Acta Scientiarum

http://periodicos.uem.br/ojs
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v44i1.62064

Vascular flora of Southern Brazilian outcrops associated with Atlantic Forest: small relict environment that needs to be preserved

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ABSTRACT. The rocky outcrops in the municipality of Campo Mourão (Paraná State) are all surrounded by remaining Atlantic Forest, unlike the typical outcrops associated with river courses, fields, or hilltops. Because it is such specific vegetation, it is essential to record the floristic composition, verifying only species and the conservation status of local populations. This study cataloged the species of vascular plants occurring in four rocky outcrops areas of Campo Mourão: Nishida outcrop (1,808 ha); Bica do Rio do Campo outcrop (0.458 ha); Perdoncini outcrop (0.228 ha), and Lago Azul State Park outcrop (0.021 ha). A total of 203 collections were analyzed, representing 152 species (eight exotic to Brazil), distributed in 66 families and 135 genera. The more richness families were Poaceae, Asteraceae, Fabaceae, Rubiaceae, and Bromeliaceae. The predominant life form was herbs and shrubs, and most species are terrestrial and rupicolous. The rocky outcrops of Campo Mourão, despite the small total area (25,150 m^2), have 10 % of the exclusive species in the municipality. Also, 14 species are endemic in Brazil, and two are endemic in Paraná, being *Portulaca hatschbachii* (Portulacaceae) officially threatened to extinction in Brazil. In these areas, several species found have been little collected in Paraná State and Brazil, in addition to the presence of life forms adapted to survival on the exposed rock. This demonstrates that despite being small, these sites are critical environments for preserving biodiversity in the region.

Keywords: Campo Mourão; Cerrado; threatened species; floristics; conservation.

Received on January 10, 2022.
Accepted on May 27, 2022.

Introduction

Since the end of the Last Great Glacier, about 18,000 years ago, there have been climatic fluctuations with drier and colder periods, which determined for the southern region of Brazil the predominance of grassland vegetation and, currently, there is a tendency for expansion forestry due to a progressively warmer and more humid climate (Bigarella, 1964). Thus, in some areas, plant typologies remain as relics of a climatic past, such as the Cerrado and the vegetation that occurs over rocky environments (Maack, 2007). An example of these areas is found in the Campo Mourão region, which represents an area of climatic transition, where the Mixed Ombrophilous Forest and the Seasonal Semideciduous Forest and also small relict enclaves of Savana (Cerrado) are in contact (Maack, 2017; Roderjan, Kuniyoshi, & Hatschbach, 2002; Hatschbach et al., 2005), which makes the region potentially rich in plant biodiversity, as well as a refuge for many endangered species (Tomadon, Dettke, Caxambu, Ferreira, & Couto, 2019).

Until the end of the 19th century, around 83 % of the territory of Paraná State was forest (Maack, 2017). In less than a century of colonization, the state has lost diversity quite sharply (Maack, 2017; Oliveira & Cunha, 2017; Vannini & Kummer, 2018; Borinelli, Matos, Godoy, & Capelari, 2020; Rompatto, 2020), and currently, 29.3 % (5.8 million ha) of natural forest cover remains in Paraná State, and only about 4 % are protected in Conservation Units (Brazilian Forest Service, 2018).

The Campo Mourão region is located in northwestern of Paraná State. This region has suffered significant biodiversity losses due to the intense process of forest fragmentation caused by urban and agro-industrial development (Ferreira, Bragion, Ferreira, Benedito, & Couto, 2019). For the Mourão River Basin, in the part

where the municipality is located, more than 97 % of the fragments (out of a total of 4,000) have less than 50 ha, being areas with low capacity to support biodiversity (Tomadon et al., 2019). However, several of these fragments have high floristic diversity, such as relict areas of the Cerrado and rocky outcrops, as well as the presence of many endangered species (Tomadon et al., 2019).

Rocky outcrops occur in the region in a very particular way, and are not directly associated with river courses; they are surrounded by Atlantic Forest remnants (mixing the Seasonal Semideciduous Forest and the Mixed Ombrophilous Forest), different from the outcrops that typically occur associated with the Campos and Cerrado areas of southern and eastern Paraná (ex., municipality of Palmas, Guarapuava, Tibagi, Jaguariaíva) or outcrops on tops of hills, already at high altitudes (e.g., municipality of Ortigueira, Sapopema, Morretes). In southern Brazil, outcrops surrounded by forests are reported on the interior of *Parque Estadual do Turvo*, in Rio Grande do Sul State, near the border with Argentina under the domain of the Deciduous Seasonal Forest (Brack et al., 1985) and on the municipality of Turvo (Paraná State), under the domain of the Ombrophilous Mixed Forest (M.G. Caxambu, personal communication). In Campo Mourão, although they are very small outcrops (less than 2 ha), they are still somehow preserved due to the shallower soils, preventing the mechanization of agriculture. However, the surrounding forests are already suppressed, significantly altered, or restricted to narrow strips (about 30 m wide), especially by monocultures (soybeans, corn, and wheat), or by the presence of rock extraction activities in quarries in the surroundings.

Therefore, studies on the flora of these areas are fundamental in order to verify the existence of exclusive species in these outcrops, and to assess the current conservation status of these populations. So, the research answers the following questions: I) What is the richness and composition of the flora located on the rocky outcrops in the municipality of Campo Mourão? II) What are the life forms, substrates uses and species adaptation to occupy such outcrops? III) Are there endemic, endangered, or rare species of Brazil in these sites? IV) Does the flora on the outcrops represent a subset of the surrounding vegetation (Seasonal/Ombrophilous Forest and Cerrado) or is it a unique grouping?

Material and methods

Study site

Campo Mourão is located in the Third Plateau of Paraná, in the central-western region of the state and is part of the so-called Plateau of Campo Mourão, characterized by being the watershed of the Ivaí and Piquirí rivers, between the coordinates 24°17‟57” to 23°57'08"S and 52°10'59" to 52°32'47"W. The predominant forms are flat tops, straight and concave slopes at the base, and valleys modeled on the Serra Geral Formation (Minerais do Paraná [MINEROPAR], 2006).

The proximity of Campo Mourão to the tropic of Capricorn provides climatic conditions influenced both by the continental tropical climate and the temperate climate, being considered, therefore, a region of climate transition (Borsato & Massoquim, 2019). The climate of the municipality of Campo Mourão is classified as Cfa in the Köppen–Geiger climate classification system, a humid subtropical mesothermal climate. The average annual temperature ranges from 19ºC to 23ºC, with more than 22ºC in the warmer months and less than 19ºC in the coldest months. Annual precipitation varies between 1,400 to 2,000 mm, and the relative humidity of the air has a yearly average of 70 to 75 %, and there is no water deficit (Nitsche, Caramori, Ricce, & Pinto, 2019).

The predominant soil in the municipality is the deep clayey Oxisol, characterized as of low fertility due to its high levels of iron. However, other soil units may also occur, such as Litholic Neossolos and Argisols (Santos et al., 2018). In the outcrops, the soils observed are derived from basalt rocks, with the presence of mature soil (Oxisol), an intermediate soil (Cambisol), and young soils (Neosol), in addition to the presence of massive basalt outcrops.

This study was carried out in four areas of rocky outcrops found in the municipality of Campo Mourão (Figure 1).

1) Nishida outcrop (Figures 1A-C): It is a private property located on the south of the old fishing lake called Nishida, at coordinates 24°01’59”S and 52°20’49”W. It has an area of approximately 1,808 ha (571 m long in the east-west direction and 333 m wide in the north-south direction), surrounded by forest remnants where the Semideciduous Seasonal Forest interpenetrates the Mixed Ombrophilous Forest, being close to soybean and corn crops and the urban area. The area presents a slope variation from 6º to 18º.

2) Bica do Rio do Campo outcrop (Figures 1D-F): it is a private property located on the left bank of the Rio do Campo, between the coordinates 24°02'09"S and 52°21'26"W. The estimated area is 0.458 ha (314 m long in the east-west direction and 68 m wide in the north-south direction) and is also surrounded by Semideciduous Seasonal Forest and elements of the Mixed Ombrophilous Forest. It is close to the dam and waterfall from the Rio do Campo, urban areas, rural roads and deactivated quarries. The entire area of the outcrop is concentrated on a slope that varies from 6º to 18º (highest point 556 m asl, lowest point 540 m asl) reaching the edge of the dam.

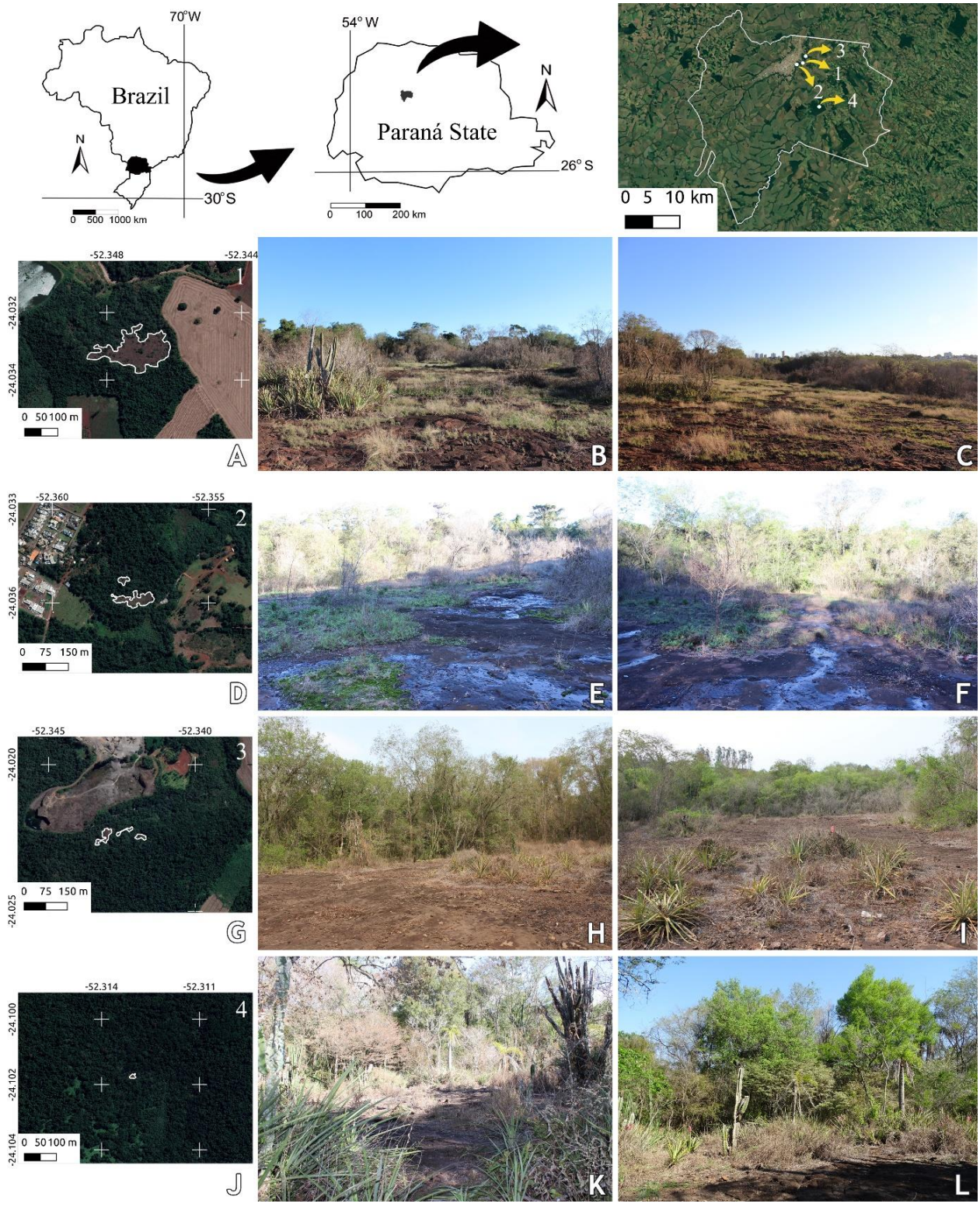

Figure 1. Location of rocky outcrop areas in Campo Mourão, Paraná, Brazil. 1) Nishida outcrop (A-C); 2) Bica do Rio do Campo outcrop (D-F); 3) Perdoncini outcrop (G-I); and 4) Parque Estadual Lago Azul outcrop (J-L). B,C,E,F,H,I,K: T. Monteiro-Ré, L: B.K. Canestraro.

3) Perdoncini outcrop (Figures 1G-I): It is a private property located on the right of the ruins of an old hydroelectric power station that was built in the 1950s, at coordinates 24°01'21"S and 52°20'30.4"W. It presents a total area of 0.228 ha (372 m long in the east-west direction and 56 m wide in the north-south direction), inserted in the interior of a forest, where there is a presence of Seasonal Semideciduous Forest with the Mixed Ombrophilous Forest. It is surrounded by soybean and corn crops and an active quarry on the north side. The total area is located on a flat terrain (536 m asl) with a 12º slope.

4) Parque Estadual Lago Azul outcrop (Figures 1J-L): it is the only area within a Conservation Unit (Lago Azul State Park), located at coordinates 24°06'06"S and 52°18'47"W. It presents an approximate area of 0.021 ha (22 m long in the east-west direction and 15 m wide in the north-south direction). This outcrop is an enclave inside the forest formed by a transition zone between the Seasonal Semideciduous Forest (predominant) and the Mixed Ombrophilous Forest. The total area is located on a flat terrain (601 m s.n.m.) with a slope between 0 and 3º.

Data collection

For the analysis of the floristic composition, the database of the SpeciesLink network (Reference Center for Environmental Information [CRIA], 2021) was consulted, which gathers collections deposited in several national and international herbaria, as well as data from groups carried out between 2009 and 2020, deposited in the collection of the Herbarium of the *Universidade Tecnológica Federal do Paraná*, Campo Mourão campus (acronym HCF). Identifications for all collections found were confirmed or made for the first time. The classification of angiosperm families followed Angiosperm Phylogeny Group (Angiosperm Phylogeny Group IV [APG IV], 2016) and for ferns it followed the Pteridophyte Phylogeny Group (Pteridophyte Phylogeny Group I [PPG I], 2016). The specific epithets and names of plant authors have been checked in REFLORA (2022) and the International Plant Name Index (IPNI, 2021).

The classification of the species regarding life forms and use of substrate was carried out based on observations of populations at the sites, information recorded on collection labels, and information about each species in REFLORA (2022).

According to the origin, species were also classified as native of Brazil or exotic (cultivated or naturalized). Native species were classified concerning endemism in Brazil and in Paraná State, using available data on incidence in Kaehler et al. (2014) and REFLORA (2022). For data on the threat of extinction in Brazil, we use the Official National List of Endangered Species of Flora by the Ministry of Environment (Brasil, 2014).

For the distribution in different vegetation types and Brazilian phytogeographic domains, we consult the REFLORA (2022). For the analysis of the local flora shared between the rocky outcrops and the surrounding vegetation (forest and Savanna (Cerrado)), we use a list elaborated for the entire municipality of Campo Mourão (T. Monteiro-Ré, unpublished data).

Results

For the vegetation of rocky outcrops in the municipality of Campo Mourão, 203 collections were analyzed, representing 152 species of vascular plants, distributed in 66 families and 135 genera (Table 1). Of these, only eight species are exotic naturalized. Figures 1 to 4 show some environments of these rock outcrops and some species.

Table 1. Species of vascular plants in rocky outcrops of Campo Mourão, Paraná, Brazil, indicate this municipality's study sites, life forms, substrate uses, voucher, and occurrence sites. Study sites: Ni – Nishida outcrop; Bi – Bica do Rio do Campo outcrop; Pa – Parque Estadual do Lago Azul outcrop; Pd – Perdoncini outcrop. Substrates uses: A – Aquatic, E – Epiphytic, R – Rupicolous, T – Terrestrial. Occurrence in Campo Mourão: FOR – Forests environments, OUT – Outcrops, SAV – Savanna (Cerrado) environments. # – exotic, naturalized species, * – endemic species in Brazil, ** – endemic species in Paraná State.

Families/Species	Study sites				Life forms	Substrate uses	Voucher (HCF)	Occurrence in Campo Mourão
	Ni	Bi	Pa	Pd				
Ferns								
Anemiaceae								
Anemia raddiana Link			x		Herb	T	4780	OUT
Anemia tomentosa (Sav.) Sw.	x	x		x	Herb	R, T	8135	FOR, OUT, SAV
Blechnaceae								
Neoblechnum brasiliense (Desv.) Gasper & V.A.O. Dittrich			x		Herb	T	4709	FOR, OUT
Lomariopsidaceae								
Nephrolepis exaltata (L.) Schott			x		Herb	R, T	4772	FOR, OUT
Ophioglossaceae								
Ophioglossum nudicaule L.f.			x		Herb	T	26428	OUT

Polypodiaceae								
Microgramma lindbergii (Mett.) de la Sota	x				Herb	E	8621	FOR, OUT
Pteridaceae								
Adiantopsis perfasciculata Sehnen *			x		Herb	T	4819	OUT
Cheilanthes micropteris Sw.	x	x			Herb	R	8140	FOR, OUT
Doryopteris concolor (Langsd. & Fisch.) Kuhn & Decken	x				Herb	R, T	8620	FOR, OUT
Doryopteris patula (Fée) Fée			x	x	Herb	R, T	4781	FOR, OUT
Doryopteris pentagona Pic. Serm.			x		Herb	R, T	4742	FOR, OUT
Thelypteridaceae								
Christella dentata (Forssk.) Brownsey & Jermy			x		Herb	R, T	4891	FOR, OUT
Angiosperms								
Acanthaceae								
Ruellia angustiflora (Nees) Lindau ex Rambo	x		x		Shrub	T	9092	FOR, OUT
Amaranthaceae								
Hebanthe erianthos (Poir.) Pedersen	x				Shrub, Subshrub	T	9087	FOR, OUT
Pfaffia glabrata Mart.			x		Herb, Subshrub	T	5047	OUT
Amaryllidaceae								
Nothoscordum bonariense (Pers.) Beauverd	x	x			Herb	R, T	8148	FOR, OUT
Anacardiaceae								
Schinus terebinthifolia Raddi			x		Shrub, Tree	T	4727	FOR, OUT
Apocynaceae								
Oxypetalum appendiculatum Mart.			x		Climber	T	4714	FOR, OUT, SAV
Araliaceae								
Hydrocotyle callicephala Cham & Schltdl.	x				Herb	T	8625	FOR, OUT
Hydrocotyle leucocephala Cham. & Schltdl.	x				Herb	T	5674	FOR, OUT
Arecaceae								
Syagrus romanzoffiana (Cham.) Glassman			x		Tree	T	4795	FOR, OUT
Asparagaceae								
Cordyline spectabilis Kunth & Bouché	x		x		Tree	T	3288	FOR, OUT
Herreria salsaparilha Mart. *	x				Climber	T	9348	OUT
Asteraceae								
Chrysolaena platensis (Spreng.) H.Rob.			x		Subshrub	T	4751	FOR, OUT, SAV
Eclipta prostrata (L.) L.			x		Herb	A, T	5239	FOR, OUT
Erechtites valerianifolius (Link ex Spreng.) DC.			x		Herb	T	4739	FOR, OUT
Gamochaeta purpurea (L.) Cabrera	x				Herb	T	8138	FOR, OUT
Mikania hemisphaerica Sch.Bip. ex Baker	x				Climber	T	9088	FOR, OUT
Moquiniastrum polymorphum (Less.) G. Sancho			x		Shrub, Tree	T	4724	FOR, OUT, SAV
Praxelis clematidea (Griseb.) R.M.King & H.Rob.	x				Herb	T	8602	FOR, OUT
Praxelis kleinioides (Kunth) Sch. Bip.	x	x			Herb	T	8609	FOR, OUT
Praxelis missiona (Malme) R.M.King & H.Rob.	x				Herb	T	8137	OUT
Wedelia kerrii N.E.Br.	x				Shrub	T	8600	FOR, OUT, SAV
Basellaceae								
Anredera cordifolia (Ten.) Steenis	x				Climber	T	8623	FOR, OUT
Begoniaceae								
Begonia cucullata Willd.	x		x		Herb	T	3283	FOR, OUT
Bignoniaceae								
Cuspidaria pulchella (Cham.) K.Schum. *	x				Climber	T	429165 (MBM)	FOR, OUT, SAV
Fridericia chica (Bonpl.) L.G.Lohmann	x				Climber	T	9114	FOR, OUT
Boraginaceae								
Cordia americana (L.) Gottschling & J.S.Mill.			x		Tree	T	7148	FOR, OUT
Cordia trichotoma (Vell.) Arráb. ex Steud.			x		Tree	T	5003	FOR, OUT
Varronia polycephala Lam.			x		Shrub, Subshrub	T	4728	FOR, OUT
Bromeliaceae								
Aechmea distichantha Lem. *			x		Herb	E, R, T	5481	FOR, OUT
Bromelia balansae Mez	x	x	x		Herb	R, T	6646	FOR, OUT
Dyckia leptostachya Baker	x				Herb	R, T	9330	OUT, SAV
Tillandsia loliacea Mart. ex Schult. & Schult.f.			x		Herb	E, R	7303	FOR, OUT
Tillandsia pohliana Mez	x				Herb	E, R	15650	FOR, OUT
Tillandsia tenuifolia L.	x				Herb	E, R	8147	FOR, OUT
Cactaceae								
Cereus hildmannianus K.Schum.	x		x		Shrub, Tree	R, T	9331	FOR, OUT
Parodia carambeiensis Buining & Brederoo *,**	x				Herb	R	15831	OUT
Cannabaceae								
Celtis spinosissima (Weed.) Miq.	x				Shrub, Climber	T	8626	FOR, OUT
Caryophyllaceae								
Cerastium rivulare Cambess. #			x		Herb	T	6917	FOR, OUT

Combretaceae						
Combretum fruticosum (Loefl.) Stuntz		x	Shrub, Climber	T	4730	FOR, OUT
Terminalia australis Cambess.	x		Shrub, Tree	T	9085	FOR, OUT
Commelinaceae						
Commelina erecta L.	x		Herb	R, T	8139	FOR, OUT
Dichorisandra paranaensis D.Maia et al. *		x	Herb	T	4792	FOR, OUT
Tripogandra diuretica (Mart.) Handlos		x	Herb	A, R, T	5232	FOR, OUT
Convolvulaceae						
Evolvulus filipes Mart.	x		Herb	R, T	8611	OUT
Crassulaceae						
Kalanchoe pinnata (Lam.) Pers. #		x	Herb	R, T	5678	FOR, OUT
Cyperaceae						
Bulbostylis capillaris (L.) C.B.Clarke	x		Herb	R, T	8136	OUT, SAV
Carex brasiliensis A.St.-Hil.		x	Herb	T	4446	FOR, OUT
Cyperus sesquiflorus (Torr.) Mattf. & Kük.	x		Herb	T	9329	FOR, OUT
Fimbristylis dichotoma (L.) Vahl *	x		Herb	R, T	8601	FOR, OUT
Dioscoreaceae						
Dioscorea campestris Griseb.	x		Climber	R, T	8606	OUT
Dioscorea polygonoides Humb. & Bonpl. ex Willd.	x	x	Climber	T	5031	FOR, OUT
Erythroxylaceae						
Erythroxylum cuneifolium (Mart.) O.E.Schulz	x		Shrub	R, T	8142	FOR, OUT, SAV
Euphorbiaceae						
Gymnanthes klotzschiana Müll.Arg.	x	x	Shrub, Tree	T	4876	FOR, OUT
Manihot grahamii Hook. *	x	x	Shrub, Tree	T	4818	FOR, OUT
Fabaceae						
Ancistrotropis peduncularis (Kunth) A. Delgado	x		Climber	T	14097	OUT, SAV
Calliandra foliolosa Benth.	x	x	Shrub, Tree	T	5715	FOR, OUT
Calliandra tweedii Benth.	x		Shrub, Tree	T	8146	FOR, OUT, SAV
Desmodium incanum (Sw.) DC. #		x	Subshrub	T	4725	FOR, OUT, SAV
Mimosa paupera Benth.	x		Herb	R, T	9328	OUT
Mimosa pilulifera Benth.		x	Shrub, Tree	T	5662	FOR, OUT
Mimosa polycarpa Kunth	x		Shrub, Subshrub	R, T	8610	OUT
Senegalia velutina (DC.) Seigler & Ebinger	x		Climber	T	8616	FOR, OUT
Vachellia farnesiana (L.) Wight & Arn.	x		Shrub	T	3734	OUT
Gesneriaceae						
Sinningia aggregata (Ker Gawl.) Wiehler	x		Herb	R	8143	OUT
Sinningia sellovii (Mart.) Wiehler	x	x	Herb	R	3282	FOR, OUT, SAV
Hypoxidaceae						
Hypoxis decumbens L.	x		Herb	T	9327	FOR, OUT
Iridaceae						
Iris domestica (L.) Goldblatt & Mabb. #		x	Herb	T	5231	FOR, OUT
Sisyrinchium micranthum Cav.	x		Herb	T	8154	FOR, OUT
Trimezia spathata (Klatt) Baker	x		Herb	T	3284	FOR, OUT, SAV
Lamiaceae						
Cantinoa mutabilis (Rich.) Harley & J.F.B.Pastore	x		Shrub, Tree, Subshrub	T	8607	OUT
Condea elegans (Briq.) Harley & J.F.B.Pastore		x	Subshrub	T	4726	FOR, OUT
Liliaceae						
Lilium formosanum A. Wallace #		x	Herb	T	4745	FOR, OUT
Loganiaceae						
Strychnos brasiliensis (Spreng.) Mart.		x	Shrub, Tree, Climber	T	3968	FOR, OUT
Malpighiaceae						
Banisteriopsis muricata (Cav.) Cuatrec.	x		Climber	T	8614	FOR, OUT
Diplopterys pubipetala (A.Juss.) W.R.Anderson & C.C.Davis	x		Climber	T	8605	FOR, OUT
Heteropterys intermedia (A.Juss.) Griseb.		x	Climber	T	5370	FOR, OUT
Heteropterys syringifolia Griseb.	x		Shrub, Subshrub	T	9091	OUT
Janusia guaranitica (A.St.-Hil.) A.Juss.	x		Climber	T	387671 (MBM)	OUT, SAV
Malvaceae						
Helicteres brevispira A.St.-Hil.		x	Shrub, Tree	T	4788	FOR, OUT
Luehea divaricata Mart.	x	x	Tree	T	4006	FOR, OUT
Melochia chamaedrys A.St.-Hil.	x		Herb, Subshrub	T	3286	FOR, OUT
Pavonia guerkeana R.E.Fr.	x		Shrub	T	15800	FOR, OUT, SAV
Pavonia hastata Cav.		x	Shrub, Subshrub	T	4702	FOR, OUT, SAV
Marantaceae						

Maranta sobolifera L. Andersson			x		Herb	T	4820	FOR, OUT
Melastomataceae								
Leandra xanthocoma (Naudin) Cogn. *			x		Shrub	T	4770	FOR, OUT
Miconia pusilliflora (DC.) Naudin	x				Shrub, Tree	T	3735	FOR, OUT
Meliaceae								
Trichilia elegans A.Juss. *			x		Shrub, Tree	T	56	FOR, OUT
Myrtaceae								
Eugenia uniflora L.	x		x		Shrub, Tree	T	5852	FOR, OUT, SAV
Myrcia selloi (Spreng.) N.Silveira	x				Shrub, Tree	T	8144	FOR, OUT, SAV
Orchidaceae								
Campylocentrum grisebachii Cogn.		x			Herb	E	4184	FOR, OUT
Capanemia micromera Barb.Rodr.	x				Herb	E	9084	FOR, OUT
Oxalidaceae								
Oxalis triangularis A.St.-Hil.	x	x	x		Herb	R, T	8145	FOR, OUT
Passifloraceae								
Passiflora eichleriana Mast.			x		Climber	T	5204	OUT
Phyllanthaceae								
Phyllanthus niruri L.			x		Herb, Subshrub	T	4816	FOR, OUT
Piperaceae								
Piper fuligineum Kunth			x		Shrub	T	5238	FOR, OUT
Plantaginaceae								
Mecardonia procumbens (Mill.) Small	x				Herb	R, T	4398	FOR, OUT
Stemodia verticillata (Mill.) Hassl.	x		x		Herb	T	8153	FOR, OUT
Poaceae								
Amphibromus quadridentulus (Döll) Swallen		x			Herb	T	4475	OUT
Chloris elata Desv.			x		Herb	T	10429	OUT, SAV
Eustachys distichophylla (Lag.) Nees			x		Herb	T	4735	FOR, OUT
Hildaea pallens (Sw.) C.Silva & R.P.Oliveira			x		Herb	T	4822	FOR, OUT, SAV
Melinis minutiflora P.Beauv. [#]			x		Herb	T	5453	FOR, OUT, SAV
Melinis repens (Willd.) Zizka [#]			x		Herb	T	6616	FOR, OUT
Merostachys multiramea Hack.			x		Shrub	T	4777	FOR, OUT
Pseudechinolaena polystachya (Kunth) Stapf	x				Herb	T	8624	FOR, OUT
Saccharum villosum Steud.			x		Herb	T	4705	OUT
Schizachyrium microstachyum (Desv. ex Ham.) Roseng. et al.			x		Herb	T	4720	OUT
Setaria vulpiseta (Lam.) Roem. & Schult.	x		x		Herb	T	4805	FOR, OUT, SAV
Polygalaceae								
Acanthocladus brasiliensis (A.St.-Hil. & Moq.) Klotzsch ex Hassk. *	x				Shrub, Subshrub	T	9089	FOR, OUT, SAV
Portulacaceae								
Portulaca hatschbachii D.Legrand *, **	x	x	x	x	Herb	R, T	3285	FOR, OUT
Proteaceae								
Roupala montana Aubl.			x		Shrub, Tree	T	5722	FOR, OUT
Rosaceae								
Prunus myrtifolia (L.) Urb.	x				Tree	T	9096	FOR, OUT, SAV
Rubiaceae								
Borreria latifolia (Aubl.) K.Schum.	x				Herb, Subshrub	R, T	8603	FOR, OUT
Chomelia obtusa Cham. & Schltdl.			x		Shrub, Tree	T	4758	FOR, OUT
Cordiera concolor (Cham.) Kuntze	x		x		Shrub, Subshrub	R, T	6654	FOR, OUT, SAV
Geophila repens (L.) I.M.Johnst.	x				Herb	T	8618	FOR, OUT
Manettia cordifolia Mart.	x				Climber	T	8608	FOR, OUT, SAV
Mitracarpus hirtus (L.) DC.		x			Herb	T	2935	OUT
Palicourea mamillaris (Müll.Arg.) C.M.Taylor *			x		Shrub, Tree	T	4003	OUT
Psychotria carthagenensis Jacq. *	x				Shrub, Tree	T	9094	FOR, OUT
Rutaceae								
Citrus limonia Osbeck [#]			x		Tree	T	5727	FOR, OUT
Esenbeckia febrifuga (A.St.-Hil.) A. Juss. ex Mart.	x		x		Tree	T	110	FOR, OUT
Helietta apiculata Benth.	x				Tree	T	8613	FOR, OUT, SAV
Pilocarpus pennatifolius Lem.	x				Tree	T	8617	FOR, OUT
Zanthoxylum petiolare A.St.-Hil. & Tul.	x				Tree	T	9350	FOR, OUT
Salicaceae								
Banara tomentosa Clos	x				Shrub, Tree	T	8679	FOR, OUT
Casearia sylvestris Sw.	x				Shrub, Tree, Subshrub	T	9095	FOR, OUT, SAV
Sapindaceae								
Allophylus guaraniticus (A. St.-Hil.) Radlk.			x		Shrub, Tree	T	4761	FOR, OUT
Matayba elaeagnoides Radlk.			x		Shrub, Tree	T	5900	FOR, OUT, SAV
Paullinia rhomboidea Radlk. *			x		Climber	T	64	FOR, OUT

Serjania laruotteana Cambess. Sapotaceae	x			Climber	T	8678	FOR, OUT, SAV
Chrysophyllum marginatum (Hook. & Arn.) Radlk. Styracaceae	x			Shrub, Tree	T	15802	FOR, OUT, SAV
Styrax leprosus Hook. & Arn. Talinaceae			x	Tree	T	5905	FOR, OUT
Talinum paniculatum (Jacq.) Gaertn. Turneraceae	x		x	Herb	R, T	4804	FOR, OUT
Piriqueta cistoides (L.) Griseb. Urticaceae	x	x		Herb, Subshrub	R, T	8604	OUT
Urera baccifera (L.) Gaudich. ex Wedd. Verbenaceae			x	Shrub, Tree	T	4699	FOR, OUT
Aloysia virgata (Ruiz & Pav.) Juss.	x			Shrub, Tree	T	5732	FOR, OUT
Glandularia aristigera (S.Moore) Tronc.	x			Herb	R, T	8152	OUT
Glandularia tenera (Spreng.) Cabrera	x			Herb	R, T	399869 (MBM)	OUT
Lippia balansae Briq.	x			Shrub	T	8615	OUT, SAV

Figure 2. Rocky outcrops in Campo Mourão, Paraná, Brazil A-F: Nishida outcrop, G: Parque Estadual do Lago Azul outcrop, H: Perdoncini outcrop. A-H: T. Monteiro-Ré.

Figure 3. Plant species from rocky outcrops of Campo Mourão, Paraná, Brazil. A-D: *Parodia carambeiensis* Buining & Brederoo (Cactaceae), E-H: *Portulaca hatschbachii* D.Legrand (Portulacaceae). A-H: T. Monteiro-Ré.

The richest botanical families were: Poaceae (11 species), Asteraceae (10), Fabaceae (9), Rubiaceae (8), and Bromeliaceae (6). These five families join 29 % of the species confirmed for the outcrops. Fifty-five families have three species or less, representing 50 % of the species in these locations.

Life forms and substrate uses are summarized in Table 2. The predominant life forms in these areas were herbs, followed by shrubs, trees, climbing plants, and sub-shrubs. Among the species with an herbaceous habit, the most representative families were Poaceae (10 species), Asteraceae (6 species), Bromeliaceae (6 species), Pteridaceae (5 species) and Cyperaceae (4 species), which together represent 41 % of the species with this life form. With shrubby and arboreal habits, the families Fabaceae (5 species), Rutaceae (5 species), Malvaceae (4 species), and Rubiaceae (4 species) were the richest (Table 1). About a quarter of the outcrop species had variable life forms, especially shrub/tree.

Regarding substrate uses, most species are terrestrial, followed by rupicolous, epiphytes and aquatic; and 22 % of the species showed variable substrate uses, most of them terrestrial/rupiculous (Table 1, 2).

Figure 4. Plant species from rocky outcrops of Campo Mourão, Paraná, Brazil. A: *Nothoscordon bonariense* (Pers.) Beauverd (Amaryllidaceae), B: *Praxelis missiona* (Malme) R.M.King & H.Rob. (Asteraceae), C-D: *Aechmea distichantha* Lem. (Bromeliaceae), E-F: *Dyckia leptostachya* Baker (Bromeliaceae), G: *Evolvulus filipes* Mart. (Convolvulaceae), H-I: *Sinningia sellowii* (Mart.) Wiehler (Gesneriaceae), J-K: *Sisyrinchium micranthum* Cav. (Iridaceae), L. *Ophioglossum nudicaule* L.f. (Ophioglossaceae), M: *Glandularia aristigera* (S.Moore) Tronc. (Verbenaceae). A-K, M: T. Monteiro-Ré, L: B.K. Canestraro.

Table 2. Summary of life forms and substrate uses of vascular flora in rocky outcrops of Campo Mourão, Paraná, Brazil.

Life Forms	Number of species	%
Herb	74	49
Shrub	45	29
Tree	39	25
Climber	21	14
Subshrub	17	11
Variable	41	27
Substrate uses		
Terrestrial	142	93
Rupicolous	37	24
Epiphytic	7	5
Aquatic	2	1
Variable	34	22

Among the native species, 14 are endemic to Brazil, and two are endemic to Paraná. Only one species is officially threatened with extinction in Brazil, in the Endangered category, *Portulaca hatschbachii* D. Legrand (Portulacaceae).

When comparing the occurrences of the species in the outcrops with the occurrences of the species in other areas of the municipality of Campo Mourão, we found that 24 species have records of occurrence only in the areas of rocky outcrops in the city. The remaining 128 species also appear in other areas, such as the Seasonal/Ombrophilous Mixed Forest (122 species) and Savanna (Cerrado) (33 species).

The distribution of species recorded in the Campo Mourão outcrops in the Brazilian phytogeographic domains is shown in Figure 5, with the most representative domains being the Atlantic Rainforest (94 % of species) and Central Brazilian Savanna (Cerrado) (75 %). Around 40 % of species (62) are common species in Brazil and appear in four or more phytogeographic domains, 24 % of species (36) appear in three domains, 25 % appear in two domains, and only 10 % in only one domain (majority in the Atlantic Forest).

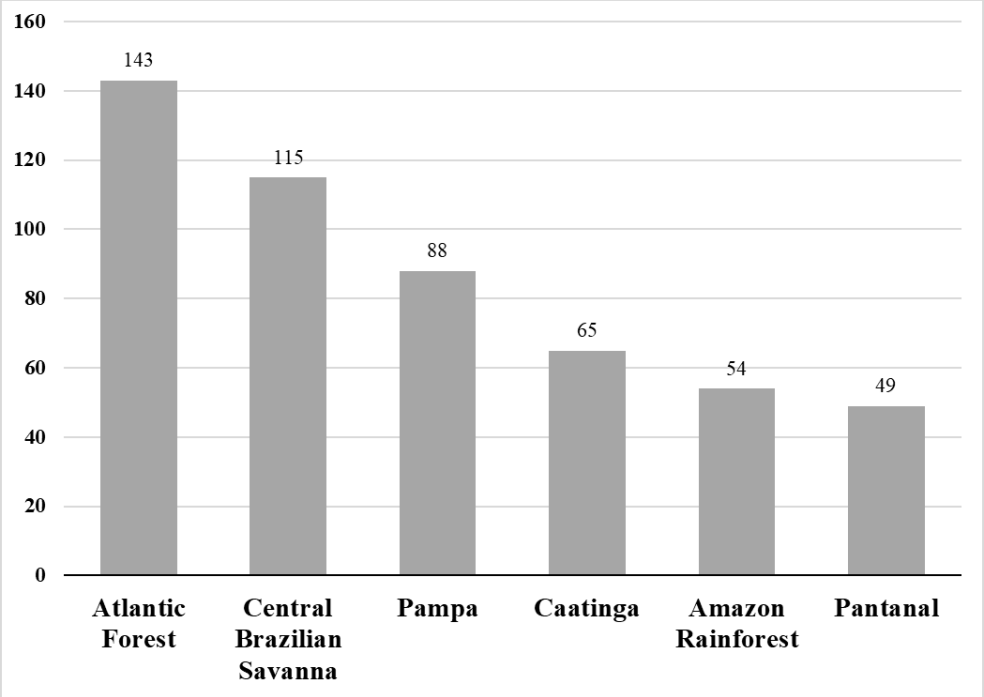

Figure 5. Species of vascular flora in rocky outcrops of Campo Mourão, Paraná, Brazil, distributed in the Brazilian phytogeographic domains that occur.

Considering the Brazilian vegetation types, the species from the Campo Mourão outcrops are distributed as in Figure 6, with most of them being registered on the Tropical Rain Forest (59 %), Savanna (Cerrado) (56 %), Seasonally Semideciduous Forest (50 %), Anthropic areas (45 %), Gallery Forest (43 %) and Mixed Ombrophyllous Forest (33 %).

Discussion

The rocky outcrops of Campo Mourão occupy a small area of 25,150 m² altogether, which represents only 0.0034 % of the municipality's area. In these locations 144 native species of vascular flora were sampled, that is 10% of the flora was recorded for the city (1,456 species according to T. Monteiro-Ré unpublished data). Considering the number of families, these areas concentrate around 40% of the families registered in Campo Mourão. This data shows that these places are critical environments for biodiversity preservation in the region.

The vegetation surrounding the rocky outcrops of Campo Mourão is covered by remnants of the Semideciduous Seasonal Forest and the Mixed Ombrophilous Forest with *Araucaria angustifolia* (Bertol.) Kuntze. The outcrop areas have well-defined limits due to the depth of the soil and the absence of shading since the plants that is found there are predominantly helophytes. The current vegetation configuration, including that found in these rock outcrops and shallow soils, is a consequence of climatic fluctuations since the Last Glacial Maximum, involving the Pleistocene and the Holocene, a hypothesis listed by Bigarella (1964).

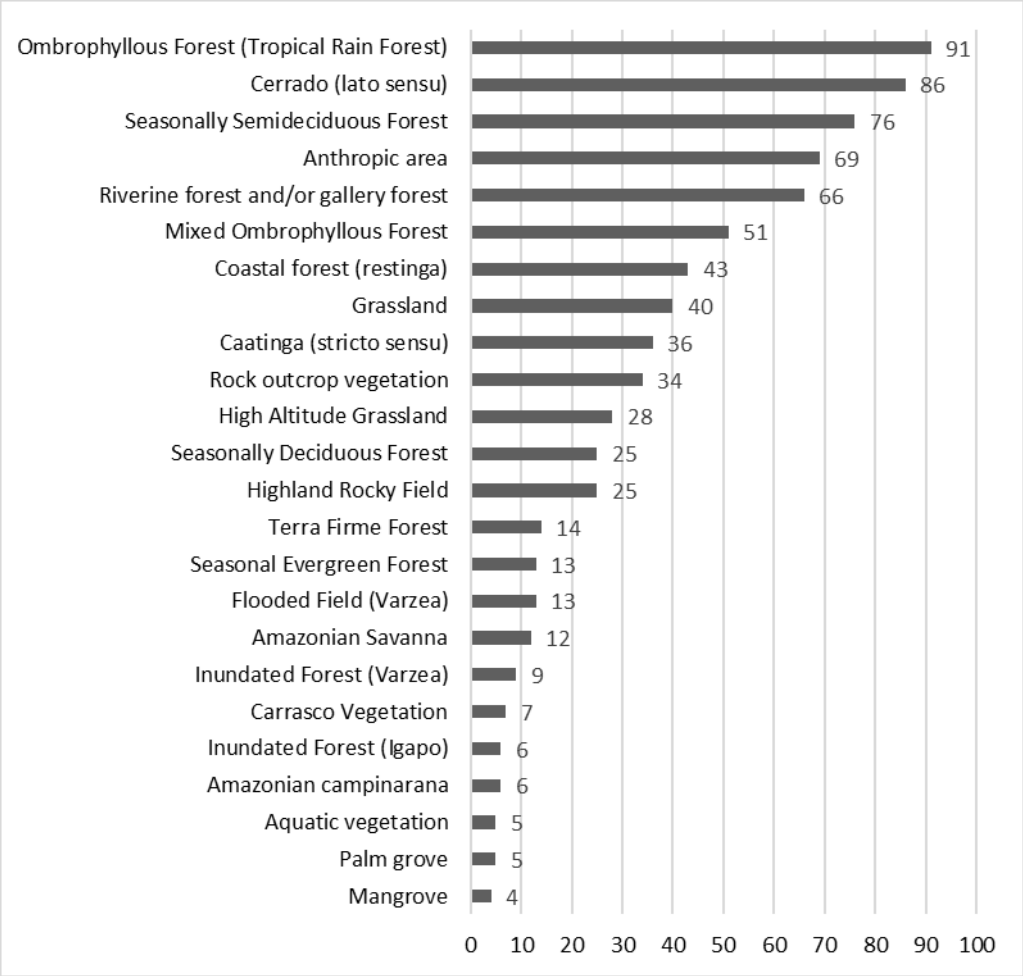

Figure 6. Species of vascular flora in rocky outcrops of Campo Mourão, Paraná, Brazil, distributed in the vegetation types that occur.

Considering that most of the outcrops sampled are close to the urban area, a more significant number of exotic species would be expected, however, these represent only 5 % of the species recorded. It is likely that the exposed rock conditions are limiting the colonization of exotic species in these sites. *Citrus limonia* Osbeck (Rutaceae), *Iris domestica* (L.) Goldblatt & Mabb. (Iridaceae) and *Kalanchoe pinnata* (Lam.) Pers. (Crassulaceae) are considered invasive plants in the state of Paraná (Instituto Ambiental do Paraná [IAP], 2015) (IAP Ordinance No. 059 of APRIL 15, 2015). Still, they are not in a situation of invasion in the outcrop areas, with few individuals in the regions visited.

In the outcrops of Campo Mourão, there is a predominance of herbaceous and shrubby vegetation (Figure 2), as the substrate conditions favor the establishment of these species, where the more delicate roots enter small rock cracks promoting the removal of nutrients.

Rupicolous (or epilithic) plants grow directly on loose rock, often succulents or xerophytes (Porembski, 2007). To survive the inhospitable conditions of rock outcrops, plant species must develop morphological adaptations, mainly to acquire the ability to colonize exposed rock sites, without soil substrate for root expansion (which provides fixation, stability, nutrients and water assimilation), in addition, to adapt to substrates with a wide range of temperature variation (Silva, Secco, & Lobo, 1996; Santos et al., 2018; Conceição, Giulietti, & Meirelles, 2007; Oliveira & Godoy, 2007). Thus, a part of the classified vegetation is part of a group well adapted to the conditions of the outcrops environments, some of them with a xeromorphic appearance, such as Cactaceae and Bromeliaceae species, seed bank-forming species such as the Asteraceae, and other species with subterranean parts, such as Gesneriaceae and Iridaceae ones. According to Cervi, von Linsingen, Hatschbach, and Ribas (2007), under such conditions, the vegetation has to be adapted to the particular microclimate, being prone to develop endemisms.

Among the Cactaceae, we have *Cereus hildmannianus* K.Schum. (Figures 2C, G) and *Parodia carambeiensis* Buining & Brederoo (Figures 2E, 3A-D), which are generally rupicolous or terrestrial cacti. Cacti can occupy different arid and semiarid environments and use survival strategies such as the transformation of leaves into

thorns, rapid water absorption by the roots, and CAM photosynthesis (Crassulacean acid metabolism), in addition to high storage and retention capacity of water in their tissues (Gibson & Nobel, 1986, Terrazas & Mauseth, 2002). These plants have epidermal tissue with a thick cuticle and develop a large proportion of parenchymal tissues with mucilaginous cells or cavities (Dettke & Milaneze-Gutierre, 2008a). *Cereus hildmannianus* is a columnar arborescent cactus with nocturnal anthesis and depends entirely on the pollination of Sphingidae moths. It is a species with wide geographic distribution in Brazil, and the optimum germination temperature is 25ºC (Becker, Dal Ri, Singer, & Singer, 2020). In Campo Mourão outcrops, several individuals are associated with the edge or nucleation regions of the Nishida outcrop, where the soil is already deeper. Parodia carambeiensis, on the other hand, is a globose cactus, endemic to Paraná, occurring in few locations in Campos Gerais and Savanna (Cerrado) in the state (Soller, Soffiatti, Calvente, & Goldenberg, 2014). In Campo Mourão, its distribution is punctual and restricted to the Nishida outcrop, where it was collected in 2008 and 2013 and currently forms dense populations, with less than a hundred individuals.

A similar mechanism of rapid water absorption, differentiated photosynthetic metabolism (CAM), and leaf succulence can also be found in Portulacaceae species, which has phylogenetic proximity of a sister-group to Cactaceae (APG IV, 2016). *Portulaca hatschbachii* (Figures 3E-H) are registered in the study areas, an endemic species in Paraná (Coelho & Giulietti, 2010), found preferentially in rural areas or rocky outcrops and considered endangered by extinction in Brazil (Brasil, 2014, Ordinance MMA No. 443/2014). According to Guimarães, Santos Filho, Barros and Maurenza (2013), this threat category is justified by the decline of the small area of occupation (less than 500 km2), by the extent of incidence of the species, and by the loss of habitat quality due to fragmentation and presence of monocultures. For the municipality of Campo Mourão, we have six collections of this species, all in the rocky outcrop areas, two of them were collected in 1962 by Gerdt G. Hatschbach and later by other collectors in 2005, 2008, 2009, and 2013. In this study, we visualized populations of *P. hatschbachii* in the four outcrop areas, and the Nishida outcrop concentrates the largest population, between 50-100 individuals, spread over the vegetation nuclei, and where it was possible to find blossoming individuals and young individuals as well. Progressively smaller populations were found in other sites, with a population of about 30 individuals in Bica do Rio do Campo outcrop, 10-20 individuals in the Perdoncini outcrop, and a more critical situation, in the Parque Estadual do Lago Azul outcrop where less than ten individuals were found, being evident only in the rainy periods.

In the Bromeliaceae species, we typically have *Aechmea distichantha* Lem (Figures 4C-D), *Bromelia balansae* Mez and *Dyckia leptostachya* Baker (Figures 4E-F) in outcrops, and some epiphyte species of *Tillandsia* are found in border regions of the surrounding forest vegetation. The principal adaptations for the ecological success of bromeliads are the arrangement of the leaves in rosettes for the formation of tanks that accumulate water, the presence of pelted trichomes for water absorption by the leaves, the succulence of the leaves, and the presence of storage organs (of water and starch) (Dettke & Milaneze-Gutierre, 2008b, Paula et al., 2015). The three species that inhabit the Campo Mourão outcrops have rhizomes or stolons, and succulent leaves, especially at the base, with spiny margins and covered with pelted trichomes. *Aechmea distichantha* and *B. balansae* also present a tank formation and convex or channeled leaves for water drainage. *Dyckia leptostachya* is found only in Nishida outcrop, as well as in the relict areas of the Savanna (Cerrado) in Campo Mourão.

The importance of rocky outcrop tank bromeliads in the process of vegetation succession is recognized, where they act as facilitators for the establishment of seedlings of shrub and tree species in the surrounding forest vegetation, playing a role in the nucleation of outcrops (Medina, Ribeiro, & Scarano, 2006; Rocha, Duarte, & Waechter, 2015; Paula et al., 2015). In the Nishida Outcrop, we observed *A. distichantha* and *B. balansae* in the nucleation areas and in the forest edge areas, associated with *Cereus hildmannianus* (Cactaceae) and some species of Myrtaceae (Figure 2C).

Among the Asteraceae species, in the outcrops we have some herbaceous species of open vegetation (such as grasslands and Savanna) that present pilose or tomentose leaves such as *Praxelis kleinioides* (Kunth) Sch. Beep. and *Praxelis missiona* (Malme) R.M.King & H.Rob. (Figure 4B), or which, in addition to leaf hairiness, may contain subterranean resistance organs, such as the well-developed xylopods in *Chrysolaena platensis* (Spreng.) H.Rob.

These subterranean organs can also appear in tubercles in the Gesneriaceae species, *Sinningia aggregata* (Ker Gawl.) Wiehler and *Sinningia sellovii* (Mart.) Wiehler (Figures 4H-I) also have pubescent branches and leaves, and they are typical rupicolous species, on rupestrian fields or rock walls. In the study areas, *S. sellovii* it appears more frequently.

In species with shrub and arboreal habit, the Fabaceae, Rutaceae, Malvaceae, and Rubiaceae families account for almost a third of this form of life. Such families are typical in formations belonging to the Semideciduous Seasonal Forest (Maack, 2017; Roderjan et al., 2002; Ramos, Durigan, Franco, Siqueira, & Rodrigues, 2008), commonly found in the municipality of Campo Mourão and bordering the outcrops.

Among the species found in the outcrops, some others stand out due to the rarity of collections in the Paraná State. One of them is *Evolvulus filipes* Mart. (Convolvulaceae) (Figure 4G), which despite being the species distributed throughout Brazil (Simão-Bianchini & Silva, 2020), there was only one collection in the extinct Sete Quedas National Park (Hatschbach 13319, MBM) in an outcrop close to the falls. This species was considered possibly extinct in Paraná by Ferreira, Simão-Bianchini, and Miotto (2014). It has been recorded in this study for Nishida outcrop, with only one individual being visualized (Figure 4G). Also, *Herreria salsaparilla* Mart. (Asparagaceae) is a climbing species that occurs in Paraná (Smidt, 2014) with few collections in the northwest region (Paraná River basin) and the areas of Cianorte and Campo Mourão. In this municipality, it was found only in the Nishida outcrop and in the Parque Estadual do Lago Azul outcrop, associated with the forest edges We also have *Lippia balansae* Briq. (Verbenaceae), with few collections in Mato Grosso, Mato Grosso do Sul, and Paraná, where it is registered only in the municipality of Campo Mourão, in the relict areas of Savanna (Cerrado) and the Nishida Outcrop.

Finally, among the fern species, we find *Ophioglossum nudicaule* L.f. (Ophioglossaceae) (Figure 4L), with wide incidence in Brazil (Perestrello & Sylvestre, 2020), but with only a few records in Paraná, in the region of Curitiba and Campo Mourão, occurring exclusively in the Parque Estadual do Lago Azul outcrop, in small populations among the mosses where there is water accumulation.

Considering the distribution of species in the municipality, the flora on the rocky outcrops of Campo Mourão represents a subset of forest species that resist or are well adapted to the shallower soil conditions and solar exposure of these environments. Most species (84%) also occur in other areas of the municipality, in forest environments, especially Seasonal Semideciduous Forest, and of these, 27 species (18 %) appear together in forest and Savanna (Cerrado) environments. Only six species occur in common between the Cerrado and the outcrops: *Dyckia leptostachya* (Bromeliaceae), *Bulbostylis capillaris* (L.) C.B.Clarke (Cyperaceae), *Ancistrotropis peduncularis* (Kunth), A. Delgado (Fabaceae), *Janusia guaranitica* (A.St.-Hil.) A.Juss. (Malpighiaceae), *Chloris elata* Desv. (Poaceae) and *Lippia balansae* (Verbenaceae), and of these, only *Dyckia leptostachya* and *Lippia balansae* are species typically from the Brazilian Cerrado (REFLORA, 2022). It is shown that, although the relict areas of the Savanna (Cerrado) de Campo Mourão are close to the study areas (between 1.8-2.3 km) and with high floristic abundance (330 species according to T. Monteiro-Ré, unpublished data), the edaphic conditions of exposed rock act as limiting factors for the colonization of Savanna (Cerrado) species in the outcrops.

However, for the flora of the municipality, 24 species are unique in the outcrops: *Pfaffia glabrata* Mart. (Amaranthaceae), *Anemia raddiana* Link (Anemiaceae), *Herreria salsaparilha* (Asparagaceae), *Praxelis missiona* (Asteraceae), *Parodia carambeiensis* (Cactaceae), *Evolvulus filipes* (Convolvulaceae), *Dioscorea campestris* Griseb. (Dioscoreaceae), *Mimosa paupera* Benth. (Fabaceae), *Mimosa polycarpa* Kunth (Fabaceae), *Vachellia farnesiana* (L.) Wight & Arn. (Fabaceae), *Sinningia aggregata* (Gesneriaceae), *Cantinoa mutabilis* (Rich.) Harley & J.F.B. Pastore (Lamiaceae), *Heteropterys syringifolia* Griseb. (Malpighiaceae), *Ophioglossum nudicaule* (Ophioglossaceae), *Passiflora eichleriana* Mast. (Passifloraceae), *Amphibromus quadridentulus* (Döll) Swallen (Poaceae), *Saccharum villosum* Steud. (Poaceae), *Schizachyrium microstachyum* (Desv. ex Ham.) Roseng., B.R.Arrill. & Izag. (Poaceae), *Adiantopsis perfasciculata* Sehnen (Pteridaceae), *Mitracarpus hirtus* (L.) DC. (Rubiaceae), *Palicourea mamillaris* (Müll.Arg.) C.M.Taylor (Rubiaceae), *Piriqueta cystoides* (L.) Griseb. (Turneraceae), *Glandularia aristigera* (S.Moore) Tronc. (Verbenaceae) and *Glandularia tenera* (Spreng.) Cabrera (Verbenaceae) which shows that these areas are important for regional biodiversity.

Considering the range of incidence of these species in Brazil, most species on the outcrops of Campo Mourão have a wide distribution, being common species in various phytogeographic domains and vegetation types, especially vegetation that is part of the flora of the municipality, such as Seasonal Semideciduous Forest, Mixed Ombrophilous Forest, and Savanna (Cerrado). Regarding the phytogeographic domains, four species were restricted to the Savanna (Cerrado): *Pfaffia glabrata* (Amaranthaceae), *Cuspidaria pulchella* (Cham.) K.Schum. (Bignoniaceae), *Trimezia spathata* (Klatt), Baker (Iridaceae), and *Lippia balansae* (Verbenaceae); and 12 were restricted to the Atlantic Forest: *Wedelia kerrii* N.E.Br. (Asteraceae), *Parodia carambeiensis* (Cactaceae), *Dichorisandra paranaensis* D.Maia Cervi & Tardivo (Commelinaceae), *Sinningia sellovii* (Gesneriaceae), *Lilium formosanum* A. Wallace (Liliaceae), *Heteropterys intermedia* (A.Juss.) Griseb. (Malpighiaceae), *Pavonia hastata* Cav. (Malvaceae), *Miconia pusilliflora* (DC.) Naudin (Melastomataceae),

Merostachys multiramea Hack. (Poaceae), *Acanthocladus brasiliensis* (A.St.-Hil. & Moq.) Klotzsch ex Hassk. (Polygalaceae), *Portulaca hatschbachii* (Portulacaceae) and *Doryopteris patula* (Fée) Fée (Pteridaceae). Five species were exclusive to Tropical Rain Forest for vegetation types: *Hydrocotyle callicephala* Cham & Schltdl. (Araliaceae), *Terminalia australis* Cambess. (Combretaceae), *Heteropterys intermedia* (Malpighiaceae), *Doryopteris patula* (Pteridaceae), and *Palicourea mamillaris* (Rubiaceae) and only one from the Semideciduous Seasonal Forest: *Microgramma lindbergii* (Mett.) de la Sota (Polypodiaceae).

Only one of these areas is part of an environmental protection area in the Lago Azul State Park; the other three are on private properties. Based on the incidence of threatened species and the uniqueness of these environments, Tomadon et al. (2019) had already proposed one of these areas, Nishida Fish Farm (the forest fragment that includes the Nishida outcrop) as a priority area for regional conservation. We agree with this proposal and suggest the addition of two other sites as priorities for conservation: Bica do Rio Mourão outcrop and Perdoncini outcrop.

Conclusion

The rocky outcrops of Campo Mourão concentrate a wide diversity of species (10 % of the species in the municipality) in four small disjointed areas, surrounded by already heavily altered forest and the agricultural regions, with only the smallest area located within a Unit of Conservation. Although a large number of the species is common to other places in the municipality and also widely dispersed in the domains and vegetation types of Brazil, these places preserve important biodiversity, with 24 species exclusive to the flora of the municipality, in addition to aggregating endangered species in the country (*Portulaca hatschbachii*), several rare and/or endemic species in the state of Paraná and Brazil, and to the presence of life forms adapted to survival in these exposed rock environments.

Acknowledgements

We would like to thank Edivando Vitor do Couto for helping to determine the areas of the outcrops, for the preparation of maps and valuable suggestions for the text. Also, to Bianca Kalinowski Canestraro for having kindly provided the photography of *Ophioglossum nudicaule*.

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