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Acanthosyris annonagustata C.Ulloa & P.Jørg. (Santalaceae), newly recorded for the flora of Peru

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Abstract

We report *Acanthosyris annonagustata* (Santalaceae) for the flora of Peru, from an Amazon rainforest site in Madre de Dios Department. We describe the species using leaf and fruit morphological traits from field observations and botanical vouchers, and we provide demographic and phenological observations. This is the second verified species of *Acanthosyris* reported from the Peruvian Amazon and the third verified species for Peru. A key for the three species reported in Peru is provided.

Keywords

Acanthosyris, Santalaceae, Amazon forest, Madre de Dios river basin, range extension, deforestation

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Introduction

The genus *Acanthosyris* (Eichler) Griseb. (Santalaceae R. Brown) is represented by six woody taxa with accepted species names (The Plant List 2013; Ulloa et al. 2017). The genus is composed of deciduous to evergreen taxa with alternate leaves, and its habit includes shrubs and small to large trees, often armed with axillary spines. The inflorescence consists of single or several axillary spikes, with drupaceous fruits that are edible in some species (Ulloa and Jorgensen 1998; Nickrent et al. 2010).

Acanthosyris has a primarily South American distribution (Der and Nickrent 2008), with habitats including tropical wet, warm temperate, and dry forests. *Acanthosyris glabrata* (Stapf) Stauffer is distributed in the Pacific coastal dry forest of Colombia, Ecuador, and Peru (Ulloa and Jørgensen 1998); *A. falcata* Griseb. is distributed in the Chaco biome of Bolivia, Paraguay, and northern Argentina, and *A. spinescens* (Mart. & Eichl.) Griseb. in the warm temperate forests of southern Brazil, Uruguay, and northeastern Argentina (Nee 1996). *Acanthosyris paulo-alvinii* G.M. Barroso is endemic to the Atlantic Forest of southern Bahia, Brazil (Barroso 1968; Nee 1996) and *A. asipapote* M. Nee has been reported for the semi-deciduous forest of Santa Cruz, Bolivia (Nee 1996) and the Amazon forest of southern Peru (W3TROPICOS 2020). *Acanthosyris annonagustata* C.Ulloa & P.Jørg. was originally described in Ecuador, in the Amazon rainforest habitat of Napo, Orellana, and Sucumbíos provinces (Ulloa and Jorgensen 1998); more recently its

distribution has been extended to Costa Rica and Brazil (Morales 2015; Ulloa et al. 2017; GBIF 2019).

Two species of *Acanthosyris* have been previously documented in Peru: *A. glabrata*, based on collections of *Lao* 5153 (MO) and *Vargas* 9 (F, MO) from the Pacific dry forest of Tumbes Department (Ulloa and Jorgensen 1998), and *A. asipapote*, collected in the Amazon forest, in Camisea District, northern Cusco Department (*P. Acevedo* 8950; CUZ, MO, USM).

During a long-term study of forest regeneration dynamics across the Madre de Dios river basin, we collected plant specimens and fruits that were identified as *A. annonagustata*, a species previously not reported from Peru. Here we report the first Peruvian record of *A. annonagustata*, the third verified species of *Acanthosyris* for the flora of Peru, and provide an updated description, images, and demographic and phenological notes for this species. Additionally, we provide a key for the three *Acanthosyris* species reported in Peru.

Methods

Plant material was collected from forest plots that were established in 2008–2009 (Swamy 2017; Bagchi et al. 2018), in a private forest reserve known as Reserva Amazónica (Monteagudo et al. 2020), approximately 15 km east from the city of Puerto Maldonado, on the left (northern) bank of the Madre de Dios River. Individuals ≥10 cm diameter at breast height (dbh) were sampled within a 4-ha (200 × 200 m) tree plot, and individuals >1 m tall and <10 cm dbh were additionally sampled within the central 1-ha (100 × 100 m) of the tree plot. Botanical samples for five individuals were collected and have been deposited in the herbarium of Universidad Nacional Mayor de San Marcos (USM) in Lima (*Chama* 8714, 8730, 8895, 8995, 8999). As part of the long-term study, fruit fall has been monitored year-round within the central hectare area of the plot over a 12-year period from 2008–2020; only one individual (with a current dbh of 47.2 cm) has consistently produced fruits over this period.

Our identification was based on vegetative and fruit characters (flowers have not been found to date), following the description and key for woody species of Santalaceae for South America (Nee 1996), with morphological traits of leaves and fruits matching the description of *A. annonagustata* by Ulloa and Jørgensen (1998, 2002). Specimens of *Acanthosyris* at the Aarhus University Herbarium (AAU) and the Universidad San Antonio Abad del Cusco herbarium (CUZ) were reviewed for this study. Our specimens were also compared with images of digital herbaria collections including F, MO, NY, US, and images retrieved from the National Database of Biodiversity of Ecuador (BNDB 2020). Herbaria acronyms follow Thiers (2021).

Maps for the previous records (Fig. 1A) and new record (Fig. 1B) were created using R v. 3.6.3 software (R Core Team 2020) with packages "maps" (Brownrigg 2018) and "sf" (Pebesma 2018) for spatial data, and "ggmap" (Kahle and Wickman 2013) for the map's visualization.

Results

Acanthosyris annonagustata C.Ulloa & P.Jørgensen

New records. Voucher. PERU – **Madre de Dios** • Tambopata province, permanent tree plot at Inkaterra Reserva Amazonica (Fig. 1B); 12.534°S, 069.053°W; 236 m alt.; 24.X.2014; adult specimens; tree, 33.8 cm dbh; V. Chama 8714 (USM) (Fig. 2A); nucleotide sequence data stored in BOLD (project ID: MDDPE284-17). •

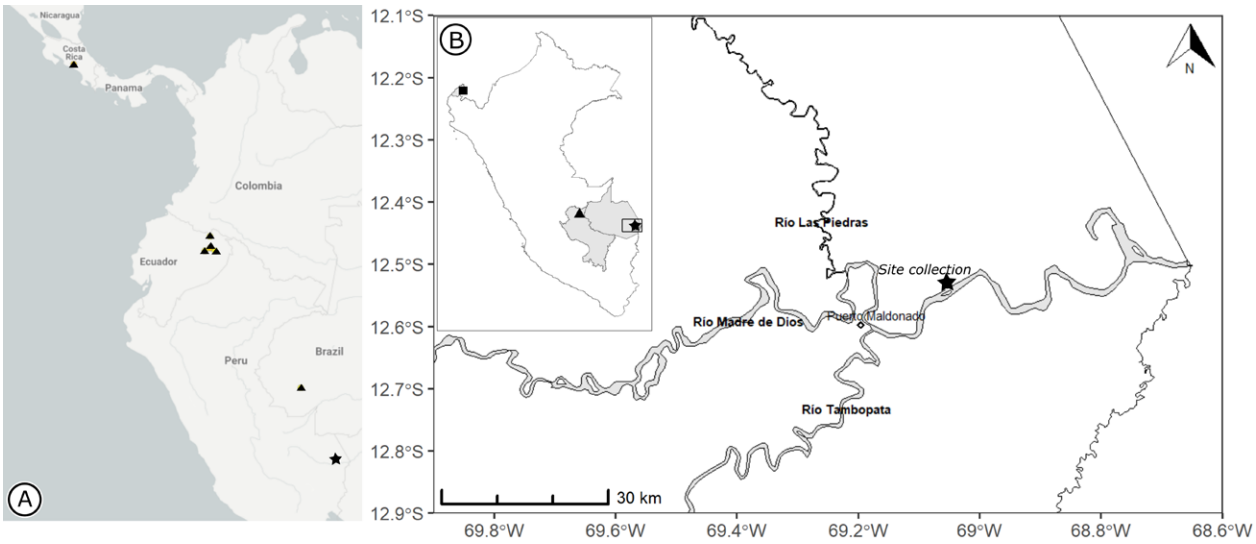

Figure 1. Geographic distribution of *Acanthosyris annonagustata* C.Ulloa & P.Jørg., *A. glabrata* (Stapf) Stauffer and *A. asipapote* M. Nee. **A.** Distribution of *A. annonagustata* in Meso and South America with location of previous record (black triangle) and new record (black asterisk). **B.** Distribution of *A. glabrata* (black square) and *A. asipapote* (black triangle) and *A. annonagustata* (black asterisk) in Peru, with insert showing close-up location of the site collection in Madre de Dios (black asterisk). Map in Figure 2A modified from GBIF (https://www.gbif.org/species/3789565).

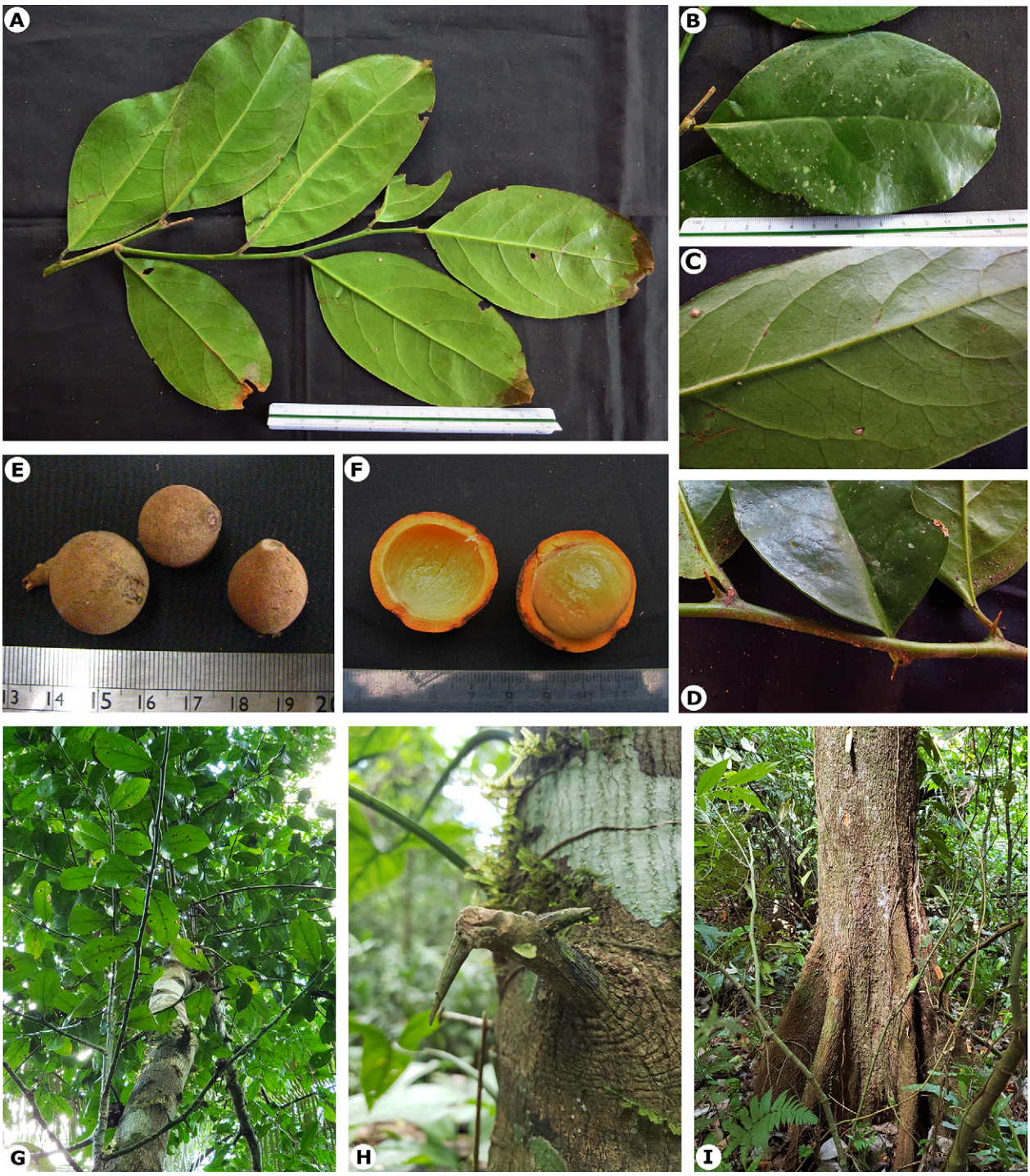

Figure 2. *Acanthosyris annonagustata* C.Ulloa & P.Jørg. **A.** Leaves disposition of mature individual. **B.** Leaf above. **C.** Leaf below and veins. **D.** Axillary spines (immature individual). **E.** Matured fruits. **F.** Endocarp and seed. **G.** Spine-covered branches from trunk of immature individual (10 cm dbh). **H.** Close-up of portion of spiny branch. **I.** Buttresses and bark characters (reproductive individual 47.2 cm dbh).

Same collection data as preceding; tree, 35.1 cm dbh; V. Chama 8895 (USM); sequence data stored in BOLD (project ID: MDDPE284-17). • Same collection data as preceding; immature individuals; V. Chama 8730, 8995, 8999 (USM).

Additional material examined. ECUADOR – **Napo** • Parque Nacional Yasuní, carretera y oleoducto de Maxus en construcción, km 20; 00°33′S, 076°30′W; 250 m a.s.l.; fruit; 28–30.VII. 1993; M. Aulestia & G. Grefa 232 (holotype: QCNE (QCNE727 [image!]); isotype: AAU [not found], GB (GB-0048637 [image!]), MO (MO-288133 [image!]), US (US00603576 [image!])) • Napo: Orellana, Yasuní National Park, road and oil pipeline under construction, km 10–12; 00°29′S, 076°33′W; 250 m alt.; fruit; 10.VII.1993; Tipaz 2724 (paratype: AAU (AAU-Herbarium-G.Tipaz 2724), MO (MO-1744176 [not seen]), QCNE (QCNE85928 [image!])) • Napo: Aguarico cantón, Huaorani Ethnic Reserve, road and oil pipeline under construction, km 67–69; 250 m alt.; flower; 1–3. XII.1993; Aulestia 1318 (paratype: AAU [not found],

MO (MO-1744178 [not seen]), QCNE (QCNE84777 [image!])) • Napo: Orellana, Yasuní National Park, road and oil pipeline , km 40, permanent tree plot No. 10; 235 m alt.; flower and fruit; 10.XII.1994; Aulestia 2987 (paratype: MO (MO-2495009 [not seen]), QCNE (QCNE88545 [image!])) – **Orellana** • Yasuní National Park, Yasuní Research Station, Río Tiputini, permanent plot 50 ha; 200–300 m alt.; fruit; 19.V.2001; Villa 1094 (paratype: F (F-2246152 [image!])) – **Sucumbíos** • Shushufindi, Poza Honda; 230 m alt.; flower; 30.VI.1996; Palacios 13892 (paratype: MO [not seen], QCNE [not seen]). BRAZIL – **Acre** • Tarauacá, Reserva Indígena Praia do Carapana; 08°26′S, 071°20′W; fruit; 21.XI.1995; Silveira 1065 (paratype: NY (NY-630761 [image!])). COSTA RICA – **Puntarenas** • Parrita, ca. 15 km northeast (straight line) from Parrita, along the valley of the Río Palo Seco, on the slopes of cerro Cabeza de Chancho; 09°36′N, 084°13′W; 500 m alt.; fruit mature, flowers; Zamora 2938 (paratype: MO (MO-802184 [image!])).

Description. Tree to ca. 15–20 m tall, (30–) 33.8–41(–47.2) cm in diameter, with buttresses of 1.0–1.5 m height. **Trunk** has a finely vertically fissured outer bark. **Inner bark** with a reddish-orange layer with white striped cortex. Immature individuals have stems emerging from the main trunk with abundant, prominent woody spines up to 15 mm long (Fig. 2H). **Leafy twig** with one or two spines to 5–10 mm long, sparsely distributed between the petiole base and axillary bud, some juvenile individuals featured more than two spines per leafy twig (Fig. 2D). **Leaves** bluntly elliptic, 14.5–16.0 cm long, 5.0–6.1 cm wide, acute apex, acute to attenuate at base, margin slightly revolute, sub-coriaceous when mature, green olive below, glabrous and lustrous; midvein impressed or flat above, faint secondary lateral venation above with 4–7 veins, the tertiary venation fine and obscure below in fresh material (Fig. 2A–C); young leaves chartaceous, shiny, light green below. **Petiole** 4–9(–10) mm long, slightly canaliculate adaxially, round abaxially. **Fruit** drupaceous, globose, 2.3–3.4 cm × 2.1–3.0(–3.2) cm greenish and tan skin, with a depressed tepalar scar 3–4 mm in diameter at the tip; exocarp woody, granulose, yellowish to orange, 3–5 mm thick; mesocarp white, 0.7 mm thick with a sweet taste; seed single, globose, 1.9–2.5 cm in diameter (Fig. 2F).

Distribution and habitat in Peru. The individuals in this study are found in mature floodplain forest habitat, which is subject to sporadic flooding during the peak of wet season months (January–March). The collection site is located on the northern bank of the Madre de Dios River, ca. 15 km east of Puerto Maldonado city, Madre de Dios Department (Fig. 1B). The Madre de Dios river basin is located in the southeastern corner of Peru (10–13°S) and has an average annual rainfall of 2500–3000 mm and a pronounced dry season between the months of June and September. This species is also distributed in Costa Rica, Ecuador, and western Brazil (Fig. 1A).

Demography. Based on an exhaustive survey of woody stems ≥10cm dbh over a 4-ha area, only four individuals of this species were found out of a total of 2061 individuals, a density of one individual per hectare, with an apparent maximum diameter of 47.2 cm. From an exhaustive survey over a 1-ha area for woody stems >1 m tall and <10 cm dbh, only eight individuals of this species were encountered out of 10,845 total individuals. These data indicate that this species is relatively uncommon and likely to be missed in less extensive floral inventory efforts.

Phenology. Over a 12-year period of year-round fruitfall monitoring in Madre de Dios, Peru (2008–2020), a single reproductive individual (currently 47.2 cm dbh), one of five individuals >10 cm dbh in the tree stand, has fruited in multiple years. The tree appears to fruit primarily in the months of September–January (ca. 80% of all observed fruit), with most fruiting in September (22%), followed by October (17%), December (16%), November (13%), and January (9%).

The genus *Acanthosyris* is now represented by three species in Peru, which can be separated by the following key:

Key to Peruvian *Acanthosyris*

1a. Leaves ovate.
  2a. Fruit ca. 2 cm in diameter; petiole 3–5 mm long; Pacific dry forest, Tumbes Department .... *A. glabrata*
  2b. Fruit ca. 5.5 cm in diameter; petiole 14–20 mm long; Amazon rainforest, northern Cusco Department .....*A. asipapote*
1b. Leaves elliptic; petiole 4–10 mm long; fruit ca. 3 cm in diameter; Amazon rainforest, Madre de Dios Department..... *A. annonagustata*

Discussion

Based on our record of *Acanthosyris annonagustata* in the Amazon forest of the Madre de Dios River floodplain, its range is now extended to southeastern Peru (Fig. 1B), 1560 km south from the collections in Ecuador and 540 km south of the collections in Brazil. The distribution of this species may extend to Bolivia, where *Acanthosyris* specimens with immature fruits have been collected in the tropical forest of Madidi National Park (*A. Fuentes et al.* 17996, 18026, 18028, 18097B, 18195, 18202, 18274, 18292 (LPB; MO) and *Ticona et al.* 100 (LPB; MO)); these specimens may correspond to *A. annonagustata*, pending determination (A. Fuentes pers. comm.). Future extension in the distribution of this species is likely as more subpopulations are expected in other Amazonian areas like the Colombian Amazon (Jørgensen and Pitman 2004).

Acanthosyris annonagustata differs markedly in leaf, petiole, and fruit compared to *A. asipapote* and *A. paulo-alvinii* (Barroso 1968), the two other species reported for the wet tropical forest of South America

(Nee 1996; Ulloa and Jorgensen 1998; Ulloa et al. 2017). Morphological features that can be used to distinguish and compare these species are shown in Table 1. In addition to their distinct morphological features, the species have apparently non-overlapping distributions. *Acanthosyris paulo-alvinii* is endemic to the Atlantic forest of Bahia, Brazil, and its conservation status is Critically Endangered (Sambuichi et al. 2008). In Peru, *Acanthosyris asipapote* and *A. annonagustata* have been documented in distinct watersheds within Amazon forests habitats, although *A. asipapote* was previously considered to be restricted to the semi-deciduous forest in Santa Cruz, south Bolivia (Nee 1996; WCMC 1998). Based on the IUCN Red List criteria (IUCN 2012), *A. asipapote* is considered to be Vulnerable (WCMC 1998) and *A. annonagustata* is Near Threatened (Jørgensen and Pitman 2004), with habitat destruction identified as the main threat.

Among the specimens analyzed, our specimens from Madre de Dios closely match with the specimens of Brazil, Costa Rica, and Ecuador in leaf morphology. However, the Ecuadorean specimens (*Aulestia* 232*, Villa* 1094) have fruits and seeds that are notably elongate-ellipsoid, whereas fruits and seeds of our specimens are globose, similar to the Brazilian (*Silveira* 1065; NY) and Costa Rican (*Zamora* 2938; MO) specimens. We are aware that floral material, useful for the distinction of species, is currently lacking for our specimens. However, *A. annonagustata* can be rarely misidentified as other *Acanthosyris* species and may be distinguished by the shape and indument of the leaves, length of the petiole, and size of the fruits (Table 1).

Although *A. annonagustata* is known from several collections made in Yasuní National Park in Ecuador (Ulloa and Jørgensen 1998, 2002; Jørgensen and Pitman 2004), its low population density might explain why the species has not been previously collected in Peru and missed in previous botanical inventories conducted in the Madre de Dios region (e.g., Gentry and Ortiz 1993; Valenzuela et al. 2007; Dueñas and Garate 2008; Monteagudo et al. 2020). In fact, in three large-scale tree inventories in the Yasuní National Park, only 21 individuals were recorded in a 200,000-tree sample, <0.01% of all stems (Jørgensen and Pitman 2004). This is even lower than the density found in our tree inventory, where four individuals out of 2061 total individuals (<0.2% of all stems) were recorded.

The area surrounding our collection site is exposed to intense hunting and deforestation by small-scale agriculture (Bagchi et al 2018), which could have a bearing on the conservation status of this species, given that it has not yet been recorded anywhere else in the basin or elsewhere in Peru. Overall, *Acanthosyris* remains a poorly studied taxonomic group (Ulloa and Jørgensen 2002) and more research is necessary to understand its distribution, diversity, and conservation status in South America.

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Authors' Contributions

JPLF reviewed herbarium specimens, collected, and identified part of the material, and wrote the manuscript; VS photographed and collected some of the material, and contributed to writing the manuscript. Both authors designed the study and established the inventory plots for the long-term study.

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Table 1. Morphological characteristics for *Acanthosyris* species reported in tropical forests of South America.

Species	Leaf shape	Leaf indument	Petiole length (mm)	Fruit diameter (cm)
A. annonagustata	Elliptic	Glabrous and lustrous	4–(9)10	2.1–3.2
A. asipapote	Ovate	Glabrate except midrib abaxial	14–20	5.5
A. paulo-alvinii	Oblong-lanceolate	Glabrous	20–30	6.0–8.0

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