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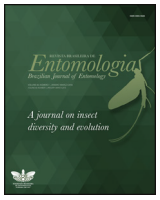

Dixella woodi Chaverri & Borkent, 2007 (Diptera, Dixidae): Description of the female and a new record from Peru

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ABSTRACT

This study provides a description of the female and a redescription of the male terminalia of *Dixella woodi* Chaverri & Borkent, 2007, which is recorded in Peru for the first time. Diagnoses for the other two Peruvian Dixidae species, *Dixella andeana* (Lane, 1942) and *Dixella peruviana* (Edwards, 1931), and remarks on their types are presented along with a key to distinguish the three species. *Dixella woodi* differs significantly from other Neotropical *Dixella* Dyar & Shannon, 1924 species, such as the presence of elongated setae on the medial portion of the katepisternum and unique characteristics in both male and female terminalia. The findings underscore the importance of systematic collection sampling and taxonomic revision in the Neotropical region to advance our understanding of Dixidae diversity and distribution.

Introduction

Dixidae is a low-diversity family of Diptera, with approximately 200 extant species in eight genera (Wagner et al., 2008; Greenwalt & Moulton, 2016). *Dixella* Dyar & Shannon, 1924 is the second most diverse genus of the family and is widely distributed worldwide, although the distribution is not uniform. Adults of meniscus midges can be found around oviposition sites where the immatures will develop, such as streams, lakes, swamps, and phytotelmata (Corrêa & Gil-Azevedo, 2018). Active search for immatures (with trays, sieves, and pipettes) and adults (with hand-net and aspirator), as well as interception and attraction traps, such as malaise, CDC, and white light, are effective for capturing the adults (Corrêa & Gil-Azevedo, 2018). The immatures can be collected and reared to obtain the adults.

Three genera are recorded in the Neotropical region: *Dixella* (31 species), *Mesodixa* Belkin, Heinemann & Page, 1970 (1 species), and *Nothodixa* Edwards, 1930 (4 species). *Mesodixa* was recorded from Jamaica and Hispaniola (Belkin et al., 1970; Belkin & Heinemann, 1972) and *Nothodixa* from Chile and Argentina (Lane, 1953). In contrast, the 31 species of *Dixella* are widely found in the Neotropical region, from Mexico to Argentina (Stone, 1966; Belkin et al., 1970; Peters, 1980; Chaverri & Borkent, 2007; Huerta & Ibáñez-Bernal, 2021, 2023; Corrêa et al., 2024).

Only two species are recorded from Peru: *Dixella andeana* (Lane, 1942) in Iquitos, and *Dixella peruviana* (Edwards, 1931) in Lima (Edwards, 1931; Lane, 1942). In this study, we present a new record from Cusco of *Dixella woodi* Chaverri & Borkent, 2007, based on two specimens, male and female, collected from the same locality. The somatic features of both are very similar allowing us the association between them, as usual in Dixidae. We describe the female, and provide comments on the male terminalia, based on our material. We also present photos and information about the type material of the other two species, *D. andeana* and *D. peruviana*, described from Peru.

Material and methods

Dixella woodi was collected by Aida Vanessa Gómez Falcón (MNRJ) and Karen Roa Castro (MUSM) via hand net in Machu Picchu, Urubamba, Cusco, Peru, on May 22, 2021 (Figs. 1G–H, 6A–C). The specimens were initially fixed in 96% ethanol and later mounted on microscope slides using Euparal (Upton & Mantle, 2010) and deposited in the Entomological Collection of Museu Nacional, Universidade Federal do Rio de Janeiro

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(MNRJ). Terminology follows Chaverri & Borkent (2007) and Cumming & Wood (2017). Photos of *D. woodi* were captured using a Leica M205C stereoscopic microscope equipped with a FusionOptics digital camera, and drawings were made using a camera lucida. Images and illustrations of *D. woodi* were edited and vectorized using Adobe Illustrator CC. Maps were created using SimpleMappr (Shorthouse, 2010).

Results

Dixella woodi Chaverri & Borkent, 2007 (Figs. 1–3)

Diagnosis. Adult. Only species of *Dixella* in Neotropical Region with katepisternum having patch of elongated setae on medial portion. Female: Sternite IX with medial portion tapered and slender (V-shaped) with undulating sides, lateral portion anteriorly wider, featuring ventral and laterally tapered projections. Segment X very elongated, extending beyond the apical portion of the cercus. Male: Gonocoxite with apical lobe with expanded apical portion with three subbasal setae (two in posterior portion and one in anterior portion) and one elongate basal seta.

Description of Female. (Figs. 1–2). Body length: 4 mm (n= 1). *Head* (Figs. 1B–C) dark brown with setae around the eyes in the posterior portion. Scape collar-like. Pedicel globose, 0.45x length of flagellomere I. Flagellum light brown with 14 flagellomeres. Flagellomere I slightly cylindrical, 1.5x length of flagellomere II. Flagellomere XIV with pair of divergent apical setae. Clypeus brown, subquadrate, with ca. 15 setae in the medial portion. Maxillary palp I–III ratio (1, 1.5, 3.5), missing the IV–V. *Thorax* (Fig. 1F). Scutum light brown with three brown stripes: one medial extending from anterior to middle portion as longitudinal slender strip; two brown longitudinal lateral stripes extending from prescutal to prescutellar area (dorsal view). Acrostichal and dorsocentral setae complete; antealar area with ca. 15 scattered setae. Antepronotum setose subtly darker than postpronotum. Postpronotum brown with five setae. Anterior and posterior anepisternum brown. Katepisternum with dorsal portion brown and ventral portion light brown, medial portion with ca. 10 setae, and postero-medial portion lighter than anterior portion. Anepimeron light brown with dorsal portion brown and antero-ventral margin lighter than medial portion. Metanepisternum and meron brown. Scutellum brown and setose without a delimitated row of setae. Mediotergite brown. *Legs* (Fig. 1A) uniformly brown with lengths of (n= 1): fore leg [femur (1.8 mm), tibia (1.8 mm), tarsus (2.8 mm)], mid leg [femur (2.2 mm), tibia (2.1 mm), tarsus (3 mm)], and hind leg [femur (1.9 mm), tibia (2.3 mm), tarsus (3.3 mm)]. Fore and hind coxae slightly lighter than mid coxa; Coxae with setae anterolaterally. Tibiae with apical spur, hind tibia spur curved and twice as long as fore and mid tibiae spurs. Hind tibia strongly swollen apically with distinct patch of setae. Claws non-pectinate with basal combs. Basal comb of claws with two ventral tines. *Wing* (Fig. 1E) (n= 1; length: 3.9

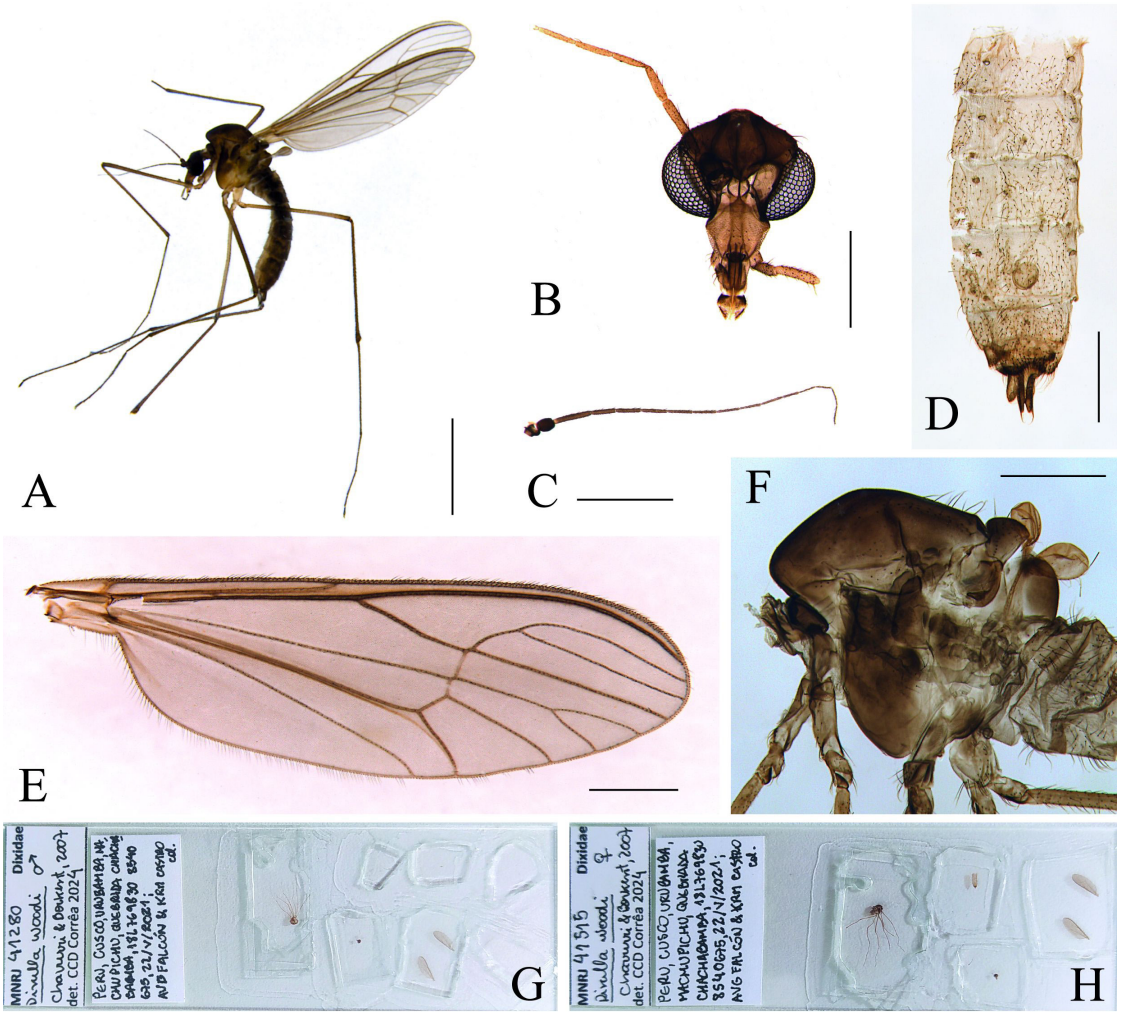

Figure 1 *Dixella woodi* Chaverri & Borkent, 2007, female. A. Habitus (lateral view); B. Head; C. Antenna; D. Abdomen (ventral view); E. Wing; F. Thorax (lateral view); G. Slide and labels of male; H. Slide and labels of female. Scale bar: A = 1.8 mm; B = 0.4 mm; C, E = 0.6 mm; D, F = 0.5 mm.

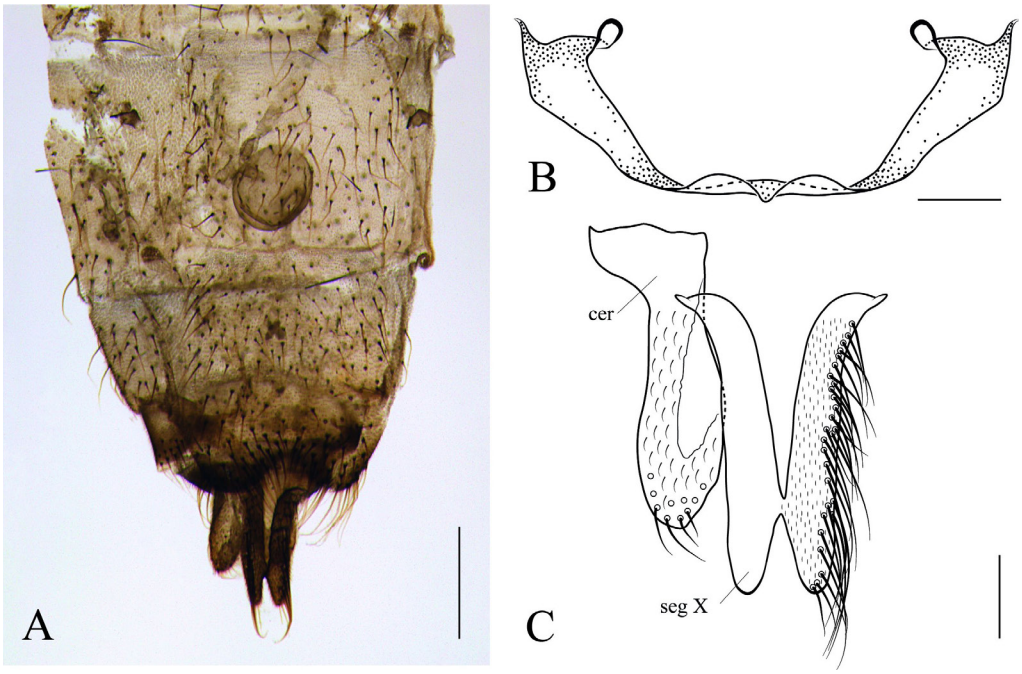

Figure 2 *Dixella woodi* Chaverri & Borkent, 2007, female. A. Terminalia (ventral view); B. Sternite IX; C. Cercus and Segment X (lateral view). Scale bar: A = 0.2 mm; B–C = 0.06 mm. Abbreviations: cer = cercus; seg X = segment X.

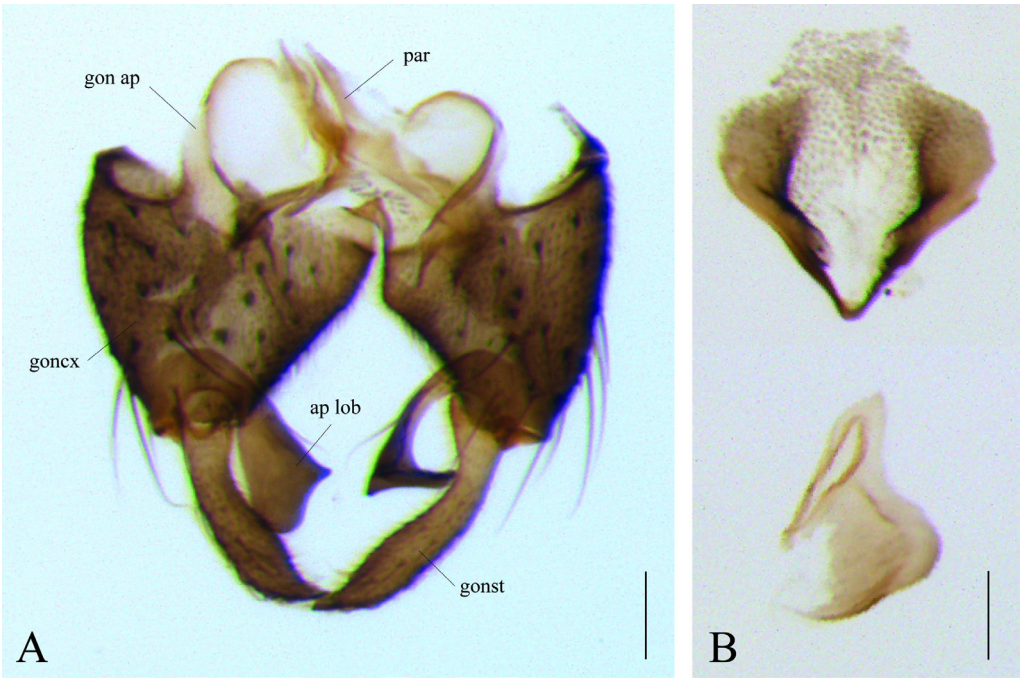

Figure 3 *Dixella woodi* Chaverri & Borkent, 2007, male. A. Terminalia (ventral view); B. Tergite X (lateral view). Scale bar: A = 0.04 mm; B = 0.05 mm. Abbreviations: ap lob = apical gonocoxal lobe; gon ap = gonocoxal apodeme; goncx = gonocoxite; gonst = gonostylus; par = paramere.

mm; width: 1.3 mm) with membrane hyaline. Wing veins brown and setose. Vein Sc ends basally to Rs origin. Vein R_{2+3} curved, branched and with the origin subtly apical to crossvein r-m origin. Vein M_{1+2} bifurcated; M bifurcation ends apical to R_{2+3} branch origin. Crossvein m-m weak and near to the crossvein r-m terminus. False vein distinct and parallel to CuA, reaching ca. the basal 2/3 of CuA. Vein CuP ends apical to Rs origin. Length ratios $R_{2+3}/R_3 = 0.35$, $M_{1+2}/M_2 = 1$. Halter brown with light brown base. *Abdomen* (Fig. 1D): uniformly light brown. *Terminalia* (Figs. 2A–C): Spermatheca rounded and brown. Sternite VIII light brown, elongate (1.6x longer than wider), posterior portion dark brown with elongate setae, and concave. Tergite IX brown with posterior margin setose. Sternite IX light brown, single piece, medial portion tapered and slender (V-shaped) with undulating sides, lateral portion with anterior portion wider. Segment X dark brown, single piece, very elongate (extending beyond apical portion of cercus), lateral margin with many elongate setae, and medial cleft projecting to subapical portion (junction point between the parts). Cercus dark brown, elongate, apical portion rounded with elongate setae.

Male redescription. (Figs. 3A–B). *Terminalia*: Tergite X with distinct lateral projection extending from basal portion of central plate (dorsal view) to sides. Parameres L-shaped (lateral view) and projecting laterally. Aedeagus like a stripe reaching approximately medial portion of base of gonocoxite (dorsal view) and with median projection extending anteriorly, featuring small invagination; lateral portion with slight expansion at base. Gonocoxal apodeme tapered, projecting anteriorly, and curving towards medial portion. This redescription of the male terminalia is meant to be complementary to the original description (Chaverri & Borkent, 2007). For somatic structures, refer to the original description.

Material. 1♂ (MNRJ#41280) and 1♀ (MNRJ#41515) in slides. Peru, Cusco, Urubamba, Machu Picchu, Quebrada Chachabamba, S13°11'18.8" W72°30'38", 2240 m, 22/V/2021, hand net, AVG Falcón & KRM Castro col. (Figs. 1G–H).

Distribution. COSTA RICA, San José, Escazú, San Antonio (type-locality); Tarrazú, San Carlos. PERU, Cusco, Urubamba (new record) (Fig. 7).

Remarks. *Dixella woodi* was described based on two adult male specimens. This species differs significantly from other species recorded from Costa Rica due to characteristics of the katepisternum and male terminalia (Chaverri & Borkent, 2007). The presence of setae on the katepisternum is a unique feature among neotropical species of *Dixella*. The shape and arrangement of setae of the gonocoxite of *D. woodi* distinguishes it from other *Dixella* species (Chaverri & Borkent, 2007), which typically have an apical lobe with an expanded apex, as seen in *D. maculata* Chaverri & Borkent, 2007, *D. hernandezi* Chaverri & Borkent, 2007, and *D. suzukii* Chaverri & Borkent, 2007. *Dixella maculata* has a wing with a brown spot over the crossvein r-m and an apical lobe with two apical setae. *Dixella hernandezi* has numerous small spicules and a bilobed apex of the apical lobe. *Dixella suzukii* has two elongated setae at the base of the apical lobe, and the base of the gonostylus is widened, tapering towards the apex.

The female of *D. woodi* is very distinct from the other females of *Dixella* species recorded for the Neotropical region. Few species of Dixidae have females known and/or described in detail, especially in the Neotropical region. Only 11 species have females described in detail that assists for comparison, namely: *Dixella atitla* Huerta & Ibáñez-Bernal, 2021, *Dixella lobata* Chaverri & Borkent, 2007, *Dixella machiotla* Huerta & Ibáñez-Bernal, 2023, *D. maculata*, *Dixella moultoni* Corrêa, Scarpa, Pinho & Gil-Azevedo, 2024, *Dixella scitula* Belkin, Heinemann & Page, 1970, *Dixella shannoni* (Lane, 1942), *Dixella spinosa* Corrêa, Scarpa, Pinho & Gil-Azevedo, 2024, *D. suzukii*, *Dixella venezuelensis* (Lane, 1942), and *Mesodixa biambulacra* Belkin, Heinemann & Page, 1970 (Lane, 1942, 1953; Belkin et al., 1970; Chaverri & Borkent, 2007; Huerta & Ibáñez-Bernal, 2021, 2023; Corrêa et al., 2024). The female of *D. woodi* can be distinguished from the other species (mentioned above) by the length of segment X, which extends beyond the apical portion of the cercus, while the other species has the length of segment X equal or shorter than the length of the cercus.

Chaverri & Borkent (2007) warned about one female specimen collected in Colombia (Cundinamarca, Finca Bella Vista) that could be a female of *D. woodi*, but due to that distance from the type locality (Costa Rica), they preferred not to designate it as the female of *D. woodi*. We believe that this material could be a female of *D. woodi*, but we did not observe it in this study.

Chaverri & Borkent (2007) described the male of *D. woodi* and made the following comment: "*Parameres, aedeagus not identified with certainty*". Some structures of the male terminalia can be challenging to visualize when fixed on slides. We described and redescribed some of these structures that were not clearly visualized, and emphasized others that were observed in the analyzed specimen, such as paramere, aedeagus, tergite X, and gonocoxal apodeme. The remaining structures in the description of *D. woodi* by Chaverri & Borkent (2007) are as described in the original description.

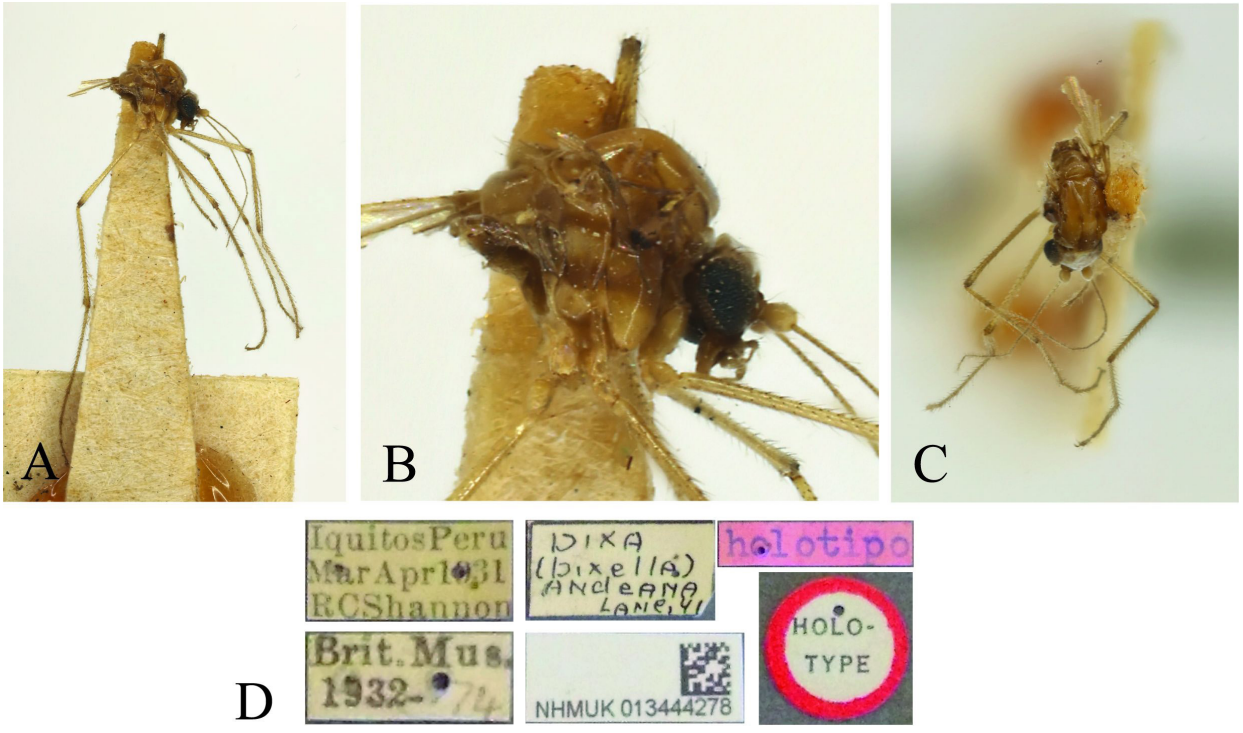

Figure 4 *Dixella andeana* (Lane, 1942), male (HOLOTYPE). A. Habitus (lateral view); B. Thorax (lateral view); C. Thorax (dorsal view); D. Labels (NHM photos).

Key to adult Dixidae from Peru

1. Katepisternum with elongate setae ..... *Dixella woodi*
- Katepisternum without setae 2
2. Wing vein R_{2+3} bifurcation origin basal relative to M_{1+2} bifurcation origin; Legs brownish ..... *Dixella peruviana*
- Wing vein R_{2+3} bifurcation origin apical relative to M_{1+2} bifurcation origin; Legs yellowish ..... *Dixella andeana*

Below, we give some remarks on the other two species of Dixidae which have been found in Peru.

***Dixella andeana* (Lane, 1942)** (Figs. 4A–D)

Diagnosis. Adults has wing vein R_{2+3} bifurcation origin apical relative to M_{1+2} bifurcation origin; vein R_{2+3} origin very apical to crossvein r-m origin; thorax (lateral view) with two parallel brown stripes.

Type Material. ♂ HOLOTYPE (pinned, NHM#013444278): PERU, *Loreto*, Iquitos

Distribution. This species is recorded only from type locality: PERU, *Loreto*, Iquitos (Fig. 7).

Remarks. *Dixella andeana* has the thorax with two parallel brown stripes, like *D. peruviana* and *D. shannoni*. They can be differentiated through wing venation: *D. shannoni* has the vein R_{2+3} bifurcation origin relatively near to the M_{1+2} bifurcation origin, while *D. peruviana* has the vein R_{2+3} bifurcation origin basal relative to the M_{1+2} bifurcation origin. Male terminalia also serve to distinguish these three species: *D. peruviana* has a thin and elongated gonostylus, while *D. andeana* has a short, wide, gonostylus strongly hirsute along outer margin; *D. shannoni* has apical lobe with two subbasal setae, while that of *D. andeana* has four apical setae (Lane, 1942, 1953; Chaverri & Borkent, 2007; Huerta & Ibáñez-Bernal, 2021).

Despite Lane (1942) naming this species with the epithet '*andeana*', the type locality is in the Amazon Rainforest (Fig. 7), an area characterized by low altitude and dense forest vegetation contrasting significantly with the high-altitude and different flora of the Andean Mountain Range.

***Dixella peruviana* (Edwards, 1931)** (Figs. 5A–D)

Diagnosis. Adults have wing vein R_{2+3} bifurcation origin relatively basal to M_{1+2} bifurcation origin; vein R_{2+3} origin apical to crossvein r-m origin; thorax (lateral view) with two parallel brown stripes.

Type Material. ♂ HOLOTYPE: (pinned, with abdomen on slide, NHM#010864741): *Lima*, Lima, Verrugas.

Distribution. This species is recorded only from type locality: PERU, *Lima*, Lima, Verrugas (Fig. 7).

Remarks. *Dixella peruviana* has thorax with two parallel brown stripes, like *D. andeana* and *D. shannoni*. They can be differentiated through wing venation and male terminalia (see *D. andeana* remarks).

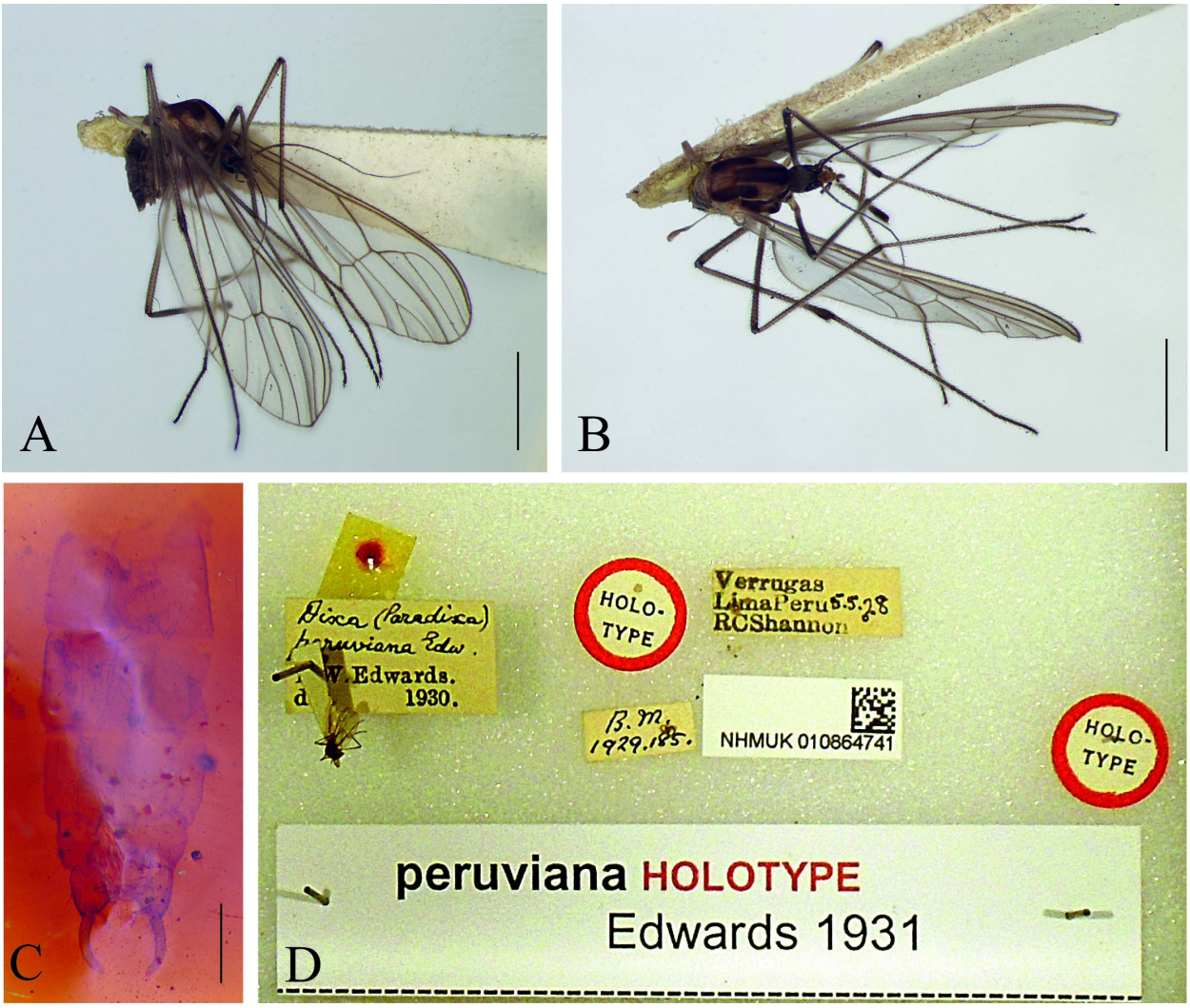

Figure 5 *Dixella peruviana* (Edwards, 1931), male (HOLOTYPE). A. Habitus (lateral view); B. Habitus (dorsal view); C. Abdomen (ventral view); D. Labels. Scale bar: A–B = 1 mm; C = 0.2 mm (NHM photos).

Figure 6 A–C. Collection site in PERU, Cusco, Urubamba, Machu Picchu, Quebrada Chachabamba.

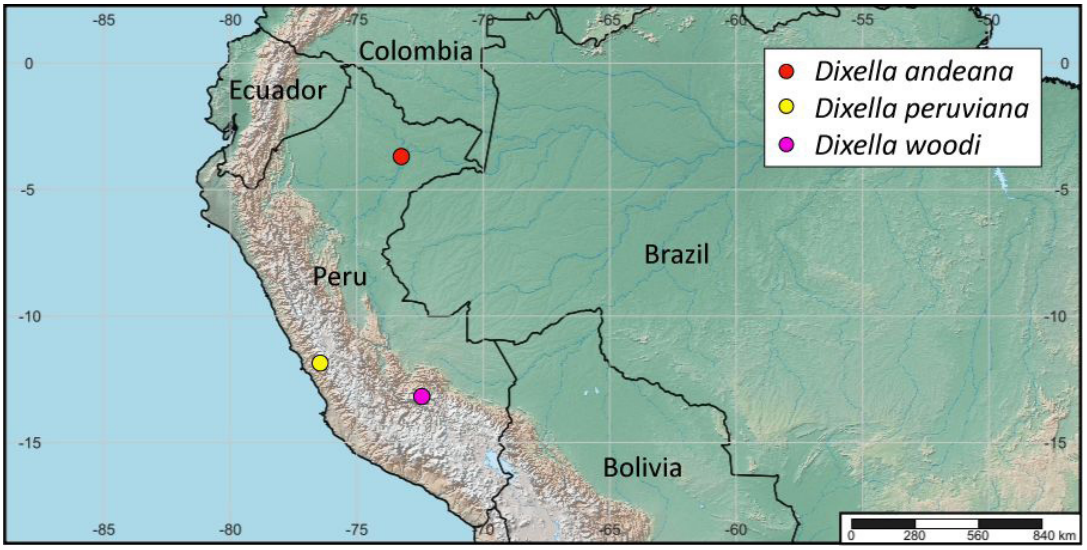

Figure 7 Distribution map of Dixidae species recorded from Peru.

Discussion

The female terminalia can be very useful for characterizing and differentiating Dixidae females. The sternite IX of *Dixella* species is very informative when comparing between species. For example, it can be found as a single piece, subdivided, and/or possess projections of varying form. The cercus and segment X can also be informative, especially the relative sizes between them and the arrangement of elongated setae (when present).

Dixella trinitensis (Lane, 1943), *D. venezuelensis*, and *D. woodi* are species with a wide distribution range in Central America and South America. In fact, we know very little about the distribution of the family in the Neotropical Region and this wide distribution range probably will be observed in other species as our knowledge advances, especially in the Amazon rainforest. The three species now recorded in Peru were found through nonsystematic sampling restricted to the type localities (*D. andenana* and *D. peruviana*) or single records (*D. woodi*). The surrounding countries also show specific records of Dixidae species, Venezuela with *D. venezuelensis*, or no records, as Bolivia, Colombia, and Ecuador. Brazil has nine recorded species, but none in the Amazon Region.

The lack of systematic collection sampling and taxonomic revision of Dixidae species, especially in the Neotropical Region, hinders the resolution of the actual diversity and distribution of the family.

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Conflicts of interest

The authors declare no conflicts of interest.

Author contribution statement

All authors contributed to this scientific research. CCDC – Original draft, writing and editing. LHGA – Writing and review.

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