



Identification and diagnosis of *Anoura fistulata* with remarks on its presumed presence in Bolivia

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Anoura fistulata is the most specialized nectarivorous bat of the genus *Anoura*. Its relationships with other species of the genus are uncertain given its external morphological resemblance to all 4 species in the *A. caudifer* species complex. Here, we show how to properly diagnose *A. fistulata* and how the glossal tube, unique to this species, should be identified. We also reassess the putative presence of *A. fistulata* in Bolivia by revisiting the measurements and soft morphology characters of the specimen used for this published record. Our morphometric analyses show that the species in the *A. caudifer* complex overlap in their morphospace for 23 cranial and postcranial measurements and are indistinguishable using Principal Component Analyses or Linear Discriminant Functions. However, comparing dissections of *A. fistulata* from Ecuador to the Bolivian record show that it lacks the soft tissue characters unique to *A. fistulata*, indicating this specimen is an individual of *A. caudifer* rather than *A. fistulata*. Given that this was the only record for the country, *A. fistulata* is not known to occur in Bolivia.

Anoura fistulata es el murciélago nectarívoro más especializado del género *Anoura*. Sus relaciones filogenéticas con otras especies de este género son desconocidas dada su semejanza morfológica con las 4 especies del complejo de especies *A. caudifer*. En este estudio, presentamos la manera correcta de diagnosticar *A. fistulata* y mostramos como el tubo glosal, el cual es una adaptación única en esta especie, debe identificarse. También reevaluamos la presencia putativa de esta especie en Bolivia mediante una revisión de las medidas morfológicas y caracteres anatómicos blandos del ejemplar usado en este registro geográfico. Nuestro análisis morfométrico muestra que los ejemplares del complejo de especies *A. caudifer* se superponen en su morfoespacio para 23 medidas craneales y poscraneales, y son indistinguibles al usar Análisis de Componentes Principales o Funciones Discriminantes Lineares. Sin embargo, al comparar las disecciones de *A. fistulata* de Ecuador con el ejemplar de Bolivia encontramos que este último no posee los caracteres anatómicos blandos únicos de *A. fistulata*, lo cual indica que este espécimen pertenece a la especie *A. caudifer* y no a *A. fistulata*. Dado que actualmente éste era el único registro de *A. fistulata* para Bolivia, la especie no se conoce para este país.

Key words: Bolivia, Chiroptera, distribution, Glossophaginae, glossal tube, nectarivorous bat

Despite being one of the most species-rich genera in the subfamily Glossophaginae, with 8 described species, the taxonomy of *Anoura* (Gray 1838) remains unclear. The genus can be readily subdivided into 2 groups based on size and dental morphology (Allen 1898; Griffiths and Gardner 2007 [2008]), with 4 small species (*A. caudifer*, *A. luismannueli*, *A. fistulata*, and *A. cadenai*.) and 4 large species (*A. geoffroyi*, *A. cultrata*, *A. latidens*, and *A. carishina*). However, species within these groups show high intraspecific variation leading to extensive interspecific overlap of morphological measurements (Tamsitt

and Valdivieso 1966; Nagorsen and Tamsitt 1981; Molinari 1994; Mantilla-Meluk and Baker 2006, 2010; Jarrín-V and Kunz 2008; Jarrín-V and Coello 2012). In this study, we focus on the tube-lipped nectar bat, *A. fistulata*, reassessing its diagnostic characters through comparison of morphological measurements for all species in the genus, and using results to reassess its known geographic distribution.

Anoura fistulata possesses several unique soft tissue adaptations useful for identification, including a tongue exceeding its body length, a glossal tube to house the tongue in the rib

cage, and a lower lip longer than that of any other species in the genus (Muchhala et al. 2005; Muchhala 2006a). However, as these are all soft tissues, they tend to preserve poorly in traditionally prepared museum skins. The presence of the glossal tube and a protruded lower lip can be particularly difficult to detect due to desiccation or improper specimen preparation.

Published records of *A. fistulata* include Colombia, Ecuador, Peru, and Bolivia (Fig. 1). Specifically, they range from the southwestern Andes of Colombia in the departments of Cauca (Santa Rosa 1.24°, -76.51°), Nariño (Colon 1.65°, -77.02°; Llorente 0.82°, -77.25°), Risaralda (Pueblo Rico 5.24°, -76.04°) (Mantilla-Meluk and Baker 2008; Mantilla-Meluk et al. 2009), eastern and western Andes of Ecuador in the provinces of Imbabura (Santa Rosa 0.33°, -78.93°), Morona Santiago (Rio Cristalino -3.52°, -78.43°; Uuntsuants -2.55°, -77.90°), Napo (Cotundo -0.64°, -77.84°; El Salado -0.25°, -77.68°; Sumaco -0.57°, -77.60°), Pichincha (Bellavista 0.00°, -78.68°; Guajalito -0.22°, -78.80°; Pahuma -0.02°, -78.63°; Yanayacu -0.58°, -77.87°) and Zamora Chinchipe (Chinapinza -4.04°, -78.59°; Cuevas de Numbala

-4.55°, -79.07°; Destacamento Militar Condor -3.64°, -78.39°; La Herradura -4.03°, -78.57° and Podocarpus National Park -4.02°, -79.02°) (Muchhala et al. 2005; Lee et al. 2008, 2010; Rex et al. 2008), and middle and southern Peru in the province of San Martín (Huicungo -7.32°, -76.77°) and Puno (Ollacea -13.66°, -70.48°) (Jiménez et al. 2008; Pacheco et al. 2009; Gárate-Bernardo and Carrasco-Rueda 2011). In this study, we revisit the identification of the Bolivian specimen deposited at the Field Museum of Natural History. Specimen FMNH-106088 was collected in the Chuquisaca Department (Hernando-Siles province -20.17°, -64.25°) in southern Bolivia (Mantilla-Meluk et al. 2014), and greatly extends the known southern distributional limit of this species' range (Fig. 1). We examine and compare this specimen with other *Anoura* species. Additionally, we present a detailed description of the soft tissue characters and morphometric measurements for diagnosing *A. fistulata*, both in the field and in mammal collections.

MATERIALS AND METHODS

We examined the type series of *A. fistulata*, focusing on the diagnostic characteristics of the species, and performed dissections of the thorax to make a detailed comparison of the internal anatomy of *A. fistulata*, *A. caudifer*, and *A. geoffroyi*. Additionally, we compared specimen FMNH-106088 to 219 *Anoura* specimens: 177 *A. caudifer*, 17 *A. cadenai*, 21 *A. luismanueli*, and 4 *A. fistulata*. We also examined specimen FMNH-106089 (identified as *A. caudifer*), which was collected near specimen FMNH-106088 (Cordillera, Santa Cruz province, Bolivia). For these specimens, we measured 12 craniodental characters and, where possible, 11 postcranial features to the nearest 0.01 mm. Craniodental characters included: greatest length of skull (GLS), condylobasal length (CBL), postorbital breadth (PB), brain case breadth (BCB), height of brain case (HBC), mastoid breadth (MB), maxillary tooth-row length (MTRL), palatal length (PL), breadth across third upper molars (M3-M3), breadth across upper canines (C-C), mandibular length (MANL), and mandibular tooth-row length (MANTRL). Postcranial measurements included: forearm (FA), length of 3rd (D3MC), 4th (D4MC), and 5th (D5MC) metacarpals, length of the 1st and 2nd phalanges of 3rd (D3P1, D3P2), 4th (D4P1, D4P2), and 5th (D5P1, D5P2) digits, and length of the tibia. Visited collections are: Colección Teriología Universidad de Antioquia (CTUA-Medellín, Colombia), Colección de Mamíferos Alberto Cadena García (ICN, Instituto de Ciencias Naturales, Universidad Nacional, Bogotá Colombia), Field Museum of Natural History (FMNH, Chicago, Illinois) and the United States Natural History Museum (USNM, Washington, D.C.). See Supplementary Data SD1 for the list of specimens reviewed and their geographical information.

We applied a Linear Discriminant Analysis (LDA) and a Principal Component Analysis (PCA) to 2 data sets. One data set ($n = 192$) includes only the 12 craniodental measurements, whereas the second ($n = 165$) includes all 23 craniodental and postcranial measurements. Both data sets include

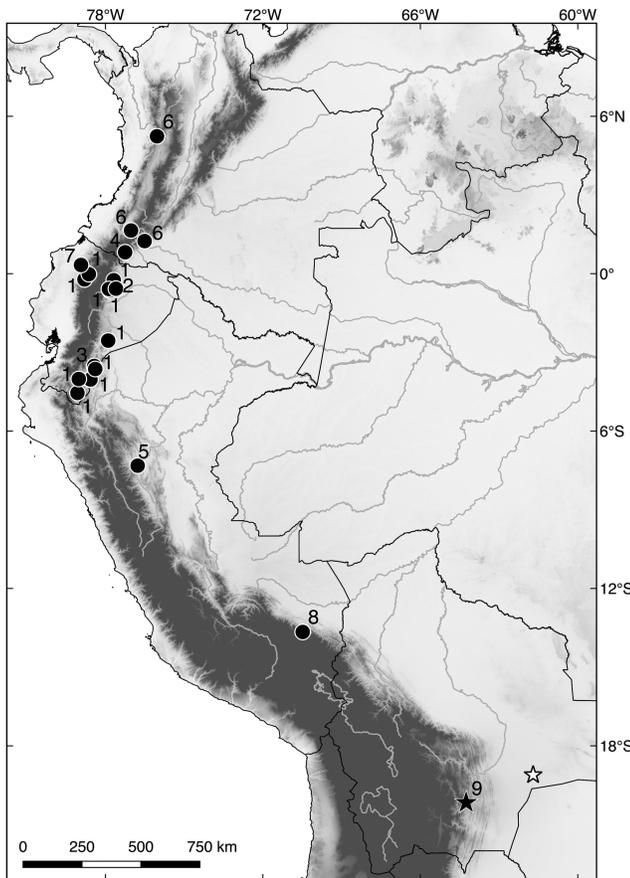


Fig. 1.—Distribution of *Anoura fistulata*. Black circles: published records of *A. fistulata*; Black star: putative record of *A. fistulata*, FMNH 106088; White star: *A. caudifer*, FMNH 106089. Numbers correspond to publications: 1 = Muchhala et al. (2005), 2 = Lee et al. (2008), 3 = Rex et al. (2008), 4 = Mantilla-Meluk and Baker (2008), 5 = Jimenez et al. (2008) and Pacheco et al. (2009), 6 = Mantilla-Meluk et al. (2009), 7 = Lee et al. (2010), 8 = Garate-Bernardo and Carrasco-Rueda (2011), 9 = Mantilla-Meluk et al. (2014).

representatives of all species of *Anoura*. The LDA and PCA differ in that an LDA uses a variable (e.g., geographical distribution or species name) as a prior to investigate the different groups present in the sample, which is useful when one is investigating the morphospace of species with well-established identities and delimitations. However, this is not always the case for the genus *Anoura* (Jarrín-V and Kunz 2008; Jarrín-V and Coello 2012), as many species overlap in measurements, and using the same variables that are used to build priors (species identities) to build the morphospace generates circularity that tends to recover the same groups established by the priors. In our LDA, we do not assign specimen FMNH-106088 as belonging to any of the groups (i.e., species). We follow the taxonomy recognized by (Griffiths and Gardner 2007 [2008]) and thus, in contradiction to Mantilla-Meluk and Baker (2006), we regard *A. aequatoris* as a junior synonym of *A. caudifer*.

RESULTS

Diagnosis and identification of A. fistulata.—When *A. fistulata* was described, the following soft tissue characters and morphometric measurements were used in its diagnosis: forearm length 35–40 mm, an elongated and protruded lower lip (Fig. 2) ranging from 3.3 to 4.8 mm in length, and a relatively wide uropatagium (3.3–7.5 mm) with a V-shaped margin and sparse hair (Muchhala et al. 2005). As described by Muchhala

(2006a), the glossal tube consists of a sleeve of tissue surrounding the base of the tongue.

Our dissections of *A. fistulata*, *A. geoffroyi*, and *A. caudifer* show that the sternohyoid muscle, which functions in retracting the tongue, extends distally into the ribcage and attaches to the xiphoid process of the sternum for all 3 species (Fig. 3A). This posterior shift in the origin of the sternohyoid relative to other bats has been previously described as an apomorphy for glossophagines (Griffiths 1982). However, while the base of the actual tongue coincides with the base of the oral cavity for *A. geoffroyi* and *A. caudifer* (the typical condition for mammals), for *A. fistulata* the base of the tongue is located between the heart and the posterior face of the sternum and ribs. Posterior to the oral cavity, a sleeve of tissue surrounds the tongue, following the ventral surface of the trachea back through the neck and into the thoracic cavity (Fig. 3). The sternohyoid muscle connects to the xiphoid process for all 3 species.

Figure 1B in Mantilla-Meluk et al. (2014) shows the dissected upper thorax of FMNH 106088, including the pectoral muscles, sternomastoid muscles, and trachea. The legend states that the glossal tube and tongue insertion are visible. However, the structure marked as glossal tube is in fact the sternomastoid muscle, and the tongue insertion should not actually be visible given that the tongue attaches to the xiphoid process (via the sternohyoid muscle; see Fig. 3B) and that the xiphoid process is out of the frame of this image. In *A. fistulata*, the glossal tube

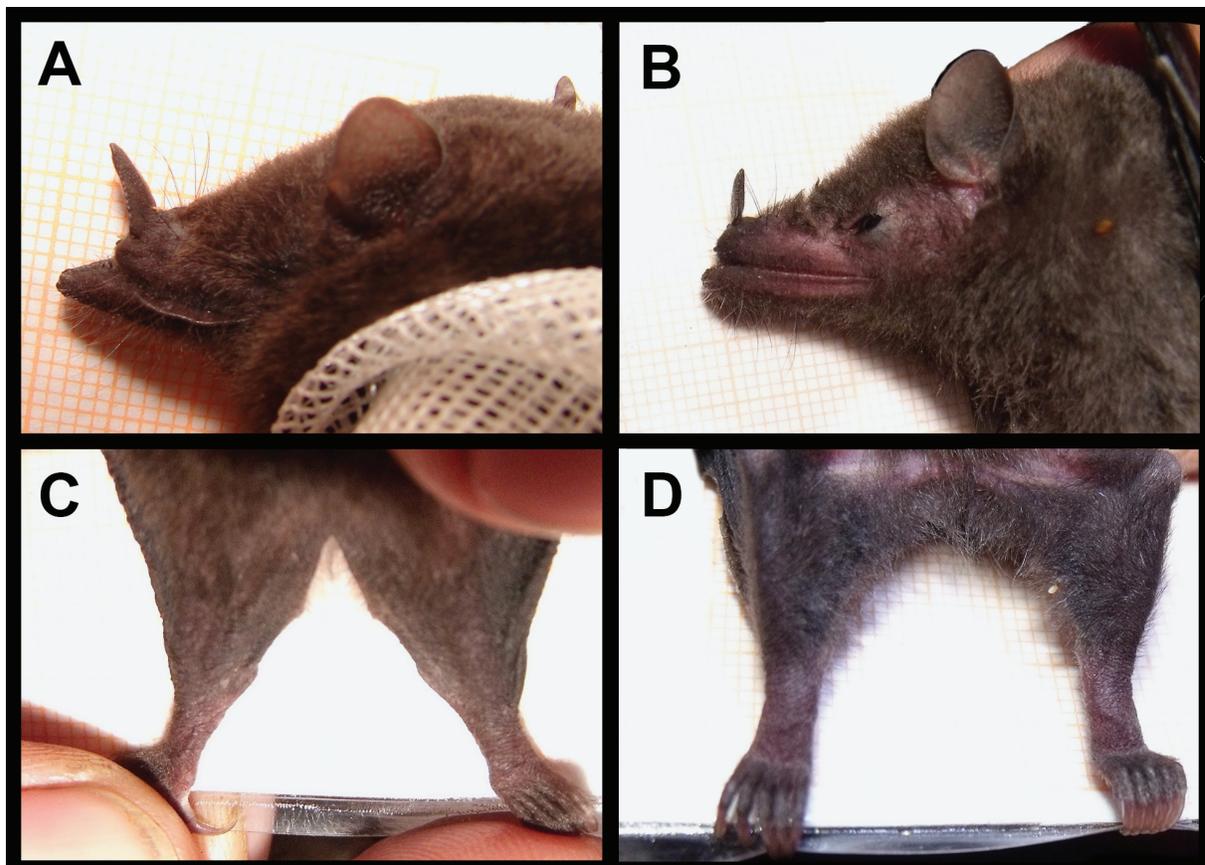


Fig. 2.—Comparison of external characters of *Anoura fistulata* and *A. caudifer*: Lower lip of *A. fistulata* (A) and *A. caudifer* (B), V-shaped uropatagium in *A. fistulata* (C) and U-shaped uropatagium in *A. caudifer* (D).

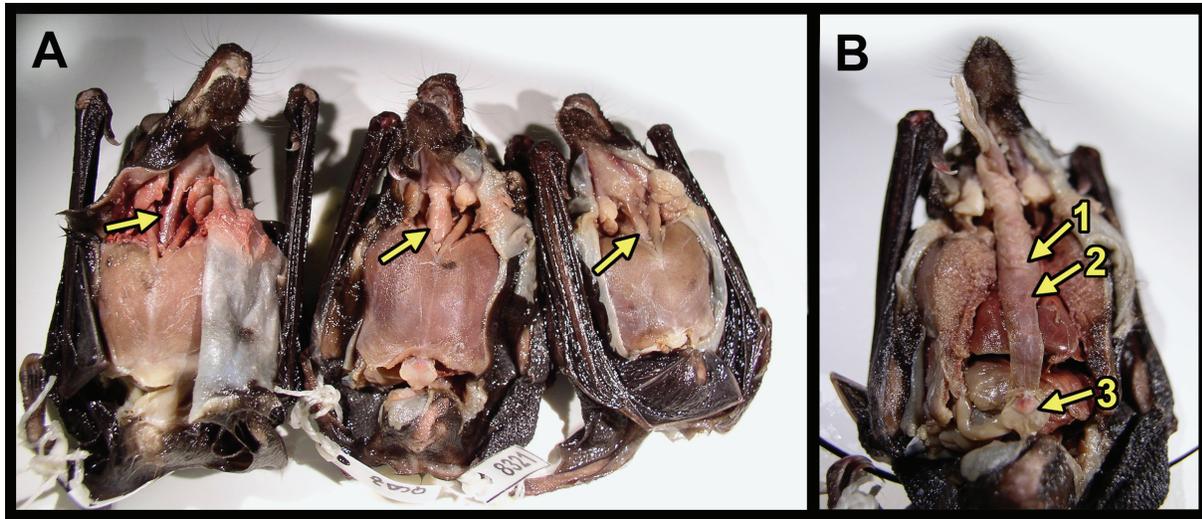


Fig. 3.—Soft tissue morphology comparisons of *Anoura geoffroyi* QCAZ 8324 (left), *A. fistulata* QCAZ 8322 (center), and *A. caudifer* QCAZ 8321 (right). Arrows indicate the glossal tube in *A. fistulata* and the trachea and tongue in the case of *A. caudifer* and *A. geoffroyi* (A), note how the glossal tube makes the trachea look wider in *A. fistulata* and how the sternomastoid muscles are positioned on both sides of the trachea in the 3 specimens. (B) Dissection of the glossal tube of *A. fistulata*; arrows show the sleeve of tissue surrounding the tongue and trachea i.e., the glossal tube; (1), the location of the base of the tongue (2), and the point of attachment of the sternohyoid muscle to the xiphoid process (3).

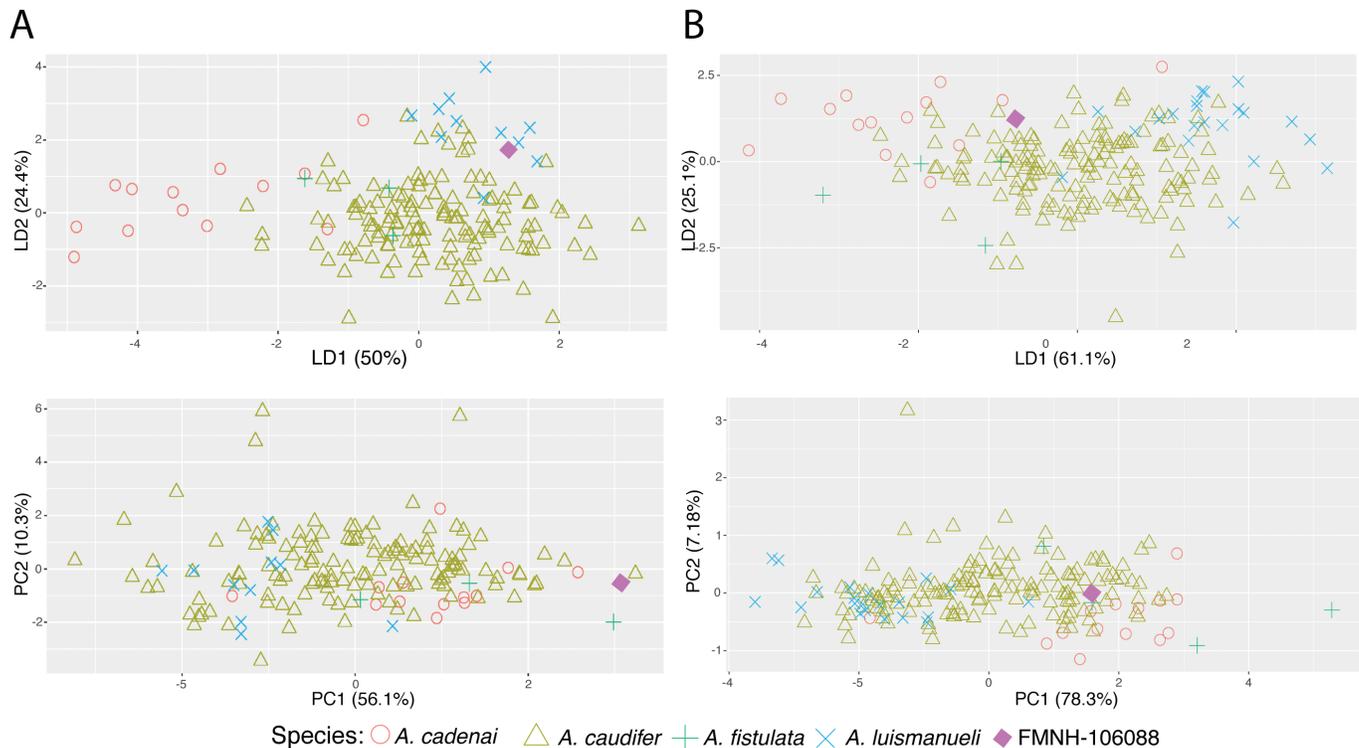


Fig. 4.—(A) Linear Discriminant Analysis (LDA) and Principal Component Analysis (PCA) analyses using 12 craniodental and 11 postcranial measurements of *Anoura* specimens. (B) LDA and PCA analyses using only the 12 craniodental measurements of *Anoura* specimens.

envelopes the trachea, making it look larger and wider (Fig. 3A), a feature that is not present in Fig. 1B of Mantilla-Meluk et al. (2014). Comparative dissections of *A. caudifer*, *A. fistulata*, and *A. geoffroyi* show how the sternomastoid muscles are positioned on both sides of the trachea in all 3 species (Fig. 3). Our re-evaluation of specimen FMNH-106088 shows no sign of the glossal tube.

Tongue length is a useful character for identifying *A. fistulata*; however, current reports of *A. fistulata* portraying its tongue length might be overestimating tongue size given the methodology used for measurement. Although previous records from southern Colombia (Mantilla-Meluk and Baker 2008; Mantilla-Meluk et al. 2009) do belong to *A. fistulata* specimens, the measured tongue length (over 4 cm past the lower

Table 1.—Measurements of the Bolivian specimen deposited at the Field Museum of Natural History compared to all small *Anoura* in our sample. Abbreviations can be found in the “Methods” section.

	FMNH 106088	<i>A. fistulata</i>	<i>A. caudifer</i>	<i>A. cadenai</i>	<i>A. luismanueli</i>
GLS	22.62	23.46 (22.11–25.19) <i>SD</i> = 1.36, <i>n</i> = 4	22.22 (20.73–23.59) <i>SD</i> = 0.68, <i>n</i> = 175	23.06 (21.38–24.18) <i>SD</i> = 0.66, <i>n</i> = 17	21.28 (20.38–22.16) <i>SD</i> = 0.44, <i>n</i> = 21
CBL	22.05	22.95 (21.95–24.46) <i>SD</i> = 1.18, <i>n</i> = 4	21.59 (19.99–23.04) <i>SD</i> = 0.71, <i>n</i> = 173	22.55 (20.62–23.48) <i>SD</i> = 0.64, <i>n</i> = 17	20.67 (19.61–21.88) <i>SD</i> = 0.56, <i>n</i> = 21
PB	4.58	4.72 (4.47–5.02) <i>SD</i> = 0.28, <i>n</i> = 4	4.58 (4.25–5.01) <i>SD</i> = 0.14, <i>n</i> = 176	4.59 (4.44–4.91) <i>SD</i> = 0.11, <i>n</i> = 17	4.54 (4.21–4.92) <i>SD</i> = 0.19, <i>n</i> = 21
BCB	8.80	9.22 (9.11–9.42) <i>SD</i> = 0.14, <i>n</i> = 4	8.89 (8.19–9.48) <i>SD</i> = 0.20, <i>n</i> = 175	9.06 (8.94–9.29) <i>SD</i> = 0.12, <i>n</i> = 16	8.79 (8.45–9.12) <i>SD</i> = 0.16, <i>n</i> = 21
HBC	7.72	7.18 (6.87–7.47) <i>SD</i> = 0.25, <i>n</i> = 4	7.03 (6.40–7.74) <i>SD</i> = 0.28, <i>n</i> = 175	7.23 (6.79–7.61) <i>SD</i> = 0.25, <i>n</i> = 17	7.10 (6.39–7.78) <i>SD</i> = 0.36, <i>n</i> = 21
MB	9.32	9.73 (9.54–9.94) <i>SD</i> = 0.16, <i>n</i> = 4	9.23 (8.47–9.98) <i>SD</i> = 0.27, <i>n</i> = 176	9.53 (8.74–9.95) <i>SD</i> = 0.28, <i>n</i> = 16	8.85 (8.54–9.48) <i>SD</i> = 0.19, <i>n</i> = 21
MTRL	8.51	8.60 (8.34–8.89) <i>SD</i> = 0.26, <i>n</i> = 4	8.18 (7.54–8.95) <i>SD</i> = 0.28, <i>n</i> = 174	8.60 (7.83–9.05) <i>SD</i> = 0.28, <i>n</i> = 17	7.77 (7.06–8.10) <i>SD</i> = 0.26, <i>n</i> = 21
PL	12.66	12.80 (12.39–13.56) <i>SD</i> = 0.53, <i>n</i> = 4	11.65 (9.90–13.47) <i>SD</i> = 0.62, <i>n</i> = 164	12.01 (10.43–13.47) <i>SD</i> = 0.52, <i>n</i> = 15	10.71 (9.86–12.10) <i>SD</i> = 0.47, <i>n</i> = 21
M3-M3	5.82	5.52 (5.22–5.73) <i>SD</i> = 0.22, <i>n</i> = 4	5.46 (4.17–6.12) <i>SD</i> = 0.26, <i>n</i> = 170	5.89 (5.41–6.18) <i>SD</i> = 0.19, <i>n</i> = 16	5.43 (4.80–5.71) <i>SD</i> = 0.21, <i>n</i> = 21
C-C	3.99	4.10 (3.91–4.29) <i>SD</i> = 0.17, <i>n</i> = 4	4.02 (3.62–4.46) <i>SD</i> = 0.16, <i>n</i> = 174	4.24 (3.95–4.48) <i>SD</i> = 0.17, <i>n</i> = 17	3.84 (3.58–4.02) <i>SD</i> = 0.11, <i>n</i> = 21
MANL	17.03	17.25 (15.89–18.23) <i>SD</i> = 1.02, <i>n</i> = 4	15.90 (12.21–17.09) <i>SD</i> = 0.62, <i>n</i> = 172	16.87 (15.31–17.68) <i>SD</i> = 0.52, <i>n</i> = 17	15.24 (14.07–16.61) <i>SD</i> = 0.59, <i>n</i> = 21
MANTRL	8.82	9.05 (8.84–9.57) <i>SD</i> = 0.35, <i>n</i> = 4	8.56 (7.79–9.33) <i>SD</i> = 0.28, <i>n</i> = 172	9.06 (8.22–9.62) <i>SD</i> = 0.33, <i>n</i> = 17	8.09 (7.56–8.57) <i>SD</i> = 0.28, <i>n</i> = 21
FA	38.98	37.55 (36.63–38.26) <i>SD</i> = 0.83, <i>n</i> = 3	35.78 (32.68–38.40) <i>SD</i> = 1.15, <i>n</i> = 159	36.81 (34.93–38) <i>SD</i> = 0.79, <i>n</i> = 15	35.11 (34.13–36.15) <i>SD</i> = 0.59, <i>n</i> = 11
D3MC	37.62	36.43 (35.23–37.69) <i>SD</i> = 1.23, <i>n</i> = 3	35.28 (31.20–39.23) <i>SD</i> = 1.42, <i>n</i> = 158	36.10 (33.48–38.31) <i>SD</i> = 1.04, <i>n</i> = 15	33.95 (32.33–35.26) <i>SD</i> = 1, <i>n</i> = 11
D3P1	13.25	13.12 (12.33–13.70) <i>SD</i> = 0.71, <i>n</i> = 3	11.95 (10.21–13.63) <i>SD</i> = 0.66, <i>n</i> = 158	12.86 (11.81–13.60) <i>SD</i> = 0.53, <i>n</i> = 15	11.62 (10.43–13.35) <i>SD</i> = 0.77, <i>n</i> = 11
D3P2	20.79	19.87 (18.91–21.28) <i>SD</i> = 1.25, <i>n</i> = 3	18.64 (11.57–22.99) <i>SD</i> = 1.31, <i>n</i> = 158	19.22 (16.26–20.56) <i>SD</i> = 0.98, <i>n</i> = 15	18.68 (17.00–20.71) <i>SD</i> = 1.13, <i>n</i> = 11
D4MC	37.22	34.41 (33.49–36.05) <i>SD</i> = 1.42, <i>n</i> = 3	33.42 (29.34–38.21) <i>SD</i> = 1.44, <i>n</i> = 158	34.14 (31.15–36.58) <i>SD</i> = 1.52, <i>n</i> = 15	32.29 (31.04–33.74) <i>SD</i> = 1.02, <i>n</i> = 11
D4P1	10.22	9.65 (8.42–10.92) <i>SD</i> = 1.25, <i>n</i> = 3	8.83 (7.15–10.60) <i>SD</i> = 0.54, <i>n</i> = 157	8.90 (7.93–9.81) <i>SD</i> = 0.45, <i>n</i> = 15	8.83 (8.13–9.84) <i>SD</i> = 0.46, <i>n</i> = 11
D4P2	12.85	12.89 (11.71–14.59) <i>SD</i> = 1.51, <i>n</i> = 3	11.66 (9.38–13.32) <i>SD</i> = 0.81, <i>n</i> = 157	12.13 (10.62–13.60) <i>SD</i> = 0.66, <i>n</i> = 15	11.76 (10.91–13.53) <i>SD</i> = 0.76, <i>n</i> = 11
D5MC	32.87	30.11 (27.51–32.40) <i>SD</i> = 2.46, <i>n</i> = 3	29.11 (19.96–32.71) <i>SD</i> = 1.64, <i>n</i> = 158	29.71 (27.14–31.41) <i>SD</i> = 1.16, <i>n</i> = 15	27.57 (26.34–29.65) <i>SD</i> = 0.98, <i>n</i> = 11
D5P1	8.44	7.81 (7.24–8.33) <i>SD</i> = 0.55, <i>n</i> = 3	7.54 (6.41–10.30) <i>SD</i> = 0.5, <i>n</i> = 157	7.80 (6.83–8.36) <i>SD</i> = 0.43, <i>n</i> = 15	7.39 (6.90–8.07) <i>SD</i> = 0.36, <i>n</i> = 11
D5P2	12.05	11.48 (10.76–12.10) <i>SD</i> = 0.68, <i>n</i> = 3	10.59 (8.71–12.70) <i>SD</i> = 0.73, <i>n</i> = 157	10.96 (9.51–12.69) <i>SD</i> = 0.83, <i>n</i> = 15	10.34 (9.23–11.39) <i>SD</i> = 0.77, <i>n</i> = 11
Tibia	14.73	13.12 (11.64–13.92) <i>SD</i> = 1.28, <i>n</i> = 3	11.96 (9.98–14.46) <i>SD</i> = 0.83, <i>n</i> = 156	11.77 (10.27–12.98) <i>SD</i> = 0.69, <i>n</i> = 15	11.47 (10.55–12.27) <i>SD</i> = 0.52, <i>n</i> = 11

lip) in Fig. 4 of Mantilla-Meluk et al. (2009) could be biased. Tongue length should not be measured by manually extending the tongue of a live or dead specimen, as there is no way to standardize the amount of stretching or to make comparisons with tongue extension capabilities of live animals measured in flight cages (Winter and von Helversen 2003; Muchhala 2006a; Tschapka et al. 2015) and inadvertent overstretching can lead to the improper identification of individuals of other *Anoura* as *A. fistulata*. If the researcher has access to a live animal it can be held temporarily in a flight cage and provided with a tube filled with sugar-water to measure the maximum depth the liquid can be consumed (see Muchhala 2006b).

Morphometric analysis.—Both the Principal Component Analysis and the Linear Discriminant Function on the 12 craniodental measurements show that 85% of the variation is explained by the first 2 components of each analysis (LD1 61.1%, LD2 25.1%; PC1 78.3%, PC2 7.18%), with the greatest length of the skull accounting for most of the variation of each component. Conducting the analysis with all 23 craniodental and postcranial measurements provides similar results regarding the position of specimen FMNH-106088 in the morphospace, however the variation explained by the first 2 components (LD1 50%, LD2 24.4%; PC1 56.1%, PC2 10.3%) accounts for only 75% of the variation. In both the LDA and PCA analyses using

only skull measurements, FMNH-106088 is nested within *A. caudifer* as are *A. fistulata* specimens (Fig. 4). When taking into account craniodental and postcranial measurements, specimen FMNH-106088 is nested within the *A. caudifer* morphospace in the LDA, however in the PCA it occupies the morphospace between the *A. caudifer* and *A. luismanueli* (Fig. 4). Although other principal components explain little of the variation, their graphical representation also shows specimen FMNH-106088 occupying the morphospace of *A. caudifer* (Figs. A–D, Supplementary Data SD2). When compared to the type series of *A. fistulata* (Muchhala et al. 2005) and to our sample (Table 1), many measurements of FMNH-106088 overlap with both *A. caudifer* and *A. fistulata*. It is worth noting that all 4 species of the *A. caudifer* species complex, as well as *A. geoffroyi*, present some degree of overlap with each other in most morphometric measurements. However, the values of brain case breadth (8.80 mm), mastoid breadth (9.32 mm), and mandibular tooth row length (8.82 mm) for specimen FMNH-106088 fall within the ranges of *A. caudifer* and outside of the ranges of *A. fistulata* (Table 1).

DISCUSSION

Several morphological traits exhibited by *A. fistulata* facilitate its identification in the field, particularly its lower lip and its uropatagium shape. However, it is possible that many *A. fistulata* remain unidentified in museum collections. Based on our analyses, small *Anoura* (including *A. fistulata*, *A. caudifer*, *A. luismanueli*, and *A. cadenai*) show a high overlap in morphospace (Fig. 4 and Supplementary Data SD2) and cannot be separated using classical morphometrics. However, comparing *A. fistulata* dissections to specimen FMNH-106088 demonstrate that the structures shown in Fig. 1B in Mantilla-Meluk et al. (2014) do not represent a glossal tube. Furthermore, 3 craniodental measurements (brain case breadth, mastoid breadth, and mandibular tooth row length) of FMNH-106088 fall outside of the range of *A. fistulata* and inside the range of *A. caudifer*. We conclude that this specimen is not *A. fistulata*; its morphometrics and soft tissue morphology instead identify it as *A. caudifer*.

Specimen FMNH-106089 (identified as *A. caudifer*) from a locality close to that of specimen FMNH-106088 in Bolivia (Fig. 1) shows similar morphometric measurements as those of FMNH-106088. This supports our conclusion that FMNH-106088 was misidentified, and in fact both specimens represent individuals of *A. caudifer*. Given this, *A. fistulata* is not presently known to occur in Bolivia, and the southern limit of the species is the Puno province in Peru.

Proper delimitation of species ranges is critical to establishing conservation priorities and actions. Our study adjusts the known distribution of *A. fistulata*, moving the southernmost extent of its range north by 971 km to the Puno department in southern Peru (Gárate-Bernardo and Carrasco-Rueda 2011). We believe that misidentified records can negatively impact the work of conservation programs, such as the Latin American Network for Bat Conservation –RELCOM (Aguirre et al. 2014), and should

always be reviewed carefully, particularly with species that have a conservation status of data deficient and are poorly represented in mammal collections.

SUPPLEMENTARY DATA

Supplementary data are available at *Journal of Mammalogy* online.

Supplementary Data SD1.—Database of specimens examined and their geographical information including localities and geographical coordinates.

Supplementary Data SD2.—Graphical visualization of other linear discriminants and principal components explaining the morphospace of small *Anoura*

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