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Ferns and Lycophytes as new challenges

Amauropelta platensis (Thelypteridaceae), a new combination for the endemic Southern Cone fern flora

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Abstract

Athyrium decurtatum var. *platense* (= *Thelypteris decurtata* subsp. *platensis*) is transferred to the genus *Amauropelta* and raised to the species level based on morphological, palynological and geographical evidences. This fern species is endemic to the Delta of Paraná district, belonging to the Esteros del Iberá biogeographic province in the Southern Cone of South America.

Key words: *Amauropelta*, Argentina, endemism, ferns, Uruguay.

Resumo

Athyrium decurtatum var. *platense* (= *Thelypteris decurtata* subsp. *platensis*) é transferida para o gênero *Amauropelta* e elevada ao nível de espécie com base em estudos morfológicos, palinológicos e geográficos. Esta espécie é endêmica do distrito Delta do Paraná, pertencendo à província biogeográfica dos Esteros del Iberá, no Cone Sul da América do Sul.

Palavras-chave: *Amauropelta*, Argentina, endemismo, samambaias, Uruguay.

Thelypteridaceae is one of the largest families of ferns, cosmopolitan in distribution with more than 1,200 species highly diverse morphologically and ecologically (Fawcett & Smith 2021), inhabiting mainly tropical and subtropical regions of the world (Smith 1992; Smith *et al.* 2006, 2008; PPG I 2016). As usually construed, the family is monophyletic and recent molecular phylogenetic studies have recovered two main groups: the phegopteroid and the thelypteroid lineages (Smith & Cranfill 2002; He & Zhang 2012; Almeida *et al.* 2016; Fawcett & Smith 2021), which are recognized at subfamily level (PPG I 2016). In the subfamily Thelypteridoideae (thelypteroid lineage), the amauropeltoid clade comprises the genera *Amauropelta* Kunze, related to the genera *Coryphopteris* Holttum, and *Metathelypteris* (H.Itô) Ching (Almeida *et al.* 2016; Fawcett & Smith 2021; Fawcett *et al.* 2021). *Amauropelta* Kunze is a genus morphologically circumscribed by the base of the lamina gradually or abruptly reduced, with one-to-many pairs of auriculiform or glanduliform pinnae, the veins from adjacent segments usually meeting at the blade margins above the sinuses on pinnatifid pinnae, and sporangia either rarely or not setose (Ponce 1995; Salino *et al.* 2015; Ponce & Zanotti 2018; Fawcett & Smith 2021). *Amauropelta* is characterized also by the spore wall with reticulate ornamentation (Ponce 1987). According to Fawcett & Smith (2021), *Amauropelta* is distinguished from *Metathelypteris* (eastern Asia) by characters as veins running to the margins, adaxially grooved costae and a base chromosome number of x = 27, 29, 31 (*vs.* usually x = 35 in *Metathelypteris*). From *Coryphopteris*, *Amauropelta* differs by the combination of usually greatly reduced proximal

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pinnae, lack of sessile, resinous, reddish glands on the lamina between veins (except in the *A. resinifera* group) and usually creeping or suberect rhizomes (*vs.* upright and trunklike).

Amauropelta comprises more than 200 species mainly distributed in the Neotropical region, with 21 of them growing in Argentina (Ponce 1987, 1998, 2016; Ponce & Zanotti 2018; Yañez *et al.* 2022). Recent molecular phylogenetic studies in Thelypteridaceae, along with morphological data, support the monophyly of *Amauropelta* (Smith & Cranfill 2002; Alvarez-Fuentes 2010; Almeida *et al.* 2016; Fawcett *et al.* 2021). In this genus, species delimitation is complicated, probably due to recent diversification and hybridization events (Almeida *et al.* 2016).

In the Neotropics, the Delta del Paraná district, belonging to the Esteros del Iberá biogeographic province, is an area of endemism that promotes speciation processes (Arana *et al.* 2021). This district covers the estuary and the islands of the Paraná and Uruguay Rivers, and associated fluvial formations in the Río de la Plata coastal plains. Various endemic taxa of ferns develop in this area, such as *Goniopteris burkartii* Abbiatti, a member of Thelypteridaceae, among other endemic taxa of plants, fungi and animals (Arana *et al.* 2021).

An overlooked endemic taxon from Delta of Paraná district was originally described by Weatherby as *Athyrium decurtatum* var. *platense* Weath., quite different from *Athyrium decurtatum* (Kunze) Fée due to its "indusiisque minute pallideque glandulosis aliter glabris" (Weatherby 1946). The type specimen of *A. decurtatum* var. *platense* was collected by A. Burkart in river-bank woods that develop along the estuary of the Río de La Plata. The reason why the taxon was first included in *Athyrium* Roth was that the sori are "more or less athyrioid". Later, de la Sota (1983) demonstrated that the morpho-anatomical and chromosomal features of *A. decurtatum* coincided with those of the Thelypteridaceae, particularly its chromosomal number x = 29, placing the taxon within *Thelypteris* subgenus *Amauropelta*. According to Fawcett & Smith (2021), this chromosomal number is an apomorphy of *Amauropelta* subgenus *Amauropelta*. Then, *Athyrium decurtatum* was transferred to the genus *Thelypteris*, and in the same work, the variety described by Weatherby was raised to a subspecific level, as *Thelypteris decurtata* subsp. *platensis* (Weatherby) de la Sota.

The molecular phylogenetic reconstruction of the Thelypteridaceae (Almeida *et al.* 2016; Fawcett *et al.* 2021) confirmed the monophyly of numerous subgenera of *Thelypteris*, which were elevated to genera, as occurred with *Amauropelta*. Thereby, *Thelypteris decurtata* (Link) de la Sota was transferred to *Amauropelta* by Salino *et al.* (2015). However, the necessary combination of *Thelypteris decurtata* subsp. *platensis* within the genus *Amauropelta* is missing. To rectify this taxonomic issue, we provide the combination and raise the endemic taxon occurring in the Delta del Paraná district to species level, based on morphological characteristics of the sporophyte (including palynological features), along with biogeographical data. Our decisions are based on clear morphological and geographical discontinuities that define two easily distinguishable species of *Amauropelta* in Argentina and Uruguay. The species delimitation used here follows the morphological cluster species concept (Mallet 1995), in combination with a very distinctive geographical range of distribution.

Nomenclatural decisions for the name treated are based upon the analysis of protologues, related bibliography, and herbarium samples lodged at BA, GH, LP, RCVC, and SI, including types. Also, living specimens of *Amauropelta decurtata* were collected in Yungas of Nevados del Aconquija at the banks of Cochuna River (27°19'S, 65°53'W), Chicligasta Department, in Tucuman province (Argentina), whereas those of *Thelypteris decurtata* subsp. *platensis* were collected at Punta Lara Nature Reserve, Partido de Ensenada (34º47'33''S, 58º00'28.32''W), located on the banks of La Plata River, 12 km north of La Plata city (Province of Buenos Aires, Argentina) (Fig. 1a). Features such as the morphology of the rhizome scales, indument morphology and distribution in the laminae, sori, and indusia were examined under a Nikon SMZ1000 stereoscopic microscope and a Nikon E200 light microscope (LM). Scales from the whole sporophyte were mounted in 20% glycerin without prior treatment. The spores of *T. decurtata* subsp. *platensis* were analyzed and described in previous work by Giudice *et al.* (2014). To carry out a complete study of this taxon, new fresh samples were observed with a scanning electron microscope (SEM). Materials were mounted on aluminium stubs without prior treatment and covered with gold for 10 minutes. Observations were made in a microscope FEI Quanta 200 model (Servicio de Microscopía Electrónica de Barrido y Microanálisis del LIMF, Facultad de Ingeniería,

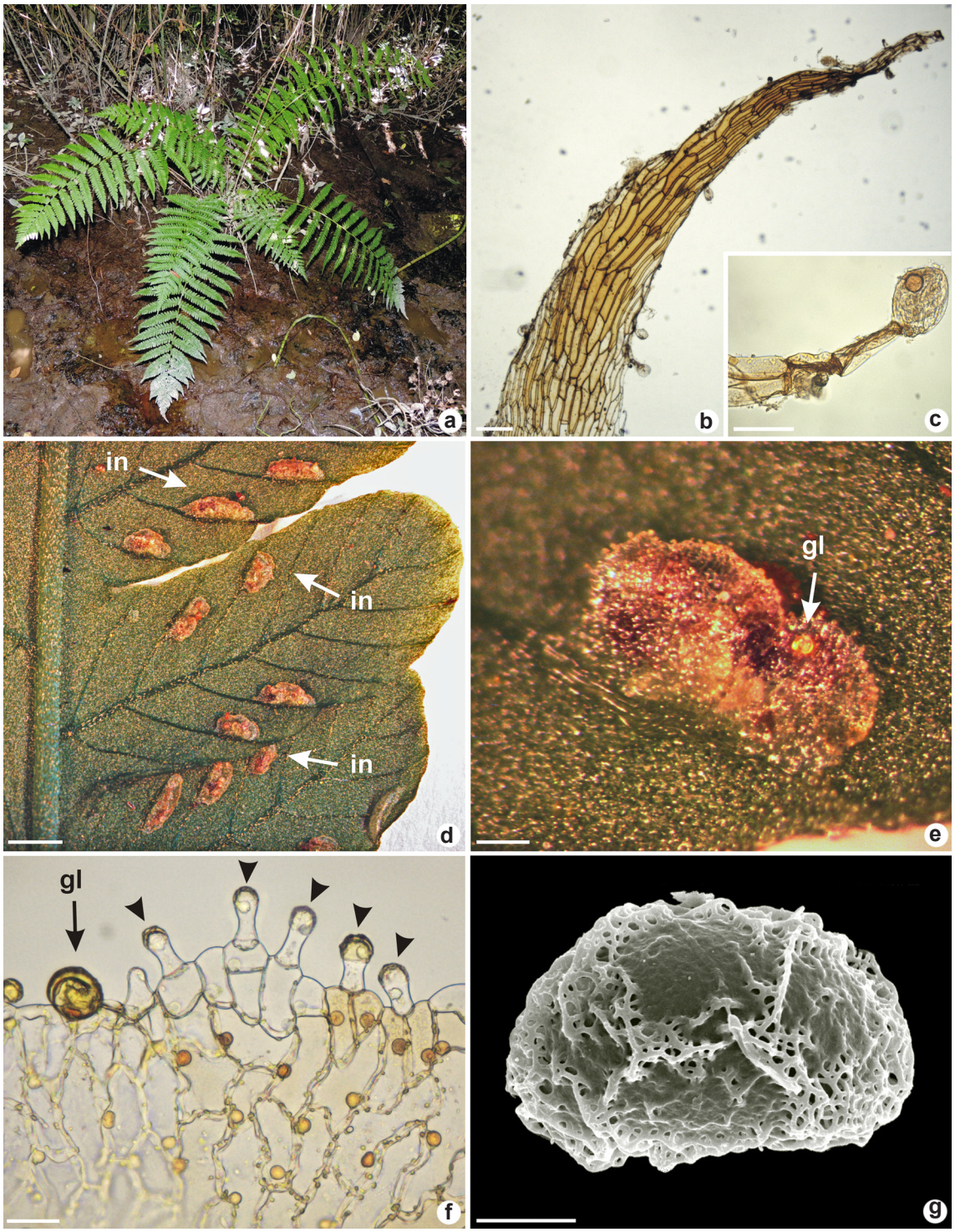

Figure 1 – a-g. *Amauropelta platensis* diagnostic characteristics – a. living specimen inhabiting Punta Lara Nature Reserve; b. light microscope (LM) micrograph of a rhizome scale; c. a glandular hair in detail; d. abaxial surface of a pinna showing indusia (arrows) and scattered glandular hairs; e. an indusium in detail (the arrow indicates an orange glandular hair); f. LM micrograph of the indusium where the papillate hairs (arrowheads) can be seen on the margin and a glandular hair (gl) (arrow); g. SEM micrograph of a spore. gl = glandular hair; in = indusium. (a-f. from Berrueta, Ponce & Luna 320; g. from Giudice, Ramos Giacosa & Luna 110).

Universidad Nacional de La Plata) with a 15 kV voltage. The palynological terminology used in the descriptions refers to Tryon & Lugardon (1991) and Lellinger (2002). All the microscopic preparations are preserved in the Laboratory of Comparative Anatomy, Propagation and Conservation of Embryophytes "Dr. Elías R. de la Sota", Faculty of Natural Sciences and Museum, National University of La Plata.

Amauropelta platensis (Weath.) Ponce & Arana, comb. et stat. nov. Basionym: *Athyrium decurtatum* var. *platense* Weatherby, *Amer. Fern J.* 36: 95. 1946.
Thelypteris decurtata subsp. *platensis* (Weath.) de la Sota, *Lilloa* 36(1): 65. 1983.
TYPE: ARGENTINA. BUENOS AIRES: Partido Ensenada: Río Santiago, "monte a la orilla del Río de la Plata (circa de La Plata)", XI.1931, *A. Burkart 3681* (holotype GH 00075931!; isotype SI 000042!). Paratypes: ARGENTINA. BUENOS AIRES: Partido Berazategui: Arroyo Las Conchitas, monte ribereño del Rio de la Plata, 16.IV.1927, *A. Burkart 1309* (GH, SI!); Delta del Paraná, Carabelas, I.1931, *Pérez Moreau s.n.* (GH, BA 589!), *Pérez Moreau s.n.* (GH, BA 3998!), *A. Burkart 4327* (GH, SI!).

Terrestrial (Fig. 1a); rhizomes erect, scaly apices, scales brown, narrowly triangular or subulate, clathrate, with glandular hairs and papillae (Fig. 1b-c); fronds polystic, 0.50–1 m; petioles stramineous, 1/3 of the total length of the frond, glabrous or papillate, with scales at the base similar those to the rhizome; laminae elliptic in outline, 10–25 cm wide, abruptly tapering at the base, herbaceous, rachis stramineous, glabrous or papillate; pinnae distal and medial linear-triangular, basal pinnae elliptic or subelliptic, 6–15 cm × 1.5–2 cm, with 2–4 pairs of reduced basal pinnae, the smallest up to 3 mm, costae glabrous or with minute papillae; segments linear, oblique, 2–3 mm wide, with acute or obtuse apex, margin entire or crenulate; with 6–9 pairs of veins, adaxial side glabrous, abaxial side with few sessile, yellowish to orange glands; sori elliptic, medial; indusium (Fig. 1d-f) developed on one side of the vein ("athyrioid"), sometimes with a basal extension on both sides ("subathyrioid") or, more rarely, developed on both sides of the vein (reniform), glabrous or with sessile, yellowish to orange glands (Fig. 1e), margin with single-celled, whitish or hyaline papillae (Fig. 1f); spores light brown, perispore plegate-reticulated with folds or ridges (Fig. 1g), of 25–28 µm in polar diameter and 35–40 µm in equatorial diameter, with straight laesura, 23–28 µm long.
Aditional specimens examined: ARGENTINA. BUENOS AIRES: Partido Ensenada, Reserva Punta Lara, 19.XII.2012, *Giudice, Ramos Giacosa & Luna 110* (LP); sendero el burrito, 15.V.2017, *Berrueta, Ponce & Luna 320* (LP); Río Santiago, 9.X.1906, *Pastore 110* (SI); 28.X.1909; Isla Santiago, 30.IV.1932, *Cabrera 2162* (LP, SI); Partido Tigre, Tigre, Isla de Forbes, 28.XII.1902, *Hicken 22* (SI); Delta del Paraná, Arroyo Gambado, 19.XII.1955, *Burkart 19970* (SI); isla sobre Río Sarmiento, entre arroyos Curubica y Otamendi, cerca del recreo "Las Rosas II", 4.IV.2009, *Hurrell, Ulibarri & Bazzano 6845, 6848* (SI). Partido San Fernando, Delta del Paraná, Canal Gobernador Arana, 27.XI.1932, *Burkart 5068* (SI). ENTRE RÍOS: Islas del Ibicuy, Brazo Largo, Campo Ichauspe, *Rosillo 376* (SI); Delta del Paraná, Río Ceibo, 24.XI.1932, *Burkart 5117* (SI). URUGUAY. COLONIA. Barra de San Juan, *Doello* (BA).

Amauropelta platensis is distinguished from *Amauropelta decurtata* (Fig. 2 a-b) by the indusia glabrous with whitish or hyaline unicellular glandular hairs on the margins (Fig. 1d-f; Fig. 2d) and some unicellular glandular orange hairs on the surface (Fig. 1d-f) versus indusia with acicular and glandular orange hairs on the whole surface (Fig. 2b), and absence of unicellular whitish glandular hairs on the margins in *A. decurtata*. Also *A. platensis* lacks acicular hairs on the lamina, rachis and costae (Fig. 2c), which are characteristic on both surfaces of the fronds of *A. decurtata* (Fig. 2a).

Field observations made on living plants, together with the examination of range-wide herbarium specimens, led us to determine the existence of many novel distinctive features for *Amauropelta platensis*. The species is characterized by rhizome scales with pluricellular, glandular, orange hairs on margins (Fig. 1b-c) (*vs.* rhizome scales with acicular hairs or glabrescent in *A. decurtata*); laminae without acicular hairs (*vs.* laminae with acicular hairs on both sides in *A. decurtata*, Fig. 2a); rachis and costae glabrous or papillate (*vs.* rachises and costae pilose, or glabrescent, with ephemeral, subulate hairy scales in *A. decurtata*). In *Amauropelta platensis* the indusia surfaces are glabrous or with some scattered orange glandular hairs similar to those of the laminae, and the margins have whitish or hyaline, papillate unicellular hairs (Fig. 1d-f; Fig. 2d) (*vs.* indusia with unicellular acicular hairs and orange, sessile spherical glandular hairs in *A. decurtata* (Fig. 2b). The spores are similar in size to the both species, but the spores of *A. platensis*

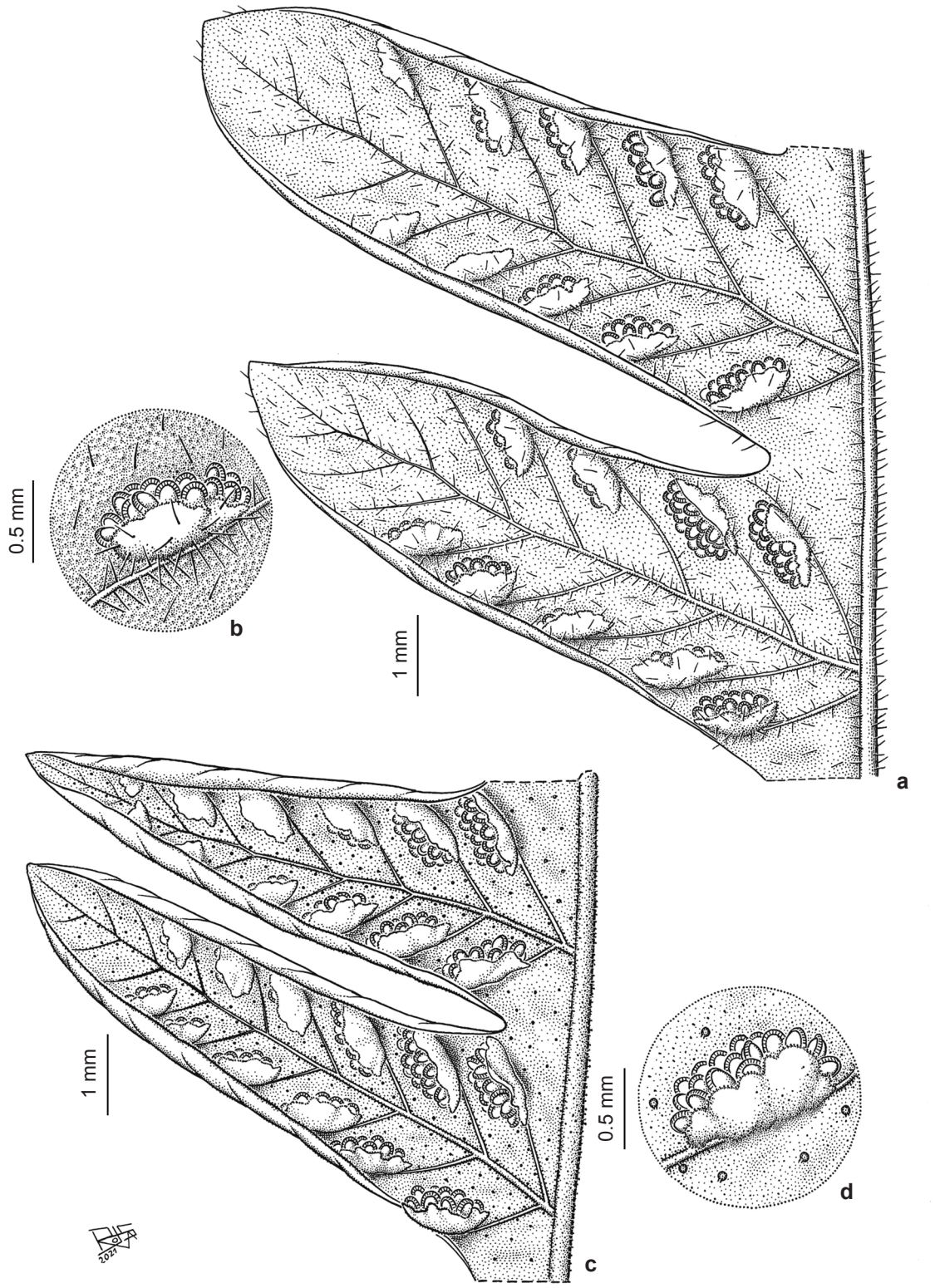

Figure 2 – a-d. Segments of *Amauropelta platensis* and *A. decurtata* – a. abaxial surface of last segments of *A. decurtata*, showing indument, venation and disposition of sori; b. detail of sorus showing the indument of the indusium; c. abaxial surface of last segments of *A. cisplatina*, showing indument, venation and disposition of sori; d. detail of sorus. (a-b. from Burkart 5165 (SI); c-d. from Burkart 5117).

have perispore plegate-reticulated (Giudice *et al.* 2014) (Fig. 1g), *vs.* perispore reticulated with some cristae in *A. decurtata*.

Amauropelta platensis has a very restricted distribution area, growing exclusively in Northeastern Buenos Aires and Southern Entre Ríos provinces in Argentina, and also in the nearer coastal places of Uruguay. In contrast, *Amauropelta decurtata* has a much wider distribution, with a disjunct pattern in tropical Andes and Southern Brazil (Fig. 3). Particularly in Argentina, it grows in North-western and North-eastern areas, in the provinces of Corrientes, Jujuy, Misiones and Tucumán (de la Sota 1983; Ponce 2016).

Amauropelta platensis is apparently endemic to the Delta of Paraná district, which occupies part of Buenos Aires and Entre Ríos Provinces in Argentina, and also the opposite coast of the Uruguay river, in the Oriental Republic of Uruguay (Fig. 3). In this area, a variety of ecological niches develop, as flooded savannas of *Cephalanthus glabratus* (Spreng.) K. Schum. (Rubiaceae), *Cyperus byssaceus* Pereira-Silva, *Schoenoplectus californicus* (C.A. Mey.) Soják (Cyperaceae), and *Luziola peruviana* Juss. *ex* J.F. Gmel. (Poaceae); intermixed with wetland vegetation and gallery forests of *Tessaria integrifolia* Ruiz & Pav. (Asteraceae), *Myrsine laetevirens* (Mez) Arechav. (Myrsinaceae), *Nectandra angustifolia* (Schrad.) Nees & Mart. (Lauraceae), *Syagrus romanzoffiana* (Cham.) Glassman (Arecaceae), *Inga uraguensis* Hook. & Arn. (Fabaceae), *Blepharocalyx salicifolius* (Kunth) O. Berg (Myrtaceae) and *Sambucus australis* Cham. & Schltdl. (Viburnaceae) along the rivers (Arana *et al.* 2021). These ecosystems dissect the grassland and xerophytic forest of

Figure 3 – Complete distribution map of *Amauropelta platensis* and *A. decurtata*.

the Pampa plains with riverine scrubs, gallery forest, tropical-subtropical megathermic swamp grasslands and particular aquatic communities (Arana *et al.* 2021). Historically cited for Delta del Paraná and Río Santiago area on the coast of the Río de La Plata (de la Sota 1983; Ponce 1987), *Amauropelta platensis* was discovered inhabiting the gallery forests of Punta Lara Natural Reserve, Buenos Aires Province (Giudice *et al.* 2014).

The genus *Amauropelta* has traditionally been considered a natural (probably monophyletic) subgenus within *Thelypteris* Schmidel (Ponce 1987, 1995; Smith 1974, 1983, 1990, 1992). This also occurs with other neotropical and paleotropical taxa, *i.e.* the subgenus *Cyclosorus*. Recent molecular studies (*e.g.*, Almeida *et al.* 2016 and Fawcett *et al.* 2021) has demonstrated that the genus *Amauropelta* is a monophyletic group. Thus, these authors propose to rehabilitate the generic range established in previous classifications (*i.e.*, Holttum 1971; Smith & Cranfill 2002), criteria followed by PPG I (2016). Within *Amauropelta* and following Fawcett & Smith (2021), *A. platensis* belongs to *Amauropelta* subgenus *Amauropelta* because the proximal pinnae typically gradually reduced, x = 29 (de la Sota 1983), and rhizomes typically erect, and > 3 mm diameter.

The often-subtle morphological characters needed to distinguish genera and to identify species have contributed to the reputation of Thelypteridaceae as a taxonomically difficult lineage (Fraser-Jenkins *et al.* 2017). This is particularly true in *Amauropelta*, where *e.g.*, 12 of the 54 Bolivian species of *Amauropelta* are known only from one to three collections (Smith & Kessler 2017). This likely reflects a combination of factors, including narrow endemism, rarity, paucity of herbarium collections, and failure of general collectors to recognize subtle variations in the field (Fawcett *et al.* 2021). In the present work, *Amauropelta platensis* is designated as a distinct entity from *Amauropelta decurtata*, because of the diagnostic features of the sporophytes already reported, combined with the restricted geographic distribution of *A. platensis*, which occurs only in the estuary of the Río de la Plata, and nearer coasts of Paraná and Uruguay rivers. In this study, we found only two specimens of *A. decurtata* from Entre Ríos Province in the Ibicuy Islands Department (Río Bravo, *Burkart* 1238, SI, and Concordia, Duraznal, *Castellanos* s.n., BA 31/859) between more than 50 examined collections. These specimens could be treated as accidental because they may have been transported south by the periodic floodings, as was previously hypothesized by de la Sota (1983). This phenomenon occurs with a several plants and animals in the Esteros del Iberá biogeographic province (Arana *et al.* 2021), which represents a rare case of a transboundary system that has not yet been fragmented by dams, and still retains its regular flood pulses and free connectivity between the main channels and their vast floodplains (Baigún & Minotti 2021). Also, *Amauropelta decurtata* has a wide disjunct distribution tropical-Andean and Austro-Brazilian and Northern Uruguayan, in the Departments of Cerro Largo and Tacuarembó (Fig. 3). According to de la Sota (1983) this type of distribution, combined by the morphological variations observed in the different populations covering the entire range of *A. decurtata* may be due to this taxon could be, in fact, a species complex.

Below we provide a key to identify the species studied.

Identification key to the species of *Amauropelta* studied here

1. Lamina pilose on both surfaces, with simple, acicular hairs and unicellular spherical, orange glandular hairs on the abaxial surface. Indusia pilose, with acicular hairs and spherical, sessile, orange, glandular hairs throughout the adaxial surface and margins. Spores 24–30 µm in polar diameter × 34–52 µm in equatorial diameter, perispore reticulated with some cristae. Disjunct distribution, tropical Andes and Southern Brazil ..... *Amauropelta decurtata*

1'. Laminae lacking acicular hairs, having unicellular spherical, orange glandular hairs on abaxial surface. Indusia glabrous on the adaxial surface, rarely with some scattered orange, spherical glands, with whitish or hyaline unicellular papillate hairs on the margins. Spores 25–28 µm in polar diameter × 35–40 µm in equatorial diameter, perispore plegate-reticulated. Restricted distribution area, growing exclusively in the marginal forest of the Delta del Paraná district in Argentina and Uruguay .... *Amauropelta platensis*

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Data availability statement

In accordance with Open Science communication practices, the authors inform that all data are available within the manuscript.

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