



## Two in one: the little bat that pollinates and disperses plants at an urban site in Southeastern Brazil

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**Abstract:** The glossophagine Pallas's long-tongued bat (*Glossophaga soricina*) fares well in urban environments across its range. In addition to roost sites, there are nectar and fruit sources available in diverse situations across the urban gradient. Phyllostomid bats that thrive in urbanized situations are behaviorally plastic generalists and rely on patches of ornamental or feral plants as food sources. Herein we report on *G. soricina* and its food sources at an urbanized site in Southeastern Brazil. This small phyllostomid bat consumes nectar from landscaping ornamental plants, besides consuming the soft pulp along with the tiny seeds of pioneer trees and shrubs. In addition to these natural sources, the bat exploits hummingbird feeders to consume the sugared water. Ingested small seeds are defecated in flight, the bat acting as a disperser of pioneer plants that favor cleared areas. *Glossophaga soricina* role as flower-pollinator and seed-disperser at Neotropical urban areas merits further attention due both to the maintenance of urban biodiversity and delivery of ecosystem services.

**Keywords:** *Ecosystem services; Flowers; Foraging behavior; Fruits; Phyllostomidae.*

## Dois em um: o pequeno morcego que poliniza e dispersa plantas em local urbano no Sudeste do Brasil

**Resumo:** O morcego beija-flor (*Glossophaga soricina*) adapta-se a ambientes urbanos na sua área de distribuição. Além de abrigos diurnos, há fontes de néctar e frutos ao longo do gradiente urbano. Morcegos filostomídeos que se adaptam a situações urbanas são generalistas comportamentalmente flexíveis e dependem de trechos com plantas ornamentais ou ferias como fonte alimentar. Relatamos aqui informações sobre o morcego beija-flor e suas fontes alimentares em um local urbanizado no sudeste do Brasil. Este pequeno morcego glossofagíneo busca néctar em plantas usadas em paisagismo, além de consumir a polpa macia, juntamente com as sementes minúsculas, de plantas pioneiras. Além destas fontes naturais, o morcego explora água açucarada dos bebedouros de beija-flores. Sementes pequenas são defecadas em voo e o morcego age como dispersor de plantas poineiras em áreas sem vegetação. A função de *G. soricina* como polinizador de flores e dispersor de sementes em áreas urbanas nos Neotrópicos merece atenção adicional devido à manutenção da biodiversidade urbana e da prestação de serviços ecossistêmicos.

**Palavras-chave:** *Comportamento alimentar; Flores; Frutos; Phyllostomidae; Serviços ecossistêmicos.*

## Introduction

The Pallas's long-tongued bat (*Glossophaga soricina*) is a phyllostomid widespread in South America east of the Andes (Alvarez 1991, Dias et al. 2017, Calahorra-Oliart et al. 2021), and fares well in urbanized environments across its distribution (e.g., Lemke 1985, Ballesteros et al. 2012, Nunes et al. 2017, Turcios-Casco et al. 2021). In addition to roost sites, there are nectar and fruit sources available for phyllostomid bats in diverse situations across the urban gradient (Bredt et al. 2002, Silva et al. 2005, Kruszynski et al. 2016, Vilar et al. 2016, Nunes et al. 2017). Phyllostomid bats that thrive in urbanized situations are behaviorally plastic and rely on patches of ornamental or feral plants as food sources (Bredt et al. 2002, Kruszynski et al. 2016, Garcia et al. 2000, Pellón et al. 2021, Turcios-Casco et al. 2021).

Notwithstanding its widespread occurrence in South America and commonness in urban areas, Pallas's long-tongued bat remains understudied from the perspective of food resources at a given urban area (but see Pellón et al. 2021). We had the opportunity to sporadically observe and record this phyllostomid bat at a very small urbanized site in Southeastern Brazil for a period spanning about 10 years. Herein, we present a snapshot report on the food sources of *G. soricina* and the behavior displayed on these resources at the site.

## Material and Methods

The study area is a block of about 60.000 m<sup>2</sup>, including streets, sidewalks, gardens, and backyards at an urban area (22°49'36"S, 47°04'15"W, 621 m.a.s.l.) in the vicinity of the Universidade Estadual de Campinas, São Paulo, South-eastern Brazil. We sporadically observed Pallas's bats feeding activity on trees and shrubs used in landscaping and gardening, besides some feral ones for a period spanning 10 years (2009-2019). We observed the bats with bare eyes and documented its behavior with a 70-300 mm telephoto lens mounted on a SLR camera from a distance of about 2-4 m. Streetlight and lamps in gardens and backyards allowed an adequate view of the bats' activity on most food

sources. During the observational sessions we used "ad libitum" and "sequence" samplings (Altmann 1974), which are choice methods to record temporary or unpredictable events. One bat individual was recognized due to a natural mark on the forearm. We examined fecal samples scattered on vegetation after the bat's visits to a given food source. Images of the bats feeding on some of the food sources are on file in the Coleção de Imagens (ZUEC-PIC 448-453) at the Museu de Diversidade Biológica, Universidade Estadual de Campinas, Campinas, São Paulo, Brazil.

## Results

At our study site, *Glossophaga soricina* exploited three night-blooming flower species in two families, and four fruit species in four families (Table 1). The flowers lasted one night only and the fruits lasted until consumed entirely by bats at night and birds during the day, which could last for weeks as new infructescences matured.

*Glossophaga soricina* used three different types of food sources at the studied small urban site (Figure 1). A regularly visited food source were night-blooming flowers, such as those of *Lafoensia pacari* and *Luehea alternifolia* trees (Figure 1a-b). Another regularly visited source were fruit-bearing trees and shrubs such as those of *Cecropia pachystachya* and *Piper aduncum* when the pulp was ripe and soft (Figure 1c). Sugared water in a hummingbird feeder (Figure 1d) was used sporadically, mostly when flower or fruit bearing plants grew near the feeder, which had a stable position for several years.

The *Lafoensia pacari* tree had numerous (up to 40) open flowers per night, whereas the *Luehea alternifolia* tree had smaller number (up to 8-10) of open flowers each night. The *Callianthe fluviatilis* shrub opened up to five flowers per night (but 2-3 was the usual number). *Lafoensia pacari* flowers were often visited by 2-3 bat individuals at the same time, which chased one another around the tree. A given bat made a flight pass over the tree and appeared to assess the flowers for

**Table 1.** Food sources used by the phyllostomid bat *Glossophaga soricina* at a small urban site in Campinas, São Paulo, Southeastern Brazil. Plant families, genera, and species in alphabetical order. E= exotic. Last line is provisioned food. Color flower/fruit is color visible to humans.

Plants	Habit	Food type	Color flower/fruit
Lythraceae			
<i>Lafoensia pacari</i>	Tree	Nectar	White
Malvaceae			
<i>Callianthe fluviatilis</i>	Shrub	Nectar	Light yellow
<i>Luehea alternifolia</i>	Tree	Nectar	White
Moraceae			
<i>Morus nigra</i> <sup>E</sup>	Tree	Infructescence pulp	Purple
Muntingiaceae			
<i>Muntingia calabura</i>	Tree	Fruit	Yellowish green
Piperaceae			
<i>Piper aduncum</i>	Shrub	Infructescence pulp	Light green
Urticaceae			
<i>Cecropia pachystachya</i>	Tree	Infructescence pulp	Greyish yellow
<b>Provisioned food source</b>			
Hummingbird feeder	NA	Sugared water	Yellow base



**Figure 1.** The Pallas's long-tongued bat (*Glossophaga soricina*) exploits three food source types at an urbanized site in Campinas, São Paulo, Southeastern Brazil: (a) the bat laps the copious nectar from the flowers of a *Lafaensia pacari* tree, (b) the bat laps nectar from a flower of a *Luehea alternifolia* tree, (c) the bat chews a portion of the soft pulp of *Piper aduncum*, swallowing the tiny seeds along - note pulp already chewed out, (d) the bat laps sugared water from a hummingbird feeder left in place overnight. *Glossophaga soricina* visits each food source hovering fleetingly.

nectar content before the actual visit. After this exploratory flight, the bat visited up to 10-15 flowers in succession, making rounds over the tree during up to 5 min. It visited the flowers hovering fleetingly, tenths of a second. Visits to a given *L. pacari* tree were at intervals of up to 30 min, but sometimes the intermissions were shorter (about 10-15 min), possibly due to the bats being different individuals. The bat visited the *Luehea alternifolia* tree at intervals of 50-60 min, exploiting all the available flowers at each visit (we recognized the bat due to a natural marking). Its visits were similar to those described on *L. pacari* flowers. The flowers of *C. fluviatilis* were visited by the bat at irregular intervals of up to 60 min, and even more fleetingly than the visits to the *L. pacari* and *L. alternifolia* flowers. During visits to flowers of these three plant species, the bats touched the reproductive parts, which would result in pollination.

When visiting the *Cecropia pachystachya* tree and the *Piper aduncum* shrub, the bat chewed out a portion of the infructescences while hovering and flew away with a mouthful. It visited these two food sources at irregular intervals that lasted about 5-40 min. We often observed bats defecating along their pathway, spraying small seeds on the ground or house walls. We also found seeds of both *C. pachystachya* and *P. aduncum* in the feces scattered on vegetation after the bat's visits to a given food source.

Pallas's long-tongued bat took out a portion of the *Morus nigra* tree in a way similar to those described above, also at irregular intervals that lasted about 5-30 min. Due to poor illumination of the single *Muntingia calabura* tree, we were unable to observe whether the bat grabbed a fruit while hovering or had to cling to be able to tear the fruit from its stalk and fly away with the fruit in its mouth.

The bat visited hummingbird feeders at irregular intervals that lasted 5-15 min, lapping the sugared water while hovering fleetingly. It combined its visits to the feeder with those on a few *L. pacari* flowers available at the time, and the *P. aduncum* shrub that was close to the sugared water source.

## Discussion

Our observations centered on Pallas's long-tongued bat constitute the second study about food sources used by this bat species at an urban site. Plants used as food by *Glossophaga soricina* were recently studied at an urban site in Lima, Peru (Pellón et al. 2021). However, judging from the recent review of the genus by Calahorra-Aliart et al. (2021), the species that occurs in Peru is *Glossophaga valens* (distribution in Handley et al. 1991 as *G. soricina valens*), which renders our snapshot study as the first that address diverse food sources of *G. soricina* at an urban site.

The visits of *Glossophaga soricina* to nectar-offering flowers did not differ from available studies on flower-visiting bats to night-blooming plants, including *Lafaensia pacari* and *Luehea alternifolia* (Silva & Peracchi 1999, Sazima et al. 1982). However, visits of this bat to flowers of *Callianthe fluviatilis* are not available in the scientific literature, besides a brief mention to its one night-lasting flowers in Buzato et al. (1994) as *Abutilon peltatum*. We were surprised by the exceedingly fleeting visits, which precluded photographic records with the equipment we had. Pollination of the three plant species would be expected, as the flowers fit within the known types usually pollinated by bats (Buzato et al. 1999).

Visits to fruits by *G. soricina* apparently remain undescribed in the scientific literature to date. This small bat secures the pulp of *Cecropia pachystachya*, *Piper aduncum*, and *Morus nigra* infructescences with a hovering flight similar to that it displays when visiting flowers for nectar. We expected that it would cling on the infructescence to chew a mouthful as displayed by some phyllostomid bats such as Seba's short-tailed bat *Carollia perspicillata*, which is able to hover while feeding on flowers but also cling to some fruits (Sazima & Sazima 1978, Sazima et al. 2003). We were unable to observe how *G. soricina* secures the *Muntingia calabura* fruits, but conceive it would cling on a branch.

Visits of Pallas's long-tongued bat to hummingbird feeders left unattended at night were observed since the nineteen-nineties in Southeastern Brazil. In Vitória, a seaside town in Espírito Santo, visits of this bat to feeders are known since about 1995 (J.L. Gasparini, pers. comm.), and we photographed the visits there in 1997. This behavior spread through *G. soricina* populations and now is a common view at several urban and suburban regions in Brazil (Esbérard et al. 1999, Santos & Uidea 2002). However, visits to hummingbird feeders are not restricted to urban sites. We recorded this bat species exploiting bird feeders on the veranda of a hotel within the Atlantic forest at the Itatiaia National Park, Rio de Janeiro state, at about 1.200 m a.s.l.

Despite its use of sugared-water feeders, Pallas's long-tongued bat still relies on flowers and fruits for its nutritional and energy intakes. This is likely due to its low energy reserves and failure to maintain an adequate level of blood glucose after a short-fasting period, contrary to which happens with essentially fruit-feeding phyllostomid species (Pinheiro et al. 2006, Amaral et al. 2019). There is some evidence that the use of hummingbird feeders interfere with pollination of plants in a given area covered by flower-visiting birds (Arizmendi et al. 2007, Maruyama et al. 1999). Even if the breeding success of a given plant is lower in the close presence of the feeder (Arizmendi et al. 2007), or the hummingbird assemblage may change with provision of feeders (Maruyama et al. 1999), the plants still are visited and pollinated. A similar situation is likely to occur with *G. soricina*.

In conclusion, Pallas's long-tongued bat exploited a variety of food sources available at our very small urbanized study site, including nectar, fruit pulp, and sugared water. Even in an urban settings, the bat retained its ecological functions as a flower-pollinator and seed-disperser. Some of these two ecosystem services are recorded in other urbanized areas across the range of this small bat (Bredt et al. 2002, Silva et al. 2005, Kruszynski et al. 2016, Vilar et al. 2016, Nunes et al. 2017), and contributes to maintain and even expand the local biodiversity, as it occurred with the "feral" *Piper aduncum* in our study. This plant was probably transported to the study site via defecated seeds, as *P. aduncum* was not present at the site until after *Glossophaga soricina* began visiting *Cecropia pachystachya* trees. The seed dispersal role of this bat was already commented upon by Augusto & Hayashi (2004), which lends support to our assumption on the important role of *G. soricina* in maintaining ecosystem services at urbanized areas.

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## Author Contributions

Ivan Sazima: Data collection; data analysis and interpretation; manuscript preparation; critical revision.

Marlies Sazima: Data collection; data analysis and interpretation; critical revision.

## Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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