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Coexistence between Nearctic-Neotropical migratory shorebirds and humans on urban beaches of the Southern Hemisphere: a current conservation challenge in developing countries

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Abstract The arrival of migratory shorebirds on beaches in urban communities in developing countries is a current challenge for the protection of these migrant birds. Nearctic-Neotropical migrants rely on roosting and feeding sites during their stopover on wintering sites in the Southern Hemisphere to acquire sufficient energy to complete their migratory cycles. On the other hand, cities in the Southern Hemisphere are growing rapidly, which results in increasing competition for space between humans and birds, such as for use in beach habitats. In the present study, I analyze the probability for occurrence for Nearctic-Neotropical migratory birds relative to the number of people in southeastern Brazil, the most populated region of South America. The frequency of occurrence of migrants, their distance of tolerance to people and the number of people were recorded in sample areas (circle plots with 20 m radius) on a 9 km stretch of urban beaches from November to February from 2009 to 2013. The probability of occurrence of Nearctic birds decreased as the number of people increased. When the number of people exceeded 20, the probability of occurrence of birds was almost zero. Furthermore, more than 95 % of birds moved off when people were within 16 m of reach. These results are discussed in the context of conservation actions since no management plan has been developed for migrant shorebirds that use urban beaches as stopover or wintering sites in developing countries.

Keywords Adaptive management · Charadriidae · Conservation · Migration · Scolopacidae · South America

Introduction

Every year, numerous birds migrate thousand of kilometers from the Nearctic region to South America, relying on roosting and feeding sites to acquire sufficient energy to complete their migratory cycles (Skagen 2006). Throughout these journeys, birds are exposed to numerous

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threats, such as loss of stopover and wintering areas, scarce food resources, and human disturbances that may severely compromise their fitness, survival, and return to breeding areas (Burger 1981; Morrison 2004; Burton et al. 2006). With increased urbanization in the Southern Hemisphere, wintering and stopover sites, such as beaches which are frequently used by migrant shorebirds are now intensively used by humans for recreation (Thomas et al. 2003; Burger and Niles 2012). Walking, jogging, fishing, and dog-walking are examples of common recreational activities. Therefore, sharing of coastal habitats by humans and migratory shorebirds is an ongoing challenge for the conservation of these birds.

The dynamics of human activity and its impacts on birds on coastal beaches may vary in space and time, thereby influencing the dynamics of birds' occurrence in such habitats (Burger 1981; Pfister et al. 1992). Studies have revealed that several migratory shorebirds are not adapted to the presence of people and that they preferentially forage and roost in beach areas where disruptions are less frequent (Burger 1981; Burger and Gochfeld 1991; Pfister et al. 1992; Burger and Niles 2012). When coexisting with humans, birds may forage less, thus decreasing the total amount of time dedicated to feeding (Burger 1993; Thomas et al. 2003; Cestari 2011) or they may move to other more profitable beaches (if they exist), thus decreasing the area of available habitat and increasing their energy demand (Burger et al. 2004).

Studies that focus on the levels of human disturbance that birds tolerate and their effects on bird behavior and population size are needed in order to find ways of minimizing the detrimental effects of human disturbances on birds (Sutherland 2007). A wide range of scientific approaches and conservation measures that involve stakeholders exist to understand and mitigate the effects of human activities on shorebirds in North America, especially in urban environments (Burger and Gochfeld 1991; Gill 2007; Burger and Niles 2012). In contrast, we know little about how shorebirds tolerate human activity in developing countries such as Brazil that is currently experiencing a rapid increase in urbanization (Malik 2013).

Brazil has approximately 9.200 km length of coastal area as most of its northeastern through southern region is adjacent to the Atlantic Ocean. During the austral spring and summer, Nearctic-Neotropical migratory birds migrate in mass to the Southern Hemisphere and these birds can be found along urban beaches along the coast. Flocks of Nearctic-Neotropical migratory birds simultaneously use these beaches as stopover sites (Cestari 2009), while large numbers of people use these same beaches as recreational areas. This overlap in the use of beaches results in unequal competition for space between shorebirds and people. In the present study, I analyzed the tolerance limit of wintering Nearctic-Neotropical shorebirds to human presence on urban beaches in southeastern Brazil, the most populated region of South America and also part of the major wintering complex of beaches that receive Nearctic-Neotropical migrants using the Atlantic Ocean migration route (Antas 1984). I ask two main questions: (1) do people affect the presence of migratory shorebirds on beaches?, and (2) what is the maximum number of people and the distance to them that migrants tolerate before behavioral disruption? Finally, I discuss what conservation actions might be taken to sustain populations of Nearctic-Neotropical shorebirds on urban beaches of southeastern Brazil.

Methods

Study areas

I considered as urban beaches all the stretches of beach habitats that interfaced with metropolitan areas. The studied area (24°13′28,9″ S and 46°51′20,2″ W, to 24°16′23,4″ S and 46°55′

52,1″ W; Fig. 1) is characterized by two kinds of urban beaches 1) beaches adjacent to commercial properties with many people that use the beach, and 2) beaches adjacent to residential properties with relatively few people using the beach. These two beach types allowed me to compare tolerance of birds to different levels of human disturbance. Due to the urban expansion in the region, it is actually difficult to find stretches of beach habitat that border native coastal ecosystems (e.g., *restinga*, mangroves) or rural areas in the region. In the study area, the local population is estimated to be~87,000 inhabitants, which is increasing an annual rate of 1.5 % a year (IBGE 2014). From November (late spring) to February (summer), the period that coincides with the presence of Nearctic-Neotropical migrants (see below), this region receives a large influx of tourists from São Paulo city, which increases the local population up to five times. São Paulo, located ~100 km from the study area, is the largest urban area in South America with 11,387,685 inhabitants (IBGE 2014).

Beaches are sandy, compact, and flat with a slope angle from 4 to 6°. The extension of the beaches perpendicular to the sea averages approximately 87 m±9 m at low tide, during the time this study was conducted. A number of Nearctic bird species (i.e., American Golden Plover *Pluvialis dominica*, Red Knot *Calidris canutus*, Ruddy Turnstone *Arenaria interpres*, Sanderling *Calidris alba*, Semipalmated Plover *Charadrius semipalmatus*, and White-rumped Sandpiper *C. fuscicollis*) form flocks and use these beaches to rest and forage from November to April (Cestari 2009). The climate is subtropical and humid. Annual mean temperature and rainfall is 21.4 °C and 2,278 mm, respectively (Tarifa 2004).

Sampling design

The number of people and the presence of Nearctic-Neotropical migratory birds were recorded in 1,256 m^2 sample areas (circle plots with 20 m radius) on a 9 km stretch of beach from November to February in 2009–2013. During these months, there is an overlap in the peak use

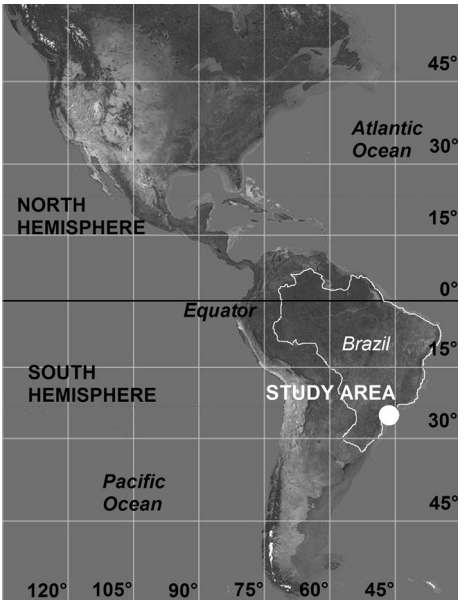

Fig. 1 Study area where the number of people and the presence of Nearctic-Neotropical migratory birds were recorded in the southeastern Brazil

of urban beaches by people and migrant birds. Beaches were sampled between 800 h and 1230 h on days that were at least 1 week apart. I used a bicycle with an average speed of 10 km/h to move along the beach thus minimizing the likelihood of sampling the same individuals of birds and people. Two methods were simultaneously used to discern spatial dynamics in patterns of use by birds and people on the stretch of beaches observed in this study. In the first method, I carefully stopped the bicycle at 5 min intervals to record the presence of migrants and count the number of people in circle plots without disturbing them. In this case, samples of circle plots with no birds and/or people detected also were considered in the analyses. In the second method, every time that the presence of a solitary or flock of migrants was detected before the 5 min interval, I stopped the bicycle and counted the number of birds and people around (in 20 m radius circle) without disturbing them. Therefore, the spatial distribution of circle plots in the 9 km stretch of beaches varied during each day of sampling according to the presence of migrant birds and 5 min sampling interval. For statistical proposes (see Data Analysis), I tried to equilibrate the number of circle plots sampled using the two methods. The daily number of circle plots sampled ranged from 7 to 22. Nearctic migrants found in intraspecific or heterospecific groups up to 5 m from each other were considered a flock. This definition follows that applied to in previous studies where bird flocks exhibit cohesive unidirectional movements in flight when disturbed by people (Cestari 2008, 2009).

The approach distance to a randomly chosen foraging or roosting Nearctic shorebird was determined by walking slowly (one step per second on average) and directly towards a peripheral bird in a flock or a solitary individual and recording the moment (and position) that the bird ran in the opposite direction or flew away. The distance from my position to the position of the disrupted bird was then measured using a metric tape. I measured approach distance method only on individuals of Semipalmated Plover *C. semipalmatus* due to the higher abundance of this Nearctic migratory species in the region (Barbieri and Mendonça 2006; Cestari 2009).

Data analyses

The frequency of occurrence (presence and absence) of birds in the circle plots was compared using a Chi-square test with a Yates correction with the null hypothesis being an equal proportion of presence and absence frequencies of birds on the beaches. The probability of occurrence of Nearctic-Neotropical migratory birds relative to the number of people in circle plots was analyzed using logistic regression. Bioestat software version 5.0 was used in all analyses.

Results

The following species were recorded in descending order of frequency of occurrence in the circle plots (n=297): *C. semipalmatus* (169), *C. alba* (33), *C. fuscicollis* (31), *A. interpres* (20), *C. canutus* (5), *P. dominica* (3), and Lesser Yellowlegs *Tringa flavipes* (1). On average, 7.8±12 people (range 0–61) were recorded per circle plot. Birds were present in more samples (170) than absent (127) (χ^2_1=6.22, p=0.01). The probability of occurrence of Nearctic birds decreased as the number of people increased (p<0.0001) (Table 1). When the number of people exceeded 20, the presence probability of birds was almost zero (Fig. 2).

The approach distance limit at which birds ran or flew away ranged from 5.0 to 19.9 m (average: 10.7±2.6 m, n=72). The highest percent of birds were disrupted when people were within 16.0 m (Fig. 3).

Table 1 Logistic regression analysis relating presence of Nearctic-Neotropical migratory birds and the number of people in 297 circle plots during November to February from 2009 to 2013 along urban beaches in southeastern Brazil

Predictor	β	SE β	Z	*p*	Odds ratio	IC 95 %
Constant	1.84	0.222	–	–	–	–
People	−0.28	0.04	−7.50	<0.0001	0.75	0.70–0.81

Discussion

Nearctic migratory species have an extraordinary capacity to move across an expansive latitudinal area, from their breeding sites at 70°N to wintering regions at 47°S (Morrison 2004; Skagen 2006). The farther they migrate the more the energy they need to meet these energy requirements. Consequently, migratory shorebirds need stopover areas which are free from human perturbation so that they can feed and rest. Many of these stopover areas, though, are apparently located in urban areas where human disruptions are frequent. When any disruption occurs, birds spend less time foraging and spend energy moving to more profitable places, which may result in loss of weight and fitness (Burger 1981; Burger et al. 2004; Morrison 2004). The results of this study indicate that there exists an inverse relationship in the use of urban beaches by migratory birds in relation to the number of humans. Birds tolerated up to 20 people in 20 m radius sampled plot areas, and when people approached to within 16 m, the majority of birds moved off. Availability of food resources, which was not included in this study, can also affect the presence of birds. Sites with higher levels of human

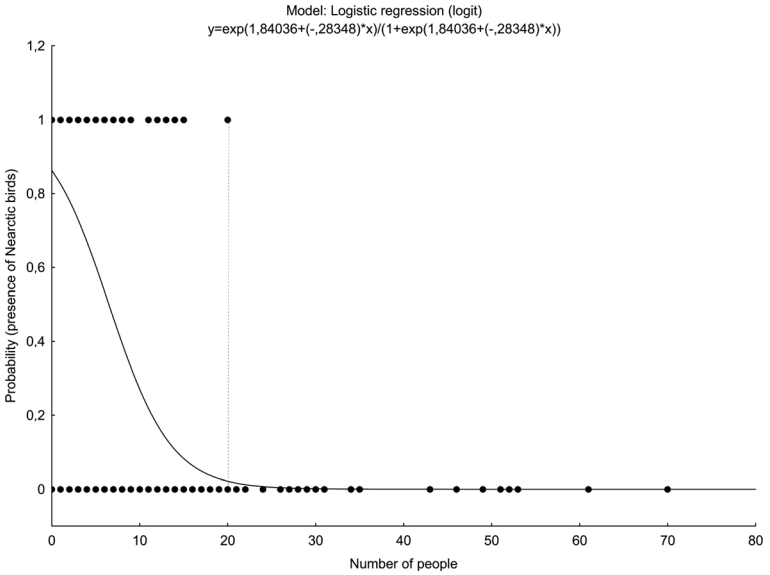

Fig. 2 Logistic regression relating the presence of Nearctic birds to the number of people in 297 sampling plots (circles with 20 m radius) during November to February 2009–2013 along urban beaches in southeastern Brazil. A point in the graph may indicate more than one sample area due to the repetition of the number of people in the samples. The model equation is shown above. The *dashed line* indicates the maximum number of people tolerated by birds

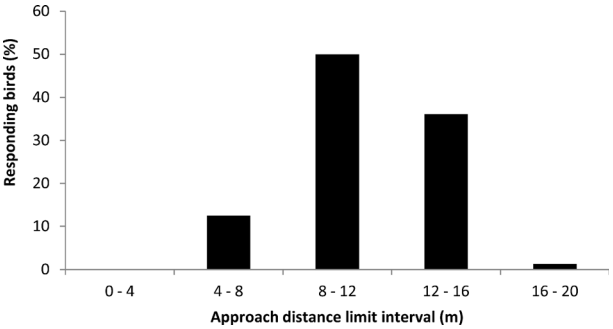

Fig. 3 Approach distance intervals to test tolerance of Nearctic-Neotropical migratory birds during November to February 2009–2013 along urban beaches in southeastern Brazil. The graph should be read as the percent of birds that move off when people are within a particular approach distance interval

disturbance may also have lower levels of resource availability, thus confounding the relationship between human presence and the presence of birds (Gill 2007). However, food availability was unlikely to bias the results of the present study due to a large number of randomly sampled areas.

Shorebird conservation in urbanized coastal beaches of South America is by far behind that of the North America. Despite the fact that migrants depend on specific southern wintering areas to complete their annual cycle (Morrison 2004; Burton et al. 2006), there are few detailed quantitative data that show the negative impact of recreational activity on shorebirds in the Southern Hemisphere's wintering and stopover areas (Vooren and Chiaradia 1990; Cestari 2008, 2011; Valente et al. 2011). Stopover areas in developing countries of the Southern Hemisphere are experiencing a rapid increase in urbanization. Increasing development means that the native habitats adjacent to beaches are being rapidly substituted by commercial and residential buildings, gardens, paths and seaports, which attract a large number of recreationists and increase competition for space between humans and birds. The southeastern region of Brazil is by far the most urbanized and populated area of South America and thus, exemplifies the impact of urbanization on birds in coastal environments. For instance, because of the high density of humans and urbanized areas (including a huge seaport, i.e., Santos seaport) in São Paulo State, beaches located in areas of extremely high disturbance north from the region studied (from Praia Grande to Santos municipalities) are rarely used by Nearctic-Neotropical migrant shorebirds (C. Cestari, unpubl. data 2013).

There are several examples of successful management of beaches that promote coexistence of humans and birds in highly urbanized locations in North America (Burger et al. 2004; Burger and Niles 2012). However, no active management plan has been developed for migrant shorebirds using urban beaches in the Southern Hemisphere (Cestari 2008). Given the results presented here, such management plans should be developed. Educational materials such as images and texts on the natural history of migratory bird species, their importance within the food chain, and ways to prevent their perturbation, should be made available to people on beaches. Government agencies and stakeholders should also develop laws that limit the minimum distance (i.e., 20 m) that people can approach migratory birds on beaches. Beach segments of 0.5–1 km should be closed to recreationists to serve as refueling areas during the critical migration period of shorebirds (November to April). Additionally, bird watching activities should be encouraged as a recreational option and viewing platforms installed on beaches, thus avoiding close contact between people and birds. To reach success, management to conserve shorebirds needs active participation of government and citizens not only in

reserves but also in urban areas (Burger et al. 2004; Burger and Niles 2012). These recommendations would improve the environmental quality of beaches in wintering areas currently used by birds and reverse the current absence of birds in critical segments of beaches adjacent to urbanized areas in the Southern Hemisphere. Further, these recommendations would also help to increase sustainable and organized ecotourism throughout the extensive coastal shoreline of Brazil.

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