Research Article / Artículo de Investigación

Diversity of sarcosaprophagous dipterans (Insecta: Diptera) associated with street markets in the semiarid of northeastern Brazil

Diversidad de dípteros sarcosaprófagos (Insecta: Diptera) asociados a mercados callejeros en el noreste semiárido de Brasil

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Abstract. Diptera have high capacity to adapt to anthropized environments and they present high medical and sanitary relevance, since they are related to pathogens transmission and myiasis causing. In this context, it is known that anthropic environments (*e.g.*, street markets) with high human circulation and food supply can directly influence the composition and structure of muscoid dipterans assemblages. The aim of this work was to evaluate the effect of street markets on the composition and structure of assemblages of flies with sanitary importance in an urban environment of Toritama city, Pernambuco state, Brazil. The flies were captured using adhesive mousetrap "Cola Rato" before and after the occurrence of free markets. A total of 7,780 specimens belonging to six families and 14 species were collected. Muscidae was the most representative and diverse family, with 96.98% of all flies captured and four species. We observed that the assemblages were more abundant after the occurrence of the street markets ($H = 6.56$; $df = 1$; $P < 0.01$). Regarding the composition of the assemblies, 50% of the species were common to both treatments, with emphasis on the dominant species *Musca domestica* and *Megaselia scalaris*. This study reveals that free markets can modulate the structure and composition of flies' assemblages in urban environments, including being able to offer health risks, considering that species of medical importance are related to this environment.

Key words: Insect vectors; *Musca domestica*; muscoid dipterans; synanthropy.

Resumen. Los dípteros tienen una alta capacidad de adaptación al medio antropizado y gran relevancia médica y sanitaria, ya que están relacionados con la transmisión de patógenos y miasis. En este contexto, se sabe que los ambientes antrópicos (es decir, los mercados callejeros) con alta circulación humana y suministro de alimentos pueden influir directamente en la composición y estructura de los ensambles de dípteros muscoides. El objetivo de este trabajo fue evaluar el efecto de ferias libres sobre la composición y estructura de ensambles de moscas con importancia sanitaria en el medio urbano de la ciudad de Toritama, estado de Pernambuco, Brasil. Las moscas fueron capturadas utilizando trampas adhesivas para ratones "Cola Rato"antes y después de la realización de las ferias libres. Se recolectaron un total de 7.780 ejemplares pertenecientes a seis familias y 14 especies. Muscidae fue la familia más representativa y diversa con el 96,98% de todas las moscas capturadas y cuatro especies. Observamos que los ensambles eran más abundantes después de las

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ferias libres (H = 6,56; gl = 1; P < 0,01). En cuanto a la composición de los ensambles, el 50% de las especies fueron comunes a ambos tratamientos, con énfasis en las especies dominantes *Musca domestica* y *Megaselia scalaris*. Este estudio revela que las ferias libres pueden modular la estructura y composición de los ensambles de moscas en ambientes urbanos, presentando riesgos para la salud, ya que especies de importancia médica y sanitaria están relacionadas con este ambiente.

Palabras clave: Dípteros muscóideos; insectos vectores; *Musca domestica*; sinantropía.

Introduction

Sarcosaprophagous flies have great medical and veterinary relevance. They act as mechanical vectors of microorganisms (Greenberg 1973; Paiva 1994), they can cause myiasis (lesions resulting from the infestation of biontophagous and/or necrophagous fly larvae in human and animal tissues), and they are constantly associated with animal and human harassment, not only due to their walking, but also due to the hematophagic capacity some species have (Zumpt 1965; Greenberg 1973; Guimarães and Papavero 1999).

In this context, synanthropic taxa stand out for being able to colonize anthropic environments (Polvony 1971), where they feed on detritus and excrement resulting from human and animal presence. This scenario is prevalent in both urban and rural environments and has a direct influence on the composition and structure of dipteran assemblages (Nuorteva 1963; Linhares 1981). In urban and rural areas, human activities such as holding street markets can cause radical changes in the composition and structure of fly assemblages (Linhares 1981; Mulieri *et al*. 2011), resulting in the accumulation of organic matter and attracting different insect species (Guerra *et al*. 2019).

Anthropogenic activities may also favor the success of exotic species (Carmo and Vasconcelos 2016; Barbosa *et al*. 2017), where the ones with a strong attraction to urban environments are more successfully adapted. Ribeiro (1998) reports that the introduction of species of the genus *Chrysomya* Robineau-Desvoidy, 1830 (Calliphoridae) in Brazil led to a decrease in the frequency of *Cochliomyia macellaria* (Fabricius, 1775) (Calliphoridae), a native species of the Neotropical region. In this way, the direct competition between insects well adapted to anthropogenic disturbances can lead to a future homogenization of the fauna in anthropic environments, such as urban centers, and significantly increase the density of fly species with medical and sanitary significance (Carmo and Vasconcelos 2016; Barbosa *et al*. 2017).

In view of this, the present study aims to analyze the influence of street markets on the composition and structure of sarcosaprophagous dipteran assemblages in the Agreste region of Pernambuco state, Brazil. We specifically sought to compare the composition and structure of the assemblages before and after the fair, analyzing variables such as species richness, abundance, sex ratio, constancy, and dominance. Our hypothesis is that the street markets increase the density of a few species with high medical-sanitary potential, for example, *Musca domestica* and *Chrysomya albiceps.*

Materials and Methods

Study area

The study was carried out in the municipality of Toritama (08°0'24" S and 36°03'24" W), located in the Agreste region of Pernambuco state (Fig. 1). The municipality has an area equivalent to 25,704 km² with a population of 44,254 inhabitants, with the majority concentration in the urban area. The surrounding vegetation is shrubby hypoxerophic

caatinga, with trees and shrubs interspersed with cacti and bromeliads. The climate is arid and semi-arid with low rainfall, equivalent to an annual average of 550 mm and average temperature of 30 °C (Alvares *et al*. 2013).

The main economic activity in Toritama is the manufacture of industrial jeans, an activity that has rapidly proliferated throughout the region, and today accounts for 15% of all jeans manufacturing in Brazil (Governo Municipal Toritama 2020). The municipality also has street markets on weekends, usually known as "street markets", where meat, vegetables and fruits are sold in covered and outdoor tents. These environments attract a diverse range of dipterans (Guerra *et al*. 2019) due to the odors released by the food.

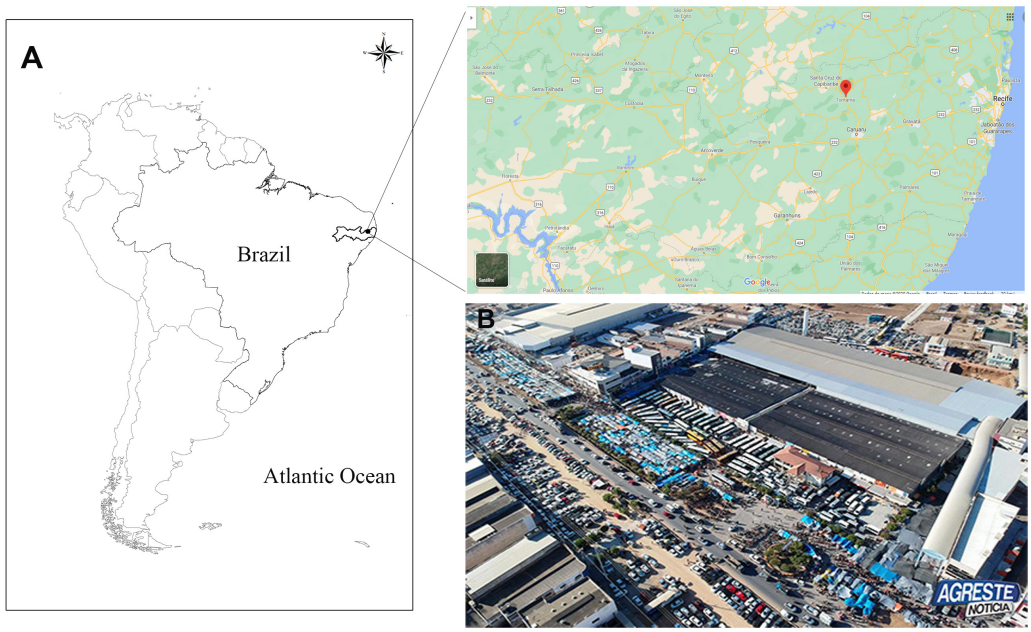


Figure 1. A. Location of the municipality of Toritama in the state of Pernambuco, Brazil. **B.** Jeans Fair held in Toritama, Pernambuco, Brazil. Source: Adapted from Google Maps and Agreste Notícia (2020). / **A.** Ubicación del municipio de Toritama en el estado de Pernambuco, Brasil. **B.** Feria del Jeans realizada en Toritama, Pernambuco, Brasil. Fuente: Adaptado de Google Maps y Agreste Notícia (2020).

Collection and identification of specimens

Adult flies were collected in six sampling events between April and May of 2020, three before and three after the fair. To capture the adult flies, an unattractive adhesive mousetrap called "Cola Rato" was used, which consists of a rectangular cardboard surface completely filled with a non-toxic and odorless glue (American Pets 2019). The trap is easy to handle and can be placed on any surface. They were distributed at a commercial point located in the street market at a veterinary house, the traps remained at 25 m from each other, in which 12 independent samples were obtained (six samples before the street markets and six after the street markets).

In the trap, the capture of insects is done at the time of landing, when the flies, in search of rest or to analyze the environment, touch the glue and become trapped. This method was chosen considering its simplicity of use in an environment with considerable human activity, as well as the non-release of odors, which could disturb the occurrence of the street markets itself if suspended traps with animal baits were used (Ferreira 1978).

The traps were exposed in the veterinary house for 48 hours during each collection/treatment (before and after the street market), placed 1 meter above the ground, on the shelves of the facilities. After 48 h, the cards were collected, analyzed and the flies removed. Mineral oil was used to facilitate the removal of flies from the traps without compromising the morphology of the specimens, maintaining their morphological characters essential for taxonomic identification. All specimens were stored in pots containing 70% alcohol and taken to the Laboratory of Insects and Vectors - LIVe (UFRN) to be sorted and identified. Identification was performed using a stereoscopic microscope, using specific taxonomic keys (Carvalho and Ribeiro 2000; Carvalho and Mello-Patiu 2008). For Sarcophagidae, only male specimens were identified since the identification of insects in this family is based on observing the morphological characteristics of male genitalia (Carvalho and Mello-Patiu 2008).

Data analysis

Diptera assemblages were characterized by absolute abundance, relative frequency, species richness, constancy, and dominance. Constancy refers to the distribution of each species over the collection events and were calculated by the following equation: C = P x 100 / N, where: P = number of collection events containing the studied species; N = total number of collection events. Based on the constancy analysis, the species were classified as: i) constant = when present in more than 50% of collections; ii) accessory = present between 25% and 50% of collections or iii) accidental = present in less than 25% of collections (Silveira Neto *et al*. 1976).

To access the species dominance, the dominance limit was calculated using the equation: DL = (1/S) x 100, in which DL corresponds to the dominance limit and S corresponds to the total number of species, with species classified as dominant (D) when the frequencies are higher than the DL, and non-dominant when the DL is higher than the frequencies (Silveira Neto *et al*. 1976).

Diversity before and after the fair was calculated using the Shannon-Wiener index, while the model proposed by Pielou (Magurran 1988) was used for the equitability index. Differences in abundance and richness under the factor "presence or absence of the fair" were accessed using analysis of variance (Kruskal-Wallis). To evaluate the sex ratio, the chi-square test was used. Abundance data per environment were also log-transformed (X+1) to obtain a similarity matrix. Based on the Bray-Curtis index, non-metric multidimensional scaling (nMDS) cluster analysis was performed to assess the degree of similarity among the sampled areas.

The sampling effort was evaluated based on the species accumulation curve. For this, we use the Jacknife 1 and 2 estimators that consider rare species and number of samples ("uniques" and "duplicates") and Bootstrap that considers data from all species collected (Magurran 1988). During the analysis of the species accumulation curve, the 999 permutations resource was used. All statistical analyses were carried out using the statistical program Biostat 5.0, while the ecological analyzes were carried out using Primer 6.0, both with a significance level of 0.05%. For the construction of graphs and assembly of tables, the Excel/2019 program of the Microsoft Office package was used.

Results

Diversity of sarcosaprophagous dipterans

A total of 7,780 specimens from six families, 12 genera and 14 species were recorded. Muscidae was the most representative family, with 96.98% of all flies captured, followed

by Sarcophagidae (1.99%), Phoridae (0.53%), Calliphoridae (0.42%), Fanniidae (0.03%), and Stratiomyidae with 0.02% of the representatives. Muscidae was the most richness taxon (4 spp.), followed by Sarcophagidae (3 spp.), Calliphoridae (2 spp.), Phoridae (2 spp.), Stratiomyidae (2 spp.) and Fanniidae (1 spp.) (Tab. 1).

Table 1. Absolute abundance (N), relative frequency (%), constancy and dominance of the species of sarcosaprophagous dipterans recorded in street markets from Toritama, Pernambuco, Brazil. / Abundancia absoluta (N), frecuencia relativa (%), constancia y dominancia de las especies de dípteros sarcosaprófagos registradas en mercados callejeros de Toritama, Pernambuco, Brasil.

Family/Species	N	%	Constancy	Dominance
Calliphoridae				
Lucilia cuprina	19	0.24	Constant	Dominant
Lucilia eximia	14	0.18	Constant	Dominant
Fanniidae				
Fannia pusio	2	0.03	Accidental	Non-dominant
Muscidae				
Atherigona orientalis	3	0.04	Accidental	Non-dominant
Musca domestica	7,537	96.88	Constant	Dominant
Stomoxys calcitrans	1	0.01	Accidental	Non-dominant
Synthesiomyia nudiseta	6	0.08	Accessory	Dominant
Phoridae				
Megaselia scalaris	37	0.48	Constant	Dominant
Phoridae sp.	4	0.05	Acidentais	Non-dominant
Sarcophagidae				
Peckia (*Sarcodexia*) *lambens*	3	0.04	Accidental	Non-dominant
Sarcophaga (*Liopygia*) *ruficornis*	4	0.05	Accessory	Non-dominant
Tricharaea (*Sarcophagula*) *occidua*	8	0.10	Accessory	Dominant
Stratiomyidae				
Hermetia illucens	1	0.01	Accidental	Non-dominant
Ptecticus sp.	1	0.01	Accidental	Non-dominant
Sarcophagidae spp. (female)	140	1.80		
Total	**7,780**	**100**		

Musca domestica Linnaeus, 1758 was the most abundant species of Muscidae, accounting for 96.85% of these individuals, followed by *Synthesiomyia nudiseta* (Wulp, 1883) (0.08%), *Atherigona orientalis* (Schiner, 1868) (0.04%) and *Stomoxys calcitrans* (Linnaeus, 1758) with 0.01% of the specimens. For Sarcophagidae, *Tricharaea* (*Sarcophagula*) *occidua* (Fabricius, 1794) was the most abundant species, comprising 0.10% of the specimens, followed by *Sarcophaga* (*Liopygia*) *ruficornis* (Fabricius, 1794) (0.05%) and *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830) (0.04%). For Calliphoridae, *Lucilia cuprina* (Wiedemann, 1830) and *Lucilia eximia* (Wiedemann, 1819) were recorded. *Megaselia scalaris* (Loew, 1866) (Phoridae), *Hermetia illucens* (Linnaeus, 1758) (Stratiomyidae), *Fannia pusio* (Wiedemann, 1830) (Fanniidae) and *Ptecticus* sp. (Loew, 1855) (Stratiomyidae), were also recorded, in addition to a morphospecies of Phoridae.

However, it is worth noting that the high abundance of the Sarcophagidae family was due to the 140 female specimens collected, which were not identified at the species level (Tab. 1). Of the total, 53.3% of the recorded taxa were classified as constant or accessory (Tab. 1), with *M. domestica* occurring in all samples. As for species dominance, it was observed that the dominance limit value was 0.06 (DL = 1/15). Thus, only *M. domestica*, *M. scalaris*, *L. cuprina*, *L. eximia*, *T.* (*S.*) *occidua* and *S. nudiseta* were classified as dominant (Tab. 1).

Effect of street markets on dipterans assemblages

During the study, it was observed that the street markets modulated the structure and composition of sarcosaprophagous fly assemblages, with the highest abundance of assemblages ($H = 6.56$; $df = 1$; $P < 0.01$) (Tab. 2) observed after the fair. However, there were no statistical differences in species richness ($H = 0.42$; $df = 1$; $P > 0.05$), although the composition of the assemblages differs, with five species occurring exclusively before the fair and two species occurring exclusively after the fair (Fig. 2A). It should also be noted that 50% of the species were common to both treatments, with emphasis on the dominant species *M. domestica* and *M. scalaris* (Fig. 2A).

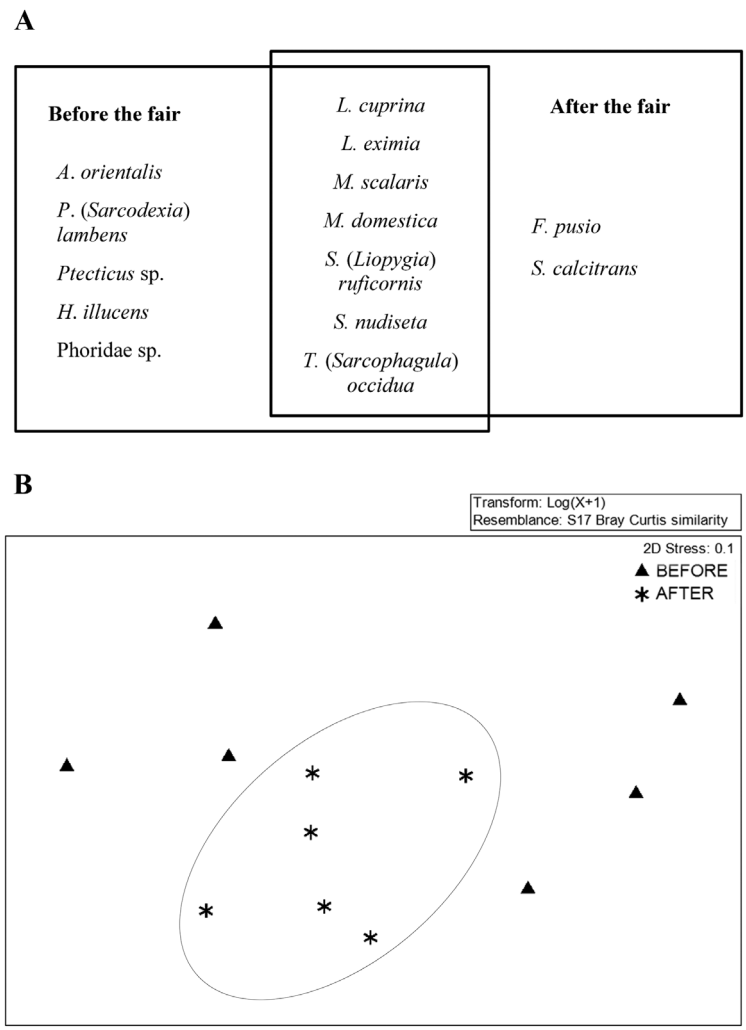
Diversity and equitability indexes also varied between treatments, with the values observed before the fair (H' =2.2; J = 088) higher than after the fairs (H' =1.8; J = 0.84). Furthermore, in both treatments, *M. domestica* was dominant, representing over 90% of all adults sampled (Tab. 2). The non-metric multidimensional scaling analysis (NMDS) of the abundance data indicated a trend of aggregation among post-fair treatment samples, with a similarity level above 75% (Fig. 2B).

Table 2. Absolute abundance (N) and relative frequency (%) of sarcosaprophagous dipteran species by treatments recorded in street markets from Toritama, Pernambuco, Brazil. / Abundancia absoluta (N) y frecuencia relativa (%) de especies de dípteros sarcosaprófagos por tratamientos registrados en mercados callejeros de Toritama, Pernambuco, Brasil.

Family/Species	Treatments			
	Before the fair		After the fair	
	N	%	N	%
Calliphoridae				
Lucilia cuprina	7	0.20	12	0.28
Lucilia eximia	5	0.15	9	0.21
Fannidae				
Fannia pusio	-	-	2	0.05
Muscidae				
Atherigona orientalis	3	0,09	-	-
Musca domestica	3,295	95.81	4,242	97.72
Stomoxys calcitrans	-	-	1	0.02
Synthesiomyia nudiseta	4	0.12	2	0.05
Phoridae				
Megaselia scalaris	26	0.76	11	0.25
Phoridae sp.	4	0.12	-	-

Sarcophagidae				
Peckia (*Sarcodexia*) *lambens*	3	0.09	-	-
Sarcophaga (*Liopygia*) *ruficornis*	2	0.06	2	0.05
Tricharaea (*Sarcophagula*) *occidua*	6	0.17	2	0.05
Stratiomyidae				
Hermetia illucens	1	0.03	-	-
Ptecticus sp.	1	0.03	-	-
Sarcophagidae spp. (♀)	82	2.38	58	1.34
Total	**3,439**	**100**	**4,341**	**100**

Figure 2. A. Distribution of Diptera species in an urban environment of Toritama city, Pernambuco state, Brazil, by treatments (before the fair and after the fair). **B.** Sorted by non-metric multidimensional scaling (NMDS), using Bray-Curtis similarity. / **A.** Distribución de especies de Diptera en un ambiente urbano de la ciudad de Toritama, estado de Pernambuco, Brasil, por tratamientos (antes y después de la feria). **B.** Ordenado por escalamiento multidimensional no métrico (NMDS), usando similitud de Bray-Curtis.



The presence of the street markets also influenced the sex ratio, with greater abundance of females and males after the fairs (Fig. 3). However, only the abundance of females exhibited a statistically significant difference ($\chi 2$ yates = 111.87; df = 1; $P < 0.01$), while no difference was observed for male specimens ($\chi 2$ yates = 2.67; df = 1; $P < 0.05$). The data also demonstrate that although the study presents a short sampling period, the species accumulation curve shows that the observed fauna (species richness) is close to the estimated richness (Sobs = 14 spp; Jackinife 1 = 18 and Bootstrap = 16 spp.), with the Jacknife 2 estimate being higher with 20 spp (Fig. 4).

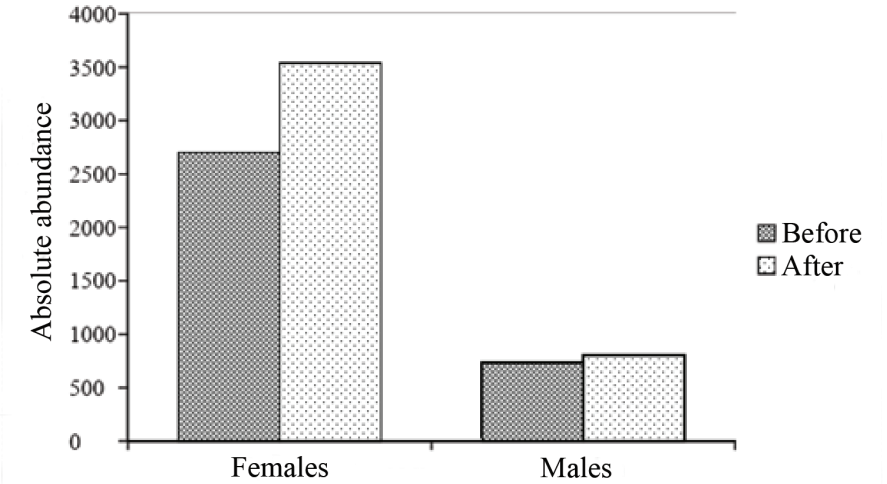


Figure 3. Sex ratio of specimens sampled in an urban environment of Toritama city, Pernambuco state, Brazil, by treatments (before the fair and after the fair). / Proporción de sexos de ejemplares muestreados en un ambiente urbano de la ciudad de Toritama, estado de Pernambuco, Brasil, por tratamientos (antes y después de la feria).

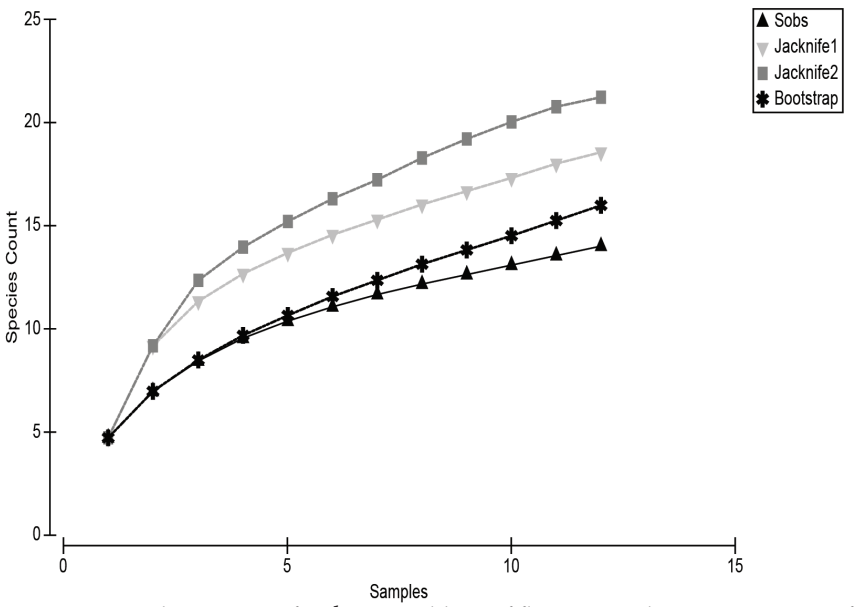


Figure 4. Species accumulation curve for the assemblage of flies in an urban environment of Toritama city, Pernambuco state, Brazil. / Curva de acumulación de especies para el ensamblaje de moscas en un ambiente urbano de la ciudad de Toritama, estado de Pernambuco, Brasil.

Discussion

Here we demonstrate that street markets acted as a modulating factor for sarcosaprophagous fly assemblages with medical, forensic, and veterinary potential because: I) there was an influence on the composition of assemblages, which were generally composed of synanthropic species; II) assemblages were more abundant after the occurrence of street market, which was associated with the fact that the fair provides feeding sites and temporary resources for the development of immature stages of synanthropic species (*e.g*., vegetable remains or garbage) and III) before the fair , the assemblages had greater diversity and equitability, which reveals greater balance in the distribution of taxa. These results suggest that the increase in anthropic activity due to street market consumers may have led to a decrease in diversity, as previously reported (Folgarait 1998; Kearns 2001).

There was also a trend towards homogenization of assemblages in view of the high dominance of *M. domestica*, which corroborates our previous hypothesis. In addition, the pattern observed in the NMDS showed that the samples, after the street market, were more similar, probably due to their lower diversity and high composition of *M. domestica*. The fact that *M. domestica* was constant and dominant in the study reinforces the cosmopolitan characteristic of its assemblages, which may be related to the eusynanthropic and endophilic aspect of this species, which uses different media as a breeding substrate (*i.e*., feces, animal and plant organic matter in decomposition), in addition of being an important vector of pathogenic microorganisms (Greenberg 1973).

It should also be noted that *M. domestica* adults are markedly abundant in indoor and outdoor environments, free markets, food retail units, also in indoor environment of food production and processing industries (Greenberg 1971; 1973; Keiding 1999; Mariconi *et al*. 1999). In addition, their larvae have been described as causing intestinal myiasis by ingestion of contaminated food or drinks (Zumpt 1963), nasopharyngeal myiasis (Riyaz *et al*. 2004) and cutaneous myiasis (Burgess and Davies 1991), representing a high risk for human and animal health. Other species are also of medical importance, such as *L. cuprina*, *L. eximia*; *F. pusio*, *M. scalaris*; *A. orientalis*, *S. calcitrans*, *S. nudiseta*; *P.* (*S.*) *lambens*, *S.* (*L.*) *ruficornis* and *T.* (*S.*) *occidua*. These species are associated with different public health problems such as myiasis in humans and animals or mechanical vectors of pathogens, whose species with medical potential can be seen in Tab. 3.

Interestingly, the absence of species from the genus *Chrysomya* was observed in this study, contradicting our previous hypothesis that species of this genus would be among the most abundant since they are commonly found and dominant in other environments in Pernambuco (Vasconcelos *et al*. 2015; Carmo and Vasconcelos 2016; Barbosa *et al*. 2017; Oliveira and Vasconcelos 2020). The absence of species of this genus may be related to the type of trap used in the study. Unlike Ferreira's (1978) trap, the adhesive mousetrap "Cola Rato" does not use animal or vegetable baits to attract and consequently capture these muscoid dipterans.

Another factor that may explain the absence of individuals from the genus *Chrysomya* is its seasonal distribution of species. Previous studies reported a pattern of population seasonality between species of the genera *Chrysomya* e *Lucilia* Robineau-Desvoidy, 1830, more specifically between *L. eximia* and *C. albiceps*, with dominance of *L. eximia* in dry periods, and *C. albiceps* during winter (Vianna *et al*. 1998; Kruger *et al*. 2010). Moretti *et al*. (2008) and Kruger *et al*. (2010) attributed this seasonality pattern to three possible reasons: type and amount of substrate available in each season; optimal development conditions; and the predation capacity of *C. albiceps*, which may affect the abundance of other calliphorids that colonize ephemeral resources. Furthermore, even with the absence of *Chrysomya*, the species accumulation curve tends to reach the asymptote, with the number of observed species very close to the estimated one, especially for the bootstrap estimator, which indicates that the sampling effort was efficient.

Table 3. List of species with medical and veterinary importance recorded in street markets from Toritama, Pernambuco, Brazil. / Lista de especies con importancia médica y veterinaria registradas en mercados callejeros de Toritama, Pernambuco, Brasil.

Family/Species	Vector of pathogens	Myiasis	Reference
Calliphoridae			
Lucilia cuprina	X	X	Greenberg 1971, 1973; Guimarães & Papavero 1999
Lucilia eximia	X	X	Greenberg 1971, 1973; Guimarães & Papavero 1999; Moretti & Thyssen 2006
Fannidae			
Fannia pusio	X		Greenberg 1971
Muscidae			
Atherigona orientalis	X		Greenberg 1971; Oliveira *et al*. 2002
Musca domestica	X	X	Greenberg 1971, 1973; Guimarães & Papavero 1999; Zumpt 1963; Oliveira *et al*. 2002
Stomoxys calcitrans	X		Greenberg 1971
Synthesiomyia nudiseta	X	X	Greenberg 1971; James 1947
Phoridae			
Megaselia scalaris	X	X	Greenberg 1971; Zumpt 1965
Sarcophagidae			
Peckia (*Sarcodexia*) *lambens*		X	Fernandes *et al*. 2009
Sarcophaga (*Liopygia*) *ruficornis*		X	Bernhardt *et al*. 2019
Tricharaea (*Sarcophagula*) *occidua*	X		Greenberg 1973

The quantitative prevalence of females compared to males is a common pattern in studies with dipterans (Marilius *et al*. 1990; Marinho *et al*. 2006; Barbosa *et al*. 2017). However, the significant increase in the number of females after the fair may indicate a greater search for laying sites. This hypothesis is supported by the theory that the increase in ephemeral resources implies the search for a substrate for oviposition and maintenance of breeding sites (Mariconi *et al*. 1999).

Soares *et al*. (2014) in a study carried out at street markets in the city of Petrolina - Pernambuco, found that the disposal and storage of marketed products were inappropriate and deficient, and that such aspects combined with precarious hygiene conditions were decisive in the proliferation of mechanical vectors. Therefore, making the population aware of cleaning fair areas can help control fly species, including highly synanthropic taxa (*e.g*., *M. domestica*). Chavasse *et al*. (1999) reported that controlling the fly population in villages in Pakistan led to a 23% reduction in childhood diarrhea cases. Emerson *et al*. (1999) also showed that control of flies carried out in Gambian villages resulted in a 75% reduction in new cases of trachoma and a 26% reduction in cases of diarrhea.

Thus, we should alert the population to the importance of controlling insects with sanitary significance in urban environments, since chemical management does not

represent an adequate solution, since in addition to not controlling the population of flies effectively and in the long term, the insecticides may contribute to the emergence of resistant strains (Keiding 1999). Alternative techniques have already been presented, such as basic sanitation, sanitary landfill, composting, recycling and selective collection (Dias *et al*. 2014). We demonstrate that the adhesive mousetrap "Cola Rato" can be considered an alternative control method for environments with high human traffic, such as street markets. After carrying out this work, merchants in the collection areas began to use this trap as a way to control the number of flies in their commercial points.

Conclusion

This study demonstrated that large-scale anthropic actions, such as free markets, can interfere with the composition and structure of fly assemblages, favoring synanthropic species of medical and veterinary importance. However, more studies are needed to achieve a greater understanding of this dynamic, especially regarding the role of flies as dispersers of microorganisms, in order to promote effective ways of control, and consequently reduce the transmission and incidence of diseases.

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Literature Cited

Alvares, C.A., Stape, J.L., Sentelhas, P.C., Moraes Gonçalves, J.L. and Sparovek, G. (2013) Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, *22*(6): 711-728.

American Pets (2019) Ratoeira Adesiva Cola Rato. Available in: https://www.americanpets.com.br/ratoeira-adesiva-cola-rato/. Accessed on: 11/10/2020.

Barbosa, T.M., Carmo, R.F.R., Silva, L.P., Sales, R.G. and Vasconcelos, S.D. (2017) Diversity of sarcosaprophagous calyptratae (Diptera) on sandy beaches exposed to increasing levels of urbanization in Brazil. *Environmental Entomology*, *46*: 460-469.

Bernhardt, V., Finkelmeier, F., Verhoff, M.A. and Amendt, J. (2019) Myiasis in humans - a global case report evaluation and analysis. *Parasitology Research*, *118*: 389-397.

Burgess, I. and Davies, E.A. (1991) Cutaneous myiasis caused by the house fly, *Musca domestica*. *British Journal of Dermatology*, *125*: 377-379.

Carmo, R.F.R. and Vasconcelos, S.D. (2016) Assemblage of necrophagous Diptera in Atlantic insular environments and response to different levels of human presence. *Neotropical Entomology*, *45*: 471-481.

Carvalho, C.J.B. and Ribeiro, P.B. (2000) Chave de identificação das espécies de Calliphoridae (Diptera) do Sul do Brasil. *Revista Brasileira Parasitologia Veterinária*, *9*(2): 169-173.

Carvalho, C.J.B. and Mello-Patiu, C.A. (2008) Key to the adults of the most common forensic species of Diptera in South America. *Revista Brasileira de Entomologia*, *52*(3): 390-406.

Chavasse, D.C., Shier, R.P., Murphy, O.A., Huttly, S.R., Cousens, S.N. and Akhtar, T. (1999) Impact of fly control on childhood diarrhea in Pakistan: community randomised trial. *Lancet*, *353*: 22-25.

Dias, L.S., Gabriel Filho, L.R.A. and Guimaraes, R.B. (2014) Evaluation of the impact of selective collection program in the frequency of Calliphoridae and Muscidae in Tupã, São Paulo (Brazil). *Sociedade e Natureza, 26*(1): 127-137.

Emerson, P.M., Lindsay, S.W., Walraven, G.E.L., Faal, H., Bogh, C., Lowe, K. and Bailey, R.L. (1999) Effect of fly control on trachoma and diarrhea. *Lancet, 353*: 1401-1403.

Fernandes, L.F., Pimenta, F.C. and Fernandes, F.F. (2009) First report of human myiasis in Goias state, Brazil: frequency of different types of myiasis, their various etiological agents, and associated factors. *Journal of Parasitology, 95*: 32-38.

Ferreira, M.J.M. (1978) Sinantropia de dípteros muscoideos de Curitiba, Paraná. I: Calliphoridae. *Revista Brasileira de Biologia, 38*: 445-454.

Folgarait, P. (1998) Ant biodiversity and its relationship to ecosystem functioning: A review. *Biodiversity and Conservation, 7*: 1221-1244.

Governo Municipal Toritama. Toritama. 2020. Available in: https://toritama.pe.gov.br/dados-e-caracteristicas/. Accessed in: 11/10/2020.

Greenberg, B. (1971) *Flies and disease: Ecology, classification and biotic association*. New Jersey: Princeton University Press, v. 1, Pp. 57-83.

Greenberg, B. (1973) *Flies and disease: Biology and disease transmission*. Princeton: Princeton University Press, NJ, v. 2, 447 pp.

Guerra, M.P., Oliveira, V.M.D. and Madureira, M.S. (2019) Enterobactérias e estafilococos em moscas capturadas em feira-livre no município de Teixeira de Freitas-BA. *Brazilian Journal of Animal Environmental Research, 2*(3): 1130-1144.

Guimarães, J.H. and Papavero, N. (1999) *Myiasis in man and animals in the Neotropical region*. São Paulo: Plêiade, 308 pp.

James, M.T. (1947) *The flies that cause Myiasis in man*. Government printing office, Washington, D.C. 631. 173 pp.

Kearns, C.A. (2001) North American dipteran pollinators: Assessing their value and conservation status. *Conservation Ecology, 5*: 5.

Keiding, J. (1999) Review of the global status and recent development of insecticide resistance in field populations of the housefly, *Musca domestica* (Diptera: Muscidae). *Bulletin of Entomological Research, 89*(1): 67.

Krüger, R.F., Kirst, F.D. and Souza, A.S.B. (2010) Rate of development of forensically-important Diptera in southern Brazil. *Revista Brasileira de Entomologia, 54*: 624-629.

Linhares, A.X. (1981) Synanthropy of Calliphoridae and Sarcophagidae (Diptera) in the city of Campinas, São Paulo, Brazil. *Revista Brasileira de Entomologia, 25*: 189-215.

Magurran, A.E. (1988) *Ecological Diversity and its Measurement*. Princeton: Princenton University Press. 179 pp.

Mariconi, F.A.M., Guimarães, J.H. and Berti, F.E. (1999) *A mosca doméstica e algumas outras moscas nocivas*. Piracicaba: FEALQ. 135 pp.

Marilius, J.C., Schnack, J.Á., Muzon, J. and Spinelli, G.L. (1990) Moscas Calliphoridae y Mesembrinellidae de Puerto Iguazu. Composicion específica y ecología (Insecta, Diptera). *Graellsia, 46*: 7-18.

Marinho, C.R., Azevedo, A.C.G., Valgode, M.A., Queiroz, M.M.C. and Aguiar-Coelho, V.M.A. (2006) Diversity of Calliphoridae (Diptera) in Reserva Biológica do Tinguá, Nova Iguaçu, Rio de Janeiro. *Brazilian Journal of Biology, 66*(2): 95-100.

Moretti, T.D.C. and Thyssen, P.J. (2006) Miíase primária em coelho doméstico causada por *Lucilia eximia* (Díptera: Calliphoridae) no Brasil: relato de caso. *Arquivo Brasileiro e Medicina Veterinária e Zootecnia, 58*: 28-30.

Moretti, T.D.C., Ribeiro, O.B., Thyssen, P.J. and Solis, D.R. (2008) Insects on decomposing carcasses of small rodents in a secondary forest in Southeastern Brazil. *European Journal of Entomology, 105*: 691-696.

Mulieri, P.R., Patitucci, D., Schnack, J.A. and Mariluis, J.C. (2011) Diversity and seasonal dynamics of an assemblage of sarcophagid Diptera in a gradient of urbanization. *Journal of Insect Science*, *11*: 91.

Nuorteva, P. (1963) Synanthropy of blowflies (Dpt., Calliphoridae) in Finland. *Annales Entomologicae Fennicae*, *29*: 1-49.

Oliveira, D.L. and Vasconcelos, S.D. (2020) Do native and invasive blow fly (Diptera: Calliphoridae) species differ in their preferential time of flight? Empirical evidence from a seasonally dry tropical forest. *Journal of Arid Environments*, *17*: 103985.

Oliveira, V.C., Mello, R.P. and D'Almeida, J.M. (2002) Dípteros muscóides como vetores mecânicos de ovos de helmintos em jardim zoológico, Brasil. *Revista de Saúde Pública*, *36*(5): 614-620.

Paiva, D.P. (1994) Controle integrado de moscas em criações de suínos. *Concórdia: Suinocultura Dinâmica*, *12*: 1-5.

Polvony, D. (1971) *Sinantropy*. *In*: Greenberg, B. *Flies and disease. Ecology, Classification and Biotic Associations*. Princeton, New Jersey: Princeton University Press. v. 1, Pp. 17-49.

Ribeiro, O.B. (1998) Dynamics of equilibrium in experimental populations of *Cochliomyia macellaria* (Dipterta, Calliphoridae). *Revista Brasileira de Entomologia*, *42*(1- 2): 43-51.

Riyaz, A., Riyaz, N. and Anoop, P. (2004) Nasopharyngeal myiasis in anhidrotic ectodermal dysplasia. *Calcutta Medical Journal*, *2*: 7.

Silveira-Neto, S., Nakano, O., Barbin, D. and Villa Nova, N.A. (1976) *Manual de Ecologia dos Insetos.* 1 Edição. São Paulo: Agronômica Ceres, Pp. 419.

Soares, J.M.D., Mendes, M.L.M. and Messias, C.M.B.O. (2014) Feiras livres: avaliação da estrutura física e do comércio. *Revista Baiana de Saúde Pública*, *38*(2): 318-326:

Vasconcelos, S.D., Barbosa, T.M. and Oliveira, T.P.B. (2015) Diversity of forensically-important dipteran species in different environments in northeastern Brazil, with notes on the attractiveness of animal baits. *The Florida Entomologist*, *98*: 770-775.

Vianna, E.E.S., Brum, J.G.W., Ribeiro, P.B., Berne, M.E.A. and Silveira Jr, P. (1998) Synanthropy of Calliphoridae (Diptera) in Pelotas, Rio Grande do Sul State, Brazil. *Revista Brasileira de Parasitologia Veterinária*, *7*: 141-147.

Zumpt, F. (1963) The problem of intestinal myiasis in humans. *South African Medical Journal*, *23*(37): 305-307.

Zumpt, F. (1965) *Myiasis in man and animals in the Old World*. Butterworths. 267 pp.