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The Biodiversity of Blackflies (Diptera: Simuliidae) in Brazil: New Distribution Records and Updated Checklist

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Abstract

Currently, according to the most recent Simuliidae World Inventory, there are 97 valid species of blackflies recorded in Brazil, some of which act as vectors for zoonoses such as human onchocerciasis and mansonellosis in the northern and central-western regions of the country. Meanwhile, other species can cause serious socioeconomic problems due to the nuisance of female bites. Therefore, accurate knowledge of their distribution is crucial for the development and implementation of successful preventive strategies. With this aim, this study reviewed and updated the geographical distribution of the blackfly fauna throughout the Brazilian states. The data were compiled from three main sources: geographic information of material deposited at the Simuliidae Collection of the Instituto Oswaldo Cruz (CSIOC-IOC), a comprehensive review of scientific literature, and online biodiversity databases. We present a total of 71 new distribution records of 38 different Simuliidae species for 24 Brazilian states. Neither of these sets of records has been included in the Simuliidae World Inventory. Consequently, an updated Brazilian Simuliidae checklist, comprising a total of 98 valid species, is presented, highlighting these new distribution records. We also discuss six dubious records for the country and the implications of this updated data for the Simuliidae species richness of Brazil, its states, and biomes. This information is essential for future studies in the taxonomy, systematics, and biogeography of this family in Brazil.

Keywords Taxonomy · Spatial distribution · Medical entomology · Neotropical region · Biological collections

Introduction

Simuliidae (Diptera), also known as blackflies, are one of the most bothersome groups of hematophagous for humans, causing health issues such as severe allergic reactions due to female bites (Crosskey 1990; Adler et al. 2004). Certain species are also vectors of pathogens such as bacteria, protozoa, nematodes, and viruses, which cause diseases in vertebrates (Crosskey 1990; Adler et al. 2004; Shelley et al. 2010). They act, for example, as vectors of leukocytozoonosis in birds, animal onchocerciasis in cattle, and onchocerciasis and mansonellosis in humans (Crosskey 1990; Shelley et al. 2010). Blackflies also generate serious socioeconomic problems in certain regions, where they can harm tourism due to the nuisance of their bites, or agricultural and livestock activities by transmitting diseases to birds or domestic mammals (Adler et al. 2004).

Despite their negative effects, blackflies play a vital role in lotic ecosystems. Their larvae and pupae, which occur in large numbers under favorable conditions, are an important food source for vertebrate, such as fish, and invertebrate organisms, and they also process dissolved organic matter, making it more readily available in the food chain (Malmqvist et al. 2001, 2004; Currie and Adler 2008). Human interference in aquatic environments, such as alterations in water flow, removal of riparian vegetation, erosion, siltation, and the release of industrial and domestic waste, leads to changes in the composition and spatial distribution of blackfly species. The immatures of species that are less tolerant to these anthropogenic actions serve as excellent indicators of water quality (Strieder et al. 2006a, b; Docile et al. 2015). On the other hand, adults serve as a food source

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in the food web for invertebrates and birds (Crosskey 1990; Werner and Pont 2006).

These insects have a wide distribution across all continents except Antarctica and are present in most major archipelagos, except for Hawaii, the Falklands Islands, and some Pacific islands (Currie and Adler 2008; Adler 2022). According to the most recent Simuliidae World Inventory by Adler (2022), which provides the most comprehensive and up-to-date information on blackfly species worldwide, the family consists of 2384 species distributed among 31 genera. However, it is estimated that there are still many species left to be discovered, with the total worldwide richness suspected to be over 3000 species (Currie and Adler 2008).

Taxonomic classification of Brazilian blackfly fauna has undergone significant changes over time, particularly at the supra-specific levels. Pinto (1931) identified two genera and 37 species within the country, while Vulcano (1967) recognized two genera and 53 species. Py-Daniel and Moreira-Sampaio (1995) reported a total of 13 genera and 77 species. More recently, Coscarón et al. (2008) identified four genera and 12 subgenera, totaling 86 species, whereas Shelley et al. (2010) listed only two genera, six subgenera, and 80 species. Nonetheless, Adler (2022) reports that there are currently 97 valid blackfly species in Brazil, distributed among three genera: *Araucnephia* Wygodzinsky and Coscarón (two spp.), *Lutzsimulium* D'Andretta and D'Andretta (four spp.), and *Simulium* Latreille (91 spp.). Moreover, Brazilian *Simulium* are distributed among seven subgenera: *S.* (*Aspathia*) Enderlein (two spp.), *S.* (*Chirostilbia*) Enderlein (15 spp.), *S.* (*Notolepria*) Enderlein (four spp.), *S.* (*Psaroniocompsa*) Enderlein (39 spp.), *S.* (*Psilopelmia*) Enderlein (11 spp.), and *S.* (*Trichodagmia*) Enderlein (20 spp.). However, Molina and Gil-Azevedo (2021) divided this latter subgenus into two different subgenera: *S.* (*Trichodagmia*) (15 spp.) and *S.* (*Hemicnetha*) Enderlein (five spp.). Of the 97 species recorded in Brazil, 51 are exclusively found in this country (Adler 2022), indicating potential endemism of the group within the country.

In Brazil, at least 32 species of blackflies have females that feed on human blood (Coscarón and Coscarón-Arias 2007; Shelley et al. 2010). Among them, *S. argentiscutum* Shelley and Luna Dias, *S. exiguum* Roubaud, *S. guianense* Wise, *S. incrustatum* Lutz, *S. oyapockense* Floch and Abonnenc, and *S. roraimense* Nunes de Mello are known to be vectors of onchocerciasis or mansonellosis (Shelley et al. 2010). Moreover, *S. nigrimanum* Macquart, in Brazil, is incriminated in cases of the disease Endemic *Pemphigous foliaceus* (Eaton et al. 1998). *Simulium* species are also related to the Altamira Haemorrhagic Syndrome (Pinheiro et al. 1974). Other anthropophilic species are known for their voracity, such as *S. pertinax* Kollar, *S. inaequale* (Paterson and Shannon), and *S. minusculum* Lutz (Coscarón and Coscarón-Arias 2007; Shelley et al. 2010). In fact, the impact of these insects in Brazil has led to the development of control programs in states such as Paraná (Petry et al. 2004), Rio Grande do Sul (Mardini et al. 2000; SES/CEVS 2018), and São Paulo (Araújo-Coutinho 1995). Thus, accurate knowledge of the Brazilian blackfly fauna and its geographic distribution is essential for conducting epidemiological analyses and assessing the potential expansion of parasitic diseases vectored by these insects.

Several studies have gathered information about the distribution of blackflies in Brazil at both national and regional levels, including Pinto (1931), Vulcano (1967), Almeida et al. (1999), Coscarón and Coscarón-Arias (2007), Coscarón et al. (2008), and Shelley et al. (2010) (some of which are national catalogs) provide national-level data, while state-specific data are available for Acre (Nascimento et al. 2009), Amapá (Hamada et al. 2003), Amazonia (Shelley et al. 1997; Hamada and Adler 2001; Hamada et al. 2002), Bahía (Hamada et al. 2004; Landeiro et al. 2009), Ceará (Pessoa et al. 2005), Espirito Santo (Bertazo et al. 2010, 2013), Goiás (Shelley et al. 2000), Mato Grosso (Zampiva and Pepinelli 2017), Pará (Monteiro-Santos and Gorayeb 2005), Paraná (Lozovei et al. 2004; Dos Santos et al. 2010), Rio de Janeiro (Gil-Azevedo and Maia-Herzog 2004, 2009), Rio Grande do Norte (Andrade and Py-Daniel 1995), Rio Grande do Sul (Strieder et al. 1992; Strieder 2004; Strieder et al. 2006a, b; Menzel et al. 2019, 2021; Hentges et al. 2019; Limberger et al. 2021), Rondônia (Velasques et al. 2012), Roraima (Shelley et al. 1997; Hamada and Grillet 2001; Riccardi et al. 2022), Santa Catarina (Coscarón et al. 2011), and São Paulo (Araújo-Coutinho et al. 1988; Pepinelli et al. 2003, 2005; Pepinelli 2011).

Despite these efforts, there is still a significant lack of knowledge about the biodiversity and distribution of blackflies in Brazil, even in regions that represent centers of endemism for neotropical fauna and flora. For example, the ecosystems *campos rupestres* (rock fields) and *campos de altitude* (highland fields), which make up roughly one-third of the type localities for Brazilian blackfly species described in the past 30 years (11 of 30 species), still have sampling gaps (Aranda et al. 2021).

This gap in knowledge about the geographic distribution of blackfly species, known as the Wallacean deficit, can lead to misinterpretations of actual patterns of biodiversity distribution (Lomolino 2004; Whittaker et al. 2005). Precisely identifying the biodiversity of blackflies in Brazil could expand the capacity of the agents responsible for managing pest species and support the implementation of surveillance systems for disease-vector species. Therefore, this study aimed to review and update the knowledge about the richness and geographic distribution of the Brazilian blackfly fauna, serving as an initial step towards regularly inventorying the occurring Simuliidae species in the country.

Methods

The distribution records were compiled from three main sources: (1) the Simuliidae material deposited at the CSIOC/Fiocruz. All CSIOC records can be accessed at http://csioc.fiocruz.br/catalogue; (2) a comprehensive review of scientific articles about blackfly distribution in Brazil, including catalogs and checklists of states, biomes, or environmental preservation areas; and (3) the following online biodiversity databases: BoldSystem (www.boldsystems.org); SpeciesLink (https://specieslink.net/); The Brazilian Biodiversity Information System—SiBBr (https://sibbr.gov.br/); and The Global Biodiversity Information Facility—GBIF (https://www.gbif.org/).

Records found exclusively at the CSIOC are here referred to as "exclusive records," whereas records found in the literature but not yet included in the Simuliidae World Inventory of Adler (2022) will be referred to as "supplementary records."

To obtain new records at the CSIOC, batches of species with records from different Brazilian states, not indicated in Adler (2022), were previously listed. Whenever available, at least five lots of each species were taxonomically examined and certified. The identity of each newly-recorded species found at the CSIOC was confirmed using specific blackfly literature (e.g., Coscarón and Coscarón-Arias 2007; Shelley et al. 2010) and by comparison with deposited material of the same species. Specimens displaying poor preservation, uncertain identity, or unclear locality information found at the CSIOC dataset were not included in the analysis.

In addition to the exclusive CSIOC records, some supplementary records found in the bibliography and databases on biodiversity, including other biological collections or DNA barcode records (whose vouchers are deposited in biological collections), were considered. It is important to highlight that, in order to consider a record as valid, we use the following criteria: (1) it must be a primary source of information; (2) it must present a clear indication of the origin and life stage of the examined material; (3) the taxonomic determination must be carried out by a specialist in the group (researcher who traditionally produces knowledge about the taxonomy and/or systematics of Simuliidae); and (4) preferably there should be a voucher in biological collections, which will allow future verification of any inconsistencies.

The species included in the updated checklist are ordered alphabetically by genus and subgenus. As a taxonomic source of information, we follow Adler (2022), while also considering the taxonomic changes proposed by Molina and Gil-Azevedo (2021) for *S*. (*Hemicnetha*) and *S*. (*Trichodagmia*).

Acronyms for the Brazilian states, plus the Federal District, used throughout the text are those officially recognized in the country: **AC**—Acre; **AL**—Alagoas; **AP**—Amapá; **AM**—Amazonas; **BA**—Bahia; **CE**—Ceará; **DF**—Distrito Federal; **ES**—Espírito Santo; **GO**—Goiás; **MA**—Maranhão; **MT**—Mato Grosso; **MS**—Mato Grosso do Sul; **MG**—Minas Gerais; **PA**—Pará; **PB**—Paraíba; **PR**—Paraná; **PE**—Pernambuco; **PI**—Piauí; **RJ**—Rio de Janeiro; **RN**—Rio Grande do Norte; **RS**—Rio Grande do Sul; **RO**—Rondônia; **RR**—Roraima; **SC**—Santa Catarina; **SP**—São Paulo; **SE**—Sergipe; and **TO**—Tocantins.

The following acronyms of institutions are also cited thought the text: **CMN/FIOCRUZ—**Coleção de Mosquitos Neotropicais, MG, Brazil; **CSIOC/IOC—**Coleção de Simulídeos do Instituto Oswaldo Cruz, RJ,, Brazil; **FSP-USP—**Faculdade de Saúde Pública da Universidade Federal de São Paulo, SP, Brazil; **INPA—**Instituto Nacional de Pesquisas da Amazonia, AM, Brazil; **LSO/IOC—**Laboratório de Simulídeos e Oncocercose, RJ, Brazil; **MACN—**Museu Argentino de Ciências Naturais, Argentina; **MN/UFRJ—**Museu Nacional / Universidade Federal do Rio de Janeiro, RJ, Brazil; **MPEG—**Museu Paraense Emilio Goeldi, PA, Brazil; **MZUSP—**Museu de Zoologia da Universidade de São Paulo, SP, Brazil; **NHM—**The Natural History Museum, London, England; **UERJ—**Universidade do Estado do Rio de Janeiro, Brazil; **UEZO—**Universidade do Estado do Rio de Janeiro campus Zona Oeste, RJ, Brazil; **UFGD—**Museu da Biodiversidade / Universidade Federal da Grande Dourados, MS, Brazil; **UFSCar—**Universidade Federal de São Carlos, SP, Brazil.

Results

Tables 1 and 2 list all the species reported, their distribution, and the works that originally cited them. Table 3 presents the updated checklist of the 98 valid Simuliidae species registered for Brazil, classified by genus and subgenus. Of those records, 6 are listed as questionable due to non-conformity with the established criteria, the details of which will be discussed later. Table 4 contains all CSIOC-certified specimens that confirmed new species records, along with their distribution data (states and municipalities) and CSIOC catalog numbers.

Among all the materials deposited in CSIOC, we found 53 distribution records of several species. After the analysis and taxonomic certification of the specimens, 38 were confirmed as exclusive to CSIOC, after our analysis and taxonomic certification of the specimens (Table 1). These exclusive records correspond to 29 different Simuliidae species from 16 Brazilian states that were not included in Adler (2022).

The literature survey yielded 47 different references. In 31 of them, we found 53 additional distribution records of 35 different species in 22 Brazilian states that were not included in the World Blackflies Inventory of Adler (2022) (Table 1). Of these supplementary records, 29 were considered valid

Table 1 New distribution records of Brazilian blackflies. Species names with asterisk symbol indicate records findings in both the CSIOC and the literature. Supplementary records that were not considered are indicated

Region	State	Spp. number in Adler (2022)	CSIOC records	Supplementary records
Central-West	Distrito Federal (DF)	10	*S. brevifurcatum* *S. lutzianum* *S. perflavum* *S. rappae** *S. rubrithorax*	*S. rappae**, in Hernández et al. (2007) and Coscarón et al. (2008)
	Goiás (GO)	25	*S. bertellii** *S. limbatum** S. *oyapokense s.l* *S. paraguayense*	*S. amazonicum*, in Pinto (1931) and Forattini et al. (1971). **Record not considered** *S. bertellii**, in Py-Daniel et al. (2021a) *S. maranguapense*, in Coscarón et al. (2008). **Record not considered** *S. margaritatum*, in Hernández et al. (2007). **Record not considered** *S. limbatum**, in Shelley et al. (2010)
	Mato Grosso (MT)	28	*S. clavibranchium* *S. quadrifidum*	*S. amazonicum*, in Forattini et al. (1971). **Record not considered** *S. cauchense*, in Shelley et al. (2010). **Record not considered** *S. limbatum*, in Shelley et al. (2010)
	Mato Grosso do Sul (MS)	16	*S. cuasiexiguum*	*S. auristriatum*, in D´Andretta and D´Andretta, (1949), Vulcano (1967) and Forattini et al. (1971), Coscarón and Coscarón-Arias (2007) and Coscarón et al. (2008) *S. distinctum*, in Forattini et al. (1971). **Record not considered** *S. inaequale*, in Eaton et al. (1998), Shelley et al. (2010) and Zampiva and Pepinelli (2017) *S. rubrithorax*, in Zampiva and Pepinelli (2017)
Northeast	Alagoas (AL)	2	*S. brachycladum* *S. limbatum** *S. incrustatum*	*S. limbatum**, in Shelley et al. (2010)
	Bahía (BA)	26	-	*S. amazonicum*, in Pinto (1931). **Record not considered** *S. clavibranchium*, in Coscarón (1987); Almeida et al. (1999). **Record not considered** *S. scutistriatum*, in Landeiro et al. (2009). **Record not considered**
	Ceará (CE)	8	-	*S. guianense*, in Dos Santos-Neto et al. (2015)
	Maranhão (MA)	3	*S. goeldii*	*S. oyapockense*, in Shelley et al. (2010)
	Paraíba (PB)	5	-	*S. perflavum*, in Almeida et al. (1999)
	Pernambuco (PE)	6	*S. hirtipupa* *S. inaequale* *S. pertinax* *S. rubrithorax*	*S. guianense* in Shelley et al. (2010)
	Piauí (PI)	1	-	*S. guianense*, in Dos Santos-Neto et al. (2015)
	Rio Grande do Norte (RN)	2	*S. subpallidum**	*S. perflavum, S. rubrithorax,* and *S. subpallidum**, in Andrade and Py-Daniel (1995)
	Sergipe (SE)	0	*S. subpallidum* *S. limbatum**	*S. limbatum**, in Shelley et al. (2010)

Table 1 (Continued)

Region	State	Spp. number in Adler (2022)	CSIOC records	Supplementary records
North	Acre (AC)	5	*S. exiguum* *S. ochraceum*	*S. lutzianum*, in Nascimento et al. (2009). **Record not considered**
	Amapá (AP)	16	-	*S. damascenoi*, in Py-Daniel et al. (2021b) *S. siolii*, in Coscarón et al. (2008) and Shelley et al. (2010). **Record not considered**
	Amazonas (AM)	25	*S. anamariae* *S. rubrithorax*	-
	Pará (PA)	16	-	*S. damascenoi*, in Py-Daniel et al. (2021b) *S. incrustatum*, in Monteiro-Santos and Gorayeb (2005)
	Rondônia (RO)	14	*S. clavibranchium*	*S. exiguum s.l.*, in Pepinelli et al. (2006), Coscarón et al. (2008) and Shelley et al. (2010)
	Roraima (RR)	28	*S. rorotaense**	*S. kabanayense*, in Coscarón and Coscarón-Arias (2007) and Coscarón et al. (2008). **Record not considered** *S. rorotaense**, in Shelley et al. (1997), Hamada and Adler (1999) and Shelley et al. (2010)
	Tocantins (TO)	16	*S. brachycladum* *S. hirtipupa** *S. limbatum** *S. rappae* *S. rubrithorax* *S. subnigrum*	*S. dekeyseri* and *S. subnigrum* in Figueiro et al. (2012). **Record not considered** *S. hirtipupa** and *S. limbatum**, in Shelley et al. (2010) *S. venezuelense*, in Coscarón et al. (2008). **Record not considered**
Southeast	Espírito Santo (ES)	30	*S. obesum* *S. rorotaense*	-
	Minas Gerais (MG)	38	*S. anamariae* *S. botulibranchium* *S. brevifurcatum* *S. cuasiexiguum** *S. dinellii* *S. limbatum**	*S. amazonicum*, in Pinto (1931). **Record not considered** *S. botulibranchium*, in Vulcano (1967) and Coscarón et al. (2008). **Record not considered** *S. dinellii*, in Coscarón and Coscarón-Arias (2007) and Coscarón et al. (2008). **Record not considered** *S. cuasiexigum** e *S. limbatum**, in Shelley et al. (2010)
	Rio de Janeiro (RJ)	38	*S. brevifurcatum** *S. brunnescens* *S. lobatoi* *S. lutzianum* *S. minusculum* *S. serranus*	*S. amazonicum*, in Forattini et al. (1971). **Record not considered** *S. brevifurcatum**, in Vulcano (1962), Vulcano (1967), Coscarón and Coscarón-Arias (2007), Coscarón et al. (2008), and Gil-Azevedo and Maia-Herzog (2009)
	São Paulo (SP)	50	-	*L. flavopubescens*, in Lane and Porto (1939), Forattini et al. (1971), Vulcano (1967), Py-Daniel (1982), and Coscarón et al. (2008). **Record not considered** *S. amazonicum*, in Forattini et al. (1971). **Record not considered**

Table 1 (Continued)

Region	State	Spp. number in Adler (2022)	CSIOC records	Supplementary records
South	Paraná (PR)	27	*S. limbatum** *S. minusculum*	*S. brevifurcatum*, in Vulcano (1962), Vulcano (1967), Coscarón and Wygodzinsky (1984); Strieder (2004); Coscarón and Coscarón-Arias (2007), and Coscarón et al. (2008)
				S. dinellii, in Coppo and Lopes (2010). **Record not considered**
				*S. limbatum**, in Shelley et al. (2010)
				S. romanai, in Cunha and Bassi (1997). **Record not considered**
				S. rubiginosum, in Coppo and Lopes (2010). **Record not considered**
	Santa Catarina (SC)	28	*S. botulibranchium**	*S. botulibranchium**, in Coscarón and Coscarón-Arias (2007), Coscarón et al. (2008), and Coscarón et al. (2011)
	Rio Grande do Sul (RS)	30	-	-

and are discussed below, while 24 were not included in the checklist as they did not meet the established criteria. Additionally, 14 of these supplementary records were corroborated by records found at CSIOC, while the remaining 15 were based solely on bibliographic sources (Table 1).

Regarding the records searched for in biodiversity databases, eight potential new records were identified in four data repositories. However, only six records met the established criteria and were included in the checklist, two of which were corroborated by records found at CSIOC and the literature (Table 2).

Table 2 Records found in online biodiversity databases and other collections online repositories

Repository	Specie	State	Commentaries
MN/UFRJ https://sibbr.gov.br/	*L. flavopubescens*	**MG**	Batch DIPSIM-383 (male and pupa). The material was destroyed. However, it was identified by a specialist in 2016. Record corroborated by Boldsystem
	S. spinibranchium	**CE**	Batch DIPSIM-49 (female and pupa). The material was destroyed. However, it was identified by a specialist in 2013
BOLDSYSTEM (IBOL) www.boldsystems.org	*L. flavopubescens*	**MG**	Batches BNBMP349-09, BNBMP350-09, BNBMP360-09 (15 larvae and three pupae). Material collected and identified by specialists. In the photos of the pupae, the shape of the cocoon and the gill filaments correspond to the species. Material deposited at UFSC. Occurrence corroborated by MN/UFRJ records
	S. subnigrum	**MA**	Batches MPBNB281-07, MPBNB300-07 (20 pupae). Material collected and identified by a specialist. In the photos of the pupae, the shape of the cocoon and the gill filaments correspond to the species. Material deposited at UFSC
	S. itaunense	**PR**	Batches BNBMP216-09 a BNBMP225-09 (10 larvae). Material collected and identified by a specialist. Only 3 last-instar specimens are observed, however, with gill histoblasts and integument setae consistent with the pattern of the species. Material deposited at UFSC
NHM https://specieslink.net/	*S. limbatum*	**AL SE**	AL (four specimens), SE (three specimens). Material collected and identified by specialists. Locations sampled in the NHM Collection correspond to CSIOC locations and are corroborated by Shelley et al. (2010)
	S. dinellii	**PA**	A female without an exuvia attached. Material collected in 1936, without information about the taxonomic determinant. Also, this species is part of a species complex (Adler 2022), and is easily confused with several species of the same subgenus. **Record not considered**
CMN/Fiocruz https://sibbr.gov.br	*S. distinctum*	**AM**	Batch CMN 9665–952 (female). Material collected in 1940, without information about the taxonomic determinant. In the CMN/Fiocruz virtual catalog this record is not found, it is only found on the SIBBR website. **Record not considered**

Table 3 Updated checklist of Simuliidae species recorded in Brazil, classified by genus and subgenus. The distribution in Brazilian states is based on the exclusive CSIOC records, in addition to those reported by Adler (2022), and supplementary records from the bibliography and biodiversity databases (referenced in Tables 1 and 2)

Genus *Araucnephia* Wygodzinsky & Coscarón, 1973
Araucnephia cearensis Pessoa, Rios-Velásquez & Py-Daniel, 2012 - CE
Genus *Lutzsimulium* D´Andretta & D´Andretta, 1947
Lutzimulium flavopubescens (Lutz, 1910) - RJ, MG
Lutzimulium hirticosta (Lutz, 1909) - BA, ES, MG, PR, RJ, RS, SC, SP
Lutzimulium pernigrum (Lutz, 1910) - MG, RJ, RS, SP
Lutzimulium simplicicolor (Lutz, 1910) - AM, MT, PA, RO
Genus *Simulium* Latreille, 1802
Subgenus *Simulium* (*Aspathia*) Enderlein, 1935
Simulium covagarciai Ramírez-Pérez, Yarzábal, Takaoka, Tada & Ramírez, 1984 - RR
Simulium metallicum Bellardi, 1859 - PR, RR, SP
Subgenus *Simulium* (*Chirostilbia*) Enderlein, 1921
Simulium bifenestratum Hamada & Pepinelli, 2004 - SP
Simulium brunnescens Maia-Herzog, Valente, Luna-Dias, Gil-Azevedo & Marchon-Silva, 2012 - MT, RJ
Simulium dekeyseri Shelley & Py-Daniel, 1981 - BA, DF, GO, MG, MS, MT, PR, RJ, SP
Simulium distinctum Lutz, 1910 - ES, MG, PR, RJ, RS, SC, SP
Simulium empascae Py-Daniel, Souza & Caldas, 1988 - RJ, RS, SC, SP
Simulium friedlanderi Py-Daniel, 1987 - MT, SP
Simulium jefersoni Hamada, Hernández, Luz & Pepinelli, 2006 - BA
Simulium obesum Vulcano, 1959 - ES, MG, RJ, RS, SC, SP
Simulium papaveroi Coscarón, 1982 - BA, MG
Simulium pertinax Kollar, 1832 - AM, BA, DF, ES, GO, MG, MS, MT, PB, PE, PR, RJ, RO, RR, RS, SC, SP, TO
Simulium riograndense Py-Daniel, Souza & Caldas, 1988 - PR, RJ, RS, SC, SP
Simulium serranus Coscarón, 1981 - MG, MT, RJ, SP
Simulium spinibranchium Lutz, 1910 - BA, CE, DF, ES, GO, MG, MS, MT, PE, PR, RJ, RR, RS, SC, SP, TO
Simulium subpallidum Lutz, 1910 - AL, AP, BA, CE, DF, ES, GO, MG, MS, MT, PA, PE, PR, RJ, RN, RR, RS, SE, SC, SP, TO
Simulium vitribasi Hamada, Nascimento & Pepinelli, 2015 - MG, SP
Subgenus *Simulium* (*Hemicnetha*) Enderlein, 1934
Simulium brachycladum Lutz & Pinto [in Pinto, 1931] - AL, BA, CE, ES, GO, MG, PB, PE, PR, RJ, RN, SP, TO
Simulium cristalinum Coscarón & Py-Daniel, 1989 - RR
Simulium lobatoi Luna Dias, Hernández, Maia-Herzog & Shelley, 2004 - BA, ES, GO, MT, RJ
Simulium mutucuna Nunes de Mello & Vieira da Silva, 1974 - RR
Simulium rubrithorax Lutz, 1909 - AM, BA, CE, DF, ES, GO, MG, MT, MS, PE, PR, RJ, RN, RR, RS, SC, SP, TO
Subgenus *Simulium* (*Notolepria*) Enderlein, 1930
Simulium cuasiexiguum Shelley, Luna Dias, Maia-Herzog & Lowry, 2000 - GO, MG, MS, MT, SP, TO
Simulium exiguum Roubaud, 1906 - AC, AM, BA, DF, ES, GO, MG, MS, MT, PR, RJ, RO, RR, SP, TO
Simulium paraguayense Schrottky, 1909 - BA, GO, MG, RJ, SC, SP
Subgenus *Simulium* (*Psaroniocompsa*) Enderlein, 1934
Simulium amazonicum Goeldi, 1905 - AC, AM, RO, RR
Simulium anamariae Vulcano, 1962 - AM, ES, MG, PR, RJ, RS, SC, SP
Simulium argentiscutum Shelley & Luna Dias, 1980 - AC, AM, BA, RO
Simulium auristriatum Lutz, 1910 - MG, MS, RJ, SC, SP
Simulium bertellii Py-Daniel, Longaray, Pujol-Luz & Pessoa, 2021 [*combinatio nova*] - GO
Simulium botulibranchium Lutz, 1910 - ES, MG, PR, RJ, RS, SC, SP
Simulium brevifurcatum Lutz, 1910 - DF, MG, PR, RJ, RS, SP
Simulium cauchense Floch & Abonnenc, 1946 - AM, AP, PA, RR
Simulium cerradense Coscarón, Cerqueira, Schumaker & La Salvia, 1992 - BA
Simulium clavibranchium Lutz, 1910 - AM, ES, MG, MT, RJ, RO, RS, SC, SP
Simulium daltanhani Hamada & Adler, 1998 - AM
Simulium damascenoi Py-Daniel, 1988 - AP, PA
Simulium diversibranchium Lutz, 1910 - MG, RJ, RS, SC, SP
Simulium goeldii Cerqueira & Nunes De Mello, 1967 - AM, AP, MA, PA, RO, RR
Simulium guaporense Py-Daniel, 1989 - MT, RO
Simulium inaequale (Paterson & Shannon, 1927) - AP, BA, DF, ES, GO, MG, MT, MS, PB, PE, PR, RJ, RR, RS, SC, SP, TO
Simulium incrustatum Lutz, 1910 - AL, AP, BA, CE, DF, ES, GO, MG, MS, MT, PB, PA, PE, PR, RJ, RN, RR, RS, SC, SP, TO
Simulium limbatum Knab, 1915 - AL, AP, BA, ES, GO, MG, MT, PA, PB, PE, PR, RJ, RR, SC, SE, SP, TO
Simulium lundi (Py-Daniel & Barbosa, 2007) - AM
Simulium lutzi Knab, 1913 - BA, DF, ES, GO, MG, MS, MT, PR, RJ, RS, SC, SP, TO
Simulium maranguapense (Pessoa, Ríos-Velásquez & Py-Daniel, 2005) - CE

Table 3 (continued)

Simulium margaritatum Pepinelli, Hamada & Luz, 2006 - BA
Simulium marins Pepinelli, Hamada & Currie, 2009 - SP
Simulium minusculum Lutz, 1910 - AM, BA, ES, GO, MA, MG, MT, PA, PI, PR, RJ, RO, RR, RS, SC, SP, TO
Simulium oyapockense Floch & Abonnenc, 1946 - AC, AM, AP, ES, GO, MA, MG, MS, MT, PA, PR, RO, RR, RS, SP, TO
Simulium petropoliense Coscarón, 1980 - ES, RJ
Simulium pujoli (Py-Daniel, Coscarón & Pessoa, 2017) - GO
Simulium quadrifidum Lutz, 1917 - AC, AM, AP, MT, PA, RO, RR, TO
Simulium rappae Py-Daniel & Coscarón, 1982 - DF, ES, GO, MG, RJ, SP, TO
Simulium roraimense Nunes De Mello, 1974 - RR
Simulium siolii Py-Daniel, 1988 - GO, MA, MS, MT, RO, TO
Simulium souzalopesi Coscarón, 1980 - RJ
Simulium stellatum Gil-Azevedo, Figueiró & Maia-Herzog, 2005 - BA, MG, RJ, SP
Simulium subnigrum Lutz, 1910 - AM, BA, CE, DF, ES, GO, MA, MG, MS, MT, PR, RJ, RO, RR, RS, SC, SP, TO
Simulium tergospinosum Hamada, 2000 - AM
Simulium travassosi D'Andretta & D'Andretta, 1947 - ES, GO, MG, PR, RJ, RS, SC, SP
Simulium ulyssesi (Py-Daniel & Coscarón, 2001) - AM, RO
Subgenus *Simulium* (*Psilopemia*) Enderlein, 1934
Simulium dinellii (Joan, 1912) - ES, MG, MS, RJ, RS, SC, SP
Simulium iracouboense Floch & Abonnenc, 1946 - AM, AP, PA, RR
Simulium lutzianum Pinto, 1931 - AM, DF, ES, GO, PR, RJ, RR, RS, SC, SP
Simulium maroniense Floch & Abonnenc, 1946 - AM, AP, MT, PA, RR
Simulium ochraceum Walker, 1861 - AC, AM, ES, RJ, RR, SP
Simulium perflavum Roubaud, 1906 - AC, AM, AP, BA, CE, DF, ES, GO, MG, MS, MT, PA, PB, PE, PR, RJ, RN, RO, RR, RS, SC, SP, TO
Simulium rorotaense Floch & Abonnenc, 1946 - AM, AP, ES, MT, PA, RO, RR
Simulium suarezi Ramírez-Pérez, Rassi & Ramírez, 1977 - AM, RR
Simulium trombetense Hamada, Py-Daniel & Adler [In Hamada & Adler, 1998] - AM, AP, PA, RR
Simulium virescens Hamada, Silva & Pereira, 2012 - BA, MS
Subgenus *Simulium* (*Trichodagmia*) Enderlein, 1934
Simulium coscaroni Nascimento, Hamada & Adler, 2017 [2018] - MG
Simulium criniferum Nascimento, Hamada, Andrade-Souza & Adler, 2017 [2018] - AP
Simulium duodenicornium Pepinelli, Hamada & Trivinho-Strixino, 2005 - MG, SP
Simulium guianense Wise, 1911 - AM, AP, CE, ES, GO, MA, MG, MT, PA, PE, PI, PR, RJ, RR, SC, SP, TO
Simulium hirtipupa Lutz, 1910 - AL, BA, ES, GO, MG, MS, MT, PE, RJ, RS, SP, TO
Simulium itajara Nascimento, Hamada & Pepinelli, 2020 - BA
Simulium itaunense D'Andretta & Dolores González, 1964 - PR, RS, SC, SP
Simulium jeteri (Py-Daniel, Darwich, Mardini, Strieder & Coscarón, 2005) - RS
Simulium litobranchium Hamada, Pepinelli, Mattos-Glória & Luz, 2010 - GO, MG
Simulium maiaherzogae Aranda, Molina, Chimes & Py-Daniel, 2021 - MG
Simulium nigrimanum Macquart, 1838 - DF, ES, GO, MG, MS, MT, PA, PR, RJ, SP, TO
Simulium nunesdemelloi Hamada, Pepinelli & Hernández, 2006 - AM
Simulium orbitale Lutz, 1910 - MG, MS, PR, RJ, RS, SC, SP
Simulium perplexum Shelley, Maia-Herzog, Luna Dias & Couch, 1989 - PA
Simulium scutistriatum Lutz, 1909 - ES, GO, MG, MT, PR, RJ, SP, TO
Dubious records
Araucnephia iberaensis Coscarón & Coscarón-Arias, 2002 - PR
Simulium* (*Notolepria*) *incertum Lutz, 1910 - MG, SP
Simulium* (*Psaroniocompsa*) *catarinense Pinto, 1931 - SC
Simulium* (*Psaroniocompsa*) *delponteianum Wygodzinsky, 1961 - RS
Simulium* (*Psaroniocompsa*) *quadristrigatum Enderlein, 1934 - PR
Simulium* (*Psilopelmia*) *shewellianum Coscarón, 1985 - SP

In total, this work presents 71 new distribution records (considering the 38 exclusive records from CSIOC, 15 exclusive literature supplementary records, 14 shared between CSIOC and the literature, and 4 exclusive database records) of 38 different Simuliidae species (Table 1 and 2) distributed across all Brazilian states except BA, RS, and SP.

Concerning the Brazilian regions, the blackfly fauna of the Southeast region is the best known, with records of 60 different species, followed by the North (50 spp.), Central-West (43 spp.), South (43 spp.), and Northeast regions (32 spp.). Currently, the state of SP reports the highest known blackfly diversity in Brazil (50 spp.), followed by MG (45 spp.), RJ (44 spp.), and ES (32 spp.). Conversely, the states with the fewest species records are MA (6 spp.), PB (6 spp.), AL (5 spp.), RN (5 spp.), SE (2 spp.), and PI (2 spp.) (Fig. 1). *Simulium perflavum* Roubaud is the most widely distributed

Table 4 CSIOC-certified materials, indicating the state, municipality, CSIOC catalogue number and life stage of species with new distribution records. 'Reared' indicates that the specimens have associated pupal exuviae

Genus *Simulium* Latreille, 1802

Subgenus *Simulium* (*Chirostilbia*) Enderlein, 1921

Simulium brunnescens Maia-Herzog, Valente, Luna-Dias, Gil-Azevedo & Marchon-Silva, 2012 – **RJ** (Sapucaia: CSIOC9921 – 1♂ reared)

Simulium obesum Vulcano, 1959 – **ES** (Santa Leopoldina: CSIOC13883 - 1 pharate pupa. CSIOC13884 - 1 pharate pupa. CSIOC13885 - 1 pharate pupa. CSIOC13887 - 1 pharate pupa. CSIOC13982 - 1♂ reared. CSIOC13983 - 1♀ reared)

Simulium pertinax Kollar, 1832 – **PE** (Moreno: CSIOC1958 - 1♂ reared. CSIOC1962 - 1♂ reared. CSIOC1968 - 1♂ reared)

Simulium serranus Coscarón, 1981 – **RJ** (Itaipava: CSIOC96 - 1 pharate pupa)

Simulium subpallidum Lutz, 1910 – **RN** (Natal: CSIOC288 - 1♂ reared. CSIOC289 - 1♂ reared). **SE** (Japoatã: CSIOC22568 - 1♂ reared. CSIOC22572 - 4 pharate pupae and 4 pupal exuviae. CSIOC22574 - 1♀ reared. CSIOC22575 - 2 pharate pupae. CSIOC22576 - 1♂ reared. CSIOC22577 - 3 pharate pupae and 1 pupal exuvia. CSIOC22565 - 2 pharate pupae)

Subgenus *Simulium* (*Hemicnetha*) Enderlein, 1934

Simulium brachycladum Lutz & Pinto [in Pinto, 1931] – **AL** (União dos Palmares: CSIOC21320 - 6 pupal exuviae. CSIOC21321 - 5 pharate pupae and 5 pupal exuviae). **TO** (São Salvador: CSIOC13125 - 1 pharate pupa. CSIOC13299 - 1 pharate pupa)

Simulium lobatoi Luna Dias, Hernández, Maia-Herzog & Shelley, 2004 – **RJ** (Itaguaí: CSIOC1590 - 1♂ reared. CSIOC1591 - 1♀ reared. CSIOC1592 - 1♀ reared; Rio de Janeiro: CSIOC16708 - 2 pharate pupae. CSIOC16709 - 7 pharate pupae. CSIOC18132 - 4 pharate pupae)

Simulium rubrithorax Lutz, 1909 – **AM** (Barcelos: CSIOC21092 - 13 pharate pupae and 3 pupal exuviae. CSIOC21094 - 27 pharate pupae. CSIOC21099 - 1♀ reared and 26 pupal exuviae. CSIOC21102 - 6 pharate pupae. CSIOC21113 - 1♀ reared, 25 pharate pupae, and 18 pupal exuviae). **DF** (Brasília: CSIOC220 - 1♀ reared. CSIOC857 - 3 pharate pupae. CSIOC858 - 4 pharate pupae. CSIOC859 - 3♀ reared). **PE** (Moreno: CSIOC1943 - 1♀ reared). **TO** (São Salvador: CSIOC13057 - 1 pharate pupa. CSIOC13431 - 14 pharate pupae; São Sebastião: CSIOC13096 - 1 pharate pupa. CSIOC13100 - 2 pharate pupae. CSIOC13102 - 3 pharate pupae)

Subgenus *Simulium* (*Notolepria*) Enderlein, 1930

Simulium cuasiexiguum Shelley, Luna Dias, Maia-Herzog & Lowry, 2000 – **MG** (Lassance: CSIOC770 - 1 pupal exuvia. CSIOC782 - 1♂ reared. CSIOC4190 - 15♂ reared, 24♀ reared, and 28 pharate pupae; Pirapora: CSIOC2312 - 1♀ reared. CSIOC8520 - 1♂ reared). **MS** (Dois Irmãos: CSIOC827 - 1♀ reared. CSIOC828 - 1♂ reared and 1♀ reared)

Simulium exiguum Roubaud, 1906 – **AC** (Bujari: CSIOC7282 - 3 pharate pupae. CSIOC7291 - 1 pharate pupa. CSIOC7318 - 1 pharate pupa. CSIOC7324 - 2 pharate pupae; Porto Acre: CSIOC7312 - 2 pharate pupae.

Simulium paraguayense Schrottky, 1909 – **GO** (Formoso: CSIOC19288 - 1♀ reared; Niquelândia: CSIOC19287 - 2♀ reared; Minaçú: CSIOC19290 - 1♀ reared)

Subgenus *Simulium* (*Psaroniocompsa*) Enderlein, 1934

Simulium anamariae Vulcano, 1962 – **AM** (São Paulo de Olivença: CSIOC18719 - 1♀ reared). **MG** (Lassance: CSIOC3432 - 1♀; Lima Duarte: CSIOC20963 - 1 pupal exuvia; Pedralva: CSIOC1779 - 1♀ reared. CSIOC2617 - 1♀. CSIOC3229 - 1♀ reared and 4 pharate pupae. CSIOC3246 - 1♀ reared and 2 pharate pupae; Sacramento: CSIOC3535 - 3 pharate pupae. CSIOC3540 - 4 pharate pupae. CSIOC3547 - 1♀ reared; Wenceslão Braz: CSIOC3200 - 1♀ reared)

Simulium bertellii Py-Daniel, Longaray, Pujol-Luz & Pessoa, 2021 – **GO** (Alto Paraíso de Goiás: CSIOC19886 - 2 pharate pupae and 2 last-instar larvae)

Simulium botulibranchium Lutz, 1910 – **MG** (Corinto: CSIOC3154 - 1 pharate pupa; Itajubá: CSIOC3898 - 2 pharate pupae; Pedralva: CSIOC541 - 1♂ reared. CSIOC542 - 1♀ reared. CSIOC2629 - 1♂. CSIOC2630 - 1♂. CSIOC2631 - 1♀. CSIOC2632 - 1♀. CSIOC2633 - 1♀. CSIOC2634 - 1♀. CSIOC2635 - 1♀). **SC** (Ilhota: CSIOC5346 - 1 pharate pupa; Joinville CSIOC4814 - 1♀ reared)

Simulium brevifurcatum Lutz, 1910 – **DF** (Brasília: CSIOC2929 - 1♂ reared. CSIOC2930 - 1♂ reared). **MG** (Pedralva: CSIOC2626 - 1♂. CSIOC2627 - 1♀. CSIOC2628 - 1♂. CSIOC3230 - 1♂ reared. CSIOC3254 - 1♂ reared and 2 pharate pupae. CSIOC3271 - 1 pharate pupa. CSIOC3275 - 1 pharate pupa. CSIOC3392 - 2 pharate pupae; Sacramento: CSIOC3542 - 1 pharate pupa). **RJ** (Macaé: CSIOC20769 - 1 pharate pupa).

Simulium clavibranchium Lutz, 1910 – **MT** (Chapada dos Guimarães: CSIOC2794 - 1♀ reared. CSIOC10431 - 1♀ reared and 1 pharate pupa. CSIOC10434 - 1♀ reared. CSIOC10436 - 1♀ reared. CSIOC10447 - 1♀ reared. CSIOC10464 - 1♀ reared. CSIOC11790 - 1♀. CSIOC11829 - 1♂ reared. CSIOC11854 - 1♀ reared and 3 pharate pupae. CSIOC11857 - 1♀ reared. CSIOC11891 - 1♀ reared. CSIOC11892 - 1♀ reared and 1 pharate pupa. CSIOC11895 - 1♀ reared). **RO** (Ji-Paraná: CSIOC4822 - 1♂ reared. CSIOC4825 - 1♀ reared. CSIOC4828 - 1♂ reared. CSIOC4829 - 1 pharate pupa).

Simulium goeldii Cerqueira & Nunes De Mello, 1967 – **MA** (Barreirinhas: CSIOC22580 - 9♀. CSIOC22581 - 14♀. CSIOC22582 - 9♀. CSIOC22583 - 14♀. CSIOC22584 - 15♀. CSIOC22585 - 10♀. CSIOC22586 - 6♀. CSIOC22587 - 9♀)

Simulium inaequale (Paterson & Shannon, 1927) – **PE** (Moreno: CSIOC1940 - 1♀ reared. CSIOC1947 - 1♀ reared. CSIOC1959 - 1♀ reared).

Simulium incrustatum Lutz, 1910 – **AL** (Novo Lino: CSIOC8525 - 1♀ reared. CSIOC8526 - 1♀ reared. CSIOC8527 - 1♀. CSIOC8528 - 1♀; Marechal Deodoro: CSIOC22545 - 1♀ reared. CSIOC22540 – 1 pupal exuvia).

Table 4 (continued)

Simulium limbatum Knab, 1915 – **AL** (Marechal Deodoro: CSIOC22546 - 1♀ reared. CSIOC22547 - 2♂ reared; Joaquim Gomes: CSIOC22536 - 1♀ reared; Satuba: CSIOC22523 - 1♀. CSIOC22525 - 14 pharate pupae and 1 pupal exuvia. CSIOC22526 - 1♀). **GO** (Minaçú: CSIOC20033 - 1♀). **MG** (Além Paraíba: CSIOC7838 - 1♀ reared. Chiador: CSIOC10151 - 2 pharate pupae); Corinto: CSIOC3951 - 1♀. CSIOC3982 - 1♀. CSIOC3983 - 1♀). **PR** (Prudentópolis: CSIOC19128 - 1♀. CSIOC19129 - 1♀. CSIOC19130 - 1♀. CSIOC19131 - 1♀. CSIOC19132 - 1♀). **TO** (Paranã: CSIOC5666 - 1♀ reared and 1 pharate pupa. CSIOC5686 - 1♂ reared. CSIOC5690 - 1♀ reared. CSIOC5693 - 1♀ reared. CSIOC13608 - 1♂ reared and 1 pharate pupa. CSIOC13614 - 1♂ reared). **SE** (Japoatã: CSIOC22570 - 1♀ reared. CSIOC22573 - 1♂ reared, 1 pharate pupa and 1 pupal exuvia)

Simulium minusculum Lutz, 1910 – **PR** (Foz do Iguaçu: CSIOC4877 - 1♀ and 2♂), **RJ** (Três Rios: CSIOC7965 - 1♂ reared. CSIOC7966 - 1♂ reared. CSIOC8002 - 1♀ reared. CSIOC9210 - 1♂ reared)

Simulium oyapockense Floch & Abonnenc, 1946 [*s.l.*] – **GO** (Cavalcante: CSIOC6400 - 1♀. CSIOC6418 - 1♂ reared; Minaçú: CSIOC6393 - 2♀. CSIOC6394 - 2♀. CSIOC6397 - 2♀. CSIOC6398 - 2♀. CSIOC6419 - 1♂ reared)

Simulium pujoli (Py-Daniel, Coscarón & Pessoa, 2017) – **GO** (Teresina de Goiás: CSIOC19885 - 2 pharate pupae and 1 last-instar larva. CSIOC22951 - 1♀ reared)

Simulium quadrifidum Lutz, 1917 – **MT** (Chapada dos Guimarães: CSIOC11878 - 1♂ reared. CSIOC11923 - 1♂ reared and 1♀ reared. CSIOC11924 - 1♀ reared; Sorriso: CSIOC19333 - 1♀ reared)

Simulium rappae Py-Daniel & Coscarón, 1982 – **DF** (Brasília: CSIOC191 - 1♀ reared. CSIOC22107 – 1 pharate exuvia), **TO** (Formosa: CSIOC194 - 1♀ reared. CSIOC572 - 1♀ reared. CSIOC573 - 1♀ reared. CSIOC574 - 1♀ reared)

Simulium subnigrum Lutz, 1910 – **TO** (Peixe: CSIOC5725 - 1♀ reared; São Salvador: CSIOC5620 - 1♀ reared. CSIOC5916 - 1♀ reared. CSIOC5917 - 1♀ reared. CSIOC6122 - 1♂ reared; Paranã: CSIOC6347 - 1♀ reared)

Subgenus *Simulium* (*Psilopelmia*) Enderlein, 1934

Simulium dinellii (Joan, 1912) – **MG** (Chiador: CSIOC11513 - 1♀ reared; Além Paraíba: CSIOC11520 - 1♂ reared. CSIOC11686 - 1♂ reared. CSIOC13734 - 5 pharate pupae. CSIOC14079 - 1♂ reared and 4 pharate pupae)

Simulium lutzianum Pinto, 1931 – **DF** (Brasília: CSIOC1040 - 1♀ reared. CSIOC1044 - 1♀ reared. CSIOC2912 - 1♀ reared. CSIOC9838 - 1♀ reared. CSIOC17650 – 1 pharate pupa). **RJ** (Rio Claro: CSIOC4998 - 9 pharate pupae)

Simulium ochraceum Walker, 1861 – **AC** (Bujari: CSIOC7411 - 1 pharate pupa. CSIOC7249 - 1 pharate pupa. CSIOC7280 – 3 pharate pupae. CSIOC7290 - 1 pharate pupa; Porto Acre: CSIOC7307 - 1 pharate pupa) **AM** (Boca do Acre: CSIOC7237 - 1♂ reared)

Simulium perflavum Roubaud, 1906 – **DF** (Brasília: CSIOC210 - 1♂ reared. CSIOC8546 - 1♀ reared. CSIOC8578 - 1 pharate pupa. CSIOC8636 - 1♀ reared)

Simulium rorotaense Floch & Abonnenc, 1946 – **ES** (Santa Leopoldina: CSIOC13876 - 1 pharate pupa. CSIOC13895 - 2 pharate pupae. CSIOC13909 - 2 pharate pupae. CSIOC13936 - 1♂ reared and 1 pharate pupa. CSIOC13964 - 1♂ reared). **RR** (Alto Alegre: CSIOC2238 - 1♀ and 1 pharate pupa. CSIOC2239 - 1♂ and 1 pharate pupa. CSIOC2240 - 1♀ and 1 pharate pupa. CSIOC2242 - 1♂. CSIOC2242 - 1♀ and 1 pharate pupa)

Subgenus *Simulium* (*Trichodagmia*) Enderlein, 1934

Simulium hirtipupa Lutz, 1910 – **TO** (Arraias: CSIOC512 - 1♂ reared. CSIOC515 - 1♀ reared; Miracema do Tocantins: CSIOC1190 - 1♂ reared; Paranã: CSIOC5792 - 1♂ reared; Lajeado: CSIOC19136 - 1♂ reared). **PE** (Undetermined municipality. Border between the states of PE and AL, Rio Mirim, Fazenda Engenho Boa Sorte: CSIOC22876 - 4 pharate pupae and 1 pupal exuvia)

hydrographic basins in RN) and noted that the material examined, consisting of pupae and larvae, was certified by specialists. However, they did not specify where this material is housed. Conversely, the record of *S. subpallidum* is supported by the study of material deposited at the CSIOC (Table 1 and Table 4).

Almeida et al. (1999) documented the presence of larvae and pupae of *S. perflavum* in three localities in PB (Table 1). Although the determiner and location of the deposited material are not indicated, it was collected by one of the authors of the study and a leading specialist for the family in Brazil (Dr. V. Py-Daniel). This species is also recorded in three Northeast states, two of which are adjacent to PB (Adler 2022). Therefore, this record provides sufficient evidence to be considered valid.

Monteiro-Santos and Gorayeb (2005) recorded *S. incrustatum* in PA (Table 1). This publication indicates the collection points and the material, including immatures and adults, was certified by specialists at INPA. However, there is no indication where the material is housed. Therefore, there are sufficient elements to consider this record as valid.

Pepinelli et al. (2006) documented *S. exiguum s.l.* in RO (Table 1). The collection point is indicated and the examined material, last-instar larvae, was collected, identified, and deposited at INPA by the authors. Additionally, this record is also supported by Coscarón et al. (2008) and Shelley et al. (2010).

The material examined in Hernández et al. (2007) documented the occurrence of *S. rappae* Py-Daniel & Coscarón in DF (Table 1). This material consisted of reared adults collected from three different locations. It was examined by specialists and deposited at the CSIOC, but it has not been catalogued. This record is further corroborated by Coscarón et al. (2008) and supported by material found at the CSIOC (Table 1 and Table 4).

Shelley et al. (2010) reported several new records. *Simulium cuasiexiguum* Shelley, Luna Dias, Maia-Herzog and Lowry was recorded in MG (Table 1). In the examined material section, the occurrence of this species in MG was mentioned, and the material was identified by specialists and deposited in IOC (Table 4) and NHM. *Simulium guianense*

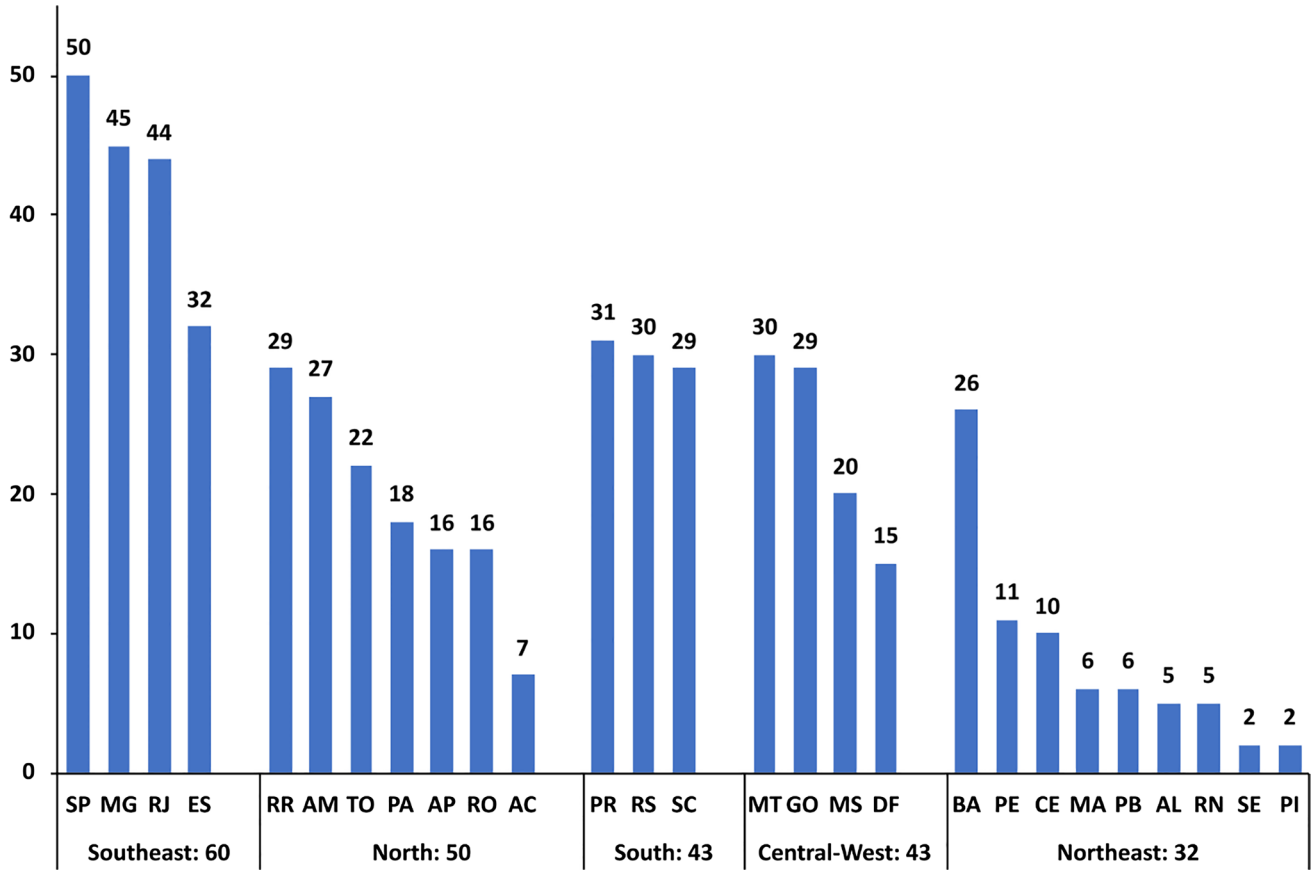

Fig. 1 Species richness of Simuliidae recorded for each Brazilian state and region

species in Brazil, being reported in 23 states, followed by *S. incrustatum* (21), *S. subpallidum* (21), *S. pertinax* (18), *S. rubrithorax* Lutz (18), and *S. subnigrum* Lutz (18) (Table 3).

Regarding species of medical importance, based on the CSIOC studied material, the geographical distribution of the following onchocerciasis vectors species is updated: *Simulium exiguum* (AC), *S. incrustatum* (AL), and *S. oyapockense* (GO) (Table 1 and Table 3). We also found new distribution records for the following vector species: *Simulium exiguum* (RO), *S. incrustatum* (PA), *S. oyapockense* (MA), and *S. guianense* (CE, PE, PI) (Table 1 and Table 3), based on our literature survey.

Discussion

The checklist of Brazilian blackflies has been updated to include 98 species (Table 3). However, it is important to note that 10 species currently recorded for the country (*S. roraimense*, *S. exiguum*, *S. guianense*, *S. hirtipupa* Lutz, *S. incrustatum*, *S. lutzianum* Pinto, *S. maroniense* Floch and Abonnenc, *S. metallicum* Bellardi, *S. ochraceum* Walker, and *S. oyapockense*) belong to species complexes (Adler 2022). In these specific cases, future studies that aim to solve taxonomic problems through an integrative approach (combining different methods such as cytogenetic, molecular, and morphological analysis), as employed for example by Adler and Huang (2022), could contribute to the recognition of the identities of these complexes and, probably, increase the number of blackfly species cited for Brazil.

Six species represent dubious records as they lack elements that provide robust evidence of their occurrence in the country: *Araucnephia iberaensis* Coscarón and Coscarón-Arias; *S. shewellianum* Coscarón; *S. delponteianum* Wygodzinsky; *S. quadristrigatum* Enderlein; *S. catarinense* Pinto; *S. incertum* Lutz. Given this reality and the reasons detailed below, we have chosen not to include these species in the checklist (Table 3) but to list them subsequently as "Dubious records," indicating the need for further investigation.

The original description of *A. iberaensis* was based exclusively on Argentinian material, with Coscarón and Coscarón-Arias (2007) subsequently recording its presence in Brazil as "Brazil: Paraná (unpublished information)" without indicating examined material, collection locality, date, collectors, or depositing institution. Based on this imprecise record, subsequent catalogs and books

on the Brazilian simulids fauna have considered the Brazilian record of this species as valid (e.g., Coscarón et al. 2008; Shelley et al. 2010; Adler 2022). The curator of Entomological Collection of the MACN, where Dr. Sixto Coscarón's collection is deposited, was contacted, but this material was not located, nor were its collection data.

Simulium shewellianum was recorded by Pepinelli et al. (2003) based solely on immatures and without indicating the examined material (quantities and whether they were larvae or pupae), for São Paulo (SP) in Southeast Brazil. Additionally, according to Adler (2022), the species belongs to the Dinellii group of *S.* (*Psilopelmia*), which includes other species with very similar immatures, such as *S. dinelli* and *S. ochraceum*, which are widely distributed in the South and Southeast of Brazil. Shelley et al. (2010) also did not consider this record, arguing that it is practically impossible to distinguish *S. shewellianum* from other species of *S.* (*Psilopelmia*) without the analysis of reared adults.

Another similar case is that of *S. delponteianum*, which has a single record by Strieder (2004) based solely on immatures collected in Rio Grande do Sul (RS), without specifying the number of specimens and whether they are larvae or pupae. According to Adler (2022), the species is included in the Amazonicum group of *S.* (*Psaroniocompsa*), along with other species with very similar immatures, of which nine species are recorded for Brazil. Shelley et al. (2010) indicate the need for further verification of the record and do not consider it valid for Brazil for the same reasons.

The remaining three species have insufficient original descriptions to allow for their correct identification, as they are based on a single stage and are considered *species inquirenda* by other authors. Furthermore, they also present problems such as the absence of voucher material or poorly preserved specimens.

Simulium quadristrigatum was described solely for "Paraná" based on a single female. Coscarón and Coscarón-Arias (2007), Coscarón et al. (2008), and Shelley et al. (2010) consider the species as *species inquirenda* because it was described from a single female of unknown origin and indistinguishable from other females of the Amazonicum group of *S.* (*Psaroniocompsa*), in which it is included (Adler 2022). Coscarón and Coscarón-Arias (2007) mention that the type specimen is poorly preserved, pinned through the scutum, with fungal residue and loss of claws. The authors also argue that the type locality "Paraná" is confusing, as it can refer to the Brazilian state of Paraná or the Paraná River, which runs through several states in Southeast Brazil, Paraguay, and Argentina.

Simulium catarinense was described based on a single male from São Bento, SC, supposedly deposited in CSIOC but not located there. This species is considered as a *species inquirenda* by Coscarón and Wygodzinsky (1984), Coscarón (1987, 1991), Coscarón and Coscarón-Arias (2007), Coscarón et al. (2008), and Shelley et al. (2010).

The last species, *S. incertum*, was described from MG and SP based on pupae and larvae and is considered as *species inquirenda* by Coscarón (1987, 1991), Coscarón and Coscarón-Arias (2007), Coscarón et al. (2008), and Shelley et al. (2010). The type material was also supposedly deposited at the CSIOC; however, it was not found. It is worth noting that Lutz (1910), in the description of this species, suggested possible synonymy with *S. paraguayense* Schrottky.

The six species mentioned above are among the 29 species listed for only one state (Table 3). According to their original descriptions, 15 of these species were described from high-elevation regions above 700 m: *A. cearensis* Pessoa, Rios-Velásquez, and Py-Daniel (CE); *S. bertellii* Py-Daniel, Longaray, Pujol-Luz and Pessoa (GO); *S. bifenestratum* Hamada and Pepinelli (SP); *S. catarinense* (SC); *S. cerradense* Coscarón, Cerqueira, Schumaker, and La Salvia (BA); *S. coscaroni* Nascimento, Hamada, and Adler (MG); *S. covagarciai* Ramírez-Pérez, Yarzábal, Takaoka, Tada, and Ramírez (RR); *S. itajara* Nascimento, Hamada, and Pepinelli (BA); *S. jefersoni* Hamada, Hernández, Luz, and Pepinelli (BA); *S. lundi* (Py-Daniel and Barbosa) (AM); *S. maiaherzogae* Aranda, Molina, Chimes, and Py-Daniel (MG); *S. margaritatum* Pepinelli, Hamada, and Luz (BA); *S. marins* Pepinelli, Hamada, and Currie (SP); *S. pujoli* (Py-Daniel, Coscarón, and Pessoa) (GO); *S. souzalopesi* Coscarón (RJ).

Plateaus above 900 m correspond to 7.3% of the Brazilian territory (Vesentini 2006) and include centers of endemism for the Neotropical region (Rapini et al. 2008; Vasconcelos 2011). These ecosystems, known as "rock fields" (above 900 m) and "altitude fields" (above 1500 m), represent isolated refuges for flora and fauna, presenting more constant climatic conditions at the top of the relief compared to their surroundings, with distinct vegetation. These locations serve as the type locality for many recently described Simuliidae species, which have remained restricted to these isolated "islands" within the larger altitudinal gradient. This rationale can be applied to, approximately, half of the species records for a single state (15 out of 29 spp.).

Another set of species recorded for a single state includes eight Amazonian species: *S. criniferum* Nascimento, Hamada, Andrade-Souza and Adler (AP); *S. cristalinum* Coscarón and Py-Daniel (RR); *S. daltanhani* Hamada and Adler (AM); *S. mutucuna* Nunes de Mello and Vieira da Silva (RR); *S. nunesdemelloi* Hamada, Pepinelli and Hernández (AM); *S. perplexum* Shelley, Maia-Herzog, Luna Dias and Couch (PA); *S. roraimense* (RR); *S. tergospinosum* Hamada (AM). Most of these species were collected sporadically in streams that cross roads and highways or in remote areas near indigenous villages. Difficulties in accessing and traversing the

Amazonian territory hinder the execution of detailed inventories by hydrographic basins, which may limit our knowledge of the geographical distribution of these species, which have remained restricted to their type localities.

The Southeast region of Brazil has the highest known diversity of Simuliidae, with 60 different species being present (representing 61.8% of the Brazilian blackfly fauna) (Table 3 and Fig. 1). This knowledge is a result of the extensive studies on blackflies carried out in this region, which have addressed various ecological issues (e.g., Bertazo and Figueiró 2012; Couceiro et al. 2014; Docile et al. 2015; Figueiró et al. 2006, 2008; Pepinelli et al. 2005), diversity (e.g., Araujo-Coutinho et al. 1988; Bertazo et al. 2010, 2013; Gil-Azevedo et al. 2005; Gil-Azevedo and Maia-Herzog 2004, 2009; Pepinelli et al. 2003, 2005, 2006; Pepinelli 2011), and entomological control (e.g., Araújo-Coutinho 1995; Campos and Andrade 2002; Docile et al. 2021).

Also present in the Southeast region are the Atlantic Forest and Cerrado biomes, both considered hotspots due to their high biodiversity, endemism, and anthropic pressure. As a result, these biomes are a priority in global efforts to conserve biodiversity (Myers et al. 2000; Ribeiro et al. 2011; Sawyer et al. 2018). It is worth noting that the highlands (regions above 700 m), which make up the smallest portion of the Brazilian relief, are well represented in the Southeast region, and are home to undersampled biomes for blackflies.

The Brazilian Northeast region, with 32 different species, presents significant gaps in the sampling of Simuliidae diversity (Fig. 1). This region is a convergence area between the Amazon, Cerrado, Caatinga, and Atlantic Forest biomes, which harbor areas of great endemism such as the Atlantic Forest region north of the São Francisco River, the Northeast swamps, and the Pernambuco Center of Endemism. The Diamantina (BA), Araripe (CE, PE, and PI), and Mesas (MA) plateaus also deserve attention, as they exhibit a significant altitudinal gradient, separate hydrographic basins, and function as islands for biodiversity, promoting population isolation and speciation. In recent decades, some species have been specifically described for the highlands of Northeast Brazil, including *A. cearensis*, *S. cerradense*, *S. jefersoni*, *S. margaritatum*, *S. virescens* Hamada, Silva and Pereira, and *S. itajara*. Of these species, three were specifically described for the Diamantina plateau. The only species described with a type locality in coastal regions is *S. maranguapense* (Pessoa, Ríos-Velásquez, and Py-Daniel), which was described for the north coast of CE. This reinforces the need for new collections also in coastal areas.

All considered, the actual biodiversity of blackflies in the Brazilian Northeast may be greater than what is currently known, particularly if we take into account the sampling gaps in several short and isolated river basins with a high rate of endemism that extend along the coast from BA to CE and are present in the *Tabuleiro* forest associated with the Atlantic Forest biome.

An analysis of available data on Brazilian biodiversity from information networks such as SIBBR/GBIF and speciesLink reveals gaps in sampling in both accessible areas and those with strong endemism in the Atlantic Forest and Northeast region of the country, where most states are undersampled. For instance, the coastal lowlands extending from the Lakes Region of RJ to the Northeast Region of the country remain undersampled.

Analysis of supplementary records considered valid but not included in Adler's (2022) Simuliidae World Inventory

D´Andretta and D´Andretta (1949) reported the occurrence of *S. auristriatum* Lutz in the Maracaju municipality of MT (Table 1). The examined material, which is deposited in FSP-USP, is indicated, and the collection sites are specified, with certification by specialists. This record was also reported by Vulcano (1967) and the deposition of part of this material at FSP-USP is confirmed by Forattini et al. (1971). However, in 1977, the state of MT was divided into the states of MT and MS, consequently, the municipality of Maracaju became part of MS. Thus, this record is now considered valid for MS.

Vulcano (1962) documented the occurrence of *S. brevifurcatum* Lutz in both PR and RJ (Table 1). This work specifies the source of the material (one collection point for PR and two for RJ), identified by Dr. M. Vulcano, and deposited in the MZUSP. The record for PR is also cited by Vulcano (1967), Coscarón and Wygodzinsky (1984), Strieder (2004), Coscarón and Coscarón-Arias (2007), and Coscarón et al. (2008). The RJ record is also supported by Vulcano (1967), Coscarón and Coscarón-Arias (2007), Coscarón et al. (2008), and Gil-Azevedo and Maia-Herzog (2009).

Shelley et al. (1997) recorded *S. rorotaense* Floch & Abonnenc for RR (Table 1). The material, consisting of adults and exuviae obtained from reared pupae, was collected in five different locations, examined by specialists, and deposited at the NHM. This record is further corroborated by Hamada and Adler (1999) and with material found at the CSIOC (Table 1 and Table 4).

Eaton et al. (1998) cited the occurrence of *S. inaequale* in MS (Table 1). The collection site and examined material are indicated, with vouchers identified by Dr. A. J. Shelley. However, the location where this material is housed is not specified. Additionally, this record is also supported by Shelley et al. (2010) and Zampiva and Pepinelli (2017).

Andrade and Py-Daniel (1995) recorded the presence of *S. perflavum*, *S. rubrithorax*, and *S. subpallidum* in RN (Table 1). The authors provided the collection sites (three

was recorded in PE (Table 1), and a male and female (both without associated exuviae) were deposited in the MLP. Although it is not clear whether Dr. S. Coscarón was a collector or a determiner, the characteristic pattern of the male lends credibility to the record. Moreover, this species is also distributed in the Northeast region and neighboring states of PE (Table 3). *Simulium hirtipupa* was recorded in TO (Table 1), and the material examined was identified by specialists and deposited in IOC (Table 4) and NHM. *Simulium limbatum* Knab was recorded in AL, MT, SE, and GO (Table 1). The publication mentions the places of origin of the examined material, which was identified by specialists and deposited in NHM. Some of the locations mentioned have correspondence with material from the CSIOC backlog (Table 4). After searching the CSIOC, this species was found for AL and SE, with reference to the same locations indicated in Shelley et al. (2010) (Table 4). *Simulium oyapockense* was recorded in MA (Table 1). Although the authors indicated that this species is widely distributed in Brazil, primarily in the northern region of RR, and less frequently in the southern Amazon basins, the Material Examined section of this work mentions its occurrence in MA. The specimens were identified by specialists and deposited at NHM.

Coscarón et al. (2011) documented the occurrence of *S. botulibranchium* Lutz in SC (Table 1). The authors provided information about the collection sites, and the material was identified by specialists and deposited in the CSIOC and MLP. This record is also supported by study material deposited in the CSIOC (Table 1 and Table 4).

Dos Santos-Neto et al. (2015) reported the occurrence of *S. guianense* in CE and PI (Table 1). Despite this species being a complex of several cytoforms (Adler et al. 2017), the authors collected a significant amount of material, including pupae and larvae of different instars, which allowed them to define the ontogenetic series of immatures. Additionally, all collection points are specified, and the material was identified by specialists and deposited in the INPA.

Zampiva and Pepinelli (2017) documented the presence of *S. inaequale* and *S. rubrithorax* in MS (Table 1). The material was collected in several different localities, identified by specialists, and housed at UFGD.

Py-Daniel et al. (2021b) revalidated *Shelleyellum damascenoi* (Py-Daniel), originally described as *Simulium* (*Psaroniocompsa*) *damascenoi* and later synonymized by Shelley et al. (2010) with *S. venezuelense* Ramírez-Pérez and Peterson. The revalidation of the species involved examination of topotype material of *S. venezuelense*, with the designation of a neotype. The authors provide specific diagnoses for all developmental stages (larva, pupa, male, and female) of *S. damascenoi*, compared with its congeners, and offer an extensive redescription of the larva. They also record the species in AM and PA. However, for the taxon record in the checklist presented in this study (Table 3), the proposed combination from the original species description, *S.* (*Psa.*) *damascenoi*, was reinstated.

Py-Daniel et al. (2021a) described a new species, *Psaroniocompsa bertellii*, discovered in the state of GO. In the current study, this species is added to the checklist of Brazilian Simuliidae fauna (Table 3). However, based on its original description and following the taxonomic arrangement of Adler (2022), it is included here under the subgenus *S.* (*Psaroniocompsa*).

Our analyses of supplementary records not considered valid by Adler (2022) reveal that the number of valid black fly species documented for Brazil now stands at 98.

Analysis of supplementary records not considered

Misidentifications, which can result in synonymies, is common in Simuliidae taxonomy due to the extraordinary similarity between many species, especially when identifications are based on a single developmental stage (Adler 2022). Incomplete information regarding the origin of specimens, as well as the lack of data about the examined material and its deposition in biological collections, are factors that impair the verification and reliability of some of the discovered records. Therefore, with respect to the supplementary records listed in the bibliography (Table 1), the following records cannot be considered valid:

Pinto (1931) cited *S. amazonicum* for the States of GO, MG, and BA (Table 1). However, the author only mentioned Dr. Arthur Neiva's observations of females of this species in hematophagous activity, without indicating the material examined or declaring where specimens were deposited. Hence, this record cannot be considered valid. Forattini et al. (1971), in the catalog of entomological collections of the FSP-USP, also reported this species for MT (five females), GO (one female), RJ (three female), and SP (nine females) (Table 1). However, despite this work indicating the collection site, deposited material, and species identificator, *S. amazonicum* is part of a species group of 13 species (the Amazonicum species group) (Adler 2022), on which most females have a very similar thoracic pattern (see Shelley et al. 2010). Therefore, to obtain accurate taxonomic identification, it is essential to mount the genitalia of specimens on a slide for examination, as well as to rear the specimens in order to obtain adults with their respective pupal exuviae, which facilitate identification since the pupae or exuviae are less homogeneous. Forattini et al. (1971) only indicated female material without attached exuviae. Hence, this distribution record cannot be considered valid because it could be an identification error.

Lane and Porto (1939) reported the occurrence of *L. flavopubescens* (Lutz) in SP (Table 1), but this record cannot be considered valid as it is based on a single female

collected in 1935, which, according to the authors, "corresponds, in part, with Lutz's description for this species." Females of the four known *Lutzsimulium* species are very similar and can be easily confused (see Shelley et al. 2010). Later works by Vulcano (1967), Forattini et al. (1971), and Coscarón et al. (2008) refer to the same material. Py-Daniel (1982) also examined this very specimen and attested that, despite being in a poor state of conservation, it had a greater number of mandibular teeth and differences in the nudiocular area when compared to the syntype of *L. flavopubescens*, which he also examined. He concluded that the specimen possibly belongs to *Lutzsimulium*, but that confirmation would not be possible due to the precarious state of the material.

Vulcano (1967) reported the occurrence of *S. botulibranchium* in MG (Table 1). However, the author cited the work of D'Andretta and D'Andretta (1947) as a reference, which does not report this species for MG but for RJ and SP (as already cited in Adler 2022). Therefore, Vulcano's (1967) record is not valid. Nevertheless, this species was found in MG after studying the material deposited at the CSIOC (Table 1 and Table 4), which represents the original record for the state.

Forattini et al. (1971) reported the deposition of two females of *S. distinctum* Lutz at FSP-USP, collected in the municipality of Dourados, MS (Table 1). The material was identified by an expert in 1943, but as females of this species have a thoracic pattern that is very similar to other related species of *S.* (*Chirostilbia*) (see Shelley et al. 2010), and since the cited material does not indicate attached exuviae, this record could easily be a misidentification and, therefore, cannot be considered valid. Moreover, no other bibliographic reference was found indicating the presence of this species in MS.

Almeida et al. (1999) reported the occurrence of *S. clavibranchium* Lutz in BA (Table 1). The authors relied on Coscarón (1987), who listed *S. mbarigui* Coscarón and Wygodzinsky as a synonym of *S. clavibranchium* in BA. However, Coscarón and Wygodzinsky (1984) had already identified *S. mbarigui* as a synonym of *S. subnigrum*, not *S. clavibranchium*, and this was not considered in Coscarón (1987). As a result, this error was repeated in Almeida et al. (1999). In Coscarón (1991), *S. mbarigui* was once again listed as a synonym of *S. subnigrum*. Therefore, the record by Almeida et al. (1999) does not correspond to *S. clavibranchium* but to *S. subnigrum*, which had already been reported in BA (Crosskey and Howard 1997). Consequently, the record by Almeida et al. (1999) cannot be considered valid.

Hernández et al. (2007) documented the occurrence of *S. margaritatum* in GO (Table 1). The record was deposited at CSIOC with a specific collection site (site 183). However, in the description of *S. pujoli*, Py-Daniel et al. (2017) examined the material collected by Hernández and found that it was actually *S. pujoli*. The material of *S. margaritatum* deposited in CSIOC mentioned by Hernández et al. (2007) (one female with associated exuvia mounted in a permanent slice) was examined and re-identified as *S. pujoli*. Therefore, the record of *S. margaritatum* for GO is invalid.

In a Catalogue of Neotropical Diptera (Simuliidae), Coscarón et al. (2008) cited the occurrence of *S. maranguapense* in GO, *S. siolii* Py-Daniel 1988 in AP, and *S. venezuelense* in TO (Table 1). However, the authors did not provide specific collection site information or details about the material examined for any of these records. Additionally, Coscarón et al. (2008) are not a primary source, and the authors cite other references for each species. Two references for *S. maranguapense* (Coscarón and Coscarón-Árias 2007 and Hernández et al. 2007), four for *S. siolii* (Py-Daniel 1983; Ramírez-Pérez 1983; Crosskey and Howard 1997, and Coscarón and Coscarón Arias 2007), and five for *S. venezuelense* (Py-Daniel and Sampaio 1995, Crosskey and Howard 1997, Hamada et al. 2003, Py-Daniel and Pessoa 2005, and Coscarón and Coscarón-Arias 2007). None of these sources indicate the occurrence of these species in the mentioned states. Thus, the records of *S. maranguapense* for GO, *S. siolii* for AP, and *S. venezuelense* for TO are also invalid.

Coscarón and Coscarón-Arias, (2007) and Coscarón et al. (2008) also cited the occurrence of *S. dinellii* (Joan) in MG (Table 1). However, Shelley et al. (2010) considered this record invalid due to a misinterpretation of the collection locality of the material, which was mistakenly attributed to MG when it actually belonged to BA. The same authors also report that the original label of this material identified it as "varians" (a synonym of *S. perflavum*). Nonetheless, after searching the CSIOC backlog (Table 1 and Table 4), new records of *S. dinellii* in MG were confirmed.

Landeiro et al. (2009) reported the first record of *S. scutistriatum* Lutz for BA (Table 1), based on material collected from a single location in Mucugê Municipality in The Chapada Diamantina National Park, identified by experts and deposited at INPA. However, in the description of *S. itajara*, Nascimento et al. (2020) is indicated that *S. scutistriatum* was misidentified in Landeiro et al. (2009) and that all previous records of *S. scutistriatum* in the Brazilian Northeast region should be reevaluated.

Nascimento et al. (2009) initially reported the presence of *S. lutzianum* for AC (Table 1), based on eight specimens deposited at CSIOC. However, upon examination, it was found that these specimens were S. *ochraceum*, a species that differs significantly from *S. lutzianum* in several morphological features. Additionally, specimens previously identified as *S. lutzianum* but collected in the State of AM (Rio Acre) were also re-identified as *S. ochraceum*, making this material the first record of *S. ochraceum* for AC (Table 1).

Coppo and Lopes (2010) recorded *S. dinelii* for PR (Table 1), but this record was based only on two last instar larvae. As *S. dinellii* belongs to a morphologically

homogeneous group, its larvae can be easily confused with other species, such as *S. ochraceum*, which is also present in Brazil. Consequently, this record cannot be considered valid.

In their examined material section, Shelley et al. (2010) reported a record of "Simulium near siolii" for AP (Table 1). However, the CSIOC heritage book indicated that the preliminary identification of the material from locality 1325, which was cited in Shelley et al. (2010), was as *S. quadrifidum* Lutz/*S. cauchense* Floch and Abonnenc. Although Shelley et al. (2010) had previously identified the same material as *S. quadrifidum* by Dr. A.J. Shelley and is housed in the NHM, due to the morphological similarity of these species and because the authors themselves not being categorical regarding the identification, this record was not considered valid. Additionally, Shelley et al. (2010) also recorded *S. cauchense* for MT (Table 1) in their examined material, which is deposited at the CSIOC and has a defined collection point (site 1241 of the CSIOC heritage book). However, upon examination, it was found that the material consisted of two females without associated exuvia and with different thoracic patterns. Furthermore, despite being mentioned as *S. cauchense* in Shelley et al. (2010), the CSIOC material identification label, made by Dr. L.M. Hernández, listed it as *S. siolii*. Due to the poor state of conservation of the material and the great similarity between the thoracic pattern of the females of the Amazonicum species group of *S.* (*Psaroniocompsa*) (as described by Shelley et al. 2010), it was not possible to accurately certify this record, and therefore, it is also considered as not valid.

Figueiró et al. (2012) recorded *S. dekeyseri* Shelley and Py-Daniel and *S. subnigrum* for TO (Table 1). However, these records cannot be considered valid as the authors only collected larvae that were identified as *S. pertinax*/*S. dekeyseri* and *S. subnigrum*/*S. inaequale* respectively, and at this stage, these species are indistinguishable, as indicated by the authors themselves.

During the literature review, three species not previously reported for Brazil in Adler (2022) were identified. Cunha and Bassi (1997) reported the presence of *S. romanai* Wygodzinsky in the Municipality of Morretes, PR (Table 1), but did not specify the source of this information, cite any examined material, or indicate where it was deposited. Coppo and Lopes (2010) reported *S. rubiginosum* (Enderlein) in the municipality of Telêmaco Borba, PR (Table 1), but did not specify whether pupae or larvae were examined, nor where they were deposited. Furthermore, the immatures of the Bicoloratum species group of *S.* (*Psilopelmia*), which includes *S. rubiginosum*, are morphologically similar and can easily be confused without examining adults (Coscarón and Coscarón-Arias 2007; Shelley et al. 2010). Finally, Coscarón and Coscarón-Arias (2007) and Coscarón et al. (2008) included *S. kabanayense* Ramírez-Pérez and Vulcano in their list for the State of RR (Table 1) but did not provide any locality data or indicate whether any examined material was available. Moreover, none of the references cited by the authors for this species mentioned Brazil. Although *S. kabanayense* was previously listed for Brazil in Adler and Crosskey's (2008, 2009, 2010, and 2011), its distribution was restricted to just Venezuela and Guyana from the Adler and Crosskey´s (2012) inventory onward. Given this evidence, the records of *S. kabanayense*, *S. romanai*, and *S. rubiginosum* are not sufficient to be considered valid for Brazil.

On the biological databases records

The biological database survey identified eight records, of which six were considered for inclusion in the checklist as they were identified by specialists, had defined collection sites, and were deposited in publicly accessible collections (Table 2). The two records excluded from the checklist were females without attached exuviae. One of them was a record of *S. distinctum* for the State of AM, housed at the CMN/Fiocruz, but lacked an indication of the determiner. The other record was of *S. dinellii* for PA, housed at the NHM, which was not considered valid because this species can be easily confused with its congeners and is difficult to certify without the analysis of the pupal exuvia. The remaining records that met the established criteria are presented in Table 2.

The significance of the Simuliidae Collection of the Oswaldo Cruz Institute—CSIOC/Fiocruz

The CSIOC is located at the LSOEMF/IOC and is a relatively new collection compared those of institutions such as MN/UFRJ, MPEG, or MZUSP. Nevertheless, it presently contains representative material from 18 countries, with a focus on Brazilian and neotropical blackflies. Currently, it contains 23,028 cataloged records, which can be translated into 3798 locality data for 143 species (87 for Brazil). Figure 2 shows the Brazilian CSIOC records.

Its origins date back to the mid-1970s when the first studies on onchocerciasis and mansonellosis were carried out in Brazil, resulting in the preservation of specimens. In recent decades, the CSIOC staff has undertaken new field trips in the Amazon region and the Central-West of Brazil, which have led to the collection's expansion. The CSIOC has also included voucher material from various entomological monitoring projects of large enterprises, such as hydroelectric plants, ecology, taxonomy, and systematic works on the group, which carry implications for the cataloging and preservation of over 200 type specimens. Additionally, the historical collections of Adolpho Lutz and César Pinto are also under the care of the CSIOC.

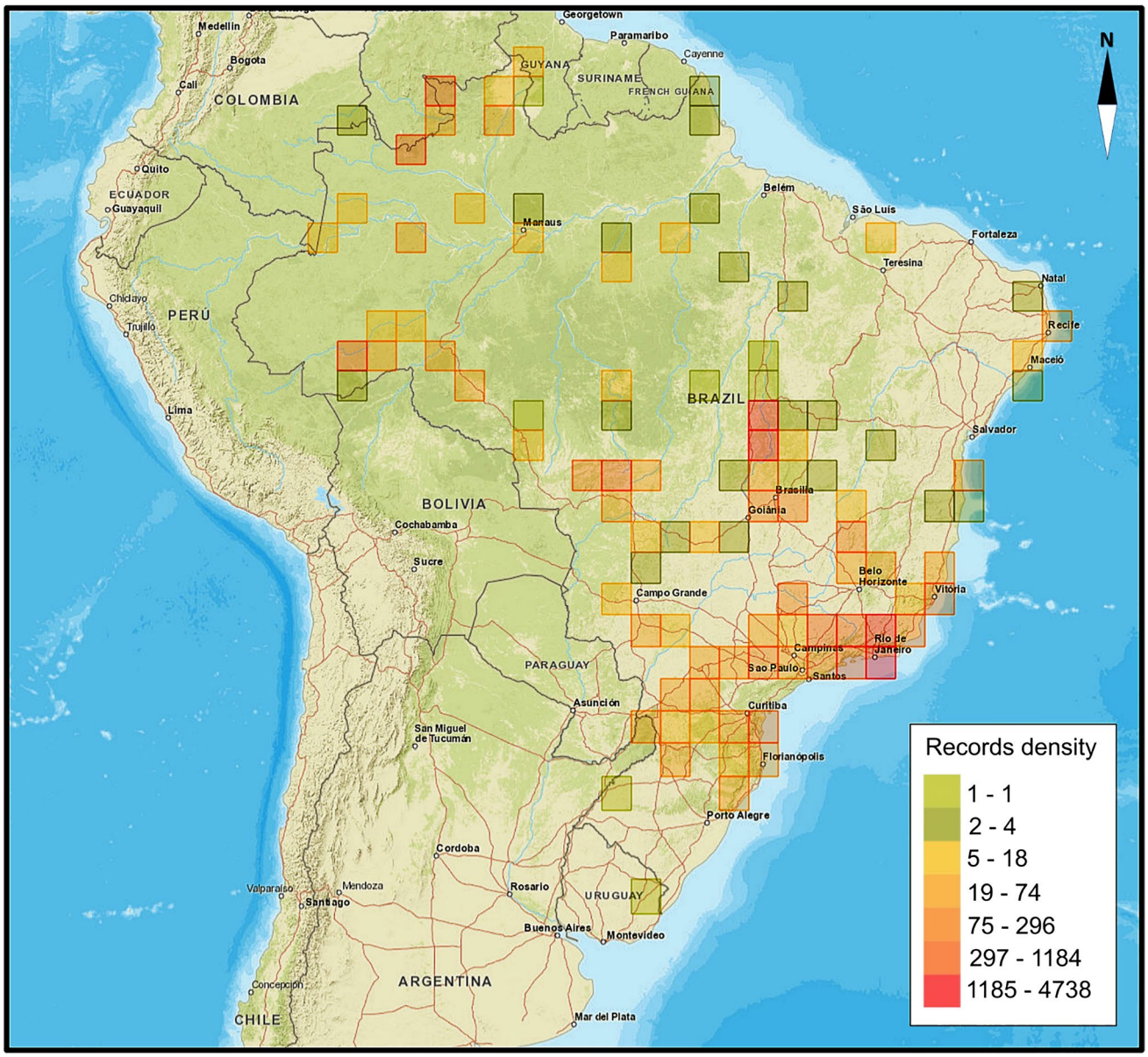

Fig. 2 Map showing the density of Simuliidae records from CSIOC for Brazil

The CSIOC is the primary repository of public information on the distribution of blackflies in Brazil, contributing to 90% of the family current records available in the Brazilian Biodiversity Information System (SIBBR), the Brazilian node of GBIF, and the speciesLink network. The certification of biological material referring to the records of other repositories that are already part of these biodiversity information networks, as well as the inclusion of new databases, can enhance the accuracy of the distribution of blackflies in Brazil and their entomological monitoring. Furthermore, they can highlight knowledge gaps, indicating the necessity for collaborative projects on faunal inventories in strategic areas, such as the Northeast Region, mountainous regions of the Southeast, or undersampled biomes, such as the Caatinga, among other gaps previously mentioned.

Exclusive records found in the CSIOC

With the discovery of an autochthonous case of onchocerciasis in the Brazilian Central-West Region, from Minaçu, GO, and on the border with TO (Gerais and Ribeiro 1986), collections of blackflies by the former LSO team (currently LSOEMF/IOC) intensified in this region with the aim of characterizing the composition of the Simuliidae fauna in the secondary focus for onchocerciasis (Maia-Herzog

et al. 1999; Shelley et al. 2000, 2001). Subsequently, faunal inventory projects and entomological monitoring were carried out for large hydroelectric power plant construction companies in the Tocantins River Basin regions, in the states of GO and TO (Eletrobras/FURNAS: Serra da Mesa HEP—1996–2000 and Peixe Angical HEP—2004–2008; CESS: São Salvador HEP—2007–2009 and 2011–2013) and the Cuiabá River Basin, MT (FURNAS/PROMAN: Manso HEP—2002–2003 and 2009–2011). The voucher material from these research projects and technical works was deposited in the CSIOC. The sampling effort carried out for several years in this region resulted in the description of *S. cuasiexiguum* (for GO), *S. lobatoi* Luna Dias, Hernández, Maia-Herzog and Shelley (for GO and MT), and *S. brunnescens* Maia-Herzog, Valente, Luna-Dias, Gil-Azevedo and Marchon-Silva (for MT), as well as in the large number of new exclusive records from the CSIOC reported for these states in this study: GO (four new records), MT (2), and TO (4) (Table 1 and Table 4).

According to Adler (2022), the Northeast region of Brazil has only 30 recorded species of Simuliidae, and in some states, the richness of this family is virtually unknown: PI (one species), AL (two), RN (two), MA (three), PB (five), CE (six), and PE (six). It is important to note that only 26 species are recorded for BA, which represents 86% of the Simuliidae diversity in the Northeast region, and no species have been recorded in SE. These results demonstrate the urgent need to inventory the fauna throughout the region. The exclusive records found at CSIOC (Table 1 and Table 4) considerably expand the knowledge of Simuliidae diversity for some of these states: AL (two new records), MA (one), SE (two), and PE (four) (Fig. 1). It is important to highlight that most of these new records were obtained from identified material that was in the CSIOC backlog, from a single expedition carried out by the LSO team to the Northeast states of Brazil in August 1993, as part of research projects funded by the British Council/CNPq and the European Community. This fact illustrates a favorable scenario in which, at a relatively low cost, it is possible to obtain significant results in generating knowledge about Brazilian biodiversity by prioritizing sampling gaps in strategic areas.

The Southeast region of Brazil presents the highest number of Simuliidae species in the country, concentrating several faunistic inventory studies. In São Paulo, for instance, the implementation of various projects, especially the Biota project (e.g., Pepinelli 2011), has contributed to a large sampling effort, resulting in the highest known richness of the group in the country. In this context, universities and research institutes located in the Brazilian Southeast region, such as MN/UFRJ, LSOEMF/IOC, UERJ, MZUSP, UFSCar, and UEZO, have a greater number of collections or researchers interested in Simuliidae than other regions. This richness can be observed in Adler (2022), which records 50 species for SP, 38 for MG, 38 for RJ, and 30 for ES.

The Simuliidae records from CSIOC material presented here (Table 1 and Table 4) represent an increase of six species for RJ and two species for ES. The material from these states was collected through research projects, voucher material from dissertations and theses, long-term projects involving the ecology of Simuliidae in the Atlantic Forest, and technical works at the Simplício Hydroelectric Power Plant, located in the Paraíba do Sul River Basin, on the border between RJ and MG.

Despite being close to RJ, where the CSIOC is located, the state of ES has a significant gap in representation in its collection. In June 2014, one of the authors (ATA) participated in a research project on rapids-dwelling fish of the Atlantic Forest of ES, which are endemic to the mountainous region of the state. In order to evaluate the record of new Simuliidae species, four blackfly collection points were defined within the occurrence area of three endemic fish species of the region. A total of 238 lots of specimens were collected, corresponding to 13 Simuliidae species in just four collection points in the Santa Maria da Vitória and Reis Magos River basins, including the type locality of two fish species. Although no new black fly species were discovered, the first specimens of *S. obesum* Vulcano and *S. rorotaense* were recorded for ES (Table 1 and Table 4) in the municipality of Santa Leopoldina. This is a good example of how investigating strategic areas endemic to other aquatic organisms can aid in generating knowledge about Simuliidae diversity, even from a few sporadic samplings.

Conclusion

The present study contributes to the knowledge of the diversity of Simuliidae in Brazil by providing 71 new geographical distribution records of 38 species in 24 states of the country. These findings highlight the need for increased sampling efforts in areas that are currently undersampled and have potential for endemism. Collaborative work is crucial to further expand the geographic range of recorded species, potentially add new species, and enhance our understanding of the group's ecology and distribution.

The updated checklist is also essential for entomological monitoring of blackflies, which can act as vectors of disease-causing agents. This information is vital for epidemiological analysis and forecasting of the spread of diseases due to climate change, as well as understanding changes in the demographic patterns of anthropophilic species in human-altered regions.

To ensure the sustainability of physical collections and associated information for future generations, it is essential to establish a national policy for the preservation of biological collections in Brazil. Regular government actions can help maintain collections and make their data

available to the broader scientific community and society as a whole.

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Author Contribution OSM and ATA: conceptualization, data curation, formal analysis, research methodology, validation, original manuscript writing, reviewing, and editing; ATA: financing acquisition; FGC: data curation, formal analysis, validation, and reviewing.

Data Availability Availability of Data and Materials All materials deposited at the CSIOC and studied here are listed in Table 4 (supplementary material), indicating the CSIOC catalogue number

Declarations

Competing Interest The authors declare no competing interest.

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