Iheringia
Série Zoologia

e-ISSN 1678-4766
www.scielo.br/isz

Museu de Ciências Naturais

Article

Effects of anthropogenic disturbance in the survival of the sand lizard, *Liolaemus occipitalis* (Squamata: Liolaemidae)

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Received 5 December 2021
Accepted 8 April 2022
Published 01 July 2022

DOI 10.1590/1678-4766e2022014

ABSTRACT. Habitat fragmentation is one of the sources of the global threat to wildlife populations. During the last four decades, urban development in Brazil's southern coastline has seen considerable growth, fragmenting the habitat of the sand lizard *Liolaemus occipitalis* Boulenger, 1885, thus threatening it with extinction. In order to assess the influence of urban development on this species, we used tagging and recapture data to study two populations in Brazil's southern coastline, one in a conserved area rarely subjected to disturbance and the other in an area undergoing different kinds of anthropogenic disturbance. We explored the consequences of this change in the natural landscape by comparing estimates of survival and abundance with Robust Design Model, and the body condition of individuals in both populations with analysis of covariance and variance. Survival of individuals were lower in the disturbed population than in the conserved population. The abundance of this lizard species was similar between populations. The body condition of females was higher in the disturbed area than in the conserved area, while males were similar among populations, but longer (SVL). This study shows how anthropic impacts can affect a population of lizards and the importance of maintaining protected areas and their interconnection to preserve *Liolaemus occipitalis*.

KEYWORDS. Sand dune, anthropogenic impact, body condition, demography.

RESUMO. Efeitos do distúrbio antropogênico na sobrevivência do lagarto da areia, *Liolaemus occipitalis* (Squamata: Liolaemidae). A fragmentação do habitat é uma das fontes de ameaça global às populações de vida selvagem. Durante as últimas quatro décadas, o desenvolvimento urbano do litoral sul do Brasil teve um crescimento considerável, fragmentando o habitat da lagartixa-da-praia lagarto-da-areia *Liolaemus occipitalis* Boulenger, 1885, ameaçando-o de extinção. Para avaliar a influência do desenvolvimento urbano sobre esta espécie, usamos dados de marcação e recaptura para estudar duas populações, uma em uma área conservada raramente sujeita a perturbações, e a outra em uma área submetida a diferentes tipos de perturbações antrópicas. Exploramos as consequências dessa mudança na paisagem natural comparando estimativas de sobrevivência e abundância com Modelo Robusto de Pollock, e condição corporal dos indivíduos com análises de covariância e variância, em ambas as populações situadas no litoral sul do Brasil. A abundância da espécie foi semelhante nas duas áreas, mas a sobrevivência dos indivíduos foi menor na população perturbada do que na conservada. A condição corporal das fêmeas foi maior na área perturbada, enquanto que o CRC dos machos foi maior na área conservada. Este estudo mostra como impactos antrópicos podem afetar uma população de lagartos e a importância da manutenção de áreas protegidas e sua interconexão para a preservação de *Liolaemus occipitalis*.

PALAVRAS-CHAVE. Dunas, impacto antrópico, condição corporal, demografia.

All main sources of threat to reptiles are linked to humankind, including habitat loss and degradation, pollution, global climate change (Gibbons *et al.*, 2000). Many species face severe shrinkage of their distribution areas or total loss of their habitats due to increased human activity. This progressive increase of anthropogenic activities diminishes the size of suitable natural fragments, reducing the connectivity between habitat patches (Gaines *et al.*, 1997).

Habitat fragmentation is usually defined as a landscape-scale process involving habitat loss and breakage (Fahrig, 2003). Fahrig (2003) suggests that the term "fragmentation" should be used exclusively to refer to habitat breakage regardless of its loss since habitat fragmentation produces weaker effects on biodiversity. Although fragment size, isolation, and distance to the edge may have direct effects on the abundance and species diversity, environmental variables and vegetation can also shape animal communities in fragments because of restrictions species present to survive and reproduce (How & Dell, 2000).

Despite being a protected area under federal law since 1965, the restinga vegetation of the coastal plain of southern Brazil has undergone severe fragmentation due to urban development. In the decade of 1980, the human population living in the cities of the coastal plain represented about 5% of the total population of the state of Rio Grande do Sul (Vieira & Rangel, 1988). Within 30 years, demographic density in the region increased fivefold (Instituto Brasileiro de Geografia e Estatística, 2010), degrading the native fauna and flora due to sand dune removal for urban development purposes, waste disposal, human and pet trampling, and motor vehicle traffic (Tabajara *et al.*, 2005).

In Brazil, the coastal plain reaches its maximum coverage in the Rio Grande do Sul state, spreading over 33,000 km^2, with a 620 km length and up to 80 km width (Tomazelli *et al.*, 2000). This ecosystem shows plant assemblages typical of flooded areas, including *capões*, natural puddles, and dunes, which play an important thermal function in the soils (Vieira & Rangel, 1988). Among the native fauna, the small sand lizard, *Liolaemus occipitalis* Boulenger, 1885 occurs in the southern Brazilian coastline, from the south of Santa Catarina to Rio Grande do Sul states (Verrastro & Bujes, 1998; Verrastro & Krause, 1999), and in part of the Uruguayan coast (from Barra del Chuy to the left bank of the Arroio Valizas) (Verrastro *et al.*, 2006). *Liolaemus occipitalis* is classified as "Vulnerable" to extinction in regional (Estado do Rio Grande do Sul, 2014), national (Instituto Chico Mendes de Conservação da Biodiversidade, 2018), and global lists according to the B1+2bc criteria (extent of estimated occurrence lower than 20,000 km² + continuous decline of inhabited area) (Di Bernardo *et al.*, 2000).

Vertebrate population size is one of the main parameters used to determine the risk of extinction since it is related to genetic variability (Broders *et al.*, 1999; Reed *et al.*, 2003). The less isolated and larger a population is, the greater its genetic diversity (Madsen *et al.*, 2000). Loss of genetic variability may cause changes in species' vital rates such as growth and reproduction, reducing their adaptive ability to cope with stressful environments (Hedrick *et al.*, 1996). In addition, isolated populations are more likely to suffer declines due to stochastic extinction events combined with the incapability of recolonizing distant habitat patches (Pickett *et al.*, 2013).

Sand lizards are considered residents and have relatively small home ranges (Rocha, 1999; Kacoliris *et al.*, 2009). This resident behavior makes them even more susceptible to anthropic disturbances in their characteristic habitat. The degradation of the coastal dunes' native vegetation decreases the refuges available to the lizards, increasing the risk of predation. Thus, the lizards' behavioral strategy may present changes, such as increasing their movement speed, leading to the deterioration of body condition (mass and SVL) due to a higher energetic cost (Amo *et al.*, 2007).

Liolaemus occipitalis has an omnivorous diet (Verrastro & Ely, 2015) and a diurnal habit strongly associated with sand dune native vegetation (Verrastro & Bujes, 1998; Bujes & Verrastro, 2006). The degradation of this vegetation due to anthropic disturbances may cause fluctuation of resources that are essential to *L. occipitalis*, such as foraging sites, thermoregulation sites, and sites of protection against predators (Verrastro & Bujes, 1998). Considering the fragmentation process occurring in the last 30 years in the coastal Plain of southern Brazil, the anthropic impacts in the natural habitat of this species can drastically affect its populations, being extremely important to know and quantify these populations in order to develop conservation strategies.

Therefore, our main goal is to assess the influence of urban development on the individual body condition and population demography of the sand lizard, *L. occipitalis*. We tested the hypothesis that anthropogenic disturbance negatively affects the populations, and we predict that individuals from a disturbed area would present reduced survival rates and body condition. Consequently, population abundance should be smaller in disturbed areas than in preserved ones.

MATERIAL AND METHODS

Study area. We selected two geographically isolated areas, 8.4 km apart, located in the Torres municipality in the northern limit of the Rio Grande do Sul coastal plain, Brazil. The first area is a conserved habitat inside the State Park of Itapeva (hereafter PEI, 29°22'5.55"S, 49°45'10.68"W), an area protected by law since 2002 (Secretaria estadual do meio ambiente, 2017), and characterized by low anthropogenic disturbance (rare human and domesticated animal presence). The second area is Real beach (hereafter Real, 29°26'9.84"S, 49°47''58.68"W), a beach surrounded by high anthropogenic disturbance (i.e., with the presence of humans, pets, waste disposal, and motor vehicles) (Fig. 1).

We chose both Real and PEI areas following two criteria. First, their proximity, thus assuring they are under the same climate regime, latitude, and environmental conditions. Second, both areas are similar in size: Real (disturbed area) present 2.53 ha, and PEI (conserved area) present 2.60 ha. Real is limited in the east by the sea, north by a spillway, and in the west and south by an urban allotment with public pathways. The PEI area is limited in the east by dense vegetation cover and north, west, and south by high, naked, mobile dunes. Thus, both areas are naturally limited, and anthropogenic disturbance was the main difference between them.

Data collection. We conducted six field surveys in the PEI population and five in the Real population between January 2015 and December 2016, during the breeding season of *Liolaemus occipitalis*, in austral spring and summer (Verrastro & Krause, 1999; Verrastro & Rauber, 2013). In 2015 we performed the sampling in January, February, and November. In 2016, it occurred in February, November, and December in both populations. Only the fifth sampling occasion (November 2016) cannot be held in the disturbed area (Real). Each field survey lasted from two to four days, totaling 15 sampling occasions in PEI and 13 sampling occasions in Real. In each sampling occasion, we measured the air temperature using a K-Type thermometer (0.1%+1°C) and wind speed using a portable weather station (Portable Digital Termo-Higro-Anemometer-Luxímeter) at the beginning, the middle, and the end of sampling to obtain daily averages of these variables.

Fig. 1. Location map of sampling areas for the two populations of *Liolaemus occipitalis* Boulenger, 1885 in the study, Rio Grande do Sul, Brazil. Triangle: Real beach; Circle: State Park of Itapeva (PEI).

Two observers randomly searched for lizards in both areas, from 3 to 7 hours per sampling occasion, between 8h and 18h, the period of *Liolaemus occiptalis* activity (Verrastro & Bujes, 1998). Lizards were visually located, captured by hand, and marked using toe clipping by removing the distal one-third of the toe (Woodbury, 1956) (SISBIO Animal Welfare Permit 43002). Besides being low-cost, this method usually entails lower individual stress levels than other known marking techniques (Bórges-Landáez & Shine, 2003; Paulisen & Meyer, 2008; Ekner *et al*., 2011). After marking, we measured snout-vent length (SVL) and mass using analogical caliper (0.01 mm) and a dynamometer (0.1g), respectively.

The captured individuals were grouped according to age (adult or juvenile) and gender. Males with SVL>50 mm and females with SVL>45 mm were considered adults (Verrastro & Krause, 1994, 1999; Verrastro & Rauber, 2013). Gender was determined according to the presence of cloacal pores in males, a sexually dimorphic trait (Verrastro, 2004).

Data analysis. We used mark-recapture models (Lebreton *et al*., 1992; Williams *et al*., 2002) to estimate demographic parameters for both populations. Mark-recapture models dissociate ecological processes from observational processes, which are subject to sampling errors, by estimating the probability of recapture of individuals (Williams *et al*., 2002; MacKenzie *et al*., 2006). In this study, we used Pollock's Robust Design Model, which considers sampling periods when populations are closed, with no input or output of individuals (secondary occasions), and periods when populations are open (primary occasions), i.e., when populations increase and decrease. Pollock's Design provides more robust estimates because estimates and variances are not strongly affected, like when premises of separate closed or open population models are not properly followed (Pollock, 1982; Williams *et al*., 2002).

We estimated the following parameters: apparent survival probability (ϕ), temporary emigration probability (γ), capture probability (p), recapture probability (c), and abundance (N). To check if there was a difference between the input and output of individuals in the populations, we have constructed markovian temporary emigration probability models (γ), in which we measured the probability of an individual leaving the area of study in time t+1 (γ''), the probability of an individual remaining outside the same area (γ'), and a random emigration probability ($\gamma'' = \gamma'$). To include the effect of a modification in the disturbed area (Real) caused by an invasion of the spillway, which destroyed much of the area available for the lizards, we included a binary variable (0/1) (SG) designating the period before and after the event.

Between sampling periods (5-6 field expeditions), populations are geographically and demographically open, and the model provides estimates of apparent survival probability and temporary emigration probability; these periods are called primary sampling occasions. Within the sampling periods (2-4 days), populations are closed, thus assuming no birth/immigration or death/emigration, and the model provides estimates of capture probability, recapture, and abundance (Pollock, 1982); these periods are called secondary sampling occasions. We adjusted parameter estimation for uneven time intervals.

We included group effect (adult males, adult females, and juveniles of both sexes) as a predictor of survival due to possible variability among groups. In addition, we included the effects of air temperature (Ta), wind speed (V), and effort, measured in hours (H), on the probability of capture (p) and recapture (c). We used Huggins' closed capture estimator to test the effects of individual and temporal covariates on the parameters (Huggins, 1989, 1991). All three variables were included as additive effects. Models were ranked using Akaike Information Criterion (AICc), and the model with the lowest AICc value was used to report the effects of the predictors on the parameters. We assumed models with delta AIC < 2 as models with strong support (Burnham & Anderson, 2002).

Since Pollock's Robust Design does not include a goodness-of-fit test, we used the "median $\hat{c}$ test" and the Program RELEASE in an open population approach (CJS model) to test for overdispersion in our models (Cooch & White, 2015). All analyses were carried out using the MARK software, Version 8.1 (White & Burnham, 1999).

We used body condition, calculated as the ratio between mass and SVL, to measure health status, since it is related to environmental fluctuations (Forsman & Lindell, 1996; Hoare *et al.*, 2006). To assess the effects of anthropogenic disturbance on the lizards' body condition, we performed analysis of covariance (ANCOVA) comparing individual body condition between populations, using mass as the response variable and SVL as a covariate. In addition, we tested individual SVL between populations, with analysis of variance (ANOVA), to find if there was any effect on individual size alone. We conducted separate tests for males and females since males are larger than females. Also, a separated test can indicate if the genders are differently impacted by the anthropic disturbance. Statistical analyses were conducted using the Past3 software, Version 3.20.

RESULTS

We captured 133 lizards throughout the study, with similar numbers of individuals marked in Real (n = 65) and PEI (n = 68) populations. Almost half of the captures were recaptures (48.5%) in PEI, while in Real only 17.7% of captures were recaptures.

Survival probability. Annual apparent survival probability differed between populations. The estimates did not show differences between adults and juveniles in Real ($\phi = 0.70 \pm 0.17$) (Tab. I), while in PEI, survival was higher for adults (Males = 0.98 ± 0.40; Females = 0.94 ± 0.50; Juveniles = 0.71 ± 0.80) (Tab. II). Only the data from Real showed overdispersion (2.54), and we adjusted the models accordingly. The three best-ranked models for the Real population slightly differed (ΔAICc<0.48) (Tab. I). Thus, we model-averaged the estimates to interpret the results (Burnham & Anderson, 2002) (Tab. I).

Tab. I. Models adjusted for the population of *Liolaemus occipitalis* Boulenger, 1885 in Real beach (QAICc, Akaike Information Criterion adjusted by overdispersion; DQAICc, difference between the first model and the competing models; QAICc weight, weight of the model; *K*, number of parameters; Deviance, difference between the overall model and the saturated model; SG, spillway effect; Abiotic variables (Ta = air temperature in ºC; V = wind speed in km/h; H = number of sampling hours per day).

Model	QAICc	ΔAICc	QAICc weight	k	Deviance
$\phi(.)\ \gamma'' = \gamma'\ p$ (V) c (V)	95.38	0.00	0.29	5	32.59
$\phi(.)\ \gamma'' = \gamma'\ p$ (H) c (H)	95.58	0.20	0.26	5	32.79
$\phi(.)\ \gamma'' = \gamma'\ p$ (Ta) c (Ta)	95.85	0.47	0.23	5	33.06
$\phi(.)\ \gamma'' = \gamma'\ p$ (V+H) c (V+H)	97.30	1.92	0.11	6	32.17
$\phi(SG)\ \gamma'' = \gamma'\ p$ (V) c (V)	97.50	2.11	0.10	6	32.37

Tab. II. Results of the models of the population of *Liolaemus occipitalis* Boulenger, 1885 in the State Park of Itapeva (PEI), Rio Grande do Sul, Brazil (AICc, Akaike Information Criterion; ΔAICc, difference between the first model and the competing models; AICc weight, weight of the model; *K*, number of parameters; Deviance, difference between the overall model and the saturated model; G, group (adult males, adult females and juveniles); t, time; Abiotic variables (Ta, air temperature in ºC; V, wind speed in km/h; H, number of sampling hours per day).

Model	AICc	ΔAICc	AICc weight	k	Deviance
$\phi(G)\ \gamma''\ \gamma'\ p$ (Ta+H) c (Ta+H)	387.69	0.00	0.50	9	257.03
$\phi(G)\ \gamma'' = \gamma'\ p$ (Ta+H) c (Ta+H)	389.78	2.09	0.17	8	261.44
$\phi(G+t)\ \gamma''\ \gamma'\ p$ (Ta+H) c (Ta+H)	389.80	2.11	0.17	13	249.46
$\phi(G)\ \gamma''\ \gamma'\ p$ (Ta+V+H) c (Ta+V+H)	390.04	2.35	0.15	10	257.02

During the last field expedition to the disturbed area (Real), we observed a change caused by an outflow of water from the spillway, which limited the area in the north, drastically reducing the area available for the lizards. We tested the effect of this change in apparent survival by including a binary predictor (SG) in the model, which was the fifth best-ranked model (ΔAICc = 2.11) (Tab. I). We estimated the lowest survival probability of the whole study ($\phi = 0.9 \pm 0.85$) on that sampling occasion.

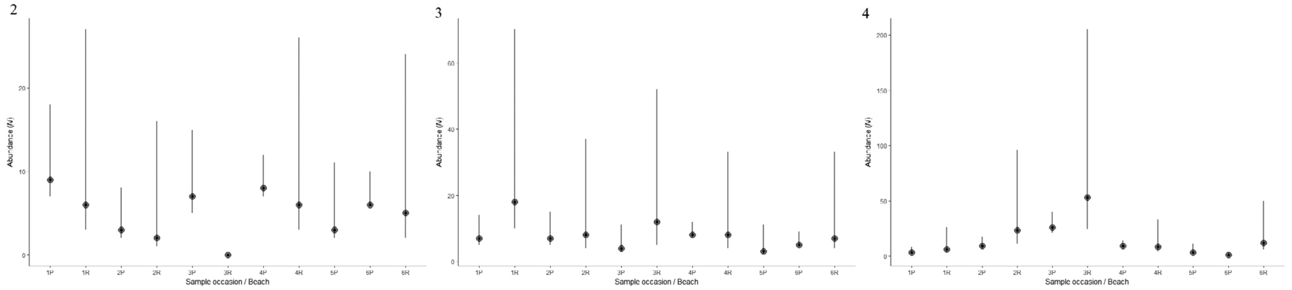
Temporary emigration probability. The best-ranked models for Real included random emigration, although with low precision estimates ($\gamma = 0.28 \pm 0.99$, CI = 0 to 0.99) (Tab. I). There was a difference in emigration probabilities in PEI: the probability of an individual leaving the area of the study in time *t+1* was 32% ($\gamma'' = 0.32 \pm 0.13$, CI = 0.12 to 0.61) ($\beta\gamma'' = -0.73$, CI = -1.9 to 0.05), while the probability of an individual remaining outside the same area was 100% ($\gamma' = 1.00 \pm 0.17\text{E-}004$, CI = 0.99 to 100) ($\beta\gamma' = 18.37$, CI = -4643.3 to 4680.03) (Tab. II).

Probability of detection. In Real, the estimates of *p* and *c* varied according to sampling occasion, from 0.13 to 0.23 and from 0.09 to 0.18, respectively. The lowest probabilities of capture (*p*) and recapture (*c*) were estimated in the last field expedition ($p = 0.13 - 0.19$; $c = 0.09 – 0.11$), when the available habitat decreased due to the water outflow. Air temperature ($\beta_{Ta} = -0.004$, CI = -0.22 - 0.21), wind speed ($\beta_{V} = -0.031$, CI = -0.12 - 0.06), and sampling effort ($\beta_{H} = 0.06$, CI = -0.18 - 0.31) did not show important effects on detection probabilities (Tab. I).

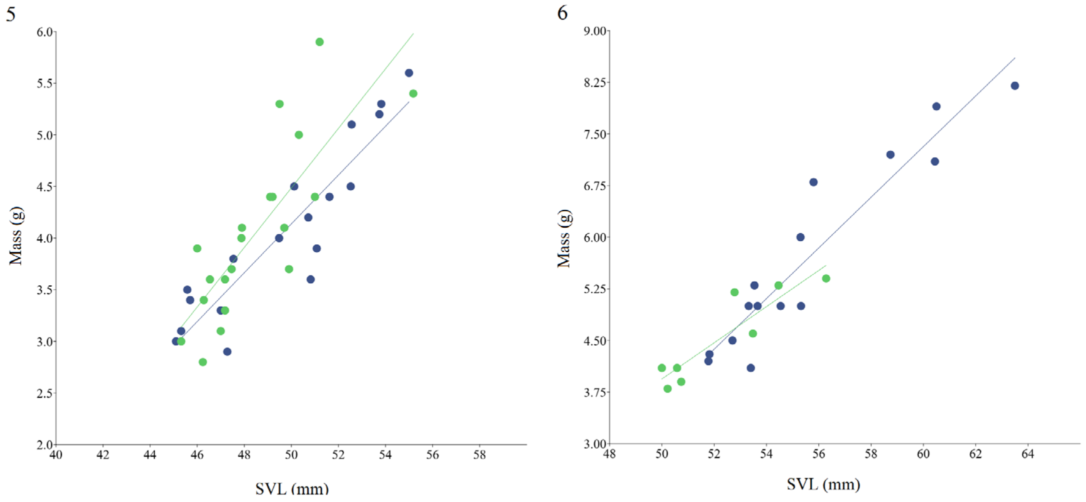
In PEI, detection probabilities were higher than in Real: *p* varied between 0.19 and 0.64, and *c* varied between 0.15 and 0.49. Air temperature ($\beta_{Ta} = 0.18$, CI = 0.03 - 0.31) and sampling effort ($\beta_{H} = 0.26$, CI = 0.05 - 0.47) had a positive influence on detection (Tab. II).

Abundance. The estimated lizard abundance varied according to age and gender classes between populations. At the Real, we estimated from 0 to 18 adults (0-6 males and 7-18 females) and from 6 to 53 juveniles, while at the PEI, we estimated from 3 to 9 adults (3-9 males and 3-8 females) and from 1 to 26 juveniles (Figs 2, 3, 4).

Individual body condition. Female and male body condition varied between populations. When we compare females between populations, we observe that although they do not differ in terms of length (SVL), they are heavier in the disturbed population (ANOVA, $F = 1.80$, $df = 1$, $p = 0.19$, $Npei = 18$, $Nreal = 20$), (ANCOVA, $F = 4.05$, $df = 1$, $p = 0.05$, $Npei = 18$, $Nreal = 20$) (Fig. 5). Males are larger (SVL) in the preserved population, they do not differ in body condition between populations (ANOVA, $F = 5.61$, $df = 1$, $p = 0.02$, $Npei = 15$, $Nreal = 8$), (ANCOVA, $F = 1.11$, $df = 1$, $p = 0.99$, $Npei = 15$, $Nreal = 8$) (Fig. 6).



Figs 2-4. Abundance of *Liolaemus occipitalis* Boulenger, 1885 estimated in each primary sampling occasion for State Park of Itapeva (P) and Real beach (R), Rio Grande do Sul, Brazil: 2, adult males; 3, adult females; 4, juveniles. Samplings 1 – 3 were conducted in 2015 and 4 – 6 in 2016; Vertical lines are representative of confidence intervals of 95%.



Figs 5, 6. *Liolaemus occipitalis* Boulenger, 1885 size in State Park of Itapeva (green circle) and Real beach (blue circle), Rio Grande do Sul, Brazil: 5, female; 6, male.

DISCUSSION

In agreement with our predictions, the survival rate of the individuals of *Liolaemus occipitalis* was lower in the population that suffered from several anthropic disturbances. The high survival of adults in the conserved area is highlighted, mainly males, which usually have a bigger home range than females and the young, as described for other sand lizards populations (Rocha, 1999; Kacoliris *et al*., 2009). Predation on adult males may be higher due to their exposure when displaying territorial behavior (Tinkle & Ballinger, 1972; Parker & Pianka, 1973; Kacoliris *et al*., 2013). The high survival probability of males found in the PEI area suggests that the pressure suffered through predation may be lower in the conserved area than in the disturbed area. In Real, the human presence through motor vehicles, pets, and tourism, may disturb lizards, destroying their refuge sites. For the record, the only individual found in the Real in both years was a young, healthy female with no signs of agonistic interaction (scars, regenerated tail). However, this individual had lost two fingers in the second year, besides presenting a broken finger, many scars, and a regenerated tail. No lizard with so many bruises was observed in the conserved area.

Survival and abundance estimates were already reported for three out of the 12 species of the *L. wiegmannii* species complex, corresponding to the sand lizards *Liolaemus arambarensis* Verrastro, Veronese, Bujes & Dias-Filho, 2003 (Martins *et al*., 2017) and *Liolaemus lutzae* Mertens, 1938 (Rocha, 1998; A. H. B. Soares, 2010, unpubl. data), from Brazil, and *Liolaemus multimaculatus* (Duméril & Bibron, 1837) (Vega *et al*., 2000; Kacoliris *et al*., 2013), from Argentina. All three species are endangered due to habitat degradation (IUCN, 2016). Among these studies, only A. H. B. Soares (unpubl. data) and Vega *et al.* (2000) cover anthropic disorders. A. H. B. Soares, 2010 (unpubl. data) analyzed three populations of a lizard endemic of the Rio de Janeiro state, *L. lutzae* – one of these introduced 22 years ago –, and found greater survival rates and population size in the population with less anthropic influence. Vega *et al.* (2000) analyzed an Argentine population of *L. multimaculatus* that was reduced by 87% after seven years of construction of a road in its natural habitat.

We did not expect similar abundance estimates between populations, given the amount of anthropogenic disturbance observed in the Real area and the isolation of this population due to urban development in progress for at least 20 years (N. R. Matias, pers. observ.). In addition, we expected survival estimates lower than 0.70, compared to the apparent survival probability estimated for *L. multimaculatus* in conserved area (0.67) (Kacoliris *et al*., 2013) and *Liolaemus arambarensis* (Martins *et al*., 2017) in two protected areas (0.74 – 0.85). This result may indicate that the population of Real beach can sustain itself until November 2016.

On the last sampling occasion (November 2016), the spillway limiting the area of the disturbed beach to the north invaded the dunes, spreading over a large part of the habitat in which lizards were captured. We estimated the lowest survival probability of the whole study on that sampling occasion, but this model presented low support (ΔAICc = 2.11) and showed lower survival probabilities for adults than for juveniles. The shortest survival probability in adults suggest lower reproductive output and the consequent decline of the population (Pike *et al*., 2008).

Pike *et al*. (2008) conducted a study using life history data from 46 lizard populations of 20 species and showed that juvenile survival was strongly related to adult survival but 13% lower on average than that of adults. The annual apparent survival probability for adults in the conserved population (PEI) was 28% for males and 24% for females higher than that for the juveniles of the same population. This pattern may be related to higher predation rates affecting juveniles due to their smaller size (Bull, 1987), or to the fact that juveniles could present inferior escaping abilities in comparison with adults (Kacoliris *et. al*., 2013), or because of the difficulty in spotting them (Pike *et al*., 2008).

Kacoliris *et al*. (2013) found survival to be slightly higher for adults than for juveniles of *L. multimaculatus* in a population located in a protected area in Argentina, indicating that this pattern might be characteristic of a stable population (Pike *et al*., 2008). In this study, *L. multimaculatus* showed the lowest estimates of survival (0.47 - 0.67) (n = 601) among all the lizards of the *wiegmannii* species complex ever studied (A. H. B. Soares, unpubl. data; Kacoliris *et al*., 2013; Martins *et al*., 2017). A. H. B. Soares (2010, unpubl. data) and Martins *et al.* (2017) did not find a significant difference in survival probabilities of adults and juveniles in *L. lutzae* and *L. arambarensis*, respectively. Even mortality risk between adults and juveniles due to predators, disease, or resource fluctuation may explain such similarities (A. H. B. Soares, 2010, unpubl. data; Martins *et al*., 2017).

In the second year of the study (2016), we observed a decrease in juvenile abundance in both populations, which may be related to the season we started sampling (February, November, December). Lizard births occur from January to March (Verrastro & Rauber, 2013) resulting in a greater number of adults found.

In this study, we obtained some unreliable CIs, mainly for the disturbed area with its low rate of recaptures of individuals. We suggest that in future works that use the Robust Pollock Model to estimate the probability of annual survival of a population of lizards, the experimental design contains more primary sampling occasions in each year of the study. Still, we believe that considering imperfect detection is essential to obtain more reliable results on population dynamics.

Body size of individuals was consistent with previous studies, except for males from the disturbed area (Verrastro & Krause, 1994, 1999; Verrastro, 2004; Verrastro & Rauber, 2013). Contrary to what we expected, females showed better body condition in the disturbed area, but the body size did not differ. The body condition did not differ for males between populations, however, when comparing only SVL, males from the conserved area were higher.

The higher probability of survival observed for the conserved area in the present study indicates that possibly the males survive longer than in the most impacted area, thus achieving greater size (SVL).

We hypothesize that most of the individuals found in 2015 died in the second year of the study (2016) in the disturbed area, mainly after the decrease of habitat availability caused by water invasion from the spillway. This area does not present another possible habitat for the lizards in its environs since it is surrounded by urban allotments. On the last sampling occasion, the spillway limiting the area of the disturbed beach to the north invaded the dunes, spreading over a large part of the habitat in which lizards were captured. This change in the stream dynamics is influenced by urban development since urban settlements increased water flow. Changes in the flow of water from spillways are usually natural processes in the coastal plain. We thus suppose that if the lizards could have been able to disperse into an immediate area with the necessary conditions for their survival, this environmental modification would not have been so harmful. We conclude that urban development reduced the survival of the species, with potentially negative consequences for populations of *Liolaemus occipitalis*. This study shows the importance of preserving protected and connected areas for the conservation of *L. occipitalis*.

Acknowledgements. This study was carried out with the doctoral scholarship grant for NRM (#140083/2014-6) granted by CNPq (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*). We are grateful to everyone who helped with the fieldwork: Angelo Marcon, Arthur de Oliveira, Cláudia Mata, Gabriel Armiliato, Lídia Martins, Marcelo Freire, Mariana Luchese, Marluci Rebelato, Pedro Ivo Figueiredo, Raíssa Bressan, Tobias Kunz, Vanessa Scalco, Vinícius Ferri.

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