



Corticolous myxobiota of the Pernambuco Center of Endemism, Brazil

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ABSTRACT

Situated within the Atlantic Forest domain, the *Centro de Endemismo Pernambuco* (Pernambuco Center of Endemism) - CEPE is regarded as a priority for biodiversity conservation worldwide. Covering an area of approximately 56,000 km², it encompasses part of the states of Alagoas, Pernambuco, Paraíba and Rio Grande do Norte in northeastern Brazil. Here we present an identification key to 73 species of Myxomycetes that compose the known corticolous myxobiota of the Dense Ombrofilous Lowland Forest, Semideciduous Lowland Forest, Restinga Forest and Mangrove environments of CEPE. Specimens included here were found developed in natural conditions in the field or obtained through moist chamber culture. Among the species found, *Arcyria cinerea*, *Clastoderma debaryanum*, *Cribraria confusa*, *C. violacea* and *Echinostelium minutum* were the most common; and *Comatricha longipila*, *Licea pedicellata*, *Paradiachaeopsis longipes*, *Perichaena calongei* and *Stemonaria fuscoides* were the most rare. Our data indicates that the species richness of corticolous myxomycetes in rainforests is lower than that of temperate forests. These same data also suggest that taxonomic diversity (mean number of species per genus) is similar to, or higher than, that found in temperate regions of the world.

Keywords: Atlantic Forest, biodiversity, microhabitat, Myxogastria, Myxomycetes

Introduction

Myxomycetes (Amoebozoa) are unicellular phagotrophic eukaryotes that prey on fungus and bacteria, and occur in terrestrial environments as haploid, uninucleated myxamoebae and swarm cells or as diploid multinucleated plasmodium that produce fungus-like fruiting bodies (Gray & Alexopoulos 1968). About one third of the species of Myxomycetes have worldwide distribution, but some seem to be restricted to the tropics and others to temperate regions (Stephenson *et al.* 2008). Studies of soil microbiota shows the importance of this group of organisms to the

ecosystems where they occur, serving as regulators of microbial populations of bacteria, yeasts and filamentous fungi and in nutrient cycling and mineralization (Keller & Everhart 2010; Stephenson & Feest 2012).

Myxomycetes are classified into ecological groups according to the microhabitats where they develop and sporulate, being lignicolous and foliicolous myxomycetes the most well-known (Ing 1994). Corticolous myxomycetes inhabit the bark of living shrubs and trees. Species typical of this ecological group generally produce sporangia up to 1 mm in height and usually have protoplasmodia (≤ 0.5 mm), which have low mobility and are capable of responding

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rapidly to environmental conditions that induce sporulation (Everhart & Keller 2008). Species of this group are not distributed randomly among the different environments where they are recorded, and neither occur with the same abundance throughout the year since their trophic stages are strongly influenced by temperature, moisture and substrate pH as well food availability (Madelin 1984; Tran *et al.* 2006). There is no evidence of endemism among species of myxomycetes, but differences in myxobiota composition between different types of microhabitats have already been observed (Novozhilov *et al.* 1999; 2003; 2006; Stephenson *et al.* 2000; Schnittler 2001).

Studies performed in tropical forests, which are characterized by high levels of pluviosity and air humidity, suggests that their myxomycete diversity is lower than that observed in temperate forests, and with low corticolous species richness (Stephenson *et al.* 2004). Analysing the composition of the corticolous myxobiota from temperate moist forest in the Great Smoky Mountains National Park (GSMNP), Snell & Keller (2003) recorded 84 species from moist-chambers mounted with samples obtained from 25 trees. In urban environments of the province of Madrid, Spain, 37 species were documented from 81 moist-chamber cultures mounted with bark of living *Quercus ilex* (Fagaceae) (Basanta 1998).

Studies focusing on the corticolous myxobiota of Brazil were initiated by Cavalcanti (1974), who recorded 20 species on the bark of 300 trees of the Cerrado biome, of which 13 taxa were obtained through moist-chamber culture. Bezerra & Cavalcanti (2007) listed ten species found on 20 specimens of *Terminalia cattapa* (Combretaceae), during 12 months of study in urban environments in Recife, Pernambuco. In Restinga of the Parque Estadual Dunas do Natal, Bezerra *et al.* (2007) obtained only 12 species from 200 moist-chamber plates prepared with cortex of trees typical of this vegetation.

Distributed along the latitude of 28°, the Atlantic Forest is the second largest Neotropical forest, and is considered a biodiversity hotspot with numerous endemic species of different taxa distributed among centers of Brazilian endemism, including *Centro de Endemismo Pernambuco* (CEPE) (Tabarelli *et al.* 2006). Currently, information on corticolous myxomycetes occurring in the northeastern part of the Atlantic Forest and its associated ecosystems are scarce (Silva & Cavalcanti 2010; Damasceno *et al.* 2011; Cavalcanti *et al.* 2014).

Aiming to expand up on the existing knowledge of the ecosystem distribution of myxomycetes in the Neotropics, this paper presents 73 corticolous species found in different forest environments of the CEPE and provides a key for their identification, based on records made between the years of 1970 and 2016.

Materials and methods

Study area

Situated in the Atlantic Forest domain, CEPE comprises ~56,4000 km² distributed from north of the São Francisco River, Alagoas, northward to Rio Grande do Norte (5° 00' to 10° 30' S; 34° 50' to 37° 12' W) (Fig. 1). A humid tropical climate (Köppen's As'), prevails throughout CEPE, with Autumn-Winter rains and precipitation varying from 1,500 to 2,000 mm a year (Coimbra-Filho & Câmara 1996; Roda & Pereira 2006; Rolim *et al.* 2007; Silva *et al.* 2011). This forest fragment differs from other Atlantic Forests fragments by the influences from the Amazon rainforest and Atlantic Forest of the south and southeastern of the Brazil it receives (Tabarelli & Santos 2004).

CEPE is comprised of a variety of different vegetation types, including Ombrophilous and Seasonal Semideciduous Forests, ecological tension areas and pioneer formations, where about 8% of the species of higher plants of the Brazilian Atlantic Forest occur, plus Restinga and mangroves (Tabarelli *et al.* 2006). According to Uchôa Neto & Tabarelli (2002), 1,200 species of trees and shrubs comprise the CEPE macroflora, with some of them being endemic, such as *Manilkara dardanoi* Ducke (Sapotaceae), *Couepia impressa* Prance and *C. pernambucensis* Prance (Chrysobalanaceae).

Species listed in the present work are from the following localities within CEPE:

Paraíba: 1. Biological Reserve (REBIO) Guaribas, Mamanguape, 06°40'40"S and 35°12'47" W. Seasonal Semideciduous Forest (lowland), 3,378 ha.

Pernambuco: 2. Charles Darwin Ecological Refuge, Igarassu, 07°48'55"S and 34°57'16"W. Dense Ombrophilous Forest (lowland), 60 ha; 3. REBIO Usina São José, Igarassu, 07°50'00.46"S and 34°54'30.05" W. Seasonal Semideciduous Forest (lowland), 323,3 ha; 4. REBIO Mata da Jaguarana, Paulista, 7°54'58.16"S and 34°51'24.83"W. Seasonal Semideciduous Forest (lowland), 332, 8 ha; 5. REBIO Carnijó, Moreno, 8°06'50.96"S and 35°05'47.34"W. Seasonal Semideciduous Forest (lowland), 135,5 ha; 6. Recife's Botanical Garden, Recife, 8°04'42.15"S and 34°57'28.34"W. Seasonal Semideciduous Forest (lowland), 27,0 ha; 7. Dois Irmãos State Park, Recife, 08°00'33"S and 34°56'37"W. Dense Ombrophilous Forest (lowland), 387,40 ha; 8. REBIO Gurjaú System forest, Cabo de Santo Agostinho, 8°14'21,7"S and 35°03'004"W. Dense Ombrophilous Forest (lowland), 1.340,72 ha; 9. REBIO Salinho, Rio Formoso and Tamandaré, 08° 43'49.7"S and 035° 10'54.0"W. Dense Ombrophilous Forest (lowland), 475 ha; 10. Rio Formoso Mangrove, Rio Formoso, 08°39'50"S and 35°09'32"W. Mangrove, 12 Km.

Rio Grande do Norte: 11. Dunas do Natal State Park, Natal, 05°49'12"S and 35°11'16"W, Restinga, 1,172 ha; 12. Private Reserve of Natural Heritage (RPPN) Mata Estrela, Baía Formosa, 06°22'S and 35°00'W. Restinga, 2, 365 ha.



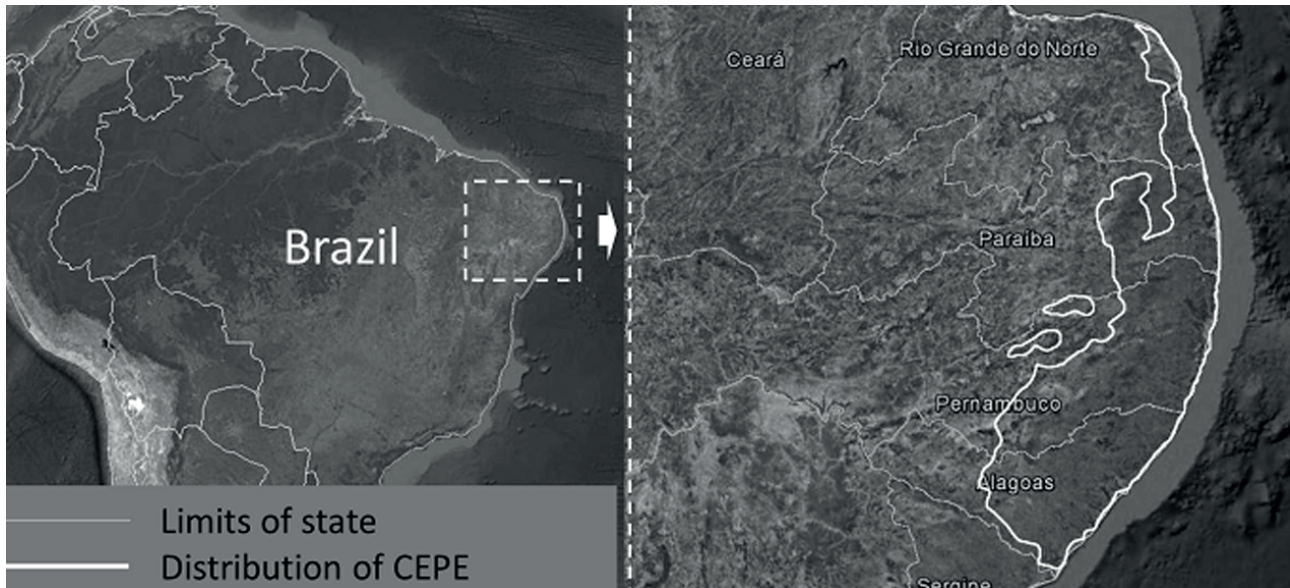


Figure 1. Localization of the Pernambuco Center of Endemism in the Northeastern Region of Brazil.

Collection and identification

Inventory was based on field collections, moist-chamber culture and specimens deposited in the herbaria UFP, URM and IPA, for which identifications were confirmed or redetermined, and binomials updated according to Lado (2015). The monographs of Martin & Alexopoulos (1969), Farr (1976), Lado & Pando (1997) and the keys and illustrations of Mitchell (2004) and Poulain *et al.* (2011) were used for species identification.

The taxonomic diversity index (S/G) was calculated according to Cavalcanti *et al.* (2014) and Stephenson *et al.* (1993).

Results

A total of 73 species was recorded from the cortex of living trees and shrubs of CEPE. The species belong to Myxogastromycetidae and Stemonitomycetidae and represent five orders, encompassing members of Clastodermataceae, Echinosteliaceae, Dictydiaethaliaceae, Reticulariaceae, Liceaceae, Arcyriaceae, Trichiaceae, Physaraceae, Didymiaceae and Stemonitaceae.

An identification key is presented for all the corticolous species recorded at CEPE. After the species and author names, numbers representing the localities where the species were recorded are given as superscripts.

Identification key (index number show occurrence places at CEPE - see Study area)

1. Lime absent, occasionally present on peridium surface 2
- 1'. Lime typically present in the sporophore as amorphous granules or crystals (Physarales)..... 17
2. Capillitium present, abundant to rudimentary 3
- 2'. Capillitium absent. Pseudocapillitium sometimes present (Liceales) 6
3. Filaments of the capillitium smooth; columella present4
- 3'. Filaments of the capillitium ornamented with spirals, warts, spines, cogs, ridges, half-rings, rings and/or reticulations; columella absent (Trichiales) 61
4. Stalk filled with granular matter (Echinosteliales) 5
- 4'. Stalk hollow or fibrous (Stemonitales) 43
5. Sporocarp 1–1.2 mm total height; stalk brownish, filled with granular material bellow, translucent and tapering abruptly upwards after a droplet-like swelling; filament of the capillitium with membranous platelets attached at the tip; spores brown (Clastodermataceae)
..... *Clastoderma debaryanum* A. Blytt. ^(3,4,6,9,10,11)
- 5'. Sporocarp 0.25–0.55 mm total height; stalk hyaline, filled with granular material, tapering gradually upwards; filaments of the capillitium without platelets at the tip; spores hyaline (Echinosteliaceae) *Echinostelium minutum* de Bary. ^(1,3,4,5,6,9,12)
6. Peridium persistent as a complete reticulum or a reticulum above and a calyculus bellow; dictydine granules always



- present in sporocarp (Cribrariaceae) 7
- 6'. Peridium persistent (total or partially), but never as a network; dictydine granules absent 11
7. Peridial reticulum consisting of longitudinal and subparallel ribs, transversally connected by a slender filament; calyculus absent, rarely present *Cribraria cancellata* (Batsch) Nann.-Bremek. ^(4,7,12)
- 7'. Peridial reticulum consisting of a well-developed network 8
8. Sporocarp violaceous; calyculus deep, 1/2–2/3 of sporotheca height *Cribraria violacea* Rex. ^(3,4,5,6,9,12)
- 8'. Sporocarp with brownish shades; calyculus up to 1/3 of sporotheca height 9
9. Sporocarp yellowish-brown, up to 0.8 mm total height; nodes of peridial reticulum as small membranous junctions *Cribraria confusa* Nann.-Bremek. & Y. Yamam. ^(1,3,4,6,9,10,12)
- 9'. Sporocarp reddish-brown, 1.5–3 mm total height; nodes of peridial reticulum well-defined 10
10. Stalk long, 6–12 times sporotheca diameter; peridial net without free ends, nodules thick, protruding, rounded *Cribraria microcarpa* (Schrad.) Pers. ^(3,4,6,8,9,11,12)
- 10'. Stalk 3–5 times the sporotheca diameter; peridial net with (1) 2–4 (5) free ends, nodes angular *Cribraria intricata* Schrad. ^(6,9,12)
11. Sporophore a pseudoaethalium; pseudocapillium present 12
- 11'. Sporophore sporocarpic or plasmodiocarpic; pseudocapillitium absent (Liceaceae) 13
12. Mature pseudoaethalium with brownish shades, flat; dehiscence by hexagonal plates; pseudocapillitium filament connected at the extremities of peridial plates; spores pale yellow (Dictydiaethaliaceae) *Dictydiaethalium plumbeum* (Schumach.) Rostaf. ⁽²⁾
- 12'. Mature pseudoaethalium with greyish shades, subglobose; dehiscence by an apical pore; pseudocapillitium filament hyaline, free of the peridium; spores hyaline (Reticulariaceae) *Lycogala exiguum* Morgan. ⁽³⁾
13. Sporocarp sessile or plasmodiocarpic 14
- 13'. Sporocarp short or long stalked 15
14. Sporophore sporocarpic, sessile, wider than high; peridium dehiscence operculate, inner face smooth *Licea kleistobolus* G. W. Martin. ^(10,12)
- 14'. Sporophore plasmodiocarpic, elongate and fusiform, laterally compressed; dehiscence by a longitudinal preformed fissure; inner face of peridium ornamented *Licea biforis* Morgan. ⁽⁹⁾
15. Spores in mass mostly dark; stalk, when present, short and nearly continuous with sporotheca; calyculus absent .. *Licea pedicellata* (H.C. Gilbert) H.C. Gilbert. ⁽⁹⁾
- 15'. Spores in mass mostly pale; stalk always present, sporotheca distinct from stalk; peridium persistent as a calyculus ... 16
16. Peridium single, dehiscence operculate, verrucose on the inner surface; spores hyaline, 8–12 µm diam *Licea operculata* (Wingate) G.W. Martin. ^(6,7,9)
- 16'. Peridium double, dehiscence by longitudinal plates, not verrucose on the inner surface; spores with pinkish shades 13.5–15 µm diam *Licea erecta* K.S. Thind & Dhillon. ^(6,9)
17. Lime granular or crystalline, present in sporophore (peridium, columella, stalk and/or hypothallus); capillitium not calcareous (Didymiaceae) 18
- 17'. Lime granular, present in sporophores; capillitium completely or partly calcareous (Physaraceae) 23
18. Stellate crystals (druses) present in peridium and sometimes columella; peridium typically single, less frequently double 19
- 18'. Rhombic crystals or granular lime present in peridium, columella and/or stalk; peridium typically double, rarely single or triple 20
19. Sporotheca globose to hemispheric; stalk slender, about 2–3 times as long as sporotheca diam; peridium densely covered with white lime crystals; columella subglobose, brown, calcareous *Didymium nigripes* (Link) Fr. ⁽⁴⁾
- 19'. Sporotheca discoid; stalk rather thick, sometimes very short; peridium more or less covered with white lime crystals above, thickened and limeless on the underside; columella represented by thickened, discoid, sporotheca base *Didymium clavus* (Alb. et Schwain.) Raben. ⁽¹⁰⁾
20. Sporophore plasmodiocarpic, flattened and lobate or sporocarp discoid, sessile to short-stalked, gray to grayish-white; peridium with lime granules forming a thin crust; columella flesh-colored, sometimes rudimentary *Diderma chondrioderma* (de Bary & Rostaf.) G. Lister. ⁽³⁾
- 20'. Sporophores sporocarpic, cylindrical to ellipsoid, stalked, bluish or bronze; stalk and columella white, strongly impregnated with lime; peridium membranous, without lime, iridescent *Diachea leucopodia* (Bull.) Rostaf. ⁽¹⁰⁾



21. Sporophore a pulvinate aethalium, with a calcareous, well developed yellow cortex, usually solitary; pseudocapillitium present *Fuligo septica* (L.) Wigg. ⁽⁷⁾
- 21'. Sporophore a sporocarp or plasmodiocarp, isolated or gregarious; pseudocapillitium absent 22
22. Capillitium with tubular infoldings at peridium inner face, simple or forked, totally filled with lime granules, usually bifurcate, tapered to tips, filaments hyaline, short, without lime, generally forked and which attaches to the base
..... *Badhamiopsis ainoae* (Yamash.) T.E. Brooks & H.W. Keller. ⁽³⁾
- 22'. Capillitium with rounded, fusiform or angular calcareous nodes, connected by hyaline filaments, without lime, short or long, simple or branched 23
23. Dehiscence by preformed operculum or irregularly circumscissile; basal portion persisting as a calyculus (Craterium)
..... 24
- 23'. Dehiscence irregular, lobate or areolate; basal portion, when persistent, shallow or flat (Physarum) 26
24. Sporocarp reddish-violet, fading to grayish-lilac; sporotheca globet-shaped or long and cylindrical; pseudocolumella pale violet; capillitium pale violet, with large violet lime-knots *Craterium paraguayense* (Speg.) G. Lister. ⁽⁷⁾
- 24'. Sporocarp red-brown, golden-yellow or greenish; sporotheca globose, ovoid, obovoid, cylindrical or turbinate; pseudocolumella yellowish or white; capillitium with white, yellow or ochraceous lime-knots 25
25. Sporotheca golden-yellow or greenish, fading almost to white, obovoid, ovoid or globose; peridium single, cartilaginous base with yellow lime-granules; pseudocolumella absent or represented by a yellow central mass; capillitium yellow, lime-knots yellow *Craterium aureum* (Schum.) Rostaf. ⁽⁷⁾
- 25'. Sporotheca white or whitish above and with red-brown or ochraceous base, ovoid, cylindrical or turbinate; peridium double, membranous; pseudocolumella calcareous, elongate, white or yellowish; capillitium yellow, lime-knots white, yellowish or ochraceous *Craterium leucocephalum* (Pers.) Ditmar. ⁽⁷⁾
26. Sporophore sporocarpic, stalk not calcareous; peridium and capillitial nodes scarlet-red or pinkish; spores pinkish-brown *Physarum roseum* Berk. & Broome. ^(3,11)
- 26'. Sporophore sporocarpic or plasmodiocarpic, white or with grayish, brownish, yellowish or orange shades; spores brown
..... 27
27. Peridium double or triple 28
- 27'. Peridium single 29
28. Plasmodiocarp strongly laterally compressed; peridium chalky white, double, outer layer smooth, calcareous, inner layer membranous, iridescent; dehiscence apical by preformed fissure; spores with conspicuous spines
..... *Physarum echinosporum* Lister. ^(9,11)
- 28'. Plasmodiocarp not compressed; peridium brown to beige, triple, outer layer smooth, middle layer white, inner layer membranous, rugose, white to brownish; peridial layers breaking up in angular fragments above and triangular, reflexed lobes, laterally; spores nearly smooth to verruculose *Physarum bogoriense* Racib. ⁽⁷⁾
29. Pseudocolumella presente 30
- 29'. Pseudocolumella absent 31
30. Stalk calcareous; dehiscence floriform; pseudocolumella calcareous, white, globose; capillitial nodes white, calcareous, small, fusiform to ovoid, connected by abundant hyaline filaments; spores 8–10 µm diam
..... *Physarum stellatum* (Masse) G. W. Martin. ^(6,7)
- 30'. Stalk not calcareous; capillitial nodes calcareous, small, rounded, densely aggregated in the center; spores 6.5–7.5 µm diam *Physarum nucleatum* Rex. ^(4,6)
31. Sporophore plasmodiocarpic or sporocarpic, sessile or short-stalked 32
- 31'. Sporophore sporocarpic, stalk well-developed 34
32. Plasmodiocarp in rosete-like mass, sometimes densely aggregated, occasionally mixed with contorted sporocarps ..
..... *Physarum gyrosum* Rostaf. ^(8,9)
- 32'. Plasmodiocarp short, sometimes ramificated or ring-shaped to sporocarpic, sessile or short-stalked
..... 33
33. Sporophore orange to greenish-yellow, plasmodiocarpic, cylindrical, sometimes ramificated or ring-shaped, or sporocarpic, sessile, pulvinate to subglobose, rarely short-stalked; peridium membranous, dotted with prominent glossy lime scales, nearly limeless basally; spores dark brown, verruculose *Physarum auriscalpium* Cooke. ⁽¹⁰⁾
- 33'. Sporophore yellow, plasmodiocarpic or sporocarpic, depressed-globose to pulvinate, sessile or short-stalked; calcareous yellow scales included in the rugose or areolate peridium; spores violaceous-brown, spinulose
..... *Physarum decipiens* M. A. Curtis. ⁽¹¹⁾
34. Sporotheca with yellowish, greenish, orange or ochraceous shades 35
- 34'. Sporotheca white or with grayish shades, rarely grayish-brown 37
35. Stalk not calcareous 36



35'. Stalk calcareous	37
36. Sporotheca subglobose to lenticular, yellow, greenish to reddish-orange; peridium membranous, delicate, dehiscence areolate above, floriform below	<i>Physarum viride</i> (Bull.) Pers. ^(9,11)
36'. Sporotheca globose to depressed-globose or obovoid, yellow to ochraceous with brownish base; peridium thickened and persistent as a cup below	<i>Physarum oblatum</i> T. Macbr. ⁽⁷⁾
37. Stalk white, rarely ochraceous, sometimes reddish below, up to half total height; dehiscence irregular; columella short, conic, white or yellowish, rarely orange	<i>Physarum melleum</i> (Berk. & Broome) Massee. ⁽³⁾
37'. Stalk pale yellow above, often becoming darker below, more than half of total height; dehiscence commonly by petaloid lobes; columella absent	<i>Physarum tenerum</i> Rex. ⁽¹⁰⁾
38. Sporocarp strongly compressed, reniform, fan-shaped or lobate	<i>Physarum compressum</i> Alb. & Schwein. ^(3,4)
38'. Sporocarp globose, subglobose, depressed-globose, obovoid, cylindrical, clavate, discoid, saucer-shaped or lenticular	39
39. Sporotheca globose, subglobose, obovoid, cylindrical or clavate; dehiscence irregular	40
39'. Sporotheca depressed-globose to lenticular; dehiscence areolate, sometimes floriform	42
40. Stalk calcareous, stout, tapering upward, white, rarely yellowish, up to half total height; peridium densely frosted with lime granules	<i>Physarum leucopus</i> Link. ⁽⁷⁾
40'. Stalk not calcareous, fuscous to reddish-brown or black, 1/3 to 2/3 of total height; peridium flecked with lime squamules or marked with calcareous veins and dots, sometimes rather strongly calcareous	41
41. Columella cylindrical, attaining the apex of the sporotheca, or short, clavate to conic, dark brown; capillitial nodes angular or rod-like, mostly horizontal; spores somewhat ellipsoid, 10–13 µm diam	<i>Physarum crateriforme</i> Petch. ⁽⁷⁾
41'. Columella absent; capillitial nodes mostly rounded, or angular and branching; spores globose, 9–11 µm diam	<i>Physarum leucopheum</i> Fries. ⁽⁷⁾
42. Sporotheca depressed globose to lenticular; dehiscence areolate, annular or petaloid; stalk black at the base, tapering toward the white apex; spores (7) 8–9 (10) µm diam	<i>Physarum album</i> (Bull.) Chevall. ⁽⁹⁾
42'. Sporotheca discoid to saucer-shaped; stalk slender, twisted, translucent, reddish brown; peridium breaking areolately above; spores 10–17 µm diam	<i>Physarum pezizoideum</i> (Jungh.) Pavill. & Lagarde. ⁽⁷⁾
43. Columella and stalk hollow, occasionally opaque and fibrous at base	44
43'. Columella and stalk fibrous from base to apex	55
44. Sporocarp long-cylindrical, usually > 2 mm in total height	45
44'. Sporocarp globose to subglobose, usually < 2 mm in total height	52
45. Surface capillitial reticulum present, fragmented or complete	46
45'. Surface capillitial reticulum absent	50
46. Peridium silvery, partially evanescent, persistent as patches and/or a basal cup; surface reticulum fragmented; spores typically with scattered, more or less prominent clusters of dark warts	<i>Stemonitopsis typhina</i> (F.H. Wigg.) Nann.-Bremek. ⁽⁸⁾
46'. Peridium totally evanescent; surface reticulum complete; spores without clusters of prominent warts	47
47. Sporocarp fuscous to deep reddish-brown; spores verrucose-reticulate or spinulose-reticulate	<i>Stemonitis fusca</i> Roth. ^(3,4,10,11)
47'. Sporocarp dull cinnamon, rusty or purplish brown to nearly black; spores verrucose to nearly smooth	48
48. Surface reticulum with meshes mostly over 20 µm in diameter; sporotheca dark purplish-brown to nearly black; columella becoming coiled and tortuous near apex	<i>Stemonitis splendens</i> Rostaf. ⁽⁸⁾
48'. Surface reticulum with meshes mostly up to 20 µm in diameter; sporotheca rusty brown to dull cinnamon; columella becoming dissipated bellow apex	49
49. Sporocarps densely clustered; stalk ca. half of its total height; surface reticulum persistent; spores nearly smooth, 5–7.5 µm diam	<i>Stemonitis axifera</i> (Bull.)T. Macbr. ⁽⁶⁾
49'. Sporocarps in small clusters; stalk less than one third of its total height; surface reticulum persistent above; spores verrucose, 7–9 µm diam	<i>Stemonitis herbatica</i> Peck. ⁽⁷⁾
50. Columella flexuous, attaining apex of the sporotheca; capillitium without expansions and with numerous free ends	51
50'. Columella dissipating in 2–3 branches bellow apex; internal capillitium with many expansions, becoming thinner towards periphery, with rare free ends; spores brown, verrucose-reticulate	<i>Stemonaria fuscoidea</i> Nann.-Brem. & Y. Yamam. ⁽¹⁰⁾
51. Sporangium up to 10 mm long, semi-erect; columella attaining apex where it may expand; capillitium flexuous, not dichotomously furcate, with hyaline free ends at the periphery; spores densely verrucose, often paler on one side	<i>Stemonaria irregularis</i> (Rex) Nann.-Bremek., R. Sharma & Y. Yamam. ⁽¹⁰⁾
51'. Sporocarp 10–50 mm long, pendent; capillitium rigid, horizontal, dichotomously branching; spores verrucose-reticulate	



.....	<i>Stemonaria longa</i> (Peck) Nann.-Bremek., R. Sharma & Y. Yamam. ⁽⁷⁾	
52. Peridium evanescent, not iridescente		53
52'. Peridium persistent, iridescente		54
53. Capillitium lax, consisting of 3–4 main filaments, dichotomously branching, arising from apex of columella; spores with clusters of prominent dark warts, 6.5–8 µm diam	<i>Macbrideola martinii</i> (Alexop. & Beneke) Alexop. ⁽⁹⁾	
53'. Capillitium scarce, rudimentary; spores with warts varying in size and distribution, 7–9 µm diam	<i>Macbrideola decapillata</i> H.C. Gilbert. ^(4,11)	
54. Sporocarp up to 0.4 mm total height; capillitium absent to scarce; spores with evenly distributed warts	<i>Macbrideola scintillans</i> H. C. Gilbert. ^(9,10,11)	
54'. Sporocarp > 0.4 mm total hight; capillitium abundant; spores with clusters of prominent warts	<i>Collaria arcyronema</i> (Rostaf.) Nann.-Bremek. ex Lado. ^(6,10,11)	
55. Sporocarp usually < 2 mm total height; capillitia with filaments dichotomously branched, never or rarely anastomosed		56
55'. Sporocarp usually < 2 mm total height; capillitia anastomosing, not dichotomously branched		57
56. Stalk 8/10 or more of total height; capillitium flexuous; spores 7–8 µm diam	<i>Paradiacheopsis longipes</i> Hooff & Nann.-Bremek. ⁽¹¹⁾	
56'. Stalk up to 2/3 of total height; capillitium not flexuous; spores 8–10 µm diam	<i>Paradiacheopsis rigida</i> (Brândza) Nann.-Bremek. ^(1,9)	
57. Sporotheca fusiform; spores spinulose, with clusters of prominent spines	<i>Comatricha tenerrima</i> (M.A. Curtis) G. Lister. ⁽⁴⁾	
57'. Sporotheca globose to short-cylindric; spores verrucose, when spinulose, spines not clustered		58
58. Columela reaching at most the middle of the sporotheca; capillitium arising from the top of columela	<i>Comatricha elegans</i> (Racib.) G. Lister. ^(7,11)	
58'. Columella surpassing half of sporotheca; capillitium arising from the whole columella		59
59. Capillitium anastomosed at periphery, without free ends.....	<i>Comatricha pulchella</i> (C. Bab.) Rostaf. ⁽¹⁰⁾	
59'. Capillitium with numerous free ends		60
60. Capillitium with dichotomously branched filaments, rarely anastomosed; spores 6–7.5 µm diam	<i>Comatricha longipila</i> Nann.-Bremek. ⁽¹¹⁾	
60'. Capillitium with filaments not dichotomously branched, anastomosed, forming internal loose reticulum; spores 8–11 µm diam	<i>Comatricha laxa</i> Rostaf. ^(3,7)	
61. Capillitium filaments always decorated with well-defined spirals (Trichiaceae)		62
61'. Capillitium filaments decorated with warts, spines, cogs, ridges, half-rings, rings and/or reticulations; spirals absent. (Arcyriaceae)		65
62. Sporophore plasmodiocarpic, branched, reticulate or ring-shaped; spores banded reticulate, bands non-pitted, border thickness 1–2 µm	<i>Hemitrichia serpula</i> (Scop.) Rostaf. ^(7,8)	
62'. Sporophore sporocarpic, stalked; spores spinulose to verrucose		63
63. Peridium single, membranous, remaining as a deep calyculus; inner face densely papillate or faintly subreticulated; stalk long, filled with cysts at base; capillitium filaments uniform in diameter; spores verrucose to spinulose, 6.5–7.5 (–8) µm diam	<i>Hemitrichia calyculata</i> (Speg.) M.L. Farr. ^(4,6,10,11)	
63'. Peridium double, inner layer attached to the outer layer, persistent but not forming a calyculus; inner surface papillate or faintly wrinkled; stalk short, rarely absent; capillitium filaments with expansions and constrictions		64
64. External layer of peridium gelatinous, with dark brown protuberances of refuse matter, persistent as brown pustules, inner layer membranous, papillate; spores 9–11 µm diam	<i>Hemitrichia pardina</i> (Minakata) Ing. ^(4,9)	
64'. External layer of the peridium membranous, tightly adhered to membranous inner layer; spores 11–13 µm diam	<i>Hemitrichia minor</i> G. Lister. ⁽⁷⁾	
65. Sporophore sporocarpic, with grayish or reddish shades; stalk filled with cysts; peridium single, persistent, the lower portion remaining as a calyculus		66
65'. Sporophore plasmodiocarpic or sporocarpic, with brownish shades; stalk, if present, not filled with cysts; peridium single or double, partially persistent		69
66. Capillitium remaining attached to the calyculus at maturity; sporotheca with reddish, grayish or yellowish shades; inner surface of calyculus decorated with warts, spines, ridges or fine reticulations, sometimes almost smooth		67
66'. Capillitium detached from calyculus at maturity; sporotheca reddish-brown to reddish-orange; inner surface of calyculus reticulate or alveolate	<i>Arcyria ferruginea</i> Sauter. ⁽⁷⁾	
67. Sporotheca with reddish shades; capillitium decorated with warts or spines, cogs, ridges, rings or half-rings, helicoidally arranged	<i>Arcyria denudata</i> (L.) Wettst. ⁽⁹⁾	



- 67'. Sporotheca with grayish or yellowish shades; capillitium decorated with warts or spines, not helicoidally arranged 68
68. Sporotheca subglobose to obpyriform, yellowish-gray or olivaceous; stalk filled at the base with subglobose or slightly angular cysts, 25–38 μm ; capillitium flexuous, greenish-yellow by transmitted light, with uniform filaments, 2–5 (–8) μm diam, decorated with warts and/or spinules, occasionally with clavate or rounded free ends *Arcyria pomiformis* (Leers) Rostaf. ⁽⁶⁾
- 68'. Sporotheca typically subcylindric, sometimes ovoid to subglobose, usually pale gray; stalk filled with globose cysts, 15–21 μm diam.; capillitium flexuous, hyaline by transmitted light, with filaments of lower portion irregular, smooth, 2–6 (–10) μm diam. and those of upper portion densely spinulose, more symmetrical, 1.5–4.0 μm diam *Arcyria cinerea* (Bull.) Pers. ^(1,3,4,5,6,8,10,11)
69. Sporophore plasmodiocarpic, linear, reticulate or ring-shaped; capillitium filaments with long spines of up to 5 μm in length *Perichaena chrysosperma* (Curr.) Lister. ^(4,6,7,9)
- 69'. Sporophore sporocarpic; capillitium filaments with constrictions, warts or short spines of up to 2 μm in length 70
70. Sporocarp stalked to almost sessile, isolated or rarely in groups of two or three; dehiscence irregular, areola-shaped or in polygonal plates 71
- 70'. Sporocarp sessile, densely grouped, seldom sparse, dehiscence circumcissile 72
71. Stalk developed, up to 0.7 mm long; dehiscence irregularly apical or areola-shaped; spores (8–) 9–10 μm *Perichaena pedata* (Lister & G. Lister) Lister ex E. Jahn. ^(1,2)
- 71'. Stalk very short, up to 0.35 mm long or absent; dehiscence by polygonal plates, peridium remaining at base as a petaloid calyculus; spores 10–13.5 μm diam *Perichaena calongei* Lado, D. Wrigley & Estrada. ⁽⁹⁾
72. Sporotheca flattened, base fully supported by substrate, dehiscence line on bottom third, close to base; spores spinose, 9–11 μm diam *Perichaena depressa* Lib. ^(3,4,5,6,7,9)
- 72'. Sporotheca subglobose, base not fully supported by substrate, average dehiscence line; spores faintly warted, 12–14 μm diam *Perichaena corticalis* (Batsch) Rostaf. ^(3,4,6,7)

Discussion

The number of corticolous species of Myxomycetes currently known from CEPE corresponds to 23.5% of the total number recorded by Cavalcanti (2015) in northeastern Brazil for most ecological groups and vegetation types. Although this number is significant, half of the species were recorded from only one site within CEPE; eleven were collected in Seasonal Semideciduous Forests (Lowland) and 12 in Dense Ombrophilous Forest (Lowland) (Tab. 1). *Comatricha longipila*, *Paradiachaeopsis longipes* and *Physarum decipiens* were recorded as corticolous in CEPE only in Restinga of the state of Rio Grande do Norte. Although *Comatricha pulchella*, *Physarum auriscalpium*, *Stemonaria fuscoidea* and *S. irregularis* have only been reported from mangroves of Rio Formoso (Tab. 1), they occur as lignicolous or suculentulous at other localities in CEPE and in Caatinga and Cerrado vegetation in northeastern Brazil, with the exception of *S. fuscoidea* (Rufino & Cavalcanti 2007; Tenorio *et al.* 2009; Ferreira & Cavalcanti 2011).

Among the 16 most common corticolous species at Great Mountains National Park (Snell & Keller 2003), nine occur at CEPE, of which *A. cinerea*, *Clastoderma debaryanum*, *C. confusa*, *C. violacea* and *E. minutum* are the most common, being recorded in all vegetation types (Tab.1). *Arcyria cinerea* has been recorded in all regions of Brazil, occurring in Caatinga, Cerrado, Atlantic Forest, Mangrove and Restinga, where it occupies different micro-habitats,

with decaying wood and bark of living trees being the most common (Cavalcanti 2015). *Clastoderma debaryanum* occurs worldwide and is considered among the most common species on living trees (Eliasson & Keller 1996). In Brazil, this species has an extensive distribution, mainly in the Northeast Region (Bahia, Paraíba, Pernambuco, Piauí, Rio Grande do Norte), but there are also records in the Southeast (São Paulo) and South (Santa Catarina) regions, where they are corticolous and lignicolous in Atlantic Forest, Caatinga and Cerrado (Cavalcanti 2015). *Cribraria confusa* is one of the myxomycetes with the smallest sporocarps, being very hard to detect; this species is cited worldwide as corticolous on a variety of vegetation. In Brazil, this species has been recorded only in the Northeast Region (Alagoas, Maranhão, Pernambuco, Rio Grande do Norte, Sergipe), in Cerrado and moist forest environments (Cavalcanti 2015). Although rare, *Cribraria confusa* also is part of the CEPE lignicolous myxobiota, as reported by Cavalcanti *et al.* (2006) for Mata Bom Jesus of Usina Serra Grande in the municipality of São José da Laje, Alagoas. *Cribraria violacea* also produce small sporangia, and is very common on the cortex of living trees and, less frequently, on dead wood. In Brazil, this species has been recorded from almost all northeastern states, plus once in the South Region (Santa Catarina) and once in the Southeast Region (São Paulo), occurring as corticolous and lignicolous in the Atlantic Forest and Caatinga (Gusmão *et al.* 2005; Silva & Cavalcanti 2010; Bezerra *et al.* 2011; Silva & Cavalcanti 2012). *Echinostelium minutum* is known only from the Northeast (Alagoas, Bahia, Maranhão, Pernambuco) and



Table 1. Vegetation types where were found corticolous myxomycetes at the Pernambuco Center of Endemism (CEPE), Northeastern of Brazil. SDF = Seasonal Semideciduous Forest (Lowland), ODF= Dense Ombrophilous Forest (Lowland), MG= Mangrove and RT = Restinga.

Species	SDF	ODF	MG	RT	CEPE Localities (%)
<i>Arcyria cinerea</i>	+	+	+	+	75
<i>Arcyria denudata</i>		+			8
<i>Arcyria ferruginea</i>		+			8
<i>Arcyria pomiformis</i>	+				8
<i>Badhamiopsis ainoae</i>	+				8
<i>Clastoderma debaryanum</i>	+	+	+	+	50
<i>Collaria arcyronema</i>			+	+	17
<i>Comatricha elegans</i>		+		+	17
<i>Comatricha laxa</i>	+	+			17
<i>Comatricha longipila</i>				+	8
<i>Comatricha pulchella</i>			+		8
<i>Comatricha tenerrima</i>	+				8
<i>Craterium aureum</i>		+			8
<i>Craterium leucocephalum</i>		+			8
<i>Craterium paraguayense</i>		+			8
<i>Cribraria cancellata</i>	+	+		+	25
<i>Cribraria confusa</i>	+	+	+	+	58
<i>Cribraria intricata</i>	+	+		+	25
<i>Cribraria microcarpa</i>	+	+		+	58
<i>Cribraria violacea</i>	+	+		+	50
<i>Diachea leucopodia</i>			+		8
<i>Dictydiaethalium plumbeum</i>	+				8
<i>Diderma chondrioderma</i>	+				8
<i>Didymium clavus</i>			+		8
<i>Didymium nigripes</i>	+				8
<i>Echinostelium minutum</i>	+	+		+	58
<i>Fuligo septica</i>		+			8
<i>Hemitrichia calyculata</i>	+		+	+	33
<i>Hemitrichia minor</i>		+			8
<i>Hemitrichia pardina</i>	+	+			17
<i>Hemitrichia serpula</i>		+			17
<i>Licea biforis</i>		+			8
<i>Licea erecta</i>	+	+			17
<i>Licea kleistobolus</i>		+	+	+	25
<i>Licea operculata</i>	+	+			25
<i>Licea pedicellata</i>		+			8
<i>Lycogala exiguum</i>	+				8
<i>Macbrideola decapillata</i>	+			+	8
<i>Macbrideola martinii</i>		+			8
<i>Macbrideola scintillans</i>		+	+	+	25
<i>Paradiacheopsis longipes</i>				+	8
<i>Paradiacheopsis rigida</i>	+	+			17
<i>Perichaena calongei</i>		+			8
<i>Perichaena chrysosperma</i>	+	+			33
<i>Perichaena corticalis</i>	+	+			33
<i>Perichaena depressa</i>	+	+			50
<i>Perichaena pedata</i>	+	+			17
<i>Physarum album</i>		+			8
<i>Physarum auriscalpium</i>			+		8
<i>Physarum compressum</i>	+				17
<i>Physarum crateriforme</i>		+			8
<i>Physarum bogoriense</i>		+			8
<i>Physarum decipiens</i>				+	8



Table 1. Cont.

Species	SDF	ODF	MG	RT	CEPE Localities (%)
<i>Physarum echinosporum</i>		+		+	17
<i>Physarum gyrosum</i>		+			17
<i>Physarum leucopus</i>		+			8
<i>Physarum leucopheum</i>		+			8
<i>Physarum melleum</i>	+				8
<i>Physarum nucleatum</i>	+				17
<i>Physarum oblatum</i>		+			8
<i>Physarum pezizoideum</i>		+			8
<i>Physarum roseum</i>	+			+	17
<i>Physarum stellatum</i>	+	+			17
<i>Physarum tenerum</i>			+		8
<i>Physarum viride</i>		+		+	17
<i>Stemonaria fuscoides</i>			+		8
<i>Stemonaria longa</i>		+			8
<i>Stemonaria irregularis</i>			+		8
<i>Stemonitis axifera</i>	+	+			17
<i>Stemonitis fusca</i>	+		+	+	33
<i>Stemonitis herbatica</i>		+			8
<i>Stemonitis splendens</i>		+			8
<i>Stemonitopsis typhina</i>		+			8
Total	33	48	15	21	

Southeast (SP) regions of Brazil, occurring as corticolous in Caatinga, Cerrado, Atlantic Forest and Mangrove (Cavalcanti 2015); it is one of the first to sporulate, and its sporangium can be observed within two to three days after culture initiation.

Some corticolous species that occur in CEPE have been rarely recorded in Brazil. Among these are *Perichaena calongei*, *Physarum gyrosum*, *Licea biforis* and *L. pedicellata*, which have been recorded in Ombrophilous Forest of Biological Reserve in the municipality of Saltinho, and *Comatricha longipila*, *Paradiachaeopsis longipes* and *Physarum decipiens*, which were found in Restinga vegetation of Dunas do Natal State Park. *Perichaena calongei* was reported in Brazil for the first time by Araujo *et al.* (2015), who obtained it from moist chamber culture mounted with dead leaves and bark of living trees from Cerrado in the state of Goiás. This species was recorded for the first time in the Northeast Region in Ombrophilous Dense Submontane Forest of the Atlantic Forest in the state of Bahia, by moist-chamber culture mounted with lianas collected at Private Reserve of Natural Heritage (RPPN) Serra do Teimoso and, subsequently, at CEPE in Restinga of RPPN Mata Estrela in the state of Rio Grande do Norte (Cavalcanti *et al.* 2016).

Considering the myxobiota from REBIO Saltinho, one of the most humid environments among the 12 areas explored for myxomycetes in the CEPE, the present work documented 21 species (ca. of 44% of the species currently known from CEPE), occurring in 256 moist-chambers with bark of living trees. Although this is greater than the number of corticolous species observed by Stephenson *et al.* (2004)

in the rainforest of the Maquipucuna Reserve in Ecuador (14 spp), it is lower than that encountered in temperate forests by Snell & Keller (2003), who reported 84 species and 24 genera ($S/G = 3.5$) from 418 moist chamber cultures and Everhart & Keller (2008), who recorded 46 species and 20 genera ($S/G = 2.3$) in 580 moist chambers.

The data presented herein are consistent with the observation that tropical corticolous myxobiota are less rich than those of temperate regions. However, the taxonomic diversity recorded at REBIO Saltinho ($S/G = 2.3$) and CEPE ($S/G = 2.8$), are equal to, or higher than, that of some temperate forests (*e.g.*, Snell & Keller 2003; Everhart & Keller 2008).

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