What do we not know? Quantifying data gaps and biases in knowledge of bat co-roosting

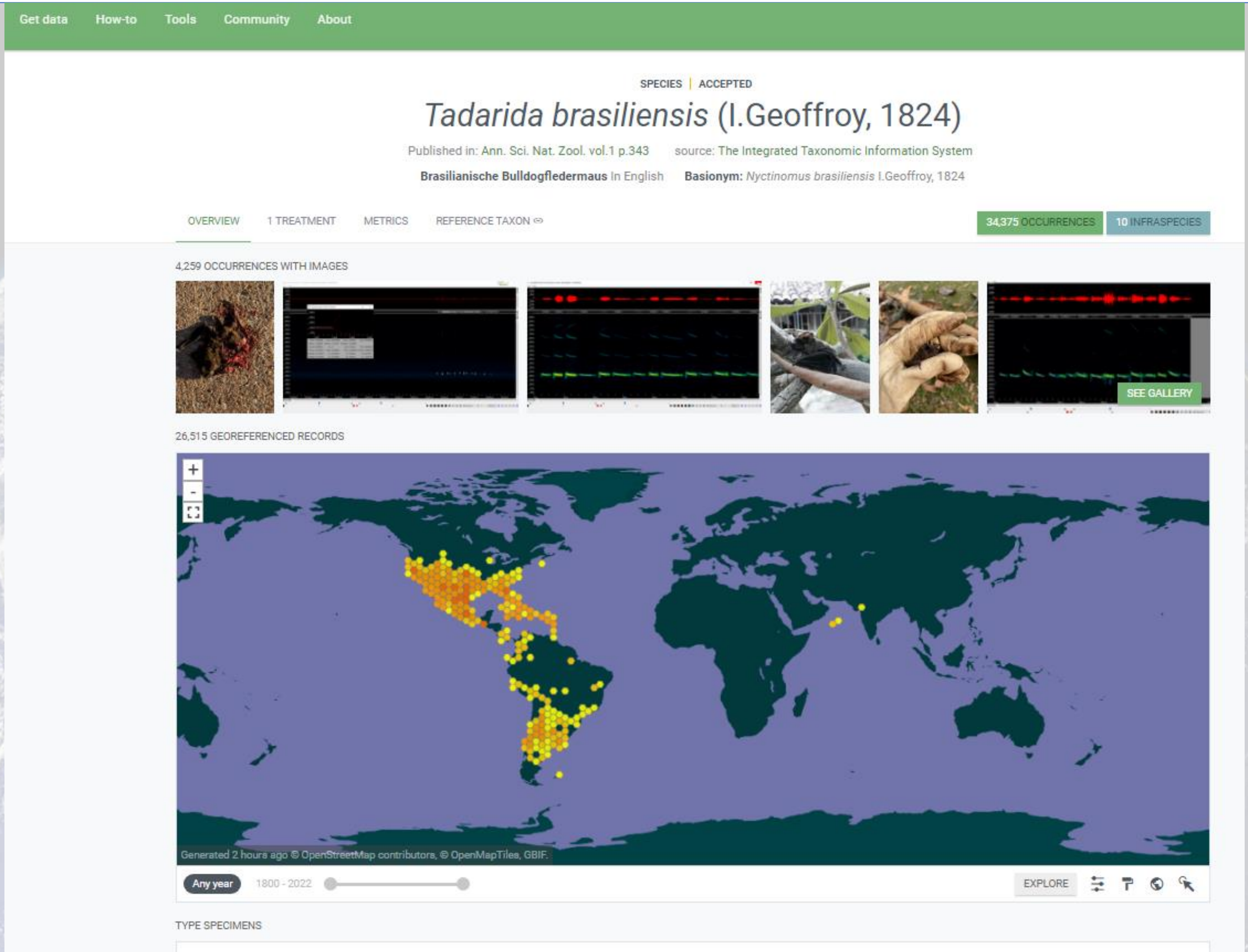
Aja C. Sherman[1], Cullen Geiselman[1], Nancy B. Simmons[2], Nathan S. Upham[3], Jorrit H. Poelen[4,5], DeeAnn M. Reeder[6], Sandro Bertolino[7], Quentin Groom[8], Kendra Phelps[9], Donat Agosti[10] and Anna R. Willoughby[11,12]

CETAF-DISSCO COVID-19 TASKFORCE

NASBR/IBRC 2022- Austin, TX

Occurrence data in abundance

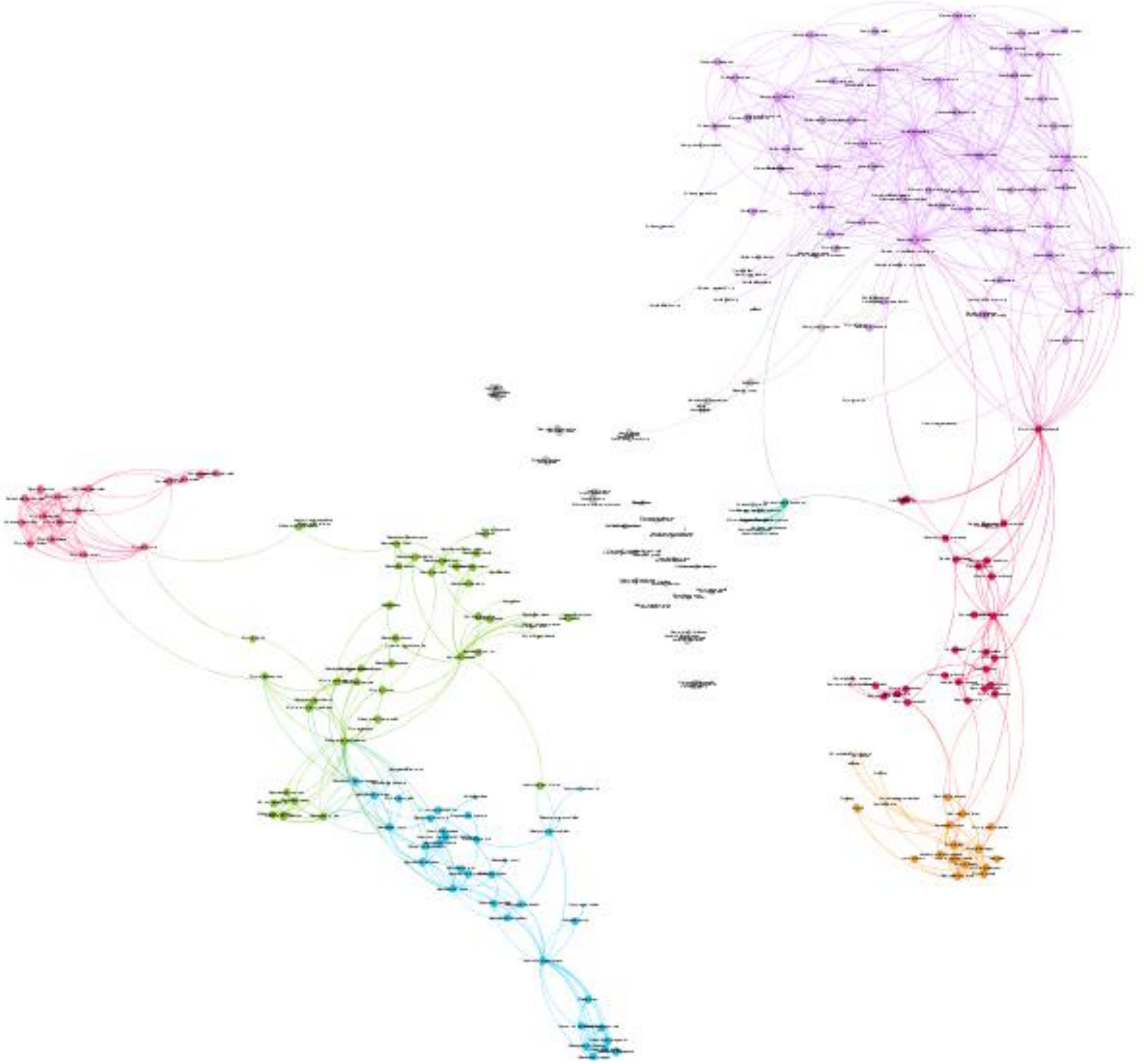
GBIF



Occurrence data in abundance

GBIF

Background



Objective

1. What bat species co-roost?
2. Where are they co-roosting?
3. What are common characteristics of the environment where co-roosting occurs?

The Nutritional Ecology Lab – R. ferrumequinum roosting with M. emarginatus and Asellia tridens

Methods – Literature Collections

Systematic searches did not yield relevant literature

- ❑ Simmons Collection
- ❑ Citation collections
  - ❑ Willoughby et al. 2017
  - ❑ Mammal Species
  - ❑ BatBase.org

Methods - Unattainable Literature

Access options

Rent or Buy article

Get time limited or full article access on ReadCube.

from $8.99

Rent or Buy

All prices are NET prices.

Subscribe to Journal

Get full journal access for 1 year

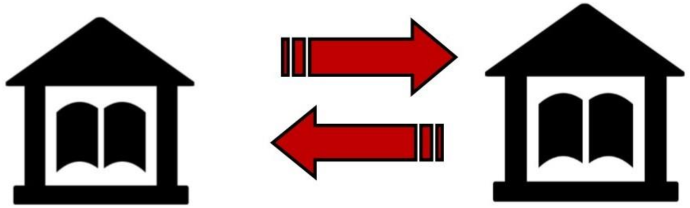
223,63 €

only 4,38 € per issue

Subscribe

All prices include VAT for Ireland.

InterLibrary Loan



FAIR Data – extracted from publications

Viewpoint

Liberating host–virus knowledge from biological dark data

Nathan S Upham, Jorrit H Poelen, Deborah Paul, Quentin J Groom, Nancy B Simmons, Maarten P M Vanhove, Sandro Bertolino, DeeAnn M Reeder, Cristiane Bastos-Silveira, Atriya Sen, Beckett Sterner, Nico M Franz, Marcus Guidoti, Lyubomir Penev, Donat Agosti

Connecting basic data about bats and other potential hosts of SARS-CoV-2 with their ecological context is crucial to the understanding of the emergence and spread of the virus. However, when lockdowns in many countries started in March, 2020, the world's bat experts were locked out of their research laboratories, which in turn impeded access to large volumes of offline ecological and taxonomic data. Pandemic lockdowns have brought to attention the long-standing problem of so-called biological dark data: data that are published, but disconnected from digital knowledge resources and thus unavailable for high-throughput analysis. Knowledge of host-to-virus ecological interactions will be biased until this challenge is addressed. In this Viewpoint, we outline two viable solutions: first, in the short term, to interconnect published data about host organisms, viruses, and other pathogens; and second, to shift the publishing framework beyond unstructured text (the so-called PDF prison) to labelled networks of digital knowledge. As the indexing system for biodiversity data, biological taxonomy is foundational to both solutions. Building digitally connected knowledge graphs of host–pathogen interactions will establish the agility needed to quickly identify reservoir hosts of novel zoonoses, allow for more robust predictions of emergence, and thereby strengthen human and planetary health systems.

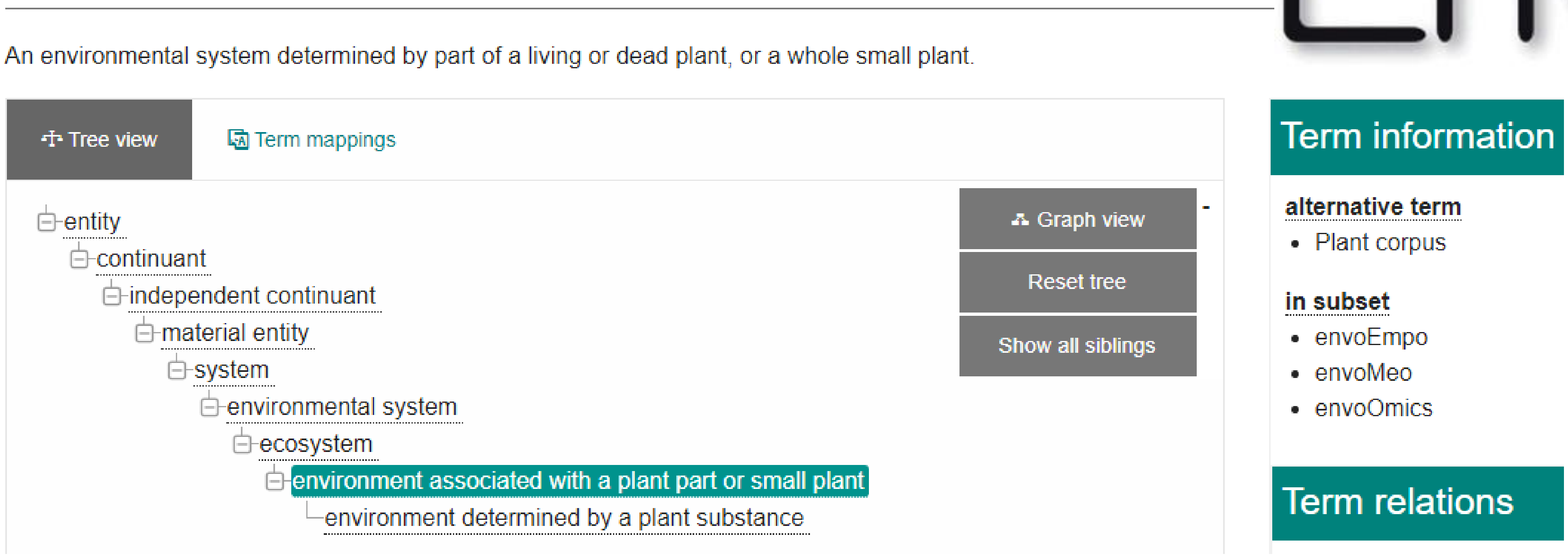
Lancet Planet Health 2021

Published Online
September 22, 2021
https://doi.org/10.1016/
S2542-5196(21)00196-0

School of Life Sciences, Arizona State University, Tempe, AZ, USA (N S Upham PhD, B Sterner PhD, Prof N M Franz PhD); **Ronin Institute for Independent Scholarship, Montclair, NJ, USA** (J H Poelen MSc); **Cheadle Center for Biodiversity and Ecological Restoration, University of California**

FAIR Data – extracted from publications

Methods – Ontologies



https://sites.google.com/site/environmentontology/

What we have so far

11,500 interaction records

>**360** bat species

>**137** countries

>**175** publications

1860-2020

all accessible via the Coronavirus-Host community at Zenodo;

CETAF-DiSSCo/COVID19-TAF biodiversity-related knowledge hub working group: indexed biotic interactions and review summary

Methods – Example

**58 interactions*

- 16 roost
- 4 anthropogenic
- 1 co-roost
- 36 other

Effects of Tropical Cyclonic Storms on Flying Fox Populations on the South Pacific Islands of Samoa

E. D. PIERSON,*§ T. ELMQVIST,† W. E. RAINEY,* AND P. A. COX‡

*Museum of Vertebrate Zoology, University of California, Berkeley, CA 94720, U.S.A.,
†Department of Ecological Botany, University of Umeå, Umeå S-901 87, Sweden
‡Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602, U.S.A.

Abstract: *The South Pacific islands of Samoa have two extant flying fox species,* Pteropus samoensis *and* P. tonganus. *Following two severe cyclonic storms, we examined their differential behavioral responses and evaluated the effectiveness of recently established reserves in providing refugia. Although the cyclones disrupted activity patterns and foraging behavior for both species, comparisons with pre-storm data suggested that the more common, widely distributed* P. tonganus *experienced more severe population declines than the endemic* P. samoensis. *This differential mortality could be explained by a combination of ecological and behavioral factors.* P. tonganus *had a greater tendency to enter villages to feed on fallen cultivated fruits, making it more vulnerable to human hunting and predation by domestic animals. In addition,* P. samoensis *appeared to use survival strategies not observed in* P. tonganus. *Leaves, which were far more available than flowers or fruits in the immediate post-storm period, comprised a major part of the post-storm diet of* P. samoensis. *This species also fed on the fleshy bracts of a storm-resistant native liana,* (Freycinetia reineckei). *In contrast, a seasonally important food of* P. tonganus *is nectar from the delicate flowers of* Syzygium inophylloides *(asi), a canopy tree that is very vulnerable to wind damage and has become increasing scarce with the clearing of lowland forest. Rainforest reserves, established prior to the storms, served as adequate refugia for local* P. samoensis *populations, which appeared to feed relatively close to their roosts, primarily in native forest, but did not protect* P. tonganus *populations, which traveled outside reserves to forage in areas lacking hunting bans. Although wind damage was patchy and not consistent between storms, areas of high topographic complexity (e.g., volcanic cones and deep valleys) were the most likely to retain areas with some foliage and should be given priority in the design of future reserves.*

El efecto de las tormentas ciclónicas tropicales sobre las poblaciones de zorros voladores en las islas del Pacifico Sur de Samoa.

Resumen: *Las islas del Pacífico Sur de Samoa tienen dos especies existentes de zorros voladores,* Pteropus samoensis *y* P. tonganus. *Luego de dos severas tormentas ciclónicas, examinamos sus diferentes respuestas de comportamiento y evaluamos la efectividad de las reservas recientemente establecidas para proveer de refugio. Si bién los ciclones perturbaron los patrones de actividad y forrajeo en ambas especies, las comparaciones con datos previos a las tormentas sugieren que la especie mas común y ampliamente distribuida,* P. tonganus, *experimentó declinaciones poblacionales mas severas que la especie endémica* P. samoensis. *Esta mortalidad diferencial podría ser explicada por una combinación de factores ecológicos y de comportamiento.* P. tonganus *presentó una mayor tendencia a entrar en las aldeas para alimentarse de frutos cultivados caídos, haciendose mas vulnerable a la caza por humanos y a la de predación por parte de animales domésticos. Además,* P. samoensis *pareció usar estrategias de supervivencia no observadas en P. tonganus. Las hojas, que estuvieron mucho mas disponibles que las flores o frutos inmediatamente después de las tormentas, comprendieron la mayor parte de la dieta de* P. samoensis, *durante el período posterior a las tormentas. Por otra parte, esta especie se alimenta de las bracteas carnosas de una liana na*

§Address correspondence to Elizabeth D. Pierson, 2556 Hilg

Paper submitted November 20, 1993; revised manuscript ac

Conservation Biology, Pages 438–451
Volume 10, No. 2, April 1996

Methods – Retained verbatim text

“On a number of occasions P. tonganus were observed feeding simultaneously in the same trees with P. samoensis.”

Table 2. Number of identified *Pteropus samoensis* roosts at selected sites in Samoa before the first cyclone, after Cyclone Ofa (post-Ofa), and after Cyclone Val (post-Val).

	Inside reserves			*Outside reserves*			
Date	*Falealupo*	*Tafua*	*Olovalu*	*Vai'a'ata*	*Afono*	*Amalau*	*Alava*
Pre-Cyclone							
July 1987	—	—	—	—	2	5	—
July 1988	2	—	—	—	—	5	—
July 1989	—	—	—	1[a]	—	—	—
January 1990	—	4	—	—	—	—	—
Post-Ofa							
June 1990	2	5	—	0	—	4	—
October 1990	—	9	3	0	2	5	—
August 1991	2	—	—	0	—	5	—
Post-Val							
January 1992	—	8	5	—	2	—	7
January 1993	2	12	7	0[b]	2	4	1

[a] *This site was unusual because it had over 40 animals (Wilson & Engbring 1992).*
[b] *Wilson & Engbring 1993.*

The first survey of Olovalu Crater, nine months after Cyclone Ofa in November 1990, identified three *P. samoensis* roosts. In January 1992, a few weeks after Cyclone … roosts were found. Two addi- … d in January 1993. This site sus- … many areas.

… 'ata in the year and a half after … of *P. samoensis* … in 1989 was gone. Although … rved foraging in the area in late … red to be roosting there. No … there by Wilson and Engbring …

… in July 1987, two *P. samoensis* … Afono Valley and five on the ridge above Amalau Valley. The number of roosts in Afono Valley has remained the same on all subsequent visits (November 1990, January 1992, and January 1993), although the number in Amalau Valley has fluctuated between four and five, and was at four in January 1993. In January 1992, a few weeks after Val, seven *P. samoensis* roosting sites (1–2 individuals each) were identified, associated with a series of defoliated small cones along the 5.5-km Alava Ridge road. This road experienced a substantial amount of recreational four-wheel drive traffic during 1992, and one of the roosting cones was partially cleared for a taro (*Colocasia esculenta*) plantation. In January 1993 only one roost, the one farthest from the main road), appeared occupied.

Pre- and Post-Cyclone Activity Patterns

ternoon. The majority of *P. tonganus* foraged at night, and during *Mangifera indica* (mango; mago) or *Ceiba pentandra* (kapok; vavae) season could be heard all night long squabbling in feeding trees in villages. The foraging times of the two species, however, overlapped … dawn and frequently appeared in foraging trees well before dark. On a number of occasions *P. tonganus* were observed feeding simultaneously in the same trees with *P. samoensis*. Although *P. samoensis* showed a flexible foraging pattern, feeding alone on some resources (*F. rei-* … groups on others (*Planchonella torricellensis* [mama lava], *Cananga odorata* [moso'oi], or *Ficus obliqua* [banyan] [aoa]), *P. tonganus* typically was encountered in aggregations (Elmqvist at al. 1992).

Immediately following both Cyclones Ofa and Val, *P. tonganus* showed considerable disruption of its normal activity pattern. It disappeared from most known roost sites, became far more diurnal, and was generally observed feeding alone. It also showed an increased tendency to enter villages and seek fruit very close to human habitation. In contrast, *P. samoensis* remained in pre-cyclone roost sites and continued to forage diurnally, primarily within the forest. The only noticeable change was that, immediately after the storm, its activity appeared to be more evenly distributed throughout the day, and the late afternoon activity peak was not evident. Also, soaring behavior, characteristically observed near roost sites in late afternoon, was seen less often.

In January 1993, one year after Val, *P. samoensis* activ-

Results

What kind of interactions are we finding?

Results – Interactions of interest

Co-roosts with	http://purl.obolibrary.org/obo/RO_0002801

Results – Interactions of interest

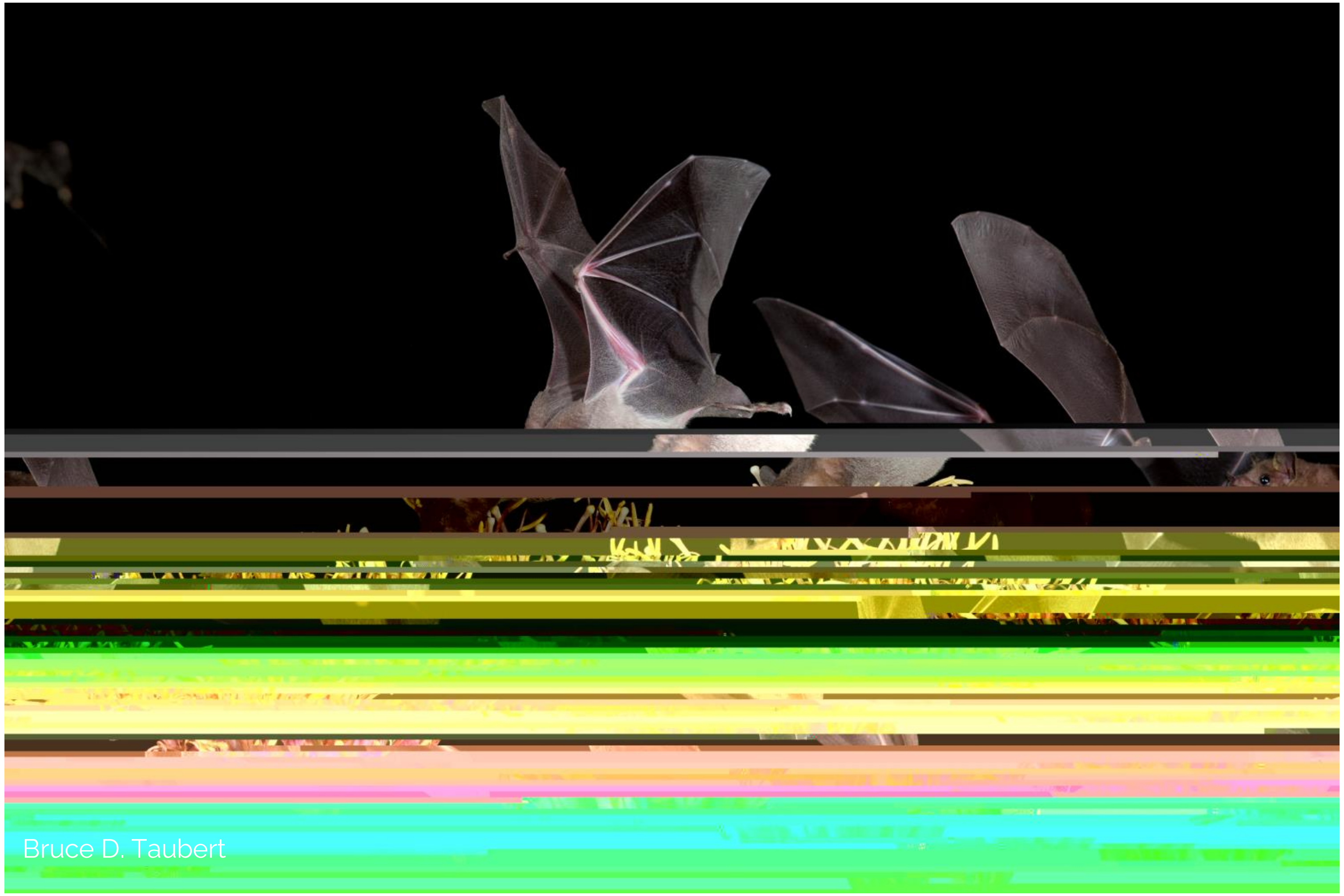
Preyed upon by	http://purl.obolibrary.org/obo/RO_0002458

Results – Interactions of interest

Feces eaten by	http://purl.obolibrary.org/obo/OMIT_0004607

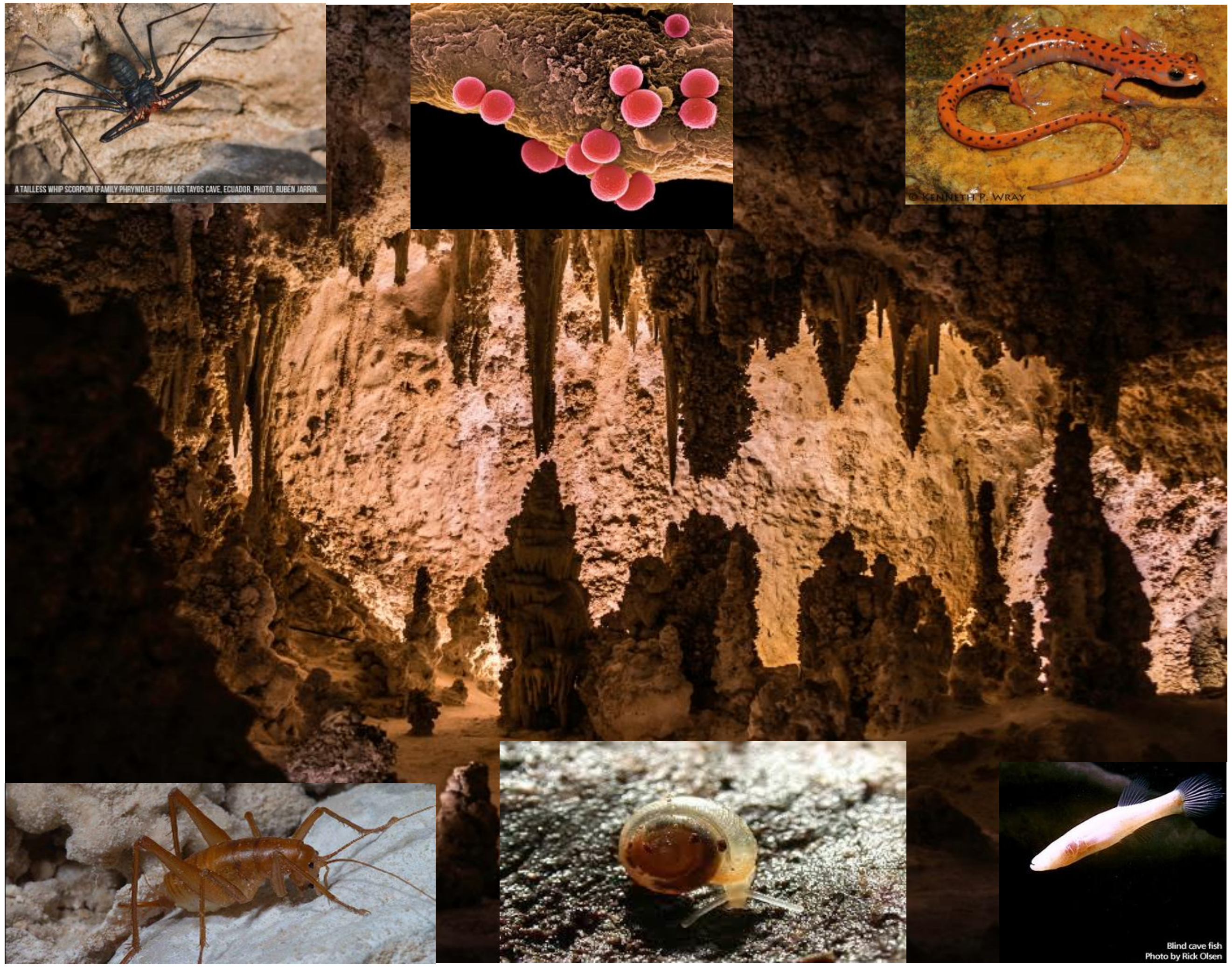
Results – Interactions of interest

Visits flowers of	http://purl.obolibrary.org/obo/RO_0002622



Results – Interactions of interest

Cohabitates with	???



What kind of roosts are bats using?

Results – Co-roosting Environments

tree	ENVO_01001057	standing tree		cavity in standing tree	

Results – Co-roosting Environments

cave	ENVO_00000067	

Results – Co-roosting Environments

foliage		modified leaves	ENVO_01001057	leaf tent	

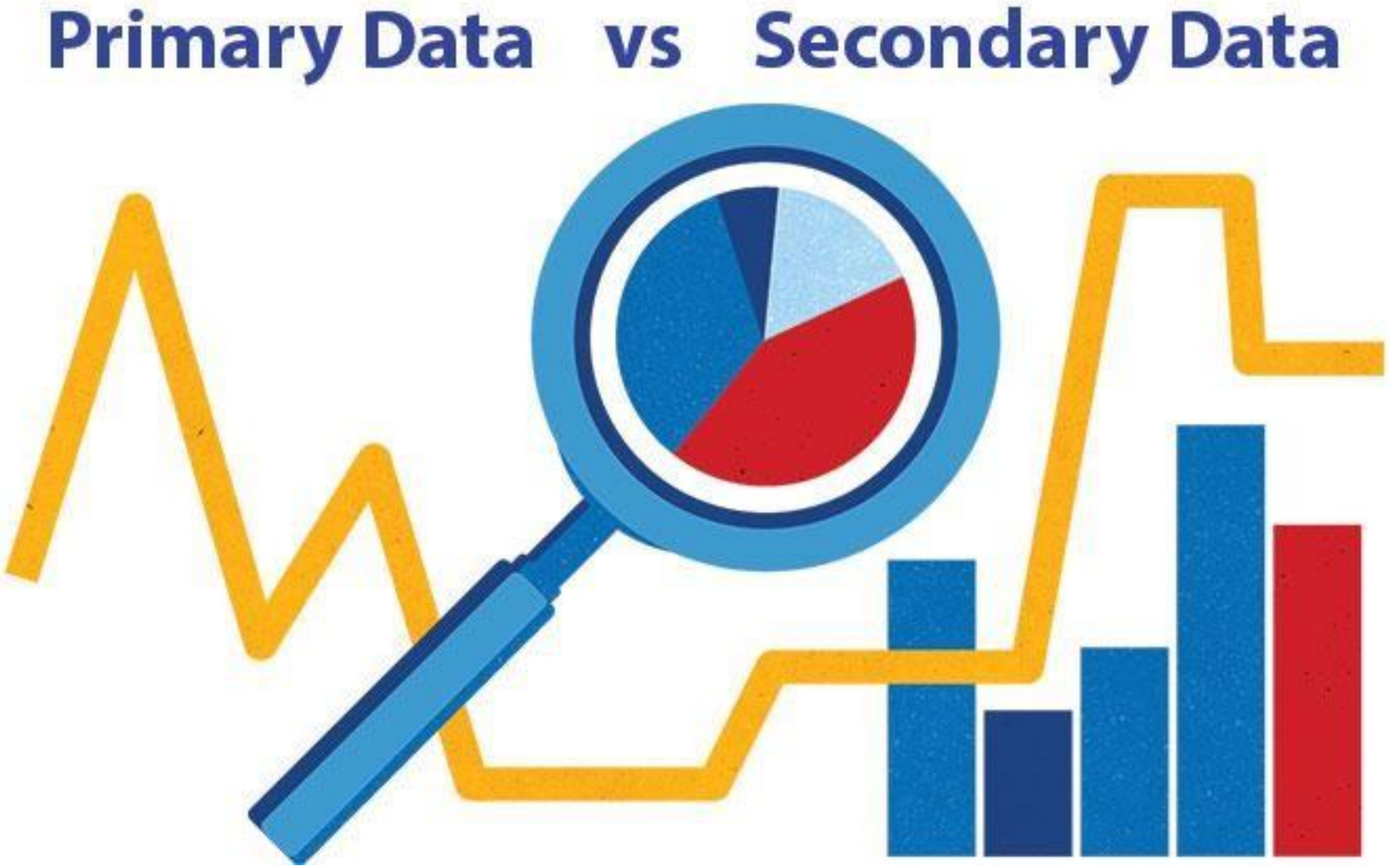
Results – Co-roosting Environments

rock shelter	ENVO_00000481	in crack or crevice			

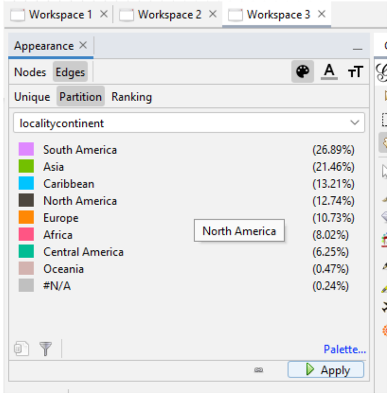
Results – Co-roosting Environments

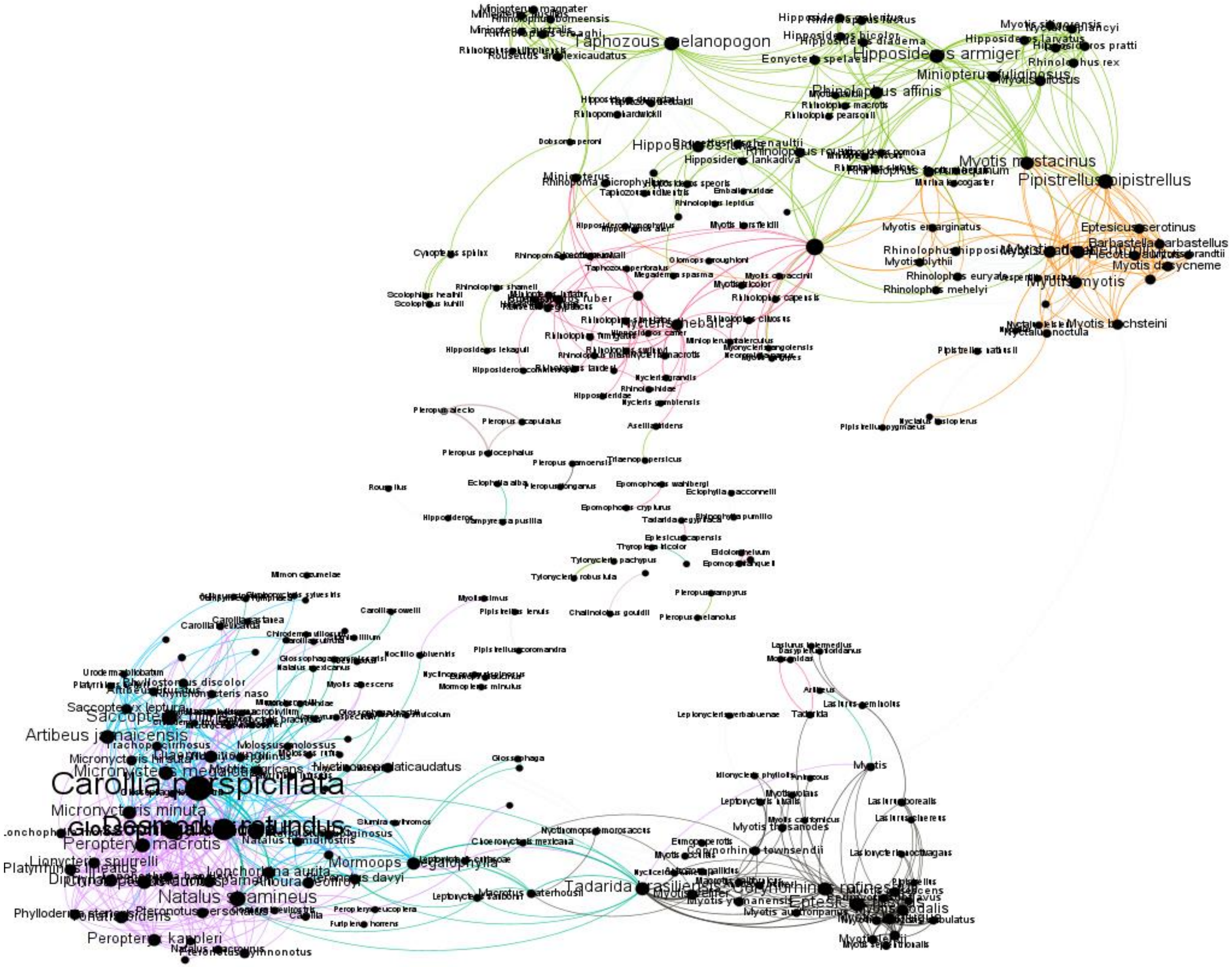
anthropogenic	ENVO_00000070	domestic building	ENVO_00000073	in roof	ENVO_01000472

Results - Provenance

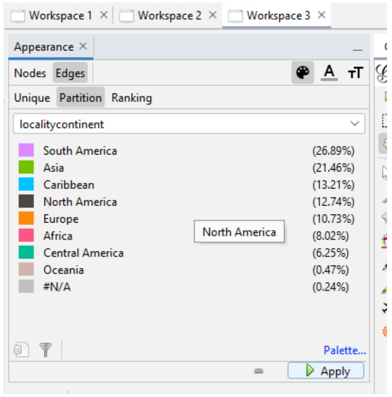


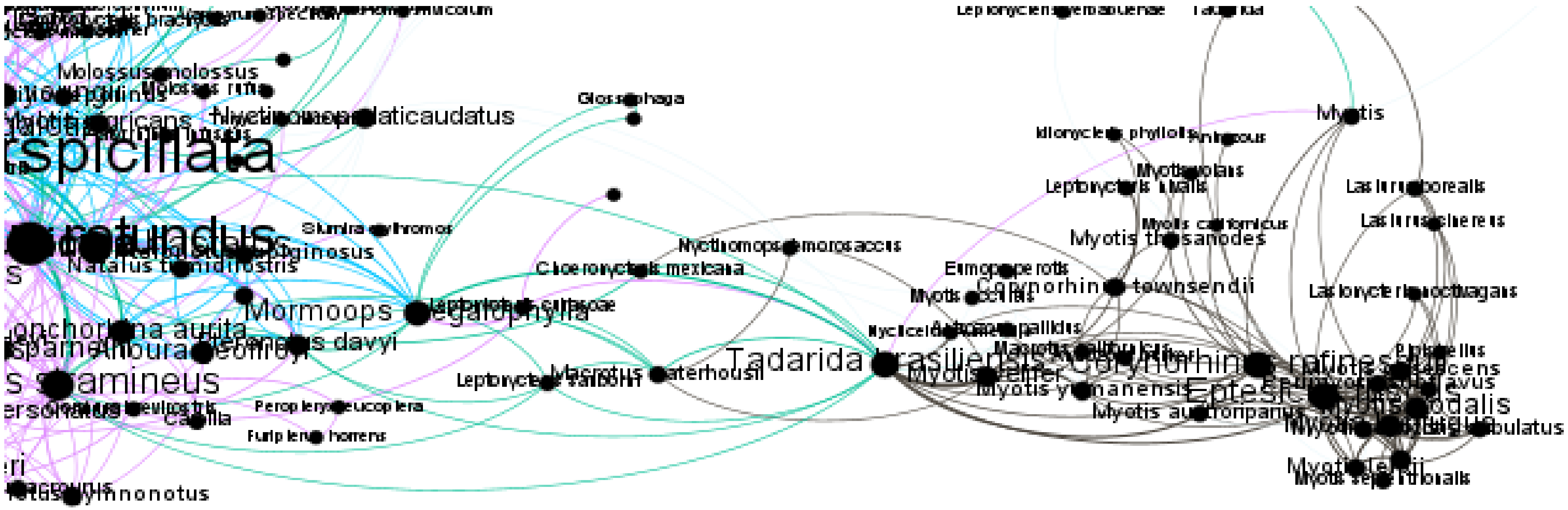
First **Outputs – Co-roosting**



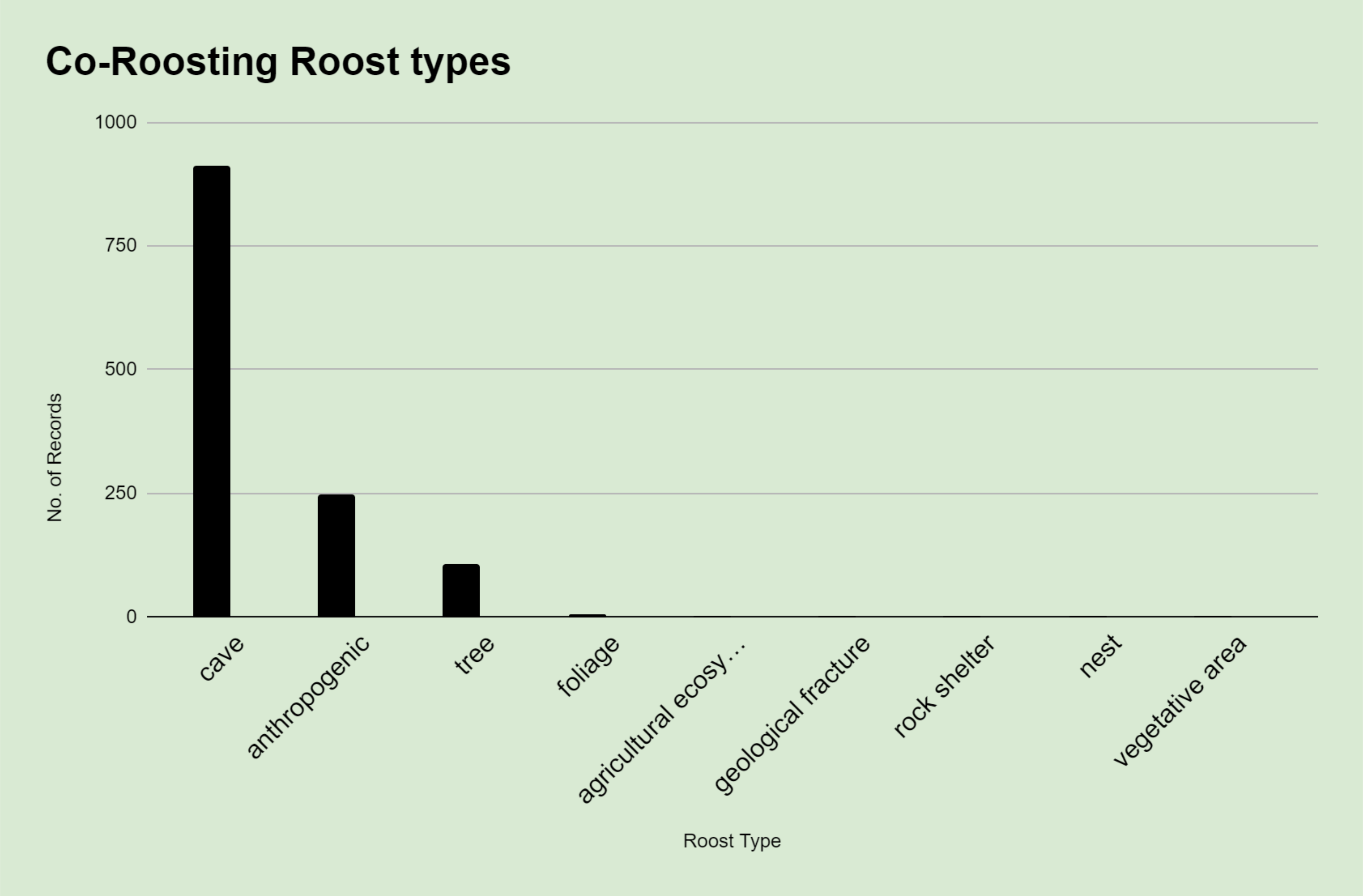


First **Outputs – Co-roosting**

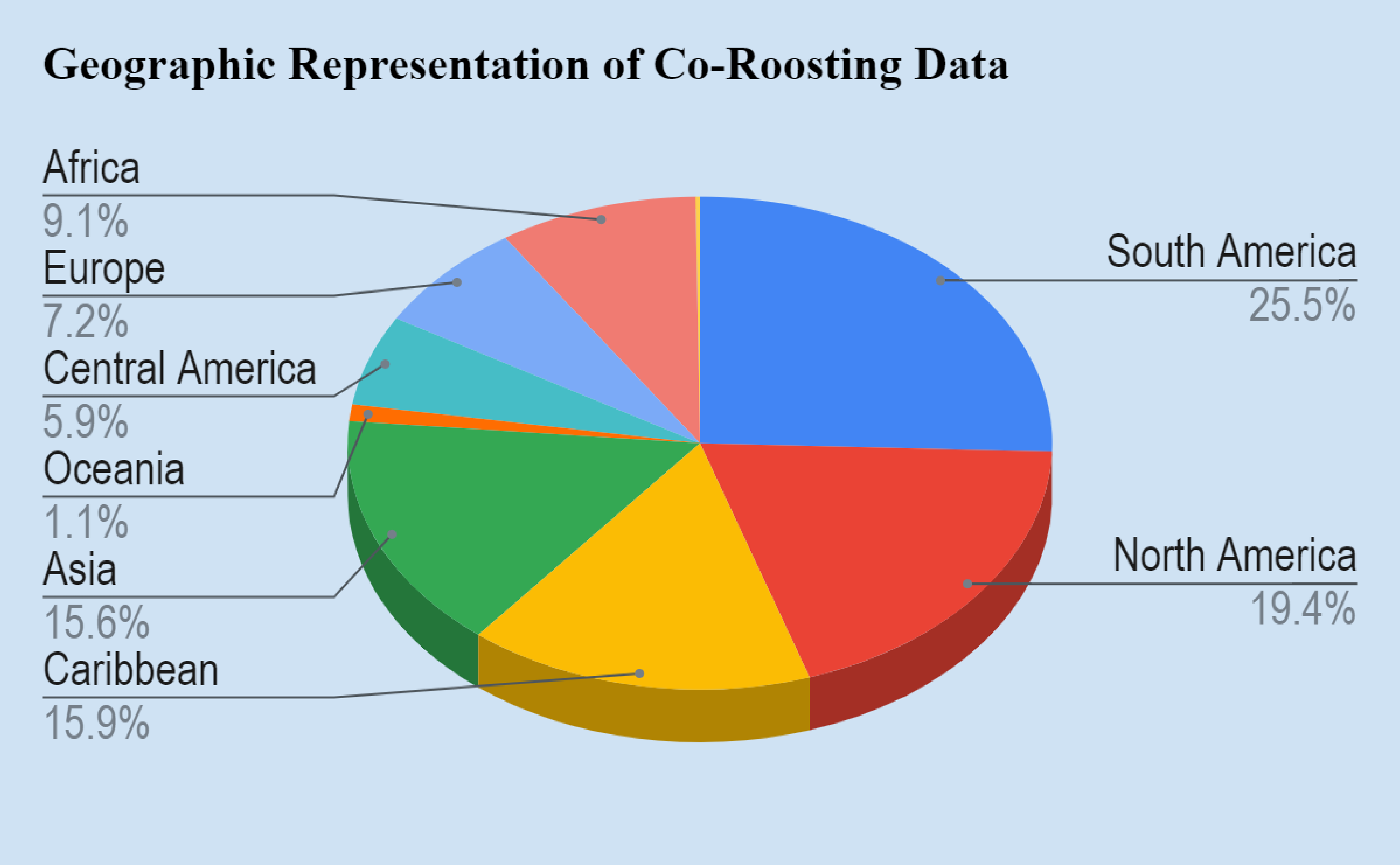




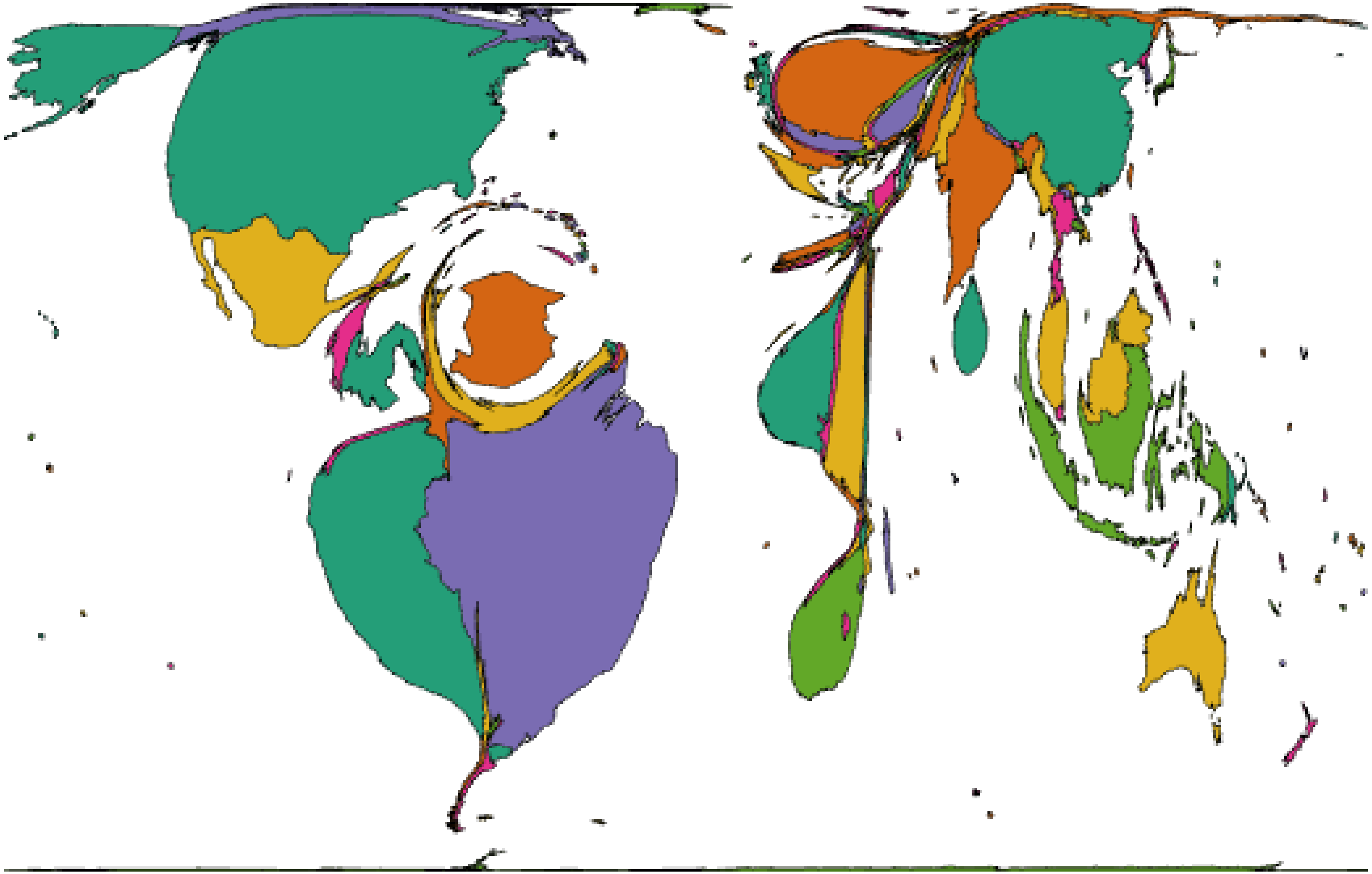
First Outputs – Co-roosting



First Outputs – Co-roosting



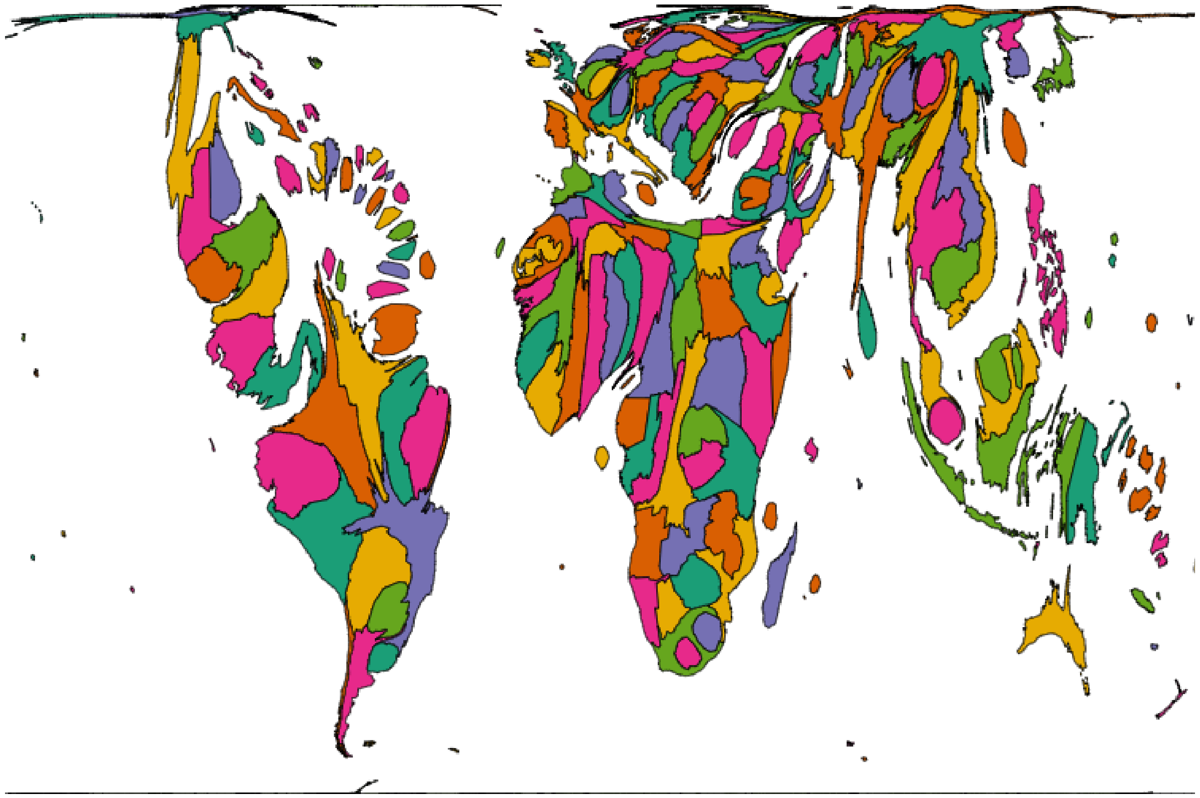
Data Distribution

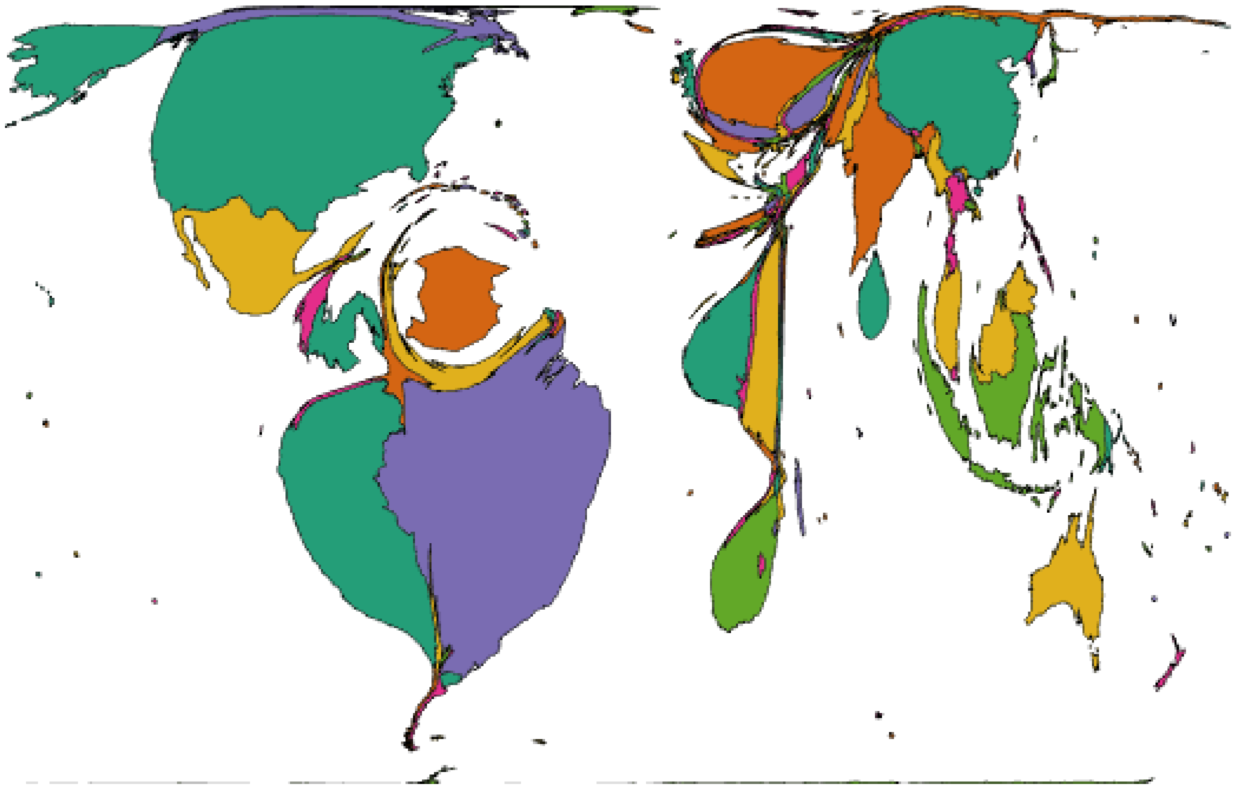


A cartogram of co-roosting data for those records that have a specific country

Gastner MT, Seguy V, More P. Fast flow-based algorithm for creating density-equalizing map projections. Proc Natl Acad Sci USA 115(10):E2156–E2164 (2018).

Data Bias Relative to Species Richness

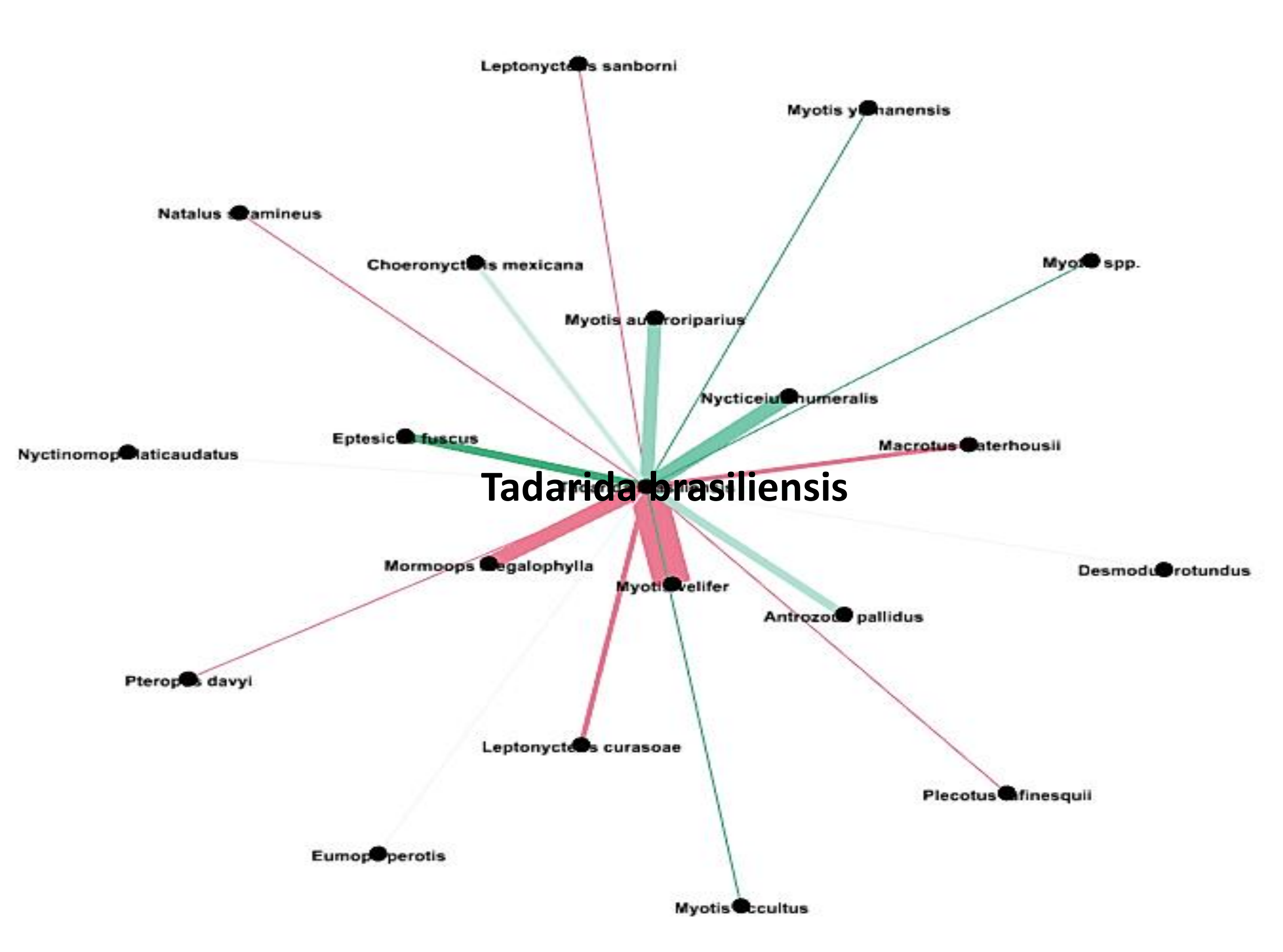




A cartogram of bat species richness
Mammal Diversity Database v1.8

A cartogram of co-roosting data for those records that have a specific country

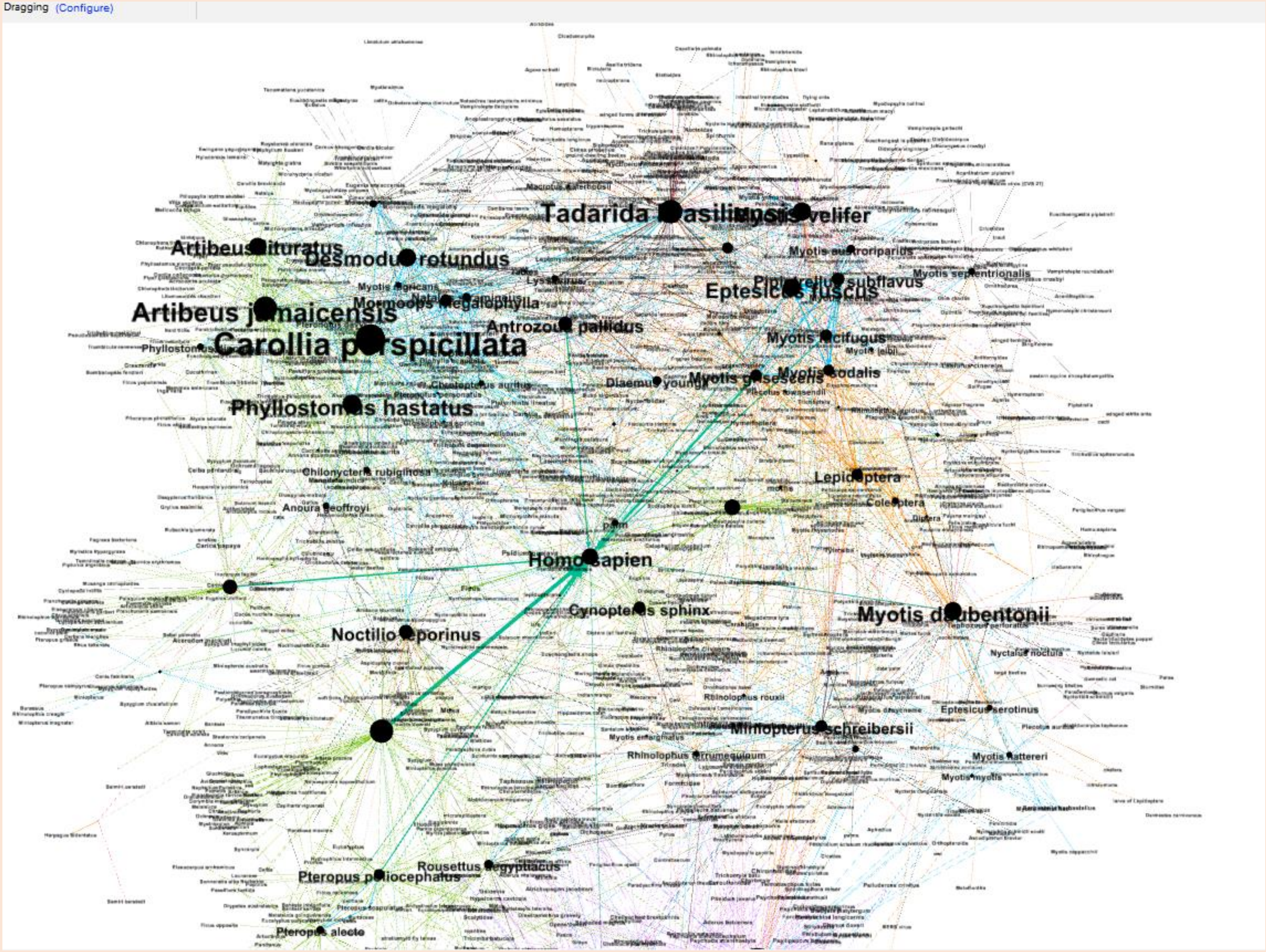
Interactions with Context



Tadarida brasiliensis co-roosting occurrences

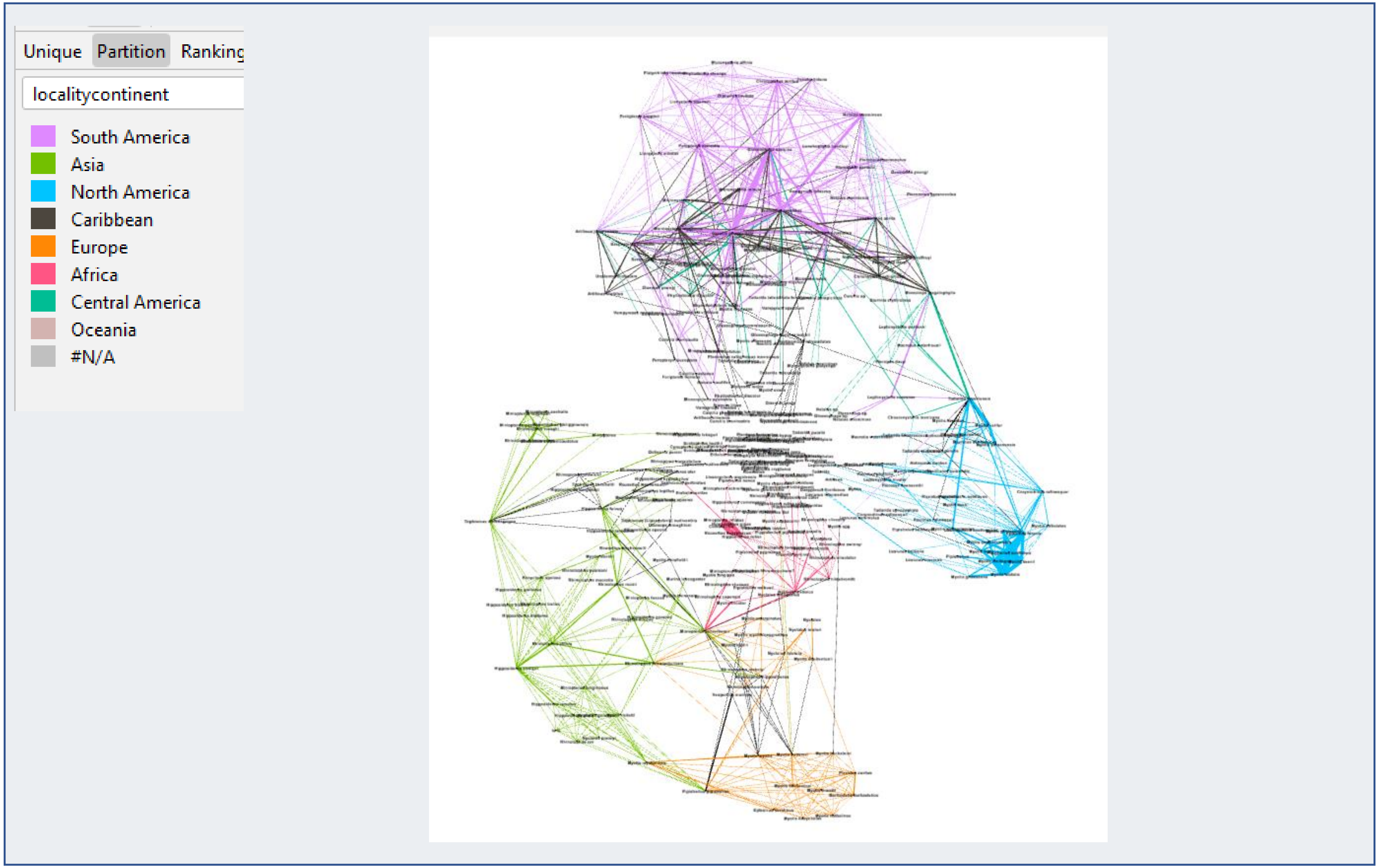
occurenceId
sourceTaxonName
targetTaxonName
interactionTypeName
interactionTypeId
Season
Start Month
Start Date
Start Year
Start Month
End Date
End Year
Country
localityName
synchronous_YN
contact_YN
roostCat1
ENVO_cat1
roostCat2
ENVO_cat2
roostCat3
ENVO_cat3
roostTaxon
InteractionText
TextType
roostUsageType
InteractionReferencePage
Basis of record
FrequencyofOccurences
PlantTaxonName
Tags
Habitat
referenceDOI
referenceURL
referenceCitation
referencePage
referenceFileName
contributors

Interactions with Context

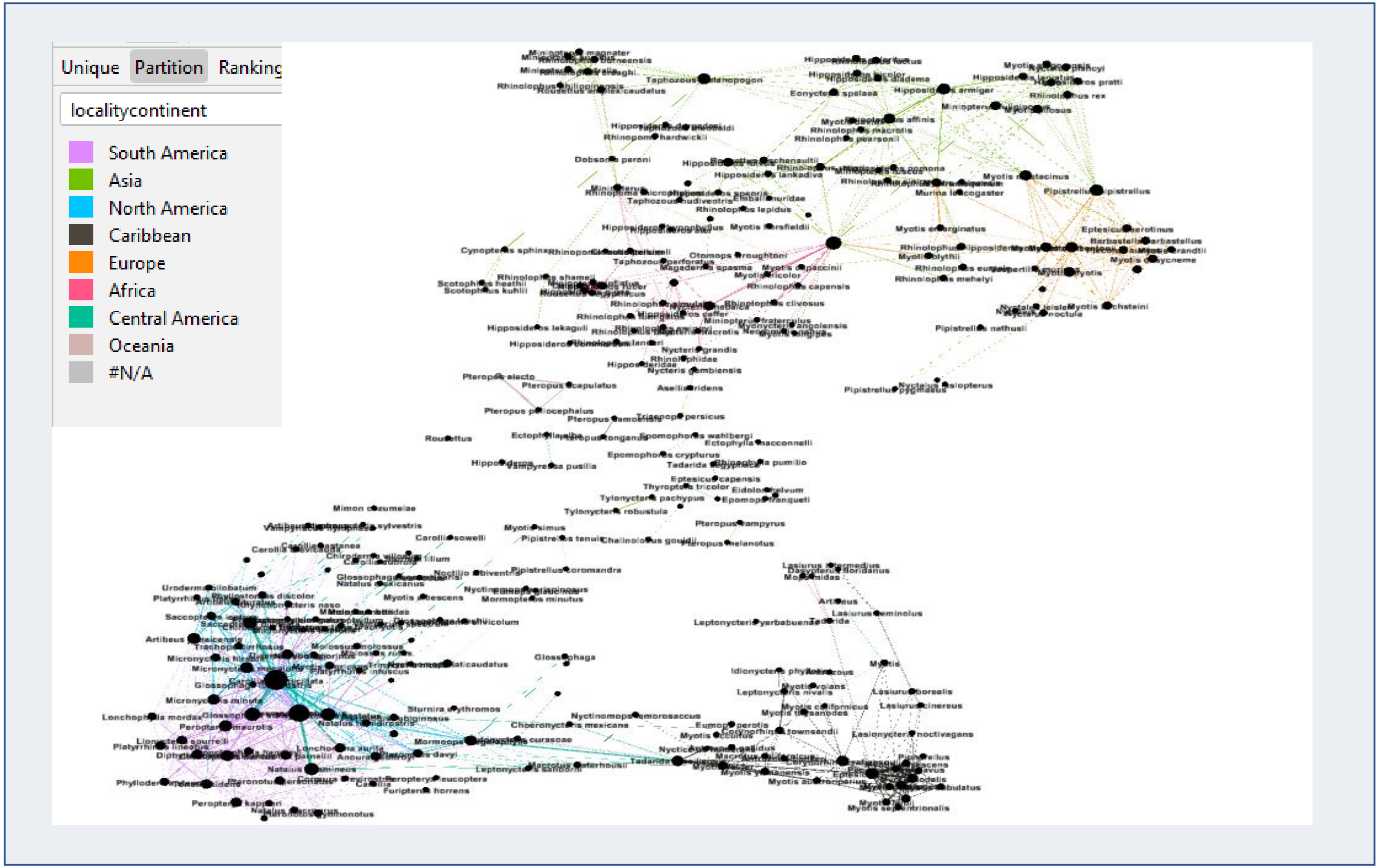


Tadarida brasiliensis all interactions

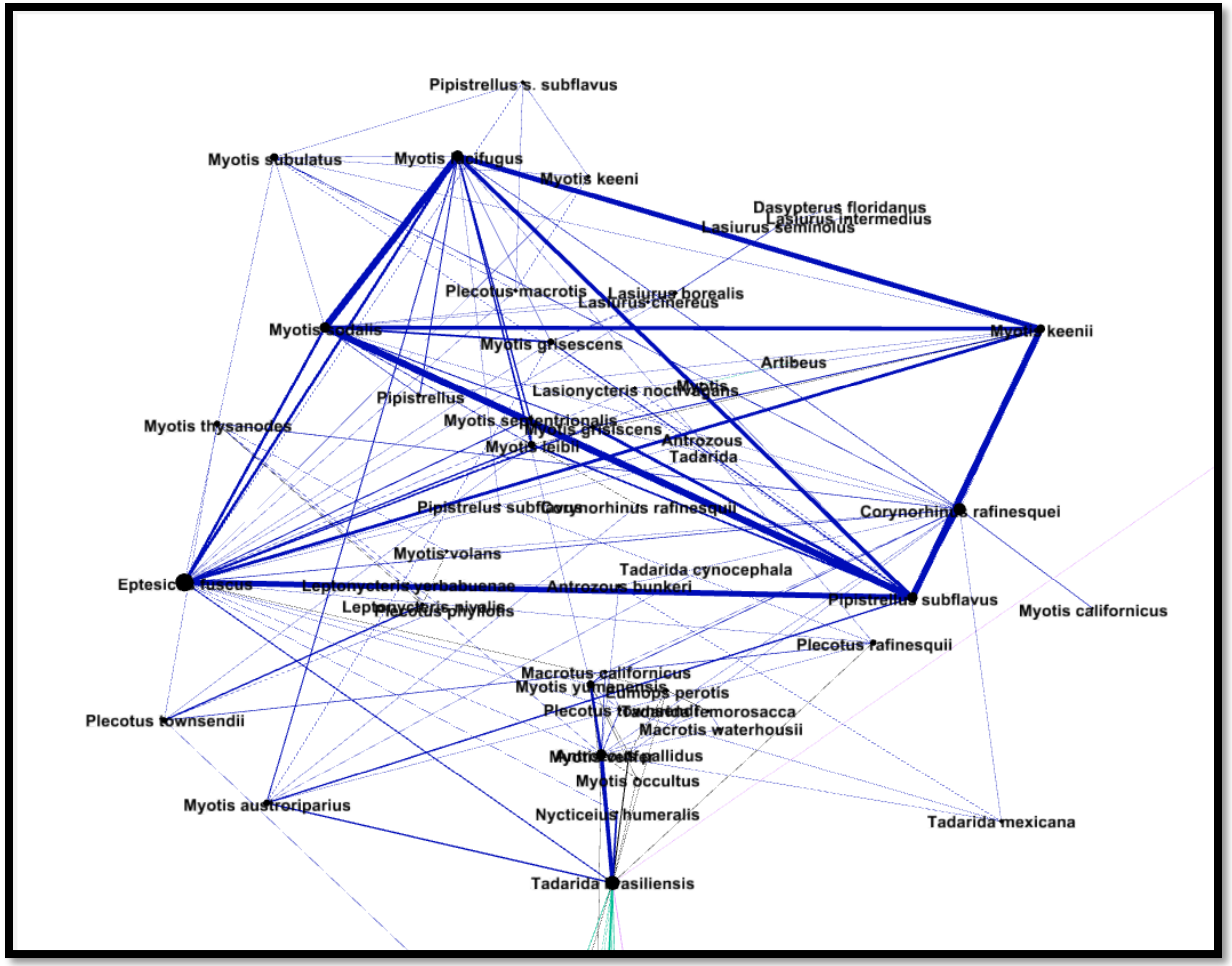
Challenges and Opportunities with Taxonomy

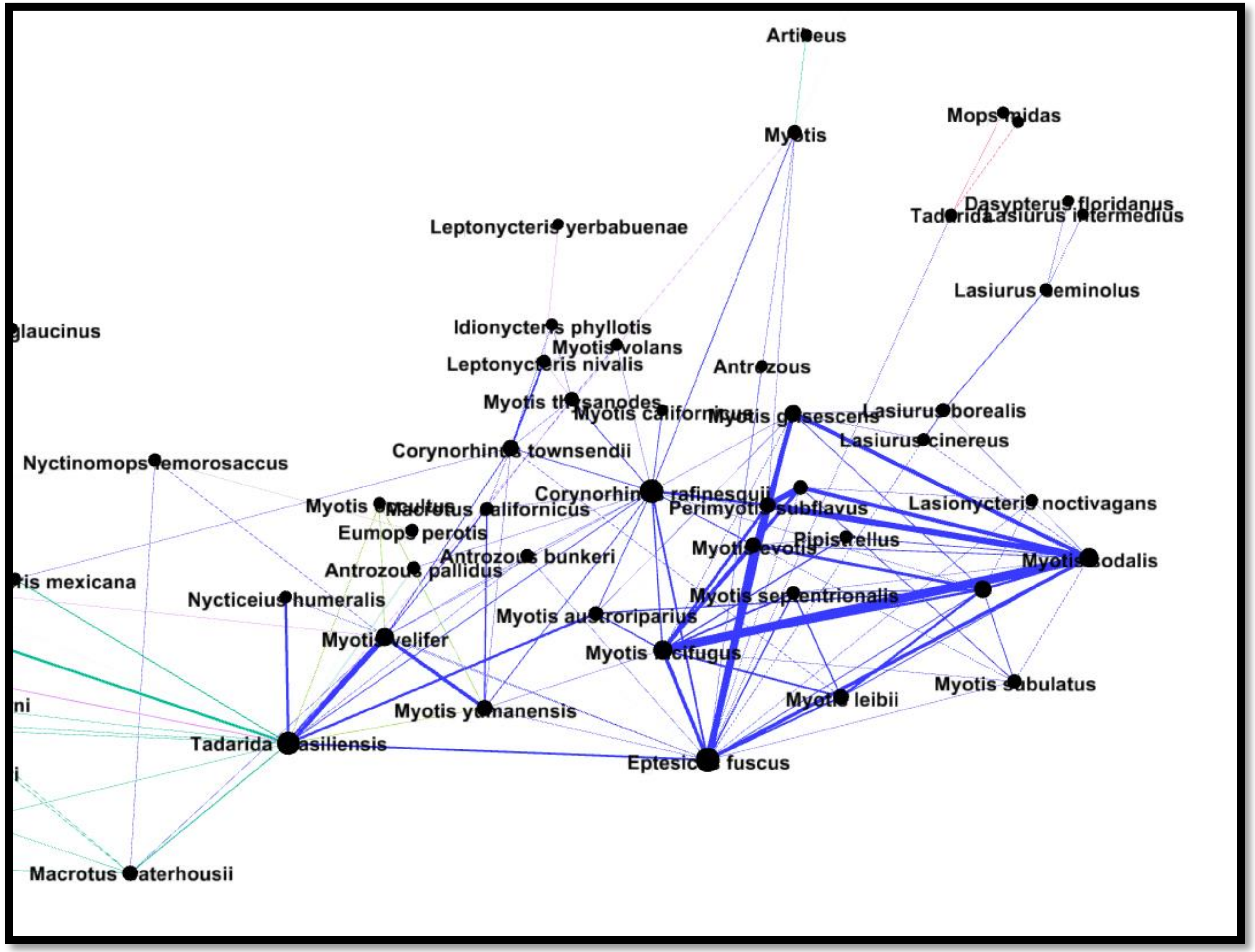


Challenges and Opportunities with Taxonomy



Resolved Taxonomy

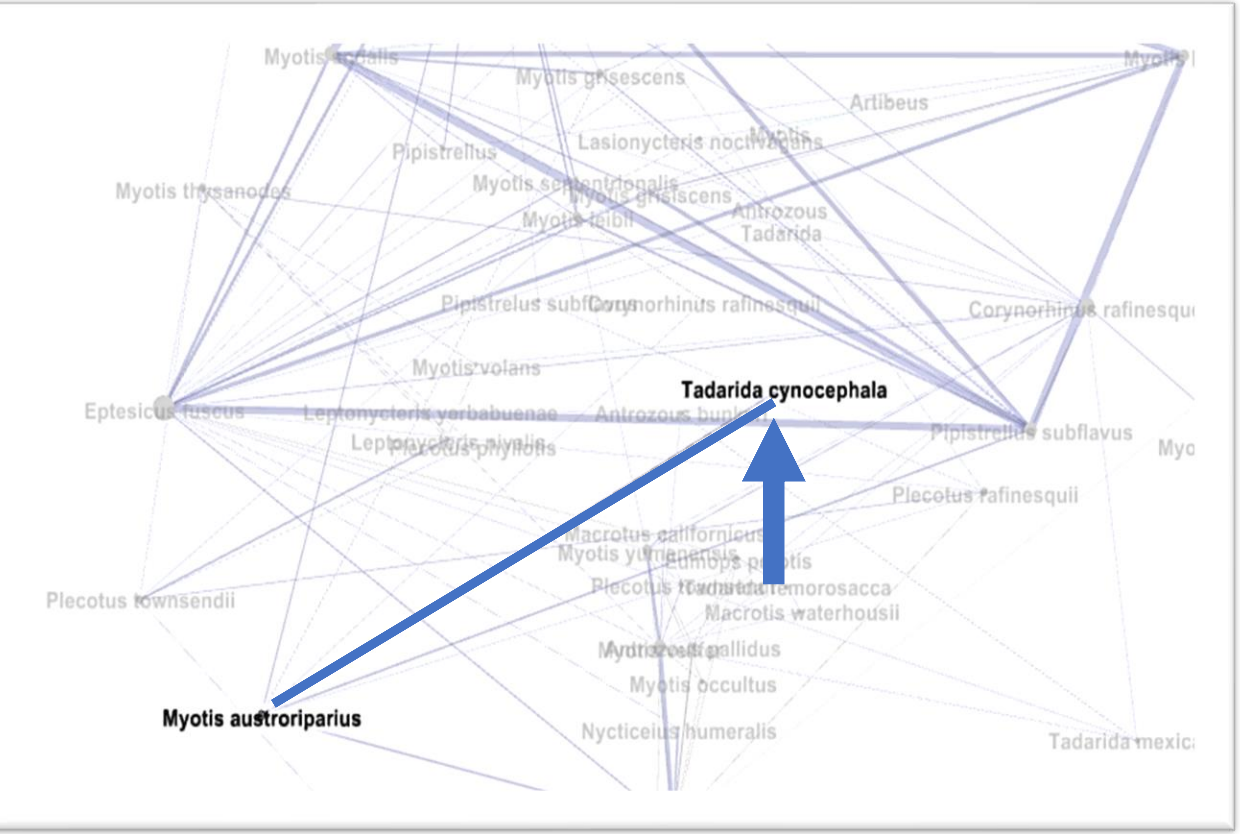


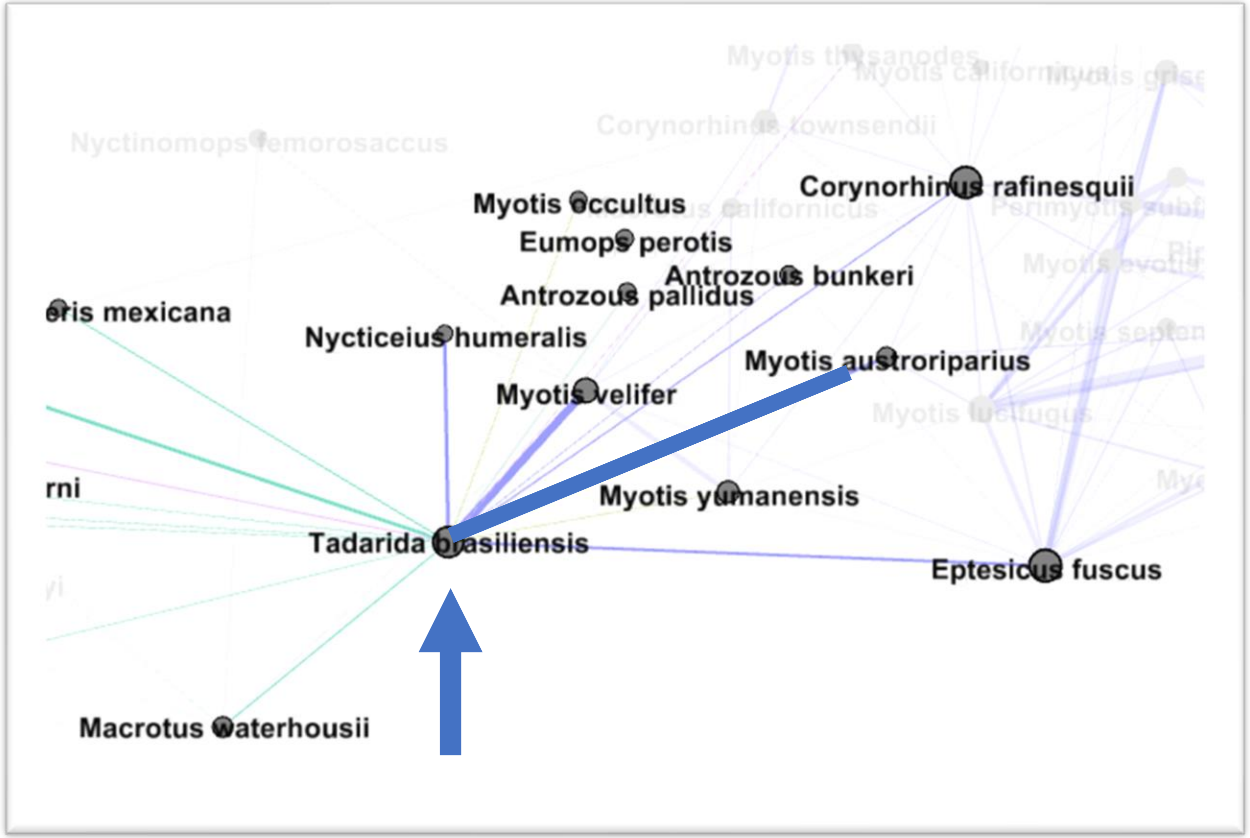


Before **After**

Tadarida cynocephala now considered a subspecies of Tadarida brasiliensis

Resolved Taxonomy

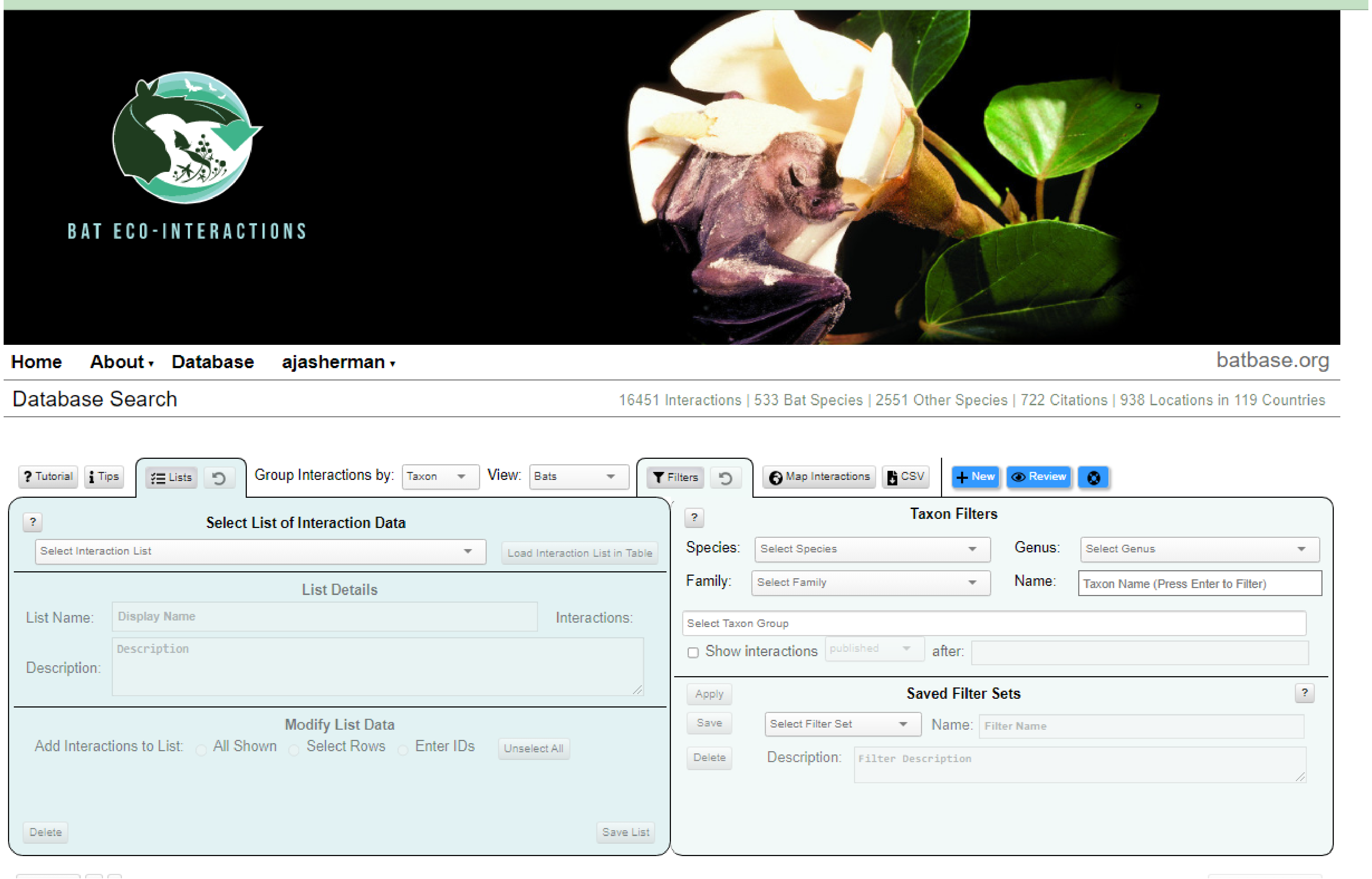




Before **After**

Tadarida cynocephala now considered a subspecies of Tadarida brasiliensis

Next steps


BAT ECO-INTERACTIONS
Home
About
Database
ajasherman
batbase.org
Database Search
16451 Interactions | 533 Bat Species | 2551 Other Species | 722 Citations | 938 Locations in 119 Countries
Tutorial
Tips
Lists
Group Interactions by:
Taxon
View:
Bats
Filters
Map Interactions
CSV
New
Review
Select List of Interaction Data
Select Interaction List
Load Interaction List in Table
List Details
List Name:
Display Name
Interactions:
Description:
Description
Modify List Data
Add Interactions to List:
All Shown
Select Rows
Enter IDs
Unselect All
Delete
Save List
Taxon Filters
Species:
Select Species
Genus:
Select Genus
Family:
Select Family
Name:
Taxon Name (Press Enter to Filter)
Select Taxon Group
Show interactions
published
after:
Saved Filter Sets
Apply
Save
Delete
Select Filter Set
Name:
Filter Name
Description:
Filter Description

Next steps – Teaching the robots

Next steps

Questions?

Contact details

Next steps

- Identify areas of the world where data are lacking
- Teach AI data collection process
- Generalism vs. specialism of roosting behavior
- Demonstrate social-economic challenges in transcribing literature
- Demonstrate the varied skills needed to build a species interaction datas
- connect them to other cyber infrastructure like taxonomic systems, geo-spatial coding schemes (e.g., geonames), ontologies