Biota Neotropica 14(4): 1–12, 2014
www.scielo.br/bn

biotaneotropica
ISSN 1676-0611 (online edition)
inventory

Checklist of climbing plants in an Araucaria forest of Rio Grande do Sul State, Brazil

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SEGER, G.D.S., HARTZ, S.M. **Checklist of climbing plants in an Araucaria forest of Rio Grande do Sul State, Brazil.** Biota Neotropica. 14(4): 1–12. http://dx.doi.org/10.1590/1676-06032014006214

Abstract: Climbing plants are remarkable components of forests, highly contributing for the diversity and dynamics of communities. Studies focusing on climbing plants are scarce and for many vegetation types little is known about climbing species composition and their traits relevant for dispersal and establishment. The focus of this study is to provide the first floristic inventory of climbing plants in an *Araucaria* forest of Brazil, describing the dispersal syndromes and climbing mechanisms of species and comparing these traits and species composition patterns with other study sites in Southern Brazil. We found 104 taxa belonging to 33 families, with Asteraceae (22 spp.) and Apocynaceae (14 spp.) being the richest families. Among climbing mechanisms, stem twiner (50 spp.) is the most common, followed by tendril (20 spp.) and scrambler (12 spp.), while in relation to the dispersal syndromes, anemochoric species (65 spp.) are the most relevant followed by endozoochoric (28 spp.). Three new species registries were found for Rio Grande do Sul State expanding their occurrence range towards South Brazil. The comparison of climbers' survey sites showed two sharp groups in relation to species composition and traits proportion, Seasonal and *Araucaria*/Atlantic forest sites, but with no difference of traits frequency between sites. There is a predominance of stem twiners species in all sites, but the relative difference for tendril species increases in *Araucaria* and Atlantic forest sites. The Asteraceae and Apocynaceae families were the most relevant, contrasting to Seasonal forests of Southeast Brazil. Interesting patterns can be achieved with a more detailed classification of climbing mechanisms and the results found in this study contributes to enhance the knowledge on climbers' traits and diversity in South Brazil.
Keywords: *Lianas, Vines, Climbing mechanisms, Dispersal syndromes, Floristic of climbers.*

SEGER, G.D.S., HARTZ, S.M. **Florística de trepadeiras em uma floresta de Araucária do Estado do Rio Grande do Sul, Brasil.** Biota Neotropica. 14(4): 1–12. http://dx.doi.org/10.1590/1676-06032014006214

Resumo: Trepadeiras são importantes componentes florestais, contribuindo na diversidade e dinâmica de comunidades vegetais. Estudos focados em trepadeiras são escassos e para muitos tipos vegetacionais pouco se sabe sobre a composição de espécies de trepadeiras e seus atributos relevantes para dispersão e estabelecimento. O foco deste estudo é fornecer o primeiro inventário florístico de plantas trepadeiras em uma floresta de Araucária no Brasil, descrevendo as síndromes de dispersão e mecanismos de escalada das espécies e comparando esses atributos e a composição de espécies com outros sítios no Sul do Brasil. Foram encontrados 104 taxa pertencentes a 33 famílias, sendo Asteraceae (22 spp.) e Apocynaceae (14 spp.) as famílias mais ricas. Dentre os mecanismos de escalada, o tipo volúvel (50 spp.) é o mais comum, seguido por gavinhas (20 spp.) e apoiantes (12 spp.), enquanto em relação às síndromes de dispersão as espécies anemocóricas (65 spp.) são as mais relevantes seguidas por endozoocóricas (28 spp.). Três novos registros de espécies foram encontrados para o Estado do Rio Grande do Sul, expandindo suas extensões de ocorrência para o Sul do Brasil. A comparação entre sítios evidenciou dois grupos nítidos em relação à composição de espécies e proporção de atributos, sítios em florestas sazonais e nas florestas com Araucária e Atlântica, porém não há diferença na frequência dos atributos entre os sítios. Há uma predominância de espécies volúveis em todos os sítios, entretanto a diferença relativa para espécies com gavinhas aumenta nos sítios de floresta com Araucária e Atlântica. As famílias Asteraceae e Apocynaceae foram as mais relevantes, contrastando com florestas sazonais no Sudeste do Brasil. Padrões interessantes podem ser encontrados com uma classificação mais detalhada dos mecanismos de escalada e os resultados encontrados neste estudo contribuem para aumentar o conhecimento sobre os atributos e a diversidade de trepadeiras no Sul do Brasil.
Palavras-chave: *Lianas, Mecanismos de Escalada, Síndromes de dispersão, Florística de Trepadeiras.*

Introduction

The *Araucaria* forest, part of Mata Atlântica Biome, is the main forest type of South Brazil (IBGE 2004). It occurs continuously in the highlands of the Southern Brazilian Plateau and in small isolated areas of Argentina, Paraguay, Southeast Brazil and ''Serra do Sudeste'' formation in Rio Grande do Sul State, Brazil (Hueck 1972, Carlucci *et al*. 2011a). Timber logging of *Araucaria angustifolia* (Bertol.) Kuntze and other species was an important economic feature in the last century (Reitz *et al*. 1983), which contributed for reducing the *Araucaria* forest to less than 12.6% of its original area (Ribeiro *et al*. 2009). In spite of its wide geographic range, studies in the *Araucaria* forest manly focused on trees' communities (e.g. Duarte *et al*. 2012), no study to date has focused on climbing plants.

Climbing plants are important components of forests dynamics, contributing with biomass and plant diversity (Schnitzer & Bongers 2011), affecting mortality and growth of trees (Ingwell *et al*. 2010), collaborating with treefall gaps formation and preventing trees regeneration on it (Schnitzer & Carson 2010). Climbing species show a diversity of climbing mechanisms/strategies (Hegarty & Caballé 1991) to reach the best productive position, with full access to sunlight where they reproduce and spread through other trees canopies (Campbell & Newbery 1993). Forest structure directly influences the abundance, diversity and distribution of climbers. For instance, forest edges and treefall gaps present high diversity and density of climbers (Laurance *et al*. 2001, Londré & Schnitzer 2006), strongly determined by light availability on these early successional stages (DeWalt *et al*. 2000).

The *Araucaria* forest is expanding over *Campos* grasslands since the Holocene (Behling & Pillar 2007), mainly through forest edge expansion (Carlucci *et al*. 2011b) and nucleation process (Duarte *et al*. 2006). These expansion processes create a great amount of habitats for climbing species like forest edges and patches with different sizes and light availability, which are similar to fragmented landscapes caused by anthropic action known to positively affect climber's abundance (Londré & Schnitzer 2006). Since climbers are considered pioneer species and play an important role in forest succession (DeWalt *et al*. 2000), it is important to know their diversity, as well as their traits that might give an important overview of their limitations and capacity of dispersal and establishment at different environments. In this context, the aim of this study is to provide the first survey focused on climbing plants in an *Araucaria* forest of Southern Brazil and compare species traits (dispersal syndromes and climbing mechanisms) and composition with other study sites belonging to different forest types in South Brazil. We hypothesize that study sites of the same forest type are similar in relation to species composition and traits proportion.

Material and Methods

The floristic survey was carried out at the National Forest of São Francisco de Paula - ICMBIO (''Floresta Nacional de São Francisco de Paula''; FLONA–SFP), a conservation unit of sustainable use, located in São Francisco de Paula municipality in Rio Grande do Sul State (29°25'24''S, 50°23'13''W; Figure 1). FLONA–SFP is composed by a mosaic landscape of *Araucaria* forest remnants together with ecologically-managed *Araucaria angustifolia* (Bertol.) Kuntze, *Eucalyptus* spp. and *Pinus* spp. plantations and a small area of unmanaged *Campos* grassland. It covers 1,606 ha, where 36.6 % is covered by *Araucaria* forest remnants, ranging in altitude from 600 to 923 m a.s.l. The regional climate is characterized as subtropical rainy, with precipitation uniformly distributed throughout the year. The annual mean rainfall reaches 2,252 mm and the annual mean temperature is 14.4 °C with the occurrence of negative temperatures from April to November and rare events of snow (National Institute of Meteorology – INMET).

Climbers were monitored monthly from July 2007 to August 2009 along 13 km of trails inside and at the edges of *Araucaria* forest remnants and planting areas of *A. angustifolia*. Additionally, another 15 field trips were done from March 2010 to October 2013 at areas not visited before. These extra field trips covered around 70 ha of *Araucaria* forest remnants and 240 treefall gaps. The total survey comprised around 200 days of field trips. Voucher specimens were deposited at ICN Herbarium (Departamento de Botânica, Instituto de Biociências, Universidade Federal do Rio Grande do Sul). All taxa were classified into families following the APG III system (APG 2009) and according to its dispersal syndrome and climbing mechanism, using specialized literature and personal observation. Dispersal syndromes were classified according to van der Pijl (1982) into anemochoric, endozoochoric, epizoochoric, autochoric and barochoric. Some species uncertain about their dispersal syndrome and not clearly classified in specialized literature, were classified as anemochoric only when specialized appendices like plumes or wings were present, otherwise were considered as barochoric. The climbing mechanisms were classified according to Hegarty (1991) into stem twiner, petiole twiner, secondary shoot twiner, tendril (that coil), clasp tendril, adhesive tendril (terminal adhesive pads), scrambler, hook/spine (also aculeus or trichomes that prevent slipping) and adherent roots. Many species combine different climbing mechanisms, making them difficult to be correctly classified (Hegarty 1991). In these cases, we considered the main climbing mechanism the first to appear during species development (personal observation), but we also cite the secondary climbing mechanism. Species abundance was estimated by counting individuals during July 2007 to August 2009 (with an exception for new species found within March 2010 to October 2013) and species were classified as singletons (one individual found), low abundance (two to five individuals) and high abundance (more than 100 individuals).

In the State of Rio Grande Sul (RS), 11 studies sampled climbing species (Table 1) in different forest types, but only three of them, besides this survey, strictly focused on climbing plants. For the comparison between sites we selected the studies with more than 40 climbing species (eight sites), considered as reliable surveys. In each study, we compiled the checklist, checked for species synonymies, excluded exotic species, and complemented the survey reviewing species deposited at ICN and PACA (Instituto Anchietano de Pesquisas/UNISINOS) herbariums, assessing herbarium records from *species*Link (CRIA 2014) and consulting taxonomic studies for RS State. Species were classified in relation to their dispersal syndromes and climbing mechanisms following the same classification explained before, combining personal knowledge and specialized literature. To analyze sites relationship according to species composition and traits proportion (dispersal syndromes and climbing mechanisms) we performed separate cluster

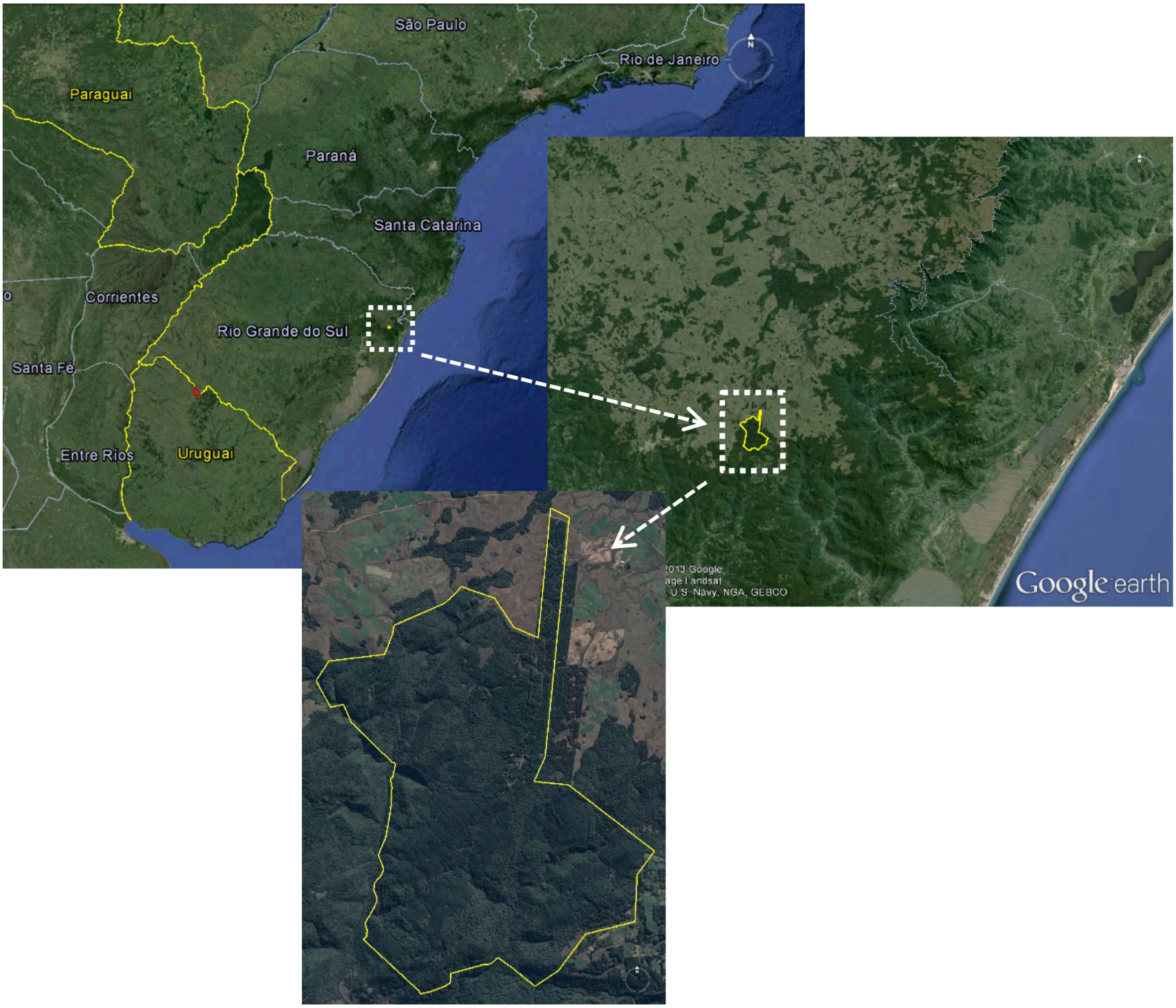

Figure 1. Location of the National Forest of São Francisco de Paula, RS, Brazil (29°25'24''S, 50°23'13''W) (Source: http://earth.google.com, 2013).

analyses, using Ward's clustering criterion and evaluating groups partition sharpness through 10,000 bootstrap resampling (Pillar 1999). As resemblance measurements between sites, we used the complement of Jaccard's similarity for species composition, and a modification of Gower's distance (Pavoine *et al*. 2009) for traits proportion. We also performed Fisher's exact tests with 10,000 Monte Carlo test replicates to evaluate whether there was a difference in the frequency of dispersal syndromes and climbing mechanisms between all sites. The modified Gower's distance was calculated in the package *ade4* v.1.6-2 (Dray & Dufour 2007) in the R Statistical Environment (R Core Team 2014). The complement of Jaccard's similarity and clustering analyses were performed using MULTIV 3.27b statistical software (by V.D. Pillar; available at http://ecoqua.ecologia.ufrgs.br/software).

Results

A total of 104 taxa were found at FLONA-SFP, belonging to 103 species, 62 genera and 33 families (Table 2). The richest families were Asteraceae (21 species), Apocynaceae (14), Fabaceae (10), Rubiaceae (7), Bignoniaceae and Malpighiaceae (5). Altogether these six families comprise 62 taxa (60% of total richness). Around a half of the families (16) contain two or more taxa, comprising 84% of total richness, while 20 genera containing two or more taxa comprise 62 taxa (60% of total richness). The richest genera were *Mikania* Willd. with 12 species, *Oxypetalum* R.Br. and *Manettia* Mutis ex L. with five. Around 29 species presented low abundance with a maximum of five individuals found and within them, six were singletons (Table 2). Considering the species in reproductive activity during July 2007 to August 2009 (G.D.S. Seger, unpublished data), eight species presented more than 100 individuals, while considering sterile individuals this number rises up to 27 species (Table 2).

The most common climbing mechanism is stem twinner (50 taxa) followed by tendril (20), scrambler (12), hook/spine (8), petiole twinner (6), adherent roots (3), clasp tendril (2), secondary shoot twinner (2) and adhesive tendril (1) (Table 2). A secondary climbing mechanism is present in six species.

Table 1. Floristic surveys of climbing plant species in Rio Grande do Sul State, Brazil. **Forest types**: AR - *Araucaria* forest; AT - Atlantic forest; D - Deciduous forest; R – Restinga forest; SD – Semideciduous forest; †Floristic survey of all plant life forms; Forest types classification is according to IBGE (2012).

Site (Coordinates)	Species richness	Forest type	Richest families (species number)	Reference
Derrubadas - P.E. Turvo † (27°13'15"S, 53°52'52"W)	130	D	Asteraceae (14), Bignoniaceae (13), Apocynaceae (12), Fabaceae (11) and Sapindaceae (9)	Brack *et al.* (1986) and herbarium review
Santa Maria (29°41'37"S, 53°48'51"W)	70	D	Sapindaceae (8), Apocynaceae, Bignoniaceae & Convolvulaceae (7)	Durigon *et al.* (2009)
São Jerônimo and Butiá † (29°57'23"S, 51°46'24"W)	37	SD	Bignoniaceae & Asteraceae (5) and Convolvulaceae & Sapindaceae (4)	Bueno *et al.* (1987)
Guaíba (30°10'47"S, 51°23'33"W)	92	SD	Asteraceae (14), Apocynaceae (11) and Fabaceae (9)	Durigon & Waechter (2011) and Matzenbacker *et al.* (2011)
Porto Alegre - Lami † (30°15'29"S, 51°6'11"W)	22	R	Asteraceae & Bignoniaceae (5) and Passifloraceae (3)	Fuhro *et al.* (2005)
Viamão - Morro do Coco † (30°16'3"S, 51°3'20"W)	60	SD	Bignoniaceae (8), Apocynaceae (6) and Convolvulaceae (5)	Knob (1978), Backes (1981), Aguiar *et al.* (1986) and herbarium review
Viamão - Morro da Grota † (30°21'57"S, 51°1'17"W)	33	SD	Bignoniaceae (5) and Asteraceae & Rubiaceae (3)	Aguiar *et al.* (1986)
Viamão - Morro Grande (30°5'8"S, 50°49'35"W)	44	SD	Asteraceae (7), Apocynaceae, Bignoniaceae & Passifloraceae (5)	Venturi (2000) and herbarium review
São Francisco de Paula (29°25'24"S, 50°23'13"W)	103	AR	Asteraceae (21), Apocynaceae (14), Fabaceae (10), Rubiaceae (7), Bignoniaceae & Malpighiaceae (5)	This study
Dom Pedro de Alcântara † (29°24'21"S, 49°50'53"W)	49	AT	Apocynaceae (7) and Asteraceae & Passifloraceae (5)	Silva Filho *et al.* (2013)
Torres - P.E. Itapeva † (29°21'28"S, 49°45'34"W)	100	AT	Asteraceae (20), Apocynaceae (13) and Cucurbitaceae (5)	SEMA (2006) and herbarium review

There is a predominance of anemochoric dispersal syndrome (65 taxa) followed by endozoochoric (28), barochoric (6), autochoric (4) and epizoochoric (1). Within anemochory, there are more pogonochoric species (plummed diaspores; 39 species) than pterochoric (winged diaspores; 26 species) (Table 2).

We found three new registries for the State of RS, *Matelea dusenii* Morillo (Apocynaceae family), *Manettia verticillata* Wernham (Rubiaceae) and *Piptadenia affinis* Burkart (Fabaceae) (Figure 2), extending their occurrence range towards South Brazil. *P. affinis* presented low abundance with only eight individuals found. *M. dusenii* is very rare with just one sapling and one individual at reproductive stage found, while *M. verticillata* presented only three individuals.

The floristic surveys with more than 40 species (eight sites) comprised 286 species, distributed in 131 genera and 49 families. The richest families were Apocynaceae and Asteraceae (36 spp.), Fabaceae (24), Bignoniaceae (18), Cucurbitaceae and Convolvulaceae (16), Malpighiaceae (15), Passifloraceae and Sapindaceae (13) and Rubiaceae (11). These families comprised 69% of total richness. The richest climbing mechanism was stem twiner (144 spp.), followed by tendrils (66), scramblers (31) and hook/spine (21). Anemochoric species (154 spp.) were the most common, followed by endozoochoric (81), barochoric (26) and autochoric (18). The cluster analysis of species composition revealed two major groups that were the only group's combination supported by group's partition sharpness analysis, one with the Atlantic and *Araucaria* forests sites and other with Seasonal forest sites (Figure 3). The cluster analysis of traits proportion showed support for up to four sharp groups (Figure 4), firstly separating the Atlantic and *Araucaria* forests sites from Seasonal forest sites, the Semideciduous from Deciduous forest sites and the Torres (Tr) site from the FLONA-SFP and Dom Pedro de Alcântara (DP) sites. There is a clear predominance of the anemochoric dispersal syndrome in all sites followed by endozoochoric syndrome (Figure 5). Comparing the most abundant climbing mechanisms (stem twiner, tendrils, scramblers and hook/spines), that together represent between 86 and 95% of total richness in each site, there is a predominance of stem twiners in all sites, followed by trendril climbers (Figure 6). Other interesting patterns are the inversion of scramblers proportion in relation to hook/spine species in the Atlantic forest sites (DP and Tr; Figure 6) and the presence of species that climb with the aid of adherent roots in eastern sites (FLONA-SFP, DP and Tr; Figure 6). Comparing the floristic surveys, the Fisher's exact test showed no difference for dispersal syndromes ($P = 0.94$) and climbing mechanisms ($P = 0.23$). Although there is a trend of observing a lower difference between anemochory and endozoochory in Semidecidual forest sites and a higher difference between stem twiners and tendril climbers in the Atlantic and *Araucaria* forest sites (Figures 5 and 6). When analyzing climbing mechanisms combining them in four major groups (joining stem twiner species with petiole twiner and secondary shoot twiner; tendril species with clasp tendril and adhesive tendril species; scrambler species with hook/spine species; and the adherent root species), as commonly seen in studies that classify the species' climbing mechanisms (e.g. Santos *et al.* 2009), the Fisher's exact test showed a significant result ($P = 0.02$).

http://dx.doi.org/10.1590/1676-06032014006214

Table 2. Species list, climbing mechanism, dispersal syndrome and the ICN voucher number of climbing species surveyed at the National Forest of São Francisco de Paula, RS, Brazil. **Climbing mechanism**: STw (Stem Twiner); PTw (Petiole Twiner); SSTw (Secondary Shoot Twiner); Td (Tendril); CTd (Clasp Tendril); ATd (Adhesive Tendril); Sc (Scrambler); HS (Hook/Spine); R (Adherent Roots). **Dispersal Syndrome**: A (Anemochoric); Z (Endozoochoric); Ep (Epizoochoric); T (Autochoric); B (Barochoric); Anemochoric subtypes (Pg - Pogonochoric; Pt - Pterochoric). **Abundance**: S (Singleton); L (Low; two to five individuals); H (High; more than 100 individuals). *Voucher deposited at the HUCS Herbarium (Universidade Federal de Caxias do Sul, Rio Grande do Sul State, Brazil).

Family/Species	Climbing mechanism	Dispersal Syndrome	Abundance	ICN Number
ALSTROEMERIACEAE				
Bomarea edulis (Tussac) Herb.	STw	Z	-	162137
APOCYNACEAE				
Araujia sericifera Brot.	STw	A (Pg)	L	175748
Forsteronia cf. *refracta* Müll.Arg.	STw	A (Pg)	L	175742
Mandevilla pentlandiana (A.DC.) Woodson	STw	A (Pg)	L	-
Marsdenia montana Malme	STw	A (Pg)	-	175100
Matelea dusenii Morillo	STw	A (Pg)	L	161668
Orthosia scoparia (Nutt.) Liede & Meve	STw	A (Pg)	H	183748
Orthosia urceolata E. Fourn.	STw	A (Pg)	H	183739
Orthosia virgata (Poir.) E. Fourn.	STw	A (Pg)	-	153827
Oxypetalum appendiculatum Mart.	STw	A (Pg)	L	175739
Oxypetalum pedicellatum Decne.	STw	A (Pg)	L	153826
Oxypetalum mosenii (Malme) Malme	STw	A (Pg)	-	162152
Oxypetalum pannosum Decne.	STw	A (Pg)	-	161716
Oxypetalum wightianum Hook. & Arn.	STw	A (Pg)	-	161718
Peltastes peltatus (Vell.) Woodson	STw	A (Pg)	L	175746
ASTERACEAE				
Baccharis anomala DC.	Sc	A (Pg)	H	172502
Baccharis oxyodonta DC.	Sc	A (Pg)	S	172508
Baccharis trinervis (Lam.) Pers.	Sc	A (Pg)	-	172526
Calea pinnatifida (R.Br.) Less.	Sc	A (Pg)	H	172510
Lepidaploa balansae (Chodat) H.Rob.	Sc	A (Pg)	-	172524
Mikania burchellii Baker	STw	A (Pg)	H	169834
Mikania campanulata Gardner	STw	A (Pg)	-	169822
Mikania cordifolia (L.f.) Willd.	STw	A (Pg)	S	-
Mikania hirsutissima DC.	STw	A (Pg)	-	169833
Mikania involucrata Hook. & Arn.	STw	A (Pg)	H	169836
Mikania laevigata Sch. Bip. ex Baker	STw	A (Pg)	-	161685
Mikania micrantha Kunth	STw	A (Pg)	-	169824
Mikania oreophila Ritter & Miotto	STw	A (Pg)	-	162153
Mikania orleansensis Hieron.	STw	A (Pg)	H	169840
Mikania paranensis Dusén	STw	A (Pg)	-	169842
Mikania parodii Cabrera	STw	A (Pg)	L	169844
Mikania ternata (Vell.) B.L.Rob.	STw	A (Pg)	-	161682
Mutisia campanulata Less.	Td	A (Pg)	L	162216
Mutisia speciosa Aiton ex Hook.	Td	A (Pg)	-	172498
Pentacalia desiderabilis (Vell.) Cuatrec.	R/Sc	A (Pg)	-	161683
Piptocarpha ramboi G.Lom.Sm.	Sc	A (Pg)	H	172519
BASELLACEAE				
Anredera tucumanensis (Lillo & Hauman) Sperling	STw	Z	L	175752
BEGONIACEAE				
Begonia fruticosa A. DC.	R	A (Pt)	-	175091
BIGNONIACEAE				
Amphilophium crucigerum (L.) L.G.Lohmann	Td	A (Pt)	H	175060
Bignonia sciuripabula (K.Schum.) L.G.Lohmann	Td	A (Pt)	-	175078
Dolichandra uncata (Andrews) L.G.Lohmann	CTd/R	A (Pt)	H	175081
Dolichandra unguis-cati (L.) L.G.Lohmann	CTd/R	A (Pt)	H	175065
Tanaecium selloi (Spreng.) L.G.Lohmann	Td	A (Pt)	L	-
BORAGINACEAE				
Tournefortia breviflora DC.	STw	Z	-	183179
Tournefortia paniculata Cham.	Sc	Z	-	172522

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Table 2. Continued.

Family/Species	Climbing mechanism	Dispersal Syndrome	Abundance	ICN Number
CANNABACEAE				
Celtis iguanaea (Jacq.) Sarg.	HS	Z	H	183511
CAPRIFOLIACEAE				
Valeriana scandens L.	STw	A (Pg)	-	175074
CELASTRACEAE				
Pristimera celastroides (Kunth) A.C.Sm.	STw	A (Pt)	L	175109
CONVOLVULACEAE				
Convolvulus crenatifolius Ruiz & Pav.	STw	B	L	183177
CUCURBITACEAE				
Apodanthera laciniosa (Schltdl.) Cogn.	Td	Z	-	161694
Cayaponia diversifolia Cogn.	Td	Z	L	161712
Cayaponia palmata Cogn.	Td	Z	-	161713
Cayaponia pilosa (Vell.) Cogn.	Td	Z	H	162151
DIOSCOREACEAE				
Dioscorea multiflora Mart. ex Griseb.	STw	A (Pt)	-	183514
Dioscorea subhastata Vell.	STw	A (Pt)	-	175088
EUPHORBIACEAE				
Tragia volubilis L.	STw	Ep	-	175063
FABACEAE				
Canavalia bonariensis Lindl.	STw	B	-	161672
Dalbergia frutescens (Vell.) Britton	SSTw	A (Pt)	H	172530
Lathyrus nervosus Lam.	Td	T	L	183549
Lathyrus paranensis Burkart	Td	T	S	175097
Mimosa niederleinii Burkart	Sc	T	-	183223
Phanera microstachya (Raddi) L.P.Queiroz	Td	A (Pt)	-	175111
Piptadenia affinis Burkart	HS	B	-	164538
Senegalia nitidifolia (Speg.) Seigler & Ebinger	HS	B	-	175747
Senegalia velutina (DC.) Seigler & Ebinger	HS	B	H	172517
*Vigna peduncularis (*Kunth) Fawc. & Rendle	STw	T	L	166514
GRISELINIACEAE				
Griselinia ruscifolia (Clos) Taub.	R	Z	-	183543
LOGANIACEAE				
Strychnos brasiliensis Mart.	HS	Z	H	175086
MALPIGHIACEAE				
Heteropterys aenea Gris.	STw	A (Pt)	-	172514
Heteropterys intermedia (A. Juss.) Griseb.	STw	A (Pt)	-	175902
Heteropterys syringifolia Griseb	STw	A (Pt)	-	175898
Janusia guaranitica (A. St.-Hil.) A. Juss.	STw	A (Pt)	L	172523
Tetrapterys phlomoides (Spreng.) Nied.	STw	A (Pt)	-	172529
MALVACEAE				
Abutilon vexillarium E. Morren	Sc	B	S	162390
MENISPERMACEAE				
Cissampelos pareira L.	STw	Z	-	175087
Disciphania contraversa Barneby	STw	Z	-	175106
ONAGRACEAE				
Fuchsia regia (Vell.) Munz	Sc	Z	L	161673
PASSIFLORACEAE				
Passiflora actinia Hook.	Td	Z	H	183527
Passiflora caerulea L.	Td	Z	H	161691
Passiflora foetida var. negelliflora L.	Td	Z	S	161693
PHYTOLACCACEAE				
Seguieria americana L.	HS	A (Pt)	H	175070
POACEAE				
Melica sarmentosa Nees	STw/HS	A (Pg)	L	175738
RANUNCULACEAE				
Clematis bonariensis Juss. ex DC.	PTw	A (Pg)	L	161678

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Table 2. Continued.

Family/Species	Climbing mechanism	Dispersal Syndrome	Abundance	ICN Number
Clematis dioica L.	PTw	A (Pg)	H	172528
ROSACEAE				
Rubus erythrocladus Mart.	HS	Z	H	175056
Rubus sellowii Cham. & Schltdl.	HS	Z	H	169892
RUBIACEAE				
Galium hypocarpium subsp. *gracillimum* (Ehrend.) Dempster	Sc	Z	-	175093
Galium hypocarpium subsp. *hypocarpium* (L.) Endl. ex Griseb.	Sc	Z	H	175090
Manettia gracilis Cham. & Schltdl	STw	A (Pt)	S	HUCS 10935*
Manettia paraguariensis Chodat	STw	A (Pt)	L	161695
Manettia pubescens Chamisso & Schlechtendal	STw	A (Pt)	-	183751
Manettia tweedieana K.Schum.	STw	A (Pt)	-	168751
Manettia verticillata Wernham	STw	A (Pt)	L	168754
SAPINDACEAE				
Serjania cf. *laruotteana* Cambess.	Td	A (Pt)	-	175704
Serjania meridionalis Cambess.	Td	A (Pt)	-	175705
Urvillea ulmacea Kunth	Td	A (Pt)	L	183744
SMILACACEAE				
Smilax cognata Kunth	Td/HS	Z	H	183555
SOLANACEAE				
Solanum flaccidum Vell.	PTw	Z	-	161700
Solanum inodorum Vell.	PTw	Z	-	167122
Solanum laxum Spreng.	PTw	Z	H	183212
TROPAEOLACEAE				
Tropaeolum pentaphyllum Lam.	PTw	Z	-	192397
VIOLACEAE				
Anchietea pyrifolia A. St.-Hil.	STw	A (Pt)	H	161708
VITACEAE				
Cissus striata Ruiz & Pav.	ATd	Z	H	175107
Cissus verticillata (L.) Nicolson & C.E.Jarvis	Td/R	Z	-	175062

Discussion

This is the first study focused only on climbing plant species realized in an *Araucaria* forest in Brazil. Studies focusing on climbing species are scarce in South Brazil (Citadini-Zanette 1997, Venturi 2000, Durigon *et al*. 2009, Durigon & Waechter 2011, Carneiro & Vieira 2012) and even when climbing habit is included on broad floristic surveys, the species richness is commonly underestimated. Nevertheless, in many cases broad floristic surveys give an important overview of climbers' richness, contributing for the knowledge of patterns like families' richness in some regions. Among them, the study of Brack *et al*. (1985) at the Seasonal forest of Turvo State Park presented the highest richness of RS State, with around 130 species and since it was not focused only on climber plants, the richness could be even greater. The cluster analysis results partially agreed with our hypothesis that species composition is similar within forest types, showing two sharp groups of Seasonal forests and *Araucaria*/Atlantic forests, with no clear pattern association of Deciduous and Semideciduous forests. The study of Durigon & Waechter (2011) found that the species composition of Guaíba site, one of the sites analyzed in this study, is similar to the biogeographic expansion line represented by the States from the north border of RS State. Our sites comparison is more detailed in relation to forest types, showing that the Semideciduous forests that are geographically close and present a mixture of floristic contingents of different origins (Waechter 2002) are more similar to Deciduous forests than *Araucaria*/Atlantic forests. It is noteworthy, as cited by Santos *et al*. (2009) that any species richness comparison between these surveys should be done with some caution, since they differ in sampled area and time effort and some studies may be underestimating the real richness of the study areas.

The richest families sampled at FLONA-SFP are according to other surveys in the Atlantic forest of Southeast Brazil (Lima *et al*. 1997, Barros *et al*. 2009, Villagra & Neto 2010), but there is a clear predominance of Apocynaceae and Asteraceae families not only at FLONA-SFP but also in most sites of RS State. In Seasonal forests of Southeast Brazil (Santos *et al*. 2009, Udulutsch *et al*. 2010), there is a predominance of species from Bignoniaceae, Fabaceae and Malpighiaceae families, in which the first two are also more representative in Seasonal forests of RS State. This demonstrates that the order of importance of families might not be only ruled by the vegetation type, but by the diversity center of some rich families/genera. In Seasonal forests of Southeast Brazil, Bignoniaceae presents its main diversity center (Lohmann *et al*. 2013), while in rainforests Asteraceae family increases in importance. The highest richness of Asteraceae family is reported to high altitudes and its great representativeness is

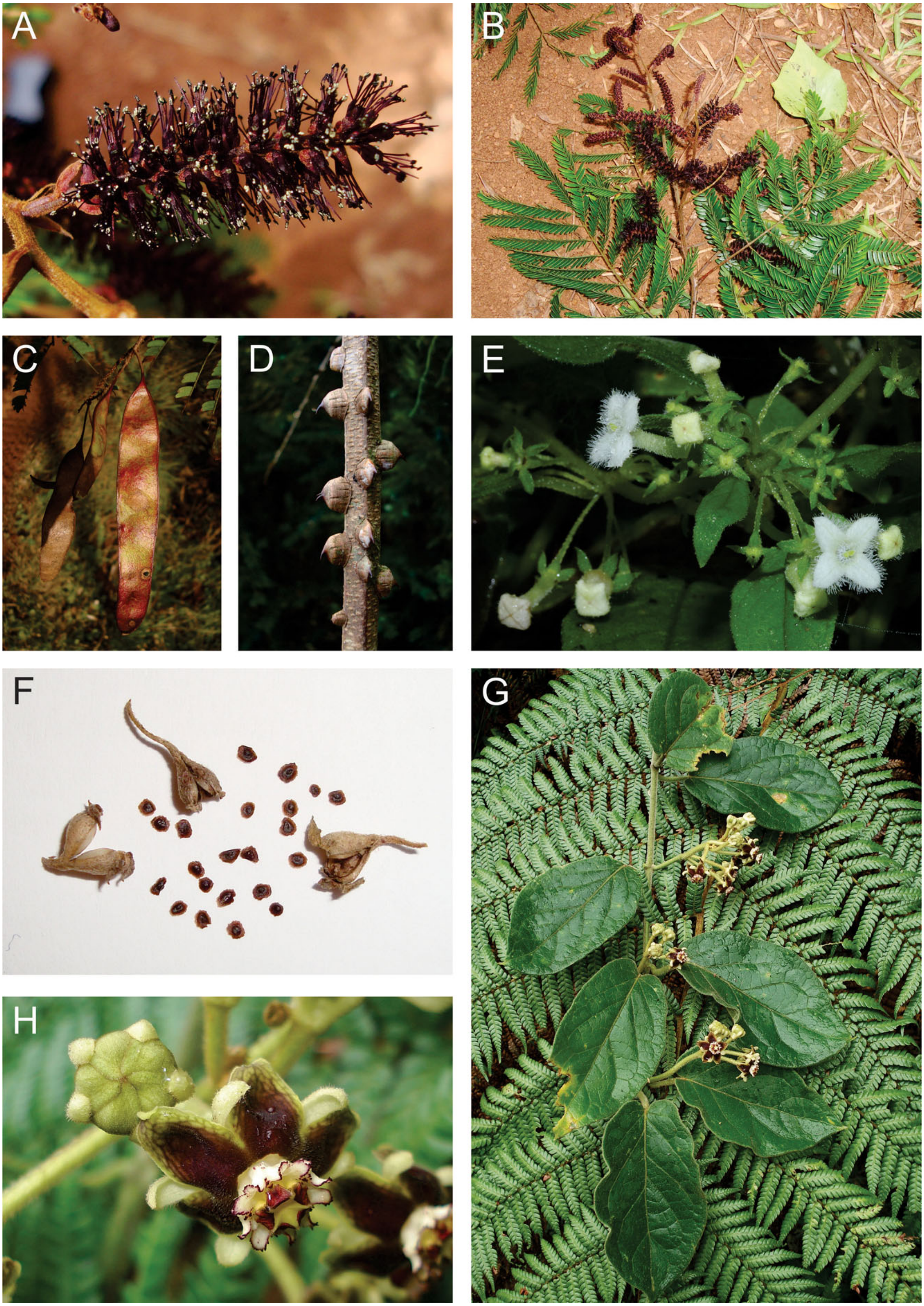

Figure 2. New species occurrences for Rio Grande do Sul State, Brazil. A-D: *Piptadenia affinis* Burkart; E and F: *Manettia verticillata* Wernham; G and H: *Matelea dusenii* Morillo.

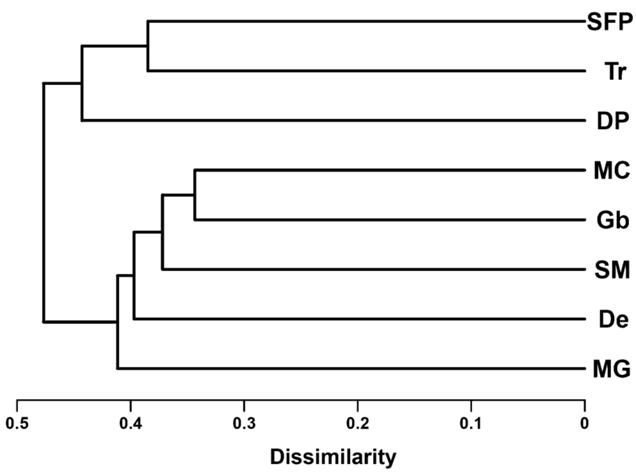

Figure 3. Dendrogram of climbers' survey sites according to species composition in Rio Grande do Sul State, Brazil. Cluster analysis performed using Ward's clustering criterion and the complement of Jaccard's similarity as resemblance measure. **Sites**: De – Derrubadas (Turvo State Park); SM – Santa Maria; MC – Viamão (Morro do Coco); MG – Viamão (Morro Grande); Gb – Guaíba; SFP – National Forest of São Francisco de Paula; DP – Dom Pedro de Alcântara; Tr – Torres (Itapeva State Park).

driven by *Mikania* Willd., the sixth world largest genus of climbers (Gentry 1991), that present its main diversity center in the Atlantic forest (Ritter & Waechter 2004). These phytogeographical patterns directly influences the climbing mechanisms and dispersal syndromes patterns over sites, since both families are anemochoric and Asteraceae is predominantly twiner while Bignoniaceae predominantly presents tendrils that coil. In Seasonal forests of Southeast Brazil, tendril species (encompassing trendrils that coil, clasp and adherent tendrils) overcome twiner species in many sites (Santos *et al*. 2009) whereas in Seasonal forests of RS State there is a prevalence of stem twiners. Adherent root climbers were more represented in the *Araucaria* and Atlantic forest sites, confirming their association with areas with high precipitation levels (Durigon *et al*. 2013).

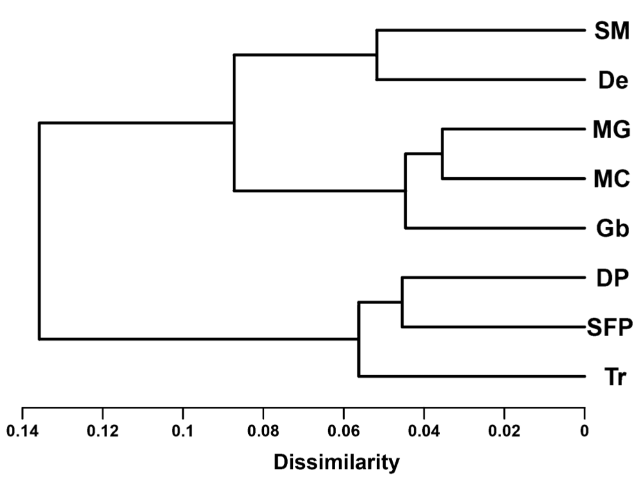

Figure 4. Dendrogram of climbers' survey sites according to climbing mechanisms and dispersal syndromes proportion in Rio Grande do Sul State, Brazil. Cluster analysis performed using Ward's clustering criterion and a modification of Gower's distance as resemblance measure. For sites abbreviations consult Figures 3 and 5.

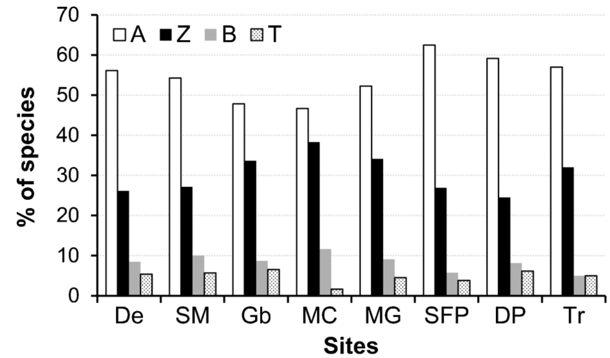

Figure 5. Species proportion at each study site (sites with more than 40 species) at Rio Grande do Sul State, according to its dispersal syndrome. Sites are disposed from west (left) to east (right). **Dispersal Syndrome:** A (Anemochoric); Z (Endozoochoric); B (Barochoric); T (Autochoric). **Sites:** De – Derrubadas (Turvo State Park); SM – Santa Maria; MC – Viamão (Morro do Coco); MG – Viamão (Morro Grande); Gb – Guaíba; SFP – National Forest of São Francisco de Paula; DP – Dom Pedro de Alcântara; Tr – Torres (Itapeva State Park).

The cluster analysis confirmed our hypothesis that species traits proportion were similar within forest types, showing that traits patterns are not modified by species turnover between sites and that it might be ruled by an association of vegetation type and geographic scale.

Not only light availability determines climbers' distribution, but also the presence of suitable supports, which influences each climbing mechanism. Trelisses density, that is higher on forest edges and treefall gaps, limits climbers' access to the canopy, since few species are capable to climb supports with more than 10-20 cm of diameter (Putz 1984, Putz & Holbrook 1991). In this way, each climbing mechanism has support limitations that direct its occurrence and abundance to different successional stages with particular vegetation structure and/or forest disturbance regimes (Schnitzer & Bongers, 2002). The trendril climbers' group formed by species with clasp tendrils, adhesive tendrils and tendrils that coil, present different support limitations which determine its success on climbing supports with high diameters and different types of bark. Tendrils are usually limited to supports with a maximum of 10 cm of diameter (Putz 1984), while clasp and adherent

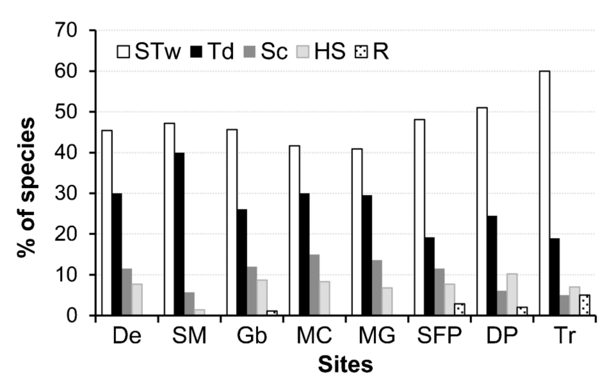

Figure 6. Species proportion at each study site (sites with more than 40 species) in Rio Grande do Sul State, according to its climbing mechanism. Sites are disposed from west (left) to east (right). **Climbing mechanism**: STw (Stem Twiner); Td (Tendril); Sc (Scrambler); HS (Hook/Spine); R (Roots). For sites abbreviations consult Figure 3 and 5.

tendril's species do not have any support limitation, climbing trees with large diameters. These limitations also occur with the twiner's group that climbs through shoot tips, secondary shoots and petioles. Our sites comparison revealed that the frequency of climbing mechanisms did not change over sites when using a detailed classification, while grouping species in major categories showed a significant result, indicating a difference between sites. So, it is interesting to classify the species as more specific as possible instead of grouping on major categories, to capture these strategies that directly influence species distribution in different environments. It is also important to pay attention on species that combine different climbing mechanisms, developing a secondary mechanism (e.g. adherent roots), which clearly gives them an advantage to firmly attach on their supports.

The three new occurrences for RS State found at FLONA-SFP had their occurrence range expanded towards South Brazil. The species *M. dusenii* was endemic to Paraná State (PR; Koch *et al*. 2013), *P. affinis* was endemic to Santa Catarina State (SC; Burkart 1979) and *M. verticillata* was registered for SC, PR, Minas Gerais and Rio de Janeiro States (Marinero *et al*. 2012). Based on this information we indicate these species to be included in future evaluations of the red list of threatened flora of RS State and Brazil.

As the definition of climber says it has to germinate and always keep contact with soil, some species can be confounded with hemiepiphytes, specifically the root-climber species. In this survey *Begonia fruticosa* A. DC., *Pentacalia desiderabilis* (Vell.) Cuatrec. and *Griselinia ruscifolia* (Clos) Taub. were considered climbers even though they can present a hemiepiphytes/epiphyte habit (Falkenberg & Voltolini 1995, Orihuela & Waechter 2010). The first species was always found as a climber, while the second was found a few times as a hemiepiphyte and the latter the majority of times as a hemiepiphyte (personal observation). Other example is *Mandevilla atroviolacea* (Stadelm.) Woodson, which was found just once with an epiphyte habit but was observed as a climber many times in adjacent areas near FLONA-SFP (*i.e.* Centro de Proteção e Conservação da Natureza Pró-Mata; personal observation). Another similar issue occurs with scrambler species that can be found at initial growth stages as shrubs or with a prostrate habit. The species *Fuchsia regia* (Vell.) Munz was found just three times as scrambler at FLONA-SPF, while in adjacent areas (*i.e.* CPCN Pró-Mata) this is the common habit. The species *Mimosa niederleinii* Burkart was commonly found as a prostrate herb, but in some cases it clearly climbs the vegetation, scrambling up to three meters of height.

An important issue at FLONA-SFP is the impact of the invasive climbing species *Hedera helix* L. and *Lonicera japonica* Thunb. that spreads over the edges and inside of tree plantations, preventing the recruitment and establishment of native species (personal observation). Their management and control is very difficult, being dispersed mainly by birds and may cause in a short time a great loss of habitat for many climbing species. In spite of this threat for climbing diversity, the great amount of forest edges, the unmanaged trees plantations where the understory is not periodically removed, and the *Araucaria* plantations that provide a high incidence of sunlight in the understory due to its canopy structure, allow a great establishment and development of climbers. These landscape features are only possible since FLONA-SFP is a conservation unit of sustainable use, and future management strategies of tree plantations in the area should consider the impact it may cause in climber species.

Acknowledgments

We are thankful to FAPERGS and CAPES for the scholarship to G.D.S Seger and CNPq for the researcher grant to S.M. Hartz (306816/2010-5); to Instituto de Biociências (UFRGS), Edenice B. S. Avila and the entire team of the São Francisco de Paula National Forest for all logistical support provided; Frediny B. Colla, Elisa V. Salengue and Evelise Bach for field work help; the graphic designer Victória D. Seger for species image treatment; Taís Guimarães for geoprocessing help; all the staff of ICN Herbarium; and the following taxonomists for the help on identifications: Mara R. Ritter, Renato A. Záchia, Martin Grings, Luis F. P. Lima, Silvia T. S. Miotto, Luis R. M. Baptista, João Iganci, Lilian Mentz, Édson L. Soares, Maria Ana Farinaccio, Angelo A. Schneider, Jaqueline Durigon, Priscila P. A. Ferreira, Jorge E. A. Mariath, Leila F. N. Macias, João A. Jarenkow, Cláudio A. Mondin, Rosangela S. Bianchini and Felipe Marinero.

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Received 12/04/2014
Revised 04/10/2014
Accepted 06/10/2014