UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
INSTITUTO DE BIOCIÊNCIAS
PROGRAMA DE PÓS-GRADUAÇÃO EM BOTÂNICA

Dissertação de Mestrado

Distribuição e conservação de orquídeas terrestres em florestas subtropicais brasileiras

Frediny Bettin Colla

Porto Alegre, março de 2014

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Dissertação apresentada ao Programa de Pós-Graduação em Botânica da Universidade Federal do Rio Grande do Sul como um dos requisitos para obtenção do título de Mestre em Botânica.

Orientador
Dr. Jorge Luiz Waechter

Comissão examinadora
Dr. Luiz Menini Neto (CESJF)
Dra. Lilian Eggers (UFRGS)
Dra. Vanilde Citadini-Zanette (UNESC)

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SUMÁRIO

INTRODUÇÃO GERAL

Orchidaceae é a segunda maior família de angiospermas, com cerca de 880 gêneros e 24.500 espécies (Dressler 2005, Govaerts *et al.* 2014). A família é amplamente distribuída pelo mundo, sobretudo em regiões tropicais e subtropicais úmidas (Stevens 2012). Quanto ao hábito ou substrato que ocupam, as orquídeas são comumente divididas em terrestres, rupestres e epifíticas, cabendo as primeiras cerca de um terço da riqueza total da família (Benzing *et al.* 1983). O hábito terrestre é considerado por alguns autores como uma condição basal em Orchidaceae (Benzing 1987, Neyland & Urbatsh 1995), sendo representado principalmente em quatro das cinco subfamílias: Apostasioideae, Vanilloideae, Cypripedioideae e Orchidoideae (Pridgeon *et al.* 1999, 2001, 2003, 2006). A presença de plantas terrestres na subfamília Epidendroideae, a mais avançada, seria uma reversão do estado de caráter ancestral (Neyland & Urbatsh 1995).

Estudos com abordagens ecológicas e geográficas para Orchidaceae têm verificado variações na distribuição e na diversidade de espécies em diferentes tipos de formações vegetais. Bulafu *et al.* (2007) e Jacquemyn *et al.* (2007) evidenciaram a presença de uma associação entre a composição de espécies e as zonas de vegetação em montanhas de Uganda e da Ilha Reunião, localizada próxima a Madagascar. No Brasil, nas restingas do Espírito Santo, os diferentes tipos de vegetação apresentam baixa similaridade florística para Orchidaceae terrestres, sobretudo entre áreas florestais e formações abertas, e florestas secas e paludosas (Fraga & Peixoto 2004). A influência da quantidade de luz, decorrente do tipo de formações vegetal (florestal ou herbácea), e a drenagem do solo (arenoso ou turfoso) também foram os principais fatores determinantes na distribuição de orquídeas terrestres no norte da Planície Costeira do Rio Grande do Sul (Rocha & Waechter 2010). Estes estudos evidenciaram uma nítida tendência das orquídeas terrestres ocuparem apenas

um ou poucos dos ambientes considerados.

A participação de orquídeas na riqueza de comunidades herbáceas terrestres florestais é variável segundo regiões fitoecológicas. Na Floresta Ombrófila Densa Orchidaceae em geral representa uma das famílias mais diversificadas (Citadini-Zanette 1984, Citadini-Zanette & Baptista 1989, Andreata *et al.* 1997, Jurinitz & Baptista 2007). Em Florestas Estacionais Semideciduais e formações de Restinga, Orchidaceae comumente está entre as cinco famílias mais ricas do estrato herbáceo (Müller & Waechter 2001, Pereira *et al.* 2004, Inácio & Jarenkow 2008, Palma *et al.* 2008). Para a sinúsia herbácea de Floresta Ombrófila Mista o número de espécies citadas é relativamente baixo (Cestaro *et al.* 1986) e até mesmo nulo (Barddal *et al.* 2004, Citadini-Zanette *et al.* 2011).

Na família Orchidaceae aproximadamente a metade das espécies ameaçadas de extinção são terrestres (IUCN 2013). Muitas espécies da subtribo Goodyerinae, formada tipicamente por plantas terrestres, não foram recoletadas após a descrição com base em coletas feitas no final do século 19 e início do século 20 (Ormerod 2009). Entre as causas mais prováveis está a degradação e o desaparecimento das florestas, as orquídeas são em geral afetadas negativamente por alterações no *habitat*, que envolvem teor de matéria orgânica, disponibilidade de água e disponibilidade de luz. Estas modificações afetam a sobrevivência de plantas adultas, a capacidade de germinação de sementes e desenvolvimento das plântulas até a fase adulta (Swarts & Dixon 2009). Embora algumas espécies sejam típicas de ambientes alterados, a maioria das orquídeas terrestres é encontrada exclusivamente em florestas primárias (IUCN/SSC Orchid Specialist Group 1996). Esta relação é demonstrada por Rasingam & Parthasarathy (2009), que em estudo de comunidades herbáceas de florestas tropicais na Índia em ambientes com e sem distúrbio, encontraram espécies de orquídeas terrícolas que ocorreram apenas nos últimos.

Diversos estudos focalizados em Orchidaceae citaram espécies terrestres para

florestas subtropicais brasileiras, incluindo trabalhos para todo o Brasil (Pabst & Dungs 1975, 1977), para o Cone Sul (Schinini *et al.* 2008), ou focalizados no Rio Grande do Sul (Schlechter 1925, Rambo 1965, Batista *et al.* 2012). Apesar dessas citações, pouco se sabe sobre a composição, a diversidade e a distribuição das espécies. O litoral norte do Rio Grande do Sul é a única região com estudos de composição e distribuição de orquídeas geofíticas (Rocha & Waechter 2006, 2010). A maior parte dos dados de abundância e ocorrência das espécies está disperso em numerosos inventários florísticos e trabalhos fitossociológicos direcionados a comunidades herbáceas.

ARTIGO I:

Distribution and conservation of terrestrial orchids in Brazilian subtropical forests

ABSTRACT

Terrestrial orchids occur widespread in tropical and temperate environments around the world. The terrestrial habitat for orchid species comprises several distinct plant formations, like forests, woodlands, grasslands and wetlands. In this study we focused the estimation of range sizes and the occurrence of these plants in nine forest types in the South Brazilian state of Rio Grande do Sul, located entirely in subtropical latitudes. We revised sampled specimens deposited in seven regional herbaria and updated species identifications to current generic circumscriptions. Based on sampling locations we estimated two range size parameters, namely extent of occurrence and area of occupancy, aiming to determine the conservation status according to IUCN categories. As a result we found 22 genera and 50 species, most genera (15) having of them a single species in the state. The most diversified genera were *Cyclopogon*, *Aspidogyne* and *Malaxis*, with 14, eight and four species, respectively. Four additional genera presented three (*Pelexia*) or two (*Habenaria*, *Prescottia*, and *Sarcoglottis*) species in forest environments. Range size estimations, especially through area of occupancy, resulted in an outstanding number of threatened species. Critically endangered species according to extent of occurrence were distributed in seven genera and 18 species. The most diversified forest types were the central Serra Geral seasonal forests, followed by the Atlantic rainforest and the southeast Crystalline Shield seasonal forests. A total of 19 species occurred in a single forest formation and only four species occurred widespread in six or seven forest types. The number of recordings in this study showed to be exponentially related to species range according to forest types. Our study showed that terrestrial orchids in forest environments are an overlooked plant group, which has been poorly sampled and poorly evaluated in ecological studies concerning understory populations and communities. Further studies are necessary to determine more precisely the extent of occurrence, the size of populations, and the real conservation status of native species.

Key words: floristic composition, extent of occurrence, area of occupancy, threatened species, Orchidaceae, Rio Grande do Sul.

RESUMO

As orquídeas terrestres estão distribuídas amplamente em ambientes tropicais e temperados do mundo. O habitat terrestre, para orquídeas, engloba distintas formações vegetais, como florestas, savanas, campos e banhados. Neste estudo consideramos, para a estimativa da amplitude e da ocorrência destas plantas, nove tipos de florestas no estado do Rio Grande do Sul no sul do Brasil, localizadas totalmente em latitudes subtropicais. Revisamos amostras de espécimes depositadas em sete herbários regionais e atualizamos a identificação das espécies para as circunscrições genéricas atuais. Com base nas localizações das amostras estimamos dois parâmetros de amplitude, nomeados extensão de ocorrência e área de ocupação, objetivando determinar o estado de conservação das espécies de acordo com as categorias da IUCN. Como resultado, encontramos 22 gêneros e 50 espécies, a maioria dos gêneros (15) possui apenas uma espécie no estado. Os gêneros mais diversificados foram *Cyclopogon*, *Aspidogyne* e *Malaxis*, com 14, oito e quatro espécies, respectivamente. Outros quatro gêneros apresentaram três (*Pelexia*) ou duas (*Habenaria*, *Prescottia*, e *Sarcoglottis*) espécies nos ambientes florestais. As estimativas de amplitude, especialmente a área de ocupação, resultaram em um elevado número de espécies ameaçadas. Espécies criticamente ameaçadas, considerando a extensão de ocorrência, estão distribuídas em sete gêneros e 18 espécies. O tipo de floresta mais diversificado foi a floresta estacional da Serra Geral, seguido pela floresta Atlântica e pela floresta estacional do Escudo Cristalino. Um total de 19 espécies ocorreu somente em uma formação e apenas quatro espécies ocorreram em seis ou sete tipos de florestas. O número de registros neste estudo mostrou que as orquídeas terrestres em ambientes florestais são um grupo subamostrado, que possuem poucas coletas e são pouco avaliadas em estudos ecológicos com populações e comunidades de sub-bosque. Mais estudos são necessários para determinar com maior precisão a extensão de ocorrência, o tamanho das populações, e o estado real de conservação das espécies nativas.

Palavras-chave: composição florística, extensão de ocorrência, área de ocupação, espécies ameaçadas, Orchidaceae, Rio Grande do Sul.

INTRODUCTION

Orchidaceae is the second largest family of flowering plants (following Asteraceae), comprising ca. 880 genera and 21950 species (Dressler 2005, Govaerts *et al.* 2014). Orchids are also widely distributed around the world, especially in moist tropical and subtropical regions (Stevens 2012). In relation to the habitat or substrate on which orchids occur, plants are commonly divided into terrestrial, rupestrial and epiphytic species (Dressler 1993). However, some less frequent but interesting types of habitats may also occur, as the marshy or semiaquatic environments, represented by many species of *Habenaria* Willd. (Batista *et al.* 2006), and the unusual completely underground habitat, exclusively found in the Australian saprophytic genus *Rhizanthella* R.S.Rogers (Bougoure *et al*. 2008).

Terrestrial orchids comprise around one third of all species in the family (Benzing *et al.* 1983), and are also distributed along the entire phylogenetic tree of the family (Pridgeon *et al.* 1999, Cameron 2005). This type of life form is often considered as an ancestral condition in Orchidaceae (Benzing 1987, Neyland & Urbatsh 1995), and this condition is evidenced by the predominant occurrence in the four most basal subfamilies Apostasioideae, Vanilloideae, Cypripedioideae and Orchidoideae (Pridgeon *et al.* 1999, 2001, 2003, 2006). The occurrence of terrestrial orchids in the most advanced and most diversified subfamily Epidendroideae is regarded as a reversion to the ancestral condition (Neyland & Urbatsh 1995).

Terrestrial orchids may be found in closed forests as shade-tolerant species and in open grasslands and wetlands, where they often grow fully exposed to solar radiation. Otherwise than epiphytic orchids, which are mostly restricted to tropical and subtropical forests, terrestrial orchids occur in all climatic regions of the world (Gravendeel *et al.*

2004), being common in moist mid-temperate regions and even extending to cold-temperate subpolar regions (Dressler 1981, Teteryuk & Kirillova 2011). From an adaptive point of view, terrestrial orchids are most commonly hemicryptophytes (with buds near the ground surface) and geophytes (with underground buds), but may also occur as saprophytes (mycotrophic plants lacking chlorophyll) and climbers or hemiepiphytes (partially or temporarily connected to the soil), as most species in the genus *Vanilla* Plum. *ex* Mill. (Dressler 1981, 1993).

In the first comprehensive publication on the orchids of Rio Grande do Sul, Brazil, Schlechter (1925) cited 61 genera and 174 species. In this floristic account approximately one third (20 genera) can be recognized as terrestrial genera, and among the comments on species occurrences several are mentioned as occurring in primary forests (*im Uhrwalde*), at forest edges or in shadowy environments. Forty years later Rambo (1965) published another extensive list of orchids, resulting from his own collections throughout the state. The taxonomic account was slightly increased to 63 genera and 185 species, and among these, 24 genera are typically formed by terrestrial orchids. The author provides detailed information on habit, habitat and geographic distribution (both regional and general) for each species, and so 18 species have been characterized as terrestrial orchids occurring in forest environments.

Information on Southern Brazilian terrestrial orchids in general can be found in several types of publications, including mostly regional or general taxonomic revisions (Rocha & Waechter 2006, Buzatto *et al.* 2014), and local ecological descriptions or analyses of forest herbaceous communities. This later approach has been carried out in several forest types in Rio Grande do Sul, including coastal rain forests (Citadini-Zanette 1984, Citadini-Zanette & Baptista 1989, Jurinitz & Baptista 2007), montane araucaria forests (Cestaro *et al.* 1986), semi-deciduous seasonal forests (Inácio & Jarenkow 2008,

Palma *et al.* 2008), and coastal lowland “restinga” forests (Müller & Waechter 2001, Záchia & Waechter 2011). A single publication describes the distribution of terrestrial orchids according to vegetation types, performed in the northeastern Atlantic region of the state (Rocha & Waechter 2010).

Although updated information on the taxonomic status and the geographic distribution of orchids are now available at on-line floristic lists (Schinini *et al.* 2008, Barros *et al.* 2014, Govaerts *et al.* 2014), more precise information on the biodiversity and regional biogeography is still poorly known. Facing this lack of information, our objectives in this study are (i) to carry out a floristic survey of terrestrial orchids in different forest formations of Rio Grande do Sul, (ii) to provide information on distribution for a better understanding of the regional conservation status of native orchids.

MATERIAL AND METHODS

The area focused in this study is the state of Rio Grande do Sul, the southernmost in Brazil, which is entirely located in subtropical latitudes (roughly between 27-34°S) in eastern South America. Aside from being a relatively large political unity, with an area of approximately 282,184 km² (Teixeira *et al.* 1986), the east-coast subtropical location provides an overall moist and warm-temperate climate and an interesting biogeographic transition between northern tropical-like Atlantic forests and southern Pampean grasslands and woodlands (Cabrera & Willink 1980). Elevations vary from sea-level near the Atlantic coast to almost 1400 m in the northeastern highlands (Hasenack *et al.* 2009). This overall scenario provides an interesting area for the study of distribution patterns of plants and animals.

Two major climatic regions are commonly recognized in Rio Grande do Sul,

according to the Koeppen Classification System. In the lowlands, depressions and lower mountain slopes, which extend throughout most of the state area, a subtropical moist (Cfa) climate occurs. In relatively smaller areas in the northeast and southeast highlands climate changes into a moist temperate (Cfb) type (Kuinchtner & Buriol 2001). Snowfall is relatively rare, but frost days during winter months are common especially at the higher elevations (900 to 1400 m) in the northeast highlands. Mean annual temperatures vary from 20 to 26 °C in the warmest months and from 10 to 15 °C in the coldest months. Mean annual rainfall lies between 1,250 and 2,250, being higher in the northern forested regions and lower in the southern grassland areas, which are more subject to summer water-deficit (Moreno 1961).

Data on the composition and occurrence of terrestrial orchids are based mainly on herbarium collections and in some cases on published information and original samplings carried out during the project development. We revised the following herbaria: HAS, HUCS, ICN, MPUC, PACA, PEL e SMDB (acronyms according to Thiers 2014). Illustrations and photographic of type specimens, now often available on-line, were examined to improve species identifications and to reduce or eliminate eventual taxonomic uncertainties. In the results we opted to cite a single herbarium specimen for each forest type (Appendix 1), as defined below. Original samplings performed during field trips are stored at the Herbarium of Universidade Federal do Rio Grande do Sul (ICN).

The distribution of orchids within Rio Grande do Sul was mostly based on the revised herbarium specimens, but sometimes also included photographic and published material as a source, especially for rare species. The conservation status of each species was mainly based on the distribution range, estimated with the aid of the software GeoCAT – Geospatial Conservation Assessment Tool (available at www.geocat.kew.org). This software allows the estimation of two range parameters, the extent of occurrence, resulting

from a polygon defined by the extreme occurrence points, and the area of occupancy, resulting from the number of effective occurrence points multiplied by 4 km²). For those species with only one or two observations, we added additional points close or around the observed ones (up to three points), in order to define a polygon which is necessary to estimate the extent of occurrence.

Each of the above mentioned range estimations generate a conservation status in accordance with the IUCN nomenclature: Least Concern (LC), Not Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR). Facing the absence of precise data on population sizes in space and time for most species of terrestrial orchids, we based our information on conservation status essentially on the two range estimations as defined by the GeoCAT software.

For the distribution according to forest types we recognized nine major formations as occurring in the South-Riograndean area, adapted from current vegetation systems (Leite & Klein 1990, IBGE 2012): 1) tropical rainforests in the northeast lowlands and the Atlantic slopes of the Serra Geral range; 2) montane Araucaria forests in the central and northeast highlands; 3) semi-deciduous seasonal forests in the northern Upper Uruguay basin; 4) semi-deciduous seasonal forests along the central and mostly south-facing slopes of the Serra Geral range; 5) semi-deciduous seasonal forests on the southeast slopes of the Crystalline Shield; 6) gallery forests in the northern mostly montane grasslands; 7) gallery forests in the southern mostly lowland and upland grasslands; 8) coastal lowland dune-forests, on well-drained sandy soils; 9) coastal lowland peat-forest, on poor-drained and often inundated organic soils (Figure 1).

We compared the nine forest regions according to orchid occurrence using several similarity or distance coefficients followed by multivariate methods of ordination and classification. Some of these analysis resulted in more or less overlapping patterns and so

we chose a scatter plot obtained by non-metric multidimensional scaling (NMDS), which allowed an interpretation relating climatic and edaphic factors associated with the forest types under consideration. For this analysis we included all species occurring in at least two forest regions, i.e. excluding single-site occurrences. The similarity measure was the Euclidean distance for qualitative data, i.e., the square root of the sum of the number of species restricted to one and another of the two forests under comparison. Analyses were performed with the software PAST version 2.01 (Hammer 2010).

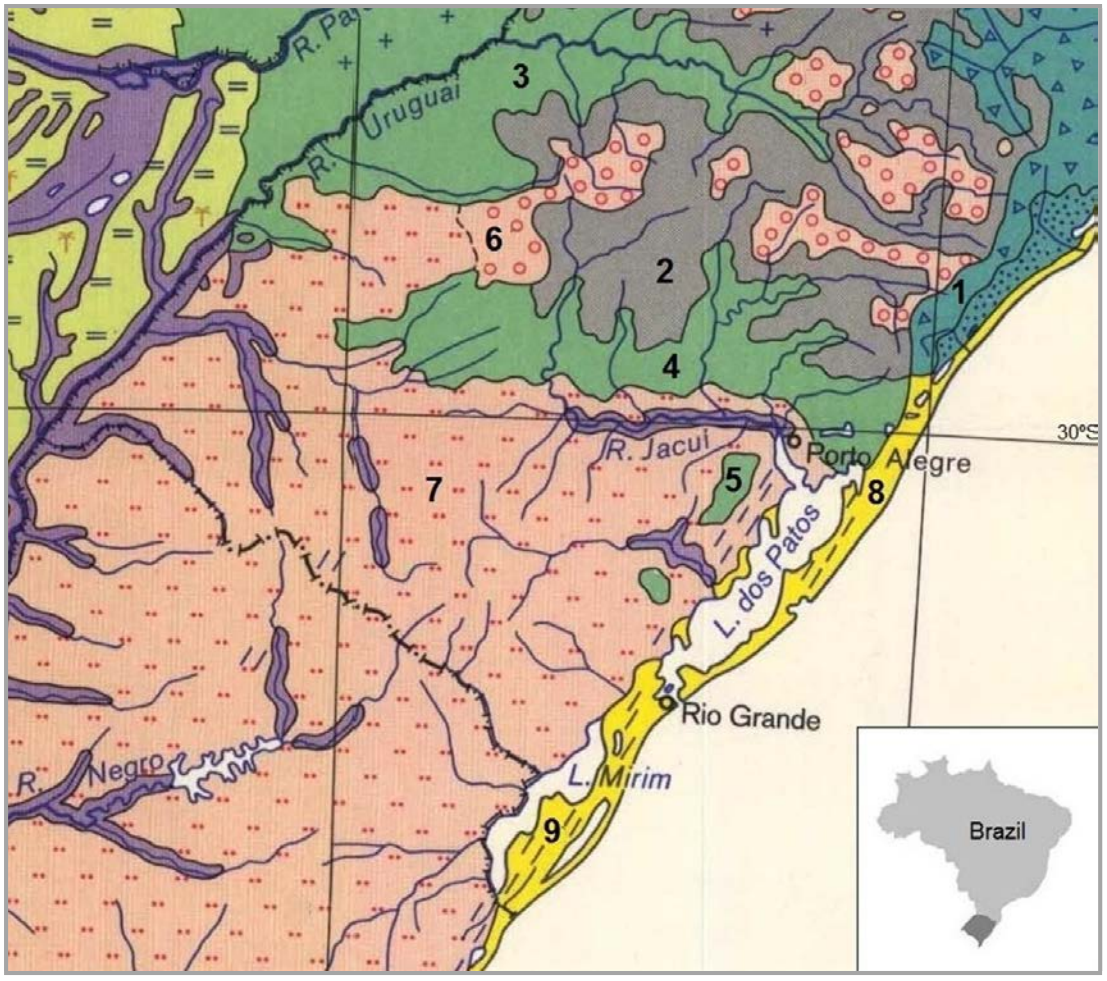

Figure 1. Forest regions in Rio Grande do Sul recognized for the distribution of terrestrial orchids: 1 = Atlantic rainforest; 2 = Araucaria montane forest; 3 = Upper Uruguay seasonal forest; 4 = Serra Geral seasonal forest; 5 = southeast Crystalline Shield seasonal forest; 6 = northern gallery forests; 7 = southern gallery forests; 8 = coastal dune forests; 9 = costal peat forests. Gallery forests (6, 7) and coastal forests (8, 9) are largely discontinuous on a matrix of grasslands and wetlands. Vegetation map is an extract from Hueck & Seibert (1981) vegetation map of South America.

RESULTS

1 – Taxonomic composition

We found 50 orchid species as occurring in forest ecosystems of Rio Grande do Sul. These species belong to two subfamilies, eight tribes and 22 genera (Table 1). These numbers are a result of 442 records, mostly including specimens deposited in regional herbaria, but in a few cases also photographic material or bibliographical citations, including plants not found or not seen in the revised herbaria. The subfamilies Orchidoideae and Epidendroideae occurred with an approximate number of genera, 12 and 10, respectively. However, the number of species was much higher in the Orchidoideae than in the Epidendroideae, 37 and 13, respectively.

The high diversification in the subfamily Orchidoideae was largely due to a relatively large number of species in the genera *Cyclopogon* C. Presl. (14 spp.) and *Aspidogyne* Garay (8 spp.). Five genera presented from two to four species, namely *Malaxis* Sol. ex Sw. (4 spp.), *Pelexia* Poit. ex Rich. (3 spp.), *Habenaria* Willd. (2 spp.), *Prescottia* Lindl. (2 spp.) e *Sarcoglottis* C.Presl (2 spp.). A total of 15 genera presented a single species in South Riograndean forests formations (Table 1).

In this study we found two new recordings for the orchid flora of Rio Grande do Sul, namely *Cyclopogon iguapensis* Schltr. and *Malaxis jaraguae* (Hoehne & Schltr.) Pabst. In earlier works these species were erroneously identified as *C. dusenii* Schltr. and *M. histionantha* (Link) Garay & Dunst., respectively (see comments below on excluded species).

Table 1. Systematics of terrestrial orchids found in forest ecosystems of Rio Grande do Sul, South Brazil, mostly following Górniak et al. (2010). The rightmost columns indicate the number of species in the focus of this study and the total number of species in the genus worldwide, after Govaerts et al. (2014).

Subfamily	Tribe	Subtribe	Genus	Study	Total
Orchidoideae	Orchideae	Orchidinae	*Habenaria*	2	837
	Cranichideae	Chloraeinae	*Chloraea*	1	52
		Goodyerinae	*Aspidogyne*	8	46
			Microchilus	1	137
		Cranichidinae	*Cranichis*	1	53
			Prescottia	2	26
		Spiranthinae	*Cyclopogon*	14	81
			Hapalorchis	1	10
			Mesadenella	1	7
			Pelexia	3	78
			Sarcoglottis	2	46
			Sauroglossum	1	11
Epidendroideae	Triphoreae		*Psilochilus*	1	8
			Triphora	1	19
	Gastrodieae		*Wullschlaegelia* (*)	1	2
	Tropidieae		*Corymborkis*	1	6
	Calypsoeae		*Govenia*	1	24
	Malaxideae		*Liparis*	1	424
			Malaxis	4	178
	Cymbidieae	Eulophiinae	*Oeceoclades*	1	39
		Catasetinae	*Galeandra*	1	37
		Zygopetalinae	*Warrea*	1	3

(*) According to Górniak et al. (2010) *Wullschlaegelia* appears close to *Xerorchis*, a genus included in tribe Nervilieae or Xerorchideae (Pridgeon et al. 2006). We opted to maintain the genus provisionally in tribe Gastrodieae, following Dressler (1993).

2 – Range size and conservation status

The two range size methods resulted into quite different patterns of conservation status (Table 2, Figure 2). The estimation of extent of occurrence resulted into five conservation categories, and more than half of the species (27/50) were classified into a threatened status: 18 species were Critically Endangered (CR), four Endangered (EN) and five Vulnerable (VU). Moreover, according to this criterion 15 species were classified as

Least Concern (LC) and eight into the Not Threatened (NT) status. According to the estimation of area of occupancy, all species resulted into one or another threatened conservation status, 33 as Endangered (EN) and 17 as Critically Endangered (CR).

Critically Endangered species based on extent of occurrence were found in seven orchid genera (Table 2, Figure 3). The two most diversified genera in forest environments, *Cyclopogon* and *Aspidogyne*, also showed the largest number of species in this category, six in each genus. A single Critically Endangered species occurred in the genera *Malaxis*, *Microchilus*, *Oeceoclades* and *Triphora*. At another extreme, our area of occurrence estimations indicated two outstanding species for their widespread distribution in Rio Grande do Sul (> 125,000 km²): *Mesadenella cuspidata* and *Cyclopogon subalpestris* (Table 2). These two species also figured among the ten most widespread species according to forest types (Table 3).

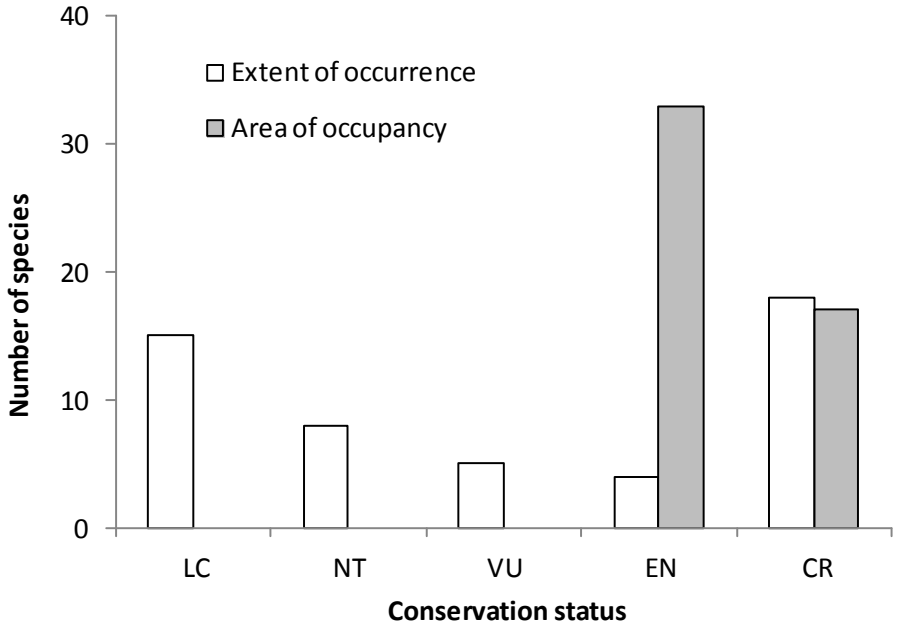

Figure 2. Number of orchid species in forest formations of Rio Grande do Sul, South Brazil, distributed according to range size estimation and conservation status. LC = Least Concern; NT = Not Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered.

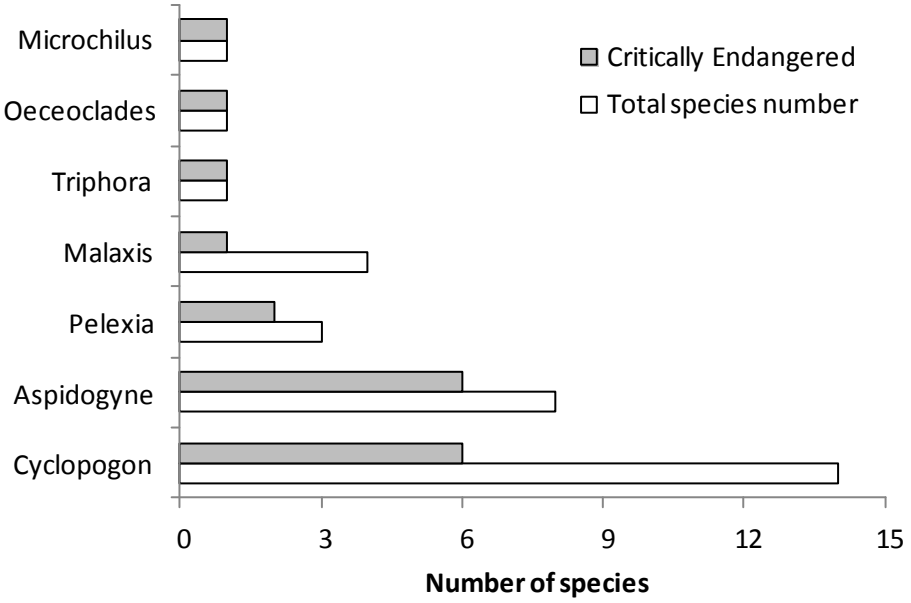

Figure 3. Number of critically endangered species based on extent of occurrence. This category was distributed in eight genera occurring in forest formations of Rio Grande do Sul, South Brazil.

3 – Diversity and distribution in forest types

The number of terrestrial orchids in the nine forest types defined for this study varied from four to 33 species (Table 3, Figure 4). The species richness values can be roughly divided into four categories: 1) a single richest formation, the central Serra Geral seasonal forest, with 33 species; 2) two formations with 24 and 21 species, the southeast Crystalline Shield seasonal forest and the Atlantic rainforest, respectively; 3) four formations with an intermediate number of species, the montane Araucaria forest(15 spp.), the coastal dune forests (14 spp.), the northern Upper Uruguay seasonal forest (14 spp.) and the coastal peat forests (13 spp.); 4) two formations very poor in terrestrial orchids, the northern gallery forests (5 spp.) and the southern gallery forests (4 spp.).

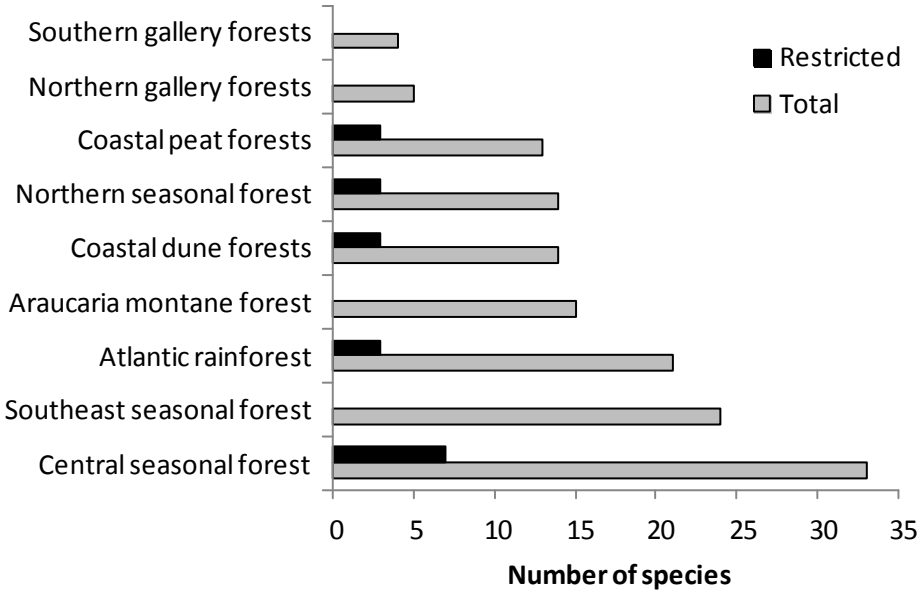

Figure 4. Number of total and restricted orchid species in forest formations of Rio Grande do Sul, South Brazil (distributed according to a diversity gradient varying from four to 33 species).

The distributional range of terrestrial orchids according to the nine forest types varied from one to seven formations (Table 3, Figure 4). The most widespread species were *Cyclopogon chloroleucus* and *Malaxis parthoni*, which occurred in seven formations, followed by *Cyclopogon subalpestris* and *Wullschlaegelia aphylla*, which occurred in six formations. A total of 19 species were restricted to a single forest formation. The highest number of restricted species coincided with the most diversified forest formation, the central Serra Geral seasonal forests (Figure 4). Among the eight remaining formations, half showed only three restricted species, and the other half showed no restricted species. The absence of restricted species occurred in those forests distributed at higher elevations and southern latitudes, as the araucaria forests and the southeast seasonal forests, respectively. Moreover also in the northern and southern gallery forests, which coincidentally were the least diversified formations in terrestrial orchids (Figure 4).

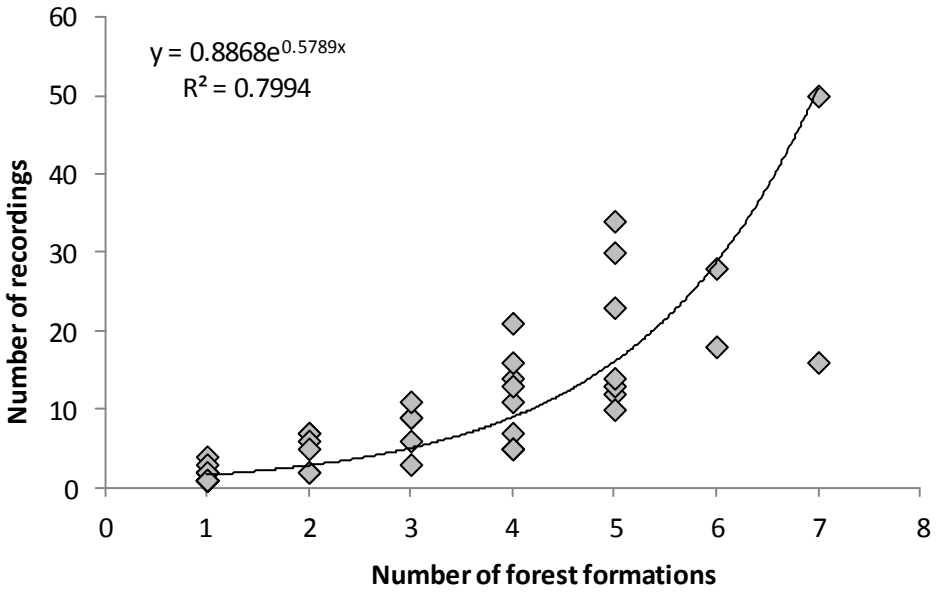

Figure 5. Relation between the range of occurrence in forest types and the number of orchid recordings in Rio Grande do Sul, South Brazil.

The relation between the number of forest formations (in which each species occurred) and the number of orchid recordings, showed a significant exponential regression (U = 794; P = 0.001372; N = 50), indicating that those species with a wider biogeographic distribution were also more frequently collected or otherwise recorded throughout the state of Rio Grande do Sul (Figure 5).

Table 2. Range size (km²) and conservation status of terrestrial orchids found in forest ecosystems of Rio Grande do Sul, South Brazil. Status I is based on extent of occurrence (EOO) and Status II on area of occupancy (AOO).

Species of orchids	Occurrence	Occupancy	Status I	Status II
Aspidogyne bidentifera (Schltr.) Garay	25,376.69	32.00	NT	EN
Aspidogyne bruxelii (Pabst) Garay	2.56	12.00	CR	EN
Aspidogyne commelinoides Barb.Rodr.	0.00	8.00	CR	CR
Aspidogyne decora (Rchb.f.) Garay & G.A.Romero	0.01	4.00	CR	CR
Aspidogyne fimbrillaris (B.S.Williams) Garay	8.25	8.00	CR	CR
Aspidogyne kuczynskii (Porsch) Garay	47,518.67	40.00	LC	EN
Aspidogyne lindleyana (Cogn.) Garay	0.00	8.00	CR	CR
Aspidogyne malmei (Kraenzl.) Garay	0.00	4.00	CR	CR
Chloraea membranacea Lindl.	85,398.93	52.00	LC	EN
Corymborkis flava (Sw.) Kuntze	70,772.98	104.00	LC	EN

Cranichis candida (Barb.Rodr.) Cogn.	22,842.53	48.00	NT	EN
Cyclopogon argyrifolius (Barb.Rodr.) Barb.Rodr.	0.00	4.00	CR	CR
Cyclopogon bicolor (Ker Gawl.) Schltr.	18,303.54	32.00	VU	EN
Cyclopogon calophyllus (Barb.Rodr.) Barb.Rodr.	0.00	4.00	CR	CR
Cyclopogon chloroleucus (Barb.Rodr.) Schltr.	75,073.96	52.00	LC	EN
Cyclopogon congestus (Vell.) Hoehne	32,764.05	40.00	NT	EN
Cyclopogon elatus (Sw.) Schltr.	67,414.88	48.00	LC	EN
Cyclopogon iguapensis Schltr.	47,992.68	24.00	LC	EN
Cyclopogon itatiaiensis (Kraenzl.) Hoehne	0.00	4.00	CR	CR
Cyclopogon longibracteatus (Barb.Rodr.) Schltr.	43,290.57	24.00	NT	EN
Cyclopogon micranthus (Barb.Rodr.) Schltr.	30,627.06	24.00	NT	EN
Cyclopogon subalpestris Schltr.	126,855.65	120.00	LC	EN
Cyclopogon trifasciatus Schltr.	0.39	8.00	CR	CR
Cyclopogon variegatus Barb.Rodr.	0.00	8.00	CR	CR
Cyclopogon vittatus Dutra ex Pabst	0.00	4.00	CR	CR
Galeandra beyrichii Rchb.f.	63,197.25	44.00	LC	EN
Govenia utriculata (Sw.) Lindl.	21,133.52	64.00	NT	EN
Habenaria josephensis Barb.Rodr.	7,302.28	44.00	VU	EN
Habenaria pleiophylla Hoehne & Schltr.	131.79	20.00	EN	EN
Hapalorchis lineata (Lindl.) Schltr.	52,565.20	96.00	LC	EN
Liparis nervosa (Thunb.) Lindl.	11,581.50	52.00	VU	EN
Malaxis excavata (Lindl.) Kuntze	51,302.89	44.00	LC	EN
Malaxis jaraguae (Hoehne & Schltr.) Pabst	6,343.70	24.00	VU	EN
Malaxis parthoni C.Morren	71,823.55	172.00	LC	EN
Malaxis warmingii (Rchb.f.) Kuntze	0.00	8.00	CR	CR
Mesadenella cuspidata (Lindl.) Garay	128,864.84	160.00	LC	EN
Microchilus arietinus (Rchb.f & Warm.) Ormerod	0.00	4.00	CR	CR
Oeceoclades maculata (Lindl.) Lindl.	0.00	4.00	CR	CR
Pelexia burgeri Schltr.	0.00	4.00	CR	CR
Pelexia lindmanii Kraenzl.	35,213.09	20.00	NT	EN
Pelexia novofriburgensis (Rchb.f.) Garay	0.00	8.00	CR	CR
Prescottia oligantha Lindl.	8,272.85	60.00	VU	EN
Prescottia stachyodes (Sw.) Lindl	20,524.60	56.00	NT	EN
Psilochilus modestus Barb.Rodr.	1,263.97	16.00	EN	EN
Sarcoglottis juergensii Schltr.	500.72	12.00	EN	EN
Sarcoglottis ventricosa (Vell.) Hoehne	3,588.98	12.00	EN	EN
Sauroglossum elatum Lindl.	84,126.51	96.00	LC	EN
Triphora santamariensis Portalet	0.00	4.00	CR	CR
Warrea warreana (Lodd. ex. Lindl.) C. Schweinf.	45,502.15	20.00	LC	EN
Wullschlaegelia aphylla (Sw.) Rchb.f.	75,193.52	68.00	LC	EN

Table 3. Distribution of terrestrial orchid species in nine forest types of Rio Grande do Sul: Atlantic rainforest (Atlan), Araucaria forest (Arauc), northern seasonal forest (Nseas), center seasonal forest (Cseas), southern seasonal forest (Sseas), northern gallery forest (Ngall), southern galley forest (Sgall), coastal dune-forest (Cdune) and coastal peat-forest (Cpeat). Range denotes the number of forest types in which a given species occurred.

Orchid species \ Forest types	Atlan	Arauc	Nseas	Cseas	Sseas	Ngall	Sgall	Cdune	Cpeat	Range
Aspidogyne bidentifera	0	6	0	0	0	0	1	0	0	2
Aspidogyne bruxelii	0	1	0	0	0	1*	0	0	0	2
Aspidogyne commelinoides	0	0	2	0	0	0	0	0	0	1
Aspidogyne decora	2	0	0	0	0	0	0	0	0	1
Aspidogyne fimbrillaris	4	0	0	0	0	0	0	0	0	1
Aspidogyne kuczynskii	1	0	3	5	0	0	0	0	0	3
Aspidogyne lindleyana	0	0	0	2	0	0	0	0	0	1
Aspidogyne malmei	0	0	1	0	0	0	0	0	0	1
Chloraea membranacea	0	7	0	1*	1*	2	1*	0	0	5
Corymborkis flava	12	0	2	11	3	0	0	2	0	5
Cranichis candida	2	0	0	2	5	0	0	0	5	4
Cyclopogon argyrifolius	0	0	0	1	0	0	0	0	0	1
Cyclopogon bicolor	0	0	0	6	1	0	0	0	0	2
Cyclopogon calophyllus	0	0	0	1	0	0	0	0	0	1
Cyclopogon chloroleucus	3	1	0	3	1*	1*	0	3	4	7
Cyclopogon congestus	0	0	4	3	2	0	0	0	0	3
Cyclopogon elatus	0	1	0	3	4	0	0	3	0	4
Cyclopogon iguapensis	2	0	0	2	2	0	0	1	0	4
Cyclopogon itatiaiensis	0	0	0	0	0	0	0	1	0	1
Cyclopogon longibracteatus	0	2	1	1	1	0	0	0	0	4
Cyclopogon micranthus	0	4	0	0	0	0	2	0	0	2
Cyclopogon subalpestris	0	2	1	11	10	1	0	3	0	6
Cyclopogon trifasciatus	0	0	0	3	0	0	0	0	0	1
Cyclopogon variegatus	1	0	0	0	0	0	0	0	1	2
Cyclopogon vittatus	0	0	0	1	0	0	0	0	0	1
Galeandra beyrichii	0	0	2	5	3	0	1*	2	0	5
Govenia utriculata	4	0	1	10	1	0	0	0	0	4
Habenaria josephensis	0	1	0	2	8	0	0	0	0	3
Habenaria pleiophylla	0	0	0	0	0	0	0	1	0	1
Hapalorchis lineata	1	2	0	2	13	0	0	5	0	5
Liparis nervosa	7	0	0	1	2	0	0	0	3	4
Malaxis excavata	1	2	0	1	3	0	0	0	3	5
Malaxis jaraguae	2	0	0	3	0	0	0	1	0	3
Malaxis parthoni	3	2	0	18	19	1	0	4	3	7
Malaxis warmingii	0	0	0	0	0	0	0	0	1	1
Mesadenella cuspidata	5	0	3	5	19	0	0	2	0	5
Microchilus arietinus	0	0	1	0	0	0	0	0	0	1

Oeceoclades maculata	1*	0	0	0	0	0	0	0	0	1
Pelexia burgeri	0	0	0	0	0	0	0	0	1	1
Pelexia lindmanii	0	1	0	1*	2	0	0	1*	0	4
Pelexia novofriburgensis	0	0	0	0	0	0	0	0	2	1
Prescottia oligantha	0	0	0	0	0	0	0	1	0	1
Prescottia stachyodes	4	0	1*	3	4	0	0	0	2	5
Psilochilus modestus	1	0	0	0	0	0	0	0	4	2
Sarcoglottis juergensii	0	1	0	1*	1*	0	0	0	0	3
Sarcoglottis ventricosa	0	0	0	1	0	0	0	0	0	1
Sauroglossum elatum	4	0	0	5	11	0	0	0	1	4
Triphora santamariensis	0	0	0	1*	0	0	0	0	0	1
Warrea warreana	1*	0	1*	2	1	0	0	0	0	4
Wullschlaegelia aphylla	4	2	2	8	1	0	0	0	1	6
Number of species	21	15	14	33	24	5	4	14	13	50

(*) observed occurrences without exsiccates deposited in regional herbaria.

4 – Floristic affinities between forests

Coordinate 1 of non-metrical multidimensional scaling (NMDS) separated the mostly well-drained mountain slope forests (Atlantic and seasonal forests to the left of Figure 6) from the riverside forests immersed in grassland ecosystems and at the same time subject to periodic inundation (gallery forests to the right of Figure 6). This differentiation is also coincident with the highest and lowest values of orchid richness, respectively. The number of species was strongly and significantly correlated with coordinate 1 of the NMDS analysis ($r = -0.902$; $P = 0.000873$; $N = 9$). Coordinate 2 distinguished forest regions from relatively favorable environments (warm and moist), as the Atlantic rain and peat forests to the upper portion of the graphic from those forests subject to a climatic or edaphic limitation, as the relatively colder Araucaria forests and the relatively drier dune forests, both to the lower portion of the graphic.

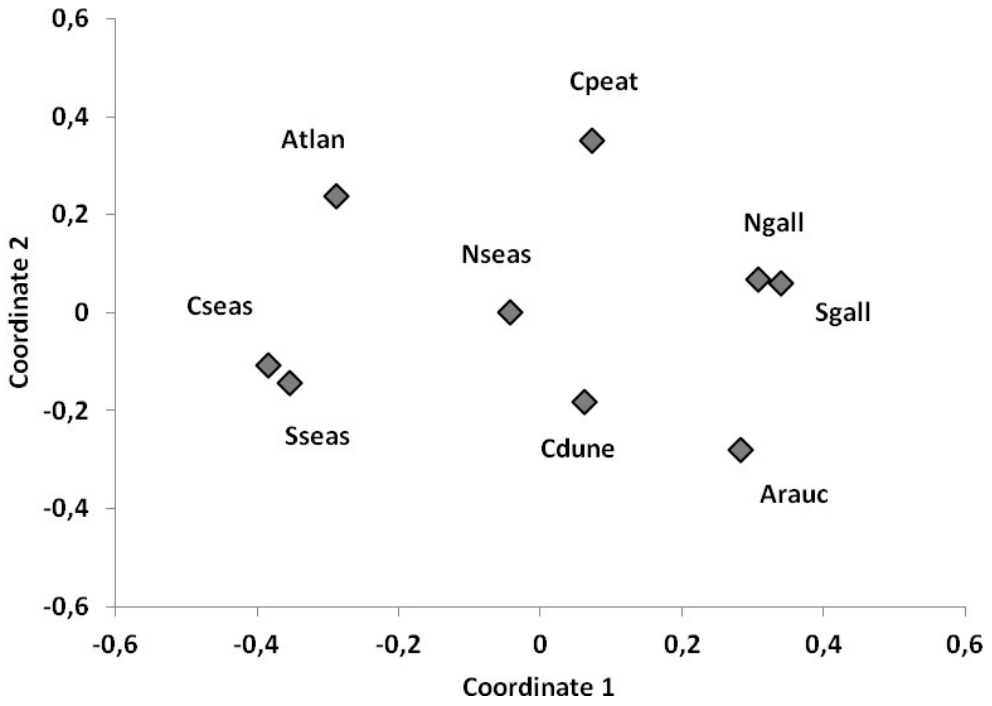

Figure 6. Affinities between major forest regions of Rio Grande do Sul based on the occurrence of terrestrial orchid species (excluding the species restricted to a single forest type). The analysis is a non-metrical multidimensional scaling (NMDS) using Euclidean distances between forest sites. See Table 3 for acronyms of forest regions.

5 – Excluded species from the study area

A set of nine species cited for Rio Grande do Sul in previous publications could not be found during our taxonomic revision. These species were mostly misidentified by earlier authors or, in a few cases, could not be found in the revised herbaria neither in our field expeditions. A more detailed interpretation for each species is given below.

*Aspidogyne argentea (*Vell.) Garay. The species was cited by Pabst & Dungs (1975), Schinini *et al.* (2008), Rocha & Waechter (2010) and Barros *et al.* (2014). A closer examination of a single specimen identified as *A. argentea* (ICN 152362) showed to be *A. fimbrillaris*. The confusion between the two species possibly results from the citation of Pabst & Dungs (1975), since these authors considered *A. argentea* as a synonym of *A.*

fimbrillaris, the species which in fact occurs in Rio Grande do Sul.

Aspidogyne longicornu (Cogn.) Garay. The species was cited by Schinini *et al*. (2008), but no collection was found from Rio Grande do Sul. According to Barros *et al*. (2014) *A. longicornu* occurs in tropical Brazil, not extending to the southern region of this country.

Cyclopogon dusenii Schltr. The species was cited by Rocha & Waechter (2006). According to our interpretation all exsiccates from Rio Grande do Sul previously identified as *C. dusenii* correspond to *C. iguapensis*.

Cyclopogon dutrae Schltr. The species was originally described from a specimen collected in Rio Grande do Sul (Dutra 839 (ICN), and compared by the author to *C. trilineatus* (Lindl.) Schltr. and *C. alpestris* Barb. Rodr., now *C. longibracteatus* (Barb.Rodr.) Schltr. and *C. congestus* (Vell.) Hoehne, respectively. We examined the type material, which resembles *C. elatus* (Sw.) Schltr., but the degraded flowers did not allow a precise comparison to other related species.

Cyclopogon elegans Hoehne. The species was cited by Buzatto *et al.* (2007). In our opinion the material collected in Rio Grande do Sul corresponds to *C. subalpestris*.

Malaxis histionantha (Link) Garay & Dunst. The species was cited by Rocha & Waechter (2006), Schinini *et al.* (2008), Rocha & Waechter (2010), Záchia & Waechter (2011) and Barros *et al.* (2014). Our analyses of herbarium specimens previously identified as *M. histionantha* showed to be in part *M. jaraguae* (Hoehne & Schltr.) Pabst and in part *M. parthonii* C. Morren.

Malaxis pabstii (Schltr.) Pabst. The species was cited by Pabst & Dungs (1975) and by Diesel (1991), but no herbarium specimen was found during our revisions, so we consider that this species might be endemic to the state of Santa Catarina.

Malaxis pubescens (Lindl.) Kuntze. The species was cited by Rocha & Waechter (2006) and Rocha & Waechter (2010). We transferred all the material identified as *M. pubescens* to *M. jaraguae*, including a duplicate deposited in PEL (Jarenkow 2346), referred as *M. pubescen*s at the site SpeciesLink (http://www.splink.org.br).

Pelexia macropoda (Barb.Rodr.) Schltr. The species was cited by Pabst & Dungs (1975) and Barros *et al.* (2014). No specimen from Rio Grande do Sul was found during our revision.

DISCUSSION

Terrestrial forest orchids are seldom the focus of a study in tropical or subtropical regions, were epiphytic species are commonly more diversified and in general attract more attention due to larger and showier flowers. Subtropical regions can be regarded as transitional climatic zones and are as well transitional in the relation between geophytic (in the sense of terrestrial) and epiphytic orchids (Rocha & Waechter 2010). Although entirely located in subtropical latitudes, Rio Grande do Sul has much more epiphytic than terrestrial orchids, in great part due to the Atlantic forests in the northern part of the state (Rambo 1960, Waechter 1998). The total number of terrestrial species found in this study (50) is lower than the number of epiphytic species (66) reported for a unique small site, the

Itapeva State Park in the northeastern Atlantic region (Waechter 1986, Waechter & Baptista 2004). In other subtropical areas, as Florida (US), Uruguay and Buenos Aires province (Argentina) the species number of terrestrial orchids largely exceeds the epiphytic species (Luer 1972, Correa 1968, Izaguirre de Artucio 1985, Primavera 2010).

Despite their relatively low diversity in forest ecosystems, terrestrial orchids make up an interesting assembly of understory plants. Although all species possibly share a common tolerance to shady environments, the entire assembly is extremely heterogeneous from an adaptive point of view, including at least four different life-forms: hemicryptophytes, geophytes and saprophytes (as defined in Mueller-Dombois & Ellenberg, 2003). All these adaptive categories were found in our study, although in very different proportions. The adaptive heterogeneity, including pollination and dispersion mechanisms, probably influences geographic distribution and habitat selectivity. The restriction to one particular forest type was outstandingly higher in our study than if open vegetation types, as peat marshes and dune meadows, are considered together (Rocha & Waechter 2010).

Approximately two thirds of all genera showed only one species in forest formations of Rio Grande do Sul. This relatively high proportion seems outstanding, but it can be explained by several aspects of orchid biology: 1) the low number of species in one entire genus, such as in *Corymborkis*, *Warrea* and *Wullschlaegelia*; 2) the small number of species in Brazil or perhaps outside Andean and Amazonian South America, like *Chloraea*, *Cranichis*, *Govenia*, *Mesadenella* and *Psilochilus*; 3) the selective occurrence of most species in open vegetation types, like grasslands and wetlands, especially in the large genus *Habenaria*. A low specific representation can also be credited to those genera having a pantropical distribution, and eventually a species concentration in Africa and/or Asia, as *Liparis*, *Malaxis*, and *Oeceoclades* (Pridgeon *et al*. 2006, 2009).

The estimations of range sizes resulted in a surprisingly high number of threatened species, included in the Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) categories. This result became still more evident with the area of occupancy estimations, as this criterion positioned all species into the last two categories. To how extent this result is determined by sampling deficiency must be better investigated. However, some evidences can be deduced from several species which were not collected in the last ± 30 years, as *Aspidogyne decora*, *A. lindleyana*, *Cyclopogon calophyllus*, *C. itatiaiensis*, *C. variegatus*, *C. vittatus* and *Microchilus arietinus*. Another species, *Aspidogyne malmei*, is only known from a single specimen collected in 1893, in the seasonal forests of the Upper Uruguay. Other important aspects of orchid biology are also poorly known, as the quantitative participation in understory communities and the extent of selective sampling of ornamental species, especially those with variegated leaves (several species in the *Aspidogyne*, *Cyclopogon*, *Habenaria*, *Mesadenella*, *Pelexia*, and *Oeceoclades*).

In relation to official lists of threatened species, our study indicates a considerable increase in the number of terrestrial orchids. In the Red List of Rio Grande do Sul (available at http://www.fzb.rs.gov.br/extincao.htm), published in 2002, only two species of terrestrial orchids are mentioned in threatened categories: *Choraea membranacea* and *Microchilus arietinus*. In the Red Book of the Brazilian flora (Menini Neto *et al.* 2013) two of the species found in this study appear in a threatened status, namely *Chloraea membranacea* as Endangered and *Malaxis jaraguae* as Vulnerable. Three endemic species from Rio Grande do Sul should perhaps be added to this list, if future investigation will in fact confirm their validity (and not as synonyms of other more widespread species). These species are *Sarcoglottis juergensii*, *Pelexia burgeri*, and *Triphora santamariensis*, the former defined as Endangered and the latter two as Critically Endangered according to our

areas estimations.

The highest number of species found in the central Serra Geral seasonal forests was in fact not expected in this study, since this forest area is not in a closer contact or continuity with the northern state boundaries, where mostly tropical genera and species concentrate (Rambo 1961, Waechter 2002). However, this high diversity can be explained by a relatively large area, estimated as 31,566.60 km² of continuous forest (Cordeiro & Hasenack 2009) before the present generalized fragmentation. Moreover, the entire area occupied by this forest region has a relatively rich flora originated from both eastern and western migration routes, as demonstrated in a study focusing the tree flora (Jarenkow & Waechter 2001). Finally, the mostly south facing slopes of the Serra Geral mountain range has an humid mid-elevation forest environment, shown to be a favorable habitat for terrestrial orchids (Jacquemyn *et al.* 2007, Acharya *et al.* 2011).

The relatively low number of species found in the Atlantic rainforest and the northern Upper Uruguay seasonal forest was neither expected at the beginning of this study, since this forest regions are perhaps the most diversified in Rio Grande do Sul, mostly as a result of southern geographic boundaries of tropical genera and species (Rambo 1960, Waechter 2002). In the case of these forest areas, the much smaller original cover might be also an explanation, estimated as 1,218.24 km² for the Atlantic rainforest, and 17,125.23 km² for the Upper Uruguay seasonal forest (Cordeiro & Hasenack 2009). However, other factors should be investigated in the future, as the effect of sampling deficiency and the impact of forest fragmentation on local or regional extinctions. Otherwise, several genera of terrestrial forest orchids occurring in adjacent Santa Catarina state (Brazil) and Misiones province (Argentina) may possibly also be found in Rio Grande do Sul, as *Eltroplectris*, *Ligeophila*, *Paradisanthus*, *Platythelys* and *Pteroglossa* (Johnson 2001, Schinini *et al*. 2008,).

The two-dimensional display of forests regions produced by non-metrical multidimensional scaling (NMDS) should be interpreted as a preliminary and exploratory analysis of floristic and diversity affinities. Nevertheless, the analysis provided interesting and apparently consistent relationships between forest regions. The most important differentiation seems to occur between tall seasonal forests on well-drained soils and generally small gallery forests on alluvial soils. The higher species richness of the former may be related to a more widespread distribution, although now largely fragmented and replaced by farmlands. Further studies are needed to evidence if or how leaf seasonality and soil inundation are, respectively, favorable and restrictive to orchid occurrence and diversity.

Araucaria forests also occupy an extreme position which can be related to the coldest climate in South Brazil, associated to elevations between 500-1300 meters (Hueck & Seibert 1981). The separation of the northern seasonal forests from the central and southeast formations of the same type suggests a floristic heterogeneity in these formations, possibly due to spatial discontinuity and the influence of distinct biogeographic provinces, i.e., the western Paranean and the eastern Atlantic provinces (Rambo 1961, Cabrera & Willink 1980, Jarenkow & Waechter 2001). Although geographically occurring close together, coastal dune and peat forests grow on quite different soil drainage regimes, a factor which probably affects their separation on the ordination graphic. The influence of a relatively wide latitudinal distribution of these formations must be better studied in the future, in order to confirm an expected north-south diversity gradient, as evidenced for epiphytic orchids (Waechter 1998).

The threatening factors for biodiversity conservation can be regarded as specific for different forest types and for different biotic populations. Examples of threats mentioned for plant species in general (Coates & Atkins 2001), and for orchid species in particular

(Hone 2002, Wotavová *et al.* 2004) are also found in South Brazil, such as hydro-ecological changes, biological invasions, and soil over-fertilization, especially in areas with extensive monocultures.

The present forest remnants in Rio Grande do Sul, although representing a small proportion of the relatively large original forest cover, are still threatened by urban expansion over natural areas, dam constructions along river systems, and perhaps especially by the invasion of wild pigs (*Sus scrofa* Linnaeus, Suidae) throughout the state (Deberdt & Scherer 2007). These animals have been reported to unbury underground tubers of Australian terrestrial orchids in the genera *Gastrodia* R.Br. and *Chiloglottis* R.Br. (Hone 2002), and to facilitate the establishment of exotic plant species through the modification of soil properties and understory communities (Stone 1991). Large populations of wild pigs have been observed in the Aracuri Ecological Station, a relatively small conservation unit in northern Rio Grande do Sul, where at least two threatened orchid species occur, *Aspidogyne bruxelii* and *Sarcoglottis juergensii*, the former restricted to South Brazil and nearby northeast Argentina, the latter endemic to Rio Grande do Sul.

The use of additional information to define the conservation status of terrestrial orchids, such as the criteria defined by IUCN (2012), is presently very limited in South Brazil. There is a single detailed study focusing spatial distribution of a single species in a restricted area (Budke et al. 2004). Abundance of terrestrial orchids, mostly as cover and/or frequency estimates, is available in around 20 regional papers concerning the structure of understory communities in several forest types (e.g. Citadini-Zanette 1984, Inácio & Jarenkow 2008). All these papers together comprise less than 25 species, and thus amounting around 50% of the species reported here as occurring in forest ecosystems. The number of terrestrial orchid species in a particular forest is generally low, mostly varying between none to five species, and only exceptionally achieving seven species in a stand of

Atlantic rain forest (Citadini-Zanette 1984). In face of the limited contribution available in published material, the best parameters for the definition of conservation status in a regional scale are the estimations of extent of occurrence and area of occurrence, such as we did in our study.

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APPENDIX I: Herbarium specimens examined

Aspidogyne bidentifera (Schltr.) Garay

Brazil. Rio Grande do Sul: Bom Jesus, 28/I/1935, *J. Dutra 1168* (ICN); Cambará, 25/I/1948, *B. Rambo* s.n. (ICN 16572); Eldorado do Sul, 19/XII/2001, *J. L. Waechter & C. Giongo 222* (ICN); São Francisco de Paula, 2/I/1955, *B. Rambo* s.n. (PACA 56361).

Aspidogyne bruxelii (Pabst) Garay

Brazil. Rio Grande do Sul: Esmeralda, XI/1981, *J. L. Waechter* s.n. (ICN 53149).

Aspidogyne commelinoides (Barb.Rodr.) Garay

Brazil. Rio Grande do Sul: Tenente Portela, 29/V/2004, *C. D. Inácio 4* (ICN); Tenente Portela, 11/III/2005, *C. D. Inácio 60* (ICN).

Aspidogyne decora (Rchb.f.) Garay & G.A.Romero

Brazil. Rio Grande do Sul: Torres, 3/XII/1976, *L. R. M. Baptista & V. Citadini* s.n. (ICN 33847); Torres, 3/XII/1976, *V. Citadini et al. 142* (ICN).

Aspidogyne fimbrillaris (B.S.Williams) Garay

Brazil. Rio Grande do Sul: Dom Pedro de Alcântara, 18/XI/1971, *J. C. L. et al.* s.n. (ICN 9182); Dom Pedro de Alcântara, 3/I/2000, *C. Jurinitz 21* (ICN); Dom Pedro de Alcântara, 7/X/2007, *C. R. Buzatto 322* (ICN); Torres, 15/XI/1979, *J. L. Waechter 1490* (ICN).

Aspidogyne kuczynskii (Porsch) Garay

Brazil. Rio Grande do Sul: Agudo, XII, *J. L. Waechter 1491* (ICN); Pareci, 20/I/1934, *Orth* s.n. (PACA 837); Santa Cruz do Sul, 16/XII/1979, *J. L. Waechter 1475* (ICN); Tenente Portela, 12/XI/1976, *J. L. Waechter 417* (ICN); Tenente Portela, 17/01/2005, *C. Inácio 43* (ICN).

Aspidogyne lindleyana (Cogn.) Garay

Brazil. Rio Grande do Sul: Santa Cruz do Sul, 13/II/1980, *J. L. Waechter 1550* (ICN).

Chloraea membranacea Lindl.

Brazil. Rio Grande do Sul: Augusto Pestana, 05/XII/1953, *Pivetta 488* (PACA); Caxias

do Sul, 9/XII/2009, *L. Eggers 308* (ICN); Vacaria, 29/12/1951, *B. Rambo* s.n. (PACA 52648).

Corymborkis flava (Sw.) Kuntze

Brazil. Rio Grande do Sul: Derrubadas, 29/05/2004, *C. D. Inácio 6* (ICN); Mariana Pimentel, 23/VI/1977, *L. R. M. Baptista et al.* s.n. (ICN 34371); Porto Alegre, 19/X/2006, *R. Setubal & M. Grings 413* (ICN); Santa Cruz do Sul, 01/11/1987, *J. A. Jarenkow & J. L. Waechter 1659* (PEL); Santa Maria, V/1985, *M. Sobral 3858* (ICN); Torres, 25/III/1977, *J. L. Waechter 476* (ICN).

Cranichis candida (Barb.Rodr.) Cogn.

Brazil. Rio Grande do Sul: Guaíba, 14/VI/1994, *V. F. Nunes 1412* (ICN); Nova Petrópolis, 6/VI/2010, *M. Grings 1047* (ICN); Tavares, 26/VI/2003, *R. Záchia 5629* (ICN); Tramandaí, 21/V/1976, *V. Citadini* (ICN 31291); Torres, 19/VII/1991, *J. L. Waechter* (ICN 130944).

Cyclopogon argyrifolius (Barb.Rodr.) Barb.Rodr.

Brazil. Rio Grande do Sul: Santa Maria, 9/XI/2012, *A. Portalet 81* (SMDB).

Cyclopogon bicolor (Ker Gawl.) Schltr.

Brazil. Rio Grande do Sul: Taquara, 11/XI/1987, *S. Diesel* s.n. (PACA 71188); Unistalda, V/2010, *A. Portalet et al.* s.n. (SMDB 13806); Viamão, *A. Nilson 17* (HAS).

Cyclopogon calophyllus (Barb.Rodr.) Barb.Rodr.

Brazil. Rio Grande do Sul: Sapiranga, IX, *J. Dutra 1062* (ICN).

Cyclopogon chloroleucus (Barb.Rodr.) Schltr.

Brazil. Rio Grande do Sul: Dom Pedro de Alcântara, 18/IX/1999, *C. F. Jurinitz 14* (ICN); Esmeralda, 19/IX/1982, *K. Kleebank 04* (ICN); Nova Prata, 20/IX/2012, *F. B. Colla* s.n. (ICN 190665); Piratini, 19/XI/1989, *J. A. Jarenkow* 1467 (PEL); Santa Maria, 15/VI/2010, *A. Portalet 88* (SMDB); Tavares, 24/IX/2002, *R. Záchia 5506* (ICN); Torres, 1/X/1976, *V. Citadini et al.* s.n. (ICN 33222).

Cyclopogon congestus (Vell.) Hoehne

Brazil. Rio Grande do Sul: Porto Alegre, 2/IX/1933, *J. Dutra 1155* (ICN); Sapiranga, 30/X/1928, *J. Dutra 1023* (ICN); Tenente Portela, 4/X/1979, *J. L. Waechter 1396* (HAS).

Cyclopogon elatus (Sw.) Schltr.

Brazil. Rio Grande do Sul: Caçapava do Sul, 25/IX/1984, *B. Irgang et al.* s.n. (ICN 92581); Esmeralda, 19/IX/1982, *K. Kleebank 2* (ICN); Flores da Cunha, 9/X/1989, *R. Wasum* s.n. (HUCS 6263); Tavares, 13/X/2003, *R. Záchia 5688* (ICN).

Cyclopogon iguapensis Schltr.

Brazil. Rio Grande do Sul: Arroio do Sal, 2/IX/1989, *M. G. Rossoni 159* (ICN); Dom Pedro de Alcântara, 6/IX/1977, *K. Hagelund 11510* (ICN); Gravataí, 3/IX/1954, *C. Orth* s.n. (PACA 624); Pinheiro Machado, 9/X/1977, *M. Fleig* (ICN 35184); Santa Maria, 11/VI/2009, *A. Portalet 58* (SMDB).

Cyclopogon itatiaiensis (Kraenzl.) Hoehne

Brazil. Rio Grande do Sul: Palmares do Sul, 15/X/1988, *H. Longhi-Wagner & I. Boldrini* s.n. (ICN 80034).

Cyclopogon longibracteatus (Barb.Rodr.) Schltr.

Brazil. Rio Grande do Sul: Marcelino Ramos, 23/IX/1987, *J. A. Jarenkow 735* (PACA); São Francisco de Paula, 13/III/1950, *G. Pabst 602* (PACA); Sapiranga, 25/VIII/1991, *V. F. Nunes et al.* s.n. (PACA 71148); Porto Alegre, 15/XI/1933, *C. Orth 1711* (PACA).

Cyclopogon micranthus (Barb.Rodr.) Schltr.

Brazil. Rio Grande do Sul: Aceguá, VIII/2006, *M. Grings* s.n. (ICN 182531); Esmeralda, 19/IX/1983, *J. L. Waechter 1983* (ICN); Santa Maria, 15/VI/2010, *A. Portalet 87* (SMDB).

Cyclopogon subalpestris Schltr.

Brazil. Rio Grande do Sul: Barracão, 09/VIII/2000, *M. Neves et al.* s.n. (HAS 37468); Capão do Leão, 12/X/1972, *J. C. Lindeman et al.* s.n. (HAS 5635)**;** Esmeralda, 19/IX/1983, *J. L. Waechter* 1984 (ICN); Machadinho, 4/VIII/2000, s.c. (HAS 37288); Palmares do Sul, 27/IX/2002, *J. Mauhs* s.n. (PACA 94129); Unistalda, VII/2010, *A. Portalet et al.* s.n. (SMDB 13807).

Cyclopogon trifasciatus Schltr.

Brazil. Rio Grande do Sul: Santa Maria, *A. Portalet 55* (SMDB); Santa Maria, 21/07/2013, *M. Grings & A. S. Mello* s.n. (ICN 182284);

Cyclopogon variegatus Barb.Rodr.

Brazil. Rio Grande do Sul: Torres, 21/IV/1979, *J. L. Waechter 1231* (ICN); Torres, 29/08/1980, *V. C. Zanette 381* (ICN).

Cyclopogon vittatus Dutra ex Pabst

Brazil. Rio Grande do Sul: Torres, 21/IV/1979, *J. L. Waechter 1231* (ICN); Torres, 29/08/1980, *V. C. Zanette 381* (ICN).

Galeandra beyrichii Rchb.f.

Brazil. Rio Grande do Sul: Derrubadas, 18/I/2006, *C. Inácio 76* (ICN); Porto Alegre, 12/I/1933, *C. Orth* s.n. (PACA 262); Santa Cruz do Sul, 4/I/1980, *J. L. Waechter 1524* (ICN); São Jerônimo, 30/III/1982, *M. L. Abruzzi 575* (HAS); Sapiranga, 23/VI/1991, *Nunes et al. 1287* (PACA); Tavares, 5/II/2004, *R. Záchia 5728* (ICN).

Govenia utriculata (Sw.) Lindl.

Brazil. Rio Grande do Sul: Barra do Ribeiro, 25/IX/2003, *Hofman & Gauer* s.n.(ICN 129007); Dom Pedro de Alcântara, 24/IV/1976, *L. R. M. Baptista* s.n. (ICN 31287); Pinhal da Serra, 22/01/2005, *M. R. Ritter & M. E. Beretta* s.n. (ICN 170593); Sapiranga, 29/II/1991, *V. F. Nunes et al.* 1239 (PACA); Veranópolis, 20/XII/2013, *F. B. Colla* (ICN 176954).

Habenaria josephensis Barb.Rodr.

Brazil. Rio Grande do Sul: Passo Fundo, 25/04/2013, *M. Verdi 6398* (FURB); Porto Alegre, 23/VI/1987, *N. Silveira 5653* (HAS); Sapiranga, 20/IV/1991, *V. F. Nunes et al.* s.n. (PACA 71142).

Habenaria pleiophylla Hoehne & Schltr.

Brazil. Rio Grande do Sul: Arroio do Sal, 22/IV/1990, *M. G. Rossoni 438* (ICN).

Hapalorchis lineata (Lindl.) Schltr.

Brazil. Rio Grande do Sul: Dom Pedro de Alcântara, 6/X/2007, *C. R. Buzatto 316* (ICN);

Porto Alegre, 25/VIII/1932, *C. Orth 118* (PACA); Santa Maria, 3/X/1989, *N. Silveira 6930* s.n. (HAS); São Francisco de Paula, 3/X/2013, *G. D. S. Seger & E. Bach* s.n. (ICN 182282); Tapes, 26/IX/1975, *J. L. Waechter 136* (ICN).

Liparis nervosa (Thunb.) Lindl.

Brazil. Rio Grande do Sul: Maquiné, 30/III/1984, *J. Mattos et al. 25849* (HAS); São Leopoldo, 5/IX/1935, *B. Rambo* s.n. (PACA 2069); Tavares, 18/VII/2003, *R. Záchia 5626* (ICN); Torres, 7/03/2004, *J. L. Waechter 2697* (ICN).

Malaxis excavata (Lindl.) Kuntze

Brazil. Rio Grande do Sul: Caçapava do Sul, 30/V/1976, *J. L. Waechter et al. 282* (ICN); Torres, 21/VII/1978, *J. L. Waechter 880* (ICN); São Francisco de Paula, 12/III/2013, *G. D. S. Seger 774* (ICN); Porto Alegre, 23/I/2009, *M. Grings & R. Setubal 1412* (ICN); Veranópolis, 22/VI/1984, *N. Silveira 1106* (ICN).

Malaxis jaraguae (Hoehne & Schltr.) Pabst

Brazil. Rio Grande do Sul: Maquiné, 25/II/1977, *L. Amaral* s.n. (ICN 33234); Santa Cruz do Sul, 18/II/1980, *J. L. Waechter 1562* (ICN); Torres, 25/III/1977, *J. L. Waechter 477* (ICN); Santa Maria, 10/IV/1956, *O. R. Camargo* s.n. (PACA 60345).

Malaxis parthoni C.Morren

Brazil. Rio Grande do Sul: Caçapava do Sul, 25/V/1983, *J. Mattos & N. Silveira 27157* (ICN); Cotiporã, 14/V/2010, *G. D. S. Seger 1080* (ICN); Júlio de Castilhos, 28/IV/1988, *N. Silveira et al. 7215* (HAS); Santa Maria, 16/03/1988, *J. L. Waechter 2307* (ICN); São Francisco de Paula, 18/XII/1950, *B. Rambo* s.n. (PACA 49456); Tavares, 16/IX/2004, *R. Záchia 5766* (ICN); Torres, 15/IV/1977, *J. L. Waechter 504* (ICN).

Malaxis warmingii (Rchb.f.) Kuntze

Brazil. Rio Grande do Sul: Tavares, 16/IX/2004, *R. Záchia 5765* (ICN).

Mesadenella cuspidata (Lindl.) Garay

Brazil. Rio Grande do Sul: Derrubadas, 18/I/2005, *C. Inácio 77* (ICN); Pelotas, 4/V/1959, *Sacco 1130* (ICN); Santa Cruz do Sul, 1/III/1978, *J. L. Waechter 760* (ICN); Tramandaí, 13/III/1976, *V. C. Citadini et al. 66* (ICN); Torres, 27/II/1988, *N. Silveira & K. Hagelund* s.n. (HAS 82104); Viamão, 22/IV/1976, *J. L. Waechter 248* (ICN).

Microchilus arietinus (Rchb.f & Warm.) Ormerod

Brazil. Santa Catarina: Itapiranga, I/1934, *J. Dutra 1160* (ICN).

Pelexia burgeri Schltr.

Brazil. Rio Grande do Sul: Torres, 7/III/2004, *J. L. Waechter 2698* (ICN).

Pelexia lindmanii Kraenzl.

Brazil. Rio Grande do Sul: Agudo, 1893, *A. Lindman 1041* (S); Passo Fundo, XII/1921, *C. Jürgens 56* (ICN); Porto Alegre, 15/12/1932, *C. Orth* s.n. (PACA 570).

Pelexia novofriburgensis (Rchb.f.) Garay

Brazil. Rio Grande do Sul: Torres, 16/I/1980, *J. L. Waechter 1536* (ICN).

Prescottia oligantha Lindl.

Brazil. Rio Grande do Sul: Arroio do Sal, 29/X/1987, *Mondin 261* (ICN).

Prescottia stachyodes (Sw.) Lindl.

Brazil. Rio Grande do Sul: Camaquã, 20/XII/2001, *C. F. Jurinitz 285* (ICN); São Francisco de Paula, 4/XII/2004, *R. Wasum & J. Bordin* s.n. (HUCS 24651); Tavares, 16/IX/2004, *R. A. Záchia 5767* (ICN); Torres, 18/VIII/1979, *J. L. Waechter 1311* (ICN).

Psilochilus modestus Barb.Rodr.

Brazil. Rio Grande do Sul: Morrinhos do Sul, 20/XII/2011, *L. C. Mancino & J. Durigon* s.n. (ICN 174017); Tavares, 22/I/1992, *C. Costa 88* (HAS).

Sarcoglottis juergensii Schltr.

Brazil. Rio Grande do Sul: Esmeralda, 29/III/1982, *J. L. Waechter 1871* (ICN).

Sarcoglottis ventricosa (Vell.) Hoehne

Rio Grande do Sul: Santa Maria, 3/I/1999, *A. Portalet 20* (SMDB).

Sauroglossum elatum Lindl.

Brazil. Rio Grande do Sul: Camaquã, 10/V/2001, *C. F. Jurinitz 197* (ICN); Maquiné, 27/IX/1978, *J. Mattos & N. Mattos* s.n. (HAS 81945); São Leopoldo, IX/1926, *J. Dutra*

969 (ICN); Tenente Portela, 19/X/1989, *N. Silveira 8857* (HAS); Torres, 16/IX/1978, *J. L. Waechter 984* (ICN).

Triphora santamariensis Portalet

Brazil. Rio Grande do Sul: Santa Maria, 4/II/2001, *A. Portalet 44* (SMDB).

Warrea warreana (Lodd. ex. Lindl.) C. Schweinf.

Brazil. Rio Grande do Sul: Camaquã, 20/I/2001, *C. F. Jurinitz 136* (ICN); Porto Alegre, I/1986, *E. D. Silveira* s.n. (ICN 85187); Sapiranga, II/1928, *J. Dutra 1017* (ICN).

Wullschlaegelia aphylla (Sw.) Rchb.f.

Brazil. Rio Grande do Sul: Camaquã, 4/II/2001, *C. F. Jurinitz 161* (ICN); Giruá, 16/XI/1977, *J. L. Waechter* s.n. (HAS 82516); Santa Cruz do Sul, 15/II/1985, *J. L. Waechter 2083* (ICN); Tenente Portela, 12/I/1977, *J. Mattos & N. Mattos* s.n. (HAS 82515); Torres, 18/I/1979, *J. L. Waechter 1174* (ICN).

CONSIDERAÇÕES FINAIS

Considerando os dados encontrados na literatura, este trabalho ampliou consideravelmente o conhecimento sobre a composição, distribuição e ameaça das espécies de orquídeas terrestres florestais do Rio Grande do Sul. O grupo ainda possui poucos trabalhos com abordagem ecológica e taxonômica.

A determinação de grande parte das espécies nativas de orquídeas terrícolas pode ser feita somente quando estão com flores. Porém, para os gêneros com os maiores números de espécies, *Aspidogyne* e *Cyclopogon*, a determinação das espécies mesmo com flores é complicada. Estes gêneros ainda possuem poucos estudos no estado e no Brasil, e, possivelmente, por este fato encontramos muitas determinações equivocadas nos herbários.

O elevado número de espécies ameaçadas alerta para que medidas de conservação sejam implementadas. A presença de espécies restritas a poucos ambientes, sobretudo florestas primárias, e também a ampla distribuição de espécies com algum nível crítico de ameaçada ressaltam a importância de estabelecer áreas de proteção ambiental que contemplem os diferentes tipos de florestas do Rio Grande do Sul.

Ainda são necessários estudos de ecologia de populações para confirmar os níveis de ameaça das espécies citadas neste trabalho. Os principais fatores que contribuem para a extinção das orquídeas precisam ser avaliados. No caso dos javalis exóticos, estratégias para conter a expansão destes animais devem ser tomadas.

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