An Acad Bras Cienc (2024) 96(4): e20240388 DOI 10.1590/0001-3765202420240388
Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences*
Printed ISSN 0001-3765 I Online ISSN 1678-2690
www.scielo.br/aabc | www.fb.com/aabcjournal

ECOSYSTEMS

Flesh flies (Diptera: Sarcophagidae) from transitional Caatinga-Cerrado areas in the state of Piauí, Northeast Brazil

JOSÉ ORLANDO A. SILVA, JOSENIR T. CÂMARA, KALIANE D. LEAL & FERNANDO S. CARVALHO-FILHO

Abstract: The Sarcophagidae family (Diptera) encompasses a group of flies of significant ecological importance. Additionally, numerous species within this family hold substantial value in the realms of medicine, veterinary and forensic science. The objective of this study was to conduct a comprehensive survey of Sarcophagidae species within transitional zones between the Caatinga and Cerrado biomes in the Northeastern region of Brazil. To achieve this, a total of 15 field expeditions were conducted across three distinct phytophysiognomies—riparian, vereda, and a segment of shrubby Caatinga—from 2019 to 2021. A total of 16 genera and 40 species were collected. Among them, a new species for science (*Titanogrypa* (*Airypel*) sp. nov.), *Emblemasoma emblemasoma* Dodge is newly recorded from South America/Brazil and the Caatinga biome, and three species constitute new records for the Northeast region (*Dexosarcophaga patiuorum* Santos, Pape & Mello-Patiu, *Lepidodexia* (*Notochaeta*) *fumipennis* (Lopes), and *Oxysarcodexia meridionalis* (Engel)). The most abundant species were *Oxysarcodexia thornax* (Walker), *Oxysarcodexia avuncula* (Lopes), and *Argoravinia* (*Argoravinia*) *catiae* Carvalho Filho & Esposito, collectively constituting 56.11% of the entire collected sample. The distribution of species across different vegetations was noted, with 19 species exclusive to riparian vegetation, three to vereda vegetation, and seven species unique to the Caatinga.

Key words: Cerrado-Caatinga, ecotone, inventory, Sarcophaginae.

INTRODUCTION

Piauí, encompassing an area of approximately 251,755.481 square kilometers, ranks as the third-largest state by land area within the Northeast region of Brazil (IBGE 2021a). This state is geographically divided into four macro-regions: the Coastal region, characterized by its mangrove ecosystems; the Meio-Norte, distinguished by the Mata de Cocal (a type of palm tree forest) and Cerrado (savanna-like vegetation) areas; the Cerrados, primarily consisting of Cerrado-type vegetation; and the Semiarid region, uniquely dominated by Caatinga (semi-arid tropical vegetation), endemic to Brazil. These distinct macro-regions contribute to the formation of several ecotonal zones—transitional areas between biomes—predominantly between the Caatinga and Cerrado biomes, including significant riparian and vereda vegetations, as identified by the Pereira et al. (2017).

Given the extensive variety of phytophysiognomies within the state of Piauí, coupled with the limited number of researchers and studies focused on these environments, a significant gap exists in our understanding of the state's animal biodiversity, particularly regarding insects. Insects play crucial roles from ecological, economic, medical, and veterinary perspectives, impacting both human

life and the survival of numerous animal and plant species (Rafael et al. 2024). Among the insufficiently studied insect taxa in Piauí is the Sarcophagidae family (Diptera), notable for its scarce representation in the region with only three species officially recorded: *Peckia* (*Peckia*) *pexata* (Wulp, 1895), *Sarcophaga opifera* Coquillett, 1892, and *Titanogrypa* (*Cucullomyia*) *albuquerquei* (Lopes, 1976) (Mello-Patiu et al. 2024). This family represents the second largest within the Schizophora flies, encompassing over 2,820 valid species distributed across all continents, except Antarctica. About 941 species have been recorded in the Neotropical Region (Pape 1996, 2024), and 387 species have been found in Brazil, including 40 endemic species (Mello-Patiu et al. 2024).

Within the larval phase, Sarcophagidae exhibit a diverse range of feeding behaviors, including sarcosaprophagy, coprophagy, parasitism, and predation on insects, gastropod mollusks, lizards, and amphibians (Pape & Dahlem 2010, Yan et al. 2020). Sarcosaprophagous species consume the remains of invertebrates—such as ants, crustaceans, snails, and squid—and vertebrates, including fish, frogs, snakes, rats, rabbits, dogs, pigs, and even human cadavers (Shewell 1987, Dahlem 1991, D'Almeida 1994, Pape & Dahlem 2010, Beuter et al. 2012, Vasconcelos & Araujo 2012, Barbosa et al. 2019, Andrade-Herrera et al. 2020, Guimarães et al. 2022, Madeira-Ott et al. 2022, Silva et al. 2022, 2023, 2024). Furthermore, the significance of many Sarcophagidae species extends into forensic entomology within the medico-legal field, owing to the adults' practices of feeding, mating, and/or larvipositing on human corpses, with their larvae developing within such substrates (Catts & Goff 1992, Oliveira-Costa 2011, Guimarães et al. 2022).

Research on Sarcophagidae species conducted in various phytophysiognomies of the Northeast region of Brazil, specifically within the state of Maranhão—including Cerrado *stricto sensu*, Cerradão, and Mata Ciliar (riparian vegetation)—utilizing a variety of traps and baits such as bovine lungs and pig carcasses, has led to the identification of new species records for the biome, region, and state. Additionally, these efforts have resulted in the discovery of species previously unknown to science (Sousa et al. 2015, Carvalho-Filho et al. 2017, Nascimento et al. 2021, Silva et al. 2022, 2023). Similar findings have been reported in other regions of the country, encompassing the Midwest (Barros et al. 2008, Toma et al. 2020), Southeast (Mello-Patiu et al. 2014), and North (Carvalho-Filho et al. 2022), as well as within the Caatinga biome, particularly in areas of states of Paraíba and Pernambuco that are proximal to the Atlantic Forest in the Northeast region (Barbosa et al. 2019, 2023).

Considering the aforementioned context, there is a well-founded expectation that conducting comprehensive inventories in the Caatinga biome and its ecotonal regions with the Cerrado—employing a wide array of collection methodologies and trapping techniques, both with and without the use of attractive baits—will facilitate the discovery of new records and, potentially, new Sarcophagidae species. Such endeavors aim to mitigate the knowledge gap regarding the distribution of species (Wallacean shortfall) and the identification of species present in each habitat. Therefore, the primary objective of this study was to inventory the Sarcophagidae species present in the state of Piauí, particularly within the transitional zones between the Caatinga and Cerrado biomes in Northeastern Brazil. Additionally, this research documents new occurrences of Sarcophagidae species in South America and Brazil, within the Caatinga, the Caatinga-Cerrado ecotone, the broader Northeast region, and specifically within the state of Piauí.

MATERIALS AND METHODS

Study site

The research was carried out across three distinct phytophysiognomies—riparian vegetation, vereda vegetation, and a segment of shrubby Caatinga—situated within the ecotonal zones between the Caatinga and Cerrado biomes, in the municipalities of Cristino Castro (encompassing a total area of 1,845.698 square kilometers) and Bom Jesus (covering an area of 5,471.024 square kilometers) (Table I). Both municipalities are located in the southern portion of the state of Piauí, within the Northeast region of Brazil (Figure 1a). Piauí is geographically positioned between the coordinates 2°44'22" and 8°55'37" South latitude and 41°58'31" and 45°59'39" West longitude. It is bounded by the Atlantic Ocean to the north and shares a border with the states of Bahia and Tocantins to the south, Ceará and Pernambuco to the east, and Maranhão to the west (IBGE 2021a). The municipalities of Cristino Castro and Bom Jesus lie within the Cerrados macro-region, specifically in the Chapada das Mangabeiras development territory, and adjoin the Semi-arid macro-region (Pereira et al. 2017). The climate of these municipalities, according to the Köppen climate classification for Brazil, is categorized as Tropical Aw, characterized by an annual rainfall ranging from 700 mm to 1,300 mm and an average annual temperature exceeding 24 °C (Alvares et al. 2013).

The ecotonal zones, where the research was conducted, exhibit significant variance and are

Table I. Municipalities, biomes, phytophysiognomies and geographic coordinates of the collection areas in the state of Piauí, Northeast region of Brazil, between 2019-2021.

Collect	Collect area	Municipality / Village	Biome	Phytophysiognomy	Coordenates
1	A1	Cristino Castro	Caatinga-Cerrado	Riparian vegetation	08°49'42.8"S; 44°13'35.4"W
2	A1	Cristino Castro	Caatinga-Cerrado	Riparian vegetation	08°49'42.8"S; 44°13'35.4"W
3	A1	Cristino Castro	Caatinga-Cerrado	Riparian vegetation	08°49'42.8"S; 44°13'35.4"W
4	A1	Cristino Castro	Caatinga-Cerrado	Riparian vegetation	08°49'42.8"S; 44°13'35.4"W
5	A1	Cristino Castro	Caatinga-Cerrado	Riparian vegetation	08°49'42.8"S; 44°13'35.4"W
6	A1	Cristino Castro	Caatinga-Cerrado	Riparian vegetation	08°49'42.8"S; 44°13'35.4"W
7	A2	Bom Jesus	Caatinga-Cerrado	Riparian vegetation	09°02'20.5"S;44°18'40.1"W
8	A2	Bom Jesus	Caatinga-Cerrado	Riparian vegetation	09°02'20.5"S;44°18'40.1"W
9	A2	Bom Jesus	Caatinga-Cerrado	Riparian vegetation	09°02'20.5"S;44°18'40.1"W
10	A3	Bom Jesus / Resfriado	Caatinga-Cerrado	Vereda vegetation	09°13'17.0"S; 44°28'03"W
11	A3	Bom Jesus / Resfriado	Caatinga-Cerrado	Vereda vegetation	09°13'17.0"S; 44°28'03"W
12	A4	Bom Jesus / ADUFPI	Caatinga	Fragment of Caatinga	09°4'55.15"S; 44°19'53.46"W
13	A4	Bom Jesus / ADUFPI	Caatinga	Fragment of Caatinga	09°4'55.15"S; 44°19'53.46"W
14	A4	Bom Jesus / ADUFPI	Caatinga	Fragment of Caatinga	09°4'55.15"S; 44°19'53.46"W
15	A4	Bom Jesus / ADUFPI	Caatinga	Fragment of Caatinga	09°4'55.15"S; 44°19'53.46"W

characterized by the intersection of the Caatinga and Cerrado biomes. Riparian vegetation, one of the studied environments, fringes narrow and shallow water bodies, often referred to as creeks or swamps. This vegetation primarily consists of small shrubs that are deciduous during the dry season, complemented by grasses that flourish in the wet season. In contrast, vereda vegetation represents a more saturated landscape, characterized by its muddy terrain and a dense cover of perennial, small-sized vegetation, including herbaceous plants

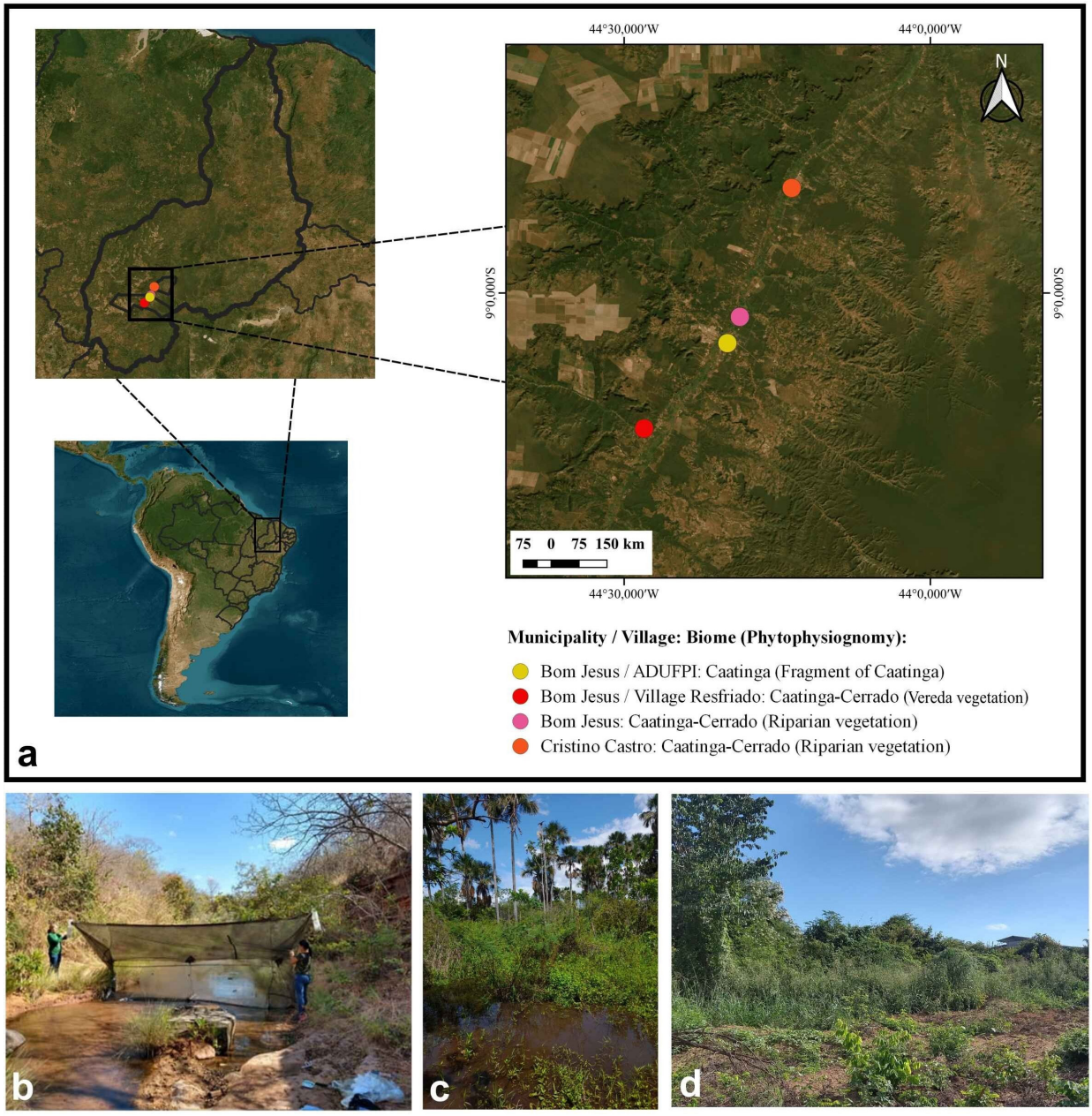

Figure 1. a) Location of the study area in the municipalities of state of Piauí, Northeastern Brazil. Phytophysiognomies where flesh flies (Diptera: Sarcophagidae) were collected with a Malaise trap: b) Riparian vegetation; c) Vereda vegetation; and d) Fragment of Caatinga. Source of Figure 1a: IBGE (2021b) (Modified by R.F.O. Nascimento 2022).

interspersed with sporadic buriti palms (*Mauritia flexuosa* Linnaeus; Arecales, Arecaceae). The shrubby Caatinga segment, on the other hand, is distinguished by the presence of small to medium-sized trees and is situated in a peri-urban area within the vicinity of the Professor Cinobelina Elvas Campus (CPCE), associated with the Association of Professors of the Universidade Federal do Piauí (ADUFPI), in the municipality of Bom Jesus (Figures 1b-d).

Data collection

This study comprised 15 collection events, with six conducted in the municipality of Cristino Castro and nine in Bom Jesus. These collections spanned the months of April, May, June, September, October, and November of 2019, accounting for 10 collection sessions, followed by two sessions in February and March of 2020, and three sessions in February and March of 2021. The geographical coordinates of the specific collection sites were accurately determined using a GPS system and are denoted by acronyms (A1, A2, A3, and A4) as listed in Table I.

Specimen collection was conducted utilizing two Malaise traps (Gressitt & Gressitt 1962), positioned 20 to 30 meters apart, and deployed in each study environment for durations ranging from four to 10 days. The setup of the Malaise traps involved anchoring their base at ground level or spanning across stream watercourses. The extremities of each trap were secured to tree branches and/or stakes using ropes and/or strings, with these stakes being embedded into the soil. Flies captured by these traps were collected into cups filled with 70% ethyl alcohol for preservation, positioned at both ends of the traps (Figure 1b).

The specimens collected from the traps were subsequently transferred into plastic jars ranging from 0.5 to 1 liter in volume, each securely sealed with a lid and accurately labeled with details of the collection location, date, and the collectors' names. These prepared containers were transported to the Zoology Laboratory at the Professor Cinobelina Elvas Campus (CPCE) of the Universidade Federal do Piauí (UFPI), located in the municipality of Bom Jesus, state of Piauí, Brazil, for further processing and sorting. To ensure their preservation, the Sarcophagidae specimens were stored in 70% alcohol within 50 ml Falcon tubes and 0.5 to 2 ml Eppendorf tubes.

Analysis of collected material

Specimen identification was conducted at the Laboratory for the Study of Lepidoptera (LEI) within the Universidade Estadual do Maranhão (UEMA), Caxias Campus, Maranhão, Brazil. This process involved a detailed examination of morphology of the specimens, with a particular focus on the male genitalia. To facilitate a more precise observation of these structures, the genitalia were, in some instances, dissected from the body. Consequently, only male specimens were identified, due to the absence of comprehensive literature that facilitates the identification of female specimens. The identification process utilized identification keys, descriptions, and taxonomic reviews (Lopes 1954, 1956, 1974, 1982, 1983, 1985, 1988, Lopes & Tibana 1988, Mello 1996, Mello-Patiu 2002, Guimarães 2004, Carvalho & Mello-Patiu 2008, Pape & Dahlem 2010, Vairo et al. 2011, Carvalho-Filho & Esposito 2012, Buenaventura & Pape 2013, Carvalho-Filho et al. 2014, 2017, 2021, Mulieri et al. 2016, Mello-Patiu & Salazar-Souza 2016, Souza et al. 2020, Camargo (unpublished data), Barbosa et al. 2021, Santos et al. 2022). Additionally, comparisons were made with species previously identified within the Zoological Collection of Maranhão (CZMA) at UEMA, Caxias *Campus*, Maranhão, Brazil, and the Entomological Collection of the Museu Paraense Emílio Goeldi (MPEG), located in Belém, Pará.

The voucher specimens are deposited in the entomological collections of CZMA and MPEG.

RESULTS

In this study, a total of 262 male Sarcophagidae specimens, encompassing 16 genera and 40 species, were collected across four distinct areas. Specifically, in collection area A1, located within riparian vegetation at the Caatinga-Cerrado ecotone, 159 specimens representing 24 species were collected. Area A2, also within riparian vegetation at the Caatinga-Cerrado ecotone, yielded 42 specimens belonging to 13 species. In area A3, situated in vereda vegetation within the same ecotone, 19 specimens belonging to nine species were collected. Lastly, in area A4, located in a fragment of shrubby Caatinga, 42 specimens comprising 16 species were documented (Table II).

In the course of this study, a species previously unrecorded in scientific literature was found, *Titanogrypa* (*Airypel*) sp. nov. (n = 1). This species is slated for future detailed description in an upcoming taxonomic revision of the subgenus. Additionally, the species *Emblemasoma emblemasoma* Dodge, 1968 (n = 1; Figure 2a and b) represents a new record for South America and Brazil, marking the first occurrence of the genus *Emblemasoma* Aldrich, 1916 within the Caatinga biome and the Northeast region of Brazil. Furthermore, the species *Dexosarcophaga patiuorum* Santos, Pape & Mello-Patiu, 2022 (n = 1; Figure 2c), *Lepidodexia* (*Notochaeta*) *fumipennis* (Lopes, 1946) (n = 1; Figure 2d), and *Oxysarcodexia meridionalis* (Engel, 1971) (n = 1; Figure 2e) were recorded for the first time in the Northeast region of Brazil. Except for *P.* (*P.*) *pexata*, all species identified (39 spp.) are new records for the state of Piauí (Table II).

Table II. Composition and abundance of Sarcophagidae species collected in the Caatinga and Caatinga-Cerrado transition area in the municipalities of Cristino Castro, and Bom Jesus, state of Piauí, Northeastern Brazil.

SPECIES	MUNICIPALITY / COLLECTION AREA				TOTAL	NEW RECORD					FI
	Cristino Castro	Bom Jesus									
	A1	A2	A3	A4		SA/BR	Ca	NE	PI	CC	
Argoravinia (*Argoravinia*) *catiae* Carvalho Filho & Esposito, 2012	25	4			29				X	X	X
Blaesoxipha (*Gigantotheca*) *stallengi* (Lahille, 1907)	3	4			7				X	X	X
Chrysagria duodecimpunctata Townsend, 1935		1			1				X	X	
Dexosarcophaga (*Bezzisca*) *ampullula* (Engel, 1931)	4				4				X	X	X
Dexosarcophaga carvalhoi (Lopes, 1980)			1		1				X	X	X
***Dexosarcophaga patiuorum* Santos, Pape & Mello-Patiu, 2022**	1				1			X	X	X	
Dexosarcophaga paulistana (Lopes, 1968)	2				2				X	X	X
Dexosarcophaga pusilla Lopes, 1975		1			1				X	X	X

Table II. Continuation.

Dexosarcophaga transita Townsend, 1917	12			2	14				X	X	X
***Emblemasoma emblemasoma* Dodge, 1968**				1	1	X	X	X	X		
Helicobia aurescens (Townsend, 1927)	1				1				X	X	X
Helicobia cearensis Tibana, 1976	1		1		2				X	X	
Helicobia iheringi Lopes, 1939		1			1				X	X	
Helicobia morionella (Aldrich, 1933)	1				1				X	X	X
Helicobia pilifera Lopes, 1939	2	1	1		4				X	X	X
***Lepidodexia* (*Notochaeta*) *fumipennis* (Lopes, 1946)**				1	1		X	X	X		
Lepidodexia (*Notochaeta*) sp. 1	1				1				X	X	
Lipoptilocnema crispula (Lopes, 1938)	1			1	2				X	X	X
Lipoptilocnema salobrensis Lopes, 1942		1			1				X	X	X
Nephochaetopteryx pallidifacies Lopes, 1975	1			1	2				X	X	
Oxysarcodexia amorosa (Schiner, 1868)	1		2	7	10				X	X	X
Oxysarcodexia angrensis (Lopes, 1933)				1	1				X		X
Oxysarcodexia avuncula (Lopes, 1933)	39	4	6	3	52				X	X	X
Oxysarcodexia culmiforceps Dodge, 1966			3		3				X	X	X
***Oxysarcodexia meridionalis* (Engel, 1971)**			1		1			X	X	X	
Oxysarcodexia parva Lopes, 1946	3	4			7				X	X	X
Oxysarcodexia simplicoides (Lopes, 1933)	2			1	3				X	X	X
Oxysarcodexia thornax (Walker, 1849)	39	17	3	7	66				X	X	X
Oxysarcodexia timida (Aldrich, 1916)				2	2				X		X
Oxyvinia excisa Lopes, 1950	1				1				X	X	X
Peckia (*Peckia*) *chrysostoma* (Wiedemann, 1930)				2	2				X		X
Peckia (*Peckia*) *pexata* (Wulp, 1895)		2			2					X	X
Peckia (*Sarcodexia*) *lambens* (Wiedemann, 1830)				6	6				X		X
Ravinia advena (Walker, 1853)	1				1				X	X	X
Ravinia belforti (Prado & Fonseca, 1932)	6		1	5	12				X	X	X
Ravinia effrenata (Walker, 1861)	4	1			5				X	X	X
Retrocitomyia mizuguchiana Tibana & Xerez, 1985	7			1	8				X	X	X
Titanogrypa (*Cuculomyia*) *larvicida* (Lopes, 1935)	1				1				X	X	X
Titanogrypa (*Airypel*) sp. nov.				1	1	X	X	X	X		
Tricharaea (*Sarcophagula*) *occidua* (Fabricius, 1794)		1			1				X	X	X
TOTAL	**159**	**42**	**19**	**42**	**262**						

***Notes*: Collection area: A1 = Caatinga-Cerrado ecotone / Riparian vegetation; A2 = Caatinga-Cerrado ecotone / Riparian vegetation; A3 = Resfriado village / Caatinga-Cerrado ecotone / Vereda vegetation; A4 = ADUFPI / Caatinga biome / Fragment of Caatinga. New records: SA/BR = South America/Brazil; Ca = Caatinga biome; NE = Northeast region; PI = state of Piauí; CC = Caatinga-Cerrado ecotone. FI = Forensic Importance (References: Alves et al. 2014, Mulieri et al. 2016, Silva et al. 2023, 2024).**

The genera with the highest species richness were *Oxysarcodexia* Townsend, 1917, with nine species, followed by *Dexosarcophaga* Townsend, 1917, with six species, and *Helicobia* Coquillett, 1895, with five species. Three species collectively accounted for over half (56.11%) of all specimens collected. *Oxysarcodexia thornax* (Walker, 1849) was the most abundant, comprising 25.19% of the total specimens collected, succeeded by *Oxysarcodexia avuncula* (Lopes, 1933) at 19.85%, and *Argoravinia* (*Argoravinia*) *catiae* Carvalho-Filho & Esposito, 2012, making up 11.07%. The remaining species (37 spp.) together constituted 43.89% of the total specimens collected (Table II).

Within the scope of species sampled, 19 species were exclusively found in the riparian vegetation types, located within the Caatinga-Cerrado ecotone in areas A1 and/or A2. These species include *A.* (*A.*) *catiae, Blaesoxipha* (*Gigantotheca*) *stallengi* (Lahille, 1907), *Chrysagria duodecimpunctata* Townsend, 1935, *Dexosarcophaga* (*Bezzisca*) *ampullula* (Engel, 1931), *D. patiuorum, Dexosarcophaga*

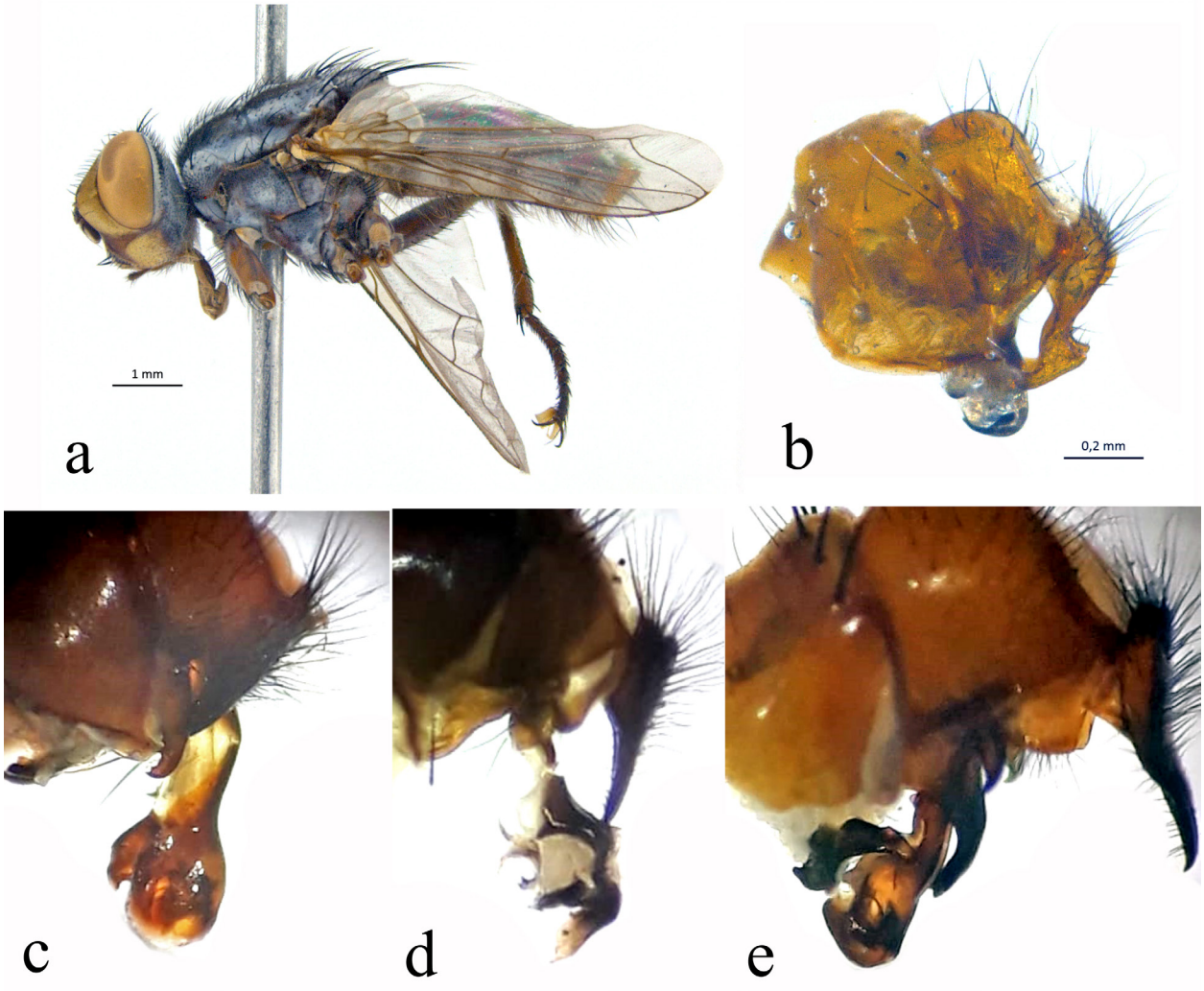

Figure 2. ***Emblemasoma emblemasoma*** **Dodge, 1968: a)** ***Habitus*****, lateral view; and b) Male terminalia, lateral view. And male terminalia, lateral view: c)** ***Dexosarcophaga patiuorum*** **Santos, Pape & Mello-Patiu, 2022; d)** ***Lepidodexia*** **(*Notochaeta*)** ***fumipennis*** **(Lopes, 1946); and e)** ***Oxysarcodexia meridionalis*** **(Engel, 1971). Photos of** ***E. emblemasoma*****: J. J. Sousa.**

paulistana (Lopes, 1968), *Dexosarcophaga pusilla* Lopes, 1975, *Helicobia aurescens* (Townsend, 1927), *Helicobia iheringi* Lopes, 1939, *Helicobia morionella* (Aldrich, 1933), *Lepidodexia* (*Notochaeta*) sp. 1, *Lipoptilocnema salobrensis* Lopes, 1942, *Oxysarcodexia parva* Lopes, 1946, *Oxyvinia excisa* Lopes, 1950, *P.* (*P.*) *pexata, Ravinia advena* (Walker, 1853), *Ravinia effrenata* (Walker, 1861), *Titanogrypa* (*Cuculomyia*) *larvicida* (Lopes, 1935), and *Tricharaea* (*Sarcophagula*) *occidua* (Fabricius, 1794). Conversely, three species were uniquely identified within the vereda vegetation type in the Caatinga-Cerrado ecotone, specifically in area A3, including *Dexosarcophaga carvalhoi* (Lopes, 1980), *Oxysarcodexia culmiforceps* Dodge, 1966, and *O. meridionalis*. Additionally, seven species were solely found in the fragment of the Caatinga biome, located in area A4. These species comprise *E. emblemasoma, L.* (*N.*) *fumipennis, Oxysarcodexia angrensis* (Lopes, 1933), *Oxysarcodexia timida* (Aldrich, 1916), *Peckia* (*Peckia*) *chrysostoma* (Wiedemann, 1930), *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830), and *T.* (*A.*) sp. nov. (Table II).

Seven species were observed in two distinct phytophysiognomies: *Helicobia cearensis* Tibana, 1976, and *Helicobia pilifera* Lopes, 1939, were found in both riparian vegetation (areas A1 and/or A2) and vereda vegetation (area A3). Conversely, *Dexosarcophaga transita* Townsend, 1917, *Lipoptilocnema crispula* (Lopes, 1938), *Nephochaetopteryx pallidifacies* Lopes, 1975, *Oxysarcodexia simplicoides* (Lopes, 1933), and *Retrocitomyia mizuguchiana* Tibana & Xerez, 1985, were collected in riparian vegetation (areas A1 and/or A2) as well as in the Caatinga fragment (area A4). Moreover, four species were present across all three studied phytophysiognomies—riparian vegetation (areas A1 and/or A2), vereda vegetation (area A3), and Caatinga fragment (area A4): *Oxysarcodexia amorosa* (Schiner, 1868), *O. avuncula, O. thornax,* and *Ravinia belforti* (Prado & Fonseca, 1932) (Table II).

DISCUSSION

This research significantly expands the inventory of Sarcophagidae species known in the state of Piauí from three to 42 species. This augmentation underscores the critical importance and the imminent need for additional faunal surveys, akin to the present study, to address the existing gaps in our understanding of species distribution. Concerning the newly records, the genus *Emblemasoma* comprises 16 species, primarily distributed through the Neartic and Neotropical regions, predominantly within tropical rainforest (Pape 1996). Within Brazil, eight species of this genus have been identified, with six located in the Southeast, specifically in the state of Rio de Janeiro, within the Atlantic Forest biome, and one in the Midwest, in the state of Goiás, within a Cerrado environment (Pape 1996, 2024, Mello-Patiu et al. 2024). The species *E. emblemasoma* was previously recorded solely in Central America (Panama) (Pape 1996), marking its documentation in this study as a new record for South America and Brazil.

The discovery of three additional species, previously unrecorded in the Caatinga, or the transitional zone between the Caatinga and Cerrado, and/or the Northeastern region of Brazil, highlights the unique faunal diversity of the Neotropical region. *Lepidodexia* (*N.*) *fumipennis* is known from Ecuador, where it inhabits tropical forests, and from Brazil, specifically in the southern state of Paraná, and the southeastern state of Rio de Janeiro (Pape 1996), within Atlantic Forest areas. This species now also been identified in the northeastern state of Piauí, within the Caatinga biome. *Lepidodexia* (*N.*) *fumipennis* is parasitic to vertebrates and has been associated with myiasis in anurans,

birds, and mammals, including cats and humans (D'Bastiani et al. 2020, Madeira-Ott et al. 2022). *Oxysarcodexia meridionalis* has been recorded in Bolivia and Argentina, captured in traps baited with fruit or decomposing squid, and in Brazil, collected from goat and pig carcasses in anthropized areas and Cerrado vegetation, in the regions Midwest (in the states of Goiás, Mato Grosso, and Mato Grosso do Sul), and Southeastern (in the states of Minas Gerais, Rio de Janeiro, and São Paulo) (Dufek et al. 2016, Faria et al. 2018, Paseto et al. 2019, Souza et al. 2020). In this study, we document the first occurrence of *Oxysarcodexia meridionalis* in the Northeast, specifically within vereda vegetation in a transitional area between the Caatinga and the Cerrado biomes.

In this study, *D. patiuorum* is documented for the first time within riparian vegetation situated in the transitional zone between the Caatinga and Cerrado biomes of the Northeast region. This species was only recently described by Santos et al. (2022) based on a single male specimen collected with Malaise trap (similarly to the methodology employed in the present study) in the state of Mato Grosso do Sul, municipality of Rio Verde. This location is notably situated in a transitional area that bridges the Cerrado and Pantanal biomes in the Midwest region. Conversely, the majority of other species newly recorded for the state of Piauí in this research have been previously identified in various other states, regions, and/or biomes across Brazil, as well as in other countries within the American continent (Mello-Patiu et al. 2024, Pape 2024).

Oxysarcodexia stands as one of the most species-rich genera within the Neotropical region and is consistently noted for its abundance and diversity in numerous Brazilian studies (Sousa et al. 2016, Souza et al. 2020, Nascimento et al. 2021, Carvalho-Filho et al. 2022, Silva et al. 2023). *Oxysarcodexia thornax*, in particular, has emerged as the most frequently collected species, distinguished not only by its prevalence but also by its substantial abundance relative to species from other genera within the same family (Faria et al. 2018, Barbosa et al. 2019, Toma et al. 2020, Carvalho-Filho et al. 2022, Silva et al. 2023). This pattern of prominence was also observed in the current study. Moreover, it is of particular interest that *A.* (*A.*) *catiae* was identified as the third most abundant species in this investigation, a notable finding given its lesser abundance in previous studies conducted within Cerrado regions in the Northern, in the state of Pará, and Northeastern, in the state of Maranhão, Brazil (Carvalho-Filho et al. 2022, Silva et al. 2023). This species appears to have an affinity for open, dry habitats, such as those found in the Cerrado and Caatinga biomes.

The riparian vegetation within the Caatinga and Cerrado ecotone exhibited greater species richness compared to both the vereda vegetation areas of the Caatinga-Cerrado ecotone and the Caatinga fragment in the state of Piauí. The riparian zones serve as crucial refuges for preserving the diversity of Sarcophagidae flies, potentially accounting for the elevated species richness observed in this research (Nascimento et al. 2021). These three distinct phytophysiognomies—riparian vegetation, vereda vegetation, and Caatinga—remain underexplored in Brazil concerning the diversity of Sarcophagidae species. The limited studies conducted within these environments have uncovered new records of Sarcophagidae species for various states, regions, and/or biomes across Brazil (Barbosa et al. 2019, Nascimento et al. 2021), and have led to the discovery of species new to science (Barbosa et al. 2023), as demonstrated in the present study.

Given their frequent presence on, and the development of their larvae throughout the decomposition stages of animal remains,

such as pig carcasses, and human corpses, 30 species identified in this study are noted for their forensic relevance in the Neotropical region (Table II) (Alves et al. 2014, Mulieri et al. 2016, Silva et al. 2023, 2024). Among these, three species are implicated in causing myiasis in humans (*H. morionella* and *P.* (*S.*) *lambens*) and in anurans (*L.* (*N.*) *fumipennis* and *P.* (*S.*) *lambens*) (D'Bastiani et al. 2020, Martins et al. 2021). However, it is imperative to underscore the necessity of conducting targeted studies within these areas of expertise—forensic, medical, and veterinary—specifically in the phytophysiognomies explored in this research. Such investigations are crucial to ascertain the actual utility of these species and to identify the presence of additional species, considering the extensive diversity of phytophysiognomies in the state of Piauí that remain unexplored.

It is highly probable that additional species of Sarcophagidae exist within the state of Piauí, given the extensive diversity of described species within this family that inhabit a variety of environmental contexts (Pape 2006, 2024, Mello-Patiu et al. 2024). Moreover, the present study employed solely the Malaise trap as a method for specimen collection. The incorporation of traps with attractive baits, such as decomposing animal matter and fermented fruits, known for their efficacy in capturing Sarcophagidae species (Sousa et al. 2016, Nascimento et al. 2021, Carvalho-Filho et al. 2022, Silva et al. 2023, 2024), could significantly expand the list of identified species in the state of Piauí, as well as in the broader Northeast region, across various phytophysiognomies, and throughout Brazil.

Acknowledgments

We thank to Sâmya Miranda, Sara Santos, Ana Clara Marcelino, Juliana Leal, Selton Miranda, Edneia Silva, Ricardo Fialho and Cicero Chagas for their assistance in field work and/or laboratory. We are grateful to Dra. Joseleide Teixeira Câmara, for providing the infrastructure and laboratory support to carry out the identification of Sarcophagidae species at the Universidade Estadual do Maranhão. We are also grateful to Raimundo Francisco Oliveira Nascimento, and Josué de Jesus Sousa for his assistance in preparing the map and photos of the Emblemasoma emblemasoma species, respectively. We thank Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Brazil, for the financial support n° 433694/2018-1 (Universal).

REFERENCES

ALVARES CA, STAPE JL, SENTELHAS PC, GONÇALVES JLM & SPAROVEK G. 2013. Koppen's climate classification map for Brazil. Meteorol Z 22(6): 711-728.

ALVES ACF, SANTOS WE & CREÃO-DUARTE AJ. 2014. Diptera (Insecta) de importância forense da região Neotropical. Entomotropica 29(2): 77-94.

ANDRADE-HERRERA KN, MELLO-PATIU CA, NÚNEZ-VÁZQUEZ C & ESTRELLA E. 2020. Flesh flies (Diptera: Sarcophagidae) attracted to a snake carcass (*Boa constrictor*) in Yucatan Peninsula, Mexico. J Med Entomol 57(6): 2011-2015.

BARBOSA TM, MELLO-PATIU CA & VASCONCELOS SD. 2019. First record of Sarcophagidae (Diptera) species in seasonally dry tropical forests (Caatinga), with notes on their attractiveness to decomposing substrates. Entomol News 129(1): 89-97.

BARBOSA TM, MELLO-PATIU CA & VASCONCELOS SD. 2021. Revision of the New World subgenus *Titanogrypa* (*Cucullomyia*) (Diptera: Sarcophagidae), with a reassessment of diagnostic characters. J Nat Hist 55(5-6): 305-340.

BARBOSA TM, MELLO-PATIU CA & VASCONCELOS SD. 2023. A new Sarcophaginae (Diptera: Sarcophagidae) from Brazil: the peculiar colour of *Petrolina bifasciata* gen. nov., sp. nov., from the Caatinga xeric shrubland of Northeastern Brazil. Zootaxa 5352: 235-244.

BARROS RM, MELLO-PATIU CA & PUJOL-LUZ JR. 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(4): 606-609.

BEUTER L, FERNANDES PA, BARROS PB, SOUZA CR & MENDES J. 2012. Insetos de potencial 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 Pat Trop 41(4): 480-490.

BUENAVENTURA E & PAPE T. 2013. Revision of the new world genus *Peckia* Robineau-Desvoidy (Diptera: Sarcophagidae). Zootaxa 3622: 1-87.

CARVALHO CJB & MELLO-PATIU CA. 2008. Key to the adults of the most common forensic species of Diptera in South America. Rev Bras Entomol 52(3): 390-406.

CARVALHO-FILHO FS, BARBOSA RR, FAVACHO CAC & DE-SOUZA CC. 2022. Flesh flies (Diptera: Sarcophagidae) from the brazilian amazonian savannas, a poorly sampled and threatened environment. J Med Entomol 59(6): 2030-2044.

CARVALHO-FILHO FS & ESPOSITO MC. 2012. Revision of *Argoravinia* Townsend (Diptera: Sarcophagidae) of Brazil with the description of two new species. Zootaxa 3256(1): 1-26.

CARVALHO-FILHO FS, ESPOSITO MC & MELLO-PATIU CA. 2021. Revision of *Nephochaetopteryx* Townsend, 1934 (Diptera: Sarcophagidae). Zootaxa 4928(1): 1-83.

CARVALHO-FILHO FS, SOUSA JRP & ESPOSITO MC. 2014. New species and new records of *Dexosarcophaga* Townsend (Diptera: Sarcophagidae) from Brazil with a key to species of the subgenus *Bezzisca*. Neotrop Entomol 43(1): 63-67.

CARVALHO-FILHO FS, SOUZA CC & SOARES JMM. 2017. A new species of *Sarcofahrtiopsis* (Insecta, Diptera, Sarcophagidae) from mangrove forests in the Brazilian Amazon, with a key to species identification. Acta Amazonica 47(4): 349-354.

CATTS EP & GOFF ML. 1992. Forensic entomology in criminal investigations. Ann Rev Entomol 37: 253-272.

DAHLEM GA. 1991. Sarcophagidae (Oestroidea). In: Stehr FW (Ed), Immature Insects, Vol. 2, Kendall/Hunt Publishing Company, Dubuque, p. 871-873.

D'ALMEIDA JM. 1994. Ovipositional substrats used by Calyptrate Diptera in Tijuca forest, Rio de Janeiro. Mem Inst Oswaldo Cruz 89(2): 261-264.

D'BASTIANI E, TEIXEIRA CP, DE LA TORRE GM, DUDCZAK AC, DOS SANTOS LE, SILVA ALF, ODA FH, MELLO-PATIU CA & CAMPIÃO KM. 2020. How deadly sarcophagid fly larvae are for anurans? New interactions and review to Neotropical region. Parasitol Res 119(4): 1415-1422.

DUFEK MI, OSCHEROV EB, DAMBORSKY MP & MULIERI PR. 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(4): 827-835.

FARIA LS, PASETO ML, COURI MS, MELLO-PATIU CA & MENDES J. 2018. Insects associated with pig carrion in two environments of the Brazilian savanna. Neotrop Entomol 47(2): 181-198.

GRESSITT JL & GRESSITT MK. 1962. An improved Malaise trap. Pac Insects 4(1): 87-90.

GUIMARÃES HJL. 2004. Redescrição dos machos de dez espécies neotropicais de *Ravinia* Robineau-Desvoidy, 1863 (Diptera, Sarcophagidae). Arq Mus Nac 62(1): 45-66.

GUIMARÃES SEF, MELO DMP, BARBOSA TM, FARIAS RCAP & BICHO CL. 2022. First report of *Peckia* (*Squamatodes*) *ingens* (Walker, 1849) (Diptera: Sarcophagidae) colonizing human corpse in the Neotropical region. Pap Avul Zool 62: e202262020.

IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. 2021a. Cidades e estados. https://cidades.ibge.gov.br/brasil/pi/panorama. Accessed 06th November 2022.

IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. 2021b. Estado do Piauí, Brasil. https://www.ibge.gov.br/geociencias/downloads-geociencias.html. Accessed 11th November 2022.

LOPES HS. 1954. Contribuição ao conhecimento do gênero *Sarcophagula* Wulp, 1887 (Diptera-Sarcophagidae). Mem Inst Oswaldo Cruz 52(3-4): 587-602.

LOPES HS. 1956. Sobre o gênero "*Titanogrypa*" Townsend, 1017 (Diptera, Sarcophagidae). Rev Bras Entomol 16(2): 207-211.

LOPES HS. 1974. On the types of some Sarcophagidae from Panama, described by H. R. Dodge (Diptera). Rev Bras Biol 34(4): 511-522.

LOPES HS. 1982. On some Sarcophagidae (Diptera) from Pirapora, state of Minas Gerais, Brazil. Rev Bras Biol 40: 5-8.

LOPES HS. 1983. On *Nothochaeta* (Diptera, Sarcophagidae) with descriptions of five new species. Mem Inst Oswaldo Cruz 40(1): 71-81.

LOPES HS. 1985. On *Orodexia*, *Anolisomyia* (Revalidated), *Euflettcherimyia* and *Nothochaeta* (Diptera, Sarcophagidae) with key to species. Rev Bras Entomol 29(3-4): 559-570.

LOPES HS. 1988. On *Emblemasomini* (Diptera, Sarcophagidae) with descriptions of four new species. Mem Inst Oswaldo Cruz 83(1): 17-27.

LOPES HS & TIBANA R. 1988. On Johnsoniini (Diptera, Sarcophagidae) with *Nothochaetisca* new name, and descriptions of eight new species. Rev Bras Biol 48(2): 315-332.

MADEIRA-OTT T, SOUZA CM, BUNDE PRS, RIES ACR, BLOCHTEIN B & THYSSEN PJ. 2022. Forensically relevant flesh flies (Diptera, Sarcophagidae, Sarcophaginae) of Southern Brazil. J Med Entomol 59(2): 488-507.

MARTINS LGV, BARBOSA TM & GAMA RA. 2021. Myiasis in humans: Case reports in Northeastern Brazil including multispecies co-infestation by Sarcophagidae. Parasitol Int 85: 102436.

MELLO CA. 1996. Revisão do gênero *Farrimyia* Dodge, 1965 (Diptera, Sarcophagidae) – Parte II. Rev Bras Biol 56(3): 473-483.

MELLO-PATIU CA. 2002. Revision of some *Dexosarcophaga* species described by R. Dodge (Diptera: Sarcophagidae). Zootaxa 122: 1-16.

MELLO-PATIU CA, PASETO ML, FARIA LS, MENDES J & LINHARES AX. 2014. Sarchophagid 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(2): 142-146.

MELLO-PATIU CA & SALAZAR-SOUZA M. 2016. *Retrocitomyia* Lopes, 1982 (Diptera: 1008 Sarcophagidae): new species, new records, key to males, and an updated catalog. Zootaxa 4171(3): 534-548.

MELLO-PATIU CA, SANTOS JR, CARVALHO-FILHO FS & GOMES MM. 2024. Sarcophagidae in Catálogo Taxonômico da Fauna do Brasil. PNUD. http://fauna.jbrj.gov.br/fauna/faunadobrasil/1151. Accessed 30th June 2024.

MULIERI PR, MELLO-PATIU CA & ABALLAY FH. 2016. Taxonomic revision of *Lipoptilocnema* (Diptera: Sarcophagidae), with notes on natural history and forensic importance of its species. J Med Entomol 54(1): 50-75.

NASCIMENTO RFO, SILVA JOA & CARVALHO-FILHO FS. 2021. Scavengers flesh flies (Diptera, Sarcophagidae) from two phytophysiognomies in the state of Maranhão, Northeastern of Brazil. Biota Neotrop 21(4): e20211192.

OLIVEIRA-COSTA J. 2011. Entomologia forense: quando os insetos são vestígios. Tratado de perícias criminalísticas, 3rd ed., Brazil: Editora Millennium, 502 p.

PAPE T. 1996. Catalogue of the Sarcophagidae of the world (Insecta: Diptera). Memoirs on Entomology, International, Vol. 8, Gainesville: Associated Publisher, p. 1-58. https://www.researchgate.net/publication/284259176. Accessed 02th March 2021.

PAPE T. 2024. Family: Sarcophagidae. A taxonomic database to all flesh flies. https://diptera.dk/sarco/index.php. Accessed 30th June 2024.

PAPE T & DAHLEM GA. 2010. Sarcophagidae. In: Brown BV, Borkent A, Cumming JM, Wood DM, Woodley NE & Zumbado M (Eds.), Manual of Central American Diptera, Vol. 2, Ottawa: NRC Research Press, p. 1313-1335.

PASETO ML, FARIA LS, MENDES J & LINHARES AX. 2019. Diversity of Sarcophagidae (Insecta, Diptera) associated with decomposing carcasses in a rural area of the state of Minas Gerais, Brasil. EntomoBrasilis 12(3): 118-125.

PEREIRA SLB, NASCIMENTO MS & RODRIGUES JVS. 2017. Compatibilização entre territórios de desenvolvimento e instâncias de gestão regionais. Teresina: Fundação CEPRO. http://www.cepro.pi.gov.br/download/201712/CEPRO21_42341bfc90.pdf. Accessed 30th May 2023.

RAFAEL JA, MELO GAR, CARVALHO CJB, CASARI SA & CONSTANTINO R. 2024. Insetos do Brasil: diversidade e taxonomia, 2nd ed., Brasil: Editora INPA, 880 p.

SANTOS JR, PAPE T & MELLO-PATIU CA. 2022. Eight new species of *Dexosarcophaga* Townsend, 1917 (Diptera, Sarcophagidae) from the Neotropical Region. Eur J Taxon 828: 109-137.

SHEWELL GE. 1987. Sarcophagidae. In: McAlpine JF, Peterson BV, Shewell GE, Teskey HJ, Vockeroth JR & Wood DM (Eds.), Manual of Nearctic Diptera, Vol. 2, Research Branch, Agriculture Canada. Monograph 28, Ottawa: Biosystematics Research Centre, p. 1159-1186.

SILVA JOA, BRASIL LS & CARVALHO-FILHO FS. 2023. Flesh flies (Diptera: Sarcophagidae) of forensic importance collected from pig carcasses in the Cerrado of Northeastern Brazil. J Med Entomol 60(2): 272-281.

SILVA JOA, BRASIL LS, DE-SOUZA CC & CARVALHO-FILHO FS. 2022. *Helicobia neuzalmeidae* sp. nov., a new species of Sarcophagidae (Diptera) reared from a pig carcass in the Brazilian savanna. J Med Entomol 59(5): 1601-1606.

SILVA JOA, CARVALHO-FILHO FS & BRASIL LS. 2024. Succession of medico- legal important flesh flies (Diptera: Sarcophagidae) in the temporal gradient of pig decomposition in the Brazilian Cerrado. Sci Rep 14: 8218.

SOUSA JRP, CARVALHO-FILHO FS & ESPOSITO MC. 2015. Distribution and abundance of necrophagous flies (Diptera: Calliphoridae and Sarcophagidae) in Maranhão, Northeastern Brazil. J Insect Sci 15(1): 70.

SOUSA JRP, CARVALHO-FILHO FS, JUEN L & ESPOSITO MC. 2016. Evaluating the effects of different vegetation types on necrophagous fly communities (Diptera: Calliphoridae; Sarcophagidae): implications for conservation. PLoS ONE 11(10): e0164826.

SOUZA CM DE, PAPE T & THYSSEN PJ. 2020. *Oxysarcodexia* Townsend, 1917 (Diptera: Sarcophagidae) – a centennial conspectus. Zootaxa 4841: 1-126.

TOMA R, KOLLER WW, MELLO-PATIU CA & MELLO RL. 2020. New records of Sarcophagidae (Insecta: Diptera) collected in cerrado fragments in the municipality of Campo Grande, Mato Grosso do Sul state, Brazil. EntomoBrasilis 13: e0873.

VAIRO KP, MOURA MO & MELLO-PATIU CA. 2011. Pictorial identification key for species of Sarcophagidae (Diptera) of potential forensic importance in southern Brazil. Rev Bras Entomol 55(3): 333-347.

VASCONCELOS SD & ARAUJO MCS. 2012. Necrophagous species of Diptera and Coleoptera in Northeastern Brazil: state of the art and challenges for the forensic entomologist. Rev Bras Entomol 56(1): 7-14.

YAN L, BUENAVENTURA E, PAPE T, KUTTY SN, BAYLESS KM & ZHANG D. 2020. A phylotranscriptomic framework for flesh fly evolution (Diptera, Calyptratae, Sarcophagidae). Cladistics 37: 540-558.

How to cite

SILVA JOA, CÂMARA JT, LEAL KD & CARVALHO-FILHO FS. 2024. Flesh flies (Diptera: Sarcophagidae) from transitional Caatinga-Cerrado areas in the state of Piauí, Northeast Brazil. An Acad Bras Cienc 96: 20240388. DOI 10.1590/0001-3765202420240388.

Manuscript received on April 16, 2024;
accepted for publication on August 11, 2024

JOSÉ ORLANDO A. SILVA[1]
https://orcid.org/0000-0002-1993-9953

JOSENIR T. CÂMARA[2]
https://orcid.org/0000-0001-7549-0575

KALIANE D. LEAL[2]
https://orcid.org/0009-0004-3870-8933

FERNANDO S. CARVALHO-FILHO[3]
https://orcid.org/0000-0002-2480-3874

[1]Universidade Federal do Maranhão (UFMA), Centro de Ciências de Codó (CCCo), Curso de Licenciatura Interdisciplinar em Ciências Naturais/Biologia, Av. Dr. José Anselmo, n° 2008, São Benedito, 65400-000 Codó, MA, Brazil

[2]Universidade Federal do Piauí (UFPI), Campus Professora Cinobelina Elvas, BR 135, km 3 - Planalto Horizonte, 64900-000 Bom Jesus, PI, Brazil

[3]Museu Paraense Emílio Goeldi (MPEG), Programa de Pós-Graduação em Zoologia (PPGZOOL), Departamento de Zoologia, Laboratório de Entomologia, Av. Perimetral, n° 1901, Terra Firme, 66077-830 Belém, PA, Brazil

Correspondence to: **José Orlando de Almeida Silva**
E-mail: jose.orlando@ufma.br

Author contributions

JTC designed the study, carried out the field experiments and contributed to the revision of the manuscript. KDL carried out the field experiments, carried out the identification of the specimens. JOAS and FSCF carried out the identification of the specimens and contributed to the revision of the manuscript. All authors contributed to the writing of the manuscript.