



## Drosophilidae (Insecta, Diptera) in the state of Pará (Brazil)

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**Abstract:** This list contains information on the Drosophilidae that occur in the Brazilian state of Pará, Amazon biome, and an analysis of the current knowledge of Drosophilidae based on museum material and literature records. This list includes a detailed account of the material deposited in the entomological collections of the Museu Paraense Emílio Goeldi and Museu de Zoologia da Universidade de São Paulo, up to 2015. In total, 122 species of Drosophilidae were registered, including 27 new records for the state of Pará and 22 are new records for the Amazon; for instance, the genera *Diathoneura* and *Rhinoleucophenga*, and three new records for Brazil, (*Drosophila fasciola*, *Diathoneura flavolineata* and *Drosophila neochracea*). The state of Pará is the third state in Brazil in terms of numbers of species of Drosophilidae, with 17% locally native species. Despite the high species richness, there is still a lot to be known about the states's Drosophilidae fauna. This study highlights the importance of scientific collections, particularly as an aid to study regional biodiversity.

**Keywords:** *species composition, Amazon, Diathoneura, Rhinoleucophenga.*

## Drosophilidae (Insecta, Diptera) no estado do Pará (Brasil)

**Resumo:** As informações reunidas nesta lista referem-se à ocorrência de Drosophilidae no estado do Pará, bioma Amazônia com uma análise do estado de conhecimento do grupo. Este documento contém uma revisão detalhada do material depositado na Coleção Entomológica do Museu Paraense Emílio Goeldi e Museu de Zoologia da Universidade de São Paulo até 2015, bem como a análise de toda a literatura relevante. Um total de 122 espécies de Drosophilidae foi registrado, com 27 novos registros para o estado do Pará e 22 são novas ocorrências para a Amazônia. Entre estes o primeiro registro para os gêneros *Diathoneura* e *Rhinoleucophenga*, além de três registros novos para o Brasil (*Drosophila fasciola*, *Diathoneura flavolineata* e *Drosophila neochracea*). O estado do Pará é o terceiro maior estado brasileiro em termos de número de espécies registradas, com 17% das espécies com ocorrência exclusiva no Estado. Ainda assim há grandes lacunas para o conhecimento da fauna dos Drosophilidae do estado. Este estudo destaca a importância das coleções científicas, acima de tudo, como um elemento crucial para compreensão da biodiversidade regional.

**Palavras-chave:** *Composição de espécies, Amazônia, Diathoneura, Rhinoleucophenga.*

### Introduction

There are more than 4,200 Drosophilidae species in the world (Bächli 2015). This number will most likely increase as new species are continuously being described, particularly in the Neotropical region (Silva & Martins 2004, Vilela & Bächli 2005, Ratcov & Vilela 2007, Culik & Ventura 2009, Schmitz et al. 2009, Figuero & Rafael 2011, Figuero et al. 2012, Gottschalk et al. 2012, Acurio et al. 2013, Poppe et al. 2014, Junges & Gottschalk 2014, Guillín & Rafael 2015, Junges et al. 2016, Vidal & Vilela 2015). In Brazil, the Drosophilidae family is represented by 16 genera and 305 species (Tidon et al. 2015). Taxonomic inventories are needed to we fill the knowledge gaps on biodiversity (Hortal et al. 2015). Although the first collections for the Amazon dating from

1920-1959 period (Duda 1927; Hendel 1936; Dobzhansky & Pavan 1943; Pavan 1950; Pavan 1959), the richness of Drosophilidae fauna of the Brazilian Amazon is still little known, states such as Acre, Amapá, Roraima, Rondônia e Tocantins have less than 12 recorded species (Gottschalk et al. 2008). Among the Amazonian states, only Amazonas and Pará have more consistent inventory Drosophilid (Bächli 2015). As the result, the scenario of the distribution of species for this region is still very incomplete.

The Drosophilidae fauna of the state of Pará has been sporadically studied since 1920, by pioneer systematists (Duda 1927; Hendel 1936; Burla et al. 1949), evolutionary biologists (Pavan 1950) and more recently by ecologists (De Toni et al. 2005; Martins & Oliveira 2007;

Martins & Santos 2007; Silva & Martins 2009; Praxedes & Martins 2014 and Robe et al. 2014). Currently, in Pará there are 75 Drosophilidae species from nine genera that are from two subfamilies Steganinae and Drosophilinae (Bächli 2015).

Throughout the years a great volume of material has accumulated in scientific collections. Material from the state of Pará is, for the most part, deposited in the collections Museu Paraense Emílio Goeldi (MPEG) and Museu de Zoologia da Universidade de São Paulo (MZUSP). The Drosophilidae species in the MPEG deposit were mostly collected in the Amazon, from expeditions dating back to the 1970s. At MZUSP it is known to hold Brazil's largest Diptera collection, with specimens from large expeditions during the 1940s and 1950s, particularly in the Amazon, coordinated by Dr. Crodowaldo Pavan (Magalhães 2010). We analyzed material from these two collections and using literature data to complement our survey. Our goal was to list the species of Drosophilidae that are found in the state of Pará, with the aim to fill a knowledge gap of Drosophilidae found in the Amazon.

## Material and Methods

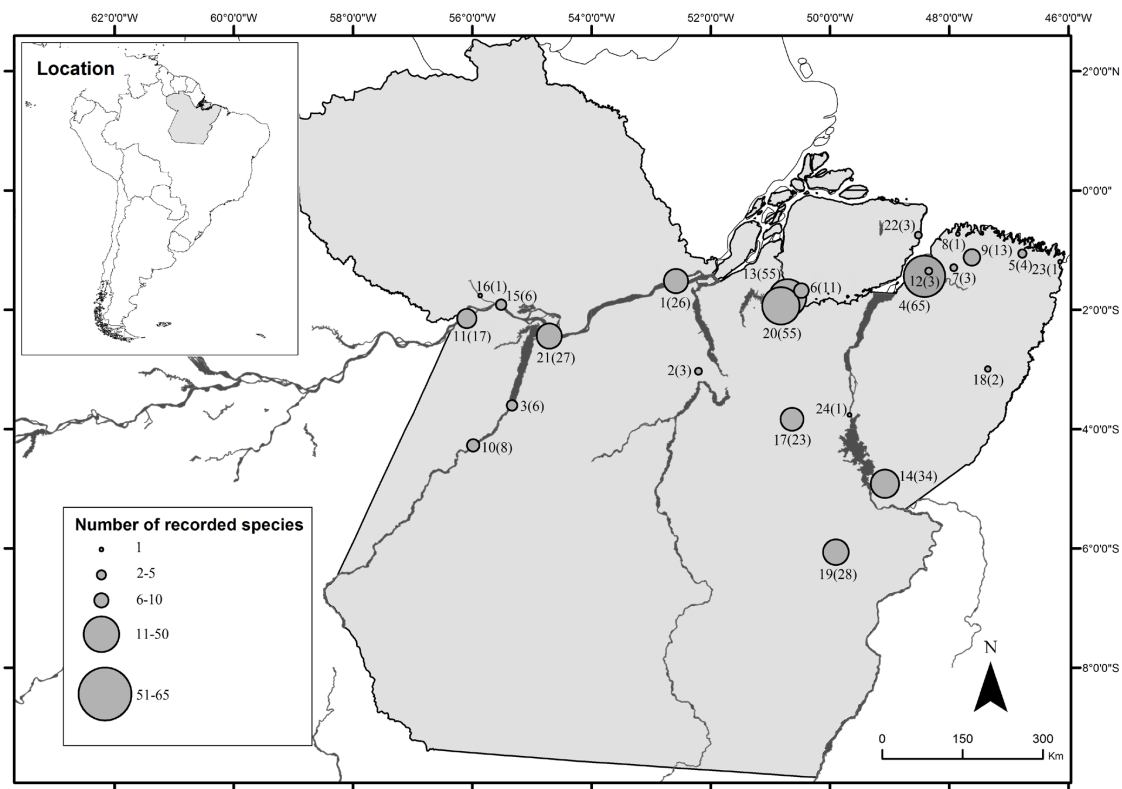
The state of Pará, Northern Brazil, has an area of 1,248,000 km<sup>2</sup>, is completely immersed in the Amazon Biome (IBGE 2010). The climate is Equatorial (Am) and Tropical (As), according to Köppen classification, with a mean temperature of 25 °C and minimum precipitation of 1,300 mm per year and maximum of 2,400 mm per year (Moraes et al. 2005).

Occurrence data for Drosophilidae was compiled based on literature research, and the examination of material deposited in the entomological collection of the MPEG and MZUSP up to 2015. Data was plotted on a map of Brazil's municipalities. The identification of all Drosophilidae at MPEG was rechecked. For this, we dissected the genitalia of, and examined, up to five males of each species (following the procedure described by Bächli et al. 2004). The identity of species represented only by females was checked using external morphological characters whenever possible. Drosophilidae specimens that were in 70% ethanol and from the wet collection at MPEG, were mounted on entomological pins after being dissected. The specimen terminalia were stored in microtubes containing glycerin and pinned together with the specimen. Specimens deposited in the MZUSP had already been dissected and their terminalia were stored in microtubes containing glycerin, thus facilitating confirmation. The individual number of each species deposited in the MPEG collection was recorded. The total number of individual specimens of each species found in MZUSP was not accounted.

We searched Drosophilidae literature using the website compiled by Gerhard Bächli (Bächli 2015). We also verified and analyzed each literature reference for the state of Pará.

## Results and Discussion

In total, 122 species of Drosophilidae in 11 genera were found, distributed in 24 of the 144 municipalities of the state of Pará (Figure 1). Nine genera belong to the subfamily Drosophilinae (*Chymomyza* Czerny,



**Figure 1.** Distribution of Drosophilidae in Pará, indicating the known species richness of each municipality. Map of South America at the upper left with the state of Pará highlighted in gray. The numbers on the map correspond to the following municipalities. In parenthesis correspond to the number of species for each locality. 1. Almeirim (1°31'22" S, 52°34'55" W); 2. Altamira (3°2'10" S, 52°12'21" W); 3. Aveiro (3°36'21" S, 55°19'55" W); 4. Belém (1°26'27" S, 48°24'50" W); 5. Bragança (1°3'46" S, 46°46'22" W); 6. Breves (1°40'55" S, 50°28'48" W); 7. Castanhal (1°17'49" S, 47°55'19" W); 8. Curuçá (0°44'2" S, 47°51'18" W); 9. Igarapé-Açu (1°7'37" S, 47°37'4" W); 10. Itaituba (4°16'33" S, 55°59'2" W); 11. Juruti (2°9'7" S, 56°5'31" W); 12. Marituba (1°21'18" S, 48°20'31" W); 13. Melgaço (1°48'14" S, 50°42'43" W); 14. Nova Ipixuna (4°55'15" S, 49°4'37" W); 15. Óbidos (1°55'4" S, 55°31'4" W); 16. Oriximiná (1°45'57" S, 55°51'57" W); 17. Pacajá (3°50'16" S, 50°38'16" W); 18. Paragominas (2°59'42" S, 47°21'10" W); 19. Parauapebas (6°4'4" S, 49°54'7" W); 20- Portel (1°56'9" S, 50°49'15" W); 21. Santarém (2°26'34" S, 54°42'28" W); 22. Salvaterra (0°45'10" S, 48°31'1" W); 23. Viseu (1°11'49" S, 46°8'24" W); 24. Tucuruí (3°46'4" S, 49°40' 22" W).

1903, *Diathoneura* Duda, 1924, *Drosophila* Fallén, 1823, *Hirtodrosophila* Duda, 1923, *Mycodrosophila* Oldenberg, 1914, *Neotanygastrella* Duda, 1925, *Scaptodrosophila* Duda, 1923, *Zaprionus* Coquillett, 1901 and *Zygothrica* Wiedemann, 1830) and two belong to Steganinae (*Leucophenga* Mik, 1886 and *Rhinoleucophenga* Hendel, 1917). The actualized list of all species can be found in Table 1. References in the column 'record' of Table 1 represent the oldest record for the species. The table also shows the municipalities of Pará where each species was recorded from, and the total number of specimens deposited in the collection of the Museu Paraense Emílio Goeldi. The map (Figure 1) shows the distribution

of Drosophilidae in Pará, indicating the known species richness of each municipality. The municipality of Belém had the greatest number of species, 65, followed by Melgaço (MEL) and Portel (POR), with 55 species, and Santarém (SAN), with 27. More than half of the species (66) occurred in less than three municipalities. *Drosophila malerkotliana*, an invasive species present in the Amazon since the 1980s, was the most widespread species, occurring in 15 municipalities. The second most abundant species was the native species *Drosophila nebulosa*, *Drosophila sturtevantii* and *Drosophila willistoni*, which were found in 13 of the 24 municipalities.

**Table 1.** Drosophilidae recorded in the state of Pará, Brazil. Municipalities: ALM = Almeirim, ALT = Altamira, AVE = Aveiro, BEL = Belém, BRA = Bragança, BRE = Breves, CAS = Castanhal, CUR = Curuçá, IGA = Igarapé-Açu, ITA = Itaituba, JUR = Juruti, MAR = Marituba, MEL = Melgaço, NIP = Nova Ipixuna, OBI = Óbidos, ORI = Oriximiná, PAC = Pacajá, PARG = Paragominas, PARP = Parauapebas, POR = Portel, SAN = Santarém, SAL = Salvaterra, TUC = Tucuruí and VIS = Viseu. Records: MPEG = Museu Paraense Emílio Goeldi and MZUSP = Museu de Zoologia da Universidade de São Paulo collections. # in col: Total Drosophilidae specimens deposited in the MPEG.

Species	Municipalities	Records	# in col
<b>Subfamily Drosophilinae</b>			
<b>Genus Chymomyza</b>			
<b>aldrichii group</b>			
<sup>3</sup> <i>Chymomyza bicoloripes</i> (Malloch, 1926)	ALM and SAN	Hendel (1936)	
<i>Chymomyza diatropa</i> Grimaldi, 1986	MEL and POR	MPEG and Schmitz et al. (2013)	23
<b>Genus Diathoneura</b>			
<sup>1,2,4</sup> <i>Diathoneura flavolineata</i> Duda, 1927	BEL	MZUSP	
<b>Genus Drosophila</b>			
<b>Subgenus Drosophila</b>			
<b>annulimana group</b>			
<sup>1</sup> <i>Drosophila annulimana</i> Duda, 1927	BEL, MEL and POR	MPEG	5
<i>Drosophila araicas</i> Pavan & Nacur, 1950	ALM, BEL, MEL and POR	MPEG and Val (1982)	7
<sup>1,4</sup> <i>Drosophila arapuan</i> Da Cunha & Pavan, in Pavan & Da Cunha, 1947	PARP	MPEG	1
<i>Drosophila ararama</i> Pavan & Da Cunha, 1947	BEL and NIP	MPEG, Pavan & Cunha (1947)	14
<sup>3</sup> <i>Drosophila caxiuana</i> Gottshalk et al., 2012	MEL and POR	MPEG and Gottschalk et al. (2012)	5
<b>bromeliae group</b>			
<sup>3</sup> <i>Drosophila speciosa</i> Silva & Martins, 2004	BEL, CUR, MEL and POR	MPEG and Silva & Martins (2004)	429
<b>calloptera group</b>			
<i>Drosophila atrata</i> Burla & Pavan, 1953	AVE and PARP	MPEG and Burla & Pavan (1953)	2
<i>Drosophila calloptera</i> Schiner, 1868	BEL, MEL, POR and SAN	MPEG and Burla & Pavan (1953)	5
<sup>1,4</sup> <i>Drosophila quadrum</i> (Wiedemann, 1830)	OBI	MZUSP	
<b>canalinae group</b>			
<sup>3</sup> <i>Drosophila annularis</i> Sturtevant, 1916	SAN	Hendel (1936)	
<sup>1,4</sup> <i>Drosophila annulosa</i> Duda, 1929	MEL and POR	MPEG	2
<i>Drosophila canalinae</i> Patterson & Mainland, 1944	BEL, MEL, PARP and POR	MPEG and Patterson & Stone (1952)	1
<i>Drosophila davidgrimaldii</i> Vilela & Bächli, 1990	MEL, SAN and POR	MPEG and Vilela & Bächli (1990)	1
<sup>3</sup> <i>Drosophila hendeli</i> Vilela & Bächli, 1990	SAN	Vilela & Bächli (1990)	
<b>caponei group</b>			
<sup>1,4</sup> <i>Drosophila caponei</i> Pavan & Cunha, 1947	BEL	MPEG	9
<sup>1,2,4</sup> <i>Drosophila neochracea</i> Wheeler, 1959	BEL and TUC	MPEG	5
<b>cardini group</b>			
<b>cardini subgroup</b>			
<i>Drosophila cardini</i> Sturtevant, 1916	BEL, NIP, PAC and PARP	MPEG and Heed & Russell (1971)	17
<i>Drosophila cardinoides</i> Dobzhansky & Pavan, 1943	AVE, BEL, IGA, MAR, NIP and PARP	MPEG and Streisinger (1946)	9
<i>Drosophila neocardini</i> Streisinger, 1946	MEL, NIP, PAC and POR	MPEG and Silva & Martins (2009)	2
<i>Drosophila neomorpha</i> Heed & Wheeler, 1957	ALM, BEL, JUR, MEL, NIP, PAC, PARP and POR	MPEG and De Toni et al. (2005)	11
<i>Drosophila parthenogenetica</i> Stalker, 1953	MEL, NIP, PAC and POR	MPEG and De Toni et al. (2005)	6
<i>Drosophila polymorpha</i> Dobzhansky & Pavan, 1943	BEL and BRE	Dobzhansky & Da Cunha (1955)	
<b>coffeata group</b>			
<i>Drosophila coffeata</i> Williston, 1896	ALM, BEL, MEL, PARP, POR and SAN	MPEG and Hendel (1936)	91
<i>Drosophila fuscolineata</i> Duda, 1925	BEL	MPEG and Dobzhansky & Pavan (1950)	2

<sup>1</sup>New records for the state of Pará; <sup>2</sup>New records for Brazil; <sup>3</sup>Species that are recorded in Brazil only in the state of Pará; <sup>4</sup>New records for Amazon

Table 1. Continued...

Species	Municipalities	Records	# in col
<b>dreyfusi group</b>			
<i>Drosophila camargoi</i> Dobzhansky & Pavan in Pavan, 1950	BEL BRE, MEL, NIP and POR	MPEG and Pavan (1959)	71
<sup>3</sup> <i>Drosophila decemseriata</i> Hendel, 1936	SAN	Hendel (1936)	
<b>flavopilosa group</b>			
<sup>3</sup> <i>Drosophila melina</i> Wheeler, 1962	BEL	MPEG and Santos & Martins 2000	256
<b>guarani group</b>			
<b>guaramunu subgroup</b>			
<sup>1,4</sup> <i>Drosophila griseolineata</i> Duda, 1927	PARP	MPEG	1
<b>guarani subgroup</b>			
<i>Drosophila ornatifrons</i> Duda, 1927	BEL	MPEG and Pavan (1959)	1
<b>pallidipennis subgroup</b>			
<i>Drosophila pallidipennis</i> Dobzhansky & Pavan, 1943	BEL	Dobzhansky & Pavan (1950)	
<b>peruensis subgroup</b>			
<i>Drosophila peruviana</i> Duda, 1927	AVE and BEL	MZSP and Pavan (1959)	
<b>repleta group</b>			
<b>fasciola subgroup</b>			
<i>Drosophila ellisoni</i> Vilela, 1983	ALM, BEL, IGA, JUR, NIP and PAC	MPEG and Vilela (1983)	11
<sup>1,2,3,4</sup> <i>Drosophila fasciola</i> Williston, 1896	NIP, PAC and PARP	MPEG	7
<i>Drosophila fascioloides</i> Dobzhansky & Pavan, 1943	BEL	Wasserman (1962)	
<sup>1,4</sup> <i>Drosophila ivai</i> Vilela, 1983	ALM, NIP, PAC, PARP and POR	MPEG	19
<sup>1,4</sup> <i>Drosophila mapiriensis</i> Vilela & Bächli, 1990	BEL, MEL, NIP and POR	MPEG	6
<i>Drosophila moju</i> Pavan, 1950	BEL, JUR, NIP and PARP	MPEG and Vilela (1983)	11
<sup>3</sup> <i>Drosophila mojuoides</i> Wasserman, 1962	BEL	MPEG and Vilela (1983)	1
<sup>1,4</sup> <i>Drosophila papei</i> Bächli & Vilela, 2002	NIP and PARP	MPEG	12
<sup>1,4</sup> <i>Drosophila querubimae</i> Vilela, 1983	MEL, NIP, PAC and POR	MPEG	3
<b>hydei subgroup</b>			
<i>Drosophila hydei</i> Sturtevant, 1921	BEL	MPEG and Martins & Oliveira (2007)	6
<b>mercatorum subgroup</b>			
<sup>1</sup> <i>Drosophila mercatorum</i> Patterson & Wheeler, 1942	BEL	MPEG	1
<sup>1</sup> <i>Drosophila paranaensis</i> Barros, 1950	NIP and PARP	MPEG	7
<b>mulleri group</b>			
<sup>1</sup> <i>Drosophila aldrichi</i> Patterson, in Patterson & Crow, 1940	ALT, MEL and POR	MPEG	10
<b>repleta subgroup</b>			
<i>Drosophila eleonorae</i> Tosi et al., 1990	ALT	MPEG and Tosi et al. (1990)	41
<i>Drosophila fulvimacula</i> Patterson & Mainland, 1944	ALM, BEL, JUR, MEL, NIP, PAC, PARP, POR	MPEG and Dobzhansky & Da Cunha (1955)	52
<sup>1,4</sup> <i>Drosophila limensis</i> Pavan & Patterson in Pavan & Da Cunha, 1947	MEL and POR	MPEG	2
<sup>1</sup> <i>Drosophila repleta</i> Wollaston, 1858	MEL and POR	MPEG	11
<b>tripunctata group</b>			
<b>I subgroup</b>			
<i>Drosophila mediocris</i> Frota-Pessoa, 1954	MEL and POR	MPEG and Praxedes & Martins (2014)	1
<i>Drosophila neoguaramunu</i> Frydenberg, 1956	BEL	MPEG and Martins & Santos (2007)	1
<sup>1,4</sup> <i>Drosophila setula</i> Heed & Wheeler, 1957	PAC	MPEG	3
<b>II subgroup</b>			
<sup>1,4</sup> <i>Drosophila cuaso</i> Bächli, Vilela & Ratcov, 2000	ALM, BEL, MEL, NIP, PARP and POR	MPEG	9
<b>III subgroup</b>			
<i>Drosophila addisoni</i> Pavan, 1950	BEL	Pavan (1959)	
<i>Drosophila frotapessoai</i> Vilela & Bächli, 1990	BEL, MEL and POR	MPEG and Martins & Oliveira (2007)	1
<i>Drosophila medioimpressa</i> Frota-Pessoa, 1954	MEL and POR	MPEG and Praxedes & Martins (2014)	1
<i>Drosophila mediopicta</i> Frota-Pessoa, 1954	MEL and POR	MPEG and Praxedes & Martins (2014)	1
<i>Drosophila mediotriata</i> Duda, 1925	BEL, MEL and POR	Martins & Oliveira (2007)	
<i>Drosophila mesostigma</i> Frota-Pessoa, 1954	BEL	Val (1982)	
<sup>1,4</sup> <i>Drosophila paramediotriata</i> Townsend & Wheeler, 1955	BEL and PARP	MPEG	4
<sup>1,4</sup> <i>Drosophila trapeza</i> Heed & Wheeler, 1957	PARP	MPEG	1
<b>IV subgroup</b>			
<sup>1,4</sup> <i>Drosophila albicans</i> Frota-Pessoa, 1954	PARP	MPEG	4

<sup>1</sup>New records for the state of Pará; <sup>2</sup>New records for Brazil; <sup>3</sup>Species that are recorded in Brazil only in the state of Pará; <sup>4</sup>New records for Amazon

Table 1. Continued...

Species	Municipalities	Records	# in col
<b>Without subgroup</b>			
<sup>3</sup> <i>Drosophila argenteifrons</i> Wheeler, 1954	CAS	Wheeler (1954)	
<b>Subgenus <i>Phloridosa</i></b>			
<sup>1,4</sup> <i>Drosophila lutzii</i> Sturtevant, 1916	BEL	MPEG	6
<b>Subgenus <i>Sophophora</i></b>			
<b><i>melanogaster</i> group</b>			
<b><i>ananassae</i> subgroup</b>			
<i>Drosophila ananassae</i> Doleschall, 1858	BEL, BRA, IGA, MEL, NIP, PAC, PRAP and POR	MPEG and Praxedes & Martins (2014)	107
<i>Drosophila malerkotiana</i> Parshad & Paika, 1964	ALM, BEL, BRA, BRE, IGA, JUR, MEL, NIP, PAC, PARG, PARP, POR, SAN, SAL and VIS	MPEG and Martins (2001)	533
<b><i>melanogaster</i> subgroup</b>			
<i>Drosophila melanogaster</i> Meigen, 1830	BEL, MEL and POR	MPEG and David et al. (2006)	15
<i>Drosophila simulans</i> Sturtevant, 1919	ALM, BEL, IGA, JUR, MEL, NIP and POR	MPEG and Dobzhansky & Pavan (1950)	44
<b><i>montium</i> subgroup</b>			
<i>Drosophila kikkawai</i> Burla, 1954	BEL, IGA, MEL, NIP, PAC, PARG and POR	MPEG and Praxedes & Martins (2014)	88
<b><i>saltans</i> group</b>			
<b><i>cordata</i> subgroup</b>			
<i>Drosophila neocordata</i> Magalhães, 1956	ALM, BEL, MEL, NIP and POR	MPEG and Praxedes & Martins (2014)	9
<b><i>elliptica</i> subgroup</b>			
<i>Drosophila neoelliptica</i> Pavan & Magalhães in Pavan, 1950		MPEG and Praxedes & Martins (2014)	1
<b><i>parasaltans</i> subgroup</b>			
<i>Drosophila parasaltans</i> Magalhães, 1956	ALM, JUT, MEL and POR	MPEG and Praxedes & Martins (2014)	2
<i>Drosophila subsaltans</i> Magalhães, 1956	ALM, BEL, JUR, MEL, NIP, PAC and POR	MPEG and Magalhães (1956)	2
<b><i>saltans</i> subgroup</b>			
<i>Drosophila austrosaltans</i> Spassky, 1957	BEL, JUR, MEL and POR	MPEG and Praxedes & Martins (2014)	2
<i>Drosophila prosaltans</i> Duda, 1927	ALM, ALT, AVE, BEL, BRA, BRE, JUR, MEL, NIP, PAC, PARG and POR	MPEG and Dobzhansky & Streisinger (1944)	3
<i>Drosophila pseudosaltans</i> Magalhães, 1956	MEL and POR	MPEG and Bicudo (1973)	16
<i>Drosophila saltans</i> Sturtevant, 1916	ALM, MEL and POR	MPEG and De Toni et al. (2005)	1
<b><i>sturtevanti</i> subgroup</b>			
<i>Drosophila dacunhai</i> Mourão & Bicudo, 1967	MEL and POR	MPEG and Martins et al. (2008)	5
<sup>3</sup> <i>Drosophila milleri</i> Magalhães, 1962	MEL and POR	MPEG and Praxedes & Martins (2014)	5
<i>Drosophila magalhaesi</i> Mourão & Bicudo, 1967	ALM, BEL, JUR, MEL and POR	MPEG and Martins et al. (2008)	18
<i>Drosophila sturtevanti</i> Duda, 1927	ALM, AVE, BEL, BRE, IGA, ITA, JUR, MEL, NIP, PAC, PARG, POR and SAN	MPEG and Dobzhansky (1944)	132
<b><i>willistoni</i> group</b>			
<b><i>bocainensis</i> subgroup</b>			
<i>Drosophila capricorni</i> Dobzhansky & Pavan, 1943	BEL, MEL and POR	MPEG and Dobzhansky & Pavan (1950)	1
<i>Drosophila fumipennis</i> Duda, 1925	BEL, BRE, JUR, MEL and POR	MPEG and Pavan (1959)	35
<i>Drosophila nebulosa</i> Sturtevant, 1916	ALM, AVE, BEL, BRE, IGA, JUR, MEL, NIP, PAC, PARG, PARG, POR and SAL	MPEG and Dobzhansky & Pavan (1950)	63
<b><i>willistoni</i> subgroup</b>			
<i>Drosophila equinoxialis</i> Dobzhansky, 1946	ALM, BEL, BRE, IGA, MEL, NIP, PAC, PARG, POR and SAN	MPEG and Burla et al. (1949)	23
<i>Drosophila paulistorum</i> Dobzhansky & Pavan in Burla et al., 1949	ALM, BEL, BRE, IGA, JUR, MEL, NIP, PAC, PRAP, POR and SAN	MPEG and Townsend (1954)	105
<i>Drosophila tropicalis</i> Burla et al., 1949	BEL, MEL, POR, SAN and SAL	MPEG and Burla et al. (1949)	26
<i>Drosophila willistoni</i> Sturtevant, 1916	ALM, BEL, BRA, BRE, IGA, ITA, JUR, MEL, NIP, PAC, PARG, POR and SAN	MPEG and Dobzhansky & Mayr (1944)	104
<b>Ungrouped species</b>			
<i>Drosophila impudica</i> Duda, 1927	BEL, JUR, NIP, PAC and PARG	MPEG, MZSP and Pavan (1959)	8
<i>Drosophila tuchaua</i> Pavan, 1950	BEL, MEL and POR	MPEG and Pavan (1950)	55
<b>Subgenus <i>Siphodora</i></b>			
<sup>1,4</sup> <i>Drosophila flexa</i> Loew, 1866	NIP	MPEG	2

<sup>1</sup>New records for the state of Pará; <sup>2</sup>New records for Brazil; <sup>3</sup>Species that are recorded in Brazil only in the state of Pará; <sup>4</sup>New records for Amazon



Table 1. Continued...

Species	Municipalities	Records	# in col
<b>Hirtodrosophila</b>			
<b>Ungrouped species</b>			
<sup>3</sup> <i>Hirtodrosophila pictiventris</i> Duda, 1925	Localities not mentioned	Vilela & Bächli (2004)	
<i>Hirtodrosophila subflavohalterata</i> Burla, 1956	MEL and POR	Robe et al. 2014	
<b>Genus <i>Mycodrosophila</i></b>			
<sup>3</sup> <i>Mycodrosophila brunnescens</i> Wheeler & Takada, 1963	BEL	Wheeler & Takada (1963)	
<sup>3</sup> <i>Mycodrosophila elegans</i> Wheeler & Takada, 1963	CAS	Wheeler & Takada (1963)	
<i>Mycodrosophila projetans</i> Wheeler & Takada, 1963	MEL and POR	Robe et al. (2014)	
<b>Genus <i>Neotanygastrella</i></b>			
<sup>3</sup> <i>Neotanygastrella chymomyzoides</i> Duda, 1927	BEL	Hendel (1936)	
<i>Neotanygastrella tricoloripes</i> Duda, 1925	SAN	Hendel (1936)	
<b>Genus <i>Paraliodrosophila</i></b>			
<i>Paraliodrosophila antennata</i> Wheeler, 1957		Wheeler (1954)	
<b><i>latifasciaeformis</i> group</b>			
<i>Scaptodrosophila latifasciaeformis</i> (Duda, 1940)	BEL, BRE, IGA, JUR, MEL, NIP, PAC, PARP and POR	MPEG and Pavan (1959)	50
<b>Genus <i>Zaprius</i></b>			
<b><i>vittiger</i> group</b>			
<i>Zaprius indianus</i> Gupta, 1970	ALM, BEL, MEL, NIP, PAC, PARP, POR and SAN	MEPG and David et al. (2006)	8
<b>Genus <i>Zygothrica</i></b>			
<b><i>dispar</i> group</b>			
<b><i>aldrichii</i> subgroup</b>			
<sup>3</sup> <i>Zygothrica aldrichi</i> Sturtevant, 1920	BEL	Hendel (1936)	
<sup>3</sup> <i>Zygothrica mediovitta</i> Grimaldi, 1987	SAN	Grimaldi (1987)	
<i>Zygothrica microeristes</i> Grimaldi, 1987	ALM, BEL, ITA, OBI and ORI	MZSP and Grimaldi (1987)	
<i>Zygothrica paraldrichi</i> Burla, 1956	ALM, BEL, ITA, MAR, OBI and SAN	MZSP and Grimaldi (1987)	
<i>Zygothrica pilipes</i> Hendel, 1936	ITA, OBI and SAN	MZSP and Hendel (1936)	
<sup>3</sup> <i>Zygothrica radialis</i> Grimaldi, 1987	ALM, BEL and ITA	MZSP and Grimaldi (1987)	
<sup>3</sup> <i>Zygothrica somatia</i> Grimaldi, 1987	ALM, OBI and SAN	MZSP and Grimaldi (1987)	
<i>Zygothrica zygia</i> Grimaldi, 1987	OBI and SAN	Grimaldi (1987)	
<b><i>caudata</i> subgroup</b>			
<i>Zygothrica caudata</i> (Hendel, 1913)	SAN	Hendel (1936)	
<b><i>dispar</i> subgroup</b>			
<i>Zygothrica dispar</i> (Wiedmann, 1830)	SAN	MZUSP and Hendel (1936)	
<i>Zygothrica prodispar</i> Duda, 1925	BEL, ITA, MAR and SAN	MPEG and Grimaldi (1987)	3
<b><i>atriangula</i> group</b>			
<i>Zygothrica atriangula</i> Duda, 1927	SAN	Burla (1956)	
<b><i>atriangulata</i> group</b>			
<i>Zygothrica virgatinigra</i> Burla, 1956	MEL and POR	Robe et al. (2014)	
<b><i>bilineata</i> group</b>			
<i>Zygothrica bilineata</i> (Williston, 1896)	ITA	Grimaldi (1990)	
<b><i>orbitalis</i> group</b>			
<i>Zygothrica orbitalis</i> (Sturtevant, 1916)	SAN	Hendel (1936)	
<b><i>vittinubila</i> group</b>			
<sup>1,4</sup> <i>Zygothrica vittinubila</i> Burla, 1956	NIP	MPEG and MZUSP	1
<b>Ungrouped species</b>			
<sup>3</sup> <i>Zygothrica laevifrons</i> Duda, 1927	SAN	Hendel (1936)	
<b>Subfamily Steganinae</b>			
<b>Genus <i>Leucophenga</i></b>			
<sup>3</sup> <i>Leucophenga argenteofasciata</i> Kahl, 1917	SAN	Duda (1927)	
<b>Genus <i>Rhinoleucophenga</i></b>			
<sup>1,4</sup> <i>Rhinoleucophenga punctulata</i> Duda, 1929	CAS	MPEG	5

<sup>1</sup>New records for the state of Pará; <sup>2</sup>New records for Brazil; <sup>3</sup>Species that are recorded in Brazil only in the state of Pará; <sup>4</sup>New records for Amazon

The scientific collections contributed 27 new records for Pará and 22 for the Amazon. Of these, 24 were in the MPEG collection, two in the MZUSP collection and one recorded in both collections. Among the new records, *Drosophila fasciola* (Williston, 1896), *Diathoneura flavolineata* Duda, 1927 and *Drosophila neochracea* Wheeler, 1959 are new records for Brazil. *D. fasciola* Williston, 1896 had been recorded from the United States, Mexico, El Salvador, Caribbean, Panama, Colombia and Guyana; *Drosophila flavolineata* (Duda, 1927) only from Costa Rica; and *Drosophila neochracea* (Wheeler, 1959) from Bolivia and Ecuador (Bächli 2015). The *vittimaculosa* group of *Zygothrica* (*Z. vittinubila* Burla, 1956), the subgenus *Siphlodora* of *Drosophila* (*D. flexa*), the genera *Rhinoleucophenga* (*R. punctulata*) and *Diathoneura* (*D. flavolineata*) are new records for Pará. Seven cosmopolitan or semi-cosmopolitan species were found in the state; *Drosophila ananassae*, *D. kikkawai*, *Drosophila malerkotliana* Parshad & Paika, 1964, *Drosophila melanogaster* Meigen, 1830, *D. simulans* Sturtevant, 1919, *Scaptodrosophila latifasciaeformis* (Duda, 1940) and *Zaprionus indianus* Gupta, 1970.

Of the 29 species listed in Table 1 and which were found in neither collections, only 23 of the species are only known from their original descriptions. Three were recently collected in Pará, but the reference specimens were not preserved (*Drosophila pallidipennis* Dobzhansky & Pavan, 1943, *Zygothrica aldrichi* Sturtevant, 1920 and *Zygothrica dispar* Wiedemann, 1830). Three species, *Drosophila polymorpha* Dobzhansky & Pavan, 1943, *Drosophila mesostigma* Frota-Pessoa, 1954 and *Drosophila mediostrata* Duda, 1925 were listed as being in the MPEG collection, but upon re-examination of the respective material, their identification was not confirmed. In the case of *D. polymorpha*, the males were identified as *Drosophila neomorpha* Heed & Wheeler, 1957. The similarity between their terminalia and the possibility of introgression between these two species was discussed by De Toni et al. (2005). Upon re-examination of material identified as *D. mediostrata*, we found *Drosophila paramediostrata* Townsend & Wheeler, 1955 and *Drosophila frotapessoai* Vilela & Bächli, in addition to underscribed species.

The species *Drosophila medioocris* Frota-Pessoa, 1954, *Drosophila medioimpressa* Frota-Pessoa, 1954, *Drosophila neoelliptica* Pavan & Magalhães, 1950, *Drosophila pseudosaltans* Magalhães, 1956 and *D. milleri* Magalhães, 1962, mentioned in the literature, are represented in the MPEG collection. However, only by females preserved in ethanol, precluding detailed examination of the parts that are necessary to confirm identification. Among these, only *D. milleri* was not known from other parts of Brazil, being historically restricted to Puerto Rico.

Wheller (1957), suggests that the presence of *Hirtodrosophila thoracis* (Williston, 1896) in Pará, based on Burla (1956). However, here, we considered this record as belonging to *Paraliodrosophila antennata* Wheeler, 1957, following Vilela & Bächli (2007), according to whom the genitalia of the holotype of *P. antennata* was illustrated by Burla as if it was *H. thoracis*.

Among the species recorded from Pará, 21 species have been nowhere else in Brazil, but have been recorded or observed in other countries (Table 1). Most of those species had only been previously found in Northern localities of the Neotropical region, particularly Colombia, Central America and Caribbean (Bächli 2015). This finding suggests an affinity between the Amazon fauna and the fauna of those other regions.

Additionally, six species occur only in Pará: *D. caxiuana*, *D. speciosa*, *Z. somatia*, *D. hendeli*, *D. decemseriata* and *M. brunnescens*. The last three are known only from their original descriptions; *D. hendeli* and *D. decemseriata* were collected more than 85 years ago, by the Austrian entomologist Hans Zerny in 1927, during an expedition to Fazenda Taperinha, in Santarém (Zerny 1929). At that time, the specimens were deposited at the Naturhistorisches Museum Wien (NMW). There, in 1936, the entomologist Friedrich Hendel determined 11 specimens as *D. annularis* Sturtevant, 1916 and nine as *D. decemseriata* (Hendel 1936). In 1990 Vilela

and Bächli described *D. hendeli*, based on one of the specimens identified as *D. annularis* by Hendel (Vilela & Bächli 1990). *D. decemseriata* which was described in 1936 by Hendel has not been found anywhere else. The type of *M. brunnescens* was collected by the geneticist Theodosius Dobzhansky in Belém-PA, in 1952 (Wheeler & Takada 1963), and was apparently never collected again. *D. caxiuana* and *D. speciosa*, in contrast, have been recorded more recently. In 2001, *D. speciosa* was recorded from cacaú flowers (*Thebroma speciosum* Willd. Ex Spreng) (Silva & Martins 2004) and was thus collected from flowers in various municipalities across the state, as observed in the MPEG (Table 1). *D. caxiuana* was collected in 2008 in banana traps (Gottschalk et al. 2012). It is possible that these taxa are locally endemic to the Amazon Biome, however, it is possible that their rarity is due to collecting limitations.

There is still a lot to be learnt about the richness and composition of Drosophilidae species in the Amazon biome. Despite being the second largest state of Brazil, and being within the Amazon biome, Pará comes third in Drosophilidae species richness in the country, with 17% of locally native species, behind the states of São Paulo and Santa Catarina (Gottschalk et al. 2008). Considering the geographic coverage of the records in the collections and literature records, it is obvious that there is still much to be learned about the region's biodiversity. The known distribution of poorly sampled, diverse groups such as the Drosophilidae often reflects where past collecting efforts were more concentrated, rather than the real local diversity. Only 24% of the species known to occur in the state were not represented in the collections studied and those, in turn, have contributed to widen the known geographic distribution of 21% of the species in the list. This result highlights the importance of scientific collections as a source of information on local biodiversity. Most records, either in the literature or in the collections, are from material collected with banana baits. It is possible that the list presented here can be enriched not only by collecting in places that have not been sampled, but also by using other sources, such as flowers, fungi, decomposing leaves and other attractants.

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## Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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