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A case of communal egg-laying of *Gonatodes albogularis* (Sauria, Sphaerodactylidae) in bromeliads (Poales, Bromeliaceae)

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Abstract

The Neotropical Yellow-Headed Gecko *Gonatodes albogularis* commonly use cavities in the trees as a microhabitat for egg-laying. Here, we present the first record of this species in Colombia using the tank bromeliad *Tillandsia elongata* as nesting sites, along with the occurrence of communal egg-laying in that microhabitat.

Key Words

Andean disturbed, Colombia, forests, communal egg-laying, nesting sites, *Tillandsia elongata*

Introduction

Tank bromeliads (Bromeliaceae) are phytotelmata that potentially provide humidity, resources and shelter to vertebrates (Benzing 2000; Schaefer and Duré 2011; Silva et al. 2011; McCracken and Forstner 2014). Some lizard species are considered as bromeligenous (*sensu* Peixoto 1995) because they have been recorded using bromeliads as oviposition sites (e.g. *Anolis alutaceus*: Dunn 1926; *Gonatodes humeralis*: Maciel et al. 2005; *Phyllopezus pollicaris*: Ávila and Cunha-Avellar 2005). In some of those records (Ávila and Cunha-Avellar 2005; Maciel et al. 2005), nests have been considered communal when two or more conspecific females deposit groups of eggs (Espinoza and Lobo 1996; Doody et al. 2009).

The communal egg-laying is a common breeding behaviour of lizards (Graves and Duvall 1995; Doody et al. 2009), which has been recorded in some species of *Anadia* (Mendoza and Rodríguez-Barbosa 2017), *Anolis* (Rand 1967; Estrada 1987; Montgomery et al. 2011), *Gonatodes* (Quesnel 1957; Rivero-Blanco 1964; Vitt et al. 1997; Oda 2004; Rivas Fuenmayor et al. 2006; Jablonski 2015), *Gymnodactylus* (Cassimiro and Rodrigues 2010), *Hemidactylus* (Bezerra et al. 2011; Sousa and Freire 2010), *Kentropyx* (Magnusson and Lima 1984; Filadelfo et al. 2013), *Lygodactylus* (Greer 1967), *Neusticurus* (Uzzell 1966), *Pholidobolus* (Ramos-Pallares et al. 2013), *Phyllopezus* (Ávila and Cunha-Avellar 2005; Lima et al. 2011), *Ptychoglossus* (Medina-Rangel and López-Perilla 2014), *Ptyodactylus* (Mateo and Cuadrado 2012) and *Sphenomorphus* (Ota et al. 1989).

Gonatodes albogularis (Duméril and Bibron 1836) is a gecko species distributed from the south of Mexico to the north of South America (Colombia and Venezuela) and the Caribbean islands (Aruba, Cuba, Curaçao, Haiti, Jamaica and Martinique), with introduced populations in Florida (United States) and Caiman islands (Schwartz and Henderson 1991; Krysko 2005; Uetz et al. 2017). This diurnal lizard is mainly found in tropical dry forests below 1900 m elevation (Moreno-Arias 2016) and also in disturbed areas (Savage 2002). Furthermore, *G. albogularis* is found on trunks and trees branches, under rocks, debris and, with less frequency, in the soil litter (Schwartz and Henderson 1991; Savage 2002; Köhler 2003; Domínguez-López et al. 2015). Females commonly use tree holes to deposit a single egg (Sexton and Turner 1971), but there are some reports of communal egg-laying in the base of trees in Costa Rica and Panama (Sexton and Turner 1971; Fitch 1973; Serrano-Cardozo et al. 2007; Jablonski 2015). We are not aware of any published report of *G. albogularis* using other types of microhabitats to nest. In this paper, we present for the first-time evidence of *G. albogularis* both nesting in tank epiphytic bromeliads (*Tillandsia elongata*) and for the occurrence of communal egg-laying in those bromeliads.

Materials and methods

We recorded the nests of *G. albogularis* in a mixed forest near the train track in the "Bosques de la Esmeralda" municipality of Chinchiná (Caldas, Colombia), western versant of the Cordillera Central (5.050642, -75.741902, datum WGS84; elev. 866 m). This locality is a tropical moist forest (following Holdridge 1996), with a bimodal rainfall regime consisting of two dry seasons in January-March and July-August, respectively and two rainy seasons in the months of April-June and October-November, respectively, a mean annual precipitation of 2245 mm and a mean annual temperature of 22.5°C (range 17.6–29.7°C). The "Bosques de la Esmeralda" are a mosaic of vegetation formed by the natural regeneration of a mixed forest plantation, initially constituted in the early 1970s by four species of native trees (*Aegiphila grandis*, *Cedrela odorata*, *Cordia alliodora* and *Cupania americana*) (Guzmán and Baldión 2003; Castaño-Villa et al. 2008; Sanín et al. 2014).

Figure 1. Presence of egg (long egg axis = 5.8 mm) of *Gonatodes albogularis* in the bromeliad I-06 of *Tillandsia elongata* collected in "Bosques de la Esmeralda" (Chinchiná, Caldas, Colombia).

On 4 August 2017, between 1100 h and 1300 h, we sampled 18 individuals of the bromeliad *T. elongata* located at a height of 4–5 m on Pink Cedar trees (*Cedrela odorata*). The bromeliads were transported to the Ecology laboratory at Universidad de Caldas (Manizales, Colombia). For each of the bromeliads were measured the rosette diameter (D in cm, following Richardson 1999), height of the rosette (HR), number of leaves (NL) and the litter accumulated amount (= weight in g). We found both eggs (Fig. 1) and individuals of *G. albogularis* of different ages (neonate, juveniles and adults) in the bromeliad receptacles. We counted the eggs and the long axis was measured (LA in mm). The development state of the eggs was determined through ovoscopy (Organización Mundial de la Salud & Organización de las Naciones Unidas para la Agricultura y la Alimentación 2009). We measured all recorded individuals for snout-vent length (SVL in mm). We made the morphometric measures with digital calipers (to the nearest 0.02 mm) and the weight of the litter was recorded with electronic scales (to the nearest 0.001 g). Eggs were preserved in 96% ethanol and the lizards were sacrificed with lidocaine 2%, fixed in 10% formaldehyde solution and preserved in 70% ethanol. We deposited all specimens in the Museo de Historia Natural de la Universidad de Caldas (two adult females: MHN-UCa 0346–0347; one adult male: MHN-UCa 0348; one juvenile: MHN-UCa 0349; two neonates: MHN-UCa 0351–0352; eggs: MHN-UCa 0352). Statistical data are given as mean ± 1 SD.

Results

Of all 18 bromeliads sampled, the mean of the rosette diameter was 103.1 ± 13.8 cm (range = 83.4–130 cm), height of the rosette was 71.2 ± 9.2 cm (range = 59.0–94.2 cm), number of leaves was 54.4 ± 20.3 (range = 31–113) and the litter accumulated amount was 14.55 ± 8.73 g (range = 0.6–31.4 g). We found amongst the receptacles of 33% (n = 6) of the bromeliads, eggs, juveniles and adults of *G. albogularis* (Table 1). In these bromeliads, both the rosette diameter and the litter accumulated amount were 103.8 ± 11.4 cm (range = 91–123.5 cm) and 21.5 ± 8.9 g (range = 7.4–31.4 g), respectively (Table 1).

The documented specimens of *G. albogularis* were eight eggs in different states of development, two hatchlings, two juveniles and three adults (two females and one male) (Table 1). Together with empty eggshells in bromeliad I-04, we found five eggs, one hatchling and three adults. We consider this finding as an example of a communal oviposition. The mean number of eggs per bromeliad was 1.3 ± 1.9 (range = 1–5 eggs), which had a mean length of 5.8 ± 0.04 mm. Mean SVL of adults was 35.8 ± 4.1 mm (n = 3) and that of hatchlings and juveniles was 19.7 ± 5.6 mm (n = 4) (Table 1). We did not ob-

Table 1. Morphological characteristics of six bromeliads of *Tillandsia elongata* and number and size (diameter and snout-vent length) of eggs and lizards (neonates, juveniles and adults) of *Gonatodes albogularis* found inside the bromeliads collected in "Bosques de la Esmeralda" (Chinchiná, Caldas, Colombia). Abbreviations: ID, field number of the bromeliad collected; D, diameter of the rosette; LA, long egg axis; SVL, snout-vent length.

Characteristic	Bromeliad ID (n = 6)					
	I-01	I-04	I-06	I-08	I-12	I-16
	Tillandsia elongata					
D (cm; average by bromeliad)	96.5	107.0	98.3	91.0	106.5	123.5
Accumulated litter-fall (g)	19.5	31.4	17.7	22.7	7.4	30.2
	Gonatodes albogularis					
Number of eggs/bromeliad	0	5	1	1	0	1
Egg LA (mm)	-	5.8	5.8	5.8	-	5.8
Neonates (n = 2) and juveniles (n = 2) SVL (mm)	26.7	15.5*	-	-	21.8**	14.8*
Adult SVL (mm; n = 3)	-	33.3♀ 33.5♂ 40.5♀	-	-	-	-

* Neonate; ** Juvenile in decomposition state.

serve a direct relationship between the presence/absence of eggs or lizards with the bromeliad diameter, while we found the communal egg-laying in the bromeliad that had a higher amount of leaf litter (Table 1).

Discussion

To our knowledge, the data, here shown, represent the first record of *G. albogularis* using bromeliads as a microhabitat for egg-laying. In addition, we consider this species as a facultative bromelicolous lizard and that the use of bromeliads for egg-laying is opportunistic because this species has been recorded nesting in other types of microhabitats (Sexton and Turner 1971; Serrano-Cardozo et al. 2007; Jablonski 2015). Other lizards also use bromeliads as nesting sites such as *P. pollicaris* (Ávila and Cunha-Avellar 2005) and *G. humeralis* (Maciel et al. 2005), while others, for instance members of the genus *Abronia*, apparently live most of their lives amongst epiphytes (Cruz-Ruiz et al. 2012). As these lizards that have been reported nesting in bromeliads also use other types of microhabitats for that same purpose (e.g. *P. pollicaris* using rock crevices: Righi et al. 2004), we could assume that the use of bromeliads for egg-laying by the lizards is occasional, just as they use for that activity other potential environments available in their habitats. The use of sites that are above ground for egg-laying, like bromeliads, could potentially bring benefits for the development of eggs and neonates: reduce the risk of predation against terrestrial predators, provide humidity that minimises the risk of egg desiccation and provide food resources in the same place (Fitch 1973; Benzing 1990; Armbruster et al. 2002; Krysko et al. 2003; Maciel et al. 2005).

The occurrence of communal egg-laying in *G. albogularis* apparently is not a rare event, since it has been observed in other populations throughout its geographic range and several times in the same year (e.g. Panama: Sexton and Turner 1971; Colombia: Serrano-Cardozo et al. 2007; Costa Rica: Jablonski 2015). We assumed the occurrence of this behaviour in our observations, based on the simultaneous presence of several eggs of similar size, hatchlings and juveniles in the same nest, as has been observed in other studies with *Gonatodes* (e.g. Oda 2004; Serrano-Cardozo et al. 2007; Jablonski 2015).

Radder and Shine (2007) and Doody et al. (2009) recognised two possible hypotheses explaining the occurrence of communal nests. The restriction hypothesis is related to the scarcity of optimal oviposition sites, either because of the high environmental heterogeneity or because the high population density of reproductive females exceeds the supply of these optimal sites. The adaptive hypothesis is related to the benefits obtained by both females and progeny of the communal egg-laying behaviour. As the data here reported are somewhat anecdotal, we do not have information on the availability of different types of suitable egg-laying sites for *G. albogularis*, in order to evaluate some of these hypotheses or both together. However, the occurrence of communal nests in bromeliads with greater amount of leaf litter may be a product of the mutual attraction of the females to egg-laying sites with more suitable conditions compared to others (Graves and Duvall 1995). A greater amount of litter potentially offers higher moisture conditions for eggs and neonates in comparison with the other bromeliads, which could reduce the risk of the eggs desiccation in the dry season (Maciel et al. 2005). In addition, a greater amount of leaf litter can also offer shelter for eggs and neonates. Such conditions of moisture and refuge could be maximising both the hatching success of the eggs (considering the observed presence of hatchlings and juveniles) and the reproductive success of the females.

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