

NeoBat Interactions: a data set of bat-plant interactions in the Neotropics

Guillermo L. Florez-Montero^{1*} Renata L. Muyllaert⁴ Marcelo R. Nogueira³
Cullen Geiselman² Sharlene E. Santana⁵ Richard D. Stevens⁶
Marco Tschapka⁷ Francisco A. Rodrigues⁸ Marco A. R. Mello⁹

1 Universidade Federal do ABC (UFABC). Centro de Ciências Humanas e Naturais. 09210-580 Santo André, SP, Brazil.

2 Massey University. Molecular Epidemiology and Public Health Laboratory, Hopkirk Research Institute. 4442. Palmerston North, New Zealand

3 Universidade Federal Rural do Rio de Janeiro (UFRRJ). Instituto de Biologia, Laboratório de Mastozoologia. 23890-000 Seropédica, RJ, Brazil.

4 Bat Conservation International, Austin, TX, USA

5 Department of Biology and Burke Museum of Natural History and Culture, University of Washington, Seattle, WA, 98195, USA

6 Department of Natural Resources Management and Museum of Texas Tech University, Lubbock, TX, USA

7 Institute of Evolutionary Ecology and Conservation Genomics, Ulm University, Ulm, Germany

8 Universidade de São Paulo. Departamento de Matemática Aplicada e Estatística, Instituto de Ciências Matemáticas e de Computação. 13560-970 São Carlos, SP, Brazil

9 Universidade de São Paulo (USP), Instituto de Biociências, Departamento de Ecologia Geral. 05508-090 São Paulo, SP, Brazil.

*Corresponding author: Guillermo L. Florez-Montero (gflorezmontero@gmail.com)

INTRODUCTION

Open access to primary scientific data is fundamental to assure the social contract that governs scientific publishing (Vision 2010). This contract relies on the transparency, reproducibility, and progress of science by allowing independent verification and reuse of published data (Costello 2009). Data access has been facilitated in the information age through important frameworks for the production, storage, curation, and sharing of data. These frameworks aim to preserve data in the long term, even beyond the life of their initial compilers and curators (Chavan and Ingwersen 2009).

One major framework for making data available are data papers, which optimize efforts in the discovery, organization, and availability of information (Chavan and Penev 2011). They have the potential to offer highly reliable data sources, as they have been subjected to quality control protocols, such as peer review and editorial inspection of data and metadata (Costello *et al.* 2013). This new kind of publication has revolutionized contemporary biology by making decades of naturalistic information widely available in highly accessible and comprehensive formats.

Recently, the revolution has also reached mammalogy. Data papers on mammal communities are growing in number. There are, for instance, data papers on non-volant mammals on a global scale (Thibault *et al.* 2011). Another important source is the BioTIME database of biodiversity time series for the Anthropocene (Dornelas *et al.* 2018). Others have larger scope, such as the global database for meta-community ecology, integrating species, traits, environments, and space (Jeliazkov *et al.* 2020). Others attempt to harmonize and curate all main data sets for mammal traits, phylogeny, and viral sharing (<https://github.com/viralemergence/clover>).

In Brazil, the most famous mammalogical data papers were produced by the ATLANTIC Series and NEOTROPICAL Series, which contain information about the biodiversity of the Atlantic Forest of South America and the Neotropics, respectively. This series includes data papers on plant-frugivore interactions (Bello *et al.* 2017), rodents and marsupials: (Bovendorp *et al.* 2017), bats (Muylaert *et al.* 2017), primates (Culot *et al.* 2019), and medium- and large-sized mammals (Souza *et al.* 2019). Many other data papers were produced by other research groups outside the ATLANTIC Series, focusing on groups such as small mammals (Figueiredo *et al.* 2017). Nevertheless, only a few of them covered larger spatial scales, such as Neotropical xenarthrans (Santos *et al.* 2019) and Neotropical Carnivores (). In addition, most of them, particularly in the Atlantic Forest and Cerrado, are based on abundance-incidence data whereas species interactions received much less attention.

Mutualistic interactions between animals and plants are a cornerstone of terrestrial ecosystems. Almost 94% of plants in neotropical communities are pollinated by animals (Ollerton *et al.* 2011), while 70–94% have their seeds dispersed by vertebrates (Jordano 2013). Bats are especially important in this context, as they represent the second largest group of seed dispersers in the Neotropics, after birds (Bello *et al.* 2017). On the other hand, even though insects pollinate most flowering plants, bats are also the second group of pollinating vertebrates since they pollinate about 2% of the extant plant genera (Sekercioglu 2006). Bat-plant interactions also generate ecosystem services, such as the pollination of economically important plants and the dispersal of seeds from pioneer plants that are key to habitat regeneration (Kunz *et al.* 2011).

Therefore, bats and their food-plants are the focus of our data paper. We compiled a georeferenced database of 2571 interaction records of frugivory and nectarivory between 93 bat species and 501 plant species. The data came from 169 studies covering 200 locations in 16 countries all over the Neotropical region (Figure 1). The database compiled by Geiselman and Younger (2002) was used as a starting point and was filtered, revised, and updated. We added mainly new literature, specially from South America.

After this update, NeoBat Interactions is so far the most extensive bat-plant interaction database both in geographic and taxonomic terms. Most sampling sites are georeferenced with high coordinate accuracy. All records came from primary sources and were taxonomically verified and updated. Besides, our database

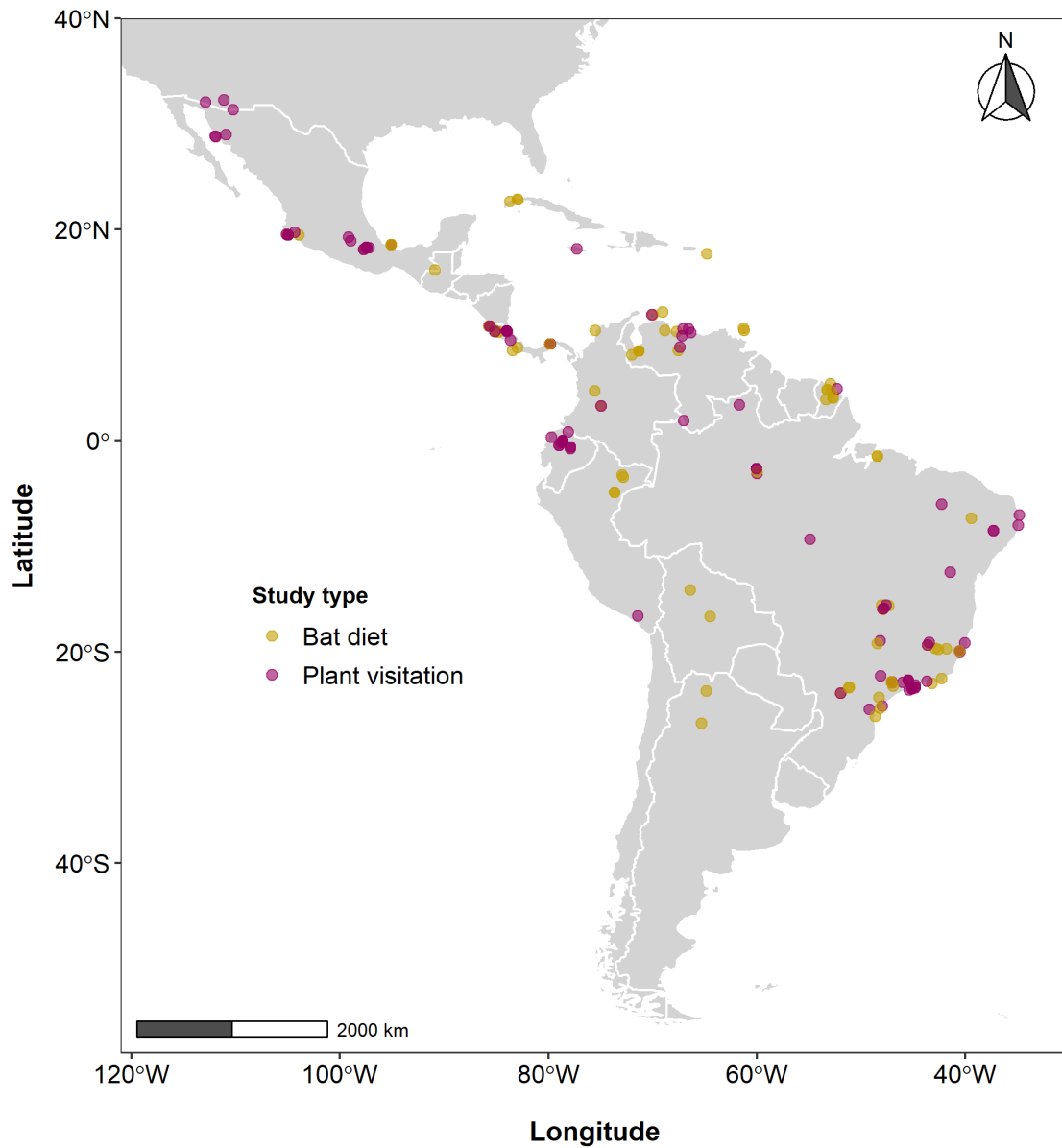


Figure 1: Distribution of sampling sites included in NeoBat Interactions. Dots show the location of original studies focused on plant visitation (purple) and bat diet (yellow). White lines show country borders. We included only studies with records of bat-plant interactions that were confirmed either by indirect or direct observation.

includes some geographic and abiotic information of study sites such as vegetation type and rainfall. Our database also includes ecological information for most species, such as a life form and successional stage of plants, and trophic guild of bats. The data are organized and standardized at different levels of ecological complexity and temporal and geographic scales, which allows using them in a variety of studies with different scopes.

METADATA

CLASS I. DATA SET DESCRIPTORS

A. Data set identity

Title: NeoBat Interactions: a data set of bat-plant interactions in the Neotropics

B. Data set identification

Data set identity codes:

NeoBat_Interactions_References.csv

NeoBat_Interactions_Sites.csv

NeoBat_Interactions_Records.csv

C. Data set description

Principal Investigator(s):

1. Guillermo L. Florez-Montero. Universidade Federal do ABC. Centro de Ciências Humanas e Naturais. 09210-580 Santo André, SP, Brazil.
2. Marco A. R. Mello. Universidade de São Paulo, Instituto de Biociências, Departamento de Ecologia Geral. 05508-090 São Paulo, SP, Brazil.

Abstract:

Data papers and open databases revolutionized contemporary science, as they provide the long-needed incentive to collaborate in large international teams and make naturalistic information widely available. Nevertheless, most of them focus on occurrence or abundance, while species interactions received much less attention. To help fill this gap, we compiled a georeferenced data set of interactions between 93 bat species of the family Phyllostomidae (Chiroptera) and 501 plant species of 68 families. Data came from 169 studies published from 1957 to 2007 in the entire Neotropical Region, with most records from Brazil (34.5% of all study sites), Costa Rica (16%), and Mexico (14%). Our data set includes 2571 records of frugivory (75.1% of all records) and nectarivory (24.9%). The best represented bat genera are *Artibeus* (28% of all records), *Carollia* (24%), *Sturnira* (10.1%), and *Glossophaga* (8.8%). *Carollia perspicillata* (187), *Artibeus lituratus* (125), *Artibeus jamaicensis* (94), *Glossophaga soricina* (86), and *Artibeus planirostris* (74) are the bat species with the broadest diets recorded in number of plant species. Among plants, the best represented families are Moraceae (17%), Piperaceae (15.4%), Urticaceae (9.2%), and Solanaceae (9%). Plants of the genera *Cecropia* (46), *Ficus* (42), *Piper* (40), *Solanum* (31), and *Vismia* (27) hold the largest number of interactions. These data are stored as arrays (records, sites, and studies) organized by logical keys and rich metadata, which helps compile the information at

different ecological and geographic scales, according to how they should be used. Our data set on bat-plant interactions is so far the most extensive both in geographic and taxonomic terms, and also includes some abiotic information of study sites and ecological information of plants and bats. It has already helped us develop several studies and we hope it will stimulate novel analyses and syntheses, in addition to pointing out to important gaps in knowledge.

D. Key words

Databases, frugivory, mutualism, nectarivory, networks, pollination, seed dispersal, species interactions.

E. Description

This database includes 2571 records of interactions involving the consumption of nectar and fruits by bats, taken from studies focused on bat diets or plant visitation by bats across the Neotropics (Figure 1). The information came from 16 countries, from southwestern United States of America to northwestern Argentina. We have compiled 169 scientific papers carried out over 50 years, in 200 study locations. The spatial and temporal distribution of the studies is not heterogeneous. Brazil (69), Costa Rica (32), Mexico (28) and Venezuela (16) are the countries where most studies have been carried out (Figure 2A). Likewise, the number of studies on frugivory and nectarivory was low between the 1950s and the 1970s, peaking between the 1980s and the 2000s (Figure 2B).

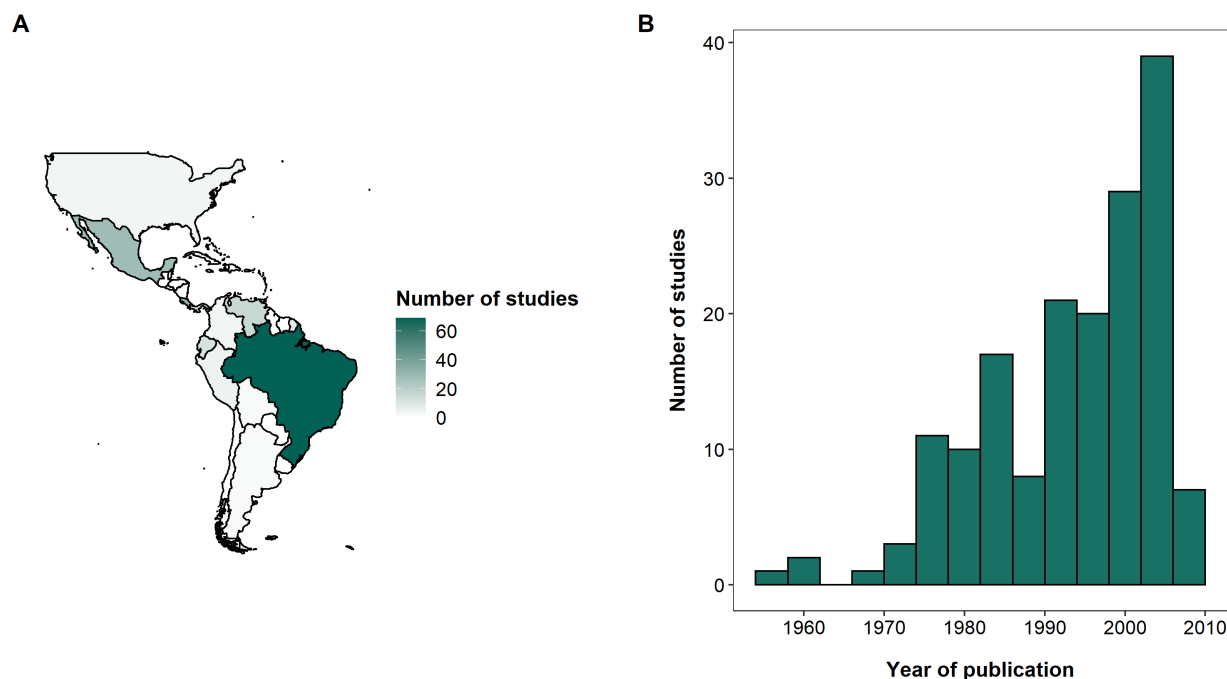


Figure 2: Distribution of the number of studies on frugivory and nectarivory by bats, published by country (A) and throughout the recorded period (B).

The best represented interaction type was frugivory (75.1% of all records) while nectarivory came second (24.9% of all records). Although most data come from primarily fruit- and nectar-feeding bats, there are also interaction records of species from other trophic guilds that occasionally feed on fruit or nectar. Likewise, this database includes information mainly on trees and shrubs, although it also contains other plant life forms such as vines and herbs. Several plant species have no information on successional stage, but there are many classified as early successional species (Table 1).

We have also included information about interaction strength, nevertheless 44.5% of the records have no such data, mainly because strengths were not reported in the source papers. Regarding their conservation status, 8.6% of the bat species and 2.8% of the plant species are listed in some category of threat according to the IUCN (Table 2). However, most plant species (59.9%) and some bat species (17.2%) have not been listed in any category.

Table 1: Ecological information of bat and plant species recorded in the NeoBat Interactions database

Ecological trait	Class	Number of species	%
Trophic guild of bats	Foliage gleaner	5	5.4
	Frugivore	55	59.1
	Nectarivore	27	29.0
	Omnivore	6	6.5
Successional stage of plants	Early	152	29.8
	Late	112	22.0
	Not information	246	48.2
Life form of plants	Herb	52	10.1
	Palm-tree	8	1.6
	Shrub	135	26.3
	Succulent	25	4.9
	Tree	231	45.0
	Vine	36	7.0
	Not information	26	5.1

The taxonomic scope of this data paper encompasses 93 species and 40 genera of bats of the family Phyllostomidae, and 501 species, 189 genera, and 68 families of plants. The most frequently recorded bat was *Carollia perspicillata*, followed by *Artibeus lituratus*, which have been also reported as hyper-dominant species in other community-focused databases (Muylaert *et al.* 2017) as they are cosmopolitan species, widely distributed across the neotropical region (Gardner 2008). Only seven species were responsible for almost 50% of records: *Carollia perspicillata* (16.49%), *Artibeus lituratus* (9.3%), *Artibeus jamaicensis* (7.62%), *Glossophaga soricina* (5.6%), *Artibeus planirostris* (3.89%), *Carollia castanea* (3.46%) and *Carollia castanea* (3.46%). In contrast, most of bats species are infrequent, 67 species have a relative frequency $\leq 1\%$ (Figure 3A). *Chiroderma gorgasi*, *Choeroniscus godmani*, *Choeroniscus minor*, *Glossophaga leachii*, *Glyphoncycteris sylvestris*, *Lamproncycteris brachyotis*, *Lionycteris spurrelli*, *Lonchophylla bokermanni*, *Lonchophylla inexpectata*, *Micronycteris megalotis*, *Phyllostomus latifolius*, *Platalina genovensium*, *Platyrrhinus brachycephalus*, *Pygoderma bilabiatum*, *Sturnira aratathomasi* and *Tonatia bakeri* were the rarest species, representing 0.64% of all records.

Plants of the genera *Piper* (15.17% of the records), *Ficus* (15.13%), *Cecropia* (9.02%) and *Solanum*

Table 2: IUCN conservation status of animals and plants species reported in the NeoBat Interactions database

Group	IUCN Status	Number of species	%
Plants	Critically Endangered (CR)	1	0.2
	Endangered (EN)	4	0.8
	Vulnerable (VU)	5	1.0
	Near Threatened (NT)	4	0.8
	Least Concern (LC)	183	36.5
	Conservation Dependent (CD)	1	0.2
	Data Deficient (DD)	3	0.6
	Not Evaluated (NE)	300	59.9
Bats	Endangered (EN)	3	3.2
	Vulnerable (VU)	2	2.2
	Near Threatened (NT)	3	3.2
	Least Concern (LC)	67	72.0
	Data Deficient (DD)	2	2.2
	Not Evaluated (NE)	16	17.2

(6.81%) were the most abundant in this database, as they represent the main food source for bats of the genera *Carollia*, *Artibeus*, and *Sturnira*, which are abundant groups (Fleming 1982). Several species are recorded as unidentified (6.22%) which reflects the difficulty of identifying plants from seed samples, which was the principal sampling method used in the studies (Figure 3C). Plants of the genera *Acacia*, *Adenocalymma*, *Aechmea*, *Alexa*, *Aureliana*, *Bakeridesia*, *Beilschmiedia*, *Bombax*, *Calliandra*, *Calycolpus*, *Capsicum*, *Chelonanthus*, *Clarisia*, *Cobaea*, *Copaifera*, *Cucurbita*, *Cynometra*, *Cynophalla*, *Elizabetha*, *Emmotum*, *Encholirium*, *Eriolarynx*, *Genipa*, *Gustavia*, *Harporchilus*, *Heisteria*, *Hesperalbizia*, *Hillia*, *Karwinskia*, *Lecythis*, *Livistona*, *Mimosa*, *Myrcia*, *Nectandra*, *Oenocarpus*, *Phenakospermum*, *Phytolacca*, *Praecereus*, *Protium*, *Prunus*, *Pseudolmedia*, *Randia*, *Ruellia*, *Schultesianthus*, *Siparuna*, *Socratea*, *Souroubea*, *Symphonia*, *Tabernaemontana*, *Thespesia*, *Thunbergia*, *Tovomita*, *Turpinia*, *Weberbauerocereus*, *Xanthosoma* and *Zapoteca* were the less represented in this database, accumulating the 2.24% of all records.

Carollia perspicillata (187 species of plants), *Artibeus lituratus* (125), *Artibeus jamaicensis* (94) and *Glossophaga soricina* (86) were the species with highest number of interactions as they also were very abundant species (Figure 3B). Most of species of bats 55 interact with at least five species of plants. The species with only one interaction recorded in this database were: *Anoura fistulata*, *Chiroderma gorgasi*, *Choeroniscus godmani*, *Choeroniscus minor*, *Glossophaga leachii*, *Glyphonycteris sylvestris*, *Lamproncycteris brachyotis*, *Lionycteris spurrelli*, *Lonchophylla bokermanni*, *Lonchophylla inexpectata*, *Micronycteris megalotis*, *Musonycteris harrisoni*, *Phyllostomus latifolius*, *Platalina genovensium*, *Platyrrhinus brachycephalus*, *Pygoderma bilabiatum*, *Sturnira aratathomasi*, *Tonatia bakeri* and *Vampyressa pusilla*.

On the contrary, most of plants recorded (430 species) interact with less than five bat species. *Ficus sp.* (31 species), *Cecropia sp.* (23) and *Piper sp.* (23) hold the highest number of interactions. The rest of plant species (68) interact with between 6 and 16 bat species (Figure 3D).

Each species of plant interact with a relatively low number of bat species and the range of the number of interactions varies considerably ($\bar{x} = 3$, range=1-23). Most of species of trees hold the a large number

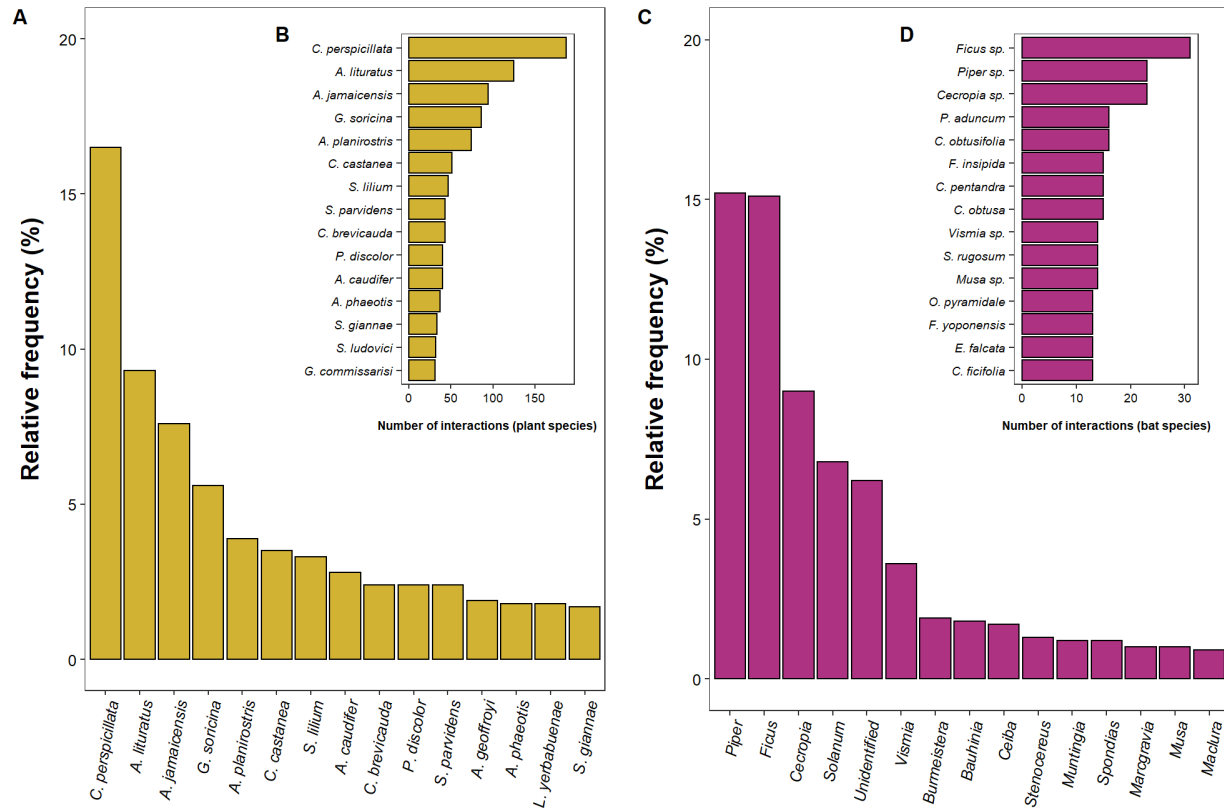


Figure 3: Ranking of frequency of the 15 most abundant bat species (A) and plant genera (C). Internal plots represent the number of each one of the 15 species of bats (B) and plants (D) with most interactions recorded in the NeoBat Interaction database

of interactions of frugivory (176 species, range=1-20 interactions) and the largest number of nectarivory (68 species, range = 1-15 interactions). A large number of shrubs (121 species) holds interactions of frugivory (range=1-23 interactions), and a very small number of species (18) of nectarivory (range=1-6 interactions). Despite trees and shrubs are the life form of plants with most number of records, this database also includes information of nectarivory and frugivory of vines, succulents (Cactaceae) and palm-trees (Figure 4A).

Most frugivory interactions come from early succesional plants (145 species), holding interactions with between 1 and 20 bat species while late succesional plants (80 species) interact with between 1 and 15 bat species. Otherwise, nectarivory interactions came from late succesional plants (39 species) against Early (13 species). Both groups interacting with between 1 and 15 bat species (Figure 4B). Most of the records in NeoBat Interactions come from fruit eating bats. Frugivorous can eat fruits of a large number of plant species (range = 1 - 188 interactions). Some species (18) also can eat nectar of a considable wide number of plants (range = 1 - 34 interactions). Nectarivorous bats eat nectar from 1 - 68 species and fruits from 1 - 1 species of plants. Species of omnivorous bats interact with fruits and nectar of up to 32 plant species. Finally, this database also contains information of foliage gleaner bats of the genus *Lamproncycteris*, *Glyphonycteris*, *Trinycteris*, and *Micronycteris* eating fruits and nectar of up to nine species of plants (Figure 4C).

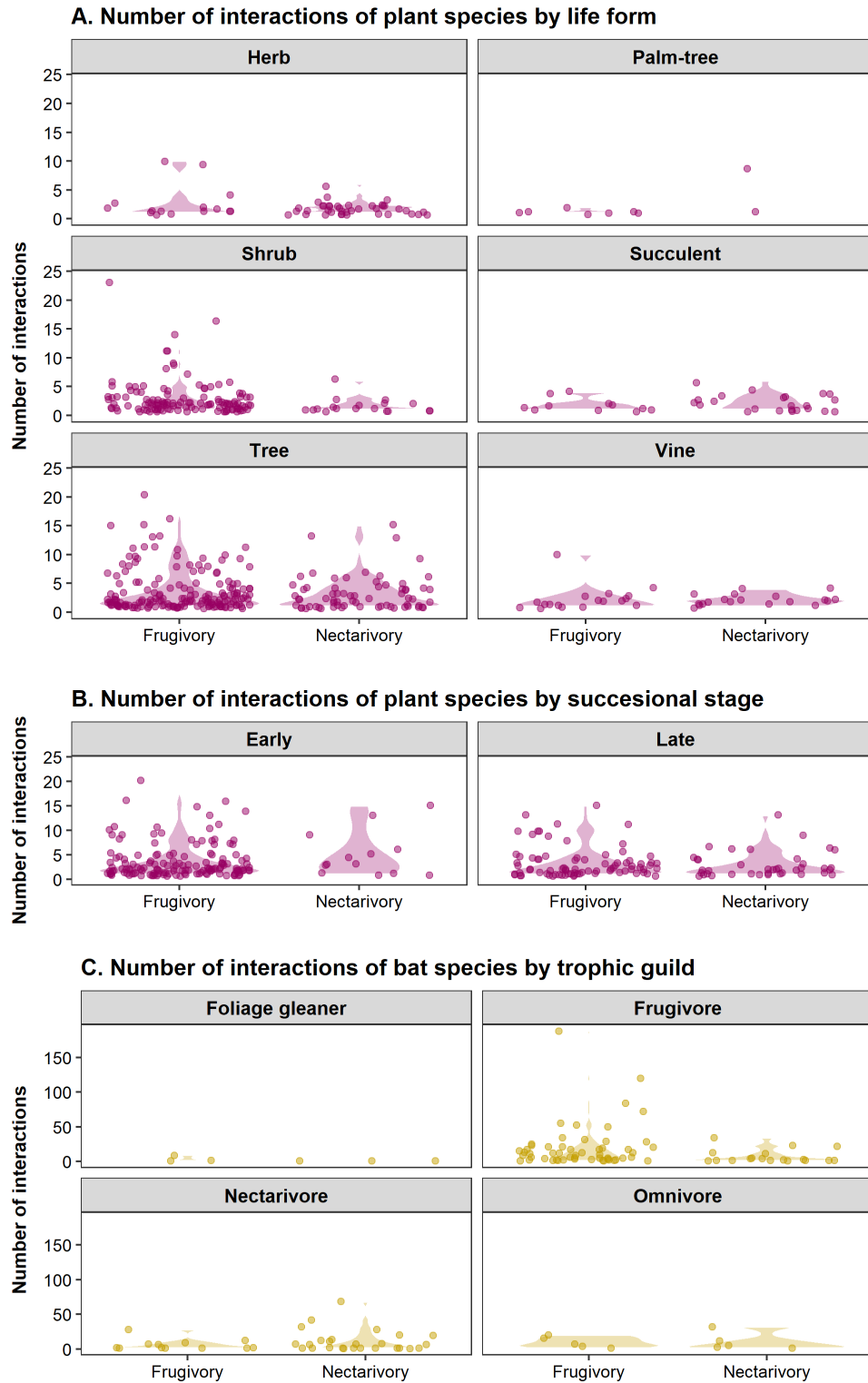


Figure 4: Number of interactions holds by plant and bat species according to their ecological traits: A) Life form of plants, B) Successional stage of plants and C) Trophic guild of bats. Each violet point on A and B represents one plant species, each yellow point on C represents one bat species.

CLASS II. RESEARCH ORIGIN DESCRIPTORS

A. Overall project description

Identity: A compilation of bat-plant interactions in the neotropical region.

Period of study: Dates of source publications range from 1957 to 2007.

Objectives: We aimed (1) to summarize and make available the information about frugivory and nectarivory interactions between bats and plants in the Neotropics, as well as some ecological information to be used in studies of community ecology, ecological networks, and macroecology; and (2) to identify gaps in knowledge about bat-plant interactions (Eltonian shortfalls) to direct future research and sampling effort. This data set represents the most extensive and complete catalogue of bat-plant interactions in the neotropical region.

Abstract: Same as above.

Source of funding: This study was financed by the Brazilian Coordination for the Improvement of Higher Education Personnel (CAPES, student scholarships), the São Paulo Research Foundation (FAPESP, grant 2018/20695-7), Brazilian Council for Scientific and Technological Development (CNPq, grants 302700/2016-1, 304498/2019-0, and PEC-PG doctoral scholarship 190585/2017-0), Alexander von Humboldt Foundation (AvH, grants 1134644, 3.4-8151/15037, and 3.2-BRA/1134644) and Dean of Research of the University of São Paulo (PRP-USP, grant 18.1.660.41.7).

B. Specific subproject description

Site description: The neotropical region is one of the eight biogeographic realms of the world and extends from southeastern United States to Patagonia, including the Caribbean and some pacific islands (Olson *et al.* 2001). The region is comprised by 17 Phytogeographic Domains divided in 96 eco-regions including the Nearctic Mexico Domain (Oliveira-Filho 2017). The vegetation of the region is very diverse, including xeric and thorny shrubs, open fields, sandy and rocky vegetation, woodlands, savannas, deciduous and semideciduous forest, rainforest, cloud forest, dwarf forest, and floodplains.

The Neotropics is the most species-rich realm in the world and has high levels of endemism (Ulloa *et al.* 2017). Due to this high level of endemism and the number of threats in some areas, seven of the 25 hotspots of biodiversity are in the neotropical region: Mesoamerica, Caribbean Islands, Tumbes-Choco-Magdalena, Tropical Andes, Cerrado, Atlantic Forest, and Chilean Winter Rainfall and Valdivian Forests (Mittermeier *et al.* 2011), beside the Amazon Forest, the most biodiverse ecoregion in the world (Hoorn *et al.* 2010).

Data compilation: The present database was originally compiled from the Bat-Plant Interaction Database, currently known as Bat Eco Interactions (Geiselman and Younger 2002). We have also carried out a bibliographic search of different sources: (1) the online databases Web of Knowledge, Scopus, Scielo and Google Scholar; (2) references cited in the literature;

and (3) direct communication with local experts. The bibliographic search was performed using the keywords: bat-plant interactions; bat(s) diet + frugivory; bat(s) diet + nectarivory; plant visitation + bat(s), bat(s) pollination, bat(s) seed dispersal. The search was conducted in English, Spanish, Portuguese, and French. We compiled information from 169 references, mainly papers but also technical reports, books chapters, and unpublished data. For each sampling site we collected information about vegetation type, mean temperature, rainfall, altitude, potential evapo-transpiration, and aridity index (see Table 4).

Research methods: We included studies that reported interactions of frugivory or nectarivory in the field, through the analysis of bat diets, observation of plant visitation, and cafeteria experiments. We excluded records from secondary references or unconfirmed potential interactions. When available, interaction strength was reported as the number of bat fecal samples containing the seeds of a given plant species for frugivory, and the number of visits of each bat species to each plant species per sampling unit for nectarivory. Missing information was coded as NA. We also included geographic information of the study sites (latitude, longitude, locality, state, and country). Geographic information was manually curated for all sites using Google Maps and clues from each publication.

We compiled information of bat-plant interactions from Greenhall (1957), Alcorn *et al.* (1961), Carvalho (1961), Jimbo and Schwassmann (1967), Wilson (1971), Heithaus *et al.* (1974), Howell and Burch (1973), Heithaus *et al.* (1975), Sazima and Sazima (1975), Janzen *et al.* (1976), Sazima (1976), Fleming *et al.* (1977), Nellis and Ehle (1977), Sazima and Sazima (1977), Heithaus and Fleming (1978), Morrison (1978a), Morrison (1978b), Sazima and Sazima (1978), Bonaccorso (1979), Morrison (1980), Sazima and Sazima (1980), Voss *et al.* (1980), August (1981), Fleming (1981), McCracken and Bradbury (1981), Uhl *et al.* (1981), Heithaus *et al.* (1982), Sazima *et al.* (1982), Dos Reis and Guillaumet (1983), Steiner (1983), Foresta *et al.* (1984), Estrada *et al.* (1984a), Estrada *et al.* (1984b), Helversen and Reyer (1984), Hopkins (1984), Lemke (1984), Ramirez *et al.* (1984), Fleming (1985), Fleming *et al.* (1985), Uieda and Vasconcellos-Neto (1984), Charles-Dominique (1986), Coates-Estrada and Estrada (1986), Dinerstein (1986), Fleming and Heithaus (1986), Herbst (1986), Bonaccorso and Gush (1987), Eguiarte *et al.* (1987), Sazima and Sazima (1987), Palmeirim *et al.* (1989), Sazima *et al.* (1989), Fleming and Williams (1990), Hokche and Ramirez (1990), Charles-Dominique (1991), Handley Jr and Leigh Jr (1991), Handley *et al.* (1991), Marinho-Filho (1991), Soriano *et al.* (1991), Ascorra and Wilson (1992), Buzato and Franco (1992), Fischer (1992), Hernandez and Martinez del Rio (1992), Muller and Reis (1992), Ascorra *et al.* (1993), Gribel and Hay (1993), Kress and Stone (1993), Sosa and Soriano (1993), Willig *et al.* (1993), Buzato *et al.* (1994), Galetti and Morellato (1994), Marinho-Filho and Vasconcellos-Neto (1994), Sazima *et al.* (1994a), Sazima *et al.* (1994b), Zortea and Chiarello (1994), Cunningham (1995), Engriser (1995), Gorchov *et al.* (1995), Silva and Peracchi (1995), Figueiredo (1996), Sahley (1996), Sosa and Soriano (1996), Valiente-Banuet *et al.* (1996), Bizerril and Raw (1997), Hernandez-Conrique *et al.* (1997), Iudica and Bonaccorso (1997), Locatelli *et al.* (1997), Nassar *et al.* (1997), Pedro and Taddei (1997), Petit (1997), Ruiz *et al.* (1997), Valiente-Banuet *et al.* (1997), Lppolito and Suarez (1998), Kalko and Condon (1998), Machado *et al.* (1998), Casas *et al.* (1999), Gastal and Bizerril (1999), Giannini (1999), Gibbs *et al.* (1999), Gribel *et al.* (1999), Sazima *et al.* (1999), Tschapka and Helversen (1999), Tschapka *et al.* (1999),

Arizaga *et al.* (2000), Garcia *et al.* (2000), Godínez-Alvarez and Valiente-Banuet (2000), Ruiz *et al.* (2000), Slauson (2000), Soriano *et al.* (2000), Wendeln *et al.* (2000), Charles-Dominique and Cockle (2001), Herrera M *et al.* (2001a), Herrera M *et al.* (2001b), Kay (2001), Varassin *et al.* (2001), Banack *et al.* (2002), Coelho and Marinho-Filho (2002), Godínez-Alvarez *et al.* (2002), von2002glossophagine, Martino *et al.* (2002), Mikich (2002), Muchhala and Jarrin-V (2002), Stoner *et al.* (2002), Aguirre *et al.* (2003), Cáceres and Moura (2003), Lobo *et al.* (2003), Lobova *et al.* (2003), Mikich *et al.* (2003), Molina-Freaner and Eguiarte (2003), Naranjo *et al.* (2003), Nogueira and Peracchi (2003), Passos and Passamani (2003), Passos *et al.* (2003), Sazima *et al.* (2003), Giannini and Kalko (2004), Lima and Reis (2004), Lobova and Mori (2004), Lopez and Vaughan (2004), Machado and Vogel (2004), Mello *et al.* (2004), Passos and Graciolli (2004), Quesada *et al.* (2004), Thies and Kalko (2004), Tschapka (2004), Valiente-Banuet *et al.* (2004), Vogel *et al.* (2004), Aguiar (2005), Delaval *et al.* (2005), Ibarra-Cerdeña *et al.* (2005), Korine and Kalko (2005), Lobo *et al.* (2005), Mancina *et al.* (2005), Mello *et al.* (2005), Sanmartin-Gajardo and Sazima (2005), Tschapka (2005), Vogel *et al.* (2005), Acosta and Aguanta (2006), Arias-Cóyotl *et al.* (2006), Mancina *et al.* (2002), Muchhala (2006a), Muchhala (2006b), Tschapka *et al.* (2006), Aguiar and Marinho-Filho (2007), Estrada-Villegas *et al.* (2007), Lopez and Vaughan (2007), Mancina *et al.* (2007), Olea-Wagner *et al.* (2007), Oria and Machado (2007), and Tavares *et al.* (2007).

The interaction records of Giannini and Kalko (2004) do not appear in the original article as the information collected in that study were identified, reviewed, and manually added. The rest of the information can be verified in the original articles.

Taxonomic information: For bat species, we followed the taxonomic arrangement in Simmons and Cirranello (2020). We added a column with the current bat species name following verification of the taxonomy and geographic distribution. Taxonomic verification was conducted by Marcelo Nogueira. Taxonomic changes in the current name of species and geographic distribution was checked in Cole and Wilson (2006), Solari and Baker (2006), Mantilla-Meluk *et al.* (2009), Velazco *et al.* (2010), Mantilla-Meluk (2014), Nogueira *et al.* (2014), Tavares *et al.* (2014), Velazco and Patterson (2014), Velazco and Patterson (2019), Basantes *et al.* (2020), Catzeffis (2020), Lim *et al.* (2020), Ramírez-Chaves *et al.* (2020), Siles and Baker (2020), Tirira *et al.* (2020), Turcios-Casco *et al.* (2020), Vargas-Arboleda *et al.* (2020), and Velazco (2020). For plant taxonomy, we updated taxonomy and corrected for synonyms following The Plant List (2013) and REFLORA (2020).

Functional traits information: We reported the life form and the successional stage of plant species. We compiled this information from the literature (Dinerstein 1986; Galindo-González *et al.* 2000; Garcia *et al.* 2000, 2011; Kammesheidt 2000; Lopez and Vaughan 2004; Mantovani *et al.* 2005; Oatham and Ramnarine 2006; Olea-Wagner *et al.* 2007; Marimon *et al.* 2008; Fleming *et al.* 2009a; Gusson *et al.* 2009; Ramos *et al.* 2011; Swanson *et al.* 2011; Sampaio *et al.* 2012; Condé and Tonini 2013; Paolucci *et al.* 2019; Aximoff *et al.* 2020), and also from the species information of the REFLORA (2020), and the virtual herbarium of the *Smithsonian Museum of Natural History* (<https://collections.nmnh.si.edu/search/botany/>) and the *Royal Botanic Garden Edinburgh* (<https://data.rbge.org.uk/>). The trophic guild classification of bat species was made following Gardner (1977), Willig (1986) and Soriano (2000).

C. Data limitations and potential enhancements

NeoBat interactions database has some caveats, first of all a temporal bias. Although this database includes 50 years of publications on bat-plant interactions, it already has a delay of 14 years. This delay will be reduced in future updates, as our database has a live online version. The second bias is related to representativeness: our database is clearly biased towards frugivory studies of common and abundant bat species. Thus, our database represents only a small subset of all bat-plant interactions that actually occur in the neotropical region. The rarefaction curve shows that despite having registered 1,581 interactions within 200 sampling sites, the trend is far from reaching an asymptote (Figure 5).

The lack of standardization in the frugivory and nectarivory sampling methods makes it difficult to acquire data that validate interactions in the field. Sampling methods vary significantly between studies focused on plants or bats. Studies focused on plants are sampled primarily through the observation of a single species and its floral visitors or fruit removers. On the other hand, studies focused on bats are made mainly by the analysis of fecal samples from one species or the entire assemblage. In these studies, capture is carried out mainly with mist nets, which adds a bias towards animals that fly in the understory and usually do not detect the nets (Tschapka 1998). Some studies used seed traps to collect the seeds rain under the canopy (Medellin and Gaona 1999; Arteaga *et al.* 2006). However, these methods do not allow to identify which bat species each fecal sample belongs to, and therefore are not useful for recording pairwise interactions.

We also have identified some shortfalls in large-scale knowledge about bat-plant interactions in the region (Hortal *et al.* 2015):

Linnean Shortfall: Identifying species is a great challenge for studying ecological interactions. This database presents some gaps in different taxonomic levels mainly in the identification of plants. 707 records of 2571 are identified only at the genus level, 160 are registered as “unidentified” genus of which only 116 are not even identified at the family level. Nevertheless, bat taxonomy is at least more clear as only 57 records of *Platyrrhinus* from the Amazon and Venezuela, and small-sized *Artibeus* were not identified to the species. Most of the studies on frugivory and some on nectarivory come from the analysis of bat diets. This represents a great issue since identifying plant species from seeds and pollen is remarkably difficult. Carrying out diet studies involves a much greater effort than only collecting and identifying biological samples. To improve the precision in plant identification, it is necessary to make reference collections of seeds and pollen over long periods. Some studies have chosen to use more advanced techniques, such as DNA barcoding, to identify diet items (González-Varo *et al.* 2014; Lim *et al.* 2018). These techniques can improve the taxonomic resolution of the data but involve an increase in operating costs that makes them difficult to use in many neotropical countries. On the other hand, studies on floral visits and fruit removal carried out from observation or photographic records can also lead to misidentification of bat species. In this sense, combining photographic records with mist-netting can help researchers to solve these types of issues, when voucher specimens cannot be collected.

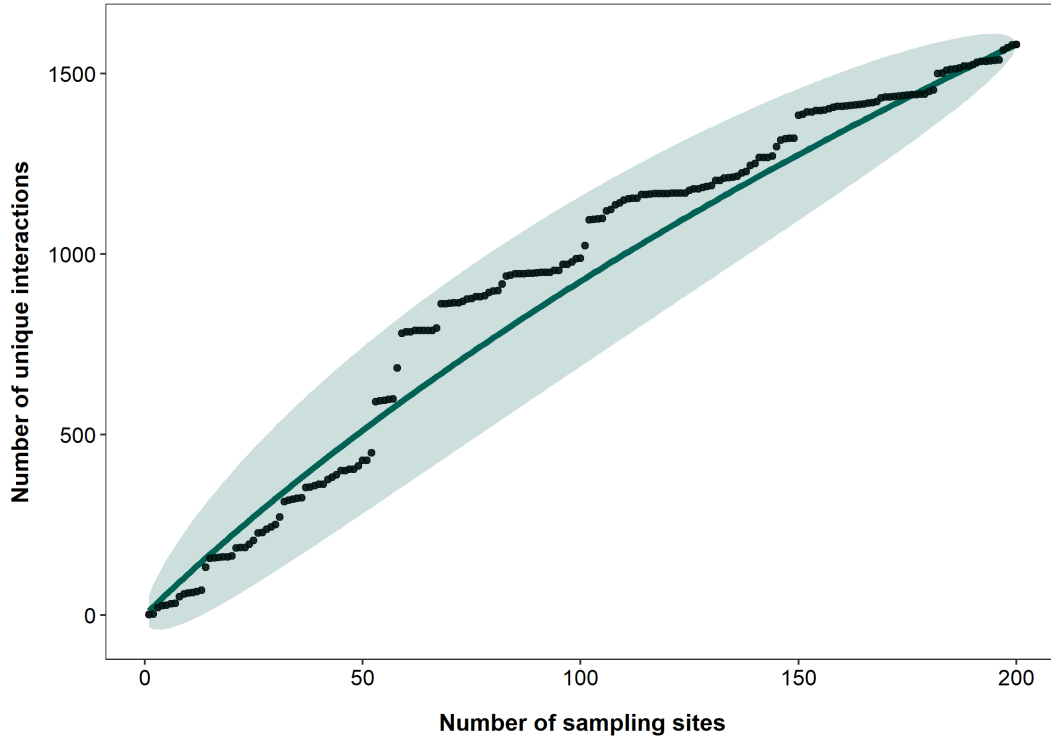


Figure 5: Interactions accumulation curve by sampling site. Black dots represent the empirical accumulation data, green line represents the rarefaction curve based on Chao2 non-parametric estimator and green polygon is the 95% confidence interval of the rarefaction curve.

Wallacean Shortfall: The lack of information about geographic distribution of species is a worldwide issue (Lomolino 2004). Despite the increasing effort to sample animals and plants separately, this effort is not enough to reduce this shortfall in the case of ecological interactions. Inferring ecological interactions only from co-occurrence data is not correct since interactions can be conditioned by another kind of biotic and abiotic processes, more than the simple presence of the two species in the same place at the same time (Blanchet *et al.* 2020). In this database we have only compiled verified interactions, but there is clearly a large gap in sampling and publishing about bat-plant interactions in the region (Figure 1). There is likely a large amount of gray literature on bat-plant interactions in different neotropical universities and research centers. However, this information is not digitally available or has usage restrictions, which makes it even harder to fill the gaps and understand the geographic distribution of such interactions.

Prestonian Shortfall: This shortfall concerns the gap in knowledge about species abundance (Cardoso *et al.* 2011). Most papers compiled in our database (55.5% of records) provide information on the presence of each interaction, but they include no abundance data. Quantifying the strength of ecological interactions allows to acquire insights on the complex structure of mutualistic networks that could not be obtained from binary data of presence and absence (Fründ *et al.* 2015). Due to the variety of sampling methods used, quantifying the abundance of bat-plant interactions in a comparable way can be a difficult task. Studies on bat diets, in which samples of pollen or feces are taken directly from the animal body, generally report the strength of the interaction as the number of samples in which pollen or seeds of each plant species were

present. However, in many cases, the authors do not report the number of fecal samples collected by species, and others only report the number of seeds obtained in the total samples of each species of bat. Studies on plant visitation usually report the number of visits of each species of bats to each plant, and, in some cases, they report only the duration of flower visits or even the number of flowers visited. Despite being useful for analyzing aspects of autecology, much of these data are not useful for quantifying the strength of ecological interactions. Then, collecting and reporting data to calculate the frequency of interactions between pairs of species as a proxy for the strength of the interaction could be an option to overcome this shortfall (Vázquez *et al.* 2005).

Eltonian Shortfall: It refers to the lack of information about interactions among species (Hortal *et al.* 2015). We have extended the definition of this shortfall as the lack of verification about the type of interaction that takes place between a pair of species. Roughly, we tend to assume that frugivory necessarily implies seed dispersal, and nectarivory necessarily implies pollination. We even tend to define both as mutualistic interactions, but these assumptions are imprecise and unclear without additional information. This issue gets even more complicated, when we consider that ecological interactions are not fixed in time and space. The effect of one species on the population dynamics of another can be modulated by internal factors such as population densities, and external factors such as environmental conditions (Hernandez 1998). This conditioning enables a context-dependent transition from mutualisms to antagonisms under variable environments. Overcoming this shortfall for bat-plant interactions requires considerable effort. Frugivory can only be assumed as mutualistic, if the balance between seed destruction and safe gut passage results in a fitness gain for the plant (Genrich *et al.* 2017). The benefit can be measured in terms of fruit production, the genetic variability of the propagules, or the dispersal distance of pollen to establish that the nectarivory represents a mutualistic interaction (Fleming *et al.* 2009b).

This database points to the need for increasing the investment in systematic, long-term studies on bat-plant interactions. Future studies also need to incorporate quantitative information about the frequency of the interactions, and new techniques that improve the taxonomic resolution in species identification. We suggest caution in labeling bat-plant interactions as mutualistic. Potential biases derived from the shortfalls mentioned above should be taken seriously.

CLASS III. DATA SET STATUS AND ACCESSIBILITY

A. Status

Latest update: October 2020.

Latest archive date: October 2020.

Metadata status: Last updated January 2021, version submitted.

Data verification: Data were compiled as presented is in the sources. We corrected transcription errors, checked the geographic coordinates of study sites, and verified the taxonomic information.

B. Accessibility

Contact person: Guillermo Florez-Montero (gflorezmontero@gmail.com) or Marco Mello (marmello@usp.br).

Download link: https://github.com/gflorezm/NeoBat_Interactions

Copyright restrictions: Creative Commons Attribution 4.0 International License.

Proprietary restrictions: Please cite this *Ecology* data paper when the data are used in any kinds of publication, as well as research, outreach, and teaching activities.

Costs: None.

CLASS IV. DATA STRUCTURAL DESCRIPTORS

A. Data set file

Identity:

- (1) NeoBat_Interactions_References.csv
- (2) NeoBat_Interactions_Sites.csv
- (3) NeoBat_Interactions_Records.csv

Size:

- (1) NeoBat_Interactions_References.csv, 168 references, 34.9 KB
- (2) NeoBat_Interactions_Sites.csv, 200 study sites, 49.4 KB
- (3) NeoBat_Interactions_Records.csv, 2571 records, 402.3 KB

Format and storage mode: Data frames as comma-separated values (.csv)

Alphanumeric attributes: Mixed

Data anomalies: If no information is available for any cell, this is indicated as 'NA'.

B. Variable information

Table 3. References information

Table 4. Study sites information

Table 5. Interaction records information

CLASS V. SUPPLEMENTAL DESCRIPTORS

A. Data acquisition

1. **Data request history:** None
2. **Data set updates history:** None
3. **Data entry/verification procedures**

G. History of data set usage

The data were used in the following studies, in chronological order:

1. Mello, M. A. R., F. M. D. Marquitti, P. R. Guimarães Jr., E. K. V. Kalko, P. Jordano, M. A. M. de Aguiar, and P. R. Guimaraes.
2011. The missing part of seed dispersal networks: structure and robustness of bat-fruit interactions. *PLoS One* 6: e17395.
2. Mello, M. A. R., F. M. D. Marquitti, P. R. Guimarães, E. K. V. Kalko, P. Jordano, and M. A. M. de Aguiar.
2011. The modularity of seed dispersal: differences in structure and robustness between bat- and bird-fruit networks. *Oecologia* 167: 131–140.
3. Sarmiento, R., C. P. Alves-Costa, A. Ayub, and M. A. R. Mello.
2014. Partitioning of seed dispersal services between birds and bats in a fragment of the Brazilian Atlantic Forest. *Zoologia* 31: 245–255.
4. Mello, M. A. R., F. A. Rodrigues, L. da F. Costa, W. D. Kissling, Ç. H. Şekercioğlu, F. M. D. Marquitti, and E. K. V. Kalko.
2015. Keystone species in seed dispersal networks are mainly determined by dietary specialization. *Oikos* 124: 1031–1039.
5. Mello, M. A. R., G. M. Felix, R. B. P. Pinheiro, R. L. Muylaert, C. Geiselman, S. E. Santana, M. Tschapka, N. Lotfi, F. A. Rodrigues, and R. D. Stevens.
2019. Insights into the assembly rules of a continent-wide multilayer network. *Nat. Ecol. Evol.* 3: 1525–1532.

ACKNOWLEDGMENTS

Firstly, we thank Prof. Mauro Galetti and Prof. Milton Ribeiro, from the State University of São Paulo, Brazil, who started the Atlantic Series of data papers and inspired our entire community to take their data out of their drawers. Our labmates and colleagues helped us at different stages of this project. Our sponsors, especially the Alexander von Humboldt-Stiftung (AvH), Brazilian Council of Scientific and Technological

Development (CNPq), Brazilian Coordination for the Improvement of Higher Education Personnel (CAPES), and São Paulo Research Foundation (FAPESP), gave us grants, fellowships, and scholarships. Last, but not least, we thank the Stack Overflow Community, where we solve most of our coding dilemmas.

TABLES

Table 3: Information about the references in the NeoBat Interactions database

Variable	Description	Levels	Example
RefCode	Identification of each reference. This code links the reference matrix to the other matrices	BPR001 to BPR168	BPR066
Author	Short name of the author(s), if there are three or more authors, we use et al.	...	Hernández-Conrique et al.
Year	Year of publication.	1957 to 2007	1997
Reference	Extended reference.	...	Hernández-Conrique, D., L.I. Iñiguez-Dávalos & J.F. Storz. 1997. Selective feeding by phyllostomid fruit bats in subtropical montane cloud forest. Biotropica 29: 376-379

Table 4: Information about the samplig sites in the NeoBat Interactions database

Variable	Description	Levels	Example
SiteCode	Identification of each sampling site. This code links the site matrix to the record matrix. In many cases, a paper can have more than one sampling site.	BPA001 to BPA200	BPA074
RefCode	Identification of each reference. This code links the reference matrix to the other matrices.	BPR001 to BPR168	BPR066

Table 4: Information about the samplig sites in the NeoBat Inter-
actions database (*continued*)

Variable	Description	Levels	Example
Locality	Locality where fieldwork was carried out, based on information reported in the paper. We checked all names using the Google Earth database.	...	Sierra de Manantlan Biosphere Reserve
State	State, Department or Province of the study site based on the geographic coordinates.	...	Jalisco
Country	Country where fieldwork was carried out (English name).	Argentina Bolivia Brazil Colombia Costa Rica Cuba Curacao Ecuador French Guiana Jamaica Mexico Panama Peru Trinidad and Tobago United States Venezuela	Mexico
Latitude	Corrected latitude in decimal degrees (Projection WGS84 EPSG:4326). In studies with two or more sampling sites with less than 5 km of linear distance between them we used the centroid coordinate.	Decimal degrees	19.485675

Table 4: Information about the samplig sites in the NeoBat Interactions database (*continued*)

Variable	Description	Levels	Example
Longitude	Corrected longitude in decimal degrees. See Latitude for more information.	Decimal degrees	-103.950087
Precision	In some cases, papers reported the precise coordinates of each sampling site. Other papers reported only geographic references (basins, rivers, municipality, or distance from a village). In these cases, we validated these references with Google Earth satellite images. We consider Not Precise when coordinates mismatch the written information in the paper, or when the paper only reported the coordinates of the municipality or region.	Precise Not Precise	Precise
YearStart	The year in which sampling started.	1960 to 2006	1993
YearEnd	The year in which sampling ended.	1960 to 2006	1994
Duration	Unstandardized duration of the sampling period (in months).	1 to 37	7
SamplingEffort	For studies based on feces collection: Total number of fecal samples. For studies based on the observation of plant visitation events: Total number of events recorded.	6 to 6809	68

Table 4: Information about the samplig sites in the NeoBat Inter-
actions database (*continued*)

Variable	Description	Levels	Example
StudyType	The type of study according to the focus reported in the reference paper. Bat diet refers to study focused on describing the diet of a bat species or assemblage. Plant visitation refers to studies aimed at describing the visitors of a plant species or assemblage.	Bat diet Plant visitation	Bat diet
EcologicalScale	The ecological scale studied. When there were more than one species of bat (when the Study type is Bat diet) or plant (when the study type is Plant visitation), we considered as Assemblage.	Population Assemblage	Assemblage
SamplingMethod	The sampling method as described in the reference paper. We have standardized the levels to five broad methods. Some studies have more than one sampling method	Direct observation Experimental Feces collection Pollen collection Roost inspection	Experimental
SamplingSeason	Climatic season in which sampling was performed. Some studies were conducted in both, dry and wet season.	Dry Wet	Dry and Wet
Vegetation	Vegetation type as described in the reference paper.	...	Subtropical montane cloud forest

Table 4: Information about the samplig sites in the NeoBat Inter-
actions database (*continued*)

Variable	Description	Levels	Example
VegType	Vegetation type corrected according to Oliveira-Filho (2017).	Cloud forest Coastal sandy mosaic Deciduous forest Floodplain forest Limestone deciduous woodland Limestone Rainforest Mixed forest Montane woodland Rainforest Rocky woodland Savanna woodland Seasonal riverine forest Semi-arid thorny woodland Semi-desert and desert Semideciduous forest	Mixed forest
Ecoregion	Ecological region according to Olson et al. (2001).	...	Trans-Mexican Volcanic Belt pine-oak forests
Domain	Phytogeographic domain according to Oliveira-Filho (2017).	Amazonia Atlantic Forest Caatinga Caribbean Cerrado Los Llanos Mesoamerica Nearctic Mexico Northern Andes Southern Andes	Mesoamerica
Altitude	Meters above sea level reported in the reference paper.	2 to 2700	1900

Table 4: Information about the samplig sites in the NeoBat Inter-
actions database (*continued*)

Variable	Description	Levels	Example
X1kmAlt	Meters above sea level, from the Hydro-1K dataset (United States Geological Survey-USGS, 2001. Global 30 arc-seconds Elevation (GTOPO30).	0 to 2686	2462
AnnRain	Annual Rainfall in mm from WorldClim 2.0 with 30 arc seconds resolution (Fick and Hijmans 2017).	66 to 3912	1116
MeaAnnTemp	Mean annual temperature in Celsius degrees from WorldClim 2.0 with 30 arc seconds resolution (Fick and Hijmans 2017).	10.3 to 27.9	14.2
PET	Global Potential Evapo-Transpiration (annual average in mm) from CGIAR-CSI (Trabucco and Zomer 2009), with resolution of 30 arc seconds.	1021 to 2588	1577
GAI	Global Aridity Index model from CGIAR-CSI (Trabucco and Zomer 2009), with resolution of 30 arc seconds.	0 to 3	0.7072

Table 5: Information about the interaction records in the NeoBat Interactions database

Variable	Description	Levels	Example
IDCode	Identification code of each interaction record.	BPI0001 to BPI2574	BPI0077
SiteCode	Identification of each sampling site. This code links the site matrix to the record matrix. In many cases, a paper can have more than one sampling site.	BPA001 to BPA200	BPA008
RefCode	Identification of each reference. This code links the reference matrix to the other matrices.	BPR001 to BPR168	BPR008
BatGenus	Current scientific name of the bat genus.	...	Uroderma
BatSpecies	Scientific name of the bat as reported in the reference paper.	...	Uroderma bilobatum
CurrentBatSpecies	Current scientific name of the bat species	...	Uroderma bilobatum
TrophicGuild	Trophic guild of the bat species	Foliage gleaner Frugivore Nectarivore Omnivore	Frugivore
PlantFamily	Current scientific name of the plant family.	...	Piperaceae
PlantGenus	Current scientific name of the plant genus.	...	Piper
PlantSpecies	Scientific name of the plant as reported in the reference paper.	...	Photomorpha peltata

Table 5: Information about the interaction records in the NeoBat Interactions database (*continued*)

Variable	Description	Levels	Example
CurrentPlantSpecies	Current scientific name of the plant, validated with The Plant List database (http://www.theplantlist.org) and the REFLORA database (http://reflora.jbrj.gov.br).	...	Piper peltatum
LifeForm	Life form of the plant species.	Herb Palm-tree Shrub Succulent Tree Vine	Shrub
SuccessionalStage	Successional stage of the plant species.	Early Late	Early
Interaction	Type of interaction described.	Frugivory Nectarivory	Frugivory
Weight	Frugivory: Number of fecal samples containing the plant seed. Nectarivory: Number of visits per sampling unit.	1 to 219	1

REFERENCES

- Acosta L and Aguinta F. 2006. Un nuevo aporte en el conocimiento de la dieta de los murciélagos frugívoros *artibeus lituratus* y *a. jamaicensis*. *Kempffiana* **2**: 127–33.
- Aguiar LM de S. 2005. First record on the use of leaves of *solanum lycocarpum* (solanaceae) and fruits of *emmotum nitens* (icacinacea) by *platyrrhinus lineatus* (e. Geoffroy)(Chiroptera, phyllostomidae) in the brazilian cerrado. *Revista Brasileira de Zoologia* **22**: 509–10.
- Aguiar L and Marinho-Filho J. 2007. Bat frugivory in a remnant of southeastern brazilian atlantic forest. *Acta Chiropterologica* **9**: 251–60.
- Aguirre L, Herrel A, Van Damme R, and Matthysen E. 2003. The implications of food hardness for diet in bats. *Functional Ecology* **17**: 201–12.
- Alcorn SM, McGregor S, and Olin G. 1961. Pollination of saguaro cactus by doves, nectar-feeding bats, and honey bees. *Science* **133**: 1594–5.
- Arias-Cóyotl E, Stoner KE, and Casas A. 2006. Effectiveness of bats as pollinators of *stenocereus stellatus* (cactaceae) in wild, managed in situ, and cultivated populations in la mixteca baja, central mexico. *American Journal of Botany* **93**: 1675–83.
- Arizaga S, Ezcurra E, and Peters E *et al.* 2000. Pollination ecology of agave *macroacantha* (agavaceae) in a mexican tropical desert. II. The role of pollinators. *American Journal of Botany* **87**: 1011–7.
- Arteaga LL, Aguirre LF, and Moya MI. 2006. Seed rain produced by bats and birds in forest islands in a neotropical savanna 1. *Biotropica* **38**: 718–24.
- Ascorra C, Gorchoy D, and Cornejo F. 1993. The bats from jenaro herrera, loreto, peru. *Mammalia* **57**: 533–52.
- Ascorra C and Wilson D. 1992. Bat frugivory and seed dispersal in the amazon, loreto, peru. *Publicaciones del Museo de Historia Natural UNMSM (A)* **43**: 1–6.
- August PV. 1981. Fig fruit consumption and seed dispersal by *artibeus jamaicensis* in the llanos of venezuela. *Biotropica* **13**: 70–6.
- Aximoff IA, Soares HM, and Bernadello G. 2020. *Acnistus arborescens* (solanaceae): An important food resource for birds in an atlantic forest site, southeastern brazil. *Rodriguésia* **71**: e02232018.
- Banack SA, Horn MH, and Gawlicka A. 2002. Disperser-vs. Establishment-limited distribution of a riparian fig tree (*ficus insipida*) in a costa rican tropical rain forest. *Biotropica* **34**: 232–43.
- Basantes M, Tinoco N, and Velazco PM *et al.* 2020. Systematics and taxonomy of *tonatia saurophila koopman & williams, 1951* (chiroptera, phyllostomidae). *ZooKeys* **915**: 59.
- Bello C, Galetti M, and Montan D *et al.* 2017. Atlantic frugivory: A plant–frugivore interaction data set for the atlantic forest. *Ecology* **98**: 1729–9.
- Bizerril MX and Raw A. 1997. Feeding specialization of two species of bats and the fruit quality of *piper arboreum* in a central brazilian gallery forest. *Revista de Biologia Tropical* **45**: 913–8.
- Blanchet FG, Cazelles K, and Gravel D. 2020. Co-occurrence is not evidence of ecological interactions. *Ecology Letters* **23**: 1050–63.
- Bonaccorso FJ. 1979. Foraging and reproductive ecology in a panamanian bat community. *Bulletin of the Florida Museum of Natural History* **24**: 359–408.
- Bonaccorso FJ and Gush TJ. 1987. Feeding behaviour and foraging strategies of captive phyllostomid fruit bats: An experimental study. *The Journal of Animal Ecology* **56**: 907–20.
- Bovendorp RS, Villar N, and Abreu-Junior EF de *et al.* 2017. Atlantic small-mammal: A dataset of communities of rodents and marsupials of the atlantic forests of south america. *Ecology* **98**: 2226–6.

- Buzato S and Franco AL. 1992. Tetrastylis ovalis: A second case of bat-pollinated passionflower (passifloraceae). *Plant Systematics and Evolution* **181**: 261–7.
- Buzato S, Sazima M, and Sazima I. 1994. Pollination of three species of abutilon (malvaceae) intermediate between bat and hummingbird flower syndromes. *Flora* **189**: 327–34.
- Cardoso P, Erwin TL, Borges PA, and New TR. 2011. The seven impediments in invertebrate conservation and how to overcome them. *Biological Conservation* **144**: 2647–55.
- Carvalho CT de. 1961. Sobre os hábitos alimentares de phyllostomídeos (mammalia, chiroptera). *Revista de Biologia Tropical* **9**: 53–60.
- Casas A, Valiente-Banuet A, Rojas-Martínez A, and Da'vila P. 1999. Reproductive biology and the process of domestication of the columnar cactus stenocereus stellatus in central mexico. *American Journal of Botany* **86**: 534–42.
- Catzeffis F. 2020. Liste des mammifères de guyane française (février 2020).
- Cáceres NC and Moura MO. 2003. Fruit removal of a wild tomato, solanum granulosoleprosum dunal (solanaceae), by birds, bats and non-flying mammals in an urban brazilian environment. *Revista Brasileira de Zoologia* **20**: 519–22.
- Charles-Dominique P. 1986. Inter-relations between frugivorous vertebrates and pioneer plants: Cecropia, birds and bats in french guyana. In: Estrada A, Fleming TH (Eds). Frugivores and seed dispersal. Dordrecht: Springer Netherlands.
- Charles-Dominique P. 1991. Feeding strategy and activity budget of the frugivorous bat carollia perspicillata (chiroptera: Phyllostomidae) in french guiana. *Journal of Tropical Ecology* **7**: 243–56.
- Charles-Dominique P and Cockle A. 2001. Frugivory and seed dispersal by bats. In: Bongers F, Charles-Dominique P, Forget P-M, Théry M (Eds). Nouragues: Dynamics and plant-animal interactions in a neotropical rainforest. Dordrecht: Springer Netherlands.
- Chavan VS and Ingwersen P. 2009. Towards a data publishing framework for primary biodiversity data: challenges and potentials for the biodiversity informatics community. *BMC Bioinformatic* **10**: S2.
- Chavan VS and Penev L. 2011. The data paper: a mechanism to incentivize data publishing in biodiversity science. *BMC Bioinformatic* **12**: S2.
- Coates-Estrada R and Estrada A. 1986. Fruiting and frugivores at a strangler fig in the tropical rain forest of los tuxtlas, mexico. *Journal of Tropical Ecology* **2**: 349–57.
- Coelho D and Marinho-Filho J. 2002. Diet and activity of lonchophylla dekeyseri (chiroptera, phyllostomidae) in the federal district, brazil. *Mammalia* **66**: 319–30.
- Cole FR and Wilson DE. 2006. Leptonycteris curasoae. *Mammalian Species*: 1–3.
- Condé TM and Tonini H. 2013. Fitossociologia de uma floresta ombrófila densa na amazônia setentrional, roraima, brasil. *Acta Amazonica* **43**: 247–60.
- Costello MJ. 2009. Motivating Online Publication of Data. *BioScience* **59**: 418–27.
- Costello MJ, Michener WK, and Gahegan M *et al.* 2013. Biodiversity data should be published, cited, and peer reviewed. *Trends in Ecology & Evolution* **28**: 454–61.
- Culot L, Pereira LA, and Agostini I *et al.* 2019. Atlantic-primates: A dataset of communities and occurrences of primates in the atlantic forests of south america. *Ecology* **100**: e02525.
- Cunningham SA. 1995. Ecological constraints on fruit initiation by calyptrogyne ghiesbreghtiana (arecaceae): Floral herbivory, pollen availability, and visitation by pollinating bats. *American Journal of Botany* **82**: 1527–36.

- Delaval M, Henry M, and Charles-Dominique P. 2005. Interspecific competition and niche partitioning: Example of a neotropical rainforest bat community. *Revue d'écologie (Terra et Vie)* **60**: 149–65.
- Dinerstein E. 1986. Reproductive ecology of fruit bats and the seasonality of fruit production in a costan Rican cloud forest. *Biotropica* **18**: 307–18.
- Dornelas M, Antão LH, and Moyes F *et al.* 2018. BioTIME: A database of biodiversity time series for the anthropocene. *Global Ecology and Biogeography* **27**: 760–86.
- Dos Reis RN and Guillaumet J-L. 1983. Les chauves-souris frugivores de la région de manaus et leur rôle dans la dissémination des espèces végétales. *Revue d'écologie La terre et la vie* **38**: 147–69.
- Eguiarte L, Rio CM del, and Arita H. 1987. El nectar y el polen como recursos: El papel ecologico de los visitantes a las flores de pseudobombax ellipticum (h.b.k.) dugand. *Biotropica* **19**: 74–82.
- Engriser EM. 1995. The effect of insect larvae infestation on fruit choice in phyllostomid fruit bats: An experimental study. *Biotropica* **27**: 523–5.
- Estrada A, Coates-Estrada R, Vasquez-Yanes C, and Orozco-Segovia A. 1984a. Comparison of frugivory by howling monkeys (*alouatta palliata*) and bats (*artibeus jamaicensis*) in the tropical rain forest of los tuxtlas, mexico. *American Journal of Primatology* **7**: 3–13.
- Estrada A, Coates-Estrada R, and Vazquez-Yanes C. 1984b. Observations on fruiting and dispersers of cecropia obtusifolia at los tuxtlas, mexico. *Biotropica* **16**: 315–8.
- Estrada-Villegas S, Pedraza CA, Pérez-Torres J, and Stevenson PR. 2007. Nuevo reporte sobre la dieta de sturnira aratathomasi y algunas notas sobre su distribución en colombia. *Chiroptera Neotropical* **13**: 297–304.
- Fick SE and Hijmans RJ. 2017. WorldClim 2: New 1-km spatial resolution climate surfaces for global land areas. *International journal of climatology* **37**: 4302–15.
- Figueiredo RA. 1996. Vertebrates at neotropical fig species in a forest fragment. *Tropical Ecology* **37**: 139–41.
- Figueiredo MSL, Barros CS, and Delciellos AC *et al.* 2017. Abundance of small mammals in the atlantic forest (asmaf): A data set for analyzing tropical community patterns. *Ecology* **98**: 2981–1.
- Fischer EA. 1992. Foraging of nectarivorous bats on bauhinia unguolata. *Biotropica* **24**: 579–82.
- Fleming TH. 1981. Fecundity, fruiting pattern, and seed dispersal in piper amalago (piperaceae), a bat-dispersed tropical shrub. *Oecologia* **51**: 42–6.
- Fleming TH. 1982. Foraging strategies of plant-visiting bats. In: Kunz TH (Ed). *Ecology of bats*. Springer.
- Fleming TH. 1985. Coexistence of five sympatric piper (piperaceae) species in a tropical dry forest. *Ecology* **66**: 688–700.
- Fleming TH, Geiselman C, and Kress WJ. 2009a. The evolution of bat pollination: A phylogenetic perspective. *Annals of botany* **104**: 1017–43.
- Fleming TH, Geiselman C, and Kress WJ. 2009b. The evolution of bat pollination: a phylogenetic perspective. *Annals of Botany* **104**: 1017–43.
- Fleming TH and Heithaus ER. 1986. Seasonal foraging behavior of the frugivorous bat carollia perspicillata. *Journal of Mammalogy* **67**: 660–71.
- Fleming TH, Heithaus ER, and Sawyer WB. 1977. An experimental analysis of the food location behavior of frugivorous bats. *Ecology* **58**: 619–27.
- Fleming TH and Williams CF. 1990. Phenology, seed dispersal, and recruitment in cecropia peltata (moraceae) in costan Rican tropical dry forest. *Journal of Tropical Ecology* **6**: 163–78.
- Fleming TH, Williams CF, Bonaccorso FJ, and Herbst LH. 1985. Phenology, seed dispersal, and colonization in muntingia calabura, a neotropical pioneer tree. *American Journal of Botany* **72**: 383–91.

- Foresta H de, Charles-Dominique P, Erard C, and Prévost M-F. 1984. Zoochorie et premiers stades de la régénération naturelle après coupe en forêt guyanaise. *Revue d'écologie La terre et la vie* **39**: 369–400.
- Fründ J, McCann K, and Williams N. 2015. Sampling bias is a challenge for quantifying specialization and network structure: Lessons from a quantitative niche model. *Oikos* **125**: 502–13.
- Galetti M and Morellato LC. 1994. Diet of the large fruit-eating bat *artibeus lituratus* in a forest fragment in brasil. *Mammalia (Paris)* **58**: 661–5.
- Galindo-González J, Guevara S, and Sosa VJ. 2000. Bat-and bird-generated seed rains at isolated trees in pastures in a tropical rainforest. *Conservation biology* **14**: 1693–703.
- Garcia QS, Rezende JL, and Aguiar L. 2000. Seed dispersal by bats in a disturbed area of southeastern brazil. *Revista de Biologia Tropical* **48**: 125–8.
- Garcia PO, Valente ASM, and Pifano DS *et al.* 2011. Composição e relações florísticas de encraves florestais no sul de goiás. *Rodriguésia* **62**: 123–37.
- Gardner AL. 1977. Feeding habits. In: Baker RJ, Jones JK, Carter DC (Eds). *Biology of bats of the new world family phyllostomidae*. Part ii. The Museum, Texas Tech Universit press.
- Gardner AL. 2008. *Mammals of south america, volume 1: Marsupials, xenarthrans, shrews, and bats*. University of Chicago Press.
- Gastal M and Bizerril MA. 1999. Ground foraging and seed dispersal of a gallery forest tree by the fruit-eating bat *artibeus lituratus*. *Mammalia (Paris)* **63**: 108–12.
- Geiselman CK and Younger S. 2002. Bat eco-interactions database.
- Genrich CM, Mello MAR, and Silveira FAO *et al.* 2017. Duality of interaction outcomes in a plant–frugivore multilayer network. *Oikos* **126**: 361–8.
- Giannini NP. 1999. Selection of diet and elevation by sympatric species of *sturnira* in an andean rainforest. *Journal of Mammalogy* **80**: 1186–95.
- Giannini NP and Kalko EK. 2004. Trophic structure in a large assemblage of phyllostomid bats in panama. *Oikos* **105**: 209–20.
- Gibbs PE, Oliveira PE, and Bianchi MB. 1999. Postzygotic control of selfing in *hymenaea stigonocarpa* (leguminosae-caesalpinioideae), a bat-pollinated tree of the brazilian cerrados. *International Journal of Plant Sciences* **160**: 72–8.
- Godínez-Alvarez H and Valiente-Banuet A. 2000. Fruit-feeding behavior of the bats *leptonycteris curasoae* and *choeronycteris mexicana* in flight cage experiments: Consequences for dispersal of columnar cactus seeds1. *Biotropica* **32**: 552–6.
- Godínez-Alvarez H, Valiente-Banuet A, and Rojas-Martínez A. 2002. The role of seed dispersers in the population dynamics of the columnar cactus *neobuxbaumia tetetzo*. *Ecology* **83**: 2617–29.
- González-Varo JP, Arroyo JM, and Jordano P. 2014. Who dispersed the seeds? The use of dna barcoding in frugivory and seed dispersal studies. *Methods in Ecology and Evolution* **5**: 806–14.
- Gorchov DL, Cornejo F, Ascorra CF, and Jaramillo M. 1995. Dietary overlap between frugivorous birds and bats in the peruvian amazon. *Oikos* **74**: 235–50.
- Greenhall AM. 1957. Food preferences of trinidad fruit bats. *Journal of Mammalogy* **38**: 409–10.
- Gribel R, Gibbs PE, and Queiróz AL. 1999. Flowering phenology and pollination biology of *ceiba pentandra* (bombacaceae) in central amazonia. *Journal of Tropical Ecology* **15**: 247–63.
- Gribel R and Hay JD. 1993. Pollination ecology of *caryocar brasiliense* (caryocaraceae) in central brazil cerrado vegetation. *Journal of tropical ecology* **9**: 199–211.

- Gusson AE, Lopes S de F, and Dias Neto OC *et al.* 2009. Características químicas do solo e estrutura de um fragmento de floresta estacional semidecidual em ipiaçu, minas gerais, brasil. *Rodriguésia* **60**: 403–14.
- Handley CO, Gardner AL, and Wilson DE. 1991. Food habits. In: Handley CO, Wilson DE, Gardner AL (Eds). Demography and natural history of the common fruit bat, *artibeus jamaicensis*, on barro colorado island, panamá. Smithsonian Contributions to Zoology.
- Handley Jr C and Leigh Jr E. 1991. Diet and food supply. In: Handley CO, Wilson DE, Gardner AL (Eds). Demography and natural history of the common fruit bat, *artibeus jamaicensis*, on barro colorado island, panamá. Smithsonian Contributions to Zoology.
- Heithaus ER and Fleming TH. 1978. Foraging movements of a frugivorous bat, *carollia perspicillata* (phyllostomatidae). *Ecological Monographs* **48**: 127–43.
- Heithaus ER, Fleming TH, and Opler PA. 1975. Foraging patterns and resource utilization in seven species of bats in a seasonal tropical forest. *Ecology* **56**: 841–54.
- Heithaus ER, Opler PA, and Baker HG. 1974. Bat activity and pollination of *bauhinia pauletia*: Plant-pollinator coevolution. *Ecology* **55**: 412–9.
- Heithaus ER, Stashko E, and Anderson PK. 1982. Cumulative effects of plant-animal interactions on seed production by *bauhinia unguolata*, a neotropical legume. *Ecology* **63**: 1294–302.
- Helversen O von and Reyer H-U. 1984. Nectar intake and energy expenditure in a flower visiting bat. *Oecologia* **63**: 178–84.
- Herbst LH. 1986. The role of nitrogen from fruit pulp in the nutrition of the frugivorous bat *carollia perspicillata*. *Biotropica* **18**: 39–44.
- Hernandez M. 1998. Dynamics of transitions between population interactions: A nonlinear interaction alpha-function defined. *Proceedings of the Royal Society of London Series B: Biological Sciences* **265**: 1433–40.
- Hernandez-Conrique D, Iñiguez-Dávalos LI, and Storz JF. 1997. Selective feeding by phyllostomid fruit bats in a subtropical montane cloud forest. *Biotropica* **29**: 376–9.
- Hernandez A and Martinez del Rio C. 1992. Intestinal disaccharidases in five species of phyllostomoid bats. *Comparative biochemistry and physiology B, Comparative biochemistry* **103**: 105–11.
- Herrera M LG, Hobson KA, and Leticia MM *et al.* 2001a. Sources of protein in two species of phytophagous bats in a seasonal dry forest: Evidence from stable-isotope analysis. *Journal of Mammalogy* **82**: 352–61.
- Herrera M LG, Hobson KA, and Manzo A A *et al.* 2001b. The role of fruits and insects in the nutrition of frugivorous bats: Evaluating the use of stable isotope models. *Biotropica* **33**: 520–8.
- Hokche O and Ramirez N. 1990. Pollination ecology of seven species of *bauhinia* l.(Leguminosae: Caesalpinioideae). *Annals of the Missouri Botanical Garden* **77**: 559–72.
- Hoorn C, Wesselingh F, and Ter Steege H *et al.* 2010. Amazonia through time: Andean uplift, climate change, landscape evolution, and biodiversity. *science* **330**: 927–31.
- Hopkins H. 1984. Floral biology and pollination ecology of the neotropical species of *parkia*. *The Journal of Ecology* **72**: 1–23.
- Hortal J, Bello F de, and Diniz-Filho JAF *et al.* 2015. Seven shortfalls that beset large-scale knowledge of biodiversity. *Annual Review of Ecology, Evolution, and Systematics* **46**: 523–49.
- Howell DJ and Burch D. 1973. Food habits of some costa rican bats. *Revista de Biología Tropical* **21**: 281–94.
- Ibarra-Cerdeña CN, Iñiguez-Dávalos LI, and Sánchez-Cordero V. 2005. Pollination ecology of *stenocereus queretaroensis* (cactaceae), a chiropterophilous columnar cactus, in a tropical dry forest of mexico. *Amer-*

- ican Journal of Botany* **92**: 503–9.
- Iudica CA and Bonaccorso FJ. 1997. Feeding of the bat, *Sturmira lilium*, on fruits of *Solanum riparium* influences dispersal of this pioneer tree in forests of northwestern argentina. *Studies on Neotropical Fauna and Environment* **32**: 4–6.
- Janzen DH, Miller G, and Hackforth-Jones J *et al.* 1976. Two costa rican bat-generated seed shadows of *Andira inermis* (leguminosae). *Ecology* **57**: 1068–75.
- Jeliazkov A, Mijatovic D, and Chantepie S *et al.* 2020. A global database for metacommunity ecology, integrating species, traits, environment and space. *Scientific Data* **7**.
- Jimbo S and Schwassmann H. 1967. Feeding behavior and daily emergence pattern of ‘“artibeus jamaicensis”’ Leach (chiroptera, phyllostomidae). In: Atas do simpósio sobre a biota amazonica.
- Jordano P. 2013. Fruits and frugivory. In: Gallagher RS (Ed). *Seeds: The ecology of regeneration in plant communities*. Commonwealth Agricultural Bureau International.
- Kalko EK and Condon M. 1998. Echolocation, olfaction and fruit display: How bats find fruit of flagelliferous cucurbits. *Functional Ecology* **12**: 364–72.
- Kammesheidt L. 2000. Some autecological characteristics of early to late successional tree species in venezuela. *Acta Oecologica* **21**: 37–48.
- Kay E. 2001. Observations on the pollination of *Passiflora penduliflora*. *Biotropica* **33**: 709–13.
- Korine C and Kalko EK. 2005. Fruit detection and discrimination by small fruit-eating bats (phyllostomidae): Echolocation call design and olfaction. *Behavioral Ecology and Sociobiology* **59**: 12–23.
- Kress WJ and Stone DE. 1993. Morphology and floral biology of *Phenakospermum* (strelitziaceae), an arborescent herb of the neotropics. *Biotropica* **25**: 290–300.
- Kunz TH, Braun de Torrez E, and Bauer D *et al.* 2011. Ecosystem services provided by bats. *Annals of the New York Academy of Sciences* **1223**: 1–38.
- Lemke TO. 1984. Foraging ecology of the long-nosed bat, *Glossophaga soricina*, with respect to resource availability. *Ecology* **65**: 538–48.
- Lima IP de and Reis NR dos. 2004. The availability of piperaceae and the search for this resource by *Carollia perspicillata* (linnaeus) (Chiroptera, phyllostomidae, carollinae) in parque municipal arthur thomas, londrina, paran , brazil. *Revista Brasileira de Zoologia* **21**: 371–7.
- Lim V-C, Clare EL, and Littlefair JE *et al.* 2018. Impact of urbanisation and agriculture on the diet of fruit bats. *Urban Ecosystems* **21**: 61–70.
- Lim BK, Loureiro LO, and Garbino GS. 2020. Cryptic diversity and range extension in the big-eyed bat genus *Chiroderma* (chiroptera, phyllostomidae). *ZooKeys* **918**: 41.
- List TP. 2013. A working list of all plant species. Version 1.1.
- Lobo JA, Quesada M, and Stoner KE. 2005. Effects of pollination by bats on the mating system of *Cecropia pentandra* (bombacaceae) populations in two tropical life zones in costa rica. *American Journal of Botany* **92**: 370–6.
- Lobo JA, Quesada M, and Stoner KE *et al.* 2003. Factors affecting phenological patterns of bombacaceous trees in seasonal forests in costa rica and mexico. *American Journal of Botany* **90**: 1054–63.
- Lobova TA and Mori SA. 2004. Epizoochorous dispersal by bats in french guiana. *Journal of tropical ecology* **20**: 581.
- Lobova TA, Mori SA, and Blanchard F *et al.* 2003. *Cecropia* as a food resource for bats in french guiana and the significance of fruit structure in seed dispersal and longevity. *American journal of Botany* **90**: 388–403.

- Locatelli E, Machado IC, and Medeiros P. 1997. Floral biology and bat pollination in pilosocereus catingicola (cactaceae) in northeastern brazil. *Bradleya* **15**: 28–34.
- Lomolino MV. 2004. Conservation biogeography. In: Lomolino MV, Heaney LR (Eds). *Frontiers of biogeography: new directions in the geography of nature*. Sunderland, Mass.. Sinauer Associates.
- Lopez JE and Vaughan C. 2004. Observations on the role of frugivorous bats as seed dispersers in costan Rican secondary humid forests. *Acta chiropterologica* **6**: 111–9.
- Lopez JE and Vaughan C. 2007. Food niche overlap among neotropical frugivorous bats in costa rica. *Revista de biología tropical* **55**: 301–13.
- Lppolito A and Suarez AV. 1998. Flowering phenology and pollination of cobaea aschersoniana (polemoniaceae). *Biotropica* **30**: 145–8.
- Machado ICS, Sazima I, and Sazima M. 1998. Bat pollination of the terrestrial herb irlbachia alata (gentianaceae) in northeastern brazil. *Plant Systematics and Evolution* **209**: 231–7.
- Machado IC and Vogel S. 2004. The north-east-brazilian liana, adenocalymna dichilum (bignoniaceae) pollinated by bats. *Annals of Botany* **93**: 609–13.
- Mancina C, Balseiro F, and others. 2005. Pollen digestion by nectarivorous and frugivorous antillean bats. *Mammalian Biology* **70**: 282–90.
- Mancina CA, García L, and Hernández F *et al.* 2002. Las plantas pioneras en la dieta de aves y murciélagos de la reserva de la biosfera Sierra del rosario, cuba. *Acta Botánica Cubana* **193**: 14–20.
- Mancina CA, García-Rivera L, and Capote RT. 2007. Habitat use by phyllostomid bat assemblages in secondary forests of the 'Sierra del rosario' Biosphere reserve, cuba. *Acta Chiropterologica* **9**: 203–18.
- Mantilla-Meluk H. 2014. Defining species and species boundaries in uroderma (chiroptera: Phyllostomidae) with a description of a new species. Museum of Texas Tech University.
- Mantilla-Meluk H, Jiménez-Ortega AM, and Baker RJ. 2009. Phyllostomid bats of colombia: Annotated checklist, distribution, and biogeography. Museum of Texas Tech University.
- Mantovani M, Ruschel AR, and Puchalski Â *et al.* 2005. Diversidade de espécies e estrutura sucessional de uma formação secundária da floresta ombrófila densa diversity of species and successional structure of a secondary formation in an atlantic rain forest. *Scientia Forestalis* **67**: 14–26.
- Marimon BS, Felfili JM, and Marimon Júnior BH *et al.* 2008. Desenvolvimento inicial e partição de biomassa de brosimum rubescens taub.(Moraceae) sob diferentes níveis de sombreamento. *Acta Botanica Brasilica* **22**: 941–53.
- Marinho-Filho JS. 1991. The coexistence of two frugivorous bat species and the phenology of their food plants in brazil. *Journal of Tropical Ecology* **7**: 59–67.
- Marinho-Filho J and Vasconcellos-Neto J. 1994. Dispersão de sementes de vismia cayennensis (jacq.) pers.(Guttiferae) por morcegos na região de manaus, amazonas. *Acta Botanica Brasilica* **8**: 87–96.
- Martino AM, Aranguren JO, and Arends A. 2002. Feeding habits of leptonycteris curasoae in northern venezuela. *The Southwestern Naturalist* **47**: 78–85.
- McCracken GF and Bradbury JW. 1981. Social organization and kinship in the polygynous bat phyllostomus hastatus. *Behavioral Ecology and Sociobiology* **8**: 11–34.
- Medellin RA and Gaona O. 1999. Seed dispersal by bats and birds in forest and disturbed habitats of chiapas, mexico 1. *Biotropica* **31**: 478–85.
- Mello MAR, Leiner NO, Guimarães Jr PR, and Jordano P. 2005. Size-based fruit selection of calophyllum brasiliense (clusiaceae) by bats of the genus artibeus (phyllostomidae) in a restinga area, southeastern brazil. *Acta Chiropterologica* **7**: 179–82.

- Mello MAR, Schittini GM, Selig P, and Bergallo HG. 2004. Seasonal variation in the diet of the bat *carollia perspicillata* (chiroptera: Phyllostomidae) in an atlantic forest area in southeastern brazil. *Mammalia* **68**: 49–55.
- Mikich SB. 2002. A dieta dos morcegos frugívoros (mammalia, chiroptera, phyllostomidae) de um pequeno remanescente de floresta estacionai semidecidual do sul do brasil. *Revista brasileira de Zoologia* **19**: 239–49.
- Mikich SB, Bianconi GV, Maia BHLNS, and Teixeira SD. 2003. Attraction of the fruit-eating bat *carollia perspicillata* to piper gaudichaudianum essential oil. *Journal of Chemical Ecology* **29**: 2379–83.
- Mittermeier RA, Turner WR, and Larsen FW *et al.* 2011. Global biodiversity conservation: The critical role of hotspots. In: Zachos FE, Habel JC (Eds). Biodiversity hotspots: Distribution and protection of conservation priority areas. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Molina-Freaner F and Eguiarte LE. 2003. The pollination biology of two paniculate agaves (agavaceae) from northwestern mexico: Contrasting roles of bats as pollinators. *American Journal of Botany* **90**: 1016–24.
- Morrison DW. 1978a. Foraging ecology and energetics of the frugivorous bat *artibeus jamaicensis*. *Ecology* **59**: 716–23.
- Morrison DW. 1978b. Influence of habitat on the foraging distances of the fruit bat, *artibeus jamaicensis*. *Journal of Mammalogy* **59**: 622–4.
- Morrison DW. 1980. Efficiency of food utilization by fruit bats. *Oecologia* **45**: 270–3.
- Muchhala N. 2006a. The pollination biology of *burmeistera* (campanulaceae): Specialization and syndromes. *American Journal of Botany* **93**: 1081–9.
- Muchhala N. 2006b. Nectar bat stows huge tongue in its rib cage. *Nature* **444**: 701–2.
- Muchhala N and Jarrin-V P. 2002. Flower visitation by bats in cloud forests of western ecuador. *Biotropica* **34**: 387–95.
- Muller MF and Reis NR dos. 1992. Partição de recursos alimentares entre quatro espécies de morcegos frugívoros (chiroptera, phyllostomidae). *Revista Brasileira de Zoologia* **9**: 345–55.
- Muyllaert RdL, Stevens RD, and Esbérard CEL *et al.* 2017. Atlantic bats: A data set of bat communities from the atlantic forests of south america. *Ecology* **98**: 3227–7.
- Naranjo ME, Rengifo C, and Soriano PJ. 2003. Effect of ingestion by bats and birds on seed germination of *stenocereus griseus* and *subpilocereus repandus* (cactaceae). *Journal of Tropical Ecology* **19**: 19–25.
- Nassar JM, Ramírez N, and Linares O. 1997. Comparative pollination biology of venezuelan columnar cacti and the role of nectar-feeding bats in their sexual reproduction. *American Journal of Botany* **84**: 918–27.
- Nellis DW and Ehle CP. 1977. Observations on the behavior of *brachyphylla cavernarum* (chiroptera) in virgin islands. *Mammalia (Paris)* **41**: 403–10.
- Nogueira MR, Lima IP de, and Moratelli R *et al.* 2014. Checklist of brazilian bats, with comments on original records. *Volume 10, Número 4, Pags 808-821*.
- Nogueira MR and Peracchi AL. 2003. Fig-seed predation by 2 species of chiroderma: Discovery of a new feeding strategy in bats. *Journal of Mammalogy* **84**: 225–33.
- Oatham MP and Ramnarine S. 2006. Dynamics of pioneer and primary successional stage trees in a logged trinidadian tropical rainforest and the influence of drought. *Tropical Ecology* **47**: 13–26.
- Olea-Wagner A, Lorenzo C, and Naranjo E *et al.* 2007. Diversidad de frutos que consumen tres especies de murciélagos (chiroptera: Phyllostomidae) en la selva lacandona, chiapas, méxico. *Revista mexicana de biodiversidad* **78**: 191–200.

- Oliveira-Filho AT. 2017. NeoTropTree, flora arbórea da região neotropical: Um banco de dados envolvendo biogeografia, diversidade e conservação.
- Ollerton J, Winfree R, and Tarrant S. 2011. How many flowering plants are pollinated by animals? *Oikos* **120**: 321–6.
- Olson DM, Dinerstein E, and Wikramanayake ED *et al.* 2001. Terrestrial ecoregions of the world: A new map of life on earth a new global map of terrestrial ecoregions provides an innovative tool for conserving biodiversity. *BioScience* **51**: 933–8.
- Oria FV and Machado MC. 2007. Determinación de la dieta de algunas especies de murciélagos (mammalia: Chiroptera) de la cordillera central de venezuela. *Revista FARAUTE de Ciencias y Tecnología* **2**: 5–15.
- Palmeirim J, Gorchoy D, and Stoleson S. 1989. Trophic structure of a neotropical frugivore community: Is there competition between birds and bats? *Oecologia* **79**: 403–11.
- Paolucci LN, Pereira RL, and Rattis L *et al.* 2019. Lowland tapirs facilitate seed dispersal in degraded amazonian forests. *Biotropica* **51**: 245–52.
- Passos FC and Gracioli G. 2004. Observações da dieta de artibeus lituratus (olfers)(Chiroptera, phyllostomidae) em duas áreas do sul do brasil. *Revista Brasileira de Zoologia* **21**: 487–9.
- Passos JG and Passamani M. 2003. Artibeus lituratus (chiroptera, phyllostomidae): Biologia e dispersão de sementes no parque do museu de biologia prof. Mello leitão, santa teresa (es). *Natureza on line* **1**: 1–6.
- Passos FC, Silva WR, Pedro WA, and Bonin MR. 2003. Frugivoria em morcegos (mammalia, chiroptera) no parque estadual intervalos, sudeste do brasil. *Revista Brasileira de Zoologia* **20**: 511–7.
- Pedro WA and Taddei VA. 1997. Taxonomic assemblage of bats from panga reserve, southeastern brazil: Abundance patterns and trophic relations in the phyllostomidae (chiroptera). *Boletim do Museu de Biologia Mello Leitão Nova Série* **6**: 3–21.
- Petit S. 1997. The diet and reproductive schedules of leptonycteris curasoae curasoae and glossophaga longirostris elongata (chiroptera: Glossophaginae) on curaçao. *Biotropica* **29**: 214–23.
- Quesada M, Stoner KE, and Lobo JA *et al.* 2004. Effects of forest fragmentation on pollinator activity and consequences for plant reproductive success and mating patterns in bat-pollinated bombacaceous trees 1. *Biotropica* **36**: 131–8.
- Ramirez N, Sobrevila C, Enrech NX de, and Ruiz-Zapata T. 1984. Floral biology and breeding system of bauhinia benthamiana taub.(Leguminosae), a bat-pollinated tree in venezuelan “llanos”. *American Journal of Botany* **71**: 273–80.
- Ramírez-Chaves HE, Noguera-Urbano EA, and Morales-Martínez DM *et al.* 2020. Endemic bats (mammalia: Chiroptera) of colombia: State of knowledge, distribution, and conservation. *Universitas Scientiarum* **25**: 55–94.
- Ramos E, Torres RB, Veiga RF de A, and Joly CA. 2011. Estudo do componente arbóreo de dois trechos da floresta ombrófila densa submontana em ubatuba (sp). *Biota Neotropica* **11**: 313–35.
- REFLORA. 2020. Flora do brasil 2020 em construção.
- Ruiz A, Santos M, Cavelier J, and Soriano PJ. 2000. Estudio fenológico de cactáceas en el enclave seco de la tatacoa, colombia. *Biotropica* **32**: 397–407.
- Ruiz A, Santos M, and Soriano PJ *et al.* 1997. Relaciones mutualísticas entre el murciélago glossophaga longirostris y las cactáceas columnares en la zona arida de la tatacoa, colombia. *Biotropica* **29**: 469–79.
- Sahley CT. 1996. Bat and hummingbird pollination of an autotetraploid columnar cactus, weberbauerocereus weberbaueri (cactaceae). *American Journal of Botany* **83**: 1329–36.

- Sampaio MTF, Polo M, and Barbosa W. 2012. Estudo do crescimento de espécies de árvores semidecíduas em uma área ciliar revegetada. *Revista Árvore* **36**: 879–86.
- Sanmartin-Gajardo I and Sazima M. 2005. Chiropterophily in sinningieae (gesneriaceae): *Sinningia brasiliensis* and *paliavana prasinata* are bat-pollinated, but *p. Sericiflora* is not. Not yet? *Annals of Botany* **95**: 1097–103.
- Santos PM, Bocchiglieri A, and Chiarello AG *et al.* 2019. Neotropical xenarthrans: A data set of occurrence of xenarthran species in the neotropics. *Ecology* **100**: e02663.
- Sazima I. 1976. Observations on the feeding habits of phyllostomatid bats (carollia, anoura, and vampyrops) in southeastern brazil. *Journal of Mammalogy* **57**: 381–2.
- Sazima M, Buzato S, and Sazima I. 2003. *Dyssochroma viridiflorum* (solanaceae): A reproductively bat-dependent epiphyte from the atlantic rainforest in brazil. *Annals of Botany* **92**: 725–30.
- Sazima M, Buzato S, and Sazima I. 1999. Bat-pollinated Flower Assemblages and Bat Visitors at Two Atlantic Forest Sites in Brazil. *Annals of Botany* **83**: 705–12.
- Sazima M, Fabián M, and Sazima I. 1982. Pollination of *luehea speciosa* (tiliaceae) by *glossophaga soricina* (chiroptera, phyllostomidae). *Revista Brasileira de Biologia* **42**: 505–13.
- Sazima I, Fischer W, Sazima M, and Fischer E. 1994a. The fruit bat *artibeus lituratus* as a forest and city dweller. *Ciencia e cultura* **46**: 164–8.
- Sazima M and Sazima I. 1975. Quiropterofilia em *lafoensia pacari* st. Hil.(Lythraceae), na serra do cipó, minas gerais. *Ciência e Cultura* **27**: 405–16.
- Sazima I and Sazima M. 1977. Solitary and group foraging: Two flower-visiting patterns of the lesser spear-nosed bat *phyllostomus discolor*. *Biotropica*: 213–5.
- Sazima M and Sazima I. 1978. Bat pollination of the passion flower, *passiflora mucronata*, in southeastern brazil. *Biotropica* **10**: 100–9.
- Sazima M and Sazima I. 1980. Bat visits to *marcgravia myriostigma* tr. Et planch.(Marcgraviaceae) in southeastern brazil. *Flora* **169**: 84–8.
- Sazima M and Sazima I. 1987. Additional observations on *passiflora mucronata*, the bat-pollinated passion-flower. *Ciencia e Cultura* **39**: 310–2.
- Sazima M, Sazima I, and Buzato S. 1994b. Nectar by day and night: *Siphocampylus sulfureus* (lobeliaceae) pollinated by hummingbirds and bats. *Plant Systematics and Evolution* **191**: 237–46.
- Sazima I, Vogel S, and Sazima M. 1989. Bat pollination of *encholirium glaziovii*, a terrestrial bromeliad. *Plant Systematics and Evolution* **168**: 167–79.
- Sekercioglu CH. 2006. Increasing awareness of avian ecological function. *Trends in Ecology & Evolution* **21**: 464–71.
- Siles L and Baker RJ. 2020. Revision of the pale-bellied *micronycteris* gray, 1866 (chiroptera, phyllostomidae) with descriptions of two new species. *Journal of Zoological Systematics and Evolutionary Research* **58**: 1411–31.
- Silva SS and Peracchi AL. 1995. Observation of visit of bats (chiroptera) to the flowers of *pseudobombax grandiflorum* (cav.) a. Robyns. *Revista Brasileira de Zoologia* **12**: 859–65.
- Simmons NB and Cirranello AL. 2020. Bat species of the world: A taxonomic and geographic database.
- Slauson LA. 2000. Pollination biology of two chiropterophilous agaves in arizona. *American Journal of Botany* **87**: 825–36.
- Solari S and Baker RJ. 2006. Mitochondrial dna sequence, karyotypic, and morphological variation in the *carollia castanea* species complex (chiroptera: Phyllostomidae) with description of a new species. Texas

- Tech University. Natural Science Research Laboratory.
- Soriano PJ. 2000. Functional structure of bat communities in tropical rainforests and andean cloud forests. *Ecotropicos* **13**: 1–20.
- Soriano P, Ruiz A, and Nassar J. 2000. Notas sobre la distribución e importancia ecológica de los murciélagos *leptonycteris curasoae* y *glossophaga longirostris* en zonas áridas andinas. *Ecotropicos* **13**: 91–5.
- Soriano PJ, Sosa M, and Rossell O. 1991. Hábitos alimentarios de *glossophaga longirostris* Miller (chiroptera: Phyllostomidae) en una zona árida de los andes venezolanos. *Revista de Biología Tropical* **39**: 263–8.
- Sosa M and Soriano PJ. 1993. Solapamiento de dieta entre *leptonycteris curasoae* y *glossophaga longirostris* (mammalia: Chiroptera). *Revista de Biología Tropical* **41**: 529–32.
- Sosa M and Soriano PJ. 1996. Resource availability, diet and reproduction in *glossophaga longirostris* (mammalia: Chiroptera) in an arid zone of the venezuelan andes. *Journal of Tropical Ecology* **12**: 805–18.
- Souza Y, Gonçalves F, and Lautenschlager L *et al.* 2019. Atlantic mammals: A data set of assemblages of medium- and large-sized mammals of the atlantic forest of south america. *Ecology* **100**: e02785.
- Steiner KE. 1983. Pollination of *mabea occidentalis* (euphorbiaceae) in panama. *Systematic Botany* **8**: 105–17.
- Stoner KE, Quesada M, Rosas-Guerrero V, and Lobo JA. 2002. Effects of forest fragmentation on the colima long-nosed bat (*musonycteris harrisoni*) foraging in tropical dry forest of jalisco, mexico. *Biotropica* **34**: 462–7.
- Swanson ME, Franklin JF, and Beschta RL *et al.* 2011. The forgotten stage of forest succession: Early-successional ecosystems on forest sites. *Frontiers in Ecology and the Environment* **9**: 117–25.
- Tavares VDC, Gardner AL, Ramírez-Chaves HE, and Velazco PM. 2014. Systematics of *vampyressa melissa thomas*, 1926 (chiroptera: Phyllostomidae), with descriptions of two new species of *vampyressa*. *American Museum Novitates* **2014**: 1–27.
- Tavares VC, Perini FA, and Lombardi JA. 2007. The bat communities (chiroptera) of the parque estadual do rio doce, a large remnant of atlantic forest in southeastern brazil. *Lundiana: International Journal of Biodiversity* **8**: 35–47.
- Thibault KM, Supp SR, and Giffin M *et al.* 2011. Species composition and abundance of mammalian communities. *Ecology* **92**: 2316–6.
- Thies W and Kalko EK. 2004. Phenology of neotropical pepper plants (piperaceae) and their association with their main dispersers, two short-tailed fruit bats, *carollia perspicillata* and *c. Castanea* (phyllostomidae). *Oikos* **104**: 362–76.
- Tirira DG, Brito J, and Burneo SF. 2020. Mamíferos del ecuador: Lista actualizada de especies. Asociación Ecuatoriana de Mastozoología.
- Trabucco A, Zomer RJ, and others. 2009. Global aridity index (global-aridity) and global potential evapotranspiration (global-pet) geospatial database. *CGIAR Consortium for Spatial Information* **89**: 1–2.
- Tschapka M. 1998. A compact and flexible method for mist-netting bats in the subcanopy and canopy. Un método compacto y flexible para la captura de murciélagos en redes de niebla en la subcopia y la copa de los árboles. *Bat Research News* **39**: 140–1.
- Tschapka M. 2004. Energy density patterns of nectar resources permit coexistence within a guild of neotropical flower-visiting bats. *Journal of Zoology* **263**: 7–21.
- Tschapka M. 2005. Reproduction of the bat *glossophaga commissarisi* (phyllostomidae: Glossophaginae) in the costa rican rain forest during frugivorous and nectarivorous periods 1. *Biotropica: The Journal of*

- Biology and Conservation* **37**: 409–15.
- Tschapka M, Dressler S, and Helversen O von. 2006. Bat visits to *marcgravia pittieri* and notes on the inflorescence diversity within the genus *marcgravia* (marcgraviaceae). *Flora-Morphology, Distribution, Functional Ecology of Plants* **201**: 383–8.
- Tschapka M and Helversen O von. 1999. Pollinators of syntopic *marcgravia* species in costa rican lowland rain forest: Bats and opossums. *Plant Biology* **1**: 382–8.
- Tschapka M, Helversen O von, and Barthlott W. 1999. Bat pollination of *weberocereus tunilla*, an epiphytic rain forest cactus with functional flagelliflory. *Plant Biology* **1**: 554–9.
- Turcios-Casco MA, Ávila-Palma HD, and LaVal R *et al.* 2020. A systematic revision of the bats (chiroptera) of honduras: An updated checklist with corroboration of historical specimens and new records. *Zoosystematics and Evolution* **96**: 411.
- Uhl C, Clark K, Clark H, and Murphy P. 1981. Early plant succession after cutting and burning in the upper rio negro region of the amazon basin. *The Journal of Ecology* **69**: 631–49.
- Uieda W and Vasconcellos-Neto J. 1984. Dispersão de *solanum* spp.(Solanaceae) por morcegos, na região de manaus, am, brasil. *Revista Brasileira de Zoologia* **2**: 449–58.
- Ulloa CU, Acevedo-Rodríguez P, and Beck S *et al.* 2017. An integrated assessment of the vascular plant species of the americas. *Science* **358**: 1614–7.
- Valiente-Banuet A, Coro Arizmendi M del, Rojas-Martinez A, and Dominguez-Canseco L. 1996. Ecological relationships between columnar cacti and nectar-feeding bats in mexico. *Journal of Tropical Ecology* **12**: 103–19.
- Valiente-Banuet A, Molina-Freaner F, and Torres A *et al.* 2004. Geographic differentiation in the pollination system of the columnar cactus *pachycereus pecten-aboriginum*. *American Journal of Botany* **91**: 850–5.
- Valiente-Banuet A, Rojas-Martinez A, and Casas A *et al.* 1997. Pollination biology of two winter-blooming giant columnar cacti in the tehuacán valley, central mexico. *Journal of Arid Environments* **37**: 331–41.
- Varassin IG, Trigo JR, and Sazima M. 2001. The role of nectar production, flower pigments and odour in the pollination of four species of *passiflora* (passifloraceae) in south-eastern brazil. *Botanical Journal of the Linnean Society* **136**: 139–52.
- Vargas-Arboleda A, Cuadrado-Rios S, and Mantilla-Meluk H. 2020. Systematic considerations on two species of nectarivorous bats (*anoura caudifer* and *a. Geoffroyi*) based on barcoding sequences. *Acta Biológica Colombiana* **25**: 194–201.
- Vázquez DP, Morris WF, and Jordano P. 2005. Interaction frequency as a surrogate for the total effect of animal mutualists on plants. *Ecology Letters* **8**: 1088–94.
- Velazco PM. 2020. Murciélagos del Perú.
- Velazco PM, Gardner AL, and Patterson BD. 2010. Systematics of the *platyrrhinus helleri* species complex (chiroptera: Phyllostomidae), with descriptions of two new species. *Zoological Journal of the Linnean Society* **159**: 785–812.
- Velazco PM and Patterson BD. 2014. Two new species of yellow-shouldered bats, genus *sturnira* gray, 1842 (chiroptera, phyllostomidae) from costa rica, panama and western ecuador. *ZooKeys*: 43.
- Velazco PM and Patterson BD. 2019. Small mammals of the mayo river basin in northern peru, with the description of a new species of *sturnira* (chiroptera: Phyllostomidae). *Bulletin of the American Museum of Natural History* **2019**: 1–70.
- Vision TJ. 2010. Open Data and the Social Contract of Scientific Publishing. *BioScience* **60**: 330–1.

- Vogel S, Lopes AV, and Machado IC. 2005. Bat pollination in the ne brazilian endemic mimosa lewisii: An unusual case and first report for the genus. *Taxon* **54**: 693–700.
- Vogel S, Machado IC, and Lopes AV. 2004. Harpochilus neesianus and other novel cases of chiropterophily in neotropical acanthaceae. *Taxon* **53**: 55–60.
- Voss R, Turner M, and Inouye R *et al.* 1980. Floral biology of markea neurantha hemsley (solanaceae), a bat-pollinated epiphyte. *American Midland Naturalist* **103**: 262–8.
- Wendeln MC, Runkle JR, and Kalko EK. 2000. Nutritional values of 14 fig species and bat feeding preferences in panama. *Biotropica* **32**: 489–501.
- Willig MR. 1986. Bat community structure in south america: A tenacious chimera. *Revista Chilena de Historia Natural* **59**: 151–68.
- Willig MR, Camilo GR, and Noble SJ. 1993. Dietary overlap in frugivorous and insectivorous bats from edaphic cerrado habitats of brazil. *Journal of Mammalogy* **74**: 117–28.
- Wilson DE. 1971. Food habits of micronycteris hirsuta (chiroptera: Phyllostomidae). *Mammalia (Paris)* **35**: 107–10.
- Zortéa M and Chiarello A. 1994. Observations on the big fruit-eating bat, artibeus lituratus, in an urban reserve of south-east brazil. *Mammalia (Paris)* **58**: 665–70.