COMMUNAL NESTING AND SEXUAL DIMORPHISM IN THE MICROENDEMIC GECKO FROM MEXICO *PHYLLODACTYLUS DELCAMPOI* (GEKKOTA: PHYLLODACTYLIDAE)

ANIDACIÓN COMUNAL Y DIMORFISMO SEXUAL DEL GECKO MICROENDÉMICO DE MÉXICO *PHYLLODACTYLUS DELCAMPOI* (GEKKOTA: PHYLLODACTYLIDAE)

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Resumen.– *Phyllodactylus* está compuesto por geckos nocturnos y ovíparos que habitan áreas rocosas en regiones tropicales y subtropicales de América. A pesar de su abundancia, el conocimiento sobre su historia natural es escaso. Aquí documentamos algunos aspectos reproductores de *P. delcampoi*, un gecko microendémico de un bosque tropical caducifolio de Guerrero, México. Encontramos un nido comunal con 18 huevos dentro de una grieta en una roca de granito. Aunque la anidación comunal en geckos se ha observado previamente, este es el primer registro documentado en lagartijas mexicanas. Las puestas comunales podrían estar asociado con hábitats rocosos y una alta abundancia de individuos, como se observó en la especie estudiada. Además, encontramos un individuo adulto que permaneció frecuentemente cerca del área circundante al nido comunal, lo que sugiere cuidado parental en *P. delcampoi*. Adicionalmente, tomamos medidas morfométricas para determinar el dimorfismo sexual y encontramos que los machos son más grandes y pesados que las hembras.

Palabras clave.– Bosque tropical caducifolio, cuidado parental, estado de Guerrero, historia natural, *Phyllodactylus delcampoi*.

Abstract.– *Phyllodactylus* consists of nocturnal, oviparous geckos that inhabit rocky areas in tropical and subtropical regions of the Americas. Despite their abundance, knowledge about their natural history is scarce. Here, we documented some reproductive aspects of *P. delcampoi*, a microendemic gecko from the tropical dry forests of Guerrero, Mexico. We found a communal nest with 18 eggs inside a granite rock crevice. Although communal nesting is known in various gecko species, this is the first documented case in a Mexican lizard species. Communal nesting may be associated with rocky habitats and high individual abundance, as observed in the study species. Furthermore, we found an adult individual that frequently remained close to the surroundings of the community nest, which suggests parental care in *P. delcampoi*. Additionally, we recorded morphometric measurements to determine sexual size dimorphism and found that males are larger and heavier than females.

Keywords.– Guerrero state, natural history, parental care, *Phyllodactylus delcampoi*, tropical dry forest.

The leaf-toed geckos (genus *Phyllodactylus*) are primarily nocturnal animals that inhabit rocky areas in tropical and subtropical regions of America (Dixon, 1964; Ramírez-Reyes & Flores-Villela, 2018). These organisms exhibit oviparous reproduction and display a wide variety of reproductive cycles (Vitt, 1986; Okada et al., 2002; Colli et al., 2003; Goldberg, 2007). The clutch size is limited to one or two eggs per laying (Dixon, 1964; Vitt, 1986; Doughty, 1997; Ramírez-Sandoval et al., 2006). Some studies conducted to date have demonstrated that precipitation, temperature, photoperiod, sexual dimorphism, or their combinations play a significant role in the reproductive activity and egg size and mass of these species (Vitt, 1986;

Ramírez-Sandoval et al., 2006; Goldberg, 2007; Zhang et al., 2009). Specifically, we know that some species of *Phyllodactylus* distributed in Mexico exhibit a continuous reproductive cycle, meaning that females produce multiple clutches throughout the year, with peak egg production between December and April (Dixon, 1964; Ramírez-Sandoval et al., 2006). Additionally, some species exhibit sexual dimorphism, with males showing larger body sizes compared to females (Argote-Rodríguez, 2006; Ramírez-Sandoval et al., 2006).

On the other hand, despite Mexico's abundance of *Phyllodactylus* species, knowledge about the natural history of these lizards is practically nonexistent. In particular, one of these species is Del Campo's Leaf-toed Gecko, *Phyllodactylus delcampoi* Mosauer, 1936. This gecko species is relatively large, with a mean snout-vent length of approximately 72.4 mm (Dixon, 1964). It exhibits a dark brown coloration with a series of banded spots distributed along its back (Fig. 1A) (Dixon, 1964). This species is micro-endemic to Mexico, with a geographical distribution restricted to the vicinity of Tierra Colorada, Guerrero, where it occupies crevices and caves formed by large granite boulders in the Tropical Deciduous Forest (Dixon, 1964; Palacios-Aguilar et al., 2018; Muñoz-Nolasco et al., 2019). *Phyllodactylus delcampoi* is classified as threatened species according to the Mexican Official Standard 059-SEMARNAT (SEMARNAT, 2010). The available information on the natural history of this species is limited and scarce (Dixon, 1964; Muñoz-Nolasco et al., 2019). Therefore, in this work we present the first record of communal nesting and parental care in *P. delcampoi*. Additionally, we include data of the sexual dimorphism on in this species.

Area of study. Reproductive data were collected during the dry season on 20 and 26 April 2024, in the locality of Tierra Colorada, Guerrero (17.16° N, 99.53° W). The study site is at an altitude of 165 m a.s.l., with an average ambient temperature of 27.5 °C (ranged from 18.3 to 36.8 °C) and an average precipitation of 1,342 mm (Muñoz-Nolasco et al., 2019). The exact geographic coordinates of the study site are not included. However, they can be requested via email to corresponding author for scientific purposes.

Communal egg-laying. In the first sampling carried out on 20 April 2024, at 10:43 h, a nesting site composed by 18 eggs was found, arranged together and placed vertically, parallel to each other (Fig. 1B). The nest was located inside a crevice in a granite rock. Using a digital caliper, we measured the crevice where the nest was located. The width of the crevice was 20 mm, and the nest was situated at a depth of approximately 15 cm from the outer edge of the rock. Additionally, the eggs exhibited an opalescent white coloration, were calcified, and adhered to the substrate, which prevented accurate measurements. However, to estimate the approximate size of the eggs, we used a digital measurement application. This approach was taken to avoid compromising the integrity of the nest. The average length and width of the eggs were 18 x 10 mm (N = 18). Additionally, an adult specimen of *P. delcampoi* was found next to the communal nesting site.

Subsequently, 26 April 2024, at 11:00 h, a second visit to the nesting site was conducted to collect additional temperature and humidity data. Temperature data were taken with a Fluke 51-II thermometer connected to a type K sensor (± 0.1°C). The mean surface temperature of 10 eggs in the nest was 31.8 ± 0.25 °C. The substrate and air temperatures, measured within the crevice adjacent to the nest, were 32 and 33.6 °C, respectively. Additionally, a UNI-T hygrometer (± 5%) was used to record the ambient relative humidity around the eggs. The maximum humidity value was 47.9% and the minimum was 42.9%. During this second visit, an adult organism was again observed in the same position, next to the nesting site (Fig. 1C). Finally, to determine the species, it was necessary to collect one of the eggs, which contained a well-developed *P. delcampoi* preneonate. This specimen was male, with a snout-vent length (SVL) of 22.9 mm and a tail length (TL) of 19.4 mm. The specimen was deposited in the Colección Nacional de Anfibios & Reptiles at Universidad Nacional Autónoma de México (CNAR IBH-3663).

Morphological data. During the sampling on 20 and 26 April, we collected 30 adult individuals of *P. delcampoi*. It is worth noting that no data are available on the minimum size at which *P. delcampoi* individuals are considered adults. However, all collected individuals had a size greater than 66.7 mm, whereas the minimum size to consider adults in other medium-sized *Phyllodactylus* species, such as *P. benedetti*, is 49 mm (Ramírez-Sandoval et al., 2006; Ramírez-Reyes & Flores-Villela, 2018). Therefore, we estimate that the collected individuals of the studied species were adults. We transported the geckos to the Laboratorio Integral de Vida Silvestre at the Universidad Autónoma de Guerrero, Mexico, where we determined their sex by eversion of the hemipenis and recorded the following morphological variables (mm): snout-vent length (SVL), tail length (TL), axilla-groin length (AGL), upper arm length (UAL), forearm length (FAL), upper leg length (UL), lower leg length (LL), head length (HL), head width (HW), head height (HH), as well as the body mass (g) of the organisms (Christian & Garland,1996; Ramírez-Bautista et al., 2009; García-Bastida et al., 2013). After data collection, lizards were in the under observation for 48 hours before being returned to the capture sites. The morphological data are presented by sex in Table 1.

Sexual dimorphism. To evaluate the sexual size dimorphism, we first performed a normality and homoscedasticity tests (Zar, 1999). We implemented t-student tests to compere the body size and body mass between females and males. Then, we conducted Generalized Linear Mixed Models (GLMM) to identify the morphometric variables related with the differences between sexes, using the function glm in R program version 4.2.1 (R Development Core Team, 2022). It is worth mentioning that for these models, we removed the effect of body size. Following this, we implemented a comparison between sexes across ten models with analyses of deviance with anova function from the car package (see Table 2 for more information). Finally, we selected the best model identifying the most significant variables in sexual dimorphism using the Akaike Information Criterion corrected (AICc), supported by MuMin package and AICc function. Statistical analyses were performed in R program version 4.2.1 (R Development Core Team, 2022).

The comparisons between size (SVL) and mass presented significant differences in both sexes ($t = 2.413$, $p = 0.023$; $t = 2.196$, $p = 0.035$, respectively). Also, females and males showed significant differences in all models, except for the axilla groin length (AGL), indicating that males are larger than females (Table 2). We also found that the most significant morphometric variables contributing to sexual dimorphism were head measurements, with males exhibiting larger heads than females (Table 2).

Although communal nesting has been widely documented in various gecko species, including some species of the genus *Phyllodactylus*, our observation is the first documented record of intraspecific communal egg-laying of a Mexican leaf-toed gecko (Graves & Duvall, 1995; Doody et al., 2009; Domingos et al., 2017). Communal nesting has been associated with unfavorable climatic conditions, such as extreme temperatures, arid conditions and excessive moisture, due to these factors may limit the availability of microhabitats with suitable conditions for egg incubation (Doody et al., 2009; Montgomery et al., 2011). However, the study area lacks these adverse characteristics, as it exhibits homogeneous temperatures and moisture levels (Muñoz-Nolasco et al., 2019). Other factors associated with communal nesting include limited resources or habitat saturation, as competition with other oviparous species also may

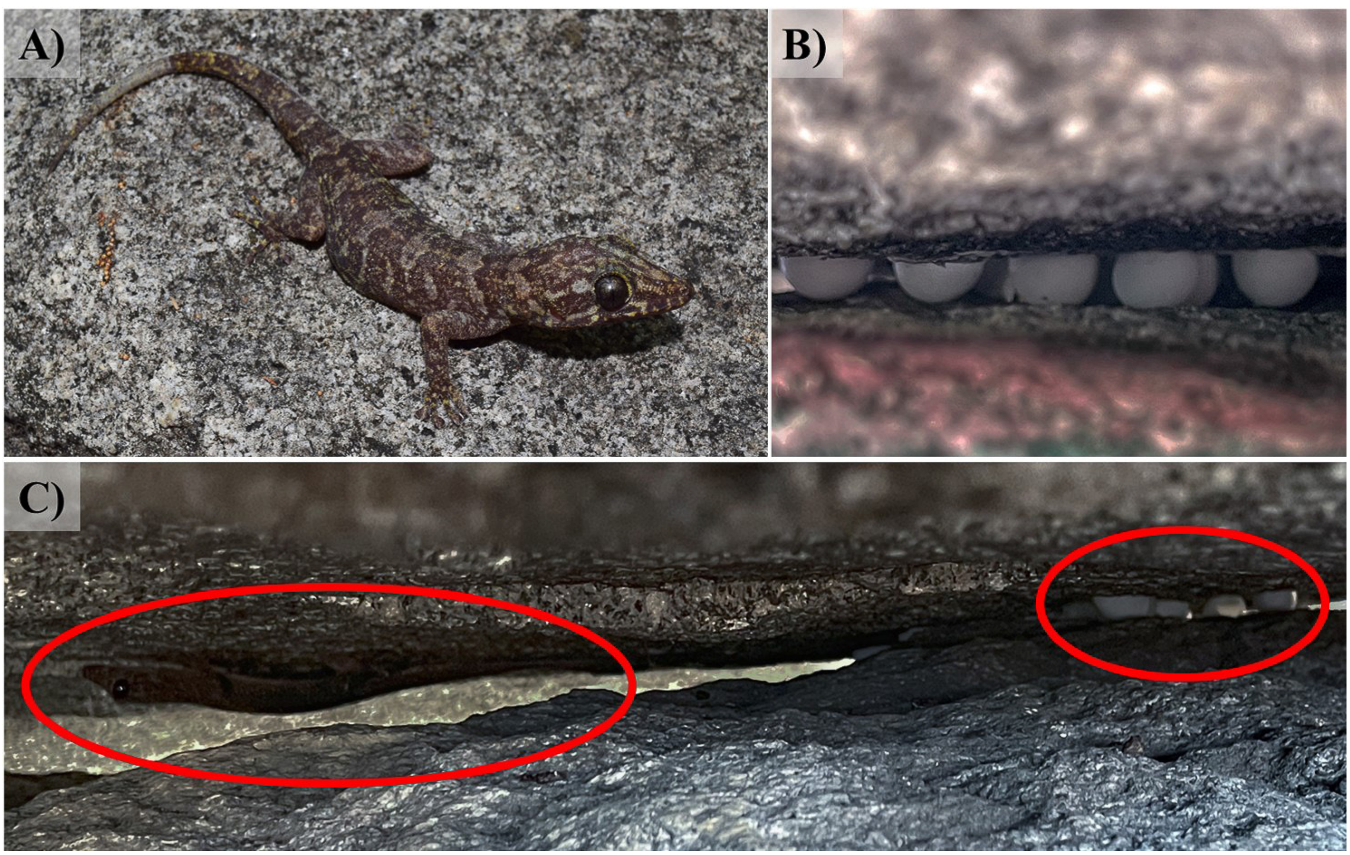

Figura 1. Macho adulto de *Phyllodactylus delcampoi* en el área de estudio (A), puesta comunal (B) e inviduo cerca del nido comunal (C).

Figure 1. Adult male of *Phyllodactylus delcampoi* in study area (A), communal clutch (B), and individual near to the communal clutch (C).

Tabla 1. Masa en g y variables morfométricas en mm de *Phyllodactylus delcampoi* por sexos (16 machos y 14 hembras). SVL = longitud hocico-cloaca; TL= longitud de la cola; AGL = longitud axila-ingle; UAL = longitud del brazo; FAL = longitud del antebrazo; UL = longitud del fémur; LL = longitud de la tibia; HL = longitud de la cabeza; HW = ancho de la cabeza; HH = alto de la cabeza. Se presentan el valor promedio, la desviación estándar (±), los valores mínimo y máximo (min — max).

Table 1. Mass in g and morphometric variables in mm of *Phyllodactylus delcampoi* by sex (16 males and 14 females). SVL = snout-vent length; TL = tail length; AGL = axilla-groin length; UAL = upper arm length; FAL = forearm length; UL = upper leg length; LL = lower leg length; HL = head length; HW = head width; HH = head height (HH). The average value, standard deviation (±), and minimum and maximum values (min — max) are presented.

Traits	Mass	SVL	TL	AGL	UAL	FAL	UL	LL	HW	HH	HL
Male	10.95 ± 2.04 (7.43 — 14.57)	81.12 ± 4.52 (72.8 — 88.2)	77.4 ± 10.5 (60.2 — 106.2)	37.96 ± 2.54 (34 — 43.5)	11.91 ± 0.88 (10.6 — 14)	13.53 ± 1.45 (10.9 — 16.3)	16.19 ± 1.52 (11.2 — 18.3)	13.09 ± 1.14 (11.1 — 14.5)	14.66 ± 1.03 (12.8 — 16.4)	7.87 ± 0.97 (6.7 — 10.1)	19.08 ± 1.4 (15.5 — 21.1)
Female	9.2 ± 2.33 (5.28 — 12.79)	76.46 ± 6.07 (66.7 — 89.7)	72.0 ± 7.2 (54.4 — 86.3)	36.6 ± 4.61 (28.4 — 45.4)	10.69 ± 0.89 (9.2 — 12.2)	12.64 ± 1.56 (9.5 — 14.9)	15.04 ± 1.47 (11.9 — 17)	12.31 ± 1.22 (10.5 — 14.5)	13.74 ± 1.03 (11.6 — 14.9)	7.46 ± 1 (6 — 8.9)	17.94 ± 1.58 (15.4 — 20.7)

Tabla 2. Valores de los modelos lineales mixtos generalizados (GLMM) realizados con múltiples variables morfométricas (medidas en mm) entre sexos para la especie de estudio. El efecto de la talla (LHC) ha sido removido para cada modelo. df = grados de libertad; AICc = criterio ajustado de información de Akaike; AGL = longitud axila-ingle; UAL = longitud del brazo; FAL = longitud del antebrazo; UL = longitud del fémur; LL = longitud de la tibia; HL = longitud de la cabeza; HW = ancho de la cabeza; HH = alto de la cabeza. No incluimos datos de la longitud de la cola (TL) debido a que podría ser una variable poco informática debido a la posibilidad de autotomía caudal previa a las mediciones.

Table 2. Values of the Generalized Linear Mixed Models (GLMM) performed with multiple morphometric value (measures in mm) by sex on the study species. The effect of body size (SVL) has been removed for each model. df = degree of freedom; AICc = Akaike information criterion adjusted; M = mass in g; SVL = snout-vent length; AGL = axilla-groin length; UAL = upper arm length; FAL = forearm length; UL = upper leg length; LL = lower leg length; HL = head length; HW = head width; HH = head height (HH). We did not include tail length (TL) because it might be an uninformative trait due to caudal autotomy.

Model	Variables	df	AICc	deltaAICc	Comparison by sex
1	AGL+UAL+FAL+ ULF+LL+HL+HW+HH	4	205.6063	55.83421	$X^2 = 8.57$, df =1, $p = 0.003$
2	UAL+FAL+ULF+ LL+HL+HW+HH	4	186.9422	37.17009	$X^2 = 11.571$, df = 1, $p < 0.001$
3	HL+HW+HH	4	149.7721	0	$X^2 = 6.251$, df =1, $p = 0.01$
4	UAL+FAL+ ULF+LL	3	163.5697	13.79762	$X^2 = 10.457$, df = 1, $p = 0.001$
5	AGL	3	167.6523	17.88022	$X^2 = 0.945$, df = 1, $p = 0.331$

restrict the availability of microsites with optimal incubation conditions (Doody et al., 2009; Montgomery et al., 2011; Alfonso et al., 2012). Therefore, *P. delcampoi* could be exposed to other types of pressures as competition with other oviparous species such as *P. lanei* or *Anolis gadovii*, which inhabit the same rocky areas (Muñoz-Nolasco et al., 2019); although during our study period we did not find nests of these species.

The communal nesting is relatively common in rocky environments similar to the habitat of *P. delcampoi*, as thermal conditions within the rocks are more homogeneous and present higher humidity levels compared to other areas (Muñoz-Nolasco et al., 2019). These characteristics offer favorable conditions for embryonic development and simultaneously facilitate aggregation behavior, promoting communal egg-laying (Graves & Duvall, 1995; Montgomery et al., 2011). Additionally, there is evidence that communal egg-laying is related to parental care, particularly in populations with high abundance where nesting sites may be scarce (Doody et al., 2009). Despite our observations were conducted only during two days, we found an adult organism next to the nesting site. This observation suggests that these organisms may exhibit some degree of parental care, similar to other gecko species (Graves & Duvall, 1995; Mateo &

Cuadrado, 2012). Unfortunately, we were unable to capture it the individual to identify the sex.

Some studies suggest that communal egg-laying could be beneficial when suitable oviposition sites are constrained by high population density (Doody et al., 2009). During our sampling period, we observed that *P. delcampoi* was very abundant at the study site, which could explain the communal egg-laying of *P. delcampoi*. Therefore, the presence of an adult near the communal nest supports the idea that this behavior is related to parental care. However, further studies are necessary to confirm parental care in this gecko species.

Despite the lack of data on the minimum size of adult *P. delcampoi*, in previous samplings, carried out in the month of January 2024, we found gravid female with a minimum SVL size of 78 mm. However, a study evaluating the reproductive cycle is necessary to confirm the minimum size of adults of this species. Regarding sexual size dimorphism, we found that *P. delcampoi* exhibits significant differences in body size and body mass, with males being larger and heavier than females. Additionally, males have larger heads, a pattern previously reported in other gecko species (Vitt, 1986; Okada et al., 2002; Ramírez-Sandoval et al., 2006). These morphological differences can be attributed to differential growth rates, male-male competition (Vitt, 1982; Husak et al., 2006), territoriality (Greer, 1967), which may in turn be associated with communal egg-laying, due to that multiple females may selected a single male that attending their clutches (Doody et al., 2009). However, the communal nesting associated with sexual selection is documented more in frogs than in reptiles (Doody et al., 2009), highlighting the need for studies focused on elucidating the reproductive patterns of various lizards, especially those species with restricted distributions and specific requirements, such as *P. delcampoi*.

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