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Short Communication

Communal nesting and clutch characterization of *Lygodactylus klugei* (Squamata: Gekkonidae) from Brazilian semiarid region

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Communal nesting is a reproductive tactic used by many lizards (Graves and Duval 1995, Carvajal-Ocampo *et al.* 2019). It refers to egg laying by different conspecifics or by different species in a single shared nest (Espinoza and Lobo 1996). Of the different hypotheses explaining this behavior, avoidance of predation (Somaweera 2009) and the shortage of suitable nesting places (Rand 1967, Oda 2004) are the most accepted. This behavior, in addition to favoring offspring, can also be advantageous to females because depositing eggs in a place already chosen by other females requires less energy and results in lower predation risk during the search for nesting sites (Graves and Duvall 1995, Montgomery *et al*. 2011).

Recorded observations of communal nesting in lizards of different families have increased in neotropical regions, including Teiidae (Magnusson and Lima 1984, Filadelfo *et al*. 2013), Dactyloidae

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(Montgomery *et al*. 2011), Sphaerodactylidae (Oda 2004, Oliveira *et al.* 2014, Carvajal-Ocampo *et al*. 2019, Sales *et al*. 2020), Phyllodactylidae (Vitt 1986, Rigui *et al*. 2004, Ávila and Cunha-Avellar 2005, Cassimiro and Rodrigues 2010, Lima *et al.* 2011, Domingos *et al.* 2017), and Gekkonidae (Sousa and Freire 2010, Bezerra *et al*. 2011). Communal nests have been reported for the gekkonid genus *Lygodactylus* on the African continent (Greer 1967, Simbotwe 1983, Rodríguez-Prieto *et al*. 2010), but currently no records of this behavior have been reported for South American species.

The genus *Lygodactylus* Gray, 1864 is composed by 64 species: 62 occur in Africa and Madagascar, and two occur in South America (Uetz *et al.* 2022). In Brazil, in addition to these two species, *Lygodactylus wetzeli* (Smith, Martin, and Swain, 1977) and *Lygodactylus klugei* (Smith, Martin, and Swain, 1977), three putative cryptic species have been detected (Lanna *et al.* 2018). *Lygodactylus klugei* is one of the smallest Brazilian gekkonids and has diurnal and arboreal habits (Vitt and Ballinger 1982, Galdino *et al*. 2011, Teixeira *et al*. 2013). The species has a wide distribution in the Caatinga, extending from the state of Piauí to the state of Bahia. It also occurs in Dry Tropical Forest enclaves within the Cerrado (Vanzolini 1974, Rodrigues 2003, Mesquita *et al*. 2017, Lanna *et al.* 2018, Costa *et al.* 2021).

Lygodactylus klugei is a relatively well-known species, with studies detailing its diet (Vitt 1995, Galdino *et al.* 2011, Teixeira *et al.* 2013, Aximoff and Felix 2017, Silva *et al.* 2021), morphology (Vitt and Ballinger 1982), behavior (Teles *et al*. 2018), annual activity (Passos *et al*. 2016), parasitology (Anjos *et al*. 2011), and phylogeography (Lanna *et al*. 2018, Lanna *et al*. 2019). In terms of sexual dimorphism, females have larger body sizes and males have larger heads (Vitt 1986, Galdino *et al*. 2011). Reproduction is continuous throughout the year; egg mass is not related to female size, and each female deposits only two eggs per clutch (Vitt 1986). Herein we present the first records of communal nesting for *L. klugei* and provide additional information on egg and neonate morphometry.

Occasional records of nests of *L. klugei* were obtained from five localities between March 2018 and July 2019 (Figure 1). Three localities were in the state of Rio Grande do Norte (Campus Central da Universidade Federal Rural do Semi-Árido (UFERSA) and Estação Experimental - municipality of Mossoró, and Floresta Nacional de Açu - municipality of Assu), one in the state of Pernambuco (Sítio Russa Mansa - municipality of Itapetim) and one in the state of Ceará (countryside of the municipality of Mauriti). All measurements were taken to 0.01 mm. We measured egg length, diameter, and mass at the Rio Grande do Norte and Ceará localities. At the Pernambuco and Ceará localities, we assessed incubation time in the laboratory and measured egg mass and neonate snout–vent length (SVL). We recorded the color (white, yellow, light yellow, and grey) of the eggs when they were found in nature.

We used data from 25 eggs (from five localities) and five neonates (two from Itapetim and three from Mauriti) from both single and communal nests. We provide the median and the 1st and 3rd quartile for the morphometric egg measurements (length, diameter, and mass) and the mean and standard deviation for the morphometric neonate measurements (SVL and mass) (Table 1).

Material collected in the states of Pernambuco and Ceará was deposited in the Laboratório de Herpetologia da Universidade Federal de Campina Grande (LHUFCG), Patos municipality, state of Paraíba (LHUFCG 2632–2637). Samples from Rio Grande do Norte state were deposited in the Coleção Herpetológica do Semiárido (CHSAR), in Mossoró municipality, state of Rio Grande do Norte (CHSAR 028–031, 1058–1059, 1319–1320).

Of the eight sampled nests (six in Rio Grande do Norte state, one in Pernambuco state, and one in Ceará state), some contained one egg (N = 3), while others contained two (N = 1), three

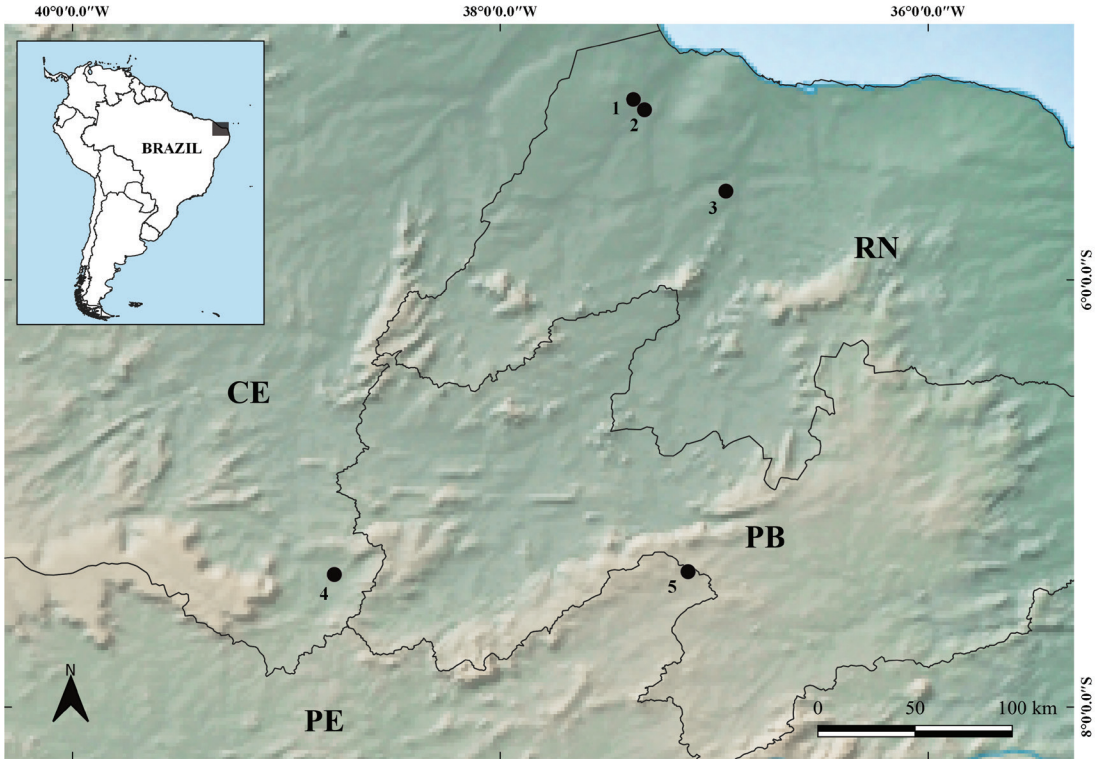

Figure 1. Localities of northeastern Brazil with *Lygodactylus klugei* communal nesting records: 1. Estação Experimental and 2. Campus Central of the Universidade Federal Rural do Semi-Árido, both in Mossoró municipality, Rio Grande do Norte state; 3. Floresta Nacional de Açu, in Assu municipality, Rio Grande do Norte state; 4. Locality in Mauriti municipality, Ceará state; and 5. Sítio Russa Mansa, in Itapetim municipality, Pernambuco state. Legend for Brazilian states: RN, Rio Grande do Norte; PB, Paraíba; PE, Pernambuco; CE, Ceará.

(N = 1), four (N = 1), six (N = 1), and eight eggs (N = 1) (Figure 2). Although this species is known for having a fixed clutch size of two eggs (Vitt 1986), we recorded three nests of *L. klugei* (37.5%) with a single egg and another nest with three eggs (12.5%). If these nests were created by young and/or small adult females, it is also possible that one of the eggs was preyed upon. However, given that the eggs of communal nests with three or more eggs (62.5%) were joined by the shells in different positions to each other (Figure 2), it seems unlikely that the nests observed with only one egg were the result of predation events on an individual egg. Other species in the genus *Lygodactlylus* produce clutches with two eggs that are often attached to each other (Glaw and Vences 1994, Bruse *et al.* 2005, Rodríguez-Prieto *et al.* 2010). The size of communal nests of *L. klugei* suggests the participation of two to four females per nest, which is similar to observations recorded for *Lygodactylus thomensis wermuthi* (Peters, 1881) in São Tomé and Príncipe in Central Africa. At least three females participated in egg deposition in those nests (Rodríguez-Prieto *et al.* 2010).

We observed nests during a rainy month (March), as well as during months with low or no precipitation (July and August) (Table 2),

Figure 2. *Lygodactylus klugei* communal nests in northeastern Brazil. Communal nesting with (**A**) eight eggs found in Mauriti, Ceará state, (**B**) three eggs in a cactus trunk in Itapetim, Pernambuco state, (**C**) four eggs in a tree trunk at the Estação Experimental, in Mossoró, Rio Grande do Norte state, and (**D**) six eggs found at the Floresta Nacional de Açu, in Açu, Rio Grande do Norte state.

reinforcing the notion that *L. klugei* has continuous breeding behavior, as observed by Vitt (1986). Egg features, such as hard eggshells and small clutch sizes (1–2 eggs), may be related to the continuous breeding behavior of this species throughout the year, which occurs in many species of gekkonids (Vitt 1986, Serrano-Cardozo *et al.* 2007, Anjos and Rocha 2008, Díaz-Pérez *et al.* 2017). Microenvironments selected for oviposition can provide suitable conditions for incubation in terms of moisture and temperature even in arid and semiarid environments like the Caatinga (Vences *et al*. 2004).

Most of the communal nests recorded in this

Table 1. Comparison of *Lygodactylus klugei* egg and neonate measurements from the present study, from Vitt (1986), and from other species in the genus. SVL = snout–vent length, NA = not available. Legend for localities: [a]Exu, Brazil, [b]Kafue Flats, Zambia, [c]Island of São Tomé, São Tomé and Príncipe, [d]Mount Namuli, Mozambique, [e]Lake Ihotry, Madagascar.

Species	Egg length (mm)	*N*	Egg diameter (mm)	*N*	Egg mass (g)	*N*	Neonate SVL (mm)	*N*	Neonate body mass (g)	*N*	Source
L. klugei	6.67 (Q1 6.49; Q3 6.89)	22	5.35 (Q1 5.17; Q3 5.51)	22	0.10 (Q1 0.08; Q3 0.14)	25	12.47 ± 0.31	5	0.04 ± 0.03	5	Present study
L. klugei	6.57 ± 0.06	94	4.48 ± 0.05	94	0.07 ± 0.002	94	14.00	94	0.04 ± 0.03	5	Vitt 1986[a]
L. capensis	6.40 ± 0.76	~24	4.70 ± 0.57	~24	NA			NA	NA	NA	Simbotwe 1983[b]
L. chobiensis	6.50 ± 1.22	~90	4.70 ± 0.73	~90	NA		15.17 ± 0.34	6	NA	NA	Simbotwe 1983[b]
L. thomensis wermuthi	6.00	16	NA	NA	NA		13.00	2	NA	NA	Rodrígez-Prieto *et al.* 2010[c]
L. regulus	7.7–8.00	NA	NA	NA	NA		16.80	NA	NA	NA	Portik *et al.* 2013[d]
L. verticillatus	4.50–6.70	13	3.00–5.25	13	NA		8–12	NA	NA	NA	Vences *et al.* 2004[e]

Table 2. Communal nesting features of *Lygodactylus klugei* found in four of the five study localities. Legend for Brazilian states: CE, Ceará, PE, Pernambuco, RN, Rio Grande do Norte. EE = Estação Experimental, FLONA-AÇU = Floresta Nacional de Açu.

Localities and dates	Number of eggs	Egg color	Substrate	Incubation time (days)
Mauriti, CE (20 July 2019)	8 (Figure 2A)	White (*N* = 6) and yellow (*N* = 2)	Tree trunk	32
Itapetim, PE (21 March 2018)	3	Yellow (*N* = 1), light yellow (*N* = 1) and grey (*N* = 1)	Cactus trunk (Figure 2B)	Not available
EE, RN (15 August 2018)	4 (Figure 2C)	White	Tree trunk (Figure 2C)	37 ± 14
FLONA-AÇU, RN (18 August 2018)	6 (Figure 2D)	White	Tree trunk	37 ± 14

study were found in tree trunks (Table 2), which is similar to nest microhabitats recorded by Vitt (1986). Individuals of this species are often active on tree trunks and branches of shrubs of different species in the Caatinga (Vitt 1986, Teixeira *et al.* 2013, Aximoff and Felix 2017, Silva *et al.* 2021) and less commonly observed in cacti, as found in this study.

Of the eight eggs observed in the Mauriti communal nest, two that were yellow did not hatch. Three of the neonates escaped from the terrarium. Therefore, the morphometric data was recorded for three remaining individuals in this locality. None of the eggs (with yellow, light yellow, and grey coloration) in the Itapetim communal nest hatched (Table 2). Thus, we used data of two neonates from one of the four eggs at the Estação Experimental communal nest was broken during handling; thus, we presented the measurements of 25 eggs.

Non-white eggs produced by this species did not hatch successfully in two different localities (Mauriti-CE and Itapetim-PE) (Table 2). No information about nonviable egg color was found in the literature for avian or non-avian reptiles. Nevertheless, this attribute could be explored in experimental studies about development/ incubation of oviparous species under different environmental conditions or in conservation projects that breed species in captivity with the aim of future re-introductions. Although the incubation period varied between 32 and 37 days in the laboratory (Table 2), the exact date of oviposition was not known. We cannot determine an accurate estimate of the incubation period for this species.

The median egg length, diameter and mass recorded here were similar to the measurements found by Vitt (1986) for a population in Exu-PE (Table 1). Additionally, the length and diameter of the eggs of *L. klugei* did not seem to differ greatly from other congeneric species found on the African continent (Table 1). Eggs with a length of approximately 6.5 mm may constitute an ancestral characteristic of the *Lygodactylus* genus. The mean neonate body size and mass recorded here were lower in relation to the population studied by Vitt (1986). Mean body size was also smaller than that of the three African species (*Lygodactylus chobiensis, L. thomensis,* and *L. regulus*) (Table 1).

Although Vitt (1986) did not record communal nesting in *L. klugei* in his long-term study, we recorded at least one communal nest in four relatively distant localities (between 62 and 290 km). This behavior could be more common than previously assumed for the species. Our findings about communal nesting and neonate morphometry of *L. klugei* expand the knowledge of reproductive ecology and behavior of *Lygodactylus,* contributing to the understanding of reproductive strategies of gekkonid lizards from highly seasonal dry environments, as the Brazilian semiarid region.

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