Revista Brasileira de Ornitologia, 23(3), 327-335
September 2015

ARTICLE

Population trends and conservation of the Mangrove Rail

Bianca P. Vieira[1,2]

[1] Postgraduate Program, Institute of Biodiversity, Animal Health and Comparative Medicine, University of Glasgow, Glasgow, UK.
[2] Corresponding author: biancabioufsc@gmail.com

Received on 2 June 2014. Accepted on 30 March 2015.

ABSTRACT: The Mangrove Rail occupies only mangrove areas in South America. Though present in one of the most endangered forests in the world, there is little data available on the Mangrove Rail. In this paper, I present local population trends and the latest population density estimates for the Mangrove Rail in an urban mangrove area based on two years of fieldwork conducted on the Island of Santa Catarina, southern Brazil. I have also revised the global conservation status of the Mangrove Rail based on literature and specimen records. Surveys were conducted monthly at 10 stations along a 4 km-transect. The maximum number of individuals detected was 17 (2012). Total density was around 2 rails/ha, although a significant increase in population occurred when the surveyed area developed from 8.7 ha to 43 ha. A strong relationship between the presence of rails records and mangrove extension was observed and already expected. Altogether, the Mangrove Rail occurs in an extent of 19,615 km² and an area of 12,455 km² in South America, strictly associated with mangrove forests under severe pressure by deforestation, therefore qualifying as Vulnerable at a global level according to IUCN criteria. The results presented herein reinforce the importance of preserved wetlands for the conservation of the Mangrove Rail as well as of mangrove restoration initiatives since even areas of human intervention can be a good alternative to future adaptive management strategies and the conservation of this endangered species.

KEY-WORDS: Density, occupancy, Clapper Rail, *Rallus longirostris*, mangrove, South America.

INTRODUCTION

The Mangrove Rail (*Rallus longirostris*) was recently split from the closely related rails *R. crepitans*, *R. elegans*, *R. obsoletus* and *R. caribaeus*, and its distribution is now recognized as occurring on the eastern and western coasts of South America (Maley & Brumfield 2013). The Mangrove Rail ranges from the latitudes 13°N in the northern coast of Venezuela to latitudes 3°S in Peru and 28°S in southern Brazil, with seven currently recognized subspecies (Rosário 1996, Taylor 1996, Sick 1997, Ridgely *et al.* 2005, Maley & Brumfield 2013). Unlike other *Rallus*, the Mangrove Rail is restricted to mangrove areas, and not found in salt marshes as their closely related species in Central and North America (Eddleman & ConWay 1998, Maley & Brumfield 2013).

The Brazilian coastline stretching from Pará to Santa Catarina holds available habitat with documented records of the Mangrove Rail (Rosário 1996, Lees *et al.* 2014). However, there are no studies available on the species' population trends, current distribution, threats, and other aspects. This overall lack of knowledge also applies to French Guyana, Suriname, Guyana, Trinidad and Tobago, Venezuela, Colombia, Ecuador, and Peru, where the species is also found (Taylor 1996, Sick 1997, Ridgely *et al.* 2005, Sigrist 2009, Maley & Brumfield 2013).

The state of Santa Catarina in Brazil is the only geopolitical unit to regard the Mangrove Rail as a Vulnerable species due to its dependence on mangrove areas (CONSEMA 2011). In contrast, lists of endangered species throughout South America have not included this species or any of its subspecies in the endangered categories. However, it is well known that mangrove areas are at great risk, due to anthropogenic pressure by landfills, settlements, shrimp farming, predatory fishing, dumping of waste, and other threats (Lugo & Snedaker 1974, Cintrón & Schaeffer-Novelli 1992, Valiela *et al.* 2001, MMA 2003, Vieira *et al.* 2011, 2012). Herein, this paper presents population trends and density estimates for *Rallus longirostris* in an urban mangrove area on the Island of Santa Catarina, southern Brazil, in addition to revising the species' conservation status at a global level based on distributional records according to the IUCN criteria (IUCN 2011, 2012).

MATERIAL AND METHODS

Study area

South America holds 26% of the mangrove forests in the world, with most part of these forests occurring along the Brazilian coastline (Valiela *et al.* 2001, Magris & Barreto 2010, Giri *et al.* 2011, Maley & Brumfield 2013). Mangrove areas in South America with known occurrence of the Mangrove Rail range from latitudes 13°N in the northern coast of Venezuela to latitudes 3°S in Peru and 28°S in southern Brazil, including the coastline of Brazil, French Guyana, Suriname, Guyana, Trinidad and Tobago, Venezuela, Colombia, Ecuador, and Peru (Valiela *et al.* 2001, Magris & Barreto 2010, Giri *et al.* 2011, Maley & Brumfield 2013).

Near the extreme southern limit of the Mangrove Rail distribution, the Island of Santa Catarina has seven main mangrove patches distributed along two main bays (*pers. obs.*). Located in the southern bay, the Mangrove of Pirajubaé is protected by the Marine Extracting Reserve (RESEX) of Pirajubaé, and had spread northern along the *Saco dos Limões* Bay (27°36'S and 48°32'W; 27°38'S and 48°32'W; Figure 1). Mangrove colonization along this bay is related to landfill establishment. Mangroves either naturally colonized the landfill or were planted between 1997 and 1998 to ensure that the area would not silt (Macedo 2003). This landfill was established for the construction of the Southern Expressway in 1995 (Trindade 2000), and had 43 ha of mangroves, as well as a salty lagoon, directly influenced by urban area from 2009 onwards (Figure 1).

Surveys

Population trends were based on data collected in September 1994 (ENGEVIX 1994), as well as from April 2000 to April 2001, and December 2002 to December 2003 (Rosário 2004). Additionally, a two-year long fieldwork was conducted between October 2009 and September 2010, and October 2011 and September 2012. These surveys were conducted monthly at 10 stations (within a 100 m radius) separated from each other by at least 300 m along a single 4 km-transect (an adaptation of Hinojosa-Huerta *et al.* 2008), with a total sampling effort of 214 hours. Playback was not used due to continuous frequency of natural callings. Yearly abundance indexes were calculated by dividing the number of Mangrove Rail contacts per the number of point-counts carried out each year (Hinojosa-Huerta *et al.* 2008). A robust regression from the average number of individuals per month against year (1994 to 2012) was used to estimate population trends. The Spearman correlation coefficient (rs) measured the relationship between available mangrove area and the average number of individuals detected per year. Population density was estimated for each year and based on the extent of mangrove area obtained from aerial photographs (PMF 2014) and measured by Google Earth Pro 4.2 (Google 2009). Population density was estimated using the Distance Sampling 6.0 software (Thomas *et al.* 2010). Estimates were stratified and based on Conventional Distance Sampling. A negative exponential rate model for the detection function was fixed against the records using a cosine function and assuming certainty of detection and measurements (Thomas *et al.* 2010). The

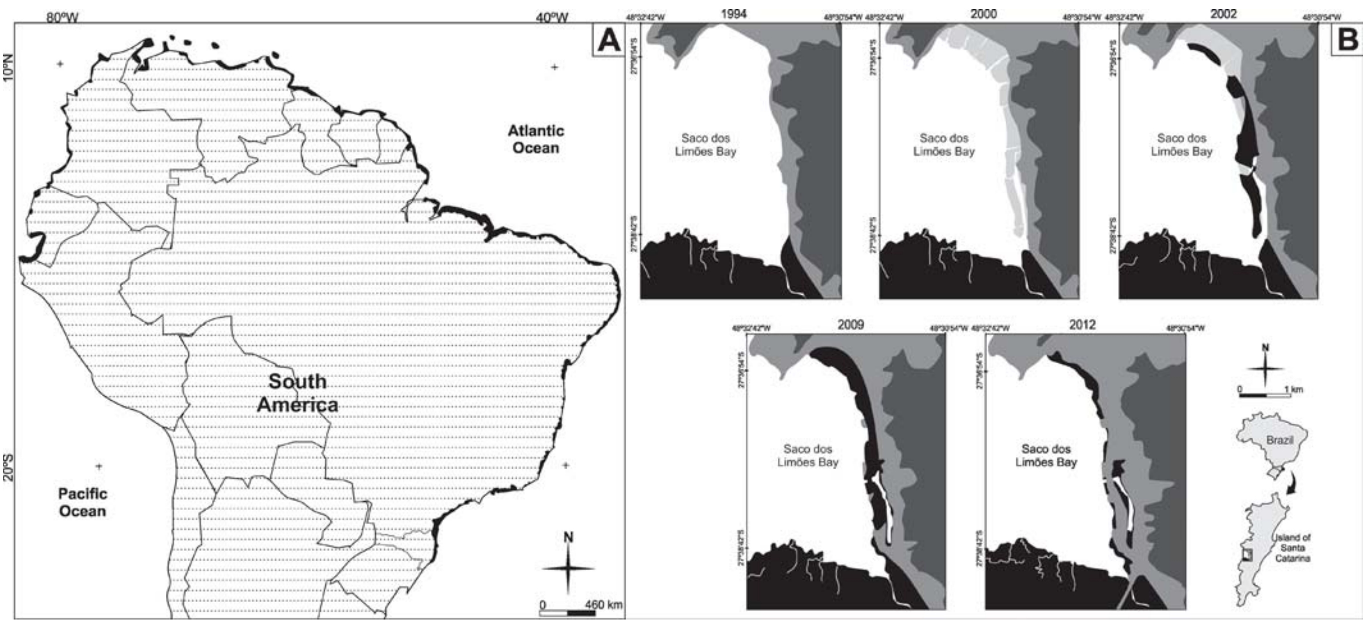

FIGURE 1. A) Distribution of mangrove forests in South America; and **B)** local landscape changes occurring between 1994 and 2012 along the Southern Expressway on the Island of Santa Catarina, southern Brazil. **Legend:** mainland (dotted), water (white), mangroves (black), landfill (light grey), urban area (middle grey), and Atlantic forest (dark grey). Maps based on Giri *et al.* (2011) and PMF (2014).

raw minimum and maximum numbers of rails observed per year were also considered.

Conservation

The Mangrove Rail global conservation status was revised according to IUCN criteria and categories (see IUCN 2011, 2012 for more details and definition of concepts). Range and population sizes, habitat threats and specificity, and population trends data presented herein as well as obtained from the literature, were contrasted against IUCN criteria and categories.

Global and national extents of occurrence for the Mangrove Rail were indirectly estimated based on mangrove forest cover in South America (based on Valiela *et al.* 2001, Cumana *et al.* 2010, Magris & Barreto 2010, and Giri *et al.* 2011) due to the species' strict association with mangroves (Holliman 1978, Taylor 1996, Sick 1997, Ridgely *et al.* 2005, Maley & Brumfield 2013) and known absence from salt marshes at latitudes higher than 28°S in southern Brazil (Rosário 1996, Sick 1997, Ridgely *et al.* 2005). Literature, web, and museum records (Figure 2) were used to confirm the Mangrove Rail area of occurrence within the estimated mangrove forest distribution. Since two major gaps of Mangrove Rail records were identified (between Bragança in Brazil and Cayenne in French Guyana, and between Guajiras in Colombia and Cojimíes in Ecuador), they were subtracted from the mangrove forest area cover in South America to obtain the species' area of occurrence. Area measurements were obtained from literature (Bacon 1993, Valiela *et al.* 2001, FAO 2005, Cumana *et al.* 2010, Magris & Barreto 2010, Giri *et al.* 2011, Anthony & Gratiot 2012) and confirmed or corrected with Google Earth Pro 4.2 (Google 2009).

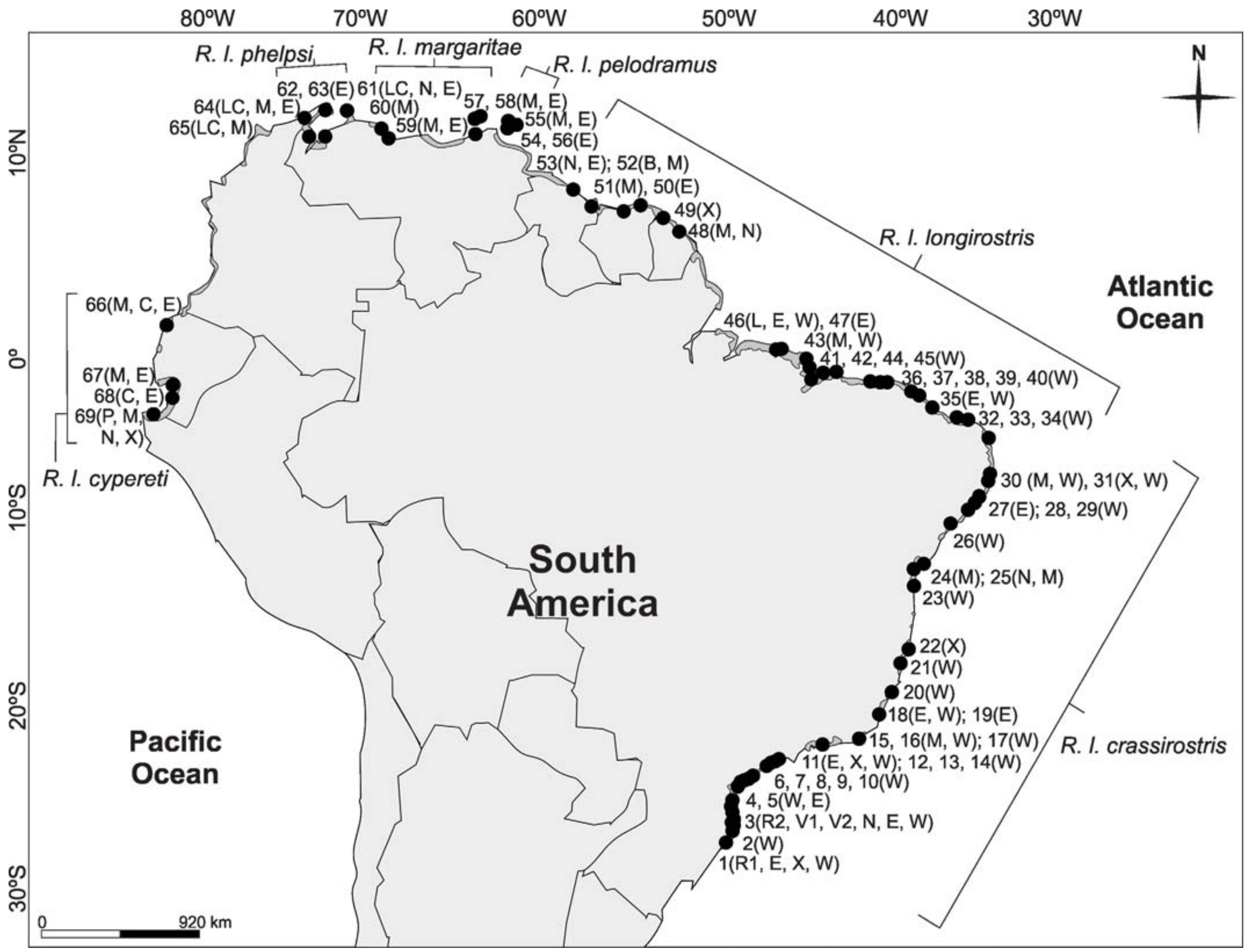

FIGURE 2. Occurrence of the Mangrove Rail (*Rallus longirostris*) and its subspecies in South America based on Maley & Brumfield (2013) and data compiled herein. Localities: 1 = Laguna (SC), Brazil; 2 = Palhoça (SC), Brazil; 3 = Florianópolis (SC), Brazil; 4 = Joinville (SC), Brazil; 5 = São Francisco do Sul (SC), Brazil; 6 = Morretes (PR), Brazil; 7 = Guaratuba (PR), Brazil; 8 = Guaraqueçaba (PR), Brazil; 9 = Antonina (PR), Brazil; 10 = Santos (SP), Brazil; 11 = Peruíbe (SP), Brazil; 12 = Itanhaém (SP), Brazil; 13 = Ilha Comprida (SP), Brazil; 14 = Cananeia (SP), Brazil; 15 = Iguapé (SP), Brazil; 16 = Rio de Janeiro (RJ), Brazil; 17 = Campo dos Goytacazes (RJ), Brazil; 18 = Cabo Frio (RJ), Brazil; 19 = Arraial do Cabo (RJ), Brazil; 20 = Vitória (ES), Brazil; 21 = Caravelas (BA), Brazil; 22 = Canavieiras (BA), Brazil; 23 = Ituberá (BA), Brazil; 24 = Jaguaripe (BA), Brazil; 25 = Salvador (BA), Brazil; 26 = Entre Rios (BA), Brazil; 27 = Santa Luzia do Itanhy (SE), Brazil; 28 = Aracaju (SE), Brazil; 29 = Pacatuba (SE), Brazil; 30

= Recife (PE), Brazil; 31 = Sirinhaém (PE), Brazil; 32 = Natal (RN), Brazil; 33 = Macau (RN), Brazil; 34 = Grossos (RN), Brazil; 35 = Icapuí (CE), Brazil; 36 = Aquiraz (CE), Brazil; 37 = Caucaia (CE), Brazil; 38 = Paracuru (CE), Brazil; 39 = Jijoca de Jericoacoara (CE), Brazil; 40 = Camocim (CE), Brazil; 41 = São José de Ribamar (MA), Brazil; 42 = Raposa (MA), Brazil; 43 = São Luís (MA), Brazil; 44 = Alcântara (MA), Brazil; 45 = Apicum-Açu (MA), Brazil; 46 = Bragança (PA), Brazil; 47 = Ajuruteua (PA), Brazil; 48 = Cayenne (Cayenne), French Guyana; 49 = Awala-Yalimapo (Awala-Yalimapo), French Guyana; 50 = Warappa Creek (Commewijne), Suriname; 51 = Diana Creek (Paramaribo), Suriname; 52 = Berbice River (East Berbice-Corentyne), Guyana; 53 = Georgetown (Demerara-Mahaica), Guyana; 54 = Nariva (Saint Andrew), Trinidad and Tobago; 55 = Caroni (Caroni), Trinidad and Tobago; 56 = Oropouche (Princes Town), Trinidad and Tobago; 57 = Puerto Cruz (Anzoátegui), Venezuela; 58 = Boca del Río (Nueva Esparta), Venezuela; 59 = Cumaná (Sucre), Venezuela; 60 = Puerto Cabello (Carabobo), Venezuela; 61 = Morrocoy (Falcón), Venezuela; 62 = Pueblo Nuevo (Falcón), Venezuela; 63 = Sabaneta de Palmas (Zulia), Venezuela; 64 = Maracaibo (Zulia), Venezuela; 65 = Uribia (La Guajira), Colombia; 66 = Cojimíes (Manabi), Ecuador; 67 = Guayaquil (Guayas), Ecuador; 68 = Churute (Guayas), Ecuador; 69 = Tumbes (Tumbes), Peru. Sources: B = Braun *et al.* (2000); C = Coopmans *et al.* (2004); E = www.eBird.org; L = Lees *et al.* (2014); LC = Lira & Casler (1979); M = museum voucher on www.ornisnet.org; N = voucher in the Natural History Museum at Tring; P = Parker *et al.* (1995); R1 = Rosário (1996); R2 = Rosário (2004); V1 = Vieira *et al.* (2014); V2 = Vieira (this study); W = www.wikiaves.com.br; X = www.xeno-canto.org.

RESULTS

Population trends

The minimum number of detections was 1 individual recorded during 2009, and the maximum number was 17 recorded during 2012 (Table 1). In mangroves planted between 1997 and 1998, the first records of Mangrove Rail did not occur until 2002 (Table 1). Mangrove Rail colonization of the whole mangrove area along the Southern Expressway took 10 years, from the first to the latest records (Table 1). The density of Mangrove Rails as an established population at the study area was 2 individuals per hectare (Table 1). As expected, the Spearman coefficient showed a very strong correlation between mangrove area development and Mangrove Rail population sizes ($rs = 1$; $p = 0.016$). A regression clearly indicated significant population increase ($y = 0.5736x – 0.9014$, $r^2 = 0.86$, $t = 44.57$, $p = 0.02$) through time.

TABLE 1. Number of Mangrove rails detected in the urban mangrove area along the Southern Expressway, Island of Santa Catarina, southern Brazil between 1994 and 2012.

	Density (rails/ha)	Average number of rails	Minimum number of rails	Maximum number of rails	Mangrove area (ha)
1994	0	0	0	0	0
2000 - 2001	0	0	0	0	0
2002 - 2003	2.1	1.5	0	4	8.7
2009 - 2010	1.4	3.2	1	8	27.1
2011 - 2012	2.0	7.2	3	17	43.5

Population size and colonizing time were probably influenced by mangrove immaturity until 2002 (Figure 3), when the first Mangrove rails were observed around the salty lagoon, the nearest formation to the Mangrove of Pirajubaé (Figure 3; Rosário 2004). From 2009 to 2010, densities were similar throughout the studied area (Figure 3). However, greater densities occurred where mangroves were more developed after 2011 (Figure 3).

Global Conservation

Literature records and vouchers of Mangrove Rail indicated occurrence at 69 localities throughout South America (Figure 2). Most of them (n = 46) were situated in Brazil (Figure 2). All records were taken in mangrove ecosystems. No Mangrove Rail records came from areas of salt marshes. Most mangrove forests with confirmed records are described as having formations of *Spartina* spp., which is often used by the Mangrove Rail to build nests and protect itself from predators (*pers. obs.*). The overall distribution of records confirmed the initial expectation of the Mangrove Rail being restricted to the extent of 19,615 km² of mangrove forests in South America (Table 2). However, the Mangrove Rail apparently does not occur continuously throughout South American mangroves (Figure 2), since two major distributional gaps were found: 1) between Bragança, Pará (Brazil) and Cayenne (French Guyana); and 2) between Guajiras (Colombia) and Cojimíes (Ecuador). Therefore, the estimated extent of occurrence for the Mangrove Rail drops to 12,455 km² when these gaps are discounted from the total mangrove forest cover of South America (Table 2).

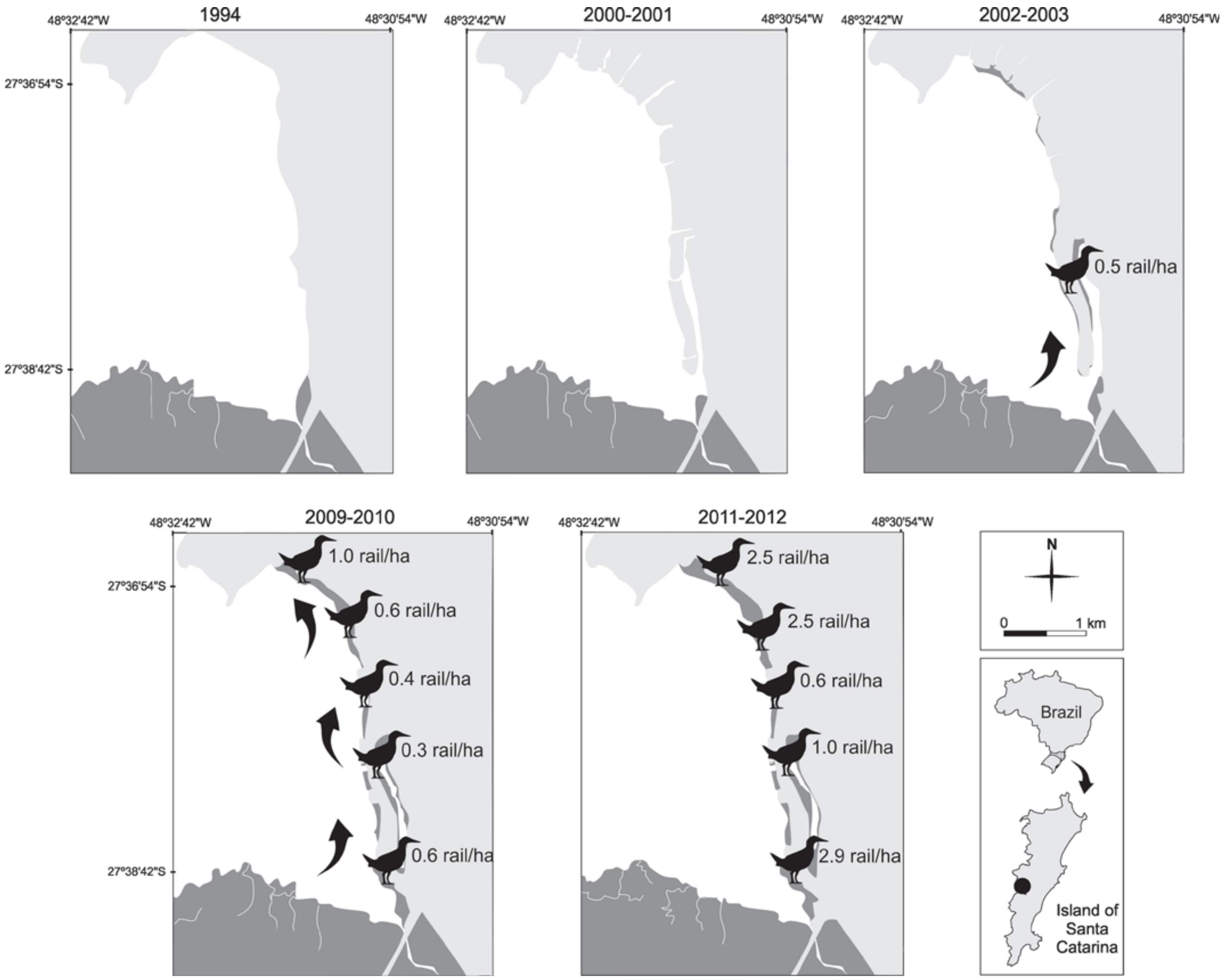

FIGURE 3. Density per hectare, probable direction of colonization (black arrows) and distribution of Mangrove rails between 1994 and 2012 along the Southern Expressway, Island of Santa Catarina, Brazil.

TABLE 2. Area of mangrove forests estimated in South America based on literature records and validated with Google Earth Pro 4.2 (Google 2009).

Country	Mangrove area (km²)	Reference
Brazil	11,114	Magris & Barreto (2010)
Colombia	3,580	Valiela *et al.* (2001)
Ecuador	1,620	Valiela *et al.* (2001)
Venezuela	1,380	Cumana *et al.* (2010)
Suriname	900	Correction of FAO (2005) who estimated 981.21 km² in 2002.
French Guiana	760	Valiela *et al.* (2001)
Guyana	160	Anthony & Gratiot (2012)
Peru	51	Valiela *et al.* (2001)
Trinidad and Tobago	50	Correction of Bacon (1993) who estimated 70 km² in 1992.
TOTAL IN SOUTH AMERICA	19,615	

Records of Mangrove rails in Peru, Ecuador and Trinidad and Tobago were inside or nearby the protected areas of the National Sanctuary Manglares de Tumbes (Parker *et al.* 1995), Ecological Reserve of Manglares de Churute (Coopmans *et al.* 2004), and Caroni Swamp National Park (voucher MVZ Egg8005 on ORNIS), respectively. In Venezuela, the Morrocoy and the Laguna de la Restinga national parks preserve mangroves areas, and both have records of Mangrove rails (Figure 2). Guyana has Coppename Nature Preserve and Wia-wia Nature Preserve protecting mangroves, but available Mangrove Rail records were outside these areas in Georgetown and Berbice (Figure 2). Records of Mangrove rails in Colombia come from Guajiras, on the border with Venezuela, and outside the six national parks (Sanquianga, Tairona, Ensenada de Utría, MacBean Lagoon, Isla Salamanca, and Uramba Bahía Málaga) that protect mangroves throughout the Colombian coastline (MADS 2015).

Brazil has dozens of protected areas covered with mangrove forests with different sizes (ICMBIO 2011). Nevertheless, these protected areas may or may not allow human activities ranging from sustainable use to industrial parks (ICMBIO 2011). According to Magris & Barreto (2010) and ICMBIO (2011), Brazil has six large protected mangrove forest areas (Biological Reserve of Lago do Piratuba and Environmental Protection Areas of Reentrâncias Maranhenses, Archipelago of Marajó, Baixada Maranhense, Delta do Parnaíba, and Guaraqueçaba), which combined preserve a total of 4,280 km² of mangrove forests, with most of them allowing only sustainable use of natural resources. Of these six protected areas, three (Reentrâncias Maranhenses, Delta do Parnaíba, and Guaraqueçaba) have confirmed records of the Mangrove Rail (Figure 2). Other smaller protected mangrove areas also preserve the extremes of the Brazilian area of occurrence of the Mangrove Rail. Extreme confirmed records (Figure 2) were at or nearby the Marine Reserves of Tracuateua, Caetetaperaçu, Arai-Peroba, and Gurupi-Piria in the state of Pará, and at Ecological Station of Carijós, Marine Extractive Reserve of Pirajubaé, Serra do Tabuleiro State Park, and Environmental Protection Area of Baleia Franca in the state of Santa Catarina (Figure 2).

DISCUSSION

Total density of *Rallus longirostris crassirostris* from the first and latest observations in the Island of Santa Catarina was around 2 rails/ha, even when both available habitat and the average number of Mangrove Rails increased. Other studies found similar densities for the former *Rallus longirostris* complex. Anderson & Ohmart (1985) found the density interval from 1.5 to 2.8 rail/ha in Arizona, USA. Hinojosa-Huerta *et al.* (2008) estimated it at 1.03 rails/ha, but the most conservative abundance estimate recorded 4,698 individuals in 5,800 ha at Ciénega de Santa Clara (México). In turn, Liu *et al.* (2012) modeled densities ranging from 0.20 to 0.34 rails/ha in 13,254 ha at San Pablo Bay, San Francisco Bay, and Suisun Bay (USA). They also estimated 1,167 Clapper Rails at San Pablo Bay, San Francisco Bay, and Suisun Bay between 2009 and 2011 (Liu *et al.* 2012).

Local population in this study increased due to dispersal, whereas spatial density remained stable after colonization of the whole sampled area. For populations already established in a certain territory, Overton *et al.* (2014) found subspecies *Rallus obsoletus obsoletus* declining in California, though *Rallus obsoletus levipes* had a stable population in the same state (Powell 2006). Such variety of results in population trends is related to specific interactions with habitats and resources, as well as due to differences in the prediction power of models and measures used. The positive relationship between presence of rails and habitat availability was already expected, because Mangrove rails are found specifically in mangrove areas, and their presence mostly depends on availability of grass, mainly *Spartina* spp., and intertidal invertebrates, mainly *Uca* spp. (*pers. obs.*). Foin & Brenchley-Jackson (1991) suggested that restoring wetlands could help improving rail populations, and the Mangrove Rail showed good capability for colonizing mangrove habitats in southern Brazil.

If the density of individuals found in southern Brazil could be extrapolated for the whole species' range, the Mangrove Rail global population would be in good numbers in South America, probably having more than 100,000 individuals. Nonetheless, mangrove forests in South America are not properly preserved in most of its distribution, and special management measures are justified. Though the loss of habitat is apparently not considerable in most extensive mangrove forests in north and northeastern Brazil, all other countries in South America and even southeastern and southern Brazil face the impacts of mangrove deforestation and contamination (Lugo & Snedaker 1974, Cintrón & Schaeffer-Novelli 1992, Valiela *et al.* 2001, MMA 2003, Anthony & Gratiot 2012, Vieira *et al.* 2011, 2012). The absence of records of Mangrove Rail in Colombia may be related to geographic constraints such as the Andes (*pers. obs.*). In Brazil, the abscence of records in extensive mangrove forests mainly in the state of Amapá is mirrored by a similar gap found between northern South American populations of *Aramides mangle* (Marcondes *et al.* 2014). Whether this gap for *A. mangle* and *R. longirostris* represent true absence or sampling artifact remains to be determined by future surveys (Marcondes *et al.* 2014).

Nevertheless this gap may be also related to ecological constrains such as low salinity levels near the mouth of the Amazon River, which may affect the habitat used by these rails (Alexander Lees 2015 *pers. comm.*).

The IUCN criteria for establishing the conservation status of a species demands investigating its degree of isolation and dispersion capacity, extent of occurrence, area of occurrence, presence in protected areas, and main threats. As local results obtained for the Island of Santa Catarina show, dispersion to new areas depends on connectivity between developed mangrove forests. Connectivity between neighboring populations also depends on mangrove extents.

The presence of Mangrove Rails in protected areas is a positive sign to its conservation, but it is important to remember that the presence in a protected area itself does not guarantee the species conservation. Management must be effective and connectivity between mangroves must exist to allow meta-population flux. Mangroves are the most endangered forest formation in the world (Valiela *et al.* 2001), and anthropogenic pressures have a devastating result in South America (Cintrón & Schaeffer-Novelli 1992, Valiela *et al.* 2001, Anthony & Gratiot 2012), reflected by the existence of less than 20,000 km² of mangrove forests in the whole continent.

Loss of habitat due to landfills, industrial activities, shrimp farms and settlements is the greatest problem Mangrove Rail populations face. These activities not only promote the loss of habitat but also contaminate the environment with dangerous and cumulative chemicals (Lugo & Snedaker 1974, Cintrón & Schaeffer-Novelli 1992, Valiela *et al.* 2001). Guyana, Suriname, and French Guyana have a fast replacement of mangrove forests for settlements (Anthony & Gratiot 2012), while Brazil loses almost 1,000 km² of mangrove forests per year (Valiela *et al.* 2001) as a result of illegal settlements, landfills, shrimp farming, and harbors even inside restricted protected areas (*pers. obs.*). Even though not tested yet in South America, the Mangrove Rail population may also be affected by heavy metals and dumping of waste as *Rallus crepitans* in North America (Novak *et al.* 2006). In a local context of isolated populations, constant use of playback by birdwatchers can affect breeding success and territory establishment, as proven to occur with other territorial birds (Mennill *et al.* 2002, Ward & Scholossberg 2004). However, ethical conduct, proper guiding and monitoring can easily regulate this activity.

Mostly because of deforestation of mangrove forests, the conservation status of the Mangrove Rail must be reviewed at all levels. The Mangrove Rail current global conservation status according to the IUCN is Least Concern. However, considering IUCN criterion VU-B1ab(i,ii,iii), the Mangrove Rail should be classified as Vulnerable at the global level. When applied to national levels, the Vulnerable status would also be supported for the Brazilian populations. In Colombia, the species (represented by *R. l. phelpsi*) should be considered as Endangered according to criterion EN-D since the local population size is most estimated as fewer than 250 mature individuals (Figure 2; Lira & Casler 1979, Pantaleón-Lizarazu & Rodríguez-Gacha 2002). Rates of mangrove deforestation in Suriname, French Guyana, Guyana, and Venezuela and national extents of occurrence calculated for these countries support the criterion EN-B1ab(i,ii,iii) for Mangrove Rail local populations, also indicating an Endangered status. Criteria EN-B2ab(i,ii,iii) and CR-B1ab(i,ii,iii), respectively, support classifying Ecuadorian and Peruvian populations (*R. l. cypereti*) as Endangered and Critically Endangered. The Trinidad and Tobago population (*R. l. pelodramus*) would also be classified as Critically Endangered according to criterion CR-B1ab(i,ii,iii).

As demonstrated by the Mangrove Rail, the conservation status of other species strictly associated with mangrove forests in South America need to be revised. Results obtained by this study show that habitat restoration can contribute to the recovery of mangrove-associated species even in areas of intensive human intervention (e.g. urban areas), which can be an alternative to future adaptive management of endangered species.

ACKNOWLEDGMENT

Thanks to Dayse Dias for her help in the fieldwork and Felipe Lima for the English review. Also, thanks to Alex Lees, the editor Alexandre Aleixo and the reviewers for valuable comments.

REFERENCES

Anderson, B. W. & Ohmart, R. D. 1985. Habitat use by clapper rails in the Lower Colorado River Valley. *Condor,* 87: 116-126.

Anthony, E. J. & Gratiot, N. 2012. Coastal engineering and large-scale mangrove destruction in Guyana, South America: Averting an environmental catastrophe in the making. *Ecological Engineering,* 47: 268-273.

Bacon, P. R. 1993. Mangroves in the Lesser Antilles, Jamaica and Trinidad and Tobago. In: Lacerda, L. D. (ed.) *Conservation and sustainable utilization of mangrove forests in Latin America and Africa Regions. Part I: Latin America.* Okinawa: International Society for Mangrove Ecosystems, International Tropical Timber Organization.

Braun, M. J.; Finch, D. W.; Robbins, M. B. & Schmidt, B. K. 2000. *A Field Checklist of the Birds of Guyana.* Washington, DC: Smithsonian Institution.

Cintrón, G. & Schaeffer-Novelli, Y. 1992. Ecology and management of New World mangroves, p. 233-258. In: Seeliger, U. (ed.). *Coastal plant communities of Latin America.* New Jersey: Academic Press.

CONSEMA, Conselho Estadual do Meio Ambiente. 2011.

Resolução nº 02/2011 – Reconhece a lista oficial de espécies da fauna ameaçadas de extinção no estado de santa catarina e dá outras providências. Florianópolis: CONSEMA/SDS.

Coopmans, P.; Moore, J. V.; Krabbe, N.; Jahn, O.; Berg, K. S.; Lysinger, M.; Navarrete, L. & Ridgely, R. S. 2004. *The birds of southwest Ecuador*. CD-ROOM, John V. Moore Nature Recordings.

Cumana, C. L.; Sanabria, C. M. E.; Leopardi, V. C. & Franco, Y. G. 2010. Plantas vasculares de los manglares del estado sucre, Venezuela. *Acta Botánica Venezuélica,* 33 (2): 273-298.

FAO, Food and Agriculture Organization of the United Nations. 2005. *Global forest resources assessment 2005, thematic study on mangroves: Surinam*. Rome: FAO Forestry Paper.

Foin, T. C. & Brenchley-Jackson, J. L. 1991. Simulation model evaluation of potential recovery of endangered light-footed clapper rail populations. *Biological conservation,* 58 (2): 123-148.

Eddleman, W. R. & ConWay, C. J. 1998. Clapper Rail (*Rallus longirostris*), no. 340. In: Poole, A. & Gill, F. (eds.). *The Birds of North America*. Philadelphia: The Academy of Natural Sciences; Washington: The American Ornithologists' Union.

ENGEVIX, Engevix Engenharia S/C Ltda. 1994. *Complementação aos estudos de impacto ambiental – contrato PJ-110/84 – Via Expressa Sul.* Florianópolis: ENGEVIX.

Google, Google Inc. 2009. *Google Earth Pro 4.2 software.* Google Inc.: Mountain View.

Hinojosa-Huerta, O. S. V. E. L.; Rivera-Díaz, J. J.; Iturribarría-Rojas, H. & Calvo-Fonseca, A. 2008. Population trends of Yuma clapper rails in the Colorado River delta, Mexico. *Studies in Avian Biology,* 37: 69-73.

Holliman, D. C. 1978. Clapper rail (*Rallus longirostris*) studies in Alabama. *Northeastern Gulf Science,* 2 (1): 24-34.

ICMBIO. 2011. *Mapa ilustrativo do sitema nacional de unidades de conservação da natureza.* Brasília: ICMBIO.

IUCN. 2011. *IUCN Red List Categories – Version 3.1.* http://www.iucnredlist.org/technical-documents/red-list-documents (access on 23 March 2015).

IUCN. 2012. *Guidelines for Application of IUCN Red List Criteria at Regional and National Levels: Version 4.0.* Gland, Switzerland, Cambridge: IUCN.

Lees, A. C.; Thompson II, I. & Moura, N. G. 2014. Salgado Paraense: an inventory of a forgotten coastal Amazonian avifauna. *Boletim do Museu Paraense Emílio Goeldi de Ciências Naturais,* 9 (1): 135-168.

Lira, J. R. & Casler, C. L. 1979. Aves acuaticas nuevas para el estado Zulia. *Boletín del Centro de Insvestigaciones Biológicas,* 13 (1): 89-96.

Liu, L.; Wood, J.; Nur, N.; Salas, L. & Jongsomjit, D. 2012. *California Clapper Rail (*Rallus longirostris obsoletus*) Population monitoring: 2005-2011.* PRBO Technical Report to the California Department of Fish and Game, California, USA.

Lugo, A. E. & Snedaker, S. C. 1974. The ecology of mangroves. *Annual Review of Ecology, Evolution and Systematics,* 5: 39-64.

Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J. & Duke, N. 2011. Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography,* 20 (1): 154-159.

Magris, R. A. & Barreto, R. 2010. Mapping and assessment of protection of mangrove habitats in Brazil. *Pan-American Journal of Aquatic Science,* 5: 546-556.

Macedo, J. F. 2003. *Caracterização do revestimento vegetal em zona de oscilação de maré, no aterro hidráulico da Via Expressa Sul – Florianópolis, Santa Catarina.* Dissertação de Mestrado, Universidade Federal de Santa Catarina, Florianópolis, Brasil, 80pp.

MADS, Ministerio de Ambiente y Desarollo Sustenible. 2015. *Parques Nacionales Naturales de Colombia.* http://www.parquesnacionales.gov.co/portal/ (access on 20 March 2015).

Maley, J. M. & Brumfield, R. T. 2013. Mitochondrial and next-generation sequence data used to infer phylogenetic relationships and species limits in the Clapper/King Rail complex. *The Condor,* 115 (2): 316-329.

Marcondes, R. S.; Del-Rio, G.; Rego, M. A. & Silveira, L. F. 2014. Geographic and seasonal distribution of a little-known Brazilian endemic rail (*Aramides mangle*) inferred from occurrence records and ecological niche modeling. *The Wilson Journal of Ornithology,* 126 (4): 663-672.

Mennill, D. J.; Ratcliffe, L. M. & Boag, P. T. 2002. Female eavesdropping on male song contests in songbirds. *Science,* 296: 873.

MMA, Ministério do Meio Ambiente. 2003. *Livro vermelho da fauna brasileira ameaçada de extinção.* Brasília, Belo Horizonte: Ministério do Meio Ambiente, Fundação Biodiversitas.

Novak, J. N.; Gaines, K. F.; Cumbee-Jr., J. C.; Mills, G. L.; Rodríguez-Navarro, A. & Romanek, C. S. 2006. The Clapper Rail as an indicator species of estuarine marsh health. *Studies in Avian Biology,* 32: 270-281.

Overton, C. T.; Casazza, M. L.; Takekawa, J. Y.; Strong, D. R. & Holyoak, M. 2014. Tidal and seasonal effects on survival rates of the endangered California clapper rail: does invasive *Spartina* facilitate greater survival in a dynamic environment? *Biological Invasions,* 1: 1-18.

Pantaleón-Lizarazu, A. & Rodríguez-Gacha, D. 2002. *Avifauna asociada a los manglares de la laguna Navío Quebrado, en el Santuario de Fauna y Flora Los Flamencos.* Monografía de practica professional, Universidad Jorge Tadeo Lozano, Bogotá, Colombia, 32pp.

Parker, T. A.; Schulenberg, T. S.; Kessler, M. & Wust, W. H. 1995. Natural history and conservation of the endemic avifauna in north-west Peru. *Bird Conservation International* 5: 201-231.

PMF, Prefeitura Municipal de Florianópolis. 2014. *Geoprocessamento coorporativo.* http://geo.pmf.sc.gov.br (access on 10 May 2014).

Powell, A. N. 2006. Are southern California's fragmented salt marshes capable of sustaining endemic bird populations? *Studies in Avian Biology,* 32: 198-204.

Ridgely, R. S.; Allnutt, T. F.; Brooks, T.; McNicol, D. K.; Mehlman, D. W.; Young, B. E. & Zook, J. R. 2005. *Digital distribution maps of the birds of the Western Hemisphere.* http://www.natureserve.org/conservation-tools/data-maps-tools/digital-distribution-maps-birds-western-hemisphere (access on 10 May 2014).

Rosário, L. A. 1996. *As aves em Santa Catarina: Distribuição geográfica e meio ambiente.* Florianópolis: Fundação do Meio Ambiente.

Rosário, L. A. 2004. *Um outro olhar da Via Expressa Sul.* Florianópolis: Edição da autora.

Sick, H. 1997. *Ornitologia brasileira.* Rio de Janeiro: Nova Fronteira.

Sigrist, T. 2009. *Guia de campo Avis Brasilis: Avifauna brasileira.* 1ª ed., vol. 2, São Paulo: Editora Avis Brasilis.

Taylor, B. 1996. Family Rallidae (rails, gallinules and coots), p. 109-209. In: Del-Hoyo, J.; Elliott, A. & Sargatal, J. (eds.). *Handbook of the birds of the world: Hoatzin to Auks.* Vol. 3, Barcelona: Lynx Edicions.

Thomas, L.; Buckland, S. T.; Rexstad, E. A.; Laake, J. L.; Strindberg, S.; Hedley, S. L.; Bishop, J. R. B.; Marques, T. A. & Burnham, K. P. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology*, 47: 5-14.

Trindade, C. C. 2000. *Limites e possibilidades de uma gestão democrática do ambiente urbano – O caso do aterro do Saco dos Limões Florianópolis-SC.* Dissertação de Mestrado, Universidade Federal de Santa Catarina, Florianópolis, Brasil, 151pp.

Valiela, I.; Bowen, J. L. & York, J. K. 2001. Mangrove forests: one of the world's threatened major tropical environments. *Bioscience*, 51 (10): 807-815.

Vieira, B. P.; Dias, D. & Hanazaki, N. 2011. Homogeneidade de encalhe de resíduos sólidos em um manguezal da Ilha de Santa Catarina, Brasil. *Journal of Integrated Coastal Zone Management,* 11 (1): 21-30.

Vieira, B. P.; Dias, D.; Nakamura, E. M.; Arai, T. I. & Hanazaki, N. 2012. Is there temporal variation on solid waste stranding in mangroves? A case study in Ratones mangrove, Florianopolis, Brazil. *Biotemas,* 26 (1): 79-86.

Vieira, B. P.; Dias, D.; Piacentini, V. Q.; Correia, E. C. & Serafini, P. P. 2014. Birds of Estação Ecológica de Carijós, southern Brazil. *Check List,* 10 (5): 1110-1122.

Ward, M. P. & Schlossberg, S. 2004. conspecific attraction and the conservation of territorial songbirds. *Conservation Biology,* 18: 519-525.

Associate Editor: Caio Graco Machado