Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 18 (5): 1045–1051
https://doi.org/10.15560/18.5.1045

PENSOFT

# First records of the genus *Aristosyrphus* Curran, 1941 (Diptera, Syrphidae) from Ecuador

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**Abstract**

We record *Aristosyrphus carpenteri* (Hull, 1945) for the first time from South America. This species was previously known from Panama and Costa Rica. New specimens, collected in Pichincha Province of Ecuador, represent the first reported occurrence of this flower fly genus from the country. Images, diagnosis, and DNA barcodes are provided to help with the identification of this species.

**Keywords**

Ant flies, *Aristosyrphus carpenteri*, flower flies, hoverflies, Microdontinae, new record

**Academic editor:** Alessandre Pereira-Colavite | Received 8 July 2022 | Accepted 2 October 2022 | Published 14 October 2022

**Citation:** Mengual X, Kilian IC, Pazmiño-Palomino A (2022) First records of the genus *Aristosyrphus* Curran, 1941 (Diptera, Syrphidae) from Ecuador. Check List 18 (5): 1045–1051. https://doi.org/10.15560/18.5.1045

## Introduction

*Aristosyrphus* Curran, 1941 (Diptera, Syrphidae) is a small genus of flower flies found in Central and South America (Cheng and Thompson 2008; Reemer and Ståhls 2013a). The biology of *Aristosyrphus* is unknown, but it is presumed that larvae are myrmecophilous like most microdontines (Reemer 2013).

*Aristosyrphus* belongs to the subfamily Microdontinae, also known as ant flies (Thompson 2020), and it is divided into two distinct subgenera: *Aristosyrphus sensu stricto* with four described species and *Aristosyrphus* (*Eurypterosyrphus*) with three species, although there are several taxa waiting for a formal description (Reemer and Ståhls 2013a). Five out of the seven described species occur in Brazil, namely *A.* (*A.*) *minutus* Thompson in Marinoni & Thompson, 2004, *A.* (*A.*) *primus* Curran, 1941, *A.* (*A.*) *boraceiensis* (Papavero, 1962), *A.* (*E.*) *macropterus* (Curran, 1941), and *A.* (*E.*) *melanopterus* (Barretto & Lane, 1947). *Aristosyrphus* (*E.*) *currani* (van der Goot, 1964), a new name for *Microdon clavicornis* Curran, 1940, is only known from the female holotype collected in Guyana. One species, *A.* (*A.*) *carpenteri* (Hull, 1945), was originally described from Panama (Hull 1945), but it has also been reported from Costa Rica (GBIF 2022).

The Neotropical Region is worldwide one of the least sampled areas for animals (Hughes et al. 2021), and insects are usually an understudied animal group (Troudet et al. 2017). Consequently, it is not surprising that in a megadiverse country like Ecuador (Mittermeier et al. 2005), a species-rich family like Syrphidae is underexplored and poorly collected (Amorim 2009). Marín-Armijos et al. (2017) reviewed the literature records of Ecuadorian syrphids and listed 201 species belonging to 51 genera and subgenera. They concluded that the syrphid fauna in Ecuador is far from being completely known. The project "Diversidad de moscas florícolas (Insecta: Diptera) del Ecuador" (MAAE-DBI-CM-2021-0167) shared between the Zoological Research Museum Koenig (Bonn, Germany) and the Instituto National de Biodiversidad (Quito, Ecuador) aims to fill the knowledge gap for flies in this country. With the help of DNA barcodes (Hebert et al. 2003) and morphological identifications, the project intends to create a species list of dipterans that will help to monitor this group by providing identification tools. As a result of the ongoing efforts, in the present work, we report for the first time the genus *Aristosyrphus* from Ecuador.

## Methods

Fieldwork was carried out between December 2019 and January 2020 in the Parroquia Pedro Vicente Maldonado, Pichincha Province, Ecuador. Sampling was performed using a double Malaise trap. This trap consists of two single Townes Malaise traps (Townes 1972) sewn back to back. The double malaise traps were placed in the transition zone between a lightly managed organic farming area and an old secondary forest. Behind the secondary forest is a primary forest with a stream, and pastures are predominant in the surrounding area (more than 100 m away from the trap in any direction). The sampling was done on the northwestern slopes of the Andes between the evergreen forest of the equatorial Choco lowlands and Piedmont evergreen forest of the western Andean Range (Noh et al. 2020; Ron 2020).

Collecting jars were filled with 96% ethyl alcohol and specimens were transferred to a vial with new 96% ethyl alcohol once they arrived at the lab and kept in a freezer at −20 °C. Specimens are deposited in Instituto National de Biodiversidad (INABIO) and Zoological Research Museum Koenig (ZFMK-DIP).

Specimens of the subfamily Microdontinae were identified to genus using the key provided by Reemer and Ståhls (2013a) and to species using a manuscript identification key (Thompson unpublished, in Primer taller de identificación de Syrphidae del Neotrópico, 21 a 27 de febrero de 2006, Facultad de Ciencias, Universidad del Valle, Cali, Colombia). The adult terminology used follows Cumming and Wood (2017), except the terms for male genitalia that follow Reemer and Ståhls (2013a).

Specimens were dried using the Leica EM CPD300 Automated Critical Point Dryer. Pinned specimens were photographed using a Canon EOS 7D® mounted on a P-51 Cam-Lift (Dun Inc., Virginia, USA) and stacked using the software Zerene Stacker® v. 1.04 (Richland, Washington, USA) with the help of Adobe Lightroom® v. 5.6 to export the images. SimpleMappr (Shorthouse 2010) was used to create Figure 1. Google Earth® was used to obtain the geographic coordinates of the holotype of *A. carpenteri*, and we also included coordinates from publicly available records (GBIF 2021; BOLD, https://www.boldsystems.org) (see Appendix Table A1).

For the selected specimens, the 5′-end of the mitochondrial cytochrome oxidase c subunit I (COI) gene was sequenced. One leg from the selected specimens was used for DNA extraction. DNA was extracted following standard protocols of the commercially available DNeasy Blood & Tissue Kit (QIAgen®). The COI barcode region was amplified using the forward primer LCO1-1490 (5′-GCTCAACAAATCATAAAGATATTGG-3′; Folmer et al. 1994) and the reverse primer COI-Dipt-2183R, also known as COI-780R (5′-CCAAAAAATCARAATARR TGYTG-3′; Gibson et al. 2011). PCR amplification, purification, sequencing protocols, and editing were carried out as described in Rozo-Lopez and Mengual (2015). The Ecuadorian Ministerio del Ambiente y Agua gave access to the genetic resources with the Marco Contract number MAAE-DBI-CM-2021-0167.

The PCR product was visualized on 1.5% agarose gel. PCR products were cleaned using the commercially available QIAquick PCR Purification Kit (QIAgen®). Bidirectional sequencing reactions were carried out by Macrogen Europe BV (Amsterdam, the Netherlands). Chromatograms were edited in Geneious v. 7.1.3. All new sequences were submitted to GenBank via BOLD. GenBank accession numbers are listed for each sequenced specimen in Results.

The software Geneious v. 7.1.3 was used to run a distance-based neighbor-joining (NJ) analysis using the Jukes-Cantor model, in which several publicly accessible DNA barcode sequences of the genus *Aristosyrphus* from BOLD were included together with the newly obtained. The DNA barcode of *Mixogaster mexicana* Macquart, 1846 (BOLD Sample ID: BIOUG58205-F02) was constrained as the root for the NJ tree. All COI sequences can be accessed in BOLD under the Dataset DS-ARISTOSY (https://doi.org/10.5883/ds-aristosy). Bootstrap support (BS) values were estimated from 1,000 replicates as spawned in Geneious v. 7.1.3. FigTree v. 1.3.1 (Rambaut 2018) and Adobe® Illustrator CS 5.1 were used to draw the NJ tree (Fig. 3).

## Results

***Aristosyrphus carpenteri* (Hull, 1945)**

*Ceratophya carpenteri* Hull 1945: 76. Type locality: Panama, Coclé Province, El Valle (holotype ♀ at the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA).

Figures 1–3

**New records.** ECUADOR – **Pichincha** • Parroquia Pedro Vicente Maldonado, near San Pancracio, roadway to Pachijal, path to the river near forest; 00.1155°N, 078.9584 °W; 737 m alt.; 26.XII.2019–02.I.2020; I. Kilian leg.; double malaise trap; 3 ♂ ZFMK-DIP-00067491

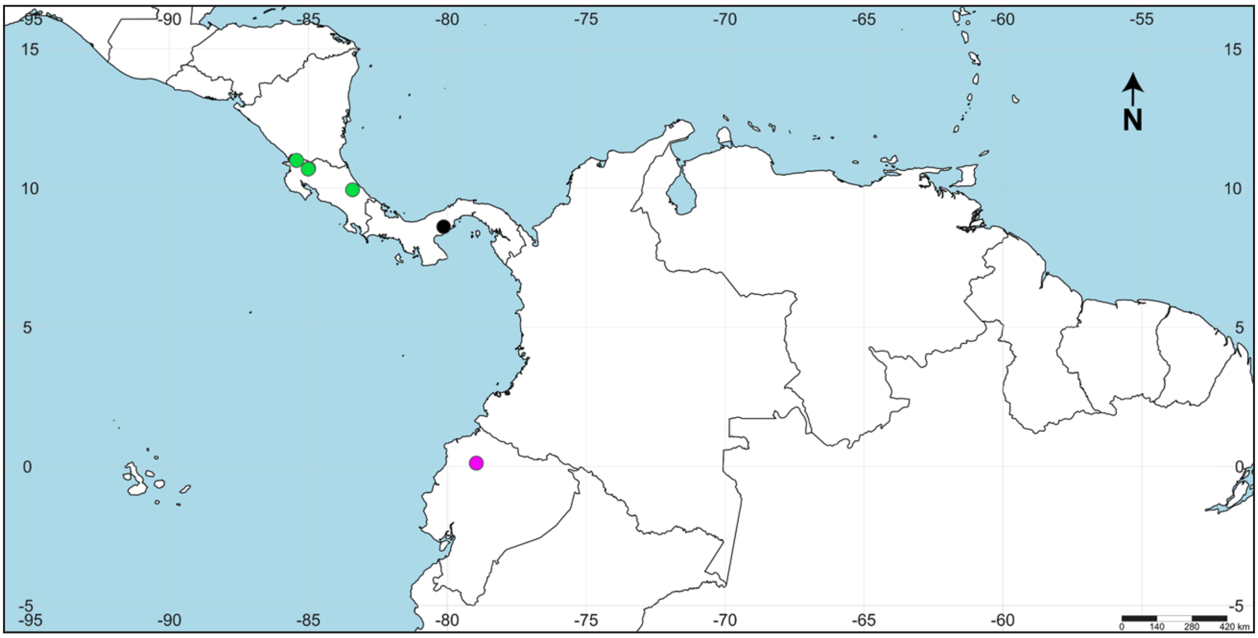


**Figure 1.** Records of *Aristosyrphus carpenteri*. The black circle is the type locality; green circles indicated localities for specimens in GBIF and BOLD; the pink circle is our new record from Ecuador.

[ZFMK; GenBank ON943477], ZFMK-DIP-00091519 [ZFMK], ZFMK-DIP-00091520 [ZFMK]; 1 ♀ ZFMK-DIP-00067499 [ZFMK; GenBank ON943475] – **Pichincha** • Parroquia Pedro Vicente Maldonado, near San Pancracio, roadway to Pachijal, area behind platform; 00.1186°N, 078.9580°W; 770 m alt.; 25–28.I.2020; I. Kilian leg.; double malaise trap; 7♂ ZFMK-DIP-00067462 [ZFMK; GenBank ON943474], ZFMK-DIP-00067466 [ZFMK; GenBank: ON943473], ZFMK-DIP-00067476 [ZFMK; GenBank ON943476], ZFMK-DIP-00091515 [ZFMK], ZFMK-DIP-00091516 [ZFMK], ZFMK-DIP-00091517 [INABIO], ZFMK-DIP-00091518 [INABIO].

**Identification.** Images of the female holotype were studied (available at https://mczbase.mcz.harvard.edu/guid/MCZ:Ent:26031) and male genitalia were compared with those of Costa Rican specimens (https://doi.org/10.15468/dl.c429d9). No morphological differences were noticed between Central American specimens and the Ecuadorian individuals (Fig. 1).

Species with a convex face, without a facial tubercle, head wider than thorax, and with long antennae, longer than the distance between antennal fossa and anterior oral margin, with postpedicel longer than scape (Fig. 2). As a member of *Aristosyrphus*, it has the postpronotum pilose, the anepimeron entirely pilose, the mesonotum with an incomplete transverse suture, wing vein $R_{4+5}$ without a posterior appendix, and abdomen parallel-sided. Moreover, the ejaculatory hood of the male terminalia is apicodorsally developed into a prong-like structure, separate from the actual phallus (Fig. 2C).

*Aristosyrphus carpenteri* is most similar to *A. primus* (Reemer and Ståhls 2013a: figs. 27–29); both have wings vividly yellow on the anterobasal half, including veins, contrasting with the infuscated, dark apical half (Fig. 2A, B). *Aristosyrphus carpenteri* differs by having legs entirely orange (legs entirely black in *A. primus*), a bare katepisternum (katepisternum dorsally pilose in *A. primus*), mesonotum golden pilose (mesonotum mostly black pilose in *A. primus*), and the first three abdominal segments entirely orange (second tergite with a medial dark marking and third tergite with anterior half or more black in *A. primus*). In addition, male genitalia for both species are distinct: surstylus with a dorsal truncated projection, curved dorsal margin, and rounded ventral tip (surstylus with dorsal and ventral triangular tips and almost straight dorsal margin in *A. primus*), and ejaculatory hood strongly curved dorsoapically (ejaculatory hood almost straight apically in *A. primus*).

We successfully sequenced five specimens of *A. carpenteri* collected in Ecuador (GenBank accession numbers ON943473, ON943474, ON943475, ON943476, and ON943477). These five COI sequences were very similar to one another (*p*-distance = 0.0–0.46%) and also quite similar to other barcode sequences from specimens collected in Costa Rica (0.98–2.13%) (Appendix Table A2). This intraspecific variability in the COI sequence is also seen among the members of an undescribed species from Costa Rica, *Aristosyrphus* sp. 1 (*p*-distance = 0.0–3.26%) (Appendix Table A2). In our NJ tree (Fig. 3), all specimens identified as *A. carpenteri* clustered together. The Barcode Index Number (BIN) (Ratnasingham and Hebert 2013) for all the *A. carpenteri* specimens is BOLD:ABY2236 (https://doi.org/10.5883/BOLD:aby2236).

## Discussion

Nothing is known about the biology of *Aristosyrphus* (Reemer 2013), and no molecular data are available to infer its phylogenetic relationships, besides a handful of

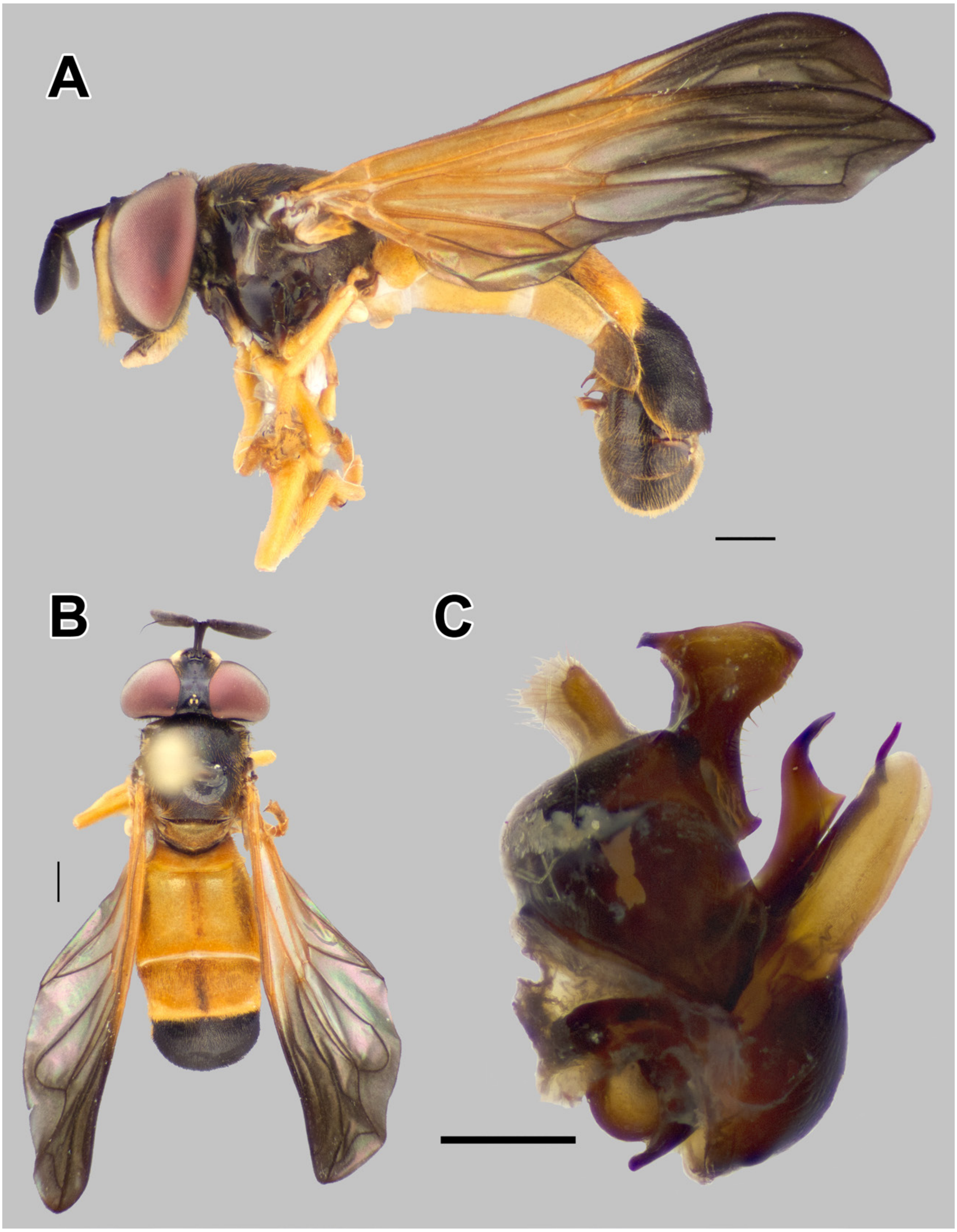


**Figure 2.** *Aristosyrphus carpenteri*, male, ZFMK-DIP-00091520. **A.** Habitus, lateral view. **B.** Habitus, dorsal view. **C.** Male genitalia, lateral view. Scale bars: A, B = 1 mm; C = 0.5 mm.

COI barcodes (Reemer and Ståhls 2013b; public data in BOLD). Our study reports the first records of the genus *Aristosyrphus* and of *A. carpenteri* from Ecuador. Our data extends the known geographical range of the species by more than 950 km southward (Fig. 1) from the type locality at El Valle [de Antón], Coclé Province, Panama (08.6098°N, 080.1317°W). Furthermore, the new records are the first specimens of *A. carpenteri* reported from South America, as the species has been only known from Central America until now.

In Costa Rica, specimens of *A. carpenteri* were collected in the provinces of Alajuela, Cartago and

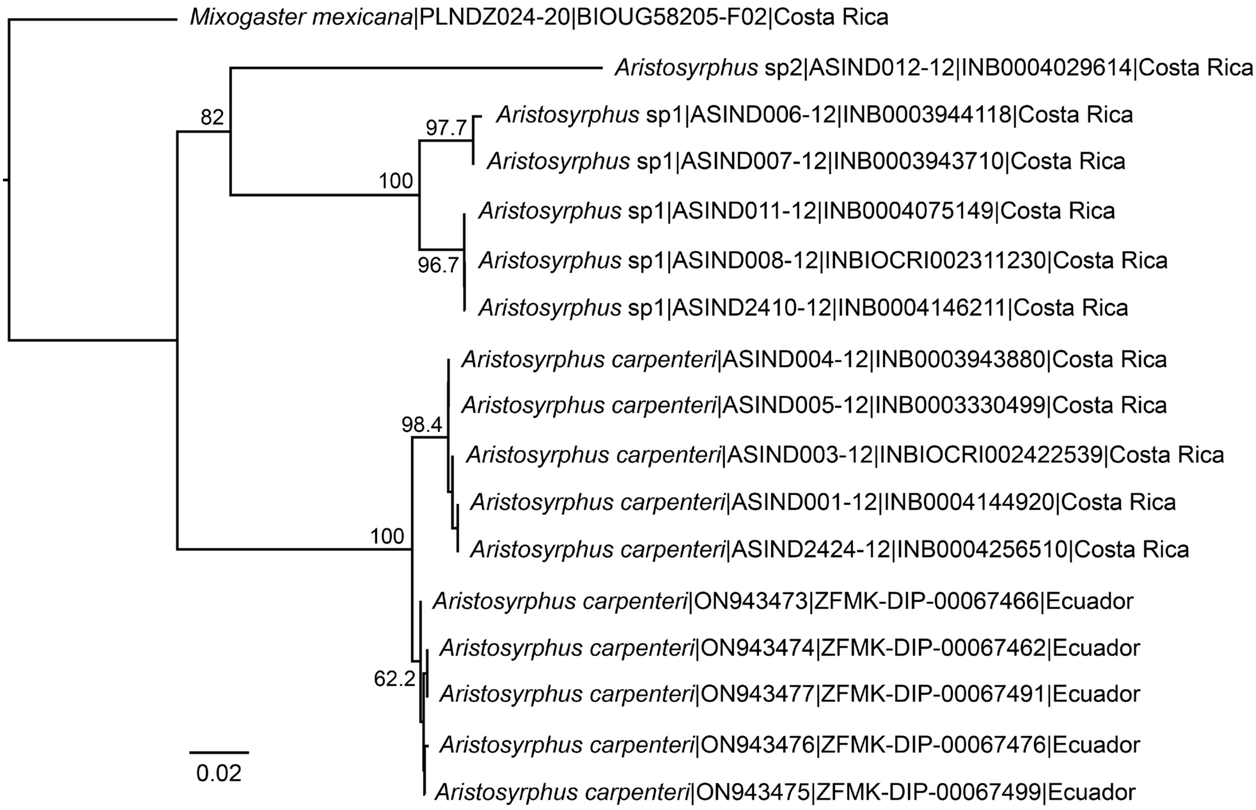


**Figure 3.** Neighbour-joining tree using Jukes-Cantor model based on public COI sequences of *Aristosyrphus*, with *Mixogaster mexicana* constrained as the outgroup. The name for each specimen has: the name of the species | Process ID or GenBank accession number | sample ID | country of origin. Bootstrap support values are given at the nodes.

Guanacaste, and in Panama the female holotype of *A. carpenteri* was collected in Coclé Province. All these localities belong to the Guatuso-Talamanca biogeographic province (Morrone 2001, 2014) and are located in two distinct ecoregions (Olson et al. 2001): Talamancan montane forests in Costa Rica and Isthmian-Pacific moist forest in Panama. Our new records come from the Cauca biogeographic province (Morrone 2014) and are within the Northwestern Andean montane forest ecoregion. Both biogeographic provinces are threatened by human activities, mostly changes in land use (conversion to agricultural land and pasture) and natural and anthropogenic fires (Dinerstein et al. 1995; Brown and Kappelle 2001; Morrone 2001); however, the Talamancan montane forests still cover 75% of their original area (WWF 2001).

DNA barcoding supports that the specimens from Central America and Ecuador belong to the same species. We believe that the biogeographic range of *Aristosyrphus* species may be larger than what the current records suggest, as reported here by us. Published records of the species from Costa Rica and Panama are from May to July, and our Ecuadorian specimens were collected in December and January. These Ecuadorian specimens may indicate a longer phenology of *A. carpenteri* (possibly year round), that the flight periods differ between Central America and Ecuador, or that the species is not univoltine.

Of the more than 6,200 flower fly species (Skevington et al. 2019), almost a third are described from the Neotropical Region (Thompson et al. 2010), and this number may represent only half of the actual number of species (Reemer 2016). More faunistic studies are needed to understand the current distribution of flower flies in Central and South America, especially for the Microdontinae since they are highly diverse in the Neotropics (Reemer and Ståhls 2013a; Reemer 2014).

## Acknowledgements

The present results are part of the Marco contract MAAE-DBI-CM-2021-0167 issued by the Ecuadorian Ministerio del Ambiente y Agua. We thank Menno Reemer for continuous support on the taxonomy of Microdontinae. We also thank the Alexander-Koenig-Stiftung (ZFMK) for providing funds to XM. We thank the reviewers Gil F.G. Miranda, Menno Reemer, and Augusto L. Montoya for their helpful comments on the manuscript and the copy editor Robert Forsyth for his valuable suggestions.

## Authors' Contributions

Conceptualization: XM. Data curation: XM, ICK, APP. Formal analysis: XM. Funding acquisition: XM. Investigation: ICK. Methodology: XM, ICK. Project administration: XM, APP. Resources: ICK, APP. Validation: XM. Visualization: XM. Writing – original draft: XM. Writing – review and editing: XM, ICK, APP.

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# Appendix

**Table A1.** Geographic coordinates for the publicly accessible records of *Aristosyrphus carpenteri* and our new records, including their source, mapped in Figure 1.

| Country | Latitude | Longitude | Sampled ID | Source |
|---|---|---|---|---|
| Costa Rica | 09.9369 | −083.4143 | INB0003943880 | BOLD; several more specimens from GBIF with the same locality data |
| Costa Rica | 09.9380 | −083.4146 | INB0003330499 | BOLD |
| Costa Rica | 10.683 | −085.009 | INB0004256510 | BOLD |
| Costa Rica | 10.705 | −084.992 | INB0004144920 | BOLD |
| Costa Rica | 10.706 | −084.993 | urn:catalog:INB:Atta:3330499 | GBIF; one more specimen from GBIF with the same locality data |
| Costa Rica | 10.9904 | −085.4272 | INBIOCRI002422539 | BOLD |
| Costa Rica | 10.9926 | −085.4295 | urn:catalog:INB:Atta:778710 | Several more specimens from GBIF with the same locality data |
| Ecuador | 00.1155 | −078.9584 | See New records | This study |
| Ecuador | 00.1186 | −078.9580 | See New records | This study |
| Panama | 08.6098 | −080.1317 | MCZ:Ent:26031 | Holotype |

**Table A2.** Uncorrected pairwise distances (% similarity) of the COI sequences between *Aristosyrphus* specimens. The name for each specimen has: the name of the species | Process ID or GenBank accession number.

<table>
<tr><th>Specimens</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td>Mixogaster mexicana | PLNDZ024-20</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus sp1 | ASIND008-12</td><td>81.579</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus sp1 | ASIND011-12</td><td>81.579</td><td>100.00</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus sp1 | ASIND006-12</td><td>80.592</td><td>96.743</td><td>96.743</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus sp1 | ASIND007-12</td><td>81.498</td><td>96.743</td><td>96.743</td><td>100.00</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus sp1 | ASIND2410-12</td><td>81.804</td><td>100.00</td><td>100.00</td><td>96.743</td><td>97.112</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus sp2 | ASIND012-12</td><td>78.746</td><td>81.433</td><td>81.433</td><td>82.736</td><td>82.827</td><td>81.763</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ASIND001-12</td><td>82.263</td><td>83.713</td><td>83.713</td><td>83.062</td><td>83.283</td><td>83.435</td><td>79.939</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ASIND003-12</td><td>80.921</td><td>83.713</td><td>83.713</td><td>83.062</td><td>83.062</td><td>83.713</td><td>79.479</td><td>100.00</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ASIND004-12</td><td>82.569</td><td>83.713</td><td>83.713</td><td>83.062</td><td>83.587</td><td>83.435</td><td>80.243</td><td>99.696</td><td>100.00</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ASIND005-12</td><td>82.569</td><td>83.713</td><td>83.713</td><td>83.062</td><td>83.587</td><td>83.435</td><td>80.243</td><td>99.696</td><td>100.00</td><td>100.00</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ASIND2424-12</td><td>82.263</td><td>83.713</td><td>83.713</td><td>83.062</td><td>83.283</td><td>83.435</td><td>79.939</td><td>100.00</td><td>100.00</td><td>99.696</td><td>99.696</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ON943473</td><td>82.569</td><td>83.713</td><td>83.713</td><td>83.062</td><td>84.043</td><td>83.891</td><td>80.471</td><td>98.176</td><td>99.023</td><td>98.48</td><td>98.48</td><td>98.176</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ON943474</td><td>83.028</td><td>84.365</td><td>84.365</td><td>83.713</td><td>84.347</td><td>84.195</td><td>80.547</td><td>97.872</td><td>98.371</td><td>98.176</td><td>98.176</td><td>97.872</td><td>99.544</td><td></td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ON943477</td><td>83.028</td><td>84.365</td><td>84.365</td><td>83.713</td><td>84.347</td><td>84.195</td><td>80.547</td><td>97.872</td><td>98.371</td><td>98.176</td><td>98.176</td><td>97.872</td><td>99.544</td><td>100.00</td><td></td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ON943476</td><td>82.722</td><td>83.713</td><td>83.713</td><td>83.062</td><td>84.043</td><td>83.891</td><td>80.243</td><td>97.872</td><td>98.371</td><td>98.176</td><td>98.176</td><td>97.872</td><td>99.696</td><td>99.696</td><td>99.696</td><td></td></tr>
<tr><td>Aristosyrphus carpenteri | ON943475</td><td>82.875</td><td>84.039</td><td>84.039</td><td>83.388</td><td>84.195</td><td>84.043</td><td>80.395</td><td>98.024</td><td>98.697</td><td>98.328</td><td>98.328</td><td>98.024</td><td>99.696</td><td>99.848</td><td>99.848</td><td>99.848</td></tr>
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