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Sisyridae (Insecta, Neuroptera) of the Estação Ecológica de Jataí, in southeastern Brazil and new records for species of *Climacia* McLachlan, 1869 and Sisyra Burmeister, 1839

ROGÉRIA I.R. LARA & NELSON W. PERIOTO

Abstract: This study characterizes the diversity of Sisyridae in an area of riparian forest (21°36'47"S; 47°49'4"W) at the Estação Ecológica de Jataí, in the municipality of Luiz Antônio, State of São Paulo, Brazil. The geographic ranges of *Climacia carpenteri* Parfin & Gurney, 1956 and *Sisyra panama* Parfin & Gurney, 1956 are expanded to include the State of São Paulo.

Key words: Climaciinae, Neotropical region, riparian forest, Sisyrinae, spongilla-flies.

INTRODUCTION

Sisyridae (Neuroptera, Osmyloidea), the only family with exclusively aquatic larvae (Tauber et al. 2009), is a cosmopolitan clade popularly known as spongilla-flies. Their larvae are associated with colonies of freshwater sponges (Porifera, Haplosclerida, Spongillidae) or with colonies of Bryozoa which they feed on (Penny 1981, Weissmair & Waringer 1994, Notteghem 2016), while the adults have been found in riparian forest areas, especially in shrubs overhanging the water, where they seek food such as pollen, honeydew and aphids, among others (Kokubu & Duelli 1983, Pupedis 1987, Notteghem 2016). Notteghem (2016) reported the predation of *Pectinatella magnifica* (Leidy, 1851) (Plumatellida, Pectinatellidae) and *Cristatella mucedo* (Cuvier, 1798) (Plumatellida, Cristatellidae) by larvae of *Sisyra nigra* (Retzius, 1783) (Neuroptera, Sisyridae) that regularly sank their mouthparts inside the zooecium during their movements on the surface of the colonies of bryozoan.

About 80 extant species of Sisyridae are known, distributed among four genera: *Climacia* McLachlan, 1869 (Nearctic and Neotropical), *Sisyborina* Monserrat, 1981 (Africa), *Sisyra* Burmeister, 1839 (cosmopolitan) and *Sisyrina* Banks, 1939 (Africa, Asia and Australia) (Cover & Resh 2008, Oswald 2019). The Neotropical fauna of sisyrids includes 24 species of *Climacia*, of which 15 are known from Brazil, and five species of *Sisyra*, all known from Brazil (Machado & Martins 2023, Assmar et al. 2022, Assmar 2022).

The knowledge about the biology, ecology, and distribution of the Brazilian species of Sisyridae is still very limited and most studies about spongilla-flies are restricted to the Amazon region (Penny 1981, Flint 1998, 2006, Hamada et al. 2014a, Bowles 2015, Assmar & Salles 2017).

The aims of the study were to characterize the diversity of Sisyridae collected in an area of riparian vegetation within the Brazilian Savannah domain located in the northeast of the State of São Paulo and to report new distributional records for *Climacia carpenteri*

Parfin & Gurney, 1956 and *Sisyra panama* Parfin & Gurney, 1956. Figures and a map with the geographical distribution of the studied species are also provided.

MATERIALS AND METHODS

Sisyridae specimens were collected with two light traps built according to Szentkirályi (2002). These traps were operated in an area of riparian vegetation (21°36′47″S; 47°49′4″W, ca 532 m above sea level) near a marginal lagoon of the Mogi Guaçu River, at the Estação Ecológica de Jataí, in Luiz Antônio municipality, State of São Paulo, Brazil (Fig. 1). The Mogi Guaçu River is part of the Upper Paraná River System, which covers in Brazil area about 900,000 km2, approximately 10% of the Brazilian territory, distributed among the states of São Paulo, Paraná, Mato Grosso do Sul, Minas Gerais, Goiás, Santa Catarina and Distrito Federal. This area includes the entire drainage of the Paraná River upstream of the Sete Quedas Falls, today flooded by the Itaipu Dam reservoir (Langeani et al. 2007, Deprá et al. 2015, ANA 2019). The climate according Köpen and Geiger is Cwa type (tropical with wet summers and dry winters) with total annual rainfall of 1,429 mm being primarily concentrated between November and April and, the mean annual temperature for this region is 21.2 °C (CLIMATE-DATA.ORG 2019).

Two light traps equipped with 250 W mercury vapor lamps were separated from each other by about 100 m and fixed in trees inside the forest, approximately 2 m from the ground. The lights were controlled by electronic timers coupled to an electromechanical contactor so that the traps remained active from dusk to dawn. Traps were operated on Mondays, Wednesdays, and Fridays between November 2007 and November 2009. In the traps, a 5% formalin solution and neutral liquid soap were used as preservative. The captured specimens were sent to the Laboratório de Sistemática e Bioecologia de Predadores e Parasitoides of the Instituto Biológico, in Ribeirão Preto, State of São Paulo, Brazil, where were identified and stored in plastic vials with ETOH 95%.

Observations were made under magnification using stereo and optical microscopes (Leica MZ9.5, Leica Microsystems, Switzerland and Leica DM500, Leica). The color

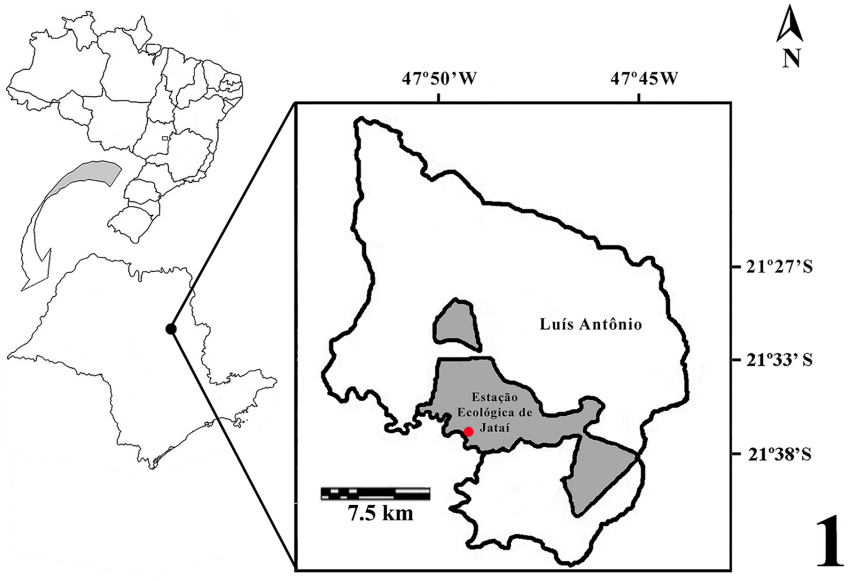


Figure 1. Map of Brazil showing State of São Paulo; in detail the municipality of Luiz Antônio and, in gray, the Estação Ecológica de Jataí. The red spot indicates the collection location of the spongilla-flies (Neuroptera, Sisyridae) species.

images were obtained with a digital camera (Leica DFC295, Leica) attached to a stereomicroscope (Leica M205C APO, Leica) as well as to an optical microscope (Leica DM500, Leica). Serial images from different layers were combined with Helicon Focus software (v. 5.3) and figures were prepared using Adobe Photoshop software (v. 11.0).

Terminalia were separated from the rest of the abdomens, cleared in a 10% KOH (potassium hydroxide) solution for about 15 min and, transferred for one hour to a 10% $C_2H_4O_2$ (acetic acid) solution to neutralize the KOH. The cleared terminalia were stored in glycerin in glass microvials, which were placed inside the same plastic vials of the respective specimens.

All studied specimens were identified by the first author using the keys provided by Parfin & Gurney (1956), Penny (1981), Flint (1998) and Assmar & Salles (2017). The morphological terms were based on Aspöck & Aspöck (2008) and Winterton & Wang (2016).

Collecting sites indicated on maps are based on Parfin & Gurney (1956), Penny (1981), Gonzalez Olazo (1983), Flint (1998, 2006), Monserrat (2005), Hamada et al. (2014b, 2015), Bowles (2015), Assmar & Salles (2017), Machado & Martins (2023) and Oswald (2019).

The voucher specimens examined in this study, 154 specimens of *C. carpenteri* (LRRP LOTE# 17), and five of *S. panama* (LRRP LOTE# 18), were preserved in wet collection under refrigeration and, deposited in the Coleção Entomológica of the Laboratório de Sistemática e Bioecologia de Predadores e Parasitoides of the Instituto Biológico (LRRP) (Ribeirão Preto, SP, Brazil).

All collections were done under SISBIO license #16473-1.

RESULTS

Were captured 154 specimens of *C. carpenteri* (Figs. 2–6), being 80 females, 65 males, and nine without abdomen (51.9 %, 42.2 % and, 5.8 %, respectively) and, five specimens of *S. panama* (Figs. 7–12), being two females, two males, and one without abdomen (40.0 %, 40.0 % and, 20.0 %, respectively) (Table I, Fig. 13).

The sex ratio (male:female) of *C. carpenteri* was 0.81:1.00. Males and females of this species had similar population fluctuations during the year, except between November and December, when fewer males were recorded. It is plausible to assume that their flight activities are concomitant in the studied area (Fig. 14).

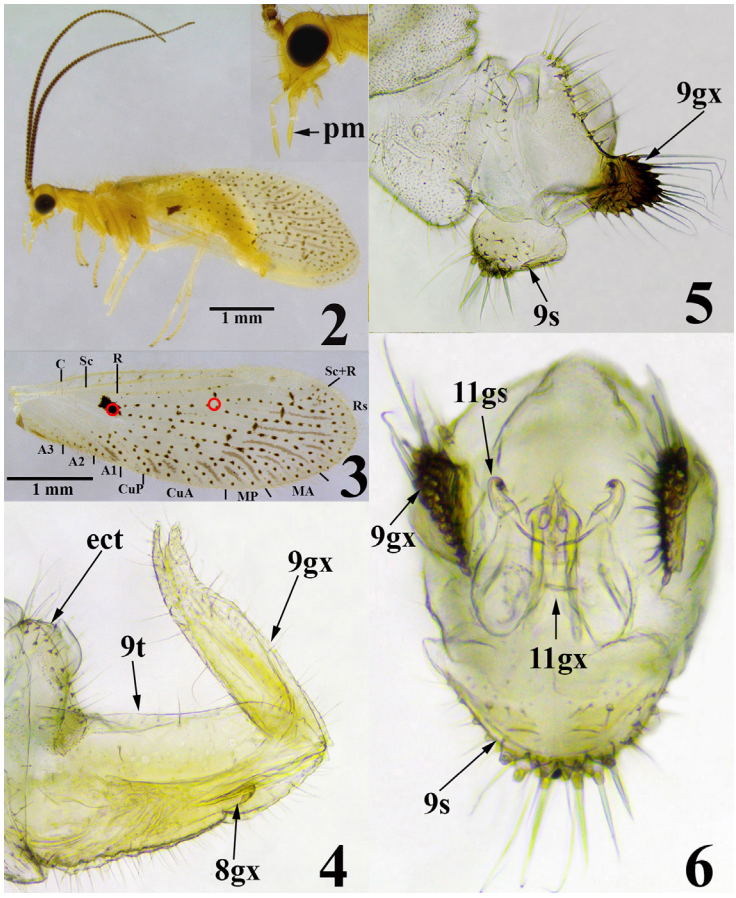
Sisyra panama was uncommon in this study, suggesting caution in interpreting of the analysis of sex ratio (Table I).

Climacia carpenteri Parfin & Gurney, 1956

Climacia carpenteri was previously known from Paraguay (Chaco, its type locality), Argentina and, Uruguay in addition to Brazil (Fig. 14) (Parfin & Gurney 1956, Gonzalez Olazo 1983, Flint 1998, 2006, Monserrat 2005, Bowles 2015, Oswald 2019, Machado & Martins 2023).

This new record from State of São Paulo extends its geographic distributional range in Brazil about 600 km southeast from Goiás, about 600 km south-west from Minas Gerais and, about 800 and 1,000 km northeast from Santa Catarina and Rio Grande do Sul, respectively (Fig. 14).

Material examined: 65 males, 80 females and nine specimens without abdomen (wa), all of them preserved in wet collection under refrigeration; LRRP LOTE# 17 (LRRP). Brasil, SP, Luiz Antônio, Estação Ecológica de Jataí, 21°36′47″S/47°49′04″W, mata ciliar, light trap, 7/XI/2007, RIR Lara and team, cols., 12 males, 7 females and one wa; same data except 21/XI/2007, 3 males and 2 females; same data except 5/XII/2007, 7 males and 6 females; same data



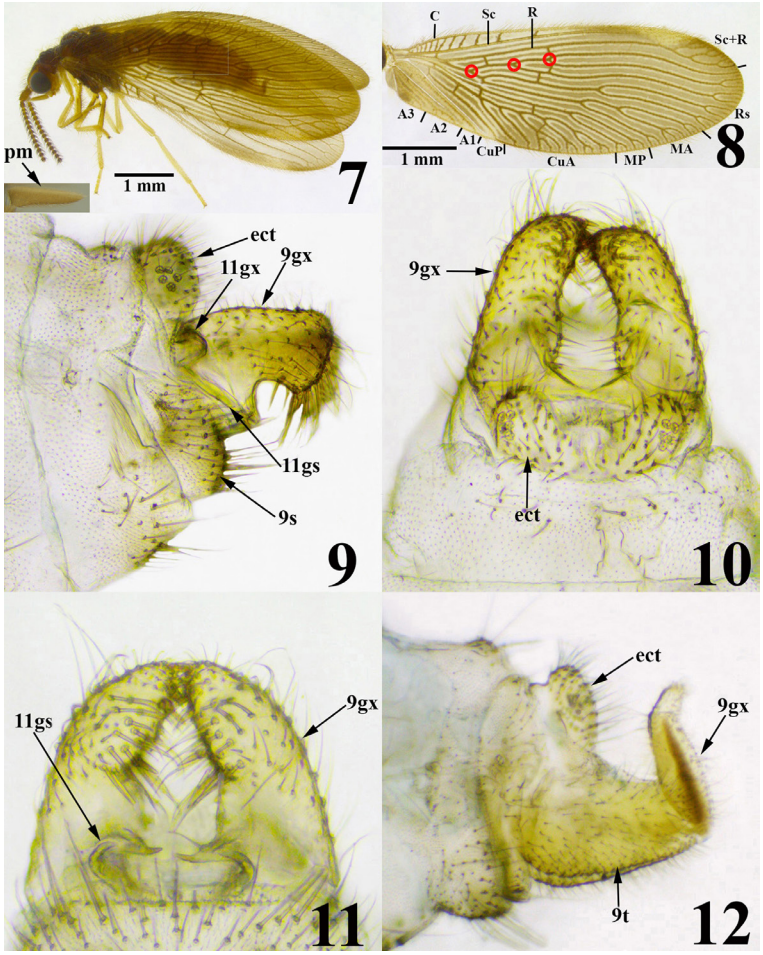
Figures 2–6. ***Climacia carpenteri*** **Parfin & Gurney, 1956 (Neuroptera, Sisyridae). 2. Habitus, lateral view and detail of terminal segment of maxillary palp. 3. Forewing, the red circles indicate the branches of radial sector. 4. Abdominal apex of female, lateral view. 5. Abdominal apex of male, lateral view. 6. Abdominal apex of male, caudal view. Abbreviations: ect = ectoproct; gs = gonostyli; gx = gonocoxite; pm = maxillary palp; s = sternite; t = tergite.**

except 19/XII/2007, 2 females; same data except 2/I/2008, 2 males, 7 females and 1 wa; same data except 16/I/2008, 2 females and 1 wa; same data except 17/IX/2008, 2 females; same data except 29/X/2008, 7 males and 6 females; same data except 12/XI/2008, 4 males, 4 females and 1 wa; same data except 27/XI/2008, 4 males, 2 females and 1 wa; same data except 10/XII/2008, 17 males, 32 females and 2 wa; same data except 22/VII/2009, 1 male; same data except 16/IX/2009, 1 male; same data except 15/X/2009, 1 male; same data except 11/X1/2009, 6 males, 8 females and 2 wa.

Sisyra panama Parfin & Gurney, 1956

Sisyra panama previously was known from Panama (Caño Sadle, near Gatún Lake, its type locality), Bolivia, Peru, and Brazil (Fig. 14) (Parfin & Gurney 1956, Penny 1981, Flint 2006, Hamada et al. 2014b, 2015, Bowles 2015, Assmar & Salles 2017, Oswald 2019, Machado & Martins 2023). This new record extends its geographic distribution in Brazil by about 4,900 km southeast from the type locality, about 2,400 and 2,100 km southeast from Amazonas and Rondônia, respectively, and about 840 and 800 km southwest from Espírito Santo and Rio de Janeiro, respectively (Fig. 14).

Material examined: two males, two females and one specimen without abdomen (wa), all of them preserved in wet collection under refrigeration; LRRP LOTE# 18 (LRRP). Brasil, SP, Luiz Antônio, Estação Ecológica de Jataí, 21°36′47″S/47°49′04″W, mata ciliar, light trap, 13/II/2008, RIR Lara and team, cols., 1 female; same data except 30/VII/2008, 1 male; same data except 27/XI/2008, 1 female; same data except 28/I/2009, 1 male; same data except 29/X/2009, 1 wa.



Figures 7–12. ***Sisyra panama*** **Parfin & Gurney, 1956 (Neuroptera, Sisyridae). 7. Habitus, lateral view. 8. Forewing, the red circles indicate the branches of radial sector. 9. Abdominal apex of male, lateral view. 10. Abdominal apex of male, dorsal view. 11. Abdominal apex of male, ventral view. 12. Abdominal apex of female, lateral view. Abbreviations: ect = ectoproct; gs = gonostyli; gx = gonocoxite; pm = maxillary palp; s = sternite; t = tergite.**

Table I. Species of Sisyridae (Neuroptera) obtained with light trap at municipality of Luiz Antônio, State of São Paulo, Brazil, between November 2007 and November 2009: number of specimens per trap (n) and sample effort in trap-days.

Species of Sisyridae	*n*	male/female/wa	sampling effort (in trap-nigths)
Climacia carpenteri Parfin & Gurney, 1956	154	65/80/9	3,96
Sisyra panama Parfin & Gurney, 1956	5	2/2/1	121,12

wa= specimens without abdomen.

DISCUSSION

In this study, carried out over two years in the Southeast Region of Brazil, we employed an extensive sampling effort with light traps (606 trap-nights) to capture Neuroptera. This sampling period was the longest known in Brazil for capturing these organisms and resulted in the capture of 159 specimens of Sisyridae. It took an average of 3.84 trap nights to capture each specimen of Sisyridae.

The effort to capture each specimen of *S. panama* (121.2 night traps) was about 30 times that required to capture each specimen of *C. carpenteri* (3.96 night traps) (Table I). The capture of more *Climacia* than *Sisyra* specimens in the same sampled locality was also reported by Bowles (2006) for two Nearctic species: *C. areolaris* (Hagen, 1861) and *S. vicaria* (Walker, 1853).

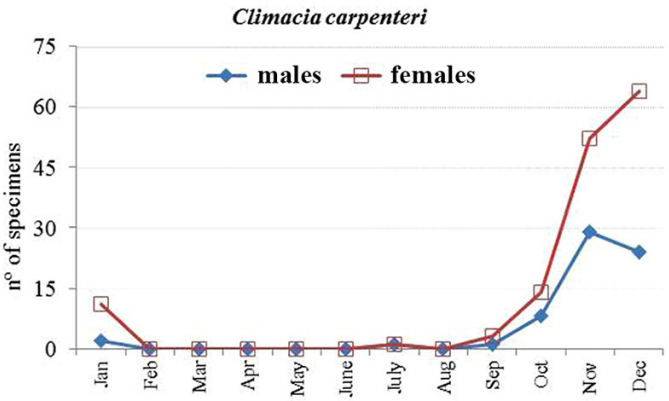


Figure 13. Seasonality of males and females of *Climacia carpenteri* Parfin & Gurney, 1956 (Neuroptera, Sisyridae) collected with light traps in riparian forest areas of Estação Ecológica de Jataí, State of São Paulo, Brazil, between November 2007 and November 2009.

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All specimens of Sisyridae were collected with light traps, although Malaise and Moericke traps were operated simultaneously in the same area, near the banks of the Mogi Guaçu River, throughout the study period. These facts corroborates the statements of Lestage (1921), Parfin & Gurney (1956), Andersen & Greve (1975), Penny (1981) and Flint (1998) that adults of Sisyridae are typically nocturnal or crepuscular and are attracted to lights, often in large numbers. Monserrat & Duelli (2014) stated that the Sisyridae depend on freshwater for the development of colonies of sponges or bryozoans, which serve as feeding substrates for their larvae.

In the current study, it was observed that the majority of captured sisyrids occurred during spring and summer, with over 90% of captures occurring between October and January (Fig. 13). Such data corroborate the records obtained by other authors for the Northern Hemisphere (Berg 1948, Parfin & Gurney 1956, Andersen & Greve 1975, Monserrat 2005, Bowles 2006, Loru et al. 2007, Fisher et al. 2019) and differs from the study of Penny (1981) conducted in the Amazon Basin, where the emergence of these insects is almost continuous, with increased occurrence between July and August.

For the Neotropical Region, Flint (1998, 2006) and Bowles (2015) reported flight periods of *C. carpenteri*, the most widely distributed of the Neotropical species of *Climacia* (Bowles 2015), between July and January. For *C. carpenteri* it was observed that about 98% of the captures occurred between October and January (Fig. 13), months where average temperatures are high (around 23 ºC) and heavy rainfall (about 810 mm, which represent about 60% of local annual rainfall) (CLIMATE-DATA.ORG 2019), conditions that should influence the abundance of their hosts.

In contrast, Parfin & Gurney (1956), Penny (1981), Flint (2006) and Hamada et al. (2014b) reported the capture of specimens of *S. panama* in February, May, July to September and November.

There are few reports in the literature about the sexual ratio of spongilla-flies (Andersen & Greve 1975, Fisher et al. 2019), which makes it difficult to discuss the obtained data. The sex ratio of *C. carpenteri* (0.81male:1.00 female) is consistent with the findings of Fisher et al. (2019) in Utah (USA) that observed a sex ratio of 0.94 and 0.84:1.00 to *Climacia californica* Chandler, 1953 (Neuroptera, Sisyridae) collected with light traps and sweeping, respectively. In contrast,

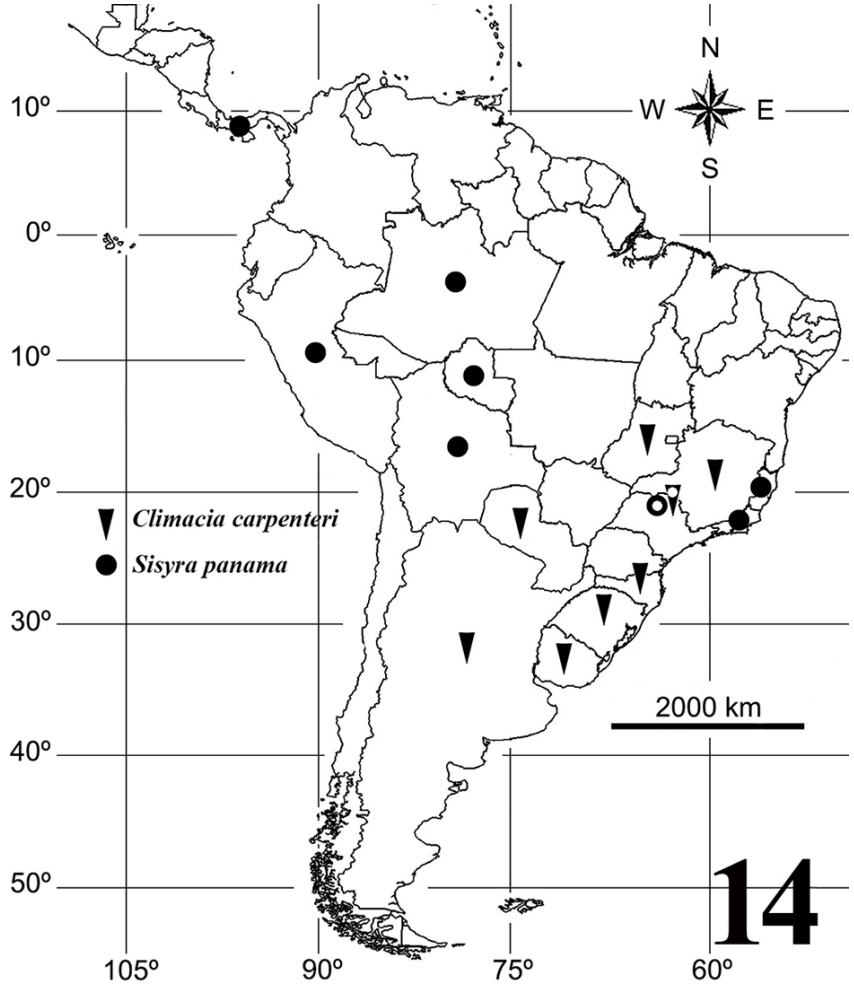

Figure 14. Map of part of Central America and South America. Black triangles indicate the known records of *Climacia carpenteri* Parfin & Gurney, 1956 and the black triangles with white dot the new one; black circles indicate the known records of *Sisyra panama* Parfin & Gurney, 1956 and the black circles with white dot the new one.

Andersen & Greve (1975) reported a sex ratio of 2.28:1.00 to *Sisyra nigra* (Retzius, 1783) [=*Sisyra fuscata* (Fabricius, 1793)] in Norway.

This study contributes to increase the knowledge of Sisyridae in the Neotropics. The data presented here indicate the need to expand the collection efforts to other Brazilian states in order to better document the fauna of these insects in the country.

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Author contributions

RIRL: Contributed with the conceptualization and identification of specimens, writing, and revision of the final manuscript. NWP: Contributed with the writing, preparation of distribution maps, edition, and revision of the final manuscript.