ATLANTIC EPIPHYTES: a data set of vascular and non-vascular epiphyte plants and lichens from the Atlantic Forest

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Introduction

Biodiversity studies tropical plant communities mainly focus on trees (*e.g.*, Gentry 1988; Oliveira and Daly 1999; Pitman et al. 2001, 2002; Condit et al. 2002; ter Steege et al. 2003; Oliveira-Filho et al. 2005; Eisenlohr et al. 2013) and many other life forms - such as lianas, herbs, shrubs and epiphytes - are frequently ignored or undervalued. However, they are responsible for high levels of species richness and endemism of these ecosystems (Gentry and Dodson 1987a, b; Nieder et al. 1999).

Epiphytic plants provide ecological services related to hydrology and nutrient cycling (Jarvis 2000; Bruijnzeel et al. 2011; Stanton et al. 2014) and contribute to diversity through their interactions with other biota (Benzing 1990; Yanoviak et al. 2007). Several invertebrate and vertebrate species use epiphytes as habitat or resource (Lasky and Keitt 2012; Angelini and Silliman 2014; Scheffers et al. 2014). Epiphytes can provide shelter and nesting materials for some insect and bird species, and also are important food sources for several foraging animals (Pike 1978; Coxson and Nadkarni 1995; Knops et al. 1996; Stuntz et al. 2002). Established in forest canopies, epiphytes get most of their nutrients from atmospheric sources and leaf litter (Gotsch et al. 2016; Zotz 2016) and thus are particularly sensitive to environmental changes. The best understanding of commensal interactions between epiphytic organisms and host trees, called phorophytes, are also very important. Epiphyte organisms depend on the structures of trees (trunk and branches) for their establishment, mainly for support (Callaway et al. 2002). Host tree traits can influence the establishment of the epiphytic organisms, such as the diameter, morphology and chemical composition of the bark, the structure and architectural patterns of the crown, the tree height, etc. (Wagner et al. 2015).

The classification of plants into epiphytic life-forms is controversial and different recommendations have been made (Benzing 1987, 1990; Batke et al. 2016, Flores-Palacios 2016). Zotz (2016) defines epiphytes as organisms that germinate and root non-parasitically on other plants without contact with the soil, at least in part of their life cycle. Additionally, Zotz (2013, 2016) accepts only the holo- and primary hemiepiphytes as epiphytes. Herein, we use the epiphyte definition according to Zotz (2013, 2016) but also include non-vascular holoepiphyte plants, as well as epiphytic Lichens.

Most of the data from epiphyte occurrence are in secondary (gray) literature, such as unpublished theses, herbarium vouchers or even from raw datasets. Even some of the published data are difficult to access as they are available in journals without indexation. Whereas many

ecological and conservation studies require large quantities of data, organizing the data of epiphytes from the Atlantic Forest, which is scattered in the literature, will stimulate the research of epiphyte ecology and plant biogeography of the Atlantic Forest as a whole. Biogeographic studies of epiphytes, for example, are mostly restricted to some classic papers (Johansson 1974; Gentry and Dodson 1987; ter Steege and Cornelissen 1989; Kreft et al. 2004; Küper et al. 2004). Only recently, epiphyte biogeography in the Atlantic Forest, one of the centers of the epiphyte diversity in the Neotropics (Gentry and Dodson 1987b; Kersten 2010), received more attention (Kersten 2010, Fontoura et al. 2012; Leitman et al. 2015; Menini Neto et al. 2016). Additionally, in their analysis of endemism patterns among vascular epiphytes in the Atlantic Forest, Freitas et al. (2016) discussed that epiphytes had a relative recent radiation (Pliocene) and higher endemism than overall vascular flora.

The Atlantic Forest domain is considered one of the most endangered ecosystems in the world (Morellato and Haddad 2000, Myers et al. 2000; Mittermeier et al. 2004) and one of the main centers of plant diversity in the Neotropics (Gentry 1982; Gentry and Dodson 1987b; Stehmann et al. 2009). About 94% of its area is situated in eastern Brazil, along the Atlantic coast, but it also spans parts of Argentina and Paraguay (Ribeiro et al. 2009; Stehmann et al. 2009). Originally, the Atlantic Forest covered around 150 million hectares, however, less than 16% of its original vegetation remains nowadays, most of the remnant patches (~80%) are <50 ha in size and the mean distance between them is 1.4 km (Ribeiro et al. 2009).

Here, we compiled a dataset composed of 89,270 holo/hemiepiphyte records (78,234 of occurrence data and 11,036 of abundance data) in the Atlantic Forest of Brazil, Argentina, Paraguay, and Uruguay (Figure 1), recorded from 1824 to early 2018. ATLANTIC EPIPHYTES is part of the ATLANTIC SERIES of datapapers, an initiative of Brazilian researchers to compile information of Atlantic Forest biodiversity. Many data collection initiatives were funded by Brazilian funding agencies (CNPq, CAPES, FAPESP, FAPEMIG, FAPERJ, FAPESC, FAPESB, FAEP, CNCFlora, FUNBIO, FUNDECT, PUCPR), as well as by Latin American agencies (ANII, CONICET, CSIC, AGENCIA, UNLP). Some articles of this series have already been published: ATLANTIC FRUGIVORY (Bello et al. 2017), ATLANTIC SMALL MAMMALS (Bovendorp et al. 2017), ATLANTIC CAMTRAPS (Lima et al. 2017), ATLANTIC BIRDS (Hasui et al. 2017), ATLANTIC BATS (Muylaert et al. 2017), ATLANTIC AMPHIBIANS (Vancine et al. in press) and ATLANTIC MAMMAL TRAITS (Gonçalves et al. 2018). All the primary data sets of this series were published into Ecology repository; however we will maintain the updated version within a Github repository: https://github.com/LEEClab/Atlantic_series/.

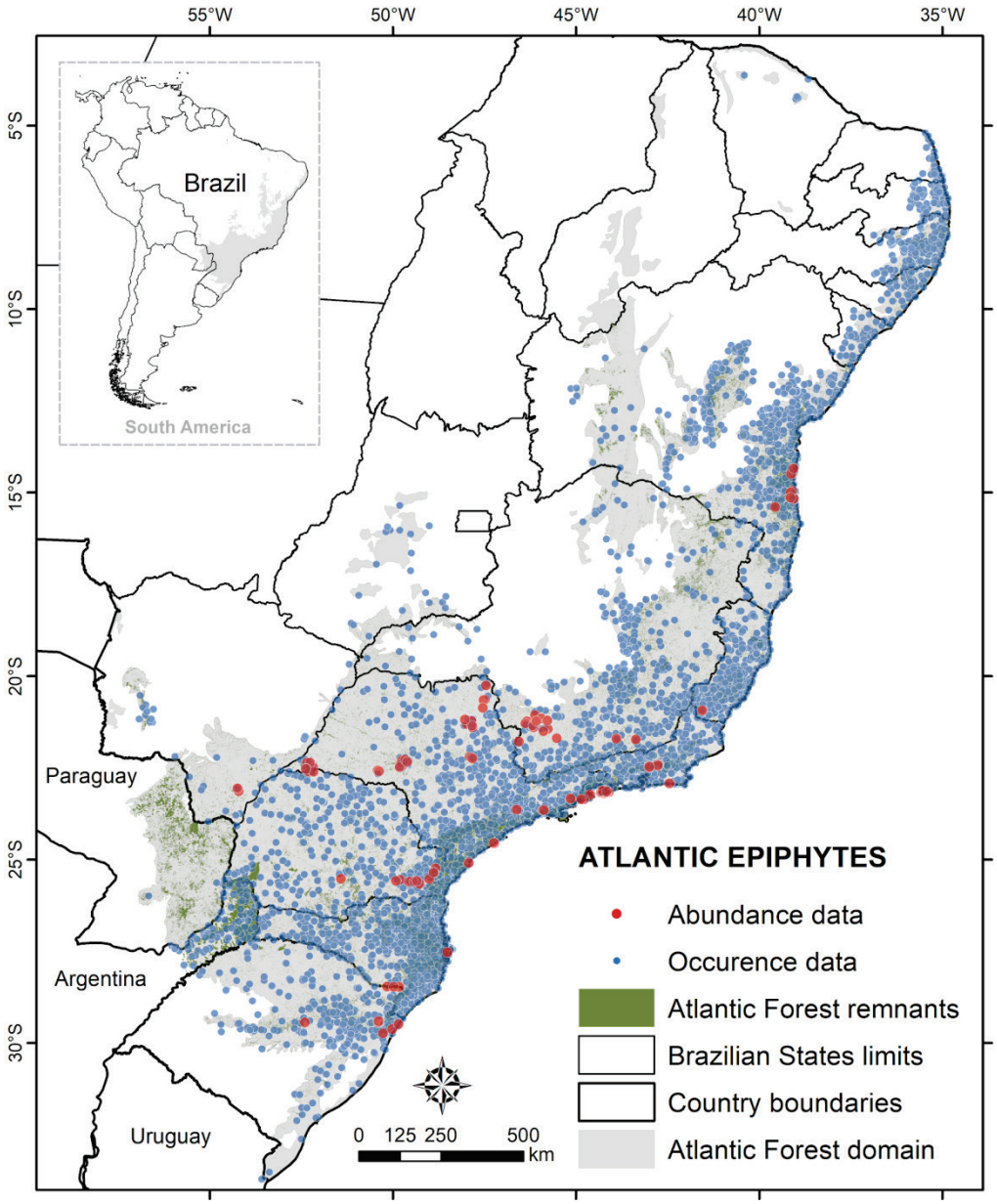

Figure 1. Distribution of holo/hemiepiphyte surveys within the Atlantic Forest domain, with occurrence (blue dots) and abundance data (red dots). Atlantic Forest domain and remnants were defined according to Huang et al. (2007) and Ribeiro et al. (2009).

METADATA

CLASS I. DATA SET DESCRIPTORS

I.A. Data set identity:

Title: ATLANTIC EPIPHYTES: a data set of vascular and non-vascular epiphyte plants and lichens from the Atlantic Forest

I.B. Data set identification code:

Suggested Data Set Identity Codes:

ATLANTIC_EPIPHYTES_Abundance.csv,

ATLANTIC_EPIPHYTES_Occurrence.csv,

ATLANTIC_EPIPHYTES_References.csv,

I.C. Data set description:

I.C.1. Principal Investigator(s):

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I.C.2. Abstract:

Epiphytes are hyper-diverse and one of the frequently undervalued life forms in plant surveys and biodiversity inventories. Epiphytes of the Atlantic Forest, one of the most endangered ecosystems in the world, have high endemism and radiated recently in the Pliocene. We aimed to (1) compile an extensive Atlantic Forest data set on vascular, non-vascular plants (including hemiepiphytes), and Lichen epiphyte species occurrence and abundance; (2) describe the epiphyte distribution in the Atlantic Forest, in order to indicate future sampling efforts. Our work presents the first epiphyte data set with information on abundance and occurrence of epiphyte phorophyte species. All data compiled here comes from three main sources provided by the authors: published sources (comprising peer-reviewed articles, books, and theses), unpublished data, and herbarium data. We compiled a data set composed of 2,095 species, from 89,270 holo/hemiepiphytes records, in the Atlantic Forest of Brazil, Argentina, Paraguay and Uruguay, recorded from 1824 to early 2018. Most of the records were from qualitative data (occurrence only, 88%), well distributed throughout the Atlantic Forest. For quantitative records, the most common sampling method was individual trees (71%), followed by plot sampling (19%), and transect sampling (10%). Angiosperms (81%) were the most frequently registered group, and Bromeliaceae and Orchidaceae were the families with the greatest number of records (27,272 and 21,945, respectively). Ferns and Lycophytes presented fewer records than Angiosperms, and Polypodiaceae were the most recorded family, and more concentrated in the Southern and Southeastern regions. Data on non-vascular plants and Lichens were scarce, with a few disjunct records concentrated in the Northeastern region of the Atlantic Forest. For all non-vascular plant

records, Lejeuneaceae, a family of liverworts, was the most recorded family. We hope that our effort to organize scattered epiphyte data help advance the knowledge of epiphyte ecology, as well as our understanding of macroecological and biogeographical patterns in the Atlantic Forest. No copyright restrictions are associated with the data set. Please cite this Ecology Data Paper if the data are used in publication and teaching events.

I.D. Keywords: abundance, Atlantic Forest, biodiversity data set, biodiversity hotspot, epiphyte, phorophyte, presence/absence, tropical forest

I.E. Description:

Published data comes from 203 references, being mostly from peer-reviewed articles (65%), followed by theses and dissertations (29%), books (3%) and unpublished data (3%). The data set covers the main vegetation types found in the Atlantic Forest of tropical and subtropical Brazil, Paraguay, Argentina, and Uruguay (Ribeiro et al. 2009) and combines 89,270 independent valid records of epiphyte species from 75 data files (Figure 1). In total, our data set contains 2,095 epiphyte species belonging to three main groups: (1) Angiosperms (1,691) with the higher number of records and species, (2) Ferns and Lycophytes (179 and 8, respectively), (3) Non-vascular plants (Mosses and Liverworts with 73 each), and Lichens (80, Table 1). Although non-vascular plants, and Lichens are much less frequent than Ferns and Lycophytes in our data base, richness of the two groups is very similar. Within the Atlantic Forest domain, most of the records were in Ombrophilous Forest (60.1%), followed by Seasonal Forest (24.9%), Savanna enclaves (7.6%) and others (7.4%; Figure 2).

Table 1: Percentage of epiphyte records, percentage of species richness, percentage of family richness and percentage of genus richness in each group: Angiosperms, Ferns and Lycophytes (vascular plants), Liverworts and Mosses (non-vascular plants), and Lichens. Total number of records in each category are in parentheses.

Group	Records	Species richness	Family richness	Genus richness
Angiosperms	81.42 (72,681)	80.7 (1,691)	26.6 (21)	55.0 (180)
Ferns	17.65 (15,756)	8.5 (179)	13.9 (11)	12.2 (40)
Lycophytes	0.38 (338)	0.4 (8)	2.5 (2)	1.8 (6)
Liverworts	0.23 (203)	3.5 (73)	22.8 (18)	10.4 (34)
Mosses	0.20 (176)	3.5 (73)	8.9 (7)	9.2 (30)
Lichens	0.12 (116)	3.4 (71)	25.3 (20)	11.4 (37)

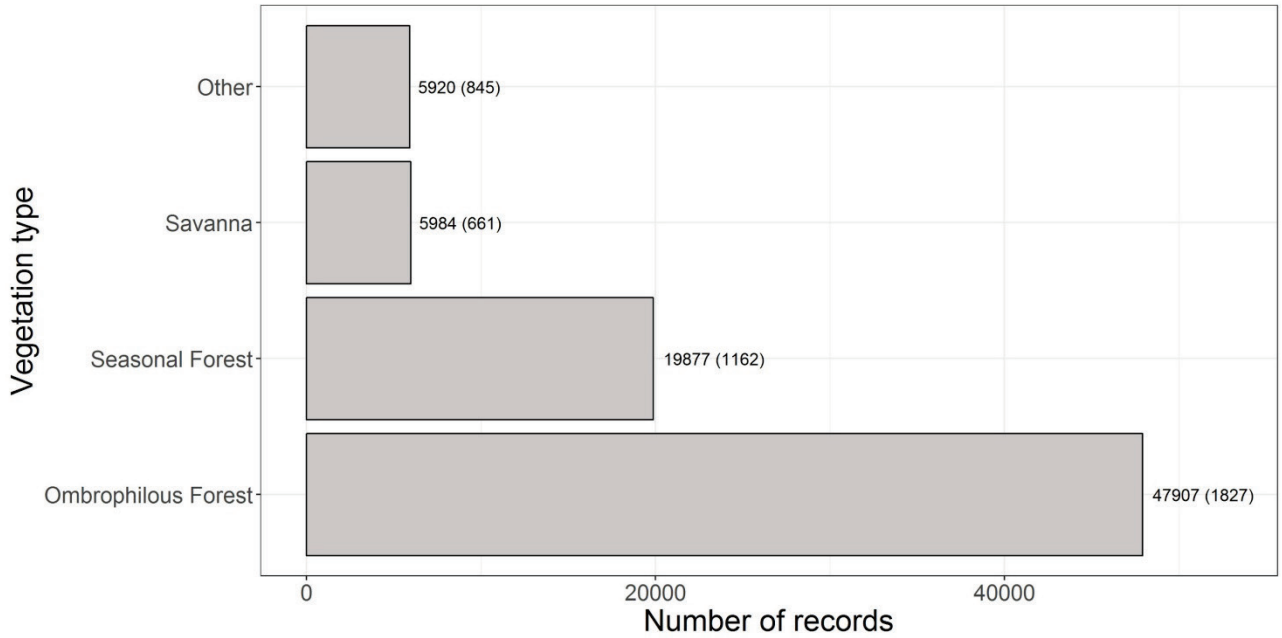

Figure 2: Number of epiphyte records (and number of species) from each vegetation type: Ombrophilous Forests = high temperature (mean 25ºC) and high precipitation levels well distributed throughout the year (0 to 60 dry days); Seasonal Forests = four to six dry months or with three months under 15ºC. Savanna = Savanna enclaves within the Atlantic Forest; and Other = less representative forest formations, such as pioneer formations and ecological refuges (sensu IBGE 2012). We had 9,582 of the records with no information about vegetation type.

Within Angiosperms, the group with most of the records, the families with the greatest number of records and species were Bromeliaceae (37.6%) and Orchidaceae (30.3%; Figure 3). Records from Bromeliaceae (Figure 4), Orchidaceae (Figure 5), and other Angiosperm families (Figure 6) were widely distributed throughout the Atlantic Forest, from coastal to interior areas. Within Bromeliaceae, the genera *Vriesea* (37%), *Tillandsia* (27.6%) and *Aechmea* (15.2%) were those with the greatest number of records, while those with the greatest number of species were *Vriesea* (25%), *Aechmea* (22.6%) and *Neoregelia* (15%; Figure 7). Within Orchidaceae, *Epidendrum* (10.5%), *Gomesa* (9.4%) and *Acianthera* (9.2%) were the most frequent genera, while the genera with the greatest number of species were *Acianthera* (10%), *Pabstiella* (7.2%) and *Epidendrum* (6.8%; Figure 8). Among the other Angiosperm families, *Peperomia* (Piperaceae, 8.3%), *Rhipsalis* (Cactaceae, 4.8%), and *Nematanthus* (Gesneriaceae, 3.5%) were the most frequent genera, while *Peperomia* (Piperaceae, 3.8%), *Philodendron* (Araceae, 2.5%), *Rhipsalis* (Cactaceae, 2.0%) were those with the greatest number of species (Figure 9).

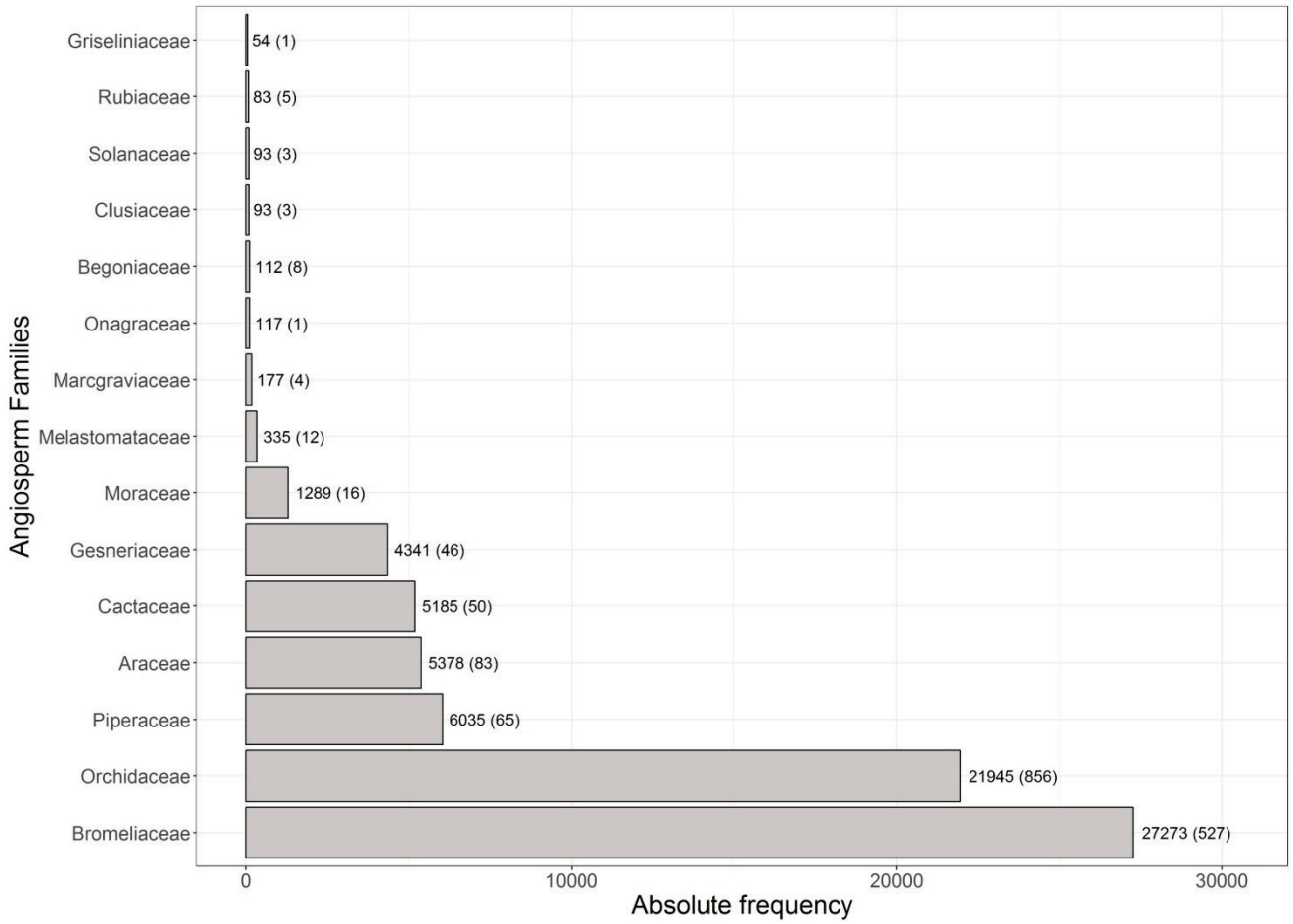

Figure 3: Frequency of records (and number of species) of the 15 Angiosperm families with the greatest number of epiphyte records.

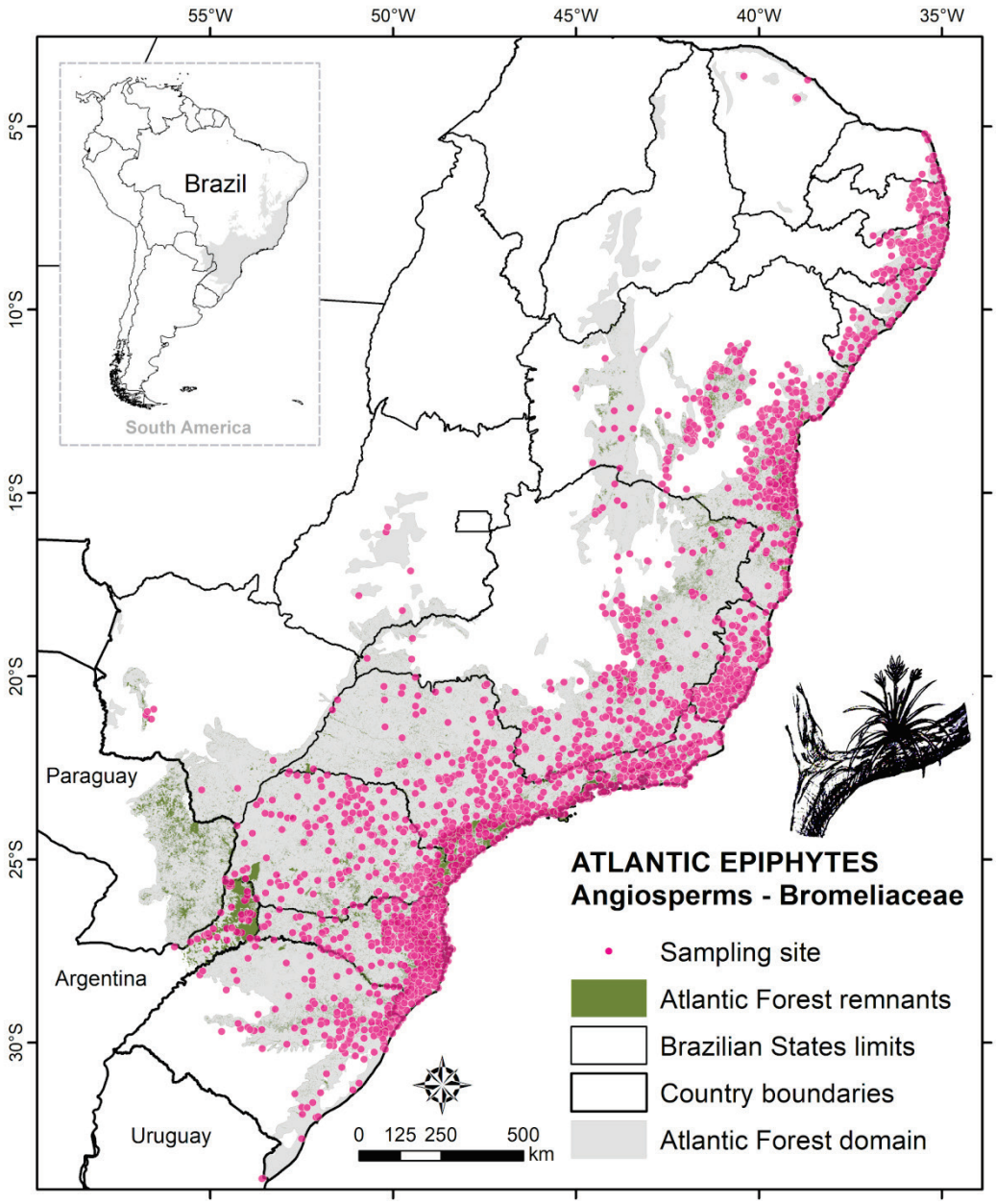

Figure 4: Distribution of epiphyte records from the Bromeliaceae family (Angiosperms) in the Atlantic Forest. Atlantic Forest domain and remnants were defined according to Huang et al. (2007) and Ribeiro et al. (2009).

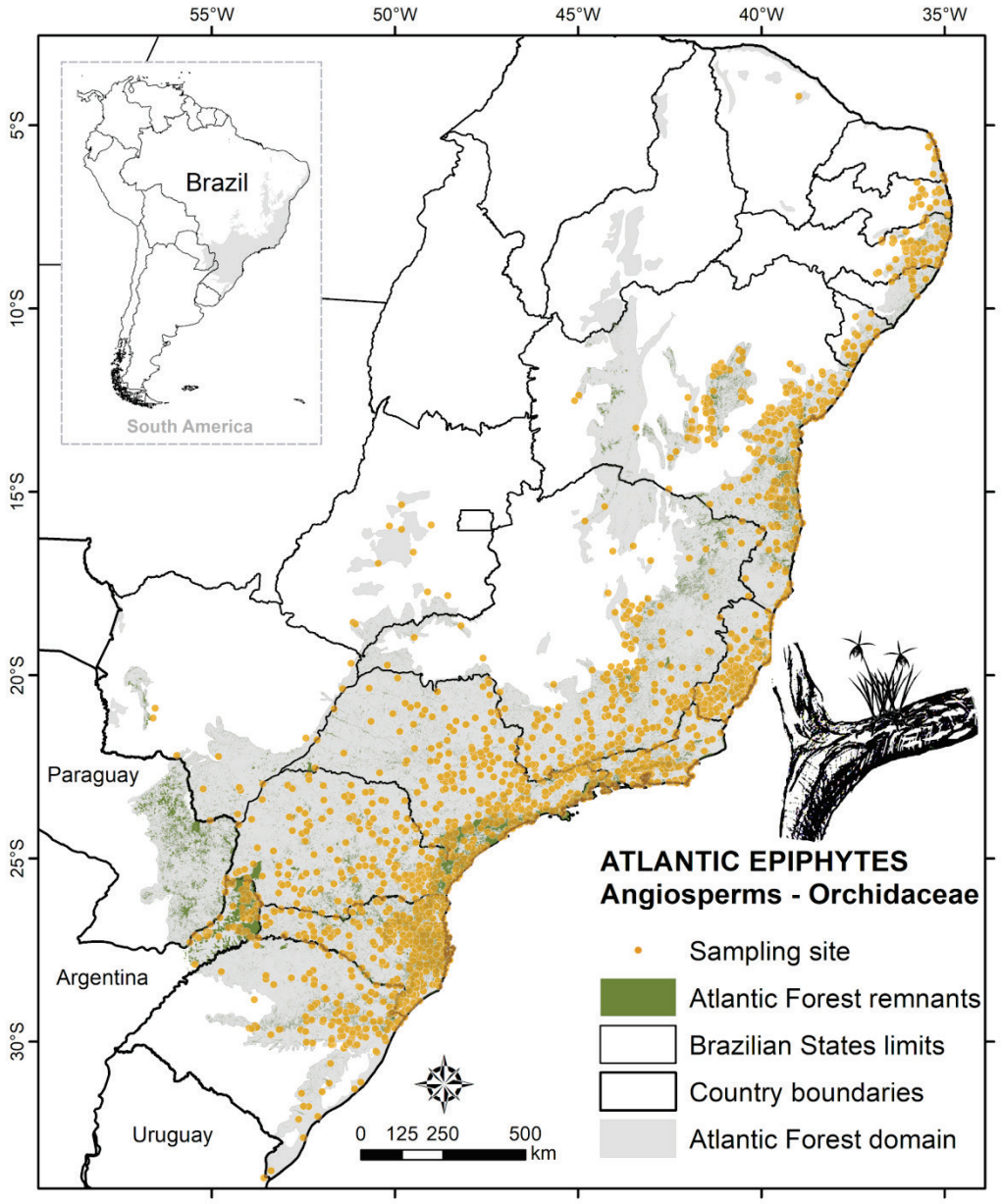

Figure 5: Distribution of epiphyte records from the Orchidaceae family (Angiosperms) in the Atlantic Forest. Atlantic Forest domain and remnants were defined according to Huang et al. (2007) and Ribeiro et al. (2009).

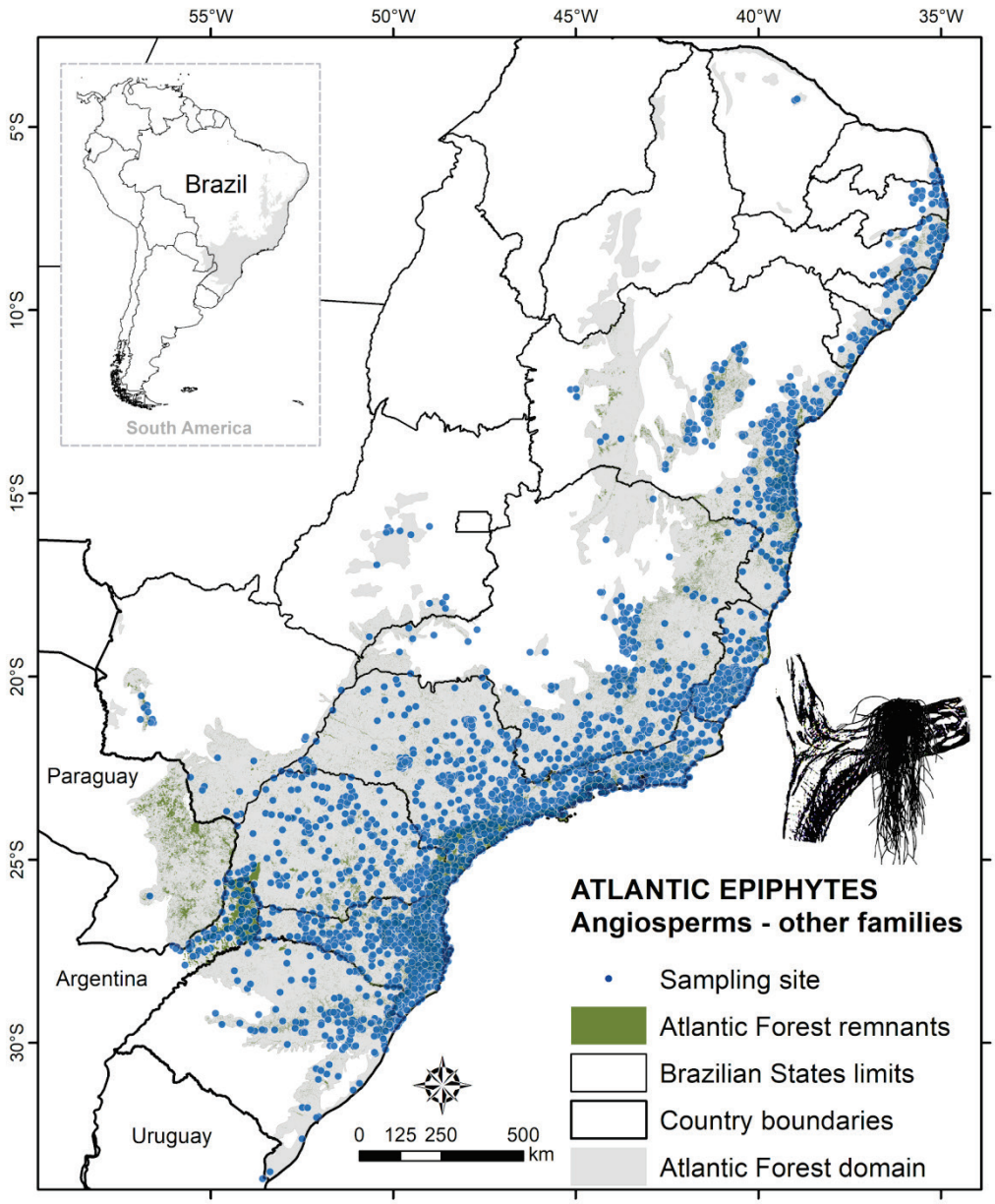

Figure 6: Distribution of epiphyte records from other Angiosperm families (excluding Bromeliaceae and Orchidaceae) in the Atlantic Forest. Atlantic Forest domain and remnants were defined according to Huang et al. (2007) and Ribeiro et al. (2009).

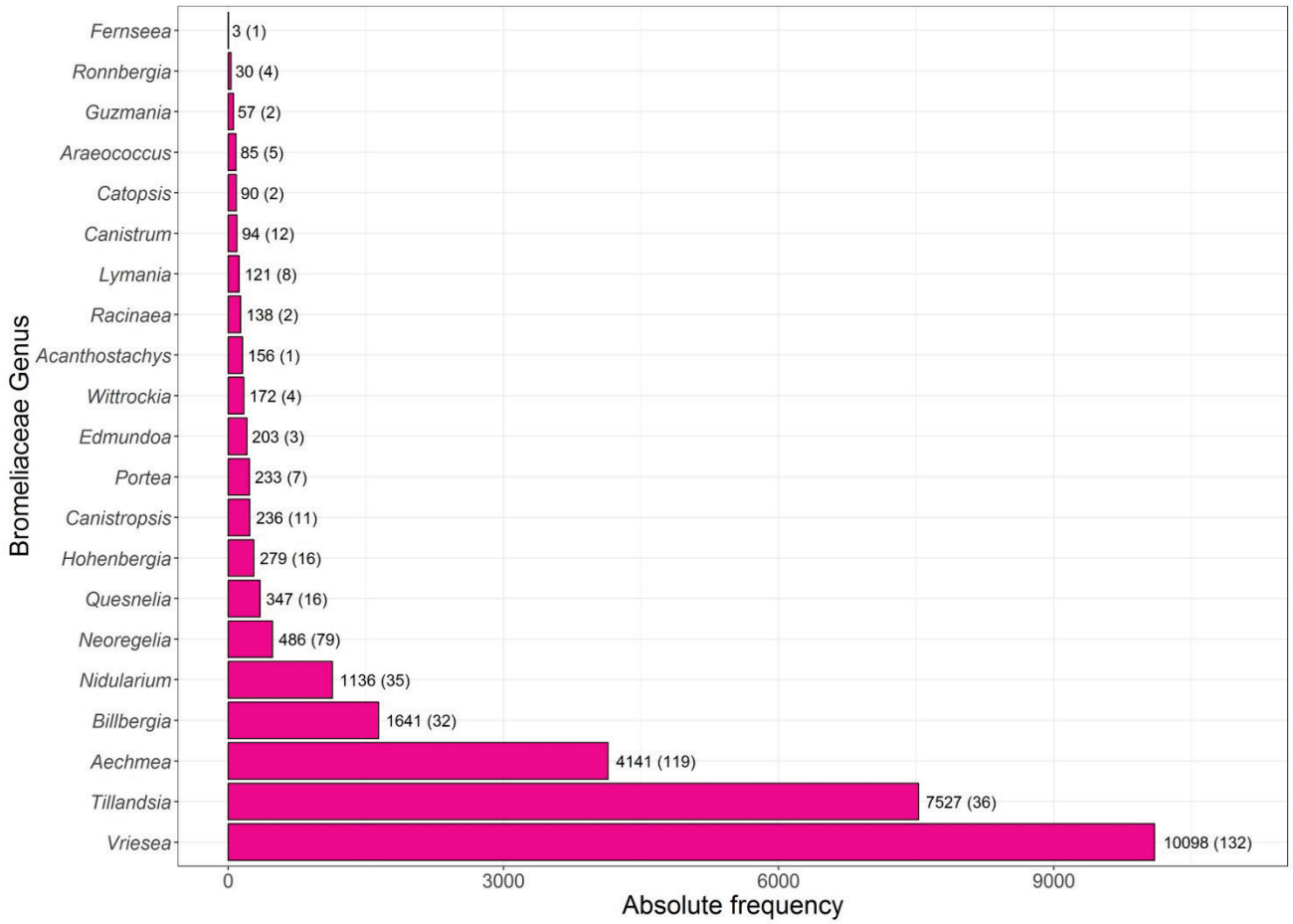

Figure 7: Frequency of records (and number of species) of the 30 Bromeliaceae (Angiosperms) genera with the greatest number of epiphyte records.

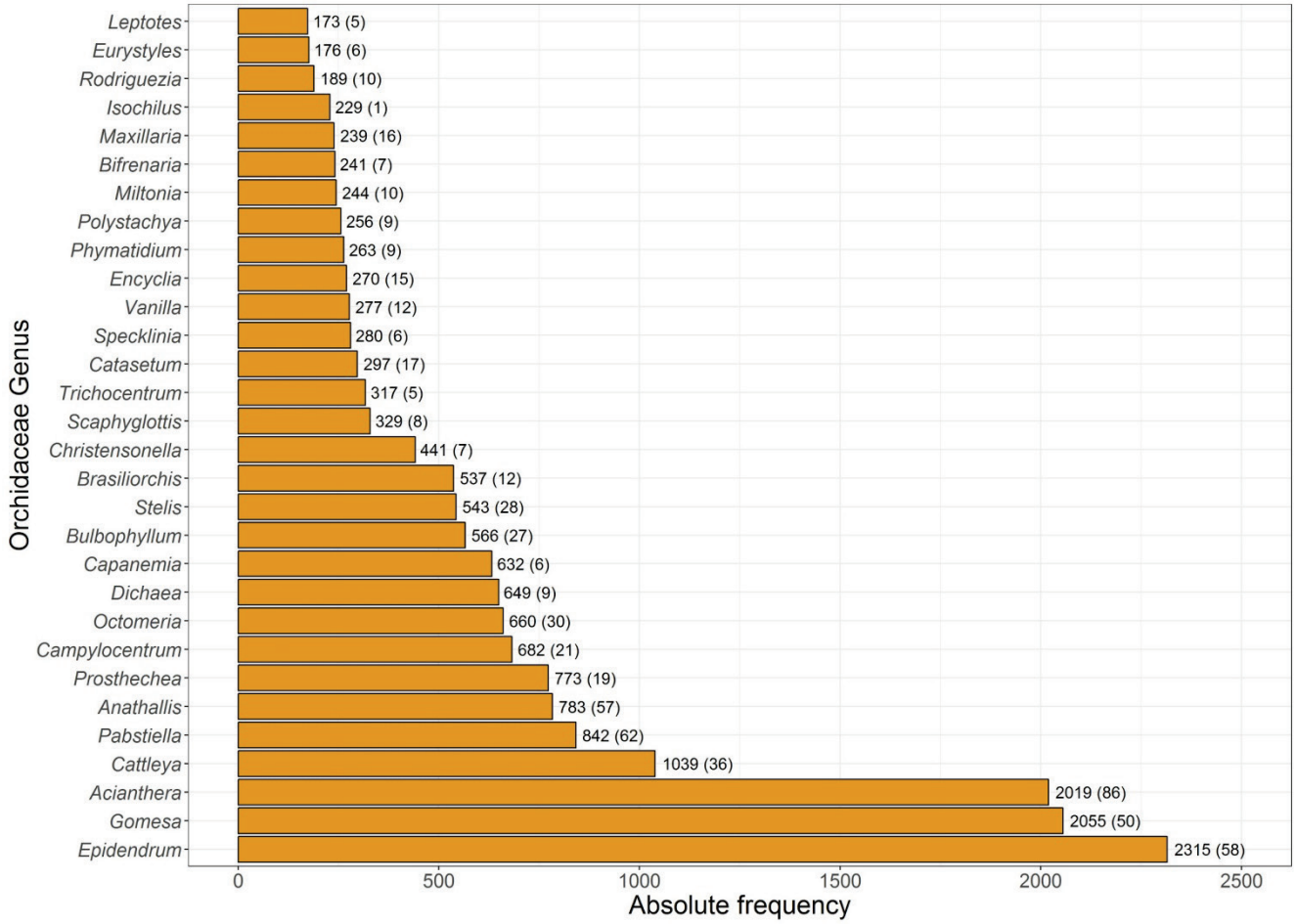

Figure 8: Frequency of records (and number of species) of the 30 Orchidaceae (Angiosperms) genera with the greatest number of epiphyte records.

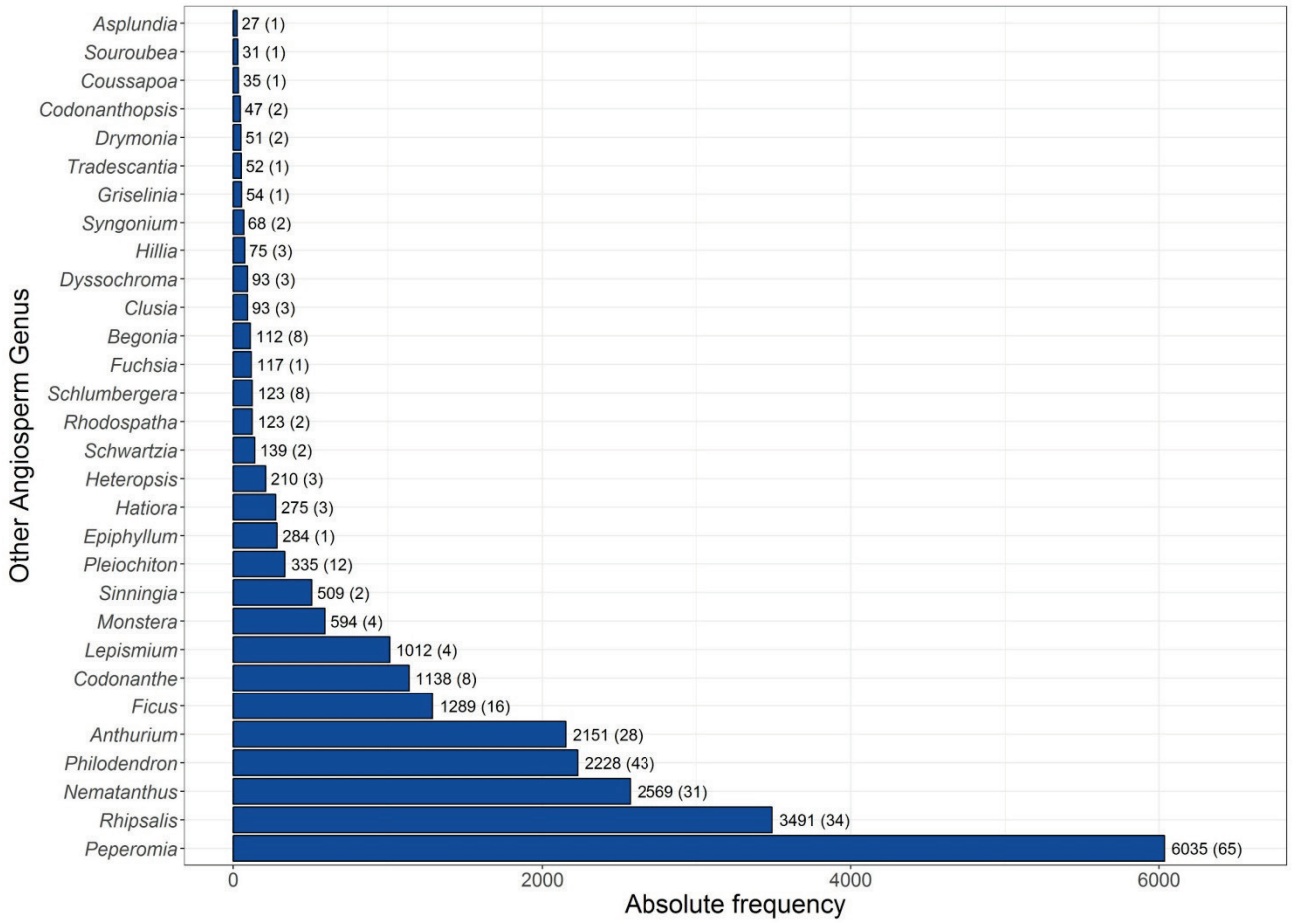

Figure 9: Frequency of records (and number of species) of the 30 genera of other Angiosperm families (i.e., excluding Bromeliaceae and Orchidaceae) with the greatest number of epiphyte records.

Ferns and Lycophytes had fewer records than Angiosperms (Table 1) and were more concentrated in the southern and southeastern regions in Brazil, near the coast. There was also a concentration of sampling sites with presence of species from this group in the Argentinian part of the Atlantic Forest (Figure 10). Polypodiaceae presented most of the records (70.6%) and species (42.2%; Figure 11). Within this fern family, the genera *Pleopeltis* (26%) and *Microgramma* (20%) concentrated most of the records, but *Elaphoglossum* (15%) and *Asplenium* (10.2%) presented greater richness (Figure 12). Among non-vascular plants and Lichens, very few and disjunctive records were included, and they were concentrated in the northeastern Brazilian region (Figure 13). Among these, the Lejeuneaceae (Liverworts) had the highest number of records (27.9%) and species (22.1%) (Figure 14). While genera *Lejeunea* (7.5%) and *Frullania* (6.7%) were those with more records, *Frullania* (4.6%) and *Heterodermia* (4.6%) were those with the greatest number of species (Figure 15).

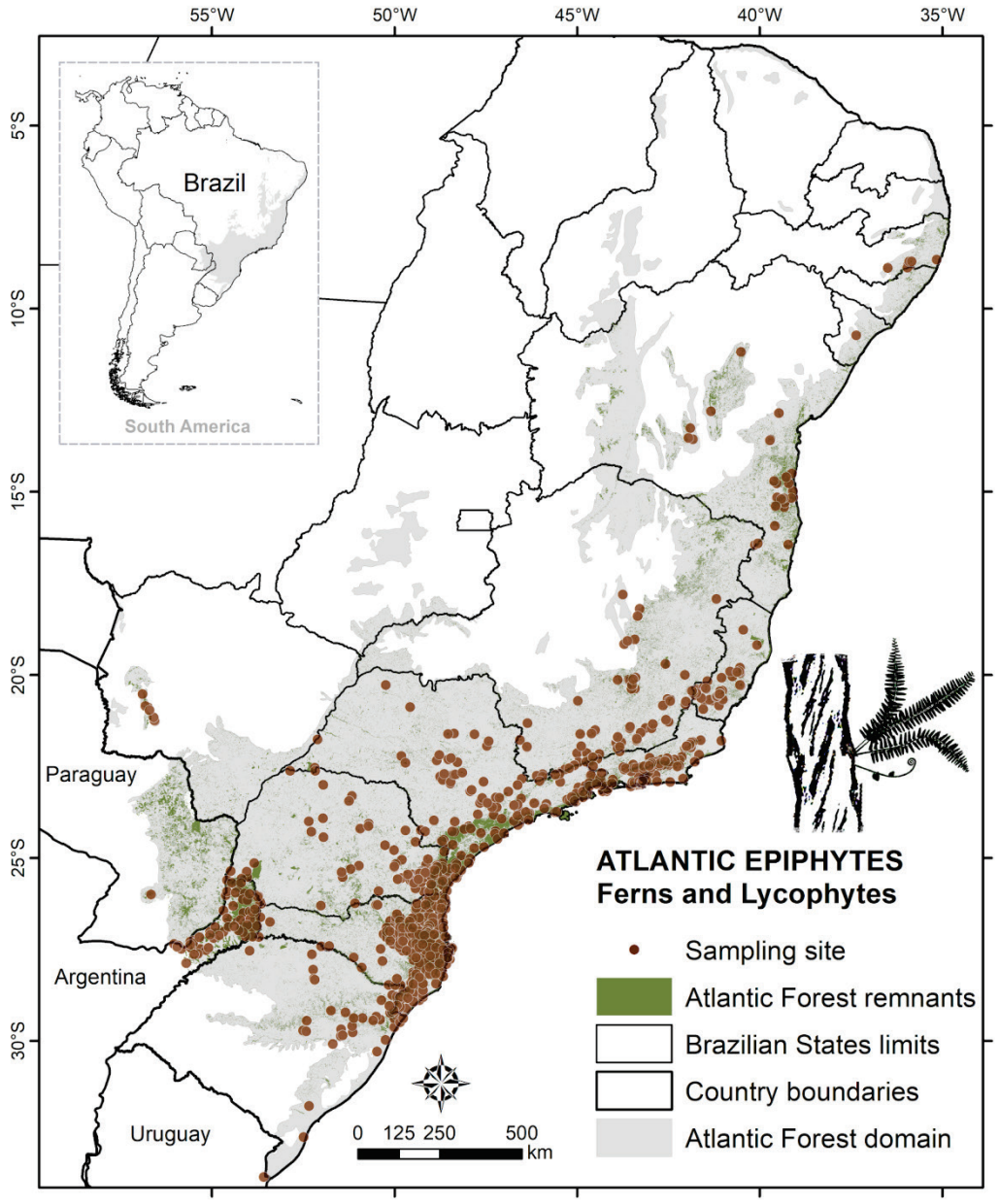

Figure 10: Distribution of epiphyte records of Ferns and Lycophytes in the Atlantic Forest. Atlantic Forest domain and remnants were defined according to Huang et al. (2007) and Ribeiro et al. (2009).

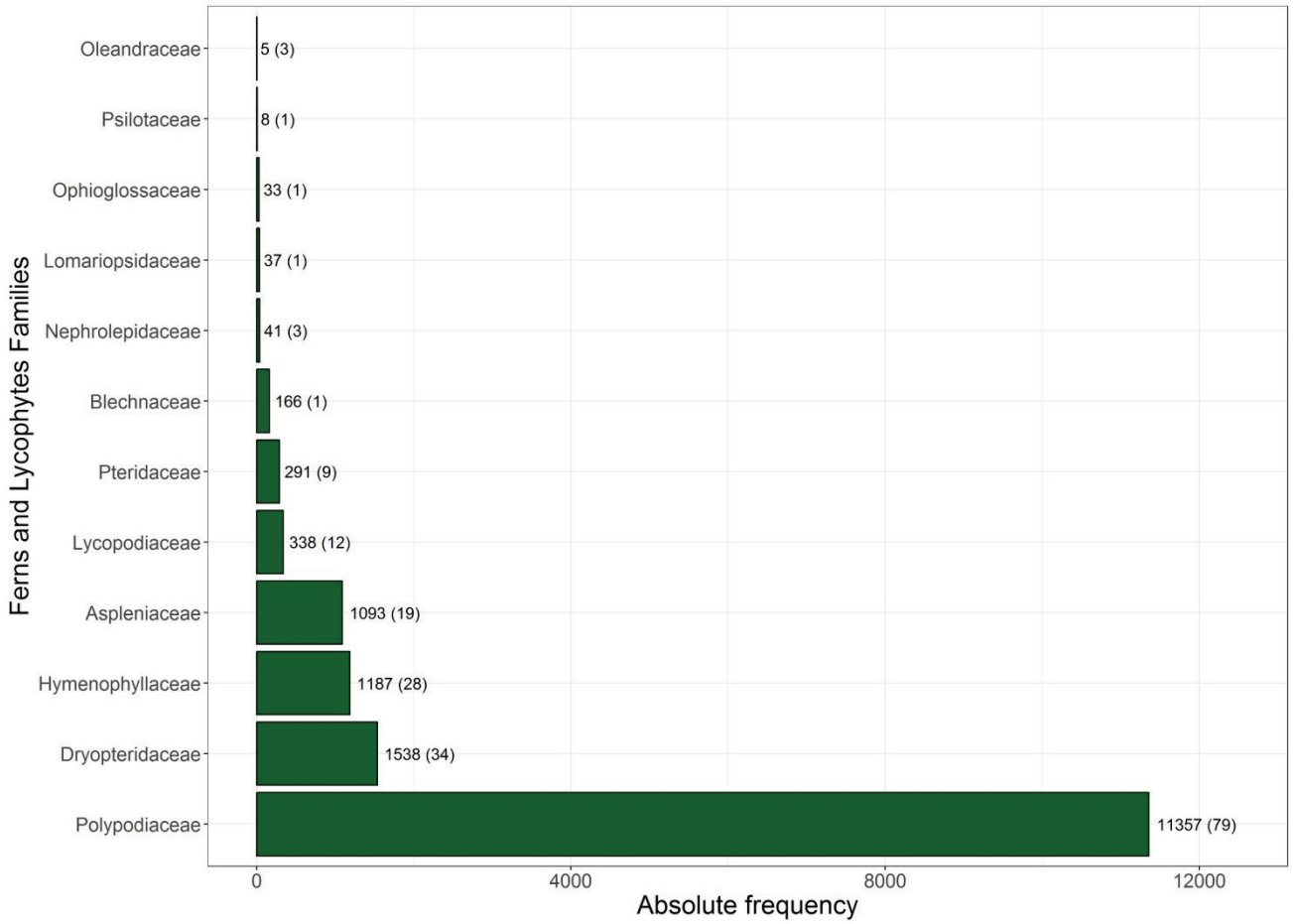

Figure 11: Frequency of records (and number of species) of the 15 Fern and Lycophyte families with the greatest number of epiphyte records.

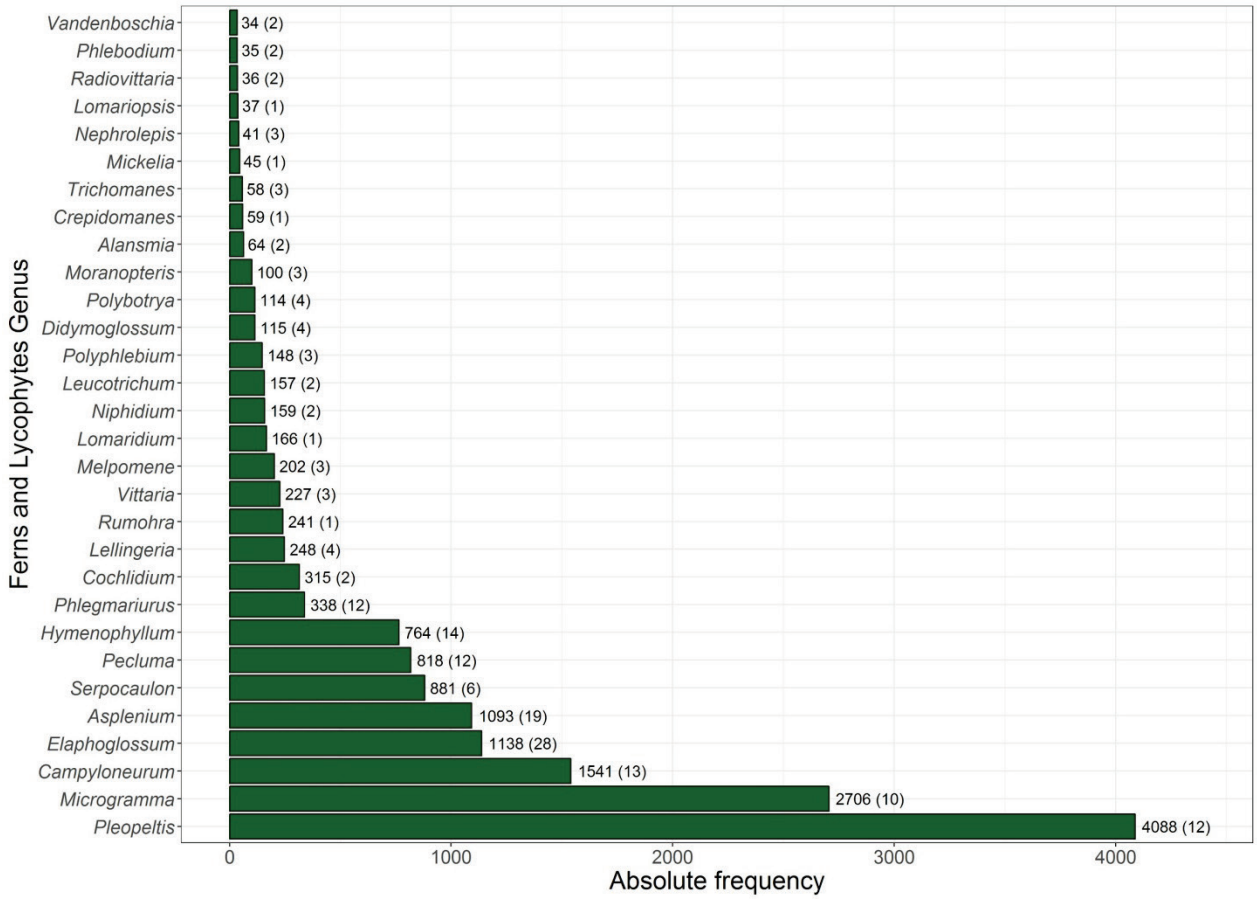

Figure 12: Frequency of records (and number of species) of the 30 Fern and Lycophyte genera with the greatest number of epiphyte records (and species number).

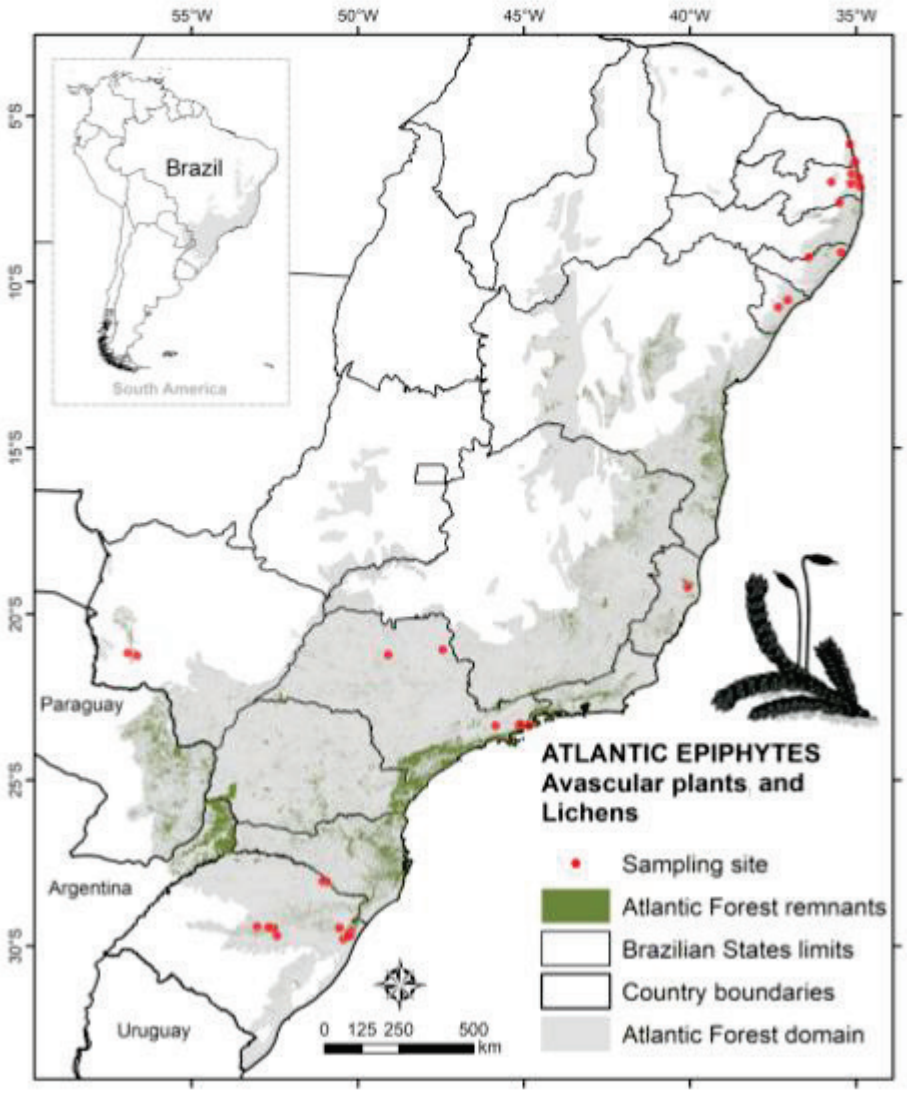

Figure 13: Distribution of epiphyte surveys of non-vascular plants and Lichens in the Atlantic Forest. Atlantic Forest domain and remnants were defined according to Huang et al. (2007) and Ribeiro et al. (2009).

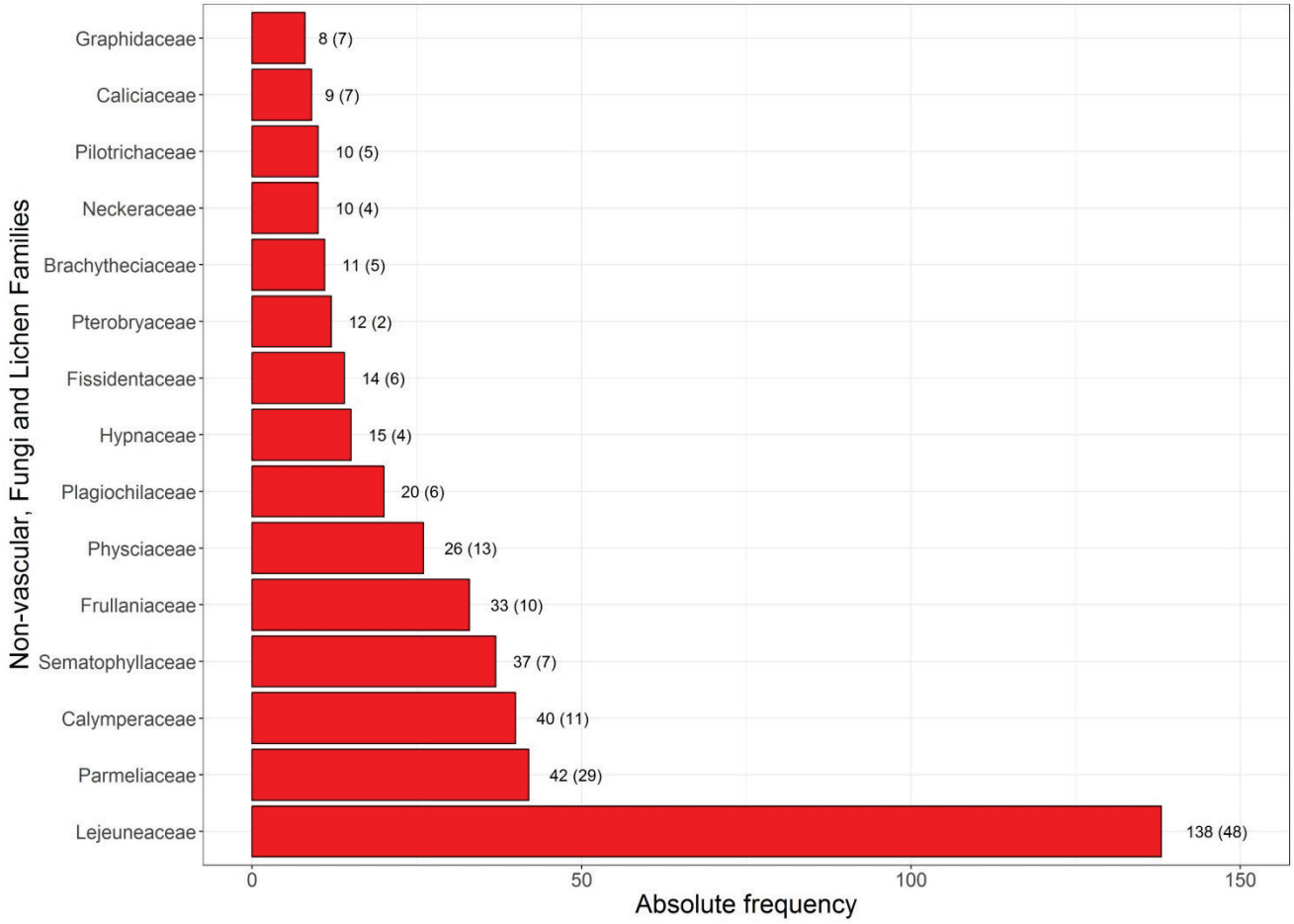

Figure 14: Frequency of records (and number of species) of the 15 non-vascular plants and Lichen families with the greatest number of epiphyte records.

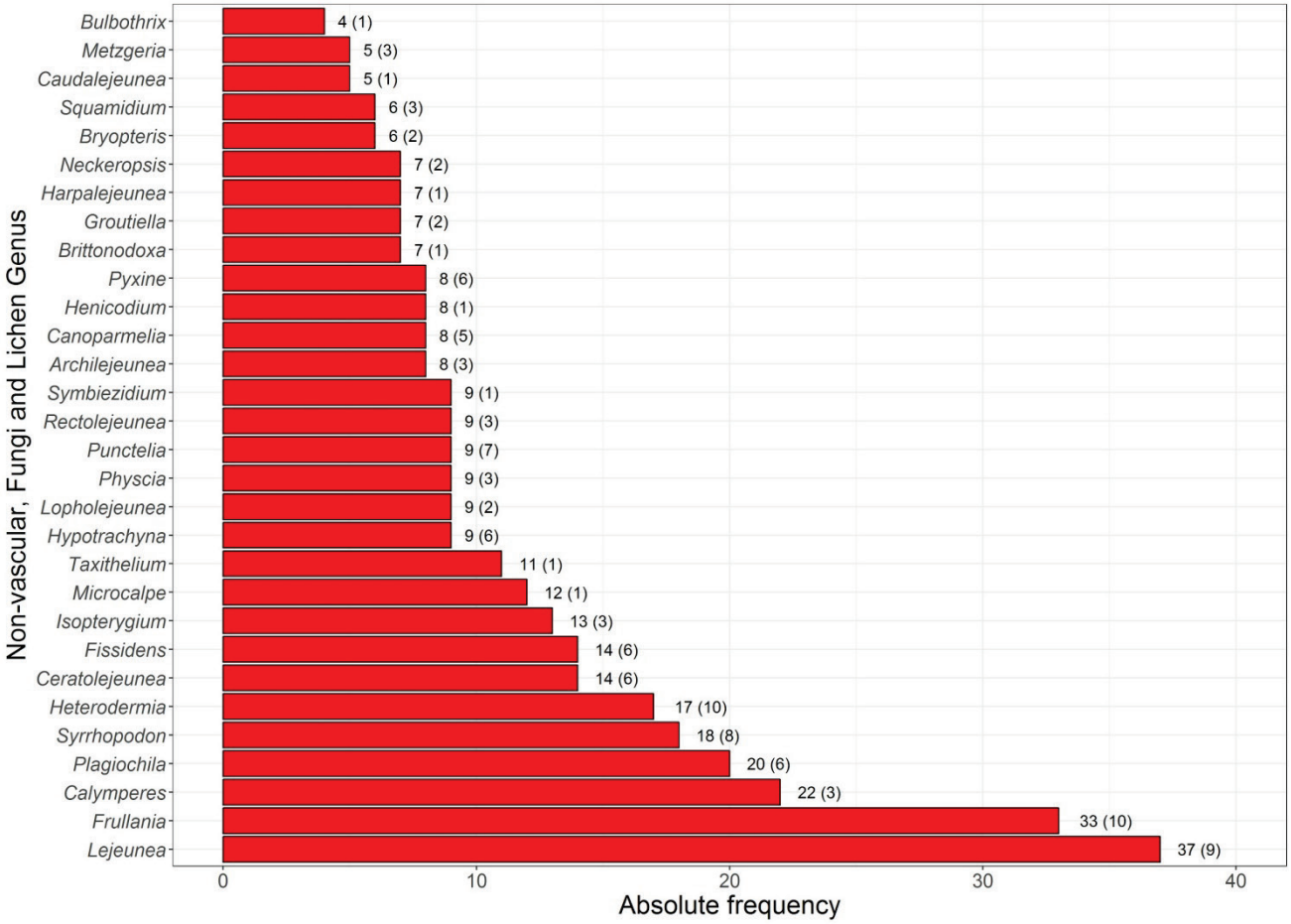

Figure 15: Frequency of records (and number of species) of the 30 non-vascular plants and Lichen genera with the greatest number of epiphyte records.

Epiphyte records can be divided into two main data types: (1) occurrence data, which include presence-only (78%) and presence-absence (10%), and (2) abundance data (12%) (Figure 16). For quantitative studies in which epiphyte abundance was recorded, the most common sample unit was individual trees (64%), followed by plot sampling (24%), and transect sampling (12%). Abundance was quantified by two methods: number of individuals (99% of abundance data) and coverage (1%). All data compiled in our data set came from three main sources: herbarium data, published sources (which comprised peer-reviewed articles, books and theses), and unpublished data (i.e. provided exclusively by the authors). Published data added up to 150 references (see in section II.B.4. Research Methods) being mostly from peer-reviewed articles (71%), followed by theses (24%), and books (5%).

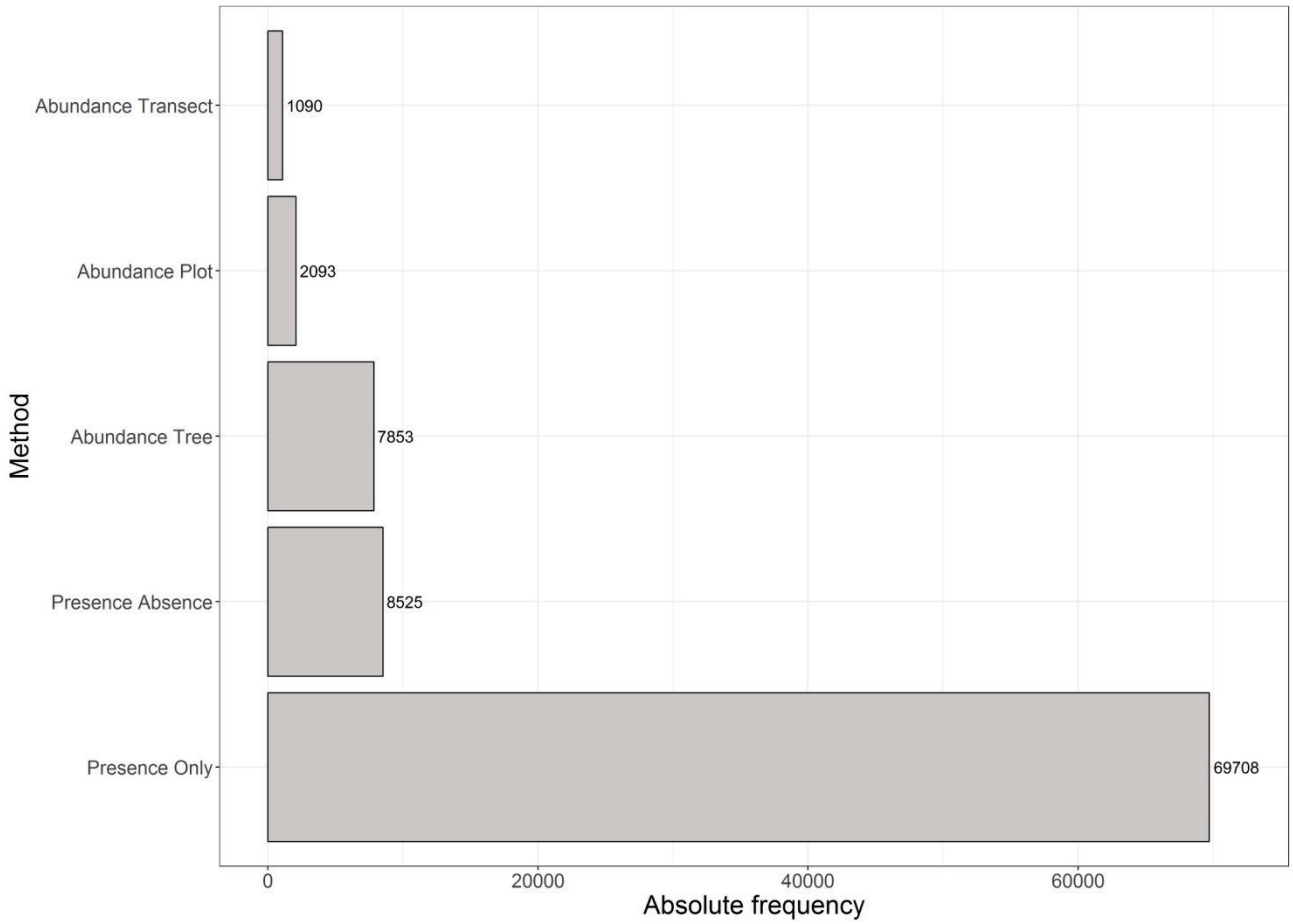

Figure 16: Number of epiphyte records of each data type and sampling method.

Among all 2,095 epiphyte species recorded here, the most frequent in the data set were: *Microgramma squamulosa* (Polypodiaceae, Ferns, 2.1% of the total number of records), *Tillandsia recurvata* (Bromeliaceae, Angiosperms, 2%), *Pleopeltis hirsutissima* (Polypodiaceae, Ferns, 1.7%), and *Tillandsia stricta* (Bromeliaceae, Angiosperms, 1.3%). We had 361 (17%) species with a single record in the data set, with those species being from all groups except Lycophytes. The subset of records in which researchers quantified abundance (12% of the total) encompassed 108,527 individuals of 448 species. Most abundant species in terms of number of individuals were: *Pleopeltis pleopeltidis* (Polypodiaceae, Ferns, 22% of the total number of individuals), *Microgramma squamulosa* (Polypodiaceae, Ferns, 13%), *Campyloneurum austrobrasilianum* (Polypodiaceae, Ferns, 5.5%), *Tillandsia stricta* (Bromeliaceae, Angiosperms, 2.5%), *Pleopeltis hirsutissima* (Polypodiaceae, Ferns, 2.4%) and *Pabstiella varellae* (Orchidaceae, Angiosperms, 2.1%). For the subset of records with abundance data, 35 species had only one individual.

Only 17% of the records (15,686) in our data base contain information on phorophyte identity, counting 410 species. The richest phorophyte families were Myrtaceae (14%), Fabaceae (10%), and Lauraceae (6%), which are amongst the dominant, species-rich families in the Atlantic

Forest (Stehmann et al. 2009). Most frequent phorophyte species were: *Guapira opposita* (Nyctaginaceae, 10.5%), *Podocarpus lambertii* (Podocarpaceae, 7%), *Gymnanthes klotzschiana* (Euphorbiaceae, 4.5%), and *Eugenia nutans* (Myrtaceae, 3.5%).

The oldest record of epiphyte in our dataset is from 1824, a species of Gesneriaceae, *Codonanthe cordifolia*, collected in Rio de Janeiro, RJ, Brazil. However, the majority of our records date from 1980 to 2018 (Figure 17). Before 1997, epiphyte studies were very scarce and most of the data (32%) are from 2014 to 2018.

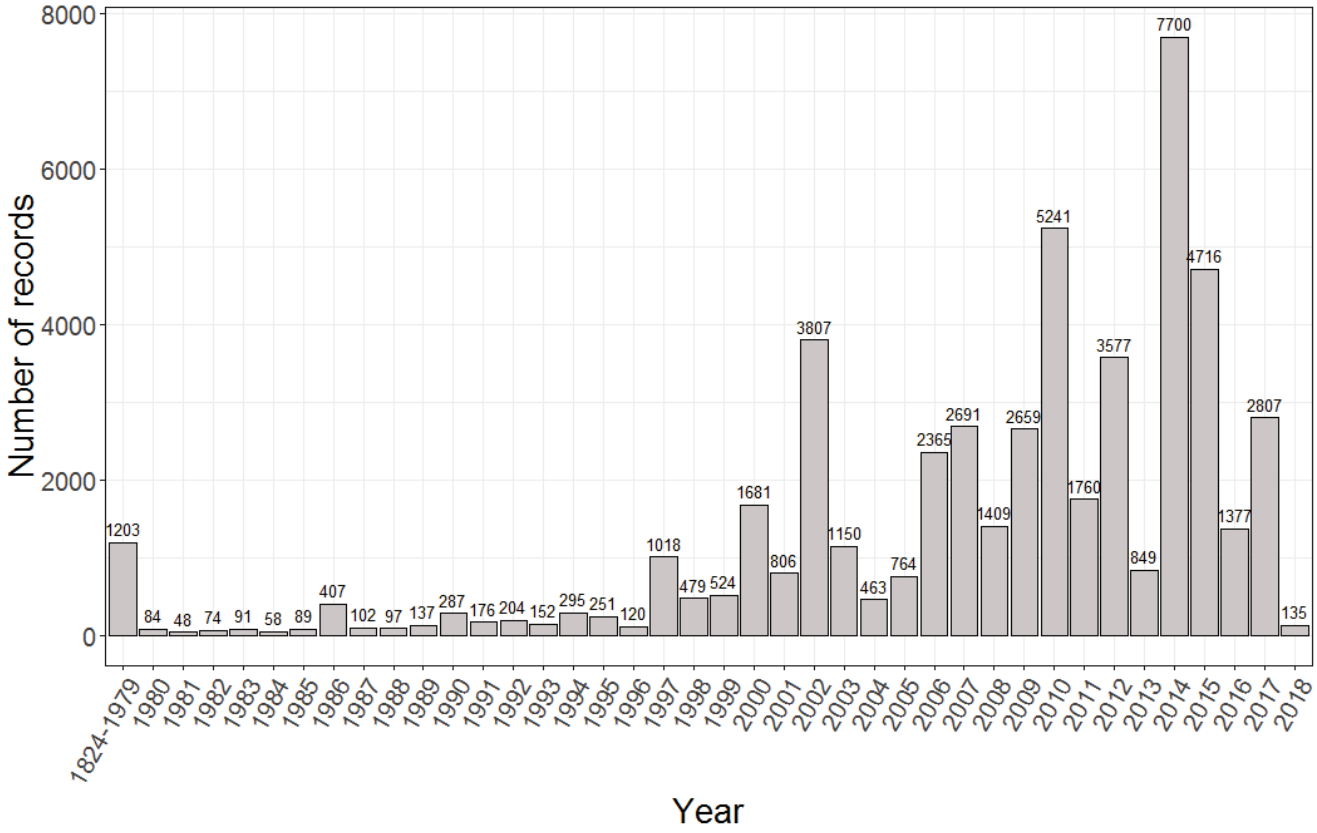

Figure 17: Number of epiphyte records per year from 1824 to 2018.

For each record in our data base, we extracted environmental variables from the WorldClim data base 1.4 (http://www.worldclim.org/version1). Annual precipitation in the record sites ranged from 375 to 3,719 mm/year with most records between 1,300 and 1,700 mm (Figure 18). Annual mean temperature varied from 11.5 to 27.7 °C with few sampling localities under 20°C (Figure 19). Epiphyte records ranged from sea level to 2,200 m a.s.l., with most records between sea level and 1,000 m a.s.l., with a decreasing trend of records as altitude increases (Figure 20).

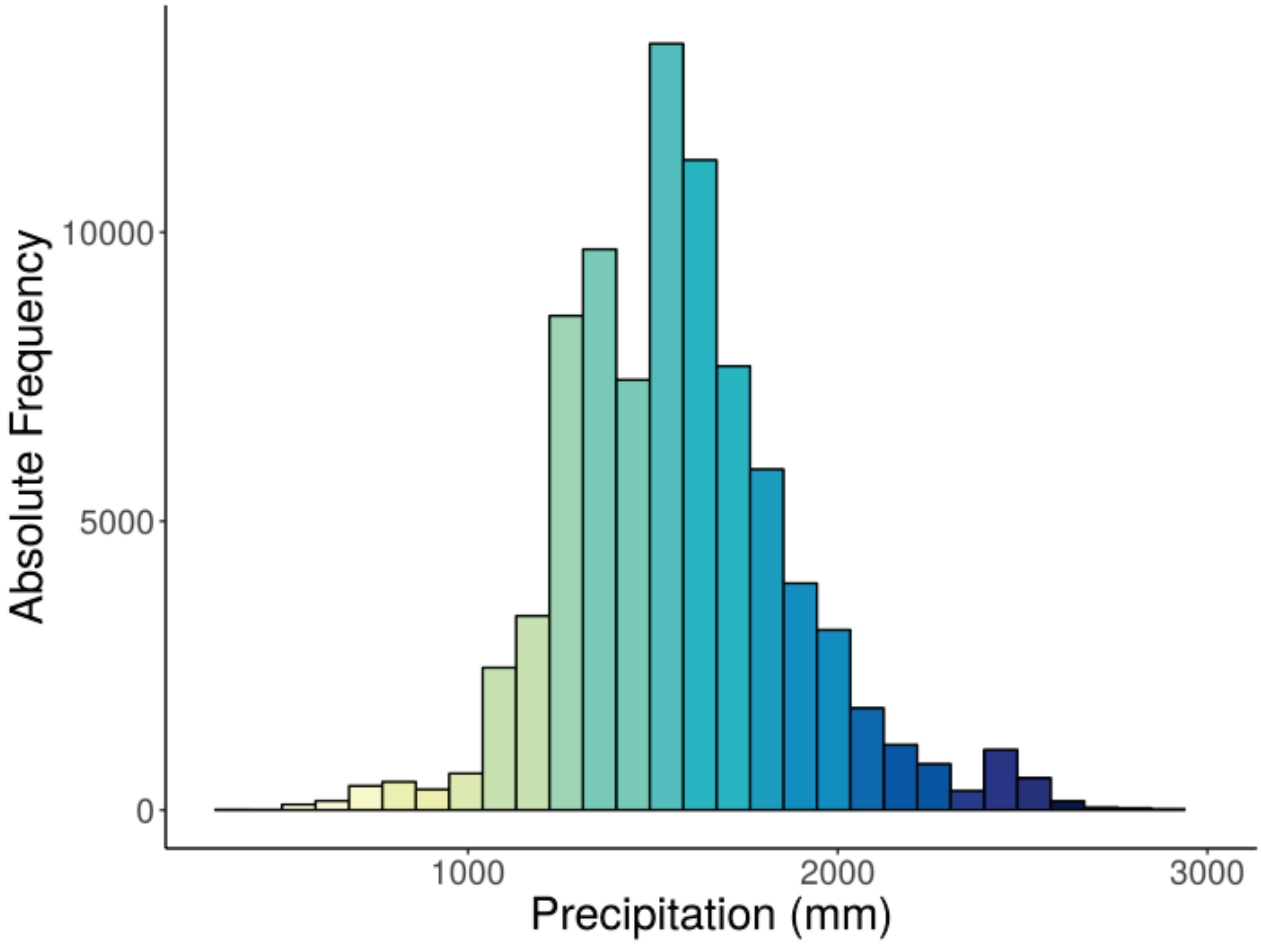

Figure 18: Frequency of precipitation values from each epiphyte record from the Atlantic Forest.

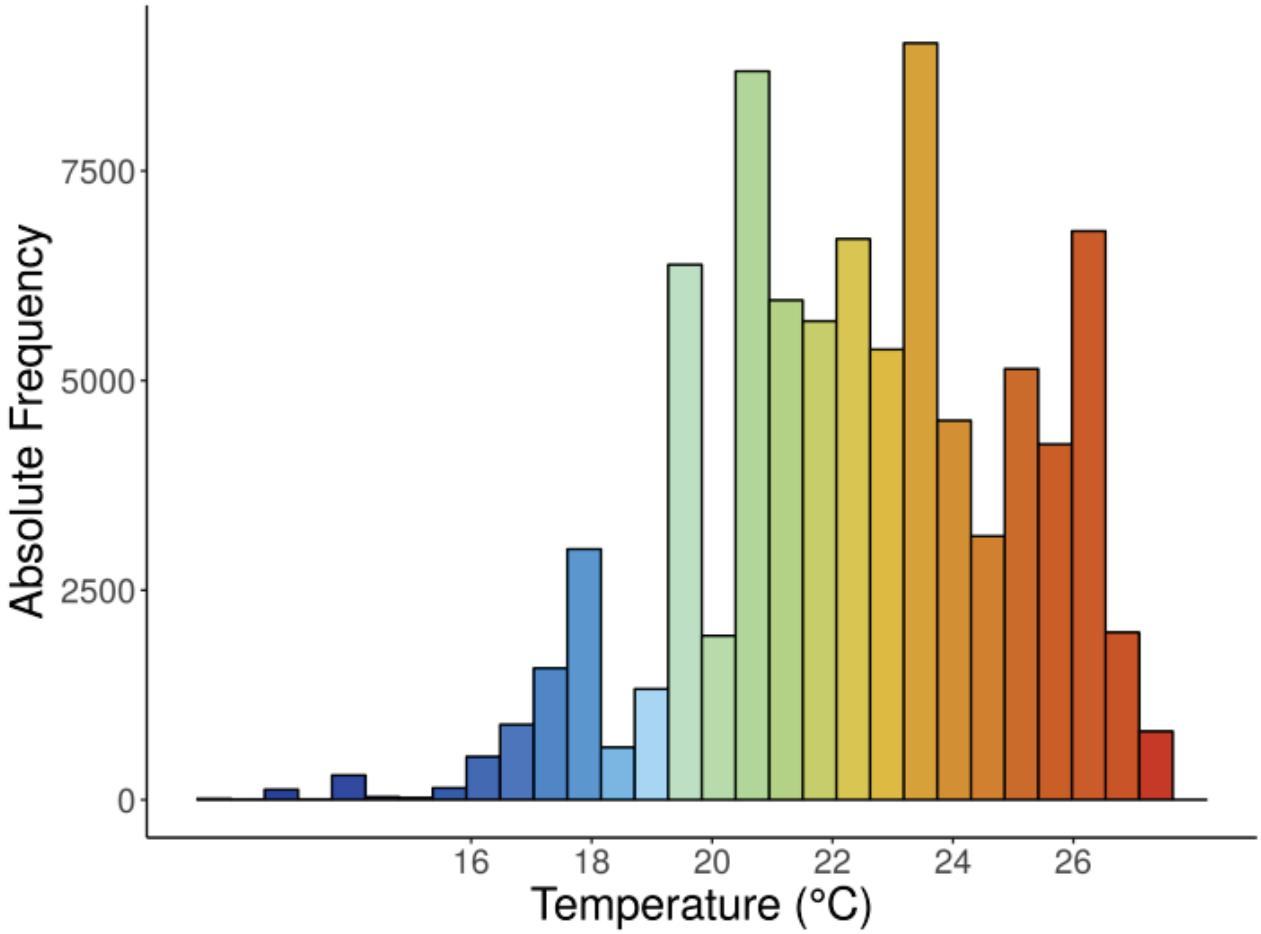

Figure 19: Frequency of temperature values from each epiphyte record from the Atlantic Forest.

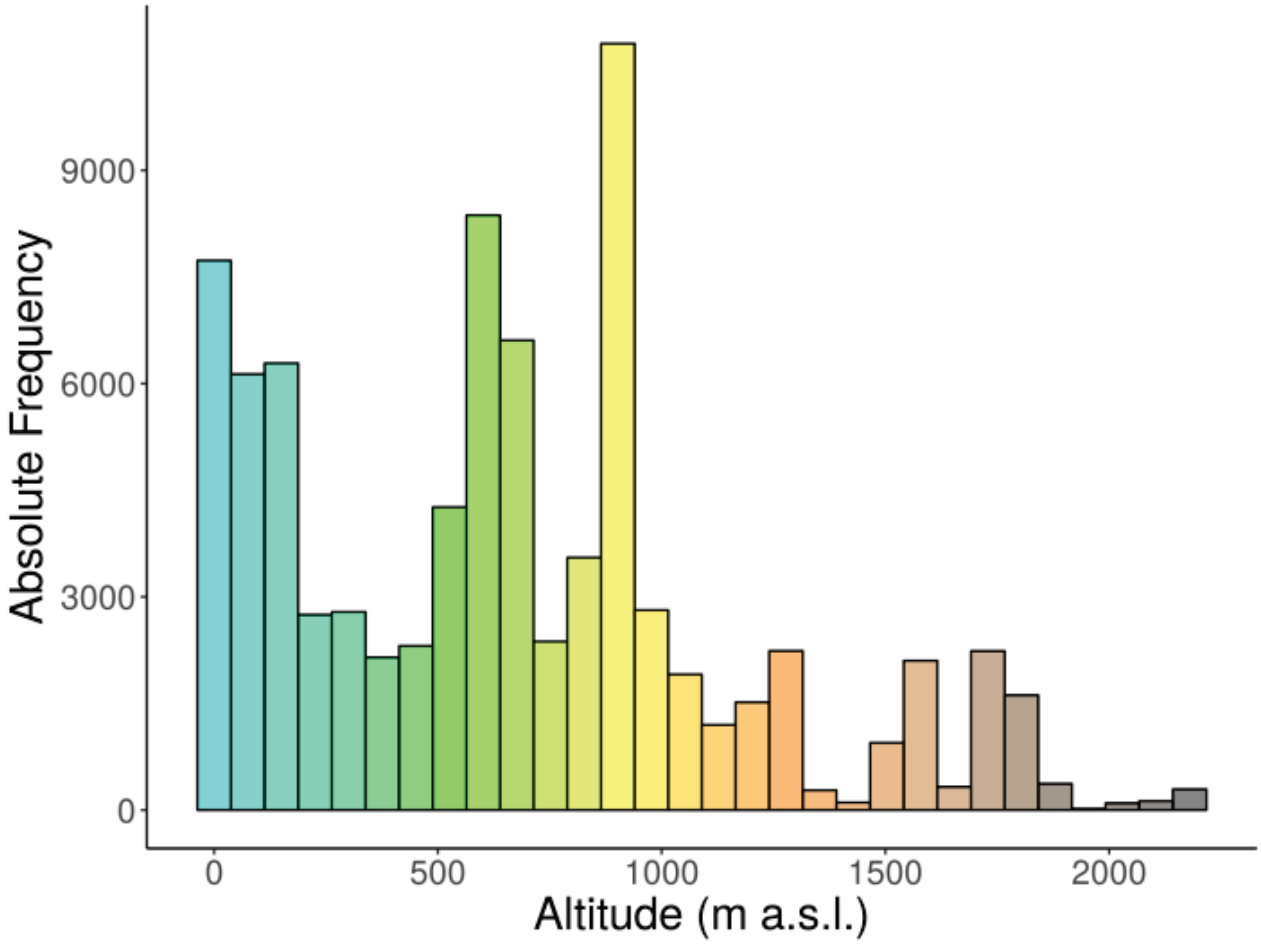

Figure 20: Frequency of altitude values (m a.s.l.) from each epiphyte record of the Atlantic Forest.

CLASS II. RESEARCH ORIGIN DESCRIPTORS

II.A. Overall project description:

II.A.1. Identity: A compilation of data on holo/hemiepiphyte occurrence and abundance sampled in the Atlantic Forest of South America.

II.A.2. Period of study: Study ranged from 1824 to 2018.

II.A.3. Objectives: We aimed to (1) compile an extensive Atlantic Forest data set on vascular, non-vascular, and Lichen epiphyte and hemiepiphyte species from occurrence and abundance available including data from published studies, gray literature and herbarium records; (2) describe the epiphyte distribution in the Atlantic Forest, in order to indicate future sampling efforts. Our work comprises the first epiphyte data set with information on abundance and occurrence of epiphyte phorophytes.

II.A.4. Abstract: Same as above.

II.A.5. Sources of funding:

The compilation of this dataset was supported by the Agencia Nacional de Investigación e Innovación (ANII), Agencia Nacional de Promoción Científica y Tecnológica (AGENCIA), Centro Nacional de Conservação da Flora (CNCFlora), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Consejo Superior de Investigaciones Científicas (CSIC), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ), Fundação de Amparo ao Ensino e Pesquisa (FAEP), Fundação de Amparo à Pesquisa do Estado da Bahia (FAPESB), Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG), Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC), Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT), Fundação Grupo Boticário de Proteção à Natureza, Pontifícia Universidade Católica do Paraná (PUCPR) and Universidad Nacional de La Plata (UNLP).

II.B.1. Specific subproject description:

II.B.2. Site description: The Atlantic Forest is the second largest tropical rainforest domain in South America with an original area of 150 million ha. It occurs over wide latitudinal (more than 27 degrees), altitudinal (0 - 2,800 m a.s.l.) and yearly rainfall (1,000 to 4,000 mm) ranges. The Atlantic Forest, therefore, includes a wide heterogeneity of habitats (Oliveira-Filho and Fontes 2000), with several vegetation types (such as forests, shrublands, marshes, mangroves and natural grassland) across environmental gradients (Oliveira-Filho et al. 2005). Coastal areas of the Atlantic Forest receives as much as 4,000 mm of rainfall over the year (Câmara 2003), and into the interior these forests receives less rainfall concentrated in only one season (~1,000 mm/year).

II.B.3. Data compilation:

We searched for any scientific literature, articles and gray literature publications (theses, reports, etc.) with epiphyte information from a wide search in online academic data bases (ISI Web of Knowledge, Scopus, Scielo, Scholar Google, and Research Gate). For the search, we used keywords in English [Epiphytes, Holoepiphytes, Hemiepiphytes, Accidental Epiphytes, Casual Epiphytes, Lichens, Bryophytes, Ferns, Lycophytes, Angiosperm, Atlantic Forest], combined in different ways, and their Portuguese translation. We then requested the data from the authors of those studies. Also, we invited authors from other studies not included in our original search that were recommended by the specialists. Therefore, our data set was obtained from (i) primary literature: peer-reviewed articles search, (ii) secondary (gray) literature search: theses, reports, etc., and (iii) indications from authors.

II.B.4. Research Methods:

We included records of vascular and non-vascular plants, and Lichen epiphytic species sampled in the Atlantic Forest of South America, regardless of sampling methods. We adopted species names validated by the Brazilian Flora 2020 and Mycobank. In order to standardize taxonomic names of epiphyte and phorophyte species we used "flora" (Carvalho 2017) and "taxize" (Chamberlain and Szocs 2013) packages in R environment (R Core Team 2018). After that, some of the specialists (Menini Neto L., Kersten R., Amorim A.M., Matos F.B, Freitas L., Nunes-Freitas A.F.) checked all species records in the dataset for nomenclatural and other inconsistencies. We included in the data base all holoepiphyte, primary hemiepiphyte (*sensu* Zotz 2013) and facultative epiphyte species. We excluded species classified as accidental epiphytes, alien, hybrids, lianas and vines, and those species that did not have an accepted taxonomic name (11,002 records). The boundary between facultative and accidental epiphytes are difficult to define, but we considered three characteristics: (i) occurrence in other substrate than trees, such as rocks and soil; (ii) the frequency of occurrence in tree trunks; (iii) the chance of the adult to survive and reproduce on tree trunks. Facultative epiphytes were defined as those that can occur in soil or rocks, but are more frequently found on tree trunks and can grow and reproduce as epiphytic species. Accidental epiphytes were defined as those that can occur on tree trunks but are more frequently found on other substrates and cannot reproduce as epiphytes (Zotz 2016). Classification of species into facultative and accidental categories was made by the team of epiphyte specialists. Specimens identified only to supra-specific levels (i.e., sp.) were excluded from our descriptive analyses (3,054 records), but we have maintained them in the final data set file, making them available to researchers for future investigations. Names of non-native phorophyte species were verified in The Plant List, Tropicos and SpeciesLink websites, and later checked by a specialist (Amorim, A.M). We maintained the non-native phorophyte species in the final data set file. In summary, a record, that was the unit base from data base, was a particular species recorded in a particular site, at any time. If there were several studies of epiphytes in the same area, there were several records of the same species altogether in one area.

For the records with no spatial coordinates, we used specific locations (such as municipality or protected area) described by authors. To define the Atlantic Forest boundaries we merged available geographic information from widely used limits: Atlantic Forest Law website (MMA 2006), World Wildlife Fund (WWF; Olson et al. 2001) and Ribeiro et al. (2009). Records that fell outside of the Atlantic Forest boundaries were excluded from our analyses and figure maps but maintained and identified in the data set file.

We organized all the data in one data base containing occurrence data (presence-absence and presence-only records) and abundance data (number of individuals, stands and coverage). We used the following literature to compile these records: Adenesky Filho et al.

(2013), Aguiar et al. (1981), Alberti and Zanin (2008), Alcantara et al. (2006), Almeida (2009), Almeida et al. (2010), Almeida et al. (2013), Alves (1997), Alves et al. (2000), Alvim (2016), Amorim et al. (2009), Araújo (1996), Araujo (2016), Araújo et al. (2004), Ariati and Kersten (2011), Azevedo (2010), Barbosa et al. (2015), Barbosa (2017), Bataghin (2013), Bataghin et al. (2008), Bataghin et al. (2017), Becker et al. (2013), Bianchi and Kersten (2014), Bianchi et al. (2012), Biganzoli and De Romero (2004), Blum (2010), Blum et al. (2011), Boelter et al. (2011), Bonin Jr. and Kersten (2016), Bonin Jr. and Kersten (2017), Bonnet et al. (2013), Borgo et al. (2002), Breier (2005), Britez et al. (1995), Buzato et al. (2000), Buzatto et al. (2007), Buzatto and Machado (2011), Buzatto et al. (2008), Buzatto et al. (2010), Camargo et al. (2002), Canela and Sazima (2003), Canêz and Marcelli (2007), Canêz and Marcelli (2010), Canêz et al. (2009), Carvalho (2017), Cecconello and Zanin (2004), Cervi and Borgo (2007), Cervi et al. (2007), Citadini-Zanette (1995), Coelho (2011), Coelho and Amorim (2014), Coelho et al. (2014), Costa et al. (2009), Costa et al. (2012), Costa (2017), Couto (2013), Couto et al. (2016a, 2016b), Couto et al. (2017), Cruz (2017), Devens et al. (2016), di Pasquo et al. (2016), Dias (2009), Dislich and Mantovani (1998), Dislich and Mantovani (2016), Dittrich et al. (1999), Dornelas (2016), Falkenberg (2003), Faxina et al. (2015), Ferreira (2011), Fischer and Araujo (1995), Fischer and Araújo (1996), Fontoura et al. (1997), Fontoura et al. (2009), Francisco (2017), Furtado (2016), Furtado and Menini Neto (2015a, 2015b), Furtado and Menini Neto (2016), Ganem et al. (2013), Geraldino et al. (2010), Giongo and Waechter (2004), Goetze et al. (2016a, 2016b), Goetze et al. (2017), Gomes-da-Silva and Costa (2011), Gomes-da-Silva (2013), Gonçalves and Waechter (2002), Gonçalves and Waechter (2003), Gonzaga (2016), Gonzaga et al. (2017), Guaraldo (2009), Guaraldo et al. (2013), Guimarães et al. (2008), Hefler and Faustioni (2004), Hekavey (2013), Hertel (1950), Höfling and Camargo (1999), Jungbluth and Marcelli (2011), Jungbluth et al. (2011), Kaehler et al. (2005), Käffer et al. (2015), Keller and Tressens (2005), Kersten (2006), Kersten and Kuniyoshi (2009), Kersten and Rios (2013), Kersten and Silva (2001), Kersten and Silva (2002), Kersten and Silva (2005), Kersten and Silva (2006), Kersten and Waechter (2011), Kersten et al. (2009), Kessous and Costa (2017), Kessous et al. (2018), Koch et al. (2012), Koch et al. (2013), Koch et al. (2016), Labiak et al. (2017), Leitman et al. (2015), Leme (1999), Leme (2002), Lenzi et al. (2006), Liboni (2018), Lopes (2002), Machado and Semir (2006), Mai et al. (2016), Mania and Monteiro (2010), Marcelli and Canêz (2008), Marquez and Yañez (2012), Márquez et al. (2006), Martins (2017a, 2017b), Martínez et al. (2016), Matos and Mickel (2014), Matos and Mickel (2018), Matos et al. (2010), Mazziero and Nonato (2015), Mazziero et al. (2015), Mendes (2017), Menini Neto et al. (2016), Mesacasa (2017), Meza Torres et al. (2006), Meza Torres et al. (2008), Monalisa-Francisco (2017), Moreira (2016), Moura (2011), Muñoz et al. (2017), Nervo (2016), Nervo et al. (2016), Nunes-Freitas (2004), Padilha et al. (2015), Pereira et al. (2009), Petean (2003), Petean (2009), Piacentini and Varassin (2007), Pincheira-Ulbrich et al. (2012), Pincheira-Ulbrich et al. (2016), Reis and Fontoura (2009), Ribeiro (2009), Rocca-de-

Andrade (2006), Rodrigues et al. (2014), Rogalski (2002), Rogalski and Zanin (2003), Rosanelli (2007), Santos (2008), Sazima and Sazima (1999), Sazima et al. (1995), Schutz-Gatti (2000), Silva and Pôrto (2013), Silva and Pôrto (2015), Siqueira Filho (1998), Siqueira Filho and Leme (2006), Siqueira Filho and Machado (2001), Smith and Downs (1977), Snow and Snow (1986), Sota and Morbelli (1985), Spielmann and Marcelli (2008a, 2008b, 2008c), Staudt et al. (2012), Tressens et al. (2008), Valebella and Sager (2010), Varassin (2002), Varassin and Sazima (2012), Vasconcelos (2017), Vidal (2013), Vieira (2009), Waechter (1986), Waechter (1992), Waechter (1998), Wolowski et al. (2013), Yañez et al. (2011), Zandoná and Catharino (2015), Zanella (2013), Zanella et al. (2016), Zanotti et al. (2012) and Zorzanelli et al. (2017).

II.C. Data limitations and potential enhancements:

Epiphyte vascular and non-vascular plants and Lichens are the most diverse groups among those compiled in the ATLANTIC series until now, and presenting information of all species in a single document was very challenging for us. In this section, we list four main limitations of our data set regarding diversity of taxonomic groups, occurrence vs. abundance data, epiphyte classification, data duplicity and taxonomic uncertainty. We strongly recommend researchers using our data set to take these limitations into account. First, different methods are applied to sampling epiphyte communities of very distinct taxonomic groups. Each sampling method presents its pros and cons, imposing biases in the results of the surveys. Some taxonomic groups, such as Angiosperms, have been historically more extensively studied than Ferns, Lycophytes, non-vascular plants (Mosses and Liverworts), and Lichens. Our work represents an initial effort to highlight information gaps on epiphyte distribution across the Atlantic Forest. Efforts to increase our knowledge about the biology and environment requirements of epiphytes are also essential to conserve and restore threatened populations in the Atlantic Forest.

Second, most surveys included in our data set comprise information on species occurrence which is useful to diversity and biogeographical studies; however, it limits the studies under community and metacommunity approaches that require abundance data. Quantifying abundance of epiphytic specimens can be hard to do in the field and methods to quantify abundance can vary from group to group. For instance, counting of individuals or estimation of plant cover are common methods to quantify abundance of Angiosperms; however ferns are often sampled in terms of number of ramets. In addition, number of individuals is quantified either as number of ramets or number of stands, which makes it difficult to standardize abundance data. It is worth mentioning that most epiphyte sampling is restricted to the understory, where researchers can gain access, while tree canopies are usually under sampled. Finally, data on species occurrence are often easy to compile and standardize; hence, we believe some authors may have chosen to make available only occurrence data, even though they had quantitative data. This data set is the first effort to compile quantitative data on epiphyte abundance and can

support community studies in a regional scale.

Third, we recognize that data duplicity can occur within our data set. The same records can be included both from herbarium data as well as from data of published surveys. Fourth, although we put a lot of effort into standardizing species names and excluding non-epiphytic species as well as taxonomic names not validated, we recognize that we compiled data from surveys with different levels of taxonomic certainty. Fifth, the distinction between primary and secondary hemiepiphyte species (*sensu* Zotz 2013), as well as between holo- and facultative epiphyte species is difficult to make, since there is not sufficient information about all the species. Therefore, the classification of some species in this data base was non-consensual among specialists. We preferred to be more inclusive and let the user of the data base include or exclude them depending of their study aims.

CLASS III. DATA SET STATUS AND ACCESSIBILITY

III.A. Status

III.A.1. Latest update: August 2018

III.A.2. Latest archive date: August 2018

III.A.3. Metadata status: Last updated August 2018, version submitted

III.A.4. Data verification: We excluded species classified as accidentals, aliens, hybrids, lianas and vines, and those species that have not been taxonomically corrected according to Flora do Brasil 2020 and MycoBank (11,002 records). Specimens identified only to supra-specific levels (i.e., sp. - 3,054 records) were excluded from both descriptive analyses and final data set file. To verify valid names of native phorophyte species we followed species names listed in Flora do Brasil 2020, but we have decided to maintain alien species and supra-specific records.

III.B. Accessibility:

III.B.1. Contact person(s): Flavio Nunes Ramos (fnramos@gmail.com) or Milton Cezar Ribeiro (miltinho.astronauta@gmail.com).

III.B.2. Copyright restrictions: None

III.B.3. Proprietary restrictions: Please cite this Ecology Data Paper if the data are used in publications and teaching events.

III.B.4. Storage locations: The original data set is available at Ecology Repository. The updated version and additional information can be accessed on the ATLANTIC SERIES GitHub Inc. repository https://github.com/LEEClab/Atlantic_series.

III.B.5. Costs: None

CLASS IV. Data structural descriptors:

IV.A. Data set file

IV.A.1. Identity:

(1) ATLANTIC_EPIPHYTES_Abundance.csv

(2) ATLANTIC_EPIPHYTES_Occurrence.csv

(3) ATLANTIC_EPIPHYTES_References.csv

IV.A.2. Size:

(1) ATLANTIC_EPIPHYTES_Abundance.csv, 3.86 MB

(2) ATLANTIC_EPIPHYTES_Occurrence.csv, 26.6 MB

(3) ATLANTIC_EPIPHYTES_References.csv, 57 KB

IV.A.3. Format and storage mode: data tables formatted as comma-separated values (*.csv)

IV.A.4. Header information: See column descriptions in section B.

IV.A.5. Alphanumeric attributes: Mixed

IV.A.6. Data anomalies: If no information is available for a cell, this is indicated as 'NA'. In this data set, we have NA values.

IV.B. Variable information

Table 2. Description of the fields related to the file ATLANTIC_EPIPHYTE_Occurrence.csv (all data). Description of the epiphyte data set obtained from (i) article search, (ii) gray literature search, and (iii) indications from authors.

Variables	Description	Levels	Examples
DATASET	Standardized identification of each record from all data sets in which letters represent authors and number represents data set line	Epiphyte data set comprises 89,269 data set IDs	ACGS_00001 GUAR_00200 MENE2_32124
DATASET_ACRONYM	Standardized identification for each data base within our data set	75 acronyms	AAMO KERB MENE
RECORD_ID	Record identification in each data set. Authors were free to use their own identification	Epiphyte data set comprises 89,269 record IDs	E0001
MUNICIPALITY	Sampled municipality	1,980 municipalities	Alfenas

STATE	Sampled state or province	23 states and provinces	MINAS GERAIS MISIONES
STATE_ACRONYM	Acronym for each sampled state or province	23 acronyms for states and provinces	MG N
COUNTRY	Sampled country	4 Countries	Brazil Argentina
ID_CODLOC	Study site identification. Authors were free to use their own identification	2,511 study site identifications	1 P01
HABITAT	Description from the sampled area: forest edge, secondary forest, scattered tree in pasture, riparian forest, urban tree, etc. For a general description of vegetation type see column VEGETATION_TYPE	105 habitat descriptions	Cocoa Plantation Seasonal Forest Secondary Forest Urban Area
LATITUDE_Y	Nearest coordinate from the record	11,016 unique coordinates	-22.436553
LONGITUDE_X	Nearest coordinate from the record	10,022 unique coordinates	-46.1841
PRECISION	Precision of coordinates of each record. If numeric, values are in meters	59 precision descriptions	10 Plot Municipality
REGIONAL_NAME_OF SAMPLED_AREA	Name of study site as known regionally given by authors. Written in Portuguese or English; favored Portuguese for local users. For a general description of vegetation type see column VEGETATION_TYPE	16,985 regional names	Garcias Morro dos Perdidos RPPN Serra Bonita
EPIPHYTE_GROUP	Name of general group to which epiphyte species belong	6 groups	Angiosperms Ferns Liverworts
EPIPHYTE_FAMILY	Name of epiphyte family	79 families	Bromeliaceae
EPIPHYTE_GENUS	Name of epiphyte genus	327 genera	*Tillandsia*
EPIPHYTE_EPITHET	Name of epiphyte epithet	1,719 epithets	*aeranthos*
EPIPYTE_SPECIES	Species name	2,093 species names	*Tillandsia aeranthos*
EPIPHYTE_HABITAT	Classification of epiphyte species into: holoepiphyte, hemiepiphyte and facultative	4 levels	holoepiphyte hemiepiphyte

PHOROPHYTE_FAMILY	Name of phorophyte family	85 phorophyte families	Araucariaceae
PHOROPHYTE_GENUS	Name of phorophyte genus	236 genera	*Araucaria*
PHOROPHYTE_EPITHET	Name of phorophyte epithet	331 epithets	*angustifolia*
PHOROPHYTE_SPECIES	Species name	411 species	*Araucaria angustifolia*
YEAR_START	Year when study began	From 1824 to 2017	2003
YEAR_FINISH	Year when study ended	From 1824 to 2018	2013
DATA_TYPE	Type of epiphyte data sampled:	Presence_only, Presence_absence or Abundance	Presence_only
ALTITUDE	Altitude (m.a.s.l.) values for each record	1,324 unique values	44 915
ANNUAL_RAINFALL	Annual rainfall (mm) for each record	1,617 unique values	1,190 1,806
ANNUAL_TEMPERATURE	Annual temperature (ºC) for each record	146 unique values	23.1 26.7
VEGETATION_TYPE	Vegetation type for each record	4 vegetation types	Ombrophilous Forest Seasonal Forest Savana
ATLANTIC_FOREST_LIMIT	Identify whether the record is inside the Atlantic Forest shapefile or not	Binary	YES or NO
OBS	Observation. Any comments from the authors of the data set		Course of Field Botany 2011 - master's in plant biology.

Table 3: Description of the fields related to the file ATLANTIC_EPIPHYTE_Abundance.csv. This data set is a subset of the data set ATLANTIC_EPIPHYTE_Occurrence.csv which includes only records in which abundance was quantified.

Variables	Description	Levels	Examples
DATASET	Standardized identification of each record from all data sets in which letters represent authors and number represents data set line	Epiphyte data set comprises 11,036 data set IDs	ACLA_00001 CROS_00241
DATASET_ACRONYM	Standardized identification for each data base within our data set	20 acronyms	ACLA BERE
RECORD_ID	Record identification in each data set. Authors were free to use their own identification	Epiphyte data set comprises 89,269 record IDs	E0001
MUNICIPALITY	Sampled municipality	63 municipalities	Alfenas
STATE	Sampled state or province	8 states and provinces	MINAS GERAIS BAHIA
STATE_ACRONYM	Acronym for each sampled state or province	8 acronyms for states and provinces	MG BA
COUNTRY	Sampled country	1 Country	Brazil
ID_CODLOC	Study site identification. Authors were free to use their own identification	295 study site identifications	F01 PA3
HABITAT	Description from sampled area: forest edge, secondary forest, scattered tree in pasture, riparian forest, urban tree, etc. For a general description of vegetation type see column VEGETATION_TYPE	31 habitat descriptions	Urban Area Secondary Forest
LATITUDE_Y	Nearest coordinate from the record	381 unique coordinates	-22.2491
LONGITUDE_X	Nearest coordinate from the record	395 unique coordinates	-47.82413

PRECISION	Precision of coordinates of each record. If numeric, values are in meters	59 precision descriptions	10 Sampled tree
REGIONAL_NAME_OF STUDY_SITE	Name of study site as known regionally given by the authors. Written in Portuguese or English, focused local users. For a general description of vegetation type see column VEGETATION_TYPE	117 regional names	RPPN Serra Bonita Floresta Nacional de Sao Francisco de Paula
EPIPHYTE_GROUP	Name of general group to which epiphyte species belong	3 groups	Angiosperms Ferns Lycophytes
EPIPHYTE_FAMILY	Name of epiphyte family	25 families	Polypodiaceae
EPIPHYTE_GENUS	Name of epiphyte genus	117 genera	*Asplenium*
EPIPHYTE_EPITHET	Name of epiphyte epithet	423 epithets	*feei*
EPIPYTE_SPECIES	Species name	448 species names	*Asplenium feei*
EPIPHYTE_HABITAT	Classification of epiphyte species into: holoepiphyte, hemiepiphyte and facultative	Holoepiphyte, hemiepiphyte, facultative or not possible to confirm	holoepiphyte hemiepiphyte
PHOROPHYTE_FAMILY	Name of phorophyte family	54 phorophyte families	Araucariaceae
PHOROPHYTE_GENUS	Name of phorophyte genus	124 genera	*Araucaria*
PHOROPHYTE_EPITHET	Name of phorophyte epithet	175 epithets	*angustifolia*
PHOROPHYTE_SPECIES	Species name	204 species	*Araucaria angustifolia*
YEAR_START	Year when study began	From 1989 to 2017	2015
YEAR_FINISH	Year when study ended	From 1992 to 2018	2017
DATA_TYPE	Type of epiphyte data sampled. All abundance data.	One level: abundance	Abundance
ALTITUDE	Altitude (m.a.s.l.) values for each record	116 unique values	44 915

ANNUAL_RAINFALL	Annual rainfall (mm) for each record	1,617 unique values	1,190 1,806
ANNUAL_TEMPERATURE	Annual temperature (ºC) for each record	146 unique values	23.1 26.7
VEGETATION_TYPE	Vegetation type for each record	4 vegetation types	Ombrophilous Forest Seasonal Forest Savana
ATLANTIC_FOREST_LIMIT	Identify whether the record is inside the Atlantic Forest shapefile or not. All inside Atlantic Forest.	One level: yes	YES
ABUNDANCE_NUMBER_OF_INDIVIDUALS	Epiphyte abundance quantified as number of ramets or genets	76 unique values	11 108
ABUNDANCE_COVERAGE_CLASS	Epiphyte abundance quantified as number of a particular coverage class	9 unique values	1 43
COVERAGE_CLASS_METHOD	Reference used to classify coverage class	4 references	Kersten, R. de A., Y. S. Kuniyoshi, and C. V. Roderjan. 2009. Epífitas vasculares em duas formações ribeirinhas adjacentes na bacia do rio Iguaçú – Terceiro Planalto Paranaense. Iheringia - Série Botânica 64:33–43.
SAMPLE_UNIT	Sampled unity: tree, plot, transect	3 levels	plot
FREQUENCY	Total number of trees where epiphytes were registered. For Abundance Data_Type only	38 unique values	1 17
TREE_TOTAL_EFFORT	Total number of trees sampled in the study	54 unique values	8 800
PLOT_SIZE	Sampled plot area (m^2)	20 unique values	20000

PLOT_TOTAL_EFFORT	Sum (m²) of all sampled plots in the study	68 unique values	300000
TRANSECT_N_POINTS	Number of points in each transect sampled	4 unique values	10 30
TRANSECT_D_POINTS	Distance (m) between points in transect sampled	3 unique values	10
TRANSECTS_NUMBER	Number of transects sampled	4 unique values	7
TRANSECTS_TOTAL_EFFORT	Total number of trees sampled in all transects	8 unique values	60
OBS	Observation. Any comments from authors of data set	806 unique observations	Course of Field Botany 2011 - Master in Plant Biology.

Table 4: Description of the fields related to the file ATLANTIC_EPIPHYTE_Reference.csv. We listed all references where the data comes from .

Variables	Description	Levels	Examples
CITATION	References citations where the data comes from, quoted throughout the text	197 citations	Alcantara et al. (2006)
REFERENCE_TYPE	Categories of data sources: article, thesis or dissertation and book	3 categories	Article
REFERENCE	Reference where the data comes from	197 references	Alcantara, S., J. Semir, and V. N. Solferini. 2006. Low Genetic Structure in an Epiphytic Orchidaceae (*Oncidium hookeri*) in the Atlantic Rainforest of South-eastern Brazil. Annals of Botany 98:1207–1213.
FILENAME	Standardized dataset filename for each data base within our data set	61 filenames	ATLANTIC_EPIPHYTES_Alcantara_Padilha_2018_03_d22_validchar.txt
DATASET_ACRONYM	Standardized identification for each data base within our data set	61 acronyms	APAD

IV.C. Data anomalies: If no information is available for a given record, this is indicated by “NA”.

CLASS V. SUPPLEMENTAL DESCRIPTORS

V.A. Data acquisition: Our data set was obtained from (i) article search, (ii) gray literature search, and (iii) indications from authors.

V.B. Data request history: None

V.C. Data set updates history: None

V.D. Data entry/verification procedures: In order to standardize the taxonomy of epiphyte and phorophyte species we used “flora” (Carvalho 2017) and “taxize” (Chamberlain and Szocs 2013) packages in R environment (R Core Team 2018). Later, specialists in taxonomy (Menini Neto L., Kersten R., Amorim A. M., Matos F.B, Freitas L., Nunes-Freitas, A. N.) checked and confirmed all species reported in the data set.

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