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

Cecilia A. Veggiani Aybar1,2,3,* , María J. Dantur Juri1,2,3 , Guillermo L. Claps1, Mercedes S. Lizarralde de Grosso1,2,3 , and Gustavo R. Spinelli2,4

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 & Mira 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 & Mira 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; Felipe-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; Seblová 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...
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 CO₂ 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: Tucumán Province, Alpachiri (27°20'S, 65°46'W), Chicligasta Department, XII-2012, II-2013, CDC traps with UV-light, anthropogenic environment and forested, Veggianni Aybar coll., 4 females, 1 male, Veggianni Aybar det.; Santa Ana (27°28'S, 65°39'W), Río Chico Department, IX-2012, CDC traps with UV-light, anthropogenic environment, Veggianni Aybar coll., 2 females, Veggianni Aybar det.; Villa Batiruana (27°38'S, 65°44'W), Juan Bautista Alberdi Department, XII-2012, CDC traps with UV-light, anthropogenic environment, Veggianni Aybar coll., 2 females, Veggianni 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, Veggianni Aybar & Dantur Juri coll., 2 females, Veggianni 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, Veggianni Aybar & Dantur Juri coll., 2 females, Veggianni Aybar det.
Subgenus Hoffmania Fox
Culicoides (Hoffmania) brasiliannum 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, Veggianni Aybar coll., 2 females, Veggianni 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, Veggianni Aybar det.
Culicoides (Hoffmania) guttatus Coquillet
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, Veggianni Aybar & Dantur Juri coll., 3 females, 1 male, Veggianni 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, Veggianni 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, Veggianni 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°48'5, 64°48'W), Ledesma Department, XI-2012, I-2010, CDC traps with UV-light and white-light, anthropogenic environment and forested; Veggianni Aybar & Dantur Juri coll., 15 females, Veggianni Aybar det.; Yuto (23°38'S, 64°28'W), Ledesma Department, XI-2012, CDC traps with UV-light and white-light, anthropogenic environment, Veggianni Aybar & Dantur Juri coll., 9 females, 1 male, Veggianni Aybar det.
Table 1. Updated checklist of Culicoides species in northwestern Argentina.

| Taxon       | Species                          | Province                                                                 |
|-------------|----------------------------------|--------------------------------------------------------------------------|
| Subgenus    |                                  |                                                                          |
| Cotocripus  | Culicoides nigrigenus Wirth & Blanton<sup>†</sup> | Salta (location not specified)                                           |
|             | Culicoides caridei Brèthes<sup>†,#</sup> | Jujuy (Ledesma Department)                                               |
|             | Culicoides chacoensis Spinelli & Wirth<sup>†,#</sup> | Salta (General José de San Martín Department)                            |
| Drymodesmyia| Culicoides saltaensis Spinelli & Wirth<sup>†,#</sup> | Salta (Cafayate Department)                                              |
|             |                                  | Tucumán (Chiligasta, Río Chico, and Juan Bautista Alberdi Departments)   |
| Hoematomydium| Culicoides debilipalpis Lutz<sup>*,†,#</sup> | Tucumán (Capital, Chiligasta, 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<sup>†,#,#</sup> | Tucumán (Capital, Chiligasta, 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<sup>†,#</sup> | Catamarca (Londres Department)                                          |
|             |                                  | Salta (Metán Department)                                                |
|             |                                  | Jujuy (Ledesma Department)                                               |
|             | Culicoides paraensis Goeldi<sup>†,#,#</sup> | Tucumán (Capital, Chiligasta, 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<sup>†,#</sup> | Tucumán (Lules and Chiligasta Departments)                              |
|             | Culicoides guttatus Coquillett<sup>†,#,#,#</sup> | Tucumán (La Cocha Department)                                           |
|             |                                  | Salta (Orán Department)                                                 |
|             |                                  | Jujuy (Ledesma Department)                                               |
|             | Culicoides insignis Lutz<sup>*,†,#,#,#</sup> | Tucumán (Capital, Chiligasta, Juan Bautista Alberdi, La Cocha, Lules, Monteros, Río Chico, Trancas, and Yerba Buena Departments) |
|             |                                  | Salta (Orán Department)                                                 |
|             |                                  | Jujuy (Ledesma Department)                                               |
|             | Culicoides pseudoheliconiae Felipe-Bauer<sup>†,#</sup> | Tucumán (Monteros Department)                                            |
| Psychophaena| Culicoides venezuelensis Ortiz & Mirsa<sup>*,†,#,#,#</sup> | Tucumán (Capital, Chiligasta, 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<sup>†,#,#</sup> | Tucumán (Monteros Department)                                           |
|             |                                  | Salta (Rosario de Lerma Department)                                     |
|             |                                  | Jujuy (Ledesma Department)                                               |
|             | Culicoides daedaloides Wirth & Blanton<sup>†,#</sup> | Salta (Orán Department)                                                 |
| Dasyophrus group| Culicoides estevezae Ronderos & Spinelli<sup>†,#</sup> | Salta (General José de San Martín Department)                          |
|             | Culicoides willinki Spinelli & Veggiani Aybar<sup>†,#</sup> | Tucumán (Monteros Department)                                           |

* First report for northwestern Argentina.

Note: Original records by: <sup>†</sup>Lien & Lu (1978), <sup>‡</sup>Spinelli & Wirth (1984), <sup>†</sup>Spinelli & Wirth (1986), <sup>†</sup>Wirth & Felippe-Bauer (1989), <sup>‡</sup>Spinelli & Wirth (1993), <sup>‡</sup>Spinelli et al. (1993), <sup>‡</sup>Spinelli & Ronderos (2005), <sup>‡</sup>Spinelli et al. (2005), <sup>‡</sup>Veggiani Aybar et al. (2010), <sup>‡</sup>Veggiani Aybar et al. (2011), <sup>‡</sup>Veggiani Aybar et al. (2012), <sup>‡</sup>Spinelli et al. (2013), and <sup>‡</sup>present study.
Table 2. Updated checklist of Culicoides species in Bolivia.

| Taxon                        | Species                                                              | Province (Department)                                                                 |
|------------------------------|                                                                     |                                                                                      |
| **Subgenus**                 |                                                                       |                                                                                      |
| **Anilomyia**                | Cylicoides efferus Fox<sup>11</sup>                                  | Chapare (Cochabamba Department)                                                       |
|                              | Cylicoides chacoensis Spinelli & Wirth<sup>10,11</sup>               | Andrés Ibáñez (Santa Cruz de las Sierras Department)                                   |
|                              |                                                                       | Sara (Santa Cruz Department)                                                          |
| **Haematomyidium**           | Cylicoides debilipalpis Lutz<sup>9,11</sup>                          | Aniceto Arce (Tarija Department)                                                      |
|                              | Cylicoides lahillei Iches<sup>9,11</sup>                             | Aniceto Arce (Tarija Department)                                                      |
|                              | Cylicoides paraensis Goeldi<sup>9,11</sup>                           | Aniceto Arce (Tarija Department)                                                      |
|                              |                                                                       | Cercado (Cochabamba Department)                                                       |
|                              |                                                                       | Nor Yungas (La Paz Department)                                                        |
| **Hoffmania**                | Cylicoides batesi Wirth & Blanton<sup>9</sup>                        | Andrés Ibáñez (Santa Cruz de las Sierras Department)                                   |
|                              | Cylicoides brasilianum Forattini<sup>9,11</sup>                     | Ichilo (Santa Cruz Department)                                                        |
|                              | Cylicoides diabolicus Hoffman<sup>9</sup>                            | Gran Chaco (Tarija Department)                                                        |
|                              | Cylicoides foxi Ortiz<sup>9,11</sup>                                | Chapare (Cochabamba Department)                                                       |
|                              |                                                                       | Chapare (Cochabamba Department)                                                       |
|                              |                                                                       | Ichilo (Santa Cruz Department)                                                        |
|                              | Cylicoides franklini Spinelli<sup>9</sup>                            | Ichilo (Santa Cruz Department)                                                        |
|                              | Cylicoides fusipalpis Wirth & Blanton<sup>9</sup>                   | Andrés Ibáñez (Santa Cruz de las Sierras Department)                                   |
|                              |                                                                       | Vallegarde (Santa Cruz Department)                                                    |
|                              | Cylicoides guttatus Coquillett<sup>11,12</sup>                      | Gran Chaco (Tarija Department)                                                        |
|                              | Cylicoides insignis Lutz<sup>9,11</sup>                              | Andrés Ibáñez (Santa Cruz de las Sierras Department)                                   |
|                              |                                                                       | Aniceto Arce (Tarija Department)                                                      |
|                              |                                                                       | Chapare (Cochabamba Department)                                                       |
|                              |                                                                       | Sara (Santa Cruz Department)                                                          |
|                              |                                                                       | Aniceto Arce (Tarija Department)                                                      |
|                              |                                                                       | Ichilo (Santa Cruz Department)                                                        |
| **Mataemyia**                | Cylicoides bricenoi Ortiz<sup>9</sup>                                | Andrés Ibáñez (Santa Cruz de las Sierras Department)                                   |
|                              | Cylicoides lenti Tavares & Luna Dias<sup>9</sup>                    | Andrés Ibáñez (Santa Cruz de las Sierras Department)                                   |
| **Psychophaena**             | Cylicoides venezuelensis Ortiz & Mirsa<sup>9,11</sup>              | Aniceto Arce (Tarija Department)                                                      |
| **Subgenus unplaced**        |                                                                       |                                                                                      |
| **Carpenteri group**         | Cylicoides carpenteri Wirth & Blanton<sup>9</sup>                   | Andrés Ibáñez (Santa Cruz de las Sierras Department)                                   |
|                              |                                                                       | Sara (Santa Cruz Department)                                                          |
|                              |                                                                       | Vallegarde (Santa Cruz Department)                                                    |
| **Daedalus group**           | Cylicoides crescentis Wirth & Blanton<sup>9,11</sup>               | Aniceto Arce (Tarija Department)                                                      |
| **Eublepharus group**        | Cylicoides rangeli Ortiz & Mirsa<sup>11</sup>                       | Chapare (Cochabamba Department).                                                      |
| **Fluvialis group**          | Cylicoides leopolodi Ortiz<sup>9</sup>                              | Location not specified.                                                               |
| **Limai group**              | Cylicoides boliviensis Spinelli & Wirth<sup>9,11</sup>              | Andrés Ibáñez (Santa Cruz de las Sierras Department).                                   |
|                              |                                                                       | Vallegarde (Santa Cruz Department).                                                  |
|                              | Cylicoides vernoni Wirth & Blanton<sup>9</sup>                      | Andrés Ibáñez (Santa Cruz de las Sierras Department).                                   |
|                              |                                                                       | Vallegarde (Santa Cruz Department).                                                  |
| **Reticulatus group**        | Cylicoides aureus Ortiz<sup>9</sup>                                 | Sara (Santa Cruz Department)                                                          |
|                              | Cylicoides paucienfuscatus Barbosa<sup>9,11</sup>                   | Andrés Ibáñez (Santa Cruz de las Sierras Department).                                   |
|                              |                                                                       | Chapare (Cochabamba Department).                                                      |
| **Stigmalis group**          | Cylicoides fluviatilis Lutz<sup>9</sup>                              | Location not specified.                                                               |
| **Miscellaneous unplaced**   | Cylicoides transferrans Ortiz<sup>9</sup>                           | Chapare (Cochabamba Department).                                                      |

<sup>1</sup>First report for Bolivia.

Note: Original records by<sup>1</sup>Lien & Lu (1978),<sup>2</sup>Spinelli & Wirth (1984),<sup>3</sup>Spinelli & Wirth (1986),<sup>4</sup>Wirth et al. (1988),<sup>5</sup>Wirth & Felippe-Bauer (1989),<sup>6</sup>Spinelli & Wirth (1993),<sup>7</sup>Spinelli et al. (1993),<sup>8</sup>Marino et al. (2002),<sup>9</sup>Veggiani Aybar et al. (2010),<sup>10</sup>Veggiani Aybar et al. (2011),<sup>11</sup>Veggiani Aybar et al. (2012), and<sup>12</sup>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, Panama, 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
**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. BO-LIVIA: 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...
Acknowledgments

We thank M. Zaidenberg and E. Laci, C. Laci, and D. Carrizo, Chief and Technicians of Coordinación Nacional de Control de Vectores, Ministerio de Salud de la Nación, for their cooperation during field work. We also give special thanks to William L. Grogan, Jr., Research Associate Florida State Collection of Arthropods, Florida Department of Agriculture and Consumer Services for invaluable comments that helped to improve the manuscript.

References Cited

Borkent A. 2004. Ceratopogonidae. Chapter 10, pp. 113-126 In Marquardt WC [ed.], Biology of Disease Vectors. 2nd edition. Elsevier Press, Amsterdam, The Netherlands. 785 pp.

Borkent A. 2014a. World species of biting midges (Diptera: Ceratopogonidae). http://www.ihns.illinois.edu/files/9913/9144/3328/CeratopogonidaeCatalog.pdf (last accessed 31 Mar 2015).

Borkent A. 2014b. The subgeneric classification of species of Culicoides. http://www.ihns.illinois.edu/files/9613/9136/7590/CulicoidesSubgenera.pdf (last accessed 31 Mar 2015).

Borkent A, Spinelli G. 2007. Neotropical Ceratopogonidae (Diptera: Insecta), pp. 1-198 In Adis A, Arias J, Rueda-Delgado G, Wnatzen KM [eds.], Aquatic Biodiversity in Latin America. Pensoft, Sofia, Bulgaria, and Moscow, Russia.

Carpenter S, Groschup M, Garros C, Felippe-Bauer M, Purse B. 2013. Culicoides biting midges, arboviruses and public health in Europe. Antiviral Research 100: 102-113.

Felippe-Bauer M, Sternheim U. 2008. Culicoides paraensis (Diptera: Ceratopogonidae) infestations in cities of the Itapocú River valley, southern Brazil. Entomological News 119: 185-192.

Gorch C, Vagnotti A, Duffy S, Miquet J, Pacheco I, Bolondi A, Draghi C, Cetra B, Soni C, Ronderos M, Russo S, Ramirez V, Lader L. 2002. Bluetongue: isolation and characterization of the virus and identification of vectors in north-eastern Argentina. Revista Argentina de Microbiología 34: 150-156.

Lien J-C, Lu L-C. 1978. A small collection of biting midges of the genus Culicoides from Bolivia (Diptera, Ceratopogonidae). Journal of the Taiwan Museum 40: 91-100.

Linley J, Hoch A, Pinheiro F. 1983. Biting midges (Diptera: Ceratopogonidae) and human health. Journal of Medical Entomology 20: 347-364.

Marino P, Spinelli GR, Cazorla C. 2002. Type specimens of Ceratopogonidae (Insecta: Diptera) in the collection of the Museo de La Plata, Argentina. Revista Museo de La Plata 42: 1-37.

Mellor P, Boorman J, Baylis M. 2000. Culicoides biting midges: their role as arbovirus vectors. Annual Review of Entomology 45: 307-340.

Perrullo GJ. 2009. Clave de las especies de Culicoides (Diptera: Ceratopogonidae) asociadas con la ganadería en la región Neotropical. Revista Científica 19: 124-133.

Ronderos M, Spinelli G, Lader I, Díaz F. 2003. La importancia sanitaria de los jejes de del género Culicoides (Diptera: Nematocera) en la Argentina. Entomología y Vectores10: 601-612.

Seblova V, Sadiova J, Carpenter S, Volf P. 2012. Development of Leishmania parasites in Culicoides nubeculosus (Diptera: Ceratopogonidae) and implications for screening vector competence. Journal of Medical Entomology 49: 967-970.

Sherlock I, Guitton N. 1965. Dermatozoonosis by Culicoides bite (Diptera: Ceratopogonidae) in Salvador, State of Bahia, Brazil. II. The bionomics of the Culicoides. Memorias do Instituto Oswaldo Cruz 62: 145-159.

Slama D, Haouas N, Remadi L, Mezhoud H, Babba H, Chaker E. 2014. First detection of Leishmania infantum (Kinetoplastida: Trypanosomatidae) in Culicoides spp. (Diptera: Ceratopogonidae). Parasites and Vectors 7: 1-3.

Spinelli GR, Ronderos M. 2005. Description of the male of Culicoides pemphigus (Diptera: Ceratopogonidae). Revista de la Sociedad Entomológica Argentina 64: 43-46.

Spinelli GR, Wirth WW. 1984. Ocho especies nuevas del género Culicoides de la región Neotropical. Primera descripción del macho de C. flinti Wirth y de la hembra de C. lenti Tavares y Luna Dias (Diptera: Ceratopogonidae). Revista de la Sociedad Entomológica Argentina 43(1-4): 171-185.

Spinelli GR, Wirth WW. 1986. Clave para la identificación de las especies del género Culicoides Lairelile presentes al sur de la Cuenca Amazónica. Nuevas citas y notas sinonímicas (Diptera: Ceratopogonidae). Revista de la Sociedad Entomológica Argentina 44(1): 49-73.

Spinelli GR, Wirth WW. 1993. Los Ceratopogonidae de la Argentina (Insecta: Diptera), pp. 1-124 In Castellano Z [ed.], fauna de agua dulce de la República Argentina, Buenos Aires, Argentina.

Spinelli GR, Greiner EC, Wirth WW. 1993. The Neotropical bloodsucking midges of the group of the subgenus Hoffmania (Diptera: Ceratopogonidae). Contributions of the American Entomological Institute 27: 1-91.

Spinelli GR, Ronderos M, Díaz, F. 2005. The bloodsucking biting midges of Argentina (Diptera: Ceratopogonidae). Memorias do Instituto Oswaldo Cruz 100: 137-150.

Spinelli GR, Santamaria E, Cabrera O, Ronderos M, Suárez M. 2009. Five new species of Culicoides Lairelile described from Colombia, yielding a new species list and country records (Diptera: Ceratopogonidae). Memorias do Instituto Oswaldo Cruz 104: 81-92.

Spinelli GR, Veggiani Aybar CA, Dantur Juri M, Lizarralde Grosso M, Marinho P. 2013. Two new species and new records of biting midges of the genus Culicoides from northwestern Argentina (Diptera: Ceratopogonidae). Memorias do Instituto Oswaldo Cruz 108: 586-589.

Veggiani Aybar CA, Dantur Juri M, Lizarralde de Grosso M, Spinelli GR. 2010. Species diversity and seasonal abundance of Culicoides biting midges in northwestern Argentina. Medical and Veterinary Entomology 24: 95-98.

Veggiani Aybar CA, Dantur Juri M, Lizarralde de Grosso M, Spinelli GR. 2011. New records of Culicoides species (Diptera: Ceratopogonidae) for Bolivia. Journal of the American Mosquito Control Association 27: 306-307.

Veggiani Aybar CA, Dantur Juri M, Stein M, Oria M, Lizarralde de Grosso M, Spinelli GR. 2012. New records of Culicoides Latreille (Diptera: Ceratopogonidae) for the Yungas and Chaco Ecorregions of Argentina. Florida Entomologist 95: 808-809.

Wirth WW, Blanton FS. 1959. Biting midges of the genus Culicoides from Panama (Diptera: Ceratopogonidae). Proceedings of the United States National Museum 109: 237-482.

Wirth WW, Dyce AL, Spinelli GR. 1988. An atlas of wing photographs: with a summary of the numerical characters of the Neotropical species of Culicoides (Diptera: Ceratopogonidae). Contributions of the American Entomological Institute 25: 1-72.

Wirth WW, Felippe-Bauer ML. 1989. The neotropical biting midges related to Culicoides paraensis (Diptera: Ceratopogonidae). Memorias do Instituto Oswaldo Cruz 84: 551-565.