

Use of microhabitat, shelter preference, activity patterns, population structure and sexual dimorphism of the Andean lizard *Riama striata* (Squamata: Gymnophthalmidae) in a high-altitude urban area of Colombia

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ABSTRACT

Gymnophthalmidae is a family of Neotropical lizards from which its ecology has been widely studied in the lowlands. However, the life history of Andean species is still poorly known. Apparently, these species are tolerant to anthropic habitats. The objective of this study is to describe some aspects of the biology of one species of this family, *Riama striata*, in a highly urbanized locality in the Eastern Cordillera of the Colombian Andes. I describe microhabitat use, shelter preference, activity patterns, population structure and sexual dimorphism of the species. *Riama striata* uses both artificial and natural substrates that are mainly microhabitats of rock or concrete, and males prefer bricks even though this is the least frequent refuge available. The species has a bimodal diurnal activity, particularly on sunny days. It is sexually dimorphic in the size of the head; males have larger heads. There is a high abundance of individuals, with a greater number of females and juveniles than males. These results, together with those of other Andean species contrast sharply with the studies in gymnophthalmids and alopoglossids of the lowlands and raise new hypotheses about the ecology and life history of these lizards and how they respond to the effects of anthropic impact.

Key words: Andean species; Urbanization; Artificial substrate; Sexual dimorphism; Anthropic impact; Gymnophthalmidae.

RESUMEN

La familia Gymnophthalmidae comprende lagartos neotropicales cuya ecología ha sido ampliamente estudiada en tierras bajas. Sin embargo, la historia de vida de especies andinas ha sido poco estudiada. Aparentemente, algunas de estas especies son tolerantes a hábitats antrópicos. El objetivo de este estudio es describir algunos aspectos de una especie de esta familia, *Riama striata*, en un área altamente urbanizada en la cordillera oriental de los andes colombianos. Se estimó el uso del microhábitat, preferencia de refugios, patrones de actividad, estructura poblacional y dimorfismo sexual de la especie. *R. striata* usa tanto sustratos artificiales como naturales, principalmente microhábitats de roca y concreto, y los machos prefieren ladrillos incluso siendo este el refugio menos frecuente. Además, esta especie presenta una actividad diurna bimodal, particularmente en días soleados; dimorfismo sexual en el tamaño de la cabeza, siendo los machos aquellos con cabezas más grandes; y alta abundancia, con una mayor cantidad de hembras y juveniles que de machos. Estos resultados, junto con los de otras especies andinas, contrastan fuertemente con los estudios en gymnophthalmidos y alopoglossidos de tierras bajas y plantean nuevas hipótesis sobre la ecología e historia de vida de estas lagartijas y cómo responden estas frente a los efectos del impacto antrópico.

Palabras clave: Especies andinas; Urbanización; Sustrato artificial; Dimorfismo sexual; Impacto antrópico, Gymnophthalmidae.

Introduction

The Gymnophthalmidae family is made up of about 257 described species of lizards distributed from southern Central America to southern South America (Soares de Oliveira and Machado-Pessanha, 2013;

Vitt and Caldwell, 2013; Uetz *et al.*, 2019). These small to medium size lizards with limb reduction and elongated bodies have fosorial, semifosorial and terrestrial habits; and can be found under leaf litter

or in terrestrial vegetation (Gomes dos Santos *et al.*, 2012; Soares de Oliveira and Machado-Pessanha 2013; Garda *et al.*, 2014).

Most studies of the ecology and life history of gymnophthalmid (or microteiid) species have been conducted in lowland areas, particularly in Brazil both in tropical forests (Vitt and Avila-Pires, 1998; Vitt *et al.*, 1998; Teixeira and Fonseca, 2003; Vitt *et al.*, 2003; Maia *et al.*, 2011) and in open areas (Maia *et al.*, 2011; Soares de Oliveira and Machado Pessanha, 2013; Dal Vechio *et al.*, 2014). This family is the most species rich in the Brazilian Amazon (Vitt and Avila-Pires, 1998; Vitt *et al.*, 1998, 2003, 2007). However, in the Andean region there are few studies on the ecology of gymnophthalmids (as an example see Doan, 2008; Ramos-Pallares *et al.*, 2015) or of species of the family Alopoglossidae (Anaya-Rojas *et al.*, 2010), a closely related clade that has several ecological or morphological similarities to the family Gymnophthalmidae (Goicoechea *et al.*, 2016).

Studies in the Andean areas have shown that gymnophthalmids are usually found in areas with high human disturbance, represented by changes in use such as agriculture and urbanization (Doan, 2008; Anaya-Rojas *et al.*, 2010; Ramos-Pallares *et al.*, 2015). These authors suggest that the apparent tolerance to this type of human activities could be related to changes in the availability of resources created by human activities, being advantageous for these type of species.

Riama (Gray, 1858) contains 15 species distributed in Ecuador, Colombia and Venezuela (Sánchez-Pacheco *et al.*, 2017). *Riama striata* (Peters, 1862) is distributed in the Eastern Cordillera of Colombia in the departments of Boyacá, Cundinamarca and Santander, between 1800 and 3300 m above sea level (m a.s.l.) in pastures, Andean forests and subparamo (Castaño-Mora *et al.*, 2000; Arredondo and Sánchez-Pacheco, 2010; Hernández, 2008; Méndez-Narváez, 2014; Méndez-Galeano and Pinto-Erazo, 2018). Lynch and Renjifo (2001) and Méndez-Galeano and Pinto-Erazo (2018) suggest that this diurnal and semifossorial lizard species is highly tolerant of human disturbance. It is found in pastures as well as under various artificial refuges such as bricks, concrete and wood (Lynch and Renjifo, 2001; Méndez-Galeano and Pinto-Erazo, 2018). Based on this hypothesis, this study aims to describe several ecological features of a population of *R. striata* in an area that is highly intervened by urbanization. Thus, this study constitutes a contri-

bution to the ecology of the gymnophthalmid lizards of the Andes that will help us to understand how different human activities in the habitat could be modifying the autoecology of the species, by generating a possible resilience or specific responses to these changes. Additionally, sexual dimorphism and a brief characterization of population structure were made to contribute to our knowledge about these Andean gymnophthalmids.

Materials and methods

Study area

The study was carried out in grassland (*Pennisetum clandestinum*) within the campus of the National University of Colombia in Bogotá (4°38'08" N; 74°04'58" W, 2560 m a.s.l.), department of Cundinamarca, Colombia. Bogotá is a city with a population density of 16,900 people per km² in its 562 km² metropolitan area (DEMOGRAPHIA, 2013). The region can be characterized as semi-dry with a bimodal rainfall regime, with peaks of rain during April-May and October-November and an average annual rainfall of 850 mm (Moreno-Arias and Urbina-Cardona, 2013). In the study area, the mean annual temperature is 14.9°C (IDEAM, 2017). After knowing that this species occurs at the University campus, the first step was to identify sites with apparently high-density populations and delimited two quadrants of 30 m² each one for sampling. The two quadrants are located in areas with a high degree of anthropic intervention, represented mainly by grazing cattle and horses and by the presence of construction debris such as bricks, pieces of concrete, boards and pieces of metal.

Use of microhabitat, shelter preference and activity patterns

To determine the use of microhabitats and the patterns of daily activity, me and other observer gathered data one day per week from January to December 2016. We observed specimens and captured the vast majority of them by hand by active search during one-hour sampling per day, for a total of 49 hours of sampling. I defined the following microhabitat categories according to the type of substrate where the specimens were found: rock, trunk and boards, grass, brick, concrete and metal. Except for the category "grass", all the microhabitats were considered shelters and were quantified by number of shelters for each category within the quadrants.

For the diurnal activity patterns, I estimated the number of observations that I made during the sampling days only from February 5 to June 9 2016. Since lizards were searched only one-hour per sampling day, I alternated the one-hour sampling between 8:00 and 16:00 hours for each day to complete the daily activity pattern of the species within this range of hours, preserving the same sampling effort per daily hour. For each observation throughout of the study, I defined the climatic conditions as sunny, partially sunny and cloudy.

Population structure and sexual dimorphism

Using a digital caliper (precision 0.05 mm) I took measurements of the snout-vent length (SVL), tail length (TL) when it was not regenerated, head length (HL) and head width (HW) for captured specimens to determine sexual dimorphism. I measured each specimen's body mass by using a Pesola precision scale (accuracy 0.5 g). I sexed each animal, considered males those lizards that had a number equal to or greater than 5 femoral pores in each hind limb (zero to four in females) (Méndez-Galeano and Pinto-Eraza, 2018), and registered reproductive condition of adult females (distended abdomens in gravid females).

I marked the specimens by toe clipping and released each animal after the data collection. I recorded recaptures of individuals throughout the study in order to avoid pseudo-replicas (Hurlbert, 1984). Also, I defined age categories as adults and juveniles based on the SVL of the known smallest female (SVL = 46 mm) and male (SVL = 50 mm) with vitellogenesis (yolk deposition) and convolute epididymides, respectively (Méndez-Galeano and Pinto-Eraza, 2018), being adults those with SVL equal to or greater than these measures.

Statistical analysis

Use of microhabitat and activity patterns – Recapture data were excluded to avoid pseudo-replicas for a possible fidelity of individuals to microhabitats (Hurlbert, 1984). The "metal" substrate category was excluded from all analyses due to a very low number of samples (N = 1). I tested if there were differences in the use of the microhabitat according to each type of substrate between sexes and ages by means of the G-test. For a comparison between sexes I did multiplicative coding of the frequencies by two, because more than 20% of the frequencies were less than 5, which allowed performing the test

and in turn it does not affect the proportions of each frequency (Sokal and Rohlf, 1995). To know if the number of observations per month was associated with the climatic conditions of the sampling days, I administered a Friedman test.

Shelter preference - In order to know the degree of specialization of *R. striata* for shelter use and taking into account the availability of each refuge in the sampling area, I calculated the Levins index (B'_A) for both the species and for each sex and age with the Hurbert correction for the availability of each shelter item (Guisande *et al.*, 2006) as follows:

$$B'_A = \frac{\left(\frac{1}{\sum_{j=1}^n \left(\frac{p_j^2}{a_j} \right)} \right) - a_{\min}}{1 - a_{\min}}$$

Where p_j is the proportion of individuals using the resource j ; j is the type of resource (each refuge item); a_j is the proportion of resource j versus total resources in the habitat, n is the total of resource categories j ; and a_{\min} is the minimum observed value of a_j (Guisande *et al.*, 2006). Thus, the values of this index go from zero (highly specialized species) to one (highly generalist species).

Population structure and sexual dimorphism - To estimate the number of lizards in the sampling area and for each quadrant, I estimated the population density by calculating the monthly average of observed individuals, including recaptures, divided into the sampling area (60 m²) and by each quadrant (30 m²). Likewise, I calculated the sex ratio (male/female) and the percentage of adult and juvenile individuals. To evaluate sexual dimorphism by body size (SVL) in adults, I applied the Mann-Whitney U test. To evaluate sexual dimorphism in body mass and head size in terms of the length (HL) and width (HW) of the head, I used a one-way ANCOVA for each variable using snout-vent length (SVL) as a covariate, thus eliminating the effect of body size. For sexual dimorphism in body mass I excluded gravid females.

I performed all analyses through the StatR application of the RWizard v3.5 (Guisande *et al.*, 2014) software and the graphics were generated through the use of the SigmaPlot program (Systat Software, San Jose, CA).

Results

Use of microhabitat, shelter preference and activity patterns

The substrates most used by *Riama striata* were rock (n = 44, 40%) and concrete (n = 26, 23%), followed by logs or wood (n = 17, 15%), brick (n = 14, 13%), grass (n = 9, 8%) and, at a minimal proportion (n = 1, 1%), metal (Fig. 1A). I found no significant differences between juvenile and adult individuals in the use of different microhabitats (G-test: G = 1.893, df = 4, P > 0.05), but I did find significant differences between adult males and adult females in the use of the different substrates (G-test: G = 18.9, df = 4, P < 0.05). I found males mostly on concrete substrates (36%), followed by substrates of rock (23%) and brick (23%), while females mostly used rock substrates (45%), followed by concrete substrates (21%, Fig. 1A). Proportionally, I found more males on brick substrates than in the case of adult females, and these in turn exhibited a greater proportional use of trunks and boards (18%) with respect to the males (Fig. 1A).

The Levins index suggested that *Riama striata* tends to be a generalist in the use of shelter ($B'_A = 0.7$). This same pattern was repeated for adults ($B'_A = 0.75$), juveniles ($B'_A = 0.64$) and adult females ($B'_A = 0.77$). Both adult females and juveniles used concrete in lower proportion than that offered by the habitat (Fig. 1B). On the other hand, adult males tended to be specialists in the use of microhabitat for the substrate categories ($B'_A = 0.4$). This trend was due to the fact that adult males use bricks more than expected by its low availability (the item of lowest supply, 4%), while concrete substrate is used by adult males in the same proportion in which this item existed (Fig. 1B).

I found two diurnal activity peaks between 10: 00-12: 00 and 13: 00-14: 00, thus it was a kind of bimodal daytime activity pattern (Fig. 2). I found significant differences in the monthly observations of the individuals in different climatic conditions ($X^2 = 7.167$, df = 2, P < 0.05); I found the largest number of individuals in sunny weather with direct incidence of sunlight (n = 59, 58%), followed by cloudy weather (n = 26, 26%) and partly cloudy (n = 16, 16%).

Population structure and sexual dimorphism

I captured a total of 115 individuals of which 62 (53.9%) were adults and 53 (46.1%) were juveniles. Among adult individuals, I captured a total of 23 (20%) males and 39 (33.9%) females in a sex ratio of 1: 1.69 male/female. The total population density was 0.19 ind / m² (quadrant 1 = 0.27 ± 0.09 ind / m²; quadrant 2 = 0.49 ± 0.14 ind / m²).

The different morphological measurements, as well as the body mass of males, females, juveniles and all individuals are listed in Table 1, and the snout-vent length distribution for males, females and juveniles is shown in Figure 3. Males were not significantly larger than females (Z = 0.282, P > 0.05).

There was a positive linear relationship between SVL and body mass for both sexes (Fig. 4A). However, I found no significant differences in body mass between sexes by removing the effect of the SVL variable (one-way ANCOVA: $F_{1,34} = 0.775$, P > 0.05), suggesting that adult males and females have similar body mass to similar sizes. Likewise, the HL (Fig. 4B) and HW (Fig. 4C) measurements had a positive linear relationship in both sexes with respect to SVL. However, males had longer and wider heads with respect to females in the same proportion of SVL. The analysis of covariance confirmed this trend, showing significant differences between

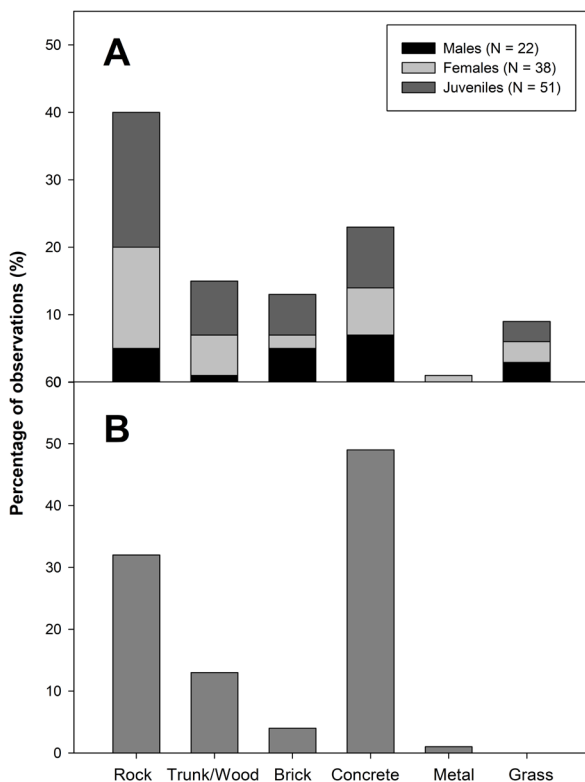


Figure 1. (A) Percentages of observations of *Riama striata* individuals in different types of substrates or microhabitats. (B) Percentages of observations of each “shelter” type of substrates or microhabitat. “Grass” category wasn’t quantified for percentages of microhabitat observations.

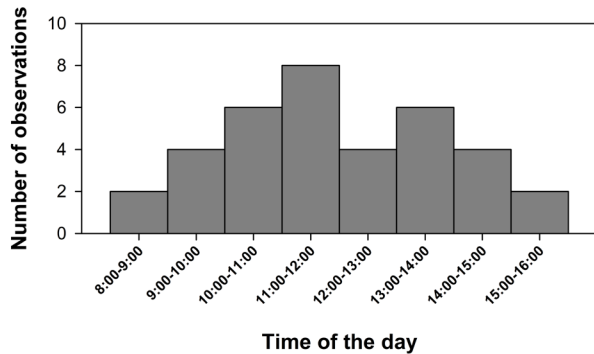


Figure 2. Diurnal activity patterns of *Riama striata* at the Universidad Nacional de Colombia, Bogotá.

sexes of HL (one-way ANCOVA: $F_{1,54} = 34.39$, $P < 0.05$) and HW (one-way ANCOVA: $F_{1,54} = 78.2$; $P < 0.05$) removing the effect of the SVL variable, suggesting sexual dimorphism for *R. striata* in the size of the head.

Discussion

The study population of *Riama striata* used mostly microhabitats of rock and concrete, being the concrete a more abundant microhabitat than rocks, woods and bricks. In general, *R. striata* used both natural and artificial shelters in equal proportion. The high preference for microhabitats of rock has also been recorded in different species of *Proctoporus* from Peru and to a lesser extent in *Ptychoglossus bicolor* (Doan, 2008; Anaya-Rojas *et al.*, 2010), both species occur in high elevation habitats. These observations contrast with studies of Amazonian species, Atlantic moist forest or "Atlantic forest" and *cerrado* in Brazil, where most species use mainly litter (Vitt and Avila-Pires, 1998; Vitt *et al.*, 1998; Teixeira and Fonseca, 2003; Vitt *et al.*, 2003, 2007; Maia *et al.*, 2011; Teixeira Jr. *et al.*, 2013). However, Soares de Oliveira and Machado-Pessanha (2013) find *Anotosaura vanzolinia* in leaf litter associated with rocky outcrops in the Brazilian *caatinga*, and Dal Vechio *et al.* (2014) find that *Micrablepharus maximiliani* mainly uses grass and sandy soil in the Brazilian *cerrado*, both in open areas, which could

also indicate that the differences in the use of the microhabitat could be due to the absence of forests that generate litter in the understory that, in these cases, is replaced by new microhabitats. Rocks and artificial microhabitats are absent in lowland habitats like the amazonian rainforest; therefore, no use can be measured.

The above highlights a methodological problem of the present study that could be obscuring the use of the *Riama striata* microhabitat. The "grass" category is, in fact, the most abundant microhabitat, given that it is the vegetation matrix in which the rest of the microhabitats are located, and could not be possible sampled in its majority due to its thickness and rooting. Also, the use of the area of study by cattle and horses could have diminished detection of individuals and, thus, underestimated the value for its use. If grass was the most utilized substrate, it would suggest another panorama in the use of the microhabitat for *R. striata*, similar to the Amazonian studies already mentioned and for *Micrablepharus maximiliani* (Dal Vechio *et al.*, 2014) studies where the matrix of the dominant vegetation is grass or litter as the most used microhabitat. This, however, remains somewhat speculative.

In spite of this, the high abundance of *R. striata* individuals found in 49 samplings by two observers is underlined here, with a total effort of only 96 man-hours of searching during 12 months of fieldwork. These results contrasted with lowland studies in gymnophthalmids and alopoglosids in areas with little disturbance, where a lesser number of individuals (<100 individuals) was found, sometimes in more than 12 months of sampling, and/or combined visual searches with pitfall traps (Table 2; Vitt and Avila-Pires, 1998; Vitt *et al.*, 1998, Fitzgerald *et al.*, 1999, Vitt *et al.*, 2003, 2007; Maia *et al.*, 2011; Gomes Dos Santos *et al.*, 2012; Soares de Oliveira and Machado-Pessanha, 2013; Teixeira Jr. *et al.*, 2013; Dal Vechio *et al.*, 2014). Similarly, Andean species in disturbed areas, with field days of 8–12 total months, found greater abundances of individuals (> 100 individuals; Doan, 2008; Anaya-Rojas *et al.*, 2010;

Table 1. Summary of morphological measures and corporal mass averages of *Riama striata* males, females, juvenile and total individuals. \pm SD: standard deviation, N = sample size.

	SVL (mm) \pm SD (N)	TL (mm) \pm SD (N)	HL (mm) \pm SD (N)	HW (mm) \pm SD (N)	W (g) \pm SD (N)
Males	58.04 \pm 5.82 (23)	112.34 \pm 10.67 (5)	12.36 \pm 1.52 (22)	8.71 \pm 1.16 (22)	4.0 \pm 0.7 (15)
Females	55.46 \pm 5.11 (39)	83.74 \pm 22.71 (15)	10.60 \pm 0.97 (36)	7.03 \pm 0.56 (36)	3.6 \pm 0.9 (21)
Juveniles	37.02 \pm 5.18 (53)	63.76 \pm 13.48 (26)	8.21 \pm 0.87 (49)	5.36 \pm 0.56 (49)	1.3 \pm 0.6 (20)
Total	47.57 \pm 11.07 (115)	76.10 \pm 22.90 (46)	9.85 \pm 1.96 (107)	6.60 \pm 1.49 (107)	2.6 \pm 1.4 (72)

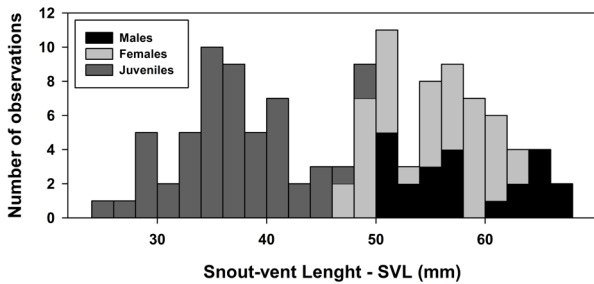


Figure 3. Distribution of snout-vent length (SVL) measures of *Riama striata* males, females and juvenile individuals.

Ramos-Pallares *et al.*, 2015), something that contrasts with *Leposoma scincoides*, a species from the lowlands found in Atlantic forest cover (along with coffee crops that undergo constant vegetation burns) where 31 individuals were observed during total fieldwork of 5 months (Table 2; Teixeira and Fonseca, 2003). Doan (2008) comments that *Proctoporus* spp. in Peru are usually found in disturbed areas from the time of the Inca civilization, and they suggest that the rock walls made by the Incas have served as artificial refuges for these species, in addition to providing a suitable food supply (arthropods with affinity for these shelters) for the species. Also, *Ptychoglossus bicolor* usually inhabits premontane moist forest mixed with organic coffee shade plantation in the Colombian Andes and *Bachia bicolor* is found underground in the gardens of houses in Bucaramanga, Colombia (department of Santander) (Anaya-Rojas *et al.*, 2010; Ramos-Pallares *et al.*, 2015).

All of this suggests that perhaps the Andean and high Andean species of gymnophthalmids and alopoglosids are to a certain degree tolerant around human disturbance or they could even benefit from anthropic disturbance, for example, when there is an increase in the abundance and diversity of prey (Doan, 2008; Anaya-Rojas *et al.*, 2010; Ramos-Pallares *et al.*, 2015), which have also been reported for some lizards species from other families (Stellatelli *et al.*, 2013; Wolf *et al.*, 2013; Rodewald and Gehrt, 2014; Pellitteri-Rosa *et al.*, 2017). However, additional studies on the ecology of lowland gymnophthalmids in disturbed habitats such as the one conducted by Teixeira and Fonseca (2003), as well as in undisturbed parts of Andean region, including non-disturbed populations of *Riama striata*, as well as populations of *Anadia bogotensis*, a vulnerable gymnophthalmid species that is codistributed with *R. striata* (Jerez & Calderón-Espinosa 2014), are necessary to confirm and support these claims.

Unlike most of other studies, this research

evaluated the possible differences between juveniles and adults and between adult males and females in their use of microhabitats, and it found differences between the sexes in adults. Preferences of males for other types of microhabitat with respect to females has been documented particularly in lizards of the genus *Anolis* (Schoener, 1967; Butler *et al.*, 2000). However, in those cases the microhabitats are natural, whereas in the case of *R. striata* the males used more artificial microhabitats (bricks and concrete) and the females used more the natural ones (rocks and trunks), something that has not been reported before in other studies of gymnophthalmids or alopoglosids.

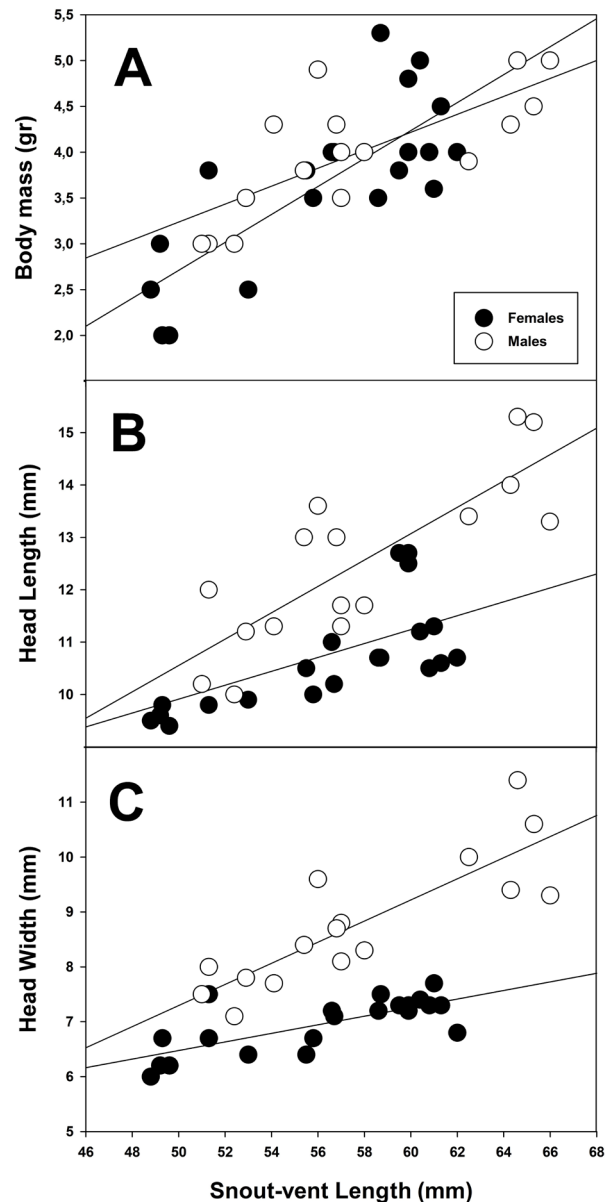


Figure 4. Relation between body mass (A), head length (B) and head width (C) with snout-vent length of adult males and females of *Riama striata*.

Table 2. Abundance of some gymnophthalmid and alopoglosid lizard species, with the duration of the field sampling in each study in parenthesis. Vegetation cover in the study area, the altitudinal range of the species and the study sources are showed.

Species	Altitudinal distribution	Vegetation cover	Abundance (Duration)	Source
<i>Potamites ecleopus</i>	Lowland	Amazon rainforest	N = 39 (3 months)	Vitt and Avila-Pires, 1998
<i>Potamites juruazensis</i>	Lowland	Amazon rainforest	N = 48 (3 months)	Vitt and Avila-Pires, 1998
<i>Cercosaura eigenmanni</i>	Lowland	Amazon rainforest	N = 71 (8 months)	Vitt <i>et al.</i> , 1998
<i>Cercosaura argulus</i>	Lowland	Amazon rainforest	N = 14 (5 months)	Vitt <i>et al.</i> , 2003
<i>Cercosaura oshaughnessyi</i>	Lowland	Amazon rainforest	N = 74 (6 months)	Vitt <i>et al.</i> , 2003
<i>Alopoglossus angulatus</i>	Lowland	Amazon rainforest	N = 59 (14 months)	Vitt <i>et al.</i> , 2007
<i>Alopoglossus atriventris</i>	Lowland	Amazon rainforest	N = 22 (14 months)	Vitt <i>et al.</i> , 2007
<i>Nothobachia ablephara</i>	Lowland	Brazilian Caatinga	N = 12 (1.5 months)	Gomes dos Santos <i>et al.</i> , 2012
<i>Anotosaura vanzolinia</i>	Lowland	Brazilian Caatinga	N = 46 (4 months)	Soares de Oliveira and Machado Pessanha, 2013
<i>Bachia geraldista</i>	Lowland	Brazilian Cerrado	N = 10 (4 months)	Teixeira Jr. <i>et al.</i> , 2013
<i>Micrablepharus maximiliani</i>	Lowland	Brazilian Cerrado	N = 67 (2.2 months)	Dal Vechio <i>et al.</i> , 2014
<i>Vanzosaura rubricauda</i>	Lowland	Argentinan Dry Chaco	N = 71 (18 months)	Fitzgerald <i>et al.</i> , 1999
<i>Pantodactylus schreibersi</i>	Lowland	Argentinan Dry Chaco	N = 1 (18 months)	Fitzgerald <i>et al.</i> , 1999
<i>Ecleopus gaudichaudii</i>	Lowland	Mata Atlantica	N = 26 (33 months)	Maia <i>et al.</i> , 2011
<i>Leposoma scincoides</i>	Lowland	fragmented Mata Atlantica with coffee plantations and burns	N = 31 (5 months)	Teixeira and Fonseca, 2003
<i>Proctoporus</i> spp.	Highland	Andean forest and puna with crops	N = 138 (3 months)	Doan, 2008
<i>Ptychoglossus bicolor</i>	Highland	pre-montane humid forest with coffee plantations	N = 218 (12 months)	Anaya-Rojas <i>et al.</i> , 2010
<i>Bachia bicolor</i>	Highland	Urban gardens	N = 156 (8 months)	Ramos-Pallares <i>et al.</i> , 2015
<i>Riama striata</i>	Highland	Urban grassland	N = 115 (12 months)	This study

Sexual dimorphism has been found in head size (broad and long) that has been documented several times in other gymnophthalmids and alopoglosids (Cruz, 1994; Vitt and Avila-Pires, 1998; Vitt *et al.*, 2003, 2007; Dal Vechio *et al.*, 2014, Garda *et al.*, 2014, Ramos-Pallares *et al.* 2015). Males and females of *R. striata* of similar size do not differ in body mass, which in principle could suggest that sexual dimorphism is not associated with differences in diet. Some studies suggest that sexual dimorphism is mainly due to sexual selection by females for males with larger heads or more robust bodies or competition between males for territory or females (Vitt and Avila-Pires, 1998; Vitt *et al.*, 2003, 2007; Dal Vechio *et al.*, 2014, Garda *et al.*, 2014). In this sense, the sexual dimorphism found for *R. striata* could then be attributed to sexual selection and territoriality, where males could find a new habitat occupied less frequently by other individuals on artificial brick substrates (Stamps, 1983, Stamps *et al.*, 1997).

As in most gymnophthalmids, *Riama striata* is a diurnal species with bimodal activity pattern, which contrasts only with diurnal and nocturnal activity in *Bachia geraldista* and *Nothobachia ablephara* (Gomes dos Santos *et al.*, 2012; Teixeira Jr. *et al.*, 2013) and a unimodal activity pattern reported in the gymnophthalmid *Potamites ecleopus* (Vitt and Avila-Pires, 1998).

The population of *R. striata* evaluated here had more females than males, unlike *Bachia bicolor* where the sexes are at the same ratio, and both juveniles and gravid females appeared throughout the year of the present study, something that also occurs in *B. bicolor* (Ramos-Pallares *et al.*, 2015). Likewise, recaptures allowed us to observe in a preliminary way that the mobility of the individuals was low. I recaptured some few individuals in the same refuges where they were captured for the first time, from periods of from one day to 7 months. So, I used the area of the quadrants to calculate the density of the

population. This was higher, although relatively similar to that recorded for *Gymnophthalmus pleei* (0.134 ind / m²), but considerably higher than that recorded for *G. underwoodii* (0.0127 ind / m²) in Dominica, a lowland diurnal species that inhabits open and xerophilous zones (Turk *et al.*, 2010). However, the spatial restriction of the population not only to the study quadrants, but to all the grassland coverage in the University campus (approximately 1.2 km²) together with the high frequency of recaptures (18%), suggested that this population of *R. striata* might be highly vulnerable to local extinction.

Further studies in populations of *Riama striata* or other species of gymnophthalmids or alopoglossids of the lowlands or in the Andes in both natural habitats and in disturbed habitats are needed. I recommend the development of an experimental design through the use of pitfall traps (Teixeira Jr. *et al.*, 2013) for a superior estimation of microhabitats, which are particularly difficult to sample, such as in the case of grass. Studies in thermal biology, diet, dynamics and population genetics could help to better elucidate the panorama shown for this population of *R. striata*.

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Literature cited

Anaya-Rojas, J.M.; Serrano-Cardozo, V.H. & Ramírez-Pinilla, M.P. 2010. Diet, microhabitat use, and thermal preferences of *Ptycho glossus bicolor* (Squamata: Gymnophthalmidae) in an organic coffee shade plantation in Colombia. *Papéis Avulsos de Zoologia* 50: 159-166.

Arredondo, J.C. & Sánchez-Pacheco, S.J. 2010. New endemic species of *Riama* (Squamata: Gymnophthalmidae) from northern Colombia. *Journal of Herpetology* 44: 610-617.

Butler, M.A.; Schoener, T.W. & Losos, J.B. 2000. The relationship between sexual size dimorphism and habitat use in Greater Antillean *Anolis* lizards. *Evolution* 54: 259-272.

Castaño-Mora, O.V.; Hernández, E. & Cárdenas, G. 2000.

Reptiles: 614-618. *En*: Rangel-Ch, J. O. (ed.), Colombia Diversidad Biótica III La región de vida paramuna. Guadalupe Ltda. Bogotá.

Cruz, F. B. 1994. Actividad reproductiva en *Vanzosaura rubricauda* (Sauria: Teiidae) del Chaco occidental en Argentina. *Cuadernos de herpetología* 8: 112-118

Dal Vechio, F.; Recoder, R.; Zaher, H. & Rodrigues, M.T. 2014. Natural history of *Micrablepharus maximiliani* (Squamata: Gymnophthalmidae) in a Cerrado region of northeastern Brazil. *Zoologia* 31: 114-118.

DEMOGRAPHIA. 2013. Demographia World Urban Areas. 9th annual edition. Available at: <http://www.demographia.com/db-worldua.pdf>. Last access: 27 February 2017.

Doan, T.M. 2008. Dietary variation within the Andean lizard clade *Proctoporus* (Squamata: Gymnophthalmidae). *Journal of Herpetology* 42: 16-21.

Fitzgerald, L. A.; Cruz, F. B. & Perotti, G. 1999. Phenology of a lizard assemblage in the dry Chaco of Argentina. *Journal of Herpetology* 526-535.

Garda, A.A.; De Medeiros, P.H.; Lion, M.B.; De Brito, M.R.; Vieira G.H. & Mesquita, D. O. 2014. Autoecology of *Dryadosaura nordestina* (Squamata: Gymnophthalmidae) from Atlantic forest fragments in Northeastern Brazil. *Zoologia* 31: 418-425.

Goicoechea, N.; Frost, D.R.; De la Riva, I.; Pellegrino, K.; Sites, J.; Rodrigues, M.T. & Padial, J. M. 2016. Molecular systematics of teioidea lizards (Teioidea/Gymnophthalmoidea: Squamata) based on the analysis of 48 loci under tree-alignment and similarity-alignment. *Cladistics* 32: 624-671.

Gomes dos Santos, M.V.G.; Macedo, I.G.S.; De Sousa, R.S.; Gogliath, M. & Ribeiro, L.B. 2012. Diet of *Nothobachia ablephara* (Squamata: Gymnophthalmidae) in a Caatinga area of the San Francisco Valley in northeastern Brazil. *Herpetology Notes* 5: 305-307.

Guisande, C.; Heine, J.; González-DaCosta, J. & García-Roselló, E. 2014. RWizard Software Version 3.5. University of Vigo. Vigo, Spain. Available at: <http://www.ipez.es/RWizard/>. Last access: 13 June 2018.

Guisande, C.A.; Barreiro, A.; Maneiro, I.; Riveiro, I.; Vergara, A. & Vaamonde, A. 2006. Tratamiento de datos. Díaz de Santos. Vigo.

Hernández, E.J. 2008. Los reptiles de la región del transecto Sumapaz: 289-310 *En*: Van Der Hammer, T. (ed.), La cordillera Oriental Colombiana. Transecto Sumapaz. Studies on Tropical Andean Ecosystems. Volumen 7. J. Cramer in der Gebr. Borntraeger Verlagsbuchhandlung. Berlin-Stuttgart.

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* 54: 187-211.

IDEAM. 2017. Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia, versión 2011. Available from: www.ideam.gov.co. Accessed on 27 February 2017.

Jerez, A. & Calderón-Espinosa, M. L. 2014. *Anadia bogotensis* (Peters, 1862). *Catálogo de Anfibios y Reptiles de Colombia* 2: 30-35.

Lynch, J.D. & Renjifo, J.M. 2001. Guía de los anfibios y reptiles de Bogotá y sus alrededores. Impresol Ltda. Bogotá.

Maia, T.; Almeida-Gomes, M.; Siqueira, C.C.; Vrcibradic, D.; Kiefer, M.C. & Rocha, C.F.D. 2011. Diet of the lizard *Eclepopus gaudichaudii* (Gymnophthalmidae) in Atlantic Rainforest, state of Rio de Janeiro, Brazil. *Zoologia* 28:

- 587-592.
- Méndez-Galeano, M.A. & Pinto-Eraza, M.A. 2018. *Riama striata* (Peters, 1862). *Catálogo de Anfibios y Reptiles de Colombia* 4: 61-67.
- Méndez-Narváez, J. 2014. Diversidad de anfibios y reptiles en hábitats altoandinos y paramunos de la cuenca del río Fúquene, Cundinamarca, Colombia. *Biota Colombiana* 15: 94-103.
- Moreno-Arias, R.A. & Urbina-Cardona, J.N. 2013. Population Dynamics of the Andean Lizard *Anolis heterodermus*: Fast-slow Demographic Strategies in Fragmented Scrubland Landscapes. *Biotropica* 45: 253-261.
- Pellitteri-Rosa, D.; Bellati, A.; Cocca, W.; Gazzola, A.; Martín, J. & Fasola, M. 2017. Urbanization affects refuge use and habituation to predators in a polymorphic lizard. *Animal Behaviour* 123: 359-367.
- Ramos-Pallares, E.; Anaya-Rojas, J.M.; Serrano-Cardozo, V.H. & Ramírez-Pinilla, M.P. 2015. Feeding and Reproductive Ecology of *Bachia bicolor* (Squamata: Gymnophthalmidae) in Urban Ecosystems from Colombia. *Journal of Herpetology* 49: 108-117.
- Rodewald, A. D. & Gehrt, S. D. 2014. Wildlife population dynamics in urban landscapes: 117-147. In: McCleery, R. A.; Moorman, C. & Peterson, M. N. (eds). *Urban wildlife conservation*. Springer, Boston, MA.
- Sánchez-Pacheco, S.J.; Torres-Carvajal, O.; Aguirre-Peñafiel, V.; Nunes, P.M.S.; Verrastro, L.; Rivas, G.A.; Rodríguez, M.T.; Grant, T. & Murphy, R.W. 2017. Phylogeny of *Riama* (Squamata: Gymnophthalmidae), impact of phenotypic evidence on molecular datasets, and the origin of the Sierra Nevada de Santa Marta endemic fauna. *Cladistics* 34: 260-291.
- Schoener, T.W. 1967. The ecological significance of sexual dimorphism in size in the lizard *Anolis conspersus*. *Science* 155: 474-477.
- Soares De Oliveira, B.H. & Machado-Pessanha, A.L. 2013. Microhabitat use and diet of *Anotosaura vanzolinia* (Squamata: Gymnophthalmidae) in a Caatinga area, Brazil. *Biota Neotropica* 13: 193-198.
- Sokal, R.R. & Rohlf, F.J. 1995. *Biometry: the principles and practice of statistics in biological sciences*. WH Free Company. New York.
- Stamps, J.A. 1983. Sexual selection, sexual dimorphism, and territoriality: 169-204. En: Huey, R.B.; Pianka, E.R. & Schoener, T.W. (eds.), *Lizard ecology: studies of a model organism*. Harvard University Press. Cambridge.
- Stamps, J.A.; Losos, J.B. & Andrews, R.M. 1997. A comparative study of population density and sexual size dimorphism in lizards. *The American Naturalist* 149: 64-90.
- Stellatelli, O. A.; Vega, L. E.; Block, C. & Cruz, F. B. 2013. Effects of tree invasion on the habitat use of sand lizards. *Herpetologica* 69: 455-465.
- Teixeira, R.L. & Fonseca, F.R. 2003. Tópicos ecológicos de *Leposoma scincoides* (Sauria, Gymnophthalmidae) da região de Mata Atlântica de Santa Teresa, Espírito Santo, sudeste do Brasil. *Boletim do museu de biologia Mello Leitão* 15: 17-28.
- Teixeira Jr. M.; Recoder, R.S.; Camacho, A.; De Sena, M.A.; Navas, C.A. & Trefaut Rodrigues, M. 2013. A new species of *Bachia* Gray, 1845 (Squamata: Gymnophthalmidae) from the Eastern Brazilian Cerrado, and data on its ecology, physiology and behavior. *Zootaxa* 3616: 173-189.
- Turk, P.A.; Wyszynski, N.N.; Powell, R. & Henderson, R.W. 2010. Population densities and water-loss rates of *Gymnophthalmus pleii*, *Gymnophthalmus underwoodi* (Gymnophthalmidae), and *Sphaerodactylus fantasticus fuga* (Sphaerodactylidae) on Dominica, West Indies. *Salamandra* 46: 125-130.
- Uetz, P.; Freed, P. & Hošek, J. 2019. The Reptile Database. Available at: <http://www.reptile-database.org>. Last access: 05 May 2019.
- Vitt, L.J. & Avila-Pires, T.C.S. 1998. Ecology of two sympatric species of *Neusticurus* (Sauria: Gymnophthalmidae) in the western Amazon of Brazil. *Copeia* 1998: 570-582.
- Vitt, L.J. & Caldwell, J. P. 2013. *Herpetology: an introductory biology of amphibians and reptiles*. Fourth Edition. Academic Press. London-Waltham-San Diego.
- Vitt, L.J.; Avila-Pires, T.C.S.; Zani, P.A.; Espósito, M.C. & Sartorius, S.S. 2003. Life at the interface: ecology of *Prionodactylus oshaughnessyi* in the western Amazon and comparisons with *P. argulus* and *P. eigenmanni*. *Canadian Journal of Zoology* 81: 302-312.
- Vitt, L.J.; Ávila-Pires, T.C.S.; Espósito, M.C.; Sartorius, S.S. & Zani, P.A. 2007. Ecology of *Alopoglossus angulatus* and *A. atriventris* (Squamata, Gymnophthalmidae) in western Amazonia. *Phyllomedusa: Journal of Herpetology* 6: 11-21.
- Vitt, L.J.; Sartorius, S.S.; Avila-Pires, T.C.S. & Espósito, M.C. 1998. Use of time, space, and food by the gymnophthalmid lizard *Prionodactylus eigenmanni* from the western Amazon of Brazil. *Canadian Journal of Zoology* 76: 1681-1688.
- Wolf, A. J.; Hellgren, E. C.; Bogosian, V. & Moody, R. W. 2013. Effects of habitat disturbance on Texas horned lizards: an urban case study. *Herpetologica* 69: 265-281.

