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Floristic composition of a freshwater swamp forest remnant in southeastern Brazil

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Abstract: The floristic composition in a freshwater swamp forest remnant located in the municipality of Botucatu, São Paulo state, Brazil, was studied. Only Angiosperms were collected in the area by means of random walks. A total of 92 species were registered. The families with greater species richness were: Orchidaceae (17 species), Rubiaceae (8) and Myrtaceae (5). The arboreal component was predominant. The profile diagram of the vegetation showed a well-defined stratification, with a continuous canopy and an inferior tree layer composed mainly by individuals of *Euterpe edulis* Mart.. A comparison among the angiosperms of the study area and those of ten swamp forests in São Paulo state suggests that the geographic position and other ecologic peculiarities of these forests, besides soil flooding, are factors that can influence their similarity concerning the floristic composition.

Introduction

Among the several vegetation formations found in Brazil, the freshwater swamp forests are very peculiar and occur in permanently flooded soil. These forests have characteristic structure and floristic composition, and cover a quite limited area, considering the entire country (Marques *et al*. 2003). The swamp forests are composed by species that occur in confined areas and this make the populations more vulnerable to extinction in the short term (Rodrigues and Leitão-Filho 2001). In these areas, environmental factors, like water stress, select species which form large populations, resulting in the occurrence of lower species diversity (Toniato *et al.* 1998; Ivanauskas *et al.* 1997; Costa *et al.* 1997).

The protection of swamp forests is highly important, considering that they are so essential to the ecological balance, being generally related to the maintenance of springs and other water bodies. Studies on reforestation and dynamics of fragmented vegetation areas depend on data provided by surveys and ecological evaluations made at different times, which can provide information on the dynamic of ecological changes in remnants of natural vegetation (Kronka *et al*. 2005).

Considering this, a floristic inventory was performed to provide a check list of the Angiosperms present in a freshwater swamp forest remnant, in the municipality of Botucatu, central-west region of São Paulo state, Brazil. This study was performed aiming to add information to the knowledge of the swamp forests floristic, especially in relation to the non-arboreal species, which are less well-known than the arboreal components of the studied vegetation.

Materials and Methods

The studied swamp forest remnant is located at coordinates 22°52'52" S and 48°29'32" W, in the District of Rubião Junior, Botucatu Municipality, at the central-west region of São Paulo State, southeastern Brazil. The municipality covers an area of 1495 km^2, and has three distinct physiographic regions: one located in the area called Peripheral Depression, with altitudes ranging from 400 to 600 meters, an intermediate region (or transition zone) composed by a slope, and one located at the top of the slope, called "Cuesta" region, which altitude varies from 700 to 900 meters (Castro 1966). In the latter region lies the study area, which is surrounded by pastures and old fields, with soil classified as Oxisol, sandy phase, in the points with higher topography, and Hydromorphic alluvial soil in the lower points (Comissão de Solos 1960). The sample area is located in a slight slope between 853 and 862 meters of altitude, where the soil is constantly wet due to the upwelling of water-holes and the intake of water from a nearby stream. These features allow the classification of the vegetation as a freshwater swamp forest permanently flooded (Rodrigues and Leitão-Filho 2001).

The climate of the region is Cfa according to Koeppen classification, that is, warm temperate (mesothermal) wet, as determined by Cunha and Martins (2009). February is the hottest month with an average temperature of 23.1°C, and July is the coldest month with an average temperature of 17.1°C. The highest average rainfall generally occurs in January and the lowest generally occurs in August. The average annual temperature and precipitation, considering a 36-year period (1971 to 2006) were 20.3°C and 1428.4 mm, respectively (Cunha and Martins 2009).

The floristic survey was carried out from November 2009 to October 2010 on a bi-monthly basis in an approximately 1 ha area of forest. All the Angiosperm species preferably in reproductive phase, present in that area, were collected and identified using specialized literature and comparison with the Herbarium BOTU collection, where the voucher specimens were deposited ("Irina Delanova Gemtchújnicov" Herbarium, Botucatu Biosciences Institute, UNESP). The adopted classification system was that recommended by the Angiosperm

Phylogeny Group III (APG III 2009). The plants habits were defined according to the descriptions found in Gonçalves and Lorenzi (2007).

Inside the sampled area a 30 x 5 m transect was delimited and all the woody plants with stem perimeter at breast height equal or superior to 12 cm were recorded and drawn, in order to prepare a profile diagram, according to Goldsmith *et al*. (1986).

Aiming to estimate the floristic similarity of the study area with 11 other surveys found in the literature, performed previously in swamp forests located in São Paulo state, a presence/absence matrix including only the arboreal components of the vegetation was elaborated to calculate the Jaccard similarity index (JSI) according to Mueller-Dombois and Ellenberg (1974) and to perform a cluster analysis using this Index and the UPGMA algorithm for the dendrogram preparation (Sneath and Sokal 1973).

Results and Discussion

A total of 92 species of angiosperms were collected and identified at least at family level. Among these, 68 were identified at the species level, seven had specific identification to be confirmed and 17 species were identified only to genus level (Table 1). In this inventory 47 families were sampled and Orchidaceae and Rubiaceae were represented by larger numbers of species, 17 and eight respectively. In descending order, after Orchidaceae and Rubiaceae which together account for 27% of the total of species, the following families can be pointed out: Myrtaceae (five species), Bromeliaceae and Meliaceae (four species each), Apocynaceae and Cyperaceae (three species each), Arecaceae, Asteraceae, Fabaceae, Melastomataceae, Myrsinaceae, Piperaceae, Rutaceae and Styracaceae (two species each), and other 32 families present in the area with only one species each.

The study area presented high family richness, especially concerning the woody components, as commonly found in swamp forests (Ivanauskas *et al*. 1997, Marques *et al*. 2003, Torres *et al*. 1994). In total, each family was represented by few species or even by just one species, as observed in 32 families (68% of the total number of families). Only the Orchidaceae and Rubiaceae were different from this pattern, being represented by a greater number of species.

The trees predominated in the area with 40 species sampled (44%). The epiphytes were the second most represented with 15 species (16%), followed by herbs with 14 species (15%), lianas with 11 species (12%), shrubs with 10 species (11%) and also two parasites (2%) (Table 1).

There are few data on the non-arboreal components of the swamp forests in São Paulo State. In fact, the comparable data (M. Carboni unpublished data; Spina *et al.* 2001; M.E.S. Paschoal unpublished data) indicate that several of these species were registered only in the present survey. There are some species that were registered in common, like *Voyria aphylla* recorded by Paschoal (unpublished data), *Phoradendron piperoides* by Carboni (unpublished data) and *Piper aduncum* by Spina *et al.* (2001), besides some Orchidaceae registered by Carboni (unpublished data) and others by Spina *et al.* (2001). There are also similarities in relation to some genera of the non-arboreal species among these surveys but the species occurred only in one location. This seems to indicate that the floristic composition of the non-arboreal species in swamp forests may also be peculiar but the scarcity of data is an obstacle to further considerations.

According to Teixeira and Assis (2005) the species *Calophyllum brasiliense*, *Protium spruceanum*, *Cedrela odorata*, *Dendropanax cuneatus*, *Magnolia ovata*, *Styrax pohlii* and *Tapirira guianensis*, all together, constitute an important group that defines a similar structure among the swamp forests of the upcountry of the São Paulo state. These forests are characterized by the existence of few species that concentrate many individuals in the total community. Among these seven species, only *Cedrela odorata* was not found in the Botucatu swamp forest. *Calophyllum brasiliense*, *Dendropanax cuneatus*, *Magnolia ovata*, *Styrax pohlii* and *Tapirira guianensis* occurred in the swamp forest in Botucatu, and also were present in other 11 surveys performed in swamp forests in the upcountry of the São Paulo state (Table 2).

Despite the fact that these swamp forests possess a peculiar group of arboreal species, the comparison among different surveys (Figure 1) evidences that in some cases there is a low floristic similarity, considering that the values obtained for the Jaccard similarity index (JSI) can be considered low, according to Mueller-Dombois and Ellenberg (1974), that is, inferior to 25%. This fact has been already reported elsewhere (Torres *et al*. 1994; Ivanauskas *et al*. 1997). The several other species, which occur less frequently in swamp forests, contribute to the greater dissimilarity among these formations. It is known that the presence or absence of these other species is related to environmental factors such as canopy openness, variations in topography, level of soil flooding (Teixeira and Assis 2009), and soil type (Teixeira and Assis 2009; Kotchetkoff-Henriques *et al*. 2005). Therefore, it is possible to find high similarity between fragments inserted in remote regions or, in the opposite way, dissimilarity between fragments located in nearby locations, as is the case of Itatinga and Botucatu, and the areas at Campinas Municipality (Campinas 1/3 and 2). The Botucatu forest was most similar to the Rio Claro and Bauru forests and the greatest dissimilarity was obtained in relation to Brotas (1), Itatinga and Ribeirão Preto forests. The dendrogram produced by the cluster analysis lead to the consideration that both the geographic position and other ecologic peculiarities of the swamp forests, besides soil flooding, might be factors that can influence their floristic composition.

The presence/absence matrix composed to perform the similarity analysis included 227 tree species, among which eight appeared only in the swamp forest in Botucatu. They are: *Esenbeckia grandiflora*, *Eugenia paracatuana*, *Metrodorea nigra*, *Myrceugenia ovata, Neomitranthes glomerata*, *Ocotea aciphylla*, *Styrax leprosus* and *Trichilia elegans*. Most of these species (except *Eugenia paracatuana* and *Myrceugenia ovata*) were previously referred by Rodrigues and Nave (2001) to be associated with some kind of riparian vegetation, although not specifically with swamp forests. Later, Baptista-Maria

et al. (2009) quoted *Eugenia paracatuana* as present in riparian forests of Central Brazil and *Myrceugenia ovata* was recorded in alluvial forests in southeastern Brazil (Silva *et al.* 2007). These records seem to indicate the association of these species with riparian vegetation, and their record in the present survey may be due to the fact that the area is located on a slope and there were some spots in the upper side of it where the soil was not so flooded. Their presence also reflects the influence of the surrounding vegetation (riparian and seasonal semidecidual forests) on the floristic composition of the study area, as previously observed by Ivanauskas *et al.* (1997) and Costa *et al.* (1997) elsewhere.

The genus *Zanthoxylum* (Rutaceae) can be frequently found in the swamp forests (Kotchetkoff-Henriques *et al*. 2005; Toniato *et al*. 1998; Torres *et al*. 1994), but was absent in the present study, although other Rutaceae genera were present (see Table 1). Another interesting fact was that the Fabaceae are generally very significant both in number of species and density of individuals in the neotropical vegetation and also in the swamp forests in São Paulo state (Teixeira and Assis 2009). However it was represented only by two species (*Clitoria* sp. and *Inga marginata*) in the present survey.

The profile diagram of the vegetation revealed a well-defined stratification, with a continuous canopy and an inferior tree layer composed mainly by individuals of *Euterpe edulis* Mart (Figure 2), a species identified as vulnerable (SMA 2006) due to its abusive exploitation to collect the apical edible meristem of this palm tree (Souza and Lorenzi 2008).

The continuous canopy layer was composed by trees measuring 13 to 17m tall, and these values are higher than those observed by Toniato *et al.* (1998) who found the canopy tree ranging between 7 and 9 m tall, but was more similar to the findings of Costa *et al.* (1997). A discontinuous layer composed by small trees and several individuals of *Euterpe edulis*, with heights ranging between 4 and 10m was found under the canopy. A large quantity of *Euterpe edulis* seedlings was present especially in flooded areas. These data agree with Teixeira and Assis (2005) who found *E. edulis* to be the most important species in a swamp forest located in Rio Claro municipality. Some emerging trees belonging to the species *Calophyllum brasiliense*, *Magnolia ovata* and *Handroanthus umbellatus* also occurred with individuals reaching 20m high. In the higher position within the surveyed slope, where some spots with more drained soil could be found, some individuals of *Cariniana estrellensis* exceeding 20m tall were also observed. This species is frequently associated with riparian (Rodrigues and Nave 2001) and seasonal semidecidual forests (Ramos *et al.* 2008) and may be one more case of intersection with the neighboring vegetation.

This survey confirmed the low floristic similarity that seems to be very frequent among the São Paulo state swamp forests and to highlight the need to conserve even small remnants of this vegetation, considering the species richness and regional peculiarities of the floristic composition. Another significant aspect is related to the occurrence of a well established population of *Euterpe edulis*, a threatened species, which must be preserved in the location and serve possibly as a source for future conservation programs.

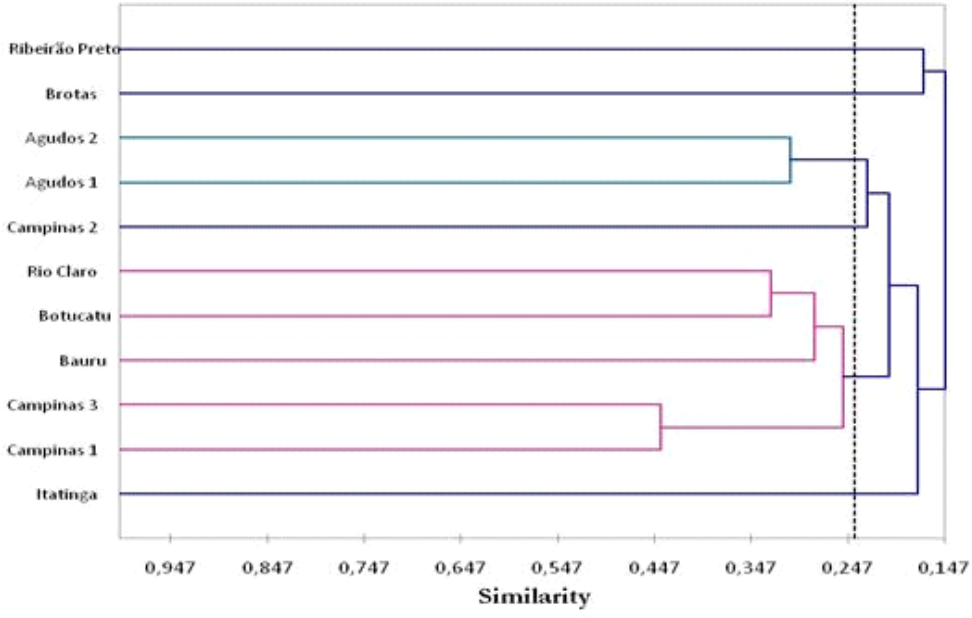

Figure 1. Cluster analysis using the Jaccard similarity index among twelve freshwater swamp forest areas in São Paulo state, southeastern Brazil. The areas are described in Table 2.

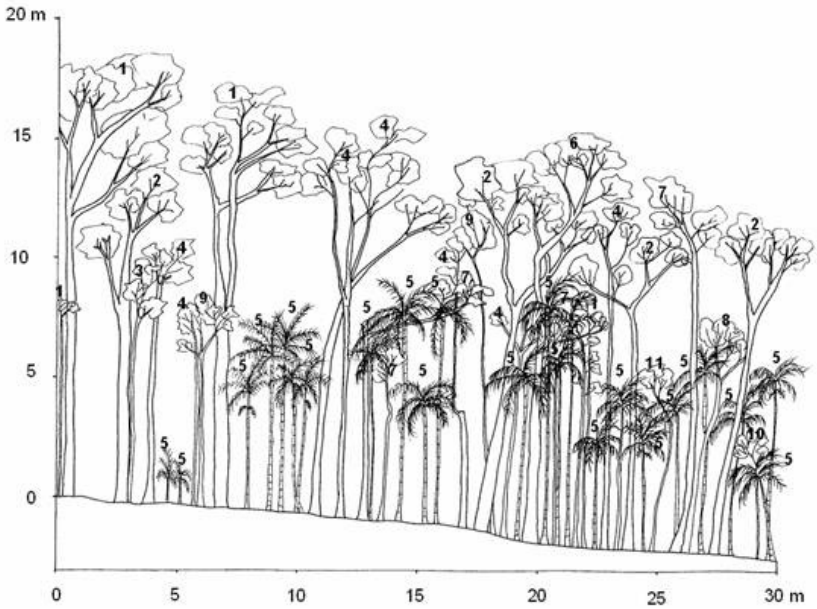

Figure 2. The arboreal components of a freshwater swamp forest fragment represented by a profile diagram. Horizontal distances from 0 to 30 m, down toward the water course. Vertical line corresponds to the plants height. 1. *Calophyllum brasiliense*; 2. *Handroanthus umbellatus*; 3. Unidentified species; 4. *Protium spruceanum*; 5. *Euterpe edulis*; 6. *Tapirira guianensis*; 7. *Dendropanax cuneatus*; 8. *Magnolia ovata*; 9. *Guarea kunthiana*; 10. *Myrceugenia ovata*; 11. *Eugenia* sp..

Table 1. Species recorded on 1 ha of freshwater swamp forest located in Botucatu, São Paulo state, southeastern Brazil. * Reproductive material not collected.

FAMILY/SPECIES	POPULAR NAME	HABIT	VOUCHER NUMBER
Acanthaceae			
Ruellia sp.	-	Shrub	27665
Amaranthaceae			
Hebanthe paniculata Mart.	-	Liana	27667
Anacardiaceae			
Tapirira guianensis Aubl.	peito-de-pomba	Tree	27668
Apocynaceae			
Peltastes peltatus (Vell.) Woodson	cipó-bênção	Liana	27672
Marsdenia cf. *macrophylla*	-	Liana	27670
Oxypetalum cf. *urbanianum*	-	Liana	27671
Araceae			
Philodendron sp.	filodendro	Epiphyte	27673
Araliaceae			
Dendropanax cuneatus Decne. and Planch.	maria-mole	Tree	27674
Arecaceae			
Euterpe edulis Mart.	palmito-juçara	Tree	27675
Syagrus romanzoffiana (Cham.) Glassman	jerivá	Tree	*
Aristolochiaceae			
Aristolochia sp.	-	Liana	27676
Asteraceae			
Dasyphyllum brasiliense (Spreng.) Cabrera	guaiapá-parreira	Liana	27678
Piptocarpha aff. *reitziana*	-	Tree	27679
Balanophoraceae			
Scybalium fungiforme Schott and Endl.	-	Holoparasite	27766
Bignoniaceae			
Handroanthus umbellatus (Sond.) Mattos	ipê-amarelo-do-brejo	Tree	27695
Bromeliaceae			
Aechmea cf. *bromeliifolia* (Rudge) Baker	bromélia	Epiphyte	27699
Billbergia sp.	-	Epiphyte	27698
Tillandsia geminiflora Brongn.	cravo-do-mato	Epiphyte	27700
Tillandsia tenuifolia L.	tilandsia	Epiphyte	27697
Burseraceae			
Protium spruceanum (Benth.) Engl.	almecegueira	Tree	27701
Celastraceae			
Hippocratea volubilis L.	fava-de-arara	Liana	27702
Chloranthaceae			
Hedyosmum brasiliense Mart ex Miq.	chá-de-soldado	Tree	27703

Table 1. *Continued.*

FAMILY/SPECIES	POPULAR NAME	HABIT	VOUCHER NUMBER
Clusiaceae			
Calophyllum brasiliense Cambess.	guanandi	Tree	27704
Cyperaceae			
Calyptrocarya longifolia (Rudge) Kunth	-	Herb	27705
Rhynchospora exaltata Kunth	capim-navalha	Herb	27706
Scleria cf. *mitis* P.J.Bergius	-	Herb	27707
Euphorbiaceae			
Croton floribundus Lund ex Didr.	capixingui	Tree	27708
Fabaceae			
Inga marginata Willd.	ingá-de-folha-lisa	Tree	27709
Clitoria sp.	-	Liana	27710
Gentianaceae			
Voyria aphylla (Jacq.) Pers.	erva-fantasma	Herb	27711
Lauraceae			
Ocotea aciphylla (Nees) Mez	canela-amarela	Tree	27712
Lecytidaceae			
Cariniana estrellensis (Raddi) Kuntze	jequitibá-branco	Tree	27713
Magnoliaceae			
Magnolia ovata (A. St.-Hil.) Spreng.	magnólia-do-brejo	Tree	27692
Malpighiaceae			
Heteropterys sp.	-	Liana	27693
Malvaceae			
Pseudobombax grandiflorum (Cav.) A.Robyns	embiruçu	Tree	27691
Marantaceae			
Ctenanthe sp.	-	Herb	27690
Melastomataceae			
Miconia hymenonervia (Raddi) Cogn.	-	Shrub	27688
Miconia sp.	-	Herb	27689
Meliaceae			
Guarea kunthiana A.Juss.	marinheiro	Tree	27682
Guarea macrophylla Vahl	marinheiro-do-brejo	Tree	27683
Trichilia elegans A.Juss.	catiguazinho	Tree	27684
Trichilia pallida Sw.	catiguá	Tree	27680
Monimiaceae			
Mollinedia schottiana (Spreng.) Perkins	pimenteira	Tree	27718
Moraceae			
Ficus insipida Willd.	figueira	Tree	27761
Myrsinaceae			
Ardisia ambigua Mart.	capororoquinha	Tree	27764
Myrsine guianensis (Aubl.) Kuntze	capororoca	Tree	27765
Myrtaceae			
Eugenia florida DC.	guamirim	Tree	27720
Eugenia hyemalis Cambess.	guamirim-miúdo	Tree	27719
Eugenia paracatuana O. Berg	-	Tree	27722
Myrceugenia ovata (Hook. and Arn.) O. Berg	-	Tree	27721
Neomitranthes glomerata (D. Legrand) Govaerts	-	Tree	27723
Orchidaceae			
Acianthera aphthosa (Lindl.) Pridgeon and M.W. Chase	-	Epiphyte	27748
Aspidogyne aff. *metallescens* (Barb. Rodr.) Garay	-	Herb	27741
Baskervilla sp.	-	Herb	27732
Brasiliorchis gracilis Lodd.	-	Epiphyte	27743
Cattleya loddigesii Lindl.	-	Epiphyte	27742
Cyclopogon sp. 1	-	Herb	27727
Cyclopogon sp. 2	-	Herb	27746
Encyclia patens Hook.	-	Epiphyte	27749
Isochilus linearis (Jacq.) R. Br.	-	Epiphyte	27739
Oeceoclades maculata (Lindl.) Lindl.	-	Herb	27740
Oncidium crispum Lodd. ex Lindl.	-	Epiphyte	27737
Oncidium pumilum Lindl.	-	Epiphyte	27730
Polystachya estrellensis Rchb. f.	-	Epiphyte	27744
Psilochilus modestus Barb. Rodr.	-	Herb	27729
Sauroglossum nitidum Schltr.	-	Herb	27745

Table 1. *Continued.*

FAMILY/SPECIES	POPULAR NAME	HABIT	VOUCHER NUMBER
Specklinia cf. *uniflora* (Lindl.) Pridgeon and M.W. Chase	-	Epiphyte	27771
Zygostates lunata Lindl.	-	Epiphyte	27731
Piperaceae			
Piper aduncum L.	pimenta-de-macaco	Shrub	27716
Piper sp.	-	Shrub	27717
Poaceae			
Parodiolyra micrantha (Kunth) Davidse and Zuloaga	-	Herb	27715
Rosaceae			
Prunus myrtifolia (L.) Urb.	pessegueiro-bravo	Tree	27753
Rubiaceae			
Faramea torquata Müll. Arg.	-	Tree	27763
Ixora venulosa Benth.	ixora-do-mato	Tree	27759
Palicourea macrobothrys (Ruiz and Pav.) Roem. et Schult.	-	Shrub	27724
Palicourea marcgravii A. St.-Hil.	erva-de-rato	Shrub	27757
Psychotria vellosiana Benth.	café-do mato	Tree	27756
Psychotria carthagenensis Jacq.	-	Shrub	27760
Psychotria sp.	-	Shrub	27725
Chomelia sp.	-	Shrub	27754
Rutaceae			
Esenbeckia grandiflora Mart.	pau-de-cotia	Tree	27758
Metrodorea nigra A. St.-Hil.	carrapateira	Tree	27752
Salicaceae			
Casearia sylvestris Sw.	lagarteira	Tree	27755
Santalaceae			
Phoradendron piperoides (Kunth) Trel.	erva-de-passarinho	Hemiparasite	27714
Sapindaceae			
Serjania sp.	-	Liana	27734
Sapotaceae			
Chrysophyllum gonocarpum (Mart. and Eichler ex Miq.) Engl.	guatambu-de-leite	Tree	27736
Siparunaceae			
Siparuna guianensis Aubl.	pau-bosta	Tree	27728
Solanaceae			
Cestrum sp.	-	Tree	27738
Styracaceae			
Styrax leprosus Hook. and Arn.	canela-seiva	Tree	27726
Styrax pohlii A.DC.	benjoeiro	Tree	27735
Theophrastaceae			
Clavija sp.	-	Shrub	27751
Verbenaceae			
Petrea subserrata Cham.	-	Liana	27733

Table 2. Freshwater swamp forest areas previously studied in São Paulo state, southeastern Brazil, compared with the present study. T & S: trees and shrubs. Random: random walks in the sampling area.

MUNICIPALITY	GEOGRAPHIC COORDINATES	ALTITUDE (M)	CLIMATE TYPE*	SAMPLED HABITS	SAMPLE METHOD	NUMBER OF SPECIES	REFERENCE
1. Botucatu	22°52'52" S, 48°29'32" W	860	Cfa	All	Random	92	Present study
2. Bauru	22°20' S, 49°01' W	560	Cwa	All	Random	108	Carboni (unpublished data)
3. Campinas (1)	22°49'45" S, 47°06'33" W	600	Cwa	T & S	Plots	55	Toniato *et al.* (1998)
4. Campinas (2)	22°55' S, 47°05' W	660	Cwa	Trees	Census	33	Torres *et al.* (1994)
5. Itatinga	23°17'41" S, 48°38'53" W	570	Cwa	T & S	Census	39	Ivanauskas *et al.* (1997)
6. Agudos (1)	22°30' S, 48°55' W	550	Cwa	Trees	Random	38	Paschoal and Cavassan (1999)
7. Campinas (3)	22°49'55" S, 47°06'33"W	580-610	Cwa	All	Random	134	Spina *et al.* (2001)
8. Brotas (1)	22°16' S, 48°06' W	470	Cwa	T & S	Random	51	Marques *et al.* (2003)
9. Rio Claro	22°21' S, 47°28' W	640	Cwa	T & S	Plots	49	Teixeira and Assis (2005)
10. Ribeirão Preto	21°11' S, 47°48' W	510-800	Aw	Trees	Expedite Survey	157	Kotchetkoff-Henriques *et al.* (2005)
11. Agudos (2)	22°15' S, 48°15' W	550	Cwa	All	Random	41	Paschoal (unpublished data)
12. Brotas (2)	22°10' S, 47°55' W	470	Cwa	T & S	Plots	33	Costa *et al.* (1997)

* According to Koeppen Classification

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