Journal of Medical Entomology, 59(2), 2022, 488–507
https://doi.org/10.1093/jme/tjab210
Advance Access Publication Date: 6 January 2022
Research

Direct Injury, Myiasis, Forensics

Forensically Relevant Flesh Flies (Diptera, Sarcophagidae, Sarcophaginae) of Southern Brazil

Tais Madeira-Ott,[1] Carina M. Souza,[2] Paulo R. S. Bunde,[3] Ana C. R. Ries,[4] Betina Blochtein,[4] and Patricia J. Thyssen[1,5]

[1]Laboratory of Integrative Entomology, Department of Animal Biology, University of Campinas, UNICAMP, PC 13083-862, Campinas, São Paulo, Brazil, [2]Faculty of Human Talents, FACTHUS, Campus I, Ecossistema UniBrasília, PC 38040-240, Uberaba, Minas Gerais, Brazil, [3]Department of Microbiology and Parasitology, Federal University of Pelotas, UFPel, PC 96010-900, Pelotas, Rio Grande do Sul, Brazil, [4]School of Health and Life Sciences, Pontifical Catholic University of Rio Grande do Sul, PUCRS, PC 90619-900, Porto Alegre, Rio Grande do Sul, Brazil, and [5]Corresponding author, e-mail: thyssenpj@yahoo.com.br

Subject Editor: Christopher Geden

Received 13 September 2021; Editorial decision 21 November 2021

Abstract

Flesh flies comprise a large fly family distributed worldwide that has great importance for forensic entomology. A robust and updated checklist of Sarcophaginae flies recorded in Southern Brazil is presented, based on material collected in the Rio Grande do Sul state and on a literature review. The forensic importance (high, moderate, or none) of the recorded flesh flies for estimating the postmortem interval (PMI) or inferring cases of neglect was determined based on their ecological habits. A total of 2,831 specimens representing 38 taxa were collected from three studies. *Oxysarcodexia* was the most abundant and species-rich genus in all three studies. *Dexosarcophaga carvalhoi* (Lopes) was registered for the first time in Southern Brazil. The checklist for Southern Brazil comprises 91 species distributed in 19 genera, with *Oxysarcodexia*, *Peckia*, and *Lepidodexia* representing the richest genera. Considering the importance of species for PMI estimation, 10, 42, and 39 species were classified as having high, moderate, or no forensic relevance, respectively. Moreover, five myiasis-causing sarcophagine flies recorded in Southern Brazil were considered to have the potential to reveal cases of neglect or mistreatment. This study revealed that *Microcerella halli* (Engel) and *Peckia* (*Euboettcheria*) *australis* (Townsend) are the most important species for PMI estimation in Southern Brazil, as they are often found breeding in corpses in this region.

Key words: flesh fly, dipterofauna survey, forensic entomology, postmortem interval, necrophagous

Sarcophaginae (Diptera, Sarcophagidae) is the largest of three subfamilies ascribed to Sarcophagidae, and it comprises approximately 2,300 described species (Buenaventura et al. 2020). Currently, 879 sarcophaginae species are reported from the Neotropical region, including 335 from Brazil (Pape 2021).

Biological features of Neotropical sarcophagines are very diverse (Pape and Dahlem 2010). Many species are attracted to decaying organic matter, such as feces (e.g., Dias et al. 1984a, Ferrar 1987, d'Almeida and Lima 1994) and decaying carcasses (e.g., Carvalho and Linhares 2001, Barros et al. 2008, Rosa et al. 2011), including corpses (e.g., Cherix et al. 2012, Vasconcelos et al. 2014, Vairo et al. 2017, Ramos et al. 2018, Thyssen et al. 2018). These resources are used both for nutritional complementation of the adult's diet (protein) and for larval development (Mello-Patiu et al. 2014a).

The feeding habits of insects that are found associated with decomposing corpses can be classified into four ecological roles (Smith 1986): necrophagous, omnivorous, predators/parasites, and incidental species. Necrophagous species develop directly in the corpse and are the most important category for estimating the postmortem interval (PMI), which is the interval between the moment of death and the time of discovery of the corpse (Amendt et al. 2007). Omnivorous species feed on both the corpse and associated fauna. Predators/parasites feed on necrophagous and omnivorous species. Both omnivorous species and predators/parasites can interfere with corpse decomposition by depleting populations of necrophagous species. Finally, incidental species are those that use the corpse as an extension of their habitat, seeking moisture, a site to rest, or are accidentally placed there; for example, together with various materials used in attempts to conceal a corpse. Therefore, obtaining information about the biology of sarcophagine flies can be helpful in forensic investigations, as the occurrence, activity or ecological role of insects can provide information for PMI estimation, manner and cause of death, or association of suspects with the death scene (Cherix et al. 2012, Vairo et al. 2017).

Two approaches for PMI estimation use insects: minimum postmortem interval (PMImin) – based on the time of development of immatures feeding on a corpse – and maximum postmortem interval (PMImax) – based on the ecological succession of insect communities visiting and/or colonizing a corpse (Catts 1992). When estimating the PMI using insects, Amendt et al. (2007) stressed that the period of insect activity (PIA), i.e., the time from insect colonization until the discovery of the remains, should also be considered; thus, PIA and PMI are always related (Matuszewski and Mądra-Bielewicz 2016). Furthermore, geographical, environmental, and genetic characteristics can affect the developmental rates of insects used for PMImin estimation (Amendt et al. 2007). A PMImin insect indicator must be a ubiquitous species and one of the first species to find the corpse (Greenberg 1991) and develop on the corpse (Amendt et al. 2007) (i.e., necrophagous).

Studies in Brazil regarding Sarcophaginae have focused on surveys and species checklists (e.g., Barbosa et al. 2019), taxonomy and construction of taxonomic keys (e.g., Camargo et al. 2018), synanthropy (e.g., Souza and Von Zuben 2016), biodiversity and population fluctuation (e.g., Dias et al. 2015), molecular characterization (e.g., Oliveira et al. 2019a) and bionomy (e.g., Xavier et al. 2015). According to Anderson (2020), the habitat, vegetation, soil type, and meteorological conditions of a specific area are defined by its biogeoclimatic zone. Nevertheless, due to the high diversity of biogeoclimatic zones in Brazil, studies on sarcophagines from some regions, such as the South, remain scarce; this includes Rio Grande do Sul (RS), where few studies (Lopes 1946, Souza et al. 2008, Krüger et al. 2010, Silva et al. 2010, Ries and Blochtein 2015, Madeira et al. 2016, Souza et al. 2020a) have been conducted.

Two types of vegetation cover predominate in RS: plains (the so-called pampas), dominated by grasses (~60% of the territory), and forests consisting of both mixed broadleaved (associated with the Atlantic Forest biome) and coniferous forests. Coastal vegetation or sandbanks comprise only 5% of the total area (IBGE 2020). According to the Köppen-Geiger climatic classification (Alvares et al. 2013), RS has a predominantly humid subtropical climate, with an average annual temperature of 12–23°C, and significant rainfall throughout the year (approximately 1,300 mm per year).

Thus, considering the biogeoclimatic zone of RS and the ecological and forensic relevance of Sarcophaginae species, this study aims to answer the following questions: Which Sarcophaginae species are distributed in RS? Which species from Southern Brazil are relevant for estimating the PMI or for inferring cases of neglect?

Material and Methods

Sampling

The collecting localities mentioned for each performed study are mapped at https://bit.ly/2PAob8p.

Study 1: Sarcophaginae Collected Using Baited Traps

Adult flies were collected monthly during 12 mo between 2012 and 2013, using a baited trap, similar to the one used for the collecting of muscoid flies by several authors (e.g., Ferreira 1979, Linhares 1981, Moretti et al. 2009). The trap was made of two soft-drink plastic bottles, with their bottom ends removed to receive an 80 g portion of bait (chicken gizzard, beef liver, or raw fish left to rot for 48 hr at room temperature, before exposure). Each trap was suspended by a string, approximately 150 cm above the ground, and remained exposed in the field for 72 hr.

Collecting was carried out in rural, urban, and wild environments in three municipalities of RS: Pelotas (31°46′29″S: 52°20′33 ″W), Piratini (31°26′32 ″S: 53°6′16 ″W), and Bagé (31°19′43 ″S: 56°6′26 ″W). Twelve traps were used in each of the three environments, with a total of 36 traps per municipality, each arranged in a 3 × 4 grid (four parallel transects, each 100 m apart from the next; in each transect, three points spaced 50 m from the next). The 50 m minimum distance from each trap to another was chosen to ensure sample independence, as proposed by Cabrini et al. (2013). In each grid, each trap received one type of bait at random. The environments were characterized as follows: (1) *wild*, locality with null or reduced human disturbance in its surroundings; (2) *urban*, locality with high population density, i.e., 151–350 inhabitants per ha (Moreira et al. 2019); and (3) *rural*, locality with at least three farms that keep livestock in their surroundings, especially cattle and sheep.

Study 2: Sarcophaginae Collected on Pig Carcasses

This study was carried out in January and September 2014, during two seasons characterized by fluctuations in temperature and rainfall: warm/dry (mid-October–March) and cold/wet (mid-April–September) (Alvares et al. 2013), in a rural environment in the municipality of Porto Alegre (30°14′18″S: 51°07′19″W) in RS. Carcasses of six domestic male pigs (*Sus scrofa* L.), weighing approximately 12 kg each, were exposed in an open area, 30 m apart. Animals were euthanized with a single shot from a.38 cal. firearm on day 1 and at the site of the study and immediately placed inside metal frame cages to exclude large scavengers. Underneath the cages, metal trays with sawdust were placed to collect dipteran larvae leaving the carcasses to pupate. To collect adult insects, a Shannon trap, similar to the one used by Carvalho et al. (2000), was placed over each cage.

Both adults and larvae were collected daily and actively: the former from inside Shannon traps, using a hand net, and the latter from metal trays, using a tweezer. All specimens were separated and labeled by collection day and carcass decomposition stage. The decomposition stages were characterized by physical parameters according to the criteria set forth by Reed (1958). More details on the methodology can be seen in Ries et al. (2021).

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. All procedures were performed in accordance with protocols approved by the CEEA (Ethics Committee on Animal Experimentation) of the Pontifical Catholic University of Rio Grande do Sul (#13/00369).

Study 3: Sarcophaginae Actively Collected

Adult flies, attracted by 150 g of raw beef liver, previously left to rot for 48 hr at room temperature, were collected using a hand net, in the months of March and September 2019. The collecting was carried out in a wild environment, during 6 hr and on each of three consecutive days, at the municipality of Arroio do Padre (31°26′34″S: 52°25′19″W) in RS.

Weather Conditions and Species Identification

Weather conditions in the field were measured daily during each fly collection, with a Celsius thermometer (model MM 5202-Incoterm), a humidity sensor (model 4463, Stäcker & Olms), and a rain gauge (with 203 mm). Further meteorological data were obtained from the

Brazilian National Institute for Space Research (INPE 2020). Daily data from the field and weather stations were compiled and the averages for temperature, humidity, and accumulated rainfall were calculated and presented per study in the Supp Material (online only).

In the laboratory, the collected male specimens were stored in absolute ethanol or pinned. Male genitalia were exposed with the aid of an entomological pin. Taxonomic keys (Carvalho and Mello-Patiu 2008, Buenaventura et al. 2009, Mulieri et al. 2010a, Vairo et al. 2011) and descriptions (Lopes 1946, 1980; Guimarães 2004) were used for species identification. Most specimens, pinned or stored in microvials with absolute ethanol from Studies 1 and 3, are deposited at the Laboratory of Integrative Entomology of the Department of Animal Biology and at the Museum of Zoology 'Adão José Cardoso' (ZUEC), both from the University of Campinas, São Paulo, Brazil. Pinned specimens from Study 2 were deposited at the scientific collection of the Entomological Forensic section of the Insect Collection of the Museum of Science and Technology (MCT) of the Pontifical Catholic University of Rio Grande do Sul (PUCRS).

Additional Information Survey

To comprehensively examine the literature on the distribution status of Sarcophaginae in Southern Brazil [comprising the states of Paraná (PR), Santa Catarina (SC), and RS], peer-reviewed literature in Portuguese, Spanish, and English published in academic journals was systematically researched in five databases: Web of Science, PubMed, SCOPUS, Google Scholar, and Scientific Electronic Library Online (SciELO). The search terms (Sarcophaginae, flesh flies, necrophagous, vectors, myiasis, attractiveness, forensic entomology, Neotropical, Southern Brazil, Paraná, Santa Catarina, Rio Grande do Sul), isolated or combined, were chosen to allow the evaluation of: (1) the number of Sarcophaginae species recorded in Southern Brazil; (2) the current knowledge on Sarcophaginae in Southern Brazil; and (3) which species are important in the context of forensic entomology. Term and search field combinations were explored by trial and error to retrieve the most comprehensive and relevant literature, excluding obviously irrelevant literature. Literature searches were conducted between April 2019 and May 2020.

Search results were systematically evaluated, and duplicate references were removed. Articles were further preselected based on title and abstract, and a thorough assessment of relevance was ascertained by reading the full texts. The full-text review excluded articles that mentioned only species of other Sarcophagidae subfamilies or did not expand the knowledge about geographic distribution or bionomic aspects. The nomenclature followed the latest taxonomic revision (Buenaventura and Pape 2013, 2015).

Sarcophaginae species were organized into ecological categories according to Ferrar (1987). This information was used to classify the species according to their value for estimating the PMI into: high (necrophagous), moderate (omnivorous or predators), and null value (detritivorous, kleptoparasite, invertebrate parasite, vertebrate parasite, and unknown ecological category). Considering that wounds in live vertebrates may attract flies that live or feed on them, data on myiasis-causing flies in vertebrates (mammals) were used to identify species with the potential to reveal cases of neglect or mistreatment.

Results

Abundance, Richness, and Weather Conditions

A total of 2,831 individuals from 38 species were collected (Tables 1–3). Although the sampling efforts, collection methodologies and temporal ranges varied, eight species were collected in all studies, 14 in at least two studies (six in Studies 1 and 2; six in Studies 2 and 3; and two in Studies 1 and 3), 14 species were collected only in Study 1 (which had a more extended temporal range and also considered different environments), and two species were collected only in Study 3. Most females, totaling 876 individuals (Tables 1 and 2), were not identified because the available taxonomic keys were for males only.

Of the 1,563 specimens collected in Study 1, *Oxysarcodexia paulistanensis* (Mattos) (*N* = 241), *Oxysarcodexia culmiforceps* Dodge (*N* = 235), *Ravinia advena* (Walker) (*N* = 87), and *Oxysarcodexia thornax* (Walker) (*N* = 58) were the most abundant species (*N* > 50) (Table 1). These species were present in all the studied environments. *Oxysarcodexia* was the most abundant (at least 788 specimens) and species-rich (10 identified taxa) genus. Regarding the environments, five, two, and five taxa with one to six individuals each were reported exclusively in rural, urban, and wild environments, respectively (Table 1). Regarding the attractiveness of baits, 12 taxa were associated with all the baits, 8 taxa with two baits (three collected in fish and liver, three in fish and gizzard, and two in gizzard and liver), and 10 taxa with only one bait type (seven, two and one taxa related to gizzard, fish, and liver, respectively) (Table 1). The highest abundance of specimens per month was recorded in November (*N* = 393), December (*N* = 192), and January (*N* = 174), with *O. culmiforceps* (*N* = 164) and *O. paulistanensis* (*N* = 131) as the most abundant species. In these months, the average temperature (approximately 22°C) and rainfall (approximately 127 mm) were the highest throughout the sampling period (12 mo) (Supp Material [online only]). May (*N* = 12), June (*N* = 8), and July (*N* = 2) had the lowest abundance of specimens and average temperatures (approximately 13ºC) (Supp Material [online only]).

Of the 1,137 specimens sampled in Study 2, *O. culmiforceps* (*N* = 222), *O. thornax* (*N* = 150), *O. paulistanensis* (*N* = 111), *Microcerella halli* (Engel) (*N* = 82), *Oxysarcodexia riograndensis* Lopes (*N* = 56), *Oxysarcodexia admixta* (Lopes) (*N* = 51), and *Ravinia belforti* (Prado & Fonseca) (*N* = 39) were the most abundant species (*N* > 30) (Table 2). *Oxysarcodexia* was the most abundant and species-rich genus, with 607 specimens and nine taxa identified. *Microcerella halli* (*N* = 1 and *N* = 50 in the warm/dry and cold/wet seasons, respectively) and *R. belforti* (*N* = 1 and *N* = 3 in the warm/dry and cold/wet seasons, respectively) were found rearing on pig carcasses (Table 2). Regarding the seasons, 90.4% (*N* = 1,028) of the specimens and 19 taxa were sampled in the cold/wet season (Table 2), during wich the lowest average temperature (19.3°C) combined with the highest average humidity (78.4%) and rainfall (161.4 mm) (Supp Material [online only]) contributed to the longer decomposition time of the carcasses (34 d) compared to those recorded in the warm/dry season (10 d). In the warm/dry season, the majority of taxa (8 out of 10) were associated with the bloated stage among the visiting adults, and the larvae reared in carcasses had the highest abundance (*N* = 55). In the cold/wet season, most taxa (17 out of 19) were associated with the bloated stage, and the greatest abundance (*N* = 639) was associated with the decay stage (Table 2).

Of the 131 specimens collected in Study 3, *Peckia* (*Sarcodexia*) *lambens* (Wiedemann) (*N* = 21), *O. culmiforceps* (*N* = 18), *O. admixta* (*N* = 13), and *Peckia* (*Pattonella*) *resona* (Lopes) (*N* = 12) were the most abundant species (*N* > 10) (Table 3). *Oxysarcodexia* was the most abundant and rich genus, with 57 specimens and nine taxa identified. The highest abundance (*N* = 83) and richness (*N* = 17) of specimens were recorded in September, with *P.* (*S.*) *lambens* as the most abundant species. In this month, the average temperature (14.6°C) was lower than that recorded in March (19.2°C), while rainfall was higher in September (142 mm) than in March (9.9 mm) (Supp Material [online only]).

Table 1. Abundance (*N*) of collected Sarcophaginae by locality, environment, bait, and month at Rio Grande do Sul state, using baited traps between 2012 and 2013

Taxon	Locality	Environment	Bait	Month	*N*
Dexosarcophaga carvalhoi Lopes, 1980	PI	R, U	F, L	II; XII	7
Helicobia aurescens (Townsend, 1927)	PE, PI	R, U, W	F, G, L	I; IX–XII	16
Helicobia spp.	PE, PI	R, U, W	G	XI	3
Lipoptilocnema koehleri (Blanchard, 1939)	BA	W	F, G, L	II; XI	3
Lipoptilocnema lanei (Towsend, 1927)	BA	W	G	VI	1
Microcerella halli (Engel, 1931)	BA, PE	R, U	F, G, L	I; VIII; X–XI	6
Nephochaetopterix spp.	BA, PE, PI	R, U, W	F, G, L	XI–II	34
Oxysarcodexia admixta (Lopes, 1933)	PE	R	F	VI	1
Oxysarcodexia avuncula (Lopes, 1933)	PI	R, W	G	XI	2
Oxysarcodexia bicolor Lopes, 1946	PI	U, W	G, L	I; VIII	3
Oxysarcodexia culmiforceps Dodge, 1966	BA, PE, PI	R, U, W	F, G, L	V–VI; VIII–III	235
Oxysarcodexia injuncta (Walker, 1858)	PI	R	L	X	1
Oxysarcodexia paulistanensis (Mattos, 1919)	BA, PE, PI	R, U, W	F, G, L	I –III; V–VI; VIII; X–XII	241
Oxysarcodexia riograndensis Lopes, 1946	PE	U, R	F, G, L	VI; VIII; X; XII	9
Oxysarcodexia terminalis (Wiedemann, 1830)	BA, PI	U	F, L	I; XII	4
Oxysarcodexia thornax (Walker, 1849)	BA, PE, PI	R, U, W	F, G, L	I; IV–VI; VIII–XII	58
Oxysarcodexia varia (Walker, 1836)	BA, PE, PI	R, U, W	F, G, L	VIII; X–XI	19
Oxysarcodexia spp.	BA, PE, PI	R, U, W	F, G, L	IV; VIII–II	215
Peckia (*Euboettcheria*) *australis* (Townsend, 1927)	PE	R	G	VI	1
Peckia (*Euboettcheria*) *collusor* (Prado & Fonseca, 1932)	PE	W	G	XII	1
Peckia (*Euboettcheria*) *florencioi* (Prado & Fonseca, 1932)	PE	W	F, G	VIII	4
Peckia (*Pattonella*) *resona* (Lopes, 1935)	PE	W	F, L	IV; VI; VIII; IX	6
Peckia spp.	BA, PE, PI	U, W	F, G	XI–II	8
Ravinia advena (Walker, 1853)	BA, PE, PI	R, U, W	F, G, L	I–VIII; X–XII	87
Ravinia belforti (Prado & Fonseca, 1932)	PE	R	F	VI; VIII	2
Ravinia spp.	BA, PE, PI	R, U, W	F, G, L	X–II	55
Sarcophaga (*Bercaea*) *africa* (Wiedemann, 1824)	PE	U	G, L	VIII–XI	3
Sarcophaga sp.	BA, PI	U, W	G	IV; XII–I	4
Tricharaea (*Sarcophagula*) *canuta* (Wulp, 1896)	PE	R	G	XI	1
Tricharaea spp.	BA, PE, PI	R, U	F, G	I; XI; XII	26
spp. (female)	BA, PE, PI	R, U, W	F, G, L	I–VI; VIII–XII	507
Total abundance					1,563
Total richness (taxa, not considering spp females)					30

Note: In **locality**, BA = Bagé, PE = Pelotas, and PI = Piratini. In **environment**, R = rural, U = urban, and W = wild. In **bait**, F = fish, G = gizzard, L = liver. In **month**, I = January, II = February, III = March, IV = April, V = May, VI = June, VII = July, VIII = August, IX = September, X = October, XI = November, and XII = December.

Forensic Relevance of Sarcophaginae From Southern Brazil

An updated checklist of Sarcophaginae recorded in Southern Brazil was produced based on Studies 1–3 and the literature (Table 4). Additional information regarding substrates and collection environments, obtained from the studies developed in Southern Brazil and from other studies conducted in the Neotropical region, is shown in Table 4.

A total of 91 species distributed in 19 genera were recorded in Southern Brazil; nine species are unique records for Brazil, and eight are exclusively from the Neotropical region (Table 4). The richest genera recorded were *Oxysarcodexia* (24.7%), *Peckia* (13.5%), and *Lepidodexia* (11.2%). *Dexosarcophaga carvalhoi* (Lopes) is herein recorded for the first time in Southern Brazil. For RS, 49 species were recorded with 10 new records, and 51 and 49 species were recorded in PR and SC, respectively.

The literature searches retrieved 15 relevant peer-reviewed papers published in academic journals (Ferreira 1979; Moura et al. 1997, 2005; Moura 2004; Souza et al. 2008; Krüger et al. 2010; Silva et al. 2010, 2014; Vairo et al. 2011, 2015, 2017; Ries and Blochtein 2015; Madeira et al. 2016; Gaedke and Mouga 2017; Souza et al. 2020a). The studies from RS (*N* = 7) were carried out in the three environments (urban, rural, and wild) and in five municipalities, covering only the southern half of the state. Thus, the results of Studies 1–3 presented here expand the number of localities and environments sampled for RS. The same number of studies (*N* = 7) on Sarcophaginae and with samplings in three environments was identified in PR; however, all of them were carried out in a single municipality. A single study from the SC was carried out in three municipalities from north of the state and near the coast.

Considering the baits used to attract and collect Sarcophaginae listed in the papers retrieved from the literature, the most (*N* = 11) employed were mammal carcasses of different animals (e.g., *Rattus novergicus* (Berkenhout), *Sus scrofa* L., *Oryctolagus cunniculus* L., *Didelphis albiventris* Lund, *Salvator merianae* Duméril & Bibron, *Nothura maculosa* (Temminck), *Cerdocyon thous* L., and humans). Other studies used vertebrate tissues (chicken gizzard, bovine liver, bovine meat, or fish) and human feces as bait. Most of the records obtained from the catalog (Pape 1996), species checklist (Mulieri et al. 2010a), or species revisions (Buenaventura and Pape 2013, Mulieri et al. 2015) did not provide information on the collection location or biology of the species because of the nature of the study or the lack of a label on specimens retrieved from museums.

Considering the importance of the 91 Sarcophaginae species for PMI estimation, 10, 42, and 39 species were considered to have high, moderate, and no forensic relevance, respectively. Regarding their potential to assist in identifying cases of neglect or mistreatment, five

Table 2. Abundance (*N*) of Sarcophaginae associated with pig carcasses exposed in an open area in rural environment, by season and decomposition stage, at Porto Alegre, Rio Grande do Sul state in 2014. In bold, species bred from the carcasses

Taxa	Season								*N*
	warm/dry				cold/wet				
	I	II	III	IV	I	II	III	IV	
Helicobia aurescens (Townsend, 1927)	0	3	0	0	0	0	0	0	3
Lipoptilocnema koehleri (Blanchard, 1939)	0	0	0	0	0	1	0	0	1
Microcerella halli **(Engel, 1931)**	0	1	1	1[a]	0	33[a]	41[a]	5[a]	82
Nephochaetopteryx cyaneiventris Lopes, 1936	0	0	0	0	0	0	1	0	1
Oxysarcodexia admixta (Lopes, 1933)	0	0	0	1	0	35	15	0	51
Oxysarcodexiaavuncula (Lopes, 1933)	0	0	0	0	0	2	1	1	4
Oxysarcodexia culmiforceps Dodge, 1966	2	10	6	3	1	67	115	18	222
Oxysarcodexia parva Lopes, 1946	0	0	0	0	0	1	1	0	2
Oxysarcodexia paulistanensis (Mattos, 1919)	0	4	1	1	0	48	50	7	111
Oxysarcodexia riograndensis Lopes, 1946	0	2	1	0	0	13	32	8	56
Oxysarcodexia thornax (Walker, 1849)	0	4	3	2	0	57	76	8	150
Oxysarcodexia varia (Walker, 1836)	0	0	0	0	0	0	2	0	2
Oxysarcodexia xanthosoma (Aldrich, 1916)	0	0	0	0	0	4	3	2	9
Peckia (Euboettcheria) australis (Townsend, 1927)	0	0	0	0	0	5	3	2	10
Peckia (Peckia) chrysostoma (Wiedemann, 1830)	0	0	0	0	0	1	1	0	2
Peckia (Patonella) resona (Lopes, 1935)	0	0	0	0	0	2	1	0	3
Peckia (Sarcodexia) florencioi (Prado & Fonseca, 1932)	0	0	0	0	0	1	0	0	1
Ravinia advena (Walker, 1853)	0	3	0	0	0	3	10	0	16
Ravinia belforti (Prado & Fonseca, 1932)	0	2	5[a]	3	0	8[a]	20[a]	1	39
Tricharaea (Sarcophagula) occidua (Fabricius, 1794)	0	2	0	0	0	1	0	0	3
spp. (female)	4	24	12	8	0	18	267	36	369
Total abundance	109				1,028				1,137
Total relative abundance (%)	9.6				90.4				100
Total richness (taxa, not considering spp females)	10				19				20

Note: From I to IV indicates the decomposition stages, where: I: fresh, II: bloated, III: decay, and IV: dry.
[a]Indicates the decomposition stage where postfeeding larvae were collected.

Table 3. Abundance (*N*) of collected Sarcophaginae attracted by bovine liver using a hand net in a wild environment at Arroio do Padre, Rio Grande do Sul state, in 2019

Taxon	Month		*N*
	March	September	
Lipoptilocnema koehleri (Blanchard, 1939)	4	0	4
Nephochaetopteryx cyaneiventris Lopes, 1936	6	4	10
Oxysarcodexia admixta (Lopes, 1933)	10	3	13
Oxysarcodexia bicolor Lopes, 1946	0	1	1
Oxysarcodexia confusa Lopes, 1946	0	1	1
Oxysarcodexia culmiforceps Dodge, 1966	7	11	18
Oxysarcodexia injuncta (Walker, 1858)	0	3	3
Oxysarcodexia parva Lopes, 1946	0	3	3
Oxysarcodexia paulistanensis (Mattos, 1919)	1	2	3
Oxysarcodexia thornax (Walker, 1849)	4	2	6
Oxysarcodexia xanthosoma (Aldrich, 1916)	0	9	9
Peckia (Euboettcheria) australis (Townsend, 1927)	6	1	7
Peckia (Euboettcheria) florencioi (Prado & Fonseca, 1932)	0	4	4
Peckia (Peckia) chrysostoma (Wiedemann, 1830)	0	5	5
Peckia (Patonella) resona (Lopes, 1935)	7	5	12
Peckia (Sarcodexia) lambens (Wiedemann, 1830)	0	21	21
Ravinia belforti (Prado & Fonseca, 1932)	3	5	8
Tricharea (Sarcophagula) occidua (Fabricius, 1794)	0	3	3
Total abundance	48	83	131
Total relative abundance (%)	36.6	63.4	100
Total richness	9	17	18

Table 4. List and distribution of Sarcophaginae (Diptera) species from Southern Brazil by locality, substrate (which attracted them or where they were reared), environment, and ecological category. In bold are the species registered for the first time at Rio Grande do Sul state, Brazil

Species	Localities			Substrate	Environment	Ecological Category	References
	PR	SC	RS				
Argoravinia (*Argoravinia*) *rufiventris* (Wiedemann, 1830)		X		BV; CV; FE; FI; RO; PC; TC	R, U, W	omnivorous	Pape 1996, Barros et al. 2008; Pape and Dahlem 2010; Rosa et al. 2011; Beuter et al. 2012; Alves et al. 2014; Barbosa et al. 2015, 2017, 2019; Sousa et al. 2015, 2020; Oliveira and Vasconcelos 2018; Oliveira et al. 2019b
Argoravinia (*Raviniopsis*) *aurea* (Townsend, 1918)	X			KW	unknown	kleptoparasite	Evans et al. 1974, Pape 1996
Argoravinia (*Raviniopsis*) *brasiliana* (Lopes, 1988)	X			unknown	unknown	unknown	Pape 1996
Blaesoxipha (*Acanthodotheca*) *acridiophagoides* (Lopes & Down, 1951)		X		CL; PC	R, W	invertebrate parasite	Pape 1994, 1996, Mello-Patiu et al. 2014b, Paseto et al. 2019
Blaesoxipha (*Acanthodotheca*) *brazil* Pape, 1994		X		BV	W	unknown	Pape 1996, Toma et al. 2020
Blaesoxipha (*Acanthodotheca*) *denier* (Blanchard, 1939)	X	X	X	PC	R	unknown	Pape 1996, Ries and Blochtein 2015
Blaesoxipha (*Acanthodotheca*) *lanei* (Lopes, 1938)		X	X	RO; PC	R, U, W	omnivorous	Pape 1996, Rosa et al. 2011, Beuter et al. 2012, Mello-Patiu et al. 2014b, Ries and Blochtein 2015, Faria et al. 2018, Paseto et al. 2019
Blaesoxipha (*Acanthodotheca*) *paranaensis* (Lopes, 1990)[a]	X			unknown	unknown	unknown	Pape 1996
Blaesoxipha (*Acanthodotheca*) *riograndensis* (Lopes, 1990)[a]			X	unknown	unknown	unknown	Pape 1996
Blaesoxipha (*Tephromyia*) *americana* Brauer, 1898	X			unknown	unknown	unknown	Pape 1996
Boettcheria aurifera Lopes, 1950	X	X		PC	W	unknown	Pape 1996, Vairo et al. 2011, Cavallari et al. 2015
Dexosarcophagacarvalhoi (Lopes, 1980)			X	BV; CV; FI; RO; PC	R, U, W	omnivorous	Barros et al. 2008, Rosa et al. 2011, Beuter et al. 2012, Alves et al. 2014, Mello-Patiu et al. 2014b, Barbosa et al. 2015, 2017, Sousa et al. 2015, 2020, Faria et al. 2018, Paseto et al. 2019, **current study**
Dexosarcophaga transita Townsend, 1917		X		RO; PC	R, U, W	omnivorous	Mello-Patiu 2002, Rosa et al. 2011, Beuter et al. 2012, Mello-Patiu et al. 2014b, Faria et al. 2018, Paseto et al. 2019
Engelimyia inops (Walker, 1849)		X		BV; FI; PC	W	omnivorous	Pape 1996, Amat 2010, Sousa et al. 2011, Barbosa et al. 2014, Cavallari et al. 2015, Toma et al. 2020
Helicobia aurescens (Townsend, 1927)	X		X	BV; CC; CV; FE; FI; RO; SQ; PC	R, U, W	necrophagous	Ferreira 1979, Moura 2004, Moura et al. 2005; Mariluis et al. 2007; Barros et al. 2008; Mulieri et al. 2008, 2010a, 2015; Barbosa et al. 2009, 2019; Patitucci et al. 2011, 2015; Rosa et al. 2011; Vairo et al. 2011; Mello-Patiu et al. 2014b; Oliveira-Costa et al. 2014; Sousa et al. 2014a, 2015, 2016, 2020; Cavallari et al. 2015; Souza and Von Zuben 2016; Faria et al. 2018; Paseto et al. 2019; Dufek et al. 2020; Souza et al. 2020a; Toma et al. 2020; **current study**
Helicobia pilipleura Lopes, 1939		X		BV; FI; RO; PC	U, W	omnivorous	Pape 1996; Leandro and D'Almeida 2005; Moretti et al. 2008; Barbosa et al. 2009; Sousa et al. 2015, 2016, 2020
Lepidodexia (*Asilidodexia*) *gaucha* (Lopes, 1992)[a]			X	unknown	unknown	unknown	Pape 1996
Lepidodexia (*Chlorosarcophaga*)*cal liphorina* (Enderlein, 1928)	X			unknown	unknown	unknown	Pape 1996
Lepidodexia (*Johnsonia*)*teutonia*(Lopes, 1991)[b]		X		unknown	unknown	unknown	Pape 1996

Table 4. Continued

Species	Localities			Substrate	Environment	Ecological Category	References
	PR	SC	RS				
Lepidodexia (*Lepidodexia*) *sarcophagina* (Townsend, 1927)	X	X		unknown	unknown	unknown	Pape 1996
Lepidodexia (*Notochaeta*) *cognata* (Walker, 1853)		X		unknown	unknown	unknown	Pape 1996
Lepidodexia (*Notochaeta*) *fumipennis* (Lopes, 1946)	X			WD	W	vertebrate parasite	Pape 1996, D'Bastiani et al. 2020
Lepidodexia (*Notochaeta*) *souzalopesi* (Lehrer, 1995)[b]			X	unknown	unknown	unknown	Pape 1996
Lepidodexia (*Notochaetisca*) *Rosalie* (Lopes, 1974)[b]	X			unknown	unknown	unknown	Pape 1996
Lepidodexia (*Notochaetisca*) *travassosi* (Lopes, 1983)[b]		X		unknown	unknown	unknown	Pape 1996
Lepidodexia (*Petriana*) *brevirostris* (Lopes, 1946)		X		unknown	unknown	unknown	Pape 1996
Lipoptilocnema crispina (Lopes, 1938)		X	X	FI; RO; PC	R, W	unknown	Moretti et al. 2008, Mello-Patiu et al. 2014b, Mulieri et al. 2017, Ernesto et al. 2018, Paseto et al. 2019
Lipoptilocnema crispula (Lopes, 1938)	X			BV; CV; FF; FE; FI; RO; SQ; PC	R, U, W	omnivorous	Dias et al. 1984a, b; Mendes and Linhares 2002; Leandro and D'Almeida 2005; Moretti et al. 2008; Rosa et al. 2011; Beuter et al. 2012; Mello-Patiu et al. 2014b; Sousa et al. 2015, 2020; Mulieri et al. 2017; Souza and Von Zuben 2016; Faria et al. 2018; Paseto et al. 2019; Dufek et al. 2020; Toma et al. 2020
Lipoptilocnema koehleri (Blanchard, 1939)[a]			X	BV; CV; FE; FI; SL; PC	R, U, W	omnivorous	Pape 1996; Mariluis et al. 2007; Mulieri et al. 2008, 2010a,b, 2015; Patitucci et al. 2015; **current study**
Lipoptilocnema lanei (Townsend, 1934)	X	X	X	BL; CV; FE; SQ; PC	U, W	omnivorous	Pape 1996; Mariluis et al. 2007; Mulieri et al. 2008, 2010b, 2015, 2017; Vairo et al. 2011; Patitucci et al. 2015; Dufek et al. 2020; **current study**
Microcerella analis (Townsend, 1927)	X	X		PC	W	unknown	Pape 1996, Vairo et al. 2011
Microcerella austrohartigia Pape, 1990	X		X	BV	R, U	omnivorous	Pape 1996, Mulieri et al. 2010a, 2010b
Microcerella halli (Engel, 1931)	X		X	BM; BV; CP; CV; FE; FI; LC; RO; SN; SQ; PC	R, U, W	necrophagous	Ferreira 1979; Pape 1996; Moura 2004; Moura et al. 2005; Moretti et al. 2008, 2009; Patitucci et al. 2011; Vairo et al. 2011, 2017; Alves et al. 2014; Nassu et al. 2014; Silva et al. 2014; Cavallari et al. 2015; Ries and Blochtein 2015; Ernesto et al. 2018; Barbosa et al. 2019; Dufek et al. 2020; **current study**
Microcerella pilicoxa (Lopes, 1972)			X	unknown	unknown	unknown	Pape 1996
Microcerella pilifacies (Lopes, 1983)[b]		X		unknown	unknown	unknown	Pape 1996
Microcerella wygodzinskyi (Lopes, 1954)		X		unknown	unknown	unknown	Pape 1996
***Nephochaetopteryx cyaneiventris* Lopes, 1936**	X		X	BV; CV; FE; PC	R, U, W	omnivorous	Mulieri et al. 2008, 2010b; Patitucci et al. 2011, 2015; Vairo et al. 2011; Mello-Patiu et al. 2014b; Faria et al. 2018; **current study**
Nephochaetopteryx fuscipennis Lopes, 1941[b]		X		unknown	unknown	unknown	Pape 1996

Table 4. Continued

Species	Localities PR	SC	RS	Substrate	Environment	Ecological Category	References
Oxysarcodexia admixta (Lopes, 1933)	X	X	X	BV; CV; CC; FF; FI; FE; RO; SQ; PC	R, U, W	omnivorous	Lopes 1973; Dias et al. 1984a, b; D'Almeida 1994; D'Almeida and Lima 1994; Pape 1996; Oliveira et al. 2002; Barros et al. 2008; Rosa et al. 2011; Vairo et al. 2011; Barbosa et al. 2014; Mello-Patiu et al. 2014b; Cavallari et al. 2015; Dufek et al. 2015, 2016, 2020; Sousa et al. 2015, 2016, 2020; Madeira et al. 2016; Souza and Von Zuben 2016; Faria et al. 2018; Paseto et al. 2019; Toma et al. 2020; **current study**
Oxysarcodexia amorosa (Schiner, 1868)		X		BM; BV; CC; CR; CV; FE; FF; FI; RO; SN; PC	U, R, W	omnivorous	Lopes 1973; D'Almeida 1989, 1994; Pape 1996; Oliveira et al. 2002; Leandro and D'Almeida 2005; Barbosa et al. 2009, 2014, 2015, 2017, 2019; Rosa et al. 2011; Sousa et al. 2011, 2014b, 2015, 2016, 2020; Ramírez-Mora et al. 2012; Bitar et al. 2013; Alves et al. 2014; Oliveira-Costa et al. 2014; Vairo et al. 2014; Cavallari et al. 2015; Xavier et al. 2015; Carmo and Vasconcelos 2016; Vasconcelos et al. 2016; Valverde-Castro et al. 2017; Ernesto et al. 2018; Lopes et al. 2018; Leite-Júnior et al. 2019; Andrade-Herrera et al. 2020; Toma et al. 2020
Oxysarcodexia angrensis (Lopes, 1933)		X		BM; BV; CP; CV; FE; FF; FI; ON; RO; PC	R, U, W	omnivorous	Lopes 1973, Linhares 1981, D'Almeida 1994, Pape 1996, Oliveira-Costa et al. 2001, Moretti et al. 2008, Rosa et al. 2011, Sousa et al. 2011, Ramírez-Mora et al. 2012, Bitar et al. 2013, Yepes-Gaurisas et al. 2013, Barbosa et al. 2014, Mello-Patiu et al. 2014b, Vairo et al. 2014, Cavallari et al. 2015, Souza and Von Zuben 2016, Valverde-Castro et al. 2017, Faria et al. 2018, Paseto et al. 2019, Toma et al. 2020
Oxysarcodexia augusta Lopes, 1946		X		BL; CV; FF; FE; FI; RO	R, W	omnivorous	Dias et al. 1984a, b; Pape 1996; Oliveira et al. 2002
Oxysarcodexia avuncula (Lopes, 1933)		X	X	BM; BV; CV; CC; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Dias et al. 1984a, b; Pape 1996; Carvalho and Linhares 2001; Mendes and Linhares 2002; Barros et al. 2008; Barbosa et al. 2009; 2019, Rosa et al. 2011; Ramírez-Mora et al. 2012; Vasconcelos and Araújo 2012; Vasconcelos et al. 2013, 2016; Yepes-Gaurisas et al. 2013; Alves et al. 2014; Mello-Patiu et al. 2014b; Sousa et al. 2014a, 2015, 2016, 2020; Dufek et al. 2015, 2016, 2020; Ries and Blochtein 2015; Madeira et al. 2016; Souza and Von Zuben 2016; Valverde-Castro et al. 2017; Faria et al. 2018; Paseto et al. 2019; Toma et al. 2020; **current study**
Oxysarcodexia bicolor Lopes, 1946		X	X	BV; CV; FE	R, U, W	omnivorous	Mulieri et al. 2008, 2010a,b, 2015; Patitucci et al. 2011, 2015; Madeira et al. 2016; Souza et al. 2020b; **current study**
Oxysarcodexia confusa Lopes, 1946	X	X	X	BV; CV; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Lopes 1973; Ferreira 1979; Dias et al. 1984a, b; Pape 1996; Vairo et al. 2014; Dufek et al. 2015, 2016; **current study**
Oxysarcodexia culmiforceps Dodge, 1966	X	X	X	BV; CV; FE; FI; FF; RO; SQ; PC	R, U, W	omnivorous	Ferreira 1979; Linhares 1981; Dias et al. 1984a, b; Pape 1996, Carvalho and Linhares 2001; Oliveira et al. 2002; Leandro and D'Almeida 2005; Mariluis et al. 2007; Mulieri et al. 2008, 2010a, 2015; Patitucci et al. 2011, 2015; Rosa et al. 2011; Vairo et al. 2011; Mello-Patiu et al. 2014b; Cavallari et al. 2015; Dufek et al. 2015, 2016; Carmo and Vasconcelos 2016; Madeira et al. 2016; Souza and Von Zuben 2016; Faria et al. 2018; Souza et al. 2020a; **current study**
Oxysarcodexia diana (Lopes, 1933)	X	X		BV; CV; CC; FE; FF; FI; RO; PC	R, U, W	omnivorous	Lopes 1973; Linhares 1981; Dias et al. 1984a, b; D'Almeida 1989, 1994; D'Almeida and Lima 1994; Pape 1996; Carvalho and Linhares 2001; Marchiori et al. 2001; Oliveira et al. 2002; Leandro and D'Almeida 2005; Barros et al. 2008; Barbosa et al. 2009; Rosa et al. 2011; Ramírez-Mora et al. 2012; Yepes-Gaurisas et al. 2013; Mello-Patiu et al. 2014b; Oliveira-Costa et al. 2014; Sousa et al. 2014a; Cavallari et al. 2015; Souza and Von Zuben 2016; Valverde-Castro et al. 2017; Faria et al. 2018; Lopes et al. 2018; Paseto et al. 2019; Toma et al. 2020
Oxysarcodexia floricola Lopes, 1975[a]		X		unknown	unknown	unknown	Pape 1996
Oxysarcodexia grandis Lopes, 1946	X			CV; FE; FI; PC	R, W	omnivorous	Pape 1996, Ramírez-Mora et al. 2012, Yepes-Gaurisas et al. 2013, Vairo et al. 2014

Table 4. Continued

Species	Localities			Substrate	Environment	Ecological Category	References
	PR	SC	RS				
Oxysarcodexia injuncta (Walker, 1858)	X	X	X	BV; FE	R, W	omnivorous	Lopes 1973, Pape 1996, **current study**
Oxysarcodexia marina (Hall, 1938)*a*			X	BV; FE; SQ	R, W	omnivorous	Mariluis et al. 2007; Mulieri et al. 2008,2010b; Souza et al. 2020b
Oxysarcodexia morretesi Tibana & Mello, 1983	X			unknown	unknown	unknown	Pape 1996
Oxysarcodexia notata Soares & Mello-Patiu, 2010	X			unknown	unknown	unknown	Souza et al. 2020b
Oxysarcodexia parva Lopes, 1946	X		X	BM; BV; CC; CV; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Lopes 1973; Dias et al. 1984a, b; D'Almeida 1994; Barbosa et al. 2009; Vairo et al. 2011; Alves et al. 2014; Mello-Patiu et al. 2014b; Souza and Von Zuben 2016; Faria et al. 2018; Dufek et al. 2020; Toma et al. 2020; **current study**
Oxysarcodexia paulistanensis (Mattos, 1919)	X		X	BM; BV; CV; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Lopes 1973; Ferreira 1979; Linhares 1981; Dias et al. 1984a, b; Pape 1996; Moura et al. 1997, 2005; Carvalho and Linhares 2001; Moura 2004; Mariluis et al. 2007; Barros et al. 2008; Mulieri et al. 2008, 2010a, 2015; Patitucci et al. 2011, 2015; Rosa et al. 2011; Vairo et al. 2011, 2015; Beuter et al. 2012; Mello-Patiu et al. 2014b; Sousa et al. 2014a; Armani et al. 2015, 2017; Cavallari et al. 2015; Dufek et al. 2016; Madeira et al. 2016; Souza and Von Zuben 2016; Faria et al. 2018; Paseto et al. 2019; Souza et al. 2020a; **current study**
Oxysarcodexia petropolitana Lopes, 1975		X		BM; FE	W	omnivorous	Lopes 1975, Pape 1996
Oxysarcodexia riograndensis Lopes, 1946	X		X	BM; CP; CV; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Ferreira 1979; Linhares 1981; Pape 1996; Carvalho and Linhares 2001; Moretti et al. 2008; Oliveira and Vasconcelos 2010; Rosa et al. 2011; Vairo et al. 2011, 2015; Vasconcelos et al. 2013; Mello-Patiu et al. 2014b; Dufek et al. 2016, 2020; Madeira et al. 2016; Faria et al. 2018; **current study**
Oxysarcodexia terminalis (Wiedemann, 1830)	X	X	X	BM; BV; CP; CV; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Ferreira 1979; Linhares 1981; Dias et al. 1984a, b; Pape 1996; Marchiori et al. 2001; Oliveira-Costa et al. 2001; Mendes and Linhares 2002; Oliveira et al. 2002; Mariluis et al. 2007; Mulieri et al. 2008, 2010a, 2015; Patitucci et al. 2011, 2015; Rosa et al. 2011; Beuter et al. 2012; Mello-Patiu et al. 2014b; Dufek et al. 2016, 2020; Madeira et al. 2016; Armani et al. 2017; Lopes et al. 2018; Faria et al. 2018; Paseto et al. 2019; Vilte et al. 2020; **current study**
Oxysarcodexia thornax (Walker, 1849)	X	X	X	BM; BV; CC; CP; CV; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Linhares 1981; Dias et al. 1984a, b; D'Almeida 1988, 1989, 1994; D'Almeida and Lima 1994; Pape 1996; Carvalho and Linhares 2001; Marchiori et al. 2001; Oliveira-Costa et al. 2001, 2014; Mendes and Linhares 2002; Oliveira et al. 2002; Leandro and D'Almeida 2005; Marchiori 2006, 2014; Mariluis et al. 2007; Barros et al. 2008; Moretti et al. 2008; Mulieri et al. 2008, 2010a; Barbosa et al. 2009, 2015, 2017, 2019; Patitucci et al. 2011, 2015; Rosa et al. 2011; Sousa et al. 2011; 2014a,b, 2015, 2016, 2020; Vairo et al. 2011, 2014; Beuter et al. 2012; Ramírez-Mora et al. 2012; Vasconcelos and Araujo 2012; Bitar et al. 2013; Mello-Patiu et al. 2014b; Cavallari et al. 2015; Dufek et al. 2015, 2016, 2020; Ries and Blochtein 2015; Souza and Von Zuben 2016; Vasconcelos et al. 2016; Ernesto et al. 2018; Faria et al. 2018; Lopes et al. 2018; Oliveira and Vasconcelos 2018; Leite-Júnior et al. 2019; Paseto et al. 2019; Castro et al. 2019; Souza et al. 2020a; Toma et al. 2020; **current study**
Oxysarcodexia varia (Walker, 1836)	X	X	X	BM; BV; CV; FI; FE; SQ; PC	R, U, W	omnivorous	Ferreira 1979; Pape 1996; Mendes and Linhares 2002; Mariluis et al. 2007; Mulieri et al. 2008, 2010a, 2015; Patitucci et al. 2011, 2015; Armani et al. 2015, 2017; Madeira et al. 2016; Dufek et al. 2020; Souza et al. 2020a; **current study**
Oxysarcodexia vittate (Walker, 1836)	X	X		unknown	unknown	unknown	Pape 1996

Table 4. Continued

Species	Localities			Substrate	Environment	Ecological Category	References
	PR	SC	RS				
***Oxysarcodexia xanthosoma* (Aldrich, 1916)**	X		X	BV; FE; FI; PC	R, U, W	omnivorous	D'Almeida 1994; Oliveira et al. 2002; Leandro and D'Almeida 2005; Barbosa et al. 2009; Rosa et al. 2011; Vairo et al. 2011, 2014; Cavallari et al. 2015; Toma et al. 2020; **current study**
Oxyvinia xanthophore (Schiner, 1868)*a*	X			unknown	unknown	unknown	Pape 1996
Peckia (*Euboettcheria*) *anguilla* (Curran & Walley, 1934)	X			BM; BV; CV; FE; FF; FI; RO; SL; SQ; PC	R, U, W	omnivorous	Dias et al. 1984a, b; D'Almeida 1994; D'Almeida and Lima 1994; Carvalho and Linhares 2001; Barros et al. 2008; Moretti et al. 2008; Rosa et al. 2011; Sousa et al. 2011, 2014a, 2015, 2016, 2020; Mello-Patiu et al. 2014; Yepes-Gaurisas et al. 2013; Cavallari et al. 2015; Carmo and Vasconcelos 2016; Souza and Von Zuben 2016; Valverde-Castro et al. 2017; Camargo et al. 2018; Faria et al. 2018; Dufek et al. 2020; Toma et al. 2020
Peckia (*Euboettcheria*) *australis* (Townsend, 1927)	X	X	X	BM; BV; CP; CV; FI; SQ; PC	R, U, W	necrophagous	Pape 1996; Carvalho and Linhares 2001; Rosa et al. 2011; Vairo et al. 2011, 2015; Buenaventura and Pape 2013; Cavallari et al. 2015; Dufek et al. 2015, 2016; Souza and Von Zuben 2016; Gaedke and Mouga 2017; **current study**
***Peckia* (*Euboettcheria*) *collusor* (Prado & Fonseca, 1932)**	X	X	X	BM; BV; CC; CR; CV; FE; FF; FI; FR; RO; SQ; PC	R, U, W	omnivorous	Linhares 1981; Dias et al. 1984a, b; D'Almeida 1994; D'Almeida and Lima 1994; Pape 1996; D'Almeida and Almeida 1998; Carvalho and Linhares 2001; Oliveira et al. 2002; Leandro and D'Almeida 2005; Barros et al. 2008; Moretti et al. 2008; Barbosa et al. 2009, 2014; Rosa et al. 2011; Sousa et al. 2011, 2014a, 2014b, 2015, 2016, 2020; Vairo et al. 2011, 2014; Beuter et al. 2012; Ramírez-Mora et al. 2012; Bitar et al. 2013; Buenaventura and Pape 2013; Faria et al. 2013, 2018; Yepes-Gaurisas et al. 2013; Mello-Patiu et al. 2014b; Cavallari et al. 2015; Carmo and Vasconcelos 2016; Souza and Von Zuben 2016; Valverde-Castro et al. 2017; Camargo et al. 2018; Ernesto et al. 2018; Paseto et al. 2019; Dufek et al. 2020; Toma et al. 2020; **current study**
Peckia (*Euboettcheria*) *pascoensis* (Lopes, 1990)			X	FF; SQ	R, W	unknown	Pape 1996, Dufek et al. 2015, 2016
Peckia (*Pattonella*) *intermutans* (Walker, 1861)	X	X		BM; BV; CP; CV; FI; FE; FF; FR; RO; SN; SQ; PC	R, U, W	necrophagous	Linhares 1981; Dias et al. 1984a, b; D'Almeida 1988, 1989, 1994; D'Almeida and Lima 1994; Pape 1996; Carvalho et al. 2000; Carvalho and Linhares 2001; Oliveira et al. 2002; Carvalho et al. 2004; Leandro and D'Almeida 2005; Loureiro et al. 2005; Barros et al. 2008; Moretti et al. 2008; Barbosa et al. 2009, 2010, 2014, 2015, 2017; Rosa et al. 2009, 2011; Oliveira and Vasconcelos 2010; Sousa et al. 2011, 2014a,b, 2015, 2016, 2020; Vairo et al. 2011, 2014; Ledo et al. 2012; Buenaventura and Pape 2013; Faria et al. 2013, 2018, Yepes-Gaurisas et al. 2013; Mello-Patiu et al. 2014b; Oliveira-Costa et al. 2014; Cavallari et al. 2015; Souza and Von Zuben 2016; Valverde-Castro et al. 2017; Camargo et al. 2018; Leite-Júnior et al. 2019; Paseto et al. 2019; Toma et al. 2020; Thyssen unpublished data
Peckia (*Pattonella*) *resona* (Lopes, 1935)	X	X	X	BC; BV; CC; CV; FE; FF; FI; LC; RC; RO; SQ; PC	R, U, W	necrophagous	Ferreira 1979; Pape 1996; Moura et al. 1997, 2005; Moura 2004; Souza et al. 2008; Krüger et al. 2010; Patitucci et al. 2011; Vairo et al. 2011; Buenaventura and Pape 2013; Barbosa et al. 2014; Silva et al. 2014b; Dufek et al. 2015, 2016; **current study**
***Peckia (Peckia) chrysostoma* (Wiedemann, 1830)**	X	X	X	BM; BV; CR; CP; CV; FE; FF; FI; RO; SL; SQ; PC	R, U, W	omnivorous	Lopes 1969, 1973; Linhares 1981; Dias et al. 1984a, b; D'Almeida 1988, 1989, 1994; D'Almeida and Lima 1994; D'Almeida and Mello 1996; Pape 1996; D'Almeida and Almeida 1998; Oliveira-Costa et al. 2001, 2014; Oliveira et al. 2002; Leandro and D'Almeida 2005; Marchiori 2006; Barros et al. 2008; Moretti et al. 2008; Barbosa et al. 2009, 2015, 2017, 2019; Rosa et al. 2011; Sousa et al. 2011, 2014a,b, 2015, 2016, 2020; Beuter et al. 2012; Bitar et al. 2013; Buenaventura and Pape 2013; Yepes-Gaurisas et al. 2013; Alves et al. 2014; Mello-Patiu et al. 2014b; Vasconcelos et al. 2014, 2016; Cavallari et al. 2015; Carmo and Vasconcelos 2016; Souza and Von Zuben 2016; Valverde-Castro et al. 2017; Camargo et al. 2018; Ernesto et al. 2018; Faria et al. 2018; Paseto et al. 2019; Toma et al. 2020; **current study**

Table 4. Continued

Species	Localities			Substrate	Environ-ment	**Ecological Category**	References
	PR	SC	RS				
Peckia (*Peckia*) *enderleini* (Engel, 1931)			X	BV; FF; SQ	R, U, W	omnivorous	Pape 1996; Dufek et al. 2015, 2016, 2020; Toma et al. 2020
Peckia (*Sarcodexia*) *aequata* (Wulp, 1895)[a]		X		CV; FI	R, W	unknown	Ramírez-Mora et al. 2012, Buenaventura and Pape 2013
Peckia (Sarcodexia) florencioi (Prado & Fonseca, 1932)	X	X	X	BM; BV; CV; FE; FF; FI; RO; SQ; PC	R, W	necrophagous	Lopes 1973; Ferreira 1979; Linhares 1981; Dias et al. 1984a, b; D'Almeida 1994; D'Almeida and Lima 1994; Pape 1996; Carvalho and Linhares 2001; Mulieri et al. 2010a; Rosa et al. 2011; Vairo et al. 2011, 2015; Buenaventura and Pape 2013; Mello-Patiu et al. 2014b; Sousa et al. 2014a; Souza and Von Zuben 2016; Camargo et al. 2018; Faria et al. 2018; Paseto et al. 2019; Dufek et al. 2020; Toma et al. 2020; **current study**
Peckia (*Sarcodexia*) *lambens* (**Wiedemann, 1830**)	X	X	X	BM; BV; CC; CP; CR; CV; FE; FF; FI; FR; LP; RC; RO; SL; SQ; PC; WD	R, U, W	omnivorous; invertebrate parasite; vertebrate parasite	Lopes 1969, 1973; Ferreira 1979; Linhares 1981; Dias et al. 1984a, b; D'Almeida 1989, 1994; Leão et al. 1996; Pape 1996;D'Almeida and Almeida 1998; Carvalho and Linhares 2001; Oliveira-Costa et al. 2001; Oliveira et al. 2002; Moura 2004, Hagman et al. 2005; Leandro and D'Almeida 2005; Moura et al. 2005; Marchiori 2006; Barros et al. 2008; Moretti et al. 2008; Barbosa et al. 2009, 2014, 2015, 2017, 2019; Bermúdez et al. 2010; Mulieri et al. 2010b; Oliveira and Vasconcelos 2010; Rosa et al. 2009, 2011; Sousa et al. 2011, 2014a,b, 2015, 2016, 2020; Vairo et al. 2011, 2014; Beuter et al. 2012; Ramírez-Mora et al. 2012; Ledo et al. 2012; Bitar et al. 2013; Buenaventura and Pape 2013; Faria et al. 2013, 2018; Yepes-Gaurisas et al. 2013; Alves et al. 2014; Mello-Patiu et al. 2014b; Oliveira-Costa et al. 2014; Barbosa and Vasconcelos 2015; Cavallari et al. 2015; Patitucci et al. 2015; Vasconcelos et al. 2015, 2016; Xavier et al. 2015; Carmo and Vasconcelos 2016; Dufek et al. 2016, 2020; Souza and Von Zuben 2016; Gaedke and Mouga 2017; Toma et al. 2017, 2020; Valverde-Castro et al. 2017; Camargo et al. 2018; Ernesto et al. 2018; Leite-Júnior et al. 2019; Paseto et al. 2019 D'Bastiani et al. 2020; Vilte et al. 2020; **current study**
Peckia (*Squamatodes*) *ingens* (Walker, 1849)			X	BM; BV; CC; CP; CV; FE; FI; RO; PC	R, U, W	necrophagous	D'Almeida 1994; Pape 1996; Carvalho and Linhares 2001; Leandro and D'Almeida 2005; Barros et al. 2008; Moretti et al. 2008; Oliveira and Vasconcelos 2010; Pastrana and Wolff-Echeverry 2011; Rosa et al. 2011; Sousa et al. 2011, 2014a,b, 2015, 2016, 2020; Buenaventura and Pape 2013 Vasconcelos et al. 2013; Alves et al. 2014; Mello-Patiu et al. 2014b; Vairo et al. 2014; Yepes-Gaurisas et al. 2013; Valverde-Castro et al. 2017; Camargo et al. 2018; Ernesto et al. 2018; Faria et al. 2018; Paseto et al. 2019; Toma et al. 2020
Ravinia advena (Walker, 1853)	X	X	X	BV; CC; CV; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Ferreira 1979; Dias et al. 1984a, b; Pape 1996; Carvalho and Linhares 2001; Mendes and Linhares 2002; Guimarães 2004; Mulieri et al. 2010b; Rosa et al. 2011; Alves et al. 2014; Mello-Patiu et al. 2014b; Dufek et al. 2016 2020; Faria et al. 2018; Paseto et al. 2019; Souza et al. 2020a; Toma et al. 2020; Vilte et al. 2020; **current study**
Ravinia almeidai (Lopes, 1946)	X			unknown	unknown	unknown	Pape 1996
Ravinia aureopyga (Hall, 1928)			X	BV; FE; SQ; PC	R, U; W	omnivorous	Pape 1996; Armani et al. 2015, 2017; Barbosa et al. 2019; Castro et al. 2019; Dufek et al. 2020
Ravinia belforti (Prado & Fonseca, 1932)	X		X	BM; BV; CC; CP; CV; FE; FF; FI; PO; RO; SQ; PC	R, U, W	omnivorous	Ferreira 1979; Linhares 1981; Dias et al. 1984a, b; D'Almeida 1988, 1989; D'Almeida and Lima 1994; D'Almeida and Mello 1996; D'Almeida and Salviano 1996; Pape 1996; D'Almeida and Almeida 1998; Carvalho and Linhares 2001; Marchiori et al. 2001; Oliveira-Costa et al. 2001; Mendes and Linhares 2002; Oliveira et al. 2002; Leandro and D'Almeida 2005; Barros et al. 2008; Moretti et al. 2008; Barbosa et al. 2009, 2015, 2017, 2019; Oliveira and Vasconcelos 2010; Rosa et al. 2011; Beuter et al. 2012; Bitar et al. 2013; Alves et al. 2014; Mello-Patiu et al. 2014b; Oliveira-Costa et al. 2014; Sousa et al. 2014a, 2015, 2016, 2020; Vairo et al. 2014; Cavallari et al. 2015; Ries and Blochtein 2015; Vasconcelos et al. 2015, 2016; Carmo and Vasconcelos 2016; Oliveira and Vasconcelos 2018; Souza and Von Zuben 2016; Ernesto et al. 2018; Faria et al. 2018; Paseto et al. 2019; Dufek et al. 2020; Toma et al. 2020; **current study**

Table 4. Continued

Species	Localities PR	SC	RS	Substrate	Environment	Ecological Category	References
Ravinia sueta (Wulp, 1896)[a]			X	BV; CV; FE; IP	R, U, W	predator	Hernandez 1992; Pape 1996; Mariluis et al. 2007; Mulieri et al. 2008, 2010a, 2015; Patitucci et al. 2011, 2015
Sarcophaga (*Bercaea*) *africa* (Wiedemann, 1824)	X		X	BM; BV; CP; CV; FE; FF; FI; RO; PC; WD	R, U, W	necrophagous; vertebrate parasite	Ferreira 1979; Linhares 1981; Dias et al. 1984a, b; D'Almeida and Lima 1994; Pape 1996; Barbosa et al. 2009; Mulieri et al. 2010b, 2015; Vairo et al. 2011, 2015; Cherix et al. 2012; Dutto et al. 2013; Abdel-Hafeez et al. 2015; Patitucci et al. 2015; Armani et al. 2017; Moemenbellah-Fard et al. 2018; Vilte et al. 2020; **current study**
Sarcophaga (*Liopygia*) *argyrostoma* (Robineau-Desvoidy, 1830)			X	BV; CP; FE; PC; WD	R, U, W	necrophagous; vertebrate parasite	Burgess and Spraggs 1992; Pape 1996; Mulieri et al. 2008, 2010a; Cherix et al. 2012; Graffi et al. 2013; Armani et al. 2015, 2017; Patitucci et al. 2015; Severini et al. 2015; Giangaspero et al. 2017; Pezzi et al. 2017; Leite-Júnior et al. 2019; Ayalon et al. 2020
Sarcophaga (*Liopygia*) *crassipalpis* Macquart, 1839[a]			X	BV; CP; CV; SC; FE; RC; PC; WD	R, U, W	necrophagous; vertebrate parasite	Ali-Khan and Ali-Khan 1974; Mariluis et al. 2007; Mulieri et al. 2008, 2010a, 2015; Souza et al. 2008; Krüger et al. 2010; Silva et al. 2010, 2014b; Bonacci et al. 2014; Hiraoka et al. 2015; Farrel et al. 2015; Patitucci et al. 2015; Armani et al. 2017; Toukairin et al. 2017
Sarcophaga (*Neobellieria*) *polistensis* (Hall, 1933)		X	X	BV; CV; PC	R, U, W	invertebrate parasite	Pape 1996; Giroux and Wheeler 2009; Mello-Patiu et al. 2014b; Sousa et al. 2015, 2016, 2020; Paseto et al. 2019; Vilte et al. 2020
Titanogrypa (*Sarconeiva*) *fimbriata* (Aldrich, 1916)	X	X		FI; RO; SQ; SN; PC	R, U, W	detritivore	Lopes 1940 1973, Pape 1996, Leandro and D'Almeida 2005, Rosa et al. 2011, Vairo et al. 2011, Beuter et al. 2012, Mello-Patiu et al. 2014b, Cavallari et al. 2015, Barbosa et al. 2019, Paseto et al. 2019, Dufek et al. 2020
***Tricharaea (Sarcophagula) canuta* (Wulp, 1896)**	X		X	BV; CV; FE; FI	R, U, W	omnivorous	Ferreira 1979; Leandro and D'Almeida 2005; Yepes-Gaurisas et al. 2013; Barbosa et al. 2015, 2017, 2019; Sousa et al. 2015, 2016, 2020; **current study**
***Tricharaea (Sarcophagula) occidua* (Fabricius, 1794)**	X		X	BV; CV; FE; FF; FI; RO; SQ; PC	R, U, W	omnivorous	Ferreira 1979; D'Almeida 1988, 1989; D'Almeida and Almeida 1998; Marchiori et al. 2001; Mendes and Linhares 2002; Leandro and D'Almeida 2005; Mariluis et al. 2007; Barros et al. 2008; Mulieri et al. 2008, 2010a, 2015; Barbosa et al. 2009, 2014, 2015, 2017, 2019; Patitucci et al. 2011, 2015; Rosa et al. 2011; Sousa et al. 2011, 2015, 2016, 2020; Beuter et al. 2012; Yepes-Gaurisas et al. 2013; Alves et al. 2014; Mello-Patiu et al. 2014b; Marchiori 2014; Oliveira-Costa et al. 2014; Armani et al. 2015; Carmo and Vasconcelos 2016; Vasconcelos et al. 2016; Valverde-Castro et al. 2017; de Faria et al. 2018; Oliveira and Vasconcelos 2018; Castro et al. 2019; Dufek et al. 2020; **current study**
Tripanurga albicans (Wiedemann, 1830)	X			unknown	unknown	unknown	Pape 1996
Udamopyga malacophila Lopes, 1940		X		SL	unknown	detritivore	Lopes 1940, Pape 1996
Udamopyga percita (Lopes, 1938)	X		X	BM; BV; CV; FE; RO; SL; PC	W	detritivore	Lopes 1940, 1969, 1973; Mulieri et al, 2010a; Vairo et al. 2011; Beuter et al. 2012; Sousa et al. 2014a; Patitucci et al. 2015; Santos and Mello-Patiu 2018; Toma et al. 2020
Udamopyga setigena (Enderlein, 1928)		X	X	BV; RO; SL	W	detritivore	Lopes 1940, Pape 1996, Oliveira and Vasconcelos 2018, Toma et al. 2020

[a]Unique records in Brazil.

[b]Exclusive records in Neotropical region.

By locality, where: PR= Paraná; SC= Santa Catarina; and RS= Rio Grande do Sul states. By substrates, where:

BC = bird carcass; BM = bovine meat; BV = bovine viscera; CC = canid carcass (domestic dog or crab-eating fox); CL = Coleoptera parasitoidism; CP = corpse; CR = decaying crustaceans (shrimp or crab); CV = chicken viscera; FE = feces (of human or dog); FF = fermented fruits; FI = fish carcass; FR = frog carcass; IP = insect predator; KW = kleptoparasitism in wasp nests; LC = lizard carcass; LP = Lepidoptera parasitoidism; ON = decaying onion; PC = pig carcass (*Sus scrofa*); PO = pork meat; RC = rabbit carcass (*Oryctolagus cuniculus*); RO = rodent carcass (*Rattus norvegicus* or *Mus musculus*); SC = skunk carcass (*Didelphis albiventris*); SL = decaying snail; SN = snake carcass; SQ = decaying squid; TC = turtle carcass; WD = wounds (i.e., myiasis in anurans, birds andmammals – cats or humans)

By environment, where: R = rural; U = urban; and W = wild.

myiasis-causing flies were selected based on previously recorded behavior, as shown in Table 4.

Discussion

Abundance and Richness of Sarcophaginae From RS

The use of decomposing baits, such as animal tissues or feces, to attract and collect Sarcophaginae of forensic importance is a good sampling strategy because necrophagous and omnivorous fly species look for these types of resources to address dietary or progeny needs – for ovarian development and larval growth, respectively (Ferrar 1987, Mendes and Linhares 1993) – or to select a mating site (Pape and Dahlem 2010). Moreover, the use of small decomposing carcasses has been shown to be efficient for collecting and documenting representative dipterofauna of forensic importance (Kuusela and Hanski 1982, Hewadikaram and Goff 1991). However, small carcass sizes tend to reduce the abundance of collected species (Hewadikaram and Goff 1991). The time sampling, i.e., sampling during a long time ranging, seems to exert more influence on species abundance, as observed in the comparison of Studies 1–3.

For qualitative analysis, hand nets are considerably easier to use than other methods; however, this method requires multiple interrupted sampling sessions and can cause disruption in arriving flies that do not readily return to the substrate (Cruise et al. 2018). This may explain the lower species abundance in Study 3. The highest species abundance and richness observed in Study 1 probably resulted from longer and more varied (urban, rural, and wild) sampling compared to the other two studies. As observed in Study 2, using experimental models such as pig carcasses for collecting flies of forensic importance generally results in one or two predominant species, comprising about two-thirds of the total abundance (Kuusela and Hanski 1982), with the other species presenting lower abundances.

Oxysarcodexia culmiforceps was the only species that was most abundant in both the warm and cold seasons in the three studies. Previous studies in Southern Brazil have shown that this species is quite abundant throughout the year, and it can be found in all environments, although it presents a preference for rural and wild environments (Ferreira 1979, Souza et al. 2020a). This pattern differs from that found in other Brazilian regions and Neotropical countries, where this species is generally of low abundance (Linhares 1981, Dias et al. 1984a, Mariluis et al. 2007, Mulieri et al. 2008) or rare (Oliveira et al. 2002, Leandro and D'Almeida 2005, Rosa et al. 2011, Souza and Von Zuben 2016, de Faria et al. 2018). *Oxysarcodexia culmiforceps* is endemic to the southern region of South America and is distributed only in the southern half of Brazil, Paraguay, Uruguay, and Argentina (Souza et al. 2020b), probably due to physiological adaptation to low temperatures.

Oxysarcodexia paulistanensis and *O. thornax* also showed high abundance in at least two of the three studies. Like *O. culmiforceps*, *O. paulistanensis* is distributed in the southern half of South America and has a high abundance in Southern Brazil (Ferreira 1979, Souza et al. 2020a) and Argentina (Mulieri et al. 2008, 2010b, 2015). *Oxysarcodexia thornax* has a wider distribution, from Guyana to Argentina, and is frequently found in greater abundance in sites with higher average temperatures (Linhares 1981, Oliveira et al. 2002, Rosa et al. 2011, Sousa et al. 2011, Marchiori 2014, Souza and Von-Zuben 2016, de Faria et al. 2018, Paseto et al. 2019). Both species are synanthropic, i.e., well adapted to live in environments modified by humans (Souza et al. 2020a).

Studies in Brazil using pig carcasses to survey the necrophagous fauna have reported that the bloated and dry decomposition stages present the greatest species richness and abundance of flesh flies (Barros et al. 2008, Cavallari et al. 2015, Ries et al. 2015, Paseto et al. 2019). In Study 3, the greatest abundance during the warm season was registered in the bloated stage as well as observed by Barros et al. (2008). Conversely, the greatest abundance was registered in the decay stage in the cold season, as in Cavallari et al. (2015) and Ries et al. (2015). It is worth noting that a considerable number of studies fail to report the exact association between flesh flies and the decomposition stages of corpses under experimental conditions, hampering PMI estimates that consider entomological succession. It would be important for researchers to be more attentive in detailing their experimental designs to ensure more standardized access to the results obtained.

Forensic Relevance of Sarcophaginae from Southern Brazil

Considering the four ecological categories (necrophagous, predators/parasites, omnivorous, and incidental) that can occur on a carrion/corpse, Sarcophaginae species can be important for forensic entomology (Smith 1986). Necrophagous species, generally blowflies and flesh flies, are the most important for estimating the PMI because of their developmental time (Catts and Goff 1992). For this reason, the necrophagous species recorded in Southern Brazil are considered to have high forensic relevance. Only six of the ten necrophagous species had already been collected from corpses: *M. halli* in Brazil (Vairo et al. 2017); *Peckia* (*Euboettcheria*) *australis* (Townsend) in Brazil (Gaedke and Mouga 2017); *Peckia* (*Patonella*) *intermutans* (Walker) in Brazil (larvae recorded in Thyssen et al. (2018), although the species was identified after that paper was published, Thyssen *pers. comm.*); *Sarcophaga* (*Bercaea*) *africa* (Wiedemann) in Switzerland (Cherix et al. 2012) and Iran (Moemenbellah-Fard et al. 2018); *Sarcophaga* (*Liopygia*) *argyrostoma* (Robineau-Desvoidy) in Switzerland (Cherix et al. 2012); and *Sarcophaga* (*Liopygia*) *crassipalpis* Macquart in Italy (Bonacci et al. 2014), Australia (Farrell et al. 2015), and Japan (Toukairin et al. 2017). The other four necrophagous species (*Helicobia aurescens* (Townsend), *Peckia* (*Patonella*) *resona* (Lopes), *Peckia* (*Sarcodexia*) *florencioi* (Prado e Fonseca), and *Peckia* (*Squamatodes*) *ingens* (Walker)) were already recorded as reared from decomposing carcasses of other mammals (Lopes 1973; Moura et al. 1997, 2005; Carvalho and Linhares 2001; Moura 2004; Moretti et al. 2008; Souza et al. 2008; Rosa et al. 2009; Krüger et al. 2010; Faria et al. 2013; Mello-Patiu et al. 2014b), so they have a huge potential for PMI estimation, as they are proven to colonize corpses. Furthermore, some of these necrophagous species were recorded only from corpses outside of Brazil (Cherix et al. 2012, Bonacci et al. 2014, Farrell et al. 2015, Toukairin et al. 2017, Moemenbellah-Fard et al. 2018), but it is likely that these species are capable of colonizing corpses in Brazil as well.

Microcerella halli and *P.* (*E.*) *australis* can be considered the most important species for PMI estimation in Southeastern Brazil, where they have already been collected and bred from corpses (Gaedke and Mouga 2017, Vairo et al. 2017). *Microcerella halli* is restricted to the Neotropics (Pape 1996), appears to have acclimatized to temperatures at 6–24°C (Ferreira 1979, Moretti et al. 2008, Silva et al. 2014), and has been associated with the final stages (decay and dry) of carcass decomposition (Ries and Blochtein 2015). *Peckia* (*E.*) *australis* is also a Neotropical species (Buenaventura and Pape 2013) that has been collected in periods with average temperatures of approximately 25°C (Rosa et al. 2011) and is restricted to forested areas (Souza and Von Zuben 2016).

The great richness of *Oxysarcodexia* and *Peckia* in the Neotropical region (Buenaventura and Pape 2013, Souza et al.

2020b) can be observed in the collections of the present study as well as in most studies conducted in Brazil (e.g., Dias et al. 1984a, Barros et al. 2008, Barbosa et al. 2015, Paseto et al. 2019) and other Neotropical countries (e.g., Yepes-Gaurisas et al. 2013, Valverde-Castro et al. 2017, Dufek et al. 2020). Furthermore, these genera are highly attracted by decomposing animal matter (e.g., Dias et al. 1984b, Mariluis et al. 2007, Yepes-Gaurisas et al. 2013, Barbosa et al. 2015), which explains the great abundance recorded in our collections.

Although *Lepidodexia* has been frequently reported, there is little information about the biology and behavior of its species (Mulieri et al. 2018). Some species have been reported as parasites of anurans (e.g., Mello-Patiu and Luna-Dias 2010, Mulieri et al. 2018, D'Bastiani et al. 2020), lizards (Dodge 1955), snails (e.g., Neck and Lopes 1973, Lopes 1983), or Oligochaeta (Lopes 1942), occasionally found in nature. Among the species recorded in Southern Brazil, information on behavior was found only for *Lepidodexia* (*Notochaeta*) *fumipennis* (Lopes), which is known to cause myiasis in the anuran *Bokermannohyla circumdata* (Cope) (D'Bastiani et al. 2020).

Dexosarcophaga carvalhoi has been recorded in the Southeast (Rosa et al. 2011, Beuter et al. 2012, Mello-Patiu et al. 2014b, de Faria et al. 2018, Paseto et al. 2019), Northeast (Alves et al. 2014; Barbosa et al. 2015, 2017; Sousa et al. 2015, 2020), and Midwest of Brazil (Barros et al. 2008) and is attracted by decaying animal bait and mammal carcasses. Although the literature suggests that *D. carvalhoi* is typical of the Cerrado (savanna-like) biome (Barros et al. 2008), the first record of this species in the South of Brazil is herein presented. This indicates a possible lack of sampling in other regions of the country, which should be further investigated.

Although *R. belforti* was bred in the present study, this species was not considered to have high forensic importance. There are no other records of this species breeding on decomposing carcasses or corpses. Furthermore, *R. belforti* has been reported to prefer laying larvae on feces (D'Almeida and Salviano 1996), and this genus is recognized mostly as coprophage (Pape 1996). Thus, more studies are necessary to better understand this necrophagy record and the species' importance in PMI estimation. Nevertheless, coprophagous species, such as *R. belforti*, can be of forensic importance in cases of abuse or neglect as shown by Benecke (2010).

The forensic importance of carrion-visiting species can vary, and even for the frequent ones, this value can be low or nonexistent; thus, a thorough analysis of a species' biological characteristics is mandatory before confirming its application for forensic purposes (Matuszewski et al. 2010). However, Grzywacz et al. (2017) have pointed out the possible occurrence of these species of moderate or low forensic importance is relevant for reseachers, which justifies listing these species.

Regarding the omnivorous species, Barros et al. (2008) reported that the carrion-visiting Sarcophaginae were mostly collected in the bloated stage on pig carcasses, while Beuter et al. (2012) pointed out that carrion-breeding sarcophagine species were collected in the decay stage of rat (*R. norvegicus*) carcasses; however, neither of these studies presented a species-specific correlation with the decomposition stage. Unfortunately, the lack of information on the correlation between Sarcophaginae species and the decomposition stage or the presentation of this information for only some of the collected species is common in many studies regarding forensic entomology using experimental models (mainly pigs and rats) (e.g., Carvalho and Linhares 2001; Moura 2004; Moura et al. 2005; Barros et al. 2008; Moretti et al. 2008; Rosa et al. 2011; Vairo et al. 2011; Beuter et al. 2012; Mello-Patiu et al. 2014b; Armani et al. 2015, 2017; de Faria et al. 2018; Toma et al. 2020).

Information on omnivorous species versus the decomposition stage is valuable for providing data for entomological analyses as PMI estimates. In the bloated and decay decomposition stages, Oliveira and Vasconcelos (2018) reported the presence of *Argoravinia* (*Argoravinia*) *rufiventris* (Wiedemann). *Tricharaea* (*Sarcophagula*) *occidua* (Fabricius) was found only in the bloated stage in Study 3, but Oliveira and Vasconcelos (2018) collected this species in the bloated and decay stages, Oliveira-Costa et al. (2014) and Castro et al. (2019) in the fresh, bloated, and decay stages, Paseto et al. (2019) in the bloated, decay, and dry stages, and Vasconcelos et al. (2016) in all decomposition stages. These findings highlight *T.* (*S.*) *occidua*'s potential for collection during the entire decomposition process. Ries and Blochtein (2015) reported *Blaesoxipha* (*Acanthodotheca*) *lanei* (Lopes) in the dry stage, while Paseto et al. (2019) collected this species also in the bloated and decay stages. *Dexosarcophaga carvalhoi*, *Oxysarcodexia terminalis* (Wiedemann), *Peckia* (*Euboettcheria*) *anguilla* (Curran) and *R. advena* have been reported in the bloated, decay, and dry stages; *Peckia* (*Peckia*) *chrysostoma* (Wiedemann) in the decay and dry stages; and *Lipoptilocnema crispula* (Lopes) only in the decay stage (Paseto et al. 2019). *Peckia* (*S.*) *lambens* was reported by Leite-Júnior et al. (2019) in all decomposition stages, except the dry stage, although the presence in all decomposition stages was already recorded (Vasconcelos et al. 2016, Paseto et al. 2019). *Peckia* (*Euboettcheria*) *collusor* (Prado & Fonseca) was reported in the bloated and decay stages by Cavallari et al. (2015) and at all stages by Paseto et al. (2019). *Ravinia aureopyga* (Hall) was collected during the bloated and decay stages (Castro et al. 2019). *Ravinia belforti* was reported to be present in the bloated, decay, and dry stages (Oliveira-Costa et al. 2014, Cavallari et al. 2015, Ries and Blochtein 2015, Oliveira and Vasconcelos 2018, Paseto et al. 2019), as in the present study.

Several *Oxysarcodexia* species were reported in all stages of decomposition, as mentioned by de Faria et al. (2018) for 17 collected species, although they did not name all of them. Cavallari et al. (2015) collected *Oxysarcodexia amorosa* (Schiner) and *Oxysarcodexia diana* (Lopes) in all stages of decomposition, except the dry stage; this result was also found by Leite-Júnior et al. (2019) for *O. amorosa*, while Oliveira-Costa et al. (2014) collected *O. diana* in the decay and dry stages, and Lopes et al. (2018) collected *O. amorosa* and *O. diana* in the bloated, decay, and dry stages, as well as Paseto et al. (2019) for *O. diana*; Paseto et al. (2019) collected *Oxysarcodexia angrensis* (Lopes) and *Oxysarcodexia avuncula* (Lopes) in all stages of decomposition, and *O. admixta* in the bloated, decay, and dry stages, whereas Ries and Blochtein (2015) collected *O. avuncula* only in the dry stage. The same was found for *O. admixta* in Study 3, but *O. avuncula* was recorded in the bloated, decay, and dry stages. *Oxysarcodexia paulistanensis* was collected in the bloated and decay stages (Moura et al. 1997) and in the fresh, bloated, and decay stages by Cavallari et al. (2015), while Paseto et al. (2019) and the present study collected this species in the bloated, decay, and dry stages, also corroborating the possibility of this *Oxysarcodexia* species to be collected in all decomposition stages. A similar situation occurs with *O. thornax,* which was collected in the bloated stage of decomposition of a rat carcass (Oliveira and Vasconcelos 2018), contrasting with the collection of this species in the bloated and decay stages (Ries and Blochtein 2015), the bloated, decay and dry stages (Cavallari et al. 2015, Paseto et al. 2019, Lopes et al. 2018, present study), the decay and dry stages (Oliveira-Costa et al. 2014) and in all decomposition stages (Vasconcelos et al. 2016, de Faria et al. 2018, Castro et al. 2019, Leite-Júnior et al. 2019).

With regard to myiasis, *M. halli*, *P.* (*P.*) *chrysostoma*, *P.* (*S.*) *lambens*, and *S.* (*L.*) *argyrostoma* were the only species in this study with records of parasitism in humans, cattle, cats, porcupines, and/or snakes (Almeida 1933, Mazza and Basso 1939, Calero 1949, Leão et al. 1996, Severini et al. 2015, Pezzi et al. 2017). Other cases of myiasis by flesh flies in the Neotropical region have been reported; however, these were nonspecific identifications, such as *Sarcophaga* spp. in Argentina (Mazza et al. 1930, Lacey and George 1981) or simply 'Sarcophagidae' in Brazil (Bozzo et al. 1992), which may hinder the establishment of prophylactic measures for the hosts or the control of the fly population to reduce or eradicate myiasis-causing agents. It is noteworthy that these myiasis-causing flies can only produce facultative myiasis; that is, parasitism only occurs when there is a previous injury of any etiology in the hosts. Thus, health professionals should be alert to patients who undergo surgical interventions such as tracheostomy (e.g., Severini et al. 2015) or even dental treatments (e.g., Bozzo et al. 1992), as these situations make humans more vulnerable to opportunistic parasitism. It is important to consider targeting myiasis in investigations (e.g., Lord and Rodrigues 1989, Goff et al. 1991), as larvae of myiasis-causing flies can be used to reveal cases of neglect or mistreatment.

The fragmented existing information, the challenges of collecting at nonsampled localities, and the difficulties associated with the identification of flesh fly specimens make it difficult to gather knowledge about this family. The present study addressed these aspects by gathering information on Sarcophagidae distributed in Southern Brazil. In this way, it is possible to visualize the current knowledge on the species found in this region, and to design future research to fill the gaps.

Conclusions

The results obtained in the present study expand our knowledge on the Sarcophaginae fauna in Southern Brazil and show the high diversity of flesh flies in this biogeoclimatic zone. The use of different sampling methods, periods of collection, and collection in different areas are important strategies to increase this knowledge. However, these records can be further expanded by targeting unsampled areas in PR and SC and in the northern part of RS in future surveys.

Microcerella halli and *P.* (*E.*) *australis* are considered the most important species for PMI estimation in Southeastern Brazil. *Peckia* (*P.*) *intermutans*, *S.* (*B.*) *africa*, *S.* (*L.*) *argyrostoma*, *S.* (*L.*) *crassipalpis*, *H. aurescens*, *P.* (*P.*) *resona*, *P.* (*S.*) *florencioi* and *P.* (*S.*) *ingens* are necrophagous species with the potential to colonize corpses and provide evidence in criminal investigations. Additionally, biological information about a species enables its categorization for aiding PMI estimation or revealing cases of neglect or mistreatment. Thus, it is important to stress that studies in the forensic field with corpses or carcasses should also provide information on omnivorous species, besides necrophagous species, regarding the decomposition stage, to improve the databases that can be used when considering entomological evidence.

Supplementary Data

Supplementary data are available at *Journal of Medical Entomology* online.

Acknowledgments

This research was supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001 to Madeira-Ott and Ries. Bunde is grateful to the National Postdoctoral Program (PNPD/CAPES, grant number 2382/2011). Blochtein and Thyssen would like to thank the National Council for Scientific and Technological Development (CNPq) for the research productivity grants (311184/2016 and 309339/2011, respectively). Access registries at the Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado (SisGen) – #ACD18F8 and #AB0A1F1. All collections were authorized by the Brazilian Ministry of the Environment (MMA), through the Biodiversity Authorization and Information System (SISBIO), processes number 33844-1 and 11675-1.

References Cited

Abdel-Hafeez, E. H., R. M. Mohamed, U. S. Belal, A. M. Atiya, M. Takamoto, and F. Aosai. 2015. Human wound myiasis caused by *Phormia regina* and *Sarcophaga haemorrhoidalis* in Minia Governorate, Egypt. Parasitol. Res. 114: 3703–3709.

Ali-Khan, F. E., and Z. Ali-Khan. 1974. Two cases of human *Sarcophaga* (Diptera: Sarcophagidae) myiasis in Quebec, with descriptions of the larvae. Can. J. Zool. 52: 643–647.

Almeida, J. L. 1933. Otomyase em bezerro por *Sarcophaga sternodontes* (Towsend [sic], 1982). Archos. Esc. Sup. Agric. Med. Vet. RJ. 10: 171–172.

Alvares, C. A., J. L. Stape, P. C. Sentelhas, J. L. M. Gonçalves, and G. Sparovek. 2013. Köppen's climate classification map for Brazil. Meteorol. Z. 22: 711–728.

Alves, A. C. F., W. E. Santos, and A. J. Creão-Duarte. 2014. Diptera (Insecta) de importância forense da região Neotropical. Entomotropica. 29: 77–94.

Amat, E. 2010. Notes on necrophagous flies (Diptera: Calyptratae) associated to fish carrion in Colombian Amazon. Acta Amazon. 40: 397–400.

Amendt, J., C. P. Campobasso, E. Gaudry, C. Reiter, H. N. LeBlanc, and M. J. R. Hall. 2007. Best practice in forensic entomology – standards and guidelines. Int. J. Legal Med. 121: 90–104.

Anderson, G. S. 2020. Factors that influence insect succession on carrion, pp. 103–140. *In* J. H. Byrd, and J. K. Tomberlin (eds.), Forensic entomology: the utility of arthropods in legal investigations. 3rd ed. CRC Press, Boca Raton.

Andrade-Herrera, K. N., C. A. Mello-Patiu, C. Núñez-Vázquez, and E. Estrella. 2020. Flesh flies (Diptera: Sarcophagidae) attracted to a snake carcass (*Boa constrictor*) in Yucatan Peninsula, Mexico. J. Med. Entomol. 57: 2011–2015.

Armani, A. P., N. D. Centeno, and S. L. Dahinten. 2015. Primer estudio de artropodofauna cadavérica sobre modelos experimentales porcinos en el noreste de la provincia del Chubut, Argentina. Rev. Soc. Entomol. Argent. 74: 123–132.

Armani, A. P., S. Dahinten, and N. Centeno. 2017. Artropodofauna cadavérica asociada a cerdo doméstico (*Sus scrofa*) en un ambiente ribereño en Chubut, Argentina. Rev. Colomb. Entomol. 43: 262–267.

Ayalon, A., V. Yehezkeli, Y. Paitan, K. Szpila, K. Y. Mumcuoglu, and E. Moisseiev. 2020. Massive orbital myiasis caused by *Sarcophaga argyrostoma* complicating eyelid malignancy. Case Rep. Ophthalmol. Med. 2020: 5618924.

Barbosa, T. M., and S. D. Vasconcelos. 2015. An updated checklist of myiasis-inducing Diptera species in livestock in Northeastern Brazil. Arch. Zootec. 64: 187–190.

Barbosa, R. R., C. A. Mello-Patiu, R. P. Mello, and M. M. Queiroz. 2009. New records of calyptrate dipterans (Fanniidae, Muscidae and Sarcophagidae) associated with the decomposition of domestic pigs in Brazil. Mem. Inst. Oswaldo Cruz. 104: 923–926.

Barbosa, R. R., C. A. Mello-Patiu, A. Ururahy-Rodrigues, C. G. Barbosa, and M. M. Queiroz. 2010. Temporal distribution of ten calyptrate dipteran species of medicolegal importance in Rio de Janeiro, Brazil. Mem. Inst. Oswaldo Cruz. 105: 191–198.

Barbosa, L. S., A. M. Cunha, M. S. Couri, and V. C. Maia. 2014. Muscidae, Sarcophagidae, Calliphoridae e Mesembrinellidae (Diptera) da Estação Biológica de Santa Lúcia (Santa Teresa, Espírito Santo, Brasil). Bol. Mus. Biol. Mello Leitão. 33: 131–140.

Barbosa, T. M., C. A. Mello-Patiu, and S. D. Vasconcelos. 2015. Flesh fly (Diptera: Sarcophagidae) survey on coastal environments in northeastern Brazil: new records and notes on the expanded geographical distribution. Entomotropica. 30: 112–117.

Barbosa, T. M., R. F. R. Carmo, L. P. Silva, R. G. Sales, and S. D. Vasconcelos. 2017. Diversity of sarcosaprophagous calyptratae (Diptera) on Sandy

Beaches exposed to increasing levels of urbanization in Brazil. Environ. Entomol. 46: 460–469.

Barbosa, T. M., C. A. Mello-Patiu, and S. D. Vasconcelos. 2019. First record of Sarcophagidae (Diptera) species in seasonally dry tropical forests (Caatinga), with notes on their attractiveness to decomposing substrates. Entomol. News. 129: 89–97.

Barros, R. M., C. A. Mello-Patiu, and J.R. Pujol-Luz. 2008. Sarcophagidae (Insecta, Diptera) associados à decomposição de carcaças de *Sus scrofa* Linnaeus (Suidae) em área de Cerrado do Distrito Federal, Brasil. Rev. Bras. Entomol. 52: 606–609.

Benecke, M. 2010. Cases of Neglect Involving Entomological Evidence. *In* J. H. Byrd and J.L. Castner, Forensic entomology: the utility of arthropods in legal investigations. 2nd ed. Boca Raton, Fl.: CRC Press. p. 627–638.

Bermúdez, S.E., E. Buenaventura, M. Couri, R. J. Miranda, and J.M. Herrera. 2010. Mixed myiasis by *Philornis glaucinis* (Diptera: Muscidae), *Sarcodexia lambens* (Diptera: Sarcophagidae) and *Lucilia eximia* (Diptera: Calliphoridae) over *Ramphocelus dimidiatus* (Avia: Thraupidae) chicks in Panama. Bol. Soc. Entomol. Aragon. 47: 445–446.

Beuter, L., P.A. Fernandes, P.B. Barros, C.R. Souza, and J. Mendes. 2012. Insetos de importância forense e na saúde pública em região urbana de Minas Gerais: frequência relativa e variação sazonal de fauna atraída e criada em carcaças de roedores. Rev. Patol. Trop. 41: 480–490.

Bitar, P. D. R., T. F. S. Rodrigues, and G. C. Geiser. 2013. Ocorrência da família Sarcophagidae (Insecta, Diptera) em carcaças de *Sus scrofa* Linnaeus (Suidae) em Belém-PA: colonização da carcaça e sua relação com o tempo de morte do animal. Rev. Bras. Crimin. 2: 24–31.

Bonacci, T., S. Greco, B. Cavalcanti, P. Brandmayr, and V. Vercillo. 2014. The flesh fly *Sarcophaga* (*Liopygia*) *crassipalpis* Macquart 1839 as an invader of a corpse in Calabria (Southern Italy). J. Forensic Sci. Criminol. 1: 1–5.

Bozzo, L., I. A. Lima, O. P. de Almeida, and C. Scully. 1992. Oral myiasis caused by sarcophagidae in an extraction wound. Oral Surg. Oral Med. Oral Pathol. 74: 733–735.

Buenaventura, E., and T. Pape. 2013. Revision of the New World genus *Peckia* Roniveau-Desvoidy (Diptera: Sarcophagidae). Zootaxa. 3622: 1–87.

Buenaventura, E., and T. Pape. 2015. Phylogeny of the *Peckia*-genus group: evolution of male genitalia in the major necrophagous guild of Neotropical flesh flies (Diptera: Sarcophagidae). Org. Divers. Evol. 15: 301–331.

Buenaventura, E. R., G. C. Camacho, A. G. García, and M. E. Wolff. 2009. Sarcophagidae (Diptera) de importancia forense en Colombia: claves taxonómicas, notas sobre su biología y distribución. Rev. Colomb. Entomol. 35: 189–196.

Buenaventura, E., K. Szpila, B. M. Cassel, B. M. Wiegmann, and T. Pape. 2020. Anchored hybrid enrichment challenges the traditional classification of flesh flies (Diptera: Sarcophagidae). Syst. Entomol. 45: 281–301.

Burgess, I., and P. D. R. Spraggs. 1992. Myiasis due to *Parasarcophaga argyrostoma* – first recorded case in Britain. Clin. Exp. Dermatol. 17: 261–263.

Cabrini, I., M. D. Grella, C. F. S. Andrade, and P. J. Thyssen. 2013. Richness and composition of Calliphoridae in an Atlantic Forest fragment: implication for the use of dipteran species as bioindicators. Biodivers. Conserv. 22: 2635–2643.

Calero, M. C. 1949. Cutaneous myiasis due to *Chrysostomomyia bergi* (Blanchard). J. Parasitol. 35: 545.

Camargo, S. L. X., F. S. Carvalho-Filho, and M. C. Esposito. 2018. The genus *Peckia* Robineau-Desvoidy (Diptera: Sarcophagidae) in the Brazilian Amazon: a new species, new records, descriptions of female terminalia and key to species. Zootaxa. 4483: 1–35.

Carmo, R. F., and S. D. Vasconcelos. 2016. Assemblage of necrophagous diptera in Atlantic insular environments and response to different levels of human presence. Neotrop. Entomol. 45: 471–481.

Carvalho, L. M. L., and A. X. Linhares. 2001. Seasonality of insect succession and pig carcass decomposition in a natural forest area in Southeastern Brazil. J. Forensic Sci. 46: 604–608.

Carvalho, C. J. B., and C. A. Mello-Patiu. 2008. Key to the adults of the most common forensic species of Diptera in South America. Rev. Bras. Entomol. 52: 390–406.

Carvalho, L. M., P. J. Thyssen, A. X. Linhares, and F. A. Palhares. 2000. A checklist of arthropods associated with pig carrion and human corpses in southeastern brazil. Mem. Inst. Oswaldo Cruz. 95: 135–138.

Carvalho, L. M. L., P. J. Thyssen, M. L. Goff, and A. X. Linhares. 2004. Observations on the succession patterns of necrophagous insects on a pig carcass in an urban area of Southeastern Brazil. Agrgrawal's Internet J. Forensic Med. Toxicol. 5: 33–39.

Castro, M., N. Centeno, and P. González-Vainer. 2019. An initial study of insect succession on pig carcasses in open pastures in the northwest of Uruguay. Forensic Sci. Int. 302: 109837.

Catts, E. P. 1992. Problems in estimating the postmortem interval in death investigations. J. Agric. Entomol. 9: 245–255.

Catts, E. P., and M. L. Goff. 1992. Forensic entomology in criminal investigations. Annu. Rev. Entomol. 37: 253–272.

Cavallari, M. L., F. N. Baltazar, S. S. Nihei, D. R. Muños, and J. E. Tolezano. 2015. Dipterofauna associated with *Sus scrofa* Linné, 1758, carcasses in urban and coastal regions of São Paulo State, Brazil. Psyche. 2015: 1–12.

Cherix, D., C. Wyss, and T. Pape. 2012. Occurrences of flesh flies (Diptera: Sarcophagidae) on human cadavers in Switzerland, and their importance as forensic indicators. Forensic Sci. Int. 220: 158–163.

Cruise, A., E. Hatano, D. W. Watson, and C. Schal. 2018. Comparison of techniques for sampling adult necrophilous insects from pig carcasses. J. Med. Entomol. 55: 947–954.

D'Almeida, J. M. 1988. Substratos utilizados para a criação de dípteros caliptrados em uma área urbana do município do Rio de Janeiro. Mem. Inst. Oswaldo Cruz. 83: 201–206.

D'Almeida, J. M. 1989. Substratos utilizados para a criação de dípteros caliptrados no jardim zoológico do Rio de Janeiro (Rio-Zoo). Mem. Inst. Oswaldo Cruz. 84: 257–264.

D'Almeida, J. M. 1994. Ovipositional substrates used by Calyptrate Diptera in Tijuca Forest, Rio de Janeiro. Mem. Inst. Oswaldo Cruz. 89: 261–264.

D'Almeida, J. M., and J. R. Almeida. 1998. Nichos tróficos em dípteros caliptrados, no Rio de Janeiro, RJ. Rev. Bras. Biol. 58: 563–570.

D'Almeida, J. M., and S. F. Lima. 1994. Atratividade de diferentes iscas e sua relação com as fases de desenvolvimento ovariano em Calliphoridae e Sarcophagidae (Insecta, Diptera). Rev. Bras. Zool. 11: 177–186.

D'Almeida, J. M., and R. P. Mello. 1996. Comportamento de dípteros muscóides frente a substratos de oviposição, em laboratório, no Rio de Janeiro, RJ, Brasil. Mem. Inst. Oswaldo Cruz. 91: 131–136.

D'Almeida, J. M., and R. J. Barbosa Salviano. 1996. Feeding preference of the larvae of *Chrysomya megacephala* (Fabricius) (Diptera: Calliphoridae) and *Ravinia belforti* (Prado e Fonseca) (Diptera: Sarcophagidae) concerning different diets. Mem. Inst. Oswaldo Cruz. 91: 137–138.

D'Bastiani, E., C. P. Teixeira, G. M. De La Torre, A. C. Dudczak, L. E. Dos Santos, A. L. F. Silva, F. H. Oda, C. A. Mello-Patiu, and K. M. Campião. 2020. How deadly sarcophagid fly larvae are for anurans? New interactions and review to Neotropical region. Parasitol. Res. 119: 1415–1422.

Dias, E. S., D. P. Neves, and H. S. Lopes. 1984a. Estudos sobre a fauna de Sarcophagidae (Diptera) de Belo Horizonte, Minas Gerais – I. Levantamento taxonômico e sinantrópico. Mem. Inst. Oswaldo Cruz. 79: 83–91.

Dias, E. S., D. P. Neves, and H. S. Lopes. 1984b. Estudos sobre a fauna de Sarcophagidae (Diptera) de Belo Horizonte, Minas Gerais – III. Atratividade das iscas. Mem. Inst. Oswaldo Cruz. 79: 413–417.

Dias, L. S., R. J. Pisani, R. B. Guimarães, R. Giuffrida, and V. Satarém. 2015. Análise multitemporal da distribuição de moscas sinantrópicas da família Sarcophagidae em diferentes condições de uso da terra no município de Teodoro Sampaio-SP para subsidiar medidas de controle. Periód. Eletron. Fórum Ambient. Alta Paulista. 11: 13–26.

Dodge, H. R. 1955. Sarcophagid flies parasitic on reptiles (Diptera, Sarcophagidae). Proc. Entomol. Soc. Wash. 57: 183–187.

Dufek, M.I., E.B. Oscherov, and P.R. Mulieri. 2015. Preliminary survey and inventory of Calliphoridae and Sarcophagidae (Diptera) in the province of Corrientes, Argentina, with new records of species with forensic importance. Rev. Soc. Entomol. Argent. 74: 37–46.

Dufek, M. I., E. B. Oscherov, M. P. Damborsky, and P. R. Mulieri. 2016. Assessment of the abundance and diversity of Calliphoridae and

Sarcophagidae (Diptera) in sites with different degrees of human impact in the Iberá Wetlands (Argentina). J. Med. Entomol. 53: 827–835.

Dufek, M. I., D. D. Larrea, M. P. Damborsky, and P. R. Mulieri. 2020. The Effect of Anthropization on Sarcophagidae (Diptera: Calyptratae) community structure: an assessment on different types of habitats in the humid chaco ecoregion of Argentina. J. Med. Entomol. 57: 1468–1479.

Dutto, M., M. Pellegrino, and S. Vanin. 2013. Nosocomial myiasis in a patient with diabetes. J. Hosp. Infect. 83: 74–76.

Ernesto, M. V., C. N. Liberal, A. S. Ferreira, A. C. F. Alves, D. Zeppelini, C. F. Martins, A. Pereira-Colavite, A. J. Creão-Duarte, and A. Vasconcellos. 2018. Hexapod decomposers of Serra de Santa Catarina, Paraíba, Brazil: an area with high potential for conservation of Caatinga biodiversity. Biota Neotrop. 18: 1–13.

Evans, H. E., R. W. Matthews, and E. M. Callan. 1974. Observations of the nesting behavior of *Rubrica surinamensis* (Degeer) (Hymenoptera, Sphecidae). Psyche. 84: 334–352.

Faria, L. S., M. L. Paseto, F. T. Franco, V. C. Perdigão, G. Capel, and J. Mendes. 2013. Insects breeding in pig carrion in two environments of a rural area of the state of minas gerais, Brazil. Neotrop. Entomol. 42: 216–222.

de Faria, L. S., M. L. Paseto, M. S. Couri, C. A. Mello-Patiu, and J. Mendes. 2018. Insects associated with pig carrion in two environments of the Brazilian Savanna. Neotrop. Entomol. 47: 181–198.

Farrell, J. F., A. E. Whittington, and M. P. Zalucki. 2015. A review of necrophagous insects colonising (sic) human and animal cadavers in southeast Queensland, Australia. Forensic Sci. Int. 257: 149–154.

Ferrar, P. 1987. A guide to the breeding habits and immature stages of Diptera Cyclorrhapha. Scandinavian Science Press Ltd, Leiden, Copenhagen.

Ferreira, M. J. M. 1979. Sinantropia de dípteros muscóides de Curitiba, Paraná. II. Sarcophagidae. Rev. Bras. Biol. 39: 773–781.

Gaedke, A., and D. M. D. S. Mouga. 2017. Diptera survey in human corpses in the north of the state of Santa Catarina, Brazil. Acta Biol. Catarin. 4: 42–51.

Giangaspero, A., M. Marangi, A. Balotta, C. Venturelli, K. Szpila, and A. Di Palma. 2017. Wound myiasis caused by *Sarcophaga* (*Liopygia*) *Argyrostoma* (Robineau-Desvoidy) (Diptera: Sarcophagidae): additional evidences of the morphological identification dilemma and molecular investigation. Sci. World J. 2017: 9064531.

Giroux, M., and T.A. Wheeler. 2009. Systematics and phylogeny of the subgenus *Sarcophaga* (*Neobellieria*) (Diptera: Sarcophagidae). An. Entomol. Soc. Am. 102: 567–587.

Goff, M.L., S. Charbonneau, and W. Sullivan. 1991. Presence of fecal material in diapers as a potential source of error in estimations of postmortem interval using arthropod developmental rates. J. Forensic Sci. 36: 1603–1606.

Graffi, S., A. Peretz, A. Wilamowski, H. Schnur, F. Akad, and M. Naftali. 2013. External ophthalmomyiasis caused by a rare infesting larva, *Sarcophaga argyrostoma*. Case Rep. Ophthalmol. Med. 2013: 850865.

Greenberg, B. 1991. Flies as forensic indicators. J. Med. Entomol. 28: 565–577.

Grzywacz, A., M. J. R. Hall, T. Pape, and K. Szpila. 2017. Muscidae (Diptera) of forensic importance—an identification key to third instar larvae of the western Palaearctic region and a catalogue of the muscid carrion community. Int. J. Legal Med. 131: 855–866.

Guimarães, H. J. L. 2004. Redescrição dos machos de dez espécies neotropicais de *Ravinia* Rubineau-Desvoidy 1863 (Diptera: Sarcophagidae). Arc. Mus. Nac. RJ. 62: 45–66.

Hagman, M., T. Pape, and R. Schulte. 2005. Flesh fly myiasis (Diptera, Sarcophagidae) in Peruvian poison frogs genus *Epipedobates* (Anura, Dendrobatidae). Phyllomedusa. 4: 69–73.

Hewadikaram, K. A., and M. L. Goff. 1991. Effect of carcass size on rate of decomposition and arthropod succession patterns. Am. J. Forensic Med. Pathol. 12: 235–240.

Hernandez, M. C. 1992. Descripción de los estadios larvales de *Ravinia sueta* (Wulp, 1895) (Diptera: Sarcophagidae). Rev. Soc. Entomol. Argent. 50: 25–28.

Hiraoka, H., T. Ozawa, J. Sowa-Osako, T. Ichimura, I. Kimata-Teramoto, R. Isozumi, A. Kaneko, and D. Tsuruta. 2015. Repeated myiasis in a female vulvar squamous cell carcinoma caused by *Lucilia sericata* and *Sarcophaga crassipalpis*. J. Dermatol. 42: 840–841.

IBGE. 2020. Instituto Brasileiro de Geografia e Estatística. Data available at: https://www.ibge.gov.br/cidades-e-estados.html?view=municipio. Accessed: April 7, 2020.

INPE. 2020. Instituto Nacional de Pesquisas Espaciais. Data available at: https://www.cptec.inpe.br/. Accessed: April 7, 2020.

Krüger, R. F., F. D. Kirst, and A. S. B. Souza. 2010. Rate of development of forensically-important Diptera in southern Brazil. Rev. Bras. Entomol. 54: 624–629.

Kuusela, S., and I. Hanski. 1982. The structure of carrion fly communities: the size and the type of carrion. Holarct. Ecol. 5: 337–348.

Lacey, L. A., and T. K. George. 1981. Myiasis in an Amazonian porcupine. Entomol. News 92: 79–80.

Leandro, M. J. F., and J. M. D'Almeida. 2005. Levantamento de Calliphoridae, Fanniidae, Muscidae e Sarcophagidae em um fragmento de mata na Ilha do Governador, Rio de Janeiro, Brasil. Iheringia Sér. Zool. 95: 377–381.

Leão, R. N. Q., H. Frajha-Neto, J. P. N. Cruz, and R. Tibana. 1996. Miíase uretral por *Sarcodexia lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae). Relato de um caso amazônico. Rev. Para. Med. 10: 27–29.

Ledo, R. M. D., R. M. Barros, and J. R. Pujol-Luz. 2012. Sarcophagidae and Calliphoridae related to *Rhinella schneideri* (Anura, Bufonidae), *Bothrops moojeni* (Reptilia, Serpentes) and *Mabuya frenata* (Reptilia, Lacertilia) carcasses in Brasília, Brazil. Rev. Bras. Entomol. 56: 377–380.

Leite-Júnior, D. P., E. S. O. Dantas, D. C. Nascimento, H. S. D. Corrêa, P. A. N. Felippe, R. A. A. Pires, L. S. Ruiz, M. S. C. Melhem, and C. R. Paula. 2019. Action of fauna and flora on the cadaveric phenomena observed in the carcass of *Sus scrofa* (Linnaeus-Suidae) in the wild area Brazilian savannah of the central region-Brazil. Forensic Res. Criminol. Int. J. 7: 185–199.

Linhares, A. X. 1981. Synanthropy of Calliphoridae and Sarcophagidae (Diptera) in the city of Campinas, São Paulo, Brazil. Rev. Bras. Entomol. 25: 189–215.

Lopes, H. S. 1940. Contribuição ao conhecimento do gênero *Udamopyga* Hall e de outros sarcophagideos quem vivem em molluscos no Brasil (Diptera). Rev. Entomol. 11: 924–954.

Lopes, H. S. 1942. *Notochaeta aldrichi* n. sp., parasita de Oligochaeta no Brazil (Diptera, Sarcophagidae). Rev. Bras. Biol. 2: 361–364.

Lopes, H. S. 1946. Contribuição ao conhecimento das espécies do gênero *Oxysarcodexia* Townsend, 1917. Bol. Esc. Nac. Vet. 1: 62–134.

Lopes, H. S. 1969. Neotropical Sarcophagidae reared from Gastropoda by Dr. W. Weyrauch (Diptera). Studia Ent. 12: 133–160.

Lopes, H. S. 1973. Collecting and rearing sarcophagid flies (Diptera) in Brazil during forty years. An. Acad. Bras. Cienc. 45: 279–291.

Lopes, H. S. 1975. New or little known *Oxysarcodexia* (Diptera, Sarcophagidae). Rev. Bras. Entomol. 35: 461–483.

Lopes, H. S. 1980. On *Pachygraphia* Brauer et Bergenstamm and *Pachygraphomima* n. gen. (Diptera, Sarcophagidae, Johnsoniini). Rev. Bras. Biol. 40: 415–422.

Lopes, H. S. 1983. On *Notochaetomima* (Diptera, Sarcophagidae) with description of four new species, one of them living on *Beltela* sp. (Mollusca, Gastropoda). Rev. Bras. Entomol. 27: 259–266.

Lopes, D. S., F. F. Oliveira, C. A. Mello-Patiu, F. M. Pamponet, and T. S. Thé. 2018. Espécies de *Oxysarcodexia* (Diptera: Sarcophagidae) associadas a carcaças de suínos (*Sus scrofa* Linnaeus) expostas em um fragmento de Mata Atlântica no município de Salvador, Bahia. EntomoBrasilis. 11: 103–106.

Lord, W. D., and W. C. Rodriguez. 1989. Forensic entomology: the use of insects in the investigation of homicide and untimely death. Prosecutor. 22: 41–48.

Loureiro, M. S., V. C. Oliveira, and J. M. D'Almeida. 2005. Desenvolvimento pós-embrionário de *Pattonella intermutans* (Thomson) (Diptera: Sarcophagidae) em diferentes dietas. Rev. Bras. Entomol. 49: 127–129.

Madeira, T., C. M. Souza, J. Cordeiro, and P. J. Thyssen. 2016. The use of DNA barcode for identifying species of *Oxysarcodexia* Townsend (Diptera: Sarcophagidae): a preliminary survey. Acta Trop. 161: 73–78.

Marchiori, C. H. 2006. Study of a community of flies at different altitudes in the Serra of Caldas Novas Park, Goiás, Brazil. Braz. J. Biol. 66: 849–851.

Marchiori, C. H. 2014. Relationship between duration of cattle dung exposure in pastures, its average crustal thickness and occurrences of dipterous insects and their parasitoids in South Goiás, Brazil. Commun. Appl. Sci. 2: 222–229.

Marchiori, C. H., A. T. Oliveira, and A. X. Linhares. 2001. Artrópodes associados a massas fecais bovinas no sul do Estado de Goiás. Neotrop. Entomol. 30: 19–24.

Mariluis, J. C., J. A. Schnack, P. R. Mulieri, and J. P. Torretta. 2007. The Sarcophagidae (Diptera) of the coastline of Buenos Aires city, Argentina. J. Kansas Entomol. Soc. 80: 243–251.

Matuszewski, S., and A. Mądra-Bielewicz. 2016. Validation of temperature methods for the estimation of pre-appearance interval in carrion insects. Forensic Sci. Med. Pathol. 12: 50–57.

Matuszewski, S., D. Bajerlein, S. Konwerski, and K. Szpila. 2010. Insect succession and carrion decomposition in selected forests of Central Europe. Part 2: composition and residency patterns of carrion fauna. Forensic Sci. Int. 195: 42–51.

Mazza, S., and R. Basso. 1939. Miiases de úlcera crônica de pierna por *Sarcophaga barbata* y *Cochliomyia hominivorax* (Investigaciones sobre dipteros argentinos. 1. Miiasis). Publ. Misión Estud. Patol. Reg. Argent. Jujuy. 41: 47–54.

Mazza, S., S. Parodi, and C. M. Smith. 1930. Miiasis ocular por larva de *Sarcophaga* sp. 5 Reun. Soc. Argent. Patol. Reg. Norte. 2: 1157–1159.

Mello-Patiu, C. A. 2002. Revision of some *Dexosarcophaga* species described by R. Dodge (Diptera: Sarcophagidae). Zootaxa. 122: 1–16.

Mello-Patiu, C. A., and C. Luna-Dias. 2010. Myiasis in the Neotropical amphibian *Hypsiboas beckeri* (Anura: Hylidae) by a new species of *Lepidodexia* (Diptera: Sarcophagidae). J. Parasitol. 96: 685–688.

Mello-Patiu, C. A., J. C. Mariluis, K. P. Silva, L. D. Patitucci, and P. R. Mulieri. 2014a. Sarcophagidae, pp. 475–490. *In* S. Roig-Juñent, L. E. Claps, J. J. Morrone (eds.), Biodiversidad de Artrópodos Argentinos, vol. 4. Instituto Superior de Entomología Dr. Abraham Willink (INSUE), Sociedad Entomológica Argentina, San Miguel de Tucumán. 552p.

Mello-Patiu, C. A., M. L. Paseto, L. S. Faria, J. Mendes, and A. X. Linhares. 2014b. Sarchophagid [sic] flies (Insecta, Diptera) from pig carcasses in Minas Gerais, Brazil, with nine new records from the Cerrado, a threatened Neotropical biome. Rev. Bras. Entomol. 58: 142–146.

Mendes, J., and A. X. Linhares. 1993. Sazonalidade, preferência por iscas e estágio de desenvolvimento ovariano em várias espécies de Sarcophagidae (Diptera). Rev. Bras. Entomol. 37: 355–364.

Mendes, J. M., and A. X. Linhares. 2002. Cattle dung breeding Diptera in pastures in Southeastern Brazil: diversity, abundance and seasonality. Mem. Inst. Oswaldo Cruz. 97: 37–41.

Moemenbellah-Fard, M. D., D. Keshavarzi, M. Fereidooni, and A. Soltani. 2018. First survey of forensically important insects from human corpses in Shiraz, Iran. J. Forensic Leg. Med. 54: 62–68.

Moreira, L. M. P. S., G. C. L. Vieira, K. E. R. Hora, and L. M. E. Kallas. 2019. Níveis de densidade populacional: uma proposta de classificação para Goiânia, GO. Data available at: http://anpur.org.br/xviiienanpur/anais. Accessed: June 7, 2020.

Moretti, T. C., O. B. Ribeiro, P. J. Thyssen, and D. R. Solis. 2008. Insects on decomposing carcasses of small rodents in a secondary forest in Southeastern Brazil. Eur. J. Entomol. 105: 691–696.

Moretti, T. C., S. M. Allegretti, C. A. Mello-Patiu, A. M. Tognolo, O. B. Ribeiro, and D. R. Solis. 2009. Occurrence of *Microcerella halli* (Engel) (Diptera, Sarcophagidae) in snake carrion in southeastern Brazil. Rev. Bras. Entomol. 53: 318–320.

Moura, M. O. 2004. Variação espacial como mecanismo promotor da coexistência em comunidades de insetos necrófagos. Rev. Bras. Zool. 21: 409–4019.

Moura, M. O., C. J. de Carvalho, and E. L. Monteiro-Filho. 1997. A preliminary analysis of insects of medico-legal importance in Curitiba, State of Paraná. Mem. Inst. Oswaldo Cruz. 92: 269–274.

Moura, M. O., C. J. B. Carvalho, and E. L. A. Monteiro-Filho. 2005. Estrutura de comunidades necrófagas: efeito da partilha de recursos na diversidade. Rev. Bras. Zool. 22: 1134–1140.

Mulieri, P. R., J. A. Schnack, J. C. Mariluis, and J. P. Torretta. 2008. Flesh flies species (Diptera: Sarcophagidae) from a grassland and a woodland in a nature reserve of Buenos Aires, Argentina. Rev. Biol. Trop. 56: 1287–1294.

Mulieri, P. R., J. C. Mariluis, and L. D. Patitucci. 2010a. Review of the Sarcophaginae (Diptera: Sarcophagidae) of Buenos Aires Province (Argentina), with a key and description of a new species. Zootaxa. 2575: 1–37.

Mulieri, P. R., L. D. Patitucci, J. A. Schnack, and J. C. Mariluis. 2010b. Diversity and seasonal dynamics of an assemblage of sarcophagid Diptera in a gradient of urbanization. J. Insect Sci. 11: 91.

Mulieri, P. R., L. D. Patitucci, and M. S. Olea. 2015. Sex-biased patterns of Saprophagous Calyptratae (Diptera) collected with different baits of animal origin. J. Med. Entomol. 52: 386–393.

Mulieri, P. R., C. A. Mello-Patiu, and F. H. Aballay. 2017. Taxonomic revision of *Lipoptilocnema* (Diptera: Sarcophagidae), with notes on natural history and forensic importance of its species. J. Med. Entomol. 54: 50–75.

Mulieri, P. R., E. F. Schaefer, M. I. Duré, and C. E. González. 2018. A new flesh fly species (Diptera: Sarcophagidae) parasitic on leptodactylid frogs. Parasitol. Res. 117: 809–818.

Nassu, M. P., P. J. Thyssen, and A. X. Linhares. 2014. Developmental rate of immatures of two fly species of forensic importance: *Sarcophaga* (*Liopygia*) *ruficornis* and *Microcerella halli* (Diptera: Sarcophagidae). Parasitol. Res. 113: 217–222.

Neck, R. W., and H. S. Lopes. 1973. On some North American Sarcophagidae and Calliphoridae (Diptera) reared from Gastropoda. Rev. Bras. Biol. 33: 183–192.

Oliveira, T. C., and S. D. Vasconcelos. 2010. Insects (Diptera) associated with cadavers at the Institute of Legal Medicine in Pernambuco, Brazil: implications for forensic entomology. Forensic Sci. Int. 198: 97–102.

Oliveira, T. C., and S. D. Vasconcelos. 2018. Diversity, daily flight activity and temporal occurrence of necrophagous Diptera associated with decomposing carcasses in a semi-arid environment. Neotrop. Entomol. 47: 470–477.

Oliveira, C. A., S. Faccin, P. J. Thyssen, D. Dias, E. Kalapothakis, and M. T. Rebelo. 2019a. Complete mitochondrial genomes of three species of fresh flies of forensic entomology interest from the genus *Sarcophaga* (Sarcophagidae) from Portugal and Brazil. Mitochondrial DNA Pt. B. 4: 237–239.

Oliveira, D. L., T. M. Barbosa, A. C. D. Maia, and S. D. Vasconcelos. 2019b. Development and field evaluation of a novel, inexpensive passive trap for monitoring dispersal of necrophagous dipteran larvae. J. Econ. Entomol. 112: 2497–2501.

Oliveira, V. C., J. M. D'Almeida, M. J. Paes, and A. Sanavria. 2002. Populations dynamics of calyptrate Diptera (Muscidae and Sarcophagidae) at the Rio-Zoo Foundation, Rio de Janeiro, RJ, Brazil. Braz. J. Biol. 62: 191–196.

Oliveira-Costa, J., C. A. Mello-Patiu, and S. M. Lopes. 2001. Dípteros muscóides associados com cadáveres humanos no local da morte no estado do Rio de Janeiro, Brasil. Bol. Mus. Nac. 464: 1–6.

Oliveira-Costa, J., C. M. Lamego, M. S. Couri, and C. A. Mello-Patiu. 2014. Differential Diptera succession patterns onto partially burned and unburned pig carrion in southeastern Brazil. Braz. J. Biol. 74: 870–876.

Pape, T. 1994. The world *Blaesoxipha* Loew, 1861 (Diptera, Sarcophagidae). Entomol. Scand. 45: 1–247.

Pape, T. 1996. Catalogue of the Sarcophagidae of the world (Insecta: Diptera). Associated Publishers, Gainesville.

Pape, T. 2021. Family: Sarcophagidae. A taxonomic database to all flesh flies. https://diptera.dk/sarco/index.php.

Pape, T., and G. A. Dahlem. 2010. Sarcophagidae, pp. 1313–1335. *In* B. V. Brown, A. Borkent, J. M. Cumming, D. M. Wood, N. E. Woodley, and M. Zumbado (eds.), Manual of Central American Diptera, vol. 2. NRC Press, Ottawa.

Paseto, M. L., L. S. Faria, J. Mendes, and A. X. Linhares. 2019. Diversity of Sarcophagidae (Insecta, Diptera) associated with decomposing carcasses in a rural area of the State of Minas Gerais, Brazil. EntomoBrasilis. 12: 118–125.

Pastrana, Y. R., and M. I. Wolff-Echeverry. 2011. Entomofauna cadavérica asociada a cerdos expuestos al sol y sombra, en el Piedemonte Amazónico Colombiano. Momentos Cienc. 8: 45–54.

Patitucci, L. D., P. R. Mulieri, C. Domínguez, J. C. Mariluis, and J. A. Schnack. 2011. Estudio preliminar de Calyptratae (Diptera) en la Reserva Natural Estricta Otamendi, Buenos Aires, Argentina. Rev. Soc. Entomol. Argent. 70: 157–168.

Patitucci, L. D., P. R. Mulieri, C. Domínguez, and J. C. Mariluis. 2015. An inventory of saprophagous Calyptratae (Insecta: Diptera) in urban green spaces of Buenos Aires City. Mus. Argent. Cienc. Nat. 17: 97–107.

Pezzi, M., D. Whitmore, T. Bonacci, C. N. F. Del Zingaro, M. Chicca, M. Lanfredi, and M. Leis. 2017. Facultative myiasis of domestic cats by *Sarcophaga argyrostoma* (Diptera: Sarcophagidae), *Calliphora vicina* and *Lucilia sericata* (Diptera: Calliphoridae) in northern Italy. Parasitol. Res. 116: 2869–2872.

Ramos, R. L., D. S. Lopes, F. M. Pamponet, T. S. Thé, and V. C. G. Morato. 2018. Primeiro registro de *Peckia* (*Squamatodes*) *trivittata* (Curran) (Diptera: Sarcophagidae) colonizando cadáver humano carbonizado em área de restinga da Bahia, Brasil. EntomoBrasilis. 11: 151–153.

Ramírez-Mora, M. A., E. Buenaventura, L. M. Gómez-P, and E. Amat. 2012. Updated checklist and new records of Calyptratae carrion flies (Diptera, Schizophora) from Valle de Aburrá and other localities in Colombia. Entomotropica. 27: 27–35.

Reed, H. B. 1958. A study of dog carcass communities in Tennessee, with special reference to the insects. Am. Midl. Nat. 56: 213–245.

Ries, A. C., and B. Blochtein. 2015. Insect fauna associated with exposed pig carcasses in Southern Brazil. EntomoBrasilis. 8: 180–188.

Ries, A. C. R., V. Costa-Silva, C. F. Dos Santos, B. Blochtein, and P. J. Thyssen. 2021. Factors affecting the composition and succession of beetles in exposed pig carcasses in southern Brazil. J. Med. Entomol. 58: 104–113.

Rosa, T. A., M. L. Y. Babata, C. M. Souza, D. Sousa, C. A. Mello-Patiu, and J. Mendes. 2009. Dípteros de interesse forense em dois perfis de vegetação de Cerrado em Uberlândia, MG. Neotrop. Entomol. 38: 859–866.

Rosa, T. A., M. L. Y. Babata, C. M. Souza, D. Sousa, C. M. Mello-Patiu, F. Z. Vaz-de-Mello, and J. Mendes. 2011. Arthropods associated with pig carrion in two vegetation profiles of Cerrado in the State of Minas Gerais, Brazil. Rev. Bras. Entomol. 55: 424–434.

Santos, J. R. D., and C. A. De Mello-Patiu. 2018. Review of the Brazilian species of *Udamopyga* Hall, 1938 (Diptera: Sarcophagidae), with the description of a new species and a key to males and females. Zootaxa. 4508: 1–27.

Severini, F., E. Nocita, and F. Tosini. 2015. Myiasis of the tracheostomy wound caused by *Sarcophaga* (*Liopygia*) *argyrostoma* (Diptera: Sarcophagidae): molecular identification based on the mitochondrial cytochrome c oxidase I gene. J. Med. Entomol. 52: 1357–1360.

Silva, A. Z., V. A. Anjos, P. B. Ribeiro, and R. F. Krüger. 2010. Ocorrência de muscóideos necrófagos em carcaça de *Didelphis albiventris* Lund, 1841 (Didelphimorphia, Didelphidae) no Rio Grande do Sul, Brasil. Biotemas. 23: 211–214.

Silva, A. Z., C. H. Hoffmeister, V. A. Anjos, P. B. Ribeiro, and R. F. Krüger. 2014. Necrophagous Diptera associated with wild animal carcasses in southern Brazil. Rev. Bras. Entomol. 58: 337–342.

Smith, K. G. V. 1986. A manual of forensic entomology. The Trustees of the British Museum (Natural History), London.

Souza, A. S. B., F. D. Kirst, and R. F. Krüger. 2008. Insects of forensic importance from Rio Grande do Sul state in southern Brazil. Rev. Bras. Entomol. 52: 641–646.

Sousa, J. R., M. C. Esposito, and F. S. Carvalho Filho. 2011. Composition, abundance and richness of sarcophagidae (Diptera: oestroidea) in forests and forest gaps with different vegetation cover. Neotrop. Entomol. 40: 20–27.

Sousa, J. R. P., L. S. Faria, J. Mendes, and N. S. Soares. 2014a. Riqueza de dipterofauna associada à matéria orgânica em decomposição em fragmentos de Floresta Estacional Semidecidual no sul de Goiás. Biotemas. 27: 73–81.

Sousa, J. R. P., M. C. Esposito, F. S. Carvalho-Filho, and L. Juen. 2014b. The potential uses of Sarcosaprophagous flesh flies and blowflies for the evaluation of the regeneration and conservation of forest clearings: a case study in the Amazon Forest. J. Insect Sci. 14: 1–5.

Sousa, J. R. P., F. S. Carvalho-Filho, and M. C. Esposito. 2015. Distribution and abundance of necrophagous flies (Diptera: Calliphoridae and Sarcophagidae) in Maranhão, Northeastern Brazil. J. Insect Sci. 15: 1–10.

Sousa, J. R. P., S. F. Carvalho-Filho, L. Juen, and M. C. Esposito. 2016. Evaluating the effects of different vegetation types on necrophagous fly communities (Diptera: Calliphoridae; Sarcophagidae): implications for conservation. PLoS One. 11: 1–23.

Sousa, J. R. P., F. S. Carvalho-Filho, L. Juen, and M. C. Esposito. 2020. The effects of cattle ranching on the communities of necrophagous flies (Diptera: Calliphoridae, Mesembrinellidae and Sarcophagidae) in Northeastern Brazil. J. Insect Conserv. 24: 705–717.

Souza, C. R., and C. J. Von Zuben. 2016. Synanthropy of Sarcophagidae (Diptera) in southeastern Brazil. Neotrop. Entomol. 45: 637–641.

Souza, C. M., T. Madeira-Ott, F. S. Masiero, P. R. S. Bunde, G. A. Ribeiro, and P. J. Thyssen. 2020a. Synanthropy of sarcophaginae (Diptera: Sarcophagidae) from southern brazil and its sanitary implications. J. Med. Entomol. 58: 913–920.

Souza, C. M., T. Pape, and P. J. Thyssen. 2020b. *Oxysarcodexia* Townsend, 1917 (Diptera: Sarcophagidae) – a centennial conspectus. Zootaxa. 4841: 1–126.

Thyssen, P. J., M. F. K. Aquino, N. C. S. Purgato, E. Martins, A. A. Costa, C. G. P. Lima, and C. R. Dias. 2018. Implications of entomological evidence during the investigation of five cases of violent death in Southern Brazil. J. Forensic Sci. Res. 2: 1–8.

Toma, R., A. Roel, and R. Miranda. 2017. First record of *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830) (Diptera: Sarcophagidae) parasitizing *Spodoptera frugiperda* (Smith, 1797) (Lepidoptera: Noctuidae) in Brazil. Arq. Inst. Biol. 84: 1–4.

Toma, R., W. W. Koller, C. A. Mello-Patiu, and R. L. Mello. 2020. New records of Sarcophagidae (Insecta: Diptera) collected in Cerrado fragments in the municipality of Campo Grande, Mato Grosso do Sul state, Brazil. EntomoBrasilis. 3: e0873.

Toukairin, Y., T. Arai, T. Hoshi, J. A. Oliva Trejo, and M. Nogami. 2017. The geographical distribution of fly larvae on corpses in Saitama Prefecture in Japan during the summer season. Leg. Med. (Tokyo). 24: 75–77.

Vairo, K. P., C. A. Mello-Patiu, and C. J. B. Carvalho. 2011. Pictorial identification key for species of Sarcophagidae (Diptera) of potential forensic importance in southern Brazil. Rev. Bras. Entomol. 55: 333–347.

Vairo, K. P., A. Ururahy-Rodrigues, M. O. Moura, and C. A. Mello-Patiu. 2014. Sarcophagidae (Diptera) with forensic potential in Amazonas: a pictorial key. Trop. Zool. 27: 140–152.

Vairo, K. P., M. O. Moura, and C. A. Mello-Patiu. 2015. Comparative morphology and identification key for females of nine Sarcophagidae species (Diptera) with forensic importance in Southern Brazil. Rev. Bras. Entomol. 59: 177–187.

Vairo, K. P., M. F. C. Caneparo, R. C. Corrêa, D. Preti, and M. O. Moura. 2017. Can Sarcophagidae (Diptera) be the most important entomological evidence at a death scene? *Microcerella halli* as a forensic indicator. Rev. Bras. Entomol. 61: 275–276.

Valverde-Castro, C., E. Buenaventura, J. D. Sánchez-Rodríguez, and M. Wolff. 2017. Flesh flies (Diptera: Sarcophagidae: Sarcophaginae) from the Colombian Guajira biogeographic province, an approach to their ecology and distribution. Zoologia. 34: 1–11.

Vasconcelos, S. D., and M. C. S. Araujo. 2012. Necrophagous species of Diptera and Coleoptera in northeastern Brazil: state of the art and challenges for the forensic entomologist. Rev. Bras. Entomol. 56: 7–14.

Vasconcelos, S. D., T. M. Cruz, R. L. Salgado, and P. J. Thyssen. 2013. Dipterans associated with a decomposing animal carcass in a rainforest fragment in Brazil: notes on the early arrival and colonization by necrophagous species. J. Insect Sci. 13: 145.

Vasconcelos, S. D., T. F. Soares, and D. L. Costa. 2014. Multiple colonization of a cadaver by insects in an indoor environment: first record of *Fannia trimaculata* (Diptera: Fanniidae) and *Peckia* (*Peckia*) *chrysostoma* (Sarcophagidae) as colonizers of a human corpse. Int. J. Legal Med. 128: 229–233.

Vasconcelos, S. D., T. M. Barbosa, and T. P. B. Oliveira. 2015. Diversity of forensically-important dipteran species in different environments in Northeastern Brazil, with notes on the attractiveness of animal baits. Fl. Entomol. 98: 770–775.

Vasconcelos, S. D., R. L. Salgado, T. M. Barbosa, and J. R. B. Souza. 2016. Diptera of medico-legal importance associated with pig carrion in a tropical dry forest. J. Med. Entomol. 53: 1131–1139.

Vilte, R., R. M. Gleiser, and M. B. Horenstein. 2020. Necrophagous Fly Assembly: Evaluation of Species Bait Preference in Field Experiments. J. Med. Entomol. 57: 437–442.

Xavier, A. S., R.R. Barbosa, C. G. Barbosa, and M. M. C. Queiroz. 2015. Bionomy of two flies of sanitary and forensic importance: *Peckia* (*Sarcodexia*) *lambens* (Wiedemann) and *Oxysarcodexia amorosa* (Schiner) (Diptera, Sarcophagidae). Rev. Bras. Entomol. 59: 229–233.

Yepes-Gaurisas, D., J. D. Sánchez-Rodríguez, C. A. de Mello-Patiu, and M. Wolff Echeverri. 2013. Synanthropy of sarcophagidae (Diptera) in La Pintada, Antioquia-Colombia. Rev. Biol. Trop. 61: 1275–1287.