

Synanthropy of Calliphoridae and Sarcophagidae (Diptera) in Bogotá, Colombia

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Abstract

Calliphoridae and Sarcophagidae have medical and forensic importance. Species of these families are the first insects colonizing corpses and are, therefore, useful in establishing postmortem interval and as indicators in corpse transfer. The synanthropic index (SI) measures the relation of dipteran species with human settlements. Our main objective was to determine the synanthropic index of these families during the rainy and dry seasons in Bogotá. Captures were carried out using traps with baits (beef liver) in three zones (urban, rural, and forest areas). In the family Calliphoridae, the most abundant species were *Calliphora vicina* (Robineau-Desvoidy) with a sinanthropy index (SI) of +83.1, followed by *Lucilia sericata* (Meigen) (SI=+92.2) and *Comptosomyiops verena* (Walker) (SI=+42.0). *Calliphora nigribasis* (Macquart) was not associated with human settlements, while *Sarconesiopsis magellanica* (Le Guillou) was present in the three zones and considered hemisynanthropic (SI=+19.0). *Roraimomusca roraima* (Townsend) was reported for the first time in Bogotá and was a non-synanthropic species (SI=−36.0). On the other hand, in Sarcophagidae, three species were collected: *Ravinia rufipes* (Twonsend), *Ravinia colombiana* (Lopes), and *Boettcheria* sp1, which were abundant in the rural and forest zones, the first having a dual characterization as synanthropic and hemisynanthropic, while the other two were hemisynanthropic. Our data showed differences in the association of Calliphoridae species with the three environments, whereas Sarcophagidae were distributed in locations with a lower human impact.

Introduction

The family Calliphoridae has approximately 1,000 species worldwide, of which 126 are found in the Neotropical region (Amorin *et al* 2002). Calliphoridae biology is varied: in general, they are sarcosaprophagous, but there are also predators and parasitoids (Amat & Wolff 2007). In addition, the family Sarcophagidae is one of the most diverse in Diptera, with more than 400 genera and more than 2,600 species. In turn, approximately 750 species are known to the tropical fauna. Larvae from these flies develop in decomposing organic matter. Some of them are parasites of vertebrates and invertebrates (Carvalho 2005). Additionally, species of these two families are the first to

colonize decomposing corpses and the occurrence of some of them could also indicate a possible corpse transfer (Figueroa & Linhares 2002).

The synanthropic index measures the relation of dipteran species that are confined to conditions of human settlements. Among the families that have synanthropic species, Calliphoridae is one of the most important, followed by Sarcophagidae and Muscidae, due to the high association with humans by feeding and developing on sewage, garbage, decomposing materials, and corpses of various kinds of animals (Figueroa & Linhares 2002). Studies have been made to determine the synanthropic index in Finland (Nuorteva 1963), the United States of America (Povolný 1971), Brazil (Rodrigues-Guimarães *et al* 2008), Argentina

(Centeno *et al* 2004), Peru (Baumgartner & Greenberg 1985), and Chile (Figueroa & Linhares 2002). These studies have been important due to their forensic applications, but very few data is available for Colombia.

Bogotá is a city with a large territorial extension divided into 20 localities that present specific abiotic conditions (temperature, height, and moisture) and population densities, with one of the highest mortality indexes in Colombia due to homicides, with a rate in 2010 of 21.8 for 100,000 inhabitants (Gomez 2011). Therefore, it is necessary to have data corresponding to the species of the families Calliphoridae and Sarcophagidae in the various zones of the city, as the presence of particular species in a given place may help to determine if a corpse was transferred from one area to another (Tabor *et al* 2005). This study was conducted during both the rainy and dry seasons, with the purpose of determining the sinanthropy index of Calliphoridae and Sarcophagidae of forensic importance in Bogotá D.C., Colombia.

Material and Methods

The city of Bogotá D.C. (4°36'43"N; 74°04'07"W) is located at 2,600 m asl at the geographical center of the country. It is the highest plain of the Colombian Andes and is surrounded by a mountain range that is part of the Eastern mountain chain. The hills around the city determined its initial urban development from south to north, parallel to the mountain line of which Guadalupe and Monserrate hills are part (Corradine 2002).

Dry and rainy periods alternate during the year, with the driest months being from December to March, and the rainiest from April to May and from September to November. June and July usually have little rain and August is sunny and windy (Ideam 2008). Three zones with different ecological and population characteristics were selected as study areas: urban, rural, and wild, based on their rainy and dry periods.

The urban zone was characterized as having a high transition degree by humans, with a lot of houses around it. Captures were made on the terrace of a house in a residential sector in the neighborhood of Bachué, in the locality of Engativá, having an extension of 3,612 ha, average temperature of 14°C and average altitude of 2,400 m asl (4°42'2.45"N; 74°6'49.74"W) (Corradine 2002). The area is characterized as having air pollution, water contamination, noisy conditions, and poor waste disposal. This environment attracts pests that contribute to affect the health of local people (Garzón 2008).

The rural zone was characterized as having low human density, with some neighboring houses. Captures were made in the high part of the Macarena campus of the

Universidad Distrital, located at an average altitude of 2,700 m asl (4°36'49.40"N; 74°3'46.65"W) and an average temperature of 15°C, which corresponds to the locality of Santafé. This zone is characterized as having eroded soils, in addition to deforestation of the hills. Streams are sedimented and contaminated (Duarte & Quitán 2009).

The forest zone has a lower human intervention and is characterized as a well-preserved forest environment, but streams are contaminated by solid wastes. Captures were made in the high area of the Parque Nacional which belongs to the locality of Chapinero at 2,800 m asl (4°37'8.90"N; 74°3'27.73"W) and an average temperature of 14°C (Rico & Ramírez 2007).

The collections were made over period of 1 year from January 2009 to February 2010. Each collection was performed between 10:00 and 12:00 h, Monday through Sunday every 2 days. A period of 96 h was considered to correspond to each zone. Sixteen sampling per month were carried out, with a total of 48 collections per zone. Flies were caught with traps designed by Ferreira (1978, 1983) and Linhares (1981). Briefly, a black container with holes at the bottom (to allow the access of flies) was used. A piece of liver was placed as bait on a cone with an opening at the top and a veil over it (in which flies were caught). Six traps were located in each zone, a total 18 traps with 500 g of pig liver used as bait, which was replaced twice a week every 3 days. Traps were left in each zone for 3 months each during the dry period (January, February, and March) and rainy period (September, October, and November).

Flies were also collected by placing beef liver in the open air on the ground surface for 3 h everyday and were caught using entomological nets. A period of 270 h was considered to correspond to each zone. Thirty sampling per month were carried out, with a total of ninety collections per zone during the dry period (January, February, and March), and rainy period (September, October, and November). Insects were collected and preserved in 80% ethanol for later identification using the keys of Amat (2008), Mariluis & Schnack (1989), Carvalho & Ribeiro (2000), Buenaventura *et al* (2009).

The synanthropic index for each species of fly captured was calculated following Nuorteva's formula (1963): $SI = (2a + b - 2c) / 2$ where a =the percentage of fly species in dense human settlement, b =the percentage of the same fly species in sparsely human inhabited place, and c =the percentage of the same fly species in human uninhabited area. 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 (Figueroa & Linhares 2002).

Statistical analyses

The results were analyzed using analysis of variance (ANOVA), and averages compared by using the Fisher test with $CI=95\%$ and $P<0.05$ or the t test with $CI=99\%$ and $P<0.008$ ($df=3$), using the online program ANOVA Calculator—One-Way ANOVA from Summary Data and SISA home (Soper 2004).

Additionally, a multiple correspondence analysis (MCA) was performed to observe the independent and dependent relations among the insects collected and the three sampled zones (urban, rural, and wild), the analysis of which was done using a data base created in SPAD (SPAD v.4.5).

Results and Discussion

A total of 3,951 specimens of Calliphoridae belonging *Lucilia sericata* (Meigen), *Calliphora vicina* (Robineau-Desvoidy), *Sarconesiopsis magellanica* (Le Guillou), *Calliphora nigribasis* (Macquart), *Cosmomyiops verena* (Walker), and *Roraimomusca roraima* (Townsend) were collected. In relation to Sarcophagidae, 236 specimens were collected, belonging to *Boettcheria* sp1, *Ravinia rufipes* (Twonsend), and *Ravinia columbiana* (Lopes) (Table 1).

A higher number of individuals were found in the rural and urban zones (40.4% and 48.4%) than in the forest zone (10.7%). The highest number of Sarcophagidae was collected during the rainy season. The abundance in the rural zone (64.8%) was significantly higher than in the other areas ($F=40.22$; $P=0.000$). Differently, in Brazil, Carvalho & Linhares (2001) determined that the highest abundance of species and individuals of Sarcophagidae were found in the forest zone.

The family Calliphoridae was the most abundant (93.7%) ($F=1.41$; $P=0.001$), and it was found in both periods of the year and in the three sampled zones. Calliphoridae and Sarcophagidae have been reported as the most abundant and important dipterans in forensic studies (Couri *et al* 2000, Leandro & D'Almeida 2005).

Rural and forest zones showed the highest abundance of species collected in the two families during the dry period (Table 1). Data on species diversity are contradictory, with some reporting most of the species in the forest zone (Centeno *et al* 2004), while others in environments modified by humans (Vianna *et al* 1998). Such discrepancies may be due to the variability in the distribution of the species from one place to another and from one country to another, which are given by the characteristics of each place that allow complex ecological interactions among organisms, such as competence and niche differentiation (Hwang & Turner 2005).

Table 1 Absolute and relative frequency of Calliphoridae and Sarcophagidae species in the urban, rural, and wild sampling areas in Bogotá—Colombia during the rainy and the dry periods of 2009–2010.

Period	Zone	Species												Total							
		<i>C. vicina</i>		<i>L. sericata</i>		<i>S. magellanica</i>		<i>C. verena</i>		<i>C. nigribasis</i>		<i>R. roraima</i>				<i>R. rufipes</i>		<i>Boettcheria</i> sp. n		<i>R. columbiana</i>	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	Urban	534	65	434	73	40	10	31	18	0	0	0	0	14	13	0	0	0	0	1,053	47.58
	Rural	240	30	158	27	260	63	105	62	0	0	10	40	55	53	12	35	0	0	904	40.85
	Wild	38	5	0	0	113	27	33	20	64	100	15	60	35	34	22	65	0	0	256	11.57
Rainy		812	100	592	100	413	100	169	100	64	100	25	100	104	100	34	100	0	0	2,213	100
	Urban	465	89	424	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	889	45.00
	Rural	60	11	0	0	243	61	257	100	195	75	25	50	74	100	0	0	22	100	846	43.00
	Wild	0	0	0	0	158	39	0	0	64	25	25	50	0	0	22	100	0	0	239	12.00
		525	100	424	100	401	100	257	100	0	0	50	100	74	100	22	100	22	100	1,974	100.00%

Does not show statistically significant differences ($P=0.44$; $F=0.54$).

Calliphora vicina was the most abundant species in the two periods of the year, with 1,337 individuals sampled. During the rainy period, *C. vicina* was not found in the forest zone, but was recorded in all three environments in the dry period. It was most abundant in the urban zone (Table 1), as also observed by Figueroa & Linhares (2002). However, it was recorded as the least abundant species in Pelotas—Brazil (Vianna et al 1998). But the high synanthropic index (SI) (+83.1) observed in here for this species during both the rainy (+94.3) and dry periods (+75.9), strongly indicates *C. vicina* as a synanthropic species (Table 2). SI values observed for this species followed a similar trend to those that have been observed by others in different localities (Figueroa & Linhares 2002, Gabre et al 2003).

A large number of the 1,016 specimens of *L. sericata* sampled were collected during the dry period, indicating the higher abundance of this species in the summer, as already reported (Figueroa & Linhares 2002, Tabor et al 2005). *Lucilia sericata* was highly abundant in the urban zone, both during the dry and rainy period, and was absent in the rural zone during the rainy months (Table 1). It had an average SI of +92.2, ranging from +86.6 in the dry period to +100 in the rainy period, showing a strong association with human settlements (Table 2), as already reported (Figueroa & Linhares 2002, Schnack et al 1995).

The occurrence of *L. sericata* was shown to decrease significantly in the coldest months (Figueroa & Linhares 2002), while *C. vicina* increased. Other studies stated that the temporal separation of ecological niches between *C. vicina*, and *L. sericata* explain their possible and continuous coexistence due to the resources available in those periods (Mariluis & Schnack 2002, Figueroa & Linhares 2002). In Bogotá, both species were present throughout the two periods of the year, showing a higher dominance over the

other species. Besides, they exhibited higher frequency in the urban zone, which is in accordance with what was observed in Pelotas, Brazil, where there was also preference of *L. sericata* and *C. vicina* for urban zones (Vianna et al 1998).

Sarconesiopsis magellanica was abundant during cold and rainy months (Table 1). Segura et al (2009) reported it in the rural zone in Usaquén in Bogotá, corresponding to the first species colonizing decomposing corpses. In the present study, *S. magellanica* represented 61% of the collected flies in the rural zone in the rainy period, and it was not found in the urban zone (Table 1). The SI obtained (Table 2) were in accordance with those obtained in Bariloche, Argentina (Mariluis & Schnack 1996), in where this fly is considered as hemisynanthropic. However, *S. magellanica* has been characterized as synanthropic in Peru (Baumgartner & Greenberg 1985, Amat 2009).

Calliphora nigribasis was the most representative species of the rural zone, with negative SI values and it was considered asynanthropic (Table 2), as indicated by Centeno et al (2004). *Calliphora nigribasis* was more abundant in the rainy period, and in the dry season it was collected only in the rural zone (Table 1). It is representative of zones with low temperatures such as the Paramo region of Chingaza National Park (Martínez et al 2007).

Comptosyriops verena was most abundant during the rainy period, occurring exclusively in the rural zone. During the dry period, it was found in all the zones with the highest number of individuals in the rural zone (Table 1), similarly to previous reports (Martínez et al 2007, Segura et al 2009). SI values obtained characterized this species as synanthropic (Table 2), consistently with the reports of Segura et al (2011).

Roraimomusca roraima is reported for the first time in Bogotá, with a total of 75 specimens distributed in forest and rural zones. It was highly abundant in the rainy period, and mostly in the forest zone. But in the dry period it was more frequently found in the forest zone (Table 1). It was considered an asynanthropic species (Table 2).

Ravinia rufipes was the most abundant species of the family Sarcophagidae during the two periods of the year showing higher abundance in the dry period as compared to the rainy season ($F=41.94$; $P=0.000$). During the rainy season, it was absent from the forest and urban zones (Table 1). This fly could not be clearly assigned to the hemisynanthropic or synanthropic category as the SI values calculated were quite variable (Table 2). Its synanthropic index is reported for the first time.

Boettcheria sp1 is common in the dry period. It was only present mainly in the forest, but also represented in rural zones (Table 1). This fly was considered as hemisynanthropic (Table 2). This species was found in the forest zones of Bogotá and its synanthropic index is reported for the

Table 2 Comparison of the synanthropic index (SI) of Calliphoridae and Sarcophagidae species found during the rainy and the dry periods in Bogotá, Colombia, 2009–2010.

Species	SI	SI DRY	SI RAINY
<i>Boettcheria</i> sp. n	-11.9	-11.6	-12.2
<i>Calliphora nigribasis</i>	-20.3	-50.0	-22.9
<i>Calliphora vicina</i>	83.1	75.9	94.3
<i>Comptosyriops verena</i>	42.0	29.9	50.0
<i>Lucilia sericata</i>	92.2	86.6	100
<i>Ravinia columbiana</i>	2.5		2.5
<i>Ravinia rufipes</i>	-18.4	4.7	-37.8
<i>Roraimomusca roraima</i>	-35.7	-40.0	-25.0
<i>Sarconesiopsis magellanica</i>	2.5	13.8	-9.1

SI of total for both periods (rainy and dry) of this study.

Did not show statistically significant differences ($F=0.084$; $P=0.77$).

first time; it is regarded as important in the forensic field since it is found in decomposing animal material.

Ravinia columbiana was found exclusively in the rural zone during the rainy period (Table 1); this fly predominates in cold climates and it would be exceptional to find it in urban places (Buenaventura *et al* 2009). It was considered as hemisynanthropic due the SI values obtained (Table 2), corroborating Buenaventura *et al* (2009).

The MCA (Fig 1a) and the species associated at each zone shows three groups. The first group exhibiting the rural zone in which *C. verena*, *S. magellanica*, and *R. rufipes* are located. The second group consisted of *R. roraima* and *Boettcheria* sp1 in the forest zone, and the third group, represented by *C. vicina* and *L. sericata* in the urban zone. Although *C. nigribasis* was found exclusively in the forest area, this species was not defined in the MCA within the forest group, but it is observed close to the groups formed by species associated with rural and forest areas in the dry period (Fig 1a). Similarly, *R. columbiana* was found only in the rural area with very low abundance. This was not defined in the MCA within the group of species associated with environment unspoiled by man; however, the MCA graph (Fig 1a) shows that *R. columbiana* is close to the group of species that are associated with the rural area.

The MCA for the rainy period also showed three groups (Fig 1b). The first group was composed of *R. rufipes*, *R. columbiana*, and *C. nigribasis*, and represented species

associated with the rural zone. The second group included *R. roraima*, *S. magellanica*, and *C. verena*, which were highly associated with the forest zone. These species were found related to rural habitats (Martínez *et al* 2007, Segura *et al* 2009, 2011). In the third group, *C. vicina* and *L. sericata* were found associated with the urban zone, as earlier demonstrated (Figueroa & Linhares 2002). Additionally, it is clearly evidenced that *Boettcheria* sp1 is away from the three groups defined, although it may be inferred that this species is related to forest zones only, and it is not abundant for this period.

The association of species in different environments by MCA analysis is demonstrated taking into account the period of the year because this association changes depending on the climate conditions of the place, as occurred in Calliphoridae and Sarcophagidae. These factors were observed in species such as *S. magellanica*, where a significant variation exists in the degree of synanthropy for the two places and for the two periods of the year.

The knowledge of the distribution of fly species of forensic importance and of their preference for different environments in the localities of Bogotá during the two periods of the year could contribute to the analysis of forensic cases in the possible transfer of bodies. Conditions with different ecological and population characteristics (urban, rural, and forest areas) and different seasons (rainy and dry) played a

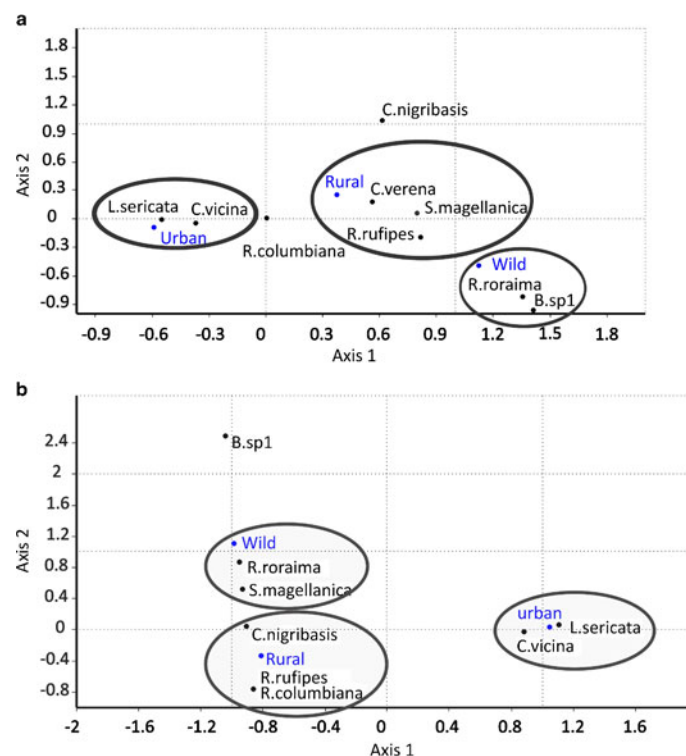


Fig 1 MCA chart for the families Calliphoridae and Sarcophagidae. **a** Dry period. **b** Rainy period.

relevant role in the present study because some species were found to be more strongly associated with one or other zone.

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