

## SHORT COMMUNICATION

# First evidence of frugivory in *Gardnerycteris crenulatum* (Chiroptera: Phyllostomidae)

Dennis CASTILLO-FIGUEROA<sup>1\*</sup>, Bryan A. TARRÁ-JARAMILLO<sup>2</sup>, Mónica M. PEÑUELA-SALGADO<sup>2</sup>, Carlos A. GIRALDO-MARTÍNEZ<sup>2,3</sup>, Carlos H. RODRÍGUEZ-LEÓN<sup>2</sup>

<sup>1</sup> Universidad del Rosario, Faculty of Natural Sciences, Biology Department, Bogotá, Colombia

<sup>2</sup> Instituto Amazónico de Investigaciones Científicas SINCHI, Florencia, Caquetá, Colombia

<sup>3</sup> Universidad de la Amazonia, Facultad de Ciencias Agropecuarias, Programa de Medicina Veterinaria y Zootecnia, Florencia, Caquetá, Colombia

\* Corresponding author: [dennis.castillof@gmail.com](mailto:dennis.castillof@gmail.com); <https://orcid.org/0000-0002-4584-0762>

## ABSTRACT

*Gardnerycteris crenulatum* is a bat species restricted to South America, being particularly rare in lowland rainforests. It is characterized by a diet composed mainly of arthropods and small vertebrates, with no confirmed evidence of fruit consumption. Here, we provide the first records of seeds in the diet of *G. crenulatum*. The seeds were found in the feces of two individuals captured in late-successional forests in the Colombian Amazon (one pregnant female and one adult male), that belonged to *Piper* sp. (n = 125) and *Cecropia engleriana* (n = 3). In germination experiments, only *Piper* seeds germinated (8%). Insectivores can potentially perform other functions than the role assigned to their corresponding guild. More research is needed on the natural history and ecology of *G. crenulatum* to elucidate its possible role as seed disperser.

**KEYWORDS:** Amazon rainforest, bats, functional role, diet, insectivores

## Primera evidencia de frugivoría en *Gardnerycteris crenulatum* (Chiroptera: Phyllostomidae)

### RESUMEN

*Gardnerycteris crenulatum* es una especie de murciélago restringida a América del Sur, siendo particularmente rara en los bosques húmedos de tierras bajas. Se caracteriza por una dieta compuesta principalmente de insectos, artrópodos y pequeños vertebrados, sin evidencia confirmada de consumo de frutos. En esta nota, reportamos los primeros registros de semillas en la dieta de *G. crenulatum*. Las semillas fueron encontradas en las fecas de dos individuos capturados en bosques de sucesión avanzada en la Amazonía colombiana (una hembra preñada y un macho adulto), pertenecientes a *Piper* sp. (n = 125) y *Cecropia engleriana* (n = 3). En experimentos de germinación, solo germinaron las semillas de *Piper* sp. (8%). Los insectívoros pueden realizar potencialmente otras funciones además del papel asignado a su gremio correspondiente. Es necesario desarrollar más investigaciones sobre la historia natural y la ecología de *G. crenulatum* para dilucidar su posible papel como dispersor de semillas.

**PALABRAS CLAVE:** dieta, insectívoros, murciélagos, papel funcional, selva amazónica

Among Neotropical bats, Phyllostomidae is the most speciose family, with 225 recognized species distributed in 60 genera (ASM 2021). Phyllostomids are the most ecologically diverse bat group, exhibiting a broad range of morphological traits (Norberg and Rayner 1987; Marinello and Bernard, 2014; Castillo-Figueroa 2020a), behavioral strategies (Kerth 2008), roosts (Voss *et al.* 2016; Garbino and Tavares 2018) and feeding habits (Wilson 1973). Food items consumed by phyllostomids include fruits, nectar, insects and other arthropods, vertebrates and blood, but some species can complement their diet by consuming uncommon items (Wilson 1973). For example, bats specialized in nectar, like

*Leptonycteris yerbabuena* Martínez and Villa-R. 1940 and *Glossophaga longirostris* Miller 1898, can also feed on fruits, thus acting as seed dispersers (Nassar *et al.* 1997; Soriano and Ruiz 2002; Rojas-Martínez *et al.* 2015; Santiago-Hernández *et al.* 2019). Likewise, frugivores such as *Artibeus lituratus* (Olfers 1818), *Carollia perspicillata* (Linnaeus 1758) and *Sturnira lilium* (E. Geoffroy 1810) have preference for *Ficus*, *Piper* and *Solanum*, respectively (Fleming 1986; Saldaña-Vázquez *et al.* 2019), yet they complement their diets by consuming other fruits, nectar and insects (Giannini and Kalko 2004). However, few cases of insectivorous bats that consume plant

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items have been reported (Aranguren *et al.* 2011; Felix *et al.* 2013; Novaes *et al.* 2015).

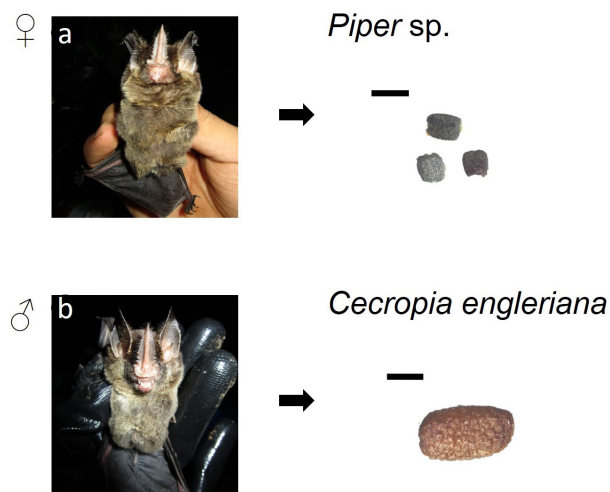
*Gardnerycteris (Mimon) crenulatum* (Geoffroy St.-Hilaire, 1803) (Phyllostomidae) is an endemic species of South America ranging from southern Brazil and northern Bolivia to southern Panamá (Koopman 1978; Williams and Genoways 2008). It mainly inhabits lowland rainforests below 900 m (Tirira 2017), using tree cavities as diurnal refuges (Voss *et al.* 2016), showing a strong roost fidelity (Bernard and Fenton 2003), and is frequently found near water, including ponds, waterholes and rivers (Mello and Pol 2006). It has been classified as a gleaning insectivore, consuming mainly insects and spiders in the understory (Pedro *et al.* 1994; Giannini and Kalko 2005; Mello and Pol 2006; Hurtado *et al.* 2015; Tirira 2017), but it can also feed on small vertebrates, nectar and pollen (Pedro *et al.* 1994; Mello and Pol 2006). *Gardnerycteris crenulatum* forms small groups (Emmons and Feer 1999) and, despite showing no sexual size dimorphism, the leaf-nose is wider in females, with larger spears that improve the ability of echolocation of prey, to satisfy the energetic demands of nursing and pup feeding (Hurtado *et al.* 2015). The species is rare in bat assemblages (Mello and Pol 2006; Solari 2019) and many aspects of its trophic ecology remain poorly known, such as complementary food items to its largely insectivorous diet and its potential role as seed disperser or seed predator.

During a bat survey in the Colombian Amazon, small seeds were collected from fecal samples of two individuals of *G. crenulatum* and germination experiments were performed to test the viability of the seeds. Here, we report the first confirmed evidence of fruit consumption by *G. crenulatum*, and its potential role as a seed disperser.

Fieldwork was carried out in forest fragments in different successional stages (0 to over 40 years) in the municipality of San Jose del Fragua (Caquetá, Colombia) during October and November 2018. The study region is part of the Colombian Andean-Amazonian transition characterized by two physiographic units (*Montaña* and *Lomerío*), with monomodal rainfall (June to August) and mean atmospheric temperature from 24 to 27 °C (Murcia-García *et al.* 2014). Field procedures followed the guidelines approved by the American Society of Mammalogists (Sikes *et al.* 2016) and the Colombian legislation for animal protection (*Estatuto Nacional para la Protección de los Animales* (Law 84/1989) under a license provided by *Comité de Ética, Bioética y Bienestar Animal* (CEBBA) from Universidad de La Amazonia (FCA-169/19). We captured bats with mist-nets placed in the understory (0-3 m above ground). Mist-nets were opened from 18:00 to 00:00. To assess the diet of the bats, we collected feces of captured individuals, which were kept in cotton bags for 30 min. Fecal samples were stored in individually labeled Eppendorf tubes. In the laboratory, we processed the fecal samples to separate food items. Identified seeds were classified into morphospecies.

For the germination experiments, seeds were kept in Petri dishes on absorbent paper that was humidified with distilled water every second day for up to 60 days. A germination chamber with constant light was used when possible, or the seeds were placed close to a window thus receiving indirect natural light under ambient temperature (25 to 28 °C). A fungicide (Vitavax) was employed to prevent fungal growth.

We found seeds in feces of two individuals of *G. crenulatum* captured in late-successional forests of > 40 years. The first was an adult female with an advanced pregnancy, captured on 29 October 2018 in *Montaña* (1°19'19.10"N, 76°0'17.40"W). Its feces contained 125 seeds of *Piper* sp., each measuring 1 mm (Figure 1a). The second was an adult male captured on 24 November 2018 in *Lomerío* (1°11'38.4"N, 75°58'19.7"W). Its feces contained three seeds of *Cecropia engleriana* Snethl. measuring 2.5 mm each (Figure 1b). None of the three *C. engleriana* seeds germinated, while 10 (8%) of the *Piper* sp. seeds germinated (five seeds at 20 days and five at 40 days after sowing).



**Figure 1.** Individuals of *Gardnerycteris crenulatum* captured in an Amazon rainforest in Colombia and the seeds found in their fecal samples. A – Pregnant female and seeds of *Piper* sp.; B – adult male and seeds of *Cecropia engleriana*. Scale bars = 1 mm. This figure is in color in the electronic version.

The unexpected presence of seeds in the two fecal samples is the first evidence of fruit consumption by an insectivorous species of *Gardnerycteris*. There is no doubt that the seeds were in these fecal samples, as the bats were kept individually inside the bags, and the bags were cleaned after each bat captured, following Novaes *et al.* (2015). As *G. crenulatum* is a gleaning insectivore, the accidental consumption of fruits seems unlikely.

There is increasing evidence that bats can perform multiple functions other than the role assigned to their guild (Aranguren *et al.* 2011; Frick *et al.* 2013; Novaes *et al.* 2015; Castillo-Figueroa 2020b). This is especially surprising in species with highly specialized diets, as is the case of insectivores that

present particular morphological, physiological and behavioral adaptations to consume animal food items. Nonetheless, some studies have demonstrated that insectivorous bats can supplement their diet with plant resources, which provide high amounts of water and sugars (Felix *et al.* 2013) and are associated with other potential functions such as pollination (Frick *et al.* 2013) and seed dispersal (Novaes *et al.* 2015). The effective performance in these functions depends on the environmental conditions and seasonality of primary trophic resources consumed, as has been previously suggested for other species (Aranguren *et al.* 2011; Felix *et al.* 2013).

Despite the low germination rate (only 8% of one of two types of seed) of seeds consumed by *G. crenulatum* in comparison with other insectivores that include fruits in their diet, such as *Myotis nigricans* (Schinz 1821) (40%) (Novaes *et al.* 2015), the seeds did not seem macroscopically damaged after gut passage, maintaining their morphological integrity. This suggests that *G. crenulatum* can consume fruit and ingest seeds without causing any apparent damage to them, but the low germination rate suggests a limited role as an effective seed disperser. Considering that *G. crenulatum* is not common in bat assemblages (we captured only six individuals among 1167 captured bats = 0.51%), the potential consumption of other plant species by this bat depends on higher sampling effort. Further dietary studies will allow a better understanding of the trophic niche and the natural history of this species. The complementation of seed dispersal by dominant frugivorous bats may be a secondary ecological role of insectivorous bats.

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