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Publisher: Taylor & Francis

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Journal of Natural History

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tnah20>

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Published online: 25 Jun 2013.

To cite this article: S.R.S. Torreias, R.L. Ferreira-Keppeler & M.M. Ronderos (2013): Biting midges (Ceratopogonidae: Diptera) present in aquatic macrophytes from wetlands of Marchantaria Island, Iranduba, Central Amazonia, Brazil, *Journal of Natural History*, DOI:10.1080/00222933.2013.791934

To link to this article: <http://dx.doi.org/10.1080/00222933.2013.791934>

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Biting midges (Ceratopogonidae: Diptera) present in aquatic macrophytes from wetlands of Marchantaria Island, Iranduba, Central Amazonia, Brazil

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(Received 1 June 2012; final version received 29 March 2013)

Ceratopogonidae (Diptera) are easily found in both aquatic and semi-aquatic sites under various environmental conditions, where their immature stages develop in areas of nutrient richness. Material was collected from six wetland areas in Ilha da Marchantaria, Iranduba, Amazonas, between July and October 2010 and February and June 2011 throughout the Amazon River's cycle (receding and flooding stages), in aquatic macrophytes *Eichhornia crassipes*, *Pistia stratiotes* and *Salvinia auriculata*. The collections produced 431 immature individuals: 191 (44.3%) in *E. crassipes*, 125 (29%) in *P. stratiotes* and 115 (26.7%) in *S. auriculata*. After development in the laboratory 16 species were identified belonging to the following genera: *Alluaudomyia* Kieffer, *Bezzia* Kieffer, *Dasyhelea* Kieffer, *Forcipomyia* Meigen, *Heteromyia* Say, *Neobezzia* Wirth and Ratanaworabhan, *Palpomyia* Meigen, *Paryphoconus* Enderlein and *Stilobezzia* Kieffer. Aquatic macrophytes are excellent substrates for immature Ceratopogonidae, which are important because of their value to the balance of biodiversity in ceratofauna in wetlands.

Keywords: Amazon; records; floodplain; immature; Solimões river

Introduction

Aquatic macrophytes are complex plants, showing complex growth and extreme morpho-anatomical plasticity (Conserva et al. 2008). They are found in marshes and other aquatic habitats. These plants play an important role in the maintenance and functioning of the trophic levels in white-water river floodplains such as Amazonian wetland areas (Wolcox and Meeker 1992). Macrophyte communities provide shelter and substrates for the development of fish and a variety of aquatic macroinvertebrates (Junk 1979; Conserva et al. 2008).

Many aquatic organisms have their life cycle associated with aquatic macrophyte populations, developing alimentary specificity for or becoming specific inhabitants of these substrates (e.g. mosquitoes of the genus *Mansonia* Blanchard) with development in macrophyte roots or other ecological relationships, as observed in Crustacea, Hirudinea, Oligochaeta and Insecta (mainly Diptera) (Junk 1973).

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Wetlands such as floodplain areas display different geographical and geomorphological characteristics. Nevertheless, they do not necessarily belong to distinct biogeographical regions (Albernaz and Costa 2008). These environments have a noticeable faunal abundance and biodiversity, especially of insects, because of the richness of nutrients, carried by water during flooding periods, and the number of available niches (Junk 1973, 1980; Nessimian et al. 2008).

Studies of organism associations in these aquatic habitats are still in the early stages, but these ecosystems are important for the Amazon region. Knowledge concerning the habitat of immature stages of Ceratopogonidae is lacking, especially in the Amazon region. Such knowledge may be important both medically and agriculturally, because the females of some species are haematophagous and consequently are possible vectors of some diseases. Others are pollinators of tropical crops (e.g. cocoa) and are of economic importance (Fish and Soria 1978).

This paper presents the results of field work carried out in Ilha da Marchantaria, a previously poorly known area in Iranduba, Central Amazonia, and provides a list of species collected from this island.

Material and methods

The specimens were collected between July and October 2010 and February and June 2011, periods that correspond to the receding and flooding stages of the Solimões river (Junk 1973, 1980), in species of floating aquatic macrophytes: *Eichhornia crassipes* (Mart.) Solms, *Pistia stratiotes* L. and *Salvinia auriculata* Aubl. (Figure 1A–D) at Lago Camaleão (03°13'14.9" S; 59°56'52.6" W) and Lago Grande (03°14'49.7" S 59°57'56.9" W), located in wetlands at Ilha da Marchantaria, Iranduba city, Amazon State (Figure 2).

The immature stages were captured using a 450-ml metallic ladle (a type of spoon with a long handle terminating in a deep bowl with dimensions of 15 × 6 cm). Specimens were separated manually into white plastic trays using tweezers, disposable pipettes and micropipettes, and flotation techniques. Physical and chemical parameters of the water (pH, temperature in °C and electrical conductivity) of the breeding plot were measured with a portable meter (WaterProof; Oakton Instruments, Vernon Hills, IL, USA).

The specimens were transported to the Laboratory of Cytotaxonomy Aquatic Insects at the Coordenação de Biodiversidade/CBIO/INPA, in thermal refrigerators to avoid the death of fourth stage larvae and pupae, which were separated and reared until adults emerged according to the techniques described in Kettle et al. (1975) and Ronderos and Díaz (2002).

The emerged adults and exuviae of immatures were preserved in 70% ethanol and mounted in Canada balsam (Borkent and Spinelli 2007) for microscopic examination. Identification was made to specific or generic level using the keys by Spinelli et al. (2005) and Borkent and Spinelli (2007), and by consulting experts from the División Entomología, Museo de La Plata, Argentina.

The species identified only to generic level were separated for future systematic studies. All material after examination will be deposited in the invertebrate collection at Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Brazil and in the División Entomología, Museo de La Plata, Argentina.

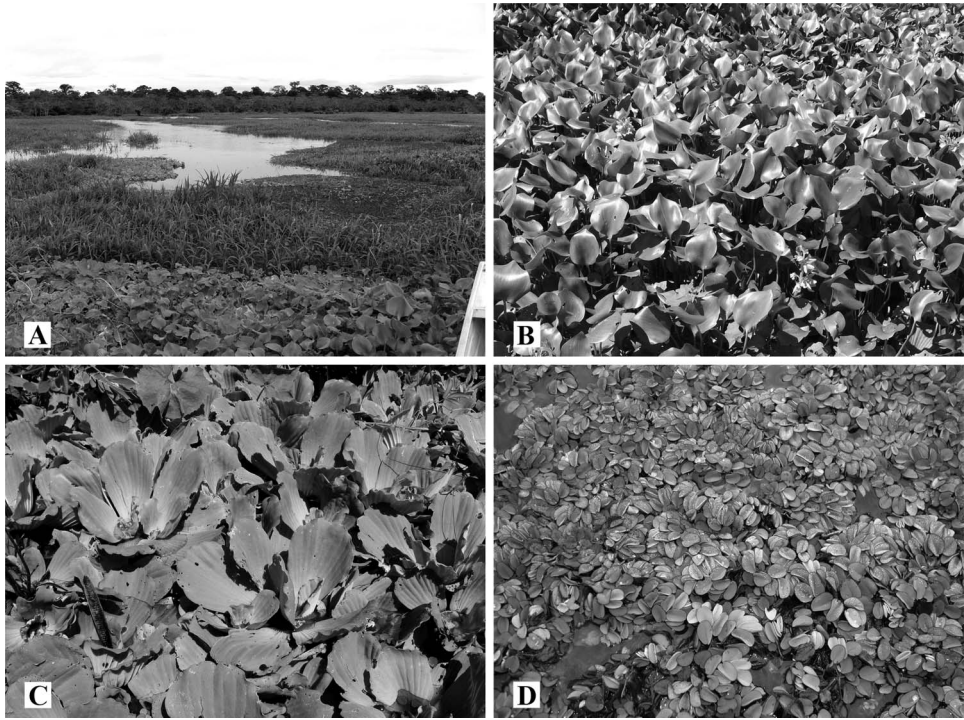


Figure 1. (A) overview of Marchantaria Island, macrophyte species studied; (B) *Eichhornia crassipes*; (C) *Pistia stratiotes* and (D) *Salvinia auriculata*. Photographs by S.R.S. Torreias and U.G. Neiss.

Results and discussion

A total of 431 specimens were captured in the following macrophytes: 191 (44.3%) individuals in *Eichhornia crassipes*, 125 (29%) in *Pistia stratiotes* and 115 (26.7%) in *Salvinia auriculata*. The midges collected were from 16 species as follows: *Alluaudomyia* Kieffer, *Bezzia* Kieffer, *Dasyhelea* Kieffer, *Forcipomyia* Meigen, *Heteromyia* Say, *Neobezzia* Wirth and Ratanaworabhan, *Palpomyia* Meigen, *Paryphoconus* Enderlein and *Stilobezzia* Kieffer.

Alluaudomyia sp.

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, aquatic macrophytes *E. crassipes*, 4 April 2011, Torreias col., 2 males (reared in laboratory, with pupal exuviae); *P. stratiotes*, 11 March 2011, Torreias and Ferreira-Keppler, 4 larvae (preserved in ethanol 70%); *S. auriculata*, Torreias and Ferreira-Keppler, 17 May 2011, 2 males, 2 females (reared in the laboratory, with pupal exuviae).

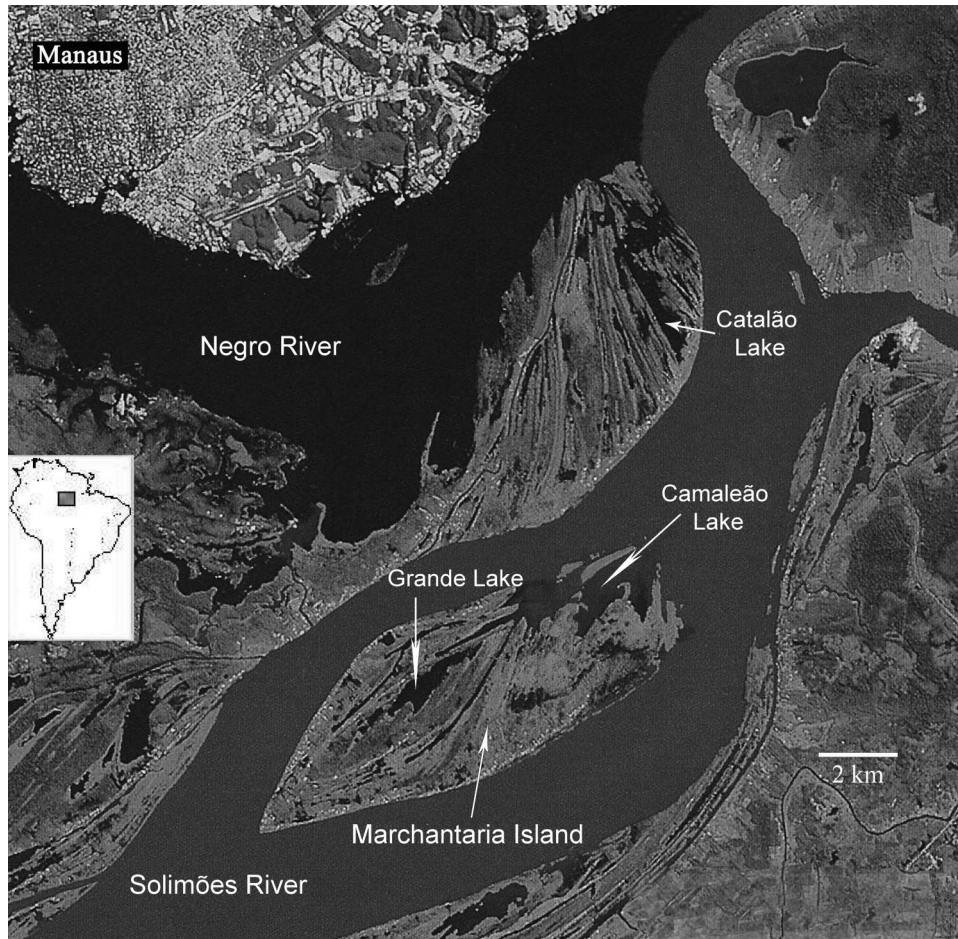


Figure 2. Map of sampling on Lago Grande and Lago Camaleão in wetlands at Ilha da Marchantaria, Iranduba, Amazonas. Note: modified from Kunth (1995).

Comments

The genus includes predatory larvae. They are commonly associated with floating plants in lakes, creeks and rivulets where they are found swimming on the surface film (Spinelli and Wirth 1993). Spinelli and Wirth (1984) described *A. amazonica*, *A. distispinulosa*, *A. fittkaui* and *A. nubeculosa* from the Amazonas State. In the present work the specimens were collected in the three species of macrophytes studied through flotation techniques. Identification to species was not possible because insufficient material was collected.

Bezzia sp.

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *P. stratiotes*, 14 March 2011, Torreias and Ferreira-Kepler, 2 males (reared in laboratory, with

pupal exuviae); Lago Camaleão, *E. crassipes* 27 June 2011, Torreias and Ferreira-Keppler, 1 pupa (preserved in 70% alcohol).

Comments

This genus has a cosmopolitan distribution. Both adults and larvae are excellent predators. The immature forms are found in many aquatic ecosystems like streams, lakes, ponds and others lentic environments, including phytotelmata (Ronderos et al. 2007b; Ronderos and Spinelli 2009). Immature stages were collected in *E. crassipes* and *P. stratiotes* using floating techniques. Identification to species was not possible because insufficient material was collected.

Dasyhelea paulistana Forattini and Rabello

Dasyhelea paulistana Forattini and Rabello, 1957: 245 (pupa and female; Brazil); Borkent and Spinelli, 2007: 61 (in Neotropical catalogue); Borkent, 2012: 68 (online catalogue).

Distribution

Brazil (Amazonas, São Paulo).

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *S. auriculata*, 17 May 2011, Torreias and Ferreira-Keppler, 2 males and 2 females (reared in laboratory, with pupal exuvia), 2 pupas (males, preserved in ethanol 70%).

Comments

A cosmopolitan genus with approximately 440 known species, which biology reveals to be highly adapted to many aquatic and semi-aquatic environments (Waugh and Wirth 1976): from phytotelmata to puddles, pits, bryophytes, ponds and artificial environments (Ronderos et al. 2003). In the present study, *D. paulistana* was collected in *S. auriculata* corroborating Borkent and Craig (2001), who mention the presence of *Dasyhelea* mining leaves of *Salvinia* in Costa Rica. This is a new record of the species from the Amazonas State.

***Dasyhelea* sp. 1**

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *P. stratiotes*, 21 March 2011, Torreias col., 1 female (reared in laboratory, with pupal exuvia).

Comments

This female specimen was identified and it was confirmed that it belongs to a new species that is being described by Díaz and Ronderos (Díaz et al. submitted), through comparison with the designed female allotype, which was collected in plastic trays at INPA, Manaus. At Marchantaria, the immature stage was collected in *P. stratiotes*.

Dasyhelea sp. 2 (*grisea* Group)

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *P. stratiotes*, 21 March 2011, Torreias and Ferreira-Keppler, 1 female (reared in laboratory, with pupal exuvia).

Comments

Immature stage was collected in *P. stratiotes*. The specific identification was not possible because only one female was collected.

Dasyhelea sp. 3 (*grisea* Group)

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *S. auriculata*, 17 May 2011, Torreias and Ferreira-Keppler, 3 males and 1 female (reared in laboratory, with pupal exuvia).

Comments

Immature stages were collected in *S. auriculata*. Identification to species was not possible because of insufficient collected material.

Dasyhelea sp. 4 (*mutabilis* Group)

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Camaleão, *E. crassipes*, 18 May 2011, Torreias and Ferreira-Keppler, 1 male and 1 female (reared in laboratory, with pupal exuvia).

Comments

Immature stages were collected in *E. crassipes*. Identification to species was not possible because insufficient material was collected.

Forcipomyia (Euprojoannisia) sp.

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *S. auriculata*, 17 May 2011, Torreias col., 1 male (reared in laboratory, without pupal exuvia);

20 May 2011, *S. auriculata*, Torreias and Ferreira-Keppler, 2 females (reared in laboratory, with pupal exuvia).

Comments

Forcipomyia is another cosmopolitan genus whose species are found in aquatic and semi-aquatic environments. The subgenus *Euprojoannisia* holds 17 valid species, five being recorded in Brazil (Borkent and Spinelli 2007). The pupae were collected using flotation techniques associated with *S. auriculata*. Identification to species was not possible because of the bad condition of the emerged male.

Heteromyia sp.

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *E. crassipes*, 4 April 2011, Torreias col., 1 male and 1 female (reared in laboratory, with pupal exuvia), Lago Camaleão, *P. stratiotes*, 25 May 2011, Torreias and Ferreira-Keppler, 2 males (reared in laboratory, with pupal exuvia).

Comments

Heteromyia species are distributed exclusively among Neotropical regions (Borkent and Spinelli 2007). Scientific literature fails to provide a great deal of information regarding its biology. Generally, the immature forms, not widely studied, have records only describing their pupae present in roots of plants in Brazil, with two records in Central Amazon and a single species, *H. clavata* Williston, in Amazonas State (Borkent and Spinelli 2007). Identification to species was not possible because insufficient material was collected.

Neobezzia fittkaui Wirth and Ratanaworabhan

Neobezzia fittkaui Wirth and Ratanaworabhan, 1972: 489 (female; Brazil); Borkent and Wirth, 1997: 120 (in world catalogue); Borkent and Spinelli, 2000: 59 (in catalogue of species south of USA); Borkent and Spinelli, 2007: 91 (in Neotropical catalogue); Ronderos et al., 2011: 474 (description of male and pupa); Borkent, 2012: 148 (online catalogue).

Distribution

Brazil (Amazonas).

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Camaleão, *S. auriculata*, Marino, Díaz and Torreias, 27 July 2010, 3 males and 2 females (reared in laboratory,

with exuvia pupal), Lago Camaleão, *P. stratiotes*, Marino, Díaz and Torreias, 27 July 2010, 1 male (reared in laboratory, with pupal exuvia).

Comments

Neobezzia is exclusively Neotropical (Borkent and Spinelli 2007). *Neobezzia albitarsis* Wirth and Ratanaworabhan, *N. amnicola* (Macfie), *N. blantoni* Wirth and Ratanaworabhan and *N. clavipes* Wirth and Ratanaworabhan are recorded in Brazilian Amazon, from Amazonas, Pará and Rondônia States. Ronderos et al. (2011) described for the first time the pupa of the genus *Neobezzia*.

Palpomyia sp.

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *P. stratiotes*, 14 March 2011, Torreias col., 1 female (reared in laboratory, with pupal exuvia).

Comments

In the Neotropical region the genus is represented by 46 species, nine recorded from the Amazon region. In the Brazilian Amazon, this genus is represented only by four species: *Palpomyia oliverai* Lane, *Palpomyia paraensis* Lane, *Palpomyia pseudolacustris* Dippolito and Spinelli, *Palpomyia versicolor* Macfie, with records from Pará and Rondônia States (Borkent and Spinelli 2007). For the first time the genus has been recorded in the Amazonas State. The immature stages of the genus are poorly known. Only two larvae and six pupae were formally described (Ronderos et al. 2004). Larvae of *Palpomyia* are active and present in water columns in many aquatic and semi-aquatic environments (Spinelli and Wirth 1993). Identification to species was not possible because only one female was collected.

Paryphoconus aemulus Macfie

Paryphoconus aemulus Macfie, 1940: 180 (female; Guyana); Borkent and Spinelli, 2007: 97 (in Neotropical catalogue), Borkent, 2012: 167 (online catalogue).

Distribution

Brazil (Amazonas, Mato Grosso), Guyana, Peru.

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Camaleão, *S. auriculata*, 27 July 2010, Marino, Díaz and Torreias, 1 male (reared in laboratory, with pupal exuvia).

Comments

The genus *Paryphoconus* is exclusively Neotropical (Borkent and Spinelli 2007). Their pupae are very poorly known, and the larvae are unknown. The genus is presently known by 41 species with 22 records throughout the Amazon region, of which 17 occur in the Brazilian Amazon, from Amazonas, Mato Grosso, Pará and Rondônia States (Borkent and Spinelli 2007; Mauad and Spinelli 2011). Recently, Ronderos et al. (2007a) recorded the occurrence of *Paryphoconus oliveirai* Lane within the Manaus city limits, the pupae of which were collected in polluted urban streams.

Stilobezzia (Eukraiohelea) elegantula (Johannsen)

Bezzia elegantula Johannsen, 1907: 109 (female; EUA, Kansas).

Probezzia elegantula (Johannsen); Malloch, 1914: 137 (combination).

Parabezzia elegantula (Johannsen); Malloch, 1915: 359 (combination).

Stilobezzia (Eukraiohelea) subsessilis Kieffer, 1917: 311.

Parabezzia (Eukraiohelea) elegantula (Johannsen); Johannsen, 1934: 345 (notes; status).

Eukraiohelea elegantula (Johannsen), 1943: 781 (combination).

Stilobezzia (Eukraiohelea) elegantula (Johannsen) in part, female; Wirth, 1953: 62 (combination; redescribed; figs.; distribution); Wirth, 1974: 43 (Neotropical catalogue); Wirth and Grogan, 1981: 78 (redescribed; figs., Potomac Valley records); Wilkening et al., 1985: 525 (Florida records); Wirth and Spinelli, 1992: 342 (redescription); Borkent and Spinelli, 2007: 86 (in Neotropical catalogue); Borkent and Grogan, 2009: 22 (in Nearctic catalogue; distribution); Grogan et al. 2010: 39 (Florida record); Borkent, 2012: 135 (online catalogue).

Stilobezzia (Eukraiohelea) maculitibia Lane and Forattini, 1956: 207.

Distribution

Argentina, Mexico (Yucatán), Panama, Paraguay, Puerto Rico (?), USA (Kansas, Maryland, Louisiana, Florida).

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Camaleão, *E. crassipes*, 18 April 2011, Torreias and Ferreira-Kepler, 2 males and 1 female (reared in laboratory, with pupal exuviae).

Comments

The subgenus *Stilobezzia (Eukraiohelea)* is known in Brazil by two species: *Stilobezzia (Eukraiohelea) amnigena* (Macfie) recorded in the Maranhão State, and *Stilobezzia (Eukraiohelea) dorsofasciata* (Lutz) from Rio de Janeiro State. This is a new record of *Stilobezzia (Eukraiohelea) elegantula* from the Brazilian Amazon and Amazonas State. The immature forms collected, but not described, is currently being extensively studied.

***Stilobezzia (Stilobezzia) pseudopunctulata* Cazorla & Ronderos**

Stilobezzia (Stilobezzia) punctulata Lane: Cazorla & Marino, 2004: 77 (misident., in part, specimens from Bolivia).

Stilobezzia (Stilobezzia) pseudopunctulata Cazorla & Ronderos, 2012: 400 (male, female; Argentina and Bolivia; pupa; Brazil, Amazonas).

Distribution

Argentina (Chaco, Formosa, Corrientes and Buenos Aires provinces), Bolivia (Santa Cruz), Brazil (Amazonas).

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *E. crassipes*, *P. stratiotes* and *S. auriculata*, 27 July 2010, Marino, Díaz and Torreias, 1 female (reared in laboratory, with pupal exuvia).

Comments

This female specimen was identified and it was confirmed that it belongs to a new species from Brazil (Amazonas), Bolivia and northeastern Argentina that was described by Cazorla and Ronderos (Cazorla et al. 2012). Borkent and Spinelli (2007) recorded 69 Neotropical species of this worldwide genus, and nine more species were subsequently described. The habitat of the immature stages includes natural and artificial environments, and plantations (e.g. rice). There are few descriptions of the immature form of this genus (Cazorla et al. 2006, 2012), with only 13 species known from immature forms (one species from egg, 2 from larvae and 12 from pupae).

***Stilobezzia (Stilobezzia) punctulata* Lane**

Stilobezzia (Stilobezzia) punctulata Lane, 1947: 204 (female; Brazil), Lane and Forattini, 1958: 220 (male; Brazil, Panamá), Wirth, 1974: 45 (catalogue of Neotropical species), Borkent and Wirth, 1997: 112 (catalogue of World species), Borkent and Spinelli, 2000: 54 (catalogue of Neotropical species), Cazorla and Marino, 2004: 75 (pupa), Borkent and Spinelli, 2007: 87 (in Neotropical catalogue), Borkent, 2012: 138 (online catalogue).

Distribution

Bolivia, Brazil (Mato Grosso and Rio de Janeiro), Colombia, Mexico (Tabasco), Panama and Peru.

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Camaleão, *S. auriculata*, 20 May 2011, Torreias and Ferreira-Keppler, 1 female (reared in laboratory, with pupal

exuvia) and 1 pupa (preserved in 70% ethanol); *S. auriculata*, 27 June 2011, Torreias col. 1 male (reared in laboratory, with exuvia pupal).

Comments

The immature stages were collected in *S. auriculata*. This is a new record of this species from the Amazonas State.

Stilobezzia (Stilobezzia) rabelloi Lane

Stilobezzia (Stilobezzia) rabelloi Lane, 1947: 203 (male and female; Brazil), Borkent and Craig, 2001: 655 (redescription, pupa); Borkent and Spinelli, 2007: 87 (in Neotropical catalogue); Borkent and Grogan, 2009: 22 (in Nearctic catalogue, distribution); Grogan et al., 2010: 41 (Florida record); Borkent, 2012: 138 (online catalogue).

Distribution

Argentina, Brazil (Mato Grosso, Rio de Janeiro), USA (Maryland to Louisiana and Florida).

Material examined

Brazil, Amazonas, Iranduba, Ilha da Marchantaria, Lago Grande, *E. crassipes*, 4 April 2011, Torreias col., 1 male and 1 female (reared in laboratory, with pupal exuviae).

Comments

This species is widely distributed through the Americas. Immatures were collected from between the leaves of *E. crassipes*. *Stilobezzia rabelloi* present body bristles and with elongated processes on their upper side, which help with balance and the insertion of spiky breathing organs into the macrophytes aerenchyma to obtain oxygen (Borkent and Craig 2001). This is a new record of this species from the Amazonas State.

For ecological records, the collected genera were sampled in floating vegetation in lentic waters. The pH, temperature and conductivity were respectively: 9.76, 29.8°C and 243.8 μ S/cm. In this system the immatures were probably feeding on organic debris accumulated in the roots of aquatic plants. According to Conserva et al. (2008) aquatic macrophytes are considered good indicators of biological diversity in permanent or temporary wetland, so composing the landscape diversity in floodplain areas.

This system is characterized as raising aquatic productivity, which enhances the development of aquatic entomofauna; in other words, the higher the diversity of aquatic macrophytes, the bigger the number of available habitats – considerably raising the richness and abundance of insects and other macroinvertebrates (Junk 1973; Conserva et al. 2008). It is mainly immature Ceratopogonidae that occur in multiple trophic webs, and form an important part of aquatic ecosystems, in terms of abundance and composition of species.

Even though there is a lack of information regarding the proper identification of some taxa, the information gathered on Ceratopogonidae, with a better taxonomic resolution (e.g. genera or morphotypes), is important to the recognition of new potential habitats that contribute to ontogenetic development, making it possible to carry out bionomic, ecological and taxonomic studies in these areas.

Although knowledge associating immature forms with the adult stages was lacking, the present study provides evidence that aquatic macrophytes are important breeding places that maintain and give balance to ceratofaunal biodiversity in wetland lakes. Also, they can be regarded as separate units, because the appearance of lakes and macrophytes is directly connected to the periodic flooding of rivers in the region, causing the occurrence of certain organisms to be ephemeral, and consequently creating possible sites of endemism and specificities.

Acknowledgements

We very much appreciate the critical review of the manuscript by Dr Gustavo R. Spinelli. Financial support was provided by MCTI/INPA/PRJ. 12.24 and PRONEX/CNPq/FAPEAM (Programa de Apoio aos Núcleos de Excelência e Fundação de Amparo Pesquisa do Estado do Amazonas). The first author thanks the PCI/MCTI/INPA/CNPq's programme for the provision of fellowships. We are also grateful to the group of specialists in Ceratopogonidae of the División Entomología del Museo de La Plata, Argentina.

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