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Tail-break frequency inferences on *Lygodactylus klugei* (Smith, Martin & Swain, 1977) (Squamata: Gekkonidae) in northeastern Brazil

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ABSTRACT
We investigated the sexual, interpopulational, and microhabitat use effects on the autotomy frequencies in the Kluge's Dwarf Gecko *Lygodactylus klugei* in 12 populations inserted in the Caatinga ecoregion, in northeast Brazil. We observed the frequency of autotomized tails in each population by analyzing sexual differences and the characteristics of the trees used, such as the number of branches, presence of thorns, and trunk texture (smooth or rough). The autotomy frequencies ranged from 28.5% to 75% among these populations. We did not find differences in population, sex or on the presence of thorns and number of branches available in the trees used on autotomy rates. On the other hand, lizards found on smooth trunks had a higher rate of autotomized tails compared to those found on rough trunks. We suggest that the presence of crevices in trees with rough trunks is an important factor responsible for protecting lizards against predator attacks.

Key Words: Antipredator behavior; Caatinga; Lizards; Predation; Tail autotomy.

Caudal autotomy in lizards is very common, occurring in many families (Gordeev *et al*., 2020), and it serves to benefit the organism in two distinct ways: i) the initial detachment of the tail from the body enables the lizard to escape away from a predator's grasp even after having been captured (Clause and Capaldi, 2006), and ii) once severed from the rest of the body, the shed tail is frequently capable of vigorous, violent movements on its own, distracting the predator from any further attack and providing the animal with time to flee to safety (Higham *et al*., 2013). However, the use of this strategy can cause social, energetic, locomotor, as well as in the life history losses of the species (see review in Bateman and Fleming, 2009).

In many studies, tail-break frequency is used as indirect measure of predatory pressure, as the presence of autotomized tails may be the result of unsuccessful predation attempts (Bateman and Fleming, 2011; Passos *et al*., 2013; Lin *et al*., 2017). Other interpretations also refer the frequency of autotomies to intraspecific competition, in cases of lizards competing for territory or for reproduction (Donihue *et al*., 2016; Itescu *et al*., 2017; BeVier *et al*., 2021; for more interpretations, see Bateman and Fleming, 2009).

Among the causes known for affecting caudal autotomy, there are factors such as: temperature, sex, age, and body shape (Bateman and Fleming, 2009; Fleming *et al*., 2013). In addition, research has also shown that the autotomy frequencies can also vary in response to habitat (Duckett and Stow, 2011; Sousa *et al*., 2016). Therefore, investigating differences in the presence of lizards with autotomized

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tails between different conditions expressed by the microhabitat can provide information on how these locations affect the risk of predation (Smith and Ballinger, 2001). That being said, this study aimed to investigate the populational, sexual, and mainly effects on the microhabitat use on the frequency of tail break of the Kluge's Dwarf Gecko *Lygodactylus klugei* (Smith, Martin & Swain, 1977), considering this parameter as indirect measure of susceptibility to predation.

Data collection was conducted during 13 months (from July 2018 to July 2019) in 12 municipalities, along five states in northeastern Brazil: Aiuaba (6°36'03"S, 40°07'24"W), Crateús (5°08'14"S, 40°51'58"W), Pentecoste (3°49'06"S, 39°20'20"W), Potiretama (5°45'35"S, 38°08 '22"W) and Quixadá (5°07'49"S, 39°03'59"W), in the state of Ceará; Caetés (8°46'32"S, 36°43'06"W), Carnaubeira da Penha (Type locality, 8°30'09"S, 38°39'42"W) and Petrolina (9°15'15"S, 40°23'57"W), in the state of Pernambuco; João Câmara (5°33'37"S, 35°54'12"W) and Mossoró (5°11'48"S, 37°20'02"W), in the state of Rio Grande do Norte; Patos (7°03'35"S, 37°16'30"W) in the state of Paraíba; and Coronel José Dias (8°50'34"S, 42°33'36"W) in the state of Piauí. We performed active searches during daytime (0700 – 1800) collecting about 20 individuals per locality. After the capture, we made notes on the characteristics of the perches used, such as: trunk texture (smooth or rough, see Fig. 1), presence of thorns, and the number of branches available at chest level (approximately 1.50 m). During the collection processing, we observed the presence of autotomized tails. After taking notes, the lizards were anesthetized with the use of 2% lidocaine gel orally, then sacrificed with an overdose of 2% liquid lidocaine via intracoelomic (following the Conselho Federal de Biologia, Portaria 148/2012), and housed in the Coleção Herpetológica da Universidade Federal of Ceará – CHUFC (Appendix). We used chi-square goodness-of-fit test to verify whether the proportion of captured males and females deviated from the expected 1:1 ratio (Chapple and Swain, 2004). We investigated possible interpopulational, sexual and perch differences in the characteristics of the perch used (trunk texture, presence of thorns, and number of branches available) in the frequencies of intact and autotomized tails using G-test (Sokal and Rohlf, 1995). We conducted all tests using the R v.4.0.4 software (R Development Core Team, 2021) with significance levels of 0.05.

In total, we captured 249 individuals of *L. kluguei* among which 134 males, 105 females, and 10 juveniles. One male who performed multiple autotomies during the capture was excluded from the analysis, as it was not possible to determine previous autotomies. Eight individuals found in non-arboreal habitats were excluded from the analyzes that addressed perch characteristics. The proportion of males (133) and females (105) did not deviate from the expected pattern of 1:1 (X-squared = 3.2941, df = 1, P = 0.06). The percentage of individuals with autotomized tails among the populations ranged from 28.5% to 75% (Table 1). There were no differences in the autotomiy frequencies between locations (G-test = 13,186, df = 11, P = 0.281). Considering all records, males (54.13%; n = 133) and females (46.66%; n = 105) did not differ in the presence of autotomized tails (G-test = 1.3106, df = 1, P = 0.252; Fig. 2A). There were also no differences between the classes of branches available at chest level (G-test = 2.3507, df = 3, P = 0.502; Fig. 2B), or in lizards that used thorn trees (G-test = 3.0557, df = 1, P = 0.08; Fig. 2C). However, we found differences for the trunk texture used (G-test = 4.4036, df = 1, P = 0.03; Fig. 2D), with individuals found in smooth trunks (55.71%; n = 140) presenting higher frequency of autotomized tails in comparison to individuals found on rough trunks (42%; n = 100).

Previous studies with *L. klugei* performed in Exú, Pernambuco, Vitt and Ballinger (1982) found a lower autotomy frequencies (38.5%) than those recorded in most of the localities investigated here (Table 1). Generally, geckos (Gekkota) have relatively high autotomy rates, above 50% (Vitt, 1983; Daniels, 1985; Vitt and Zani, 1997; Vitt *et al.*, 2007; Duckett and Stow, 2011; Recoder *et al.*, 2012; Itescu *et al.*, 2017), ranging from 40.9 to 59% for the African congener, *L. capensis* (Pianka and Huey, 1978; Medger *et al.*, 2008; Fleming and Bateman, 2012). This pattern remained similar for most of our observations. Although there are reports of intraspecific clashes for the species (Costa, 2014) we consider it unlikely that these encounters are violent enough to result in tail loss by individuals. Except for a single report of predation by *Felis catus* (Costa, 2014), nothing is known about natural predation on *L. klugei*. However, due to their small size, these lizards can have a great diversity of potential predators, such as: arthropods, other lizards, snakes, birds and small mammals, which can contribute to high autotomy rates (Sousa *et al.*, 2016; Savvides *et*

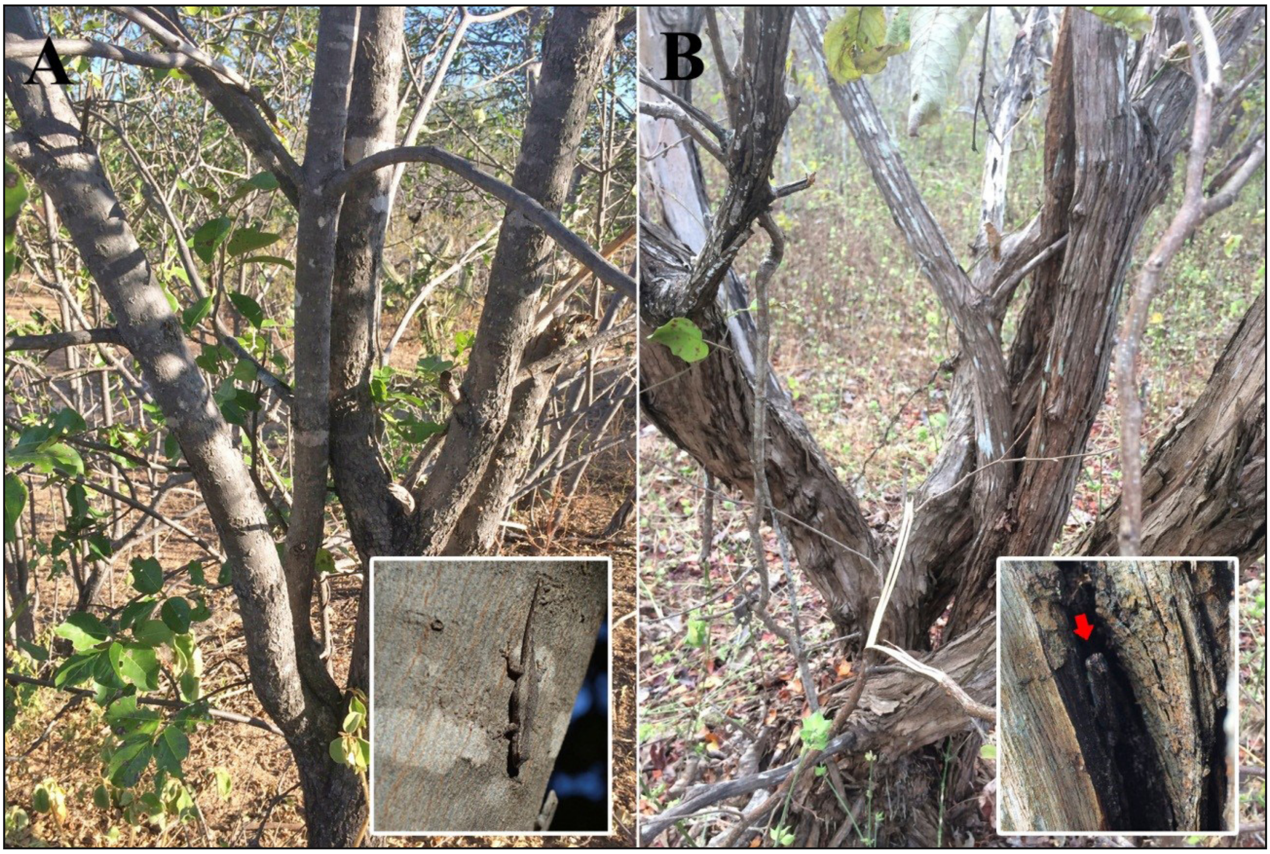

Figure 1. Specimens of trees with smooth (A) and rough (B) trunks with details for the use of the respective trunk types by *L. klugei*.

al., 2018). Although the use of this strategy can cause locomotor impairments (Fleming *et al.*, 2009), the associated costs seem to be minimized by rapid limb regeneration in the species (Vitt and Ballinger, 1982).

Vegetation cover and habitat complexity are some of the known factors that can influence the autotomy frequencies among different populations, with individuals living in more open environments which make them more susceptible to being preyed upon (Tanner and Perry, 2007; Duckett and Stow, 2011; Galdino *et al.*, 2017). Although our surveys were conducted in places that have different phytophysiognomies, including places inserted in urban environments (municipality of Patos), this difference was not significantly evidenced in our results; however, a large amplitude in the frequencies observed among populations (28.5% to 75%) may be an indication for further investigation.

Since they have different social roles, male and female lizards may show differences in the patterns in which they perform autotomy (Itescu *et al.*, 2017). However, most studies investigating sexual bias in tail loss not found these differences (Nunes *et al.*, 2012; Recoder *et al.*, 2012; Passos *et al.*, 2013; Sousa *et al.*, 2016; Pafilis *et al.*, 2017; and others). The absence of these differences in *L. klugei* may represent behavioral similarities, suggesting that both sexes may be similarly exposed to predatory pressure (Passos *et al.*, 2013). Our results are in line with those obtained by Vitt and Ballinger (1982), where sexual differences were observed with female bias, which was attributed to possible behavioral differences in individuals from that population.

The antipredatory behavior exhibited by lizards can vary in response to the physical environment in which they are inserted (Grolle *et al.*, 2014; Salido and Vicente, 2019). Differences in autotomy frequencies between trunk texture observed in our results may reflect the cryptic quality provided by these sites, with lizards being more or less exposed to visually oriented predators (Cuadrado *et al.*, 2001; Bateman and Fleming, 2011; Galdino *et al.*, 2017). Furthermore, even thoughtrees with rough trunks may have uneven surfaces, which can be detrimental to the escape velocity (Vanhooydonck *et al.*, 2005), proximity to places that function as shelters, represented in this case by the crevices that this type of microhabitat provides, can be an advantage during

Table 1. Tail-break frequency by population of *Lygodactylus klugei* of the Caatinga ecoregion, in northeast Brazil.

Localities	% (n)
Aiuaba	50.0 (20)
Caetés	45.0 (20)
Carnaubeira da Penha	42.8 (21)
Coronel José Dias	60.0 (20)
Crateús	45.0 (20)
João Câmara	75.0 (20)
Mossoró	28.5 (21)
Patos	52.1 (23)
Pentecoste	57.14 (21)
Petrolina	47.6 (21)
Potiretama	52.38 (21)
Quixadá	35.0 (20)
All	49.19 (248)

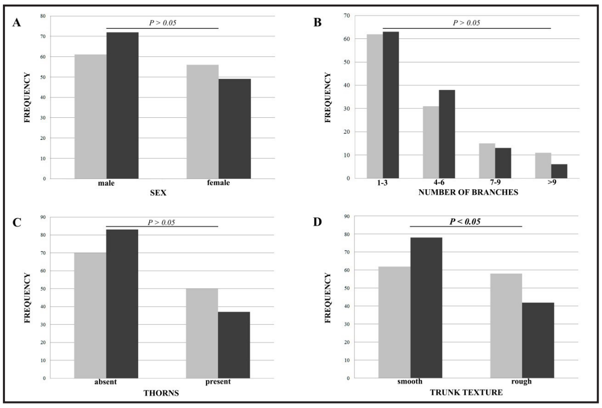

Figure 2. Frequency of lizards with tails intact (light gray bars) and autotomized (dark gray bars) in relation to sex (A), number of branches available at chest level (B), thorns (C) and trunk texture (D) with the respective significance values of the G-test.

the escape (Cooper and Whiting, 2007; Salido and Vicente, 2019). Even though *L. klugei* frequently performs short jumps between branches to get around (Vitt and Ballinger, 1982) and escape capture (pers. obs.), the number of branches available in the tree may not be a relevant element for escape. Likewise, the presence of thorns on the trees used may not provide mechanical protection against the lizard natural predators. Our studies provide new perspectives to be investigated in arboreal lizards, helping to understand how the microhabitat structure can affect the predation risk for these animals.

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Appendix. Material examined from Coleção Herpetológica da Universidade Federal of Ceará (CHUFC): Aiuaba (CHUFC L7420-7423, 7425-7432, 7434-7438 and 7440); Caetés (CHUFC L7508-7509 and 7511-7526); Carnaubeira da Penha (CHUFC L7527-7530, 7532-7534, 7536-7537 and 7539-7547); Coronel José Dias (CHUFC L7461-7471, 7473-7477 and 7479-7480); Crateús (CHUFC L7441-7450 and 7452-7460); João Câmara (CHUFC L7355-7357 and 7359-7373); Mossoró (CHUFC L7375-7377, 7379-7383, 7385-7388, 7391-7392 and 7394-7397); Patos (CHUFC L7312-7314, 7316, 7318-7323 and 7325-7335); Pentecoste (CHUFC L7251-7271); Petrolina (CHUFC L7483-7487, 7489-7495 and 7497-7500); Potiretama (CHUFC L7293-7296, 7298-7300, 7302-7304 and 7307-7312); and, Quixadá (CHUFC L7272-7287 and 7289-7290).