Brazil by Lellinger (1989), Moran (1995), Tejero-Díez (2005), and Smith *et al.* (2006), but overlooked by Brazilian pteridologists and unnoticed by Assis & Almeida (2018) in the Flora of Brazil online. Lellinger (1989) and Moran (1995) stated that the type specimen of *Polypodium cordatum* was deposited at the LZ herbarium, where it was destroyed during WW II. However, according to taxonomic literature (Stafleu & Cowan 1983), collections of *Poeppig* from Peru were deposited in W and not in LZ. We confirm this conclusion with the discovery of a collection of *Polypodium cordatum* (*Polypodium kunzeanum*) at W with label information matching the protologue of *P. cordatum*, except for the collection date, given as July 1829 in the protologue but August 1829 on the W specimen. For this reason, we lectotypify the species with a specimen at W.

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References

- Almeida, T.E. & Salino, A. (2015) Thirteen new records of ferns from Brazil. *Biodiversity Data Journal* 3: e4421
<https://doi.org/10.3897/BDJ.3.e4421>
- Assis, F.C. & Almeida, T.E. (2018) *Polypodium* in *Flora do Brasil 2020*. Jardim Botânico do Rio de Janeiro. Available from: <http://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB91541> (accessed 16 August 2018)
- Assis, F.C., Almeida, T.E., Russell, S.J., Schneider, H. & Salino, A. (2016) Molecular phylogeny and recircumscription of the fern genus *Pecluma* (Polypodiaceae-Polypodiopsida). *Phytotaxa* 247 (4): 235–246.
<https://doi.org/10.11646/phytotaxa.247.4.1>
- Blume, C.L. (1830) *Florae Javae* (Filices), J. Frank, Brussels, pp. 113–152.
- Christ, H. (1896) Filices Novae. *Bulletin de L'herbier Boissier* 4 (10): 657–663.

- Christensen, C. (1906) *Index Filicum*. H. Hagerup, Copenhagen (Hafniae).
- Desvaux, N.A. (1827) Prodrôme de la famille des fougères. *Mémoires de la Société Linnéenne de Paris* 6: 171–337.
- Kunze, G. (1834) Synopsis plantarum cryptogamicarum ab Eduardo Poeppig in Cuba insula et in America meridionali collectarum. *Linnaea* 9: 1–111.
<https://doi.org/10.5962/bhl.title.51054>
- Kunze, G. (1850) Index Filicum. *Linnaea* 23: 209–323.
- Lellinger, D.B. (1989) The ferns and fern-allies of Costa Rica, Panama, and the Chocó (Part1: Psilotaceae through Dicksoniaceae). *Pteridologia* 2A: 1–364.
- Lellinger, D.B. (2002) A modern multilingual glossary for taxonomic pteridology. *Pteridologia* 3: 1–263.
<https://doi.org/10.5962/bhl.title.124209>
- Linnaeus, C.V. (1753) *Species Plantarum*. Vol. 2. Salvius, Stockholm, 1200 pp.
- Luna-Vega, I., Tejero-Díez, J.D., Contreras-Medina, R., Heads, M. & Rivas, G. (2012) Biogeographical analysis of two *Polypodium* species complexes (Polypodiaceae) in Mexico and Central America. *Biological Journal of the Linnean Society* 106: 940–955.
<https://doi.org/10.1111/j.1095-8312.2012.01921.x>
- Moran, R.C. (1995) Polypodiaceae. In: Davidse, G. (Ed.) *Flora Mesoamericana. Psilotaceae a Salvinaceae*. Ciudad de México: Universidad Nacional Autónoma de México, pp. 333–366.
- Otto, E.M., Janßen, T., Kreier, H.P. & Schneider, H. (2009) New insights into the phylogeny of *Pleopeltis* and related neotropical genera (Polypodiaceae, Polypodiopsida). *Molecular Phylogenetics and Evolution* 53: 190–201.
<https://doi.org/10.1016/j.ympev.2009.05.001>
- PPG I. (2016) A community-derived classification for extant lycophytes and ferns. *Journal of Systematic and Evolution* 54: 563–603.
<https://doi.org/10.1111/jse.12229>
- Presl, C.B. (1836) *Tentamen Pteridographiae*. T. Haase, Prague, 256 pp.
<https://doi.org/10.5962/bhl.title.47011>
- Price, M.G. (1983) *Pecluma*, a new tropical American fern genus. *American Fern Journal* 73: 109–116.
<https://doi.org/10.2307/1546961>
- Ranker, T.A., Smith, A.R., Parris, B.S., Geiger, J.M.O., Haufler, C.H., Straub, S.C.K. & Schneider, H. (2004) Phylogeny and evolution of grammitid ferns (Grammitidaceae): A case of rampant morphological homoplasy. *Taxon* 53: 415–428.
<https://doi.org/10.2307/4135619>
- Sigel, E.M., Windham, M.D., Haufler, C.H. & Pryer, K.M. (2014) Phylogeny, divergence time estimates, and phylogeography of the diploid species of the *Polypodium vulgare* complex (Polypodiaceae). *Systematic Botany* 39: 1042–1055.
<https://doi.org/10.1600/036364414X683921>
- Smith, J. (1854) Filices. In: Berthold, S., Fitch, W.H. & Hooker, J.D. (Auts.) *Botany of the Voyage H.M.S. Herald*. Lovell Reeve, London, pp. 226–244.
- Smith, A.R., Kreier, H.P., Haufler, C.H., Ranker, T.A. & Schneider, H. (2006) *Serpocaulon* (Polypodiaceae), a new genus segregated from *Polypodium*. *Taxon* 55: 919–930.
<https://doi.org/10.2307/25065686>
- Stafleu, F.A. & Cowan, R.S. (1983) Taxonomic Literature. A selective guide to botanical publications and collections with dates, commentaries and types. Vol. IV. *Regnum Vegetabile* 4: 1–1214.
- Tejero-Díez, J.D. (2005) Revisión taxonómica del complejo *Polypodium plesiosorum* Kunze (Polypodiaceae, Polypodiophyta). PhD Thesis (Ciencias Biológicas), Universidad Autónoma Metropolitana, México, D.F., 142 pp.
- Tejero-Díez, J.D. & Pacheco, L. (2004) Taxa nuevos, nomenclatura, redefiniciones y distribución en las especies relacionadas a *Polypodium colpodes* Kunze (Polypodiaceae, Pteridophyta). *Acta Botánica Mexicana* 67: 75–115.
<https://doi.org/10.21829/abm67.2004.976>
- Tejero-Díez, J.D., Aguilar-Rodríguez, T., Terrazas, T. & Pacheco, L. (2010) Arquitectura y anatomía foliar del complejo *Polypodium plesiosorum* sensu Moran (Polypodiaceae). *Revista de Biología Tropical* 58: 955–976.
- Thiers, B. (2018) *Index Herbariorum*: A global directory of public herbaria and associated staff. New York Botanical Gardens Virtual Herbarium. Available from: <http://sweetgum.nybg.org/ih> (accessed 28 June 2018)
- Tryon, R.M. & Stolze, R.G. (1993) Pteridophyta of Peru. Part V. Aspleniaceae – Polypodiaceae. *Fieldiana, Botany, n.s.* 32: 1–190.