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PATTERNS OF INFESTATION BY THE TROMBICULID MITE *EUTROMBICULA ALFREDDUGESI* IN FOUR SYMPATRIC LIZARD SPECIES (GENUS *TROPIDURUS*) IN NORTHEASTERN BRAZIL

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Summary:

We studied the parasitism by the chigger mite *Eutrombicula alfreddugesi* on four sympatric lizard species of the genus *Tropidurus* in Morro do Chapéu, Bahia state, Brazil: *T. hispidus*, *T. cocorobensis*, *T. semitaeniatus* and *T. erythrocephalus*. For each species, we investigated the patterns of infestation and analyzed to which extent they varied among the hosts. We calculated the spatial niche breadth of the chigger mite on the body of each host species and the distribution of mites along the hosts' bodies for each *Tropidurus* species. All four species of *Tropidurus* at Morro do Chapéu were parasited by the chigger mite, with high (97-100 %) prevalences. Host body size significantly explained the intensity of mite infestation for all species, except *T. erythrocephalus*. The body regions with highest intensity of infestation in the four lizard species were the mite pockets. The spacial niche width of the chigger varied consistently among the four lizards species studied being highest for *T. erytrocephalus* and lowest for *T. cocorobensis*. We conclude that the distribution and intensity with which lizards of the genus *Tropidurus* are infested by *Eutrombicula alfreddugesi* larvae results from the interaction between aspects of host morphology (such as body size and the occurrence and distribution of mite pockets) and ecology (especially microhabitat use).

KEY WORDS : *Eutrombicula alfreddugesi*, *Tropidurus*, lizards, ectoparasitism, Brazil.

Résumé : MODÈLES D'INFESTATION PAR L'ACARIEN TROMBICULIDE *EUTROMBICULA ALFREDDUGESI* CHEZ QUATRE ESPÈCES SYMPATRIQUES DE LÉZARD (GENRE *TROPIDURUS*) AU NORD-EST DU BRÉSIL

Nous avons étudié quelques paramètres du parasitisme par les larves de l'acarien Eutrombicula alfreddugesi *sur quatre espèces sympatriques de lézards du genre* Tropidurus *à Morro do Chapéu, état de Bahia, Brésil :* T. hispidus, T. cocorobensis, T. semitaeniatus *et* T. erythrocephalus. *Pour chaque espèce, nous avons étudié les types d'infestation et leur variation parmi les hôtes. Nous avons calculé l'amplitude de la niche spatiale de l'acarien sur les hôtes, l'intensité d'infestation et les microhabitats préférés de l'acarien sur le corps des lézards. Toutes les espèces de lézard étudiées étaient parasitées, avec des fréquences élevées (97-100 %). La taille du corps des lézards explique l'intensité parasitaire pour toutes les espèces, à l'exception de* T. erythrocephalus. *Les régions de plus grande intensité parasitaire, sur les quatre espèces de lézards, étaient les bourses des acariens. La largeur de la niche spatiale des acariens varie entre les quatre espèces de lézard étudiées, plus grande sur le corps de* T. erytrocephalus *et mineure sur le corps de* T. cocorobensis. *Nous concluons que la distribution et l'intensité avec laquelle les lézards du genre* Tropidurus *sont infestés par les larves d'*Eutrombicula alfreddugesi *résultent de l'interaction entre des aspects de la morphologie et de l'écologie des lézards.*

MOTS CLÉS : Eutrombicula alfreddugesi, Tropidurus, *lézard, ectoparasite, Brésil.*

INTRODUCTION

Ectoparasites may utilize different portions of a host's body as potential microhabitats (e.g. Cunha-Barros & Rocha, 1995; Zippel *et al.*, 1996; Bittencourt & Rocha, 2002; García-de-la-Peña *et al.*, 2004; Storni *et al.*, 2005; Carvalho *et al.*, 2006). The extent of utilization of microhabitats of the host body constitutes a measure of the spatial niche breadth of the parasite and, since the bodies of different host species can constitute potentially different environments for the mite, the niche breadth of a given mite could supposedly vary according to the host species (Bittencourt & Rocha, 2002).

Chiggers are the larval forms of trombiculid mites. They are unusual in that only the larvae are parasitic, whereas the nymphs and adults are free-living and prey on small terrestrial invertebrates and their eggs (Bush *et al.*, 2001). Trombiculid mites are cosmopolitan and, with few exceptions, do not possess host-specificity, infesting an ample spectrum of hosts in all classes of terrestrial vertebrates (Ewing, 1944; Wharton & Fuller, 1952). In the western hemisphere, species of the pan-American genus *Eutrombicula* Ewing, 1938 are among the commonest forms, and parasitize mammals, birds, reptiles and amphibians (Wharton & Fuller, 1952; Loomis & Wrenn, 1984; Daniel & Stekol'nikov, 2004). Some studies have been done in Brazil, reporting ecological aspects of parasitism by *Eutrombicula alfreddugesi* (Oudemans, 1910) in lizard populations and communities (Cunha-Barros & Rocha, 1995, 2000; Vrcibradic *et al.*, 2000; Cunha-Barros *et al.*, 2003; Carvalho *et al.*, 2006). Studies on parasitism by *E. alfreddugesi*

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on sympatric congeneric lizards have shown that prevalences and intensities may vary among host species due to interspecific differences in ecological and/or morphological traits (Cunha-Barros & Rocha, 1995; Zippel *et al.*, 1996; Carvalho *et al.*, 2006). In studies involving lizard communities in Brazil, the species in the genus *Tropidurus* were always the most heavily infested ones (Cunha-Barros & Rocha, 2000; Cunha-Barros *et al.*, 2003), indicating that they may be good models for the study of parasitism by chigger mites. Those lizards usually have mite pockets, which are structures covered with greatly reduced or granular scales and located on the gular (neck), axillary (post-humeral) and/or inguinal (groin) regions of their bodies (Rodrigues, 1987). Mite pockets (also known as "acaridomatia") apparently represent a more protected (i.e. sheltered) microhabitat for chigger mites and they tend to concentrate preferentially on such structures compared to other regions of lizards' bodies (Arnold, 1986). At Morro do Chapéu, on the northern portion of the Serra do Espinhaço mountain range, in northeastern Brazil, four species of *Tropidurus* occur simpatrically: *T. cocorobensis*, *T. erythrocephalus*, *T. hispidus,* and *T. semitaeniatus*. Although these species are taxonomically close (see Frost *et al.*, 2001), they differ in body size, in the number and location of mite pockets along the body, and in some ecological aspects, such as habitat and microhabitat use (Rodrigues, 1987; Vitt, 1995). In this study we investigated the patterns of parasitism (prevalence and intensity of infestation) and the spatial niche breadth of the chigger mite *Eutrombicula alfreddugesi* in those four closely related sympatric lizard species, seeking to associate the differences found with morphological characteristics and ecological aspects of the hosts.

MATERIAL AND METHODS

Study area

The site where lizards were collected (11° 58' S; 40° 58' W; ca. 1,000 m altitude) is located in an area of contact between the caatinga (Brazilian semi-arid ecosystem of thorny shrubs and stunted trees) and the 'campos rupestres' (rocky fields) habitats (Rodrigues, 1987) in the municipality of Morro do Chapéu, in Bahia State, northeastern Brazil. Climate of the general area is relatively dry, with a mean annual temperature of 19.7° C and mean annual rainfall of 749 mm (CLINO, 1996).

Host species

Of the four studied species of *Tropidurus*, three (*T. erythrocephalus*, *T. hispidus* and *T. cocorobensis*) belong to the *torquatus* group, whereas *T. semitaeniatus* belongs to the *semitaeniatus* group (*sensu* Frost *et al.*, 2001). These species differ with respect to their ecology, and to the location and depth of mite pockets: *T. erythrocephalus* is a medium-sized, microhabitat-generalist species, with deep mite pockets on the gular, axillary and inguinal regions; *T. hispidus* is a large, microhabitat-generalist species with gular and axillary pockets but no inguinal pockets; *T. cocorobensis* is a small, sand-dwelling species, with relatively shallow gular pockets and no axilllary nor inguinal pockets; *T. semitaeniatus* is a medium-sized, exclusively saxicolous species with a dorsoventrally flattened habitus and, unlike the other three species, has smooth and juxtaposed dorsal scales (*versus* keeled and imbricate) and does not have 'true' mite pockets, but undifferentiated skin folds at the gular, axilllary and inguinal regions (Vanzolini *et al.*, 1980; Rodrigues, 1987; Frost *et al.*, 2001).

Collecting methods and analyses

Lizards were collected in late November and early December 2000, with the aid of pellet rifles, elastic rubber bands and nooses, and euthanized with ether immediately after capture. Later, they were weighted on a digital balance (precision of 0.01 g) and measured in their snout-vent length (SVL) with a caliper (precision of 0.1 mm) before fixation in 10 % formaline solution. During fixation procedures, lizards were placed on white paper towels so that any mites that eventually detached from the lizards' bodies could be easily detected due to their reddish colour. After 24 h, the fixed lizards were transferred to recipients with 70 % alcohol solution.

At the laboratory, the body of each lizard was carefully examined under stereomicroscope and the number of mites found at each region of the body was counted. Regions of the lizards' bodies considered as potential sites of infestation by the mites were the following: 1) left gular (LGU); right gular (RGU); left shoulder (LS); right shoulder (RS); left axilla (LA); right axilla (RA); left foreleg (LF); right foreleg (RF); left groin (LG); right groin (RG); left postfemoral region (LPR); right postfemoral region (RPR); left hindleg (LH); right hindleg (RH); venter (V); dorsum (D); ventral tail (VT); dorsal tail (DT); cloaca (CL); left tympanum (LT); right tympanum (RT) (Fig. 1).

For each lizard species, the prevalence, mean infestation intensity, and mean mite abundance per region of host body were calculated (all terms *sensu* Bush *et al.*, 1997). To evaluate if host body size affects mite infestation intensity for each lizard species, we performed simple regression analyses between total mite intensity and lizard SVL, after log-transforming both variables (Zar, 1999). For comparisons of infestation

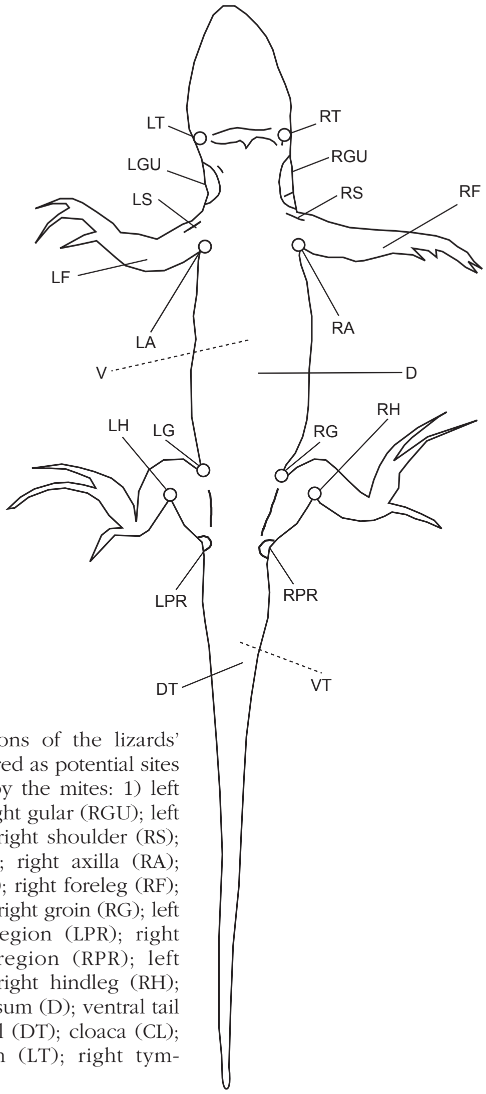

Fig. 1. – Regions of the lizards' bodies considered as potential sites of infestation by the mites: 1) left gular (LGU); right gular (RGU); left shoulder (LS); right shoulder (RS); left axilla (LA); right axilla (RA); left foreleg (LF); right foreleg (RF); left groin (LG); right groin (RG); left post-femoral region (LPR); right post-femoral region (RPR); left hindleg (LH); right hindleg (RH); venter (V); dorsum (D); ventral tail (VT); dorsal tail (DT); cloaca (CL); left tympanum (LT); right tympanum (RT).

intensity among the four lizard species, we performed an Analysis of Covariance (ANCOVA, using lizard SVL as the covariate in order to factor out the effect of host body size) coupled with a Scheffe Post-Hoc Test, (Zar, 1999). All statistical analyses were performed using Systat, 11.0.

The spatial niche breadth (*sensu* Pianka, 1973, 1986) of the mites was estimated for each host species, in terms of proportional utilization of the different regions of the lizards' bodies, using Simpson's (1949) diversity index:

$$B_{ij} = 1/\Sigma P_i^2$$

where P_i is the proportion of individuals (i) associated to each region of the host's body.

To identify the mites to species, we sampled a total of 40 specimens from different individuals of the four host species, cleared them in lactophenol and prepared them on slides using Hoyer's medium, for examination under a microscope.

RESULTS

All four *Tropidurus* species were parasitized by *Eutrombicula alfreddugesi*, with prevalences being 100 % in all of them, except *T. semitaeniatus* for which only one individual (the smallest one) was not parasitized (Table I). *Tropidurus erythrocephalus* had the highest mean infestation intensity, whereas *T. semitaeniatus* had the lowest (Table I).

Body size explained a significant portion of the intensity of mite infestation in *T. hispidus* ($R^2 = 0.41$; $F = 12.41$; $P < 0.005$; N = 20), *T. cocorobensis* ($R^2 = 0.55$; $F = 17.48$; $P < 0.005$; N = 16) and *T. semitaeniatus* ($R^2 = 0.26$; $F = 10.64$; $P < 0.01$; N = 33), but the relationship was only marginally significant for *T. erythrocephalus* ($R^2 = 0.30$; $F = 4.68$; $P = 0.05$; N = 13) (Fig. 2). Infestation intensities differed among the four lizard species ($F = 37.10$; $P < 0.001$; N = 81), but only *T. erythrocephalus* differed significantly from all other species (Scheffe Post-Hoc Test, $P < 0.05$ in all cases).

For all four host species, the regions of the body most intensely parasitized by mites were generally the gular, axillary and inguinal regions (Table II), which are the regions where mite pockets are located (whenever mite pockets were present in such regions, most or all mites were found inside them). In three of the species (*T. hispidus*, *T. cocorobensis* and *T. erythrocephalus*) the highest infestation intensities occurred on the gular region, whereas in *T. semitaeniatus* the groins were the most intensely parasitized region of the body. The breadth of the spatial niche (B_{ij}) of *E. alfreddugesi* varied consistently among the four host species in Morro do Chapéu, being highest for *T. erythrocephalus* and lowest for *T. cocorobensis* (Table I).

Host	N	Mean SVL (Range)	Prevalence	Mean Intensity (Range)	(B_{ij})
T. cocorobensis	16	64.8 (55.3-70.0) mm	100 %	70.1 ± 41.7 (21-186)	1.0
T. erythrocephalus	13	66.2 (52.2-79.4) mm	100 %	165.8 ± 126.0 (40-520)	5.4
T. hispidus	20	85.6 (70.2-117.2) mm	100 %	146.2 ± 114.2 (31-483)	3.8
T. semitaeniatus	34	62.3 (31.7-75.1) mm	97.1 %	52.3 ± 42.4 (3-162)	4.5

Table I. – Prevalence, mean intensity (± SD, with range in parentheses), and spatial niche breadth (B_{ij}) of the ectoparasitic mite *Eutrombicula* aff. *alfreddugesi* associated to four species of *Tropidurus* in Morro do Chapéu, northeastern Brazil. Sample size (N) and mean body size (with range in parentheses) for each lizard species is also given.

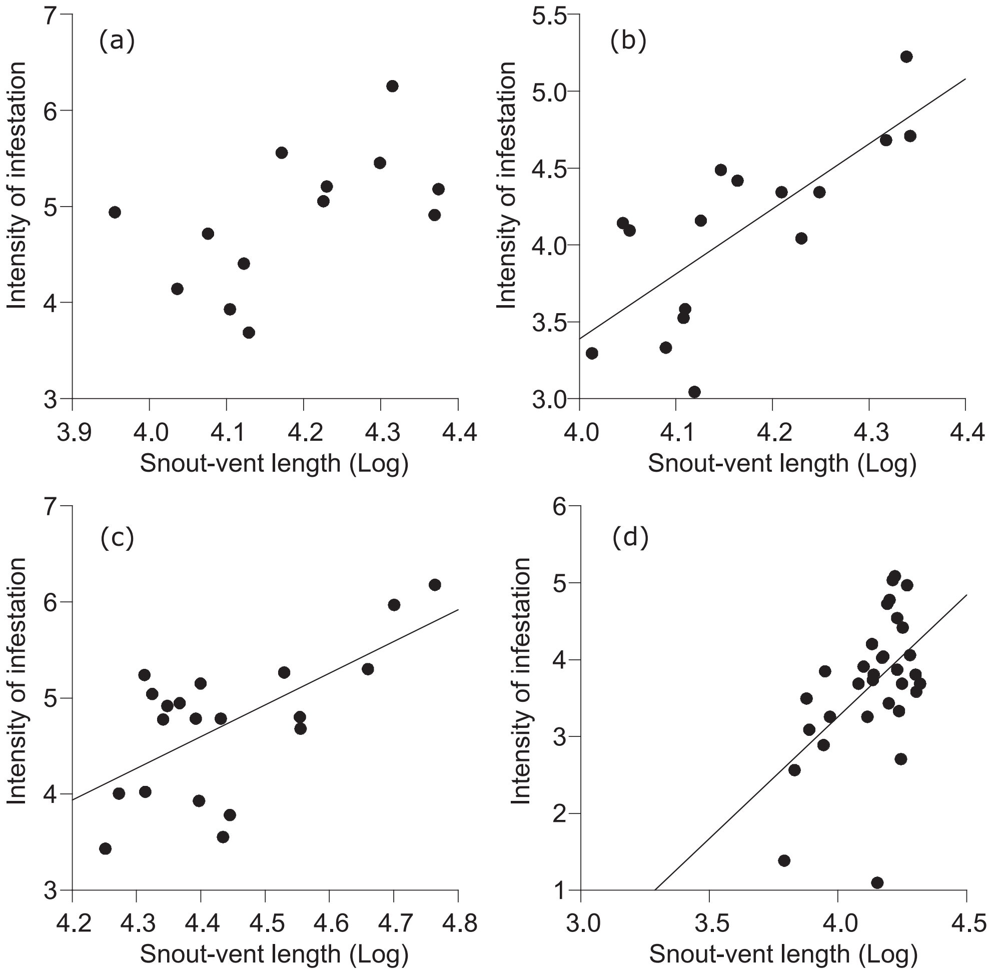

Fig. 2. – Relationship between snout-vent length (log) and intensity of infestation (log) by trombiculid mite *Eutrombicula* cf. *alfreddugesi* on (a) *Tropidurus erythrocephalus* ($R^2 = 0.30$; $F = 4.68$; $P = 0.05$; $N = 13$); (b) *Tropidurus cocorobensis* ($R^2 = 0.55$; $F = 17.48$; $P < 0.005$; $N = 16$); (c) *Tropidurus hispidu* ($R^2 = 0.41$; $F = 12.41$; $P < 0.005$; $N = 20$); and (d) *Tropidurus semitaeniatus* ($R^2 = 0.26$; $F = 10.64$; $P < 0.01$; $N = 33$).

Body regions	***T. cocorobensis***	***T. erythrocephalus***	***T. hispidus***	***T. semitaeniatus***
LGU	35.5	43.0	48.3	2.2
RGU	31.4	43.9	39.2	2.0
LS	< 0.1	–	–	–
RS	0.7	–	–	–
LA	2.0	20.5	29.2	6.5
RA	1.4	21.0	30.6	8.2
LF	–	–	–	< 0.1
RF	–	–	–	0.1
LG	0.4	29.2	–	14.1
RG	0.1	17.8	–	18.4
LPR	–	–	–	–
RPR	–	–	–	–
LH	–	–	–	0.3
RH	0.1	–	–	0.5
V	< 0.1	< 0.1	–	–
D	< 0.1	< 0.1	–	0.1
VT	–	–	–	–
DT	–	–	–	0.2
CL	–	–	–	–
LT	0.3	–	0.6	< 0.1
RT	< 0.1	–	–	–

Table II. – Mean abundance of *Eutrombicula* aff. *alfreddugesi* per region of the host's body for each of the four *Tropidurus* species at Morro do Chapéu, in northeastern Brazil. Codes for the lizards' body regions are: left gular (LGU); right gular (RGU); left shoulder (LS); right shoulder (RS); left axilla (LA); right axilla (RA); left foreleg (LF); right foreleg (RF); left groin (LG); right groin (RG); left postfemoral region (LPR); right postfemoral region (RPR); left hindleg (LH); right hindleg (RH); venter (V); dorsum (D); ventral tail (VT); dorsal tail (DT); cloaca (CL); left tympanum (LT); right tympanum (RT).

DISCUSSION

Ecological and morphological differences among the four lizard species studied may explain their different intensities of infestation by chigger mites. The semi-scansorial *T. erythrocephalus* and *T. hispidus* occur in strict syntopy in areas where they are sympatric, and both are microhabitat generalists (Rodrigues, 1987; pers. obs.). These two species had the highest mean ectoparasite intensities observed in the present study, followed by the strictly ground-dwelling *T. cocorobensis*. The species with the lowest infestation intensity was *T. semitaeniatus*, an exclusively saxicolous form. The types of habitat used by the lizards may influence the levels of infestation by mites, since the free stages of those parasites live buried in the soil (Clopton & Gold, 1993). Thus, lizards that live mostly in contact to the ground would theorically be prone to higher levels of infestation (Cunha-Barros & Rocha, 1995). However, *T. cocorobensis* is the only strictly ground-dwelling *Tropidurus* species in Morro do Chapéu and did not have the highest parasite intensity. The fact that *T. cocorobensis* is the smallest of the four host species and does not possess neither axillary nor inguinal mite pockets probably explains its relatively low overall intensity of mite infestation. The low infestation intensity of *T. semitaeniatus* is probably mostly due to its absence of 'true' mite pockets, whereas the high intensities observed in *T. erythrocephalus* and *T. hispidus* are presumably influenced by the number and depth of mite pockets in the former and large body size in the latter. Intraspecifically, body size positively influenced infestation intensity in all host species, except *T. erythrocephalus*. Nevertheless, the results of the infestation intensity-body size regression for the latter species was close to the level of significance (0.05), which indicates that the lack of a significant correlation may be due to the small sample size.

The preferential sites of infestation for the mites on the body of lizard hosts were the regions of mite pockets, as it has been observed in other studies on chiggers infesting lizards (e.g. Cunha-Barros & Rocha, 2000; Klukowski & Nelson, 2001; García-de-la-Peña *et al.*, 2004; Carvalho *et al.*, 2006). The actual function of mite pockets and whether they confer any selective advantage for the lizards is a controversial issue (e.g. Arnold 1986; Bauer *et al.*, 1990, 1993; Salvador *et al.*, 1999; Bertrand & Modry, 2004). The four studied species of *Tropidurus* vary with respect to the number, location and depth of mite pockets and the observed infestation patterns and intensities along the hosts' body regions seem to reflect this variation. *Tropidurus semitaeniatus* is the only species that does not possess 'true' mite pockets, having instead undifferentiated skin folds on the gular, axillary and inguinal regions (Vanzolini *et al.*, 1980, pers. obs.), and was also the only one in which the gular region was not the body region most infested by mites. As for the three remaining species, apart from the gular region, two (*T. hispidus* and *T. erythrocephalus*) also had intense infestation on the axillary region and the latter was also heavily infested on the groins. Those infestation patterns parallel the distribution of mite pockets among the host species, as observed in another study with sympatric *Tropidurus* species (Carvalho *et al.*, 2006). The broadest spatial niche of the mites occurred in *T. erythrocephalus*, on which mites occurred with high intensities in three body regions (*i.e.* those with mite pockets), and in *T. semitaeniatus*, which does not have mite pockets and thus parasites were distributed more evenly along the hosts' bodies. The narrowest spatial niche was observed in *T. cocorobensis*, with the mites being concentrated on a single region of the host's body (the gular pockets) and occurring at low densities elsewhere.

It is not possible, with the data at hand, to infer whether the chiggers have any significant negative effect on the lizards at Morro do Chapéu and whether the two most heavily infested species sustain greater costs to their health and body condition than the two less infested ones. Some studies have evidenced a negative effect of chiggers on their lizard hosts (Klukowski & Nelson, 2001), whereas others have concluded that no significant costs occur to the hosts (García-de-la-Peña *et al.*, 2004; Schlaepfer, 2006). Thus, the magnitude of the effects of chigger infestation on lizards may vary among different cases.

We conclude that the distribution patterns and intensity of infestation by the chigger mite *Eutrombicula alfreddugesi* on lizards of the genus *Tropidurus* may result from the interaction between aspects of the morphology (such as body size and the occurrence and distribution of mite pockets), and ecology (especially microhabitat use) of host species.

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