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Community structure of artificial container-breeding flies (Insecta: Diptera) in relation to the urbanization level

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ABSTRACT

The changes in the community structure of flies breeding in small artificial containers along environments of different urbanization level were assessed at two spatial scales; i.e. patch and landscape. A total of 8400 water-filled flower vases were inspected in 14 cemeteries from temperate Argentina. A total of 267,013 larvae were collected in 31.1% of the inspected containers. Twenty-four species belonging to eleven Diptera families were identified. Four species (from Muscidae, Culicidae, Chironomidae, and Ceratopogonidae) represented 95.6% of the larvae collected and 93.2% of the occupied containers. For the local spatial scale, i.e. patches within cemeteries, there was no evidence that the community structure differs between open green spaces and densely built areas. For the landscape spatial scale, i.e. among cemeteries surrounded by different urbanization levels, different patterns were detected. The percentage of containers harboring larvae and the abundance (total and per container) showed a clear peak at intermediate levels of urbanization (20–40% of impervious area). The species richness and composition were similar along the gradient. Our results suggest that the urbanization level affects the studied community depending on the spatial scale.

1. Introduction

Urbanization is a growing process worldwide. The urban expansion resulting from the continuous population growth leads to a gradual transformation from native or rural habitats into landscapes of increasing impervious areas (i.e. built cover). Thus, the urban sprawl affects biodiversity, promoting changes in the structure of animal and plant communities (Smith, Gaston, Warren, & Thompson, 2006). Growing urbanization have been associated with declines in local species richness and general abundance, increases in relative abundance of species tolerant to disturbance and shifts in composition of animal and plant assemblages (Hansen et al., 2005; McKinney, 2008). South America is not exempt to the biodiversity loss associated to the urbanization process (Pauchard, Aguayo, Peña, & Urrutia, 2006). In the megalopolis of Buenos Aires (Argentina), which is the second largest urban agglomeration of Latin America (UNDP, 2009), the association between urbanization and animal communities were previously studied for rodents and birds (Cavia, Cueto, & Suarez, 2009; Faggi, Krellenberg, Castro, Arriaga, & Endlicher, 2008; Garaffa, Filloy, & Bellocq, 2009).

Urban gradients can capture the entire range of urban effects (Pickett et al., 2001) and offered an effective framework to study the effects of urbanization on invertebrates (McIntyre & Rango, 2009; McKinney, 2002). Specifically, arthropods have served as useful models for testing several aspects of human-environmental changes because they are diverse and easy to sample, have short life cycle and are relevant to human health and economy (McIntyre, Knowles-Yánez, & Hope, 2000; McKinney, 2002). Studies analyzing arthropod communities in urban environments have focused mainly on terrestrial assemblages (e.g. Alaruikka, Kotze, Matveinen, & Niemelä, 2002; McIntyre & Hostetler, 2001). Among urban aquatic assemblages those of streams have received considerable attention (Paul & Meyer, 2001), and immature mosquitoes (Diptera: Culicidae) have been the most studied due to their importance as vectors of diseases (e.g. Cox, Grillet, Ramos, Amador, & Barrera, 2007; Leisnham, Lester, Slaney, & Weinstein, 2006). Among the wide range of aquatic habitats used by mosquitoes (see Service, 1995), artificial or man-made containers, such as water tanks and flower vases, are particularly widespread in urban areas. Although other Diptera families have been included in some studies dealing with artificial containers-breeding species (e.g. Ebeling, 1975; Hribar et al., 2004), the effect of urbanization on the entire fly community remains poorly studied, either in artificial containers as in others aquatic habitats. Understanding how flies respond to urbanization at different scales can improve management strategies of

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Table 1
Geographical location, size, and percentage of surface occupied by graves (GRV) and mausoleums (MSL) in each cemetery included in the study.

District	Cemetery coordinates	Size (ha)	Percentage of surface GRV/MSL	Number of monthly samples in GRV/MSL
Berazategui	34°47′26.82″S 58°11′0.97″W	25.8	100/0	200/0
San Isidro	34°29′34.96″S 58°34′46.92″W	12.8	85.2/14.8	170/30
Cañuelas	35°3′19.02″S 58°47′43.01″W	3.9	25/75	50/150
Esteban Echeverría	34°51′17.93″S 58°28′40.50″W	11.1	91.7/8.3	183/17
Escobar	34°19′43.51″S 58°47′52.08″W	6.3	93.1/6.9	186/14
Giles	34°25′23.11″S 59°26′52.80″W	5.2	71.1/28.9	142/58
Gral Las Heras	34°54′47.07″S 58°56′43.83″W	3.8	64.7/35.3	129/71
Mercedes	34°40′20.50″S 59°27′56.40″W	4.5	45.2/54.8	90/110
Morón	34°39′44.80″S 58°37′38.00″W	11.9	42.2/47.8	104/96
Quilmes	34°44′39.40″S 58°13′30.81″W	23	63.5/36.5	127/73
Gral San Martín	34°35′3.82″S 58°33′1.50″W	14	89.6/10.4	179/21
Tigre (Benavides)	34°25′32.90″S 58°42′20.97″W	5.4	95.6/4.4	191/9
Tigre (Downtown)	34°25′54.01″S 58°34′45.05″W	3.8	88/12	176/24
San Fernando	34°27′26.09″S 58°33′9.97″W	8.6	76.7/23.3	153/47

nuisance species (e.g. mosquitoes as disease vectors) and simultaneously help to the conservation of potentially useful species (e.g. chironomids as bioindicators) in urban areas.

The fauna of urban green areas (i.e. parks, gardens, vacant lots) is better known than that of impervious areas (McIntyre et al., 2000; Pickett et al., 2001; Smith et al., 2006). Cemeteries, a mandatory component of human settlements around the world, combine features of green and impervious areas and have been described as ideal settings to perform ecological studies in urbanized areas (Vezzani, 2007). In addition, cemeteries are characterized by an extremely high availability of flower vases that can serve as habitats for aquatic stages of flies. Here, we investigate the structure of the Diptera community occurring in artificial containers in environments of different urbanization level. Specifically, we assessed changes in community attributes at two spatial scales, between patches of different edification level within cemeteries and among cemeteries placed along an urbanization gradient.

2. Materials and methods

2.1. Study area

The study was conducted in Buenos Aires Province, which is located in the Pampean region where urban and rural (agriculture and pastoral farming) land uses have been developed in highly productive lands (Matteucci & Morello, 2009). The climate is temperate with annual mean temperature averaging 14–17 °C and annual precipitation ranging from 600 to 1200 mm (Magrin, Travasso, Díaz, & Rodríguez, 1997). The study area embraced the Greater Buenos Aires (GBA) and four neighboring rural districts (Cañuelas, Giles, Gral Las Heras and Mercedes) located approximately 100 km from Buenos Aires city. GBA covers 3827 km^2 and has the greater population density of Argentina (3345 inh/km^2) (INDEC, 2010).

The surveys were conducted in 14 public cemeteries (Table 1) located from highly urbanized areas of GBA to small rural localities. Sampled cemeteries were larger than 3 ha and located at least 3-km apart (range: 3.7–118.1 km). Internally, cemeteries have two main patch types easily distinguishable and related to burial traditions (Vezzani, 2007). Graves (GRV) are placed in open spaces characterized by a matrix of grass accompanied by bushes and trees and a few man-made structures. In contrast, mausoleums (MSL) are characterized by high coverage of impervious area and scarce or no vegetation cover. The proportion of the area occupied by GRV and MSL in each cemetery was quantified using Google Earth software 4.3 and further checked by ground proofing.

2.2. Data collection and insect identification

Samples were collected in the 14 cemeteries during October 2007 (spring), January 2008 (summer) and April 2008 (autumn). In each cemetery and sampling period, 200 flower vases with water were randomly selected and inspected, collecting a total of 8400 samples. The number of samples taken in GRV and MSL was proportional to the area occupied by both patch types (see Table 1). To account for all immature flies present in each vase, water was filtered with a fine mesh strainer and the resulting sample was immediately fixed in 70% ethanol. Total capacity of each container surveyed was recorded as representative of container size. Water volume contained was also measured for further estimation of immature fly densities.

Only larvae were considered in the analysis because of the complexity of pupae identification. Third and fourth instar larvae of Culicidae were identified to species using dichotomical keys (Darsie, 1985; Rossi et al., 2002). Larvae of Chironomidae were identified to genera (Epler, 2001; Wiederholm, 1983) and larvae of other Diptera to family (McAlpine et al., 1981) and further to morphospecies.

2.3. Data analysis

Dipteran community was characterized through the percentage of water-filled containers harboring larvae (CI: container index), the number of collected individuals (TA: total abundance), the number of individuals per infested container (DC: density per container) and per liter (DL: density per liter), the number of species (S: species richness) and the species composition (SC). The variable CI represents the proportion of occupied habitat, whereas DC and DL reflects the intensity of use of each container.The changes in community attributes according to the urbanization level was assessed at both scales, the local or patch (i.e. GRV versus MSL within cemeteries) and the landscape (i.e. cemeteries located along the urbanization gradient). For both approaches, community attributes were explored for each sampling season and pooled for an overall analysis.

2.4. Local scale

At the local scale, CI, S, DC, DL and SC were compared between GRV and MSL patches. CI was compared with the chi-squared test for two independent proportions (Fleiss, Levin, & Paik, 2003). S was compared using rarefaction curves and confidence intervals according to Magurran (2004). As this method includes the relative abundance of the species in the calculations, the results could be interpreted as a measure of diversity (Buddle et al., 2005). The