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Vascular grassland plants of Tibagi River Spring, Ponta Grossa, Brazil

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Abstract: A systematic survey was carried out on wet grasslands found over Histosols at Upper Tibagi River basin, between Ponta Grossa and Palmeira municipalities, in the state of Paraná, Brazil, place of high importance because of soil water retention capability and soil carbon pool composition. We provide a checklist containing 146 species, 96 genera and 42 plant families for the area. Families with higher species richness were Asteraceae (27 species; 21 genera), Poaceae (24; 16) and Cyperaceae (18; 6). Four species were classified as endangered or rare, and one as exotic. The specific richness in wet grassland environments at the state of Paraná underlines the need for conservation efforts encompassing these formations.

Introduction

The most important Rivers of the state of Paraná – Brazil, have their springs located at high altitudes (540 to 1,680 m a.s.l., MINEROPAR 2006), where low temperatures (-7.8 to 2°C, Maack 1981) and high annual rainfall (1,300 to 3,470 mm/year, Maack 1981) usually predominate, like Serra do Mar, Escarpa Devoniana or 1st cuesta (geomorphological shape between 1st and 2nd Paraná plateau) and Serra Geral or 2nd cuesta (geomorphological shape between 2nd and 3rd Paraná plateau).

Among these Rivers, the Tibagi presents various springs inserted in the dip slopes of the 1st cuesta (higher altitude), many of them under diffuse water flux in Histosols.

The *Organossolos* (Santos *et al*. 2006), resembling Histosols by Soil Survey Staff (2006), are soils located in reliefs that promote water saturation (Birkeland 1999), usually acid, with high cation exchange capacity (CEC), low nutrient availability (Breemen 1995) and low base saturation, with eventual average to high base saturation (Santos *et al*. 2006; Valladares *et al*. 2008) and large amounts of exchangeable aluminum. Pedogenesis in these soils are related to a water table level near the soil surface, with no important changes along the year, under anoxic conditions, which reduces the organic matter mineralization, thus promoting the storage of carbon-rich organic matter complexes (Santos *et al*. 2006; Sá 2007) and favouring pedogenetic processes.

Herb species predominate along areas covered by hydric soils, into high relief plateaus (wet grasslands) (Gates 1915; Breemen 1995; Costa *et al*. 2003). Besides the studies found in Costa *et al*. (2003), Cervi *et al.* (2007) and Kozera *et al.* (2009), little information is available regarding areas with similar abiotic conditions. Floristic studies of wet grasslands do not encompass only organic soils, but also mineral hydric soils. Costa *et al*. (2003) and Cervi *et al.* (2007) studied the floristic composition of floodplains with different chemical and physical soil features, which affect vegetation. Kozera *et al.* (2009) worked in grassland formations near our study area and presented a large species list, classified according to the amount of water present in soils, although lacking any soil composition analyses.

In these peat-bogs environments, an association between vascular plants and *Sphagnum* spp. (besides other mosses) is observed, alongside the presence of special conditions like chemical and physical soil features, soil water storage and water table level that favour the establishment of some species. According Costa *et al*. (2003), the floristic richness found in these areas is conditioned by relief and water table level.

The Histosols have a broad geographic distribution along the cuestas of the state of Paraná, and have important environmental functions such as carbon storage, hydrologic regulation and potential nutrient-absorbing capacity. Furthermore, when vegetation is focused, these soil types encompass a large and unique genetic diversity, threatened by inadequate management that exhausts soil capability. Despite the importance of these environments, their floristic richness is scarcely known. The present work presents a checklist of herb and shrub species that occur in Histosols at Tibagi River Spring.

Materials and Methods

The study area is located in the dip slope of 1st cuesta of state of Paraná (Escarpa Devoniana), inserted over Furnas sandstone, with elevation of 1,096 m a.s.l. The area comprises the region locally known as Campos Gerais, specially Tibagi River Spring (25°16'25" S, 49°49'29" W), between Ponta Grossa and Palmeira municipalities – PR (Figure 1), approximately 90 km from Curitiba, the state capital.

The climate is Cfb (altitudinal sub-tropical humid) according to Köppen classification, with mean annual temperature between 20 and 22 °C (Cruz 2003), and average yearly rainfall of 1,550 mm (Stipp *et al*. 2000).

The area is inserted in a flat surface (a slightly

concave relief), where Histosols or *Organossolos Háplicos* predominate due to genetic processes such as accumulation of organic material, especially herb species and bryophytes. In order to analyze floristic composition, we sampled 0.65 ha (115 x 57 m) from September 2008 to November 2009, in fortnightly field expeditions. The site is constantly grazed by sheep and cattle, a common situation in most natural grasslands in southern Brazil.

In each field expedition we collected botanical material according to the method described in Filgueiras *et al*. (1994). Surveys encompassed the same soil order, in areas with hydric conditions ranging from a water table located near the surface (a usual condition within this soil order) to a water table rather distant from the surface, a condition promoted by gully erosion that have altered local hydrological regimes. The gully erosion is present in one among the several geological faults in the area as observed in Figure 1.

We collected and preserved plant material from all vascular plant species found within the study area, preferably with reproductive structures. Vouchers for each species were deposited at MBM Herbarium, and a duplicate of each was sent to UPCB Herbarium.

Towards a better understanding of this environment, we carried out a preliminary survey of moss species present in the study area. Since a thorough survey encompassing mosses would probably result in higher species richness, we excluded the species we found from the presented checklist, although they are mentioned in our results.

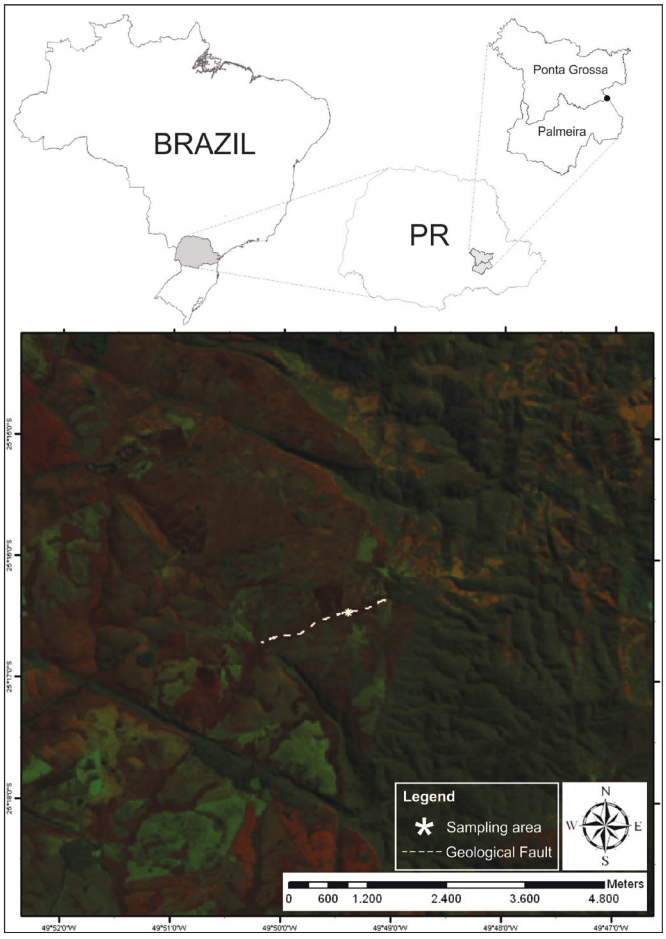


Figure 1. Map location of Tibagi River Spring (black dot) in the state of Paraná and in Brazil, and Landsat 5TM image of study area.

For species taxonomic classification, we followed Tryon and Tryon (1982) and Smith *et al*. (2006) for Pterydophyta and Angiosperm Phylogeny Group III (APG III 2009) for angiosperms. We researched valid plant names in electronic databases of World checklists (Kew 2008; especially for monocots), Missouri Botanical Garden website (MOBOT 2008) and The International Plant Names Index website (IPNI 2008). Citation of author names follows Brummit and Powell (1992) and Pichi-Sermolli (1996).

We evaluated the presence of extinction-threatened species in the study area through revision of extinction-threatened species lists (Hatschbach and Ziller 1995; IBAMA 1992 and MMA 2008). The presence of exotic plant species was evaluated through revision of a local governmental list (IAP 2009).

The floristic similarity between these data, Kozera (2008) and Costa *et al.* (2003), were calculated using Sorensen index. This analysis was carried out using software MULTIV beta (Pillar 2006).

Results and Discussion

We recorded 146 grassland taxa (132 angiosperms and 14 ferns) distributed in 42 families (Table 1). One taxon was identified only at the family level, five at the generic level. In order to achieve a better understanding of environment conditions at the study area, four moss species, were accounted for a preliminary survey: *Sphagnum oxyphyllum* Warnst. and *Sphagnum recurvum* P. Beauv (Sphagnaceae), *Pogonatum pensylvannicum* (Hedw.) P. Beauv. and *Polytrichum commune* L. (Polytrichaceae).

Families with the highest species number were Asteraceae, Poaceae and Cyperaceae. The same result was verified in other floristic and phytosociological surveys in Southern Brazil, both in hydric (Kozera *et al.* 2009; Setubal and Boldrini 2010) and non-hydric soils (Buselato and Bueno 1981; Boldrini and Miotto 1987; Zocche and Porto 1992).

Poaceae plays a key role defining landscapes along the study area, due to the abundance of cespitous species such as *Andropogon leucostachyus*, *Paspalum flaccidum* and *Leptocoryphium lanatum*. Cyperaceae is recognized as a characteristic family of wet tropical environments (Goetghebeur 1998; Alves *et al.* 2008), and was significantly represented by *Cyperus* and *Rhynchospora*. Asteraceae showed an important physiognomic value, especially due to the shrub *Baccharis crispa*.

No Fabaceae species were found, probably due to the waterlogged condition. Similarly, Kozera *et al.* 2009 and Costa *et al.* 2003 found only one Fabaceae species in their surveys, both carried out in similar waterlogged conditions. On the other hand, in surveys carried out under well-drained mineral soils, Fabaceae was among the richest families (Boldrini and Miotto 1987; Boldrini and Eggers 1996; Boldrini *et al*. 1998; Setubal and Boldrini 2010).

We observed dominance of tropical species, but there were also many temperate species like *Briza calotheca*, *Danthonia montana* and *Piptochaetium montevidense*. Herb species predominated along this evaluation, and most shrubs belong to Asteraceae, Clusiaceae, Ericaceae, Melastomataceae, Scrophulariaceae and Solanaceae. Also, we observed tree species (*Myrsine* cf. *gardneriana*

and *Rhamnus sphaerosperma Sw.*), both configuring uncommon plant species in wet grasslands, according to Tannus and Assis (2004), since the organic matter accumulation under anoxic conditions is a limiting condition for the establishment of trees. The occurrence of these species is probably related to the presence of gully erosion, which altered soil features, and can be interpreted as an indicative of poor environmental quality.

Table 1. Vascular grassland plants present at Tibagi River Spring, Ponta Grossa, Brazil.

FAMILIES/SPECIES	HABIT
Apiaceae	
Eryngium ebracteatum L.	herb
Eryngium horridum Malme	herb
Eryngium subinerme Mathias and Constance	herb
Hydrocotyle leucocephala Cham. and Schltdl.	herb
Asteraceae	
Achyrocline alata (Kunth) DC.	herb
Achyrocline satureioides (L.) DC.	herb
Ageratum conyzoides Sieber ex Steud.	herb
Austroeupatorium laete-virens (Hook. and Arn.) R.M. King and H. Rob.	shrub
Baccharis ramboi G. Heiden and L. Macias	shrub
Baccharis crispa Spreng.	shrub
Baccharis megapotamica Spreng.	shrub
Baccharis stenocephala Baker	shrub
Barrosoa betoniciiformis (DC.) R.M. King and H. Rob.	shrub
Bidens pilosa L.	herb
Campovassouria cruciata (Vell.) R.M. King and H. Rob.	shrub
Erechtites valerianifolius (Wolf) DC.	herb
Gnaphalium purpureum L.	herb
Grazielia multifida (DC.) R.M. King and H. Rob.	herb
Holocheilus hieracioides (D. Don) Cabrera	herb
Hypochaeris brasiliensis (Less.) Benth. and Hook. f. ex Griseb.	herb
Hypochaeris lutea Britton	herb
Jungia floribunda Less.	herb
Leptostelma maximum D. Don	herb
Mikania micrantha Kunth	herb
Pluchea oblongifolia DC.	herb
Senecio grossidens Dusén	herb
Solidago microglossa DC.	herb
Trixis brasiliensis (L.) DC.	herb
Trixis lessingii DC.	herb
Vernonanthura westiniana (Less.) H. Rob.	shrub
Vernonia elegans Gardner	herb
Begoniaceae	
Begonia fischeri Schrank	herb
Blechnaceae	
Blechnum cordatum (Desv.) Hieron.	herb
Blechnum polypodioides Raddi	herb
Blechnum schomburgkii (Klotzsch) C. Chr.	herb
Campanulaceae	
Lobelia exaltata Pohl	herb
Lobelia nummularioides Cham.	herb
Caryophyllaceae	
Drymaria sp.	herb
Clusiaceae	
Hypericum brasiliense Choisy	shrub
Cyatheaceae	
Cyathea phalerata Mart.	herb
Cyperaceae	
Cyperus aggregatus (Willd.) Endl.	herb
Cyperus haspan L.	herb
Cyperus hermaphroditus (Jacq.) Standl.	herb
Cyperus impolitus Kunth	herb
Cyperus incomtus Kunth	herb
Cyperus reflexus Vahl	herb
Eleocharis squamigera Svenson	herb
Eleocharis nudipes (Kunth) Palla	herb
Fimbristylis complanata (Retz.) Link	herb
Kyllinga odorata Vahl	herb
Kyllinga pumila Michx.	herb
Rhynchospora aff. *corymbosa* (L.) Britton	herb
Rhynchospora emaciata (Nees) Boeck.	herb
Rhynchospora marisculus Lindl. ex Nees	herb
Rhynchospora globosa (Kunth) Roem. and Schult.	herb
Rhynchospora aff.*polyantha* Steud.	herb
Rhynchospora rigida (Kunth) Boeck.	herb
Scleria hirtella Sw.	herb
Dicksoniaceae	
Dicksonia sellowiana Hook.	herb
Droseraceae	
Drosera communis A. St.-Hil.	herb
Dryopteridaceae	
Deparia petersenii (Kunze) M.Kato	herb
Ericaceae	
Agarista chlorantha (Cham.) G. Don	shrub
Gaylussacia pseudogaultheria Cham. and Schltdl.	shrub
Eriocaulaceae	
Eriocaulon ligulatum L.B. Sm.	herb
Eriocaulon sellowianum Kunth	herb
Leiothrix flavescens (Bong.) Ruhland	herb
Paepalanthus caldensis Malme	herb
Paepalanthus catharinae Ruhland	herb
Syngonanthus caulescens (Poir.) Ruhland	herb
Euphorbiaceae	
Euphorbia elodes Boiss.	herb

Table 1. ***Continued.***

FAMILIES/SPECIES	HABIT
Gesneriaceae	
Sinningia elatior (Kunth) Chautems	herb
Gleicheniaceae	
Dicranopteris flexuosa (Schrad.) Underw.	herb
Hypoxidaceae	
Hypoxis decumbens L.	herb
Iridaceae	
Gelasine coerulea (Vell.) Ravenna	herb
Sisyrinchium sp.	herb
Sisyrinchium vaginatum Spreng.	herb
Juncaceae	
Juncus cf. *densiflorus* Kunth	herb
Juncus cf. *effusus* L.	herb
Juncus microcephalus H.B.K.	herb
Juncus aff. *tenuis* Willd.	herb
Lamiaceae	
Lamiaceae sp.	herb
Rhabdocaulon lavanduloides (Benth.) Epling	herb
Hyptis fasciculata Benth.	herb
Lentibulariaceae	
Utricularia tricolor A. St.-Hil.	herb
Utricularia praelonga St. Hil. and Girard	herb
Liliaceae	
Nothoscordum bonariense (Pers.) Beauverd	herb
Linaceae	
Linum littorale A. St.-Hil.	herb
Lycopodiaceae	
Lycopodiella sp.	herb
Mayacaceae	
Mayaca sp.	herb
Melastomataceae	
Leandra eichleri Cogn.	shrub
Rhynchanthera brachyrhyncha Cham.	herb
Tibouchina cerastifolia Cogn.	herb
Tibouchina gracilis (Bonpl.) Cogn.	herb
Tibouchina ursina Cogn.	shrub
Myrsinaceae	
Myrsine cf. *gardneriana* A. DC.	tree
Orchidaceae	
Cyanaeorchis arundinae (Rchb. f.) Barb. Rodr.	herb
Habenaria parviflora Lindl.	herb
Osmundaceae	
Osmunda regalis L.	herb
Poaceae	
Agrostis longiberbis Hack. ex L.B. Sm.	herb
Andropogon lateralis Nees	herb
Andropogon leucostachyus Kunth	herb

Table 1. ***Continued.***

FAMILIES/SPECIES	HABIT
Andropogon macrothrix Trin.	herb
Andropogon virgatus Desv. ex Ham.	herb
Axonopus affinis Chase	herb
Axonopus polystachyus G.A. Black	herb
Briza calotheca (Trin.) Hack.	herb
Calamagrostis sp.	herb
Danthonia montana Döll	herb
Hemarthria altissima (Poir.) Stapf and C.E. Hubb.	herb
Leptocoryphium lanatum (Kunth) Nees	herb
Otachyrium versicolor (Döll) Henrard	herb
Panicum sabulorum L.	herb
Panicum schwackeanum Mez	herb
Panicum surrectum Chase ex Zuloaga and Morrone	herb
Paspalum cordatum Hack.	herb
Paspalum flaccidum Nees	herb
Paspalum polyphyllum Nees ex Trin.	herb
Piptochaetium montevidense (Spreng.) Parodi	herb
Rhytachne rottboellioides Desv. ex Ham.	herb
Saccharum asperum (Nees) Steud.	herb
Schizachyrium condensatum (Kunth) Nees	herb
Stipa sp.	herb
Polygalaceae	
Polygala longicaulis Kunth	herb
Polygala tenuis DC.	herb
Polypodiaceae	
Pleopeltis hirsutissima (Raddi) de la Sota	herb
Pteridaceae	
Adiantopsis chlorophylla (Sw.) Fée	herb
Doryopteris lomariacea (Kunze) Klotzsch	herb
Rhamnaceae	
Rhamnus sphaerosperma Sw.	tree
Rosaceae	
Acaena eupatoria Cham. and Schltdl.	herb
Rubiaceae	
Galium equisetoides (Cham. and Schltdl.) Standl.	herb
Spermacoce cf. *verticillata* L.	herb
Spermacoce sp.	herb
Scrophulariaceae	
Buddleja elegans Cham. and Schltdl.	shrub
Scoparia elliptica Cham.	herb
Selaginellaceae	
Selaginella marginata (Humb. and Bonpl. ex Willd.) Spring	herb
Solanaceae	
Solanum americanum Mill.	herb
Solanum pseudocapsicum L.	shrub
Solanum reflexum Schrank	herb
Solanum sisymbrifolium L.	herb

Table 1. ***Continued.***

FAMILIES/SPECIES	HABIT
Solanum viarum Dunal	shrub
Thelypteridaceae	
Thelypteris rivularioides (Fée) Abbiatti	herb
Xyridaceae	
Xyris filifolia A. Nilsson	herb
Xyris laxifolia Mart.	herb
Xyris neglecta Alb. Nilsson	herb
Xyris regnelli Nilsson	herb
Xyris stenophylla Alb. Nilsson	herb

Four species are present in the list of threatened species of the state of Paraná (Hatschbach and Ziller 1995) and also in the Brazilian Federal list of threatened species (MMA 2008): *Baccharis megapotamica* Spreng. (Asteraceae), *Cyanaeorchis arundinae* (Rchb. f.) Barb. Rodr. (Orchidaceae), *Paepalanthus catharinae* Ruhland (Eriocaulaceae) and *Dicksonia sellowiana* Hook. (Dicksoniaceae). The first two were classified as rare and the last two as endangered. The first three species highlight the urgent need for conservation efforts encompassing similar areas, associated to programs that promote good management of nearby protected areas. The presence of *Dicksonia sellowiana*, an uncommon species in wet grasslands, was probably a result of soil water balance alterations promoted by gully erosion. The presence of the exotic species *Deparia petersenii* (Kunze) M. Kato (Dryopteridaceae), would suggest a potential impact on grassland habitats.

Floristic similarity between the present study and Kozera *et al.* (2009) and Costa *et al.* (2003) was respectively 32.3% and 5.2 %, whereas similarity between these two studies was 10.8%. The higher similarity observed between this study and Kozera *et al.* (2009) is probably due to the geographic location (second plateau of State of Paraná). The number of sampled species is probably another factor that leads to the differences observed among the studies: Kozera *et al.* (2009) found 175 species (*Cyperus virens* Michx. and *C. intricatus* Schrad ex. Schult were considered synonyms), whereas Costa *et al.* (2003) found 47 species (*Sphagnum* sp. was not considered in the analysis). The study area of Costa *et al.* (2003) and Kozera *et al.* (2009) covered also hydric soils, but probably under organic and inorganic soil. Therefore, these authors sampled soils with different chemical and physical soil features, which probably influenced the vegetation composition.

Over the last years, grasslands in state of Paraná had their original extension reduced with the substitution of natural vegetation by crops. Even in a small sampling area, we recorded an species-rich vegetation, so we consider these vegetation data useful for supporting the elaboration of public conservation policies concerning the remaining natural areas and, moreover, efforts aiming the restoration of disturbed places.

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