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Autecology of the lizard *Colobosauroides cearensis* (Squamata: Gymnophthalmidae) from Brazilian semiarid Caatinga

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Abstract

Autecology of the lizard *Colobosauroides cearensis* (Squamata: Gymnophthalmidae) from Brazilian semiarid Caatinga. *Colobosauroides cearensis* is a diurnal lizard with a relictual distribution associated with forested habitats in the Brazilian Caatinga Domain. Knowledge of the natural history of this secretive lizard is scarce. Herein, the diet, reproduction, sexual dimorphism, microhabitat use, and thermal ecology of *C. cearensis* are described based on fieldwork in 2015–2017 in the state of Ceará, Brazil. The diet of the lizards is composed exclusively of arthropods, with Formicidae being the most important prey category. Numerical and volumetric niche breadths are 5.52 and 9.2 respectively, and trophic niche overlap between females and males is 0.3. Males are distinguished from females by the larger size of the males and the presence of femoral pores. *Colobosauroides cearensis* is cryptozoic, inhabiting the leaf litter and having no direct contact with the soil or solar radiation. The average body temperature of the lizards is 30.4 ± 3.3°C, which is positively correlated with the air temperature. Gravid females with fixed clutch size of two eggs are found in early rainy season. Oviposition occurs between April and May (when the highest number of juveniles are observed). Sexual maturity occurs early in males and testicular volume is significantly correlated with body size.

Keywords: diet, habitat, reproduction, sexual dimorphism, thermoregulation.

Resumo

Autoecologia do lagarto *Colobosauroides cearensis* (Squamata: Gymnophthalmidae) da Caatinga semiárida brasileira. *Colabosauroides cearesis* é um lagarto diurno com distribuição relictual associados a habitats florestais, no domínio da Caatiga brasileira. O conhecimento da

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história natural desse lagarto é escasso devido o seu habito secreto. Aqui, descrevemos a dieta, reprodução, dimorfismo sexual, uso de microhabitat e ecologia térmica de *C. cearensis,* com base em trabalhos de campo entre 2015–2017 no estado do Ceará, Brasil. A dieta desses lagartos é composta exclusivamente por artrópodes, sendo Formicidae a categoria de presas mais importante. A largura de nicho numérico e volumétrico foram 5,52 e 9,2, respectivamente, e a sobreposição de nicho trófico entre fêmeas e machos foi de 0,3. Os machos distinguem-se das fêmeas por apresentar maior tamanho e pela presença de poros femorais. *Colobosauroides cearensis* é criptozóico, habitando a serapilheira e não tendo contato direto com o solo ou radiação solar. A temperatura corporal média dos lagartos é de 30,4 ± 3,3°C, correlacionada positivamente com a temperatura do ar. Fêmeas grávidas com tamanho de ninhada fixa de dois ovos são encontradas no início da estação chuvosa. A ovipostura ocorre entre abril e maio (quando o maior número de juvenis foi observado). A maturidade sexual ocorre cedo nos machos, e o volume testicular está significativamente correlacionado com o tamanho do corpo.

Palavras-chave: dieta, dimorfismo sexual, habitat, reprodução, termorregulação.

Introduction

To understand the dynamics of ecosystems and evolutionary history of a species, it is essential to be familiar with the autecology of the species; this includes its diet, sexual dimorphism, reproduction, microhabitat use, and thermal ecology (Dunham *et al.* 1988, Pianka and Vitt 2003). Such information is critical to species conservation and land-management strategies, particularly now when many taxa are being extirpated owing to anthropogenic habitat destruction (Myers 2000, Primack 2008).

Studies of population and community ecology, foraging, and life histories of lizards have contributed significantly to the formulation of ecological theories (Huey *et al.* 1983, Vitt and Pianka 1994, Pianka and Vitt 2003). However, Vitt and Caldwell (2013) pointed out that only 5% of squamates have adequate information about their life history, especially in the Neotropics. Most of our knowledge of ecology and population dynamics of lizards is based on temperate species, and generalizations about life-history patterns of tropical species may be erroneous given the different ecogeographic conditions (Colli *et al.* 2003).

Gymnophthalmidae comprises 235 species (Uetz and Hošek 2016). Gymnophthalmids are restricted to the Neotropics, and are characterized by smaller body sizes and marked plasticity in habitat use, including terrestrial, semifossorial, fossorial, semiaquatic, and semiarboreal species (Pellegrino *et al.* 2001). The fossorial habits of some species are reflected in their morphology by attenuation of the body, varied reduction of the limbs, and loss of eyelids and the external ear (Pellegrino *et al.* 2001, Rodrigues *et al.* 2007).

Colobosauroides cearensis Cunha, Lima-Verdade, and Lima, 1991 has relictual distribution in the Caatinga of the Brazilian semiarid region associated with forest enclaves in Ceará. This includes peripheral areas of the city of Fortaleza (Cunha *et al.* 1991, Borges-Nojosa and Caramaschi 2003) in the state of Piauí in the Fazenda Paquetá (Silva *et al.* 2015), as well as an isolated population in the municipality of Mauriti in the southern state of Ceará (Silva-Neta *et al.* 2019). The natural history of *C. cearensis* has been unknown (Cunha *et al.* 1991), and it is classified as Data Deficient by IUCN criteria (IUCN 2017); this lack of knowledge curtails the development of conservation actions, especially for organisms with restricted distributions (Rocha *et al.* 2009). Herein, aspects of the natural history of *C. cearensis,* including diet, sexual dimorphism, microhabitat use, thermal ecology, and reproduction are described.

Materials and Methods

Study Area

The study was conducted in the municipality of Mauriti (07°22'46.08" S, 38°38'47.87" W), state of Ceará in northeastern Brazil (Figure 1). The vegetation is primarily deciduous forest and hypoxerophytic Caatinga. The local climate is hot and semiarid, with the rainy period occurring from February–April, and the mean annual rainfall ranging from 500–800 mm (IPECE 2016).

A total of 116 lizards was collected by hand in visual searches in the dry season (November 2015 and December 2016) and in the rainy season (May 2016 and April 2017). Visual surveys were carried out between 08:30 h and 16:30 h, and totaled 20 days of effort. Specimens were collected with scientific collecting permit issued by ICMBio (52214-1) and authorized by ethics committee of the Universidade Regional do Cariri (CEUA/URCA process nº 00026/ 2015.2). Lizards were euthanized with a lethal injection of sodium thiopental, fixed in 10% formalin, preserved in 70% alcohol and deposited in the Herpetological Collection of the Universidade Regional do Cariri.

Diet

Stomach contents of the lizards were examined and identified to lowest taxonomic category possible, usually the ordinal level. Prey volume was estimated with the formula for an ellipsoid: $V = (4/3\pi)(\text{length}/2)(\text{width}/2)^2$.

The inverse of the Simpson's index of diversity was calculated to measure the numerical and volumetric food niche widths described for the microhabitat; the values vary from 1 (use only one prey category) to *N* (equal use of all prey categories).

To determine the relative contribution of each prey category, we calculated the relative importance index (*I*) using: $I = F\% + N\% + V\%$, where *F*%, *N*% and V% are the percentages of frequency, number, and volume of prey categories (Powell *et al.* 1990). The food niche overlap between the males and females was assessed with Pianka's overlap index (Pianka 1973) in Ecosim 7.0 software (Gotelli and Entsminger 2004): /.

To access intersexual similarity in diet we performed a Principal Coordinate Analysis (PCoA) (Torgerson 1958, Gower 1966) with Bray-Curtis distance.

Sexual Dimorphism

The following measurements (± 0.01 mm) were recorded with digital calipers for each adult lizard: snout–vent length (SVL); tail length (TL); body width (BW); body height (BH); head width (HW); head height (HH) and length (HL); jaw length (JL); forearm length (FL); and hind-limb length (HI). To sexual dimorphism in SVL, we conducted a Student's *t*-test. The residuals from a multiple regression between each variable and SVL were used to remove the effect of body size in the analysis of sexual dimorphism. A principal component analysis (PCA) was performed using all residuals from morphometric variables except SVL and TL. Also, a permutational multivariate analysis of variance was performed to access sexual size dimorphism.

Microhabitat Use

Spatial niche breadth (*B*) was evaluated with the reciprocal of the Simpson Diversity Index: , where *i* is the microhabitat category, *P* is the proportion of *i,* and *N* is the number of categories. The value of *B* varies from 1 (use one microhabitat category) to *N* (equal use of all microhabitat categories). Spatial niche overlap between the males and females was calculated with Pianka's overlap index (presented above).

Thermal Ecology

The cloacal temperature (T_c) of the lizards was measured with a cloacal thermometer (Miller & Weber Inc., accuracy of 0.2°C) within 15 s of capture of individuals that had run no farther than

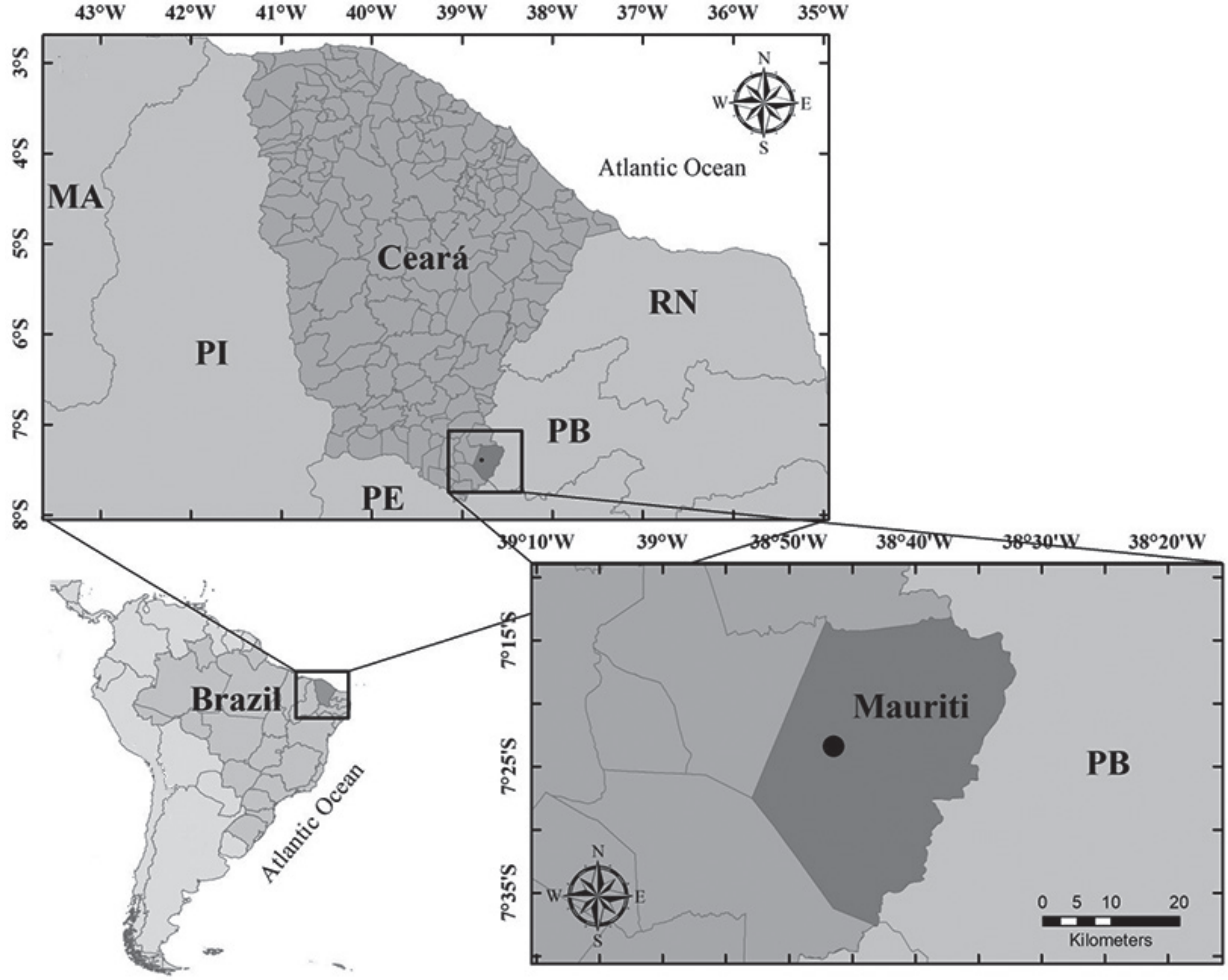

Figure 1. Map of the study site (black circle) in the municipality of Mauriti, Ceará state, northeastern Brazil.

50 cm before being captured. Substrate temperature (T_s) and air temperature (T_a) were measured 5 cm above the soil with a precision thermometer (0.2°C). We conducted a multiple regression analysis to evaluate the relationships among T_c, T_a, and T_s. We used a Student's *t*-test to evaluate seasonal differences in cloacal temperatures, as well as intersexual differences.

Reproduction

The sex of the lizards was determined by dissection and direct examination of the gonads. Females were considered sexually mature based on appearance and size of follicles, and/or the presence of oviductal eggs and corpora lutea. Females having vitellogenic follicles and eggs in the oviduct and/or presence of corpora lutea simultaneously were determined to have more than one clutch per reproductive season. Clutch size was estimated according to the number of vitellogenic follicles or eggs present in the oviduct. Males were classified as sexually mature when convoluted epididymides and enlarged testicles were present (Ballestrin *et al.* 2010). We recorded lengths and widths of both testicles in males and vitellogenic follicles and eggs in females; the volumes of these structures were

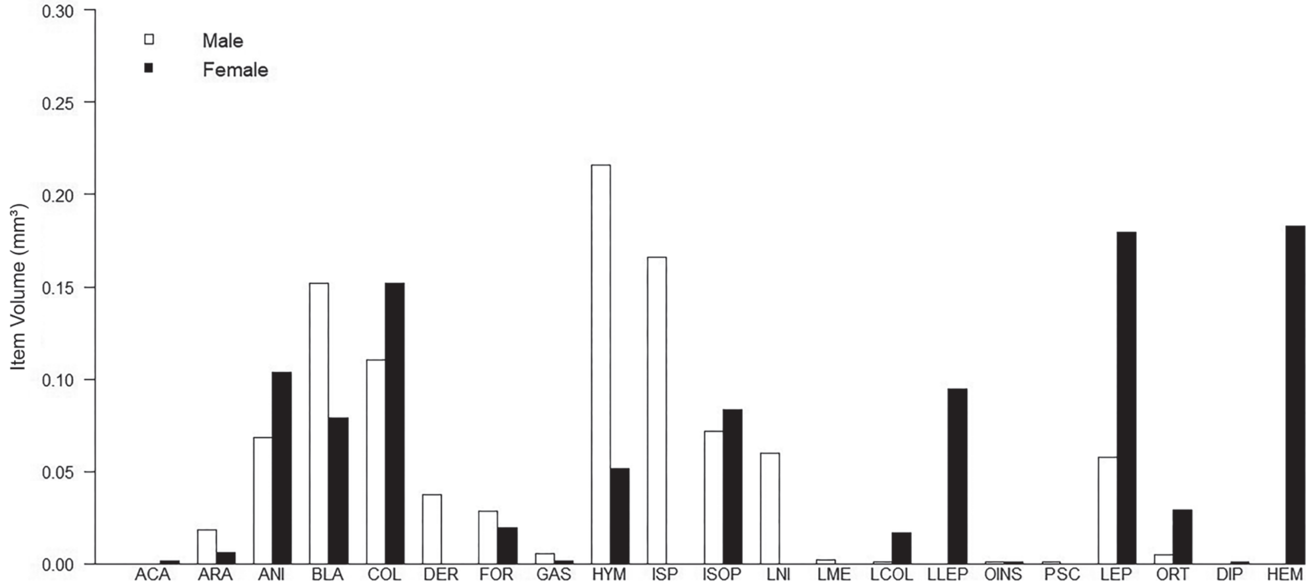

Figure 2. Proportion in volume for each prey category consumed by female and male *Colobosauroides cearensis* collected in this study. ACA, Acari; ARA, Aranae; ANI, Arthropode unidentified; BLA, Blattodea; COL, Coleoptera; DER, Dermaptera; FOR, Formicidae; HYM, Hymenoptera; ISO, Isoptera; ISOP, Isopoda; LNI, Larvae unidentified, LME, Larvae Mecoptera, LCOL, Larvae Coleoptera; LLEP, Larvae Lepidoptera; OINS, Insect egg; PSC, Pseudoscorpiones; LEP, Lepidoptera; ORT, Orthoptera; DIP, Diptera, HEM, Hemiptera.

estimated with the ellipsoid formula. Pearson and Spearman correlations were used to test whether there is correlation between the volume of eggs and SVL in females and testicular volume and SVL in males.

All statistical analyses were conducted on an R platform, version 2.15.0 (R Development Core Team 2017).

Results

Diet

We analyzed stomach contents of 120 individual lizards (61 adult females, 45 adult males and 14 juveniles), of which 3.5% ($N = 4$) had empty stomachs. We identified 21 prey categories varying in frequency from 0.3 (Diptera) to 18.4 (Formicidae). The most common items are Hymenoptera (Formicidae included) (18.7), Isoptera (14.4), and unidentified insect larvae (7.6) (Table 1). The numerical niche width calculated from Simpson's Reciprocal Index is 5.52 and volumetric width is 9.2. Females have more prey categories ($N = 20$), with Formicidae being the most important prey category (17.4). The diet of males consists of 15 taxa, among which Isoptera has the highest index of relative importance (20.4). Females have greater numerical and volumetric niche widths (4.92 and 8.44, respectively) than males (3.53 and 7.47, respectively). The niche overlap between the sexes is 0.6 and the dietary dissimilarity 30% (Figure 2).

Sexual Dimorphism

The smallest female lizard examined has a SVL of 22.21 mm, whereas the smallest male is 26.74 mm long. Mean values, standard deviations, and ranges for each morphological variable are listed in Table 2. Males are significantly larger than females (*t*-test: $t = -2.2119$; $p = 0.02937$) (Figure 3). Body shape (mean of pooled morphological variables HH, TL, HW, and JL) differs significantly between sexes (MANOVA; $F = 3.23$, $p > 0.002$) (Figure 4). Males have six femoral pores (4 preanal and

Table 1. Frequency (*F,* %), number (*N,* %), volume (V, %), and Index of Relative Importance (IRI of each prey category in the diets of male and female *Colobosauroides cearensis* collected in area of Caatinga in Ceará state, Brazil.

Prey category	General				Females				Males			
	F%	*N%*	V%	IRI	*F%*	*N%*	V%	IRI	*F%*	*N%*	V%	IRI
Arachnida												
Acari	1.4	4.2	0.07	1.9	1.6	0.58	0.06	0.76	-	-	-	-
Aranae	3.3	1.4	1.4	2.0	4.0	1.7	1.5	2.4	1.4	0.5	1.8	1.2
Pseudoscorpiones	0.9	0.2	0.1	0.4	-	-	-	-	1.4	0.5	0.06	0.6
Insecta												
Blattodea	13.0	4.2	3.6	6.9	11.3	3.6	3.3	6.1	17.1	7.4	3.4	9.3
Coleoptera	11.4	4.2	3.8	6.5	12.1	3.8	2.1	6.1	12.8	6.9	6.8	8.9
Dermaptera	0.4	0.1	12.7	4.4	1.6	0.3	12.9	4.9	-	-	-	-
Diptera	0.5	0.1	0.2	0.3	0.8	0.1	0.2	0.4	-	-	-	-
Formicidae	28.7	26.0	0.3	18.4	27.6	33.7	0.3	17.2	24.2	31.0	0.3	18.5
Hemiptera	1.4	0.3	6.9	2.9	0.8	0.1	16.8	5.9	2.8	1.0	10.7	4.9
Hymenoptera	3.3	1.0	11.8	5.4	4.0	1.1	17.5	7.6	2.8	1.0	7.6	3.8
Isoptera	16.7	25.0	1.1	14.4	15.4	21.4	1.2	12.7	17.1	41.7	1.3	20.0
Lepidoptera	2.4	1.0	11.4	4.9	1.6	0.3	16.1	6.0	4.2	3.2	8.8	5.4
Orthoptera	0.9	0.2	9.0	3.4	0.8	0.1	-	0.3	1.4	0.5	8.1	3.4
Insect egg	-	-	-	-	0.8	0.1	0.005	0.3	1.4	0.5	-	1.0
Insecta Larvae												
Coleoptera	1.9	0.6	7.7	3.4	1.6	0.3	7.1	3.0	2.8	1.6	7.4	3.9
Lepidoptera	0.9	0.2	5.4	2.2	0.8	0.1	0.07	0.3	1.4	0.5	26.8	9.6
Mecoptera	1.4	5.1	0.1	2.2	2.4	7.7	0.1	3.4	-	-	-	-
Undetermined	1.9	20.0	1.0	7.6	2.4	30.1	0.7	2.4	1.4	0.5	4.3	2.1
Crustacea												
Isopoda	0.9	0.5	17.4	6.3	1.6	0.7	17.6	6.6	-	-	-	-
Undetermined Arthropoda	4.8	1.3	4.9	3.6	4.0	0.9	1.8	2.3	5.7	2.1	12.5	6.8
Mollusca												
Gastropoda	2.3	1.2	0.3	1.3	4.0	1.9	0.8	2.2	-	-	-	-

2 femoral) on each side; these are absent in juveniles and females. Within a population, the number of cloacal scales varies between four (19 females and 15 males) or five (41 females and 24 males).

Microhabitat Use and Thermal Ecology

We observed a total of 95 *Colobosauroides cearensis* exclusively in leaf litter inside caducifolious and subcaducifolious forests, with a spatial niche breadth of 1, thus indicating habitat specialization. No lizards were found in adjacent open areas with direct incidence of sunlight. The mean body temperature of the 95 specimens (54 females, 31 males and 10 juveniles) was 30.4 ± 3.3°C (38.8–25.9°C). The mean substrate temperature was 28.1 ± 3.8°C (39.7–21°C); the air temperature was 28.1 ± 4.25°C (37.7–21°C) and the air humidity was 66.4 ± 8.5% (82–30.4%). Body temperature is positively correlated only with air temperature ($R^2 = 0.1$; $p < 0.008$). There is no correlation between body temperature and substrate temperature ($p > 0.1$). Body temperature was significantly higher in the dry season (31 ±

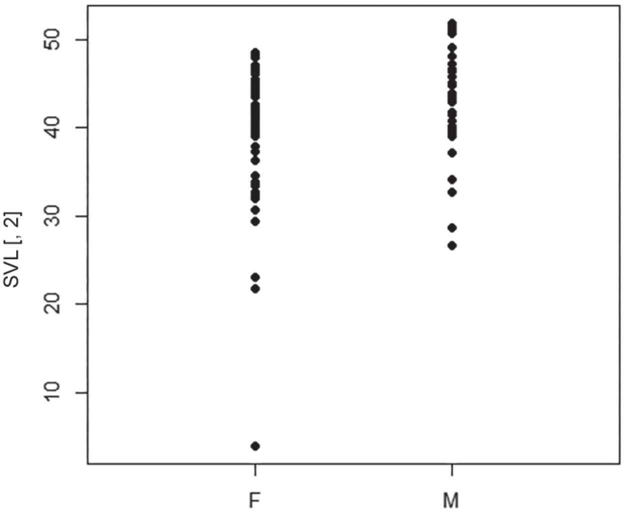

Figure 3. Result of *t*-test showing the variation in SVL between females (F) and males (M) of *Colobosauroides cearensis.*

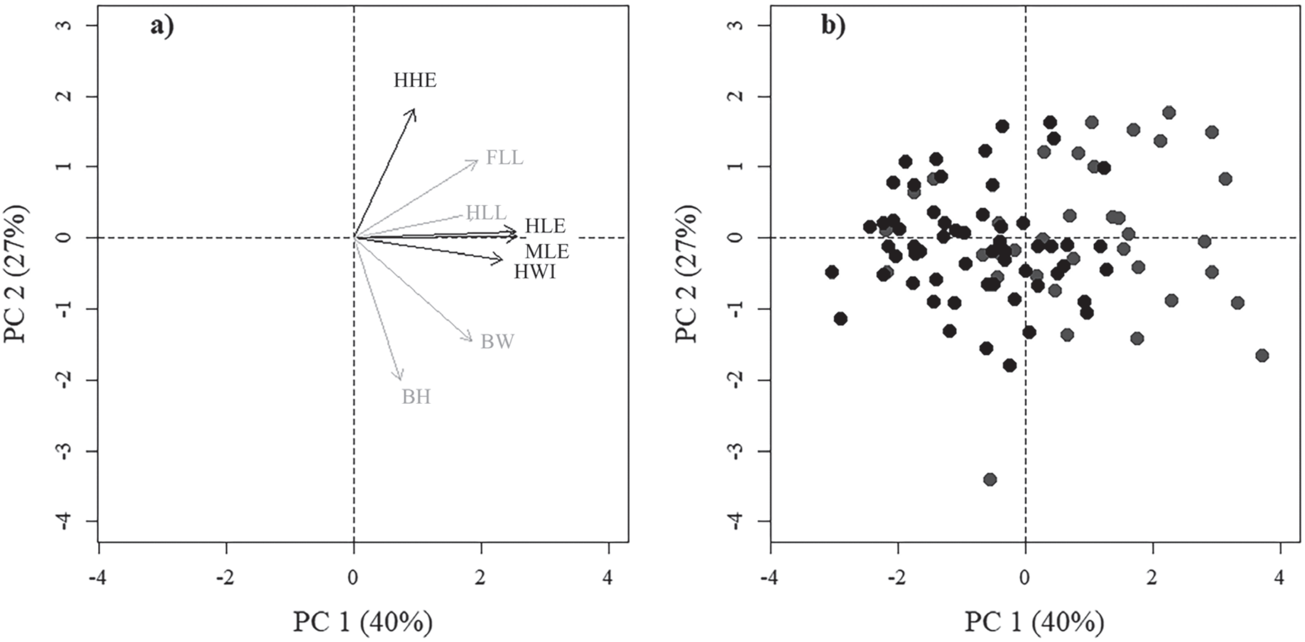

Figure 4. Results of PCA explained for two discriminant factors derived from morphometric variables for female and male *Colobosauroides cearensis.* (**A**) Black arrows indicate morphological characters accounting for sexual dimorphism. Head height (HHE), Head length (HLE), Head width (HWI), Mouth length (MLE), Body width (BW), Body height (BH), Forelimb length (FLL), Hindlimb length (HLL). (**B**) Females (black circles) and males (gray circles).

Table 2. Measurements of morphometric variables of *Colobosauroides cearensis*. Values (in mm) represent mean ± standard deviation (range).

Variable	Females	Males
Snout–vent length	39.9 ± 7.4 (23.01–48.47)	42.83 ± 5.5 (22.21–51.42)
Body width	6.13 ± 0.9 (3.59–8.12)	6.44 ± 1.0 (3.84–8.36)
Body height	4.12 ± 0.9 (2.04–6.23)	4.57 ± 1.4 (1.84–9.96)
Head width	5.21 ± 0.8 (3.73–7.75)	5.95 ± 0.9 (3.5–7.75)
Head height	3.19 ± 0.7 (1.93–6.60)	3.98 ± 1.5 (2.21–12.83)
Head length	7.49 ± 0.9 (5.09–9.31)	8.44 ± 1.2 (5.50–10.59)
Mouth length	5.38 ± 0.6 (3.34–7.32)	6.22 ± 1.2 (3.52–8.33)
Forelimb length	6.8 ± 0.8 (4.72–9.2)	7.43 ± 1.1 (5.26–9.98)
Hindlimb length	11.5 ± 1.3 (7.39–14.86)	12.27 ± 1.3 (7.57–14.65)

2.29°C) than in the rainy season ($T = -2.5003$; $p = 0.01$). There were no intersexual differences in body temperature ($T = 1.1$; $p = 0.2$) (Figure 5).

Reproduction

The SVL of the smallest reproductive female is 30.6 mm, whereas that of the smallest reproductive male is 32.8 mm. Females have a fixed clutch of two eggs ($N = 8$) being found in late December (beginning of rainy season). The mean egg volume is 96.13 mm^3, and there is no relationship between mean egg volume and female SVL ($p = 0.08$) (Figure 6). Six females have eggs and vitellogenic follicles, thereby indicating that they produce more than one clutch during the reproductive season. Testicular volumes (6.1 ± 1.5 mm^3) are positively correlated with male SVLs ($Rho = 0.4$, $p < 0.001$; Figure 7), but there is no relationship between male reproductive activity and the season. The presence of juveniles between late December and May suggests that recruitment may occur early in the rainy season.

Discussion

Diet

Like other gymnophthalmids, *Colobosauroides cearensis* feeds on a variety of small arthropods (Doan 2008, Oliveira and Pessanha 2013, Garda *et al.* 2014, Oliveira *et al.* 2018); however, there are interspecific differences of the relative importance of prey consumed. Thus, *Leposoma scincoides* Spix, 1825 consumes primarily Aranae and Isopoda, whereas *Micrablepharus maximiliani* (Reinhardt and Lütken, 1862) prefers Orthoptera and Blattaria (Teixeira and Fonseca 2003, Dal Vechio *et al.* 2014). These dietary differences between species may reflect prey availability (Teixeira and Fonseca 2003, Mesquita *et al.* 2006).

Colobosauroides cearensis feeds on both sedentary and active prey, as do other species of the Ecpleopodini tribe (Teixeira and Fonseca 2003, Maia *et al.* 2011, Oliveira *et al.* 2018). However, the higher rate of ant consumption in *C. cearensis* is unexpected, because the frequency of Formicidae usually is low in gymnophthalmids, indicating that ants are a relatively unimportant part of their diets (Mesquita *et al.* 2006, Doan 2008, Anaya-Rojas *et al.* 2010, Maia *et al.* 2011, Santos *et al.* 2012, Oliveira and Pessanha 2013, Dal Vechio *et al.* 2014, Oliveira *et al.* 2018). Ants are avoided by most lizards, owing to the harder exoskeletons and wide range of defense mechanisms of ants (Abensperg-Traun and Csiro 1997). Sit-and-wait lizards usually eat the most ants (Colli *et al.* 1997). In Scleroglossa, the reduced consumption of ants may be associated with the presence of the toxic compounds they produce (Vitt *et al.* 2003, Japiassu *et al.* 2007). Two other gymnophthalmids, *Anotosaura vanzolinia* Dixon, 1974 and *Dryadosaura nordestina* Rodrigues, Xavier-Freire, Machado Pellegrino, and Sites, 2005 (Oliveira and Pessanha 2013, Garda *et al.* 2014) also consume ants at high rates, similar data were observed in. This dietary pattern may have a phylogenetic signal (Mesquita *et al.* 2016) because all three species belong to the subfamily Ecpelopodinae (Castoe *et al.* 2004). Thus, further investigation is merited to infer the phylogenetic significance of this foraging pattern of these species and that of other closely related taxa.

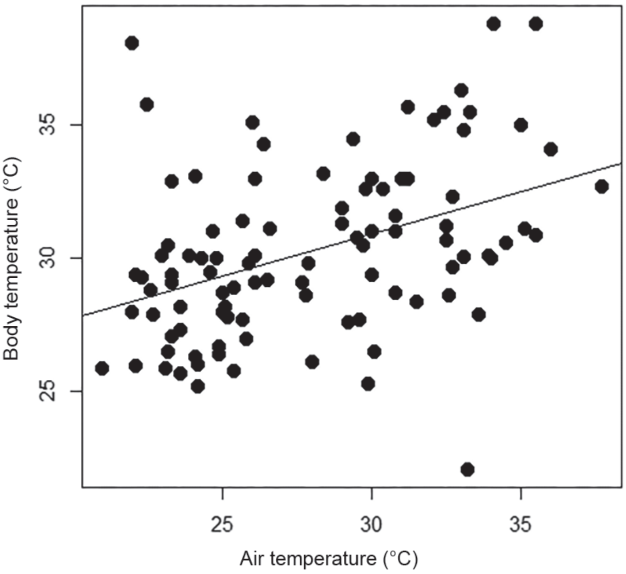

Figure 5. Correlation between the body temperature and air temperature in *Colobosauroides cearensis.*

Isoptera, of which there is a high density and abundance in the Caatinga, is the second most important item in the diet of *Colobosauroides cearensis;* the prevalence of isopterans is related

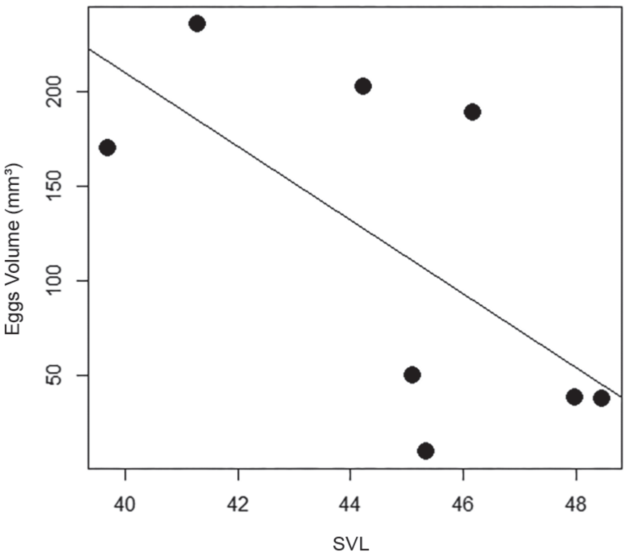

Figure 6. Relation between egg volume and female body size (SVL) of *Colobosauroides cearensis.*

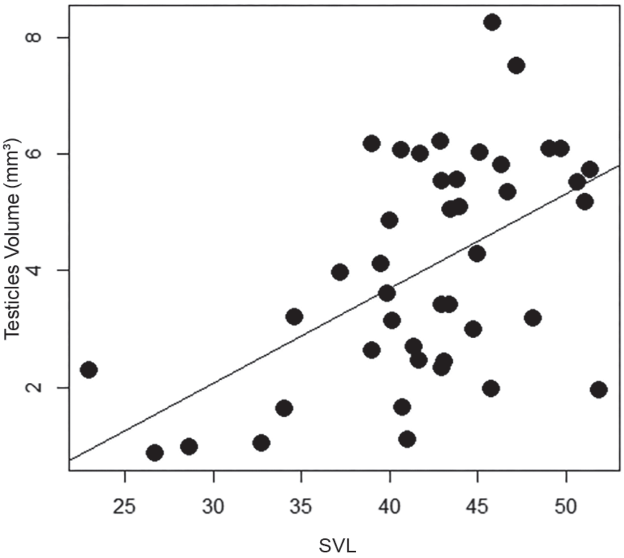

Figure 7. Relationship between testicular volume and male body size (SVL) of *Colobosauroides cearensis.*

to the Caatinga's geomorphological characteristics that favor the structure of termite nests (Araújo *et al.* 2010). The presence of insect larvae in the diet is a common feature of *C. cearensis,* as well as other gymnophthalmids (Teixeira and Fonseca 2003, Rodrigues and Ávila-Pires 2005, Santos *et al.* 2012, Oliveira and Pessanha 2013). Active foragers usually consume sedentary prey in contrast to sit-and-wait foragers that primarily consume active prey (Colli *et al.* 1997).

The dietary niche breadth of *Colobosauroides cearensis* is similar to that of other gymnophthalmids that inhabit open vegetation biomes, such as *Micrablepharus maximiliani* and *Colobosaura modesta* (Reinhardt and Lütken, 1862) in Cerrado, which have niche breadth values of 5.0 and 4.0, respectively (Mesquita *et al.* 2006, Dal Vechio *et al.* 2014), and *Anotosaura vanzolinia* in Caatinga with 5.26 (Oliveira *et al.* 2018). The dietary niche breadth of female *C. cearensis* is greater than that of males; this difference may reflect the energy that females require during egg production and maintenance (Shine 1980, Shine and Schwarzkopf 1992).

Sexual Dimorphism

Sexual size dimorphism is typical of Gymnophthalmidae, with females being larger than males (Fitch 1981, Balestrin *et al.* 2010, Garda *et al.* 2014, Dal Vechio *et al.* 2014, Ramiro *et al.* 2017). In *C. cearensi,* however, males are larger than females, corroborating the results of Ramos-Pallares *et al.* (2010) for *Ptychoglossus bicolor* (Werner, 1916). This may be because at sexual maturity, the growth rate diminishes in both sexes owing to energy invested in reproduction (Fitch 1981). In some lizards, the growth rate of females decreases as the lizard invests energy in the production of gametes, whereas males invest little energy in reproduction and continue to grow (Smith and Ballinger 1994, Van Sluys 1998).

Sexual differences in head dimensions suggest that like *Anotosaura vanzolinia* and *Dryadosaura nordestina, Colobosauroides cearensis* is territorial (Vitt *et al.* 2003, Oliveira and Pessanha 2013, Garda *et al.* 2014). Anderson and Vitt (1990) reported that individuals with larger heads are more efficient during agonistic interactions in territorial defense. In contrast, in *Calyptommatus leiolepis* Rodrigues, 1991, *Nothobachia ablephara* Rodrigues, 1984, and *Procellosaurinus tetradactylus* Rodrigues, 1991 closely related taxa to *C. cearensis,* there is no sexual dimorphism in head sizes and proportions (Ramiro *et al.* 2017).

Preanal and femoral pores in lizards produce reproductive chemical secretions (Peloso and Ávila-Pires 2010, Ramiro *et al.* 2017). Previously reported for *Colobosauroides cearensis,* the absence of pores in females was considered a sexually dimorphic trait (Cunha *et al.* 1991). Although pores usually are associated with males (Balestrin *et al.* 2010, Peloso and Avila-Pires 2010, Dal Vechio *et al.* 2014, Ramiro *et al.* 2017), in some species, they are also present in females (Rodrigues 1996, Diehl 2007, Peloso and Ávila-Pires 2010).

Interpopulational variation in cloacal scales has been documented for other populations of *C. cearensis* in the state of Ceará (Cunha *et al.* 1991). The presence of a triangular fifth cloacal plate in males was thought to be sexually dimorphic (Cunha *et al.* 1991). However, our data do not support this supposition; therefore, this feature varies variation should be considered only as interpopulational differences.

Microhabitat Use and Thermal Ecology

Colobosauroides cearensis inhabits shaded microhabitats in the Caatinga and prefers microenvironments with leaf litter and minimal direct exposure to sunlight (Borges-Nojosa and Caramaschi 2003, Rodrigues 2003, Silva-Neta *et al.* 2019). The lizard has a high fidelity to leaf litter (Vitt *et al.* 2003) in the same way that *Anotosaura vanzolinia* is nearly exclusive in its fidelity (77%) to underground retreats (Oliveira and Pessanha 2013, Oliveira *et al.* 2018). Species such as *C. cearensis* that has restricted microhabitat preferences potentially risk serious impacts on their populations if disturbances in the vegetation result in a decrease in leaf litter thereby restricting the available microhabitat. Habitat disturbance also can increase solar incidence causing changes in microhabitat temperature (Vitt and Ávila-Pires 1998), which is considered the most influential environmental variable determining the occurrence of gymnophthalmids (Winck and Rocha 2012).

Body temperatures of *Colobosauroides cearensis* are higher than those of other gymnophthalmids, such as the Amazonian species *Potamites* (= *Neusticurus*) *ecpleopus* (Cope, 1875) (*Tb* = 27.6°C), *P.* (= *Neusticurus*) *juruazensis* (Ávila-Pires and Vitt, 1998) (*Tb* = 26.4°C) and *Ptychoglossus bicolor* (*Tb* = 23.9°C) (Vitt and Ávila-Pires 1998, Anaya-Rojas *et al.* 2010). The body temperatures of 17 Amazonian gymnophthalmids, ranged from 23–33°C (Diele-Viegas *et al.* 2018); the latter authors attributed the higher body temperatures of *C. cearensis* to local environmental conditions, observing that open-habitat species tend to operate with higher temperatures. Despite their phylogenetic affinities of these taxa, body temperatures can vary depending on the environments and microclimates utilized by the species (Kohlsdorf and Navas 2006). Other factors, such as foraging behavior, are also related to active body temperature; thus, Scleroglossa (active foragers) usually have a higher average body temperature than does Iguania (Bergallo and Rocha 1994, Magnusson and Silva 1993).

The body temperature of *C. cearensis* is correlated with air temperature, as it is in other highly active lizards (Rocha and Bergalo 1990, Bergalo and Rocha 1993). Few heliothermic organisms maintain a slightly higher body temperature than that of the environment (Vitt and Ávila-Pires 1998, Anaya-Rojas *et al.* 2010). Furthermore, small-bodied lizards such as gymnophthalmids have high rates of water loss in relation to their small size; thus, they have a greater capacity for heat absorption (Steinberg *et al.* 2007).

The similarity of male and female body temperatures in *C. cearensis* indicates an absence of differential resource use. Thus, specimens sharing the same microenvironment have similar body temperature when active (Vitt and Ávila-Pires 1988). The seasonal variation found in cloacal temperatures can be influenced by habitat type (Sousa and Freire 2011). Because temperatures in the Caatinga Domain are lower during the rainy season, it is expected that body temperatures change seasonally (Leal *et al.* 2003).

Thermoregulation in Gymnophthalmidae varies according to microhabitat and environment with which the lizard is associated (Vitt and Ávila-Pires 1998, Diele-Viegas *et al.* 2018). In spite of inhabiting a region composed predominantly by Caatinga vegetation, *C. cearensis* occurs in shaded areas. Typically, forest lizards use small gaps among the leaves to expose their bodies to solar radiation for heat gain (Vitt and Ávila-Pires 1998, Vitt *et al.* 2003, Anaya-Rojas *et al.* 2010). However, none of the lizards we collected was observed to be exposed directly to the sun or even in small patches of light, evidencing a certain degree of thermo-conforming (Hertz 1992, Bujes and Verrastro 2008, Ribeiro *et al.* 2008).

Reproduction

Commonly in lizards the size of the clutch is proportional to female body size (Winck and Rocha 2012). However, female body size in *C. cearensis* has no relationship to cluthch size, as also reported for *Dryadosaura nordestina, Calyptommatus leiolepis, Nothobachia ablephara* and *Procellosaurinus tetradacytlus* in Atlantic Forest and Caatinga in Northeastern Brazil (Garda *et al.* 2014, Ramiro *et al.* 2017). However, these results may be an evolutionary indication that the species achieved a balance between egg size and size of hatchlings, retaining its body dimensions (Adamopoulou and Valakos 2000).

Fixed clutchs of two eggs, along with presence of eggs and secondary follicles, are typical of Gymnophthalmidae (Teixeira and Fonseca 2003, Balestrin *et al.* 2010, Dal Vechio *et al.* 2014, Garda *et al.* 2014, Ramiro *et al.* 2017). To minimize the demographic effect caused by small clutches, species develop different strategies to optimize breeding patterns; multiple spawning throughout the year may favor stable population size (Teixeira and Fonseca 2003, Balestrin *et al.* 2010, Dal Vechio *et al.* 2014, Garda *et al.* 2014, Ramiro *et al.* 2017).

Unpredictability of the rainfall in the Caatinga (Reis 1976, Chiang and Koutavas 2004) may be correlated with continuous reproduction. If reproduction is concentrated in a single period, which at some point, may not provide favorable conditions for the performance of physiological activities, the existence of these organisms may be compromised (Garda *et al.* 2012).

Like other gymnophthalmids, reproduction of *C. cearensis* coincides with the beginning of the rainy season (Balestrin *et al.* 2010, Dal Vechio *et al.* 2014, Ramiro *et al.* 2017). According to Mesquita *et al.* (2006) this timing assures a greater availability of resources that would favor the development of the hatchlings. Decrease in mean temperature during rainy season in the Caatinga also may also be related to this reproductive pattern (Leal *et al.* 2003). According to Wiederhecker (1999), some lizards begin their reproductive cycles in times with lower temperatures and higher humidity, reducing the losses caused by desiccation; this seems to be true for *C. cearensis,* given the dependence of this species on a constant air temperature.

The minimum size of the sexually mature male of *Colobosauroides cearensis* (32.8 mm SVL) is consistent with those of *Cercosaura schreibersii* Wiegmann, 1834 (25.9 mm SVL), *Vanzosaura multiscutata* (Amaral, 1933) (25.4 mm), *V. rubricauda* (Boulenger, 1902) (25.8 mm SVL), and *Dryadosaura nordestina* (31.2 mm SVL) (Balestrin *et al.* 2010, Garda *et al.* 2014). These species may have may mature sexually in the first months of life. In contrast, the lizards *Calyptommatus leiolepis* (45.0 mm SVL), *Nothobachia ablephara* (37.3 mm SVL), and *Pholidobolus montium* (Peters, 1863) (37.0 mm SVL) mature later than *C. cearensis* (Goldberg 2009, Ramiro *et al.* 2017). According to Tinkle *et al.* (1970), species that mature early have lower life expectancies; thus, that premature maturation allows multiple mating favoring the chances of producing offspring. In males, no clear pattern was observed regarding reproductive period and rainfall, suggesting that they are sexually active throughout the year (Ramos-Palhares *et al.* 2010). However, further histological studies of the testes should be performed to clarify this pattern.

The present study provides relevant ecological information about *Colobosauroides cearensis,* for which little was known about many aspects of the autecology, including habitat, diet, and distribution. These results will further the understanding not only of *C. cearensis,* but also the ecological patterns Gymnophthalmidae.

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