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Beneath umbrellas: Noteworthy records of tent-roosting bats in Guatemala's Maya Biosphere Reserve

Bajo sombrillas: registros notables de murciélagos tenderos en la Reserva de la Biosfera Maya, Guatemala

Ana Lucía Arévalo[1*], Luis A. Trujillo[2,3], Ricardo Sánchez-Calderón[1,4], Rodrigo A. Medellín[5], and Bernal Rodríguez-Herrera[6,7]

[1]Sistema de Estudios de Posgrado, Escuela de Biología, Universidad de Costa Rica (UCR), San Pedro de Montes de Oca, 11501-2060, San José, Costa Rica. Email: arevalofigueroaanalucia@gmail.com (ALAF); ricardosanchezc92@gmail.com (RSC).
[2]Fundación Defensores de la Naturaleza, Guatemala City, Guatemala.
[3]Escuela de Biología, Universidad de San Carlos de Guatemala, Guatemala City, Guatemala. Email: trujillososaluis@gmail.com.
[4] The School for Field Studies, Center for Amazon Studies (SFS), San Martín, Tarapoto 22201, Peru.
[5]Instituto de Ecología, Universidad Nacional Autónoma de México, Ciudad de México, México. Email: medellin@iecologia.unam.mx.(RML)
[6]Escuela de Biología, Universidad de Costa Rica, San José, Costa Rica.
[7]Centro de Investigación en Biodiversidad y Ecología Tropical, Universidad de Costa Rica, San José, Costa Rica. Email: bernal.rodriguez@ucr.ac.cr (BRH)
*Corresponding author

Neotropical tent-roosting bats can modify approximately 77 species of plants as tents, most inhabiting lowland tropical forests. At least ten of the 22 known species of tent-roosting bats occur in Guatemala. Many studies have investigated their roosting ecology in Central America. Nevertheless, this behavior is still undocumented in this country. Here, we describe for the first time the use of *Sabal mauritiiformis* and *Cryosophila stauracantha* palm trees with tents occupied by *Artibeus jamaicensis* and *Dermanura* sp. in two localities of the Maya Biosphere Reserve, (MBR) Guatemala. We report a total density of 35.11 (tents/ km2) for both localities, most of them with big seeds underneath. All S. *mauritiiformis* tents presented a type of ceiling modification that had never been reported before. This study furthers our understanding of bat ecology and behavior in Central America. We expect many tent architectures to be present in the region and tents in plant species not reported before since Guatemala has a great diversity of plants that, according to the literature, are used as tents by bats in other tropical regions. We also expect that these bats will play an important role as seed dispersers in the Guatemalan forests.

Key words: *Sabal mauritiiformis*; Neotropical bats; Guatemala; tents.

Los murciélagos neotropicales que habitan en tiendas modifican aproximadamente 77 especies de plantas como refugios, la mayoría de las cuales se distribuyen en bosques tropicales de tierras bajas. Al menos diez de las 22 especies de murciélagos que ocupan estas tiendas habitan en Guatemala. Varios estudios han investigado la ecología del refugio de estas especies en Centroamérica. Sin embargo, este comportamiento aún no ha sido documentado en este país. Describimos por primera vez el uso de *Sabal mauritiiformis* y *Cryosophila stauracantha* como refugios por *Artibeus jamaicensis* y *Dermanura* sp. en dos localidades de la Reserva de la Biosfera Maya (RBM), Guatemala. Reportamos una densidad total de 35.11 (tiendas/km2) para ambas localidades, la mayoría de estas con semillas debajo. Todas las tiendas de *S. mauritiiformis* presentaban una modificación tipo "techo" nunca antes reportada.. Este estudio abre la puerta para seguir avanzando en la comprensión de la ecología y el comportamiento de los murciélagos en Centroamérica. Esperamos que una alta diversidad de arquitecturas y de especies de plantas aún no reportadas anteriormente estén presentes en esta región, ya que Guatemala cuenta con una gran diversidad de plantas que, según la literatura, son utilizadas como tiendas por murciélagos en otras regiones neotropicales. Asimismo, esperamos que estos murciélagos cumplan un papel importante como dispersores de semillas en los bosques de Guatemala.

Palabras clave: *Sabal mauritiiformis*; Murciélagos neotropicales; Guatemala; tiendas de campaña.

Guatemala is home to 105 species of bats grouped in 8 families: Phyllostomidae, Vespertilionidae, Molossidae, Emballonuridae, Mormoopidae, Noctilionidae, Natalidae, and Thyropteridae (Kraker-Castañeda *et al.* 2016; Trujillo *et al.* 2022; Trujillo *et al.* 2024). The country's great diversity of bat species and other taxonomic groups is explained by its location between North and South America and its extensive variations in altitude and precipitation, making it one of Latin America's repositories of biodiversity (Birner *et al.* 2005). Despite the richness of bat species, this group is still not well-studied as most studies have focused on their community composition level (Meachem 1968; Dickerman *et al.* 1981; Schulze *et al.* 2000), cave-dwelling species (Kraker-Castañeda *et al.* 2023; Kraker-Castañeda *et al.* 2024), infectious diseases (Ubico and McLean, 1995; Bai *et al.* 2011; Morán *et al.* 2015), and taxonomic lists (Pérez *et al.* 2012; Kraker-Castañeda *et al.* 2016).

Of the 51 species of Phyllostomidae documented in Guatemala, only ten have been confirmed to exhibit tent-roosting behavior. This group includes members of the genera *Dermanura, Artibeus*, *Uroderma,* and *Vampyressa* (Rodríguez-Herrera *et al.* 2007). Many studies

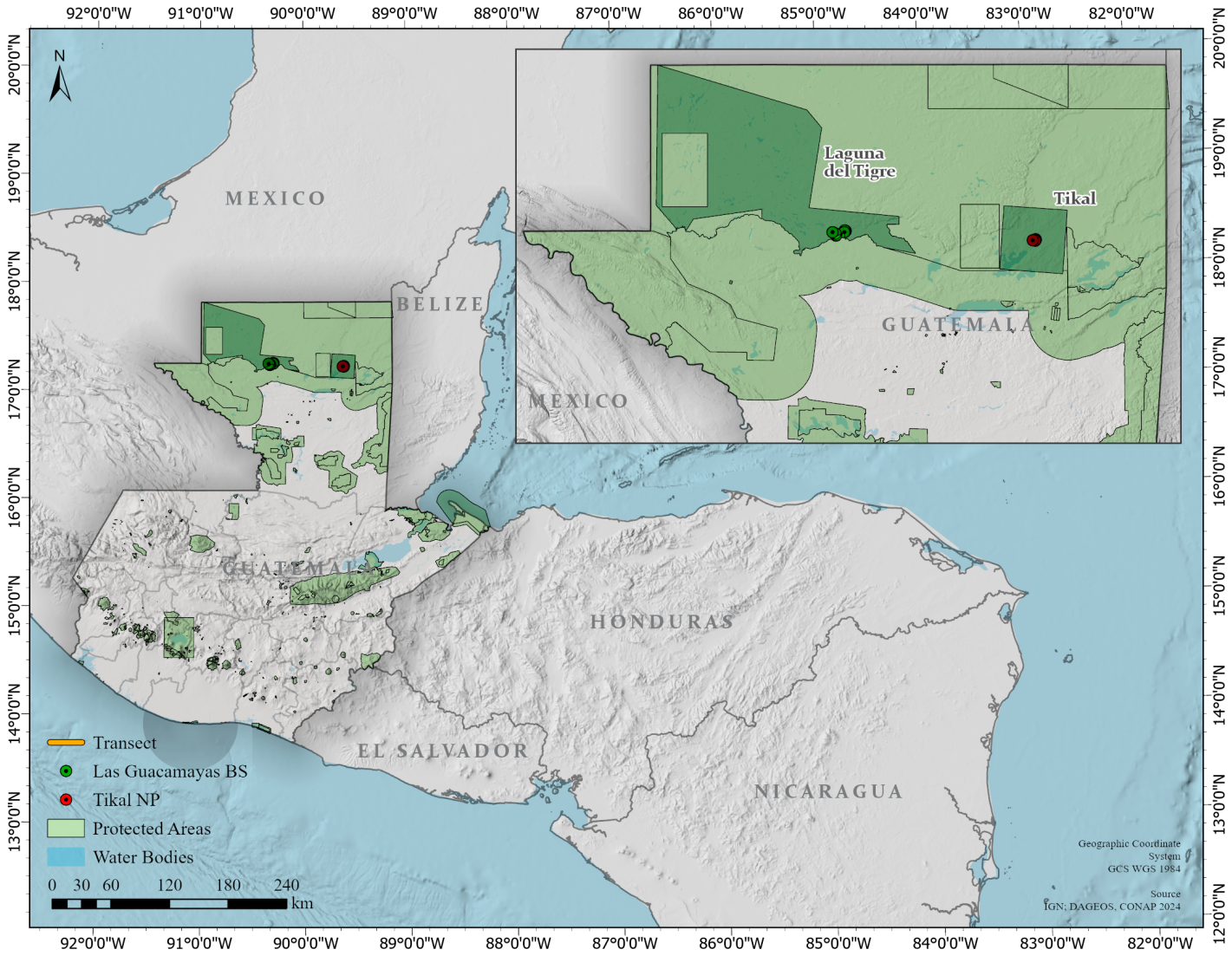

Figure 1. Study sites are represented by green polygons and sampling points by red and green circles. The Guatemalan System of Protected Areas is integrated into the main map (green polygons) (https://conap.gob.gt/direccion-de-analisis-geoespacial/) is integrated into the main map. Map elaborated by L. Trujillo.

have researched the roosting ecology of tent-roosting bats in Costa Rica (Brooke, 1897; Chaverri and Kunz, 2010; Gutiérrez-Sanabria, 2010; Rodríguez-Herrera *et al.* 2018; Rodríguez *et al.* 2021) and Panama (Choe, 1997; Lim, 1998; Cvecko, 2022); however, information on this behavior is absent in Guatemala.

In the Neotropics, around 22 species of Phyllostomidae are known to show this behavior, occurring with the greatest species diversity in Brazil, Colombia, and Perú (Tello and Velazco, 2003). These bats modify approximately 77 species of plants as tents, most inhabiting lowland tropical forests, being Arecaceae, Heliconiaceae, and Araceae, the most representative plant families, all of them present in Guatemala. Eight types of tent architecture are known to date: apical, bifid, umbrella, boat, conical, pinnate, boat-apical, and paradox (Rodríguez-Herrera *et al.* 2007). Since many of the tent-roosting bat species and their associated roosting plant species have been reported for Guatemala, we expect this behavior to be present in this country. Here, we report the tent-roosting behavior in two localities at the Maya Biosphere Reserve (MBR), Petén, Guatemala, for the first time. This report is not only the first for the study area but also for the country. It contributes to bringing attention to an understudied but important biological interaction, especially in the Central American region, and highlights the need to continue reporting these sightings.

Located in northern Guatemala, the Maya Biosphere Reserve (MBR), department of Petén, comprises Central America's largest tropical lowland forest, with a wide range of undisturbed natural habitats (Alarcón-Méndez *et al.* 2023). This region presents a medium temperature of 22 – 29° C and 1,000 mm – 1,900 mm annual precipitation (CONAP, 2016). We conducted this study in January 2024 on a short visit to Tikal National Park (17.2166, -89.6166 O) and Estación Biológica "Las Guacamayas (EBG)", Parque Nacional Laguna del Tigre (17.247216, -90.29288), both protected areas are part of the MBR (Figure 1). Tikal National Park (TNP) protects one of the largest ancient cities of the

Table 1. Number of tents registered in both study sites.

Locality	Trail (km2)	No. tents	Density (tents/km2)
EBG	0.00212	8	3.77
EBG	0.00474	29	6.11
			9.88
TNP	0.00218	32	14.67
TNP	0.00142	15	10.56
			25.23

EBG: Estación Biológica "Las Guacamayas", TNP: Tikal National Park.

Table 2. Plant species used as tents in both study sites.

Locality	Plant species	No. Tents	Architecture	Tents with seeds
EBG	*Sabal mauritiiformis*	12	Umbrella	6
	Cryosophila stauracantha	26	Umbrella	22
TNP	*Sabal mauritiiformis*	42	Umbrella	36
	Cryosophila stauracantha	5	Umbrella	2
Total		85		66

EBG: Estación Biológica "Las Guacamayas", TNP: Tikal National Park. Tents with seeds = seeds transported and consumed by bats in their roosts.

Maya Civilization, where it predominates highland forests composed of species such as *Cedrella odorata* and *Brosimum alicastrum*, among others (CONAP, 2004). At the Estación Biológica "Las Guacamayas," the dominant habitat is tropical dry forest (Murphy and Lugo 1986), mainly composed of savannas, wetlands, and highland forests (Colombo *et al.* 2015). Our study design was as simple as doing trails at least 0.5 km distance surveying for bat tents 0.02 km from the trail (wide). We surveyed a total area of 0.01046 km^2 and walked 5.23 km for both study sites, divided into shorter routes. In Estación Biológica "Las Guacamayas," we did two trails totaling 3.43 km (1.06 km and 2.37 km each x 0.02 km wide), and in Tikal National Park, we did two trails totaling 1.80 km (1.09 km and 0.71 km each x 0.02 km wide). For each route, we took the following data whenever we spotted a bat tent: 1) geographic coordinates, 2) plant species, 3) tent architecture, 4) cut shape, 5) bat species (if the tent was occupied), and 6) if there were seeds under the tent.

We found 38 tents in Estación Biológica "Las Guacamayas" and 47 tents in Tikal National Park. We report a total density of 9.88 (tents/km^2) for EBG and 25.23 (tents/km2) for TNP (Table 1). 66 of 85 tents had seeds underneath (Table 2). In both study localities, we found that *Sabal mauritiiformis* and *Cryosophila stauracantha* (Arecaceae) were used as tents in umbrella architecture and presented a heart-shaped cut. We only recorded 3 tents occupied, 2 by *Dermanura* sp. (*C. stauracantha* and *S. mauritiiformis*) and 1 *Artibeus jamaicensis* (*S. mauritiiformis*) (Table 2). All *C. stauracantha* tents presented a type of ceiling modification (Figure 2) that had never been reported before (Figure 2).

Our study is the first to report bats that use tents in the Northern Central American region, even though 10 tent-roosting bat species are reported for Guatemala. Guatemala's MBR does not count with an updated bat species list. Still, according to the species distribution and habitat requirements, only 6 tent-roosting species occur in the MBR: *Uroderma convexum, Artibeus jamaicensis, A. lituratus, Dermanura phaeotis, D. watsoni, and Vampyressa thyo*ne (Lou and Yurrita, 2005). These species can use up to 56 plant species and design 8 tent architectures throughout their distribution (Rodríguez-Herrera *et al.* 2007). Here, we only reported two bat species using tents (*Dermanura* sp. and *Artibeus jamaicensis*), two plant species (*Sabal mauritiiformis* and *Cryosophila stauracantha)*, and one type of architecture (umbrella), highlighting the urgent need to report this type of sightings to learn more about these species in other Central American localities.

Plant and tent architecture can change within localities, season and habitat types. Tent construction patterns (plant species and architectures) documented in this study area are quite different than those recorded in other studies. Villalobos-Chaves *et al.* (2016) reported 225 bat tents corresponding to 4 architectures and 14 plant species in 0.55 km2 of Costa Rica's rainforest (409 tents/km2 density). The number of tents available in each area and the plants used by bats to build their roosts could change in response to several factors, such as the availability of plant resources across space, time, and bat species preferences and behavioral plasticity (Choe and Timm, 1985; Chaverri and Kunz, 2006; Rodríguez-Herrera *et al.* 2007). The factors mentioned above could explain why we found a much smaller number of tents in the MBR, adding that this region is not as rainy as the region studied by Villalobos-Chaves *et al.* (2016).

All the tents we found were umbrella-type. Most tents with this type of architecture are built on species of the Arecaceae family (Herrera-Victoria *et al.* 2018), such as the two species reported here. (*S. mauritiiformis* and *C. stauracantha*). However, this architectural style is not present in all palms. The umbrella tent is the third most used by bat species in the Neotropics since four bat species construct them in around eight different plant species throughout the region (Rodríguez-Herrera *et al.* 2007). S. mauritiiformis tents presented a type of ceiling modification (Figure 2) that had never been reported before. Palms are distinguished by their costapalmate leaves, which are difficult to cut, to which we attribute the modification by bats. We observed a great abundance of *S. mauritiiformis*, especially at Estación Biológica "Las Guacamayas"; this might be due to using their leaves as roofs for traditional Maya houses since prehispanic times (Martínez-Ballesté *et al.* 2008). However, the preference for bat use for this plant species in our study localities is unclear.

About 77.6% of the bat tents, we found had large seeds underneath. Melo *et al.* (2009) state that Neotropical tent-roosting bat species can disperse around 43 species of large seeds, playing a key role in tropical forest regeneration. However, further research should focus on identifying which species of large seeds bats disperse in Guatemalan forests.

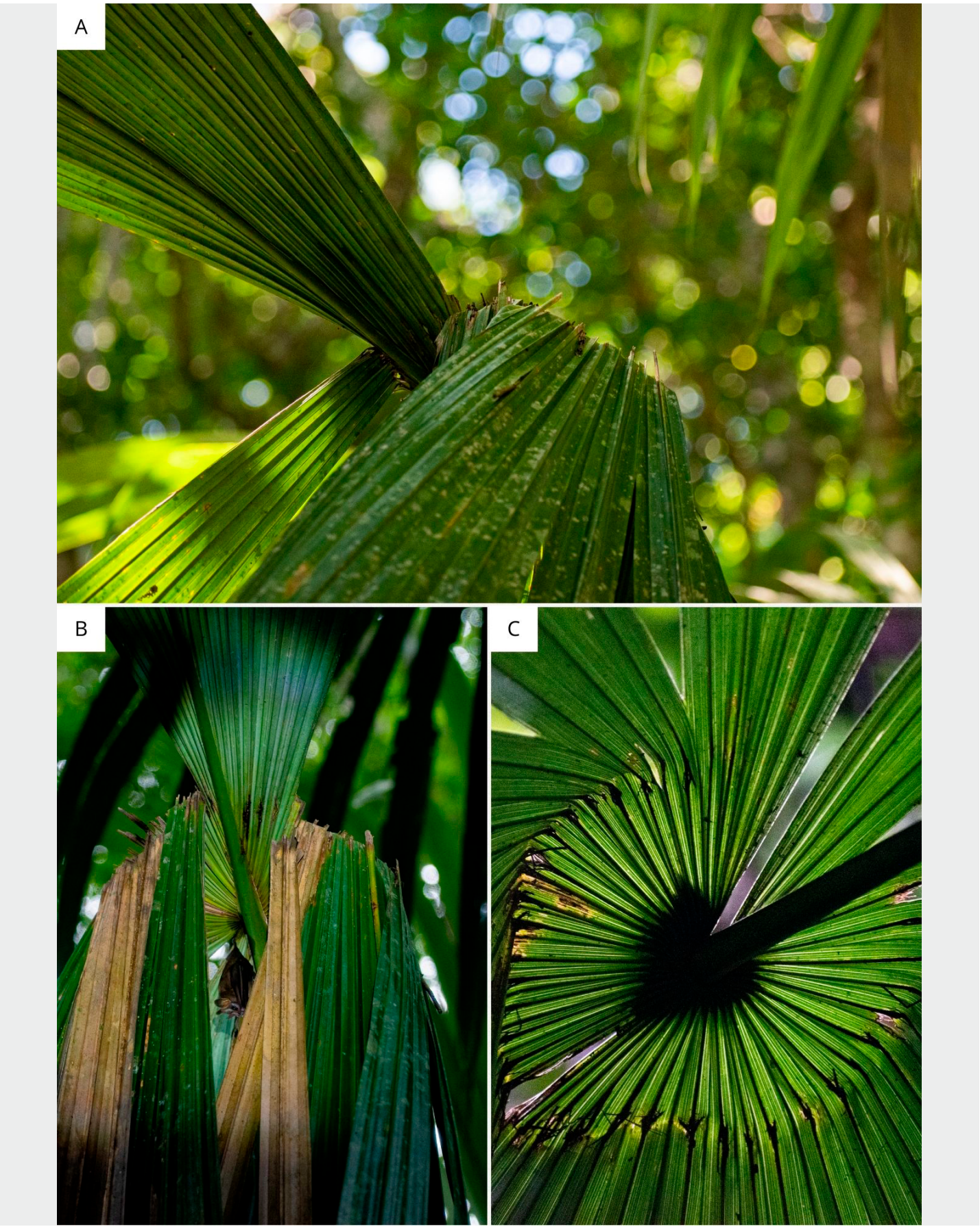

Figure 2. A) and B) *Sabal mauritiiformis* modified as tent. C) Umbrella tent of *C. stauracantha* heart-shaped cut. Photos by L. Trujillo.

Figure 3. Occupied tents registered. A) *Artibeus jamaicensis* roosting in an umbrella *S. mauritiiformis* tent. B) *Dermanura sp*. roosting in an umbrella *C. stauracantha* tent. Photos by L. Trujillo.

This study is the first report of tent-roosting behavior in Guatemala, highlighting the use of two Arecaceae species and a variant of the umbrella tent architecture for the first time. These results highlight the importance of studying tent roosting behavior in data-deficient areas, and It's the first step in continuing to look for this behavior in the species mentioned above. Further research in Guatemala should focus on tent-roosting behavior. As the literature indicates for other Neotropical areas such as Costa Rica and South America, we expect many architectures in the region and tents in plant species not reported before (Rodríguez-Herrera, 2009). Furthermore, tent-making bats are important seed dispersers in rainforests (Melo *et al.* 2009), and further research will document the scale and scope of this ecosystem service for Guatemalan forests.

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