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What is left behind when the lights go off? Comparing the abundance and composition of litter in urban areas with different intensity of nightlife use in Mar del Plata, Argentina

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ABSTRACT

Nightlife activities represents an important source of urban litter; the latter often being left behind or abandoned in public places and streets. Mar del Plata is a very important city on the Atlantic coast of Argentina and is the main tourism destination in the South Atlantic region of South America. However, few studies on urban litter related to nightlife activities have been conducted in the area. Here we assessed (*i*) the abundance and composition of litter, and (*ii*) the spatial and temporal variations of its abundance, diversity, richness and evenness in urbanized areas with different intensity of nightlife activities from April 2008 to March 2009. An overall of 13,503 items were counted. Around 92% of the total litter was comprised by cigarette butts, papers and plastics. We found significant spatial differences in the abundance of litter between sampling sites, with the greatest amounts of litter at the Alem site followed by the Hipólito site (both with an intensive nightlife activity) compared with the Chauvin site (a quiet high-income neighborhood). The composition of litter of the Alem and the Hipólito sites was relatively similar and both sites differ with respect to the Chauvin site. Cigarette butts, papers, and plastics were the items that contributed most to the dissimilarity between sampling sites. The diversity of litter was the single community parameter that significantly differed from the other seasons. We discussed the potential effect of nightlife activities on the amounts and quality of urban litter in the city of Mar del Plata.

1. Introduction

Human activities in urban areas create litter such as bottles, plastic, paper wrappings, newspapers, shopping bags, and cigarette butts and packets, among others, which is often left behind or abandoned in public places. This latter can be refereed as littering behavior (Armitage and Rooseboom, 2000). Where intense human activities concentrate, such as in urban centers, higher amounts of litter are expected to accumulate in streets and other public spaces (Arafat et al., 2007; Chapman and Risley, 1974). Population increase, urbanization and tourism activities have created an impact on several cities of Europe and South America that have to deal in modern days with a booming amount of wastes, including litter (Kousis, 2000; Medina, 2002). Litter will remain in the streets and public areas until it is either removed by the local authority or it is transported by the winds and/or storms water runoff into the drainage system; in the latter case reaching coastal marine and/or freshwater areas (Armitage and Rooseboom, 2000; Williams and Simmons, 1999). In consequence, while is aesthetically distasteful and results in unhealthy living conditions, it can cause environmental hazards to wildlife and humans (CDCP, 1997; Novotny et al., 2011; Register, 2000; Slaughter et al., 2011). For example, organic litter that is dumped indiscriminately in the streets contributes to flooding, creates rodent vectors, breeding habitat for insects and promote the spread of diseases (Zurbrügg, 2002). Further, litter that reaches the sea by the sewage system affects marine wildlife through entanglement and the ingestion of plastic litter (Bugoni et al., 2001; Mallory et al., 2006).

Taking into account that almost half of the Earths' human population lives in urban areas (50% worldwide, 80% in industrialized countries), urban nature is an important issue for recreation and the well-being of urban residents and users (Matsouka and Kaplan, 2008; Vandruff et al., 1995). Not surprisingly, one goal in urban

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development is to avoid mono-functional areas and instead aim for a mix of daytime and nightlife activities in certain districts or areas (Begg, 2002; Crewe and Beaverstock, 1998). This means placing different venues (i.e. stores, cafes, restaurants, amusement arcades, movie theaters, and other type of business and housing) side by side. This is attractive to many people because it livens up the street, but it also creates conflicts when families living in the city have to co-exist with others that use it as an entertainment center until the early hours of the morning (Nørgaard and Børresen, 2008). Nightlife activity represents an important source of urban litter in several cities around the globe. The majority of the studies were conducted in Europe and North America (Bianchini, 1995; Crivello, 2011; Grazian, 2009; among others), with an important asymmetry on with what is known for other regions, including in South America. In order to create healthy and pleasing environments for residents and users, knowledge of the effects that humans have on urban ecosystems is imperative (Niemelä, 1999).

Mar del Plata (38° 00′S, 57° 33′W), located 404 km south of Buenos Aires on the Atlantic Ocean, is the most populated coastal city of Argentina (619,000 inhabitants; CIEM, 2013). The city is truly multifunctional in that it supports a wide range of industries, including tourism, fishing, cereal crop storage, and sport industries. Mar del Plata receives between 2 and 3 million tourists during the summer months (December–March) (Bouvet et al., 2005), and offers a variety of daytime – mainly massive beach tourism – and also nightlife activities – chiefly gastronomic and after-dinning options – throughout the year (CIEM, 2013). As such, it has recently been selected as the leading touristic destination on the Argentina's Atlantic coast (Trip Advisor, 2013). As many other big cities, Mar del Plata has an intensive nightlife activity with a wide variety of venues located by district or area (e.g. the area of Alem and Hipólito Yrigoyen streets known for their quantity of restaurants, pubs and nightclubs; the area of Constitución street known for its discotheques). Littering is influenced by location, the time of day, the type of item being littered and whether the person dropping the litter is alone or in a group, among other factors (Wever et al., 2010; Williams et al., 1997). However, information about the amount and composition of litter in cities is scarce locally and even rare when it refers to peoples' activities linked to nightlife activities.

The creation of a local strategic plan in 2002 (Municipal Bylaw 14,957) triggered a number of domestic actions, including land-use planning and urban development, among others in Mar del Plata. Despite the progress achieved, issues relating to the effects of urban littering have only been partially addressed and need urgent attention. In order to contribute to local planning and urban design initiatives concerning nightlife activities in Mar del Plata, the present study was designed to assess (*i*) the abundance and composition of litter, and (*ii*) the spatial and temporal variations of its abundance, diversity, richness and evenness in areas with different intensity of nightlife activities.

2. Materials and methods

2.1. Study area, sampling methodology and classification of litter

Three urban sites, Alem, Hipólito Yrigoyen and Chauvin, were selected at Mar del Plata for the study (Fig. 1). Site Alem covers an approximately six-block area and is located in close proximity to its harbor and a major seaside resort, and it includes a commercial street that has a variety of clothing shops, restaurants, pubs, nightclubs and other entertainment venues in it. The accumulated (official) accommodation capacity for overall restaurants, pubs, nightclubs and entertainment venues at this site is around 3000 persons (authors, pers. comm.). Site Hipólito Yrigoyen (hereinafter Hipólito) is located near the city council of Mar del Plata and its central district business area. This site, which also covers an approximately six block area, includes a commercial street with a number of restaurants and pubs on it, and has an overall (official) accommodation capacity of around 1035 persons (authors, pers. comm.). While site Chauvin has opposite characteristics; it is a quiet residential, high-income that has no tall buildings or commercial and industrialized zones in it.

Two transects were surveyed in each area monthly from April 2008 to March 2009. Each transect (sampling unit) was about 1425 m^2, comprising (the same) three blocks long (87 m each and the 12 m in between) and the sidewalk (4 m) plus 1 m of curb wide (see Seco Pon and Becherucci, 2012). Each transect was covered once by the same observer, to count and classify all visible litter during the early morning (07:00–10:00 h local time; −3 GMT). Litter was not collected or weighted but was classified into eleven groups according to its composition: cardboard, paper, plastic, glass, metal, wood, cable, cloth, cigarette butts and cigarette boxes and other articles (e.g. Styrofoam, electronic appliances, car parts, etc.).

2.2. Statistical analysis

We calculated the following indices for each sampling unit: litter abundance, richness (S, total number of items), diversity Shannon (H′) (Shannon and Weaver, 1963) and evenness (J′) (Pielou, 1969).

We used a two-way ANOVA to test the effects of sampling sites and seasons on the mean abundance of litter and the mean litter "community parameters" (S, H′, and J′). Comparisons among means

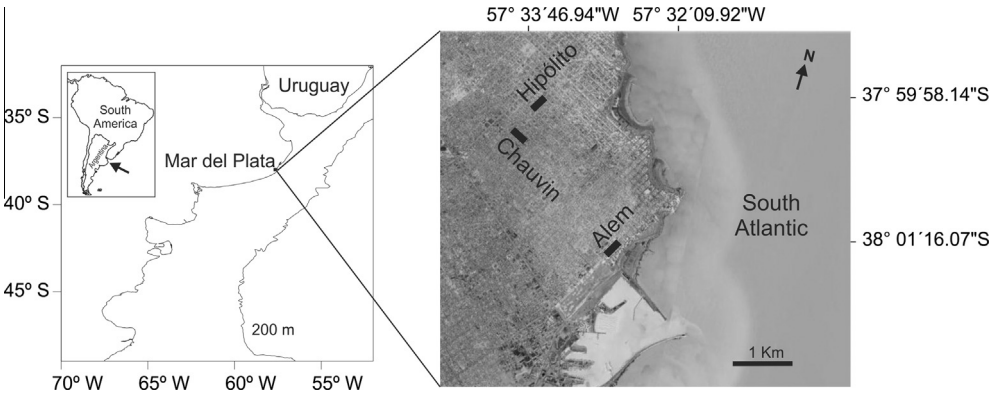

Fig. 1. Map showing the location of the three study sites (Alem, Hipólito and Chauvin) in the southeast of Argentina. The inset shows the location of Mar del Plata city. Image taken from Google Earth™.

were performed using *a posteriori* Tukey test (Zar, 1999). To run the ANOVA only litter "community parameters" data was transformed using fourth root (x) to accomplish assumptions of normality and variance homoscedasticity (Zar, 1999). Multivariate analyses were performed using the PRIMER v5.0 software package (Clarke and Warwick, 2001). Similarities and differences in litter communities were based on the abundance of all items and the effect of the factor site was explored using non-metric multidimensional scaling (nMDS) and analyses of similarity (ANOSIM; Clarke, 1993). The nMDS plots maximized rank-order correlation between distance measures and distance in ordination space. Thus sampling units were considered as points and moved to minimize "stress". Stress was considered as a measure of the mismatch between the two kinds of distance. Stress values <0.2 give a potentially useful 2-dimensional picture. In both analyses, Bray–Curtis similarity indexes were calculated and data were transformed by square root. The SIMPER procedure (Similarity Percentage Analysis) was used to determine the percentage of dissimilarity between sampling sites, and the particular items responsible for such differences (Clarke, 1993).

Statistical analysis of the data was performed using R software, Version 2.5.1. (R Development Core Team, 2012). In all cases, differences were considered significant where P was <0.05. Unless sated otherwise, all reported values are means ± S.D.

3. Results and discussion

3.1. Abundance and composition of litter

We counted 13,503 items (9.5 items per m^2) during the study period. These were classified into the 11 groups of litter (Table 1). Around 92% of the litter accounted for included 5776 cigarette butts (42.8% of the total amount), 4027 papers (29.8%), and 2667 plastic items (19.7%). Other item each comprised less than 10% of litter counted (Table 1).

Cigarette butts, paper and plastic litter represented the majority of the overall litter recorded in areas of Mar del Plata with different intensity of nightlife activities. These items also comprised the bulk of the litter recorded during daytime, or linked to daylight activities, elsewhere (Keep New Zealand Beautiful, 2013; Register, 2000; among others), including in Mar del Plata (Seco Pon and Becherucci, 2012). This predominance of cigarette butts, papers and plastics was expected given the high persistence (except for papers) and low density of the already mentioned items. For example, cigarette butts – which are commonly made of cellulose acetate, may persist for 18 months or more under normal environmental conditions (Ach, 1993). Not surprisingly, cigarette butts are the most common and ubiquitous type of litter on Earth (Novotny and Zhao, 1999; Novotny et al., 2009; Register, 2000). Furthermore, while most smokers and non-smokers today understand that cigarette litter is an environmental problem, a minority of smokers still do not recognize flicked cigarettes butts as litter or waste (Bayer and Bachynski, 2013; Rath et al., 2012). Other factors influencing the type and quantities of nightlife-related litter registered at the study area include (1) the fact that in modern days people are not legally allowed to smoke inside any local venues (i.e. clothes shops, restaurants, pubs, nightclubs, among others) regardless of the time of day (National Law 26,687), (2) advertisement of different kinds of services and activities appearing in a printed version (paper) are available in the above mentioned venues and usually displayed on the windshield of someone's car by night, and (3) most of the materials used by nightlife activities (chiefly gastronomic and after-dinning options) are made upon plastics, a very versatile organic polymers (Thompson et al., 2009), which may end up being disposed improperly after used or consumed (i.e. bottled drink). Among other items that may be disposed improperly on the streets is glass litter (see Rizvi et al., 2006; Al-Khatib, 2009). It has to be stressed that although plastics may persist for centuries (Ryan, 1987), glass may take millions of years to biodegrade. In spite of the relatively low percentage of glass litter recorded in our study (range = 1.62–4.91%), this type of litter – mainly glass bottles and pieces of broken glass- can seriously injure both animals and humans, especially children. For example, Al-Khatib (2009) reported a high incidence of injuries caused by street glass among children in Palestine.

Table 1
Abundance (N), mean, standard deviation (SD) and occurrence (%) of overall litter items recorded in sites Hipólito (n = 23), Alem (n = 23) and Chauvin (n = 13).

Site	N	Mean	SD	Occurrence (%)
HIPÓLITO				
Papers	2029	88.22	61.21	37.08
Cartoon	59	2.57	4.38	1.08
Plastics	877	38.13	27.57	16.03
Wood	7	0.30	0.63	0.13
Glass	36	1.57	2.25	0.66
Cloth	0	0.00	0.00	0.00
Cable	1	0.04	0.21	0.02
Aluminum	152	6.61	10.75	2.78
Cigarette butt	2135	92.83	70.07	39.02
Cigarette packet	168	7.30	7.25	3.07
Others[a]	8	0.35	0.88	0.15
ALEM				
Papers	1580	68.70	52.78	22.64
Cartoon	40	1.74	2.49	0.57
Plastics	1458	63.39	47.29	20.89
Wood	19	0.83	1.40	0.27
Glass	113	4.91	4.47	1.62
Cloth	4	0.17	0.65	0.06
Cable	0	0.00	0.00	0.00
Aluminum	197	8.57	11.34	2.82
Cigarette butt	3440	149.57	114.25	49.29
Cigarette packet	116	5.04	3.80	1.66
Others[a]	12	0.52	0.95	0.17
CHAUVIN				
Papers	408	31.38	24.39	39.34
Cartoon	31	2.38	2.57	2.99
Plastics	332	25.54	15.78	32.02
Wood	5	0.38	0.87	0.48
Glass	31	2.38	2.18	2.99
Cloth	1	0.08	0.28	0.10
Cable	0	0.00	0.00	0.00
Aluminum	7	0.54	1.13	0.68
Cigarette butt	201	15.46	12.04	19.38
Cigarette packet	0	0.00	0.00	0.00
Others[a]	21	1.62	1.85	2.03

[a] Others include parts of computational appliances, electrical appliances, pieces of foam and styrofoam, etc.

3.2. Spatial and temporal variations of litter abundance and composition of litter community

Using two-way ANOVA, we found no significant interactions between sampling sites and seasons for abundance of litter (two-way ANOVA $F_{5,48} = 0.7366$, $P = 0.599$) and for overall litter "community parameters" (two-way ANOVA, all $P > 0.05$). However, we found significant spatial differences in the abundance of litter between sampling sites (one-way ANOVA $F_{2,56} = 8.628$, $P < 0.001$; Tukey *post hoc* comparisons: $P_{\text{Alem-Chauvin}} < 0.05$; $P_{\text{Hipólito-Chauvin}} < 0.05$; $P_{\text{Alem-Hipólito}} = 0.303$), with the greatest amounts of litter counted at the Alem and Hipólito sites (both accumulated 92.2% of total litter) compared with Chauvin site (ca. 8%). With respect to litter "community parameters", we found significantly lower richness of litter at the Chauvin site (one-way ANOVA $F_{2,56} = 5.973$; $P < 0.001$; Tukey *post hoc* comparison $P < 0.0001$). Diversity

(one-way ANOVA $F_{2,56} = 4.058$, $P = 0.05$) and evenness of litter (one-way ANOVA $F_{2,56} = 4.799$, $P = 0.05$) not differed between sampling sites.

The nMDS plot highlighted two groups clearly differing in their spatial composition of litter. This included one group comprised by the Alem and Hipólito sites and the other one by the Chauvin site (Fig. 2). Analyses of similarities indicated that the composition of litter differed significantly between sampling sites for abundance of all litter items (ANOSIM, global $R = 0.36$, $P = 0.001$). The pairwise test revealed that the composition of litter at the Chauvin site differed significantly from the rest of the sites (ANOSIM, $R_{Chauvin\text{-}Alem} = 0.702$, $P < 0.001$; ANOSIM, $R_{Chauvin\text{-}Hipólito} = 0.518$, $P < 0.001$). Interestingly, the composition of litter between the Alem and Hipólito sites did not differ significantly (ANOSIM, $R = 0.082$, $P = 0.14$) (Fig. 3). SIMPER analysis revealed that three items, cigarette butts (cigarette $butts_{Chauvin\text{-}Alem} = 52.72\%$ and cigarette $butts_{Chauvin\text{-}Hipólito} = 39.34\%$), papers ($papers_{Chauvin\text{-}Alem} = 18.62\%$ and $papers_{Chauvin\text{-}Hipólito} = 33.49\%$), and plastics ($plastics_{Chauvin\text{-}Alem} = 17.68\%$ and $plastics_{Chauvin\text{-}Hipólito} = 14.06\%$), explained much of the average dissimilarity among the Chauvin and Alem sites (60.10%) and the Chauvin and Hipólito sites (55.65%).

The amounts of local litter varied significantly between sampling sites, with higher abundances of litter registered at the Alem site. This is not surprising given that this site is heavily used due to its proximity to Playa Grande, which is one of the major seaside resorts of the city, and the fact that it can also accommodate a higher number of people indoors than the Hipólito site. Moreover, Alem site is known for being the heart of the nightlife in the city (Turismo Mar del Plata, 2013). However, the composition of litter was relatively similar among the two most littered sites (i.e. Alem and Hipólito) according to the ANOSIM analysis. The most likely explanation for this similarity in the composition of litter between the Alem and Hipólito sites is that both places offer the same type of venues (i.e. clothes shops, restaurants, pubs, nightclubs, among others), whereas the Chauvin site not include such services nor venues.

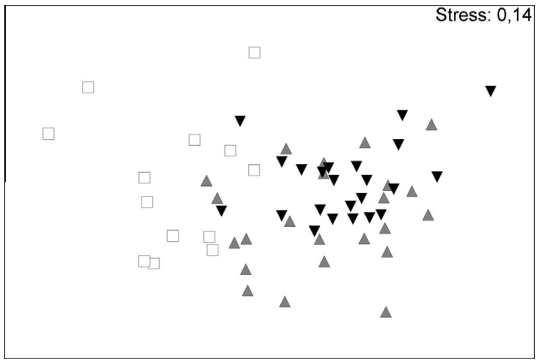

Fig. 2. Non-metric multidimensional scaling (nMDS) ordination plot using overall litter abundance with respect to (△) Hipólito, (▼) Alem and (□) Chauvin sites.

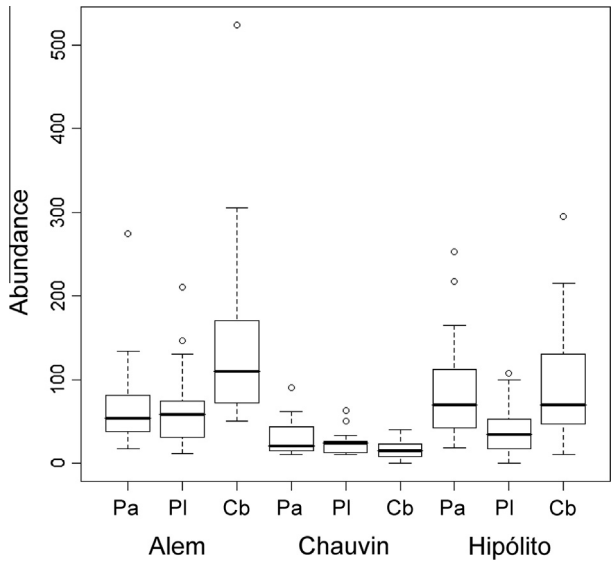

Fig. 3. Box-plot showing the abundance of papers (Pa), plastics (Pl) and cigarette butts (Cb) in the sites Alem, Chauvin and Hipólito.

We found no significant differences in the abundance (one-way ANOVA $F_{3,59} = 0.32$, $P = 0.805$), richness (one-way ANOVA $F_{3,59} = 1.74$, $P = 0.168$) and evenness of litter (one-way ANOVA $F_{3,59} = 1.088$, $P = 0.362$) between seasons, while the opposite was true for diversity of litter (one-way ANOVA $F_{3,59} = 6.571$, $P < 0.001$). Tukey *post hoc* comparisons revealed that during summer the diversity of litter was significantly higher than the other seasons (all $P < 0.032$).

Interestingly, the abundance of litter at the sampling sites was even throughout the year in spite of the peak visitor season during the late December–February summer holidays (see Bouvet et al., 2005). This may relate to several facts: (1) apart from being the most populated coastal city in Argentina, Mar del Plata usually undergoes a year-round attendance with over 8,000,000 visitor arrivals per year probably due to its proximity to Buenos Aires, (2) an important proportion of the stable local population (*ca.* 36%) is comprised by people aged between 15 and 39 years olds (CIEM, 2013) which are all potential users of nightlife venues with an enhanced littering behavior (Chatterton and Hollands, 2002; Nkwocha and Okeoma, 2009), and (3) it is possible that frequency of street-sweeping or enhanced informal sector partnership in solid waste management are partially responsible for keeping the amounts of litter at low levels during the summer season. On the other hand, diversity of litter was the single litter community parameter which varied between seasons, being significantly higher during summer. The most likely explanation for this significant variation is that sampling sites (with the exception of Chauvin site) offer a wider variety of entertainment venues, among others, for people of almost all ages during the summer (e.g. certain beach resorts like Playa Grande and the nearby Alem street comprise food venues during daylight between December and February), which can all enhance the diversity and amount of litter around the clock in the streets and other public areas.

4. Conclusions

Cigarette butts, papers and plastics were the types of litter most commonly associated with nightlife activities in highly urbanized areas of the city such as the Alem and Hipólito sites. This situation of cigarette butts-papers-plastics dominated litter was similar to that previously reported during daytime in other areas of Mar del Plata (see Seco Pon and Becherucci, 2012). However, it has to be stressed that the inclusion of street intersections in the survey method might have biased the amounts of litter recorded associated with nightlife activities (i.e. due to traffic, street-sweeping services, run offs, etc.). Still, this study showed that nightlife activities are an important source of urban litter in the streets of Mar del Plata. As previously recorded during daytime (Seco Pon and Becherucci, 2012), the most littered site linked to nightlife activities was an area close to the city's coastline. However, other areas such as Constitución Street-known for its discotheques, should be included in further studies. Finally, our results indicated that nightlife activities are an important factor to take into account when considering local urban planning in public areas and commercial

streets. Hence our findings could assist in local enforcement of litter control through the placement of litter receptacles outside nightlife venues, and through advertising campaigns to encourage people to reduce littering in public areas, thus improving both their health and the local environment. Nevertheless, law enforcement to guarantee compliance should be also discussed.

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