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Scientific Note

Necrophagy in cave environments: ecological pressure due to food scarcity? A case study of necrophagy by a harvestman *Discocyrtanus canjinjim* Carvalho & Kury, 2017 (Arachnida: Opiliones) preying on an *Eidmanacris* sp. (Orthoptera: Phalangopsidae) carcass

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Abstract. Cave environments present stable abiotic conditions, including permanent darkness, high humidity, and mild temperatures, while biotic factors reflect simplified ecological networks and energy constraints. Cave invertebrates, primarily detritivores and generalists, demonstrate specific adaptations to these conditions. Predation and necrophagy are critical behaviors shaped by the cave's scarcity of food resources. In this study, we report a rare necrophagy event involving *Discocyrtanus canjinjim* Carvalho & Kury, 2017 (Arachnida: Opiliones) feeding on a deceased cricket (*Eidmanacris* sp.) (Orthoptera: Phalangopsidae) in the Ponte de Pedra I Cave, Brazil. This limestone cave features large entrances and supports an oligotrophic system. The event occurred in an aphotic zone, where the harvestman displayed no flee behavior despite external stimuli. The presence of other predatory arachnids suggests potential intra-guild competition. Opiliones in the Cerrado and Caatinga exhibit opportunistic carnivory, consuming various prey taxa, including insects and vertebrates. Necrophagy, intra-guild predation, and cannibalism are behaviors reported in subterranean populations due to limited food availability. Climate change and anthropogenic pressures, such as deforestation and mining, threaten the stability of cave environments. Observations like this contribute to understanding the ecological dynamics within caves, highlighting the importance of preserving these fragile ecosystems.

Keywords: Brazil, cave ecology, invertebrate behavior, subterranean ecosystems.

The cave environment is a distinct element of the landscape, characterized by its stable abiotic conditions, permanent absence of light in deeper zones, high humidity near saturation, and mild temperature with little variation (Culver & Pipan 2009; Tobin et al. 2013). Biotic conditions include simplified ecological networks, minimal or no primary production within the system, and energy support from the oligotrophic system facilitated by physical and biological agents (Simon et al. 2007). Energy availability varies between caves and is influenced by factors such as the size and number of entrances, affecting the system's carrying capacity and connection to the surface environment (Silva et al. 2011; Pellegrini et al. 2016).

Cave invertebrate communities are primarily composed of detritivores or generalists (Ferreira & Martins 1999) that exhibit adaptations and tolerances to various biotic and abiotic characteristics of the epigean environment, acting as environmental filters. These invertebrates also occupy specific niches within the caves that align with their physiological and behavioral traits (Simões et al. 2015).

The study of ecological interactions and predation events within caves aims to determine whether the conditions of the cave environment, such as reduced food availability, lead to behaviors considered rare or if they are opportunistic (Bernardi et al. 2010; Souza-Silva & Ferreira 2014; Bernardi et al. 2020). Among the rare interactions occurring under conditions of scarcity is necrophagy, which is defined as a feeding strategy where organisms obtain energy from consuming the organic matter of already deceased animals (Wilson & Wolkovich 2011). Few species rely on this strategy as their primary resource; most are predators or consumers that adopt this behavior opportunistically (Trujillo et al. 2021).

In this study, we report a novel event of a male of *Discocyrtanus canjinjim* Carvalho & Kury, 2017 (Arachnida: Opiliones) preying on a previously deceased cricket, *Eidmanacris* sp. (Orthoptera: Phalangopsidae). The observation (Fig. 1) was made in the Ponte de Pedra I Cave, located in the municipality of Montividiu, Goiás State, in the central-western region of Brazil (Fig. 2). This limestone cave features large entrances and is intersected by the substantial Verdão river. The cave's formations extend laterally at higher levels above the riverbed.

Figure 1. *Discocyrtanus canjinjim* preying on the jumping leg of *Eidmanacris* sp. (Orthoptera: Phalangopsidae) in the aphotic zone of Ponte de Pedra Cave, Montividiu, Goiás.

Ponte de Pedra Cave is located in a permanent preservation area within a *strictu sensu* Cerrado matrix, featuring a tropical wet and dry (Aw) climate according to the Köppen classification (Alvarez et al.

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2013), characterized by hot, rainy summers and mild, dry winters in Montividiu, Goiás. The cave has many entrances (Fig. 3) to the epigeal zone for terrestrial areas and also at the passage of the Verdão River, in addition to a skylight. This characteristic indicates a mosaic of light zones where the aphotic area is restricted to a small area at the bottom of the cave. During the summer, the local population and tourists use the cave on weekends and the surrounding area where there are bathing areas and camping areas, which can cause stress to the local fauna and deposition of anthropic material.

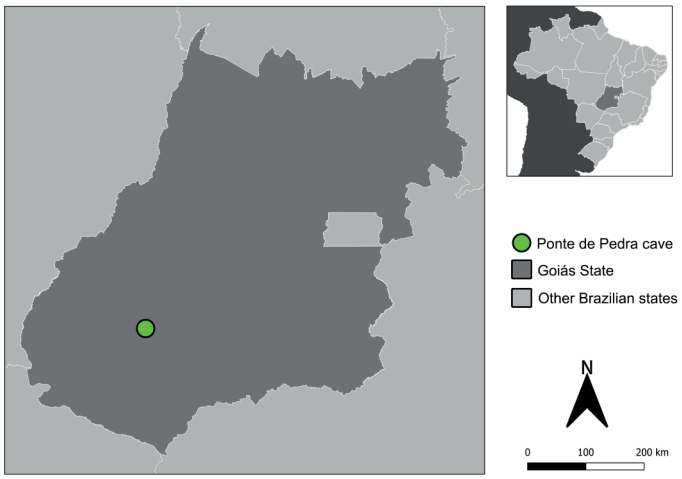

Figure 2. Location of Ponte de Pedra Cave in the state of Goiás, surrounded by a Cerrado matrix, Brazil.

The event was observed for about five minutes without any interference from the researchers, who did not collect the animals for preservation. The harvestman was found in an aphotic zone on a lateral wall approximately 1 meter above the floor where the *Eidmanacris* sp. carcass, already dried after death, was located (identification to the species level was not possible due to the state of decomposition). Despite the researchers' approach and the presence of light from their lanterns in the otherwise unlit area of the cave, the harvestman remained motionless, holding onto its prey without attempting to flee.

The cave is divided into a large entrance hall with a continuous body of water and fallen blocks, an upper hall with difficult access and a sandy floor, a deeper conduit, where there are dysphotic and aphotic zones and some narrow entrances between rocks where there is the entry of floodwaters that bring with them plant material (leaves, branches). Throughout the entire length of the cave, there is a lot of humidity due to the presence of the river crossing the entire cavity and the presence of epigean plant roots.

Other predatory arachnids, such as spiders of the genus *Loxosceles* Heineken & Lowe, 1832 (Arachnida: Sicariidae) and amblypygids *Heterophrynus* sp., among other species of spiders and harvestmen, were found in the cave and near the necrophagy event site, indicating potential intra-guild competition within this environmental niche. In addition to the arachnids found and reported in this work, lepidopterans, ants, termites, anurans, a small colony of bats, and coleopterans were also found.

Crickets *Eidmanacris sp*. are not reported for aphotic areas of caves, being normally abundant in the entrance or ecotonal areas between the epigean and hypogean environments. In this case, other individuals were sighted in the cave entrance area, which may indicate that there was predation by another predator or that the carcass was taken to this luminous zone by abiotic agents such as flooding, for example. Two other individuals of *D. canjinjim* were also seen on side walls, both in the dysphotic zone of the cave, apparently at rest, indicating that these animals move between the luminous zones.

Opiliones are nocturnal arachnids inhabiting the Cerrado and Caatinga, primarily in landscape niches such as caves, tree trunks, under stones, or on vegetation (Curtis & Machado 2007; Giupponi et al. 2017; Rubim et al. 2023). Their diet is characterized as opportunistically carnivorous, with records of various taxa, including Hymenoptera (Rubim et al. 2022), Lepidoptera, Hemiptera (Silva

Figure 3. A - Main entrance to the cave Ponte de Pedra; B - Main entrance hall, all in the photic zone of the cavity with a body of running water; C - Verdão River and skylight; D - Very narrow secondary inlet with a lot of deposition of plant organic matter; E - Waterfall around the cave; F - Karst and Cerrado surrounding the cavity.

et al. 2024), crustaceans, and annelids (Sabino & Gnaspini 1999), gastropods (Nyffeler & Symondson 2011) and even vertebrates like frogs (Menegucci et al. 2020). Temperature range and humidity levels serve as key environmental filters for these animals. Thus, more stable environments, such as caves, are conducive to their habitation (Bragagnolo et al. 2007).

Harvestmen of the genus *Discocyrtanus* Roewer, 1929 (Arachnida: Opiliones) indicate diverse feeding habits and dependence on olfactory cues from their prey via chemoreceptors, which can be live animals, dead or decomposing animals, as well as fungi and plant material (Costa & Willemart 2013; Nyffeler et al. 2023).

Necrophagy has been observed in top-predator arachnids in Neotropical caves, including necrophagy events involving bats by whip-spiders (Prous et al. 2017; Trujillo et al. 2021). Predation behaviors vary when comparing populations of generalist animals in subterranean and surface environments. The cave environment, characterized by significantly lower food availability, often leads to broader utilization of all potential prey, including dead prey (necrophagy), intra-guild predation, and even cannibalism (Chapin 2015; Prous et al. 2017; Bernardi et al. 2020).

It is important to note that stable environments are threatened by climate change (Pereira et al. 2024) and cave environments by anthropogenic pressures such as deforestation, degradation and pollution of water bodies, lowering of the water table, and mining activities (Van Beynen & Townsend 2005; Calò & Parise 2006; Sperandei et al. 2023). Scientific records of observations like this provide a foundation for ecological network studies, fostering a deeper understanding of how subterranean environments are utilized by their inhabitants.

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Authors' Contribuitions

VFS: Conceptualization, Investigation, Resources, Supervision, Writing - original draft; CMB: Investigation, Writing - review & editing; MSA: Investigation, Writing - review & editing.

Conflict of Interest Statment

The authors declare no conflict of interest.

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