



**UNIVERSIDADE FEDERAL DO OESTE DO PARÁ
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PROGRAMA DE PÓS-GRADUAÇÃO EM BIODIVERSIDADE**

LOURIVAL BAÍA DE VASCONCELOS NETO

**A HETEROGENEIDADE AMBIENTAL DAS SAVANAS AMAZÔNICAS
DETERMINA A DISTRIBUIÇÃO LOCAL DE LAGARTOS
Cnemidophorus cryptus (SQUAMATA: TEIIDAE)**

**SANTARÉM, PARÁ
2020**

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Orientador: Dr. Alfredo P. dos Santos Júnior.

Co-orientador: Dr. Rafael de Fraga.

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Assim, aos dois dias do mês de dezembro do ano de dois mil e vinte, às dez horas e trinta minutos, foi apresentado on-line a apresentação de seminário público da dissertação de mestrado do aluno LOURIVAL BAIA DE VASCONCELOS NETO. Deu-se início a abertura dos trabalhos, onde o Professor Dr. ALFREDO PEDROSO DOS SANTOS JR, após esclarecer as normativas de tramitação da defesa e seminário público, de imediato solicitou o candidato que iniciasse a apresentação da dissertação, intitulada "A HETEROGENEIDADE AMBIENTAL DAS SAVANAS AMAZÔNICAS DETERMINA A DISTRIBUIÇÃO LOCAL DE LAGARTOS *Cnemidophorus cryptus* (SQUAMATA: TEIIDAE)". Concluída a exposição, o orientador comunicou ao discente que a versão final da dissertação deverá ser entregue ao programa, no prazo de 30 dias; contendo as modificações sugeridas pela banca examinadora e constante nos formulários de avaliação da banca.

A banca examinadora foi composta pelos examinadores professores doutores listados abaixo. Os pareceres assinados seguem em sequência.

ALFREDO PEDROSO DOS SANTOS JR
Orientador

RAFAEL DE FRAGA
Co-orientador

LOURIVAL BAIA DE VASCONCELOS NETO
Discente

**A Raul Lazzaretti, o “Raulzito”, meu amado
filho e melhor amigo.**

**Aos guerreiros da Brigada de Incêndio de Alter
do Chão e demais ativistas ambientais que
lutam para manter a floresta amazônica de pé
em meio a esse cenário catastrófico.**

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**Existe uma coisa que uma longa existência me ensinou:
toda a nossa ciência, comparada à realidade, é primitiva e
inocente; e, portanto, é o que temos de mais valioso.**

Albert Einstein

RESUMO

A distribuição espacial dos organismos pode ser direta e indiretamente afetada por vários gradientes ambientais. A heterogeneidade ambiental geralmente causa variação na qualidade do habitat local e nos níveis de competição, o que pode levar à filtragem ambiental e alterar a densidade populacional em uma determinada faixa geográfica da distribuição de uma espécie. Neste estudo, testamos a hipótese generalizada de que savanas na Amazônia podem conter heterogeneidade ambiental suficiente para que as estimativas de densidade de lagartos não sejam homogêneas no espaço. Em uma Unidade de Conservação foram amostradas 26 parcelas, cada uma cobrindo 1500 m² (250 m de comprimento, 6 m de largura), para testar a influência da temperatura do ar, altitude, número de cupinzeiros, cobertura de arbustos, cobertura do dossel, densidade do concorrente e interações entre alguns desses gradientes na densidade de *Cnemidophorus cryptus* (Squamata, Teiidae). Foram encontrados efeitos positivos do número de cupinzeiros e cobertura de arbustos nas densidades de *C. cryptus*. Esses achados sugerem que a alta disponibilidade de locais de refúgio contra temperaturas elevadas (até 40 °C) experimentadas pelas savanas favorece altas densidades de lagartos. Além disso, foram encontrados efeitos negativos da altitude e temperatura nas densidades estimadas, o que sugere filtragem ambiental em locais termicamente inadequados. No entanto, um gráfico de interação mostrou que os efeitos da altitude na densidade de *C. cryptus* são significativos apenas sob temperaturas mais amenas. No geral, nossas descobertas sugerem que *C. cryptus* não ocupa homogêneamente os habitats disponíveis, mas a filtragem ambiental pode surgir da falta de abrigo e termorregulação ineficiente em relação à perda de calor corporal em altitudes relativamente baixas (<104 m) e ganho de calor em temperaturas relativamente altas (> 104 m). Discutimos nossas descobertas do ponto de vista ecológico e de conservação da biodiversidade.

Palavras-chave: Ecologia de populações. Filtragem ambiental. Gradientes ecológicos. Squamata. Teiidae.

ABSTRACT

The spatial distribution of organisms may be directly and indirectly affected by multiple environmental gradients. Environmental heterogeneity often causes variation in local habitat quality and levels of competition, which may lead to environmental filtering changing population density over a species geographic range. In this study we test the generalized hypothesis that savannas in Amazonia may contain enough environmental heterogeneity that lizard density estimates are not homogeneous across space. In a protected area we sampled 26 plots, each of which covering 1500 m² (250m long, 6 m wide), to test the influence of air temperature, altitude, number of termite mounds, shrub cover, canopy openness, competitor density, and interactions between some of these gradients on *Cnemidophorus cryptus* (Squamata, Teiidae) density. We found positive effects of number of termite mounds and shrub cover on *C. cryptus* densities. These findings suggest that high availability of refuge sites from the high temperatures (up to 40 °C) experienced by midday savannas favor high densities. Additionally, we found negative effects of altitude and temperature on the estimated densities, which suggests environmental filtering at thermally unsuitable sites. However, an interaction plot showed that altitude effects on *C. cryptus* density are only significant under mild temperatures. Overall, our findings suggest that *C. cryptus* does not homogeneously occupy available habitats, but environmental filtering may emerge from lack of shelter and inefficient thermoregulation toward body heat loss at relatively low altitudes (< 104 m), and heat gain at relatively high temperatures (> 104 m). We discuss our findings from ecological and biodiversity conservation perspectives.

Keywords: Ecological gradients. Environmental filtering. Population ecology. Squamata. Teiidae.

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INTRODUÇÃO GERAL

Como o ambiente pode influenciar a densidade de lagartos em savanas na Amazônia?¹

Qual o problema da pesquisa?

Lagartos podem viver em diversos tipos de ambientes, como savanas, florestas alagáveis e não alagáveis, desertos e áreas urbanizadas. As espécies desse grupo mostram uma grande variedade de formas, cores e tamanhos corpóreos ao longo de sua ampla distribuição que ocupa quase todo o globo terrestre, com exceção dos polos. A ausência nos polos da Terra é explicada por limitações fisiológicas impostas pelo frio extremo, uma vez que esses animais precisam de fontes externas de calor para desempenhar suas atividades primordiais como comer, fugir de predadores e reproduzir. Embora algumas espécies sejam altamente tolerantes a amplitudes térmicas (intervalo entre temperatura mínima e máxima) relativamente grandes, outras são muito mais sensíveis a variações termais, podendo deixar de ocupar locais termalmente inadequados. A qualidade termal de habitats geralmente não é homogênea ao longo de paisagens naturais, mas dependente da cobertura vegetal e da altitude, as quais variam muito. Portanto, podemos esperar que a densidade de lagartos (número de indivíduos por unidade de área) também não seja homogênea, mas varie ao longo de mosaicos de habitats mais ou menos adequados (Figura 1).

Savanas diferem consideravelmente de florestas por serem ambientes abertos, muito ensolarados e quentes. Em imagens de satélite savanas são facilmente distinguíveis de florestas, mas a variação ambiental dentro de savanas geralmente não é óbvia. Saber o quanto a temperatura e a cobertura vegetal mudam ao longo de savanas geralmente depende de medir essas

¹ Texto de comunicação científica formatado conforme as normas do “Canal Ciência - Portal de Divulgação Científica e Tecnológica”, do Instituto Brasileiro de Informação em Ciência e Tecnologia (Ibict).

Curva teórica para uma espécie

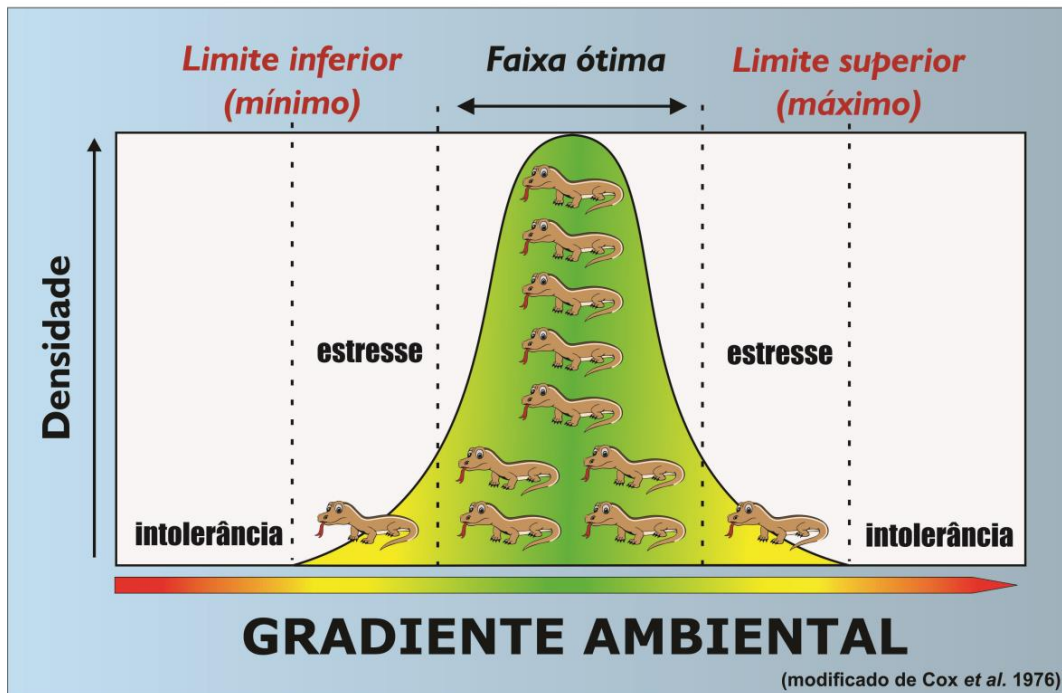


Figura 1: Curva de desempenho teórica representando uma espécie hipotética sendo filtrada ao longo de um gradiente ambiental. Na faixa ótima onde a espécie atinge seu desempenho máximo, a densidade é maior, já nos limites da distribuição essa métrica é reduzida até chegar a zero nas faixas intoleráveis.

variáveis localmente em campo. Essa abordagem pode revelar muita variação espacial na abundância de árvores, arbustos, capins e solo exposto, e, portanto, é muito mais eficiente que imagens de satélite para quantificar a variação ambiental dentro de savanas. Isso é relevante, porque as espécies residentes de savanas precisam ser bem adaptadas ao estresse hídrico e termal, e por isso savanas contêm biodiversidade única, diferente das florestas adjacentes. Biodiversidade única é um ótimo critério para definir savanas como ecossistemas de alta relevância para conservação.

Entre os mais variados tipos de animais e plantas que ocorrem nas savanas amazônicas, os lagartos são um dos grupos mais abundantes e disseminados. Algumas manchas de savana podem abrigar até 15 espécies distribuídas nos mais variados habitats. Os lagartos do gênero *Cnemidophorus* (conhecidos popularmente como calangos listrados, Figura 2a) são uns dos mais abundantes e facilmente detectáveis devido à necessidade de forragearem ativamente em busca de alimentos e sítios para termorregulação,

como cupinzeiros e arbustos, por exemplo. Como as savanas são ecossistemas que normalmente possuem temperaturas mais elevadas, a presença desses locais para perda de calor corporal pode ser determinante para os lagartos na seleção de hábitat.

Como a pesquisa foi realizada?

Sob a orientação dos herpetólogos Rafael de Fraga (Doutor em Ecologia) e Alfredo Santos-Jr (Doutor em Zoologia), o biólogo Lourival Vasconcelos Neto, acadêmico do Programa de Pós-Graduação em Biodiversidade e responsável pela pesquisa, estudou uma população de *Cnemidophorus cryptus* (Figura 2a) em savanas Amazônicas, com o objetivo de testar a hipótese de que as densidades de lagartos são limitadas por alterações locais na qualidade de habitats. Essa hipótese é baseada na ideia de que as variações locais nas características desses ambientes de savana promovem mosaicos com diferentes qualidades e, por isso, os lagartos tendem a ser filtrados (estar em baixa densidade ou mesmo ausentes) em locais com condições adversas. O estudo foi conduzido no Parque Estadual de Monte Alegre (PEMA, Figura 2b), uma Unidade de Conservação estadual com área de 3.678 ha, situada no município de Monte Alegre – PA, ao norte do Rio Amazonas, sendo uma das poucas reservas destinadas à conservação de

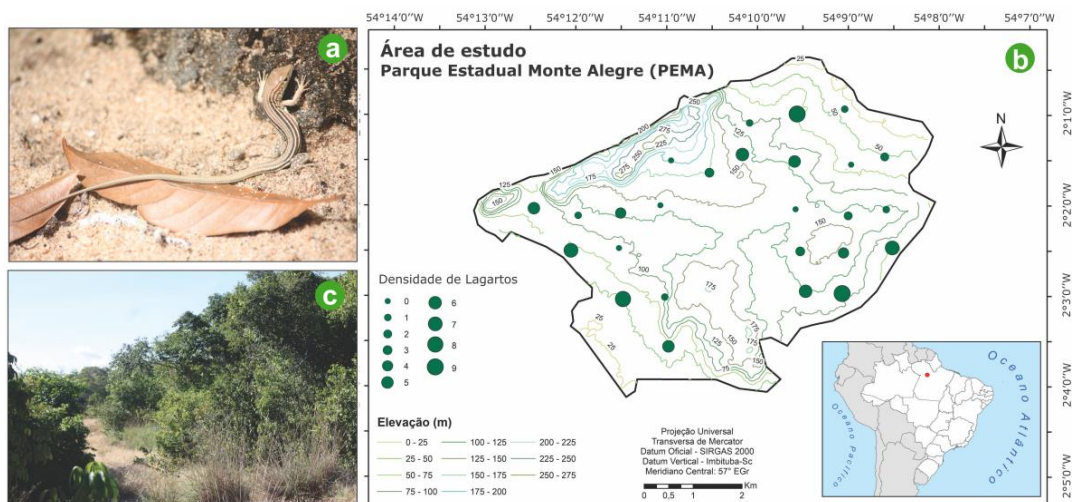


Figura 2: Informações gerais sobre o estudo no Parque Estadual Monte Alegre: a = exemplar de *Cnemidophorus cryptus*; b = mapa da área de estudo com os locais de coleta de dados representados pelos círculos verdes e a densidade de lagartos pelo tamanho do círculo; C = tipo vegetacional predominante nas savanas amazônicas.

áreas de savana na Amazônia (Figura 2c).

A pesquisa consistiu em coletar dados sobre a densidade de indivíduos (número de lagartos em parcelas de 250 x 6 m), seguindo o protocolo RAPELD (ver sugestões de leitura) para definir o eixo central de parcelas de amostragem seguindo as curvas de nível naturais do terreno. Os locais selecionados para a coleta (Figura 2b) de dados abrangeram habitats com variação nas configurações do estrato vegetal, altitude, temperatura e disponibilidade de sítios para termorregulação e alimentação. O objetivo é investigar se essas variáveis ambientais podem influenciar na densidade local de *C. cryptus*.

Qual a importância da pesquisa?

Como principal resultado, os pesquisadores evidenciaram que a distribuição espacial dos lagartos na área estudada não é aleatória, e que a heterogeneidade ambiental das savanas amazônicas é determinante para a estruturação espacial da população de *C. cryptus*. De acordo com as análises estatísticas realizadas, a proporção de arbustos, altitude, temperatura e número de cupinzeiros são atributos do habitat responsáveis por promover modificação espacial na densidade local de lagartos. Em locais com mais arbustos e cupinzeiros, a densidade de lagartos é maior, porque ambas as variáveis definem a disponibilidade de refúgios contra as altas temperaturas nas horas mais quentes do dia, e a disponibilidade de refúgios contra predadores. Em locais com temperaturas elevadas a densidade é menor, porque calor excessivo limita os processos fisiológicos e metabólicos de ectotérmicos como lagartos. A altitude também foi uma variável importante, embora tenha influenciado a densidade de lagartos indiretamente, porque gradientes altitudinais promovem variação espacial em diversas características do ambiente, como variação na cobertura vegetal, por exemplo, podendo configurar alterações na qualidade termal de habitats disponíveis em diferentes cotas altimétricas. Além disso, a pesquisa evidenciou, também, que as variáveis podem interagir e influenciar a distribuição dos indivíduos. Especificamente, foi observado que sob condições de alta temperatura os efeitos da altitude sobre a densidade dessa espécie de lagarto são

relativamente fracos. Ao contrário, em locais que mostraram temperaturas mais amenas, os efeitos negativos da altitude na densidade de lagartos foram fortes.

Esse resultado geral é relevante para a ecologia e conservação de populações naturais, pois fornece informações sobre mecanismos e processos que determinam a distribuição local dos indivíduos. Por exemplo, é possível argumentar que a escolha de uma área para conservação dessa espécie deve abranger locais heterogêneos, uma vez que a estrutura espacial da população depende da interação entre variáveis ambientais para garantir a disponibilidade locais adequados para a termorregulação. Apesar de que diversas pesquisas nas florestas Amazônicas evidenciaram respostas significativas de diferentes espécies de animais e plantas à variação ambiental, poucos estudos tiveram como foco os organismos que ocorrem nas áreas de savana. De modo geral, savanas têm sido negligenciadas pelas ciências naturais, a despeito do fato de serem ecossistemas regionalmente raros, e biologicamente complementares às florestas adjacentes.

Autores

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CAPÍTULO I

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a leitura.

1 **ENVIRONMENTAL HETEROGENEITY OF AMAZONIAN SAVANNAS**
2 **DETERMINING THE LOCAL DISTRIBUTION OF A RACERUNNER LIZARD**

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11 **Environmental heterogeneity of Amazonian savannas determining the local**
12 **distribution of a racerunner lizard**

13

14 **Abstract**

15 The spatial distribution of organisms can be affected directly and indirectly by multiple
16 environmental gradients. Environmental heterogeneity often causes variation in local
17 habitat quality and levels of competition, which may lead to environmental filtering
18 changing population density over a species geographic range. In this study we test the
19 generalized hypothesis that savannas in Amazonia may contain enough environmental
20 heterogeneity that lizard density estimates are not homogeneous across space. We
21 sampled 26 plots located in an area dedicated to the conservation of savannas in the
22 Amazon, each of which covering 1500 m² (250m long, 6 m wide), to test the influence
23 of air temperature, altitude, number of termite mounds, shrub cover, canopy openness,
24 competitor density, and interactions between some of these gradients on racerunner
25 lizard (*Cnemidophorus cryptus*) density. We found positive effects of number of termite
26 mounds and shrub cover on *C. cryptus* densities. These findings suggest that high
27 availability of refuge sites from the high temperatures (up to 40 °C) experienced by
28 midday savannas favor high densities. Additionally, we found negative effects of
29 altitude and temperature on the estimated densities, which suggests environmental
30 filtering at thermally unsuitable sites. Through an interaction graph we show that the
31 effects of altitude on the density of racerunner lizards are significant only under mild
32 temperatures. In general, our results suggest that *C. cryptus* does not occupy the habitats
33 available homogeneously, but environmental filtration may arise from the need for
34 shelter for efficient thermoregulation towards the loss of body heat. We discuss our
35 findings from ecological and biodiversity conservation perspectives.

36 **Keywords:** ecological gradients, environmental filtering, population ecology,
37 Squamata, Teiidae

38

39 **Introduction**

40 Environmental heterogeneity may play a key role in shaping the spatial distribution of
41 organisms, because occurrence and density are often limited by environmental filtering
42 (Kinnup and Magnusson, 2005; Cornwell, Schwilk and Ackerly, 2006). Although
43 species distribution at macroscales may be best predicted by historical factors (Ribas et
44 al. 2011; Dias-Terceiro et al., 2015), at local scales it is expected that spatial variation in
45 resource availability generates habitat-quality mosaics across species ranges (Vitt et al.,
46 2007; Garda et al., 2013). At suboptimal conditions (e.g. low availability of nutrients
47 and thermoregulation sites, high competition and exposure to predators), low levels of
48 birth/death ratio and immigration tend to negatively affect population density estimates,
49 because individuals are unable to survive and reproduce under certain habitat conditions
50 (Franklin et al., 2000). Therefore, species may be locally filtered from sites through
51 physiological intolerance, high exposure to intolerable temperatures and predators,
52 competition, or a combination of multiple factors (Cornwell, Schwilk and Ackerly,
53 2006; Laliberté, Zemunik and Turner, 2014). Environmental filtering has been widely
54 demonstrated as affecting biodiversity in Amazonia, both at population (Fraga et al.,
55 2013; Fraga et al., 2017), and animal (Menin et al., 2007; Menger et al., 2017; Faria,
56 Menin and Kaefer, 2019) and plant (Costa, Magnusson and Luizão, 2005; Kinnup and
57 Magnusson, 2005) assemblage levels.

58 Although biotic and abiotic factors are widely expected to limit species
59 distribution locally, most studies in Amazonia have been focused on forest ecosystems
60 (e.g. Costa, Magnusson and Luizão, 2005; Kinnup and Magnusson, 2005; Fraga et al.,
61 2013; Faria, Menin and Kaefer, 2019). However, the Amazon ecosystems contain
62 267.164 km² of savannas (4.8% of total territory) which have been poorly sampled
63 (Carvalho and Mustin, 2017). Although Amazonian savannas appear homogeneous in
64 satellite images, they may show levels of environmental heterogeneity at finer scales
65 (e.g. field-measured environmental gradients, Magnusson et al. 2008). For instance,
66 while savannas may be regionally characterized by predominantly grassy, herbaceous
67 and shrubby vegetation cover, wide local variation in the density of trees, shrubs and
68 exposed soil may be spatially expected (Eiten, 1983; Sarmiento, 1984; Magnusson et
69 al., 2008). Such variation causes heterogeneous distribution of refuge, foraging and

70 thermoregulation sites within savannas, which is expected to influence the local fauna
71 (Chamaillé-Jammes, Valeix and Fritz, 2007). Therefore, environmental filtering
72 structuring populations and assemblages should be expected not only by comparing
73 extreme portions of environmental gradients (e.g. savanna vs. forest), but also within
74 local patches of habitat types (Vitt et al., 2007; Garda et al., 2013; Nogueira et al.,
75 2019).

76 In this study we investigate the influence of environmental heterogeneity within
77 Amazonian savannas on the spatial structure of racerunner lizards *Cnemidophorus*
78 *cryptus* Cole & Dessauer, 1993 (Teiidae, Squamata). Racerunner lizards are often
79 considered as models for quantitative studies (e.g. based on density), because it is
80 relatively easy to detect in the field, which generates reliable data (Mesquita and Colli,
81 2003; Menezes and Rocha, 2013). This species is widely distributed along the
82 Amazonia, although its distribution is regionally limited to open habitats such as
83 savanna patches, forest edges and human occupations (Harvey, Ugueto and Gutberlet Jr,
84 2012; Ribeiro-Jr and Amaral, 2016).

85 As ectotherms, body temperature mediated by habitat temperature determines
86 the efficiency of processes necessary for survival and reproduction of racerunner lizards
87 (Diele-Viegas et al., 2018). This is particularly critical in savannas, because these
88 habitats often experience excessively high temperatures, which leads lizards to occupy
89 thermoregulation sites that contain a variety of fine-scale features that can ameliorate
90 temperature extremes (Scheffers et al., 2014), leading the lizards toward body heat loss.
91 Holes in the ground, termite mounds, fallen logs, shrubs, grass and other vegetated
92 habitats are among the shelters available for lizards to thermoregulate. Additionally, the
93 high openness of savannas generates relatively high exposure to predators and seasonal
94 fires (compared to forests), which makes shelter availability a relevant factor
95 determining lizard-occupied habitat proportions (Faria, Lima and Magnusson, 2004;
96 Souza et al., 2020). However, in the Amazonian savannas, the vegetation cover changes
97 considerably throughout the landscape (Magnusson et al., 2008), accordingly, thermally
98 suitable habitats are not equally available throughout the ecosystem. Topographic
99 variations usually carry a great deal of information about changes in soil and vegetation
100 characteristics across the landscape (Luizão et al., 2004; Kinnup and Magnusson, 2005).

101 In addition, considering that thermoregulating and foraging sites (e.g. shrubs, termite
102 mounds) are spatially patch distributed in open ecosystems (Eiten, 1983; Magnusson et
103 al., 2008), interspecific competition resource can also be expected as a predictor for the
104 species density (Mesquita, Costa and Colli, 2006). Therefore, it is plausible to assume
105 environmental gradients that quantify thermal habitat quality, availability of
106 thermoregulation and refuge sites, and levels of competition may predict estimates of *C.*
107 *cryptus* density.

108 In this study we test the general hypothesis that the local distribution of *C.*
109 *cryptus* is not homogeneous across space but determined by multiple environmental and
110 competition-level gradients. Specifically, we test the effects of number of termite
111 mounds, shrub cover, competitor density, altitude, temperature, and interactions
112 between some of these gradients on *C. cryptus* density. We expect low densities or
113 absence of the species in certain regions of the measured gradients (e. g. places with
114 inadequate temperature and the lack of resources), which would be interpreted as
115 environmental filtering at suboptimal habitats. We argue that testing non-random habitat
116 occupation determined by environmental filtering across habitats is particularly relevant
117 for ecology and conservation in Amazonian savannas, because they are locally rare,
118 ecologically poorly known, and often contain complementary biodiversity to adjacent
119 forests.

120 **Material and methods**

121 *Study area*

122 We sampled lizards at the Parque Estadual Monte Alegre (PEMA), a state reserve located in Monte
123 Alegre, Pará, Brazil (headquarters at 2°03'24.9" S, 54°10'46.1" W). PEMA covers 3,678 ha (Figure 1),
124 which main objective is to protect natural ecosystems of great ecological relevance and scenic beauty
125 (MMA 2009). The vegetation cover of the study area is open, dominated by herbs and grasses, and
126 showing wide local variation in tree and shrub densities (Eiten, 1983; Sarmiento, 1984; Magnusson et al.,
127 2008). In the central region of PEMA there is a portion of secondary forest that differs substantially from
128 the adjacent savannas, mainly because it is covered by trees up to 30 m high. We did not sample this
129 region, because our target species (*C. cryptus*) is absent from forests. The altitude of the study area
130 (including not-sampled forests) ranges from 10 to 250 m above sea level (MMA, 2009). The average
131 annual temperature is 27.2 °C, and the average annual rainfall is 1700 mm, which are unevenly

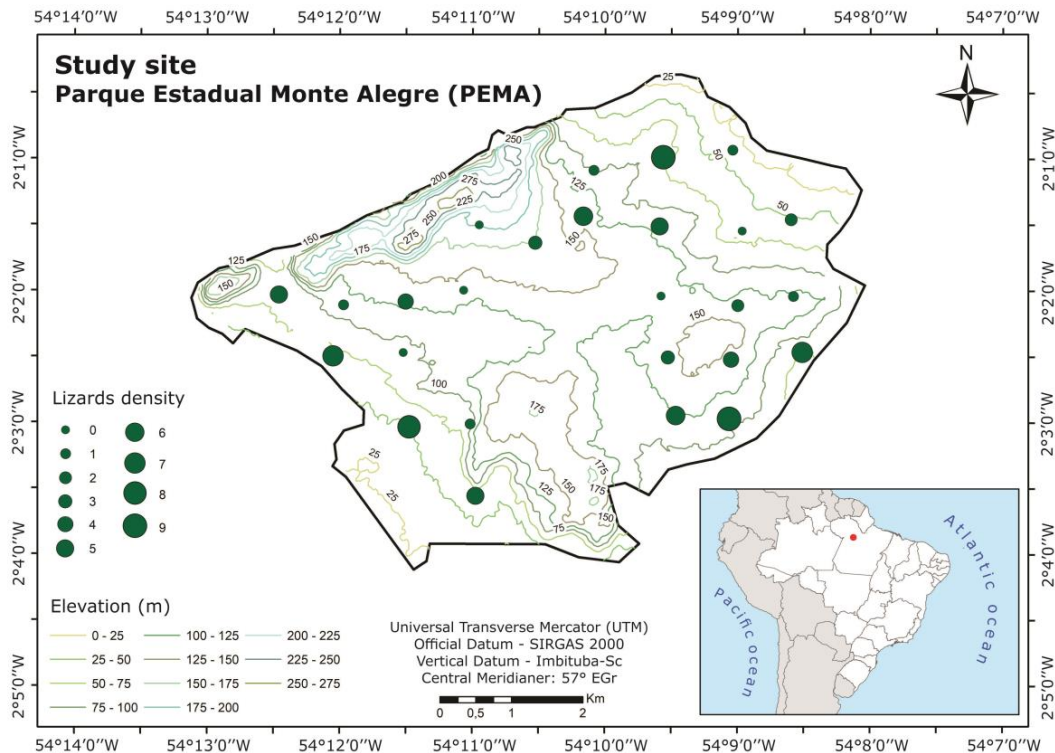


Figure 1: Study Area at Parque Estadual de Monte Alegre (PEMA), Pará, Brazil. The green circles show sampling plots, each of which 250 m long and 6 m wide, where we collected density (number of individuals) data of the racerunner lizard *Cnemidophorus cryptus*. The size of the green circles is relative to the maximum number of lizards detected in three surveys per plot. The lines mark altitudinal quotas. No plot has been installed in the central PEMA because this region is covered by forest, where *C. cryptus* is absent.

132 distributed throughout the year, but characterized by a rainy season between December and July, and a
 133 dry season between August and November (Moraes et al., 2005).

134 *Sampling design and data collection*

135 We sampled 26 plots, each of which 250 m long and 6 m wide, systematically distributed to cover 16.43
 136 km² of savannas, at least 700 m apart. We followed the RAPELD sampling protocols (Portuguese
 137 acronym composed of RAP - rapid sampling plus PELD - Long Term Ecological Surveys; Magnusson et
 138 al. 2005, 2013). This method has been modified (from Gentry, 1982) to define the main axis of the plots
 139 following the natural contour lines of the terrain. This modification has been described as efficient to
 140 minimize environmental heterogeneity within the sampling units. The RAPELD method has been shown
 141 to be effective for investigating the spatial distribution of many organism groups (Magnusson et al.,
 142 2013), including Squamata reptiles (Fraga, Lima and Magnusson, 2011; Fraga et al., 2013; Faria et al.,
 143 2019).

144 We counted *C. cryptus* individuals in each plot using visual active search employed over 19 days
 145 of field work, from February to May 2019. Since plot size and configuration are standardized, we used

146 numbers of individuals as a proxy for population density. We sampled all plots during the day, between
147 10:00 AM and 5:00 PM, on days with temperatures above 30 °C and no rain. We defined these
148 specifications based on the climatic influence on the detection of Teiidae lizards, which are mostly
149 diurnal and active in the warmer times of the day (Diele-Viegas et al., 2018). We limited the sampling
150 sections by time (60 minutes per plot) and space (plot area, 1500 m²) with two simultaneous observers.
151 To optimize detectability, we kicked grass bushes and shrubs to encourage lizard movement. When the
152 lizards were counted by an observer, he informed the other about the sighted lizard and made sure to
153 chase the lizard out of the parcel's limits and avoid overestimation. This technique has been shown to be
154 quite efficient for estimating lizard population densities in Amazonian savannas (Magnusson et al., 1996;
155 Faria, Lima and Magnusson, 2004; Souza et al., 2020). We also reduced possible detectability effects on
156 population density estimates by performing three temporal replications in each plot at different times of
157 the day and using the maximum lizard density as a dependent variable in linear models. Because *C.*
158 *cryptus* is easily detected visually, using the maximum of three counts made on alternate days and times
159 is the simplest way for reducing possible sampling biases caused by detectability.

160 *Environmental gradients*

161 We measured six gradients potentially predictive of the *C. cryptus* spatial distribution, which we thought
162 to be determinants of availability of refuge and thermoregulation sites, and competition levels (Table 1).
163 We measured air temperature because it directly affects the performance of physiological and metabolic
164 processes determining fitness for foraging, fleeing from predators, and searching for thermoregulation
165 sites (Diele-Viegas et al., 2018). We measured the temperature during lizard sampling using a
166 thermohygrometer positioned 10 cm above the ground under the shade. We measured altitude as a proxy
167 for variation in vegetation cover, microclimate, and soil water stress (Luizão et al., 2004, Costa,
168 Magnusson and Luizão, 2005; Kinupp and Magnusson 2005). We use a GPS to collect data on the
169 elevation quota in each plot. We measured number of termite mounds because they provide resting,
170 foraging and thermoregulating sites for *C. cryptus* (Magnusson, Franke and Kasper, 1986; Faria, Lima
171 and Magnusson, 2004). We used total values of sighted termite mounds within plots. We measured shrub
172 cover proportions because shrubs provide refuge from visual predators and excessively high temperatures
173 (Magnusson, Franke and Kasper, 1986; Faria, Lima and Magnusson, 2004). We observed presence or
174 absence of shrubs every two meters along the plot to estimate the proportion of the plot area covered by
175 shrub vegetation. We measured the percentage of canopy cover because this gradient broadly defines the
176 amount of solar energy reaching *C. cryptus* habitats. We used a digital camera positioned 1.5 m above the
177 ground, with the lens positioned upwards. We captured an image of the canopy at 25 m, totaling 11
178 photos per plot. We processed the photos in an image editor software to verify black (closed canopy) and
179 white (open canopy) ratios. We used average values per plot. We measured density of competing species
180 because Teiidae lizards eventually compete for food and thermoregulation sites in Amazonian savannas
181 (Mesquita, Costa and Colli, 2006), which ultimately could lead to local competitive exclusion (Hoffer,
182 Bersier and Borcard, 2004). We used active visual search to account for densities of ecologically similar

183 sympatric Teiidae lizards (*Ameiva ameiva* and *Kentropyx striata*). These competitors are selected because
 184 previous studies in the study area indicate that the species in have considerable niche overlap, favoring
 185 competition for resources (Mesquita, Costa and Colli, 2006). We quantified competitor density by
 186 summing estimated densities of both potentially competitor species. Further details on all the measured
 187 environmental and competition gradients can be found in the supplementary material (Appendix 1).

188 **Table 1.** Summary of ecological gradients used as independent variables in predictive models of
 189 *Cnemidophorus cryptus* density in Amazonian savannas. Data were collected in 26 plots (250 x 6 m
 190 each), following the natural contour lines. SD = standard deviation.

Gradient	Range	Mean	SD
Air temperature (°C)	31.1–39.9	34.27	2.22
Altitude (m)	39–195	104.4	39.15
Termite mounds (N)	0–18	2.65	4.27
Shrub cover (%)	0–30.6	13.94	7.61
Canopy cover (%)	0.35–45.69	16.33	13.28
Competitor density (N)	0–9	3.46	2.06

191

192 *Data analysis*

193 We preliminarily selected a subset of gradients as independent variables, estimating Pearson
 194 multicollinearity levels. We did not use percentage of canopy cover in the inferential model because it
 195 was 80% correlated with shrub cover. The other variables did not violate the assumptions of the statistical
 196 test used and, therefore, were included in inferential analysis.

197 To test the influence of the gradients measured on the *C. cryptus* density estimates we generated
 198 a full multiple linear model given by $lizard\ density = a + b_1 (temperature) + b_2 (altitude) + b_3 (number\ of$
 199 $termite\ mounds) + b_4 (shrub\ cover) + b_5 (competitor\ density) + b_6 (altitude * temperature) + b_7 (altitude$
 200 $* shrub\ cover)$. We included interactions in the full model because the effects of altitude on ectotherms
 201 are often indirect, since they reflect variation in environmental factors relevant to the ecology of active
 202 thermoregulators. For example, variation in soil structure, vegetation and consequently microclimate over
 203 altitudinal gradients is widely expected (Luizão et al., 2004). We used the ggplot2 R-package (Wickham,
 204 2019) to plot the interaction between some of the measured gradients.

205 We applied a stepwise regression on the full model to select the most parsimonious subset of
 206 gradients. Less informative predictor variables were sequentially removed, and a final model was selected
 207 by the lowest Akaike Information Criterion (AIC) value. We validated the most parsimonious model by
 208 testing normality of the residual distribution using a Shapiro-Wilk test. We also evaluated the effects of
 209 spatial autocorrelation on the residuals from the most parsimonious model using a global Moran's I test,
 210 which was applied in the ape R-package (Paradis et al., 2019), and a local Geary's C test, which was
 211 applied in the girmess R-package (Giraudoux et al., 2018). We defined number of distance classes in the

212 Geary's C model based on the best possible solution in terms of homogeneity in the numbers of
 213 comparisons within each distance class.

214 **Results**

215 We found 182 individuals of *C. cryptus*. The maximum density per plot was nine
 216 individuals (average 3.46). The occurrence frequency relative to sample size was
 217 88.46%, and we did not find lizards in only five plots (11.54%). The most parsimonious
 218 multiple linear model was identified with temperature, altitude, number of termite
 219 mounds, and shrub cover as independent variables (AIC = 49.38). The difference in
 220 AIC between the global model and the most parsimonious model was 3.71. Detailed
 221 stepwise regression results are shown in Table 2

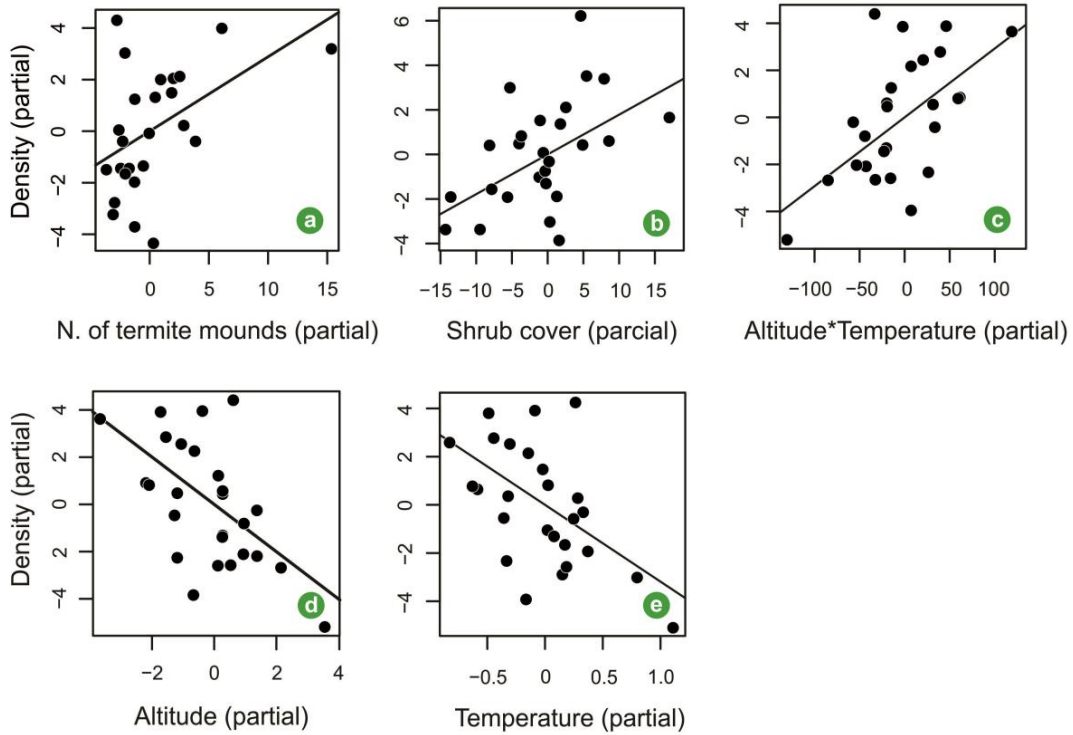
222 **Table 2.** Summary of a stepwise regression applied to select the most parsimonious combination of
 223 environmental gradients as predictors of *Cnemidophorus cryptus* density in Amazonian savannas. -
 224 denotes removal of a variable or interaction between variables, * denotes interaction between variables.
 225 The bold value of AIC shows the most parsimonious model.

step	Model	AIC
1	Full	53.09
2	- altitude * shrub cover	51.14
3	- competitor density	49.38

226

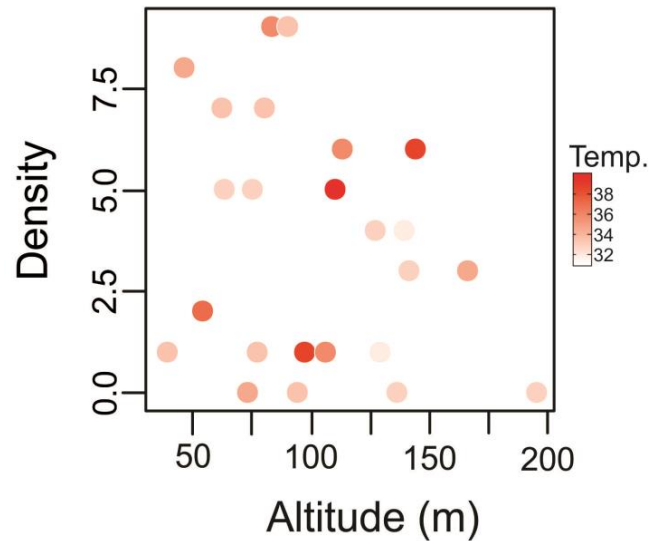
227 The most parsimonious multiple linear model explained 50% of the spatial
 228 variation in lizard density ($F_{5-20} = 4.12$, $P = 0.009$). According to this model, the
 229 variation in lizard density at a local scale is not random, but negatively related to
 230 altitude ($t = -3.275$, $P = 0.003$) and temperature ($t = -2.982$, $P = 0.007$), and positively
 231 related to the number of termite mounds ($t = 2.428$, $P = 0.02$) and shrub cover ($t = 2.650$,
 232 $P = 0.01$) (Figure 2). Additionally, we found significant effects ($P = 0.004$) of an
 233 interaction between elevation and temperature on *C. cryptus* density. Such interaction is
 234 characterized by the fact that under high temperature conditions the effects of elevation
 235 on the *C. cryptus* density are relatively weak. However, in sites where the temperature is
 236 milder, the negative effects of altitude on lizard density are strong (Figure 3).
 237 Summarized results indicate that the density of *C. cryptus* is highly dependent on the
 238 variation in the availability of refuge, foraging and thermoregulation sites.

239



240

241 **Figure 2:** Relationships (partials derived from a multiple linear regression) between environmental
 242 gradients and *Cnemidophorus cryptus* density. Data were collected in 26 plots distributed along
 243 Amazonian savannas, each of which 250 m long and 6 m wide.



244

245 **Figure 3:** Effects of an interaction between altitude and temperature on *Cnemidophorus cryptus* density.
 246 Data comes from 26 sampling plots, each of which 250 m long and 6 m wide. Transparency levels in
 247 shades of red denote variation in temperature.

248 We validated the most parsimonious model by residuals not differing from a
 249 theoretical normal distribution (Shapiro-Wilk $W = 0.97$, $P = 0.80$), and not spatially
 250 autocorrelated. Independence of geographical distance was shown by a global Moran's I
 251 test ($P = 0.49$), and a local Geary's C test ($P > 0.24$ in all distance classes). Results from
 252 the Geary's C test are summarized in Table 3.

253 Although we have found that some abiotic gradients predict the estimated *C.*
 254 *cryptus* density, we did not find any evidence that competitor density affects lizard
 255 density. Competitor density was removed by the stepwise regression from the most
 256 parsimonious linear model and showed no effect on *C. cryptus* even when we used it as
 257 an independent variable in the full model ($P = 0.67$).

258 **Table 3.** Summarized results of a Geary's C test applied to evaluate spatial autocorrelation in the
 259 residuals from the most parsimonious multiple linear regression used to test effects of environmental
 260 gradients on *Cnemidophorus cryptus* density across Amazonian savannas. The Geary's C model was set
 261 up with six geographic distance classes. N = number of pairwise comparisons per distance class; P =
 262 significance value.

Dist. (km)	Coef	P	N
0.700	1.134	0.810	90
2.079	0.940	0.300	150
3.457	1.017	0.541	146
4.836	0.948	0.343	148
6.215	0.859	0.248	86
7.593	1.031	0.538	30

263

264 Discussion

265 Our results showed that *C. cryptus* does not randomly occupy the sampled savannas, but
 266 densities depend on multiple interacting environmental gradients. This finding is
 267 consistent with environmental filtering assumptions that predict spatially explicit
 268 mosaics of varying habitat quality (Franklin et al. 2000, Cornwell, Schwilk and
 269 Ackerly, 2006). Specifically, we show that for a lizard species occupying open and very
 270 hot environments, the habitat selection is mediated by habitat quality defined mainly by
 271 the availability of thermoregulation sites. This is directly related to adaptation in the life
 272 history of *C. cryptus* and the environmental characteristics of the ecosystem in which
 273 the species evolved. In other savanna environments in the Amazon, the density of lizard

274 species also varies locally depending on the spatial variation of vegetation cover (Souza
275 et al., 2020), showing that the availability of places for thermoregulation can be decisive
276 for the habitat selection of the species that live in these ecosystems that have naturally
277 high temperatures.

278 In general, our findings converge to the clear evidence that temperature is a key
279 factor determining the local distribution of *C. cryptus*. Temperature is widely expected
280 to affect the performance of physiological and metabolic processes of ectotherms (Huey
281 and Slatkin, 1976; Cano and Nicieza, 2006; Diele-Viegas et al., 2018). In our study
282 system it was possible to show that a variation of 8 °C (31.9–39.9 °C) in environment
283 temperature may be sufficient to promote local changes in the density of the lizards.
284 However, through the set of variables selected in the best fit model, we have specifically
285 shown that the availability of thermoregulation sites towards body heat loss limits local
286 lizard density. This finding is supported by direct negative effects of temperature on
287 lizard density, and also by the positive effects of shrub density and number of termite
288 mounds. Shrubs are important thermal refuges for terrestrial lizards occupying sunny
289 habitats such as savannas (Magnusson, Franke and Kasper, 1986; Faria, Lima and
290 Magnusson, 2004, Souza et al., 2020), and low shrub density means that the travel
291 distance between shrubs is relatively high, which may cause increase in predation
292 pressure (Wilson and Cooper, 2006). Additionally, we found positive effects of number
293 of termite mounds on *C. cryptus* density, and termites have been described as important
294 dietary components of the species (Vitt, Zani and Caldwell, 1997; Mesquita, Costa and
295 Colli, 2006). Termite mounds as thermal refuges are particularly relevant during the dry
296 season when the sampled savannas experience frequent fire events (Sanaiotti and
297 Magnusson 1995; Barbosa and Fearnside, 2005, Sousa et al., 2020). In fact, mortality by
298 fire tends to be considerably reduced in Teiidae lizards by the availability of refuges
299 such as termite mounds and holes in the ground (Caughley, 1985; Faria, Lima and
300 Magnusson, 2004).

301 Our findings suggest that the spatial distribution of *C. cryptus* is highly
302 dependent on the thermal quality of habitats, mainly because lizard density is limited by
303 the availability of adequate sites to lose body heat. Thermal quality may be directly
304 measured by the local variation in temperature, but also by the availability of

305 thermoregulation sites, which may be quantified by vegetation cover varying along
306 local-scale altitudinal gradients. Thermoregulation sites provided by vegetation cover
307 often depend on soil texture and water stress, which in turn may depend on altitude
308 (Costa, Magnusson and Luizão, 2005; Kinupp and Magnusson, 2005). Therefore, our
309 results suggest that an interaction between temperature and altitude should be
310 interpreted as a proxy for multivariate environmental heterogeneity predicting *C.*
311 *cryptus* density. Specifically, we observed that under high temperature conditions the
312 effects of altitude on the lizard density are relatively weak. Contrarily, in plots that have
313 shown mild temperatures, the negative effects of altitude on lizard density were
314 stronger. The indirect effects of altitude on the spatial structure of the sampled lizards
315 were potentially mediated by changes in the thermal quality of the available habitats
316 along the measured altitudinal gradient, which was partially supported in our study
317 system by a negative correlation (Pearson $r = -0,27$) between altitude and shrub cover.
318 Therefore, our results indicate that the local density of *C. cryptus* is mediated by the
319 availability of habitats for thermoregulation, which in turn is given by means of
320 environmental variables that interact and promote the availability of sites for loss or
321 gain of body heat.

322 Although environmental filtering determined the spatial structure of a savanna
323 lizard, interspecific competition was not an efficient predictor of the estimated density.
324 This finding is relevant because it suggests that biotic interspecific interactions play a
325 minor role in determining the local spatial structure of the species studied. This is
326 consistent with lizard species from southeastern US (Buckley and Jetz, 2010) and
327 suggests that relationships among environmental gradients and lizard density are more
328 likely mediated by the sensitivity of physiological processes to environmental
329 conditions than by the carrying capacity of habitats. We argue that although levels of
330 overlap in habitat use may be expected among the sampled lizards (Mesquita, Costa and
331 Colli, 2006), interspecific competition has been considerably reduced by high resource
332 availability (e.g. places for thermoregulation) favoring sympatry (Colli et al., 2003,
333 Hibbitts et al., 2005; Rocha and Anjos, 2007). Competitive exclusion is also expected to
334 be indefinitely delayed as potentially competing species show differences in dispersal
335 capacity and habitat use. For instance, although *Ameiva ameiva* and *Kentropyx striata*

336 may eventually compete with *C. cryptus* for foraging sites, competition for
337 thermoregulation sites is unlikely, since *A. ameiva* tends to disperse to adjacent habitats
338 under adverse conditions (e.g. fire, very high temperatures), and *K. striata* tends to
339 climb the vegetation rather than fleeing into termite mounds (Faria, Lima and
340 Magnusson, 2004, Ribeiro-Jr and Amaral, 2016). This is important because the habitat
341 quality determined by the availability of thermoregulation sites (e.g. termite mounds)
342 was the main factor structuring the *C. cryptus* population. Additionally, *A. ameiva* and
343 *K. striata* also occur in forests, which suggests that they show higher levels of
344 ecological plasticity compared to *C. cryptus* (Ribeiro-Jr and Amaral, 2016). Ecological
345 plasticity often emerges from low levels of specialized habitat use, which should
346 generate low levels of local competition (Agrawal, 2001). Therefore, although savannas
347 are often considered as extreme portions of temperature and water stress gradients in
348 Amazonia (Hutyra et al., 2005), a combination of high resource availability and
349 interspecific variation in thermoregulatory behavioral strategies leads competitive
350 interactions to be negligibly relevant for the *C. cryptus* local distribution.

351 Although *C. cryptus* is widely distributed in different savannas and forest edges
352 in Amazonia (Ribeiro-Jr, 2015), our study showed that the environmental heterogeneity
353 locally limits the species distribution. This finding suggests that species distribution
354 models and predictions of climate change responses at macroscales such as the Amazon
355 Basin (e.g. Pontes-da-Silva et al., 2018) or the Planet (e.g. Sinervo et al., 2010) may not
356 be adequate to capture the fine scale at which lizards recognize distinct habitats
357 (Gillingham et al., 2012). For instance, the plant stratification provided by shrub cover,
358 and the availability of termite mounts may considerably reduce habitat temperature, and
359 therefore they act as local layers of thermal buffer. These layers hardly would be
360 detected by traditional assessments of climate effects on biodiversity, which are
361 typically derived from macroscale environmental heterogeneity (Scheffers et al., 2014).
362 Therefore, our local-scale ecological model highlights the importance of field validation
363 for species distribution models based on algorithms applied to pixels derived from
364 satellite images (Shoo, Williams and Hero, 2006; Ashcroft, Chisholm and French, 2009;
365 Suggitt et al., 2011; Gillingham et al., 2012; Scheffers et al., 2014). Field validation
366 should be used as a tool to optimize the accuracy of climate impact assessments on

367 biodiversity, which is highly useful for defining management and conservation
368 strategies. This is particularly relevant for our study area, because it is a reserve
369 specifically designed to protect patches of Amazonian savannas. These ecosystems are
370 regionally rare (covering less than 5% of the Amazonian territory) and are relatively
371 fragile since they are characterized by very poor sandy soils, very high noon
372 temperatures, and seasonal fires (Sanaiotti and Magnusson, 1995; Prance, 1996;
373 Borghetti et al., 2019). Therefore, the biodiversity of Amazonian savannas should be
374 considered as unique, and biotically complementary to regional ecosystem mosaics.

375 We showed that the spatial distribution of *C. cryptus* is not random but depends
376 on environmental gradients associated with the thermal quality of habitats, which can
377 only be detected at fine scales. This overall result is relevant for ecology because it
378 provides insights into mechanisms and processes that determine the local distribution of
379 species, and also for conservation, since lizard occurrence is not homogeneous across
380 available habitats. We highlight that lizard ecology may vary among savannas within
381 distinct regions in Amazonia, for example in diet or habitat use (Vitt, Zani and Caldwell,
382 1997; Mesquita and Colli, 2003). Therefore, the environmental gradients we found as
383 predictors of *C. cryptus* density would not necessarily be efficient predictors in other
384 savannas that we have not sampled. However, only by using a standardized sample
385 design (e.g. RAPELD) it would be possible to estimate levels of variation in species-
386 habitat relationships among savannas across different regions.

387

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Environmental heterogeneity of Amazonian savannas determining the local distribution of a racerunner lizard

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Supplementary Material

S supplementary text S1: Details of data collection on environmental variables.

Temperature was measured at the plot site during lizard sampling by a thermohygrometer positioned under the shade at the beginning of the plot. The indicated temperature was recorded at the beginning and end of each transect and the average obtained between the initial and final temperatures was considered as the local temperature value. As we performed three surveys in each plot there were three temperature values, however, for the analyses we considered only the temperature recorded during the transect with the largest number of *C. cryptus*, as was done with the density data.

The **competitor density** was accounted for the same as the density of *C. cryptus*.

The **number of termites mounds** was obtained by counting termites mounds larger than 20 cm within the limits of each plot. Smaller termites mounds have not been accounted for because they do not provide efficient lizard thermoregulation sites.

Altitude was measured on each plot with the aid of a Garmin GPSMAP 64SC ® GPS. As the plots were made to minimize relief variations in relation to the central axis

of the plot, the altitude values are relatively homogeneous over the entire length, allowing the use of this variable as a predictor of density in our models.

Shrub cover was estimated by a measuring tape stretched along the right lateral line of each plot, and every 2 m a thin metal wand was positioned vertically touching the tape measure. At each touch the data was characterized by 1 for when the wand touched a bush, and 0 for when it did not touch. Binary data collected over the entire plot (125 points) was used to calculate the proportion of each plot covered by shrubs.

Canopy cover was measured with the aid of a digital camera, stabilized on a tripod 1.5 m from the floor, with the lens positioned upwards. Each 25m one canopy photo was captured, totaling 11 photos per plot. To estimate the ratio of canopy obstruction using the Photoshop CS6® software, we first stripped the colors from the photos to black and gray. Later these grayscale images were converted to high contrast black and white through the threshold function. From this command all pixels lighter than the threshold were converted to white (component without vegetation), while all darker pixels were converted to black (component with vegetation). To quantify the proportion of the obstructed canopy, we calculate the ratio of black pixel to total pixel in the image. The value of the tree cover variable in each plot was the average proportion obstructed by vegetation in each image.

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These should be presented in a smaller font than the rest of the manuscript (e.g., Times New Roman 10 vs 12). Furthermore, they should be explained in enough detail to allow replication. The sample sizes and the number of independent replicates should be clearly stated. For experimental work details on both housing and observational conditions should be stated. Environmental conditions should be controlled as much as possible to avoid biased results. The exact dates or period of sampling and observation must be given. For studies based on a small number of study sites, the geographic coordinates must be indicated. Statistics should be explained in the methods, particularly when complex models are used.



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Results

Anecdotal results should not be presented unless they are of primary importance. Instead, they should be stated in the discussion section as personal observations. Results should focus on the main argument(s) of the manuscript. Comparisons should be tested statistically. Sample sizes should be clearly presented.

Discussion

The results should be discussed in the context of the existing literature. The discussion should not focus only on the study species or group, but should be placed into the context of arguments about other model species to render it in a more conceptual and broad concept. The literature should be covered in sufficient detail for both the topic and the study group. Each paragraph should focus on a different idea, but very short paragraphs should be combined with other paragraphs. The discussion must not be overly long. Speculation should be avoided.

References

Text Citations

These should be presented in chronological order as follows: Petranka (1998) or (Griffiths, 1996; Michimae and Wakahara, 2001; Schmidt, Feldman and Schaub, 2005). Where there are more than three authors, only the first should be named, followed by “et al.” (not in italics). Both the introduction and discussion must include an adequate number of citations for effective arguments to be established.

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In the list, references should be listed in alphabetical, and then chronological order, under the first author's name and should refer only to publications cited in the text. List references with three or more author names must be placed after those with two. Journal names must be abbreviated according to the official abbreviation. Many abbreviations are, for instance, available at: cassi.cas.org/search.jsp. No space must be inserted between the initials of the first names. No empty lines must be inserted between references. Volume numbers are written in bold. The two last authors or editors in a citation are separated only by a comma. Abstracts of conferences should not be listed in the reference list, but cited in the text as unpublished data or personal observation. The references of the species description (e.g. Linnaeus, 1758) are not necessarily included in Reference List. References must be typed in the following order and form, respectively:

- Arnold 2002
- Arnold 2003
- Arnold, Peterson 2002
- Arnold, Pfrender, Jones 2001



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- Myers, E.M., Zamudio, K.R. (2004): Multiple paternity in an aggregate breeding amphibian: the effect of reproductive skew on estimates of male reproductive success. *Mol. Ecol.* **13**: 1951-1963.
- Kiesecker, J.M. (2003): Invasive species as a global problem. Toward understanding the worldwide decline of amphibians. In: *Amphibian Conservation*, p. 113-126. Semlitsch, R.D., Ed., Washington, Smithsonian.
- Zug, G.R., Vitt, L.J., Caldwell, J.P. (2001): *Herpetology. An Introductory Biology of Amphibians and Reptiles*, 2nd Edition. San Diego, Academic Press.

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Acknowledgements

These should be kept brief, but funding agencies should be listed. If legal requirements are necessary for the study, the collecting permits must be cited with reference to the institution who issued them. Individuals are identified by their last name and the initials of their first name.

Statistics

Means and standard errors (SE) / deviations (SD) or medians and quartiles or ranges should be given as: mean \pm SE = 5.3 \pm 0.3 mm. If equations or special symbols such as the mean are used, the module MS Equation in MS Word must be used (available in "Insert Object"). Statistical symbols, such as n , F , t , U , Z ,

r must be indicated in italics. Degrees of freedom are indicated as a subscript to the test statistic ($F_{2,265}$, t_{17}). The name of the test should be given on its first appearance in front of the symbol (e.g., ANOVA, Mann-Whitney). The same test should be applied to the same kinds of analyses throughout the manuscript. P values for significant results should be quoted as below a threshold significance value ($P < 0.05$, $P < 0.01$, $P < 0.001$). Exact probabilities should be given for non-significant results (e.g. $P = 0.76$). Multiple post-hoc tests must be used with caution to avoid experimental error by chance alone. When transformations are used, they should be stated in the materials and methods. The multiple use of individuals should be controlled for or avoided. Multivariate analyses are usually requested when several explanatory variables are tested for one dependent variable or when one explanatory variable is expected to explain several dependent variables.

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Comentários à coordenação do PPGBEES:

A Dissertação está bem escrita e trata de um tema interessante. Em algumas partes do texto “heterogeneidade ambiental” é tratada como sinônimo de “gradiente ambiental”, mas isso não atrapalhou a interpretação dos resultados. Fiz vários comentários e sugestões diretamente no PDF.

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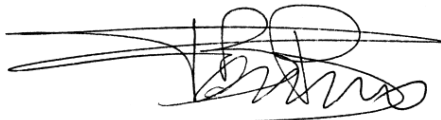
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Data: 23/11/2020



Assinatura:

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Agradeço a oportunidade de avaliar a dissertação intitulada “**A heterogeneidade ambiental das savanas amazônicas determina a distribuição local de lagartos *Cnemidophorus cryptus* (Squamata: Teiidae)**”, de autoria do mestrando **Lourival Baía de Vasconcelos Neto**. A dissertação apresenta hipótese clara (densidade de lagartos) testada sob a premissa da qualidade de habitats em savana amazônica. Os métodos aplicados foram consistentes, dando robustez aos resultados, e estes discutidos com base na ecologia de populações, comunidades e ecossistemas sob a ótica teórica da biologia, fisiologia e comportamento de lagartos. Encaminho arquivo, em anexo, com pequenas correções que poderão nortear a versão final da dissertação. Por fim, considero que o manuscrito apresentado é um indicador positivo para aprovação da dissertação.

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Prezado Coordenador,

O mestrando Lourival Neto construiu uma dissertação de qualidade, bem estruturada e bem escrita, e com grande potencial de publicação em uma revista de impacto. O aluno demonstra maturidade científica, compromisso com a qualidade do trabalho, e isso é refletido ao longo do trabalho em cada seção.

Os resultados trazem dados novos e relevantes, e certamente é um trabalho com uma grande contribuição ao conhecimento dos lagartos de savanas amazônicas. A quantidade e a qualidade das figuras são adequadas e a metodologia está clara. Os resultados e a discussão estão coerentes e claros.

Por ser uma dissertação, um material que permite uma liberdade de criação maior aos autores, eu sugiro que incluam um anexo com fotos do animal estudado e da área de estudo. As dissertações ainda são muito usadas como fonte para alunos iniciantes e certamente um trabalho bem ilustrado pode contribuir melhor para o entendimento sobre os organismos estudados, os métodos empregados e a área de amostragem. Além de ser uma boa fonte de disseminação dos trabalhos desenvolvidos pela pós-graduação.

Todas as sugestões e críticas apresentadas foram incluídos no PDF em anexo. Dessa forma, os pequenos ajustes necessários para a melhoria do trabalho provavelmente ocorrerão sem maiores contratempos.

Finalmente, dado a qualidade do material apresentado, eu aprovo (com correções) a dissertação do discente, e parabeno a ele e seus orientadores pela qualidade do trabalho.

As sugestões, comentários e críticas construtivas ao trabalho foram encaminhadas ao discente no PDF anexado.

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