Notes on *Phyllodactylus palmeus* (Squamata; Gekkonidae); A Case of Diurnal Refuge Co-inhabitancy with *Centruroides gracilis* (Scorpiones: Buthidae) on Utila Island, Honduras.

Tom Brown[1] & Cristina Arrivillaga[1]

[1]Kanahau Utila Research and Conservation Facility, Isla de Utila, Islas de la Bahía, Honduras

Introduction

The Honduran Leaf-toed Palm Gecko (*Phyllodactylus palmeus*) is a medium-sized (maximum male SVL = 82 mm, maximum female SVL = 73 mm) species endemic to Utila, Roatan and the Cayos Cochinos archipelago (McCranie and Hedges, 2013); islands which constitute part of the Bay Island group on the Caribbean coast of Honduras. The species is not currently evaluated by the IUCN Redlist, though Johnson *et al* (2015) calculated an Environmental Vulnerability Score (EVS) of 16 out of 20 for this species, placing *P. palmeus* in the lower portion of the high vulnerability category. To date, little information has been published on the natural history of *P. palmeus*, with much of its ecology and behaviour remaining unknown. *Phyllodactylus palmeus* is found active nocturnally on the bases of tree trunks, on branches, palms and foraging in leaf-litter; during the day, individuals can be observed hiding in cracks, beneath loose peeling bark, on the underside of palm fronds, on shaded hidden segments of trunk, and in porous volcanic coralline rocky outcrops (Köhler, 2008; Brown et al., 2018).

Previously on Utila, this species was known to inhabit buildings, and human settlements in high densities, although in recent years, populations have dramatically declined, being extirpated from these urban environments due to the invasion of highly competitive Asian House Gecko (*Hemidactylus frenatus*) (Wilson and Cruz Diaz, 1993: McCranie et al., 2005). Over seventeen years following the *Hemidactylus* invasion of Utila (Kohler, 2001), our current observations spanning from 2016 -2018 support those of McCranie & Hedges (2013) in that *P. palmeus* is now primarily restricted to undisturbed forested areas, and that *H. frenatus* is now unequivocally the most commonly observed gecko species across Utila. We report that *H. frenatus* has subjugated all habitat types on Utila Island, having a practically all encompassing distribution occupying urban and agricultural areas, hardwood, swamp, mangrove and coastal forest habitats and even areas of neo-tropical savannah (T. Brown pers. observ). On the other hand, populations of *P. palmeus* are left increasingly fragmented and out-competed in their natural habitats.

As an additional pressure, it should be noted that the site of the following observations was being actively deforested in preparation for sale and development. Furthermore, it is located <500 m to a locality known as Pumpkin Hill (16.12003°N, -86.88223°W), previously identified as a biodiversity hotspot for endemic lizards on the island (Brown et al., 2017[b, c]), as well as the site of previously reported observations regarding *P. palmeus* communal nesting behavior at Kanahau Utila Research & Conservation Facility (16.119383°N, 86.884989°W; WGS84) (Brown et al., 2018).

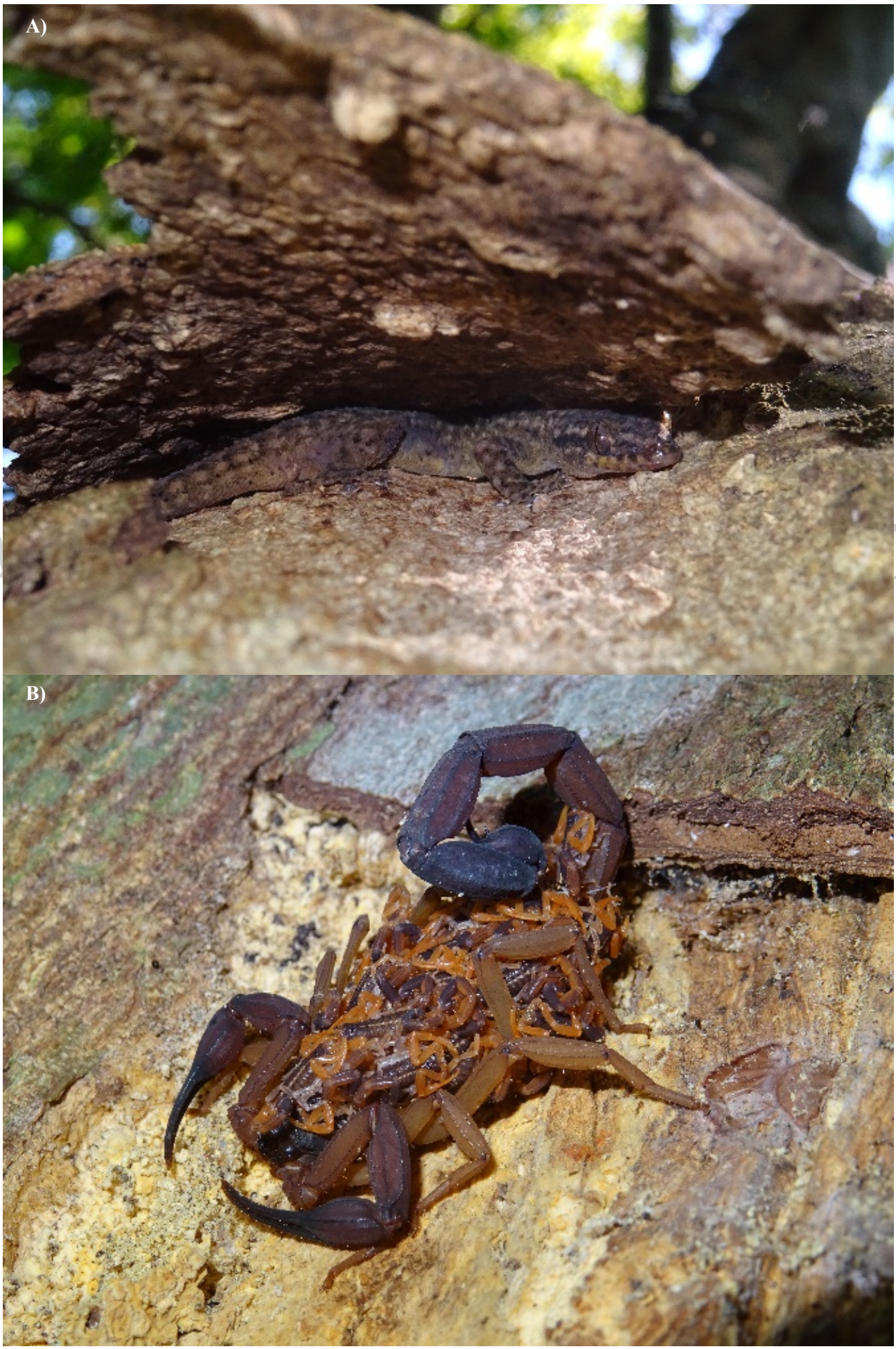

Figure 1. A) Cryptic *Phyllodactylus palmeus* seeking refuge beneath bark peel. **B)** Female *Centruroides gracilis* with offspring found co-inhabiting the same bark refuge. (Photo Credit: Tom W. Brown)

Observation

On April 4 2018, at 10:30 h, we encountered seven individuals of *P. palmeus* occurring within an area of hardwood forest on the eastern side of Utila. The composition of the forest was a diverse mixture of flowering broad-leaf trees (composed in part by the identifiable 'Gumbo-limbo' tree (*Bursera simaruba*), 'Encino' Oak (*Quercus oleoides)*, Yellow Hog Plum (*Spondias mombin)* and Fig trees (*Ficus* sp.). The understory was dominated by Paurotis palms (*Acoelorrhaphe wrightii)* as well as developing saplings and mature vines. Here, we found geckos seeking diurnal retreat beneath bark peels on the trunks of mature trees. On one trunk (Girth measurement – 285 cm), we counted > 10 bark peels with suitable space to provide refuge from heights of 0.5 – ca. >10 m. Whilst we were only able to search the suitable sites from 0.5 – 2.5 m (owing to accessibility), we encountered seven individuals sharing four such refuges. At one of these refuges, (1.6 m above ground), a single adult *P. palmeus* was observed occurring alongside an adult scorpion within a cavity created by a bark peel ca. 8 cm wide x 15 cm depth. When first encountered, the gecko and scorpion were resting adjacent to one another in close proximity, neither interacting; but then owing to disruption by the flash light, both sought to retreat out of sight before a photograph could be taken. To confirm the observation and the identification of both species, we proceeded to carefully extract the scorpion and gecko from the refuge. At this point, the female gecko (*P. palmeus)* was captured and measured to provide morphometric data (SVL – 65 mm, Tail – 63 mm, Weight – 7.5 g), then promptly released on the trunk where it retreated to a similar alternative refuge (Fig 1a). The scorpion was also then identified to be an adult female Bark Scorpion, *Centruroides gracilis* (body length ca. 43 mm) (S. Longhorn *pers. comm*., see also Teruel & Myers, 2017), additionally found to be tending to her litter of second instar young (Fig. 1b).

Remarks

Previous literature has reported co-inhabitancy of refuge sites between scorpions of the genus *Centruroides* and anurans (Escalante-Pasos, 2017), and between scorpions (Buthidae) and lizards (Agamidae) (Al-Johany & Al-Saleh, 2000). To the best of our knowledge, no such interactions have been previously recorded in the infra-order Gekkota, nor concerning female scorpions with young. In contrast, scorpions are acknowledged to predate on lizards and other small squamates (Bauer, 1990), and some geckos (e.g. *H. frenatus;* Brown et al., 2017[a]) have been found to predate on other arachnids. Fundamentally, there have been multiple records where geckos, other lizards and scorpions have preyed upon each other (Castilla, 1995; Zlotkin et al., 2003; Pérez et al., 2010).

The presented observation is also interesting when considering the degree of maternal care exhibited by scorpions. Using a closely related species, Shaffer & Formanowicz (1996) found that 65% of female Centruroides vittatus carrying young could not be induced to run, instead assuming a defensive posture. These authors also suggested that the cost of viviparity and parental care may cause females to explore alternative defensive strategies. In support, Miller et al. (2016) later found females to be more likely to stand and fight off predators, being more aggressive when compared to the males, which would usually prefer to run. Likewise, the female *C. gracilis* in our observations made no attempt to flee when disturbed; though most intriguingly, it did not consider *P. palmeus* as a threat or potential predator. Instead, the reported interaction may of facilitated mutual defensive benefits, being the first potential example of protocooperation between a gecko and scorpion species.

While not much can be said on the relations of *P. palmeus* with *C. gracilis*, the co-inhabitancy of these unlikely neighbors may not be infrequent, considering both are found in relative abundance within hardwood forest

habitats, and appear to share the same primary resources such as invertebrate prey and dark diurnal refuges.

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