

## On the natural history of the poorly known Neotropical lizard *Hemidactylus agrius* (Squamata: Gekkonidae)

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**Abstract.** *Hemidactylus agrius* is a rare gecko from semi-arid formations of northeastern Brazil. We provide herein relevant information on the natural history of this Neotropical gecko species, regarding microhabitat use, sexual dimorphism and feeding habits of a population from a typical semi-arid Caatinga area. The majority of *H. agrius* were found inactive beneath barks of trees during daylight, evidencing that this kind of microhabitat seem suitable retreat sites. There was no sexual dimorphism for morphological characters of *H. agrius*, except for body width, with females having wider bodies than males, what might be related to fecundity. The most important consumed prey was orthopterans, and the trophic niche overlap between sexes did not differ from expected by chance. The dietary composition of males and females seems explained neither by differences in head shape nor of dissimilar microhabitat use. Our findings expanded the knowledge on the poorly known *H. agrius*, thereby contributing to understand the natural history of *Hemidactylus* lizards with small geographical range.

**Key words:** Caatinga, diet, lizards, microhabitat use, sexual dimorphism.

### Introduction

Space and food are two of the most important resource axes used by lizards (Pianka 1973). Thus, information on microhabitat use and diet contribute to understand which set of resources enable a species to occur in a given area. Despite the importance of these natural history information (Vitt, 2013), great part of the knowledge on *Hemidactylus* lizards came from non-native populations. For instance, the cosmopolitans *H. mabouia* (Anjos & Rocha 2008, Iturriaga & Marrero 2013), *H. turcicus* (Williams & McBrayer 2007, Paulissen et al. 2013), and *H. frenatus* (McKay et al. 2009, Cameron et al. 2013), which have continuously extended their ranges around the world (Rödder et al. 2008). Hence, advances in the knowledge on *Hemidactylus* with narrow distribution are still needed, especially for South American native species.

Among gekkonids, the genus *Hemidactylus* is one of the most species-rich, with about 100 species inhabiting a variety of habitats, including islands and man-made environments (Carranza & Arnold 2006). *Hemidactylus agrius* Vanzolini, 1978

is a rare lizard (Vitt 1995) that was first considered to be endemic to the Caatinga, in northeastern Brazil (Vanzolini 1978), but its geographical distribution has been extended to the Cerrado (Andrade et al. 2004). Recent studies have expanded our understanding of the biology of this species. For instance, parasitism by helminths (Anjos et al. 2011), reproduction (Bezerra et al. 2011, Passos & Borges-Nojosa 2011), and activity periods (Andrade et al. 2013). Nonetheless, there are still large gaps in its natural history.

Here, we provide for the first time information on microhabitat use, sexual dimorphism, and diet of a *H. agrius* population from a semi-arid Caatinga habitat. Specifically, we evaluated intersexual variation in the use of retreat sites, body size and shape, as well as diet.

### Material and Methods

We conducted the fieldwork from February to March 2010 (rainy period) in a typical Caatinga formation in northeastern Brazil. The Caatinga is a semi-arid environment, formed by a mosaic of xerophytic and thorn scrub-

land trees. The study area is at the Vale do Curu Experimental Farm, belonging to the Universidade Federal do Ceará, in Pentecoste, Ceará, Brazil (03.91760° S, 39.33823° W; Datum WGS 1984; 60m a.s.l.). The study site has an area of 142 ha of typical Caatinga habitat, where the annual average temperature is 26.8°C and the annual average rainfall is 723.3 mm, with most of the rain occurring from February to June (Leão et al. 2004).

We searched for *H. agrius* from ca. 0700h to ca. 1600h by carrying out 54 time-constrained transects of 30 minutes (Hatano et al. 2001), totaling 27 hours of sampling effort. During search, observers carefully searched for lizards by turning out all stones, fallen tree trunks, and debris. Barks of tree trunks were also inspected. Individuals were captured manually, euthanized by lethal injection of sodium thiopental, fixed with 10% formalin, and kept in 70% ethanol (Auricchio & Salomão 2002). All collected animals were deposited at the Coleção Herpetológica da Universidade Federal do Ceará, Ceará, Brazil (CHUFC L 5577 - 5632).

We recorded the type of microhabitat for each captured lizard, and the height above ground and perch circumference to the nearest 1 cm for those perched (Van Sluys et al. 2004). We measured snout-vent length (SVL), body height (BH), body width (BW), head length (HL), head width (HW), head height (HH), and inter-limb distance (ID) of collected specimens using a digital caliper (to the nearest 0.01 mm). We also dissected all specimens for sex determination by gonads inspection, and to have access to the digestive tract.

We analyzed stomachal contents (intestines discarded) under a stereoscopic microscope, identifying preys to the taxonomic level of order, except for mollusks that were identified to the class level. We then measured the maximum length and width of food items to the nearest 0.01 mm. Prey volume was estimated as the volume of a prolate spheroid:  $V = 4/3\pi (L/2) (W/2)^2$ , where "V" is the prey volume, "L" is the prey length, and "W" is the prey width (Dunham 1983). We calculated the importance index ( $I_x$ ) as the arithmetic mean of the proportions of frequency of occurrence, abundance, and volume of each prey type (Powell et al. 1990). We estimated food niche breadth of the total sampled individuals using Levins (1968) index:  $B = 1 / \sum P_i^2$ , where "i" stands for prey category, and "P" for the proportion of utilization of resource "i" (Pianka 1973). We also estimated food niche breadth for each sex, using frequency of occurrence of items and the standardized food niche breadths values, by dividing food niche breadth of each sex by the number of prey categories consumed. Then, we estimated the food niche overlap between sexes by:  $O_{jk} = \sum P_{ij}P_{ik} / \sqrt{\sum P_{ij}^2 \sum P_{ik}^2}$ , where "j" and "k" correspond to males and females, respectively (Pianka 1973).

We evaluated the intersexual variation in microhabitat use (perch height and circumference) using a multivariate analysis of variance (MANOVA), and differences in SVL between sexes using a Student's *t*-test. We tested for a difference on the head (HL, HH and HW) and body (ID, BH and BW) measurements between sexes by analysis of covariance (ANCOVA), using SVL as covariate (one

model per response variable). The observed value of food niche overlap between males and females were compared to a null model using 1,000 randomizations using EcoSimR (Gotelli & Ellison 2013). Values are presented as mean  $\pm$  one standard deviation (range). All analyses were performed in R environment (R Core Team 2013).

## Results

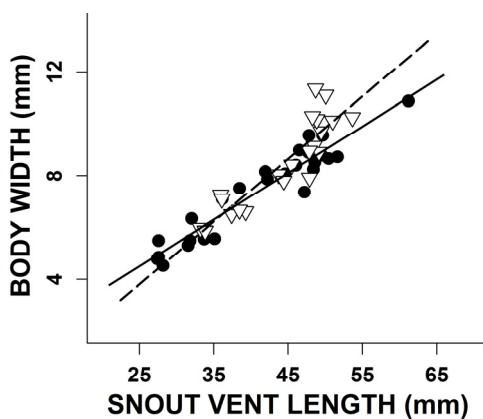
We collected 56 individuals of *H. agrius*: 21 females, 27 males, and 8 individuals that could not be reliably sexed. All lizards were immobile at first sight. The great proportion of *H. agrius* occurred beneath trunk barks of trees (84.4%,  $n = 38$ ), followed by a few ones inside termite nests (4.4%), under fallen trunks (4.4%), under stones (4.4%), and under debris (2.2%). For those under the barks of trees, the mean perch circumference was  $34.8 \pm 15.5$  cm and the mean perch height from the ground was  $113.8 \pm 78.9$  cm. For males, the average perch height was  $99.96 \pm 82.78$  cm (0 - 264 cm), and that of females averaged  $129.60 \pm 73.02$  cm (0 - 260 cm). For males, perch circumference averaged  $32.62 \pm 21.83$  cm (0 - 80 cm), and that of females averaged  $24.74 \pm 14.86$  cm (0 - 54 cm). There were no intersexual differences for perch height and circumference ( $F_{1,41} = 2.20$ ;  $P = 0.12$ ).

Males and females did not differ in SVL ( $t = 0.82$ ;  $df = 46$ ;  $P = 0.41$ ), HL ( $F_{1,45} = 1.14$ ;  $P = 0.29$ ), HH ( $F_{1,45} = 0.11$ ;  $P = 0.74$ ), HW ( $F_{1,45} = 0.19$ ;  $P = 0.66$ ), ID ( $F_{1,45} = 2.88$ ;  $P = 0.10$ ), and BH ( $F_{1,44} = 0.60$ ;  $P = 0.44$ ). Nonetheless, BW differed between males and females ( $F_{1,43} = 5.18$ ;  $P = 0.028$ ; Fig. 1), with females ( $8.49 \pm 1.70$  mm, 5.87 - 11.35 mm,  $n = 21$ ) presenting wider bodies than males ( $7.44 \pm 1.75$  mm, 4.53 - 10.89 mm,  $n = 26$ ).

We recorded 12 prey categories (Table 1), comprising eight orders of insects, three orders of arachnids, and one class of mollusks. From a total of 51 individuals analyzed, 43% presented only arthropods remnants ( $n = 20$ ) or had no preys ( $n = 2$ ) in the stomachs. The most frequent consumed preys were orthopterans (24%), spiders and scorpions (both 12%). According to the importance index, Orthoptera (0.40) was the most representative category, followed by insect larvae (0.12), and Araneae (0.09). Food niche breadth was 6.94, with standardized value of 0.53. For females, food niche breadth was 7.12 (standardized value = 0.60), and for males 4.89 (standardized value = 0.40). Observed trophic niche overlap between males and females was 0.73, not differing for the expected values under null distribution ( $P = 0.09$ ).

**Table 1.** Frequency (number of lizards that feed on each prey type), Abundance (number of preys in the stomachs), Volume (volume of ingested preys in mm<sup>3</sup>) and Index of Importance (I<sub>v</sub>) for each food category in the diet of *Hemidactylus agrius* (n = 51) from a semi-arid Caatinga area in Brazil. Percentage values are provided between parenthesis and NA means non-available data.

Food category	Frequency (%)	Abundance (%)	Volume (%)	I <sub>v</sub>
Orthoptera	12 (24)	14 (24)	1234.89 (71)	0.40
Insect Larvae	4 (8)	5 (8)	365.09 (21)	0.12
Araneae	6 (12)	7 (12)	38.55 (2)	0.09
Coleoptera	4 (8)	5 (8)	6.3 (< 1)	0.06
Diptera	2 (4)	4 (7)	7.48 (< 1)	0.04
Mollusca	2 (4)	2 (3)	26.38 (2)	0.03
Blatodea	1 (2)	1 (2)	59.94 (3)	0.02
Opiliones	1 (2)	1 (2)	4.71 (< 1)	0.01
Insect Nymph	1 (2)	1 (2)	1.05 (< 1)	0.01
Hymenoptera	5 (10)	6 (10)	NA	NA
Scorpiones	6 (12)	6 (10)	NA	NA
Lepidoptera	4 (8)	7 (12)	NA	NA
Total		48 (100)	1744.39 (100)	



**Figure 1.** Sexual dimorphism in relative body width for *Hemidactylus agrius* from a semi-arid Caatinga area in Brazil. Circles and solid line are males (n = 26), triangles and dashed line are females (n = 21).

## Discussion

The majority of the individuals of *H. agrius* were found inactive beneath barks of trees during daylight. As the species has nocturnal habits (Andrade et al. 2013), our data show that such microhabitat could represent suitable retreat sites. We suggest that *H. agrius* might benefit from the protection that barks of trees provide against predators, and even if barks are removed, lizards are still able to escape, running up and spinning around the trunk. In addition, thermal characterization of retreat sites was an important factor affecting sprint performance for other gekkotan species (Aguilar & Cruz 2010, Vasconcelos et al. 2012).

Hence, we cannot disregard the thermal importance of shelter environment for *H. agrius*, as in the Caatinga ground and air temperatures can easily pass over 40°C (Galdino pers. obs.). Additionally, barks *per se* might also act as a heat insulator during warmer periods of the day.

Males and females of *H. agrius* used perches in similar ways, and did not differ morphologically, except for body width. In fact, lizard morphology is often related to how individuals use habitats (e.g. Butler et al. 2000). Therefore, intersexual similarities in microhabitat use of *H. agrius* might be related to similarities in body shape of both sexes. Sexual size dimorphism is not a common trend in *Hemidactylus* lizards (Saenz & Conner 1996, Anjos & Rocha 2008), hence we cannot disregard a phylogenetic effect on the morphological similarities for body size between sexes in the genus *Hemidactylus* (McMahan & Zug 2007). Notwithstanding, females *H. agrius* had wider bodies than males. It is known that clutch size in gekkotans is phylogenetically constrained and species usually produce one or two eggs (Kratohvíl & Kubicka 2007). Therefore, increasing egg volume is the main way females have to maximize their fitness (Doughty 1997). Thus, selective forces to produce voluminous eggs might be related to larger body width in females of *H. agrius* compared to males, as found for other lizards (e.g. Braña 1996, Pinto et al. 2005).

The most important consumed prey of *H. agrius* was orthopterans, and there was a great number of individuals with empty stomachs. Orthopterans also contributed to a great proportion of the diet of congeners *H. mabouia* (Rocha & Anjos 2007) and *H. turcicus* (Saenz 1996). Thus, al-

though *Hemidactylus* species are usually generalists in feeding habitats (Bonfiglio et al. 2006, Albuquerque et al. 2013), orthopterans seem to be an important item in the diet of these lizards. The proportion of empty stomachs can be used as a proxy of energetic balance of a population, and many nocturnal lizards tend to have no stomach content (Huey et al. 2001). Even in the rainy period, when food availability is higher in the Caatinga, the proportion of empty stomachs in studied population of *H. agrius* (43%) was much higher than that reported for nocturnal gekkonids (21%; Huey et al. 2001), as well that found for two different populations of the congener *H. mabouia* (4.6% in Espírito Santo state - Zamprogno & Teixeira 1998, 4.8% in São Paulo state - Rocha & Anjos 2007).

The diet composition of females *H. agrius* was broader than of males, and trophic niche overlap between sexes did not differ from expected by chance. Intraspecific dietary divergences in lizards may be related to intersexual dissimilarities in morphology or microhabitat use (Saenz 1996, Rocha and Anjos 2007). Thus, given that we did not find differences between males and females in these aspects, no intersexual difference in the diet should be expected. On the other hand, intersexual food partitioning may reduce intraspecific competition (Schoener 1967), as found for *H. turcicus*, in which females preferred ground-dwelling preys, whilst males tended to feed more on flying preys (Saenz 1996). Therefore, diet composition of males and females of *H. agrius* seems neither explained by differences in head shape nor dissimilar microhabitat use between sexes as in *H. mabouia* (Rocha and Anjos 2007).

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