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Keratophagy in two lizards from Isla María Cleofas, Mexico

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Abstract. Herein, we report keratophagy in two lizard species, *Norops nebulosus* and *Phyllodactylus tuberculosus*, from Isla María Cleofas, Nayarit, Mexico. During herpetofaunal surveys conducted between May of 2017 and August of 2018, we captured individuals of both species and extracted the stomach contents to evaluate their food habits. Subsequently, our analysis revealed the remains of shed skins in six individuals of *N. nebulosus* and two individuals of *P. tuberculosus*. We suggest that the dry environmental conditions on the island during certain times of the year might drive both species to keratophagy.

Key words: Dermatophagy, epidermophagy, ceratophagia, anole, gecko, insular environmental.

Introduction

In herpetology, the term keratophagy has been defined as the eating of keratin or keratinous materials, and often is used in reference to the act of an individual eating one's own shed skin or that of a conspecific during ecdysis (Groves & Groves 1972, Lillywhite 2008, Fontenot & Pojman 2016). In other studies, several terms have been used to describe keratophagy, such as epidermophagy, dermatophagy, and ceratophagia (Mitchell et al. 2006). Keratophagy has been reported in amphibians and reptiles (Kouete et al. 2012, Fontenot & Pojman 2016, Jairam et al. 2016). The available information suggests, however, that such events are most common in reptiles, primarily in lizards such as geckos, anoles, iguanids, teiids, cordylids, varanids, scincids, anguids, but this behaviour is uncommon in snakes (Mitchell et al. 2006, Vacheva 2018). The majority of recorded events consist of accidental or anecdotal observations in the field or under laboratory conditions. Specifically, keratophagy previously has been recorded in the Yellow-bellied Gecko (*Phyllodactylus tuberculosus*) and the Clouded Anole (*Norops nebulosus*, for taxonomic status see Nicholson et al. 2018); however, certain information such as data on body size, sex, and the percentage of individuals with the presence of keratin in their stomachs remains somewhat limited, as well as information on the benefits of ingesting the shed skins. Herein, we present additional data on the presence of shed skins in the stomach contents of *P. tuberculosus* and *N. nebulosus*, based on individuals captured on Isla María Cleofas, located off the Pacific coast in the state of Nayarit, Mexico.

Material and Methods

The study area, Isla María Cleofas, is located within the Islas Marías Biosphere Reserve Archipelago (21.3228°N, 106.2296°W, WGS84; elev. <5 m), at 87.5 km from the nearest continental point in the municipality of San Blas, in the state of Nayarit. The surface area of Isla María Cleofas is 25 km^2, and the vegetation of the island consists of tropical sub-deciduous forest, deciduous tropical forest, subtropical scrub, and a small area of mangrove forest (Zweifel 1960). The climate is semi-arid with rains occurring from late June to October, and the dry season extends from November to May (CONANP 2007).

We conducted diurnal and nocturnal surveys between May of 2017 and August of 2018, to collect individuals of *Norops nebulosus* and *Phyllodactylus tuberculosus* on Isla María Cleofas. Subsequently, the lizards were taken to the María Cleofas Research Boat for sampling and data collection. We measured the snout–vent length (SVL) of individuals as from the tip of the snout to the anterior margin of cloaca (Williams 1995). We also collected the stomach contents from each individual using the hose-Heimlich lavage technique (Fitzgerald 1989). In contrast with dissected techniques that require sacrificing the animals to obtain their stomach contents, the aforementioned technique enables individuals to regurgitate their prey items for further analysis (Perkins & Eason 2019). To obtain the largest possible volume of stomach contents from each individual, we performed this technique consecutively three times in each of the anoles and geckos. In addition, all of the lizards captured were maintained in individual plastic boxes for a period from 24 to 48 h, which allowed us to obtain fecal samples before the lizards were returned to their capture sites. All of the individuals captured were returned to their capture sites within 48 h of collection. The stomach contents were preserved in 70% ethanol for laboratory analysis in the Entomology Laboratory at the Centro Universitario de la Costa of Universidad de Guadalajara in Puerto Vallarta, Jalisco, Mexico. During the laboratory analyses, the stomach contents were separated while using a Carl Zeiss Stemi DV4 stereoscopic microscope, and then examined under an Olympus optical microscope. The remains of shed skin in the stomach contents were identified based on the skin structure traits of the four lizard species that inhabit Isla María Cleofas (*Aspidoscelis communis*, *Ctenosaura pectinata*, *Norops nebulosus*, and *Phyllodactylus tuberculosus*, Zweifel 1960).

Results

We captured 36 individuals of *Norops nebulosus* and 32 of *Phyllodactylus tuberculosus*. The SVL of the *N. nebulosus* ranged from 33.02 to 52.5 mm, with a mean of 45.3 mm (1SD: 6.9), and the SVL of *P. tuberculosus* ranged from 45.0 to 77.0 mm, with a mean of 60.2 mm (1SD: 9.8). We found the remains of shed skin in the stomach contents of 16.6% (n = 6) of the *N. nebulosus*, and 6.2% (n = 2) of the *P. tuberculosus* captured during our visits to the island (Fig. 1). We did not find the remains of shed skin in any of the fecal samples. The SVL of individuals of *N. nebulosus* and *P. tuberculosus* with the remains of shed skin in their stomach contents ranged from 37.45 to 49.44 mm and from 50.2 to 52.6 cm, respectively.

Discussion

We were able to determine that the remains of shed skin came from their own respective species, but were unable to

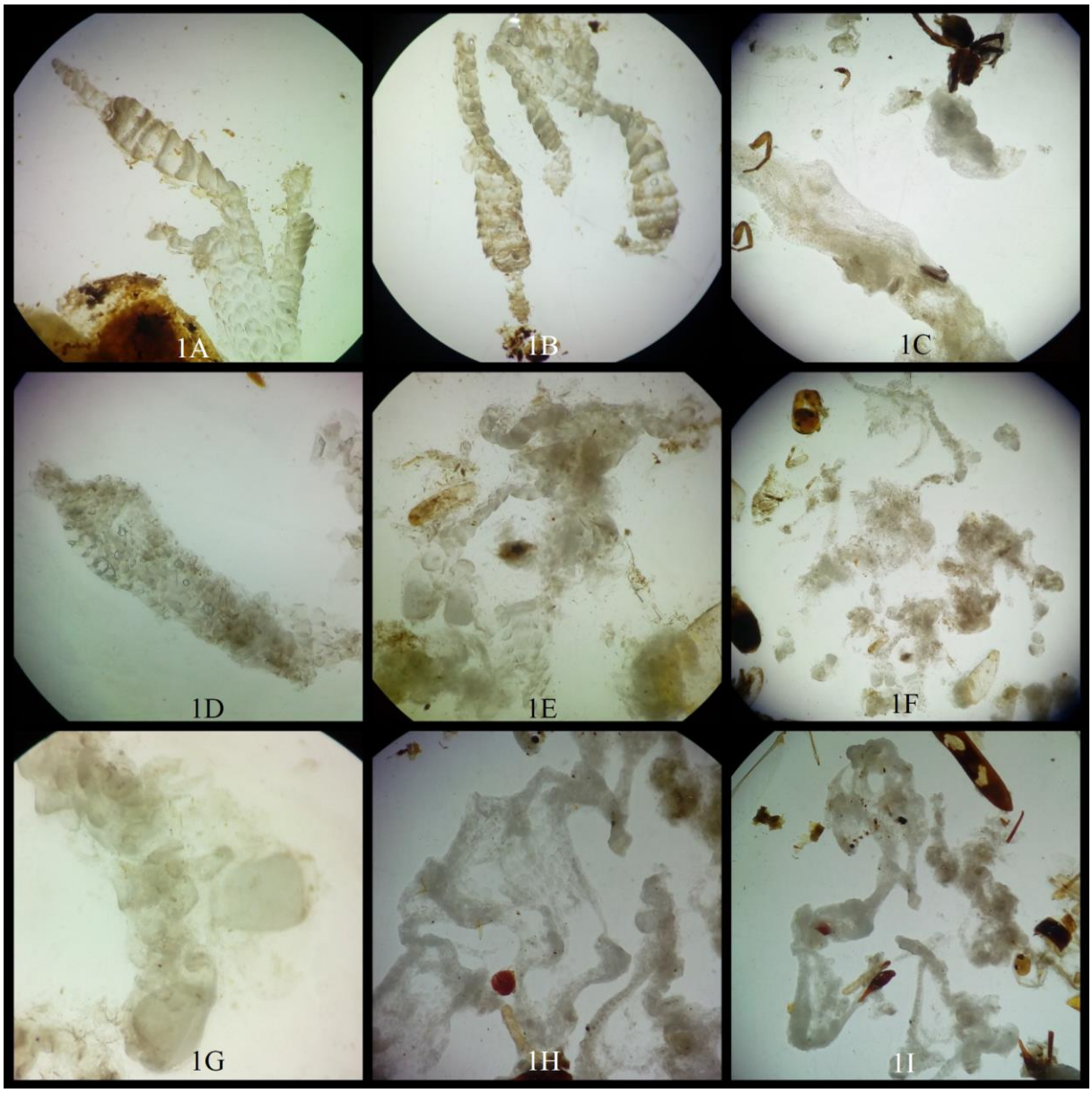

Figure 1. Evidence of keratophagy in *Norops nebulosus* and *Phyllodactylus tuberculosus* on Isla María Cleofas, Nayarit, Mexico. The photo collage shows a toes of *N. nebulosus* (A and B), C and D are shed skin found on stomach contents from both species, E and F are parts of the skin of *P. tuberculosus* and G are the adhesive pads of *P. tuberculosus*. The rest (H and I) are also shed skins found on stomach contents from both species.

determine if ingestion was by the same individual. Jenssen (1970) reported keratophagy in *N. nebulosus* based on three years of captive and field observations of shedding behaviour. For *P. tuberculosus*, the previous record was based on a questionnaire submitted to zoos and aquariums (see Weldon et al. 1993); however, potential explanations were not presented in either study. Our observations provide additional field records of keratophagy in both species, as well as the first record from an insular ecosystem.

Some ecological and adaptive hypotheses have been proposed to explain keratophagous behaviour in reptiles (Weldon et al. 1993, Mitchell et al. 2006). Weldon et al. (1993) discussed some hypotheses for families of amphibians and reptiles that consume shed skins by submitting a questionnaire to zoos and aquariums worldwide, and reviewed the available information and reported this behaviour. They reported a total 162 species of reptiles eating shed skin, but recently this behaviour has been reported in 20 additional reptile species (Mitchell et al. 2006). This information reveals that keratophagy is a habitual behaviour in most of the reptile lineages (few turtles, one sphenodontian, some snakes, and many lizards), even though they may not be phylogenetically related.

In the case of lizards, the hypotheses of why keratophagy may occur range from accidental skin eating to reducing predator behaviour and parasite load (Mitchell et al. 2006). Any of the previous hypotheses might apply if the presence of the shed skin in the stomach contents of *N. nebulosus* and *P. tuberculosus* on Isla María Cleofas occurred frequently throughout the two years of our study, but we only found the presence of shed skin in dry season (on May of 2018). Conversely, the reproductive cycle of *Norops nebulosus* has

been reported as from July to October (Ramirez-Bautista & Vitt 1997), and the available literature suggests that the individuals of *N. nebulosus* and *P. tuberculosus* with shed skin remains in their stomach contents are adults that were reproductively active (Ramirez-Bautista & Vitt 1997, Goldberg 2007). Thus, we expected to find the remains of shed skin as a result of male–male competition for females in our surveys, before and during the breeding season. For some species of *Norops*, the occurrence of shed skin has been poorly documented in relation to the amount of anoles captured (Wingate 1965, Vitt et al. 2001, 2002, Herrel & O'Reilly 2006), which suggests that it is an accidental phenomenon, as previously proposed by Mitchell et al. (2006). However, in Figure 1 we show specific structures of the lizards' skin, suggesting that there could be other factors for keratophagous behaviour. We suggest that the occurrence of shed skin in stomach contents of *N. nebulosus* and *P. tuberculosus* could be advantageous when prey availability was constrained by the dry environmental conditions on the island. Some studies on the trophic niche of insular lizards have reported herbivory in certain species, which often is due to a shortage of insect food, but also might be related to ambient temperatures (Olesen & Valido 2003). The low availability of prey during dry weather could drive this type of behaviour on the Isla María Cleofas. Future work should address questions on how temperature fluctuations might influence shedding behaviour, as well as the rate of occurrence of keratophagy under more stable conditions. Such information might provide a broader or more precise view for explaining keratophagous behaviour in reptiles.

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