



Population size estimate of *Abronia lythrochila* Smith & Álvarez del Toro, 1963 (Reptilia: Anguidae) in the Estación Biológica San José, Chiapas, Mexico

Estimación del tamaño de una población de *Abronia lythrochila* Smith & Álvarez del Toro, 1963 (Reptilia: Anguidae) en la Estación Biológica San José, Chiapas, México

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ABSTRACT. The arboreal lizard *Abronia lythrochila* was described about 60 years ago, yet its natural history remains poorly researched. The objective of this study was to estimate the population density and spatial distribution of *A. lythrochila* at the Centro para la Conservación e Investigación de la Biodiversidad de los Altos de Chiapas (CECIBACH, formerly known as the Estación Biológica San José) in Chiapas, Mexico. Based on field data collected from 2017–2019, the estimated population density was 1.7 individuals per hectare, representing an estimated population size between 7–89 specimens across the entire 16 hectares of CECIBACH. Due to human activities that threaten forests in the highlands of Chiapas, together with misperceptions of the species as dangerously venomous, this population of *A. lythrochila* could be suffering an ongoing decline. The current study offers the first-ever baseline for comparative population demography of this species.



Key words: conservation; gerrhonotinae; red-lipped arboreal alligator lizard; reptile; population density

RESUMEN. La lagartija arborícola *Abronia lythrochila* fue descrita hace unos 60 años; sin embargo, su historia natural sigue siendo poco investigada. El objetivo de este estudio fue estimar la densidad poblacional y la distribución espacial de *A. lythrochila* en el Centro para la Conservación e Investigación de la Biodiversidad de los Altos de Chiapas (CECIBACH, anteriormente conocido como Estación Biológica San José) en Chiapas, México. Con base en los datos de campo recopilados entre 2017 y 2019, la densidad de población fue de 1.7 individuos/hectárea, lo que se traduce en un tamaño poblacional estimado de 7—89 ejemplares en la totalidad de las 16 hectáreas del CECIBACH. Debido a las actividades humanas que amenazan los bosques de los Altos de Chiapas, junto con la percepción errónea de la especie como peligrosamente venenosa, esta población de *A. lythrochila* podría estar sufriendo un declive continuo. El presente estudio ofrece la primera línea de base para la demografía poblacional comparativa de esta especie.

Palabras clave: conservación; gerrhonotinae; dragoncito de labios rojos; reptil; densidad poblacional

INTRODUCTION

Estimating population density or abundance of an organism can provide a window into its status and spatial distribution (Ojasti & Dallmeier, 2000; Williams *et al.*, 2002). Abundance can be expressed in absolute terms as population size (number of individuals) or population density (average number of individuals per unit area), or by using abundance indices that usually report the number of individuals or their traces detected per unit of search effort (Ojasti & Dallmeier, 2000).

Importantly, a population estimate of an organism at a specific moment in time and space can allow comparison with or extrapolation to other populations (McCallum, 2008). Additionally, such estimates can provide baselines for follow-up monitoring of potential changes in abundance or population dynamics (Gilbert & Whitlock, 2015). These estimates can thus inform management strategies and conservation plans for wildlife species, as well as detect the loss of biodiversity caused by human activities (Nunney & Elam, 1994).

Alligator lizards in the genus *Abronia* (Squamata: Anguidae), which occur in mountainous areas throughout much of Middle America (Gutiérrez-Rodríguez *et al.*, 2021), are a wildlife group of conservation concern for which population estimates would be useful. However, such estimates are difficult to obtain due to the secretive and arboreal habits of most *Abronia*. All 41 recognized extant species in the genus, 31 are considered arboreal (García-Vázquez *et al.*, 2022). In an unpublished conference presentation, Pérez *et al.* (2015) reported preliminary population density estimates of 5100 ind/ha for *A. graminea* in Veracruz, Mexico, and 0.64 ind/ha for *A. taeniata* in Hidalgo, Mexico. For both species, these preliminary estimates were based on data collected in a single year (2015) during a limited temporal window that coincides with the reproductive season (August-October).

An arboreal *Abronia* species whose population parameters remain unstudied is *A. lythrochila* Smith & Álvarez del Toro, 1963, which is often known as the Red-lipped Arboreal Alligator Lizard but is also called the Kix'Xikin or Ch'ixchiquin (Thorn-eared Lizard) in the Tzotzil

language (Artot Ruíz, 2000; Aranda-Coello, 2019). This species is distributed from near Jitotol in Chiapas, Mexico southward across much of the Central Plateau of Chiapas (Álvarez del Toro, 1982; Grünwald et al 2016), and has also been reported from the Sierra de Los Cuchumatanes of Guatemala (Torres *et al.*, 2013). García-Padilla and Escalante-Pliego (2022) additionally reported a possible but unverified observation of *A. lythrochila* farther to the west in cloud forest near Tapalapa, Chiapas. Across its confirmed range, *A. lythrochila* lives in pine-oak forests at a range of 1840–3000 meters above sea level with a temperature of 12–24 °C (Campbell & Frost, 1993; Aranda-Coello, 2011; Grünwald *et al.*, 2016). These forests often support dense assemblages of epiphytic vegetation including the bromeliads *Tillandsia imperialis*, *T. ponderosa*, and *T. guatemalensis*, which offer water, shelter, and invertebrate food to *A. lythrochila* and constitute an ideal microhabitat for the species (Rodríguez-Pérez & Aranda-Coello, 2021).

The habitat of many *Abronia* species has been disturbed or destroyed by human activities. These impacts, together with the naturally restricted distributions of most species of *Abronia*, have made the arboreal members of genus the focus of substantial conservation concern (Hudson *et al.*, 2001). For *A. lythrochila* specifically, an accelerated regional growth of human settlements has in the last 15 years, mainly in and around the municipality of San Cristóbal de Las Casas (Aranda-Coello *et al.*, 2018; Aranda-Coello, 2019). To provide a first-ever baseline for future demography studies in the context of rapidly disappearing habitat and other threats, the aim of this study was to estimate the population density and spatial distribution of *A. lythrochila* within a small government reserve.

MATERIALS AND METHODS

Study area

This study took place at Centro para la Conservación e Investigación de la Biodiversidad de los Altos de Chiapas (CECIBACH) in the Municipio de San Cristóbal de Las Casas. Until 2019, CECIBACH was known as the Estación Biológica San José. This combined biological station/zoological park/nature reserve encompasses a 16-hectare parcel of semi-conserved pine-oak forest centered at coordinates 16°43'12" N, 92°42'03" W in the Central Plateau of Chiapas at 2350–2380 meters above sea level (Fig. 1), with a temperate subhumid climate and year-round rains (Aranda-Coello *et al.*, 2018; Aranda-Coello, 2019). The forest on the property is dominated by *Pinus oaxacana*, *P. oocarpa*, *P. pseudostrobus*, *Quercus crispipilus*, *Q. pilicaulis*, *P. peduncularis* and *Q. acatenangensis* (González-Ortega & Pérez-Suasnávar, 2007). The trees support several species of epiphytic bromeliads, with *Tillandsia guatemalensis* being the most common (Fig. 2). The CECIBACH is administered by the Secretaría de Medio Ambiente e Historia Natural and was officially established on 29 January 2015 as the first biological station in the highlands of Chiapas dedicated to regional wildlife conservation (Aranda-Coello *et al.*, 2018).

Data collection

A total of 372 daytime surveys were carried out within the CECIBACH from February 2017 to September 2019. Survey effort was restricted to two 5-ha quadrants with dimensions 100 x 500 m, each separated by 50 m. Both quadrants were sampled once a week, and they correspond to zones of the CECIBACH that possess different degrees of disturbance. Quadrant 1 (more disturbed) was located near the park entrance in an area with trails and frequent pedestrian and vehicle traffic, while Quadrant 2 (less disturbed) was in an area of the park with infrequent pedestrian traffic. In each quadrant, the number of trees and bromeliads was recorded. Temperature data were also recorded using a HOBO 64K (waterproof) Onset UA-001-64 datalogger throughout the study.

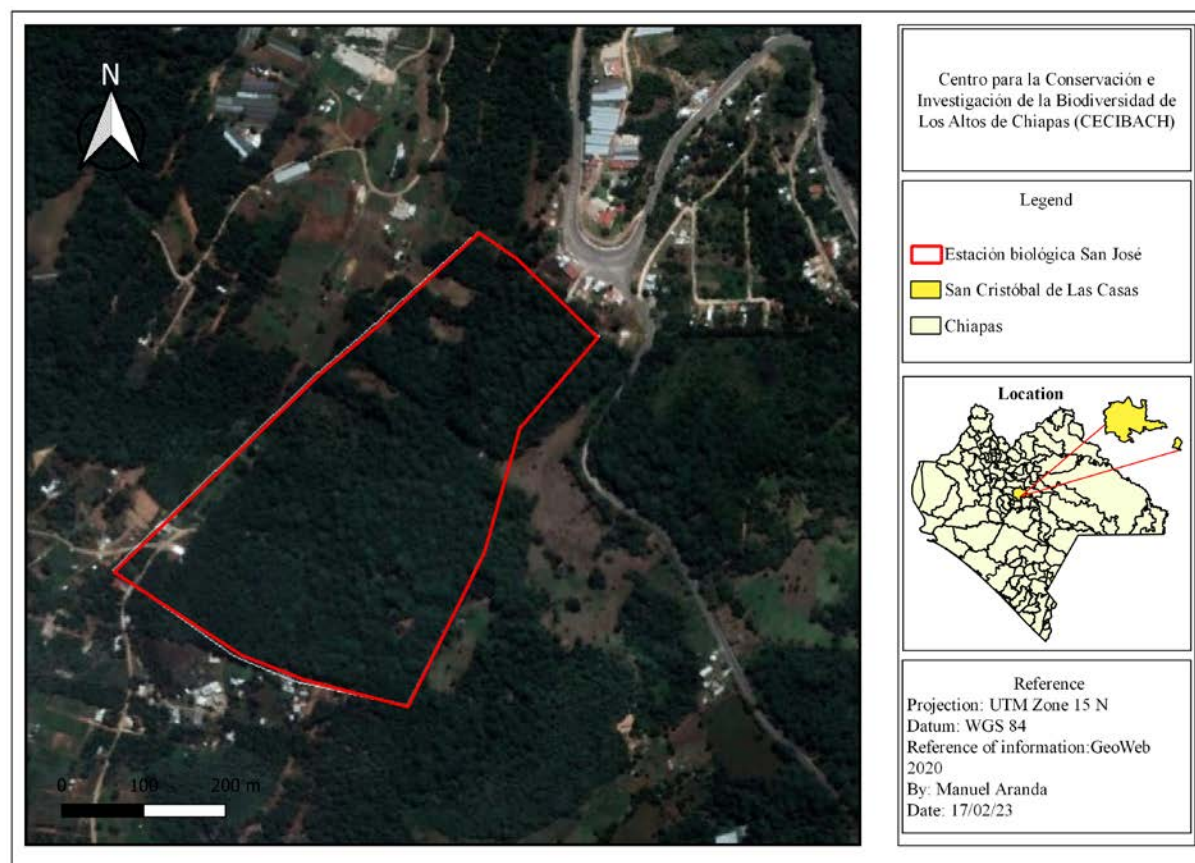


Figure 1. Geographic location of the study area at the Estación Biológica San José, San Cristóbal de Las Casas, Chiapas, Mexico (Google Earth).

During each survey, *A. lythrochila* was detected through direct observation on foot by continuous visual scanning of the tree trunks and branches, checking each bromeliad. To aid with detections in real time, a wireless camera (GoPro HERO5 Black) mounted to an extendible pole and connected to a hand-held mobile device was used (Fig. 3a; Aranda-Coello *et al.*, 2012). Once an *A. lythrochila* was located, an extendible pole with a herpetological hook attached to the tip was used to manipulate the lizard into a cloth bag attached to another extendible pole (Fig. 3b; Aranda-Coello, 2019). This technique caused no external physical harm to the lizards. Once captured, the total length (TL, measured from the tip of the snout to the tip of the tail) was measured using a vernier caliper graduated in mm. Based on total length, the lizards were grouped into three classes: CI (neonates, TL 60–100 mm), CII (juveniles, TL 110–200 mm) and CIII (adults, TL 210–300 mm). The sex of each lizard was determined by squeezing the base of the tail with the fingers to evert the male sex organs (hemipenes) (Aranda-Coello, 2019); if no hemipenes were observed, the lizard was presumed to be a female. To avoid measuring an individual twice, each *A. lythrochila* was implanted with an electronic PIT tag 2.07 mm wide, 12.50 mm long, 125 kHz frequency, 0.1020 g weight (Biomark Inc. www.biomark.com) using the technique suggested by Lobos *et al.* (2013).

Statistical analyses

The population density of *A. lythrochila* was estimated by adapting the formula proposed by Díaz-Velasco (2005) from the number of specimens sighted per quadrant:



Figure 2. Habitat of *Abronia lythrochila* at the Centro para la Conservación e Investigación de la Biodiversidad de los Altos de Chiapas, Chiapas, Mexico. a) oak forest; b) epiphytic bromeliads *Tillandsia prodigiosa* (with large pendant inflorescence) and *T. fasciculata*; c) an *Abronia lythrochila* individual.

$$\text{Population density by quadrant} = \frac{\text{Number of } A. \textit{lythrochila} \text{ observed}}{\text{Area (ha)}}$$

The spatial distribution pattern of *A. lythrochila* was determined from the aggregation value:

$$\text{Aggregation value} = \frac{\text{Variance of the number of observations per quadrant}}{\text{Average value of observed specimens}}$$



Figure 3. Spy eye technique, used for direct observation of *Abronia lythrochila*. a) wireless camera (GoPro HERO5 Black) mounted to an extendible pole; b) technique used, including two people.

For this metric, an aggregation value less than 1 represents a uniform distribution, equal to 1 represents a random distribution, and greater than 1 represents a grouped distribution.

We performed normality tests and the histograms and the dispersion of the data for each variable were evaluated graphically, the dispersion from the evaluation of the kurtosis and the symmetry in the distribution of the data. A quantile plot was also produced; this compares the ranked samples from our distribution with a similar number of ranked quantiles taken from a normal distribution. If the sample data are normally distributed, the line will be straight. In case of non-normality, they are presented in an S-shape. We used the most recommended one, Shapiro-Wilk (Thode, 2002), for the data and assessed associations between response variables (number of individuals, density of individuals, number of trees and number of bromeliads) and between explanatory variables (quadrat type and temperature). We performed an exploratory analysis (These are graphical procedures to determine variation in the data or outliers, including box-plots or scatter plots) to check if there was an effect of temperature with respect to the number of trees and the number of bromeliads; we also performed an exploratory data analysis (are Generalized Linear Models with Poisson or negative binomial error structure when there is overdispersion of the data; Burnham & Anderson, 2002) to check if there was a difference between the number of *A. lythrochila* individuals recorded in each quadrat with respect to the number of trees, the number of bromeliads and temperature. The data was analyzed with Generalized Linear Models (GLM with Poisson-type error structure), using the statistical program R version 3.5.3 (The R Foundation for Statistical Computing, 2019).

RESULTS

Population density

A total of 28 individuals of *A. lythrochila* (7 from quadrant 1 and 21 from quadrant 2) was recorded, with no recaptures. The total density was 1.75 (ind/ha) and by quadrants was from 1.4 to 4.2 (ind/ha), and the estimated total abundance is between 22 to 67 individuals.

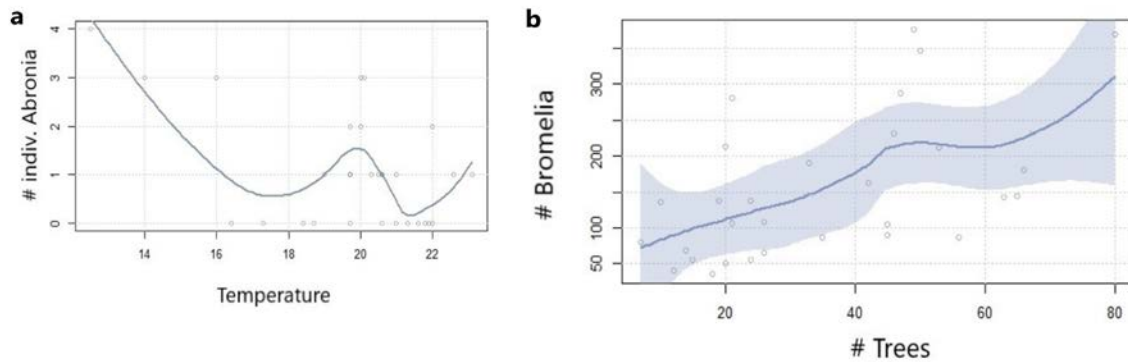


Figure 4. Ratio of the number of *Abronia lythrochila* individuals and temperature (a), and number of bromeliads and number of trees in sampling sites (b) at the Centro para la Conservación e Investigación de la Biodiversidad de los Altos de Chiapas, Chiapas, Mexico.

Population structure

The 28 individuals captured, 1 corresponded to size class CI (neonate), 4 to size class CII (juvenile) and 23 to size class CIII (adult). The average LT was 23.7 cm (range 6.5–29.5), and the average weight was 22.9 g (range 2.1–32.5). All individuals in size classes CII and CIII, 17 were females and 10 were males, yielding a 1.7:1 female: male sex ratio.

Distribution pattern

The *A. lythrochila* population showed a grouped distribution pattern (aggregation value = 4.96), likely because the individuals are concentrated in the CECIBACH with less anthropic perturbation (Quadrant 2).

There was a positive correlation between the observed *A. lythrochila* individuals and the number of trees ($R_{\text{trees, } A. lythrochila} = 0.347$). The mean proportion of trees per *A. lythrochila* was 3.46:1. In addition, the correlation between observed *A. lythrochila* and bromeliads per quadrant was positive ($R_{\text{bromeliads, } A. lythrochila} = 0.994$). The mean proportion of *A. lythrochila* per bromeliads was 37.15:1. The bromeliad species identified in the quadrants were *Tillandsia ponderosa* and *T. guatemalensis* (Aranda-Coello *et al.*, 2018). Generalized Linear Models showed that there is a significant negative relationship between the number of *A. lythrochila* individuals and temperature (Fig. 4a). Generalized linear models also showed that there was a significant positive relationship between the number of *A. lythrochila* individuals and the number of bromeliads and the number of trees (Fig. 4b) but showed no differences between the number of *A. lythrochila* individuals in trees (Fig. 5a) and the number of bromeliads (Fig. 5b) regarding the type of quadrant or temperature (Table 1).

Table 1. Differences between number of lizard and bromelid individuals in trees and the type of quadrant or temperature at Centro para la Conservación e Investigación de la Biodiversidad de los Altos de Chiapas, Chiapas, Mexico.

	Model	DAICc	Weights
Number of <i>Abronia lythrochila</i> individuals			
1	noindiv ~ 1 + temp	92.1983	0.4189379
Number of bromeliads			
1	nobrome ~ noarboles	355.8326	0.5107
2	nobrome ~ 1 + cuad + noarboles	357.1288	0.2671
3	nobrome ~ 1 + noarboles + temp	358.3775	0.1430
4	nobrome ~ 1 + cuad + noarboles + temp	360.0279	0.0626
5	nobrome ~ 1	363.7969	0.0095
6	nobrome ~ 1 + cuad	366.0605	0.0030
7	nobrome ~ 1 + temp	366.1948	0.0028
8	nobrome ~ 1 + cuad + temp	368.7183	0.00081

DISCUSSION

The estimated density and abundance of *A. lythrochila* at CECIBACH were lower than estimates for other arboreal species of the genus *Abronia*. The density for *A. graminea*, a species classified as Endangered by the IUCN Red List (Flores-Villela & Santos-Barrera, 2007), was ~ 5100 ind/ha in the state of Veracruz (Pérez *et al.*, 2015). Those authors sighted 59 *A. graminea* individuals (twice as many as in this study) were sighted over a one-year period. The same authors also reported a density of 0.64 ind/ha for *A. taeniata*, in the state of Hidalgo, a species that is considered Vulnerable by the IUCN (Canseco-Márquez & Mendoza-Quijano, 2007).

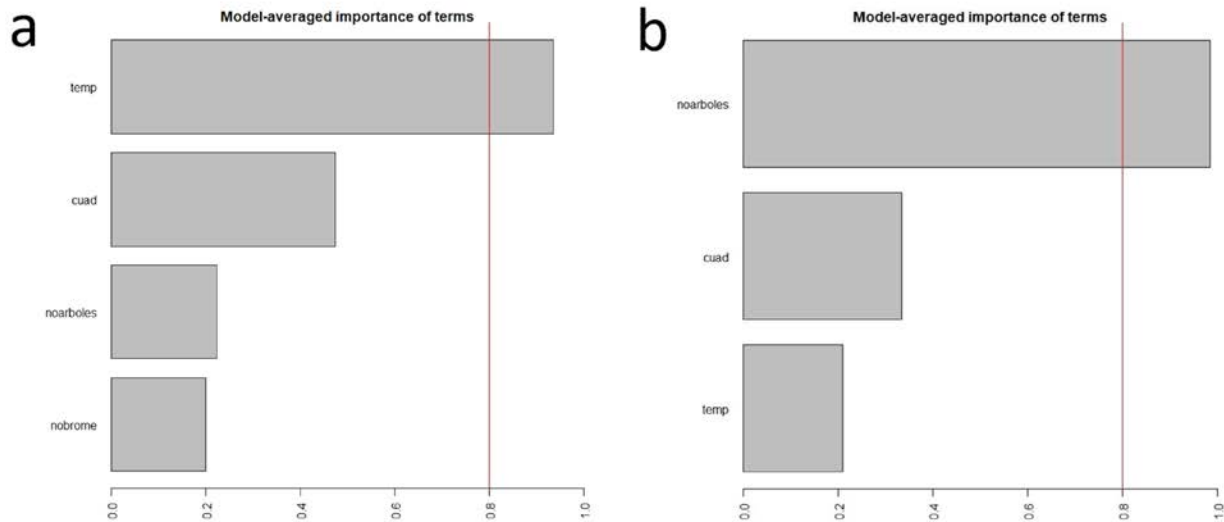


Figure 5. Variables with the highest model weights for number of *Abronia lythrochila* individuals (a), and number of bromeliads (b) at the Centro para la Conservación e Investigación de la Biodiversidad de los Altos de Chiapas, Chiapas, Mexico.

In Quadrant 1 of our study site, we documented far fewer individuals of *A. lythrochila* compared to Quadrant 2. This result could be attributable to the greater human activity in Quadrant 1. However, overall detection rates in both Quadrants were low, giving us limited predictive power and indicating that that much more sampling effort is needed to accurately estimate the size of the *A. lythrochila* population and evaluate its potential spatial variation.

Sex ratios reported for the genus *Abronia* (i.e., *A. graminea*, *A. taeniata*), range from 0.52–3.1 females for each male (Cazáres-Hernández, 2015; Pérez *et al.*, 2015). The observed sex ratio for the population of *A. lythrochila* at the CECIBACH (1.7 females for each male) fell within this range. The positive relationship found between bromeliads per quadrant and the *A. lythrochila* population at the CECIBACH (Aranda-Coello *et al.*, 2012) is consistent with expectations since these plants provide ideal microhabitat for *Abronia* (Cruz-Ruiz *et al.*, 2012). The grouped distribution pattern of the studied *A. lythrochila* population can also be explained in relation to the vegetation since its preference for epiphytic vegetation patches and conserved oak forests have been reported (Hernández, 2018).

Although almost no published population estimates exist, populations of many species of the genus *Abronia* are inferred to be declining due to deforestation and habitat fragmentation (often caused by change of land use from forestry to agriculture), and overexploitation caused by collection for the international pet trade (Ariano-Sánchez *et al.*, 2011). Each of these factors is at play for *A. lythrochila* in the Central Plateau of Chiapas, suggesting that the species is imperiled to some degree (Aranda-Coello *et al.*, 2012). Over the last 20 years, both inside and outside the CECIBACH, unregulated logging, illegal trafficking, and direct killing of *A. lythrochila* by local people who believe these animals are venomous (Aranda-Coello, 2019), have all presumably contributed to a population decline. Hudson *et al.* (2001) projected a population decrease for *A. lythrochila* of 21–50% by 2011, but again this was based purely on expert opinion rather than quantitative data. Critically, the population and demographic study presented here offers the first quantitative population baseline for *A. lythrochila*. With further work across space and time, this local-level data could allow for productive comparisons that would generate a clearer picture of the status of *A. lythrochila* populations in the region of Los Altos de Chiapas.

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