

Distribution of Phlebotominae (Diptera: Psychodidae) species and human cases of leishmaniasis in the Province of Corrientes, Argentina

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Distribución de especies de Phlebotominae (Diptera: Psychodidae) y casos humanos de leishmaniasis en la Provincia de Corrientes, Argentina

RESUMEN. Actualizamos la distribución de las especies de Phlebotominae (Diptera: Psychodidae) y los casos humanos de leishmaniasis en la provincia de Corrientes, Argentina. *Evandromyia correalimai* (Martins, Coutinho & Lutz, 1970) es un nuevo registro para la provincia, reportado en el área urbana de Santo Tomé. Incluimos el mapa de distribución actualmente conocido de las especies de flebotomos en Corrientes, y las localidades donde fueron registradas, así como un mapa de las especies vectores y los casos humanos de leishmaniasis reportados.

PALABRAS CLAVE. América del sur. Ecoepidemiología. Flebotomos. Leishmaniasis visceral y cutánea. Vector.

ABSTRACT. We updated the distribution of Phlebotominae (Diptera: Psychodidae) species and human cases of leishmaniasis in the Province of Corrientes, Argentina. *Evandromyia correalimai* (Martins, Coutinho & Lutz, 1970) is a new record for the province, reported in the urban area of Santo Tomé. We include the currently known distribution map of Phlebotominae sandfly species in Corrientes, and the localities where they were recorded, as well as a map of vector species and reported human cases of leishmaniasis.

KEYWORDS. Eco-epidemiology. Sand flies. South America. Vector. Visceral and cutaneous leishmaniasis.

Leishmaniasis are a global health problem, with high prevalence in the Americas. Their morbidity-mortality and wide geographical distribution make these diseases of public health relevance (OPS 2019).

Leishmaniasis are caused by protozoa of the genus *Leishmania* (Trypanosomatida: Trypanosomatidae); which

are transmitted by insects of the subfamily Phlebotominae (Diptera: Psychodidae). The clinical forms in humans depend mainly on the etiological agent involved. In Argentina, *Leishmania (Leishmania) infantum* (Nicolle) (syn *chagasi*) is responsible for visceral leishmaniasis (VL) and *Leishmania (Viannia) braziliensis* (Vianna) is the main responsible of cutaneous leishmaniasis (CL).

The Phlebotominae are widely distributed in the Americas, with approximately 500 species, out of which, 56 are implicated in the transmission of the causative agents of leishmaniasis (Maroli et al., 2013). In Argentina, the first autochthonous human case of VL was diagnosed in 2006 in the city of Posadas, Misiones (Salomón et al., 2008a) and nowadays, human cases of VL are reported in six provinces (Gould et al., 2013). Transmission of CL, on the other hand, is known since 1916, being endemic and presenting several "hot spots" and sporadic outbreaks in nine provinces of Argentina (Salomón et al., 2008b).

The province of Corrientes has reported cases of VL since 2009 (Salomón et al., 2011), while CL cases are reported since 1955 with epidemic outbreaks in 2003 in the town of Bella Vista (Salomón et al., 2006a) and 2015 in the town of Riachuelo (Acosta-Soto et al., 2020).

In the present work, we present a critical analysis of the literature published to date on the distribution and presence of Phlebotominae species and sites with CL and VL cases in the province of Corrientes. Both, scientific journal articles and congress presentations were included. Unpublished data from the authors were also incorporated with the aim of generating a distribution database of both vectors and human cases, to contribute to the design of focused differential health-related recommendations and interventions with the appropriate allocation of resources according to the risk of VL or CL.

Study area: The province of Corrientes, first sub-national level, has an area of 88,886 km² and a population of 992,595 inhabitants, 82.84% located in urban areas and the remaining 17.16% in rural areas (INDEC 2010).

Corrientes is located in the Mesopotamian region in northeastern Argentina. The province shares international borders with Paraguay to the north, through the Paraná River, and with Uruguay and Brazil through the Uruguay River in the east, and national borders with the provinces of Misiones, Entre Ríos Chaco and Santa Fe. The climate is humid in winter and dry in summer, with an average annual temperature of 21 °C, irregular periods of rainfall with an annual average of 1200 mm (NMS, 2018). The Esteros del Iberá wetlands are found in the north-central region of the province, with an area of ~700,000 ha.

Data sources and search strategies: To obtain information on the citations of the different Phlebotominae species in the province of Corrientes, scientific sources (scientific articles published in indexed journals and congress abstracts) containing first records or focal samplings were analyzed. An active bibliographic search was carried out in electronic databases such as PubMed, Scielo and Google Scholar. The combined keywords (in English and Spanish) used were: Leishmaniasis, Visceral Leishmaniasis or Tegumentary Leishmaniasis or Cutaneous Leishmaniasis and Corrientes Argentina. Phlebotominae or sandflies or flebotomos and Corrientes, Argentina, Leishmaniasis Tegumentaria or Leishmaniasis Cutanea or Leishmaniasis Visceral and Corrientes

Argentina. Publications between 1900 and 2020 were considered.

Unpublished data: Data from samplings conducted in the town of Mercedes on 10 and 11 November 2011 and 22, 23, 27 and 28 January 2013; in Colonia Carlos Pellegrini on 12, 13 and 15 November 2011 and in Santo Tomé on 7 and 9 April 2014, 11 March 2015, 19 April 2016, 18 and 20 September, 15 November and 12 December 2017 and 26 February 2019 were included. Sandflies samplings were carried out with REDILA light traps (Fernández et al., 2015), in sites selected under worst-case scenario criterion (Salomón et al., 2002). All these sites were georeferenced by means of a GARMIN eTrex® 30 handheld GPS.

The captured Phlebotominae were diaphanized with lactophenol (lactic acid and phenol 1:1). Subsequently, their determination was performed according to a taxonomic key (Galati, 2018).

Reports of *Nyssomyia intermedia* (Lutz & Neiva) and *Psathyromyia shannoni* (Dyar) according to original works were recorded here as *Ny. neivai* (Pinto) and *Pa. bigeniculata* (Floch & Abonnenc) due to nomenclatural changes and species re-assignment (Andrade Filho et al., 2003; Sábio et al., 2014; Szelag et al., 2016). Females of *Evandromyia cortelezii* (Brètes), *Ev. sallesi* (Galvao & Coutinho) and *Ev. chacuensis* (Szelag et al., 2018) cannot be distinguished by their morphological characteristics, so specimens were included as *Cortelezii* Complex (Galati, 2018).

Localities with reports of CL and LV cases: Confirmed human cases records by year and reporting locality were obtained from the Sistema Nacional de Vigilancia en Salud (SNVS). Data correspond to a query on 12/02/2019 and include cases recorded until then.

The first non-systematic captures of sandflies in the province of Corrientes were published in the 1950s (Bejarano & Duret, 1950; Castro, 1959; Duret, 1952). From 1990 onwards, sandflies captures were related to research projects or epidemic outbreaks. To date, 26 capture sites have been reported throughout the province (Fig. 1), with a total of 30 published articles and 10 additional unpublished samples. Sampling sites are located mainly along the river boundaries of the province, along National Route 12, bordering the Paraná River to the north and west, and Route 14 bordering the Uruguay River to the east. Not all districts within the province were sampled and no sampling records were found in the southwestern area.

A total of 15 species of Phlebotominae have been recorded: *Lutzomyia longipalpis* (Lutz & Neiva), *Ny. neivai*, *Migonemyia migonei* (França), *Cortelezii* Complex, *Pintomyia fischeri* (Pinto), *Pi. pessoai* (Coutinho & Barretto), *Pi. monticola* (Costa Lima), *Pi. misionensis* (Castro), *Micropygomyia quinquefer* (Dyar), *Ny. Whitmani* (Antunes and Coutinho), *Pa. bigeniculata*, *Brumptomyia avellari* (Costa Lima), *Br. gimaraesi* (Coutinho & Barretto),

Br. sp. y *Ev. correalimai* (Martins, Coutinho & Lutz) (Fig. 2). This latter species was captured for the first time in the city of Santo Tomé during the surveys in 2015, 2016 and 2017. The sites with the highest number of species records were Santo Tomé, Santa Tecla, Corrientes capital, San Cayetano-Riachuelo and San Cayetano. Santo Tomé and Corrientes capital are cities with little vegetation or patches of vegetation within the urban area. More than 10 samplings were carried out in these cities with different objectives and study methods, the first one taking place in the 1950s. On the other hand, Santa Tecla, San Cayetano-Riachuelo and San Cayetano are less urbanized, and even with rainforest areas with a high percentage of vegetation cover, and with up to four samplings each (Table I).

Human cases of Leishmaniasis and presence of vectors

Human cases of VL have been recorded in four cities of the province: Corrientes capital, Ituzaingó, Santo Tomé and Paso de los Libres (Fig. 3). In the first three cities there were records of *Lu. longipalpis*, while in Paso de los Libres, only *Ny. neivai* was found (Salomón et al., 2009a; Salomón et al., 2011).

Focal sampling associated with three cases of human VL has been carried out. The focal studies in Corrientes Capital (Araujo et al., 2015) and Santo Tomé confirmed the presence of the vector *Lu. longipalpis* and infected dogs in the surroundings of the detected human case (unpublished data). In contrast, in the study in Paso de los

Libres only infected dogs were found, but no presence of *Lu. longipalpis* (Blanco et al., 2014).

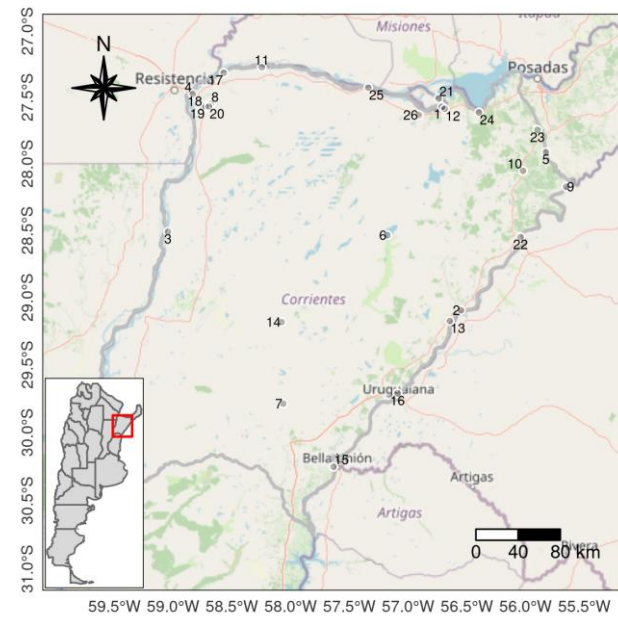


Fig. 1. Distribution of the 26 sampling sites. 1 Apipé, 2 Alvear, 3 Bella Vista, 4 Corrientes, 5 Colonia Liebig, 6 Colonia Pellegrini, 7 Curuzú Cuatiá, 8 Estación biológica de Corrientes, 9 Garruchos, 10 Gobernador Virasoro, 11 Itatí, 12 Ituzaingó, 13 La Cruz, 14 Mercedes, 15 Monte Caseros, 16 Paso de los Libres, 17 Paso de la Patria, 18 Riachuelo, 19 San Cayetano-Riachuelo, 20 San Cayetano, 21 San Antonio, 22 Santo Tomé, 23 San Carlos, 24 Santa Tecla, 25 Ita-Ibaté y 26 Villa Olivari. Base maps obtained from OpenStreetMap (<https://www.openstreetmap.org/>).

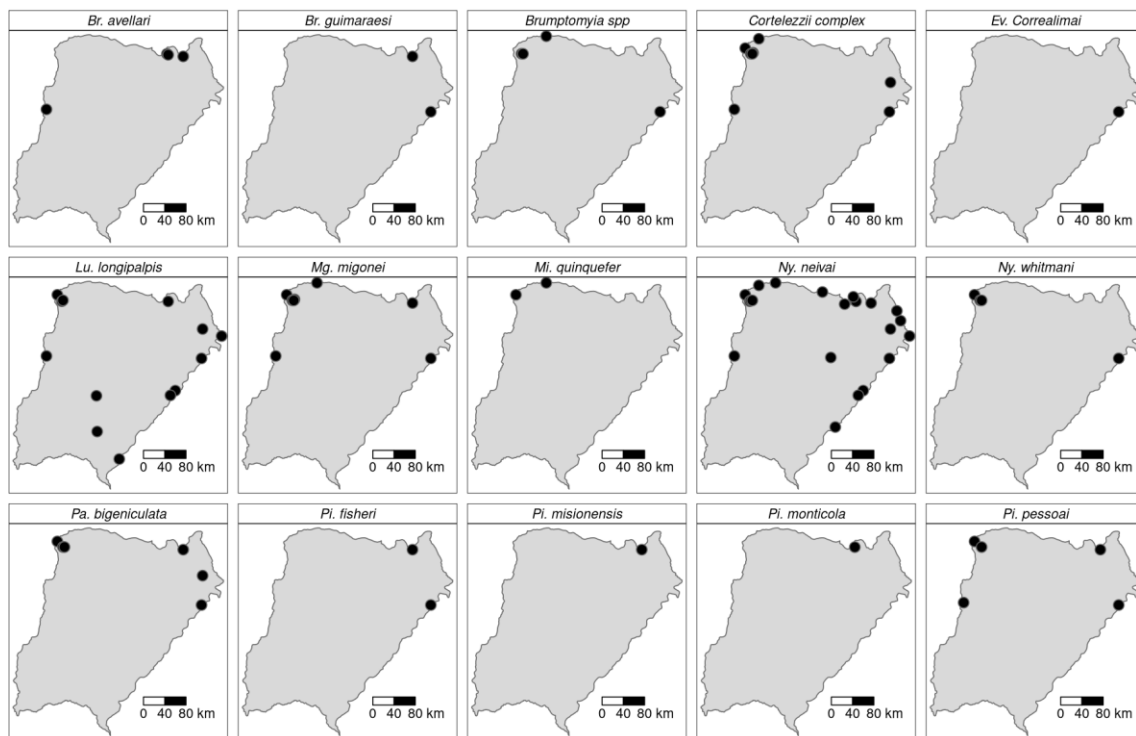


Fig. 2. Distribution of Phlebotominae species in the province of Corrientes. Each map shows the sites where the different species were recorded: *Br. avellari* 3 sites, *Br. guimaraesi* 2 sites, *Bryumptomyia sp* 3 sites, *Cortelezzi* Complex 8 sites, *Ev. correalimai* 1 site, *Lu. longipalpis* 13 sites, *Mg. migonei* 8 sites, *Mi. quinquefer* 2 sites, *Ny. neivai* 22 sites *Ny. whitmani* 4 sites, *Pa. bigeniculata* 6 sites, *Pi. fisheri* 2 sites, *Pi. misionensis* 1 site, *Pi. monticola* 1 site, *Pi. pessoai* 5 sites.

Table I. Phlebotominae reported in Corrientes province from 1951 to 2019 by species, locality, sampling year, and source of information (reference).

Species	Sampling sites	Sampling year	Reference
<i>Br. avellari</i>	Santa Tecla	1995, 1993-1998.	(Spinelli et al., 1999; Salomón et al., 2002)
	Ituzaingó	1996, 1993-1998	(Spinelli et al., 1999; Salomón et al., 2002)
	Bella Vista	2003	(Salomón et al., 2006a)
	Apipé	2008	(Salomón et al., 2009)
<i>Br. guimaraesi</i>	Santa Tecla	1994-1997, 1993-1998.	(Spinelli et al., 1999; Salomón et al., 2002)
	Santo Tomé	2014 y 2017	*
<i>Brumptomyia</i> sp.	Itatí	2010-2011	(Mierez et al., 2011)
	San Cayetano-Riachuelo	2011-2012	(Martínez et al., 2019)
	San Cayetano	2011-2012	(Martínez et al., 2019)
	Santo Tomé	2013	(Santini et al., 2015)
Cortezzi Complex	Corrientes	1992-1995, 1992-1996, 1992, n.d., 1994-2000, 2008, 2013, 2014-2016, 2012-2014.	(Borda et al., 1995, 1996, 1998a, 2002; Rosa et al., 2001; Salomón et al., 2009; Berrozpe et al., 2017, 2019; Martín et al., 2020)
	Paso de la Patria	2008	(Salomón et al., 2009)
	Santo Tomé	2010, 2013.	(Salomón et al., 2011; Santini et al., 2015)
	Bella Vista	2010	(Salomón et al., 2011)
	San Cayetano-Riachuelo	2011-2012	(Martínez et al., 2019)
	San Cayetano	2011-2012	(Martínez et al., 2019)
	Gobernador Virasoro	Salomón personal communication	(Salomón, 2008)
<i>Ev. correalimai</i>	Santo Tomé	2015, 2016 y 2017	*
<i>Lu. longipalpis</i>	Gobernador Virasoro	2008	(Salomón et al., 2009)
	Garruchos	2008	(Salomón et al., 2009)
	Ituzaingó	2008	(Salomón et al., 2009)
	Riachuelo	2008	(Salomón et al., 2009)
	Monte Caseros	2008, 2010	(Salomón et al., 2009, 2011)
	Santo Tomé	2008, 2010, 2013, n.d.	(Salomón et al., 2009; 2011; Santini et al., 2015; Pech-May et al., 2018)
	Corrientes	2008, 2010-2011, 2013, 2014-2016, n.d., 2012-2014	(Miérez & Borda, 2010; Salomón et al., 2009; Berrozpe et al., 2017, 2019; Pech-May et al., 2018; Martín et al., 2020)
	Alvear	2010	(Salomón et al., 2011)
	Bella Vista	2010	(Salomón et al., 2011)
	Curuzu Cuatiá	2010	(Salomón et al., 2011)
	La Cruz	2010	(Salomón et al., 2011)
	Mercedes	2011 y 2013	*
	San Cayetano-Riachuelo	2011-2012	(Martínez et al., 2019)
<i>Mg. migonei</i>	Corrientes	1992-1995, 1992-1996, 1992, n.d., 1994-2000 n.d., 2008, 2013, 2014-2016, 2012-2014.	(Borda et al., 1995, 1996, 1998a, 2002; Rosa et al., 2001, 2002; Salomón et al., 2009; Berrozpe et al., 2017, 2019; Martín et al., 2020)
	Santa Tecla	1993-1998	(Salomón et al., 2002)
	Bella Vista	2003, 2010	(Salomón et al., 2006a; 2011)
	Itatí	2006	(Borda et al., 2006)
	Santo Tomé	2008, 2010, 2013	(Salomón et al., 2009; 2011; Santini et al., 2015)
	Estación biológica Corrientes	2010	(Salomón et al., 2011)
	San cayetano-Riachuelo	2011-2012	(Martínez et al., 2019)
	San Cayetano	2011-2012	(Martínez et al., 2019)
<i>Mi. quinquefer</i>	Itatí	2010-2011	(Mierez et al., 2011)
	Corrientes	2013, 2014-2016.	(Berrozpe et al., 2017; 2019)
<i>Ny. neivai</i>	Corrientes	1926, n.d., n.d., 1992-1996, n.d., n.d., n.d., 1994-2000, 2008, 2013, 2014-2016, 2012-2014.	(Bejarano & Duret, 1950; Castro, 1959; Borda et al., 1995, 1996, 1998a, 2002; Spinelli et al., 1999; Rosa et al., 2001; Salomón et al., 2009; Berrozpe et al., 2017, 2019; Martín et al., 2020)
	Santo Tomé	1951, n.d., 2008, 2010, 2013.	(Duret, 1952; Castro, 1959; Salomón et al., 2009; 2011; Santini et al., 2015)
	Colonia Pellegrini	1951, n.d., 2011	(Duret, 1952; Castro, 1959; *)
	Apipé	1951, 2008	(Duret, 1952; Salomón et al., 2009).
	San Antonio	n.d.	(Castro, 1959)
	Santa Tecla	1993-1998	(Salomón et al., 2002)
	Ituzaingó	1993-1998, 2008	(Salomón et al., 2002; 2009)
	Ita-Ibaté	1993-1998	(Salomón et al., 2002)
	Villa Olivari	1993-1998	(Salomón et al., 2002)
	Bella Vista	1998, 2003, 2010	(Borda et al., 1998b; Salomón et al., 2006a; 2011)
	Itatí	2006	(Borda et al., 2006; Mierez et al., 2011)
	Gobernador Virasoro	Salomón personal communication	(Salomón et al., 2006a, Salomón, 2008)
	Paso de la Patria	2008	(Salomón et al., 2009)
	Garruchos	2008	(Salomón et al., 2009)
Colonia Liebig	2008	(Salomón et al., 2009)	

Table I (cont.). Phlebotominae reported in Corrientes province from 1951 to 2019 by species, locality, sampling year, and source of information (reference).

	San Carlos	2008	(Salomón et al., 2009)
	Alvear	2010	(Salomón et al., 2011)
	Estación biológica Corrientes	2010	(Salomón et al., 2011)
	La Cruz	2010	(Salomón et al., 2011)
	Paso de los libres	2010	(Salomón et al., 2011)
	Riachuelo	2011-2012	(Martínez et al., 2019)
	San Cayetano-Riachuelo	2011-2012	(Martínez et al., 2019)
	San Cayetano	2011-2013	(Martínez et al., 2019)
<i>Ny. whitmani</i>	San Cayetano-Riachuelo	2011-2012	(Martínez et al., 2019)
	San Cayetano	2011-2012	(Martínez et al., 2019)
	Corrientes	2012-2014	(Martín et al., 2020)
	Santo Tomé	2013	(Santini et al., 2015)
<i>Pa. bigeniculata</i>	Corrientes	1992, n.d., 1994-2000, 2012-2014	(Borda et al., 1998a, 2002; Rosa et al 2001; Martin et al., 2020)
	Santa Tecla	1993-1998	(Salomón et al., 2002)
	San Cayetano-Riachuelo	2011-2012	(Martínez et al., 2019)
	San Cayetano	2011-2012	(Martínez et al., 2019)
	Gobernador Virasoro	Salomón personal communication	(Salomón, 2008)
	Santo Tomé	Febrero 2019	*
<i>Pi. fischeri</i>	Santa Tecla	1997, 1993-1998	(Spinelli et al., 1999; Salomón et al., 2002)
	Santo Tomé	Febrero 2019	*
<i>Pi. misionensis</i>	Santa Tecla	1993-1998	(Salomón et al., 2002)
<i>Pi. monticola</i>	Apipé	2008	(Salomón et al., 2009)
<i>Pi. pessoai</i>	Santa Tecla	1993-1998	(Salomón et al., 2002)
	Corrientes	1992, 1994-2000	(Borda et al 1998, 2002)
	Bella Vista	2003	(Salomón et al., 2006a)
	Santo Tomé	2010	(Salomón et al., 2011)
	San Cayetano	2011-2012	(Martínez et al., 2019)

*unpublished captures; n.d: undefined.

Regarding positive sites for human CL reports, co-occurrence of human cases and presence of *Ny. neivai* have been recorded in Apipé, Corrientes, Bella Vista, Itatí, Riachuelo, Santo Tomé, Villa Olivari and Paso de la Patria (Borda et al., 2006; Salomón et al., 2002; 2006a; 2009;

Martínez et al., 2019), human cases without vector presence were only recorded in Mercedes while no Phlebotominae samplings were carried out in the remaining eight localities with human cases (Fig. 3).

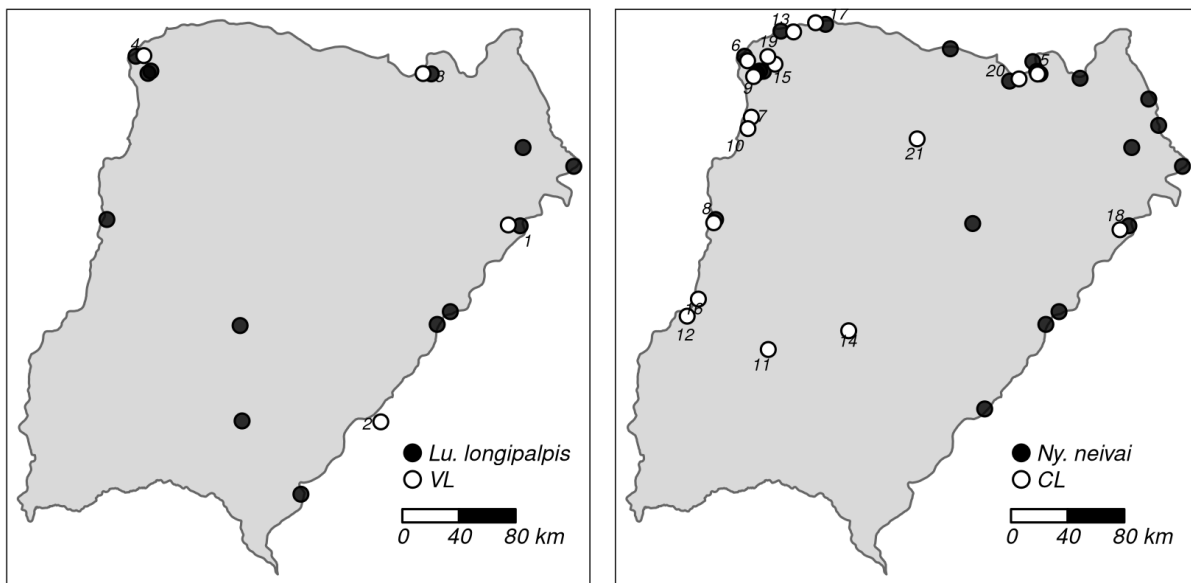


Fig. 3. Distribution of human cases of VL and CL reported by the Sistema Nacional de Vigilancia en Salud (SNVS) and sites where *Lu. longipalpis* and *Ny. neivai* were found. Cities with human VL cases are indicated as follows: 1 Santo Tomé, 2 Paso de los Libres, 3 Ituzaingó, and 4 Corrientes. Cities with human CL cases are: 5 Apipé, 6 Corrientes, 7 Manuel Derqui, 8 Bella Vista, 9 Riachuelo, 10 Empedrado, 11 Peruggoria, 12 Goya, 13 Paso de la Patria, 14 Mercedes, 15 San Luis del Palmar, 16 Santa Lucía, 17 Itatí, 18 Santo Tomé, 19 Santa Ana, 20 Villa Olivari, 21 San Miguel.

New records for Corrientes province

Evandromyia correalimai (Martins, Coutinho & Lutz) Corrientes province, Santo Tomé City 1 ♀ (Lat: -28.551079°, Long: -56.029922°) 11-III-2015; 1 ♀ (Lat: -28.546722°, Long: -56.033361°) 19-IV-2016, 3 ♀ (Lat: -28.541965°, Long: -56.032168°) 18-IX-2017, 20-IX-2017 and 15-XI-2017; collected by Villarquide, María Lucrecia. Captures are available at Fundacion Barcelo. All individuals were captured in henhouses surrounded by vegetation, at 315 m, 470 m and 240 m approximately from the Uruguay River. These dwellings are located on the edge of the city, adjacent to the river containment vegetation. All sites had chickens and dogs. *Distribution.* The only previous record for the country was in Puerto Iguazú, within few meters from the Parana river (Fernández et al., 2020), 440 km from Salto Tomé, on the Uruguay river.

The present study reported 15 Phlebotominae species in the province of Corrientes out of the 46 recorded in Argentina (Moya et al., 2021), with most of the reports distributed in the north and east of the province. Samplings were distributed throughout the peripheral area of the province, generally in cities of high population density that are located on or a few km apart from national routes 12 and 14. Towards the center of the province there are few samples and the cities have generally low population density. *Lutzomyia longipalpis* was found in 13 cities located mainly on the periphery of the province and the distribution of *Ny. neivai* was observed in 22 cities mainly in the north and east. However, the 17 cities with reported CL cases were mainly distributed in the west and southwest.

The greater number of phlebotominae species recorded in localities such as Corrientes and Santo Tomé, could be related to a greater probability of collecting species usually found in low abundances, due to the greater number of studies, and the greater number of sites sampled in these cities. Consistently, the occurrence of species such as *Mi. quinquefer*, *Ps. bigeniculata*, Cortelezzii complex, *Pi. pessoai*, *Ny. neivai*, *Ny. whitmani* and *Mg. migonei* in urbanized environments, could be related to peri-urban areas or intra-urban vegetation patches, since these species are favored by both anthropic modifications and arboreal vegetation as it was observed in previous studies in the province of Corrientes (Santini et al., 2015; Berrozpe et al., 2019; Martínez et al., 2019). A study carried out in Brazil, which assessed the presence of species in urban, transition and rainforest areas, found also the greatest species diversity in the transition zone (de Castilho Sanguinette et al., 2015). This increase in diversity in transitional areas could explain why species such as *Pi. misionensis* and *Pi. monticola* are found so far only in Santa Tecla and Apipe, sites with mixed environmental characteristics such as high vegetation coverage intermingled with domestic areas of human low density.

The cities with CL risk have been associated with environmental heterogeneity and edges with secondary vegetation, especially in small cities (Salomón et al., 2006a). The distribution of recorded CL cases could be associated with the latter condition, given that most of the cities with human CL are small or with large areas or riparian forest. However, although the sites where the vector and cases were recorded coincide, it is not possible to state that the site of the reporting is the same as the transmission site, as only the residence or place of diagnosis is the usually recorded data. Meanwhile, the place of transmission may be even in localities far away of the residence related to recreational or work activities within areas of wild vegetation (e.g., fishing, hunting, or forest clearing work), where the vectors involved in transmission are generally found (Salomón, 2019). In order to evaluate the possible sites of transmission and predict the appearance of new cases, it is important to record and detect new vector-competent species in time, for which vector surveillance and knowledge of the species present are essential.

Visceral leishmaniasis is the most severe form of the disease and can be fatal if not diagnosed or inadequately treated. During 2018, the case fatality rate of VL reached 8% for the Americas (OPS 2019). In the records collected for this study, only 4 cities in the province of Corrientes showed cases of VL. In the focal study conducted in the city of Paso de los Libres in response to the human case of VL, infected dogs were found, but no sandflies were detected, probably due to unfavorable weather conditions at the time of sampling. However, previous studies had detected the presence of *Ny. neivai*, and the epidemiological interview did not indicate whether the patient had traveled to other localities prior to symptoms manifestation (Blanco et al., 2014; Salomón et al., 2011). Likewise, the presence of *Lu. longipalpis* could not be ruled out.

The new record in the province, *Ev. correalimai*, though it is not of sanitary importance, contributes to increase the specific richness, in addition to its importance for being the second record for Argentina. *Ev. correalimai* was first recorded in Puerto Iguazú, Misiones, in protected areas (Iguazú National Park) and forest patches (Fernández et al., 2020). In Santo Tomé, the new record reported here, *Ev. correalimai* was captured in two sites located on the edge of riparian and secondary vegetation, inside henhouses.

This compilation of vector species records and cases of leishmaniasis allowed us to identify spatial gaps in information, especially in the southwestern area of the province of Corrientes. In general, the studies carried out in the province were motivated by epidemic outbreaks, while others were aimed at evaluating the presence or dispersal of *Lu. longipalpis* or *Ny. neivai* given their implication in the transmission of leishmaniasis (Salomón et al., 2002, 2006a, 2009, 2011). The last distribution

study about *Lu. longipalpis* in the province was in 2010 and did not cover all the main cities of the province (Salomón et al., 2011). It is highly likely then, that the species could be present in more cities. Likewise, in places where only *Lu. longipalpis* was recorded in the south, other species might be found if further studies were carried out, especially, taking into account that in the province of Entre Ríos to the south of Corrientes a profile of five species was found, including *Ny. neivai* and *Ny. whitmani*. Hence, these species could be present having not been recorded in southern Corrientes. They could even be implicated in some of the CL cases in the 8 positive cities where Phlebotominae sandflies were not sampled (Salomón et al., 2006b; Gould et al., 2013; Santini et al., 2018).

In conclusion, the record of 15 Phlebotominae species places Corrientes as the third province in terms of specific richness for Argentina, after the provinces of Misiones and Chaco. Most of the species are found in the north. Meanwhile, the variety of environments in the province suggests that there may still be more species that have not been recorded yet. Regarding the distribution of CL cases, they are mainly found along the coast of Paraná River, while VL cases, according to their date of occurrence, seem to be moving southward along the coast of Uruguay River. Although confirmation of the site of infection depends on both, reliable information from epidemiological interviews and the movement of individuals to areas of transmission, the number of sites with human cases in areas with no vector records calls for more vector studies. This would complement the information compiled here and would allow to contribute to the design of strategies and allocation of resources for operational research, control and sanitation policies to address the problem of leishmaniasis.

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LITERATURE CITED

- Acosta-Soto, L., Encinas E.S., Deschutter, E.J., Pasetto, R.A.L., Petri-De-Odriozola, E.M.A., Bornay-Llinares, F.J., & Ramos-Rincón, J.M. (2020) Autochthonous outbreak of Cutaneous Leishmaniasis due to *Leishmania infantum* in Corrientes Province, Argentina. *American Journal of Tropical Medicine and Hygiene*, **102(3)**, 593-597. <https://doi.org/10.4269/ajtmh.19-0527>
- Andrade Filho, J.D., Bianchi Galati, E.A., & Falcão, A.L. (2003). Redescription of *Nyssomyia intermedia* (Lutz & Neiva, 1912) and *Nyssomyia neivai* (Pinto, 1926) (Diptera: Psychodidae). *Memorias Do Instituto Oswaldo Cruz*, **98(8)**, 1059-1065. <https://doi.org/10.1590/S0074-02762003000800015>
- Araujo, A.V., Benítez Ibaló, P.I., Berrozpe, P., Gómez Ancarani, F.E., Oscherov, E.B., & Salomón, O.D. (2015) Estudio de foco ante un caso de Leishmaniasis Visceral humana en la capital de la provincia de Corrientes, Argentina. *VII Congreso Argentino de Parasitología*, **7**, 123 (ISBN 978-987-46069-1-4).
- Bejarano, J., & Duret J. (1950) Contribución al conocimiento de los flebótomos argentinos (Diptera, Psychodidae). *Revista Sanidad Militar Argentina*, **49**, 327-336.
- Berrozpe, P., Lamattina, D., Santini, M.S., Araujo, A.V., Utgés, M.E., & Salomón, O.D. (2017) Environmental suitability for *Lutzomyia longipalpis* in a subtropical city with a recently established visceral leishmaniasis transmission cycle, Argentina. *Memorias Do Instituto Oswaldo Cruz*, **112(10)**, 674-680. <https://doi.org/10.1590/0074-02760170056>
- Berrozpe, P.E., Lamattina, D., Santini, M.S., Araujo, A.V., Torrusio, S.E., & Salomón, O.D. (2019). Spatiotemporal dynamics of *Lutzomyia longipalpis* and macro-habitat characterization using satellite images in a leishmaniasis-endemic city in Argentina. *Medical and Veterinary Entomology*, **33(1)**, 89-98. <https://doi.org/10.1111/mve.12334>
- Blanco, J., Ferro, N., Gould, I., Casas, N., & Salomón, O. (2014) Estudio de foco ante el primer caso humano de leishmaniasis visceral en Paso de los Libres, provincia de Corrientes. Diciembre de 2013. *Revista Argentina de Zoonosis y Enfermedades Infecciosas Emergentes*, **9**, 53 (ISSN: 1851-3638).
- Borda, C., Rosa, J., Rea, M., & Mosqueda, L. (1995) Variación de poblaciones de transmisores de leishmaniasis según estación lunar. *Parasitología al día. Revista Sociedad Chilena Parasitología*, **(19)**, 249.
- Borda, C., Rosa, J., Rea, M., & Mosqueda, L. (1996) Poblaciones de especies de *Lutzomyia* de acuerdo al clima y fases de la luna Corrientes Argentina. *Reunión de Comunicaciones Científicas y Tecnológicas. UNNE.*, 143-146.
- Borda, C.E., Rea, M.J., Rosa, J.R., Mosqueda, L.A., & Gené, C.M. (1998a) Investigaciones sobre leishmaniasis en la Provincia de Corrientes. *Zoonosis y Enfermedades Emergentes* (ed. Seijo, A., C., Larghi, O., P., Espinosa, M., O., Rivas, M. & Sabattini, M.), pp 193-198. Asociación Argentina de Zoonosis, Buenos Aires.
- Borda, C., Rea, M., Rosa, J., & Mosqueda, L. (1998b) Foco de Leishmaniasis Cutánea y Mucocutánea en Bella Vista, Provincia de Corrientes, Argentina. *XVI Reunión Científica Anual, Sociedad Argentina Protozoología y Enfermedades Parasitarias*, 41.
- Borda, C., Rea, M., & Rosa, J. (2002). Urbanization of the human leishmaniasis in the Northeast of the Argentina. International Symposium on Phlebotomine Sand Fly, ISOPS 4. *Entomological Vectors*, **9(1)**, 56.
- Borda, C.E., Ramirez Farías, M.R., & Rea, M.F. (2006) Flebótomos de áreas endémicas de Leishmaniasis Tegumentaria Americana (LTA) en Corrientes, Argentina. *Reunión de Comunicaciones Científicas y Tecnológicas-UNNE.*, 4-7.

- Castro, M. (1959). Diptera. Psychodidae-Flebotominae. *Primeras Jornadas Entoepidemiológicas Argentinas* (ed. Bejarano, J., R., F., Del Ponte E. & Orfila, R., N.) pp. 545–546. La Prensa Médica, Buenos Aires
- de Castilho Sanguinette, C., Da Silva, D.F., Stumpp, R.G.A.V., Rego, F.D., Tonelli, G.B., Tanure, A., Gontijo, C.M.F., & Andrade Filho, J.D. (2015) Comparison of the phlebotomine (Diptera: Psychodidae) fauna of urban, transitional, and wild areas in northern Minas Gerais, Brazil. *Parasites & Vectors*, **8(1)**, 1-8. <https://doi.org/10.1186/s13071-015-1003-2>
- Duret, J.P. (1952) Notas sobre flebotomos argentinos. *Revista Sanidad Militar Argentina*, **51**, 534-536.
- Fernández, M.S., Martínez, M.F., Pérez, A.A., Santini, M.S., Gould, I.T., & Salomón, O.D. (2015) Performance of light-emitting diode traps for collecting sand flies in entomological surveys in Argentina. *Journal of Vector Ecology*, **40(2)**, 373-378. <https://doi.org/10.1111/jvec.12176>
- Fernández, M.S., Manteca-Acosta, M., Cueto, G.R., Cavia, R., & Salomón, O.D. (2020) Variation of the phlebotominae (Diptera: Psychodidae: Phlebotominae) assemblage in response to land use changes in an endemic area of leishmania transmission in northeast Argentina. *Journal of Medical Entomology*, **57(6)**, 1735-1747. <https://doi.org/10.1093/jme/tjaa090>
- Galati, E.A.B. (2018). Morfologia e terminologia de Phlebotominae (Diptera: Psychodidae). Classificação e identificação de táxons das Américas. Apostila da Disciplina Bioecologia e Identificação de Phlebotominae do Programa de Pós-Graduação em Saúde Pública. Faculdade de Saúde Pública da Universidade de São Paulo, São Paulo Vol 1 132p. <http://www.fsp.usp.br/~egalati/>
- Gould, I., Perner, M., Santini, M., Saavedra, S., Bezzi, G., Maglianese, M., Antman, J., Gutierrez, J., & Salomón, O.D. (2013). Leishmaniasis Visceral en Argentina. Notificación y Situación Vectorial (2006-2012). *Medicina (Buenos Aires)*, **73(2)**, 104-110.
- INDEC (Instituto Nacional de Estadística y Censos) (2010) National Census data. Argentina. <http://www.censo2010.indec.gov.ar/resultadosdefinitivos.asp>
- Maroli, M., Feliciangeli, M.D., Bichaud, L., Charrel, R.N., & Gradoni, L. (2013) Phlebotomine sandflies and the spreading of leishmaniasis and other diseases of public health concern. *Medical and Veterinary Entomology*, **27(2)**, 123-147. <https://doi.org/10.1111/j.1365-2915.2012.01034.x>
- Martín, M.E., Stein, M., Willener, J.A., Kuruc, J.A., & Estallo, E.L. (2020) Landscape effects on the abundance of *Lutzomyia longipalpis* and *Migonemyia migonei* (Diptera: Psychodidae: Phlebotominae) in Corrientes city, northern Argentina. *Acta Tropica*, **210**, 105576. <https://doi.org/10.1016/j.actatropica.2020.105576>
- Martínez, M.F., Santini, M.S., Kowalewski, M.M., & Salomón, O.D. (2019) Phlebotominae in peri-domestic and forest environments inhabited by *Alouatta caraya* in northeastern Argentina. *Medical and Veterinary Entomology*, **33(3)**, 367-374. <https://doi.org/10.1111/mve.12375>
- Martínez, M.F., Kowalewski, M.M., Giuliani, M.G., Acardi, S.A., & Salomón, O.D. (2020) Molecular identification of Leishmania in free-ranging black and gold howler monkeys (*Alouatta caraya*) in northeastern Argentina. *Acta Tropica*, **210**, 105534. <https://doi.org/10.1016/j.actatropica.2020.105534>
- Miérrez, M. & Borda, C. (2010) Situación de la Leishmaniasis Visceral Americana en la ciudad de Corrientes, Argentina. Anuario becas de Investigación Ramón Carrillo Arturo Oñativia Anuario 2010. *Buenos Aires Salud Investiga-Ministerio de Salud de La Nación*, **(1)**, 39.
- Mierez, M.L., Rea, M.J.F., Borda, C.E., Mosqueda, L.A. (2011) Studies of Phlebotominae sand flies in a zone of forest in Province of Corrientes northern of Argentina. International Symposium on Phlebotomine Sand Fly. ISOPS, 7, 197–199.
- Moya, S.L., Szelag, E.A., Manteca-Acosta, M., Quintana, M.G., & Salomón, O.D. (2021) Update of the Phlebotominae Fauna with New Records for Argentina and Observations on Leishmaniasis Transmission Scenarios at a Regional Scale. *Neotropical Entomology*, **51**, 311-323. <https://doi.org/10.1007/s13744-021-00934-7>
- NMS (National Meteorological Service) (2018) 1981–2010 <http://www.smn.gov.ar>
- Organización Panamericana de la Salud (OPS) (2019) Leishmaniasis Informe Epidemiológico de las Américas. Washington, D.C. Nº 8. Accessed on: 2020-8-17. <https://iris.paho.org/handle/10665.2/51739>
- Pech-May, A., Ramsey, J.M., González Ittig, R.E., Giuliani, M., Berrozpe, P., Quintana, M.G., & Salomón, O.D. (2018) Genetic diversity, phylogeography and molecular clock of the *Lutzomyia longipalpis* complex (Diptera: Psychodidae). *PLoS Neglected Tropical Diseases*, **12(7)**, 1-23. <https://doi.org/10.1371/journal.pntd.0006614>
- Rosa, J., Rea, M., & Borda, C. (2001) Sand flies fauna in the city of Corrientes, Argentina. Word Congress on Leishmaniasis. Wordleish 2. *Trend Parasitology*, **17(9)**, 123
- Rosa, J., Rea, M., & Borda, C. (2002) Biology of *Lutzomyia migonei* vector of the Cutaneous Leishmaniasis in northeast of Argentina. International Symposium on Phlebotomine Sand Fly, ISOPS 4. *Entomological Vectors*, **9(1)**, 169.
- Sábio, P.B., Andrade, A.J., & Galati, E.A.B. (2014) Assessment of the taxonomic status of some species included in the shannoni complex, with the description of a new species of *Psathyromyia* (Diptera: Psychodidae: Phlebotominae). *Journal of Medical Entomology*, **51(2)**, 331-341. <https://doi.org/10.1603/ME13153>
- Salomón, O.D. (2008) Psychodidae. *Biodiversidad de Artrópodos argentinos*, 2 (ed. Claps, L., E., Debandi, G., & Roig-Juñent, S.) pp. 253-270. SEA Ediciones, Mendoza.
- Salomón, O.D., Rossi, G.C., & Spinelli, G.R. (2002) Ecological aspects of phlebotomine (Diptera, Psychodidae) in an endemic area of Tegumentary Leishmaniasis in the Northeastern Argentina, 1993-1998. *Memorias Do Instituto Oswaldo Cruz*, **97(2)**, 163-168. <https://doi.org/10.1590/S0074-02762002000200003>

- Salomón, O.D., Sosa-Estani, S., Ramos, K., Orellano, P.W., Sanguesa, G., Fernández, G., Sinagra, A., & Rapascioli, G. (2006a) Tegumentary leishmaniasis outbreak in Bella Vista City, Corrientes, Argentina during 2003. *Memorias Do Instituto Oswaldo Cruz*, **101(7)**, 767-774. <https://doi.org/10.1590/S0074-02762006000700010>
- Salomón, O.D., Mocarbel, N.J., Pedroni, E., Colombo, J., & Sandillú, M. (2006b) Phlebotominae: Vectores de leishmaniasis en las provincias de Santa Fe y Entre Ríos, Argentina. *Medicina*, **66(3)**, 220-224.
- Salomón, O.D., Sinagra, A., Nevot, M.C., Barberian, G., Paulin, P., Estevez, J.O., Riarte, A., & Estevez, J. (2008a) First visceral leishmaniasis focus in Argentina. *Memorias Do Instituto Oswaldo Cruz*, **103(1)**, 109-111. <https://doi.org/10.1590/S0074-02762008000100018>
- Salomón, O.D., Quintana, M.G., & Rosa, J. (2008b) Ecoepidemiología de la leishmaniasis cutánea en la Argentina. *Sociedad Iberoamericana de Información Científica (SIIC)*, **16(i)**, 514-520.
- Salomón, O.D., Ramos, L.K., Quintana, M.G., Acardi, S., Santini, M.S., & Schneider, A. (2009) Distribution of vectors of Visceral Leishmaniasis in the Province of Corrientes, 2008. *Medicina (Buenos Aires)*, **69(6)**, 625-630.
- Salomón, O.D., Fernandez, M.S., Santini, M.S., Saavedra, S., Montiel, N., Ramos, M.A., Rosa, J.R., Szelag, E.A., & Martínez, M.F. (2011) Distribution of *Lutzomyia longipalpis* in the Argentine Mesopotamia, 2010. *Medicina (Buenos Aires)*, **71(1)**, 22-26.
- Salomón, O.D. (2019) Instructions on how make an Outbreak of American Cutaneous Leishmaniasis. *Journal of Tropical Medicine and Health*, **3(2)**, 146. <https://doi.org/10.29011/2688-6383.000146>
- Santini, M.S., Utgés, M.E., Berrozpe, P., Acosta, M.M., Casas, N., Heuer, P., & Salomón, O.D. (2015) *Lutzomyia longipalpis* presence and abundance distribution at different microspatial scales in an urban scenario. *PLoS Neglected Tropical Diseases*, **9(8)**, 1-16. <https://doi.org/10.1371/journal.pntd.0003951>
- Santini, M.S., Acosta, M.M., Utgés, M.E., Aldaz, M.E., & Salomón, O.D. (2018) Presence of *Lutzomyia longipalpis* and *Nyssomyia whitmani* in Entre Ríos, Argentina. *Revista Do Instituto de Medicina Tropical de Sao Paulo*, **60**, 2-5. <https://doi.org/10.1590/S1678-9946201860055>
- Spinelli, G.R., Rossi, G.C., & Rodríguez, E.A. (1999) Further notes on Phlebotominae from Argentina (Diptera: Psychodidae). *Revista de La Sociedad Entomológica Argentina*, **58(3-4)**, 197-200.
- Szelag, E.A., Andrade Filho, J.D., Rosa, J.R., Parras, M.A., Stein, M., Quintana, M.G., & Salomón, O.D. (2016) Argentinian phlebotomine fauna, new records of Phlebotominae (Diptera: Psychodidae) for the country and the province of Chaco. *Zootaxa*, **4139(3)**, 427-430. <https://doi.org/10.11646/zootaxa.4139.3.8>
- Szelag, E.A., Rosa, J.R., Galati, E.A.B., Filho, J.D.A., & Salomón, O.D. (2018) Considerations on the species complex of the Cortelezzii series (Diptera: Psychodidae) and description of *Evandromyia chacuensis* sp. nov., a new phlebotomine species of the Chaco Region, Argentina. *Journal of Medical Entomology*, **55(4)**, 902-909. <https://doi.org/10.1093/jme/tjy039>