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Climbing plants of Porto Ferreira State Park, southeastern Brazil

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Abstract: A floristic survey of climbing plants was carried out in an ecotone area of seasonal semideciduous forest (SSF) and forested savanna (CER), in Porto Ferreira State Park (PFSP), Southeastern Brazil. We sampled the reproductive specimens every month during two periods, March 2010 to September 2011 and April and July 2015. The surveys were performed by the walking method, and the sampled individuals were classified by habit, climbing mechanism and dispersal mode. Overall, 109 species, belonging to 67 genera and 29 families, were recorded; 49 species occurred in both, 29 and 31 were exclusive to SSF and CER, respectively. Bignoniaceae and Malpighiaceae were the richest families, with 17 species, followed by Sapindaceae (12 species), Asteraceae and Apocynaceae (8 species each) and Fabaceae (6). The majority of climbers were lianas, twining and anemochoric species, corresponding to 70%, 47% and 66% of all samples, respectively. In this work, we added one new family and 14 species to the Cerrado's list of climbing plants from São Paulo state, and 10 species to the Brazilian seasonal semideciduous forest's list. Therefore, we contributed to the understanding of diversity of climbing plants in vegetation types poorly studied for this plant group, mainly in the Cerradão, wherein we found new records for several species.

Key words: *Cerrado; Seasonal Semideciduous Forest; ecotone; climbing plants.*

Trepadeiras do Parque Estadual de Porto Ferreira, Brasil

Resumo: O levantamento florístico das trepadeiras foi realizado em um ecótono de Floresta Estacional Semidecidual (FES) e Cerradão (CER), no Parque Estadual de Porto Ferreira, Sudeste do Brasil. Realizamos coletas mensais dos espécimes reprodutivos ao longo de dois períodos, março 2010 a setembro 2011, abril e julho 2015. Os levantamentos foram realizados por meio do método de caminhada e os indivíduos amostrados foram classificados quanto ao hábito, mecanismo de ascensão e síndrome de dispersão. No geral, foram registradas 109 espécies, pertencentes a 67 gêneros e 29 famílias. Dentre essas, 49 espécies ocorrem nos dois tipos de vegetação, sendo que 29 e 31 espécies são exclusivas de FES e CER, respectivamente. Bignoniaceae e Malpighiaceae foram as famílias mais ricas com 17 espécies, seguidas por Sapindaceae (12 espécies), Asteraceae e Apocynaceae (8 espécies cada) e Fabaceae (6). A maioria das espécies de trepadeiras são lianas, volúveis e anemocóricas, correspondendo a 70%, 47% e 66% de toda a amostra, respectivamente. Neste trabalho, acrescentamos uma nova família e 14 espécies para a lista de trepadeiras do Cerrado paulista e 10 espécies para a lista brasileira de trepadeiras em Floresta Estacional Semidecidual. Portanto, contribuímos para o conhecimento da diversidade de trepadeiras em tipos vegetacionais pouco estudados para este grupo de planta, destacando o Cerradão, no qual encontramos novos registros para um grande número de espécies.

Palavras-chave: *Cerrado, Floresta Estacional Semidecidual; ecótono; trepadeiras.*

Introduction

Climbing plants germinate and remain on the ground, requiring external mechanical sustentation provided by others plants for access to light in the forest canopy (Darwin 1867; Putz & Windsor 1987; Gerwing et al. 2006; Lawdig & Meiners 2010; van der Heijden et al. 2013). These plants occur in many climates and vegetation types, representing up to 25% of plant diversity in some tropical forests (Gentry 1991; Engel et al. 1998; Pérez Salicrup et al. 2001). Besides climbing plants playing an important role in biodiversity maintenance, they establish competition for resources with the

host tree (phorophyte), and can change dynamic and natural regeneration in different biomes (Laurence et al. 2001; Schnitzer & Bongers 2002).

Although floristic and structural surveys of climbing plants have increased over the past decades (e.g. Durigon & Waechter 2011; Yorke et al. 2013; Vargas et al. 2014; Ibarra-Marínquez et al. 2015), climbing plants receive less attention in contrast to studies carried out with tree communities (Phillips et al. 2002; Letcher & Chazdon 2009; Carvalho et al. 2013). In Southeastern Brazil, climbing plant studies have been conducted by floristic and phytosociological surveys, mostly in semideciduous seasonal forest (e.g. Morellato & Leitão-Filho 1998; Hora & Soares 2002; Udulutsch et al. 2004; Rezende & Ranga 2005; Tibiriçá et al. 2006; Rezende et al. 2007; Santos et al. 2009; Udulutsch et al. 2010). Nevertheless, studies on vegetation types of the Cerrado are still incipient (Weiser 2002; 2007; Carvalho et al. 2013).

Porto Ferreira State Park has been the subject of numerous floristic surveys (Bertoni & Martins 1987; Bertoni et al. 2001; Colli et al. 2003; Oliveira 2012; Osaco 2012; Sabino 2013; Marcusso et al. 2016); however, studies on climbing plants have not been performed in this area. The main objective of this study was to survey the climbing flora of an ecotone area, between seasonal semideciduous forest and forested savanna (Cerradão), in Porto Ferreira State Park, São Paulo, Southeastern Brazil.

Materials and methods

1. Study site

Porto Ferreira State Park (PFSP) is located in the municipality of Porto Ferreira, in São Paulo state, Southeastern Brazil (Figure 1). The study area is 611.55 hectares, and has altitudinal variation between 540 and 608 m.a.s.l. (São Paulo 2003). PFSP is located in a geomorphological region of peripheral depression, in the central region of the watershed of Mogi-Guaçu River (São Paulo 2003).

The climate of the region is classified as Aw, according to Köeppen's classification (Bertoni & Martins 1987). The annual mean temperature is 22.3 °C and the annual mean precipitation is 1.497 mm, presenting variation between the rainy (247.9 mm) and dry seasons (26.6 mm) (CEPAGRI 2016).

PFSP has distinct vegetation types according to IBGE (2012), presenting forested savanna (Cerradão) and seasonal semideciduous forest. They are mainly differentiated in the field by their physiognomy (small average height and high density in the Cerradão), and greater average height and lower density in Semideciduous forests), ecological aspects (soil types, deciduousness) and typical and exclusive species of each vegetation type (Durigan et al. 2012). Furthermore, there are ecotonal areas among these vegetation types (Osaco 2012; Sabino 2013), in which a floristic mixture and phytophysiognomic indistinguishability occurs (IBGE 2012).

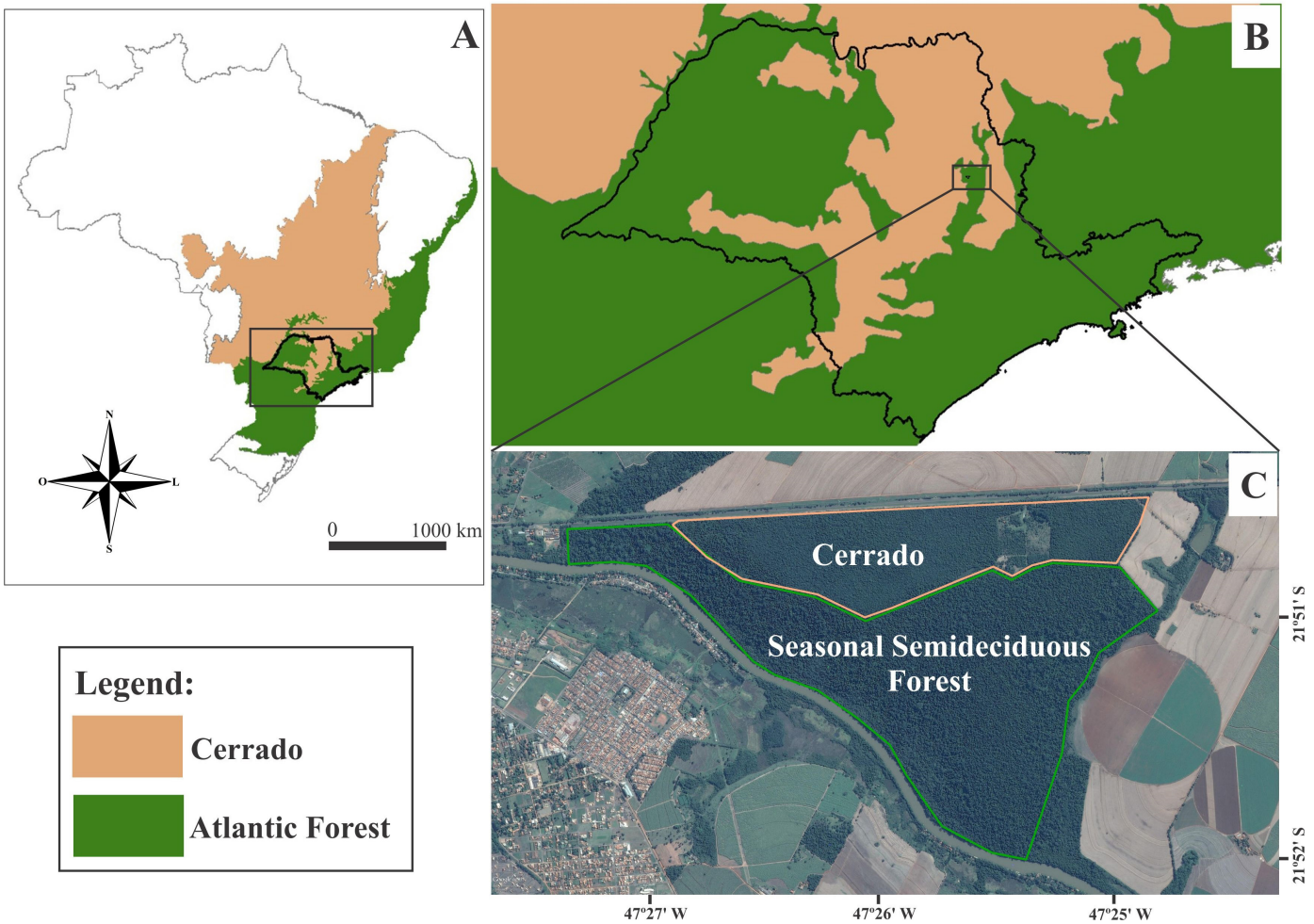

Figure 1. A. Brazilian Atlantic Forest and the Cerrado and the location of São Paulo state; B. location of Porto Ferreira State Park; C. Porto Ferreira State Park and the main vegetation types studied.

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1.2 Data collection

Climbing plants sampling was performed by the walking method (Filgueiras et al. 1994), every month between March 2010 and September 2011. According to Morellato et al. (1996), transitional and final periods between climatic seasons can be related to the flowering and fruiting peaks of climbing plants, especially of the families most abundant in species. In this way, aiming to improve the sample, we performed additional floristic surveys in April and July 2015. The reproductive specimens collected in the field were processed and herborized following the protocols of Fidalgo & Bononi (1984). The vouchers were incorporated in the Herbarium Rioclarense (HRCB). Taxonomic identity was determined through specialized literature, direct comparison with identified specimens in HRCB's collection and by expert taxonomists (cited in the acknowledgements). Synonyms were verified by BFG (2015), and we adopted APG IV (2016) to classify the botanical families.

Identified plants were classified into two different habits: woody (lianas – plants with a secondary growth stem) or herbaceous (plants without a secondary growth stem) climbing plants, following the protocols of Gentry (1991) and of Villagra & Romaniuc Neto (2014). Climbing mechanisms were categorized as twining, tendril climbing or scandent (Hergaty 1991; Villagra & Romaniuc Neto 2014). Additionally, we classified climbing plants according to their dispersal modes: anemochory, autochory or zoochory (van der Pijl 1982; Barroso et al. 1999; Peres 2016). We compared the species sampled here with the list of climbing plants for seasonal semideciduous forest (Santos et al. 2009), savanna (Weiser & Martins 2014) and Brazilian flora (BFG 2015).

Results

We recorded 109 species, distributed in 67 genera and 29 families (Table 1). We found 78 and 80 species in Seasonal Semideciduous Forest and Cerradão, respectively, of which 49 (45%) occurred in both, and 29 (26.6%) and 31 (28.4%) were exclusive for the specific vegetation types. The richest families were Bignoniaceae and Malpighiaceae (17 species each), followed by Sapindaceae (12), Asteraceae and Apocynaceae (8 species each) and Fabaceae (6), corresponding to 46.7% of overall richness (Figure 2). In contrast, 11 families (38% of total families) had only one species recorded.

Among the habits, 76 species (70%) were lianas (woody climbers). The three richest families were entirely composed by woody plants (Table 1). The twining climbing mode was the most representative strategy (51 species; 47%), followed by tendril climbing (37 species, 37%) and scandent (18 species, 16%).

Anemochory was the most representative dispersal mechanism among the climbing plants species surveyed (72 species; 66%), followed by zoochory (23 species, 21%) and autochory (14 species, 13%). Among lianas, anemochory was the main dispersal mode (63 species, 83%), followed by zoochory (8 species, 10.5%) and autochory (5 species, 6.5%), while among herbaceous species, zoochory was the most frequent dispersal mode (15 species, 45.4%), followed by autochory and anemochory (9 species each, 27.3%).

In this study, we have registered one new family and 14 species for the Cerrado list, and 10 species for the seasonal semideciduous forest list (Table 1).

Table 1. Climbing plants sampled in Porto Ferreira State Park, Porto Ferreira, Southeastern Brazil. CER: forested savanna (Cerradão); SSF: seasonal semideciduous forest. Habit: Herb: herbaceous climbing plants; Wood: woody climbing plants (liana). Climbing mode: scandent; tendril; twining. Dispersion: Ane: anemochory; Aut: autochory; Zoo: zoochory. Voucher: APO: Ana Paula Caldeira Oliveira; HRCB: Herbário de Rio Claro; JAL: Júlio Antonio Lombardi. * First family and/or species record for FES; ● first record of the family and/or species for the Cerrado (Santos et al. 2009; Weiser & Martins 2014; Brazilian Flora Group 2015).

Family/species	Vegetation type	Habit	Climbing mode	Dispersion	Voucher
Acanthaceae					
Mendoncia puberula Mart.	SSF	Herb.	Twining	Zoo.	JAL 7712
Amaranthaceae					
Alternanthera brasiliana (L.) Kuntze	SSF*	Herb.	Scandent	Ane.	JAL 7710
Chamissoa acuminata Mart.	SSF*	Herb.	Scandent	Ane.	HRCB 68052
Apocynaceae					
Condylocarpon isthmicum (Vell.) A.DC.	CER•, SSF	Wood	Twining	Ane.	JAL 7763
Forsteronia australis Müll.Arg.	CER	Wood	Twining	Ane.	HRCB 67992
Forsteronia pubescens A.DC.	CER, SSF	Wood	Twining	Ane.	HRCB 67993
Odontadenia lutea (Vell.) Markgr.	CER	Wood	Twining	Ane.	HRCB 68001
Oxypetalum appendiculatum Mart.	CER	Herb.	Twining	Ane.	HRCB 67994
Prestonia coalita (Vell.) Woodson	CER, SSF	Wood	Twining	Ane.	HRCB 67995
Secondatia densiflora A.DC.	CER, SSF	Wood	Twining	Ane.	HRCB 67996
Temnadenia violacea (Vell.) Miers	CER, SSF	Wood	Twining	Ane.	HRCB 68066
Aristolochiaceae					
Aristolochia labiata Willd.	CER, SSF	Wood	Twining	Aut.	HRCB 67998
Asteraceae					
Bidens segetum Mart. ex Colla	CER, SSF	Wood	Scandent	Ane.	HRCB 67999
Cyrtocymura scorpioides (Lam.) H.Rob.	SSF	Herb.	Scandent	Ane.	APO 116
Dasyphyllum brasiliense (Spreng.) Cabrera	SSF	Wood	Scandent	Ane.	HRCB 68000
Mikania cordifolia (L. f.) Willd.	CER	Herb.	Twining	Ane.	APO 7
Mikania laevigata Sch.Bip. ex Baker	CER	Wood	Scandent	Ane.	APO 110
Mikania sp. 1	SSF	Wood	Twining	Ane.	APO 117
Mikania sp. 2	SSF	Wood	Twining	Ane.	APO 104
Mikania triangularis Baker	SSF	Herb.	Twining	Ane.	APO 103

Table 1. Continued...

Family/species	Vegetation type	Habit	Climbing mode	Dispersion	Voucher
Bignoniaceae					
Adenocalymma bracteatum (Cham.) DC.	CER, SSF	Wood	Tendril	Ane.	JAL 7730
Adenocalymma marginatum (Cham.) DC.	CER•, SSF	Wood	Tendril	Ane.	JAL 7784
Amphilophium crucigerum (L.) L.G.Lohmann	CER, SSF	Wood	Tendril	Ane.	HRCB 68002
Amphilophium elongatum (Vahl) L.G. Lohmann	CER, SSF	Wood	Tendril	Ane.	HRCB 68003
Anemopaegma chamberlaynii (Sims) Bureau & K. Schum.	CER, SSF	Wood	Tendril	Ane.	JAL 7745
Bignonia campanulata Cham.	CER•, SSF	Wood	Tendril	Ane.	HRCB 68006
Cuspidaria convoluta (Vell.) A.H.Gentry	CER, SSF	Wood	Tendril	Ane.	HRCB 68007
Cuspidaria pulchra (Cham.) L.G.Lohmann	CER, SSF	Wood	Tendril	Ane.	JAL 7765
Dolichandra unguis-cati (L.) L.G. Lohmann	SSF	Wood	Tendril	Ane.	HRCB 68009
Fridericia craterophora (DC.) L.G.Lohmann	CER	Wood	Tendril	Ane.	HRCB 68005
Fridericia florida (DC.) L.G.Lohmann	CER	Wood	Tendril	Ane.	HRCB 68004
Fridericia formosa (Bureau) L.G. Lohmann	CER, SSF	Wood	Tendril	Ane.	HRCB 68010
Fridericia speciosa Mart.	CER, SSF	Wood	Tendril	Ane.	HRCB 68061
Lundia obliqua Sond.	CER•, SSF	Wood	Tendril	Ane.	APO 62
Pyrostegia venusta (Ker-Gawl.) Miers	CER, SSF	Wood	Tendril	Ane.	HRCB 68060
Tanaecium selloi (Spreng.) L.G. Lohmann	CER, SSF	Wood	Tendril	Ane.	APO 40
Stizophyllum perforatum (Cham.) Miers	CER, SSF	Wood	Tendril	Ane.	HRCB 68012
Boraginaceae					
Myriopus rubicundus (Salzm. ex DC.) Luebert	CER•	Wood	Scandent	Zoo.	HRCB 68013
Varronia urticifolia (Cham.) J.S.Mill.	CER•	Wood	Scandent	Zoo.	HRCB 68014
Cactaceae					
Pereskia aculeata Mill.	SSF	Wood	Scandent	Zoo.	JAL 8087
Cannabaceae					
Celtis iguanaea (Jacq.) Sarg.	SSF	Wood	Scandent	Zoo.	JAL 8532
Celastraceae					
Semialarium paniculatum (Mart. ex Schult.) N.Hallé	SSF	Wood	Scandent	Ane.	JAL 8534
Commelinaceae					
Dichorisandra hexandra (Aubl.) C.B.Clarke	SSF	Herb.	Scandent	Zoo.	JAL 7671
Convolvulaceae					
Ipomoea chondrosepala Hallier f.	CER, SSF*	Herb.	Twining	Aut.	JAL 7743
Ipomoea saopaulista O'Donell	CER, SSF	Herb.	Twining	Aut.	JAL 7744
Merremia macrocalyx (Ruiz & Pav.) O'Donell	CER, SSF	Herb.	Twining	Aut.	HRCB 68015
Merremia umbellata (L.) Hallier f.	CER, SSF*	Herb.	Twining	Aut.	APO 60
Cucurbitaceae					
Gurania sp.	CER•, SSF*	Herb.	Tendril	Zoo.	APO 55
Psiguria ternata (M.Roem.) C.Jeffrey	CER	Herb.	Tendril	Zoo.	HRCB 68016
Cyperaceae					
Scleria latifolia Sw.	SSF	Herb.	Scandent/thorn	Zoo.	HRCB 68059
Dilleniaceae					
Davilla elliptica A.St.-Hil.	SSF*	Wood	Twining	Zoo.	HRCB 68017
Davilla rugosa Poir.	CER, SSF	Wood	Twining	Zoo.	APO 46
Doliocarpus dentatus (Aubl.) Standl.	CER, SSF	Wood	Twining	Zoo.	APO 21
Dioscoreaceae					
Dioscorea dodecaneura Vell.	CER, SSF	Herb.	Twining	Ane.	JAL 7736
Dioscorea olfersiana Klotzsch ex Griseb.	CER, SSF	Herb.	Twining	Ane.	JAL 7741
Euphorbiaceae					
Dalechampia pentaphylla Lam.	CER•, SSF	Herb.	Twining	Aut.	JAL 7777
Dalechampia stipulacea Müll.Arg.	SSF	Herb.	Twining	Aut.	JAL 7709
Dalechampia triphylla Lam.	SSF	Herb.	Twining	Aut.	HRCB 68019
Fabaceae					
Canavalia picta Mart. ex Benth.	CER	Wood	Twining	Aut.	APO 92
Centrosema sagittatum (Humb. & Bonpl. ex Willd.) Brandegee	SSF	Herb.	Twining	Aut.	HRCB 68020
Dioclea violacea Mart. ex Benth.	SSF	Wood	Twining	Aut.	HRCB 68021
Rhynchosia minima (L.) DC.	CER• SSF	Herb.	Twining	Aut.	JAL 7752
Rhynchosia phaseoloides (Sw.) DC.	SSF	Wood	Twining	Aut.	HRCB 68022
Senegalia polyphylla (DC.) Britton & Rose	CER	Wood	Scandent/thorn	Aut.	JAL 8531

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Table 1. Continued...

Family/species	Vegetation type	Habit	Climbing mode	Dispersion	Voucher
Lygodiaceae					
Lygodium volubile Sw.	CER, SSF	Herb.	Twining	Ane.	HRCB 68050
Malpighiaceae					
Banisteriopsis adenopoda (A.Juss.) B.Gates	CER•	Wood	Twining	Ane.	APO 91
Banisteriopsis argyrophylla (A.Juss.) B.Gates	CER, SSF	Wood	Twining	Ane.	JAL 7755
Banisteriopsis latifolia (A.Juss.) B.Gates	CER	Wood	Twining	Ane.	HRCB 68025
Banisteriopsis malifolia (Nees & Mart.) B.Gates var. malifolia	CER, SSF*	Wood	Twining	Ane.	HRCB 68026
Banisteriopsis cf. *muricata* (Cav.) Cuatrec.	CER, SSF	Wood	Twining	Ane.	HRCB 68031
Banisteriopsis oxyclada (A.Juss.) B.Gates	CER, SSF	Wood	Twining	Ane.	HRCB 68027
Banisteriopsis stellaris (Griseb.) B.Gates	CER	Wood	Twining	Ane.	HRCB 68028
Banisteriopsis variabilis B.Gates	CER	Wood	Scandent	Ane.	HRCB 68029
Diplopterys pubipetala (A.Juss.) W.R.Anderson & C.C.Davis	CER	Wood	Twining	Ane.	APO 114
Heteropterys umbellata A.Juss.	SSF*	Wood	Twining	Ane.	JAL 8089
Heteropterys sp.	CER	Wood	Twining	Ane.	HRCB 68030
Mascagnia cordifolia (A.Juss.) Griseb.	CER	Wood	Twining	Ane.	APO 115
Mascagnia sepium (A.Juss.) Griseb.	CER, SSF	Wood	Twining	Ane.	JAL 7732
Niedenzuella lucida (A.Juss.) W.R.Anderson	SSF*	Wood	Twining	Ane.	HRCB 68034
Niedenzuella multiglandulosa (A.Juss.) W.R.Anderson	CER, SSF	Wood	Twining	Ane.	HRCB 68032
Stigmaphyllon lalandianum A.Juss.	SSF	Wood	Twining	Ane.	HRCB 68033
Tetrapterys sp.	SSF	Wood	Twining	Ane.	HRCB 68049
Menispermaceae					
Cissampelos pareira L.	CER	Wood	Twining	Zoo.	JAL 8536
Passifloraceae					
Passiflora alata Curtis	SSF*	Herb.	Tendril	Zoo.	JAL 7767
Passiflora miersii Mast.	CER	Herb.	Tendril	Zoo.	APO 95
Passiflora suberosa L.	CER	Herb.	Tendril	Zoo.	APO 2
Polygalaceae					
Bredemeyera floribunda Willd.	CER, SSF	Wood	Scandent	Ane.	HRCB 68035
Securidaca tomentosa A.St.Hil. & Moq.	CER•	Wood	Scandent	Ane.	HRCB 68065
Ranunculaceae•					
Clematis dioica L.	CER•	Wood	Twining	Ane.	JAL 8530
Rhamnaceae					
Gouania virgata Reissek	CER, SSF	Wood	Tendril	Ane.	HRCB 68037
Rubiaceae					
Galianthe laxa (Cham. & Schltdl.) E.L.Cabral	CER, SSF	Herb.	Scandent	Zoo.	JAL 7738
Manettia cordifolia Mart.	CER, SSF	Herb.	Twining	Zoo.	HRCB 68038
Sapindaceae					
Cardiospermum grandiflorum Sw.	SSF	Wood	Tendril	Ane.	HRCB 68039
Paullinia rhomboidea Radlk.	CER, SSF	Wood	Tendril	Ane.	APO 102
Serjania cf. *acoma* Radlk.	CER	Wood	Tendril	Ane.	HRCB 68040
Serjania communis Cambess.	CER•	Wood	Tendril	Ane.	APO 3
Serjania fuscifolia Radlk.	CER•, SSF	Wood	Tendril	Ane.	APO 44
Serjania laruotteana Cambess.	CER	Wood	Tendril	Ane.	HRCB 68041
Serjania lethalis A.St.-Hil.	CER	Wood	Tendril	Ane.	APO 107
Serjania meridionalis Cambess.	SSF	Wood	Tendril	Ane.	JAL 7715
Serjania paradoxa Radlk.	CER	Wood	Tendril	Ane.	APO 120
Serjania pinnatifolia Radlk.	CER, SSF	Wood	Tendril	Ane.	HRCB 68055
Serjania reticulata Cambess.	CER, SSF	Wood	Tendril	Ane.	APO 48
Urvillea laevis Radlk.	CER, SSF	Wood	Tendril	Ane.	APO 63
Smilaceae					
Smilax elastica Griseb.	CER	Herb.	Tendril	Zoo.	HRCB 68043
Smilax fluminensis Steud.	CER	Herb.	Tendril	Zoo.	HRCB 68058
Vitaceae					
Cissus erosa Rich.	CER, SSF	Herb.	Tendril	Zoo.	HRCB 68045
Cissus tinctoria Mart.	SSF	Herb.	Tendril	Zoo.	HRCB 68046
Cissus verticillata (L.) Nicolson & C.E.Jarvis	SSF	Herb.	Tendril	Zoo.	HRCB 68047

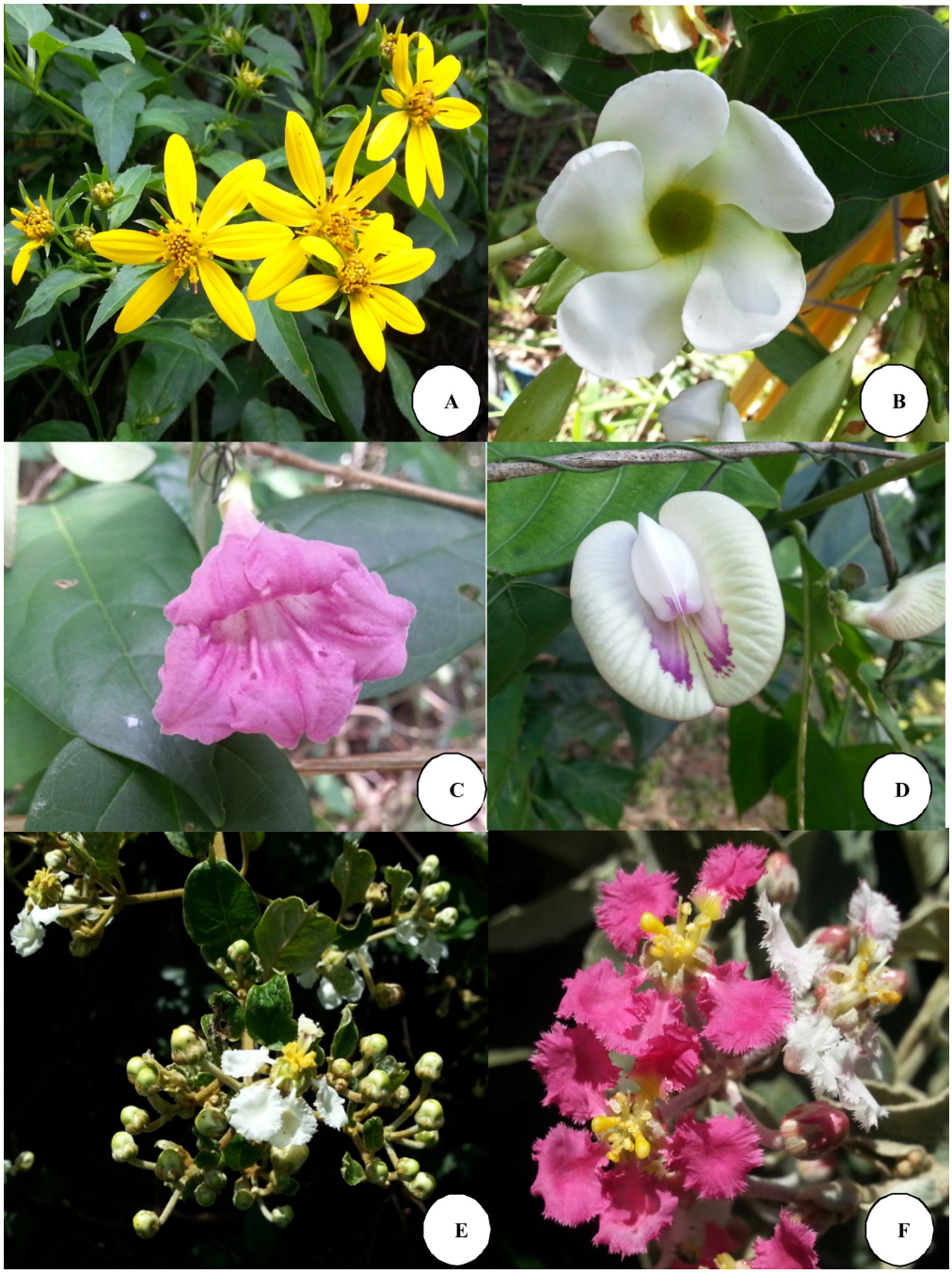

Figure 2. A. *Bidens segetum*; B. *Odontadenia lutea*; C. *Fridericia craterophora*; D. *Centrosema sagittatum*; E. *Banisteriopsis argyrophylla*; F. *Banisteriopsis adenopoda*. By: Marcusso, G., Sabino, G. and Udulutsch, R.G.

Discussion

The present study showed elevated richness of climbing plants in Cerradão, compared to other studies carried out in Cerrado *sensu stricto* in São Paulo state, where 41 (Mantovani & Martins 1993) and 15 species (Weiser & Godoy 2001) were recorded. On the other hand, in a Cerradão in Bauru, 52 species of climbers were recorded (Weiser 2007), corroborating our results that the Cerradão is richer in climbing plants than Cerrado *sensu stricto*. Although these studies had different sample time spans, the richness recorded in the present study can be considered high by the fact that the studies carried out in Cerrado *sensu stricto* had very similar sample times to ours (16 to 22 months, Mantovani & Martins 1993; Weiser & Godoy 2001, respectively), while the study in Cerradão considered a much larger sample time (51 months, Weiser 2007). However, the last considered a smaller area than the present study (1 versus 169 hectares, respectively). In this way, it is likely that other Cerradão areas are as rich in this vegetation type as that recorded in the present study.

Otherwise, the number of species found in Seasonal Semideciduous Forest can be considered low compared to the average for this vegetation type (e.g. Morellato & Leitão-Filho 1998; Udulutsch et al. 2004; Rezende & Ranga 2005; Tibiriçá et al. 2006; Carneiro & Vieira 2012). However, we did not sample months with the same frequency, as we collected one more

time during transitional months and those at the end of the climatic season (rainy and dry season), and these reproductive periods are considered the peak of flowering and fruiting for climbing plants (Morellato & Leitão-Filho 1996). This was also the case in the study of Udulutsch et al. (2010), so much that these surveys showed a similar number of species (74 species) to the present study (78 species). Furthermore, floristic surveys are usually carried out for different time spans and in areas with different sizes, which compromises comparisons of diversity and the relationships between flora of different sites (e.g. Forzza et al. 2014). In this way, we suggest that floristic studies are made considering equal sample frequency during the year, considering the reproductive stages of the plants. Therefore, it may be that the Seasonal Semideciduous Forest of PFSP is so rich as those in other studies which have reported high values for richness (e.g. Morellato & Leitão- Filho 1998; Udulutsch et al. 2004; Tibiriçá et al. 2006).

In general, the reasonably substantial number of climbing plant species recorded in this study is perhaps associated with the ecotonal condition of this area, where the floristic elements of both vegetation types (seasonal semideciduous forest and Cerradão) contribute to the richness. Although for climbing plants this aspect is poorly known, this has already been documented for vascular epiphytes (e.g. Kersten 2010; Bonnet et al. 2011; Marcusso & Monteiro 2016) and trees (e.g. Pinheiro & Monteiro 2008). This elevated richness and abundance of species in an ecotone is related to the meeting of adjacent areas, and thus encompasses the diversity of the community around it (Odum 1969; Kent et al. 1997; Kark 2012). This transitional area shares environmental conditions but also establishes the particular conditions of an ecotone, allowing coexistence of species from the surrounding vegetation, as well as rare and endemic species (Kark & Rensburg 2006; Kark 2012).

The majority of climbing plants species registered belong to few families, corroborating the hypothesis described by Gentry (1991) in which the majority of species (70% in the present study) are concentrated in only 13 families. Among the richest families, Bignoniaceae, Malpighiaceae and Sapindaceae stand out (e.g. Lombardi et al. 1999; Nabe-Nielsen 2001; Hora & Soares 2002; Tibiriçá et al. 2006). These families have a widespread geographical distribution, occurring among different vegetation types (Lohmann 2015; Mamede et al. 2015; Somner et al. 2015), and certain genera are predominantly (e.g. Bignoniaceae: *Fridericia*; Sapindaceae: *Serjania*; Malpighiaceae: *Banisteriopsis*) or exclusively (e.g. Bignoniaceae: *Lundia*, *Pyrostegia*, *Tanaecium*, *Stizophyllum*; Sapindaceae: *Urvillea*; Malpighiaceae: *Mascagnia*, *Niedenzuella*) composed by climbing species (Gentry 1991; BFG 2015).

We found a prevalence of lianas in the study area. Although an equal proportion of lianas and herbaceous climbing plants is expected in tropical forests (Gentry & Dodson 1987; Gentry 1991; Durigon et al. 2009), studies of climbing plants realized in semideciduous forest found 64% (Udulutsch et al. 2004) and 60% (Vargas et al. 2013) lianas, contradicting this estimation. On the other hand, herbaceous vines can represent almost 85% of the richness in subtropical and temperate forests (Durigon et al. 2014).

The pattern of climbing mechanism registered for tropical forests was corroborated in this study, wherein twining was the predominant mechanism, followed by tendril climbing (e.g. Gentry 1991; Araujo & Alves 2010; Vivek & Parthasarathy 2015). Despite some species having specialized structures to assist in colonization of the phorophyte, such as tendrils modified with adhesive pads and hooks, improving their colonization success (Gentry 1979; Lohmann 2006), this climbing mechanism has not been the most encountered in tropical forests (Gentry 1991). In this study, we recorded *Scleria latifolia* and *Senegalia polyphylla* with a twining habit. In general, these species are not included in climbing plant floristic surveys, but in PFSP these species were observed with this growth mode; perhaps they use scabrous and thorn features to ascend in the phorophyte.

In general, anemochory (72 species) was the most commonly found dispersal mode among climbing plants (lianas + herbaceous vines) (Durigon & Waechter 2011; Gallagher et al. 2011; Vargas et al. 2013), which is associated with environments with pronounced climatic seasonality (Dewalt et al. 2010; Schnitzer & Bongers 2011). According to Morellato & Leitão-Filho (1996), the pattern of dispersion can be considered complementary in forest phenology, wherein in periods with a smaller amount of annual precipitation, the tree community totally or partially loses its leaves (Montovani & Martins 1998), and climbing plants can use wind currents to disperse their seeds (Morellato & Leitão-Filho 1998). Although, when considering only herbaceous vines, this relation can be altered by the predominance of zoochory, thus their fruits mature during the rainy season (Morellato & Leitão-Filho 1996).

Despite floristic inventories of climbing plants increasing, they are concentrated in semideciduous forest (e.g. Hora & Soares 2002; Tibiriçá et al. 2006; Rezende et al. 2007; Udulutsch et al. 2010; Vargas et al. 2013), to the detriment of those realized in the Cerrado (Weiser & Godoy 2001; Weiser 2007; Oliveira et al. 2014). However, this study included new registers of species for both vegetation types. This is because climbing plants comprise a very diverse group, so much so that they are considered key to innovation throughout evolution, increasing angiosperm diversity (Gianoli 2015; Gianoli et al. 2016). For this reason, we highlight the importance of including climbing plants in community research (Durigon et al. 2014; Schnitzer et al. 2015), and realizing floristic inventories that include or integrate climbing plants.

The present study reveals the considerable richness of this sinusia in Porto Ferreira State Park, with a similar number of species between the vegetation types. The mainly contribution is relation to diversity, recorded species, like *Scleria latifolia* and *Senegalia polyphylla*, as climbing plants. Both to vegetation types showed new records to the climbing plants checklist. Thus, we encourage the initiatives of floristic surveys with climbing plants, with similar frequency of sample, in these vegetation types, mainly in the Cerradão, in view of the importance of its floristic richness and to filling out the remaining gaps.

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Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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