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The known species of the genus *Achagua* Rindge, 1983, with the description of three new species from the Neotropics (Geometridae: Ennominae)

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Abstract

The previously monotypic geometrid genus *Achagua* (Ennominae: Nacophorini) is reviewed following the discovery of three undescribed species. New species are as follows: *A. cooperae* **n. sp.** described from Costa Rica, *A. magna* **n. sp.** described from Ecuador, Peru, and Bolivia; and *Achagua velata* **n. sp.** described from French Guiana. Available COI barcode data is briefly reviewed, and adult and genitalic illustrations are provided for each of the four known species.

Key words: COI barcode, Guanacaste, Yungas

Introduction

Achagua is a little-known nacophorine genus inhabiting the tropical and subtropical moist broadleaf forests of Central and South America. Adults are characterized by their large size, pearly-white coloration, and brown to black wing margins. Despite their conspicuous size and appearance, *Achagua* moths are among the most infrequently documented geometrids in institutional collections, and to date, no larval or life history information is known for the genus.

Achagua was described by Rindge (1983) to include two species: *A. obsoleta* Rindge, and a second undescribed species from Peru, which for reasons unknown, Rindge chose not to formally describe. Pitkin's (2002) review of the Neotropical genera of Ennominae provided a colored illustration of the adult habitus of *A. obsoleta* and illustrations of both male and female genitalia, the latter of which had not been available to Rindge (1983). Recently, Murillo-Ramos *et al.* (2019) and Brehm *et al.* (2019) included *Achagua* in their analyses of a global geometrid phylogenetic dataset. Phylogenetic results confirmed the placement of *Achagua* in the Nacophorini and showed *Achagua* to be sister to *Gabriola* Taylor and *Cargolia* Schaus in their analyses.

In February 2023, while reviewing the geometroid holdings at the American Museum of Natural History (AMNH), I examined type material of *A. obsoleta*, located the undescribed species from Peru first identified by Rindge, and discovered a third undescribed species from Costa Rica. Following a review of publicly available COI barcode data, I was alerted to yet another undescribed species from French Guiana held at the Muséum National d'Histoire Naturelle (MNHN) in France. This entity was taken on loan, and with material gathered for all four species, the foundation of this manuscript was established.

Methods

Over the course of this study, *Achagua* holdings (including primary types) were examined from the following institutions: American Museum of Natural History (AMNH), New York City, New York, USA; Natural History Museum (NHMUK), London, United Kingdom; Muséum National d'Histoire Naturelle (MNHN), Paris, France; Colección Nacional de Insectos, Universidad Nacional Autónoma de México (CNIN), Mexico City, Mexico; Jena Phyletisches Museum (JPM), Jena, Germany; Natural History Museum of the University of Tartu (TUZ), Tartu, Estonia; and National Museum of Natural History (USNM), Washington DC, USA.

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Thirteen genitalic preparations of various *Achagua* species were studied: four males prepared by Fred Rindge at the AMNH, a female from the NHMUK, and six males and two females prepared by me following the methods described in Lafontaine (2004). Preparations were stained with chlorazol black and slide-mounted in Euparal. Images were taken using a Visionary Digital imaging system and images manipulated (background removed) with Adobe Photoshop (Adobe Systems, Mountain View, CA). SimpleMappr (Shorthouse 2010) was used to generate the geographic distribution point map (Fig. 11). GPS coordinates used to generate this map were taken verbatim from coordinates on specimen labels or estimated from label localities for specimens without coordinates.

DNA extraction, PCR amplification, and COI barcode sequencing for publicly available sequences were performed at the Canadian Centre for DNA Barcoding (Centre for Biodiversity Genomics–University of Guelph) using their standard Sanger sequencing protocols (Wilson 2012). DNA of a paratype specimen of *A. magna* (TTBO002) was extracted by Carlos Peña and mined from GenBank. Nine sequence records (dx.doi.org/10.5883/DS-ACHAGUA) were accessed via BOLD to build a neighbor-joining tree (Fig. 12) representing three of the four species using the default Kimura-2P model (Ratnasingham & Hebert 2007).

All yy-SRNP-nnnnnn vouchered specimens were collected, exported, and DNA barcoded under Costa Rican government permits issued to BioAlfa (Janzen and Hallwachs 2019) (R-054-2022-OT-CONAGEBIO; R-019-2019-CONAGEBIO; National Published Decree #41767), JICA-SAPI #0328497 (2014) and Dan H. Janzen and Winnie Hallwachs (ACGPI-036-2013; R-SINAC-ACG-PI-061-2021; Resolucioìn Nº001-2004 SINAC; PI-028-2021).

The image used in Figure 9 is property of ©The Trustees of the Natural History Museum, London, and was made available to me under Creative Commons License 4.0. This image has been modified from its original format, i.e., the original background has been removed and a shadow has been inserted.

Results

Achagua Rindge, 1983

Type Species: *Achagua obsoleta* Rindge, 1983; original designation.

Re-diagnosis. Both Rindge (1983) and Pitkin (2002) provided diagnostic comments for *Achagua*, but with the discovery of three undescribed species, it is necessary to revisit these diagnoses. The mostly bipectinate antennae of male *Achagua*, with the apical third to quarter being simple filiform, is a shared characteristic among related nacophorine genera, e.g., *Cargolia* and *Gabriola*, and thus, does not disambiguate closely related taxa. In males, the two processes of the uncus in conjunction with the subtriangular anellar processes appear to be the most reliable diagnostic features (Figs. 5a, 6a, 7a, 8a). Pitkin (2002) listed the strongly spatulate (or capitate) dorsal process of the uncus as an apomorphy for the genus, but two of the new species described herein possess a non-spatulate dorsal process (Figs. 7a, 8a). In females, the large, elongate, apically pointed, denticulate signum may be diagnostic, but only a single preparation of *A. obsoleta* (Fig. 9) and two preparations of *A. cooperae* (Fig. 10) were available for study. Superficially, the pearly-white ground color, large size, brown to black wing margins, and lack of well-defined antemedial and postmedial lines seem to also define *Achagua*. Further, the multi-locus phylogenetic results of Murillo-Ramos *et al.* (2019) and Brehm *et al.* (2019) also support the recognition of *Achagua* as distinct from related genera.

Distribution (Fig. 11)**.** *Achagua* inhabit the tropical and subtropical moist broadleaf forests of Central and South America from the Sierra de los Tuxtlas of Veracruz, Mexico (*A. cooperae*), east to the Guiana Highlands (*A. velata*), and southward through the eastern Andes of Colombia, Ecuador, and Peru to at least the Bolivian Yungas (*A. magna*).

Biology. Thus far, no life history information is known for the genus. Adults are infrequently collected at light.

Remarks. In *Achagua*, the uncus is characterized by two distinct processes. However, there is some disagreement regarding the nomenclature of these processes. Rindge (1983) referred to the much larger dorsal process as the pseudouncus, but it is unclear how he arrived at this conclusion. Alternatively, I adopt the terminology used by Pitkin (2002) and refer to these processes based on their orientation, specifically as the dorsal or ventral processes of the uncus.

Campos (2001) described the genus "*Achagua*" for a group of freshwater crabs. As the name was already preoccupied by *Achagua* Rindge (the subject of this work), "*Achagua*" Campos was rendered a junior homonym. Campos and Magalhães (2004) synonymized "*Achagua*" Campos with *Eudaniela* Pretzmann, such that this junior homonym has not been in contemporary use.

Achagua obsoleta Rindge, 1983

(Figs. 1, 5, 9, 11)

Distribution (Fig. 11)**.** *Achagua obsoleta* is known from the Magdalena Valley montane forests of Colombia.

Biology. Life history information is wanting. Adults are known to fly in August.

Material Examined. COLOMBIA • ♂; holotype; Cundinamarca, 3 km. north of Alban, Finca San Pablo; elev. 1800 m; 1–12 Aug. 1967; P. & B. Wygodzinsky leg.; Genitalia: FHR 19129; AMNH_IZC 00353008, AMNH_IZC 00353009; AMNH • 3♂; paratypes; same data as holotype; Genitalia: TAM-2023-270; AMNH • ♀; Ob. Rio Negro, Ost Colombia; elev. 800 m; Fassl. leg.; Geometridae genitalia slide No. 20288♀; BMNH(E)#275238 Digitally scanned; Joicey Bequest. Brit. Mus. 1934-120; NHMUK010293435; NHMUK.

Remarks. Only male genitalia were described and illustrated in the original description of *A. obsoleta*, however, genitalia of both sexes were described and illustrated in Pitkin (2002). Genitalia of both sexes are also illustrated in this work (Figs. 5, 9).

While not readily seen in Figure 5, *A. obsoleta*, like *A. magna*, also has a distinct postmedial digitate protuberance along the costal margin of the valve.

Achagua magna Matson, n. sp.

(Figs. 2, 6, 11, 12)
LSID: EBF2D227-50CC-420C-83F7-2939D2F9C3AD

Diagnosis. *Achagua magna* is most similar to *A. obsoleta*. While *A. magna* inhabits the eastern slopes of the central Andes in Ecuador, Peru, and Bolivia, *A. obsoleta* is thus far only known from the northern Andes in Colombia. *Achagua magna* (forewing, 21–22 mm) is noticeably larger than *A. obsoleta* (forewing, 19–20 mm), and though subtle, the pearly-white ground color of the forewing upperside appears to be marked more strongly with intermittent black scaling over the veins; especially in the antemedial and postmedial areas. *Achagua magna* also appears to bear a more strongly marked, brown to black, terminal area of the hindwing. In males, the lateral margin of the large, subtriangular, anellar processes appears to be less deeply concave in *A. magna* than in *A. obsoleta*.

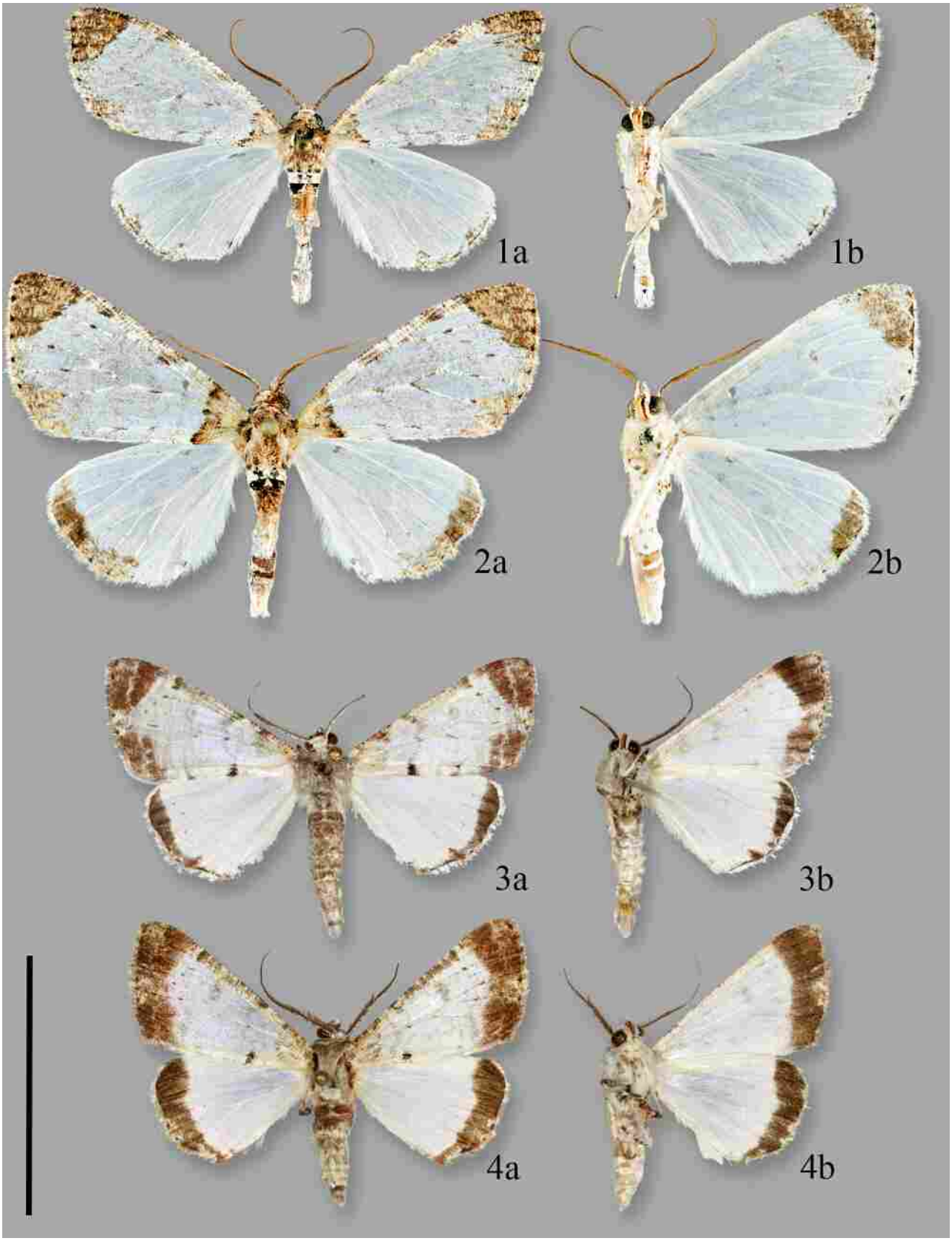
Achagua magna can be distinguished from both *A. cooperae* and *A. velata* by the absence of a conspicuous antemedial black spot along the forewing inner margin. Additionally, the male genitalia of *A. magna* (Fig. 6) bear a spatulate dorsal process of the uncus, a costa with a postmedial digitate protuberance, and a denticulate patch of cornuti on the vesica. In *A. cooperae* (Fig. 7) and *A. velata* (Fig. 8), the dorsal process of the uncus is not spatulate or obviously swollen, the costa lacks a postmedial digitate protuberance, and the vesica lacks cornuti. There are other, more subtle differences that can be observed in Figures 6–8, which further serve to differentiate *A. magna* from *A. cooperae* and *A. velata*.

Description. MALE. Forewing length, 21–22 mm (n = 8).

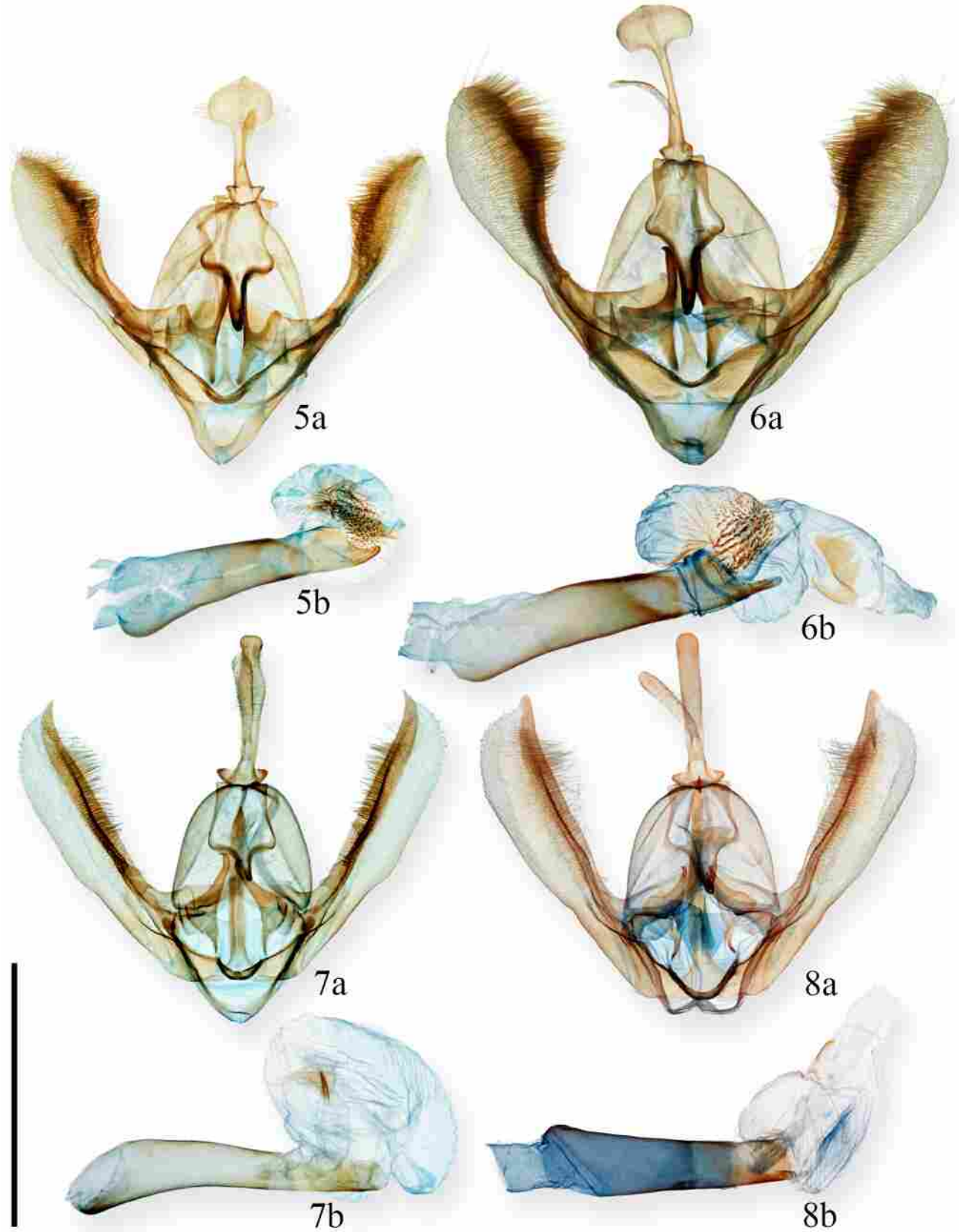
Head. Antenna mostly bipectinate, but with gradually diminishing rami that are absent in distal quarter of antenna; scales above fuscous, rami ochreous. Vertex mostly white with central gray spot; frons thinly scaled, white. Labial palpus decumbent, 1.5x diameter of eye, and with mixture of white and gray scales on outer surface and white on inner surface. Chaetosemata in transverse row; cephalic collar mostly white with few gray scales.

Thorax. Patagium, tegula, and mesothorax admixture of gray and white scales. Legs mostly white and mottled with gray; epiphysis well-developed; hind tibia with large hair pencil; tibial spur formula 0–2–4.

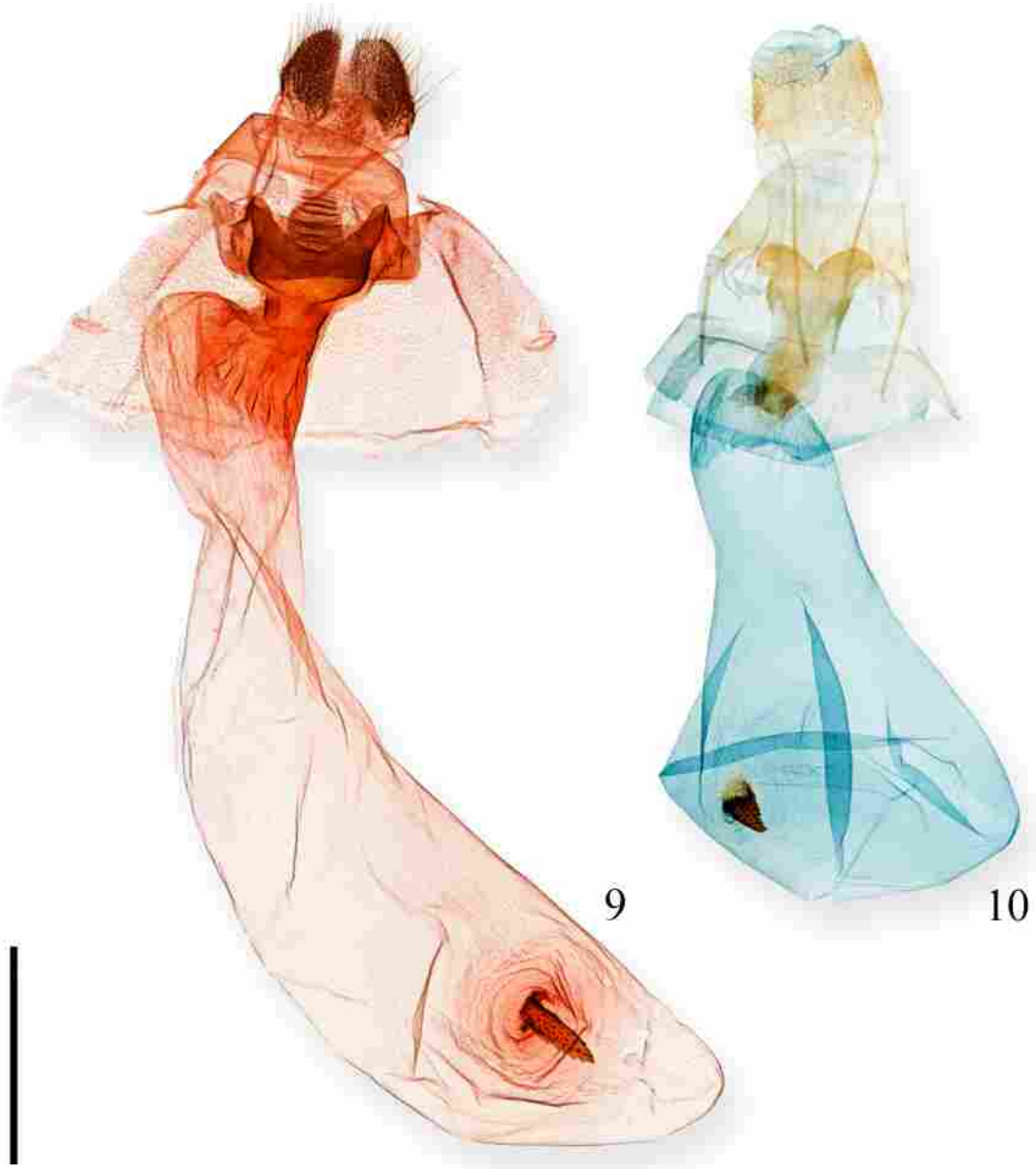
Forewing. Pearly-white; widely scattered with inconspicuous light gray scales and with intermittent black scaling over parts of veins. Basal, costal, and terminal area of outer margin broadly maculated with brown scales; basal area, apical area, and tornus, more uniformly brown. Underside more uniform pearly-white and without brown basal scaling. Apical area with more diffuse brown scaling than upperside.



FIGURES 1–4. *Achagua* adult habitus. (a) dorsal view, (b) ventral view. **(1)** *A. obsoleta* Rindge, AMNH_IZC 00353009, paratype, (Colombia: Cundinamarca), AMNH; **(2)** *A. magna* **n. sp.**, AMNH_IZC 00353021, holotype, (Peru: Cusco), AMNH; **(3)** *A. cooperae* **n. sp.**, USNMENT01771270, holotype, (Costa Rica: Alajuela), USNM; **(4)** *A. velata* **n. sp.**, holotype, (French Guiana: Régina), MNHN. Scale bar = 2 cm.



FIGURES 5–8. *Achagua* male genitalia. (a) genital capsule, (b) phallus. **(5)** *A. obsoleta* Rindge, TAM-2023-270, AMNH_IZC 00353009, paratype, AMNH; **(6)** *A. magna* **n. sp.**, TAM-2023-268, AMNH_IZC 00353023, paratype. AMNH; **(7)** *A. cooperae* **n. sp.**, TAM-2023-251, AMNH_IZC 00353028, paratype, AMNH; **(8)** *A. velata* **n. sp**., TAM-2023-289, holotype, MNHN. Scale bar = 2 mm.



FIGURES 9–10. *Achagua* female genitalia. **(9)** *A. obsoleta* Rindge, No. 20288, NHMUK010293435, NHMUK; photo credit: Louise Berridge (NHMUK); **(10)** *A. cooperae* **n. sp.**, TAM-2023-276, USNMENT01771269, paratype, USNM. Scale bar = 2 mm.

Hindwing. Pearly-white except for brown and black terminal band. Underside patterned similar to upperside, but darkened area around outer margin more diffuse and tornal area much whiter.

Abdomen. First segment white with pair of black elongate dorsal spots, second segment black with narrowly triangular white median patch, remainder of abdomen with mixture of white, gray, black, and brown scales; white below. Third sternite of male abdomen with comb of setae.

Genitalia (Fig. 6). Uncus abruptly widened at base; dorsal process thin through middle and apically spatulate; ventral process thumb-like. Base of gnathos subquadrangular, with upcurved, heavily sclerotized, pointed apical projection; apex of projection lightly dentate. Valve large and elongate with heavily sclerotized costa bearing post-medial digitate protuberance. Anellar processes large and subtriangular with elongate, slender posterior projection; lateral margin only slightly concave. Juxta with elongate, medial cylindrical process. Vesica with large denticulate basal patch and weakly sclerotized medial patch.

FEMALE. Unknown.

Type Material.

Holotype
PERU • ♂; Cusco, Quincemil; elev. 2400 ft; Aug. 1962; L.E. Pena leg.; AMNH_IZC 00353021; AMNH.

Paratypes (8♂)
PERU • 5♂; same collection data as holotype; Genitalia: FHR no. 12173, TAM-2023-255, TAM-2023-268; AMNH_IZC 00353022–AMNH_IZC 00353025, USNMENT01771249; AMNH, USNM • ♂; Cuzco, Cosnipata; (-12.9018°, -71.4117°); elev. 724 m; 28 Aug. 2016; Gunnar Brehm leg.; BOLD Process ID: PEMOA404-16; JPM • ECUADOR • ♂; Zamora Chinchipe; (-3.97388°, -79.084°); elev. 1925 m; 29 Oct. 2002; Nadine Hilt & Claudia Ramenda leg.; BOLD Process ID: NGEOE359-12; JPM • BOLIVIA • ♂; N.P. Carrasco; elev. 900m; (17°06'44"S 65°33'55"W); 05 Oct. 2010; Aare Lindt leg.; Genetic Voucher: TTBO002; TUZ.

Distribution (Fig. 11)**.** *Achagua magna* inhabits the eastern slopes of the central Andes from the Eastern Cordillera real montane forests of Ecuador south through the Peruvian and Bolivian Yungas.

Biology. Life history information is wanting. Adult records are from August and October.

Etymology. The specific epithet *magna* is from the Latin "magnus," meaning "large," as this species is the largest known member of the genus.

Molecular characterization. This species is represented in BOLD by the BIN: BOLD:ABW8871 (n =3, Peru, Ecuador, Bolivia). Specimens from Bolivia and Peru differ from the only sequenced Ecuadorian individual by about 1.2%. The distance to the nearest neighbor, *Achagua cooperae* is about 5.9%, however, the presumable sister species of *A. magna*, *A. obsoleta*, has not been sequenced.

Remarks. Multi-locus molecular data for this species were used in the phylogenetic studies of Murillo-Ramos *et al*. (2019) and Brehm *et al*. (2019). However, the sequenced individual of *Achagua* was misidentified as *A. obsoleta* in these studies. This is unsurprising considering the similarity between *A. magna* and *A. obsoleta*, and the fact that *A. obsoleta* was the only described *Achagua* at that time.

Achagua magna is the name given to the undescribed species mentioned in Rindge (1983). While Rindge initially mentioned his series of *A. magna* as being from Ecuador in the distribution section of his generic treatment, he later referred to it as being from Peru in the diagnosis and remarks sections of his species' treatment of *A. obsoleta*. After examining specimens that Rindge likely studied at the AMNH, where he curated Lepidoptera, there were no specimens from Ecuador, only from Peru. However, during this study, material from Ecuador was later confirmed from other museum collections.

Achagua cooperae Matson, n. sp.

(Figs. 3, 7, 10–12)
LSID: 2053905A-C10D-464D-A68F-694BF3E7E038

Diagnosis. *Achagua cooperae* is currently the only member of the genus known from Central America. This species bears a conspicuous antemedial black spot along the forewing inner margin and a weakly gray, discal, reniform spot that are absent in both *A. magna* and *A. obsoleta.* The male genitalia of *A. cooperae* lack a spatulate dorsal process of the uncus, a postmedial digitate protuberance on the costa, and cornuti on the vesica, all of which are found in *A. magna* and *A. obsoleta*.

Achagua cooperae is thought to be closely related to *A. velata*. One noticeable distinction is the thickness of the black terminal band on the hindwing, which tends to be thinner in *A. cooperae* compared to *A. velata*. While male *A. cooperae* share many genitalic similarities with *A. velata*, the dorsal process of the uncus appears to be knob-like in *A. cooperae*, whereas in *A. velata*, it is more uniform in shape (Figs. 7a, 8a). *Achagua cooperae* and *A. velata* may also be separated by their COI barcode (see Molecular characterization).

Description. MALE. Forewing length, 17–18 mm (n = 8).

Head. Antenna mostly bipectinate, but with gradually diminishing rami that are absent in distal third of antenna; scales above white and light gray, rami dark gray to black. Vertex white; frons mostly light gray. Labial palpus short, decumbent, 1.5x diameter of eye, light gray and white. Chaetosemata in transverse row; cephalic collar mostly white with few black scales.

Thorax. Patagium, tegula, and mesothorax admixture of gray and white scales. Legs mostly white and mottled with gray; epiphysis well-developed; hind tibia with large hair pencil; tibial spur formula 0–2–4.

Forewing. Pearly-white; widely scattered with inconspicuous light gray scales. Basal and costal areas lightly maculated with gray to brown scales. Subtle, light gray, transverse antemedial line, and weakly gray, discal, reniform spot. Inner margin with antemedial black spot. Terminal area broadly maculated with brown scales and bearing undulating, subterminal pale stripe within. Underside patterned as in upperside but darkened areas more diffuse.

Hindwing. Pearly-white except for blackened terminal area. Underside patterned as in upperside but darkened area more diffuse.

Abdomen. Admixture of gray and white. Third sternite of male abdomen with comb of setae.

Genitalia (Fig. 7). Uncus abruptly widened at base; dorsal process larger, gradually enlarging to pronounced swelling at distal third and with knob-like apex; ventral process large and thumb-like. Base of gnathos subquadrangular with upcurved, heavily sclerotized, and pointed apical projection; projection lightly papillated. Valve elongate, quadrate, and large with heavily sclerotized costa; apex strongly falcate. Anellar processes large and triangular, directed inward, and with apical recurved hooks. Juxta with medial, elongate cylindrical process with acuminate apex. Vesica with small medial sclerotized fold; cornuti absent.

FEMALE. Forewing length, 19 mm (n = 2). Outwardly undifferentiated from male.

Genitalia (Fig. 10). Papillae anales rounded; posterior apophysis 2.5x longer than anterior apophysis. Lamella antevaginalis cordiform; ostium opening into short, lightly sclerotized ductus bursae. Corpus bursae posteriorly narrow, opening into ovoid anterior portion. Signum large and invaginated, appearing somewhat cone-like; surface lightly denticulate.

Type Material.

Holotype

COSTA RICA • ♂; Alajuela, ACG [Area De Conservación Guanacaste], Rincon Rain Forest, casa de Oscar Albergue; (10.866°, -85.326°); elev. 725 m; 14 Feb. 2010; R. Franco & H. Cambronero leg. (light trap); Sample IDs: 10-SRNP-105189; Bold Process ID: BLPDQ563-10; GenBank: HQ934011; USNMENT01771270; USNM.

Paratypes (6♂, ♀)

COSTA RICA • 2♂, ♀; same collection data as holotype; Sample IDs: 10-SRNP-105551, 10-SRNP-105757, 10-SRNP-105758; Bold Process IDs: BLPDQ925-10, BLPDR132-10, BLPDR133-10; GenBank: HQ934144, HQ934347, HQ934348; Genitalia: TAM-2023-289; USNMENT01771269, USNMENT01771271; USNMENT01771272; USNM • ♂; Alajuela, ACG [Area De Conservación Guanacaste], Rincon Rain Forest, túnel de Oscar Albergue; (10.868°, -85.327°); elev. 708 m; 14 Feb. 2010; S. Rios & F. Quesada leg. (light trap); Sample ID: 10-SRNP-105667; Bold Process ID: BLPDR042-10; GenBank: HQ934257; USNMENT01771273; USNM • 3♂; Puntarenas, 35 km NE of San Vito at Las Alturas Field Station; elev. 4800 ft; [27–29] Apr. 1992; C. Snyder leg. (at light); Genitalia: F.H.R. No. 21326 and TAM-2023-251; AMNH_IZC 00353026 to AMNH_IZC 00353028; AMNH.

Other Material Examined.

MEXICO • ♂; Veracruz, Los Tuxtlas, Sierra Sta. Martha, Arroyo Claro, Neck Point; 19 Mar. 1977; R. Sánchez S. leg.; Genitalia: TAM-2023-315; CNIN • ♀; Veracruz, Est. Biol. de Los Tuxtlas; Alt. 170 m; 01 Apr. 1985; P. Sinaca leg.; Genitalia: TAM-2023-316; 10194; CNIN.

Distribution (Fig. 11)**.** *Achagua cooperae* is known to inhabit the Isthmian-Pacific and Atlantic moist forests of Costa Rica, but its distribution in other parts of Central America remains uncertain. Notably, two individuals were collected from the Sierra de los Tuxtlas, a remote volcanic range situated along the southeastern coast of the Veracruz Gulf in Mexico. These are tentatively regarded as conspecific (see Remarks).

Biology. The life history of *A. cooperae* remains unknown. Adult are known to fly from February through April.

Etymology. *Achagua cooperae*, is named in honor of Loretta Faye Cooper, former Senior Development Officer, and Deputy Director for Advancement at the Smithsonian's National Museum of Natural History. Loretta's dedication to museum research is unparalleled, and her tireless efforts to raise awareness and secure funding for the conservation and study of the natural world make her a true champion for both people and the environment. Loretta's support for the Area de Conservación Guanacaste is particularly noteworthy and greatly appreciated.

Molecular characterization. *Achagua cooperae* is represented in BOLD by the BIN: BOLD:AAM6724 (n = 5). The pairwise distance to the nearest neighbor, *Achagua velata* (n = 1, French Guiana), is about 3.8%.

Remarks. I tentatively regard two individuals from the Sierra de los Tuxtlas of Veracruz, Mexico, as *A. cooperae*. However, I have opted not to include these individuals in the type series. While the genitalia of both sexes in this Mexican population are consistent with those in Costa Rica, the Sierra de los Tuxtlas is a region characterized by biological endemism (Sánchez-González *et al*. 2008), and further, this population is disjunct from the remaining known distribution of *A. cooperae*.

The male phallus depicted in Figure 7b may give the impression of a spinate cornutus. However, this is an artifact of the preparation and the structure in question is rather a sclerotized fold.

Achagua velata Matson, n. sp.

(Figs. 4, 8, 11, 12)

LSID: 0E4A82F4-6BDF-43BE-86F8-572966809E46

Diagnosis. The following diagnosis is based on information from a single individual of *A. velata*, and caution should be exercised when interpreting it. As of now, *Achagua velata* is currently the only member of the genus known to inhabit the Guianan moist forests of northeastern South America. This species bears a conspicuous antemedial black spot along the forewing inner margin and a weakly gray, discal, reniform spot that are absent in both *A. magna* and *A. obsoleta*. The terminal band on both wings is thicker and more complete than in other congeners. The male genitalia of *A. velata* lack a spatulate dorsal process of the uncus, a postmedial digitate protuberance on the costa, and cornuti on the vesica, all of which are found in *A. magna* and *A. obsoleta*. While male *A. velata* shares many genitalic similarities with *A. cooperae*, the dorsal process of the uncus appears knob-like in *A. cooperae* (Fig. 7a), whereas in *A. velata* (Fig. 8a), it is more uniform in shape. *Achagua velata* and *A. cooperae* may also be separated by their COI barcode (see Molecular characterization).

Description. MALE. Forewing length, 17 mm (n = 1).

Head. Antenna mostly bipectinate, but with gradually diminishing rami that are absent in distal third of antenna; scales above white and light gray, rami dark gray to black. Vertex white; frons mostly light gray. Labial palpus short, decumbent, 1.5x diameter of eye, light gray and white. Chaetosemata in transverse row.

Thorax. Patagium, tegula, and mesothorax admixture of gray and white scales. Legs mostly white and mottled with gray; epiphysis well-developed; hind tibia with hair pencil (not easily visualized in holotype); tibial spur formula 0–2–4.

Forewing. Pearly-white; widely scattered with inconspicuous light gray scales. Basal and costal areas lightly maculated with gray to brown scales. Subtle, light gray, transverse antemedial line, and weakly gray, discal, reniform spot. Inner margin with antemedial black spot. Terminal area broadly maculated with brown scales. Underside patterned as in upperside, but darkened areas more diffuse and given more toward black.

Hindwing. Pearly-white except for complete, broadly dark brown outer margin. Underside patterned as in upperside.

Abdomen. Admixture of gray and white. Third sternite of male abdomen with comb of setae.

Genitalia (Fig. 8). Uncus abruptly widened at base; dorsal and ventral processes thumb-like. Base of gnathos subquadrangular, with upcurved, heavily sclerotized, pointed apical projection; projection lightly papillated. Valve elongate and large with heavily sclerotized costa; apex strongly falcate. Anellar processes large and triangulate, directed inward, and with apical recurved hooks. Juxta with medial, long cylindrical process with acuminate apex. Vesica with small medial sclerotized patch; cornuti absent.

FEMALE. Unknown.

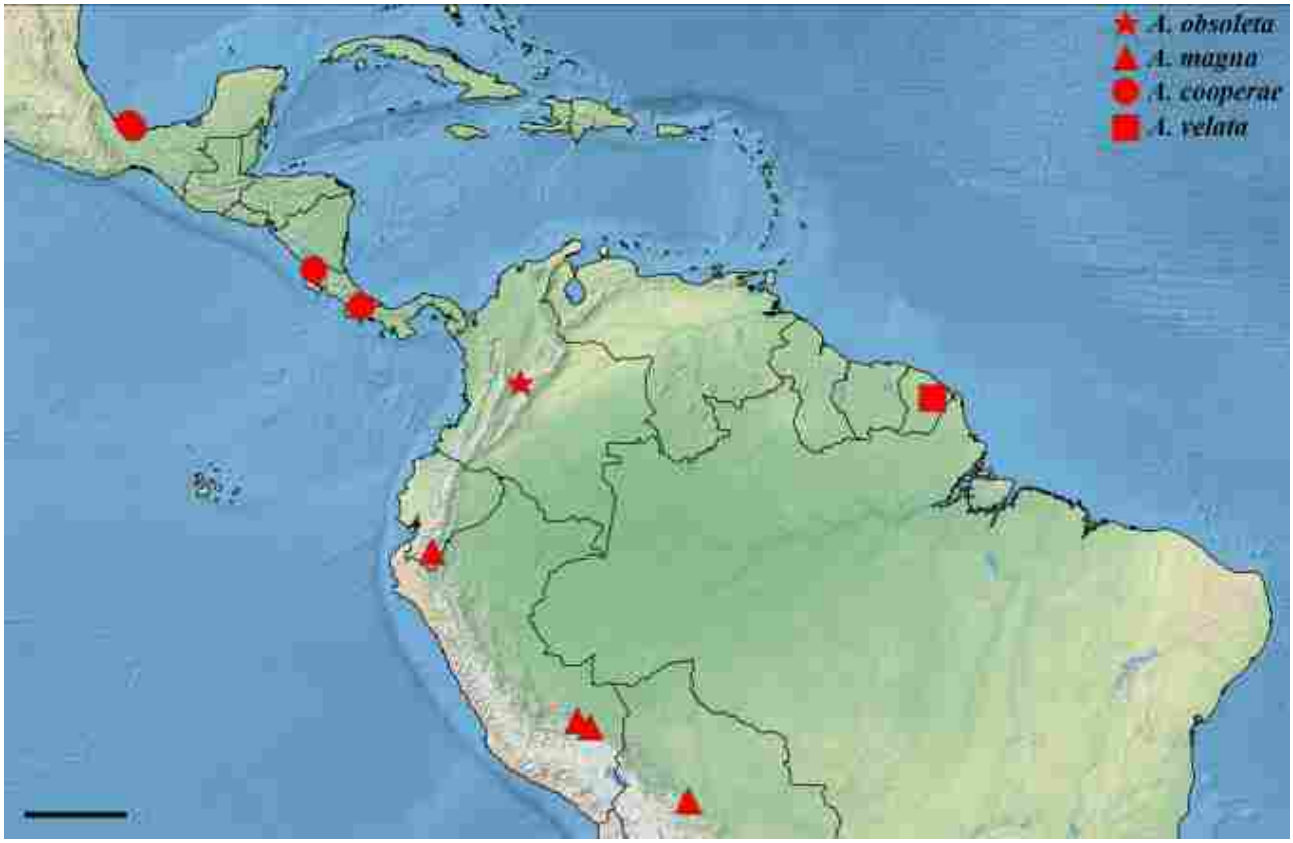


FIGURE 11. Geographic distribution of *Achagua*: *A. obsoleta* Rindge (star), *A. magna* **n. sp.** (triangle), *A. cooperae* **n. sp.** (circle), and *A. velata* **n. sp.** (square). Single dots may represent >1 individual. Scale bar = 600 km.

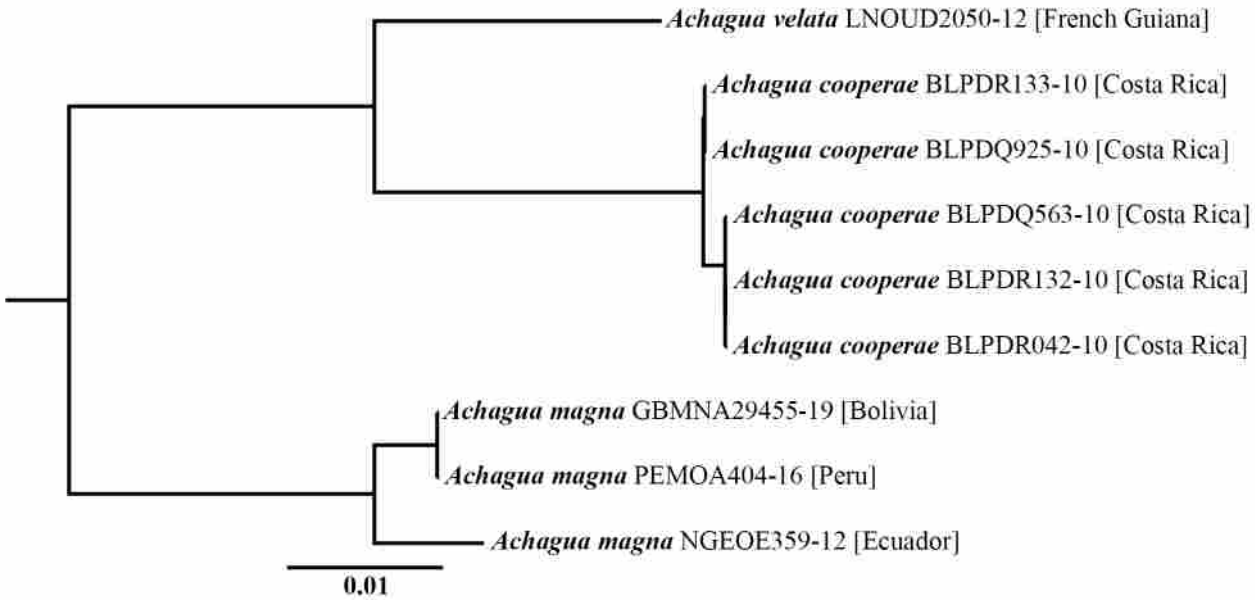


FIGURE 12. COI neighbor-joining tree generated from all publicly available *Achagua* sequences. Taxon names followed by BOLD Process ID and country of origin.

Type Material.

Holotype

FRENCH GUIANA [FRANCE] • ♂; Régina, Nouragues Nature Reserve; (4.096°, -52.683°); elev. 419 m; 09 Jul. 2010; Carlos Lopez-Vaamonde leg.; Genitalia: TAM-2023-289; BOLD Process ID: LNOUD2050-12; MNHN.

Distribution (Fig. 11)**.** Presently, *A. velata* is only known from the Guianan moist forests at the type locality in French Guiana.

Biology. Immature stages and host associations remain unknown. Adults are known to fly in July at the type locality.

Etymology. The specific epithet *velata* is derived from the Latin "velatus," meaning "veiled." The name was chosen because of the rarely seen nature of this species—thus far only known from a single individual—and for its white, wedding-veil-like ground color.

Molecular characterization. *Achagua velata* is represented in BOLD by the BIN: BOLD:ABV2454 (n = 1). The pairwise distance to the nearest neighbor, *Achagua cooperae* (n = 5, Costa Rica), is about 3.8%.

Discussion

Achagua moths are exceedingly rare in collections. In Area de Conservación, northwestern, Costa Rica, where Dan Janzen, Winnie Hallwachs, and their team of parataxonomists have collected at light and pinned 17,652 geometrid moths out of 122,696 Lepidoptera over 17 years, five individuals of *Achagua cooperae*, in a single collecting event, have been taken at light. Additionally, none have been reared among 41,364 wild-caught geometrid caterpillars since 1978. Similarly, in Ecuador, where Gunnar Brehm and colleagues have sampled ~50,000 geometrid moths, only a solitary individual of *A. magna* has been encountered. This scarcity extends to other members of the genus, with *A. velata* known solely by its holotype individual. Furthermore, the entire genus is represented by a mere three female individuals in the major collections that I have visited.

The Neotropics boasts the highest number of described geometrid species worldwide, with approximately 6,600 species (Rajaei *et al*. 2022). However, an increasing number of undescribed geometrid taxa are being revealed with more widespread geographic sampling and the use of DNA barcoding (Hebert *et al*. 2003). It is estimated that for each described geometrid species in the South American Andes, there may be three to four undescribed species (Brehm *et al.* 2016). Despite this, taxonomic papers that describe new Geometridae from the Neotropics have been infrequent, with less than three taxonomic papers published per year over the past two decades (Rajaei *et al*. 2022). The genus *Achagua* is a striking example that highlights the need for continued taxonomic research in the Neotropics, as three of the four known species were previously undescribed.

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