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Species richness in restinga vegetation on the eastern Maranhão State, Northeastern Brazil

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ABSTRACT

The State of Maranhão comprises the second largest coastline in Brazil. Nonetheless, few floristic surveys on restinga vegetation have been performed in Northeastern Brazil. This study aimed to survey floristic in a restinga of Maranhão, and to assess its similarity to other restingas in the states of Pará and Piauí. Botanical specimens were sampled at Sítio Aguahy, in the municipality of São José de Ribamar, along the eastern coast of Maranhão between June/2012 and October/2013. Species identification and life forms classification followed the usual methods employed in floristic studies. Similarities in plant composition of six sites were estimated based on cluster analysis through Bray-Curtis distance. In the studied area, we found 116 phanerogamic species, 100 genera and 52 families; 19 species were new occurrences for the restinga of Maranhão. Families with largest number of species were Fabaceae, Cyperaceae, Rubiaceae, Poaceae, Myrtaceae, Asteraceae, Malvaceae, Combretaceae, and Eriocaulaceae, which comprised 49.2% of all sampled species. We identified 41 nanophanerophytes, 34 terophytes, 15 camephytes, ten microphanerophytes, six hemicryptophytes, and five lianas. Similarity analyses indicated greater affinity between the restinga flora from the states of Maranhão and Pará than that observed for the states of Maranhão and Piauí, suggesting that the process of species colonization in the former is more likely derived from the Amazon Forest. It is expected that these results may encourage future researchers to conduct further surveys in restinga areas of the Maranhão aiming to better understand the influence of neighboring vegetation on the colonization of the coastal areas of Maranhão.

KEYWORDS: Coastal sand plains, ecotone, floristic similarity, Brazilian northeast.

Riqueza de espécies em uma restinga no leste do Maranhão, Nordeste do Brasil

RESUMO

O Estado do Maranhão possui o segundo maior litoral da costa brasileira. No entanto, poucos levantamentos florísticos foram realizados nas áreas de restinga no Nordeste do Brasil. O presente estudo teve como objetivo realizar um levantamento florístico em uma área de restinga no Maranhão e analisar a similaridade com a flora das restingas dos Estados do Pará e do Piauí. As coletas botânicas foram realizadas na restinga do Sítio Aguahy, município de São José de Ribamar, na porção oriental da Ilha do Maranhão, no período de junho de 2012 a outubro de 2013. A identificação das espécies e a classificação das formas de vida seguiu a metodologia usual em estudos florísticos. A similaridade foi realizada através de análise de cluster a partir da distância de Bray-Curtis, onde foram considerados seis estudos. Foram listadas 116 espécies fanerogâmicas, 100 gêneros e 52 famílias. Deste total, 19 espécies são apresentadas como novas ocorrências para o litoral do Maranhão. As famílias com maior número de espécies foram Fabaceae, Cyperaceae, Rubiaceae, Poaceae, Myrtaceae, Asteraceae, Malvaceae, Combretaceae e Eriocaulaceae, correspondendo a 49.2% das espécies encontradas. Quanto às formas de vida, foram identificados 41 nanofanerófitos, 34 terófitos, 15 caméfitos, 10 microfanerófitos, seis hemicriptófitos e cinco lianas. A análise de similaridade mostrou maior afinidade entre a flora da restinga do Maranhão e do Pará, do que com a flora do Piauí, sugerindo uma possível colonização da restinga estudada por espécies provenientes da floresta Amazônica. Espera-se que esses dados sejam vistos como um passo inicial para a realização de mais pesquisas nas demais restingas maranhenses para que, futuramente, proporcione a compreensão da influência da vegetação circunvizinha na colonização das áreas litorâneas do Maranhão.

PALAVRAS-CHAVE: Planície arenosa costeira, ecótono, similaridade florística, Nordeste do Brasil.

INTRODUCTION

Restinga ecosystems (coastal vegetation) are considered by some researchers (Araujo and Henriques 1984; Souza *et al*. 2008) as a type of vegetation that from coastal tropical and subtropical coastal areas, with individuals present in herbaceous, shrubby, and arboreous layers, growing on sandy plains dating from Quaternary period. These coastal ecosystems are currently threatened due to a diverse range of anthropogenic interference, such as deforestation, real estate speculation, and land occupation (Santos-Filho *et al.* 2013), thus demanding urgent conservation actions (Dias and Soares 2008). Thus, conservation efforts on this type of vegetation are needed. The efforts should be associated with initiatives that try to understand its biodiversity and the ecological interactions among species on the restinga, particularly considering the high plasticity of plant species in these areas (Scarano 2002).

Northeastern Brazil restinga floristic composition was explored in several studies (Sacramento *et al.* 2007; Cantarelli *et al.* 2012; Santos-Filho *et al.* 2013). Although Maranhão has the second largest coastline in the country (640 km) (El-Robrini *et al.* 2006), up to date, only Cabral-Freire and Monteiro (1993) examined this vegetation closely.

Previous studies suggest that southeastern and northeastern Brazil restinga vegetation could be an extension of the Atlantic Forest (Scarano 2002; Santos-Filho *et al.* 2013). However, surveys carried out on the Amazonian coast (Amaral *et al.* 2008) observed that species distribution in these coastal restinga sites are dissimilar to those of southeastern Brazil, thus highlighting the necessity for additional studies in the Amazon coast and more comparisons amongst floras of neighboring areas in eastern northeast Brazil.

Floristic assessment are fundamental to determine richness of a given area, thenceforth providing essential information to ecological studies related to composition and structure vegetation (Chaves *et al.* 2013). The aims of this study were to perform a floristic survey of an area of restinga vegetation on Maranhão Island and to evaluate its floristic similarity to other restinga sites of the neighboring States.

MATERIALS AND METHODS

Plants were sampled in the restinga of Sítio Aguahy (02º38'47"S, 44º09'05"W), an area owned by Companhia Farmacêutica Quercegen Agronegócios I Ltda., in the municipality of São José de Ribamar, of the Maranhão State, Brazil; a map of the study site is available elsewhere (Araujo *et al*. 2016). The Sítio Aguahy comprises an area of 400 ha with transitional vegetation coverage, combining fragments of regenerating Amazon Forest, mangrove swamps, and restinga (vegetation with marine influence, according to the IBGE 2012). The examined restinga site covers approximately 50 ha, with herbaceous and shrub-arboreal vegetation.

Regional climate has two distinct seasons: a rainy season from January to June, and a dry season from July to December. The local climate is classified as Aw type (Köppen 1948). Annual mean rainfall of the Maranhão State is about 1,250 - 2,000 mm, and mean temperatures throughout the year vary between 25.5°C and 28.6°C (INMET 2015).

Sampling and identification of botanical material

Botanical sampling was carried out between June/2012 and October/2013. We selected specimens with viable reproductive structures, during walk through permanent and implanted trails in study area, with the purpose of increased sampling effort.

After collection, the plant material was dried and then analyzed based on methods suggested by Mori *et al.* (1989). Plants were identified to species level based on specialized literature. Family classification followed the proposed system in APG III (2009). Species and author names were confirmed by consulting List of Species of the Brazilian Flora (2014).

The classification and grouping of life forms followed the criteria of Raunkiaer (1934) adapted by Ellenberg and Mueller-Dombois (1967). After identification, specimens were incorporated into the MAR herbarium at the Department of Biology, Federal University of Maranhão (Universidade Federal do Maranhão - UFMA).

Description of phytophysiognomy followed classification of Silva and Britez (2005), in which type of formation is related to predominant plant life forms, besides differentiating physiognomies based on the flood regime of water table. This method was previously employed to determine restinga main features in northeastern Brazil (Sacramento *et al*. 2007; Almeida Jr. *et al*. 2009; Santos-Filho *et al*. 2010).

Data Analysis

We used grouping analyses based on the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) from Jaccard distance index (Table 1) to evaluate similarity between different restinga areas. Additionally, a dendrogram was generated based on cophenetic correlation index, using Pearson's correlation. Cut off limit for grouping method was based on Borcard *et al.* (2011), observing a predetermined number of groups (in this case, n=3). These analyses were performed using Vegan package (Oksanen *et al.* 2013) of the R software version 3.1.1 (R Development Core Team 2013).

RESULTS

We identified 116 species, 100 genera and 52 families (Table 2). Families represented by largest numbers of species were Fabaceae (with 18 species; 15.3% of total); Cyperaceae (9; 7.6%); Rubiaceae (8; 6.8%); Myrtaceae (5; 4.2%); Poaceae (4; 3.4%), Asteraceae (4; 3.4%), Malvaceae (4; 3.4%),

Table 1. Restingas areas of the Brazilian north-northeast used in the Jaccard similarity analysis.

Area	State	Coordinates	Nº of Species	Physiognomies	Reference
Sítio Aguahy	Maranhão (MA)	02º38'47''S, 44º09'05''W	116	fields, shrub and forest	Present study
Ilha Grande	Piauí (PI)	02°50'84"S, 41°47'39"W	67	fields, shrub and carnaubais	Santos-Filho *et al*. (2015)
Parnaíba	Piauí (PI)	02°55'48"S, 41°40'67"W	131	fields, shrub	Santos-Filho *et al*. (2013)
Luiz Correia	Piauí (PI)	02°55'89"S, 41°30'49"W	116	restinga forest	Santos-Filho *et al*. (2013)
Algodoal 1	Pará (PA)	00°36'57,6"S, 47°32'41,7"W	171	dunes	Santos and Rosário (1988)
Algodoal 2	Pará (PA)	00°34'45"S, 47°34'12"W	224	"psamófila reptante", "brejo-herbáceo", field dunes, shrub fields, and forest	Bastos *et al*. (1995)
Maiandeua	Pará (PA)	00º34'30"S, 47º34'12"W	57	shrub restinga, and herbaceous restinga	Bastos (1988)

Table 2. List of species recorded in the Sítio Aguahy Restinga, municipality of São José de Ribamar, Maranhão State, Brazil. The species marked with an asterisk (*) represent the first record for the Maranhão Restingas.

Family / Species	Life forms	Collector / number
Aizoaceae		
Sesuvium portulacastrum (L.) L.	Terophyte	Serra, F.C.V. 168
Alstroemeriaceae		
Bomarea edulis (Tussac) Herb.	Terophyte	Serra, F.C.V. 184
Amaranthaceae		
Alternanthera brasiliana (L.) Kuntze	Terophyte	Serra, F.C.V. 125
Blutaparon portulacoides (A. St.-Hil.) Mears	Terophyte	Serra, F.C.V. 154
Anacardiaceae		
Anacardium occidentale L.	Nanophanerophyte	Serra, F.C.V. 65
Tapirira obtusa (Benth.) J.D. Mitch.	Microphanerophyte	Serra, F.C.V. 110
Annonaceae		
Annona glabra L.	Nanophanerophyte	Serra, F.C.V. 105
Duguetia surinamensis R.E.Fr. *	Nanophanerophyte	Almeida Jr., E.B. 890
Apocynaceae		
Rhabdadenia biflora (Jacq.) Müll.Arg.	Liana	Serra, F.C.V. 104
Arecaceae		
Astrocaryum vulgare Mart.	Nanophanerophyte	Serra, F.C.V. 128
Asteraceae		
Emilia sonchifolia (L.) DC.	Terophyte	Serra, F.C.V. 192
Rolandra fruticosa (L.) Kuntze	Nanophanerophyte	Serra, F.C.V. 72
Vernonanthura brasiliana (L.) H.Rob.	Nanophanerophyte	Serra, F.C.V. 94
Wedelia villosa Gardner *	Terophyte	Serra, F.C.V. 175
Bignoniaceae		
Bignonia aequinoctialis L.	Liana	Serra, F.C.V. 145
Bixaceae		
Cochlospermum orinocense (Kunth) Steud.	Microphanerophyte	Serra, F.C.V. 83
Boraginaceae		
Euploca polyphylla (Lehm.) J.I.M.Melo & Semir	Hemicryptophyte	Serra, F.C.V. 170
Varronia globosa Jacq.	Nanophanerophyte	Serra, F.C.V. 20
Cactaceae		
Cereus jamacaru DC.	Nanophanerophyte	Almeida Jr., E.B. 891
Cannabaceae		
Trema micrantha (L.) Blume	Nanophanerophyte	Serra, F.C.V. 140
Capparaceae		
Cynophalla flexuosa (L.) J.Presl *	Nanophanerophyte	Serra, F.C.V. 141

Table 2. Continuation

Family / Species	Life forms	Collector / number
Chrysobalanaceae		
Chrysobalanus icaco L.	Nanophanerophyte	Serra, F.C.V. 08
Hirtella racemosa Lam.	Nanophanerophyte	Almeida Jr., E.B. 892
Combretaceae		
Conocarpus erectus L.	Nanophanerophyte	Serra, F.C.V. 163
Terminalia argentea Mart.	Nanophanerophyte	Almeida Jr., E.B. 912
Terminalia glabrescens Mart.	Nanophanerophyte	Serra, F.C.V. 149
Commelinaceae		
Dichorisandra hexandra (Aubl.) C.B.Clarke*	Terophyte	Almeida Jr., E.B. 893
Convolvulaceae		
Merremia tuberosa (L.) Rendle	Terophyte	Almeida Jr., E.B. 906
Cyperaceae		
Cyperus laxus Lam.	Terophyte	Serra, F.C.V. 159
Cyperus sp.	Terophyte	Serra, F.C.V. 172
Eleocharis geniculata (L.) Roem. & J. Schull.	Terophyte	Almeida Jr., E.B. 914
Eleocharis sp.	Terophyte	Serra, F.C.V. 102
Fiurena umbellata Rottb.	Terophyte	Serra, F.C.V. 21
Kyllinga sp.	Terophyte	Serra, F.C.V. 100
Pycreus polystachyos (Rottb.) P.Beauv.	Terophyte	Almeida Jr., E.B. 894
Rhynchospora sp.	Terophyte	Serra, F.C.V. 87
Scleria bracteata Cav.	Terophyte	Serra, F.C.V. 113
Eriocaulaceae		
Paepalanthus bifidus Scharde *	Hemicryptophyte	Almeida Jr. E.B. 937
Paepalanthus lamarckii Kunth	Hemicryptophyte	Serra, F.C.V. 196
Paepalanthus sublitis Miq.	Hemicryptophyte	Almeida Jr., E. B. 936
Erythroxylaceae		
Erythroxylum passerinum Mart.	Nanophanerophyte	Almeida Jr., E. B. 920
Fabaceae		
Abarema cochleata (Willd.) Barneby & J.W.Grimes	Microphanerophyte	Serra, F.C.V. 115
Aeschynomene brevipes Benth.	Camephyte	Serra, F.C.V. 171
Aeschynomene fluminensis Vell.	Camephyte	Serra, F.C.V. 42
Centrosema brasilianum (L.) Benth.	Vine	Serra, F.C.V. 12
Centrosema aff. *pubescens* Benth.	Vine	Serra, F.C.V. 178
Chamaecrista diphylla (L.) Greene	Hemicryptophyte	Serra, F.C.V. 177
Chamaecrista flexuosa (L.) Greene	Hemicryptophyte	Serra, F.C.V. 59
Chloroleucon acacioides (Ducke) Barneby & J.W.Grimes	Microphanerophyte	Serra, F.C.V. 97
Copaifera langsdorffii Desf. *	Nanophanerophyte	Serra, F.C.V. 54
Crotalaria retusa L.	Terophyte	Serra, F.C.V. 40
Desmodium triflorum (L.) DC.	Camephyte	Serra, F.C.V. 29
Dioclea reflexa Hook. f. *	Liana	Serra, F.C.V. 56
Erythrina amazonica Krukoff	Nanophanerophyte	Serra, F.C.V. 49
Guilandina bonduc L.	Nanophanerophyte	Serra, F.C.V. 151
Hymenaea courbaril L.	Microphanerophyte	Serra, F.C.V. 43
Stylosanthes angustifolia Vogel	Camephyte	Serra, F.C.V. 91
Zornia guanipensis Pittier	Camephyte	Serra, F.C.V. 30
Zornia reticulata Sm.	Camephyte	Almeida Jr., E.B. 943
Gentianaceae		
Schultesia guianensis (Aubl.) Malme	Terophyte	Serra, F.C.V. 77
Heliconiaceae		
Heliconia psittacorum L. f.	Terophyte	Serra, F.C.V. 74
Hidroleaceae		
Hydrolea spinosa L.	Terophyte	Serra, F.C.V. 143

Table 2. Continuation

Family / Species	Life forms	Collector / number
Hypericaceae		
Vismia guianensis (Aubl.) Pers	Nanophanerophyte	Serra, F.C.V. 119
Lamiaceae		
Amasonia campestris (Aubl.) Moldenke	Camephyte	Serra, F.C.V. 164
Marsypianthes chamaedrys (Vahl) Kuntze	Terophyte	Serra, F.C.V. 26
Lauraceae		
Cassytha filiformis L.	Parasite	Almeida Jr., E.B. 895
Lecythidaceae		
Gustavia augusta L.	Microphanerophyte	Serra, F.C.V. 144
Lentibulariaceae		
Utricularia fimbriata Kunth *	Terophyte	Almeida Jr., E.B. 1015
Utricularia nigrescens Sylvén *	Terophyte	Almeida Jr., E.B. 1016
Loganiaceae		
Spigelia anthelmia L.	Terophyte	Serra, F.C.V. 64
Loranthaceae		
Psittacanthus sp.	Hemiparasite	Serra, F.C.V. 163
Malpighiaceae		
Banisteriopsis muricata (Cav.) Cuatrec.	Nanophanerophyte	Serra, F.C.V. 45
Byrsonima crassifolia (L.) Kunt	Microphanerophyte	Serra, F.C.V. 76
Malvaceae		
Helicteres heptandra L.B.Sm	Nanophanerophyte	Serra, F.C.V. 160
Pavonia sp.	Nanophanerophyte	Serra, F.C.V. 85
Sida ciliaris L.	Camephyte	Serra, F.C.V. 96
Sida cordifolia L.	Nanophanerophyte	Serra, F.C.V. 37
Melastomataceae		
Mouriri guianensis Aubl.	Nanophanerophyte	Serra, F.C.V. 203
Nepsera aquatica (Aubl.) Naudin	Camephyte	Serra, F.C.V. 69
Tococa guianensis Aubl.	Nanophanerophyte	Serra, F.C.V. 207
Myrtaceae		
Campomanesia sp.	Nanophanerophyte	Serra, F.C.V. 78
Eugenia sp. 1	Nanophanerophyte	Serra, F.C.V. 50
Eugenia sp. 2	Nanophanerophyte	Serra, F.C.V. 139
Myrcia sylvatica (G. Mey.) DC. *	Nanophanerophyte	Serra, F.C.V. 118
Myrciaria cf. *cuspidata* O. Berg *	Nanophanerophyte	Serra, F.C.V. 103
Nyctaginaceae		
Guapira opposita (Vell.) Reitz	Nanophanerophyte	Serra, F.C.V. 185
Ochnaceae		
Ouratea fieldingiana (Gardner) Engl. *	Microphanerophyte	Serra, F.C.V. 112
Sauvagesia erecta L.	Camephyte	Serra, F.C.V. 80
Onagraceae		
Ludwigia hyssopifolia (G. Don) Exell *	Camephyte	Serra, F.C.V. 38
Ludwigia sp.	Camephyte	Almeida Jr., E.B. 987
Olacaceae		
Heisteria ovata Benth.	Nanophanerophyte	Serra, F.C.V. 82
Plantaginaceae		
Stemodia foliosa Benth. *	Terophyte	Serra, F.C.V. 58
Poaceae		
Brachiaria sp.	Terophyte	Almeida Jr., E.B. 909
Eriochloa sp.	Terophyte	Serra, F.C.V. 15
Hymenachne pernambucensis (Spreng.) Zuloaga	Terophyte	Serra, F.C.V. 102
Penissetum sp.	Terophyte	Serra, F.C.V. 62
Polygalaceae		
Polygala paniculata L.	Terophyte	Serra, F.C.V. 179
Polygala violacea Aubl.	Terophyte	Serra, F.C.V. 181

Table 2. Continuation

Family / Species	Life forms	Collector / number
Polygonaceae		
Coccoloba mollis Casar.	Nanophanerophyte	Serra, F.C.V. 133
Coccoloba ramosissima Wedd.	Nanophanerophyte	Serra, F.C.V. 93
Rubiaceae		
Borreria verticillata (L.) G.Mey.	Camephyte	Serra, F.C.V. 95
Chiococca nitida Benth.	Nanophanerophyte	Serra, F.C.V. 57
Duroia macrophylla Huber *	Nanophanerophyte	Serra, F.C.V. 84
Faramea nitida Benth	Nanophanerophyte	Almeida Jr., E.B. 990
Guettarda angelica Mart. ex Müll.Arg.	Nanophanerophyte	Serra, F.C.V. 174
Isertia spiciformis DC.	Nanophanerophyte	Serra, F.C.V. 152
Mitracarpus salzmannianus DC. *	Camephyte	Serra, F.C.V. 47
Psychotria hoffmannseggiana (Willd. *ex* Schult.) Müll.Arg.	Nanophanerophyte	Serra, F.C.V. 153
Santalaceae		
Phoradendron quadrangulare (Kunth) Griseb.	Hemiparasite	Almeida Jr., E.B. 872
Sapindaceae		
Serjania salzmanniana Schltdl.*	Liana	Serra, F.C.V. 132
Sapotaceae		
Manilkara bidentata (A. DC.) A. Chev.*	Microphanerophyte	Serra, F.C.V. 106
Manilkara triflora (Allemão) Monach. *	Microphanerophyte	Serra, F.C.V. 32
Smilacaceae		
Smilax sp.	Liana	Almeida Jr., E.B. 896
Violaceae		
Pombalia calceolaria (L.) Paula-Souza	Camephyte	Serra, F.C.V. 48
Vitaceae		
Cissus erosa Rich.	Liana	Serra, F.C.V. 156
Xyridaceae		
Xyris jupicai Rich.	Terophyte	Serra, F.C.V. 01

Combretaceae (3; 2.5%), and Eriocaulaceae (3; 2.5%). These families comprised 49.5% of all sampled species.

In this study, we report 19 new occurrences phanerogamic species for Maranhão State. Among those, five species (*Duguetia surinamensis*, *Dioclea reflexa*, *Utricularia fimbriata*, *Duroia macrophylla* e *Manilkara bidentata*) have restricted distribution to the Amazon ecosystem, and three (*Paepalanthus caldensis*, *Guilandina bonduc*, *Ouratea fieldingiana*) to the Atlantic forest.

In terms of life forms, we identified 41 nanophanerophytes, 34 terophytes, 15 camephytes, ten microphanerophytes, six hemicryptophytes, five lianas, two vines, two hemiparasites, and one parasite (Figure 1).

Regarding the physiognomic classification of Sítio Aguahy, three physiognomies can be noticed, flooded fields, non-flooded shrubby and non-flooded forest.

Flooded fields comprise a predominant vegetation of herbs, such as *Utricularia fimbriata*, *Utricularia nigrescens*,

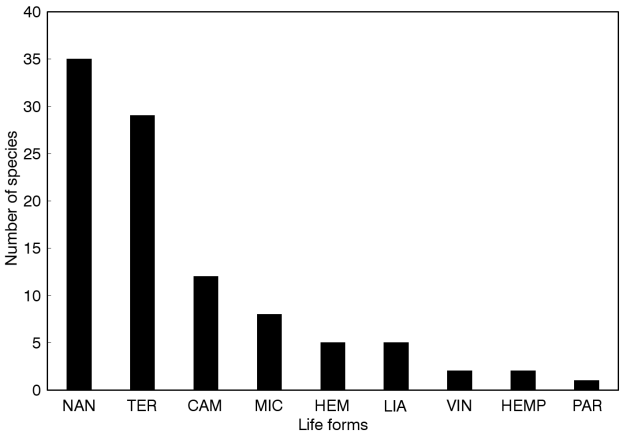

Figure 1. Number of species by life forms recorded in the Restinga of Sítio Aguahy, municipality of São José de Ribamar, Maranhão State, Brazil. Abbreviations: NAN - nanophanerophytes, TER - terophytes, CAM - camephytes, MIC - microphanerophytes, HEM - hemicryptophytes, LIA - lianas, VIN - vines, HEMP - hemiparasites, and PAR – parasite.

Paepalanthus bifidus, *Paepalanthus lamarckii*, *Paepalanthus sublitis* and *Xyris jupicai*¸ especially during the flood season. Non-flooded shrubby physiognomy counts on shrub species, e.g. *Chrysobalanus icaco* and *Byrsonima crassifolia*, which might present grouping formation like bushes or be associated to several individuals from the same species and other herbs, most likely with Cyperaceae and Poaceae representatives. Non-flooded forest physiognomy was observed in parallel to shrubby formation that occupies land until nearshore. In this system, 10 m height trees are common, such as *Manilkara bidentata*, *Manilkara triflora* and *Tapirira obtusa*. There are also few shrubs and small trees sparsely distributed closest to the shoreline with *Guilandina bonduc* and *Chloroleucon acacioides* representatives.

Similarity analysis identified three groups (Figure 2) with high levels of likeness (65%). Cophenetic analysis demonstrated that the dendrogram adequately represented original data's matrix (r = 0.97). One group was formed by this study (Aguahy site) and the restingas of Pará State (Algodoal 1 and Algodoal 2); a second group was formed by restinga areas on Ilha Grande, Parnaíba, and Luiz Correia (all in Piauí State); the Maiandeua site was the only one that displayed full dissimilarity from the others.

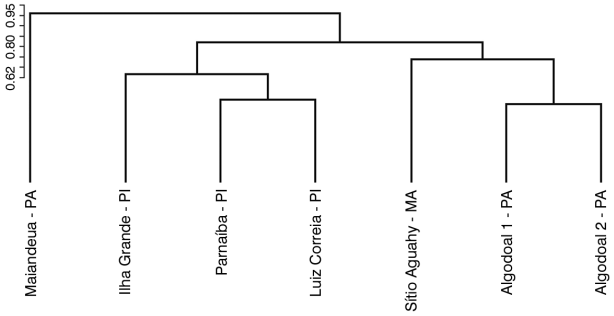

Figure 2. Dendrogram resulting from the floristic similarity analysis (Cluster) between floristic surveys of the Restinga of Sítio Aguahy, municipality of São José de Ribamar, Maranhão (this study), with other surveys in Restingas areas of Pará (PA) and Piauí (PI).

DISCUSSION

The families of greater richness in the restinga of this study were also commonly referenced in other studies of restingas in northeastern Brazil (Almeida Jr. *et al.* 2009; Cantarelli *et al.* 2012; Santos-Filho *et al.* 2013). In this context, special emphasis should be given to Fabaceae and Rubiaceae - that comprise a large number of species in lowland neotropical forests (Gentry 1988) - and Myrtaceae - in which the center for expansion is in humid forests of eastern Brazil, with representatives also later colonizing other habitats (Mori *et al.* 1983).

We hereby report our findings of 19 new botanical occurrences for Maranhão, including five species - *Duguetia surinamensis*, *Dioclea reflexa*, *Utricularia fimbriata*, *Duroia macrophylla*, and *Manilkara bidentata* - whose distribution was restricted to the Amazon forest biome, and two species associated with the Atlantic forest - *Guilandina bonduc*, *Ouratea fieldingiana*. Other species were previously known from other ecosystems, such as Caatinga and Cerrado (List of species of the Brazilian Flora 2014). This high number of new species occurrences exemplifies the scarcity of information available for restinga areas in Maranhão State, as it was also suggested by Zickel *et al.* (2004). This gap of floristic composition studies in restinga ecosystems directly affects development of detailed and deepened ecology assessment of these environments.

Life form data revealed that low-growing plants dominated vegetation in the study area, with predominant phanerophytes, but also with consistent presence of terophytes and camephytes. Similar life forms ratio were also observed in restinga areas in the states of Rio Grande do Norte (Almeida Jr. *et al.* 2006), Pernambuco (Almeida Jr. *et al.* 2007; Almeida Jr. *et al.* 2009) and Piauí (Santos-Filho *et al.* 2010; Santos-Filho *et al.* 2013). Almeida Jr. *et al.* (2009) and Santos-Filho *et al.* (2013) reported that soil type, soil nutrient levels, and depth of water table, directly influence the proportion of individuals of each life form.

Similarity between restinga flora of Sítio Aguahy and Algodoal 1 and Algodoal 2 in Pará State suggests the colonization of Maranhão coastal areas derived from the Amazon forest. However, in spite of this floristic likeness and the fact these areas are geographically close, these three floras show distinct species compositions that reflect unique abiotic and biotic interactions (Santos-Filho *et al*. 2013).

Amaral *et al.* (2008) noticed differences between restinga families' species richness throughout the Amazonian coast (Fabaceae, Cyperaceae, Poaceae, Rubiaceae, Myrtaceae and Asteraceae) and common families in the Atlantic Forest (families cited above) that were found in restinga sites along the coast of Rio de Janeiro State (Scarano 2002). A good example is Eriocaulaceae, among the ten families with greatest number of species along the coast of the Amazon region (Amaral *et al.* 2008 and present study), but was not listed even among the 20 most important families in a survey undertaken in Rio de Janeiro (Araujo 2000). Moreover, floristic surveys undertaken in northeastern Brazil often show the family Eriocaulaceae appearing among the 20 richest families (Sacramento *et al.* 2007; Almeida Jr. *et al.* 2009; Cantarelli *et al.* 2012), or completely absent in the list of species (Almeida Jr. *et al.* 2007; Santos-Filho *et al.* 2013). This scenario emphasizes the urgency for further studies in the area to ensure ultimate robust comparisons of coastal floras of Brazilian northeast region.

Another interesting remark is that *Manilkara bidentata* and *Manilkara cavalcantei* Pires & W. A. Rodrigues ex T. D. Penn. have been sampled along the coasts of Maranhão and Piauí respectively. Both taxa are preferentially Amazonian (Almeida Jr. *et al.* 2011) and their presence in restinga areas supports the hypothesis that coastal vegetation can provide ecological corridors in ecotone environments (Castro *et al.* 2012). This hypothesis can only be explored with intensive and long-term sampling effort along the coast of Maranhão, to elucidate how these species are distributed in the Brazilian coastal.

CONCLUSIONS

Although this study presents an initial survey of restinga vegetation in Maranhão State, the ecosystem showed high plant richness, and special attention should be given to the 19 new species occurrences presented here. The predominance of phanerophytes, therophytes, and camephytes show a distribution of the spectrum of species, similar to other restingas in northeastern Brazil. In addition, the greater floristic similarity amongst areas in the state of Maranhão and Pará indicate a possible influence of neighboring vegetation in the process of colonization of species in areas of restinga.

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