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Research article

Population and Community Ecology

Assessment of the Abundance and Diversity of Calliphoridae and Sarcophagidae (Diptera) in Sites With Different Degrees of Human Impact in the Iberá Wetlands (Argentina)

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Abstract

The aim of the present study was to explore the diversity and describe the spatial distribution of Calliphoridae and Sarcophagidae along an urbanization gradient in the Iberá Wetlands. The flies were collected at 18 sampling points, three per site. In total, 3,318 flies were collected (3,077 blow flies and 241 flesh flies), distributed in 13 genera and 33 species. Calliphoridae was the most abundant, comprised 92.74% of all adult flies. *Chrysomya albiceps* (Wiedemann), *Cochliomyia macellaria* (F.), *Chrysomya megacephala* (F.), and *Chrysomya putoria* (Wiedemann) were the most abundant species, representing 82.21% of the total sample. The genus *Oxysarcodexia* Townsend was the most diverse with 10 species represented. The abundance of exotic species represents 62.85% of the total sample, showing a reduction toward less disturbed sites. The results of this study indicated that sites with intermediate impact had higher diversity than those where the disturbances are high or absent. Our findings provide the first assessment of Calliphoridae and Sarcophagidae diversity in the area of the Iberá Wetlands.

Key words: anthropogenic impact, biodiversity, calyptratae, human impact, Neotropical region

The blow fly (Calliphoridae) and flesh fly (Sarcophagidae) are considered among the most important and abundant families containing synanthropic species. The term synanthropy indicates the association of a given species with human or human-modified environments (Linhares 1981), including the presence of garbage, sewage, decaying organic matter, and waste of domestic animals (Figueroa-Roa and Linhares 2002). This association may vary geographically or by intrinsic cultural patterns of human settlements, producing different habitat modification processes that affect insect populations in a specific way (Nuorteva 1963).

As necrophagous blow flies and flesh flies are common in human-disturbed habitats, several studies have explored their community patterns along urbanization gradients (Centeno et al. 2004; Esposito et al. 2009, 2010; Ferraz et al. 2009; Sousa et al. 2010, 2011; Patitucci et al. 2011). These studies have shown a loss of diversity in modified areas in comparison with pristine or almost pristine areas, probably related to the local extinction of taxa that were not able to adapt to the new conditions (Sousa et al. 2010). In contrast, some necrophagous fly species seem to be indicators of strongly modified habitats, the so-called eusynanthropic species.

From the medical and veterinary viewpoint, blow flies and flesh flies have relevance because of the existence of myiasic species (Dutto and Bertero 2010, Mulieri et al. 2014, Olea et al. 2014), in addition to necrophagous species used to predict the postmortem interval in forensic entomological research (Oliva 1997, Mariluis 2002). Several works have explored the biodiversity and abundance patterns of fly communities in environments of the Neotropics with different levels of anthropogenic intervention (Ferreira 1978, 1983, Linhares 1981, Baumgartner and Greenberg 1985, Figueroa-Roa and Linhares 2002, Rodrigues-Guimarães et al. 2008, Beltran et al. 2012). In Argentina, these kinds of studies have been performed in the Pampean region (Mariluis and Schnack 1986, 1989), the Paranaense forest (Mariluis et al. 1990), the Subantarctic temperate forest, and the Patagonian steppe (Mariluis and Schnack 1996, Patitucci et al. 2011).

The Iberá system, located in the province of Corrientes, in the northeast of Argentina, represents the largest wetland in this country (Neiff and Neiff 2006). The Iberá basin occupies an extension of about 12,300 km^2 and is situated on the plains of the Paraná River, before this merges its waters with the Paraguay River. This complex system is composed of a wide array of lentic and lotic environments, dominated by marshes, ponds, and swamps with a changing physiognomy due to changes in water levels (Poi de Neiff 2003). It houses a wide variety of terrestrial and freshwater flora and fauna (Arbo and Tressens 2002, Alvarez 2003, Frutos 2003, Poi de Neiff 2003, Zalocar 2003). Biogeographically, this is a complex area where several ecoregions, such as the Paraná Province, the Humid Chaco, and the Espinal Province, converge (Cabrera 1971). This convergence results in a complex structure of landscapes in the Iberá Wetlands, where it is interesting to explore the diversity of calyptrate flies (Dufek et al. 2015).

The spatial diversity patterns of Calliphoridae and Sarcophagidae in the northeast of Argentina, and specifically in the Iberá Wetlands, have not yet been explored. Dufek et al. (2015) provided a single preliminary study where they compiled information and listed the species inhabiting this and the surrounding areas of Corrientes province. In this context, the impact of human activity on the diversity of necrophagous Diptera in the Iberá Wetlands has not been assessed. In this study, we hypothesized that urbanized areas would contain poorer communities of blow flies and flesh flies than undisturbed areas. Therefore, the main aim of this study was to compare the spatial variation of blow fly and flesh fly populations along sites representing different levels of human impact in an urbanization gradient in the Iberá Wetlands. Also, this work describes and compares the diversity of these fly assemblages, and compares the presence of native and cosmopolitan species.

Materials and Methods

Study Area

The study sites were located in the Iberá Wetlands (28° 36′00″ S; 57° 49′00″ W), located in the north central part of Corrientes province. The climate is subtropical and humid with a mean annual temperature of 21–22°C and a mean annual precipitation of 1,500 mm. The relative humidity is higher than 60% throughout the year.

The conservation status of the Iberá Wetlands is relatively good, due to their isolation from major population centers and their relative low coverage of emerging lands (Neiff 2004, Poi and Galassi 2013). However, forestation, rice cultivation, tourism, livestock, and population growth are the main causes of contamination (Canziani et al. 2003). Among these, the breeding of domestic animals, especially cattle, has had a strong influence on the landscape of the Iberá Wetlands (Neiff 2004).

For the purpose of this work, six sites were subjectively characterized into three grades of urbanization, hereafter referred to as habitat: urban (eusynanthropic), rural (hemisynanthropic), and wild (asynanthropic; Nuorteva 1963; Fig.1) . The urban site selected was San Miguel (SM; 27° 59′42.7″ S, 57° 35′25.9″ W), one of the few villages existing in the area. This village has a population of 4,792 inhabitants (Indec 2010), and is characterized by its intense human activity and the presence of pets and exotic vegetation. Sample points within this site were placed in residential gardens.

Two rural sites were selected: Galarza (G; 28° 6′7.5″ S, 56° 40′46.6″ W), a small rural settlement with isolated houses, and El Dorado Farm (ED; 28° 44′25.4″ S, 58° 7′36.4″ W), a cattle establishment, with production of livestock, septic pit, and burial of waste.

Finally, three wild sites were selected: San Nicolás (SN; 28° 10′40.6″ S, 57° 26′50.9″ W), Cambyretá (C; 27° 52′6.3″ S, 56° 52′49.6″ W), and Capitá Miní (CM; 28° 56′23″ S, 58° 22′22.6″ W). These sites have neither human influence nor presence of livestock.

Trapping Methodology

Samplings were carried out during the warmer months, from November 2012 to October 2014. In total, 18 sampling points (three per site) were selected. Flies were collected using Van Someren-Rydon canopy traps (Rydon 1964), placed under trees in gardens of the urban site and in forests of the rural and wild sites. Each trap was alternatively baited with one of the two different types of bait used: 150 g of rotten bananas with yeast and 150 g of rotten squid. Both bait types were simultaneously placed at each capture point, totaling three sample units (sample unit = one trap with banana + one trap with squid) per site. All traps were exposed for a period of 48 h, with two events of specimen removal per day, the first at 1100–1200 hours and the second at 1600–1700 hours.

Identification

The identification of blow flies was based on keys and descriptions provided by Rognes and Paterson (2005), Silva et al. (2012), Olea and Mariluis (2013), Irish et al. (2014), Mulieri et al. (2014), and Whitworth (2014), whereas that of flesh flies was based on the keys of Lopes and Tibana (1987), Mulieri et al. (2010), Vairo et al. (2011), Buenaventura and Pape (2013), and Mello-Patiu et al. (2014). The identification was also supported by comparison with reference specimens deposited at the MACN. In the case of sarcophagid specimens, only the males were taken into account for the analysis. In such cases, their phallic structures were exposed using the technique described by Dahlem and Naczi (2006), after keeping the specimen in a moist container for 24 h. Voucher specimens are housed at the Universidad Nacional del Nordeste, Corrientes, Argentina (UNNE), and Museo Argentino de Ciencias Naturales "Bernardino Rivadavia," Buenos Aires, Argentina (MACN).

Data Analysis

The α diversity was calculated for each sample point, and analyzed using different indices, including the Shannon–Wiener (H), equitability (Shannon J'), and Simpson's dominance (D; Magurran 2004). The combined application of these indices is considered by several authors to better understand the diversity and the structure of communities (Staddon et al. 1997, Ovreas and Torsvik 1998).

The comparisons of Shannon–Wiener (H) diversity and abundance (at family or specific level) between different sites were assessed by means of one-way analysis of variance (Tukey test) using the program PAST version 3.0 (Hammer et al. 2001) considering $P < 0.05$ significance level. In addition, a Synanthropy index (SI) (Nuorteva 1963) was calculated for dominant species. This value varies from +100 to −100, and the highest value is the highest degree of association with humans, while the negative value indicates aversion to human environments. To calculate the SI regardless of the sampling effort made in each type of habitat, the total Diptera captured in each habitat type was divided by the number of sites sampled in this habitat.

We used indicator species analysis (followed by a Monte Carlo permutation test with 1,000 permutations) to identify the most important indicator species between each site type. Indicator species were selected by calculating their indicator value, which is the product of the relative abundance of a species and the relative frequency of that species at a site. Indicator values range from 0 (no indication) to 100 (perfect indication; Dufrêne and Legendre 1997).

The similarity in species composition between the different locations and types of habitat was analyzed using nonmetric multidimensional scaling (NMDS), using the Bray–Curtis index as a measure of similarity (Legendre and Legendre 1998). The distortion

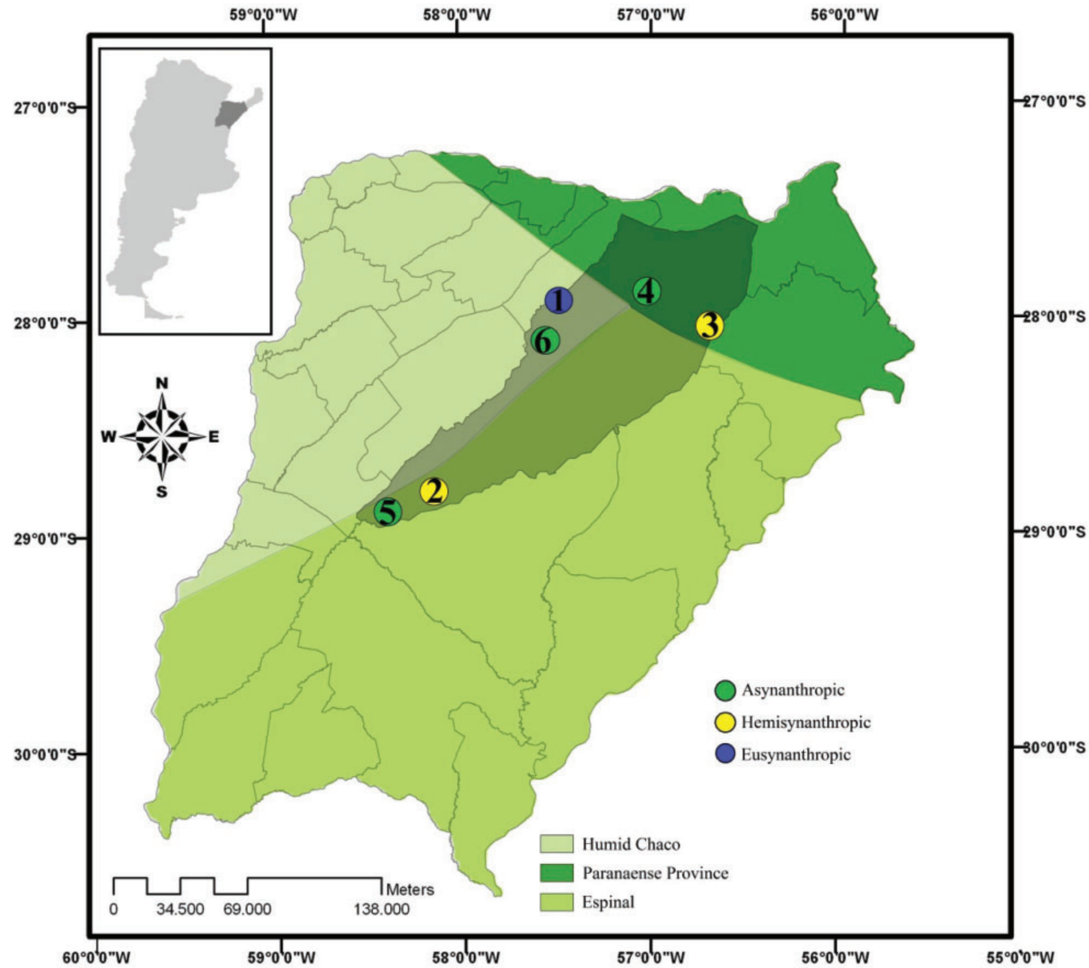

Fig. 1. Map of Corrientes province (Argentina) and its ecoregions. Adapted from Cabrera (1971). Locations of samples (sites): 1 San Miguel, 2 El Dorado, 3 Galarza, 4 Cambyretá, 5 Capitá Miní, and 6 San Nicolás (Online figure in color).

of the resolution of the two-dimensional arrangement is represented by a stress value (S). This analysis was performed using the program PRIMER version 5 (Clarke and Gorley 2001).

Results

In the overall sample, individuals of Calliphoridae outnumbered those of Sarcophagidae. In total, 3,318 specimens were captured, of which 3,077 belonged to blow flies and 241 to flesh flies (Table 1). The largest percentage of individuals was collected in wild sites (43.6%), followed by the urban (35.6%) and rural (20.7%) sites.

Among all sites, SM had the highest abundance (35.7% of flies; Table 1). Considering the total abundance of Calliphoridae across all study sites, the dominant species was *Chrysomya albiceps* (Wiedemann) (31.9%), followed by *Cochliomyia macellaria* (F.) (25.5%), *Chrysomya megacephala* (F.) (18.2%), and *Chrysomya putoria* (Wiedemann) (14.8%). These species accounted for 82.2% of all individuals collected considering both families. Regarding Sarcophagidae, the most abundant species was *Oxysarcodexia thornax* (Walker) (24%), followed by *Peckia* (*Peckia*) *enderleini* (Engel) (15.3%). *Oxysarcodexia* Townsend was the genera with the highest richness (10 species).

The proportional abundance of exotic species reached values of 40–50% in all the sites studied, except in the urban site (SM), where cosmopolitan calliphorids exceeded 90% of the specimens (Fig. 2). At the urban site, both *Ch. megacephala* and *Ch. putoria* were dominant species, but their abundance decreased toward less disturbed sites. Conversely, in rural and wild sites, one of the most abundant species was the exotic *Ch. albiceps*.

Among the sites studied, SN, C, and SM recorded the lowest diversity, while G, CM, and ED presented the highest diversity (Table 2). The highest species richness was obtained at site G, where 23 of the 33 identified species were captured. The results obtained indicate significant differences in diversity (H) among sites ($F_{5,12} = 5.787$, $P < 0.006$; Fig. 3).

Fly abundance was significantly different among the sites for Calliphoridae ($F_{5,12} = 14.02$, $P < 0.0001$) and Sarcophagidae ($F_{5,12} = 20.18$, $P < 0.00001$). However, a noticeable fluctuation was observed between sites within a disturbance category.

Five abundant species, all belonging to Calliphoridae, were analyzed individually to test whether their abundance was independent of the site. *Chrysomya megacephala* ($F_{2,6} = 27.25$, $P < 0.0009$) and *Ch. putoria* ($F_{3,8} = 30.07$, $P < 0.0001$) were most abundant at the urban site (SM), with very few specimens captured in the rural or wild sites, whereas *Chloroprocta idioidea* (Robineau Desvoidy) ($F_{3,8} = 42.59$, $P < 0.00002$) exhibited higher captures in the rural

Table 1. Abundance of Calliphoridae and Sarcophagidae species captured at urban, rural, and wild sites between November 2012 to October 2014 in the Iberá Wetlands of Argentina

	Urban/Eusynanthropic	Rural/Hemisynanthropic		Wild/Asynanthropic			
Species	SM	ED	G	C	CM	SN	Total
Calliphoridae							
Chrysomya albiceps E	65	14	254	494	18	139	984
Cochliomyia macellaria N	17	13	56	538	4	98	726
Chrysomya megacephala E	552	0	2	8	0	0	562
Chrysomya putoria E	439	0	4	7	0	6	456
Chloroprocta idioidea N	0	2	203	0	2	10	217
Lucilia ochricornis N	6	1	12	40	4	11	74
Lucilia curpina N	38	0	0	1	0	0	39
Lucilia eximia N	0	0	2	6	0	2	10
Chrysomya rufifacies E	3	0	1	1	0	0	5
Cochliomyia hominivorax N	0	0	2	0	0	1	3
Calliphora lopesi N	0	0	0	1	0	0	1
Sarcophagidae							
Oxysarcodexia thornax N	30	2	23	3	0	0	58
Peckia (*P.*) *enderleini* N	7	2	6	19	0	3	37
Oxysarcodexia terminalis N	0	0	22	0	7	0	29
Ravinia advena N	3	0	23	0	0	0	26
Oxysarcodexia paulistanensis N	18	1	1	3	0	1	24
Oxysarcodexia admixta N	4	4	3	1	1	1	14
Oxysarcodexia culmiforceps N	0	5	1	2	0	1	9
Oxysarcodexia avuncula N	0	0	4	0	4	0	8
Oxysarcodexia meridionalis N	0	0	5	1	0	0	6
Peckia (*P.*) *resona* N	0	5	0	1	0	0	6
Peckia (*S.*) *lambens* N	1	4	1	0	0	0	6
Oxysarcodexia confusa N	0	2	0	2	0	0	4
Peckia (*E.*) *australis* N	1	1	0	0	1	0	3
Oxivinia excsisa N	0	0	1	1	0	0	2
Peckia (*E.*) *pascoensis* N	0	1	0	1	0	0	2
Blaesoxipha sp	0	0	1	0	0	0	1
Dexosarcophaga sp	0	0	0	0	0	1	1
Helicobia morionella N	0	1	0	0	0	0	1
Oxysarcodexia sp 1	0	0	0	1	0	0	1
Oxysarcodexia riograndensis N	0	0	0	1	0	0	1
Udamopyga sp 1	0	0	1	0	0	0	1
Udamopyga sp 2	0	0	1	0	0	0	1
Richness	14	15	23	21	8	12	33
Total site	1,184	58	629	1,132	41	274	3,318
Total environment	1,184	687		1,447			3,318

Flies were captured in 18 sampling points (three per site) using Van Someren–Rydon traps. Rotten bananas with yeast and rotten squid were used as bait. The traps were exposed for 48 h in each site. Richness: total number of species.

SM, San Miguel; ED, El Dorado; G, Galarza; C, Cambyretá; CM, Capitá Miní; SN, San Nicolás; E, Exotic; N, Native.

sites. Conversely, *Ch. albiceps* ($F_{5,12} = 7.02$, $P < 0.002$) and *Co. macellaria* ($F_{5,12} = 7.16$, $P < 0.002$) were more abundant in wild sites (Fig. 3).

The SI was calculated for the 13 dominant species (Table 3). This index classified *Ch. megacephala*, *Lucilia cuprina* (Wiedemann), *Ch. putoria*, *Oxysarcodexia paulistanensis* (Mattos), *O. thornax*, and *Ravinia advena* (Walker) as species associated with urban settlements, *Oxysarcodexia admixta* (Lopes), *Chl. idioidea*, *Oxysarcodexia terminalis* (Wiedemann), and *P.* (*P.*) *enderleini* as species associated with moderately anthropogenic sites, and *Ch. albiceps*, *Lucilia ochricornis* (Wiedemann) and *Co. macellaria* as species associated with wild locations.

The indicator species analysis was able to detect a single indicator of hemisynanthropy and five of eusynanthropy. *Chloroprocta idioidea* was the only significant indicator species of the rural or hemisynanthropic sites, while *Ch. megacephala*, *Ch. putoria*, *L. cuprina*, *O. paulistanensis*, and *O. thornax* were indicator species of urban or eusynanthropic sites (Table 4). No indicator species of wild or asynanthropic sites were detected. In general terms, the NMDS plot separates two assemblages of flies (Fig. 4). This analysis suggests that the samples obtained in the urban site (SM) form a well-differentiated sample group. On the other hand, the rural sites (G and ED) and wild sites (SN, CM, and C) formed a single group of samples that did not differ greatly in their community composition. The relatively low S value (0.11) indicates a good representation of the overall variance.

Discussion

The biodiversity of Argentina has declined in several regions due to land conversion for agriculture, forest extraction, industrialization, and urban growth (Medan et al. 2011). Indeed, several factors

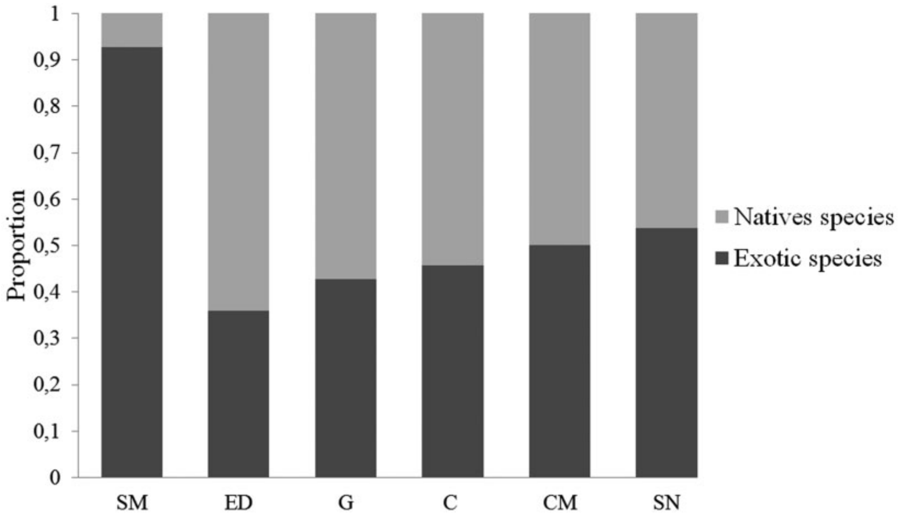

Fig. 2. Proportional species abundance for native and exotic blow fly and flesh fly communities captured at each of six localities spanning urban (SM, San Miguel), rural (ED, El Dorado; G, Galarza), and wild (C, Cambyretá; CM, Capitá Miní; SN, San Nicolás) human disturbance zones between November 2012 to October 2014 in the Iberá Wetlands of Argentina.

Table 2. Diversity indices and standard deviation for blow fly and flesh fly communities at each of the six localities sampling surveyed between November 2012 to October 2014 in the Iberá Wetlands of Argentina

Localities	Simpson	Shannon	Equitability
SM	0.382 (0.004)	1.294 (0.052)	0.532 (0.013)
ED	0.177 (0.035)	1.935 (0.064)	0.891 (0.099)
G	0.314 (0.126)	1.624 (0.400)	0.610 (0.145)
C	0.463 (0.087)	1.074 (0.232)	0.435 (0.070)
CM	0.302 (0.111)	1.364 (0.207)	0.892 (0.145)
SN	0.375 (0.065)	1.206 (0.205)	0.633 (0.100)

Sites in study correspond to an urban center (SM), two rural sites with half intervention (ED and G), and three native forests (C, CM, and SN).

SM, San Miguel; ED, El Dorado; G, Galarza; C, Cambyretá; CM, Capitá Miní; SN, San Nicolás.

critical for blow flies and flesh flies, such as availability of larval breeding substrates, or flowering plants as nectar sources for adults, change greatly between sites with different levels of human impact. Because of the importance of blow flies and flesh flies in ecological, medical, and forensic aspects, it is very important to know their patterns of distribution and diversity occurring in a particular area. This study showed differences in calliphorid and sarcophagid assemblages in response to human modification of the environments.

The anthropogenic alteration of environments has dramatic effects on the Calyptratae community (Nuorteva 1963), and these changes may affect the distribution and abundance of individual species directly as well as indirectly by altering the microclimate (Kavazos and Wallman 2012). Another key question is that such disturbing processes promote the establishment of exotic species. In the Iberá Wetlands, only two assemblages of species were detected: one strongly associated with urban settlements and the other inhabiting pristine woods and forested rural areas.

The level of disturbance present in the rural areas assessed (i.e., the intermediate areas of the gradient) seems not to be as drastic, because our data indicate that it allows the existence of native fly communities enriched with exotic elements, most probably due to the existence of habitable conditions for both types of species. In fact, our results indicate that the sites with moderate human impact (G and ED) reached higher values of richness and diversity than the wild areas. This pattern of diversity peaking in the intermediate condition may be related to the intermediate disturbance hypothesis (Connell 1978).

Changes caused by man have negative impacts on biodiversity, causing the extinction of species by loss of suitable habitats (Faeth and Kane 1978). Specifically, the anthropogenic alteration of environments seems to have dramatic effects in the case of species associated with less modified environments, such as *Lucilia eximia* (Wiedemann), *Paralucilia pseudolyrcea* (Mello), and *Sarconesia chlorogaster* (Wiedemann) (Mariluis and Schnack 1986, Schnack et al. 1995, Rodrigues-Guimarães et al. 2008).

In contrast, human activities also create patches of new habitat that can be exploited by species such as *Ch. megacephala*, *Ch. putoria*, *L. cuprina*, *L. sericata* (Meigen), *Oxysarcodexia culmiforceps* Dodge, and *O. paulistanensis*, which are able to colonize these new habitats (Mariluis and Schnack 1989, Mulieri et al. 2011). This study showed that the urban environment has low richness, suggesting that only some species, such as *Ch. megacephala* and *Ch. putoria*, can persist successfully and colonize highly disturbed sites. Although human activity can facilitate dispersion of exotic species, blow flies can disperse for long distances, including throughout non-preferred habitats (Macleod and Donnelly 1960, Mangan and Thomas 1989). This characteristic may explain the relative higher presence of exotic species at SN (wild site) in comparison with other wild sites surveyed. The distance between SN (wild) and the urban center surveyed of SM is 30 km. Thus, the urban center may influence the presence of synanthropic flies in other habitats types in its closer surroundings. At this point, the information obtained for synanthropic species must be further corroborated with similar studies in the northeast of Argentina, as SM was the only urban center available to be sampled in the Iberá Wetlands.

The modification of the natural environment by urbanization involves an increase in the number of exotic species and a decrease in the number of native species (Denys and Schmidt 1998, McIntyre 2000). In the Iberá Wetlands, the proportional abundance of exotic

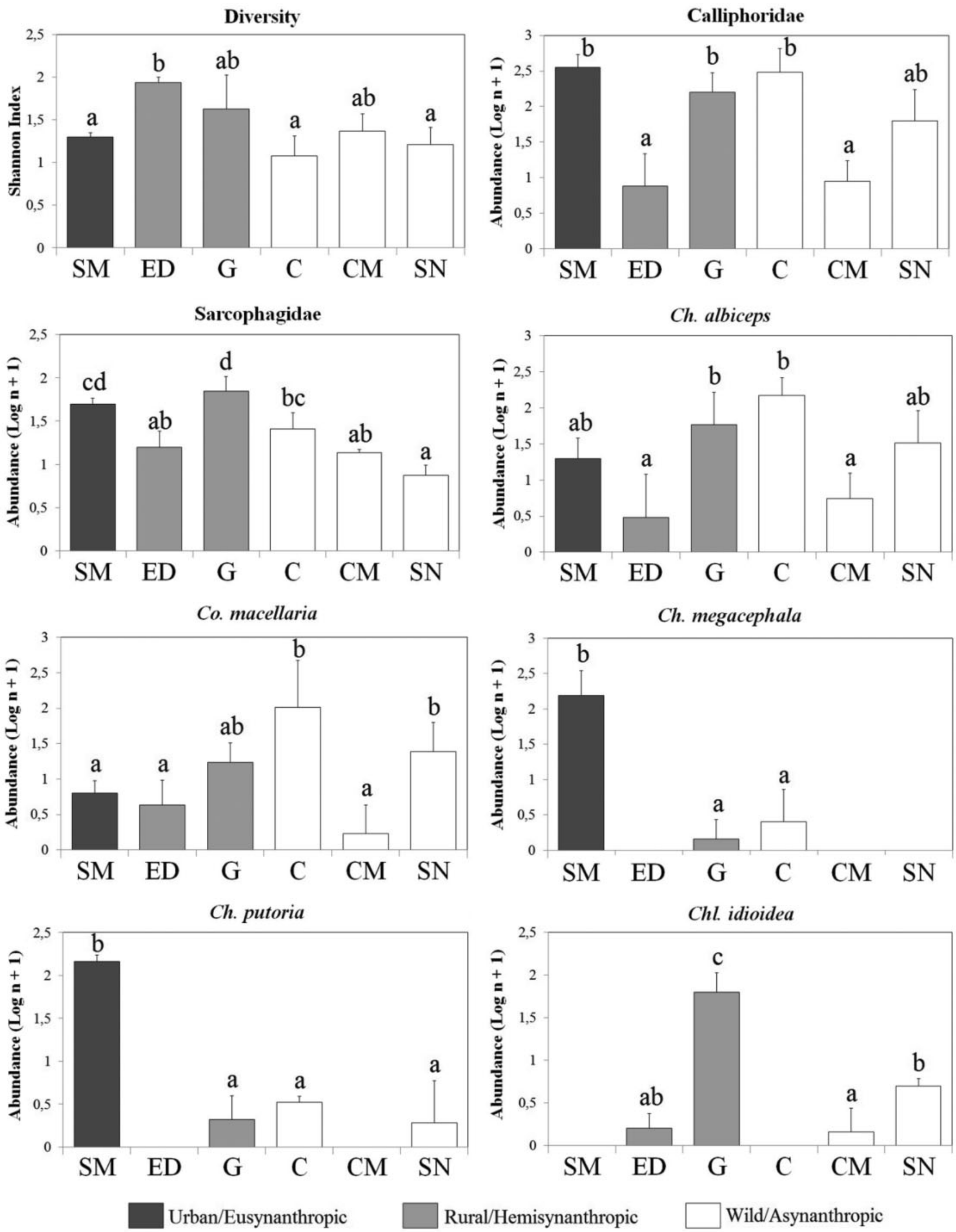

Fig. 3. Species diversity and proportional abundance of Calliphoridae and Sarcophagidae and dominant species collected in urban (SM), rural (ED and G), and wild (C, CM, and SN) habitats between November 2012 to October 2014 in the Iberá Wetlands of Argentina. Different letters above the bars indicate significant differences (Tukey test, alpha = 0.05).

species of Calliphoridae was relatively high in both assemblage types, with 40–50% in the "rural-wild" sites and >90% in the urban center. This result indicates that the current communities of carrion flies are strongly modified from the original native fauna. As documented in this study, virtually all the sites surveyed presented high abundance of *Ch. albiceps*. A similar trend has been found previously in urban gradients studied in the southern extreme of South America, whose blow fly communities are dominated by the

Table 3. SI calculated for dominant Calliphoridae and Sarcophagidae species collected between November 2012 to October 2014 in the Iberá Wetlands of Argentina

Species	SI	Significance of the index
Chrysomya megacephala	98.95	Strong preference for human settlements
Lucilia cuprina	98.28	Strong preference for human settlements
Chrysomya putoria	97.83	Strong preference for human settlements
Oxysarcodexia paulistanensis	84.46	Strong preference for human settlements
Oxysarcodexia thornax	81.03	Strong preference for human settlements
Ravinia advena	60.34	Strong preference for human settlements
Oxysarcodexia admixta	55.89	Preference for human settlements
Chloroprocta idioidea	43.92	Preference for human settlements
Oxysarcodexia terminalis	23.78	Preference for human settlements
Peckia enderleini	9.11	Preference for human settlements
Chrysomya albiceps	−20.42	Preference for uninhabited areas
Lucilia ochricornis	−29.44	Preference for uninhabited areas
Cochliomyia macellaria	−67.61	Preference for uninhabited areas

SI for the most abundant species collected in environments with different degrees of human impact (urban–rural–wild) in Iberá Wetlands. The SI ranges from+100 (species totally synanthropic) to −100 (species totally wild).

Table 4. Significant indicator species identified for hemisynanthropic and eusynanthropic sites between November 2012 to October 2014 in the Iberá Wetlands of Argentina (Monte Carlo test, alpha = 0.05)

Indicator site	Species	Indicator value	Mean	SD	*P*
H	*Chloroprocta idioidea*	79.7	40.5	15.31	0.026
E	*Chrysomya megacephala*	99.3	32.7	14.85	0.001
E	*Chrysomya putoria*	98.6	40.2	15.46	0.001
E	*Lucilia cuprina*	99.1	26.3	13.26	0.002
E	*Oxysarcodexia paulistanensis*	90	32.5	13.83	0.001
E	*Oxysarcodexia thornax*	69	36.7	12.12	0.021

SD, standard deviation; H, hemisynanthropic; E, eusynanthropic.

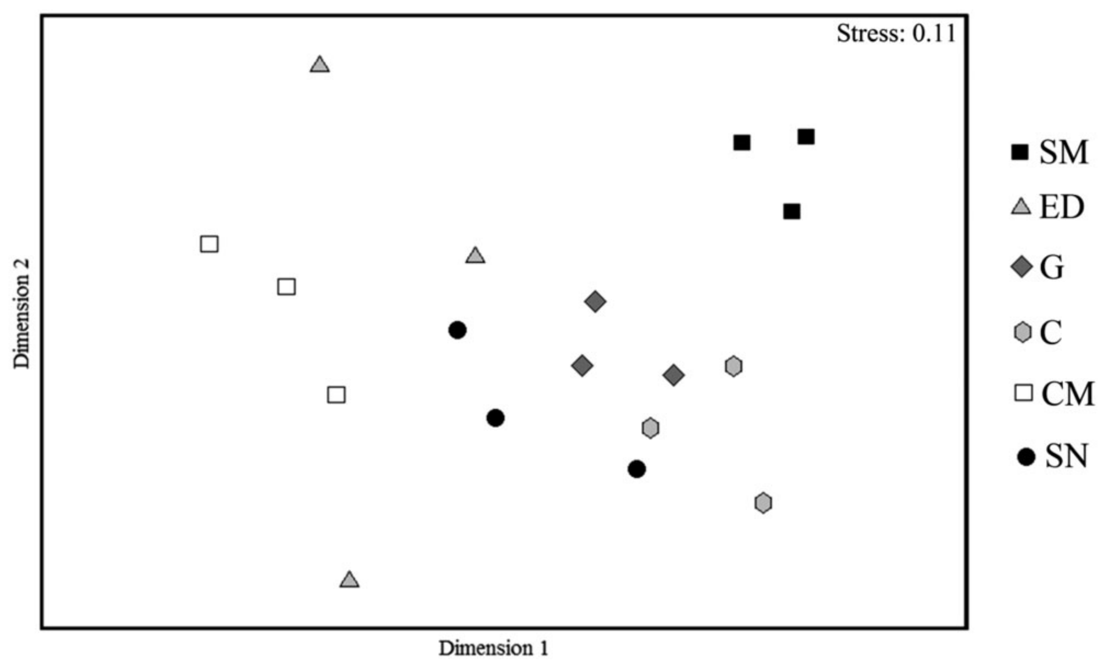

Fig. 4. Species composition NMDS of the blow flies and flesh fly communities at 18 sampling points located in the Iberá Wetlands, Argentina. The plot represents six localities in three types of environments: urban (SM, San Miguel), rural (ED, El Dorado; G, Galarza), and wild (C, Cambyretá; CM, Capitá Miní; SN, San Nicolás). This showed two assemblages of flies: eusynanthropic (SM) and hemisynanthropic + asynanthropic (ED + G + C + CM + SN).

nonnatives *L. sericata*, *Calliphora vicina* Robineau-Desvoidy, and *Protophormia terraenovae* (Robineau-Desvoidy) (Mariluis et al. 2008, Patitucci et al. 2011).

This study documented that species, such as *Ch. megacephala*, *Ch. putoria*, and *L. cuprina* among calliphorids, and *O. paulistanensis* and *O. thornax* among sarcophagids, were predominantly captured in the human-modified habitat sites in the Iberá system, and act as good species indicators of strongly urbanized areas. This agrees with the results obtained by the SI. The present results highlight the importance of assessing the abundance and diversity of fly communities in sites with different degrees of human impact.

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