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Ecology and parasitism of the lizard *Tropidurus jaguaribanus* (Squamata: Tropiduridae) from northeastern Brazil

Edna P. Alcantara,¹ Cristiana Ferreira-Silva,¹ José Guilherme G. Sousa,² Robson W. Ávila,³ and Drausio H. Morais⁴

¹ Programa de Pós-Graduação em Ciências Biológicas (Zoologia), Universidade Estadual Paulista Julio de Mesquita Filho (UNESP), Campus de Botucatu, Instituto de Biociências, Departamento de Parasitologia. Av. Bento Lopes s/n, Distrito de Rubião Junior, 18080-970, Botucatu, São Paulo, Brazil. E-mail: ednnapaulino@gmail.com.

² Programa de Pós-Graduação em Ecologia e Recursos Naturais, Universidade Federal do Ceará (UFC), Campus Universitário do Pici, Departamento de Ciências Biológicas. Av. da Universidade 2853, Benfica, 60021970, Fortaleza, Ceará, Brazil.

³ Universidade Regional do Cariri (URCA), Departamento de Química Biológica, Laboratório de Herpetologia. Rua Cel. Antônio Luiz 1161, 63100-000, Crato, Ceará, Brazil.

⁴ Universidade Federal Rural da Amazônia (UFRA). Rodovia PA-275, km 13, Zona Rural, 68515-000, Parauapebas, Pará, Brazil.

Abstract

Ecology and parasitism of the lizard *Tropidurus jaguaribanus* (Squamata: Tropiduridae) from northeastern Brazil. Specimens of *Tropidurus jaguaribanus* were collected as part of a study of their use of microhabitats, activity period, body temperature, diet, foraging, sexual dimorphism (in size and in form), reproductive biology, and parasite community composition. The preferential microhabitat of the species is the surface of rocks (saxicolous habit). The species has a bimodal diurnal activity period and a seasonal reproductive cycle. The diet is composed mainly of beetles and ants in adults and juveniles. The species is a sit-and-wait forager; the lizards scarcely move and feed on sedentary, immobile prey. The helminth community associated with these lizards is composed of five species: *Oochoristica travassosi*, *Parapharyngodon alvarengai*, *Physaloptera* sp., *Spauligodon* sp., and *Strongyluris oscari*. The prevalence, intensity of infection, and parasite abundance is the same in both sexes.

Keywords: diet, foraging, habitat, parasites, reproduction.

Resumo

Ecologia e parasitismo do lagarto *Tropidurus jaguaribanus* (Squamata: Tropiduridae) do nordeste do Brasil. Espécimes de *Tropidurus jaguaribanus* foram coletados como parte de um estudo de uso de micro-habitats, período de atividade, temperatura corporal, dieta, forrageamento,

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dimorfismo sexual (tamanho e forma), biologia reprodutiva e composição da comunidade parasitária. O micro-habitat preferencial da espécie é a superfície das rochas (hábito saxícola). A espécie possui um período de atividade diurna bimodal e um ciclo reprodutivo sazonal. A dieta é composta principalmente por besouros e formigas em adultos e juvenis. A espécie é um forrageador senta-e-espera; os lagartos movem-se pouco e alimentam-se de presas sedentárias e imóveis. A comunidade de helmintos associada a esses lagartos é composta por cinco espécies: *Oochoristica travassosi*, *Parapharyngodon alvarengai*, *Physaloptera* sp., *Spauligodon* sp. e *Strongyluris oscari*. A prevalência, a intensidade da infecção e a abundância de parasitas são as mesmas em ambos os sexos.

Palavras-chave: dieta, forrageamento, habitat, parasitas, reprodução.

Introduction

To understand the ecological role of each species in its habitat, we must conduct natural-history studies of spatial and trophic niches, as well as reproductive strategies (Pianka 1973). It is important to determine niche width and niche overlap to quantify the way in which species overlap in their use of available resources and to document the effects of competition (Pianka 1973, Vitt 1995, Albertoni *et al.* 2003). Ecological information is essential to the development of conservation strategies for species, in addition to contributing to an understanding the resource set that allows a species to occur in a particular area (Vitt 2013).

The pattern of parasite infection, especially by helminths, is strongly associated with foraging patterns and use of available resources (food and space) by lizards (Anderson 2000, Ávila and Silva 2010, Sharpilo *et al.* 2001, Brito *et al.* 2014, Galdino *et al.* 2014). Helminths are discrete components of the ecosystem and they can have a negative effect on the physical condition of their hosts (Thomas *et al.* 2010) by causing alterations in metabolic functioning (Dare and Forbes 2008), sexual selection (Kose and Møller 1999), interspecific competition (Lafferty 1999), and growth (Kelehear *et al.* 2011). Moreover, parasites of lizards can impair reproductive capacity by reducing female energetic stocks that otherwise would be used for egg production, thereby decreasing

reproductive performance (Warne *et al.* 2012).

Tropidurus jaguaribanus Passos, Lima, and Borges-Nojosa, 2011 is a diurnal member of the *T. semitaeniatus* Group, which comprises four species: *T. semitaeniatus* (Spix, 1825), *T. pinima* (Rodrigues, 1984), *T. helenae* (Manzani and Abe, 1990), and *T. jaguaribanus*. Species of this group are saxicolous, inhabiting rocky outcrops, occur exclusively in the Brazilian Caatinga, show cryptic coloration, and have dorsoventral body flattening (Passos *et al.* 2011). This flattening allows them to efficiently exploit crevices in rocks, where they adroitly find refuge from predators (Vanzolini *et al.* 1980, Frost *et al.* 2001). Despite the abundance of *T. jaguaribanus* in areas with rocky outcrops (Passos *et al.* 2011), ecological studies of the species are scarce (Passos *et al.* 2013). Thus, an assessment of the conservation status of *T. jaguaribanus* is difficult.

Several aspects of the ecology of species in the *Tropidurus semitaeniatus* Group have been studied (e.g., Kolodiuk *et al.* 2010, Caldas *et al.* 2015, Pelegrin *et al.* 2017, Xavier and Dias 2017, Maia-Carneiro *et al.* 2018). Several aspects of members of the group are phylogenetically conserved, such as specializations to live on rocks and in rock crevices, sexual dimorphism, sit-and-wait foraging, and clutch sizes of 1 or 2 eggs (with no correlation between clutch and body size). Our goal was to determine whether there are sexual and ontogenetic differences in the use of food resources, body temperatures,

and parasitism in *T. jaguaribanus*. Complete data are provided on reproduction, diet, microhabitat use, activity period, thermal ecology, foraging, and parasitism for a population of *T. jaguaribanus* from a semiarid area in the Estação Ecológica de Aiuaba, state of Ceará, northeastern Brazil.

Materials and Methods

Study Site

We conducted the present study in the Estação Ecológica de Aiuaba, state of Ceará, northeastern Brazil (06°49'03" S, 40°44'31" W, datum WGS), with an area of 11,525 ha of arboreal Caatinga (Medeiros 2004). Fieldwork comprised seven expeditions of five days each in the following months (rainfall in parentheses): 2014—April (41.4 mm³), July (1.1 mm³), September (14.3 mm³), and November (3.7 mm³); and 2015—January (22.2 mm³), February (84.2 mm³), and May (33.1 mm³) (FUNCEME 2016).

Lizards were captured either by hand or with the aid of a slingshot. The time of capture and the microhabitat in which the lizard was found were recorded for each individual. In addition, the lizards were noted to be active or inactive.

The lizards were euthanized with lethal dosages of sodium thiopental and weighed with Pesola® (to the nearest 0.1 g) scales, after which the following measurements were made with Mitutoyo® digital calipers (to the nearest 0.01 mm): snout–vent length (SVL, tip of snout–cloaca), tail length (TL, cloaca–tip of tail), body width (BW, widest part of body), body height (BH, highest part of body), head width (HW, widest part of head), head height (HH, highest part of head), and head length (HL, tip of rostral–anterior margin of ear opening). The lizards were fixed in 10% formaldehyde, preserved in 70% ethanol, and deposited in the herpetological collection of the Universidade Regional do Cariri (URCA-H 7302–7353, 10404–12457).

Microhabitat, Activity Period, and Temperature

We calculated the inverse of Simpson's Index (1949) of diversity (B) to measure the niche breadths of the microhabitat categories: $B = 1/\sum_{i=1}^n P_i^2$, 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 of only one microhabitat category) to n (equal use of every microhabitat category).

Pianka's Index (1973) was used to evaluate niche overlap between males and females calculated in the program Ecosim 7 (Gotelli 2001, Gotelli and Entsminger 2004):

$\phi_{jk} = \sum_{i=1}^n P_{ij} P_{ik} / \sqrt{\sum_{i=1}^n (P_{ij}^2)(P_{ik}^2)}$, where P_{ij} and P_{ik} are the proportions of use of the niche category i , with j and k representing the sexes compared. The overlapping values vary from 0 (no overlapping) to 1 (total overlapping).

To estimate activity period, we walked slowly and randomly in an area adjacent to the site of capture, recording time of activity and microhabitat used by the lizards. We did this on two consecutive days between 06:00 and 18:00 h.

We collected all lizards by day. Immediately after capture, temperatures of cloaca, air, and substrate were measured using a Miller and Weber cloacal thermometer. A multiple regression analysis was used to test whether air or substrate temperature influenced body temperature. The regression analyses were performed using Statistica 10.0 (StatSoft 2011).

Diet Composition

The stomach of each lizard was removed and analyzed under the stereomicroscope. The food items found were identified at the ordinal level, except for Formicidae. The length and width of the intact items were measured using a digital calipers (± 0.01 mm) and the respective volumes measured with the following ellipsoid formula: $V = (4\pi/3)(L/2)(W/2)^2$, where V = volume, L = length, and W = width.

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

The overlapping of diet between the sexes was calculated using Pianka's (1973) overlapping index, as described for microhabitat.

To determine the relative contribution of each prey category, we calculated the relative importance index (IRI) using the formula (Powell *et al.* 1990): $IRI = F\% + N\% + V\%$, where IRI = relative importance index, F = frequency, N = number, and V = volume.

A nonparametric similarity multivariate analyses (ANOSIM) was conducted to determine the existence of sexual and ontogenetic differences in the diet the Bray-Curtis coefficient of similarity. To identify the prey category that contributed the most to the dissimilarity in diet use, we performed an analysis of similarity percentage (SIMPER). Both ANOSIM and SIMPER were performed in PAST 1.26 (Hammer *et al.* 2001).

Foraging

Observers walked slowly through an area, conducting a visual survey for lizards. When a lizard was detected, the observer stopped moving to reduce disturbance of the lizard. If possible, lizards were observed continuously for 10 min; however, frequently they fled before 10 min had elapsed. The minimum observation time was 1.5 min. To guarantee that data were collected only once per sample, we did not repeat observations in an area.

Location, date, foraging behavior, and feeding attempts were recorded, in addition to the movement of the lizard. Foraging activity was determined by measuring the following variables: proportion of time spent moving (PTM), number of movements per minute (MPM) (Cooper *et al.* 1997, 2001, Huey and Pianka 1981, Perry 1995), and proportion of

attacks initiated while moving (PAM) (Cooper *et al.* 2001).

The relationships among MPM, PTM, and PAM were examined using linear regression and Spearman correlation (Zar 1999). The data analyses were performed in the programs Statistica 10.0 (StatSoft 2011) and Sigmastat 3.1 (Systat Software Inc., Richmond, California, USA).

Sexual Dimorphism

Our investigation of sexual dimorphism is based on examination of adult lizards. We performed a multivariate discriminant function analysis to determine whether morphometric variables and body shape varied sexually. To remove the effect of SVL upon other variables, we used the residuals between each variable and SVL. The residuals were obtained from a simple linear regression, following the dimorphism analysis of Sousa and Ávila (2015). Discriminant function analysis was executed using Statistica Version 10.0 (StatSoft 2011).

Reproduction

The sex of each individual was determined by dissection and direct examination of the gonads. Females lizards were judged to be reproductively mature if vitellogenic follicles or oviductal eggs were present. Follicles were considered vitellogenic if they were yellow and larger than 3 mm in diameter (Van Sluys 1993). The size of the litter was estimated by the number of vitellogenic follicles or eggs. The presence of enlarged vitellogenic follicles and either oviductal eggs or corpora lutea was considered evidence of sequential production of more than one clutch of eggs. Male lizards were considered reproductively active if they possessed enlarged testes and convoluted epididymides (Balestrin *et al.* 2010).

The width and length of testicles were measured to estimate their volumes with the ellipsoid formula described in "Diet composition." To determine any correlation

between SVL and testicle volume, we used the nonparametric correlation of Spearman. A parametric correlation was to determine whether SVL was correlated with the size of the eggs. Different tests were conducted because one data set was normally distributed, whereas the other was not. Both analyses were executed in Statistica 10.0 (StatSoft 2011).

Parasitism

The abdominal cavity, as well as the gastrointestinal, respiratory and urinary tracts, were examined for parasites. Helminths were removed and counted, cleaned, and then fixed in alcohol (70%). They were subsequently processed following classical methods (Amato *et al.* 1991).

For species identification, cestodes were stained with hydrochloric carmine and cleared with creosote. Nematodes were cleared in lactophenol (Andrade 2000). After identification, the helminths were listed in the parasitological collection of the Universidade Regional do Cariri.

The overall prevalence, mean intensity of infection, and mean abundance of parasites were calculated following the procedure of Bush *et al.* (1997). The proportions test was used (test Z) to determine whether the prevalence of parasites varied significantly between males and females and between adults and juveniles. The Mann-Whitney (test U) was used to compare the intensities of infection between the sexes, and between adults and juveniles (Zar 1999). The normality of the data was tested for each sex using the Kolmogorov Smirnov test. The Spearman coefficient of correlation (r_s) was used to evaluate the correlation between lizard SVL and parasite richness, as well as SVL and intensity of infection.

The discrepancy index (D) was calculated to characterize the distribution pattern of parasites in the host population, where $D = 1$ represents maximum aggregate and $D = 0$ represents a

uniform distribution (Poulin 1993). The analysis was executed using Quantitative Parasitology 3.0 (Rózsa *et al.* 2000) and Sigmastat 3.1 (Systat Software Inc., Richmond, California, USA).

Results

Microhabitat, Activity Period, and Temperature

Tropidurus jaguaribanus was encountered mainly in rocky habitats in the arboreal Caatinga area. Forty-eight individuals were observed on rocky outcrops (44.86%), whereas the remaining individuals were on the open ground (39.24%), or in termite nests (6.54%) and leaf-litter (9.34%).

Niche overlap between the sexes is 0.94, and 0.90 between adults and juveniles. Niche breadth is 3.51 for females, 3.13 for males, 3.54 for adults, and 2.77 for juveniles.

Tropidurus jaguaribanus has a bimodal activity period. It is active from 07:00–17:49 h, with peak between 09:00 h and 09:59 h. Its second activity period occurs from 14:00–14:59 h (Figure 1).

The average body temperature is $30.5 \pm 2.5^\circ\text{C}$, average substrate temperature is $29.3 \pm 2.3^\circ\text{C}$, and average air temperatures is $28.7 \pm 2.5^\circ\text{C}$. Results of a multiple regression analysis indicates that substrate and air temperatures influence body temperature ($r^2 = 0.55$; $p < 0.0001$) (Figure 2). If these two abiotic variables are examined individually, air temperature significantly affects body temperature ($b = 0.44$; $p = 0.0465$), but substrate temperature does not ($b = 0.336$; $p = 0.123$).

Diet Composition

Of 107 lizards collected, 91 had alimentary content in their gastrointestinal tracts. The diet of *Tropidurus jaguaribanus* is composed of 16 prey item categories (Table 1). The most frequent prey category is Coleoptera, was present in 25% ($N = 56$) of the stomachs and corresponds to 27.1% ($N = 118$) of the total number of prey (N

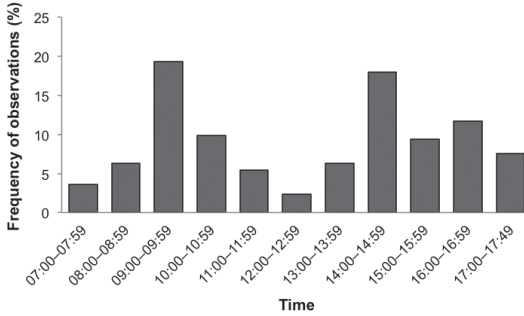


Figure 1. Relative frequency of hours of activity *Tropidurus jaguaribanus* ($N = 383$) at ESEC Aiuaba, Ceará state, northeastern Brazil.

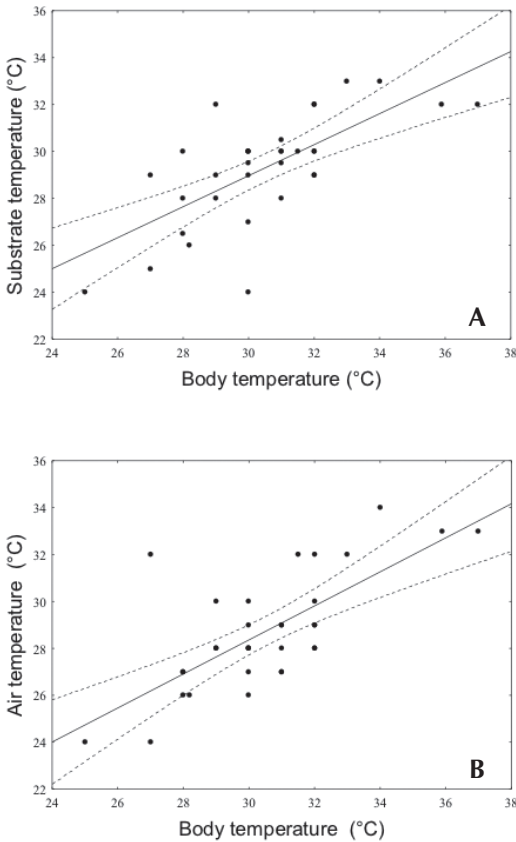


Figure 2. Bivariate correlations scatterplots between the body temperature with substrate (A) and air temperature (B).

= 435). The second most frequent item was Formicidae (23.6%) ($N = 56$), which also was ingested in the largest numbers and represents 32.4% ($N = 141$) of the total number of prey ingested. The relative importance index for prey showed that the most important item is Coleoptera, followed by Formicidae, Hymenoptera, and Lepidoptera (Table 1).

Food niche breadth of *T. jaguaribanus* is 4.82 by number and 5.59 by volume. Food niche overlap is 0.95 between males and females and 0.93 between adults and juveniles.

There is no significant difference in diet between males and females (ANOSIM, $r = 0.2222$; $p = 0.3017$) or between juveniles and adults (ANOSIM, $r = 0.3333$; $p = 0.1034$). The diets of males and females are similar (SIMPER, 33.31%), as is the diet of juveniles and adults (SIMPER, 29.77%). The prey categories that contribute the most to sexual variation in are Formicidae (19.57%), Orthoptera (17.84%), and Coleoptera (11.79%). For adults and juveniles, the prey categories that contributed the most to variation are Orthoptera (18.11%), Ecdise (16.92%), and Polydesmida (14.61%).

Foraging

Tropidurus jaguaribanus has low PTM and PAM, which is characteristic of sit-and-wait foraging (Table 2). The PTM value (0.03) indicates that *T. jaguaribanus* spends most of the time still, waiting for prey. When facing a potential prey item, *T. jaguaribanus* moves toward it, but always returns to the starting point. The type of feeding attempt observed is ambush, which resulted in more successful than failed attempts (Table 2).

The number of movements per minute (MPM) is significantly correlated to PTM ($F = 10.19$; $df = 29$; $p < 0.005$). Additionally, the proportion of attacks initiated by lizards while moving (PAM) is strongly and significantly related to MPM ($F = 4.46$; $df = 29$; $p = 0.004$), and PTM ($F = 5.14$; $df = 29$; $p = 0.03$).

Table 1. Frequency (F%), number (N%), volume (V%) and Index of Relative Importance (IRI) of each prey category in the diets of male, female, and juvenile *Tropidurus jaguaribanus* at ESFC, Atiaba, Ceará state, Brazil.

Category	General				Females				Males				Juveniles			
	F%	N%	V%	IRI	F%	N%	V%	IRI	F%	N%	V%	IRI	F%	N%	V%	IRI
INVERTEBRATES																
Araneae	0.89	0.46	1.29	0.68	-	-	-	-	1.69	0.84	3.39	1.97	1.39	0.63	0.64	0.88
Blattodea	3.12	3.91	4.90	3.29	3.09	2.47	5.27	3.61	-	-	-	-	5.56	7.61	2.29	5.15
Coleoptera	25.00	27.13	24.21	25.91	23.71	26.54	17.40	22.52	23.73	22.03	13.88	19.90	26.41	31.01	38.34	31.92
Diptera	1.34	0.92	2.70	1.73	2.06	1.23	3.11	2.13	-	-	-	-	1.39	1.27	0.07	0.91
Formicidae	23.54	32.41	17.30	24.34	20.62	25.93	14.24	20.31	25.42	41.53	19.12	28.71	25.00	31.65	27.77	28.1
Gastropoda	0.87	0.69	0.76	0.77	2.00	1.82	3.53	2.57	-	-	-	-	-	-	-	-
Hymenoptera	11.16	11.26	21.31	14.56	11.34	10.49	23.73	15.21	11.86	14.41	28.73	18.32	9.72	9.49	4.01	7.71
Isoptera	1.34	0.69	0.15	0.72	-	-	-	-	3.39	1.70	0.40	1.83	1.39	0.63	0.04	0.69
Lepidoptera	8.93	7.82	16.09	10.9	11.34	10.49	18.00	13.32	6.78	5.08	12.63	8.16	6.94	6.96	3.92	5.92
Polysmida	4.76	4.36	1.13	3.43	8.25	9.26	4.08	7.22	1.69	0.85	0.32	0.95	2.78	2.00	0.18	1.65
Not identified	1.73	0.92	0.69	1.11	1.03	0.62	1.06	0.90	-	-	-	-	4.17	2.00	1.56	2.61
Odonata	1.34	0.69	1.76	1.26	1.03	0.62	0.15	0.60	1.69	0.85	4.00	2.18	1.39	0.63	8.97	3.66
Orthoptera	13.84	7.82	28.56	16.77	14.43	9.88	20.00	14.81	13.56	7.63	40.27	20.48	12.50	5.70	43.82	20.7
VERTEBRATES																
Eclise	0.89	0.46	1.07	0.81	1.03	0.62	1.39	1.21	-	-	-	-	1.39	0.63	1.14	1.05
Lizards	0.89	0.46	0.33	0.56	-	-	-	-	3.39	1.70	2.06	2.38	-	-	-	-
PLANT MATERIAL																
Small leaves	3.03	1.58	-	-	3.00	1.81	-	-	6.77	3.38	-	-	-	-	-	-

Sexual Dimorphism

The smallest female individual examined is 48.4 mm SVL, whereas the smallest male is 53.0 mm SVL. The largest individual is a male of 93.85 mm SVL. The largest female is 89.2 mm SVL.

All adult males examined have dark spots on the ventral region (pre-vent flap and thigh), whereas no female has this secondary sex character. The bodies of males are significantly larger than those of females and individuals variables showed that males are significantly higher than females in SVL ($p = 0.01$), and BH ($p = 0.029$) (Table 3).

Reproduction

The average volume of the testicles is $7.40 \pm 5.83 \text{ mm}^3$ and there is no correlation between SVL and testicle volume ($p = 0.085$). The average clutch size, based on the presence of eggs or vitellogenic follicles, is 1.43 ± 0.51 (range: 1–2; $N = 23$). Females with two eggs are significantly larger than those with only one egg (mean = $71.33 \pm 8.14 \text{ mm}$, mean: $64.97 \pm 5.47 \text{ mm}$, respectively, $p = 0.04$). Mean egg volume is $110.59 \pm 87.9 \text{ mm}^3$ ($N = 33$). Females ($N = 5$) with oviducal eggs were captured in February. There is no correlation between SVL and egg size ($p > 0.05$). The frequency of reproductively active males increased from January–May, with a peak in February.

Parasitism

Fifty-three of 107 lizards examined for parasites were infected with at least one species (overall prevalence of 49.53%). A total of 432 helminths was recovered, with a mean abundance of 4.05 ± 0.72 and a mean intensity of infection of 8.17 ± 1.22 . The helminth community of *Tropidurus jaguaribanus* comprises five taxa: *Oochoristica travassosi* Rego and Ibañez, 1965, *Parapharyngodon alvarengai* Freitas, 1957, *Physaloptera* sp., *Spauligodon* sp., and

Strongyluris oscar Travassos, 1923. The discrepancy index recorded maximal aggregation to all parasites (Table 4).

The mean richness is 0.66 ± 0.08 helminths/host and the greatest richness ($S = 4$) is found in only one host. We found no significant difference in the prevalence of parasites between females and males ($Z = 0.65$; $p = 0.51$) or between adults and juveniles ($Z = 1.29$; $p = 0.196$). Likewise, the average intensity of infection between the sexes ($U = 613.5$; $p = 0.18$) and between adult and juveniles ($U = 376$; $p = 0.97$) is not significantly different. Additionally, there is no correlation between SVL and richness ($r_s = 0.102$, $N = 107$, $p = 0.297$) or intensity of infection ($r_s = 0.094$, $N = 53$, $p = 0.49$).

Discussion

The rocky outcrops in the Estação Ecológica de Aiuaba are the main microhabitats recorded for *T. jaguaribanus*. The dorsoventral body flattening is a characteristic of lizards inhabiting a saxicolous habitat (Vitt 1981) and favors heliophilic animals. We found that most of the lizards under intense sun exposure, probably profiting from direct radiation and from the pre-heated rock surface, as already reported for other *Tropidurus* species (Van Sluys 1992, Vitt 1995, Faria 2001, Faria and Araujo 2004, Meira *et al.* 2007).

The bimodal activity period of *Tropidurus jaguaribanus*, with peaks in mid-morning and mid-afternoon and a decrease in activity around noon when the temperature is higher, is similar to that observed in congeners in different open habitats of Brazil (Araújo 1984, Van-Sluys 1992, Bergallo and Rocha 1993, Vitt 1993, Vitt and Carvalho 1995, Hatano *et al.* 2001).

Most lizards observed were still, which is typical sit-and-wait foragers. When approached, the lizards usually sought shelter in rocky crevices, which commonly are used by other species associated with rocky habitat, such as *Tropidurus semitaeniatus* (Vitt 1981, Vitt and Goldberg 1983), *T. hispidus* (Spix 1825) (Vitt

Table 2. Mean, standard error (SE), and range for the number of movements per minute (MPM) and for the time spent moving (PTM), proportion of attacks on prey discovered while moving (PAM), success in capturing prey, and the total time observed for *Tropidurus jaguaribanus* (N = 30). Each individual was observed for 10 min when possible. Percentage values between relatives.

MPM			PTM			PAM (N)	Success (%)	Total time (min)
Mean	SE	Range	Mean	SE	Range			
1.5	0.09	0.5–2.66	0.03	0.004	0.01–0.11	0.13 (75)	61.33	274

Table 3. Mean ± SD (in mm) and results of the discriminant analysis of morphometric variables of *Tropidurus jaguaribanus*.

Variables	Males (N = 27)	Females (N = 46)	Wilk's Lambda	F	p
Body shape			0.65	5.55	0.001
SVL	87.55 ± 14.65	67.73 ± 8.65	0.80	14.13	0.001
Head length	21.2 ± 3.52	19.35 ± 1.86	0.68	2.72	0.103
Head width	15.82 ± 2.29	14.24 ± 2.56	0.66	0.16	0.690
Head height	8.5 ± 1.66	8.23 ± 8.04	0.65	0.015	0.900
Body width	25.39 ± 2.57	23.38 ± 3.31	0.65	0.09	0.750
Body height	8.44 ± 1.86	7.82 ± 1.85	0.71	4.96	0.029

Table 4. Mean abundance (MA), mean infection (IMI) with standard error (SE), range intensity of infection (RII), discrepancy index (D), and site of infection of the helminth parasites (SI: SInt, small intestine; LI, large Intestine; S, stomach; C, cavity) found in *Tropidurus jaguaribanus* at ESEC Aiuaba, Aiuaba, state of Ceará, northeastern Brazil.

Helminths	N	MA ± SE	MI ± SE	RII	D	SI
CESTODA						
<i>Oochoristica travassosi</i>	8	0.07 ± 0.02	1.14 ± 0.14	(1–2)	0.98	SInt
NEMATODA						
<i>Parapharyngodon alvarengai</i>	327	3.05 ± 0.65	8.38 ± 1.43	(1–40)	0.98	SInt/LI
<i>Physaloptera</i> sp.	11	0.10 ± 0.07	2.75 ± 1.75	(1–8)	0.99	S/CAV
<i>Spauligodon</i> sp.	19	0.17 ± 0.12	4.75 ± 2.59	(1–12)	0.98	SInt/LI
<i>Strongyluris oscar</i>	68	0.63 ± 0.21	3.77 ± 1.03	(1–15)	0.98	SInt/LI

and Carvalho 1995), and *T. itambere* Rodrigues, 1987 (Faria 2001). This sheltering behavior probably reduces the risk of predation, in addition to avoiding overheating that would lead to physiological disorders or even death (Vitt 1993, Faria 2001).

The mean body temperature of *Tropidurus jaguaribanus* is similar to those of its congeners *T. hispidus*, *T. montanus* Rodrigues, 1987 (Van Sluys et al. 2004), *T. semitaeniatus* (Vitt 1995) and *T. torquatus* (Wied-Neuwied, 1820) (Ribeiro et al. 2007). According to Kohlsdorf and Navas (2006), lizard species that are phylogenetically related tend to have similar body temperatures even in different habitats. However, the habitat type used by these lizards is also an important factor that influences body temperature (Pianka 1977, Magnusson 1993). The average body temperature recorded for *T. jaguaribanus* reflects the association between local thermic effects, activity period, and foraging type. The significant association between body temperature and habitat temperatures characterizes either heliophilic thermoregulators or tigmothermic behavior of *T. jaguaribanus*. Both behaviors have already been reported for other species of *Tropidurus* (Rocha and Bergallo 1990, Van Sluys 1992, Ribeiro et al. 2007).

The diet of *Tropidurus jaguaribanus* from ESEC Aiuaba is composed mainly of arthropods, but it also includes lizards, gastropods, and small leaves; thus, the species is a generalist predator. The high consumption of ants may be related to the gregarious behavior of *T. jaguaribanus* and/or to the availability of ants in the habitat, which increases the success of ant capture by sit-and-wait foragers. Previous records indicate that ants are important items in the diets of the congeners *T. etheridgei* Cei, 1982 (Vitt 1991a,), *T. hispidus* (Vitt 1993, Vitt et al. 1996), *T. itambere* (Van Sluys 1993), *T. montanus* (Rodrigues 1987, Vitt, 1991a), *T. oreadicus* Rodrigues, 1987 (Colli et al. 1992, Vitt 1993, Faria and Araújo 2004, Rocha and Siqueira 2008), *T. semitaeniatus* (Vitt 1993), *T. spinulosus* (Cope, 1862) (Vitt 1991a, Colli et al. 1992), and *T. torquatus* (Rocha and

Bergallo 1990, Fialho et al. 2000, Juliano et al. 2002). The high consumption of ants recorded in studies of *Tropidurus* seems to reflect the high density of this type of prey in the area (Araújo 1987), increasing the chance of contact with a sit-and-wait predator.

Tail remnants of an adult *Tropidurus* were found in the stomach of an adult male *T. jaguaribanus*. Parts of tropidurids have been found in the stomachs of other *Tropidurus*, such as *T. montanus* (Kiefer and Sazima 2002), *T. hygomi* Reinhardt and Lütken, 1862 (Dias and Rocha 2004), and *T. torquatus* (Kiefer et al. 2006), and this may indicate antagonistic interactions.

Tropidurus jaguaribanus is a sit-and-wait predator. Lima and Moreira (1993) stated that the choice of the type and size of prey is directly related to the trophic morphology and foraging strategy used by each lizard species. The few movements and the short distances that *T. jaguaribanus* travel are characteristics of sit-and-wait predators, similar to other species of *Tropidurus* (Colli et al. 1992, Howland et al. 1990, Rocha and Bergallo 1990, Vitt 1981, 1991b, Vitt and Carvalho 1995, Vitt et al. 1996). The foraging mode in *Tropidurus* involves a history of sit-and-wait foragers and a set of characters shared by Tropiduridae and by most Iguania (Cooper Jr. 1994).

Tropidurus jaguaribanus starts its reproductive period at the end of the dry season and peaks in the rainy season; they have small clutches of 1 or 2 eggs. The peak of oviposition is in the rainy season, when the females tend to improve their fitness by reducing the losses caused by eggs drying out (Van Sluys 1995). Additionally, food is more available in the rainy season.

Clutch size is not correlated with the female body size, corroborating findings in other tropidurids (Vitt and Goldberg 1983, Vitt 1991a, 1993, Vitt and Zani 1996, Galdino 2000). Van Sluys (1995) reported that the relatively constant clutch size and the lack of relation between the female body size and the clutch size can be advantageous to species that are habitat specialists,

such as the forest inhabitant *Uracentron flaviceps* (Guichenot, 1855) (Vitt and Zani 1996) and the rock-crevices inhabitants *T. semitaeniatus* (Vitt and Goldberg 1983) and *T. jaguaribanus*.

Tropidurus jaguaribanus is sexually dimorphic with respect to body shape, SVL, and BH, with males being larger than the females. Similar dimorphism also occurs in other species of *Tropidurus* (Vitt and Goldberg 1983, Vanzolini and Gomes 1979, Perez-Mellado and De la Riva 1993, Vitt 1993, Van Sluys 1998, Pinto *et al.* 2005). There may be a correlation between the larger size of males and their home ranges, which are larger than those of the females (Van Sluys 1998). The sexual dimorphism in color in *T. jaguaribanus* may be associated with hormone shifts that occur during sexual maturity, and probably represent a sexual identifying factor and factor in the social hierarchy (Pinto 1999).

The helminths found in the present study (*O. travassosi*, *P. alvarengai*, *Physaloptera* sp., *Spauligodon* sp. and *S. oscar*) are relatively common in species of *Tropidurus*. They have been recorded in *T. torquatus* (Ribas *et al.* 1998, Vrcibradic *et al.* 2000), *T. semitaeniatus* (Brito *et al.* 2014, Bezerra *et al.* 2016), *T. hispidus* (Anjos *et al.* 2013, Galdino *et al.* 2014), and *T. guarani* Alvarez, Cei and Scolaro, 1994 (Vicente 1981). All parasites found in *T. jaguaribanus* are new host records.

The overall prevalence of parasites found in *T. jaguaribanus* is low in contrast to those of other species of *Tropidurus* (e.g., Anjos *et al.* 2013, Pereira *et al.* 2013), but the value is similar to that of *T. semitaeniatus* (Bezerra *et al.* 2016). The prevalence is less than a half of that recorded for *T. hispidus* (63%) (Galdino *et al.* 2014), which is sympatric with *T. jaguaribanus*. The low prevalence rate may result from the high temperature of the study area; the temperature can exceed 40°C and affect the life cycle of the parasites (Austin *et al.* 2009).

The discrepancy index indicated aggregation among the helminth species found; this may be correlated with the low prevalence index (Zuben 1997) and might impart a lower probability of


overlap of helminth species. As a consequence, the probability of occurrence of trophic or spatial guilds, as well as other types of competition may be reduced. Such spatial distribution may be a consequence of heterogeneity in the susceptibility of each host to infection (Pereira *et al.* 2007).

Males and females do not differ in the prevalence and intensity of parasitic infection. Differences in infection levels between the sexes usually is related to a differential in the prey consumption, microhabitat use, or activity time (Aho 1990). However, both sexes in the present study had similar prey consumption and used the same microhabitat, thereby corroborating the results of Bezerra *et al.* (2016) for *T. semitaeniatus*.

Adult and juvenile *Tropidurus jaguaribanus* have similar infection prevalences and the intensity of infection is not related to lizard body size. We suspect that the differences in infection levels result from the behavioral and ecological segregation of these life stages. Thus, a positive relation among host body size, intensity of infection, and parasite richness is expected (Poulin 1997), but this correlation is not found in *T. jaguaribanus*, *T. semitaeniatus* (Rocha *et al.* 2003, Menezes *et al.* 2004, Bezerra *et al.* 2016), or *T. hispidus* (Galdino *et al.* 2014). Aho (1990) reported that the effects of age on infection patterns in lizards are related to ontogenetic differences in the diet. However, juvenile and adult *T. jaguaribanus* do not differ in the volume of prey consumed; thus, these differences in infection between adults and juveniles were not observed.

By way of summary, *Tropidurus jaguaribanus* is a generalist and opportunistic species, which is saxicolous with a bimodal and diurnal activity period. It is oviparous, with high niche overlap between both males and females and adults and juveniles that is probably is the result of similarities in microhabitat use. The associated helminth community is poor, with only five species. These data should be gathered in future ecological studies of lizards in Caatinga because complete studies on ecological aspects and helminth fauna of these species are scarce.

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