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Synanthropy of Sarcophaginae (Diptera: Sarcophagidae) From Southern Brazil and Its Sanitary Implications

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Abstract

Although different feeding habits have been reported for Sarcophaginae (Diptera, Sarcophagidae), most species are associated with decomposing organic matter such as feces and decaying corpses. This study provides the synanthropy index for males of species of Sarcophaginae collected during a 12-mo period in three different environments (urban, rural, and wild) of the state of Rio Grande do Sul, in Southern Brazil, linking this parameter with the sanitary issue. This article also investigated the presence of pathogenic bacteria on the external surface of *Oxysarcodexia paulistanensis* (Mattos), the most abundant species collected using a sanitized entomological net. Almost all the species collected most abundantly, including *O. paulistanensis* (n = 241), *Ravinia advena* (Walker) (n = 87), and *O. thornax* (Walker) (n = 58), were classified as synanthropic; *O. thornax* was the species with the highest synanthropy index (+80.3). *Escherichia coli* (Escherich), *Shigella* spp. (Enterobacteriaceae), and *Staphylococcus aureus* (Rosenbach) (Staphylococcaceae) were isolated and identified from the external surface of *O. paulistanensis*. The isolation and identification of pathogenic bacteria, and their synanthropic behavior, adds weight to potential role of some flesh flies, as *O. paulistanensis*, in a sanitary context.

Key words: flesh fly, vector, pathogen, enterobacteria, medical and veterinary entomology

Sarcophaginae (Diptera: Sarcophagidae) present a wide range of feeding habits. In addition to necrophagy, coprophagy, some species are insect predators and parasitoids, while others parasitize snails, reptiles, amphibians, domestic animals, and humans (Pape and Dahlem 2010). Flesh flies use feces and carrion for larval development and such substrates provide proteins for ovarian development (Ferrar 1987, Mendes and Linhares 1993). The synanthropic species are recognized for their close association with humans and domestic animals and have potential as mechanical vectors of disease (Greenberg 1971).

Flesh fly–associated pathogens include bacteria (*Enterobacter* spp., *Escherichia coli* (Escherich), *Klebsiella oxytoca* (Flügge), *Salmonella* spp., *Staphylococcus* spp., and *Proteus* spp.), protozoa (*Giardia lamblia* Kunstler, *Cryptosporidium parvum* Tyzzer), and viruses (rabbit hemorrhagic disease virus—RHDV) (Greenberg 1971, 1973; Barratt et al. 1998; Nascimento et al. 2003; Henning et al. 2005; Conn et al. 2007; Förster et al. 2007; Almeida et al. 2014; Cadavid-Sanchez et al. 2015). For example, members of the *Oxysarcodexia* Townsend genus are recognized for being dung-breeding (Pape and Dahlem 2010), and as *Oxysarcodexia paulistanensis* (Mattos) prefers human settlements (Linhares 1981, Dufek et al. 2016), the potential to transmit pathogens found in feces is increased.

The state of Rio Grande do Sul (RS), in Southern Brazil, is in a biogeoclimatic zone characterized as humid subtropical, with average annual temperatures ranging between 12 and 23°C and significant rainfall throughout the year (approximately 1,300 mm total rainfall accumulated over 12 mo) (Alvares et al. 2013). The prevailing vegetation consists of fields (also called 'pampa'), that cover almost 60% of the territory, and pine forests, mixed broadleaved and coniferous. The coastal vegetation or sandbank accounts for only 5% of the total area (IBGE 2020).

Data on species of Sarcophaginae from RS are quite scarce. Several publications report the occurrence of sarcophagines in the state (Lopes 1946, Pape 1996, Souza et al. 2008, Krüger et al. 2010, Silva et al. 2010, Ries and Blochtein 2015, Madeira et al. 2016), but few provided baiting information, the locality, environmental, and seasonal variation (Souza et al. 2008, Krüger et al. 2010) and none developed synanthropic indices. Nuorteva (1963) developed a synanthropic index (SI) to measure the relationship between blow flies and humans in three ecological niches. Such indices help us gain insights into the impact of species by understanding how it functions in human created environments.

The family Sarcophagidae is an important component of the Neotropical fauna. In view of this, this study has aimed to evaluate ecological, synanthropic, and potential health risks of the Sarcophaginae in three areas of Rio Grande do Sul, each differing in their degree of human intervention. In addition, the isolation and identification of pathogenic bacteria associated with flesh flies was investigated to contribute to the knowledge about which pathogenic bacteria have been commonly carried by dipterans and can cause sanitary problems.

Material and Methods

Sampling and Identification

Adult Sarcophaginae were collected monthly during 12 mo, in rural, urban, and wild environments in three different municipalities of Rio Grande do Sul (hereinafter RS) (Fig. 1): 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). According to Morrone (2014), these municipalities are within the Pampean province, which covers the southern half of the Brazilian state of RS, Uruguay and the Argentine provinces of Buenos Aires, La Pampa, Santa Fe, Cordoba, Entre Rios, and Corrientes. The most common plant landscapes in the Pampean province are the fields (with a predominance of grasses, especially of the genera *Agrostis*, *Axonopus*, and *Paspalum* e *Stipa*) and the seasonal forests (consisting of medium and large trees, not widely spaced, mainly of the genera *Ateleia*, *Paraptadenia*, and *Peltophorum*).

Weather conditions were measured daily during the period of collection with a Celsius thermometer (model MM 5202-Incoterm), a humidity sensor (model 4463, Stäcker and 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 month.

A baited trap for muscoid flies, similar to those seen in other studies (Ferreira 1979, Linhares 1981, Moretti et al. 2009), was used for collection of Sarcophaginae. Each trap was baited with an 80 g portion of chicken gizzard, bovine liver or raw fish, previously left to rot for 48 h at room temperature. Twelve traps with balanced types of baits were exposed in each of the three environments (wild, urban, and rural), for a total of 36 per municipality, arranged in a 3 × 4 grid, 100 m long, and 100 m wide. Along each transect, the traps were 50 m apart to ensure sample independence, as proposed by Cabrini et al. (2013). In each grid, each trap with a different bait was distributed randomly by transect. The environments were characterized as follows: 1) *wild*, forested locality with null or reduced human disturbance in its surroundings; 2) *urban*, locality with buildings and

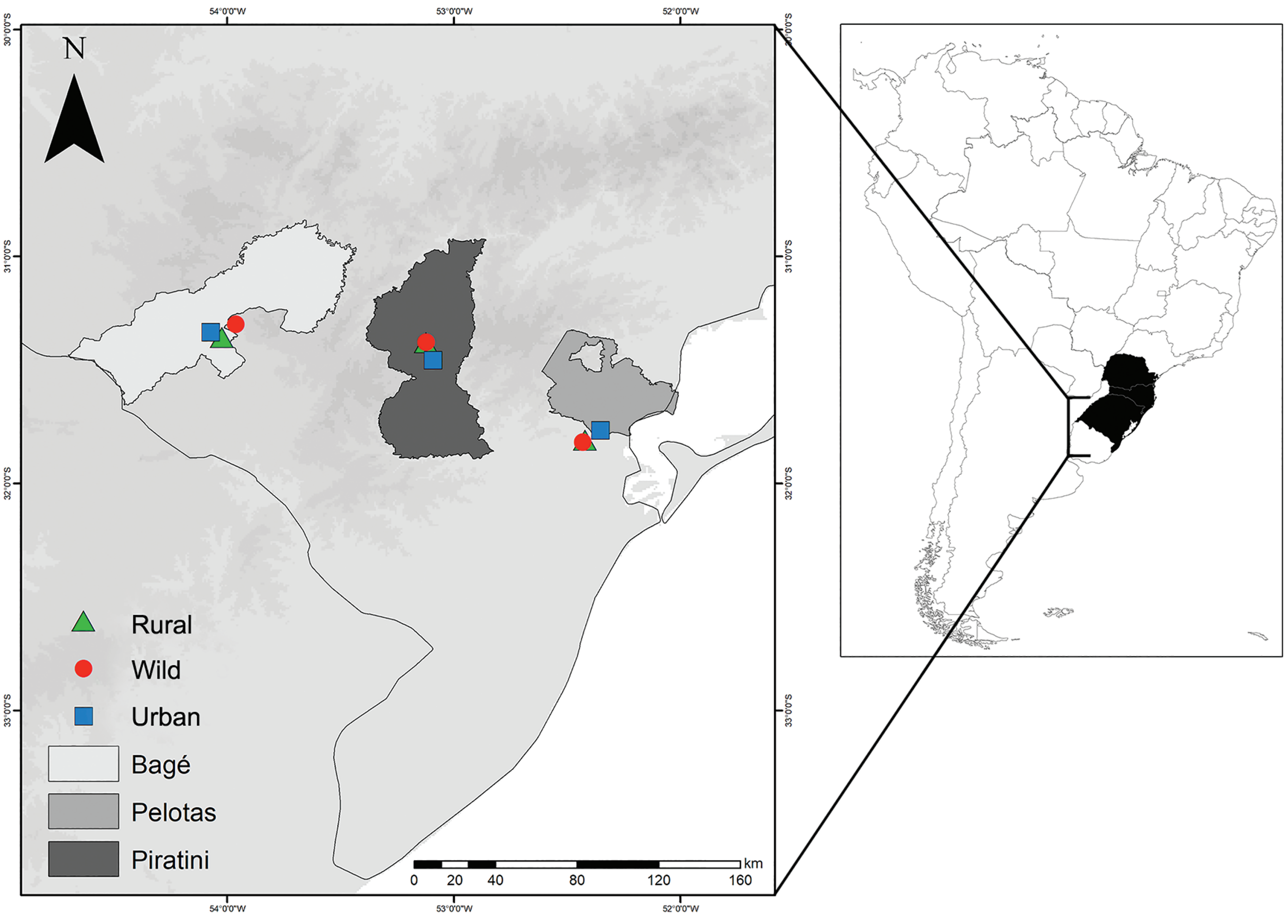


Fig. 1. Sarcophagidae collection sites in the state of Rio Grande do Sul, Brazil.

high population density, i.e., 151–350 inhabitants/ha (Moreira et al. 2019); and 3) *rural*, open pasture area with at least three or four farms that keep livestock in their surroundings, especially cattle and sheep. Each environment was at least 15 km away from each other, while the distance between locations (municipalities) was approximately 70 km.

Each trap remained exposed for 72 h. In the laboratory, the collected male specimens were killed at low temperature (−20°C/10 min) and stored in absolute ethanol or pinned. Male terminalia were exposed with the aid of an entomological pin. Species identification was done using taxonomic keys (Carvalho and Mello-Patiu 2008, Vairo et al. 2011). Specimens were included in the entomological collection of Laboratory of Integrative Entomology of the Department of Animal Biology and of the Museum of Zoology 'Adão José Cardoso' (ZUEC), both at the University of Campinas, São Paulo State, Brazil.

Abundance and SI

The comparison among the abundance of species by environment and bait was performed using one-way analysis of variance (ANOVA) and values were considered significant at $P < 0.05$. To assess possible differences among localities based on Sarcophagine species composition a nonmetric multidimensional scaling (NMDS) analysis followed by ANOSIM were performed, using the Jaccard index as a measure of similarity, where the distortion of the resolution of the two-dimensional arrangement was represented by a stress value. In addition, a principal correspondence analysis (PCA) was used to estimate the correlation of *species* and *environment*, besides *species* and *baits*. All analyses were carried out using the statistical program´ PAST version 3.06 (Hammer et al. 2001).

To quantify the degree of association of these flies with humans and with the environment modified by them, the SI was calculated using the formula proposed by Nuorteva (1963):

$$S.I. = \frac{2a + b - 2c}{2}$$

where *a*, *b*, and *c* correspond to the percentage of individuals from a given species collected in the urban, rural, and wild environments, respectively. Results may vary from −100 (intolerance to the anthropized environment) to +100 (highest degree of association with the anthropized environment). According to the SI values found, the collected species were classified as shown in Table 1.

Microbiological Analysis

During the three warmest months of the year, January to March, active collections at the same locations and environments were carried out in search of samples to carry out microbiological analyses. Several 15 cm entomological nets previously sanitized were used because the instrument was replaced with a new one for each sample collected. No attractive bait was used. Adult flesh flies were collected at random on the surfaces of objects, vegetation, fences, and walls where they landed, or on domestic animals. As soon as the flesh flies were collected, they were deposited in sterile plastic containers labeled by locality and environment. In the laboratory, the flies were individualized and identified, as previously described. The tweezers for handling the material and the stereomicroscope were cleaned at each step of the screening and identification process, with 5% $NaClO_3$ solution.

Only samples of species collected in all environments were selected for microbiological evaluation in order to compare the bacterial composition by environment. The flies were individually immersed in 0.85% physiological solution to remove large external residues and incubated in brain heart infusion (BHI) broth for 24 h at 37°C. Afterward, 100 µl aliquots of BHI were inoculated in MacConkey agar and Chapman's medium, and both were then incubated for 24 h at 37°C. All tests were performed in triplicate. MacConkey agar was used to investigate the presence of enterobacteria and Gram-negative bacteria, while Chapman's medium investigates the presence of *Staphylococcus* spp. (Tortora et al. 2015). In addition, complementary tests for the investigation of Enterobacteriaceae in terms of morphology, metabolism and motility were performed, in triplicate: 1) biochemical series: triple sugar iron, methyl-red, Voges–Proskauer citrate (IMViC), urea, and lysine iron agar; 2) coagulase and catalase tests; and 3) Gram staining.

Results

Abundance and Synanthropy

A total of 554 specimens of Sarcophaginae belonging to the species *Helicobia aurescens* (Townsend), *Oxysarcodexia culmiforceps* Dodge, *Oxysarcodexia paulistanensis* (Mattos), *Oxysarcodexia thornax* (Walker), *Oxysarcodexia varia* (Walker), and *Ravinia advena* (Walker) were identified (Table 2). *Oxysarcodexia paulistanensis* ($n = 241$) was the most abundant species (Table 2), this species alone accounting for 43% of all individuals sampled in this study. In addition, this was the first record of *H. aurescens* for RS.

Regarding the species composition, the NMDS showed that no marked difference can be observed among locations (Fig. 2) and absence of specificity in the distribution by environment was validated by ANOSIM with global *R* value closer to zero ($R^2 = 0.1328$; $P = 0.051$). In general, in the comparison within each environment and among the localities, most of the points, which represent the records of each of the sampled species, overlapped because the richness is the same or very similar (Fig. 2). Pelotas was the location with the least points of overlap and these differences were associated with low species richness in urban and wild environments (Fig. 2).

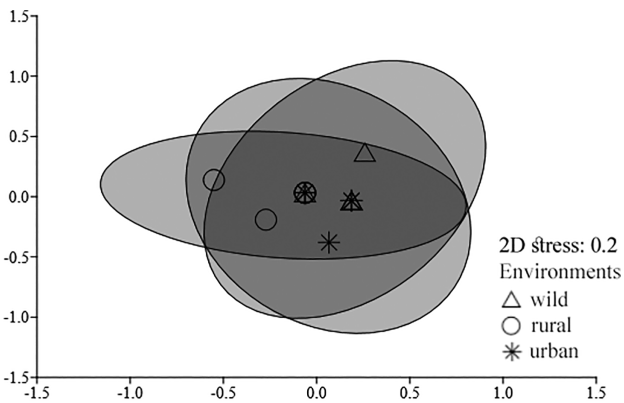
A larger number of individuals were collected in the urban environment, but no significant differences were observed in relation to the abundance among the different environments (Table 2). By environment, *O. paulistanensis* was the most abundant species in the urban and rural environments, while *O. culmiforceps* was the most abundant in the wild (Table 2). The PCA showed a strong correlation of *O. paulistanensis* and *R. advena* with the urban and

Table 1. Synanthropic classification according to Nuorteva (1963)

Classification	Habitat preference	SI values
Eusynanthropic	Strong preference for dense human settlements	+100 ≤ SI ≥ +90
	Strong preference for human settlements	+90 < SI ≥ +65
	Preference for human settlements	+65 < SI ≥ +20
Hemisynanthropic	Independence for human settlements	+20 < SI ≥0
	Preference for uninhabited areas	0 < SI ≥ −40
Asynanthropic	Complete avoidance for human settlements	−40 < SI ≥ −100

Table 2. Abundance (*N*) of Sarcophaginae species by environment and by bait and SI considering all the locations where the collections were performed

Species	N	Environments			Baits			SI
		Wild	Rural	Urban	Gizzard	Liver	Fish	
Helicobia aurescens	16	1	11	4	11	2	3	+53.1
Oxysarcodexia culmiforceps	133	46	58	29	41	57	35	+9
Oxysarcodexia paulistanensis	241	15	64	162	58	72	111	+74.3
Oxysarcodexia thornax	58	3	11	44	24	12	22	+80.3
Oxysarcodexia varia	19	3	8	8	10	2	7	+47.3
Ravinia advena	87	7	54	26	22	47	18	+53
Total	554	75	206	273	166	192	196	—
ANOVA	—	$F = 1.846$; df = 2; $P = 0.2144$			$F = 0.0461$; df = 2; $P = 0.9553$			—



Location	Environment		
	rural	urban	wild
Bagé	4	4	5
Pelotas	6	2	1
Piratini	5	5	4

Fig. 2. NMDS based on Sarcophaginae composition species by location (Bagé, Pelotas, and Piratini) and environment (rural, urban, and wild) sampled in Rio Grande do Sul state and species richness by environment and location. Each *circle* indicates a location (municipality).

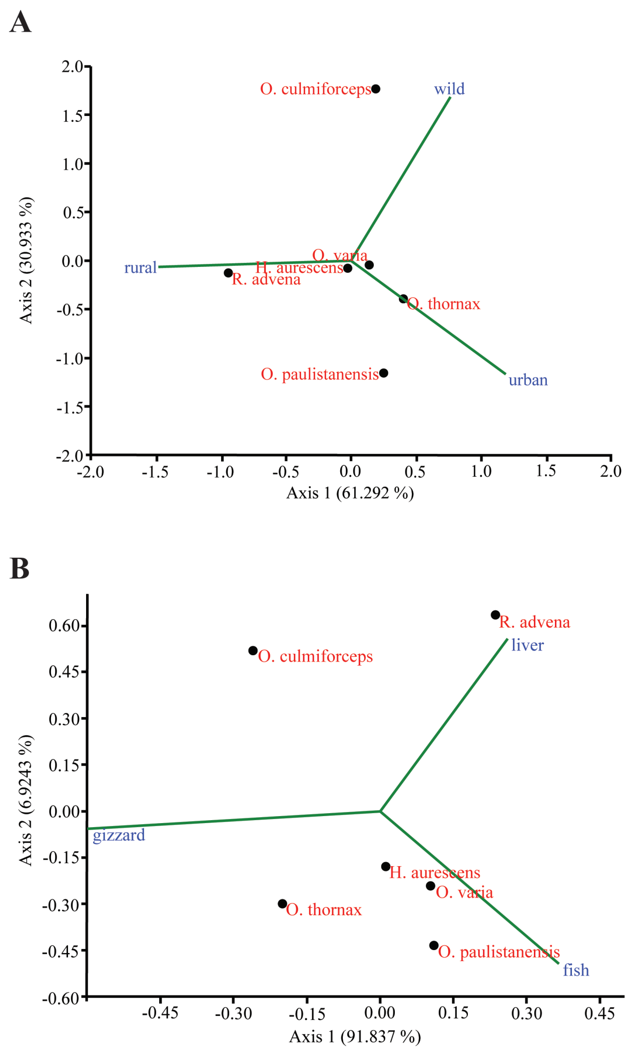


Fig. 3. Correlation matrices of PCA between *species* and *environment* (urban, rural, and wild) (A) and between *species* and *baits* (liver, gizzard, and fish) (B), considering the Sarcophaginae species collected in the different municipalities of Rio Grande do Sul state. *Biplot* showing *scores* values for the environments (A) or baits (B).

rural environments, respectively; and a moderate correlation of *O. thornax* and *O. culmiforceps* with the urban and wild environments, respectively (Fig. 3A).

In general, no significant differences were observed with respect to the abundance of flies attracted to different types of bait (Table 2). In the PCA, we observed a strong correlation of attractiveness of *O. paulistanensis* and fish bait, whereas for *R. advena*, the attractiveness is more strongly correlated to the liver bait (Fig. 3B). The other species showed a weak or moderate correlation in attractiveness, with regard to a particular type of bait (Fig. 3B).

The distribution of species over the year varied from infrequent (when recorded between 3 and 4 mo) for *O. varia* and *H. aurescens* to very frequent (when recorded between 9 and 11 mo) for all other species (Table 3). *Ravinia advena* was collected throughout the year, except in September, and even in July, when the other species were absent due to the most inhospitable environmental conditions, mainly associated with the low mean temperature of the month (Table 3). A greater abundance of species was observed between the months of October and December (Table 3), when the means of temperature, accumulated rainfall, and humidity were among 18.6–23.8°C, 74.7–80.2%, and 143–165 mm, respectively.

The SI showed that species like *O. paulistanensis* and *O. thornax* have a strong preference for human settlements (Table 2), in

Table 3. Distribution of Sarcophaginae species and weather conditions (averages of temperature and humidity, and accumulated rainfall) recorded during the period of collections, per month, considering all locations and environments of this study

	Months											
Species	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Helicobia aurescens	■								■		■	■
Oxysarcodexia culmiforceps	■		■		■	■		■	■	■	■	■
Oxysarcodexia paulistanensis	■		■	■	■	■		■		■	■	■
Oxysarcodexia thornax	■			■	■	■		■	■	■	■	■
Oxysarcodexia varia								■		■	■	
Ravinia advena	■	■	■	■	■	■	■	■	■	■	■	■
Weather conditions												
Mean temperature (°C)	21.8 ± 7.7	21.9 ± 6.9	21.5 ± 6.6	17.4 ± 5.8	17.2 ± 5.4	13 ± 4.1	10.5 ± 6.1	17 ± 5.2	15.7 ± 4.7	18.6 ± 5.3	21.3 ± 6.7	23.8 ± 8.4
Humidity (%)	78.6 ± 7.2	80.6 ± 6.4	77.1 ± 8.7	77.4 ± 7.8	78.6 ± 8.5	77.3 ± 11.2	76.5 ± 10.7	79.2 ± 10.1	79.4 ± 9.7	80.2 ± 6.7	74.7 ± 6.5	76 ± 6.9
Rainfall (mm)	89 ± 6.0	81 ± 4.4	10 ± 3.8	98 ± 3.4	91 ± 6.7	131 ± 12.3	131 ± 14.1	172 ± 10.0	58 ± 6.6	165 ± 7.1	143 ± 2.2	149 ± 2.4

agreement with what was observed in relation to abundance and PCA (Table 2, Fig. 3A), i.e., both are eusynanthropic (Table 4). The SI values also showed that the other eusynanthropic species have a preference for human settlements, but these species do not depend exclusively on the resources provided by the anthropized environment for their survival, with the sole exception of *O. culmiforceps*, considered hemisynanthropic (Table 4).

Bacteria From the Flesh Flies' External Surface

Oxysarcodexia paulistanensis was the only species that met the criteria established for conducting microbiological analyses, having been collected in all environments. Pathogenic bacteria were isolated from the external surface of flies, these bacteria including species such as *Escherichia coli*, *Shigella* spp. (Enterobacteriaceae), and *Staphylococcus aureus* (Rosembach) (Staphylococcaceae) (Table 5). Notably, *Shigella* spp. was the only bacterium isolated in all environments (Table 5).

Discussion

Abundance and Synanthropy

This study expands the record of Sarcophaginae species for RS and Southern Brazil, with special mention of the first ever record of *H. aurescens* for RS, showing that this fauna is as yet little known in this Brazilian state. Despite the reduced richness of collected Sarcophaginae species in comparison with other studies carried out in Southern Brazil (e.g., Vairo et al. 2011), the richness of species in this study is still greater than the ones found in other studies performed in RS, like the study of Souza et al. (2008), Krüger et al. (2010) and Silva et al. (2010). Still considering collections exclusively in RS, the richness of species of Sarcophaginae was equal to that found by Ries and Blochtein (2015), albeit with different species, and lower than that recorded by Madeira et al. (2016), while also showing some different records. It is important to highlight that differences in species richness can probably also be associated with the fact that only males were identified due to the lack of taxonomic keys for female identification, which did not differ from what was observed in most studies on Sarcophagidae.

The lack of significant differences in the abundance of the collected species between sampled environments suggests a distribution expansion of these species toward different habitats caused by adaptation (Valverde-Castro et al. 2017). Similarly, no significant differences were observed in the abundance of collected flies with regard to bait type, but the correlation of the collected species with the different baits suggests their ecological relationship with the baits used. The attractiveness level of a given bait for flesh flies is considered selective, as it depends on the relative importance to the life stage (physiological condition) of a given species (Mendes and Linhares 1993). Furthermore, bait attractiveness can be related to dietary needs for ovarian development or larval growth, i.e., abundant lipids and proteins, present in animal tissues (Ferrar 1987, Mendes and Linhares 1993, NEPA/UNICAMP 2006).

The highest mean values of temperature, humidity and accumulated rainfall from October to December, when combined, coincided with fly activity and abundance recorded in the present study. Flesh flies are heliophils (Pape and Dahlem 2010) and the heliophilia of some sarcophagines has already been reported (Linhares 1981). The mean temperature, albeit the highest recorded in those months for the collection area of this study, is similar to the temperature values found for the dry and cold periods for flesh flies collections in the Brazilian Cerrado (savannah-like vegetation) (Rosa et al. 2011, Faria et al. 2018, Paseto

Table 4. Synanthropic classification for Sarcophaginae species collected in the current study and comparison with literature records

Species	Synanthropic classification		
	Eusynanthropic	Hemisynanthropic	Asynanthropic
Helicobia aurescens	Current study	Dufek et al. (2020)	—
Oxysarcodexia culmiforceps	—	Linhares (1981), current study	Ferreira (1979), Dias et al. (1984a), Carmo and Vasconcelos (2016)
Oxysarcodexia paulistanensis	Linhares (1981), Dias et al. (1984a), Dufek et al. (2016), current study	Ferreira (1979)	—
Oxysarcodexia thornax	Dufek et al. (2016), Souza and Von Zuben (2016), current study	Linhares (1981), Carmo and Vasconcelos (2016)	Ferreira (1979), Dias et al. (1984a)
Oxysarcodexia varia	Dufek et al. (2020), current study	—	—
Ravinia advena	Dufek et al. (2016), current study	—	—

Table 5. Pathogenic bacteria isolated and identified from the external surface of *Oxysarcodexia paulistanensis* by municipality and environment

Municipalities	*N*	Environments	Bacteria
Bagé	12	Urban	*Shigella* spp.
	11	Rural	*Escherichia coli*, *Shigella* spp.
	8	Wild	*Staphylococcus aureus*, *Shigella* spp.
Pelotas	11	Urban	*Shigella* spp.
	10	Rural	*S. aureus*, *Shigella* spp.
	10	Wild	*E. coli*, *Shigella* spp.
Piratini	14	Urban	*Shigella* spp.
	11	Rural	*E. coli*
	10	Wild	*E. coli*, *S. aureus*

et al. 2019), but lower rainfall and mean humidity, suggesting that the temperature can be the most important abiotic factor of those three for flesh flies. Temperature has already been shown to be an important factor for flesh flies' biology, as it is considered the main cause for increased metabolic activity (Nassu et al. 2014).

In our study, the greater abundance of *O. culmiforceps* and *O. paulistanensis* was related to high humidity and heavy rainfall, unlike previous studies in Brazilian Cerrado, where these species were more abundant in the dry season, with low humidity and very low or no rainfall (Rosa et al. 2011, Faria et al. 2018). It has already been reported that some characteristics of fly populations of one same species, such as temperature dependent developmental characteristics within species may vary between geographical environments, causing phenotypic adaptation (Grassberger and Reiter 2002, Nassu et al. 2014). Therefore, observed differences of abundance of *Oxysarcodexia* species is probably influenced by geographical distribution.

The PCA for species and environments are in agreement with the synanthropy classification found for each species. The SI values suggested that the most abundant species in this study are eusynanthropic, except for *O. culmiforceps*, considered hemisynanthropic. SI values vary within species and locality sampled for the Neotropical region (Ferreira 1979, Linhares 1981, Dias et al. 1984a, Yepes-Gaurisas et al. 2014, Souza and Von Zuben 2016, Dufek et al. 2020) may be attributed to high dispersion ability and ubiquity in urban habitats (Valverde-Castro et al. 2017).

The inconsistencies found in the synanthropic classification of one same species (Table 4) can be due to factors inherent to the environment, including plant cover, relief, height, and weather conditions that can affect the SI estimated for a same species from different place, as well as the site of collection (Dias et al. 1984a) or by the influence of their geographical distribution as already discussed for the influence of the weather conditions in species abundance. For example, *Ravinia advena* is considered an 'urban adapter' species of the Humid Chaco ecoregion (Argentina) by being tolerant and resilient to land-use intensification (Dufek et al. 2020), features that can explain this species' preference for human settlements in RS.

Furthermore, the *Oxysarcodexia* and *Ravinia* genera are known to be coprophagous, mostly associated with dung (Pape and Dahlem 2010), and, along with *Helicobia*, they are commonly collected associated with carrion (e.g., Rosa et al. 2011, Faria et al. 2018, Paseto et al. 2019). The association with these substrates can enable these flies to be mechanical carriers of many microorganisms, as some fly structures such as mouthparts, wings, legs, and adhesive devices are suitable for carrying pathogens (Greenberg 1973, Tan et al. 1997, Sukontason et al. 2006).

Bacteria From the Flesh Flies' External Surface

The close association of saprophagous dipterans with the environment inhabited by humans and domestic animals has contributed to the mechanical transmission of pathogens. This fact, associated with some cultural practices and a deficient basic sanitation, can cause great public health issues (Greenberg 1971, Linhares 1981, Dias et al. 1984a). According to our findings, sarcophagines have historically been associated with anthropic environments. In addition, their high dispersion ability and ubiquity in urban habitats have already been reported (Valverde-Castro et al. 2017), highlighting their sanitary relevance.

Oxysarcodexia paulistanensis was also considered a synanthropic species for other locations (Linhares 1981, Dias et al. 1984a, Dufek et al. 2016). Another aspect that draws a lot of attention to this species is its attraction to or association with a wide range of resources, such as bovine liver, chicken viscera, fish, feces, fermented bananas, decaying squid, and mammalian carcasses (*Sus scrofa* Linnaeus 1758, *Rattus novergicus* (Berkenhout, 1769), and *Mus musculus* (Linnaeus, 1758)) (e.g., Ferreira 1979, Linhares 1981, Dias et al. 1984b, Vairo et al. 2011, Sousa et al. 2014, Dufek et al. 2015). The presence of three groups of pathogenic bacteria confirms that *O. paulistanensis* is a carrier of microorganisms in RS. *Oxysarcodexia varia*, another species of the same genus collected in this study, has already been identified as a possible mechanical vector of RHDV (Henning et al. 2005). These findings indicate that, though it is difficult to determine the real role of synanthropic Sarcophaginae in the transmission of pathogenic bacteria to humans and animals, this group deserves attention in the context of public and animal health by carrying these pathogens.

Finding *E. coli* and *S. aureus* in our fly samples confirms similar findings by Förster et al. (2007), Almeida et al. (2014), Cadavid-Sanchez et al. (2015) and, as expected, both bacteria belong to the natural human microbiota, but can cause severe illness depending on the bacterial strain, contact with the microorganism, and host immunity (Madigan et al. 2015). Certain *E. coli* strains can cause urinary tract infection, sepsis, meningitis, enteric diseases, and diarrhea to humans and other animals (Nataro and Kaper 1998). On the other hand, *S. aureus* may be associated with food poisoning due to its production of enterotoxins (Loir et al. 2003) and can cause biofilm formation in chronic wound arising from hospital infections, and cases of resistance to conventionally used antimicrobials (Clinton and Carter 2015).

Although isolated and identified associated to a single species, the presence of *Shigella* spp. in all environments and localities confirms what has been recorded in the literature (Greenberg 1971, 1973; Khan and Huq 1978; Harwood and James 1979; Umeche and Mandah 1989; Levine and Levine 1991; Manrique-Saide and Delfín-González 1997; Förster et al. 2007), which indicates that this microorganism is the one most often associated with flies that carry pathogens, such as *O. paulistanensis*. Studies also suggest a positive correlation between the presence of Diptera populations with the prevalence of diarrhea, with shigellosis being the most prevalent cause of this clinical condition (Watt and Lindsay 1948, Lindsay et al. 1953, Cohen et al. 1991, Esrey 1991). It is also worthy of mention that *Shigella* spp. are cosmopolitan and have been mentioned as a typical cause of inflammatory dysentery, being responsible for 5–10% cases of the diarroheic disease in many areas (Tortora et al. 2015), highlighting their sanitary relevance.

Conclusion

Our study correlated synanthropy and/or isolation and detection of pathogenic bacteria to a sanitary role of some species of Sarcophaginae, as highlighted for *O. paulistanensis*. Further studies are needed to investigate the SI for other Sarcophaginae species of sanitary importance and the existence of other pathogens associated with these flesh flies.

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