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Latitudinal gradient of biting midges in the genus *Culicoides* (Diptera: Ceratopogonidae) in Argentina and Bolivia

Cecilia A. Veggiani Aybar[1,2,3,], María J. Dantur Juri[1,2,3], Guillermo L. Claps[1], Mercedes S. Lizarralde de Grosso[1,2,3], and Gustavo R. Spinelli[2,4]*

Abstract

We provide the first records of 8 species of biting midges in the genus *Culicoides* (Diptera: Ceratopogonidae) in a wide latitudinal gradient of the Yungas Ecoregion in Argentina and the Chaco Ecoregion in Bolivia, including a map of their distribution, and an updated checklist of species in the study area. Additional locality records were obtained from published articles and from specimens collected in these and other ecoregions in both countries. Included are the first Argentinean records of *Culicoides crescentis* Wirth & Blanton and *C. pampaensis* Spinelli & Wirth from Salta Province; *C. caridei* Brèthes, *C. crescentis*, *C. guttatus* Coquillett, *C. insignis* Lutz, *C. pampaensis*, and *C. venezuelensis* Ortiz & Mirsa from Jujuy Province, and *C. saltaensis* Spinelli & Wirth and *C. pampaensis* from Tucumán Province. In addition, the first records of *C. brasilianum* Forattini, *C. crescentis*, and *C. guttatus* are provided from Bolivia.

Key Words: biting midge; new record; distribution; Yungas; Chaco

Resumen

Se presenta los primeros registros de 8 especies del género *Culicoides* (Diptera: Ceratopogonidae) en un amplio gradiente latitudinal tanto de la ecoregión de las Yungas en Argentina como de la ecoregión del Chaco en Bolivia, incluyendo un mapa y una lista actualizada de las especies en el área de estudio. *Culicoides crescentis* Wirth & Blanton y *C. pampaensis* Spinelli & Wirth se registran por primera vez en la provincia de Salta; *C. caridei* Brèthes, *C. crescentis*, *C. guttatus* Coquillett, *C. insignis* Lutz, *C. pampaensis* y *C. venezuelensis* Ortiz & Mirsa son reportados para la provincia de Jujuy; y *C. saltaensis* Spinelli & Wirth y *C. pampaensis* para la provincia de Tucumán. Por último, *C. brasilianum* Forattini, *C. crescentis* y *C. guttatus* se registran por primera vez para Bolivia.

Palabras Clave: jejenes; nuevos registros; distribución; Yungas; Chaco

Biting midges of the genus *Culicoides* Latreille (Diptera: Ceratopogonidae) are the most diverse group of the family Ceratopogonidae, which includes 1,366 extant worldwide species, 266 of which occur in the Neotropics (Borkent & Spinelli 2007; Borkent 2014a). Presently, 53 species of *Culicoides* are known from Argentina (Spinelli & Wirth 1993; Spinelli et al. 2005; Veggiani Aybar et al. 2010) including 2 new species recently described by Spinelli et al. (2013) from northwestern Argentina. Conversely, the *Culicoides* fauna of Bolivia is poorly known, with only 18 species reported from this country (Spinelli et al. 2009; Veggiani Aybar et al. 2011).

The diversity and abundance of Neotropical species in this genus and their well-known pestiferous hematophagous habits include some species that are vectors of diseases in humans and other vertebrates (Mellor et al. 2000; Borkent 2004). *Culicoides* species impact public health due to their nuisance biting by adult females, which can cause cutaneous pruritis with resulting formation of wheals, flares, and permanent scarring (Sherlock & Guitton 1965; Linley et al. 1983; Felippe-Bauer & Sternheim 2008). Furthermore, *Culicoides* species are vectors of important arboviruses affecting cattle, such as bluetongue virus, equine encephalitis virus, epizootic hemorrhagic disease virus, African horse sickness virus, Akabane virus, bovine ephemeral fever virus, and Schmallenberg virus (Mellor et al. 2000; Borkent 2004; Carpenter et al. 2013). *Culicoides* species have also been implicated in the transmission of certain pathogens to humans, such as *Mansonella* nematodes, *Leishmania* flagellates and Oropouche virus, among others (Mellor et al. 2000; Ronderos et al. 2003; Borkent 2004; Seblova et al. 2012; Slama et al. 2014).

Herein, we provide the first records of 8 species of *Culicoides* from northwestern Argentina and southwestern Bolivia as well as an updated list of *Culicoides* in both of these countries.

Materials and Methods

SAMPLING SITES

We collected adult *Culicoides* during 2010–2013 at the following 10 localities in the subtropical mountainous rainforest ecoregion in

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northwestern Argentina and in the Chaco Ecoregion in southwestern Bolivia: Campo Quijano and Reserva Nacional Pizarros (Salta Province), Libertador General San Martín and Yuto (Jujuy Province), and Alpachiri, Santa Ana, and Villa Batiruana (Tucumán Province) in Argentina; and Pozo del Bermejo (Aniceto Arce Province), Itavicua and Campo Verde (Gran Chaco Province) in Bolivia.

COLLECTION AND PROCESSING OF *CULICOIDES* SPECIMENS

Specimens were collected with CDC light traps with UV- or white-lights baited with CO_2 in anthropogenic and forested environments, from early dusk until morning of the next day, (17:00 to 07:00; 4 trappings/site/month).Collected specimens were frozen, sorted to morpho-species, preserved in 70% alcohol, and those difficult to accurately identify were dissected and slide-mounted in Canada balsam. Slide-mounted specimens were examined in detail with a binocular compound microscope, and identified by comparing them with illustrations, descriptions, and keys in Wirth & Blanton (1959) and Spinelli et al. (2005), as well as wing photos of females in the Neotropical wing atlas by Wirth et al. (1988).

Identification of species was based on female wing patterns, the shapes of male and female reproductive organs, the size and shape of female sensory pits on palpal segment 3, and the distribution of sensilla coeloconica female antennal flagellomeres. Assignment of species to subgenera and species groups followed the system proposed by Borkent (2014b).Voucher specimens were deposited in the entomological collection of the Instituto–Fundación Miguel Lillo (IFML), Tucumán Province, Argentina. Additional locality records for Tables 1 and 2 were obtained from published articles and specimens in IFML and the Museo de La Plata (MLPA), Argentina.

Results

In total, 4,128 *Culicoides* specimens were collected in the 2 ecoregions and 16 species were identified. Of these, 81 specimens (74 females, 7 males) belonging to 8 species are the first records from northwestern Argentina and Bolivia. Their taxonomic status, geographical distribution, type of trap with which they were collected, and surrounding environments are detailed below.

Subfamily Ceratopogoninae Newman

Tribe Culicoidini Kieffer

Genus *Culicoides* Latreille

Subgenus *Cotocripus* Brèthes

Culicoides (*Cotocripus*) *caridei* Brèthes

Current distribution: Argentina (Buenos Aires and Río Negro Provinces), Brazil, and Uruguay.

New records: ARGENTINA: Jujuy Province, Yuto (23°38'S, 64°28'W), Ledesma Department, XI-2012, CDC traps with white-light, anthropogenic environment, Veggiani Aybar & Dantur Juri coll., 2 females, 1 male, Veggiani Aybar det.; Libertador General San Martín (23°48'S, 64°48'W), Ledesma Department, X-2012, CDC traps with UV-light, anthropogenic environment, Veggiani Aybar & Dantur Juri coll., 6 females, 2 males, Veggiani Aybar det.

Subgenus *Drymodesmyia* Vargas

Culicoides (*Drymodesmyia*) *saltaensis* Spinelli & Wirth

Current distribution: Argentina (Salta and La Rioja Provinces).

New records: ARGENTINA: Tucumán Province, Alpachiri (27°20'S, 65°46'W), Chicligasta Department, XII-2012, III-2013, CDC traps with UV-light, anthropogenic environment and forested, Veggiani Aybar coll., 4 females, 1 male, Veggiani Aybar det.; Santa Ana (27°28'S, 65°39'W), Río Chico Department, IX-2012, CDC traps with UV-light, anthropogenic environment, Veggiani Aybar coll., 2 females, Veggiani Aybar det.; Villa Batiruana (27°38S, 65°44'W), Juan Bautista Alberdi Department, XII-2012, CDC traps with UV-light, anthropogenic environment, Veggiani Aybar coll., 2 females, Veggiani Aybar det.

Subgenus *Haematomyidium* Goeldi

Culicoides (*Haematomyidium*) *pampaensis* Spinelli & Wirth

Current distribution: Argentina (Catamarca, La Pampa, and Salta Provinces).

New records: ARGENTINA: Jujuy Province, Libertador General San Martín (23°48'S, 64°48'W), Ledesma Department, XI-2012, CDC traps with UV-light, anthropogenic environment, Veggiani Aybar & Dantur Juri coll., 2 females, Veggiani Aybar det. Salta Province, San José de Metán (25°30'S, 64°58'W), Metán Department, IX-2013, CDC traps with white-light, anthropogenic environment, Veggiani Aybar & Dantur Juri coll., 2 females, Veggiani Aybar det.

Subgenus *Hoffmania* Fox

Culicoides (*Hoffmania*) *brasilianum* Forattini

Current distribution: Argentina (Misiones Province) and Brazil.

New records: BOLIVIA: Aniceto Arce Province, Pozo del Bermejo (22°35'S, 64°26'W), Tarija Department, VIII-2012, CDC traps with UV-light, anthropogenic environment and forested , Veggiani Aybar coll., 2 females, Veggiani Aybar det.; Gran Chaco Province, Itavicua (21°50'S, 63°38'W),Tarija Department, X-2013, CDC traps with UV-light, anthropogenic environment, Laci & Carrizo coll., 1 female,Veggiani Aybar det.

Culicoides (*Hoffmania*) *guttatus* Coquillett

Current distribution: Argentina (Corrientes, Salta and Tucumán Provinces), Brazil, Ecuador, Paraguay, Surinam, and Venezuela.

New records: ARGENTINA: Jujuy Province, Yuto (23°38'S, 64°28'W), Ledesma Department, XI-2012, CDC traps with UV-light and white-light, anthropogenic environment, Veggiani Aybar & Dantur Juri coll., 3 females, 1 male, Veggiani Aybar det. BOLIVIA: Gran Chaco Province, Itavicua (21°50'S, 63°38'W), Tarija Department, X-2013, CDC traps with UV-light, anthropogenic environment, Laci & Carrizo coll., 2 females, Veggiani Aybar det.; Campo Verde (21°52'S, 63°34'W), Tarija Department, X-2013, CDC traps with UV-light and white-light, anthropogenic environment, Laci & Carrizo coll., 5 females, Veggiani Aybar det.

Culicoides (*Hoffmania*) *insignis* Lutz

Current distribution: Argentina (Buenos Aires, Corrientes, Salta, and Tucumán Provinces), Central America and Caribbean, México, and USA.

New records: ARGENTINA: Jujuy Province, Libertador General San Martín (23°48'S, 64°48'W), Ledesma Department, XI-2012, I-2010, CDC traps with UV-light and white-light, anthropogenic environment and forested, Veggiani Aybar & Dantur Juri coll., 15 females, Veggiani Aybar det.; Yuto (23°38'S, 64°28'W), Ledesma Department, XI-2012, CDC traps with UV-light and white-light, anthropogenic environment, Veggiani Aybar & Dantur Juri coll., 9 females, 1 male, Veggiani Aybar det.

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Table 1. Updated checklist of *Culicoides* species in northwestern Argentina.

Taxon	Species	Province
Subgenus		
	Culicoides nigrigenus Wirth & Blanton[5]	Salta (location not specified)
Cotocripus	*Culicoides caridei* Brèthes*[13]	Jujuy (Ledesma Department)
	Culicoides chacoensis Spinelli & Wirth[2,5]	Salta (General José de San Martín Department)
Drymodesmyia	*Culicoides saltaensis* Spinelli & Wirth*[2,5,13]	Salta (Cafayate Department) Tucumán (Chicligasta, Río Chico, and Juan Bautista Alberdi Departments)
Haematomyidium	*Culicoides debilipalpis* Lutz[9,10,11]	Tucumán (Capital, Chicligasta, Juan Bautista Alberdi, La Cocha, Lules, Monteros, Río Chico, Trancas, and Yerba Buena Departments) Salta (General Güemes, General José de San Martín, Metán, Orán, Rosario de la Frontera, and Rosario de Lerma Departments) Jujuy (Ledesma, Metán and Palpalá Departments)
	Culicoides lahillei Iches[3,9,10,11]	Tucumán (Capital, Chicligasta, Juan Bautista Alberdi, La Cocha, Lules, Monteros, Río Chico, Trancas, and Yerba Buena Departments) Salta (General Güemes, General José de San Martín, Metán, Orán, Rosario de la Frontera, and Rosario de Lerma Departments) Jujuy (Ledesma, Metán and Palpalá Departments)
	Culicoides pampaensis Spinelli & Wirth*[7,13]	Catamarca (Londres Department) Salta (Metán Department) Jujuy (Ledesma Department)
	Culicoides paraensis Goeldi[4,9,10,11]	Tucumán (Capital, Chicligasta, Juan Bautista Alberdi, La Cocha, Lules, Monteros, Río Chico, Trancas, and Yerba Buena Departments) Salta (General Güemes, General José de San Martín, Metán, Orán, Rosario de la Frontera, and Rosario de Lerma Departments) Jujuy (Ledesma, Metán, and Palpalá Departments)
	Culicoides calchaqui Spinelli & Veggiani Aybar[12]	Tucumán (Lules and Chicligasta Departments)
	Culicoides guttatus Coquillett*[11,13]	Tucumán (La Cocha Department) Salta (Orán Department) Jujuy (Ledesma Department)
	Culicoides insignis Lutz*[1,6,9,10,11,13]	Tucumán (Capital, Chicligasta, Juan Bautista Alberdi, La Cocha, Lules, Monteros, Río Chico, Trancas, and Yerba Buena Departments) Salta (Orán Department) Jujuy (Ledesma Department)
	Culicoides pseudoheliconiae Felippe-Bauer[12]	Tucumán (Monteros Department)
Psychophaena	*Culicoides venezuelensis* Ortiz & Mirsa*[9,10,11,13]	Tucumán (Capital, Chicligasta, Juan Bautista Alberdi, La Cocha, Lules, Monteros, Río Chico, Trancas, and Yerba Buena Departments) Salta (Orán Department) Jujuy (Ledesma Department)
Subgenus unplaced		
Daedalus group	*Culicoides crescentis* Wirth & Blanton*[9,10,13]	Tucumán (Monteros Department) Salta (Rosario de Lerma Department) Jujuy (Ledesma Department)
	Culicoides daedaloides Wirth & Blanton[12]	Salta (Orán Department)
*Dasyophrus*group	*Culicoides estevezae* Ronderos & Spinelli[8]	Salta (General José de San Martín Department)
	Culicoides willinki Spinelli & Veggiani Aybar[12]	Tucumán(Monteros Department)

* First report for northwestern Argentina.

Note: Original records by [1]Lien & Lu (1978), [2]Spinelli & Wirth (1984), [3]Spinelli & Wirth (1986), [4]Wirth & Felippe-Bauer (1989), [5]Spinelli & Wirth (1993), [6]Spinelli et al. (1993), [7]Spinelli & Ronderos (2005), [8]Spinelli et al. (2005), [9]Veggiani Aybar et al. (2010), [10]Veggiani Aybar et al. (2011), [11]Veggiani Aybar et al. (2012), [12]Spinelli et al. (2013), and [13]present study.

Table 2. Updated checklist of *Culicoides* species in Bolivia.

Taxon	Species	Distribution in Bolivia
Subgenus		**Province (Department)**
Anilomyia	*Culicoides efferus* Fox[1]	Chapare (Cochabamba Department)
	Culicoides chacoensis Spinelli & Wirth[2,6]	Andrés Ibáñez (Santa Cruz de las Sierras Department) Sara (Santa Cruz Department)
Haematomyidium	*Culicoides debilipalpis* Lutz[9,10,11]	Aniceto Arce (Tarija Department)
	Culicoides lahillei Iches[3,9,10,11]	Aniceto Arce (Tarija Department) Sara (Santa Cruz Department)
	Culicoides paraensis Goeldi[5,9,10,11]	Aniceto Arce (Tarija Department) Cercado (Cochabamba Department) Nor Yungas (La Paz Department)
Hoffmania	*Culicoides batesi* Wirth & Blanton[7]	Andrés Ibáñez (Santa Cruz de las Sierras Department) Ichilo (Santa Cruz Department)
	Culicoides brasilianum Forattini+[9,12]	Aniceto Arce (Tarija Department) Gran Chaco(Tarija Department)
	Culicoides diabolicus Hoffman[1]	Chapare (Cochabamba Department)
	Culicoides foxi Ortiz[1,7]	Chapare (Cochabamba Department) Ichilo (Santa Cruz Department)
	Culicoides franklini Spinelli[8]	Ichilo (Santa Cruz Department)
	Culicoides fusipalpis Wirth & Blanton[7]	Andrés Ibáñez (Santa Cruz de las Sierras Department) Vallegrande (Santa Cruz Department)
	Culicoides guttatus Coquillett+[11,12]	Gran Chaco (Tarija Department)
	Culicoides insignis Lutz[1,7,9,10,11,12]	Andrés Ibáñez (Santa Cruz de las Sierras Department) Aniceto Arce (Tarija Department) Chapare (Cochabamba Department) Sara (Santa Cruz Department)
	Culicoides plaumanni Spinelli[7]	Andrés Ibáñez (Santa Cruz de las Sierras Department) Ichilo (Santa Cruz Department)
Mataemyia	*Culicoides bricenoi* Ortiz[3]	Andrés Ibáñez (Santa Cruz de las Sierras Department)
	Culicoides lenti Tavares & Luna Dias[2]	Andrés Ibáñez (Santa Cruz de las Sierras Department)
Psychophaena	*Culicoides venezuelensis* Ortiz & Mirsa[9,10,11]	Aniceto Arce (Tarija Department)
Subgenus unplaced		
Carpenteri group	*Culicoides carpenteri* Wirth & Blanton[3]	Andrés Ibáñez (Santa Cruz de las Sierras Department) Sara (Santa Cruz Department) Vallegrande (Santa Cruz Department)
Daedalus group	*Culicoides crescentis* Wirth & Blanton[9,10]	Aniceto Arce (Tarija Department)
Eublepharus group	*Culicoides rangeli* Ortiz & Mirsa[1]	Chapare (Cochabamba Department).
Fluvialis group	*Culicoides leopoldoi* Ortiz[3,6]	Location not specified.
Limai group	*Culicoides boliviensis* Spinelli & Wirth[2,6,8]	Andrés Ibáñez (Santa Cruz de las Sierras Department). Vallegrande (Santa Cruz Department).
	Culicoides vernoni Wirth & Blanton[3]	Andrés Ibáñez (Santa Cruz de las Sierras Department) Vallegrande (Santa Cruz Department)
Reticulatus group	*Culicoides aureus* Ortiz[3]	Sara (Santa Cruz Department)
	Culicoides paucienfuscatus Barbosa[1,3]	Andrés Ibáñez (Santa Cruz de las Sierras Department) Chapare (Cochabamba Department)
Stigmalis group	*Culcoides fluviatilis* Lutz[4]	Location not specified
Miscellaneous unplaced	*Culcoides transferrans* Ortiz[1]	Chapare (Cochabamba Department)

+First report for Bolivia.

Note: Original records by [1]Lien & Lu (1978), [2]Spinelli & Wirth (1984), [3]Spinelli & Wirth (1986), [4]Wirth et al. (1988), [5]Wirth & Felippe-Bauer (1989), [6]Spinelli & Wirth (1993), [7]Spinelli et al. (1993), [8]Marino et al. (2002), [9]Veggiani Aybar et al. (2010), [10]Veggiani Aybar et al. (2011), [11]Veggiani Aybar et al. (2012), and [12]present study.

Subgenus *Psychophaena*

Culicoides (*Psychophaena) venezuelensis* Ortiz & Mirsa

Current distribution: Argentina (Entre Ríos, Salta, and Tucumán Provinces), Bolivia (Aniceto Arce Province), Brazil, Ecuador, Chile, Colombia, Costa Rica, Panamá, Paraguay, and Uruguay.

New records: ARGENTINA: Jujuy Province, Yuto (23°38'S, 64°28'W), Ledesma Department, XI-2012, CDC traps with UV-light and white-light, anthropogenic environment, Veggiani Aybar & Dantur Juri coll., 12 females, 1 male, Veggiani Aybar det.

Subgenus unplaced

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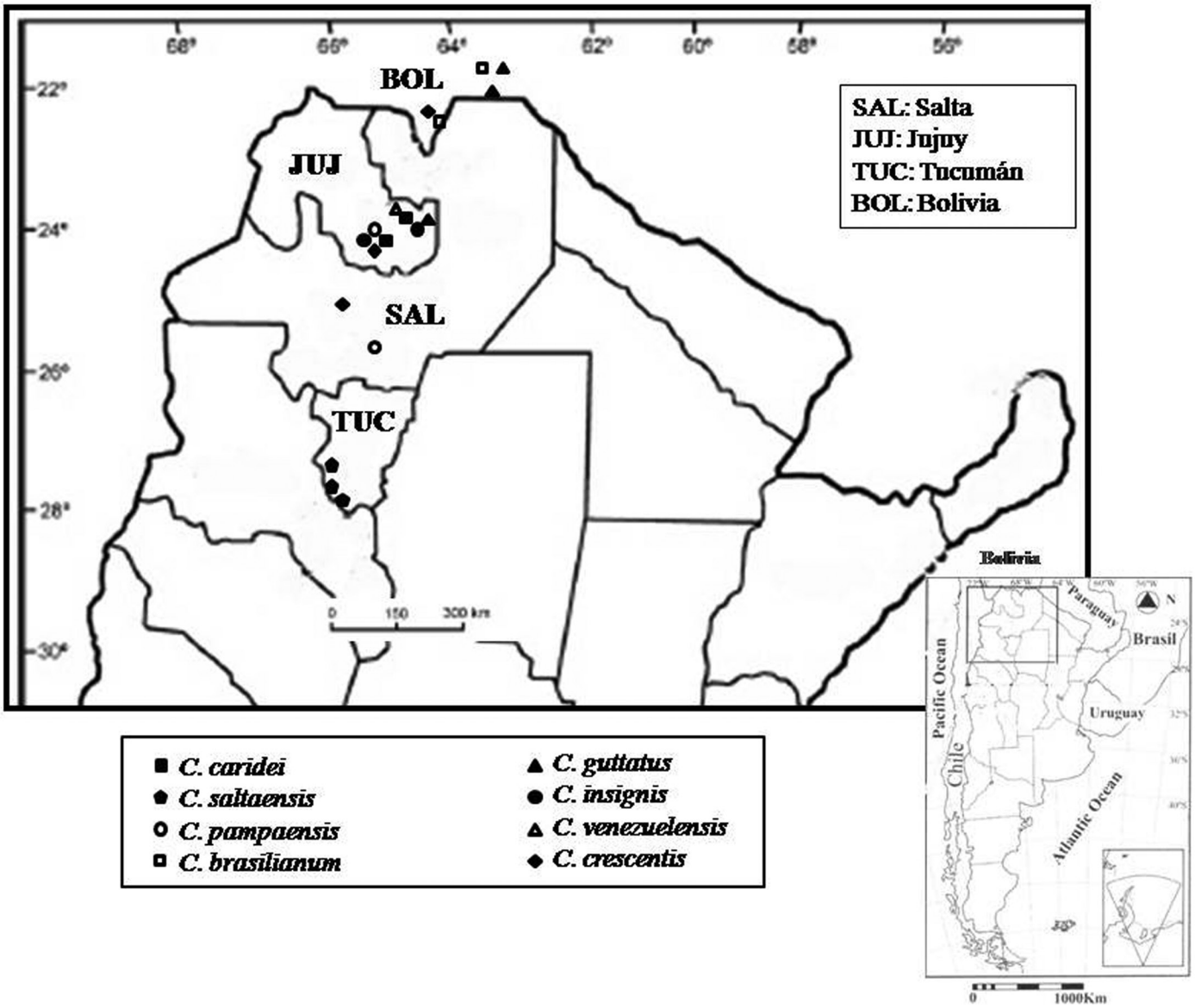


Fig. 1. Distribution map of *Culicoides* species in northwestern Argentina and southwestern Bolivia.

daedalus group

Culicoides crescentis Wirth & Blanton

Current distribution: Argentina (Salta and Tucumán Provinces), Mexico to Colombia.

New records: ARGENTINA: Jujuy Province, Libertador General San Martín (23°48'S, 64°48'W), Ledesma Department X-2012, CDC traps with white-light, anthropogenic environment, Veggiani Aybar & Dantur Juri coll., 1 female, Veggiani Aybar det. Salta Province, Campo Quijano (24°54'S, 65°41'W), Rosario de Lerma Department, X-2009, traps with UV-light, anthropogenic environment, Veggiani Aybar coll., 2 females, Veggiani Aybar det.; Reserva Nacional Pizarros (24°10'S, 64°03'W), Anta Department, I-2012, traps with UV-light, forested environment, Laci & Carrizo coll., 2 females, Veggiani Aybar det. BOLIVIA: Aniceto Arce Province, Pozo del Bermejo (22°35'S, 64°26'W), Tarija Department, VIII-2012, CDC traps with UV-light, forested environment, Veggiani Aybar & Dantur Juri coll., 2 females, Veggiani Aybar det.

LATITUDINAL DISTRIBUTION AND UPDATED CHECKLIST

Below is a map with distribution records of *Culicoides* species reported in the study area (Fig. 1). In addition, Tables 1 and 2 are updated checklists of recorded species of *Culicoides* in the Yungas and Chaco Ecoregions of Argentina and Bolivia.

Discussion

The objective of this study was to present the geographical distribution of the *Culicoides* fauna, extending its range of distribution in the subtropical mountainous rainforest ecoregion of Argentina and in the Chaco Ecoregion of Bolivia, including anthropogenic and forested environments. Other surveys of the genus *Culicoides* in this area were by Veggiani Aybar et al. (2010, 2011, 2012).

Of the species recorded, only *C. insignis* and *C. venezuelensis* have been incriminated in the transmission of diseases of veterinary importance (Ronderos et al. 2003; Perruolo 2009). For example, *C. insignis* has been reported as a vector of bluetongue virus in northeastern

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Argentina (Gorch et al. 2002; Ronderos et al. 2003). The discovery of this potential vector in the Yungas Ecoregion is of vital importance for developing health and veterinary measures aimed at minimizing the effect of this disease in this and surrounding areas.

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