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Effects of the Habitat Alteration on Three Lizard Species in Santa María, Catamarca, Argentina

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***Abstract*.—I evaluated the impact of the habitat alteration in three lizard species in a zone of Monte vegetation in Santa María, Catamarca, Argentina. In the summers of 2005 and 2006, I determined the relative abundances of *Liolaemus quilmes* (Hurdler Lizard), *L. scapularis* (Black Shoulder Lizard) and *Aurivela tergolaevigata* (no English common name). During 2006 and 2011, the habitat was modified by the destruction of bushes, soil compaction associated with the traffic of trucks and other heavy machinery, and solid waste dumping. To evaluate the effect of changes in the environment on these lizards, I collected lizards during the summers of 2017 and 2018 and determined the relative abundance of the three species again. Disturbances at the site led to the loss of dunes and loose sand. *Liolaemus quilmes* and *A. tergolaevigata* were not affected significantly by the habitat changes, but the population of *L. scapularis* completely disappeared over the study site. Loose sand soil is essential for the survival of these species so they can hide from potential predators. Even though anthropogenic disturbances only affected the population of *Liolaemus scapularis* at my study site, habitat alteration over time likely will be detrimental to all specialized species that inhabit places with loose sandy soil.**

Key Words.—anthropogenic disturbance; *Aurivela tergolaevigata*; habitat loss; *Liolaemus scapularis*; *Liolaemus quilmes*

Introduction

The main causes of extinction among amphibians and reptiles are habitat loss, changes in weather patterns, the introduction of species, and environmental pollution (Young et al. 2001). Fragmentation of natural habitats by anthropic action occurs at short time scales (compared to ecological and evolutionary scales) and with stronger effects than natural fragmentation (Forman and Godron 1986) and leads to the decline in the number of species by extinction or emigration (Pianka 1982; Thomas and Kunin 1999). The World Wide Fund for Nature (WWF; World Wildlife Fund) published its Living Planet Report 2020 (WWF 2020) in which they concluded that between 1970 and 2016 there has been a 68% decrease in the population size of almost 4,400 species of mammals, birds, amphibians, reptiles, and fish species that have been monitored globally. Europe and Central Asia accounted for a 24% decrease and Latin America and the Caribbean registered a 94% decrease in these species. As a result of human activities, biodiversity is declining in many ecosystems (Barlow et al. 2016; Chaudhary et al. 2016), but in most cases, the lack of pre-change records does not allow us to detect reductions in community diversity or population size (Rocha and Bergallo 1992).

Many studies have shown that animals are less abundant at sites disturbed by humans than at non-disturbed sites (Goode et al. 2004; Pike et al. 2010). Some studies have reported the effects of habitat alteration on the herpetofauna in South America; for instance, Gudynas (1989) described the assemblage of reptiles and amphibians in an altered site, finding that human modifications affect the richness of herpetofauna. Rocha and Bergallo (1992) found that a gradual reduction in beach vegetation over 10 y was accompanied by a decline in the population of *Liolaemus lutzae* (Lutz´s Tree Iguana) in southeastern Brazil.

To properly understand the effect of anthropogenic disturbance on wildlife, it is necessary to record population abundances before and after disturbance, which can provide powerful evidence on how organisms can be impacted by changes in their habitat (Schlesinger and Shine 1994). Studies on the effects of habitat disturbance on reptiles in Argentina are few, as well as studies with a before-and-after design to evaluate the effects of coastal dune disturbance on vertebrate communities. The only study that addressed the effects of human disturbance on lizards in Argentina is by Vega et al. (2000), who studied the changes in the relative abundance of two *Liolaemus* species after the construction of a road in a coastal dune system 2 y before the disturbance and 7 y after.

The Santa María or Yocavil Valley extends from the southwestern province of Salta to the north-eastern province of Catamarca (Argentina) and includes part of what is called the Calchaquí Valley. The Santa María Valley presents a severe case of land deterioration, with an anthropic-environmental system that is highly degraded. The main factors that caused habitat degradation in this valley were: (1) changes in seasonality from arid to semiarid; (2) surface materials highly susceptible to wind and water removal; (3) total loss or marked decreases in native vegetation cover caused by cleaning or diverse extractive activities; (4) overgrazing; and (5) improper management of soil and water for many centuries (Sayago 1992; Collantes et al. 2007). Three lizard species are common in Santa María Valley: *Liolaemus scapularis* (Black Shoulder Lizard), *L. quilmes* (Hurdler Lizard), and *Aurivela tergolaevigata* (no English common name; Fig. 1). The genus *Liolaemus* (Liolaemidae) includes more than 270 valid species (Abdala and Quinteros 2014; Abdala et al. 2016; Verrastro et al. 2017; Aguilar-Puntriano et al. 2019).

Liolaemus scapularis is included in the group with *L. wiegmannii* (Wiegmann's Tree Iguana), sharing an affinity for sandy substrate (Etheridge 2000). These two lizard species exhibit a wide spectrum of morphological and behavioral adaptations that facilitate their life on and under the sand (Halloy et al. 1998). *Liolaemus scapularis* is a small, diurnal, oviparous (Ramírez Pinilla 1991), and insectivorous (García et al. 1989) lizard that is found in areas of loose sand, which is essential for its survival because it uses sand to camouflage itself and to hide from potential predators. It is often seen near clumps of vegetation, to which they run when disturbed, or quickly bury head-first followed by a wavy lateral movement of the body and tail, sometimes leaving the tail partially exposed (Etherigde 2000). The species is distributed in the provinces of Catamarca (departments of Santa María, Andalgalá, and Tinogasta), Salta (sandy areas of Cafayate), and Tucumán (Department of Tafí del Valle), Argentina, and is always found in dunes and semi-desert areas (Díaz Gómez 2007).

Liolaemus quilmes belongs to the *L. darwinii* complex; it also is a small, diurnal, oviparous, insectivorous species (Ramírez Pinilla 1992; Halloy et al. 2006) and is frequently found in open habitats with scattered vegetation (Etheridge 1993). This species uses a variety of substrates, including rocky slopes and gravel plains, as well as on sandy substrate, where it can be synoptic with *L. scapularis,* but it is not found on open dunes (pers. obs). *Liolaemus quilmes* is distributed in Catamarca, Salta, and Tucumán provinces (Ramírez Pinilla 1992) of Argentina. *Aurivela tergolaevigata* is a Teiid and is a small, diurnal, oviparous lizard, endemic to the northwestern region of the Monte Desert (Cabrera 2004; Cabrera and Etheridge 2006). It prefers sandy soil environments with sparsely distributed bushes, and it is an excellent sand digger (Cabrera et al. 2017). This species is distributed in Catamarca, La Rioja, Salta (Cabrera and Etheridge 2006) and Tucumán provinces (Cabrera et al. 2017) of Argentina.

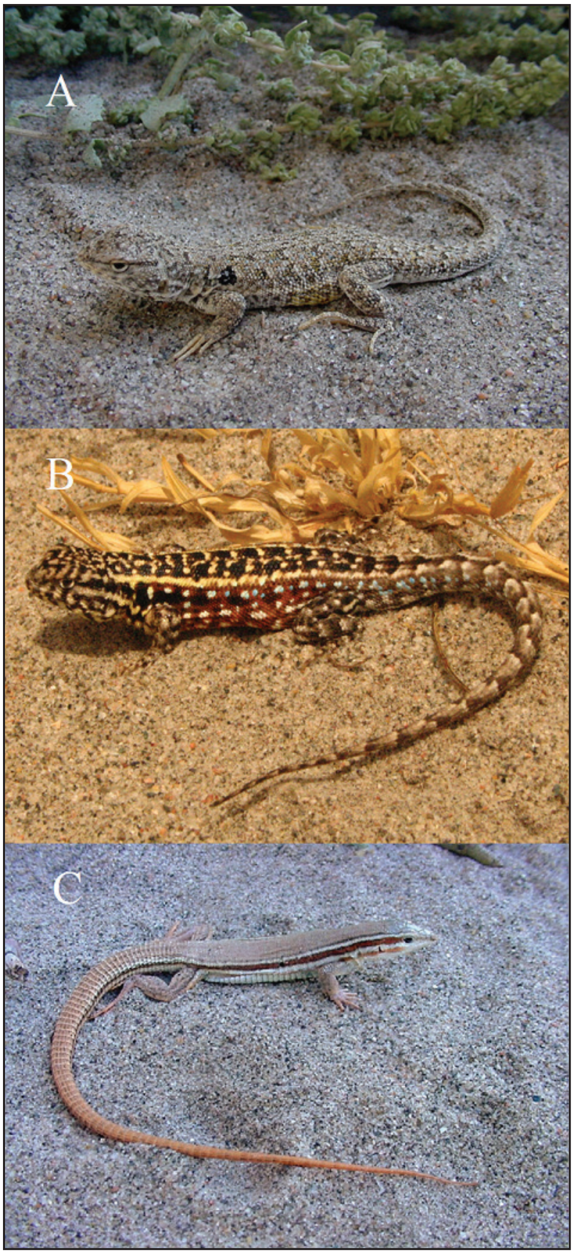

Figure 1. Abundant lizards of Santa María, Catamarca, Argentina. (A) *Liolaemus scapularis* (Black Shoulder Lizard). (B) male *Liolaemus quilmes* (Hurdler Lizard). (C) *Aurivela tergolaevigata* (no English common name) in soil sand. (Photographed by Gustavo Scrocchi).

I evaluated the impact of the habitat alteration on these three lizard species in a zone of Monte vegetation in Santa María, Catamarca, Argentina. In the summers of 2005 and 2006, I determined their relative abundances. Habitat at the site was disturbed in 2006 and 2011, and I returned in the summers of 2017 and 2018 and determined the relative abundance of the three species again. This allowed me to evaluate the effect of changes in the environment on these lizards.

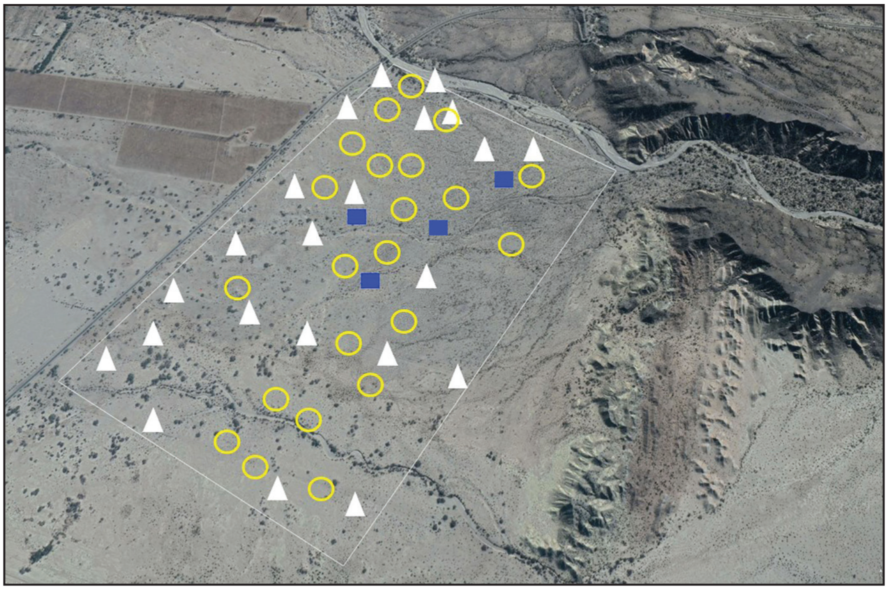

Figure 2. Study site in Santa María, Catamarca, Argentina, with the distribution of the disturbances found in the second sampling period (2017–2018): vegetation removal (yellow circles), compacted sand due to the movements of heavy vehicles (white triangles), areas of solid waste dumping (blue squares).

Materials and Methods

My study site was located on the south side of National Road 357 (26°39'02.22"S, 66°00'27.37" W; elevation 1,900 m) at the entrance to the city of Santa María in Catamarca, Argentina, covering an area of 185 ha. Phytogeographically, Santa María belongs to the Monte Province, this ecoregion is exclusive to Argentina, and is characterized by a semi-arid to arid climate, with an annual rainfall average of < 350 mm, and a great annual thermal amplitude. The vegetation composition is typical of the Monte, a bush steppe and some sparse trees can be found: Algarrobo Blanco, or White Carob (*Prosopis alba*), Algarrobo Negro, or Black Carob (*Prosopis nigra*), Churqui (*Acacia caven*), Arca o Ark (*Acacia visco*), Chañar (*Geoffroea decorticans*), Brea (*Cercidium praecox*), and also shrubs such as *Bulnesia* sp., Parrot Wing (*Monttea aphylla)*, and zones covered with jarilla, or creosote (*Larrea cuneifolia* and *Larrea divaricata*; Perea 1995; 1997).

I carried out the samplings during three days per month (in similar environmental conditions) in 2005 (November and December), 2006 (January and November), 2017 (January and February), and 2018 (January and February). I used three transects 500 m long and 20 m wide (randomly distributed in the study area), one I walked in starting at 0900, one starting at 1300, and the third at 1700, visually counting the number of individuals of each species. I surveyed each transect for 3 d each month, three times a day for 1.5 h for each transect I walked (nine sightings each month). In 2017 and 2018, I recorded the disturbance found in the area (Fig. 2). In the first sampling period (2005 and 2006), only some roads were found, but there were no pronounced disturbances as I found in 2017 and 2018 (unpubl. data).

To compare the relative abundance of the three species, I performed a Mann-Whitney U test. To test whether the abundance of the three lizard species did not differ between 2005–2006 and 2017–2018, I used the Wilcoxon signed rank test comparing the actual number of lizards observed during each census between the two periods of time. The significance level for all tests was $\alpha = 0.05$, and I did all analysis with Statistica 9 (StatSoft Inc. 2009).

Results

During 2017–2018, I observed the extraction of jarilla plants, dumping of solid waste, and compaction of sand due to the movements of heavy vehicles both within and near some transects (Fig. 3). I did not see the dune and loose sand areas that were common in the first surveys. I made 967 sightings during the study, of which 602 were *Liolaemus quilmes*, 240 *L. scapularis*, and 125 were *Aurivela tergolaevigata* (Table 1). The most abundant lizard before disturbance was *L. quilmes*, which was significantly greater than for *L. scapularis* and *A. tergolaevigata* ($Z = -3.12$, $P = 0.001$ and $Z = -4.16$, $P < 0.001$; respectively). The abundance of *L. scapularis* was also significantly higher than *A. tergolaevigata* ($Z = -4.16$, $P < 0.001$).

The average number of *L. quilmes* observed per month in 2005–2006 was 25.91 ± 4.36 (n = 12) and

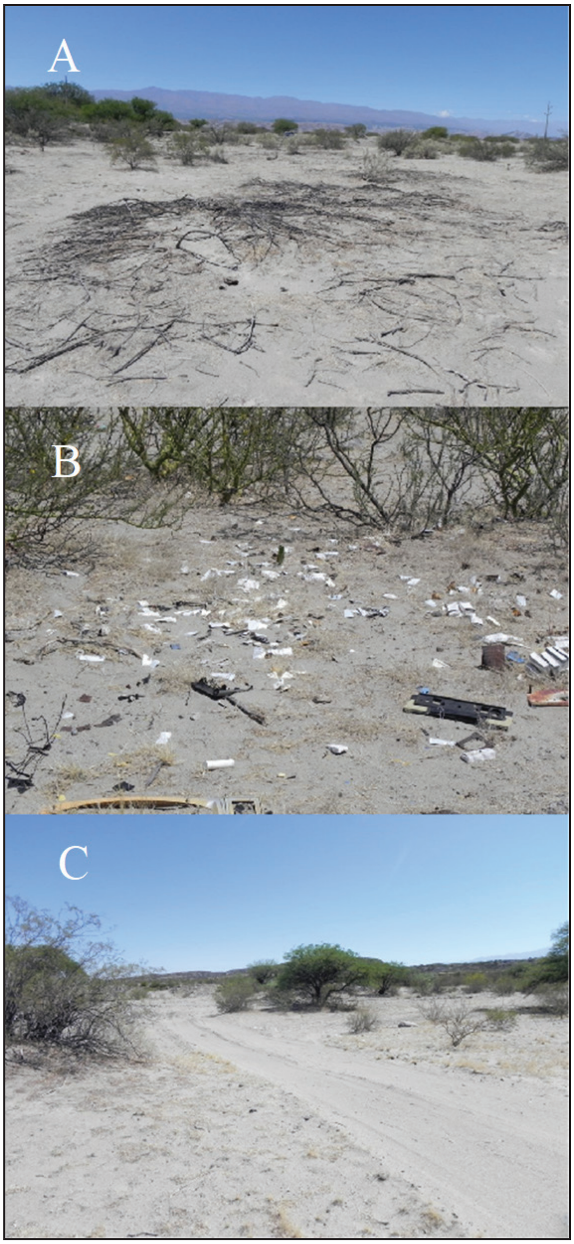

Figure 3. Sites in Santa María, Catamarca, Argentina, heavily disturbed by extraction of vegetation, especially (A) jarillas plants (*Larrea divaricatta* and *L. cuneifolia*), (B) dumping of solid waste, and (C) compaction of sand due to the movements of heavy vehicles (Photographed by María Cabrera).

Table 1. Abundances of *Liolaemus scapularis* (*Ls*), Black Shoulder Lizard, *L. quilmes* (*Lq*), Hurdler Lizard, and *Aurivela tergolaevigata* (*At*), no English common name, per year in Santa María, Catamarca, Argentina.

Species	2005	2006	2017	2018	Total
Ls	118	122	0	0	240
Lq	148	163	155	136	602
At	28	42	29	26	125
Total	294	327	184	162	967

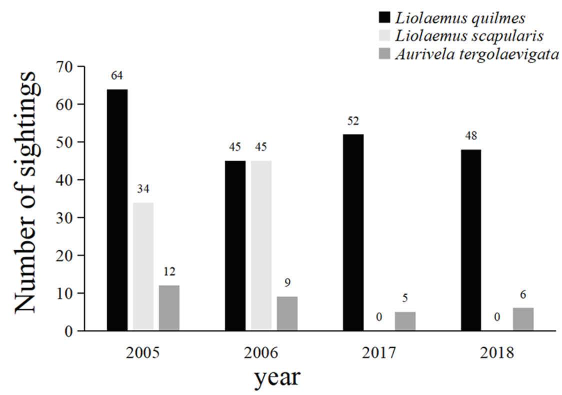

Figure 4. Abundances of *Liolaemus quilmes* (Hurdler Lizard), *L. scapularis* (Black Shoulder Lizard) and *Aurivela tergolaevigata* (no English common name) per year in Santa María, Catamarca, Argentina.

in 2017–2018 was 24.25 ± 3.94 (n = 12), which were not significantly different (*Z* = -0.845, *P* = 0.398; Fig. 4). For *Aurivela tergolaevigata*, I found 5.83 ± 2.08 individuals per month (n = 12) in 2005–2006 and 4.58 ± 1.08 (n = 12) in 2017–2018, which also were not significantly different (*Z* = -1.689, *P* = 0.091; Fig. 4). In contrast, the mean abundance of *L. scapularis* prior to disturbance was 20 ± 2.79 individuals per month (n = 12) and was significantly different from the second period, when I did not find any individuals (*Z* = -3.059, *P* = 0.002; Fig. 4).

Discussion

Before the habitat disturbance, *Liolaemus quilmes* had the highest abundance of the three lizard species I found on transects, and it maintained its abundance after the disturbance. This species can be found in a wide variety of environments. Apparently, the modification and decrease of a loose sand substrate or the elimination of some plant species, such as jarillas, did not affect the abundance of this species, because it is able to use other available habitats. *Aurivela tergolaevigata*, which also uses the sandy substrate, was not affected by the absence of this substrate either, maintaining similar abundances before and after the disturbance. This species does not depend on a sandy substratum and is able to use other substrates, similar to *L. quilmes*. One difference between *L. scapularis* and *A. tergolaevigata* is the speed of locomotion: the latter is a lizard that runs very fast (pers. obs.), which could help it to escape potential predators.

Unlike the two species that maintained similar abundances before and after human disturbance to my study site, *L. scapularis* appears to be more affected by the modification of the environment; it disappeared from the studied area. The lack of loose sand probably affects this species in many ways, due to its highly specialized cryptic coloration, behavior, and morphology adapted for a loose sand substrate (Cei et al. 1975; Gallardo 1977; Halloy et al. 1998). Loose sand is essential for *L. scapularis* survival because it uses sand to camouflage, hide, dive into it, and escape from potential predators. Another factor that could affect this species more than the other species is the extraction of jarillas. These plants are used by *L. scapulari* as shelters (pers. obs.), in addition to burying itself in the sand.

The most notable change at the study site was the extraction of jarillas, a shrub that is used by lizards, and which prevents wind erosion of small dunes. Jarillas serve to fix the elevated areas around plants with loose sand, near where individuals of *Liolaemus scapularis* are usually seen. This plant provides thermic shelter, protection from predators, nesting sites, and habitat of arthropod prey (Rocha 1988, 1989, 1995, 1996; Vega 1999) for this species. The movements of heavy vehicles at the site, either for the extraction of sand and gravel or for the dumping of solid waste, also led to the loss of loose sand and compaction of the substrate. Rocha and Bergallo (1992) concluded that the progressive reduction of beach vegetation in the past 10 y reduced the populations of the endemic lizard, *L. lutzae*, in Barra da Tijuca in Rio de Janeiro, Brazil. Rocha et al. (2009) studied different populations of *L. lutzae* in which they found that the most destructive type of habitat degradation identified was the removal of beach vegetation associated with the construction of coastal roads and/or sidewalks, and the destruction of vegetation due to trampling, vehicle traffic, and garbage dumping.

Vega et al. (2000) studied *L. multimaculatus* (Sand Dunes Lizard), endemic to coastal sand dunes, and *L. gracilis* (Slender Lizard), before and after the construction of a road. After the disturbance, they found that patches of vegetation were destroyed, promoting soil erosion, which generated a notable decrease in the abundance of *L. multimaculatus*, whereas the abundance *L. gracilis* remained the same. Before the disturbance, *L. multimaculatus* used open spaces in flat dunes barely covered by Espartillo, or Cord Grass (*Spartina ciliata*), but *L. gracilis* is a habitat generalist found in a variety of habitats throughout its range (Gallardo 1977; Cei 1993). According to Vega et al. (2000), the dramatic reduction in the abundance of *S. spartina* was the cause of the decrease in the number of *L. multimaculatus*. Even though I did not quantify the loss of vegetation in my study, it seems likely that the disappearance of *L. scapularis* was a consequence of the removal of plant species and the loss of sandbanks due to anthropic erosion.

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