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Heterogeneity of arthropod communities on the canopy of *Ouratea hexasperma* (Ochnaceae): does canopy size matter?

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ABSTRACT. Arthropods exhibit high diversity, wide ecological range, broad distribution, and are found in various environments and microhabitats. In the Cerrado biome, many arthropods interact with specific plants, which function as their habitat and foraging grounds. The shrub-tree species *Ouratea hexasperma* is common in the Cerrado and displays considerable variation in individual canopy size. A direct positive relationship linking area and richness is a widely studied topic in Ecology, with such relationship also being observed in island-like environments. Considering each canopy as an island-like community, in this study, we analyzed the relationship between arthropod richness (measured as family richness) and tree canopy size. We collected and identified 17 arthropod families from nine orders on *O. hexasperma* trees, with Insecta being the most abundant taxon, followed by Arachnida and Myriapoda. However, Arachnida presented the highest number of families (seven). Our results show a positive correlation between canopy size and arthropod richness, indicating that larger canopies support richer arthropod communities. Thus, our findings support the species-area relationships on small geographic scales.

Keywords: biodiversity; cerrado; tree; community ecology.

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Introduction

Tree canopies are important habitats for a large number of animal species and serve as the main source of primary production in the biosphere, directly influencing the water and carbon cycles. Because of their significant ecological role, tree canopies became one of the most studied habitats (Vaca-Sanchez et al., 2021; Carvalho et al., 2024; Tafesse et al., 2025). As primary producers, canopies also support diverse and complex biological communities, making them key in maintaining ecosystem health.

Among the organisms inhabiting these environments, arthropods are notable for their abundance and diversity, often constituting the most prevalent taxon in the fauna of tropical forests (Stork & Hammond, 1997; Basset et al., 2002; Novotny et al., 2002; Lucky et al., 2002). Consequently, these animals can influence the structure of tree canopies and are highly sensitive to environmental changes (Hijji et al., 2001).

In tropical environments, few arthropod species are found evenly across all vertical strata, as many undergo different stages in various parts of the forest or move seasonally in response to resource availability and climatic variations (Crowley et al., 2023). As space is often a limiting factor, it is one of the key resources that directly influences the abundance of arthropod species within a habitat (Entling et al., 2012; Marja et al., 2022). Larger canopies tend to provide greater habitat complexity and more resources (e.g., phytophagous arthropods, oviposition sites, molting refuges), which can support greater species richness (Blaise et al., 2022).

The tree *Ouratea hexasperma* (Saint-Hilaire, 1825) Baill. (Ochnaceae) exhibits considerable variation in individual size, rarely exceeding 5 meters in height. It is well-adapted to dry and arid conditions, thriving in habitats such as rocky fields, Cerrado *sensu stricto*, and Cerradão, which are characterized by poor soils and high temperatures. This adaptability highlights its resilience to harsh environments. This species has a thick bark that protects it from frequent wildfires, while its leathery leaves help reduce water loss, making it particularly suited for drought-prone areas. These traits are critical for the conservation and restoration of its native biome, the Cerrado, considered a hotspot of biodiversity and threatened by extensive agriculture (Rodrigues et al., 2016).

Additionally, *O. hexasperma* plays a key ecological role by supporting arthropod populations, serving both as habitat for residents and as a resource for visitors, such as pollinators (Barros-Henriques, 1999). A notable interaction involves the formation of galls, often referred to as "witches' brooms," which can significantly influence the abundance and diversity of other plant-dwelling arthropods (Pires et al., 2020). These galls add habitat complexity to the canopy, potentially supporting a wider variety of species. Research has shown that the number of galls on *O. hexasperma* is positively correlated with tree size, suggesting that larger individuals may host more complex arthropod communities (Araújo et al., 2011). Furthermore, canopies of the same tree species can host highly different communities (Coleman et al., 1982; Nógues-Bravo & Araújo, 2006), often being studied as island-like environments. The Island Species Area Relationship (ISAR) presents several hypotheses to explain the positive correlation between species richness and area of the habitat, which can be represented by canopy size. One of these hypotheses suggests that higher levels of habitat heterogeneity may be for the mechanisms by which larger canopies support richer communities, especially when not overshadowed by dispersal limitations, often observed in larger islands (Gooriah & Chase, 2020).

In this study, we consider each *O. hexasperma* canopy as an individual island-like environment and analyzed the structure of the arthropod community on the canopy of *O. hexasperma* along a gradient of plant size. We do so to test a direct correlation between arthropod richness and abundance and canopy size.

We expect that overall arthropod abundance, and richness will increase with canopy size, supporting the species-area relationship.

Material and methods

The study was conducted on October 4th and 9th, 2019 in the Sítio de Recreio Park, Mansões do Campus (16°34'03.7" S 49°17'00.7" W), located in the municipality of Goiânia, State of Goiás, Brazil (Figure 1), shortly after the end of the dry season, with sporadic rain and mild temperatures (28-36°C). As October is a post cerrado-burning month, the area was affected by wildfires during most of September. The study area was delimited within a 200 m^2 remnant of natural vegetation preserved in an urban area.

Figure 1. Location of the sampled area, marked in the highlighted polygon.

Ten individuals of *O. hexasperma* were randomly selected within the study area for canopy arthropod sampling, maintaining a minimum distance of 2 meters between each sampled tree. Despite the small distance between trees, *O. hexasperma* are frequently visited by pollinators, thus, we would also like to collect and identify this guild. Arthropods were collected using the beating tray technique (Saturnino & Tourinho, 2011), which involved vigorously beating the canopy of each tree for five minutes. All arthropods captured in the tray were collected and stored in individual plastic containers with 70% alcohol, with one container designated for each tree and properly labeled.

For each tree, the following measurements were recorded: (i) plant height, measured from the ground to the highest point using a measuring tape and ladders and (ii) canopy diameter, measured at chest height with a metric tape, as the distance between the most distant points of the canopy. Due to the relatively small size of the trees, these measurements were easily obtained. The total canopy size was calculated as the product of tree height and canopy diameter.

In the laboratory, arthropods were sorted and identified to the family level using stereoscopic microscopes, along with reference books and taxonomic keys (Brescovit et al., 2004). The samples were deposited in the collection of the Laboratory of Taxonomy, Ecology, and Interactions of Arachnids at the *Universidade Federal de Goiás* (Lab. TEIA, UFG).

All statistical analyses were conducted using R software (RStudio Team, 2020), and the packages ggplot2 (Wickham, 2016) and dplyr (Wickham et al., 2023). Total canopy size, the number of families collected per tree, and the number of arthropods collected per tree were log-transformed to base 10. Linear regression analysis was performed to examine the relationship between arthropod abundance and family richness in relation to total canopy size. All data used in this study are available upon request.

Results and discussion

The sampled *O. hexasperma* plants ranged in height from 1.24 to 6.20 meters. A total of 83 arthropods were collected from these plants, distributed across the classes Arachnida, Insecta, and Myriapoda. Insects were the most abundant, comprising 61% of the individuals collected, followed by Arachnida with 33% and Myriapoda at 6%. Among the taxa sampled, ants were the most numerous (Table 1).

In terms of order richness, Insecta was the most diverse, represented by six orders, while Myriapoda included one order and Arachnida included two orders. Notably, spiders stood out for their family richness, accounting for 33.3% of the total number of families identified (Figure 2). In total, 17 families were identified, with one group of Insecta remaining unidentified in this study (Table 1). The most frequent groups in small canopies were Formicidae and Curculionidae, while in larger canopies, spiders and pseudoscorpions were the most frequent (Figure 4).

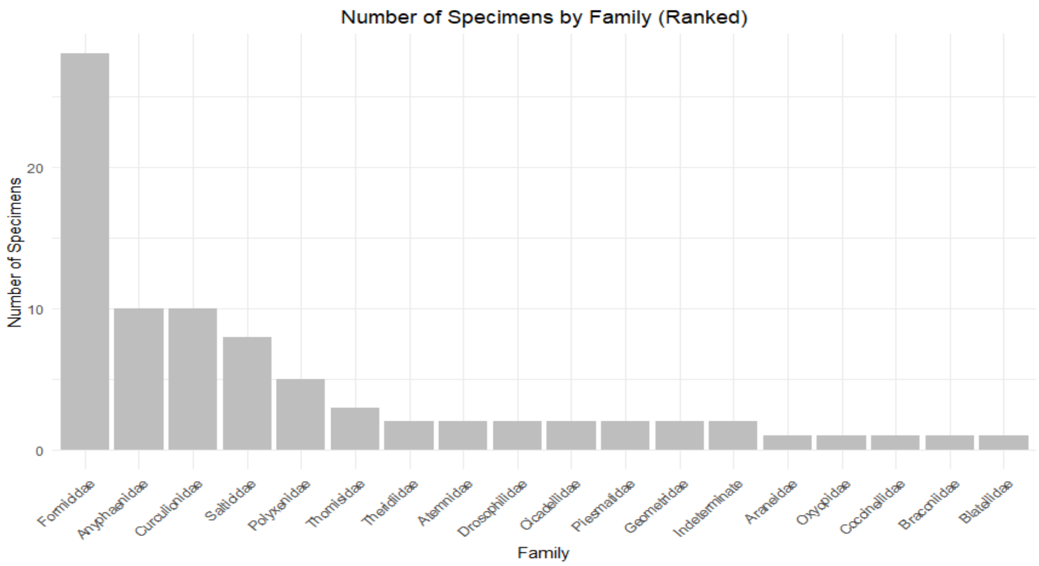

Figure. 2. Number of families found in each order of arthropods sampled in trees of *Ouratea hexasperma*.

The total number of individuals sampled per tree varied greatly, while the total number of families sampled per tree showed less variation. The mean abundance across all trees was 0.7544 individuals, while mean richness was 0.7018 families. We identified a positive relationship between canopy size and arthropod family richness (R^2 = 0.8929; p = 0.014; Estimate = 1.06639), indicating that plants with larger canopies support a greater diversity of arthropod taxa (Figure 3 - A). Furthermore, the linear regression between tree canopy size and arthropod abundance was also statistically significant (R^2 = 0.812; p = 0.0002; Estimate = 1.01870, Figure 3B). This suggests that larger canopies not only support more diverse arthropod families but also harbor a greater overall number of arthropods. Similar findings have been reported by other studies (Wildermuth et al., 2024), which also concluded that canopy size and structure are more determining to arthropod diversity than tree identity itself. Despite the small data size used in our study, the pattern we found seems to depict niche partitioning following the canopy size gradient, as described in the "habitat-heterogeneity hypothesis" (Stein & Kreft, 2015), as predatory arthropods (spiders and pseudoscorpiones) were only sampled in larger canopies, while small canopies housed mainly hymenopterans (ants) and phytophagus coleopterans (Figure 4). Additionally, other studies have found that canopy beating yields the largest richness and abundance of arthropods amongst all the other sampling methods (Crowley et al., 2023). Thus, despite the low number of sampled trees, by using the optimal sampling method, we were able to gather a large number of arthropods. Therefore, we can conclude that a great portion of the communities dwelling in the canopies was sampled, minimizing the "small sample effect" over the conducted analysis (Carvalho et al., 2024).

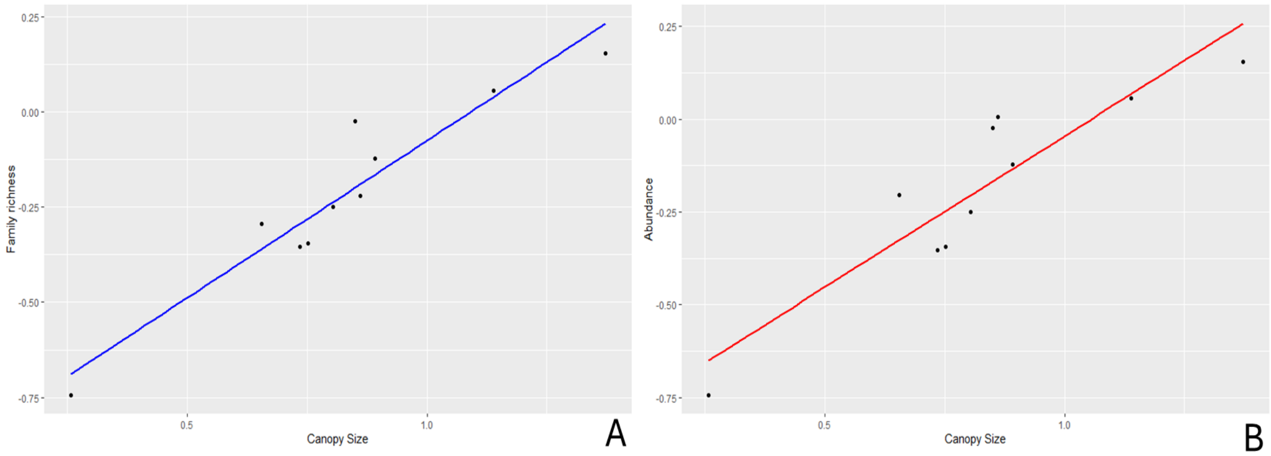

Figure 3. Linear regression analysis showing a positive correlation between (A) arthropod richness and (B) abundance (number of individuals collected per tree) with total canopy size.

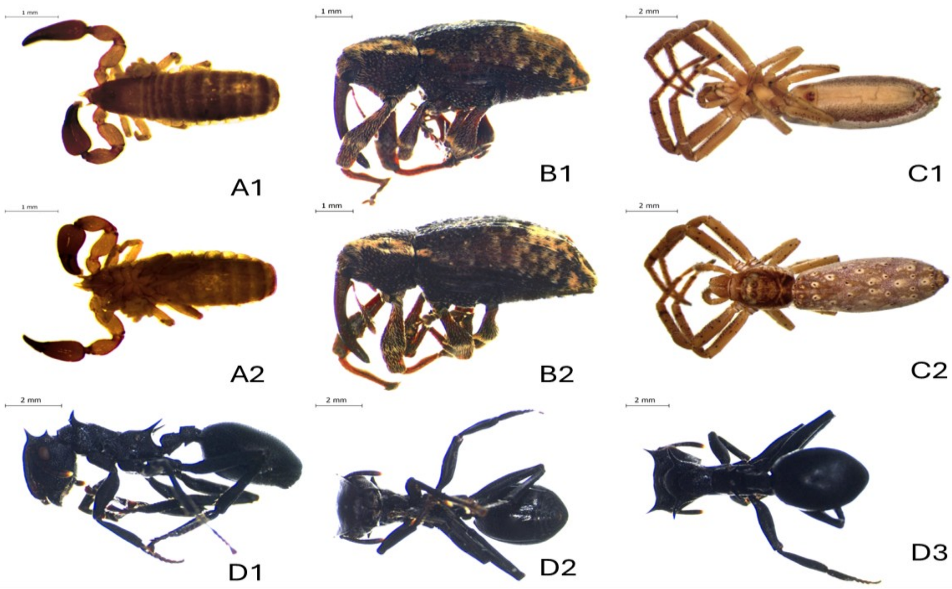

Figure 4. Sampled arthropods. A. Atemnidae pseudoscorpion (1 - dorsal view, 2 - ventral view); B. Curculionidae coleopteran (1,2 - lateral view of two different individuals); C. Thomisidae spider (1 - ventral view, 2 - dorsal view); D. Formicinae hyrmenopteran (1 - lateral view, 2 - ventral view, 3 - dorsal view).

The reported positive correlation between canopy size and our response variables (family richness and total abundance) may stem from the greater availability of resources, such as increased niche diversity, food resources (e.g., prey), and more favorable microclimatic conditions (Torres-Pulliza et al., 2020) found in larger trees. These trees appear to provide a more suitable environment for accommodating a higher number of individuals and families, leading to the observed patterns, which supports similar findings on *O. hexasperma* arthropod communities (e.g., Pires et al., 2020). Although other studies have used different approaches to sample arthropod communities, we suggest that tree size itself is a key determinant of species richness and abundance, which has often been overlooked as general background noise in other *O. hexasperma* studies (see Araújo et al., 2011; Pires et al., 2020), while being corroborated by different approaches towards canopy composition influencing arthropod communities (Müller et al., 2018 ; Tobisch et al., 2023). This pattern is not exclusive to *O. hexasperma*, as has been reported in different Ochnaceae tree species (e.g. *Ouratea spectabilis*, Del-Claro & Alves-Silva, 2016). Furthermore, this pattern is not restricted to the Cerrado biome, as the correlation has been shown to occur as an ecological rule, regardless of tree species (Wildermuth et al., 2024).

The only trees in which no predators (spiders and pseudoscorpions) were collected were the smallest specimens sampled, suggesting that the presence of spiders may only be possible in trees capable of maintaining a higher abundance of insect prey. This pattern is again evident in trees with larger canopies from which spiders were collected in large numbers, thus corroborating previous studies (e.g. Butz et al., 2023). Such observations are evidence of vertical stratification, which is a known community shaping factor for Arthropods (Zeller et al., 2023). Small *O. hexasperma* individuals had similar values of canopy height, length and width, summarizing canopy volumes close to 1 m^3, which proved too small to house significant microclimatic stratification (Sallé et al., 2021), impacting the overall abundance of arthropods (Bispo et al., 2022).

Additionally, considering the results of this study, it is possible to assume that larger *O. hexasperma* trees have higher conservation importance, as they host larger arthropod communities and, if cut down, would display a larger loss of microhabitat for the overall environment in which they occur. Therefore, we suggest such a pattern should also be considered while planning conservation efforts for *O. hexasperma* in the Brazilian Cerrado. From a conservation point of view, this relation suggests that the size of *O. hexasperma* alongside the canopy of other plants might have a key role in the stability of arthropod fauna in areas of the Cerrado biome.

Conclusion

In summary, we found that larger canopies of *O. hexasperma* host greater richness and abundance of arthropods, possibly due to increased resource availability. It is also important to point out that this is an observational study which described such a relationship in the end of Cerrado's dry season, in a conserved remnant, and despite our findings, additional and more prolonged studies would certainly add robustness to the overall "habitat-heterogeneity-hypothesis" and further elucidate the mechanisms which drive arthropod richness in canopies. Additionally, our work adds new information about the arthropods that inhabit *O. hexasperma*, which is better known for its chemical properties and related uses (e.g. Daniel et al., 2005; Fidelis et al., 2019).

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