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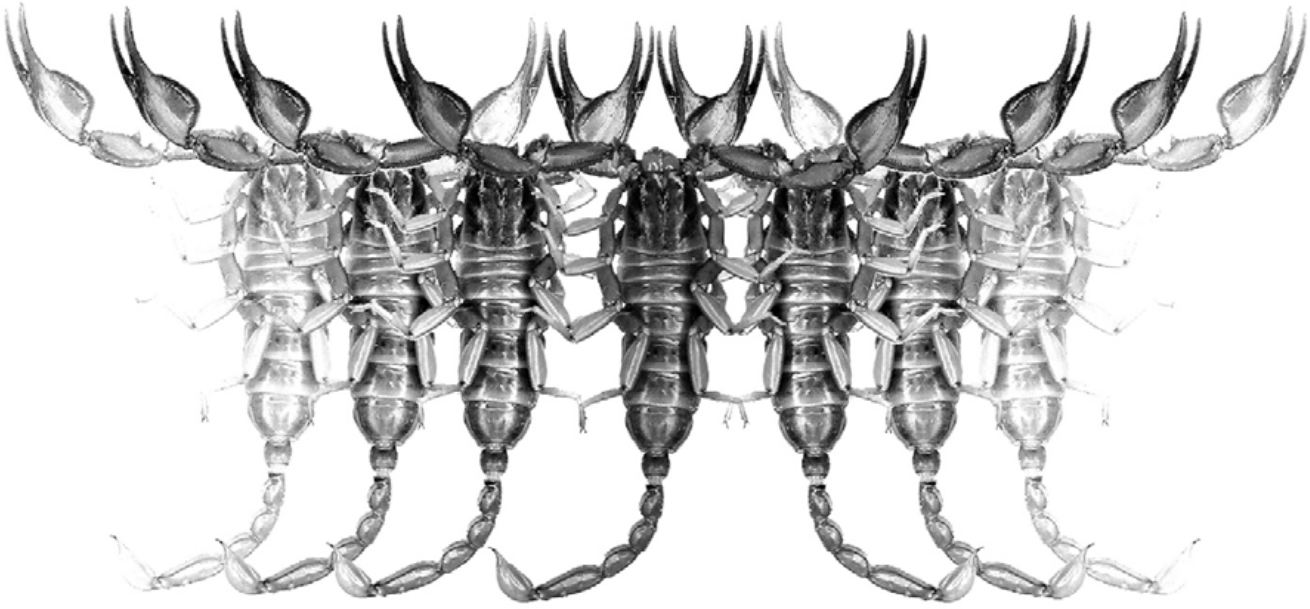

Notes on the diet and reproduction of the bark scorpion *Centruroides gracilis* (Scorpiones: Buthidae) on Utila Island, Honduras

Anna M. Davison, Tom W. Brown & Cristina Arrivillaga

July 2020 — No. 314

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Publication date: 16 July 2020

http://zoobank.org/urn:lsid:zoobank.org:pub:5DD2FBCF-53A2-47CA-B66B-863879386A26

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Notes on the diet and reproduction of the bark scorpion *Centruroides gracilis* (Scorpiones: Buthidae) on Utila Island, Honduras

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Summary

The brown bark scorpion *Centruroides gracilis* (Latreille, 1804) (Buthidae) is an abundant and widespread species, however, fairly little is known about its ecology and natural history. We include several observations from Utila Island, Honduras, that expand on the known literature regarding the diet and reproductive behavior of *C. gracilis*. We report several prey items for this opportunistic species, which include invertebrates such as spiders (including tarantulas), centipedes, katydids, and crickets; as well as a case of cannibalism between two adult females *C. gracilis*. We suggest that such cannibalism may be driven by high population densities and/or strong intraspecific competition for prey sources on the island. Additionally, we observed a courtship dance involving a female that still carried second-instar offspring, a common behavior within the Buthidae family, although, to our knowledge, not previously reported for *C. gracilis*.

Introduction

The brown bark scorpion *Centruroides gracilis* (Latreille, 1804) is a large sized (total length, 55–120 mm; Armas et al., 2012), widespread and abundant species in the Neotropical America and the insular Caribbean (Teruel & Myers, 2017), including Utila Island, Honduras (Brown & Arrivillaga, 2019). Despite being a common buthid scorpion in its range, relatively little information is available on the ecology of *C. gracilis.* Previously, most studies of *Centruroides* have focused on specimen taxonomic diversity and/or toxicity of included species (Santibáñez-López et al., 2015); hence, few *in situ* observations of its natural history and ecology are published. The diet of *Centruroides* consists primarily of invertebrates, with very infrequent instances of vertebrate predation (Bender, 1959); however, they are considered opportunistic (Lourenço & Cuellar, 1995) and may consume any prey their venomous sting can subdue. Although *C. gracilis* are not especially aggressive, their sting can, in some cases, have severe neurotoxic effects on humans (Toxinology WCH, 2018; Nentwig, 2018). Owing to the errant, non-burrowing and actively roaming nature typical of *Centruroides*, they will primarily respond to threats by fleeing instead of confronting them (Carlson et al., 2014). This differs from the only other scorpion species yet known from Utila, namely the endemic *Diplocentrus insularis* (Sagastume-Espinoza et al., 2015), which in contrast have a very cryptic lifestyle, mostly hidden under rotting wood or sometimes in burrows, and by comparison can act very defensively against threats (Longhorn, pers. comm., see also Sagastume-Espinoza et al., 2015).

The following note documents a series of opportunistic observations concerning the diet and life history of *C. gracilis* on Utila, which includes various unusual predation events, an observation of *in situ* cannibalism, and reproductive courting behavior while dependent second-instar offspring are present. All data were collected as a by-product of performing various biodiversity surveys and fieldwork on Utila Island in collaboration with local NGO Kanahau Utila Research & Conservation Facility (KURCF) from 2017–2020.

Observations

Ecology and Diet

Throughout the course of our studies, we primarily observed *C. gracilis* via flashlight after dark at various times between the hours of 19:00 h to 23:00 h, while they were active at night, searching or waiting for prey on tree trunks, rocks, or amongst the leaf-litter in forested habitats, but routinely also within urban buildings and on agricultural lands.

We recorded *C. gracilis* predating most frequently on various insects such as large cockroaches (Blattodea) and Orthoptera, including crickets (Gryllidae, Figure 1a) and katydids (Tettigoniidae, Figure 1b); or spiders (e.g. Araneae: Lycosidae, Figure 1c). Also, as we proceed to detail, several potentially dangerous prey items such as centipedes (Chilopoda: e.g. Scolopendromorpha, Figure 1d; Geophilomorpha, Figure 1e) and tarantulas (Araneae: Theraphosidae, Figure 2), as well as a case of cannibalism between two *C. gracilis* conspecifics (Figure 3).

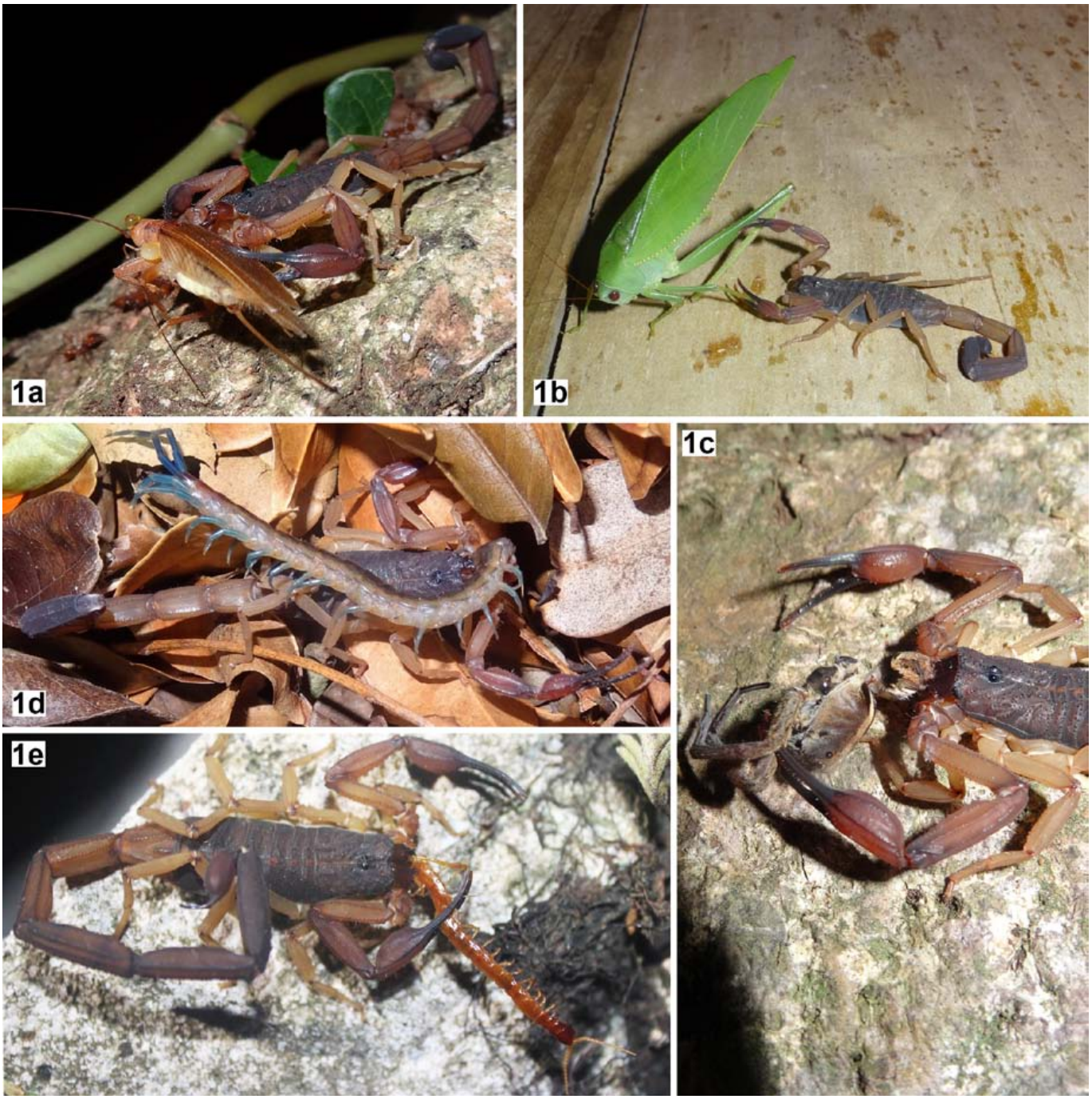

Figure 1. The diet of *C. gracilis* on Utila is composed of various invertebrates, which include; (**a**, **b**) Orthopterans, e.g. crickets (Gryllidae) and katydids (Tettigoniidae); (**c**) Arachnids such as the family Lycosidae (wolf spider); (**d**) unidentified Scolopendromopha and (**e**) unidentified Geophilomorpha centipede. [© a-d: Tom W. Brown; e: Chelsea Richardson]

On the night of 27 February 2018, c. 20:30 h, an adult female *C. gracilis* was encountered on the grounds of KURCF, perched c. 1m high on a thin branch extending from a pile of rotting logs and vegetation. The individual had captured and killed a well-grown unsexed adult *Tliltocatl albopilosus* (Valerio, 1980) and was observed in that position eating it for c. 30 minutes (Figure 2a). On 07 May 2020, 22:30h, we made a second observation of an adult male *C. gracilis* predating a small juvenile *T. albopilosus*.

On 18 July 2019, 20:45h, an adult male *C. gracilis* was encountered active amongst leaf-litter in forest habitat at a location known as New Jerico, carrying a half-eaten tarantula, which was later identified to belong to the genus *Stichoplastoris*. Compared to *T. albopilosus*, this unidentified *Stichoplastoris* species is rarely observed, and thus was immediately confiscated from *C. gracilis* to enable its identification. On further investigation, this sub-adult *Stichoplastoris* sp. can be distinguished from *T. albopilosus* by the former having a light brown dorsal colouration, more

rounded sternum, and in some individuals a golden-yellow colored ventral abdomen (Figure 2b).

On 21 July 2019, c. 21:00 h, an act of *in situ* cannibalism was observed between two adult female *C. gracilis* (Figure 3) on a tree trunk c. 40cm from the ground. Though both similarly sized, one female had apparently overpowered another, which was being held by both claws and spasming whilst being eaten. We photographed the event for over 10 minutes but did not stay to observe its full consumption.

Our observations of insect, centipede and spider predation are largely consistent with the known diet of *Centruroides* (e.g. see McCormack & Polis 1990) such as *C. gracilis*, but our observed interactions between *C. gracilis* and tarantulas do contradict existing literature. Although *C. gracilis* have been noted to attack the tarantula *Tliltocatl vagans* (Ausserer, 1875), they were never observed to be successful and, in most instances, the opposite outcome was concluded with *C. gracilis* being predated upon by the tarantula (Dor et al., 2011). Both *C. gracilis* and *T. albopilosus* are abundant on Utila Island, so predatory interactions between these two arachnids may not be uncommon. Potentially, *T. albopilosus* is not as potent a predator as *B. vagans*, meaning *C. gracilis* may be more successful at preying upon the former. That said, both the growth trajectory and the maximum size of adults of both these closely related tarantula species appears to be very similar, so we expect that some predation of *C. gracilis* by *T. albopilosus* does still occur, but predict that to be primarily by the largest and older female tarantulas. In the case of predation by *C. gracilis* upon the *Stichoplastoris* sp., these tarantulas are more pugnacious than *T. albopilosus* (T. Brown, pers. observ.), so along with further protection by their obligate burrowing nature, their predation by *C. gracilis* is also surprising. To our knowledge, *Stichoplastoris* sp. and *C. gracilis* have no prior known interactions recorded in the literature. From our three presented observations of predation by *C. gracilis* upon tarantulas together, all involved likely immatures, suggesting that regardless of genera these species are more vulnerable to predation by *C. gracilis* while they are still growing. These predatory interactions might be less frequent as the tarantulas grow, and especially when females of each become adults.

Furthermore, for interactions between scorpions, while the current literature does allude to maternal cannibalism in *C. gracilis* (Francke & Jones, 1982) and cannibalism on immature conspecifics in general (Rodríguez-Cabrera et al., 2020); there are no observed records of cannibalism between adult individuals. In fact, *C. gracilis* are often noted for their social behavior (Farley, 2008) and guides for those keeping the species in captivity generally refer to cannibalism being unlikely, suggesting these scorpions as being communal and suitably housed in groups (Weide, 2019). While acts of cannibalism may be rare in the focal species, our observation provides an actual *in situ* record of such an event, which demonstrates that, if given the opportunity, adults of *C. gracilis* may predate upon each other in a natural setting. Throughout the animal kingdom, various studies indicate that cannibalism can be more frequent during periods of low resource availability, and/or high population density, therefore acting as a self-regulatory agent by maintaining the stability of the population (Polis, 1980; Solomon, 1949). Opportunistic species, such as members of the genus *Centruroides*, commonly occupy unstable and disturbed environments, where they tend to have relatively high populations densities (Lourenço & Cuellar, 1995). Although cannibalism in *C. gracilis* might stem in part from their opportunistic predatory nature, in this case, we expect it may also relate to an exceptionally high abundance of conspecifics (T. Brown, pers. observ) and/or intraspecific competition for prey sources on Utila Island.

Reproduction

Like many buthid scorpions, males and females of *Centruroides* species will court each other and undergo external fertilisation while performing a lengthy 'dance' (Williams, 1987). Males are known to grasp the claws of the female and then lead a synchronised back and forth movement (Figure 4); during which time, the male deposits a spermatophore on the ground and then encourages the female to collect it (Williams, 1987; Polis & Sissom, 1990).

On 13 April 2020, 19:45h, we encountered a male and female of *C. gracilis* engaged in reproductive behavior, courting for c. 25 minutes (as described above) while horizontal on the flat surface of a rotting *Cecropia* trunk. Most notably however, the receptive female had a dependent brood of >30 second-instar young present on her back, which were not disturbed during the process of reproduction (Figure 4).

This observation demonstrates that *C. gracilis* can reproduce rapidly under the correct conditions, and that females will be receptive of courting males even when prior offspring are still dependent. Locomotion in the females of the Buthidae family does not seem to be greatly affected while carrying their offspring, as several genera, including *Centruroides*, reportedly feed frequently and even participate in the courtship dance whilst brooding (Williams, 1969; Polis & Sissom, 1990). Although this latter behavior has been reported for another species from another scorpion family Vaejovidae, it appears to be more common within Buthidae (Polis & Mohnac, 1990). Previous studies suggest that in order to produce another brood, female buthids need to mate again after each parturition (Armas, 1987), which could explain this somewhat unusual observation.

After giving live birth to anywhere between 26-46 offspring (Francke & Jones, 1982), the young of *C. gracilis* will seek refuge and protection on the mother's back for at least 8 days, until they surpass their first or second instar (moult) (Francke & Jones, 1982; Farley, 2008). On Utila, we have observed adult female *C. gracilis* carrying such young on numerous occasions during the months of March and April in 2016, 2017, 2020, as well as August 2018. The latter observation was of an adult female *C. gracilis* attending instar young whilst cohabiting a diurnal 'bark peel' refuge with a large endemic gecko *Phyllodactylus palmeus* Dixon, 1968, to possibly mutual benefit (as reported in Brown & Arrivillaga, 2018). Collectively, our observations suggest that *C. gracilis*

Figure 2. Two instances of tarantula predation by *C. gracilis* on Utila. (**a**) Subadult male perched on branch c.1m high with predated adult *Tliltocatl albopilosum* [© Cristina Arrivillaga]; **(b)** ventral photograph of the subadult *Stichoplastoris* sp. remains, after being confiscated from an adult *C. gracilis* prior to photograph [© Tom W. Brown]

Figures 3–**4**: **Figure 3**. A case of *in situ* cannibalism observed between adult female *C. gracilis* on Utila; both individuals were of similar size. [© Anna Davison]. **Figure 4**. An adult male *C. gracilis* (left) tentatively courts and reproduces with an adult female (right) by clasping her claws to lead a back and forth motion, while the female carries her prior brood of c. 30 second-instar offspring on her back. [© Tom W. Brown]

reproduction on Utila may be temporally restricted to the dry season, i.e. c. February–September.

We hope our presented observations further the current understanding of *C. gracilis* diet and reproductive behavior. As this species is noted to be commonly found in transported produce, such clarification of the natural diet and reproduction of this focal species could prove essential in managing it as an invader (Williams, 1987; Nentwig, 2018). Our observations may also help distinguish *C. gracilis* from other closely related species in Central America.

Acknowledgments

We would like to thank the staff a nd a ssisting student researchers at Kanahau Utila Research & Conservation Facility for their ongoing support in documenting the biodiversity of Utila. Special thanks to Ana Daniella Sansur and Chelsea Richardson for contributing an observation and/or a photograph for this publication, and to Dr. Stuart J. Longhorn for his expert reviews on this note.
All authors contributed equally to the writing of this note. We have no conflicts of interest to declare.

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