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Floristic and phytosociological analysis of palm swamps in the central part of the Brazilian savanna[1]

Isa Lucia de Morais Resende[2,5], Lázaro José Chaves[3] and José Ângelo Rizzo[4]

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ABSTRACT

We analyzed the floristics and phytosociology of three palm swamps in the municipality of Bela Vista de Goiás, located in the state of Goiás, Brazil, in the central part of the Brazilian savanna (*Cerrado*). The floristic surveys were conducted monthly from May 2008 to April 2009, and 310 species were recorded (seven bryophytes, 15 ferns and 288 angiosperms). Bryophytes belonged to five genera and five families; ferns belonged to nine genera and nine families; and angiosperms belonged to 134 genera and 45 families. The angiosperm families with the highest species richness were Poaceae, Cyperaceae, Asteraceae, Eriocaulaceae, Xyridaceae, Lentibulariaceae, Melastomataceae, Rubiaceae and Fabaceae. The palm swamps were divided into three zones of increasing humidity: edge, middle and core. The number of species was higher in the middle than at the edge and the core. The families with the highest cover values were Cyperaceae, Melastomataceae, Arecaceae and Poaceae. Although the palm swamps had been disturbed to varying degrees, those disturbances did not affect the flora in the middle or the core. Floristic similarity was high between these two zones within a given palm swamp and low between the edges of different palm swamps.

Key words: wetlands; Brazilian savanna; plant diversity

Introduction

Wetlands are environments in which water is the determining factor of abiotic and biotic conditions (Keddy 2000, Steinke & Saito 2008). These areas support several typical animal and plant species and foster a large number of ecological processes that sustain those species (Maltchik *et al.* 2003), making wetlands some of the most productive environments on the planet (Steinke & Saito 2008).

In the Brazilian savanna (*Cerrado*), despite the dominance of phytophysiognomies on well-drained soils, wetlands such as palm swamps also occur (Meireles *et al.* 2002). Palm swamps are communities composed of a continuous herb-grass layer, which occupies most of their area, and a tree-shrub layer dominated by individuals of the palm *Mauritia flexuosa* L. f. (local name, *buriti*), with a canopy cover of between 5% and 10% (Ribeiro & Walter 2008).

In addition to the diversity of plant species (Araújo *et al.* 2002, Guimarães *et al.* 2002), palm swamps present some distinct micro-ecosystems in which there are some plant-animal interactions that are still poorly understood (Oliveira *et al.* 2009). These environments serve as refuges, food sources and reproduction sites for the aquatic and terrestrial fauna of the adjacent phytophysiognomies (Guimarães *et al.* 2002). They are also sites of great scenic beauty with economic and sustainable potential for ecotourism and for extractivism involving species such as *M. flexuosa* and *Syngonanthus nitens* (Bong.) Ruhland (*capim-dourado*, which means "golden grass") by small rural communities (Schmidt *et al.* 2008).

Palm swamps are categorized as areas of permanent preservation, for ensuring the maintenance of springs and the quality of watercourses (Araújo *et al.* 2002). Although legally protected, palm swamps have suffered human disturbances that occasionally become irreversible, mainly because of their low regenerative capacity (Carvalho 1991, Araújo *et al.* 2002, Guimarães *et al.* 2002). Considering the importance and the condition of degradation of palm swamps, it is necessary to expand studies on the physical, biotic, social and anthropic aspects of this physiognomy, in a dynamic and multidisciplinary manner. Thus, it will be

[1] Based on the Doctoral thesis of the first Author.

[2] Universidade Estadual de Goiás, Unidade Universitária, Quirinópolis, GO, Brazil
[3] Universidade Federal de Goiás, Departamento de Melhoramento Genético de Plantas, Goiânia, GO, Brazil
[4] Universidade Federal de Goiás, Unidade de Conservação/PRPPG/Herbário, Goiânia, GO, Brazil
[5] Author for correspondence: isamorais1@gmail.com

possible to understand the aspects that characterize palm swamps and to support measures to mitigate possible environmental impacts. There have been a few studies on palm swamp vegetation (Araújo *et al*. 2002; Guimarães *et al*. 2002; Ramos 2004; Oliveira *et al*. 2009). However, there have been no studies on the plant diversity of this physiognomy in the central part of the *Cerrado*. Therefore, the aim of this study was to contribute to the knowledge of the floristic composition of palm swamps in the central part of the *Cerrado* and to conduct a phytosociological survey in those swamps.

Material and methods

The study sites were three disturbed palm swamps, which were selected based on previous studies involving satellite images and field trips. All three sites are located on private properties in the city of Bela Vista de Goiás, in the state of Goiás, Brazil, and are part of the riparian vegetation of the tributaries of the Peixe River, which is in turn a tributary of the Corumbá River, pertaining to the Paranaíba River watershed (Fig. 1).

The palm swamp with the lowest degree of disturbance was in an area of transition to *cerradão* and was located upstream of dams for the provisioning of cattle. The *M. flexuosa* individuals at that study site displayed signs of burning on the stems and of trampling by cattle. The other two palm swamps did not display signs of burning, and, at the time of sampling, one was surrounded by cultivated pasture dominated by *Urochloa* spp., whereas the other was surrounded by crops (primarily corn and soybean). The palm swamp surrounded by crops was the only one that was not at least partially fenced off. This site suffered interference by cattle, which were released by cattle farmers in order to graze on crop residues (mainly of corn) during the postharvest period. We also observed signs of swine, which were allowed to feed at the site on a regular basis.

According to the Köppen classification system, the climate in the region is type Aw, which is defined as megathermal, with a rainy summer and a dry winter. Mean monthly temperatures range from 19°C to 28°C and mean annual rainfall is below 2000 mm (INMET 2009).

The floristic survey was conducted between May 2008 and April 2009, with monthly collection of fertile botanical material observed in asystematic walks throughout the three sites. Each palm swamp was subdivided into three zones: edge, middle and core (Araújo *et al.* 2002, Guimarães *et al.* 2002). The edge is closest to the transitional vegetation and exhibits soil that is lighter in color and more well-drained. The middle exhibits soil that is darker and periodically saturated with water. The core is permanently flooded. For all sampled material, we recorded data on the growth habit, zone of occurrence and morphological characteristics.

The botanical material was mounted following the usual procedures, and the vouchers were deposited at the Herbarium of the Federal University of Goiás. Species were identified with the aid of specialists in various botanical families and by comparison with identified vouchers in herbaria. We adopted classification systems based on the following works: Goffinet & Buck (2004) for Bryophyta; He-Nigrén *et al.* (2006) for Marchantiophyta; Tryon & Tryon (1982) for Pteridophyta; and the Angiosperm Phylogeny Group 2009 update (APG III 2009) for Magnoliophyta (angiosperms).

The phytosociological survey was conducted with the line intercept method, adapted from Munhoz & Felfili (2006), to determine the composition and linear cover of species. At each site, we selected four transects, 10 m apart, comprising two transects on each bank of the drainage canal. The transects were positioned perpendicular to the drainage line, and, for each transect, we extended a line from the edge to the core of the palm swamp. The line was divided in 1-m sections, or sample units. We analyzed 129 sample units in the palm swamp surrounded by *cerradão*, 246 in that surrounded by pasture and 115 in that surrounded by crops. For each 1-m section, we recorded the occurrence of each species and its horizontal projection. The sum of the horizontal projections of a given species in all sample units was taken as the absolute cover value for that species in each palm swamp. The relative cover value was obtained by dividing the absolute cover value of each species by the sum of the absolute cover values of all species, and multiplying the result by 100. The record of occurrence of each species in the sample units was used in order to calculate the frequency of species in each palm swamp. To investigate the dynamics of the vegetation, the first phytosociological survey was performed in October 2009 (at the end of the dry season) and the second was performed in March 2010 (at the end of the rainy season), both surveys being performed in the same transects.

To evaluate the diversity of the community, we used an adaptation of the Shannon diversity index, using the cover values of both sampling periods instead of the number of individuals, in accordance with the method suggested by Munhoz & Felfili (2006). The floristic similarity between the palm swamps and between the zones (edge, middle and core) of each site was evaluated by the quantitative Sørensen similarity index (Mueller-Dombois & Ellenberg 1974). The data of floristic similarity (I) were transformed to dissimilarity indices (D = 1 – I) and evaluated with a cluster analysis using the unweighted pair group method with arithmetic mean, with the software GENES (Cruz, 2006).

Results and discussion

We sampled 310 species (Tab. 1): seven bryophytes, 15 ferns and 288 angiosperms. Bryophytes comprised five genera and five families; ferns comprised nine genera and nine families; and angiosperms comprised 134 genera, 45 families and one undetermined Poaceae, 64.9% of the genera and 42.2% of the families comprising only one species. The families with the largest number of species were Poaceae (n

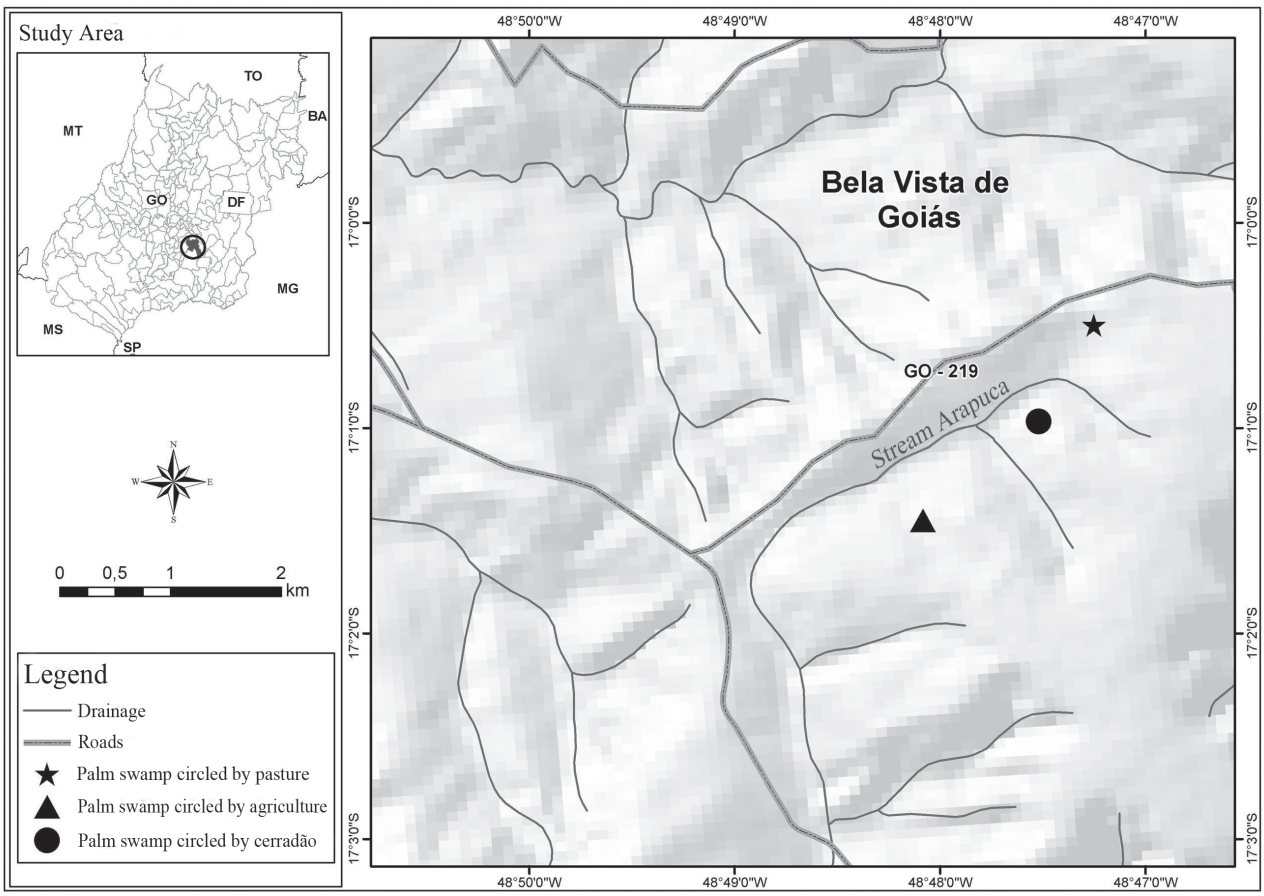

Figure 1. Location of the three palm swamp study sites in the city of Bela Vista de Goiás, state of Goiás, Brazil.

= 53), Cyperaceae (n = 44), Asteraceae (n = 24), Eriocaulaceae (n = 18), Xyridaceae (n = 17), Lentibulariaceae (n = 16), Melastomataceae (n = 12), Rubiaceae (n = 12) and Fabaceae (n = 11), collectively accounting for 71.9% of the sampled angiosperms. In the studies conducted by Araújo *et al.* (2002), Guimarães *et al.* (2002), Ramos (2004), and Oliveira *et al.* (2009), these same families, with the exception of Lentibulariaceae, also showed the highest species richness. Guimarães *et al.* (2002) registered no Lentibulariaceae species and only three Xyridaceae species.

The number of species recorded was equal or comparable among the three sites: 187 in the palm swamp surrounded by pasture; 187 in the palm swamp surrounded by crops; and 186 in the palm swamp surrounded by *cerradão*. Floristic similarity between the sites was high: 58.2% between the palm swamp surrounded by pasture and that surrounded by crops; 61.9% between the palm swamp surrounded by pasture and that surrounded by *cerradão*; and 55.1% between the palm swamp surrounded by *cerradão* and that surrounded by crops. According to Kent & Coker (1992), values ≥ 50% indicate high similarity. Although the sites had been disturbed to varying degrees, those disturbances did not affect the flora in the middle or core zones of these palm swamps, only the species at their edges.

Floristic similarity was higher between the middle and core zones and lower between the edge zones (Tab. 2). The dendrogram resulting from a cluster analysis shows the floristic similarity between the middle and the core within each palm swamp, as well as the dissimilarity between the sites (Fig. 2). The coefficient of cophenetic correlation was 0.70, indicating good representativeness of the original dissimilarity indices in the dendrogram. There was floristic dissimilarity between the edges of the three palm swamps and between the edge and the other two zones within each palm swamp. Despite belonging to different sites, the three edge zones were more similar to each other than to their respective middle and core zones. This might be attributable to the fact that an edge is a zone of transition to the adjacent vegetation. In the palm swamp surrounded by pasture and the palm swamp surrounded by crops, the colonization by diaspores of exotic or invasive species, originating from the human activities in the vicinity, might have contributed to the differences between edge zones.

The Sørensen similarity index between the zones (edge, middle and core) within each palm swamp was higher between the middle and the core and lower between the edge and the core (Tab. 2). The highest floristic similarity (76.4%) was between the middle and the core of the site surrounded

Table 1. Species, ordered by category and family, sampled in the edge, middle and core zones (E, M and C, respectively) of three palm swamps—one surrounded by pasture (PP); one surrounded by crops (PCr); and one surrounded by *cerrad*ão (PC)—in the city of Bela Vista de Goiás, state of Goiás, Brazil.

CATEGORY / FAMILY / Species	PP			PCr			PC		
	E	M	C	E	M	C	E	M	C
BRYOPHYTES									
ANEURACEAE									
Riccardia cataractarum (Spruce) Schiffner		X							
Riccardia sinuata (Hook.) Trevis.			X						
BRACHYTHECIACEAE									
Zelometeorium patulum (Hedw.) Manuel		X				X			
DICRANACEAE									
Leucoloma serrulatum Brid.**		X							
PYLAISIADELPHACEAE									
Isopterygium tenerifolium Mitt.								X	
SPHAGNACEAE									
Sphagnum cyclophyllum Sull. & Lesq.		X	X						
Sphagnum perichaetiale Hampe		X							
SEEDLESS VASCULAR PLANTS									
BLECHNACEAE									
Blechnum serrulatum Rich. North, Central and South American*		X							
CYATHEACEAE									
Cyathea atrovirens (Langsd. & Fisch.) Domin***			X			X			X
DENNSTAEDTIACEAE									
Lindsaea lancea (L.) Bedd. Central and South American*		X							
GLEICHENIACEAE									
Dicranopteris flexuosa (Schrad.) Underw. North, Central and South American*		X				X			
HYMENOPHYLLACEAE									
Trichomanes crispum L. South American*		X							
LYCOPODIACEAE									
Lycopodiella alopecuroides (L.) Cranfill. North, Central and South American*		X	X					X	X
Lycopodiella camporum B. Øllg. & P.G. Windisch	X	X	X					X	X
Lycopodiella caroliniana (L.) Pic. Serm. South American*								X	X
Lycopodiella cernua (L.) Pic. Serm.		X	X		X	X		X	X
OPHIOGLOSSACEAE									
Ophioglossum crotalophoroides Walter neotropical* – North American**								X	
PTERIDACEAE									
Pityrogramma calomelanos (L.) Link. neotropical*		X			X	X			X
THELYPTERIDACEAE									
Thelypteris biformata (Rosenst.) R.M. Tryon***						X			
Thelypteris eriosora (Fée) Ponce***					X	X		X	X
Thelypteris opposita (Vahl) Ching North, Central and South American*		X							X
Thelypteris serrata (Cav.) Alston		X	X		X	X		X	X
ANGIOSPERMS									
ACANTHACEAE									
Geissomeria pubescens Nees***	X								
Ruellia sp.	X	X					X		

Continues

Table 1. Continuation.

CATEGORY / FAMILY / Species	PP			PCr			PC		
	E	M	C	E	M	C	E	M	C
AMARANTHACEAE									
Alternanthera brasiliana (L.) Kuntze				X					
ANACARDIACEAE									
Tapirira guianensis Aubl.			X						
ANNONACEAE									
Cardiopetalum calophyllum Schltdl.	X								
Xylopia aromatica (Lam.) Mart.	X							X	
Xylopia emarginata Mart.		X	X			X			
APIACEAE									
Eryngium ebracteatum Lam. Central and South American*				X	X			X	X
AQUIFOLIACEAE									
Ilex affinis Gardner	X	X	X			X			
ARACEAE									
Urospatha sagittifolia (Rudge) Schott		X	X		X	X		X	X
Xanthosoma striatipes (Kunth & C.D. Bouché) Madison		X		X	X	X		X	X
ARECACEAE									
Mauritia flexuosa L.f.		X	X		X	X		X	X
ASTERACEAE									
Acanthospermum australe (Loefl.) Kuntze neotropical* – South American?							X		
Achyrocline alata (Kunth) DC. South American*	X	X			X				
Achyrocline satureioides (Lam.) DC. South American*	X	X			X				
Adenostemma suffruticosum Gardner					X		X		
Ageratum conyzoides L. pantropical* – neotropical, western India				X	X			X	
Bidens pilosa L. neotropical* – South American	X						X		
Conyza bonariensis (L.) Cronquist neotropical*	X								
Elephantopus mollis Kunth pantropical - neotropical							X		
Emilia fosbergii Nicolson pantropical* - Bahamas?; old world?	X			X	X				
Emilia sonchifolia (L.) DC. old world* – African?	X								
Erechtites hieraciifolius (Fisch. ex Spreng.) Griseb. South American*	X	X		X	X	X		X	X
Eupatorium amygdalinum Lam. ***		X							X
Eupatorium tremulum Hook. & Arn.***		X				X		X	X
Mikania officinalis Mart.	X	X			X		X	X	
Mikania psilostachya DC. South American*						X			
Porophyllum ruderale (Jacq.) Cass.				X			X		
Praxelis clematidea (Griseb.) R.M. King & H. Rob.				X					
Praxelis grandiflora (DC.) Sch. Bip.	X			X			X		
Praxelis kleinioides (Kunth) Sch. Bip.				X			X		
Riencourtia oblongifolia Gardner								X	X
Vernonia ararana Gardner***		X	X	X	X		X	X	X
Vernonia helophila Mart. ex DC.**[1]	X			X					
Vernonia polyanthes Less.[2]	X								
Vernonia rubriramea Mart. ex DC.	X	X				X			
BURMANNIACEAE									
Burmannia capitata (Walter ex J.F. Gmel.) Mart. North, Central and South American*		X	X		X				
Burmannia damazii Beauverd		X	X					X	X
Burmannia flava Mart. North, Central and South American*		X	X		X			X	X
Burmannia grandiflora Malme		X	X		X			X	X

Continues

Table 1. Continuation.

CATEGORY	PP			PCr			PC		
FAMILY									
Species	E	M	C	E	M	C	E	M	C
CHLORANTHACEAE									
Hedyosmum brasiliense Miq.						X			
COMMELINACEAE									
Commelina benghalensis L. paleotropical* – India, southeast of Asia				X					
CYPERACEAE									
Ascolepis brasiliensis (Kunth) Benth. ex C.B. Clarke pantropical* - neotropical		X	X		X	X		X	X
Bulbostylis capillaris (L.) C.B. Clarke		X							
Bulbostylis sellowiana (Kunth) Palla	X	X			X	X		X	X
Calyptrocarya glomerulata (Brongn.) Urb. neotropical*		X			X				
Calyptrocarya luzuliformis T. Koyama**[3]		X							
Cyperus ferax Rich. tropical cosmopolitan*					X				
Cyperus haspan L. pantropical*	X	X	X		X	X		X	X
Cyperus lanceolatus Poir.				X	X	X		X	X
Cyperus luzulae (L.) Rottb. ex Retz. neotropical*				X	X				
Eleocharis acutangula (Roxb.) Schult. pantropical*						X			X
Eleocharis capillacea Kunth Caribbean; Central and South American*		X	X	X	X	X		X	X
Eleocharis filiculmis Kunth neotropical*		X			X			X	
Eleocharis geniculata (L.) Roem. & Schult.		X		X	X	X			
Eleocharis nuda C.B. Clarke**.***						X		X	X
Eleocharis obtusetrigona (Lindl. & Nees) Steud.				X		X			X
Fimbristylis autumnalis (L.) Roem. & Schult. neotropical*	X	X			X	X	X	X	X
Fimbristylis complanata (Retz.) Link pantropical* - neotropical	X	X							
Fimbristylis dichotoma (L.) Vahl pantropical*		X		X	X		X		
Fimbristylis spadicea (L.) Vahl							X		
Kyllinga pumila Michx. neotropical and paleotropical*				X	X				
Lipocarpha humboldtiana Nees	X	X	X		X	X		X	X
Pycreus capillifolius (A. Rich.) C.B. Clarke neotropical and paleotropical*?				X	X				
Pycreus megapotamicus (Kunth) Nees**.***					X	X			
Rhynchospora brasiliensis Boeck.		X			X			X	
Rhynchospora consanguinea (Kunth) Boeck.	X	X	X		X		X	X	X
Rhynchospora corymbosa (L.) Britton pantropical* - neotropical		X			X			X	X
Rhynchospora emaciata (Nees) Boeck. South American*					X			X	X
Rhynchospora eximia (Nees) Boeck. neotropical*		X			X				
Rhynchospora globosa (Kunth) Roem. & Schult. neotropical*	X	X	X		X	X		X	X
Rhynchospora hirsuta (Vahl) Vahl**.***		X			X			X	
Rhynchospora marisculus Lindl. ex Nees Central and South American*								X	
Rhynchospora riparia (Nees) Boeckeler South American*					X	X			
Rhynchospora robusta (Kunth) Boeck.	X	X	X		X	X	X	X	X
Rhynchospora rugosa (Vahl) Gale neotropical*							X	X	
Rhynchospora speciosa (Kunth) Boeck.	X	X					X	X	
Rhynchospora tenerrima Nees ex Sprengel Central and South American*				X	X				
Rhynchospora tenuis Willd. ex Link neotropical*		X	X		X	X		X	X

Continues

Table 1. Continuation.

CATEGORY	PP			PCr			PC		
FAMILY / Species	E	M	C	E	M	C	E	M	C
CYPERACEAE									
Rhynchospora velutina (Kunth) Boeck. neotropical*	X	X			X			X	
Scleria clarkei Lindm.**.***					X				
Scleria distans Poir. pantropical*	X	X			X				
Scleria hirta Boeck.**.***		X	X					X	X
Scleria hirtella Sw. pantropical* - Caribbean	X	X						X	X
Scleria reticularis Michx. neotropical*					X			X	X
Scleria retroserrata Kük.**.***					X				
DILLENIACEAE									
Curatella americana L. Caribbean, Central and South American*					X			X	
Davilla nitida (Vahl) Kubitzki			X		X				
DROSERACEAE									
Drosera communis A. St.-Hil.		X	X		X	X		X	X
ERIOCAULACEAE									
Eriocaulon crassiscapum Bong.					X	X			
Eriocaulon humboldtii Kunth		X	X		X	X		X	X
Eriocaulon kunthii Körn.**.***								X	X
Eriocaulon linearifolium Körn.		X	X		X	X		X	X
Eriocaulon modestum Kunth	X				X	X			
Eriocaulon steyermarkii Moldenke		X	X					X	X
Leiothrix angustifolia Ruhland		X	X						
Leiothrix schlechtendalii Ruhland		X	X						
Paepalanthus flaccidus Kunth		X	X			X			X
Syngonanthus anthemidiflorus (Bong.) Ruhland		X	X						
Syngonanthus appressus (Körn.) Ruhland	X	X	X					X	X
Syngonanthus caulescens (Poir.) Ruhland		X	X		X	X		X	X
Syngonanthus densiflorus (Körn.) Ruhland		X	X		X	X		X	X
Syngonanthus fuscescens Ruhland								X	X
Syngonanthus goyazensis Ruhland					X	X			X
Syngonanthus gracilis (Bong.) Ruhland		X	X			X		X	X
Syngonanthus nitens (Bong.) Ruhland		X	X		X	X		X	X
Syngonanthus schwackei Ruhland[3]**								X	X
EUPHORBIACEAE									
Chamaesyce potentilloides (Boiss.) Croizat South American*							X	X	X
Croton glandulosus L. North, Central and South American*	X	X		X			X	X	
Croton sclerocalyx (Didr.) Müll. Arg.	X	X		X			X		
FABACEAE									
Aeschynomene paniculata Willd. ex Vogel North, Central and South American*				X			X	X	
Camptosema coriaceum (Nees & Mart.) Benth.	X								
Chamaecrista diphylla (L.) Greene Caribbean; North, Central and South American*							X		
Chamaecrista trichopoda (Benth.) Britton & Rose ex Britton & Killip							X		
Crotalaria velutina Benth.				X					
Desmodium barbatum (L.) Benth. pantropical*	X	X		X	X		X	X	
Desmodium incanum DC. pantropical*	X	X		X					
Mimosa foliolosa Benth.				X					
Stylosanthes nunoi Brandão							X		
Stylosanthes viscosa (L.) Sw.							X		
Zornia latifolia Sm.				X			X		

Continues

Table 1. Continuation.

CATEGORY	PP			PCr			PC		
FAMILY									
Species	E	M	C	E	M	C	E	M	C
GENTIANACEAE									
Curtia tenuifolia (Aubl.) Knobl.		X	X					X	X
Helia oblongifolia Mart.[4]**		X			X				
Irlbachia alata (Aubl.) Maas neotropical*		X	X	X	X	X	X	X	X
Schultesia aptera Cham.		X	X		X		X	X	X
Schultesia gracilis Mart.		X	X						
Tetrapollinia caerulescens (Aubl.) Maguire & B.M. Boom[4]**		X							
GESNERIACEAE									
Sinningia elatior (Kunth) Chautems	X	X						X	
IRIDACEAE									
Cipura paludosa Aubl.							X		
Sisyrinchium vaginatum Spreng. neotropical*							X	X	X
LAMIACEAE (LABIATAE)									
Hypenia macrantha (A. St.-Hil. ex Benth.) Harley	X								
Hyptis caespitosa A. St.-Hil. ex Benth.				X	X				
Hyptis carpinifolia Benth.								X	X
Hyptis lantanifolia Poit.neotropical*	X	X		X				X	
Hyptis subrotunda Pohl ex Benth.	X								
Hyptis tenuifolia Epling	X	X					X	X	
Hyptis velutina Pohl ex Benth.	X	X							
Marsypianthes chamaedrys (Vahl) Kuntze Central and South American*	X			X					
LAURACEAE									
Ocotea spixiana (Nees) Mez						X			
LENTIBULARIACEAE									
Genlisea filiformis A. St.-Hil. Central and South American*								X	X
Genlisea pygmaea A. St.-Hil. South American*								X	X
Genlisea repens Benj. South American*								X	X
Utricularia amethystina Salzm. ex A. St.-Hil. & Girard		X	X		X	X			
Utricularia cucullata A. St.-Hil. & Girard		X	X					X	X
Utricularia gibba L. pantropical*								X	X
Utricularia huntii P. Taylor		X	X						
Utricularia hispida Lam.	X	X	X		X	X		X	X
Utricularia nana A. St.-Hil. & Girard			X					X	X
Utricularia nervosa Weber ex Benj.[4]**		X	X					X	X
Utricularia nigrescens Sylvén		X	X		X	X		X	X
Utricularia praelonga A.St.-Hil. & Girard		X	X		X	X		X	X
Utricularia pusilla Vahl		X	X					X	X
Utricularia trichophylla Spruce ex Oliv.		X	X		X	X		X	X
Utricularia triloba Benj. South American*		X	X				X	X	X
Utricularia sp.		X	X					X	X
LIMNOCHARITACEAE									
Limnocharis flava (L.) Buchenau									X

Continues

Table 1. Continuation.

CATEGORY	PP			PCr			PC		
FAMILY / Species	E	M	C	E	M	C	E	M	C
LYTHRACEAE									
Cuphea carthagenensis (Jacq.) J.F. Macbr. Central and South American*				X					
Cuphea micrantha Kunth				X			X	X	
Cuphea polymorpha A. St.-Hil.		X							
Diplusodon lanceolatus Pohl							X	X	
MALPIGHIACEAE									
Banisteriopsis pubipetala (A. Juss.) Cuatrec.		X							
Camarea affinis A. St.-Hil.				X			X		
MALVACEAE									
Corchorus hirtus L. North, Central and South American*				X					
Melochia sp.				X					
Sida linifolia Cav. pantropical* – South American?	X	X		X	X				
Waltheria tomentosa H. St. John	X			X	X		X	X	
MELASTOMATACEAE									
Desmoscelis villosa (Aubl.) Naudin		X			X	X			
Macairea radula (Bonpl.) DC.		X			X				
Miconia albicans (Sw.) Steud. Central and South American*	X						X		
Miconia chamissois Naudin		X	X		X	X		X	X
Miconia elegans Cogn.	X	X							X
Miconia ibaguensis (Bonpl.) Triana Central and South American*						X			
Miconia stenostachya DC. Central and South American*	X						X		
Microlicia euphorbioides Mart.		X			X			X	
Microlicia helvola Triana	X	X						X	
Rhynchanthera grandiflora (Aubl.) DC.	X	X			X		X	X	X
Tibouchina gracilis (Bonpl.) Cogn. South American*		X			X				
Trembleya phlogiformis DC.		X	X					X	X
MELIACEAE									
Guarea macrophylla Vahl South American*			X						
MYRTACEAE									
Myrcia laruotteana Cambess.	X								
OCHNACEAE									
Sauvagesia erecta L. pantropical*	X	X							
Sauvagesia racemosa A. St.-Hil.	X	X	X		X	X	X	X	X
Sauvagesia sp.		X			X				
ONAGRACEAE									
Ludwigia nervosa (Poir.) H. Hara	X	X	X		X	X	X	X	X
OROBANCHACEAE									
Buchnera longifolia Kunth	X	X						X	X
PIPERACEAE									
Piper aduncum L. neotropical*					X	X			
Piper flavicans C. DC.									X
Piper fuligineum Kunth South American*					X	X		X	X
Piper sp.[1]					X	X		X	X
Piper sp.[2]									X

Continues

Table 1. Continuation.

CATEGORY	PP			PCr			PC		
FAMILY									
Species	E	M	C	E	M	C	E	M	C
PLANTAGINACEAE									
Scoparia dulcis L. pantropical*	X	X		X					
PHYLLANTHACEAE									
Hyeronima alchorneoides Allemão						X			
POACEAE									
Andropogon bicornis L. Caribbean; North, Central and South American*	X	X		X	X		X		
Andropogon fastigiatus Sw. Central and South American*					X				
Andropogon lateralis Nees South American*				X	X				
Andropogon leucostachyus Kunth Caribbean; North, Central and South American*		X			X			X	
Andropogon virgatus Desv. ex Ham. Central and South American*	X	X			X		X	X	
Andropogon sp.[1]		X		X	X			X	
Andropogon sp.[2]		X			X		X	X	
Andropogon sp.[3]		X							
Andropogon sp.[4]					X				
Andropogon sp.[5]		X		X	X			X	
Andropogon sp.[6]		X		X	X			X	
Andropogon sp.[7]								X	
Anthaenantia lanata (Kunth) Benth. Central and South American*		X			X			X	X
Arthropogon villosus Nees							X	X	
Arundinella hispida (Humb. & Bonpl. ex Willd.) Kuntze					X				
Axonopus brasiliensis (Spreng.) Kuhlm. South American*		X						X	
Axonopus comans (Trin. ex Döll) Kuhlm.		X						X	
Axonopus sp.				X				X	
Ctenium sp.			X						
Digitaria sp.				X					
Echinolaena inflexa (Poir.) Chase	X	X	X				X	X	
Elionurus muticus (Spreng.) Kybtze South American*				X					
Eragrostis secundiflora J. Presl North, Central and South American*					X			X	
Eragrostis sp.[1]				X					
Eragrostis sp.[2]				X	X				
Eragrostis sp.[3]				X					
Eragrostis sp.[4]				X					
Eriochrysis cayennensis P. Beauv. North, Central and South American*	X	X	X		X	X	X	X	
Eriochrysis holcoides (Nees) Kuhlm. South American*				X					
Hyparrhenia bracteata (Humb. & Bonpl. ex Willd.) Stapf neotropical*	X	X		X	X		X	X	X
Hyparrhenia rufa (Nees) Stapf Caribbean; North, Central and South American*								X	
Ichnanthus procurrens (Nees ex Trin.) Swallen South American*				X	X		X	X	
Luziola bahiensis (Steud.) Hitchc. North, Central and South American*									X
Melinis minutiflora P. Beauv. African*		X			X				
Otachyrium seminudum Hack. ex Send. & Soderstr.		X	X		X	X		X	X
Panicum laxum Sw.	X	X		X	X			X	
Panicum parvifolium Lam. Caribbean; North, Central and South American*		X	X	X	X	X		X	X
Paspalum compressifolium Swallen**.***				X					
Paspalum imbricatum Filg.		X							
Paspalum maculosum Trin. Caribbean and South American*		X			X			X	
Paspalum multicaule Poir. Caribbean; Central and South American*				X					
Paspalum pilosum Lam. Caribbean; Central and South American*		X		X					
Paspalum plicatulum Michx. neotropical*				X					

Continues

Table 1. Continuation.

CATEGORY / FAMILY / Species	PP			PCr			PC		
	E	M	C	E	M	C	E	M	C
Paspalum stellatum Humb. & Bonpl. ex Flüggé Caribbean; North, Central and South American*								X	
Pennisetum polystachion (L.) Schult. African*	X			X					
Rhynchelytrum repens (Willd.) C.E. Hubb.				X					
Saccharum angustifolium (Nees) Trin.			X		X	X		X	X
Saccharum asperum (Nees) Steud. South American*		X			X			X	X
Schizachyrium tenerum Nees North, Central and South American*		X							
Setaria parviflora (Poir.) Kerguélen North, Central and South American*	X			X			X		
Urochloa decumbens (Stapf) R.D. Webster African*	X			X					
Urochloa humidicola (Rendle) Morrone & Zuloaga African*				X					
Undetermined					X			X	
POLYGALACEAE									
Polygala galioides Poir.				X					
Polygala glochidata Kunth				X					
Polygala leptocaulis Torr. & A. Gray North, Central and South American*								X	X
Polygala longicaulis Kunth							X		
Polygala nudicaulis Bennett,A.W.				X					
Polygala paniculata L. North, Central and South American*	X	X			X			X	X
Polygala tenuis DC.								X	X
PRIMULACEAE									
Lysimachia pumila Sw. American* - Caribbean?				X					
Rapanea intermedia Mez							X		
RUBIACEAE									
Alibertia edulis (Rich.) A. Rich. ex DC.	X					X	X	X	
Diodia teres Walter South American*				X					
Galianthe grandiflora E.L. Cabral			X						
Mitracarpus frigidus var. salzmannianus (DC.) K. Schum. South American*				X					
*Mitracarpus hirt*us (L.) DC.				X					
Psychotria carthagenensis Jacq.			X						
Psychotria paracatuensis Standl.			X		X	X			
Sipanea hispida Benth. ex Wernham	X	X		X	X		X	X	
*Spermacoce multiflor*a (DC.) Delprete[5]		X			X				
Spermacoce ovalifolia (M. Martens & Galeotti) Hemsl.[6]				X					
Spermacoce pulchristipula (Bremek.) Delprete[7]							X		
Spermacoce schumannii (Standl. ex Bacigalupo) Delprete			X	X	X	X	X	X	X
SANTALACEAE									
Phoradendron affine (Pohl ex DC.) Engl. & K. Krause						X			
Phoradendron crassifolium (Pohl ex DC.) Eichler		X							
Phoradendron mucronatum (DC.) Krug & Urb. Caribbean and South American*								X	X
URTICACEAE									
Cecropia pachystachya Trécul		X	X		X	X		X	X
VERBENACEAE									
Stachytarpheta cayennensis (Rich.) Vahl							X		
XYRIDACEAE									
Abolboda poarchon Seub.		X	X					X	X
Xyris aurea L.B. Sm. & Downs		X	X				X	X	X
Xyris jupicai Rich. North, Central and South American*		X	X		X	X		X	X

Continues

Table 1. Continuation.

CATEGORY / FAMILY / Species	PP			PCr			PC		
	E	M	C	E	M	C	E	M	C
Xyris laxifolia Mart. South American*		X	X		X	X		X	X
Xyris lutescens Kral & Wand.								X	X
Xyris savanensis Miq. South American*		X	X		X	X		X	X
Xyris schizachne Mart. South American*								X	X
Xyris tenella Kunth South American*		X	X						
Xyris tortula Mart. South American*								X	X
Xyris sp.[1]		X	X				X	X	X
Xyris sp.[2]								X	X
Xyris sp.[3]					X	X			
Xyris sp.[4]							X	X	X
Xyris sp.[5]		X	X		X	X		X	X
Xyris sp.[6]			X					X	X
Xyris sp.[7]	X	X	X			X		X	X
Xyris sp.[8]		X	X					X	X
Total species	71	153	83	78	122	76	61	147	114

*Species that were observed at the study sites but have a wide geographical distribution (neotropical, pantropical, cosmopolitan, etc.), for which the origin, or initial distribution, cannot be indicated in the *Cerrado*, including ruderal, invasive and exotic species, according to Mendonça *et al.* (2008).
**New record for the state of Goiás.
***New record for the *Cerrado*, according to Mendonça *et al.* (2008).
[1] *Vernonia helophila* - although not cited by Mendonça *et al.* (2008), this species occurs in the states of Mato Grosso, São Paulo and Minas Gerais (Almeida 2008).
[2] *Vernonia polyanthes* - although not cited by Mendonça *et al.* (2008), this species occurs in the states of Goiás, Mato Grosso, Paraná, Bahia, São Paulo and Minas Gerais, and is considered a common species in the *Cerrado* (Almeida 2008).
[3] although not cited by Mendonça *et al.* (2008), this species has been sampled in the municipality of Jalapão, state of Tocantins (Rezende 2007).
[4] species previously sampled in palm swamps in the Triângulo Mineiro area, state of Minas Gerais (Oliveira *et al.* 2009).
[5] species previously sampled in the Federal District and in the state of Goiás (Delprete 2007).
[6] species previously sampled in the state of Goiás (Souza 2009).
[7] species with a wide distribution in South America (Delprete 2007).

by *cerradão*. The higher similarity between the middle and the core can be explained by the increase in humidity from the edge toward the core within a palm swamp, and by the fact that the middle and the core are less disturbed (Guimarães *et al*. 2002; Araújo *et al*. 2002). In contrast, edges are transitional zones to the adjacent phytophysiognomy and are more vulnerable to disturbances (such as cattle grazing and trampling, in palm swamps surrounded by pasture; Guimarães *et al*. 2002; Araújo *et al*. 2002) and invasion by exotic species (Oliveira *et al*. 2009). Sousa (2009) studied the soil texture in the three palm swamps evaluated in the present study and reported high sand content in the core zone, whereas the soil in the middle and at the edge had a high clay content, without significant textural differences. Therefore, we might infer that the topography is more important than is the soil texture in determining the establishment of humidity zones and the occurrence and floristic distribution of palm swamps, as Ramos *et al*. (2006) previously demonstrated in a study on the characterization of soils of palm swamps on different geomorphological surfaces in the Triângulo Mineiro region (state of Minas Gerais). From the dry edge toward the wet core within a palm swamp, there is a gradient of soil declivity and depth of the water table (Ramos *et al*. 2006; Guimarães *et al*. 2002), which alters the floristic composition of the three zones (Araújo *et al*. 2002).

Of the 310 species sampled, 79 (25%) were common to all three sites, 53 were exclusive to the palm swamp surrounded by crops, 45 were exclusive to the palm swamp surrounded by *cerradão*, and 38 were exclusive to the palm swamp surrounded by pasture. Species exclusive to the site surrounded by crops included *Alternanthera brasiliana* (Amaranthaceae); *Praxelis clematidea* (Asteraceae); *Commelina benghalensis* (Commelinaceae); *Cyperus ferax*, *C. luzulae* and *Pycreus capillifolius* (Cyperaceae); *Crotalaria velutina* and *Mimosa foliolosa* (Fabaceae); *Cuphea carthagenensis* (Lythraceae); *Corchorus hirtus* and *Melochia* sp.

(Malvaceae); *Lysimachia pumila* (Primulaceae); *Digitaria* sp.; four of the five *Eragrostis* species; and *Urochloa humidicola* (Poaceae). These were located mainly at the edge and might be considered invasive species. The diaspores of these plants originated from the surrounding crops. Species exclusive to the site surrounded by pasture included five of the seven bryophytes recorded in this study, as well as *Geissomeria pubescens* (Acanthaceae); *Cardiopetalum calophyllum* (Annonaceae); *Conyza bonariensis*, *Emilia sonchifolia* and *Vernonia polyanthes* (Asteraceae); *Bulbostylis capillaris*, *Calyptrocarya luzuliformis* and *Fimbristylis complanata* (Cyperaceae); both *Leiothrix* species and *Syngonanthus anthemidiflorus* (Eriocaulaceae); *Camptosema coriaceum* (Fabaceae); *Tetrapollinia caerulescens* (Gentianaceae); *Hyptis subrotunda* and *H. velutina* (Lamiaceae); *Utricularia huntii* (Lentibulariaceae); *Ctenium* sp., *Paspalum imbricatum* and *Schizachyrium tenerum* (Poaceae); and *Xyris tenella* (Xyridaceae). Despite the presence of invasive species, usually located at the edge, the species exclusive to this site were more characteristic of palm swamps and wetlands, such as bryophytes. This might have resulted from the fact that this site is fenced, which avoiding grazing and trampling by the cattle from the surrounding pasture.

Species that occurred only at the site surrounded by *cerrado* included *Lycopodiella caroliniana* (Lycopodiaceae); *Ophioglossum crotalophoroides* (Ophioglossaceae); *Acanthospermum australe*, *Elephantopus mollis* and *Riencourtia oblongifolia* (Asteraceae); *Fimbristylis spadicea* and *Rhynchospora marisculus* (Cyperaceae); *Eriocaulon kunthii*, *Syngonanthus fuscescens* and *S. schwackei* (Eriocaulaceae); two *Chamaecrista* species and two *Stylosanthes* species (Fabaceae), both of the Iridaceae species found in this study, the three *Genlisea* species and *Utricularia gibba* (Lentibulariaceae); *Diplusodon lanceolatus* (Lythraceae); *Anthaenantia lanata*, *Luziola bahiensis* and *Paspalum stellatum* (Poaceae); and five *Xyris* species (Xyridaceae). The palm swamp surrounded by *cerradão* and that surrounded by pasture displayed higher diversity of small, frail species, such as those of the families Lentibulariaceae, Burmanniaceae, Eriocaulaceae and Droseraceae. Conversely, in the palm swamp surrounded by crops, which was exposed to trampling by cattle and swine during the postharvest period, individuals of those families were rare or absent.

The fern *Ophioglossum crotalophoroides* (Ophioglossaceae), observed only in the palm swamp surrounded by *cerrado*, was not recorded in Goiás in the recent literature, and is considered a critically endangered species in Minas Gerais (COPAM 2008). Until now, it was sampled only in the Pantanal of the state of Mato Grosso do Sul (Cardoso *et al.* 2000), in the Federal District (Pereira *et al.* 2004; Felfili *et al.* 2007) and in the Quadrilátero Ferrífero area of Minas Gerais (Salino & Almeida 2008). Regarding the bryophytes, this study is the first record of *Leucoloma serrulatum* (Dicranaceae) and the second record of *Sphagnum cyclophyllum* (Sphagnaceae) in Goiás (see Sousa *et al.* 2010; Yano 2011).

For all three study sites, the number of species was higher in the middle than in the other zones. However, for the palm swamp surrounded by *cerradão*, the difference between the middle and the core was small in comparison with that observed for the other two sites (Tab. 1). At the three sites, only *Praxelis grandiflora* (Asteraceae) and *Setaria parviflora* (Poaceae) were exclusive to the edge, and *Cyathea atrovirens* (Cyatheaceae) were exclusive to the core. In the middle and core of the three palm swamps, we identified the species *Drosera communis* (Droseraceae); *Eriocaulon humboldtii*, *Syngonanthus caulescens*, *S. densiflorus* and *S. nitens* (Eriocaulaceae); *Utricularia nigrescens*, *U. praelonga* and *U. trichophylla* (Lentibulariaceae); *Miconia chamissois* (Melastomataceae); *Otachyrium seminudum* (Poaceae); *Cecropia pachystachya* (Urticaceae); and *Xyris jupicai*, *X. laxifolia*, *X. savanensis*, and *Xyris* sp. (Xyridaceae). In the edge and middle of the three sites, the species *Desmodium barbatum* (Fabaceae) and *Sipanea hispida* (Rubiaceae) occurred. The distribution patterns of the remaining species differed among the three sites.

The Shannon diversity index was 2.8 for the palm swamp surrounded by pasture, 3.0 for the palm swamp surrounded by crops and 3.4 for the palm swamp surrounded by *cerradão*. In the few studies on the vegetation of palm swamps, this index has not been calculated. Therefore, we cannot yet determine whether our results are representative of these physiognomies, i.e., whether they can be classified as conserved or disturbed.

In the phytosociological surveys, we sampled 130 species belonging to 80 genera and 37 families (Tab. 3). In the two sampling periods, we recorded 86 species at the site surrounded by pasture, 81 at the site surrounded by crops and 96 at the site surrounded by *cerradão*. The families with the highest cover values in October 2009 and March 2010, respectively, were as follows: Cyperaceae (37.9% and 21.4%), Melastomataceae (21.0% and 20.6%), Arecaceae (16.8% and 18.0%), and Poaceae (11.1% and 6.2%) in the palm swamp surrounded by pasture; Melastomataceae (25.6% and 37.9%), Cyperaceae (20.7% and 11.7%), Poaceae (17.5% and 19.7%), and Arecaceae (10.3% and 16.3%) in the palm swamp surrounded by crops; and Poaceae (29.3% and 26.3%), Cyperaceae (25.8% and 25.8%), Melastomataceae (18.0% and 11.8%), and Arecaceae (3.3% and 11.0%) in the palm swamp surrounded by *cerradão* (Fig. 3). For most of the families, relative frequency was higher than was relative cover, at all three study sites (Fig. 3). This might be attributable to the fact that most palm swamp species are herbs or subshrubs, small in height and diameter, and are widely distributed through the area (Munhoz & Felfili 2006).

The families for which the relative cover was higher than was the relative frequency included Melastomataceae, Arecaceae, Cyperaceae, Poaceae and Urticaceae. The

Table 2. Matrix of floristic similarity (Sørensen similarity index) between the nine zones of the palm swamps studied in the city of Bela Vista de Goiás, state of Goiás, Brazil.

	Zone								
Zone	EC	MC	CC	EP	MP	CP	ECr	MCr	CCr
EC	100.0	32.0	18.3	39.7	25.4	7.0	29.0	23.2	8.0
MC		100.0	76.4	31.5	61.7	16.4	21.5	57.9	21.6
CC			100.0	14.0	23.5	20.3	8.3	26.8	38.6
EP				100.0	53.6	18.2	26.8	29.2	14.4
MP					100.0	59.4	19.9	59.1	23.8
CP						100.0	1.9	13.6	30.3
ECr							100.0	30.8	11.7
MCr								100.0	55.3
CCr									100.0

Prefixes: E – edge; M – middle; C – core.
Suffixes: C – palm swamp surrounded by *cerrado*; P – palm swamp surrounded by pasture; Cr – palm swamp surrounded by crops.

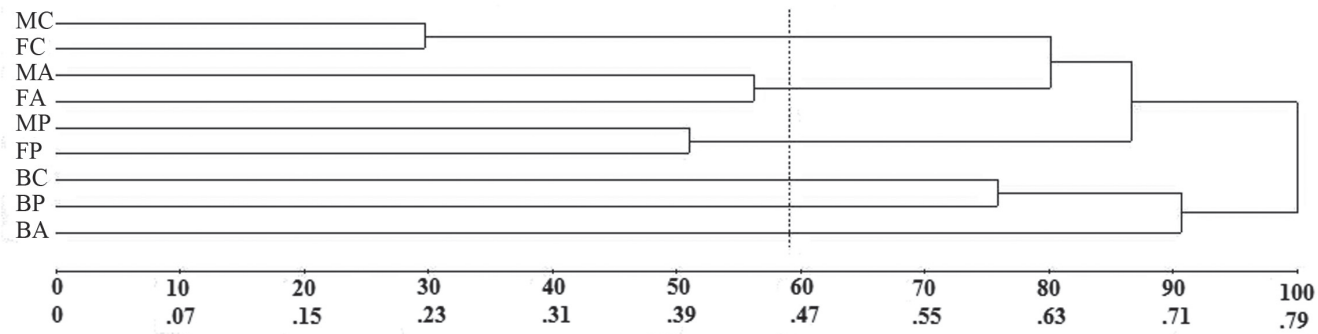

Figure 2. Dendrogram generated by the complement of the Sørensen similarity index ((D = 1 – I) between the nine zones of the palm swamps studied in the city of Bela Vista de Goiás, state of Goiás, Brazil. Prefixes: E – edge; M – middle; C – core. Suffixes: C – palm swamp surrounded by *cerradão*; P – palm swamp surrounded by pasture; Cr – palm swamp surrounded by crops. Cophenetic correlation=0.6982.

species with the highest relative cover were *Rhynchospora consanguinea*, *R. tenuis, R. globosa*, *R. robusta*, *Mauritia flexuosa*, *Miconia chamissois*, *Andropogon virgatus*, *A. bicornis*, *Rhynchanthera grandiflora* and *Saccharum angustifolium*. These species were among the ten main species in terms of the cover values, in both sampling periods; there was only one change in order from one period to the next. In addition to these species, the following species were also among the ten species with the highest relative cover: *Urospatha sagittifolia*, *Xyris* sp., *Psychotria paracatuensis, Syngonanthus densiflorus*, *S. caulescens* and *Ilex affinis* in the palm swamp surrounded by pasture; *Cecropia pachystachya*, *Hyptis lantanifolia*, *Xyris laxifolia* and *Piper aduncum* in the palm swamp surrounded by crops; and *Ludwigia nervosa*, *Xanthosoma striatipes*, *Andropogon* sp. and *Syngonanthus densiflorus* in the palm swamp surrounded by *cerradão*. Species of Poaceae and Cyperaceae usually form dense clumps or have individuals that possess rhizomes or stolons and are widely distributed in the vegetation. In contrast, the Melastomataceae species are shrubs and Arecaceae species are trees, as are Urticaceae species. This explains why relative cover was higher than was the relative frequency for those species.

There was a small difference between the two sampling periods in terms of the number of species. The number of species recorded in October 2009 and in March 2010 was, respectively, 60 and 74 in the palm swamp surrounded by *cerradão*, 65 and 72 in the palm swamp surrounded by pasture, and 61 and 57 in the palm swamp surrounded by crops. As can be seen, at the first two sites, there was a slight increase from October to March. This small variation in species number might have occurred because palm swamps have a seasonal area and a perennial area, the soil in the latter remaining water-saturated for several months of the year (Ramos 2004, Oliveira 2005).

At the study sites, the families with the highest species richness were Poaceae, Cyperaceae, Asteraceae, Eriocaulaceae, Xyridaceae, Lentibulariaceae, Melastomataceae, Ru-

Table 3. Relative frequency (RF) and relative cover (RC) of the species sampled in three palm swamps—one surrounded by pasture (PP); one surrounded by crops (PCr); and one surrounded by *cerrad*ão (PC)—in the city of Bela Vista de Goiás, state of Goiás, Brazil, in October 2009 and March 2010.

	PP				PCr				PC			
FAMILY	October 2009		March 2010		October 2009		March 2010		October 2009		March 2010	
	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF
Species	%	%	%	%	%	%	%	%	%	%	%	%
ANNONACEAE												
Xylopia aromatica									0.943	0.231	1.116	0.273
Xylopia emarginata	0.028	0.185	0.037	0.195								
APIACEAE												
Eryngium ebracteatum									0.582	0.231	0.039	0.249
AQUIFOLIACEAE												
Ilex affinis			**1.402**	**0.195**	1.780	0.264	1.304	0.356				
ARACEAE												
Urospatha sagittifolia	**1.545**	**7.394**	0.581	4.297	0.703	0.528			1.248	1.157		
Xanthosoma striatipes	0.057	0.185	0.260	1.367	0.025	**0.264**	**0.235**	1.068	2.014	4.861	0.915	3.490
ARECACEAE												
Mauritia flexuosa	**16.837**	**2.957**	**18.008**	**3.516**	**10.288**	**0.792**	**16.348**	**1.779**	**2.901**	**1.157**	**11.008**	**1.496**
ASTERACEAE												
Acanthospermum australe											0.225	0.249
Achyrocline alata	0.045	0.185	0.049	0.195	0.347	0.264						
Adenostemma suffruticosum							0.357	0.356	0.085	0.231		
Ageratum conyzoides					0.127	0.264						
Emilia sonchifolia					0.178	0.264						
Eupatorium amygdalinum									0.092	0.231		
Eupatorium tremulum	0.142	0.185	0.268	0.195					0.922	0.463	0.504	0.249
Mikania officinalis					0.042	0.264			0.738	1.852	0.093	0.249
Praxelis kleinioides							0.043	0.356			0.240	0.499
Vernonia ararana			0.033	0.195	1.415	1.319	0.313	1.068	0.426	0.926	0.798	1.496
Vernonia helophila					0.178	0.264						
BURMANNIACEAE												
Burmannia flava			0.020	0.391			0.017	0.356	0.050	0.463	0.287	0.997
CHLORANTHACEAE												
Hedyosmum brasiliense							0.191	0.356				
CYATHEACEAE												
Cyathea atrovirens	0.545	0.185	0.939	0.391	0.737	0.264						
CYPERACEAE												
Ascolepis brasiliensis			0.016	0.391								
Bulbostylis sellowiana	0.106	0.185	0.833	2.539	0.703	0.792	0.070	0.356			0.419	0.499
Cyperus haspan	0.293	1.109	0.199	0.195	1.364	2.375			0.270	0.463	0.233	0.499
Cyperus lanceolatus					0.551	0.792			0.191	0.231		
Eleocharis capillacea			0.199	0.391	0.051	0.264			0.035	0.231		
Eleocharis geniculata					0.915	1.583	0.183	0.356				
Eleocharis nuda					0.034	0.264	0.339	0.356			0.023	0.249
Eleocharis obtusetrigona											0.395	0.499
Fimbristylis autumnalis	0.130	0.185			0.576	0.528	1.191	2.135	0.589	0.926		

Continues

Table 3. Continuation.

FAMILY	PP				PCr				PC			
	October 2009		March 2010		October 2009		March 2010		October 2009		March 2010	
	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF
Species	%	%	%	%	%	%	%	%	%	%	%	%
Lipocarpha humboldtiana	0.037	0.370	0.215	1.758	0.051	0.264	0.043	0.356			0.318	0.499
Rhynchospora consanguinea	**32.622**	**20.148**	**6.813**	**4.492**	**3.585**	**2.902**	0.530	0.356	**21.447**	**14.120**	**3.977**	**1.247**
Rhynchospora emaciata	0.033	0.185										
Rhynchospora globosa	**1.923**	**1.848**	0.573	1.562			0.096	0.356	**1.908**	**2.546**	**5.171**	**4.488**
Rhynchospora robusta	**2.415**	**3.327**	1.008	2.344	**11.483**	**10.026**	**4.565**	**7.117**	1.539	1.157	2.357	2.493
Rhynchospora tenuis			**11.260**	**9.766**	0.712	0.792	**4.452**	**4.626**			**12.155**	**7.480**
Rhynchospora velutina	0.215	0.370			0.458	0.528						
Scleria distans	0.065	0.370	0.183	1.367			0.139	0.356			0.163	0.249
Scleria hirtella	0.110	0.185	0.065	0.586	0.229	0.264			0.369	0.694	0.496	0.499
Scleria reticularis							0.122	0.356			0.132	0.249
DENNSTAEDTIACEAE												
Lindsaea lancea	0.012	0.185										
DILLENIACEAE												
Curatella americana					0.441	0.264						
DROSERACEAE												
Drosera communis			0.012	0.195	0.051	0.264			0.050	0.463	0.116	0.997
ERIOCAULACEAE												
Eriocaulon humboldtii	0.451	1.294					0.183	0.356	0.865	1.852		
Eriocaulon linearifolium			0.293	1.367							1.202	2.244
Syngonanthus anthemidiflorus			0.305	4.883								
Syngonanthus appressus	0.024	0.185							0.184	0.926		
Syngonanthus caulescens	1.240	5.545	**1.085**	**3.906**	0.271	0.528			0.660	2.083		
Syngonanthus densiflorus	0.695	1.479	**1.841**	**2.539**	0.737	1.055	0.513	1.423	1.121	2.546	**3.271**	**5.236**
Syngonanthus gracilis	0.024	0.185					0.130	1.068	0.752	4.630	0.271	1.496
Syngonanthus nitens			0.085	0.391							0.140	0.249
Syngonanthus schwackei	0.122	0.924									0.070	0.997
EUPHORBIACEAE												
Croton sclerocalyx									0.128	0.231	0.047	0.249
FABACEAE												
Aeschynomene paniculata			0.122	0.195								
Desmodium barbatum	0.033	0.185	0.061	0.195	0.339	1.055	0.174	0.712			0.147	0.499
GENTIANACEAE												
Curtia tenuifolia											0.155	0.748
Irlbachia alata	0.484	2.403	0.122	1.367	0.237	0.792	0.235	1.423	0.426	1.157	0.667	1.995
Schultesia aptera			0.020	0.195					0.170	0.463		
Schultesia gracilis			0.045	0.391								
IRIDACEAE												
Sisyrinchium vaginatum									0.099	0.463	0.085	0.499
LAMIACEAE												
Hyptis lantanifolia					**2.737**	**5.013**	0.557	1.423	0.206	0.231	0.388	0.499
Hyptis tenuifolia			0.073	0.195	0.339	0.528			0.241	0.231		
Hyptis velutina									0.227	0.231		

Continues

Table 3. Continuation.

FAMILY	PP				PCr				PC			
	October 2009		March 2010		October 2009		March 2010		October 2009		March 2010	
	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF
Species	%	%	%	%	%	%	%	%	%	%	%	%
LENTIBULARIACEAE												
Genlisea filiformis											0.093	0.249
Genlisea repens											0.279	0.997
Utricularia hispida			0.033	0.586					0.106	0.463		
Utricularia praelonga											0.016	0.249
Utricularia triloba	0.354	0.370	0.370	1.758			0.017	0.356	0.035	0.463	0.806	1.496
Utricularia sp.			0.016	0.586								
LIMNOCHARITACEAE												
Limnocharis flava									0.461	0.231		
LYCOPODIACEAE												
Lycopodiella alopecuroides	0.715	1.848	0.020	0.391	0.203	0.528			0.199	0.694	0.543	1.745
Lycopodiella caroliniana	0.045	0.185							0.078	0.463		
Lycopodiella cernua	1.232	3.512	1.069	4.687	0.432	1.319	0.591	2.491	1.043	1.620	2.023	4.737
MALVACEAE												
Waltheria tomentosa	0.069	0.185	0.049	0.195	1.890	2.902	1.174	3.203	0.184	0.463	1.302	2.743
MELASTOMATACEAE												
Desmoscelis villosa			0.012	0.195	1.034	5.013	0.209	1.423	0.227	1.157	0.047	0.249
Macairea radula	0.374	0.185					0.174	0.712				
Miconia chamissois	**16.545**	**8.688**	**18.337**	**8.984**	**10.822**	**5.013**	**10.930**	**5.694**	**9.291**	**4.167**	**7.775**	**3.740**
Miconia elegans	0.394	0.185										
Microlicia euphorbioides	0.598	1.848	0.858	2.148			0.304	0.712	1.184	0.926	0.318	0.499
Microlicia helvola	0.163	0.555	0.187	0.195					1.071	0.694		
Rhynchanthera grandiflora	**2.695**	**3.327**	**1.130**	**2.734**	**13.797**	**12.929**	**26.261**	**16.014**	**6.121**	**6.019**	**3.597**	**4.986**
Trembleya phlogiformis	0.195	0.555	0.130	0.586					0.085	0.231	0.078	0.499
MELIACEAE												
Guarea macrophylla	0.317	0.370	1.057	0.391								
OCHNACEAE												
Sauvagesia racemosa	0.370	2.033	0.285	2.734	0.754	2.902	0.461	2.847	0.362	1.389	0.372	0.997
ONAGRACEAE												
Ludwigia nervosa	1.028	3.142	0.630	1.953	1.415	2.902	0.391	1.423	**3.560**	**3.935**	1.380	2.244
PIPERACEAE												
Piper aduncum					1.958	1.319	**1.704**	**1.068**	0.546	1.157	1.256	0.748
Piper fuligineum									0.099	0.231		
PLANTAGINACEAE												
Scoparia dulcis					0.068	0.264						
POACEAE												
Andropogon bicornis	**2.057**	**1.848**	0.980	1.367	**6.788**	**3.958**	**5.591**	**4.982**	**10.752**	**3.935**	**6.713**	**2.743**
Andropogon leucostachyus			0.012	0.195	0.492	0.264	0.096	0.356	0.184	0.231	0.333	0.249
Andropogon virgatus	**4.850**	**5.176**	1.016	3.125	**6.932**	**4.222**	**2.922**	**3.203**	**11.326**	**5.556**	**6.426**	**4.238**
Andropogon sp. 1	1.423	1.664			0.602	0.528	0.252	0.356	1.319	2.315		
Andropogon sp. 2							0.130	0.356	0.603	0.231		

Continues

Table 3. Continuation.

	PP				PCr				PC			
FAMILY	October 2009		March 2010		October 2009		March 2010		October 2009		March 2010	
	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF
Species	%	%	%	%	%	%	%	%	%	%	%	%
Andropogon sp. 6			0.992	2.344			0.357	1.068	**1.972**	**2.315**	1.287	1.995
Anthaenantia lanata	0.317	0.555										
Echinolaena inflexa	0.146	0.370	0.398	0.391			0.104	0.356	0.177	0.463	2.829	1.745
Elionurus muticus					0.203	0.264						
Eragrostis sp. 1					0.085	0.792	0.217	0.712				
Eragrostis sp. 2							0.217	0.712				
Eriochrysis cayennensis	0.707	0.924	0.224	0.781			0.583	0.712	0.652	1.157	0.868	1.745
Hyparrhenia bracteata	0.695	0.555	0.081	0.195	0.144	0.264			1.851	1.157		
Ichnanthus procurrens									0.298	0.231	0.147	0.249
Luziola bahiensis											0.256	0.249
Melinis minutiflora	0.537	0.370			0.729	0.528						
Otachyrium seminudum			0.020	0.195			1.183	1.423			1.147	1.247
Panicum laxum			0.191	0.391			0.643	1.423				
Panicum parvifolium	0.037	0.185	0.033	0.195	1.297	1.583	0.643	1.779	0.121	0.463		
Saccharum angustifolium	0.313	0.555	**2.065**	**2.148**	0.220	0.264	**6.339**	**3.203**			**6.302**	**3.490**
Urochloa decumbens			0.167	0.195			0.426	1.068				
POLYGALACEAE												
Polygala leptocaulis											0.039	0.249
Polygala longicaulis											0.023	0.249
Polygala tenuis									0.220	0.926	0.457	0.997
PTERIDACEAE												
Pityrogramma calomelanos	0.057	0.185	0.126	0.195	0.322	0.264	0.383	0.712				
RUBIACEAE												
Alibertia edulis									0.177	0.231	0.101	0.249
Psychotria paracatuensis	0.370	0.185	**2.215**	**0.391**								
Sipanea hispida					0.161	0.528						
Spermacoce schumannii	0.134	0.739	0.069	0.977	0.331	1.055	0.817	2.847	0.525	0.694	0.318	0.997
SANTALACEAE												
Phoradendron crassifolium	0.053	0.185	0.089	0.195	0.034	0.264						
THELYPTERIDACEAE												
Thelypteris biformata									0.071	0.231		
Thelypteris eriosora											0.101	0.249
Thelypteris opposita	0.187	0.185	0.598	0.586					0.638	0.463	0.372	0.499
Thelypteris serrata	0.346	0.185	1.024	0.781	0.161	0.264	0.452	0.712	0.404	0.231	1.977	1.247
URTICACEAE												
Cecropia pachystachya	0.260	0.370	0.541	0.391	**3.856**	**0.792**	**2.774**	**1.423**	0.567	0.463	0.659	0.249
XYRIDACEAE												
Abolboda poarchon	0.045	0.185	0.012	0.195							0.186	0.249
Xyris laxifolia	0.337	1.664	0.183	1.367	**2.263**	**8.179**	1.130	6.050	0.872	2.546	0.938	3.490
Xyris lutescens	0.154	0.555	0.207	0.977					0.489	1.157	0.310	0.997
Xyris savanensis	0.106	0.555	0.033	0.391	1.186	4.485	0.139	1.423	0.418	2.083	0.147	0.997
Xyris tortula											0.279	0.748
Xyris sp. 1	**1.545**	**3.882**	0.439	1.758	0.136	0.792	0.052	0.356	0.234	0.926	0.279	0.499
Total species	64		73		61		58		71		74	

Bold indicates the ten main species with the highest RC per period and per area.

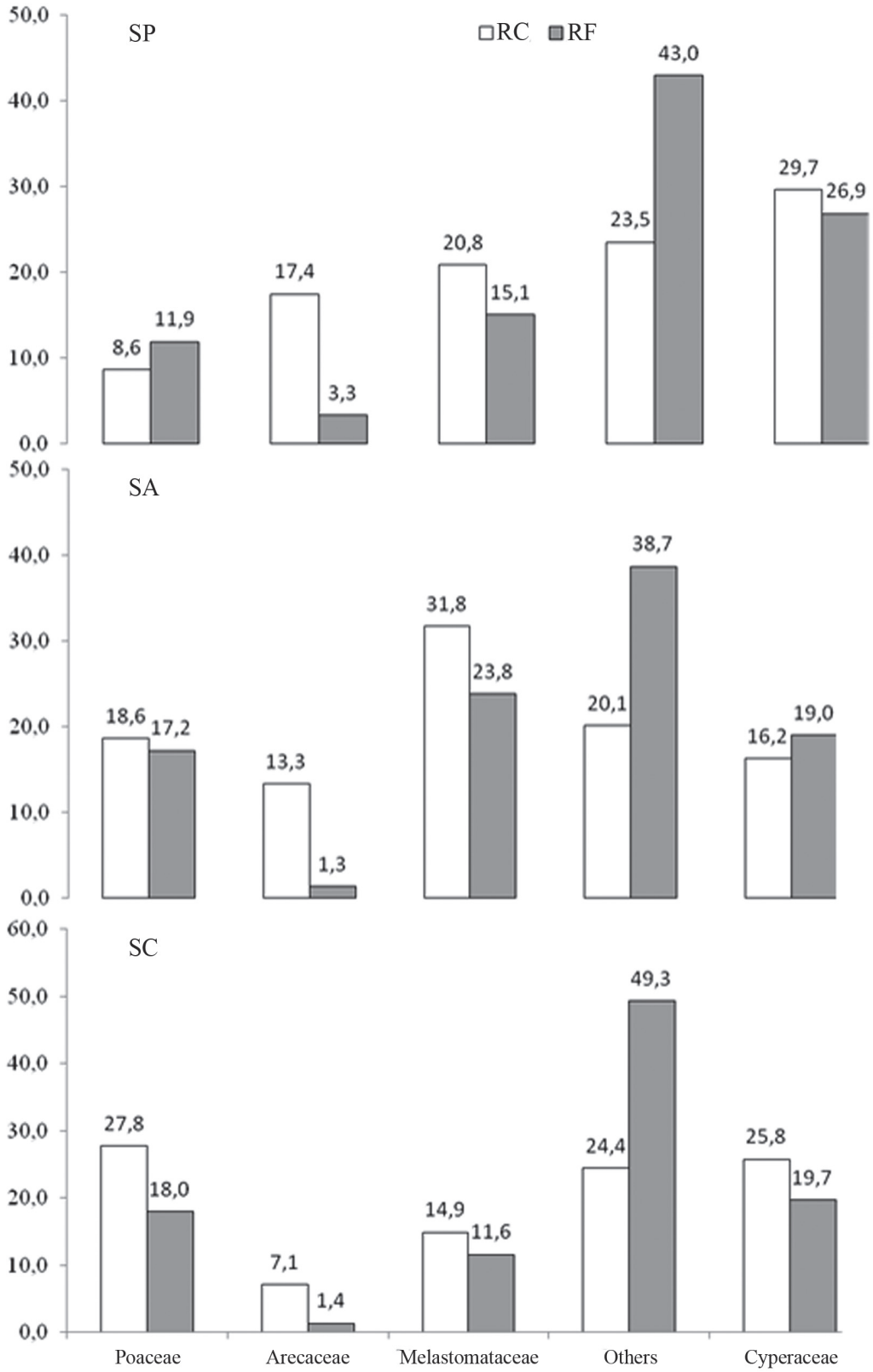

Figure 3. Distribution of cover values and relative frequencies (means of the two sampling periods), by family, for the flora of three palm swamps in the city of Bela Vista de Goiás, state of Goiás, Brazil.
PP – palm swamp surrounded by pasture; PCr – palm swamp surrounded by crops; PC – palm swamp surrounded by *cerradão*.

biaceae and Fabaceae. We found that the floristic similarity was greatest between the middle and core zones within a palm swamp and lowest between the edge zones of different palm swamps. However, additional studies comparing different areas for larger periods of time are needed in order to determine whether there are patterns in the spatial and temporal distribution of plant species in palm swamps, as well as to quantify the effect that human disturbance has on these environments.

Although the herb-subshrub layer is dominant in several phytophysiognomies in the *Cerrado* and exhibits high species richness, as in the case of palm swamps, its vegetation has been poorly studied. This lack of data impedes the enforcement of public policies for the conservation and sustainable management of palm swamps. These environments support significant biodiversity and a rich flora. Because palm swamps occur in areas where there are natural springs, protecting these swamps also protects water resources.

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