Species

Iberá Wetlands: diversity hotspot, valid ecoregion or transitional area? Perspective from a faunistic jumping spiders revision (Araneae: Salticidae)

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ABSTRACT

In the present work, the fauna of jumping spiders or Salticidae of the Iberá Wetlands was investigated. Patterns of species richness, composition and endemism in hygrophilous woodlands and savannah parklands in ten locations covering the Iberá Wetlands were analyzed. Samples were obtained using four methods: garden vacuum, pit-fall trap, beating and litter extraction. 75 species were collected, representing one third of the known Argentine salticids. Six species are recorded for the first time for Argentina. The community structure of the investigated locations suggests that the high diversity of jumping spiders is the result of the mixing of species of adjacent ecoregions such as Humid Chaco, Atlantic forest and Espinal. The transitional character of Iberá Wetlands, in combination with no endemism in nominally identified taxa, questions the ecoregion validity of Iberá for jumping spiders. The importance of taxonomy and the use of mature spiders in ecological studies is discussed.

Keywords: diversity hotspot; Argentina; salticid; jumping spider; wetland

1. INTRODUCTION

The Iberá Marshes are located in the north-central province of Corrientes covering an area of over 12000 km^2. These wetlands are one of the largest in South America (Neiff and Poi de Neiff, 2006). Iberá's current landscape was originated by the Paraná River during the Pliocene-Pleistocene and includes a vast mosaic of forests, scrublands, grasslands, pastures, lakes, wetlands, swamps and shallow lakes, most of which (60%) remain permanently inundated. In the southeast, the area of the Iberá wetlands are bordered by the Southern Cone Mesopotamian Savanna and the Espinal, in the northwest by the Humid Chaco and the north-eastern boundaries are near to the Upper Paraná Atlantic Forest areas (Burkart et al. 1999; Olson et al. 2001).

The Iberá is one of the most diversified wetlands of the warm climate biosphere, with 1659 species of vascular plants and 300 vertebrate species (Neiff and Poi de Neiff, 2006). Despite being a refuge for many organism groups, previous surveys have focused on vertebrates, while ecologically important invertebrate groups have only been scarcely studied. Studies on invertebrates focused on Odonata (Muzón et al. 2008), Calliphoridae and Sarcophagidae flies (Dufek et al. 2016), ants (Calcaterra et al. 2010), true bugs (Coscaron et al. 2009) and orb-weaving spiders (Rubio and Moreno 2010). All of the before mentioned invertebrate studies confirmed the importance of Iberá as a species richness hotspot, although, the drivers for such high species richness have been scarcely studied. Previous authors hypothesized that the high species richness results from high habitat heterogeneity (Muzón et al. 2008; Ingaramo et al. 2012) and/or the mixing of species from different ecoregions that converge in the Iberá wetlands (Calcaterra et al. 2010). However, while the former relationship has been corroborated by data from Odonata (Muzón et al. 2008) and anurans (Ingaramo et al. 2012), the latter hypothesis has not been supported to date.

Another interesting aspect that has been discussed in the literature is the validity of the Iberá wetlands as a distinct ecoregion. While Burkart et al. (1999), Neiff (2004), Neiff and Poi de Neiff (2006) consider the Iberá wetlands as a distinct biogeographical unit, Cabrera (1976), Olson et al. (2001), and Giraudo and Arzamendia (2017) refer to low endemism rates and recognize the Iberá wetlands as part of the Humid Chaco, similar to wetlands that can be observed in such ecoregion.

The family Salticidae is the most diverse amongst spiders, with more of 6000 species described (WSC, 2018). In Argentina over 220 species are known (CAA, 2018); they are countrywide distributed (Grismado et al. 2014), but found especially in warm and humid areas with structurally complex vegetation (Jocqué, 1984; Uetz, 1991). No study has evaluated how the salticid species are distributed through the country, available data is limited to the scattered records from the original descriptions and papers of Galiano (WSC, 2018). However, there is a better knowledge for the extreme northeast in the province of Misiones (Rubio, 2014, 2016; Argañaraz et al. 2017a).

Salticids have daytime habit and are well known for having a great ability to jump and a particular arrangement of their visual apparatus that give them precision in hunting (Forster, 1977). They are conspicuous and highly abundant, inhabiting a wide variety of microhabitats, including vegetation, tree trunks, bark, or litter (Żabka et al. 2017), and they are usually associated with certain vegetation structures (Cumming and Wesolowska, 2004). Based on these characteristics, jumping spiders are considered as an appropriate model for biodiversity studies (Coddington and Levi, 1991; New, 1999; Rubio, 2016; Argañaraz et al. 2017a).

In the current contribution, we investigate patterns of jumping spider species richness and composition in ten locations in the Iberá Wetlands. We test the hypothesizes that (i) Iberá represents a diversity hot spot for jumping spiders, (ii) the expected high diversity is explained by high endemism rates, which would support the ecoregion validity of Iberá Wetlands, or, alternatively, (iii) that high species richness is attributed to high species turnover, in particular in Northwest-Southeast direction, and/or a homogeneous fauna throughout the region, which would indicate that Iberá is a transitional area for jumping spiders that are

discovery

related to major adjacent ecoregions. We also discuss the importance of using adult specimens in the analysis of species richness patterns and possible conservation implications for Iberá with respect to jumping spiders.

2. MATERALS AND METHODS

Salticid richness distribution in Argentina and other areas

In order to obtain a comparative framework on the known distribution of Salticidae richness for different regions of the country and other Latin American areas, a review was carried out from the databases of Argentinean species (CAA, 2018; WSC, 2018) and the available bibliography obtaining the cited records. In addition, the databases of the following collections were also reviewed including a total of 234 species: Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN-Ar, C. Scioscia), Museo de La Plata (MLP, L. Pereira) and IBSI-Ara (G. Rubio). Data from Argentina are summarized in figure 1A, first numbers in bold represent the sum of species recorded in each Province; second numbers between parentheses are the amount of those species described by the arachnologist M.E. Galiano.
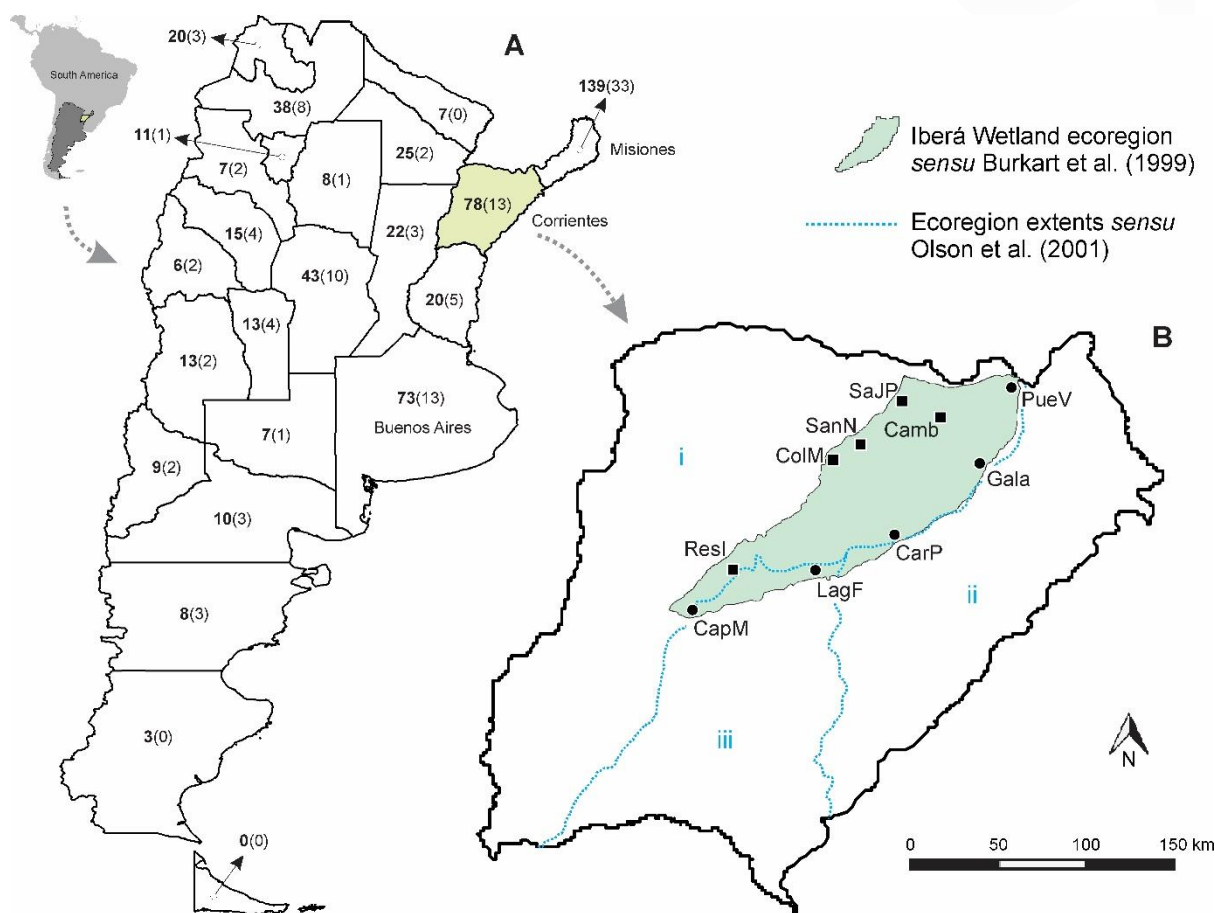

Figure 1

(**A**) Richness and distribution of salticids from Argentina, first numbers (in bold) represent the recorded species sum in each Province; second numbers (between parentheses) are the amount of those described by M.E. Galiano. (**B**) Location records of systematized sampling in Iberá. Squares= Northwest coast; dots= Southeast coast; ecoregions= i (Humid Chaco), ii (Southern Cone Mesopotamian Savanna), iii (Espinal) from Olson et al. (2001).

Area of systematized sampling

Our study took place forming a parallelogram perimeter located at north-center of the Corrientes province, between the coordinates 27º33'S, 57º08'W to 28º56S, 58º34'W (Northwest side) and 27º34'S, 56º20'W to 28º57'S, 57º45'W (Southeast side), area corresponding to the Iberá Wetlands ecoregion *sensu* Burkart et al. (1999). This region covers about 13000 km². This is characterized as a complex macrosystem with predominance of hygrophilous woodlands, savannah parklands and marshy vegetation. The

distribution of these last two habitats are not limited to the mainland, but are also found on floating organic soils known as "embalsados", which are found in lentic and lotic waters. The climate is subtropical, warm and humid, with an annual temperature of 17-27 ºC and a total annual precipitation of 1600-1800 mm (Neiff and Poi de Neiff, 2006). The study was carried out at following10 locations, separated by a distance no smaller than 15 km and reaching 245 km between the most distant pair (geo-referenced in figure 1B).

These locations were analyzed according to two coasts, on Northwest coast of Iberá: Estancia San Juan Poriajú (abbreviated as **SaJP**; 27º41'S, 57º11'W), Reserva Cambyretá (**Camb**; 27º52'S, 56º52'W), Reserva San Nicolás (**SanN**; 28º10'S, 57º26'W), Colonia Montaña (**ColM**; 28º3'S, 57º32'W), and Reservaltatí (**Resl**; 28º44'S, 58º7'W); on Southeast coast: Establecimiento Puerto Valle (**PueV**; 27º36'S, 56º26'W), Reserva Paraje Galarza (**Gala**; 28º6'S, 56º41'W), Colonia Carlos Pellegrini (**CarP**; 28º32'S, 57º11'W), Estancia El Rincón (**LagF**; 28º44'S, 57º40'W), and Capitá Mini (**CapM**; 28º56'S, 58º22'W).

Sampling procedure

Sampling days were during the following months and years: December 2011 (CarP, LagF), November 2012 (SanN, Gala), November 2013 (SaJP, Camb), December 2013 (Resl), March 2014 (CapM), November 2014 (ColM), March 2015 (PueV). In each location two habitats were sampled, hygrophilous woodlands and savannah parklands. Within each habitat, fifteen quadrants 50 m apart were randomly sampled where jumping spiders were collected diurnally from 9 am to 5 pm, using four different methods: (1) G-vac method to suck spiders from the vegetation in savannah parklands, and (2) foliage beating in hygrophilous woodlands. The G-vac consists of a vacuum cleaner Mod. 220 V-AR with tube of 1.10 m of longitude and 0.12 m of diameter (flow 710 m^3 h-1), and each sample is the suction of the vegetation in an area of 1 m^2 during one minute. Beating was done by firmly striking branches and foliage with a mallet, over a 2.50 m^2 white cloth quadrant, and striking was repeated ten times. To catch epigeous salticids, (3) pit-fall trap was installed in each habitat on each of the fifteen quadrants, consisting in a 1000cc plastic container with preservative solution (ethylenglicol:water in 1:10 proportion), active for 48 hours. In woodlands, floor spiders were also obtained by (4) sieving an area of 0.50m^2 per sample and passed through a sieve of 1 cm mesh opening on a cloth. Thus, a total of 15 samples of foliage (vacuum or beating) and 30 for ground stratum were taken per habitat, being 90 samples per location for a total of 900 samples. The material collected was placed in polyethylene bags with 70% ethyl alcohol, labeled and transported to the laboratory for analysis.

On the use and identification of spiders

Salticidae represents a relatively well-known taxon in the northeastern region of Argentina (Rubio, 2014; Galvis and Rubio, 2016; Rubio, 2016; Rubio and Baigorria, 2016); and was found that subsets of data comprising adult Salticidae specimens result good potential indicators of global spider diversity (Argañaraz et al. 2017b). In this sense, when studying adults of a restricted taxon, common errors derived from the use of morphospecies and immature specimens of large taxonomic groups (as all Araneae) to characterize richness are strongly reduced (Argañaraz et al. 2017a), avoiding thus the misinterpretation of results (Bortolus, 2008). Only adult jumping spiders were identified in this study, using in the first instance the database websites by Metzner (2018) and Prószyński (2016), and by the use of original papers with descriptions and revisions for each corresponding salticid group where diagnostic characteristics were used to distinguish species, even in situations of sexual dimorphism. Due to the difficulty of assigning most immature spiders to species, juveniles were not included. Collected specimens were deposited in the IBSI-Ara (Instituto de Biología Subtropical; G.D. Rubio) and CARTROUNNE (Cátedra de Biología de los Artrópodos; G. Avalos) collections of the Universidad Nacional de Misiones and Universidad Nacional del Nordeste, respectively.

Statistical and diversity analyses

Alpha ecological diversity: To estimate the completeness of the sampling and to compare the true alpha diversity on the Northwest and Southeast coasts, the profiles of q0, q1 and q2 with a confidence interval of 5-95% were calculated using the online iNEXT statistical program (Chao and Jost, 2012); q0 represents species richness, q1 equitability (species proportional abundance), and q2 dominance. In addition, for the comparison of true alpha diversity between coasts at the same sampling coverage, we used rarefacted values of 0D, 1D and 2D at 56% of coverage. To evaluate, compare and complement other ecological measures on salticid assemblages of the ten locations, richness, Caho1-bc estimation, Shannon (entropy) diversity and Berger-Parker dominance were calculated using PAST v3.16 (Hammer et al. 2001). The estimated diversity was contrasted from the overlap of confidence intervals (95%).

Alpha taxonomic diversity: The Average Taxonomic Distinctness (Δ+) and Variation in Taxonomic Distinctness (Λ+) were the taxonomic measures used following Clarke and Warwick (1998, 2001). These taxonomic indices are relevant measures of diversity

due to their lack of dependence on sampling effort and having a statistical framework for the assessment of the significance of departure from expectation (Warwick and Clarke, 1998). On one hand, Δ+ is a direct measure of taxonomic diversity: a high value reflects high taxonomic diversity or low relatedness among species, while Λ+ is a measure of unevenness in the taxonomic tree, reflecting the degree to which certain taxa are over- or under-represented in samples. For detailed assumptions and complete interpretation, see Warwick and Clarke (1995) or Magurran (2004). For these analyses the species were classified into genera, tribes, subfamilies and family, reaching five levels; subfamily and tribes classification of salticids was based on Maddison (2015). To detect differences in the taxonomic distinctness at each observed location category, a randomization test with 1000 random samples, taking into account the number of species sampled, was also performed from the expected values derived from the species pool (Clarke and Warwick, 1998). The null hypothesis assumes that each sample contains species randomly selected from the pool and that it should therefore fall within the 95% confidence intervals. All the analyses of taxonomic diversity measures and randomization tests were performed using PRIMER (Clarke and Gorley, 2001).

Beta diversity: To estimate changes in species composition (beta diversity) and probable groupings between locations, we carried out a non-metric multidimensional scaling analysis (NMDS) using the abundance and species with Jaccard index in PAST v3.16 software (Hammer et al. 2001). To understand changes on species composition we first calculated the Jaccard index of dissimilarity (β_{cc}) between coasts. Then, we decomposed the Jaccard´s index in two components, species replacement (β_{-3}) and species richness differences (β_{rich}), using the BAT package in R (Cardoso et al. 2015). We compared (β_{-3}) and (β_{rich}), between locations by using an ANOVA or Kruskal-Wallis test with Tukey and Post Hoc comparisons, respectively.

3. RESULTS

Community composition and species richness

A total of 301 adult salticids representing two subfamilies, 13 tribes, 46 genera and 75 species were present in the samples in this study (Appendix 1). In terms of abundance, the most frequent species of Iberá were *Hisukattus transversalis* (56 individuals, collected in all locations), *Cotinusa horatia* (21 individuals, in five locations) and *Chira gounellei* (18, eight locations). The observed richness was higher in the Camb (S=20), CapM (S=18), and PueV, Gala and SaJP (S=17 each) locations than the ResI (S=9), SanN (S=9), and CarP (S=10) locations. The non-overlap of 95% confidence intervals infers significant differences between the more and the less richness locations; however, there is no a location that differs significantly by itself throughout the ecoregion (Fig. 2A). The highest expected richness (Chao1-bc) was 48.33 ± 16.20 for CapM and 39 ± 16.75 for PueV, compared to the approximately twice and half lower observed richness (Fig. 2B).

Concerning both coasts of Iberá, the differences in abundance (Northwest coast = 145 individuals; Southeast = 156) and in species richness (q0) (Northwest = 45 species; Southeast = 50) were not significant for the Salticidae fauna (p> 0.05). Sampling coverage was higher than 85% on both coasts, therefore sampling was representative. Extrapolating to twice as many individuals from the coast that has the least abundance, the observed richness would be 56.69 in Northwest coast and 64.33 in Southeast, reaching coverages of 95% and 92% respectively. However, the estimated q0 values were 63 and 79 species for Northwest and Southeast coasts.

Alpha diversity: taxonomic and ecological connotation

The Average Taxonomic Distinctness index had higher values of taxonomic salticid diversity in PueV and Gala locations (Δ+ = 78.92 and 78.87, respectively) than in the other eight locations, although not significantly different among all them, except for ResI where it was significantly lower (Δ+ = 69.63; p = 0.016) (Fig. 3A). A similar pattern was found on the ecological diversity, with the Shannon (entropy) index, where PueV and Gala had values within the highest: 2.65 the former and 2.47 the later. Nonetheless, a single location, Camb, had higher ecological diversity (2.77) than PueV and Gala, although without significant differences among the three (Fig. 2C). Regarding dominance in ecological connotation, the ResI and CapM locations have more dominant species (42%) in their assemblages (Fig. 2D), but in case of index of the Variation in Taxonomic Distinctness (taxonomic dominance), ResI was comparable with LagF by its high value (Λ+ = 169) although this latter location was statistically higher from the value calculated with the randomization test (Λ+ = 185.48; p = 0.05) (Fig. 3B).

Concerning both coasts of Iberá Wetlands, no significant differences of taxonomic diversity were found between Northwest (Δ+ = 76.09; p = 0.71) and Southeast (Δ+ = 76.59; p = 0.68). The taxonomic dominance was slightly higher in Northwest (Λ+ = 105.32) than in Southeast coast (Λ+ = 93.61), with no significant differences (p > 0.19). The pattern is similar in terms of ecological diversity, the q1 index showed that both Northwest and Southeast coasts have the same equitability (27.82 vs. 27.81), i.e. the same distribution of the species abundances; whereas regarding the dominance (q2) there was a lower dominance of the common species

in the Northwest than in the Southeast (17.89 vs. 13.91). Concerning to 0D, median species richness was similar in both coast (GLM, df = 1, p = 0.76). Same pattern was observed with 1D and 2D. Neither evenness (species proportional abundance) (GLM, df = 1, p = 0.82) and dominance (GLM, df = 1, P = 0.98) showed differences between sampling sites.

Figure 2
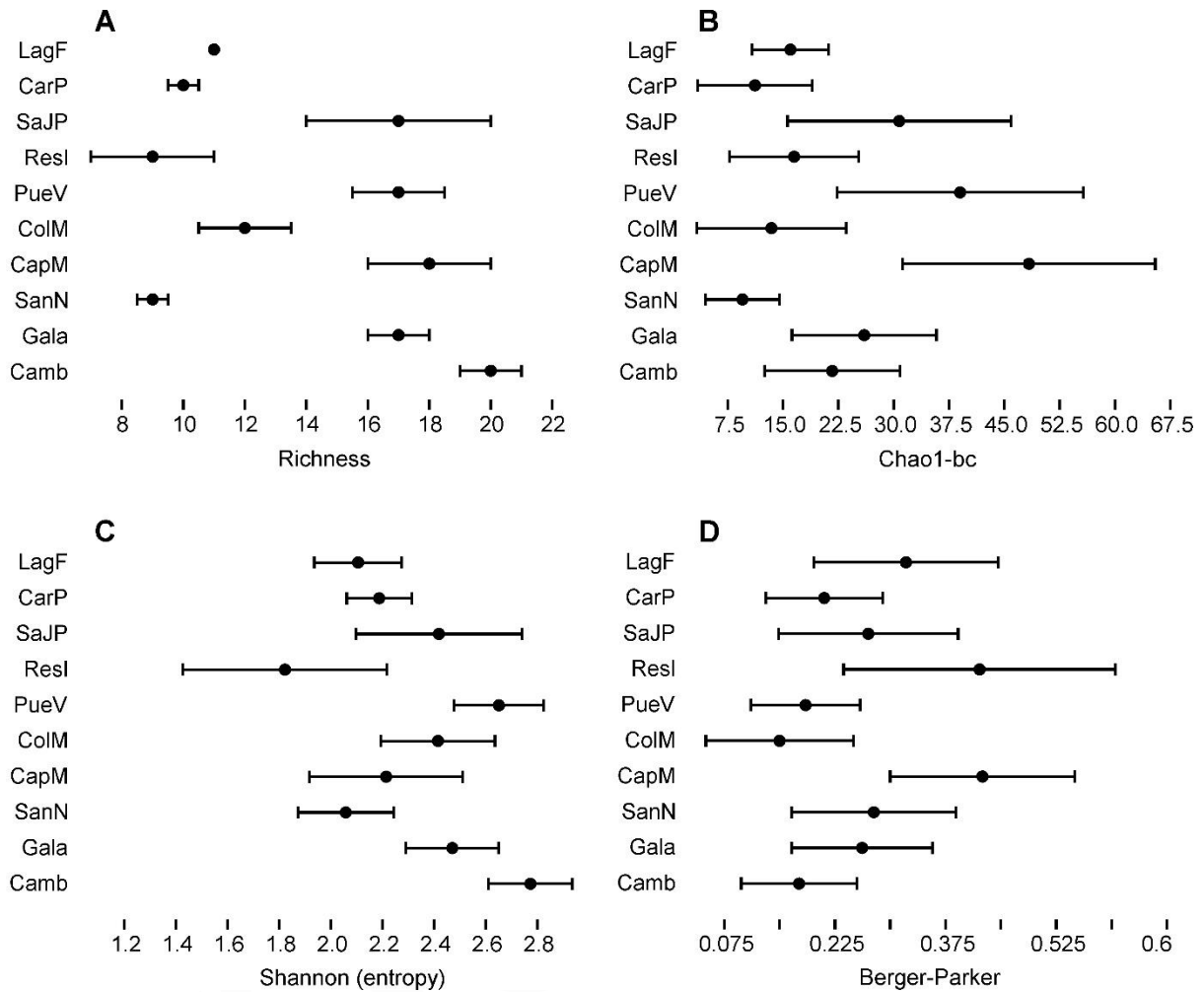Observed (**A**) and estimated (**B**) richness, diversity (**C**) and dominance (**D**) of jumping spiders (Salticidae) in the ten locations studied, Iberá, Argentina. The bars are 95% confidence intervals.
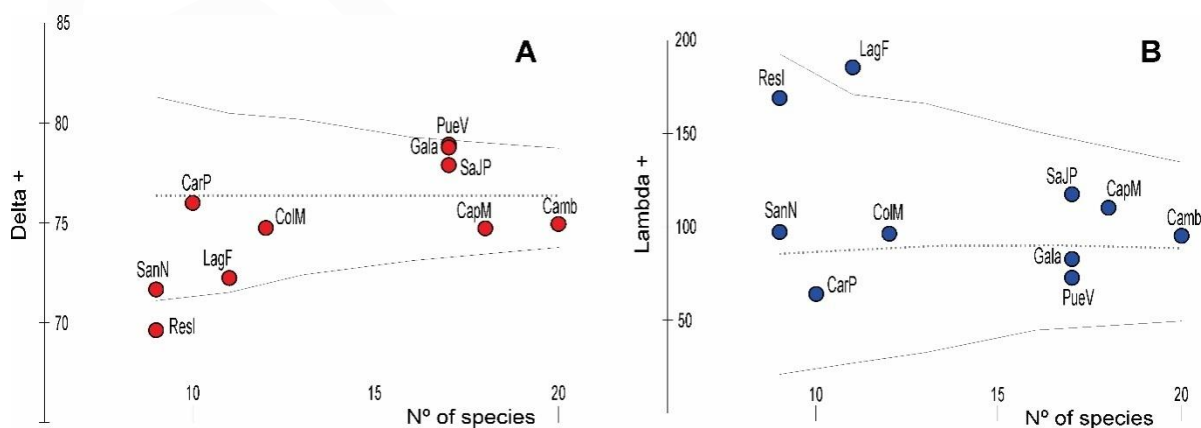
Figure 3
Confidence funnel (95 %) for Average Taxonomic Distinctness (**A**) and Variation in Taxonomic Distinctness (**B**) of jumping spiders (Salticidae) for each location from Iberá, Argentina.
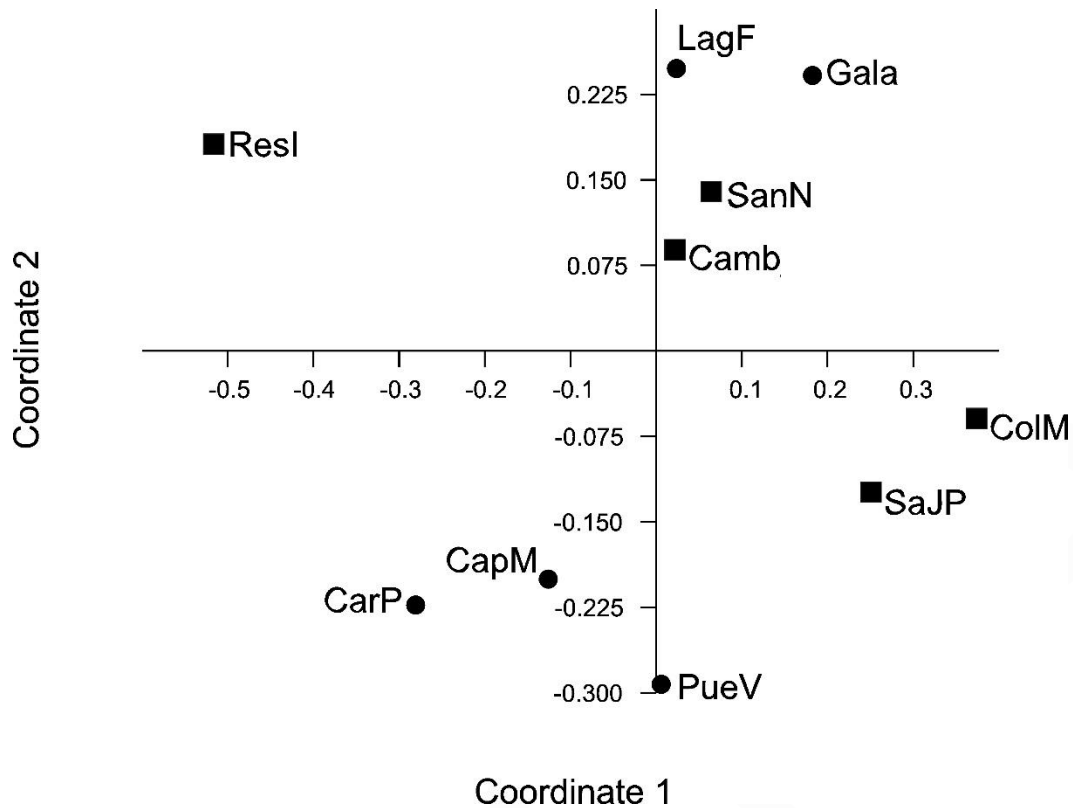
Figure 4

Non-metric multidimensional scaling (NMDS) analysis of jumping spider fauna (Salticidae) in Iberá Wetland, Argentina. Squares represent Northwest coast, dots Southeast coast. Stress is 0.22
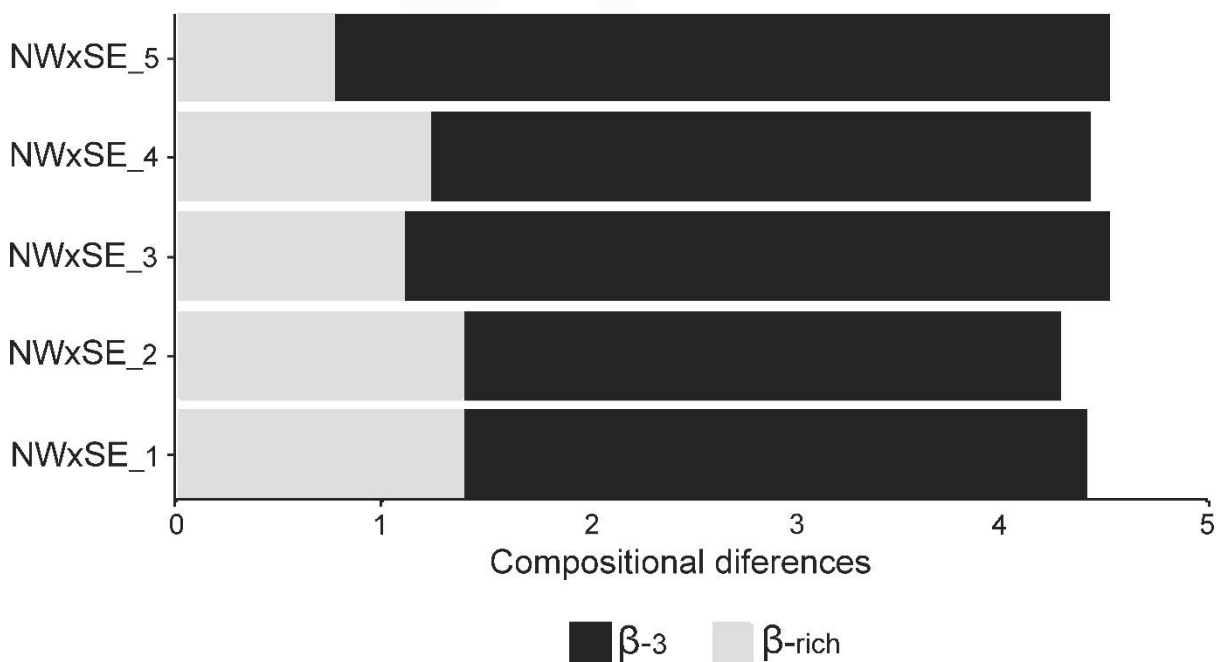
Figure 5

Salticid dissimilarity (β_{cc} index) in species composition and component of species replacement (β_{-3}) and species richness differences (β_{rich}) between all possible combinations of the ten locations and both Northwest (NW) and Southeast (SE) coasts

Beta diversity: richness difference and species turnover

Thirty species were unique to Southeast coast and 25 species were unique to Northwest (Appendix 1), based on this composition of salticid assemblages, the NMDS analysis did a weak cluster of locations of Northwest coast, segregating only ResI from that, although it was not statistically significant with a relatively high stress (Jaccard index, stress = 0.22) (Fig. 4), because 20 species were shared by both coasts. Regarding the beta diversity (β_{cc}), we found a dissimilarity of 12% between coasts according to Jaccard abundance index (0.88). The beta diversity components showed that the differences between both coasts were mainly due to the species replacement ($\beta_{-3=}$ 0.6489), since the differences in species richness (β_{rich}) were just of 0.2388. If compare among the locations of both coasts, no statistical differences were found between the composition of species of the Southeast and the Northwest (F= 1.239, p= 0.326), as well as in the replacement of species (F=0.812, p= 0.532) and differences in species richness components (F=0.534, p=0.712). Figure 5 shows the possible comparisons between each of the five locations on the Northwest coast vs. the five locations on the Southeast coast.

4. DISCUSSION

Iberá as a salticid diversity hotspot in Argentina

The results from this study signify a considerable increase in knowledge of the salticid fauna from the country. Six species (indicated in appendix 1) are recorded for the first time for Argentina; see WSC (2018) and CAA (2018) for distribution. However, what is most notable is the great concentration of species richness in the Iberá Wetlands region, 75 recorded species that represent 33% of the Salticidae fauna of the country (CAA, 2018; Metzner, 2018). This is comparable with the high diversity found in Misiones province, which was of 106 species (Rubio, 2014), although at the present time unpublished data show a much greater richness (Fig. 1A). However, Iberá represents an area that is less than half, 59% smaller than Misiones. Results are also relevant if compared with what was found by Buckup et al. (2010), they cite 72 species of Salticidae in Rio Grande do Sul, Brazil. In Paraguay, 34 species of salticids were recorded (Mello-Leitão, 1946), but currently data reach 42 species (Metzner, 2018). More comparisons with other works in Latin America can be seen in appendix 2. On the other hand, in two reserves of the Delta and Islands of the Paraná ecoregion (Northern Buenos Aires), two diversity studies with cogent taxonomy were carried out, corresponding to Grismado et al. (2011) and Marfil et al. (2015), where 20 and 29 salticid species were respectively recorded. Based on the available information of original descriptions, including numerous Galiano papers between 1962 and 2001 (Rubio, 2014, 2016), the Northeastern tip of Argentina presents higher levels of Salticidae diversity (Fig. 1A). Moreover, many ecoregions converge further south, in Corrientes (Olson et al. 2001), which could be in favor of global diversity for this family of spiders, and may result from overlapping distributional ranges of faunal elements —an example in Perger and Perger (2017). In this sense, there is a prediction example that indicates that the southern region of Misiones (border with Corrientes) has a greater taxonomic diversity of Salticidae regarding to the rest of the province (Rubio, 2016). In line with this ecotone perspective, Iberá seems to have an exclusive high diversity of salticid spiders.

Endemism in Iberá salticids: a regionally homogeneous but not endemic fauna

In our study, most taxa are foliage dwellers and ground inhabitants from woodlands and grasslands. The community structures of salticids were similar in abundance and richness throughout the Iberá Wetlands region, which support part of our hypotheses. From the ecological point of view, species diversity incorporates information on the community in terms of species abundances assuming that a community with a more even distribution of abundances among the species is more diverse than a community that is clearly dominated by a few species and has many rare (Rubio and Moreno, 2010). From a taxonomic vein, the degree of species phylogenetic relatedness is an additional feature that can be used in the analysis of species diversity (Vane-Wright et al. 1991; Williams et al. 1991; Warwick and Clarke, 1995, 1998; Clarke and Warwick, 1999). This last facet of biodiversity is based on the idea that a community with closely related species is less biodiverse than a community with low relatedness among species (Warwick and Clarke, 1995; Clarke and Warwick, 1998). In the Iberá Wetlands region the taxonomic and ecological measurements of diversity had the same pattern for the salticid faunas, although they imply independent connotations. Results of this work are coherent with the assumption that there is no significant zonation or exclusive salticid assemblage in different areas within the same region, reflecting a relative homogeneity of the vegetation throughout the ten locations (Neiff, 2004; Neiff and Poi de Neiff, 2006). Nevertheless, none of the nominally identified species (55) was endemic to the Iberá Wetlands, and twenty species were undetermined (or *affinis*) consequently there is no endemism information of them. Therefore, at the moment of the known all species found have wider distributions outside the Iberá region, which would not support the hypothesis of ecoregion validity for the Iberá Wetlands considering the jumping spider fauna. Regarding some frequent species, *Hisukattus transversalis* shows affinity with the Humid Chaco ecoregion in other areas of the country and Paraguay, *Cotinusa horatia* and *Chira gounellei* seem to have affinity with the Atlantic Forest, finding these also in Misiones, Brazil and Paraguay (the last).

Salticids in a wetlands region

How would the Salticidae be widely distributed in this wetlands region where water is omnipresent, taking into account that spiders cannot remain alive for a long time over or submerged in it? One of the dispersion techniques that allows Salticidae spiders to migrate and recolonize environments is ballooning (Salmon and Horner, 1977; Dean and Sterling, 1985; Richman and Jackson, 1992). This consists of the use of the silks together with the dragging of the air currents to disperse (Richman and Jackson, 1992). The use of ballooning as a dispersion technique involves the risk of landing in habitats unsuitable for survival (Bonte et al. 2003), for example, in lakes. However, the hydrographic system of the Iberá wetlands, instead of being an obstacle to the dispersal of these terrestrial animals, could act as an agent facilitating this, through a dispersion technique, which could act in a complementary way to the ballooning, known as rafting or sailing (Żabka and Nentwig, 2000). It is feasible that spiders are dispersed by this practice using branches and floating vegetation as support, and although future research is required on this, this behavior has already been reported in at least one species of Salticidae (Hill and Beaton, 2017). In addition, the use of embalsados, to move on water instead of using less stable supports such as small branches, isolated camalots, could further minimize the risk of death of salticids. On the other hand, the spiders make their egg sacks with threads that are waterproof, which could allow them to survive flood events and disperse by rafting by attaching them to floating elements or plants. This could be inferred from the observations that have been made of egg sacks attached to trunks transported by water (Żabka and Nentwig, 2000).

Apart from dispersal potential, it is important if the species finally finds its ecological niche to be able to live; which apparently occurs in the homogeneity of the Iberá wetlands. But, why were 30 species unique detected in the Southeastern and 25 unique in the Northwestern when dispersal is presumably so easy? The bibliographic source shows that the species of both coasts have geographical affinities with other ecoregions close to any of the coasts of the wetlands, indistinctly. So, we see a weak grouping of the NMDS that infers an affinity of the Northwest coast with the Chaco Humid ecoregion, and the ResI location was segregated, probably due to the influence of Espinal on salticid fauna (region "iii" in figure 1B); the remaining locations were not ordered coherently. We could infer that by intensifying the sampling effort the exclusive species would decrease; i.e., as a possible explanation, in this survey we have not detected them in their broadest distribution.

Importance of using adult specimens

A general problem, that prevents knowing the distribution and diversity of the spiders, is that many of the work on structure of the community include juveniles in analyzes, treating these unidentified species as morphospecies (e.g. Avalos et al. 2007; Rubio et al. 2008; Armendano and González, 2010; Almada et al. 2012; Rubio, 2015; Rodriguez-Artigas et al. 2016; Almada et al. 2017). In spider beta diversity studies, why use a confined taxon of adult specimens instead of a more general one and including juveniles? When analyzing a group of bounded data where species are recognized and delimited, correct interpretations can be achieved with simple analyzes; the point is that it is easier to detect the loss / gain of a recognized population in a community than that of many diffusely delimited populations, for example, in case of replacement or nesting (Argañaraz et al. 2017a: 159). Within a single genus, spider species are practically impossible to recognize by juveniles, which generally represent about 70% of the data. Some authors concentrate all their attention interpreting results that derive from complex analysis, without realizing that raw material (the species) were not recognized as such. In the Campos and Malezales ecoregion, matching to the region "ii" in figure 1B (Eastern Corrientes, Argentina), 40 morphospecies of Salticidae were detected as one of the most important spider taxa in the replacement of species along a north-south gradient sampled every ~13 km (Rodriguez-Artigas et al. 2016), but doubts that arise are: How could the authors have delimited the species if the juveniles were included? How was the sexual dimorphism resolved in that case? Was the interpretation of the results reliable? Within the regional pool of salticid species of the Corrientes province five species of *Aphirape*, three of *Beata*, three of *Dendryphantes* and three of *Sassacus* are included, and there are another 15 genera with two species each (can be seen in this study). In this Rodriguez-Artigas and collaborators' particular paper, we find ourselves discouraged because it was not feasible to make diversity comparisons between the faunas of Salticidae of the ecoregions from the same province, except for two species identified as *Chira spinosa* "(Simon, 1902)" —probably *C. gounellei* (Simon, 1902) because the distribution and the error in the species author— and the Panamanian *Metaphidippus cupreus* F. O. Pickard-Cambridge, not found in our study or other samplings. Nevertheless, this is just one example of many, there are other works showing this type of shortcomings, including some of our own authorship: Avalos et al. (2007), Rubio et al. (2008), and Avalos et al. (2013), where 23, 12 and 38 salticid morphospecies were respectively detected, but few nominally identified species. As we mentioned above, two of the few taxonomically cogent studies (Grismado et al. 2011; Marfil et al. 2015) taking into account only adults. Henceforth, we strongly recommend the analysis of adult specimens in studies of diversity and ecology with spiders.

5. CONCLUSION

The bio indicator attributes that has a relatively well known and mega diverse group of spiders, such as the Salticidae were utilized in this study, allowing us to evaluate the diversity perspective of the most important wetland in Argentina (here proposed as a salticid diversity hotspot), carrying out a richness comparison with what is known for the rest of the country (mainly) and, slightly, other Latin American areas. The importance of taxonomy and the use of mature spider specimens in ecology studies for correct interpretations of the results, feasible comparisons and for a pragmatic knowledge about the distribution of the species was evident. The idea of a transitional area, or mixture of faunal elements, is supported by the absence of endemic species among the 55 nominally identified taxa. For the 20 undetermined species, no information of endemism was available; they may contain widely distributed species but also species endemic to Iberá Wetlands. Further taxonomic work to clarify the affinities of these species is needed. The identified species have wider distributions either e.g. in the Humid Chaco ecoregion or in the Atlantic forest. Based on the current state of knowledge, the low endemism questions the assumption that Iberá represents an ecologically distinct ecoregion for jumping spiders. Likewise, the high diversity of these spiders, low endemism and the transitional character of Iberá wetlands suggest that the omnipresent water bodies don't act as dispersal barriers for spiders and the habitat islands in the strongly fragmented landscape may serve as stepping stones for dispersal.

Finally, in this study we also try to make available an information source for conservation management and to encourage an area for protection, since knowledge about the diversity and spatial distribution of species is important to redouble conservation efforts in key regions such as this one, the Iberá Wetlands.

Authors' contributions

GA and GDR conceived and designed the sampling; GDR and RP carried out conceptualization; GA, MFN and GDR collected data and processed samples; GDR, ACM and RP analyzed and interpreted the data; GDR, MFN and RP wrote the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

Appendix 1

Species and abundance of salticids in the ten locations of Iberá Wetlands, Argentina. The asterisk indicates first record for the country. Estancia San Juan Poriajú (SaJP), Reserva Cambyretá (Camb), Reserva San Nicolás (SanN), Colonia Montaña (ColM), Reserva Itatí (ResI), Establecimiento Puerto Valle (PueV), Reserva Paraje Galarza (Gala), Colonia Carlos Pellegrini (CarP), Estancia El Rincón (LagF), Capitá Mini (CapM).

Species/locations	Camb	Gala	SanN	CapM	ColM	PueV	ResI	SaJP	CarP	LagF	SUBTOT
*Aillutticus raizeri** Ruiz & Brescovit, 2006					3						3
Akela ruricola Galiano, 1999		1	2		2						5
Aphirape aff. *riojana* (Mello-Leitão, 1941)				1			1				2
Aphirape boliviensis Galiano, 1981					1	3		1			14
Aphirape flexa Galiano, 1981				1							1
Aphirape gamas Galiano, 1996	2		2	1				1		1	7
Aphirape riojana (Mello-Leitão, 1941)						2					2
Aphirape uncifera (Tullgren, 1905)	1	5									6
Arachnomura querandi Bustamante & Ruiz, 2017				1					1		2
Asaphobelis physonychus Simon, 1902			1								1
*Atelurius segmentatus** Simon, 1901				5		1		3			9
Beata aenea (Mello-Leitão, 1945)				1							1
Beata cf. *lucida* (Galiano, 1992)									1		1
Beata fausta (Peckham & Peckham, 1901)	2										2
Breda apicalis Simon, 1901		2			2						4

Species	1	2	3	4	5	6	7	8	9	10	TOTAL
Breda tristis Mello-Leitão, 1944		1									1
Bryantella smaragdus (Crane, 1945)								1			1
cf. *Phidippus* sp1		2									2
cf. *Selimus* sp1		1									1
Chira gounellei (Simon, 1902)	3	5	2	2	2	1			2	1	18
Colonus germaini (Simon, 1900)				1	1						2
Coryphasia sp1				1				1			2
Corythalia aff. *barbipes* (Mello-Leitão, 1939)		3									3
Cotinusa horatia (Peckham & Peckham, 1894)	9	3		1				7		1	21
Cotinusa vittata Simon, 1900				1		1			2		4
Dendryphantes mordax (C. L. Koch, 1846)							3				3
Dendryphantes sp16			2								2
Dendryphantes sp17		1									1
Freya nigrotaeniata (Mello-Leitão, 1945)					2			1			3
Gastromicans sp17	1										1
*Gastromicans tesselata** (C. L. Koch, 1846)				1					2		3
Gypogyna forceps Simon, 1900	5	2	2					1			10
Helvetia albovittata Simon, 1901									1		1
Helvetia cancrimana (Taczanowski, 1872)		1								2	3
Hisukattus transversalis Galiano, 1987	4	11	5	17	2	1	8	2	3	3	56
Hisukattus tristis (Mello-Leitão, 1944)	2				1		1	1		3	8
Hyetussa cribrata (Simon, 1901)	1										1
Hyetussa sp1						1					1
Lyssomanes pauper Mello-Leitão, 1945		1				1		2			4
*Maeotadorsalis** Zhang & Maddison, 2012						1					1
Megafreya sutrix (Holmberg, 1875)										3	3
Metaphidippus odiosus (Peckham & Peckham, 1901)		1								1	2
Metaphidippus sp1								1			1
Noegus bidens Simon, 1900						5					5
Pachomius sp16	2		1			2					5
Phiale gratiosa C. L. Koch, 1846				1							1
Phiale roburifoliata Holmberg, 1875							1		1		2
Philira micans (Simon, 1902)	2			2		1			4		9
Psecas chapoda (Peckham & Peckham, 1894)							1				1
*Pseudofluda pulcherrima** Mello-Leitão, 1928	2	1									3
Rudra humilis Mello-Leitão, 1945	1										1
Saitis sp1						1					1
Saphrys aff. *tehuelche* (Galiano, 1968)						3					3
Sarinda imitans Galiano, 1965	2										2
Sarinda marcosi Piza, 1937					2			1			3
Sarinda nigra (Peckham & Peckham, 1892)								1			1
Sassacus sp1										3	3
Sassacus sp2										9	9
Sassacus sp3										1	1
Sassacus sp4								1			1
Semiopyla cataphracta Simon, 1901	1										1
Semiopyla viperina Galiano, 1985						1					1
Semora sp1								1	2		3
Simprulla argentina Mello-Leitão, 1940					2						2
*Simprulla nigricolor** Simon, 1901							1				1
Sitticus cf. *cellulanus* Galiano, 1989				1							1
Sumampattus hudsoni Galiano, 1996	3		1								4
Sumampattus quinqueradiatus (Taczanowski, 1878)						1					1
Tartamura adfectuosa (Galiano, 1977)	2										2
Titanattus andinus (Simon, 1900)				1							1
Titanattus n. sp.		1			1						2
Tullgrenella aff. *selenita* Galiano, 1970							1				1
Tullgrenella musica (Mello-Leitão, 1945)				1							1
Zygoballus cf. *gracilipes* Crane, 1945	1										1
Zygoballus sp28	5			1		1		2			9
TOTAL (75 species)	51	42	18	40	20	27	19	37	19	28	301

Appendix 2

Studies obtaining species richness of Salticidae in different areas in Latin America by using beating tray sampling (B), manual active search (M), Winkler extraction (W), fogging (F), funnel traps (FT), Pitfall traps (P), sweep net (S); SR, species richness; G, generic richness; U, undetermined.

Location/forest type	Sampling method/effort (h)	Area	SR	G/U	Reference
Adolpho Ducke forest reserve (Brazil), Amazon rainforest	B; M; P; FT; F Hundreds of excursions	100 km2	112	6	Bonaldo et al. 2009
Parque Estadual do Turvo, Rio Grande do Sul (Brazil), Floresta do Alto Uruguai	B: 199; M; P; W	2 transects, ~6 km and ~10 km	104	30/38	Podgaiski et al. 2007
Amazon river (Brazil) floodplain forest	B: 194; M: 50	26 sites with 8-14 plots 30 x 5 m along a transect of 3000 km	84	31/20	Rego et al. 2009
Rio Urucu, Amazonas state (Brazil), Amazon rainforest	B: 33; M: 33; W	33 transects 30 m	81	19/29	Dias and Bonaldo 2012
			75	46	This study
Serra do Cachimbo, Pará (Brazil), ombrophilous dense forest, Cerrado, riparian forest	B: 96; M: 96; W	96 plots 30 x 10 m	75	35/19	Ricetti and Bonaldo 2008
Pico da Neblina (Brazil) Amazon rainforest, montane forests, scrubland	B: 162; M: 162	162 plots 30 x 10 m	60	21/13	Nogueira et al. 2014
Baja California (Mexico), oases	B: 528; S; P	4 sites with 10 transects 150 m	36	14	Jiménez et al. 2015
Pakitza, Manu River (Peru) floodplain and tierrafirme Amazon rainforest	B+M: 109	3 transects between ~1000-1500 m; additional 4 sites, area n.a.	31	3/28	Silva and Coddington 1996
Martín García Island (Argentina) jungle, shore forest, xerophilous forest	B; M	5 sites (covering 12 months)	29	24/14	Marfil et al. 2015
Otamendi (Argentina) pasture and forest	S: 32; P; B	5 sites (covering 6 months)	20	15/7	Grismado et al. 2011

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