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

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INTRODUCTION

Open access to primary scientific data is fundamental to assure the social contract that governs scientific publishing (Vision 2010). Making primary data available improves the transparency, reproducibility, and progress of science by allowing independent verification and reuse of published data. (Costello 2009). This access has been facilitated in the information age through important frameworks for the production, storage, curation, and sharing of ecological 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 of those frameworks are data papers, which optimize efforts in the discovery, organization, and availability of ecological data (Chavan and Penev 2011). They offer a highly reliable source of data, as they have been subjected to high-quality control measures, such as peer review and editorial control of data and metadata (Costello et al. 2013). This new kind of publication has revolutionized contemporary science by making decades of naturalistic information widely available in highly accessible and comprehensive formats.

The revolution has also reached mammalogy. Data papers on mammal communities are growing in number. There are, for instance, data papers on the global non-volant mammal community (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 metacommunity ecology, integrating species, traits, environment, and space (Jeliazkov et al. 2020).

In Brazil, the most famous mammalogical data papers were produced by the ATLANTIC Series, which contains information about the biodiversity of the Atlantic Forest of South America. 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). In addition, most of them are based on abundance-incidence species 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, Winfree, and Tarrant 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).

In the present 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 and updated. 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 includes some geographic and abiotic information of study sites such as vegetation type, rainfall and precipitation, and ecological information of 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.

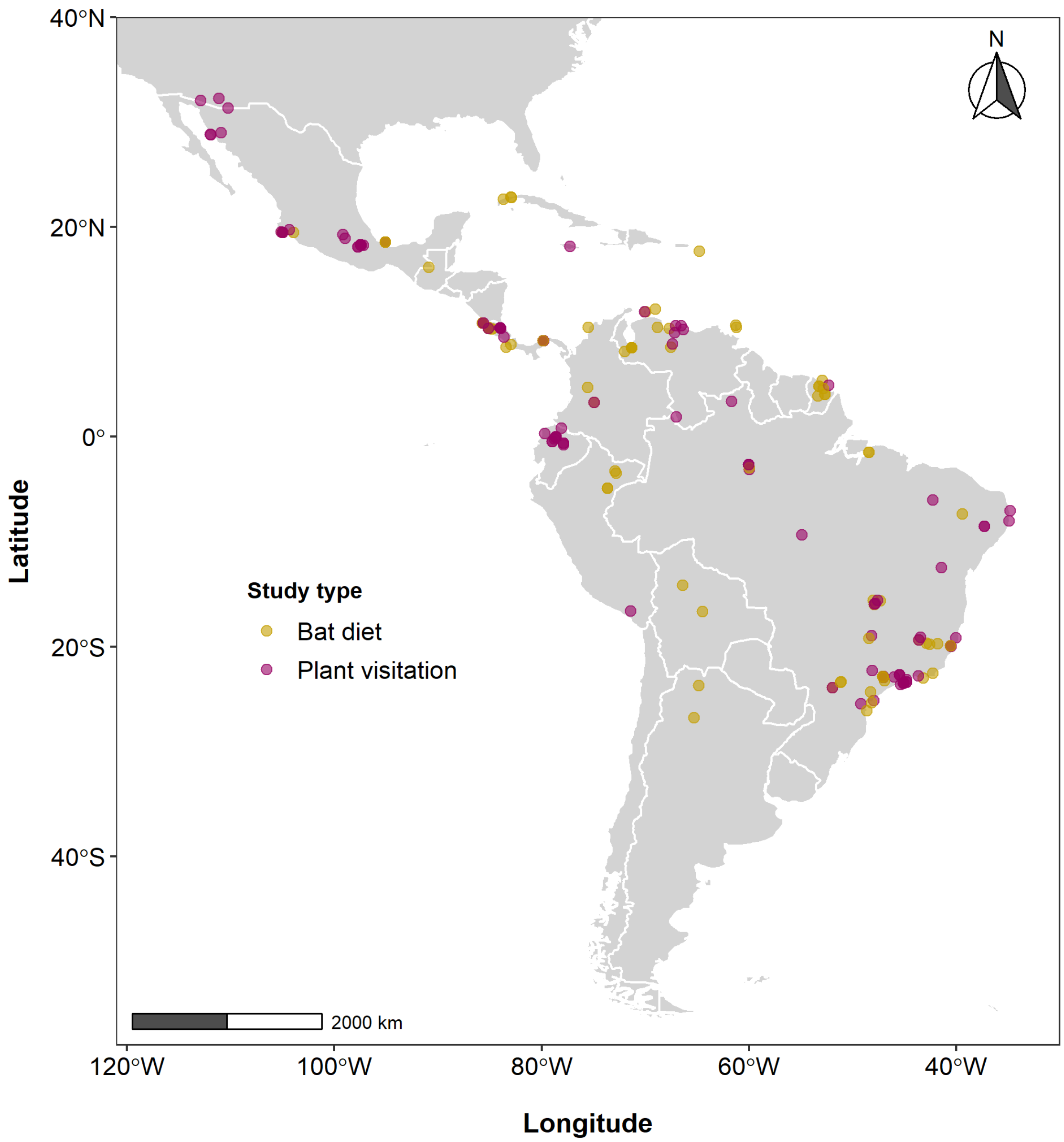

Figure 1: Distribution of sampling sites included in NeoBat Interactions. Dots show the location of original studies focused on plant visitation (purple) and bat diet (yellow). White lines show country borders. We included only studies with records of bat-plant interactions that were confirmed either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

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 code

Suggested data set identity codes:

NeoBat_Interactions_References.csv

NeoBat_Interactions_Sites.csv

NeoBat_Interactions_Records.csv

C. Data set description

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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

Species interactions, mutualism, nectarivory, frugivory, pollination, seed dispersal, databases, networks.

E. Description

This data base includes 2571 records of interactions involving the consumption of nectar and fruits by bats, taken from studies carried out 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).

The best represented interaction type was frugivory (75.1% of all records) while nectarivory represents (24.9%) of the records. Although most data come from 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 species have no information on successional stage, but there are many classified as early successional species (Table 1). We have 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.

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 frequent bat recorded was *Carollia perspicillata*, followed by *Artibeus lituratus* which have also been 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 are 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*, *Glyphonycteris sylvestris*, *Lampronycteris 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.

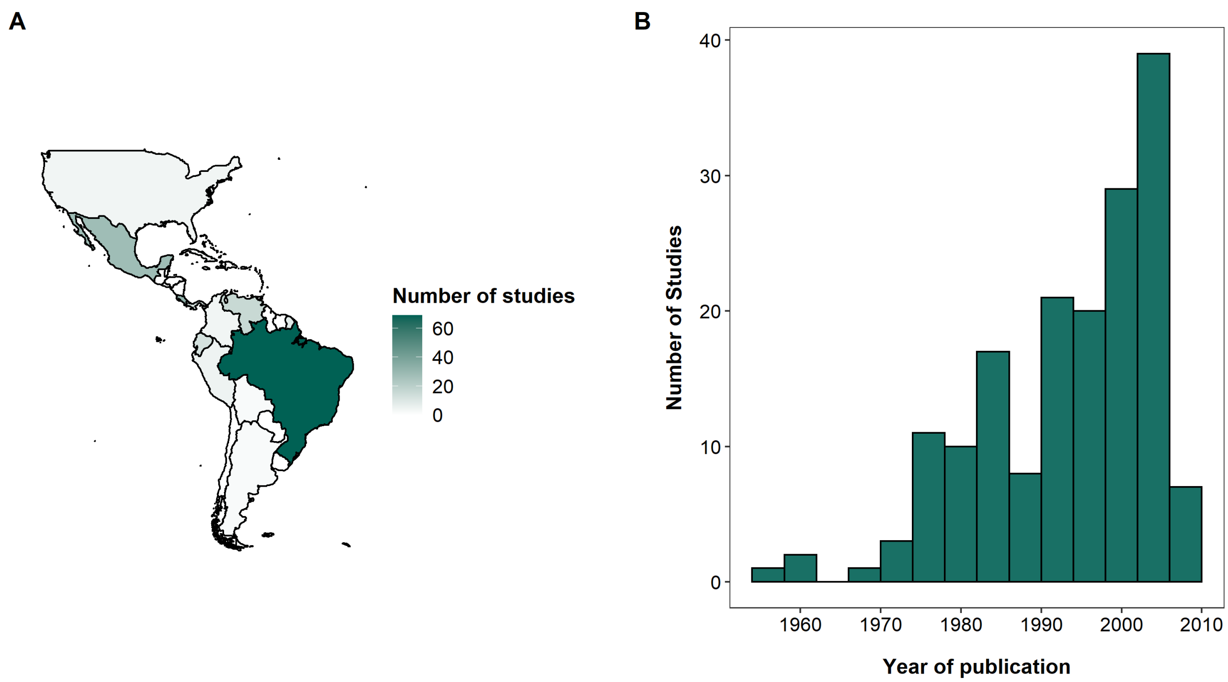

Figure 2: Distribution of the number of studies on frugivory and nectarivory by bats, published by country (A) and throughout the recorded period (B).

Plants of the genera *Piper* (15.17% of the records), *Ficus* (15.13%), *Cecropia* (9.02%) and *Solanum* (6.81%) were the most abundant in this data base, as they represent the main food source for bats of the genera *Carollia*, *Artibeus* and *Sturnira*, which also were relatively abundant groups recorded (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, Harpochilus, 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 data base, 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, Lampronycteris* *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).

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
Succesional 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

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

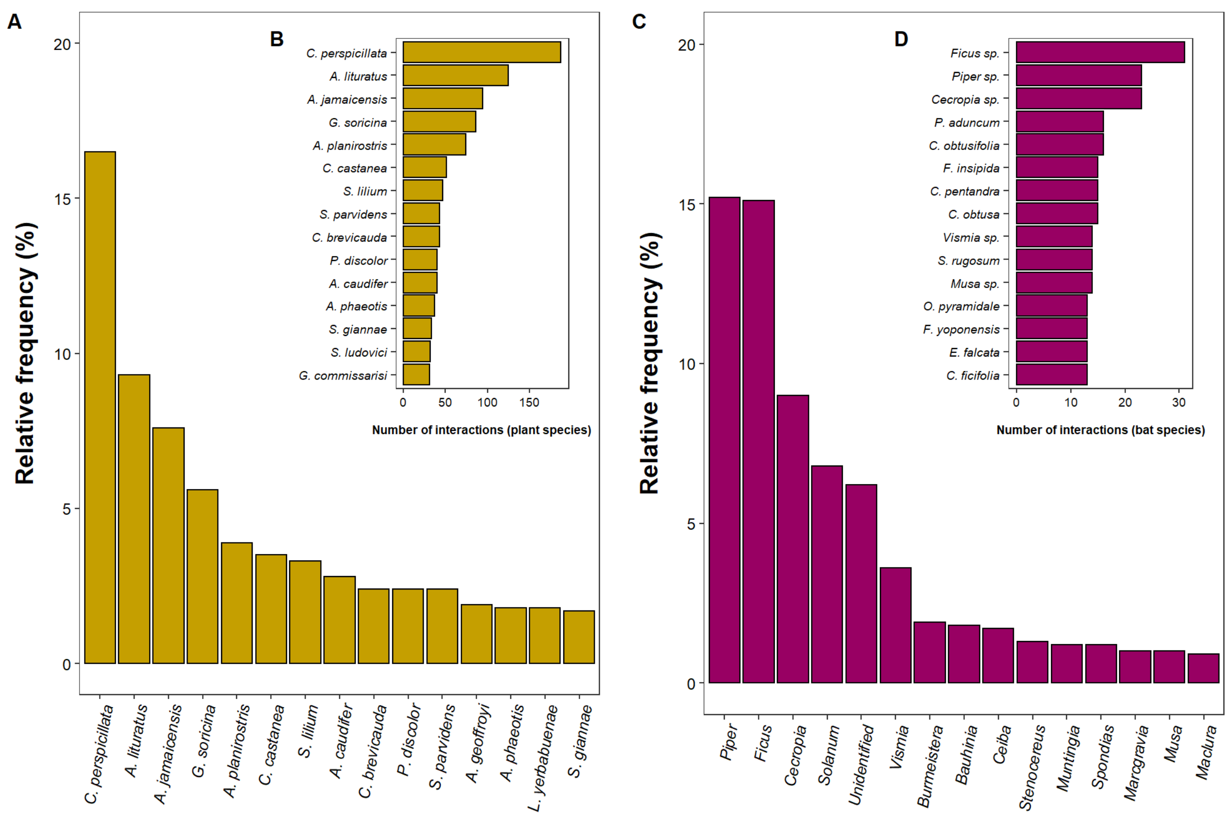

Figure 3: Ranking of frequency of the 15 most abundant bat species (A) and plant genera (C). Internal plots represent the number of each one of the 15 species of bats (B) and plants (D) with most interactions recorded in the NeoBat Interaction database

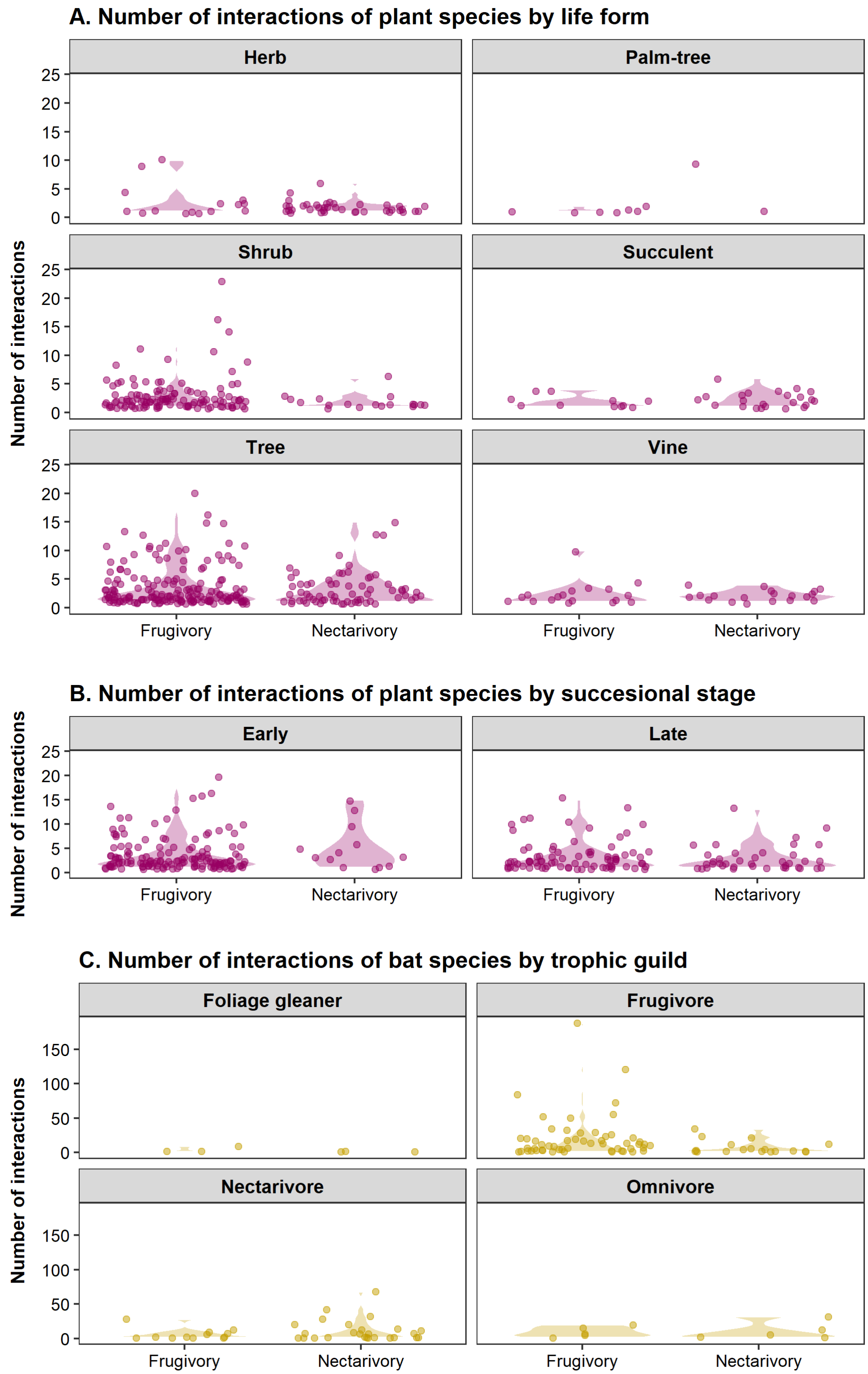

Figure 4: Number of interactions holds by plant and bat species according to their ecological traits: Life form of plants (A), Successional stage of plants (B) and Trophic guild of bats (C)

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
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

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

Variable	**Description**	**Levels**	**Example**
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
Longitude	Corrected longitude in decimal degrees. See Latitude for more information.	Decimal degrees	-103.950087

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

Variable	**Description**	**Levels**	**Example**
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 Interactions 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 Interactions 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 NatureServe (2013) and 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 Interactions database *(continued)*

Variable	Description	Levels	Example
X1kmAlt	Meters above sea level, from the Hydro-1K dataset (United States Geological Survey â€“ 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.	66 to 3912	1116
MeaAnnTemp	Mean annual temperature in Celsius degrees from WorldClim 2.0 with 30 arc seconds resolution.	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

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

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	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

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