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Diversity of myxomycetes in an environmentally protected area of Atlantic Forest in northeastern Brazil

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ABSTRACT

The present study was carried out on three trails, each presenting a different degree of disturbance, within the Pau--Ferro Forest Environmentally Protected Area, a 600 ha area of highland forest located in the municipality of Areia (06°58'12"S; 35°42'15"W; elevation, 400-600 m), in the state of Paraíba, Brazil. In 2005, we analyzed the species richness, abundance, constancy and phenology of myxomycetes over seven consecutive months (rainy and dry seasons) in five types of microhabitats: dead tree trunks, the bark of living trees, basidiomata, ground litter and aerial litter. A total of 753 specimens of 48 species were obtained from the trails known as Flores (4 km), Boa Vista (3 km) and Cumbe (700 m). The Sørensen similarity coefficient revealed that the three trails are similar. The most constant and abundant species were *Hemitrichia calyculata*, *H. serpula*, *Arcyria cinerea*, *A. denudata* and *Ceratiomyxa fruticulosa*. Although myxomycetes sporulate throughout the year, some species have well-defined sporulation seasons. In terms of the constancy and abundance of species, Trichiaceae is the most important family in the rain forest studied, which is representative of the highland forests of northeastern Brazil.

Key words: Highland forests, myxobiota, Neotropics

Introduction

In northeastern Brazil, there are currently 2626.68 km^2 of highland forests (known locally as *brejos de altitude*), which account for a large portion of the remaining Atlantic Forest that still covers the coastal zone of the region (IBGE 1985). Such fragments include areas quite near the coast, like Brejo dos Cavalos, in the state of Pernambuco, at 132 km inland, as well as areas further inland, like Serra Negra, which is approximately 434 km from the coast, within the same state (Compasso 2004; Rodal & Nascimento 2002). Elevation also varies, ranging from 400 m in the lowermost fragments to 1190 m at the Pico do Jabre State Reserve, in the state of Paraíba (Pôrto *et al.* 2004).

There are 47 highland forests in northeastern Brazil, all of which share characteristic vegetation that is distinct from that of neighboring areas, where the vegetation is typical of the *caatinga* (shrublands). This difference is due to a combination of orographic and climatic aspects that allow cooler temperatures in the highland forests, where there is also good availability of water throughout the year (Tabarelli & Santos 2004).

The Pau-Ferro Forest (PFF) Environmentally Protected Area is located in the mesoregion known as the Brejo Paraibano, which is considered one of the most representative highland forest areas in the state of Paraíba. The PFF is approximately 127 km from the coast, in the municipality of Areia (Mayo & Fevereiro 1982). Floristic and ecological studies of the PFF, such as those carried out by Barbosa *et al.* (2004), have identified 309 species of Angiospermae, distributed among 84 families, the most important of which is Leguminosae (with 30 species).

Despite the fact that microorganisms are known to play a major role in the equilibrium of ecosystems, little is known regarding the species of microbiota, especially myxomycetes, in the highland forests of Paraíba. Although barely perceptible in the environments in which they occur, myxomycetes contribute to the decomposition of organic matter (Kalyanasundaram 2004). In addition, a number of animal species, Coleoptera in particular, use the plasmodia and sporocarps of myxomycetes for foraging, reproduction and refuge from predators (Newton & Stephenson 1990). To date, only Silva & Cavalcanti (1988; 2012) have offered information on species that occur in the highland forests of the state of Pernambuco, whereas Costa *et al.* (2009; 2011) made the first records for the state of Paraíba.

The present study had the following aims: to evaluate the species richness and abundance of myxomycetes

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communities in the PFF; to estimate the similarity in the composition of species among trails presenting different degrees of disturbance; and to analyze the seasonality of the myxobiota of the area. The overarching objective was to gain a better understanding of the microbiota of the Atlantic Forest, especially that of the highland forests of northeastern Brazil.

Materials and methods

Study area

The PFF is in the microregion of Areia, at the eastern edge of the Borborema plateau, in northeastern Brazil (Fig. 1). The PFF occupies an area of 600 ha and is 5 km to the west of the center of the municipality of Areia (6°58'12"S; 35°42'15"W), at an elevation of 400-600 m (Tabarelli & Santos 2004). The climate is humid, the average monthly temperatures being 15-18°C in winter and 22-30°C in summer, with a relative humidity of approximately 85%. The rains are in autumn and winter, with a total annual precipitation of approximately 1450 mm (Mayo & Fevereiro 1982). The soil is deep and moderately fertile. The hydrography of the area is characterized by small and medium-sized watercourses; the runoff oscillates greatly between seasons.

In the area under study, vast areas of forest were cleared for agriculture use and are currently abandoned, the razed areas presenting different stages of succession. Therefore, although the PFF is the most representative highland forest in the state of Paraíba, it has been under considerable anthropogenic pressure, most notably prior to its official establishment as an environmentally protected area in 1992. In addition to its scientific importance, the PFF covers practically the entire catchment area of the Vaca-Brava Dam, a reservoir that supplies water to a number of municipalities in the mesoregion of Brejo Paraibano (Mayo & Fevereiro 1982).

During 2005 (the year studied), the total annual precipitation in the microregion of Areia was 1161.7 mm (Fig. 2), the monthly total being highest in May (246.5 mm) and June (342.0 mm), whereas they were lowest in October (10.2 mm) and November (6.5 mm). Average monthly temperatures were lowest in July (20.6°C) and August (20.2°C), whereas they were highest in February (24,4 °C) and March (24,9 °C). According to meteorological data regarding the annual water balance in the municipality of Areia for the same year, there was an average surplus of 6.00 mm/day in June and July (rainy season), monthly minimums ranging from 2.44 mm/day to 1.87 mm/day during the rainy season, whereas the monthly maximums ranged from 13.5 mm/day to 21.81 mm/day, the latter recorded in August. In September, the minimum surplus dropped to an average of 0.07 mm/day, with a maximum of 1.14 mm/day, and reaching a deficit of −0.91 mm/day. In the dry season, the water balance was negative, with minimum deficits ranging from −3.16 mm/day to −4.74 mm/day, whereas the maximum deficits ranged from −4.93 mm/day to −5.25 mm/day.

Collection, preparation and identification of specimens

Between June and December of 2005 (including rainy and dry months), we carried out six two-day excursions. Specimens were collected in different months on three different trails (Fig. 1), along which we explored areas of approximately 15.0 × 35.0 m, at intervals of at least 100.0 m (7 areas/trail): the Cumbe Trail, (700 m), which is under strong anthropogenic influence because it is at the edge of the forest near state road PB 079; the Boa Vista Trail (3 km), which leads toward the interior of the forest, near the Vaca Brava Dam, and passes through various clearings; and the Flores Trail (4 km), which runs parallel to the Cumbe Trail but presents denser vegetation.

We surveyed the following ecological groups (microhabitats): lignicolous (trunks of dead unidentified trees, either standing or fallen); corticolous (bark of living trees); foliicolous (ground litter and aerial litter); and myceticolous (basidiomata). Substrate samples from the different trails were placed in plastic bags (60 ml) and used in order to establish 100 moist chambers, which were maintained under observation for three months in room light and at room temperature (Stephenson *et al.* 2001).

Species identification followed Lister (1925), Martin & Alexopoulos (1969), Lado & Pando (1997) and Poulain *et al.* (2011). For the indication of the binomials and authors of the species, we followed Lado (2005-2013). The material studied was deposited at the Herbarium UFP of the Department of Botany of the Federal University of Pernambuco, in Recife, Brazil.

Ecological analysis

Species abundance was calculated using the criteria proposed by Schnittler *et al.* (2002), which are based on the proportional distribution of samples among species and the total number of samples. The species were thereby classified as follows: abundant (> 6.5%); common (>3.5% to 6.5%); occasional (1.5% to 3.5%); or scarce (< 1.5%). Species constancy was based on the methodology adopted by Cavalcanti & Mobin (2004), considering the ratio between the number of excursions and the number of excursions during which at least one specimen of a given species was collected. Based on the percentages obtained, the species were classified as either constant (>50%), accessory (25% to 50%) or accidental (< 25%). The Sørensen similarity coefficient (Stephenson 1989) was used in order to compare the three trails in terms of the composition of the myxobiota. We also evaluated diversity with the Shannon-Wiener diversity index (H').

We performed non-metric multidimensional scaling (NMDS) ordination analysis with a dissimilarity matrix of the species abundance from each excursion using the Bray-

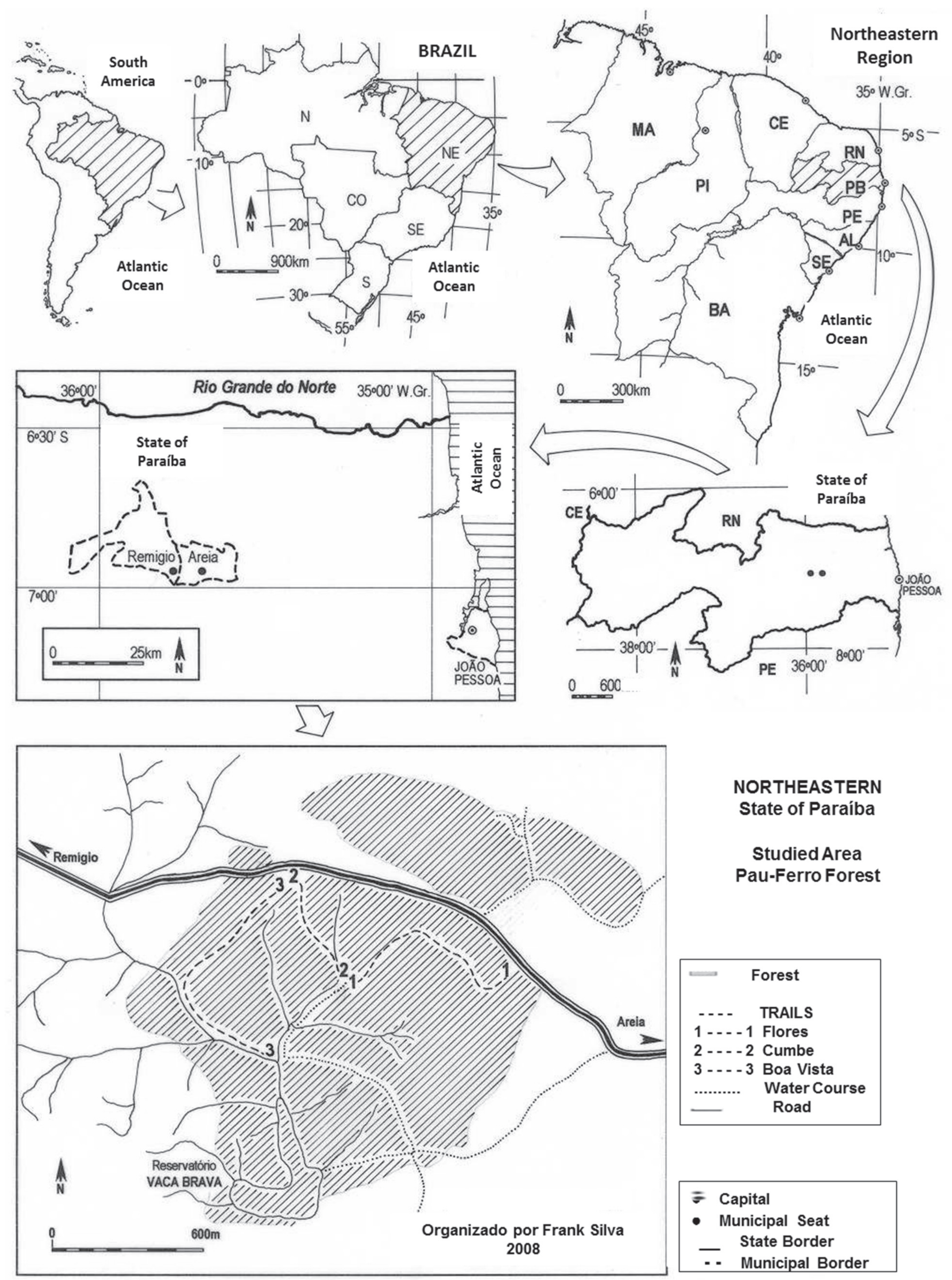

Figure 1. Map indicating the trails explored in the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil.
Source: Brazilian Institute of Geography and Statistics (data for the year 2000).

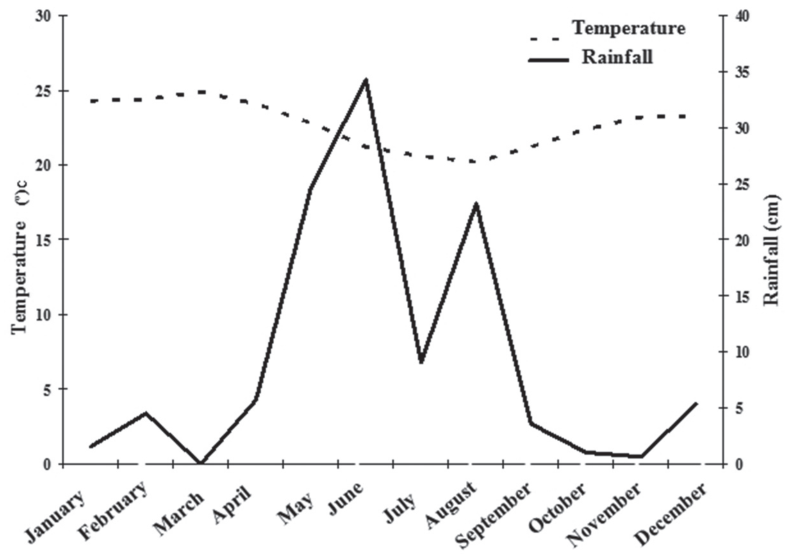

Figure 2. Variation in temperature and rainfall throughout the study period (2005) in the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil.

Curtis index. Species that occurred on only one occasion were excluded from the analysis. The influence that the average temperature and rainfall of the month of collection had on the occurrence of the myxomycetes species was analyzed by fitting as linear trends in the resulting ordination, with the coefficient of determination (r^2) indicating the strength of the correlation and the vectors indicating the direction of the correlation. The statistical significance of each variable was assessed by permutation test (1000 permutations). All statistical analyses were performed using the software R (R Development Core Team; http://www.r-project.org/), with the "vegan" package.

Results and discussion

Among the 753 specimens collected, 48 species were recorded for the PFF, revealing a high level of species richness for myxomycetes in this type of highland forest. For the PFF, we recorded three species of the subclass Ceratiomyxomycetidae, which is found on the lists of the five highland forests in the state of Pernambuco (Cavalcanti *et al.* 2008). *Ceratiomyxa fruticulosa* (O.F. Müll.) T. Macbr. is included among the five most abundant species in the PFF, although it is restricted to the rainy season (Tab. 1).

The subclass Stemonitomycetidae was represented by nine species in the myxobiota of the PFF, of which *Stemonitis fusca* Roth and *Stemonitis splendens* Rostaf. are also cited for the Serra dos Cavalos forest in Pernambuco. *Stemonitopsis typhina* (F.H. Wigg.) Nann.-Bremek. was recorded for the first time for highland forest environments by Costa *et al.* (2009).

The subclass Myxogastromycetidae was represented by four orders and six families. The order Liceales was scarce in the myxobiota studied, represented by three families, five genera and 12 species (25% of the total). The family Didymiaceae was represented by three genera and five species, all scarce and accidental in the myxobiota of the PFF (Tab. 1). As in other tropical rain forests, the majority of representatives of the family Physaraceae were accidental and scarce in the myxobiota studied, with the exceptions of *Physarum stellatum* (Massee) G.W. Martin and *P. viride* (Bull.) Pers.

Although Trichiaceae was the most abundant and constant family on the trails studied, two of its species—*Metatrichia vesparia* (Batsch) Nann.-Bremek. ex G.W. Martin & Alexop. and *Perichaena chrysosperma* (Curr.) Lister were scarce and were considered accidental in the myxobiota studied (Tab. 1). *Perichaena depressa* Lib. was abundant but was classified as accessory, because it sporulated only in the dry season (Tab. 1). *Hemitrichia calyculata* (Speg.) M.L. Farr, *H. serpula* (Scop.) Rostaf. ex Lister, *Arcyria denudata* (L.) Wettst. and *A. cinerea* (Bull.) Pers. were the most constant and abundant species (Tab. 1 and Fig. 3).

Hemitrichia calyculata is recorded for the five highland forests studied in the state of Pernambuco, and *H. serpula* is cited for the Baixa Verde and Madre de Deus forests, in the same state (Silva & Cavalcanti 1988; 2012); *Arcyria denudata* occurs in the Serra dos Cavalos and Serra Negra forests in the municipality of Bezerros, also in Pernambuco, and *A. cinerea* is recorded only for the Serra dos Cavalos forest. Silva & Cavalcanti (1988) cite *Perichaena depressa* for the Madre de Deus forest (Tab. 1 and Fig. 3). *Lycogala epidendrum* (L.) Fr. (Reticulariaceae) is recorded for the Serra dos Cavalos forest and was common in the PFF, with records in the rainy and dry seasons (Tab. 1). Although either scarce or occasional in the PFF (Tab. 1) and with records for only a few highland forests in Pernambuco, *Cribraria cancellata* (Batsch) Nann.-Bremek. (Cribrariaceae) and

Table 1. Constancy and relative abundance of the myxomycete species found in the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil.

Constancy/Abundance	Species
Accessory/Abundant	*Ceratiomyxa fruticulosa*; *Perichaena depressa*; *Physarum stellatum*; *Stemonitis fusca*; *Stemonitopsis typhina*
Accessory/Common	*Collaria arcyrionema*; *Lycogala epidendrum L. exiguum*; *Stemonitis smithii*; *S. splendens*
Accessory/Occasional	*Cribraria cancellata*; *C. microcarpa*; *Physarum viride*; *Stemonitis axifera*
Accidental/Scarce	*Ceratiomyxa morchella*; *C. sphaerosperma*; *Clastoderma debaryanum*; *Cribraria languescens*; *C. minutissima*; *C. mirabilis*; *C. violacea*; *Cribraria* sp; *Diachea silvaepluvialis*; *Dictydiaethalium plumbeum*; *Diderma hemisphaericum*; *Didymium clavus*; *D. minus*; *D. nigripes*; *Fuligo septica*; *Licea biforis*; *Macbrideola scintillans*; *Metatrichia vesparia*; *Perichaena chrysosperma*; *Physarum album*; *P. echinosporum*; *P. pulcherrimum*; *Stemonaria longa*
Accidental/ Occasional	*Comatricha pulchella*; *Physarella oblonga*; *Physarum nucleatum*; *P. penetrale*; *Tubifera microsperma*
Constant/Abundant	*Arcyria cinerea*; *A. denudata*; *Hemitrichia calyculata*; *H. serpula*; *Metatrichia floriformis*; *Trichia affinis*

Constant – > 50%; Accessory – 25-50%; Accidental – < 25%; Abundant – > 6.5%; Common – >3.5-6.5%; Occasional – 1.5-3.5%; Scarce – < 1.5%.

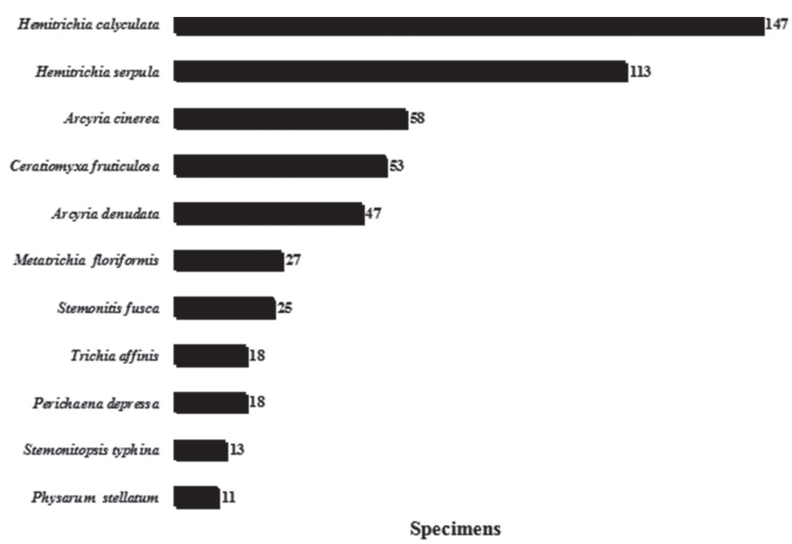

Figure 3. Most abundant myxomycete species in the myxobiota of the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil.

Tubifera microsperma (Berk. & M.A. Curtis) G.W. Martin (Reticulariaceae) are common to both states and can be considered accessory components of the myxobiota in the highland forests of northeastern Brazil. *Licea biforis* Morgan (Liceaceae), *Clastoderma debaryanum* A. Blytt (Clastodermataceae), *Diderma hemisphaericum* (Bull.) Hornem. and *Diachea silvaepluvialis* M.L. Farr (Didymiaceae), are found in fragments of the Atlantic Forest in different regions of the country, with the exception of *D. silvaepluvialis*, which is only recorded for the Serra de Itabaiana National Park, in the state of Sergipe (Bezerra *et al.* 2008).

Comparing the PFF trails in terms of the number of records and species diversity (Tab. 2), we found that there were 30 species, from 20 genera, on the Flores Trail (H' = 2.67), which has denser vegetation, with lower levels of light intensity and slightly higher humidity; 27 species, from 13 genera, on the Cumbe Trail, which has more evident signs of anthropogenic influence (H' = 2.57); and 24 species, from 16 genera, on the Boa Vista Trail (H' = 2.19), which is near the Vaca Brava Dam and has higher levels of light intensity due to a greater number of clearings. There were 12 species—belonging to the families Ceratiomyxaceae, Trichiaceae, Stemonitaceae and Reticulariaceae—that occurred on all three trails. On the basis of the Sørensen similarity coefficients, the myxobiotas on the three trails can be considered comparable: Cumbe vs. Boa Vista = 0.67; Cumbe vs. Flores = 0.57; Boa Vista vs. Flores = 0.52. The Flores Trail, with its denser vegetation, had the highest numbers of exclusive genera and species, which explains its lower similarity to the other trails explored in the PFF (Tab. 2).

Representatives of the families Clastodermataceae, Liceaceae and Didymiaceae were all accidental and scarce (Tab. 1). Twelve species were found exclusively on the Flores Trail, corresponding to 40% of all species found on that trail. *Ceratiomyxa morchella* A.L. Welden, *Ceratiomyxa sphaerosperma* Boedijn, *Comatricha pulchella* (C. Bab.)

Table 2. Distribution of myxomycetes species on the trails explored in the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil.

Trail	Species (number of specimens)
Cumbe	*Cribraria languescens* (1); *C. mirabilis*(1); *Cribraria* sp. (1); *Didymium clavus* (1); *D. minus* (1); *Metatrichia vesparia* (2); *Perichaena chrysosperma* (1); *Stemonaria longa* (1)
Boa Vista	*Cribraria violacea* (1); *Diachea silvaepluvialis* (1); *Macbrideola scintillans* (2); *Physarum album* (1); *P. echinosporum* (1); *P. pulcherrimum* (1)
Flores	*Ceratiomyxa morchella* (1); *C. sphaerosperma* (4); *Clastoderma debaryanum* (1); *Comatricha pulchella* (3); *Cribraria microcarpa* (3); *C. minutissima* (1); *Dictydiaethalium plumbeum* (1); *Diderma hemisphaericum* (1); *Fuligo septica* (1); *Licea biforis* (1); *Physarum viride* (4); *Stemonitis axifera* (4); *Tubifera microsperma* (1)
Cumbe/Boa Vista	*Didymium nigripes* (1/1); *Physarum nucleatum* (3/1); *Stemonitis smithii* (3/2); *S. splendens* (5/1)
Cumbe/Flores	*Cribraria cancellata* (1/3); *Physarum penetrale* (2/2); *P. stellatum* (1/10)
Boa Vista/Flores	*Collaria arcyrionema* (1/4); *Physarella oblonga* (2/1)
Cumbe/Boa Vista/Flores	*Arcyria cinerea* (21/12/25); *A. denudata* (17/12/18); *Ceratiomyxa fruticulosa* (24/10/19); *Hemitrichia calyculata* (63/32/52); *H. serpula* (28/59/26); *Lycogala epidendrum* (1/1/5); *L. exiguum* (2/1/4); *Metatrichia floriformis* (18/2/7); *Perichaena depressa* (13/2/3); *Stemonitis fusca* (18/6/1); *Stemonitopsis typhina* (7/12/3); *Trichia affinis* (10/3/5)

Trail length: Cumbe – 700 m; Boa Vista – 3 km; Flores – 4 km.

Rostaf. and *Tubifera microsperma* were rare and found only in the rainy season. *Cribraria mirabilis* (Rostaf.) Massee and *Licea biforis* were rare and found in September (beginning of the dry season). *Clastoderma debaryanum*, *Dictydiaethalium plumbeum* (Schumach.) Rostaf. and *Fuligo septica* (L.) F.H. Wigg. were rare and occurred between October and December. Although constant on the Flores Trail (50%), *Cribraria microcarpa* (Schrad.) Pers. (found in the rainy season and beginning of the dry season), *Physarum viride* and *Stemonitis axifera* (Bull.) T. Macbr. were not recorded for the other two trails (Tab. 2). *Collaria arcyrionema* (Rostaf.) Nann.-Bremek. ex Lado was also constant on the Flores Trail, but was accidental on the Boa Vista Trail and absent from the Cumbe Trail. *Physarella oblonga* (Berk. & M.A. Curtis) Morgan was accidental and scarce on the Boa Vista and Flores Trails (present only at the beginning of the dry season) and absent from the Cumbe Trail. Ogata *et al.* (1996) stated that, despite being cosmopolitan, *P. oblonga* is always scarce, which is corroborated by the present study. *Physarum stellatum* and *Cribraria cancellata* were constant on the Flores Trail, although accidental on the Cumbe Trail and absent from the Boa Vista Trail. *Physarum penetrale* Rex was accidental on the Flores and Cumbe Trails, with no records for the Boa Vista Trail. Those two species were more abundant in September and October (beginning of the dry season). *Cribraria violacea* Rex, *Didymium nigripes* (Link) Fr., *Physarum nucleatum* Rex, *Stemonitis splendens* and *S. smithii* T. Macbr. were found in September, October and December, revealing that they sporulate either at the beginning or middle of the dry season. Common only to the Cumbe and Boa Vista Trails, these species were accidental in the myxobiota studied; *P. nucleatum*, *S. smithii* and *S. splendens* can be classified as accessory on the Cumbe Trail (Tab. 2).

The lignicolous group was very well represented in the PFF in terms of richness (with 40 species from 22 genera, accounting for 83.3% of the species identified) and abundance, sporulating in the rainy and dry seasons (Tab. 3). The most constant and abundant species of the myxobiota studied belong to this group, including *Hemitrichia calyculata*, *H. serpula*, *Arcyria cinerea* and *A. denudata* (Tab. 2). The first three were also cited as the most abundant in a deciduous tropical forest at an elevation of 500 m in the state of Vera Cruz, Mexico (Ogata *et al*. 1996), as well as in a mountain rain forest (≈ 3000 m in elevation) in Costa Rica, although, in the latter, *A. cinerea* and *A. denudata* were only occasional (Rojas & Stephenson 2007). In a high-plains evergreen forest fragment (elevation, 870 m) in the municipality of Botucatu, located in the state of São Paulo, Brazil, Maimoni-Rodella & Gottsberger (1980) collected *A. cinerea* and *A. denudata* on 31% of their excursions, whereas they collected *H. serpula* on 15%, thus allowing us to classify these species as accessory or accidental; the only constant and abundant species was *H. calyculata*, collected on 77% of the excursions and included by the authors among the most abundant species. Although predominantly lignicolous, *A. denudata* and *H. calyculata* were classified in more than one ecological group and were the only species to be classified as myceticolous, with one or two records on the basidiocarps of Aphyllophorales during the study period (Tab. 3).

Lado *et al.* (1999) analyzed microhabitats occupied by myxomycetes at the Chamela Biological Station in Mexico (elevation, 70-580 m). The authors found that 74% of the species were lignicolous and only 9.5% were foliicolous, whereas 16.5% were lignicolous and foliicolous. As leaves are the most important substrate for myxomycetes in tropical forests, the authors attributed the low number of foliicolous species to the sampling season, which was at the end of the rainy season, when dead leaves are almost completely decomposed. In that study, most of the foliicolous species were from the family Didymiaceae [*Diachea radiata* G. Lister & Petch, *D. silvaepluvialis* and *D. bulbillosa* (Berk. & Broome) Lister], although there was one representative of the family

Table 3. Distribution of myxomycetes species in different ecological groups according to sporulation substrate on which specimens were collected in the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil.

Ecological group	Species
Corticicolous	*Didymium minus* (1); *Arcyria denudata* (2); *Hemitrichia calyculata* (1); *H. serpula* (2)
Foliicolous	*Ceratiomyxa sphaerosperma* (4); *Comatricha pulchella* (3); *Diachea silvaepluvialis* (1); *Diderma hemisphaericum* (1); *Didymium clavus* (1); *Hemitrichia calyculata* (2); *H. serpula* (12); *Macbrideola scintillans* (2); *Metatrichia floriformis* (26); *M. vesparia* (1); *Physarum echinosporum* (1); *Stemonitis fusca* (1); *S. splendens* (1); *Trichia affinis* (2)
Lignicolous	*Arcyria cinerea* (58); *A. denudata* (44); *Ceratiomyxa fruticulosa* (35); *C. morchella* (1); *Clastoderma debaryanum* (1); *Collaria arcyrionema* (5); *Cribraria cancellata* (4); *Cribraria languescens* (1); *Cribraria microcarpa* (3); *Cribraria minutissima* (1); *Cribraria mirabilis* (1); *Cribraria violacea* (1); *Cribraria* sp. (1); *Diachea silvaepluvialis* (1); *Didymium nigripes* (2); *Dictydiaethalium plumbeum* (1); *Fuligo septica* (1); *Licea biforis* (1); *Hemitrichia calyculata* (141); *H. serpula* (99); *Lycogala epidendrum* (7); *L. exiguum* (7); *Metatrichia floriformis* (1); *M. vesparia* (1); *Perichaena chrysosperma* (1); *P. depressa* (18); *Physarella oblonga* (3); *Physarum album* (1); *P. nucleatum* (4); *P. penetrale* (4); *P. pulcherrimum* (1); *P. stellatum* (11); *P. viride* (4); *Stemonaria longa* (1); *Stemonitis axifera* (9); *S. fusca* (24); *S. splendens* (5); *Stemonitopsis typhina* (22); *Trichia affinis* (17); *Tubifera microsperma* (1)
Myceticolous	*Arcyria denudata* (1); *Hemitrichia calyculata* (2)

Physaraceae (*Fuligo megaspora* Sturgis), which is what we observed in the PFF. The preference for the microhabitat offered by dead tree trunks was confirmed, as the sampling in the present study was carried out in both the rainy and dry seasons, the latter of which has no lack of leaves. Studying an area of savanna in Botucatu, Maimoni-Rodella & Gottsberger (1980) found a predominance of foliicolous species, whereas lignicolous species were found to be more frequent in the rain forest that the authors used for comparison. Among the most abundant species, *Arcyria cinerea* was the only one to behave as both foliicolous and lignicolous on the savanna, whereas *A. denudata*, *Hemitrichia calyculata* and *H. serpula* were exclusively lignicolous.

In the present study, the foliicolous group was represented by eight genera and nine species, including some of the most abundant in the myxobiota, such as *Hemitrichia serpula*, *Metatrichia floriformis* (Schwein.) Nann.-Bremek., *Stemonitis fusca* and *Trichia affinis* de Bary (Tab. 3); *M. floriformis* behaved nearly exclusively as a foliicolous species (96.3%), sporulating on palm leaves (*Attalea* sp.) present in the necromass, with a single record of a specimen on a fallen dead tree, whereas the others behaved predominantly as lignicolous species. *Physarum echinosporum* Lister, *Diachea silvaepluvialis*, *Diderma hemisphaericum* and *Comatricha pulchella* were exclusively foliicolous; *Ceratiomyxa sphaerosperma* was recorded in the necromass but sporulated only on the fruit of *Artocarpus heterophyllus* Lam. (Jack fruit). *Didymium clavus* (Alb. & Schwein.) Rabenh., *Didymium minus* (Lister) Morgan (on the cortex of living trees on the Cumbe Trail) and *Macbrideola scintillans* H.C. Gilbert (on the inflorescence of Bromeliaceae in the necromass on the Boa Vista Trail) were recorded only in the moist chamber cultures.

As can be seen in the graph generated from the NMDS ordination analysis data (Fig. 4), species which often occurred at the same collection time are nearest each other. Using linear trends, we correlated the environmental variables at the collection times with the distribution of the species in the graph and found that those distributions correlated significantly with temperature ($r^2 = 0.99$, $p < 0.01$) and rainfall ($r^2 = 0.87$, $p < 0.05$). The data are partially consistent with what was previously reported by Rojas & Stephenson (2007), because the temperature, despite the low amplitude of variation during the study period, also seems to strongly influence the sporulation of myxomycetes. Observing the myxobiota of the area as a whole, we can observe that taxonomic groups, such as families and orders, do not have similar ecological behaviors, not forming distinct groups and each species requiring particular conditions for sporulation. However, some trends can be observed: *Lycogala* species showed a preference for high humidity and temperature; and Stemonitaceae species sporulated predominantly in the dry season. The Trichiaceae family, which was dominant in the study area, has the greatest range of sporulation conditions. We found that, in the PFF, the sporulation of most species peaks two to four months after of the period of heaviest rainfall, which corroborates the findings of Ogata *et al*. (1996) for the myxobiota of a rain forest in Mexico, as well as those of Chiappeta *et al*. (2003) for *Fuligo septica* in *bagasse* (sugarcane leaves and sheaths) in Brazil.

In a study of factors that influence the behavior of myxomycetes in a highland rain forest in Costa Rica, Rojas & Stephenson (2007) concluded that precipitation is the main macro-environmental parameter to be considered. However, given the proportions of myxomycete species recorded in the myxobiota during the rainy and dry seasons (54% and 56%, respectively), rainfall had no apparent influence on the sporulation phase or species richness. A more detailed analysis revealed that rainfall did in fact have a strong influence on species abundance and richness in the myxobiota, whether by class, as a whole (Fig. 5 and 6) or for each of the families and respective species that occur in the PFF. Differences were observed between the rainy and dry seasons in terms of the composition of the myxobiota: *Hemitrichia calyculata*, for example, sporulated throughout the study

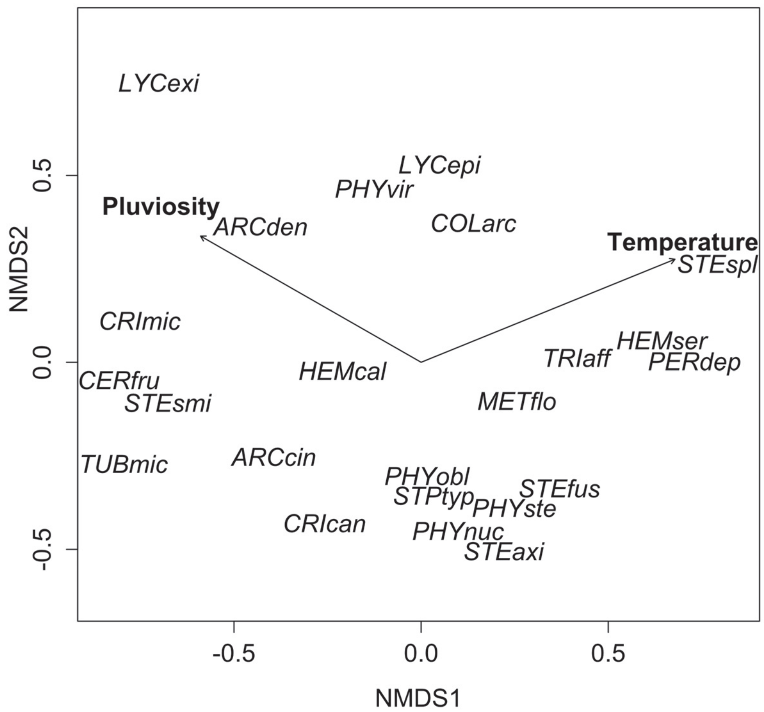

Figure 4. Graph resulting from the non-metric multidimensional scaling (NMDS) ordination analysis of data related to the myxobiota during excursions on trails within the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil. Vectors indicate the direction of the relationship of environmental variables. The dissimilarity matrix was generated from the Bray-Curtis index (stress = 0.0203).
ARCcin – *Arcyria cinerea*; ARCden – *A. denudata*; CERfru – *Ceratiomyxa fruticulosa*; CRIcan – *Cribraria cancellata*; CRImic – *Cribraria microcarpa*; CORarc – *Collaria arcyrionema*; HEMcal – *Hemitrichia calyculata*; HEMser – *H. serpula*; LYCepi – *Lycogala epidendrum*; LYCexi – *L. exiguum*; METflo – *Metatrichia floriformis*; PERdep – *Perichaena depressa*; PHYobl – *Physarella oblonga*; PHYnuc – *Physarum nucleatum*; PHYste – *Physarum stellatum*; PHYvir – *Physarum viride*; STEaxi – *Stemonitis axifera*; STEfus – *Stemonitis fusca*; STEsmi – *Stemonitis smithii*; STEspl – *Stemonitis splendens*; STPtyp – *Stemonitopsis typhina*; TRIaff – *Trichia affinis*; TUBmic – *Tubifera microsperma*.

period, with a peak in September and less abundance in the dry season (November-December); *H. serpula*, the second most abundant species in the myxobiota, concentrated its sporulation in the dry season; and *Arcyria cinerea* also exhibited peak sporulation in the dry season, whereas *A. denudata* sporulated in the rainy season, although there was no significant difference in abundance between the two (Fig. 3). *Trichia affinis* (18 specimens) and *Perichaena depressa* (18 specimens)—both of which also belong to the family Trichiaceae—exhibited the same abundance (Fig. 3), albeit with different temporal distributions, the latter concentrating its sporulation in the dry season. Although representatives of different families, *Stemonitis fusca* and *Metatrichia floriformis* initiate sporulation at the end of the rainy season, with a peak in the dry season—in October and December, respectively. *Ceratiomyxa fruticulosa* sporulates at the end of the rainy season, with peak sporulation in August (during the transition to the dry season), thus differing from all of the other species evaluated. That difference might be explained by the fact that *C. fruticulosa* is exosporous and therefore has difficulty in either strong rains or very dry periods.

The species classified as common in the myxobiota of the PFF, such as *Collaria arcyrionema*, *Lycogala epidendrum* and *L. exiguum* Morgan, sporulated in different seasons, although some were more abundant in the dry season or were even exclusive to that season, one example being *Stemonitis splendens* (Tab. 3). Those classified as occasional or scarce were also found in both seasons, but their sporulation was concentrated in the transition period between the rainy and dry seasons.

In the PFF, Liceales mainly sporulated in the rainy season, although sporocarps from *Cribraria cancellata* and *C. violacea* were also collected in October, and *C. minutissima* Schwein. was recorded only in November. Species belonging to the family Physaraceae predominantly sporulated at the end of the rainy season and the beginning of the dry season; some species of this family, such as *Fuligo septica* and *Physarum pulcherrimum* Berk. & Ravenel were restricted to the period in which soil water availability was lowest.

In conclusion, the myxobiota of the PFF has a set of dominant species in the rainy season that differs from that found in the dry season. Because of the taxonomic diversity, constancy and abundance of its species, Trichiaceae is the most important family in this highland rain forest, which is representative of the highland forests of northeastern Brazil.

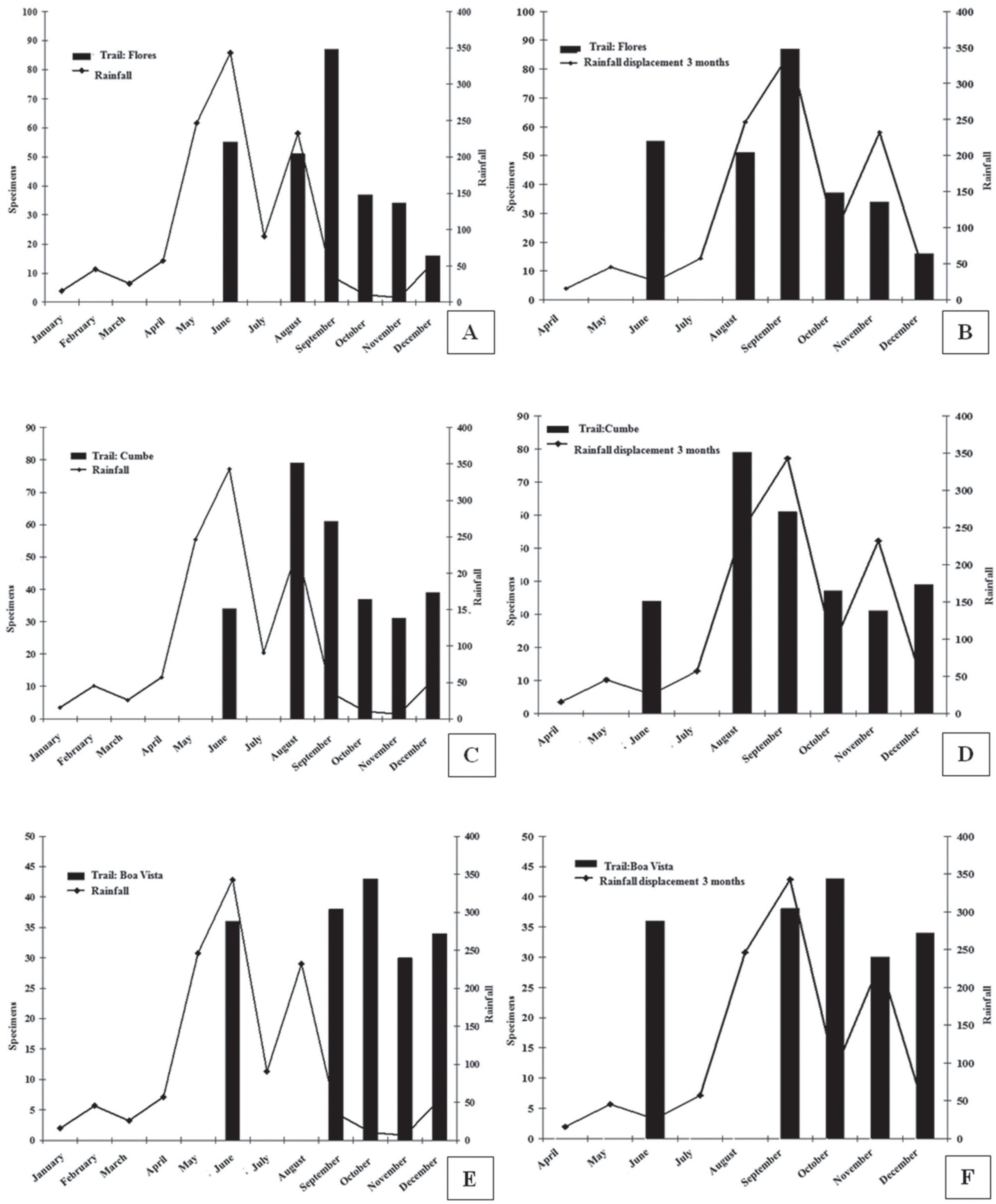

Figure 5. Monthly rainfall and myxomycetes abundance in the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil. **A**) Monthly rainfall on the Flores Trail throughout the study period (2005); **B**) Monthly rainfall on the Flores Trail for the same period but displaced by three months (January ➔ April, etc.); **C**) Monthly rainfall on the Cumbe Trail throughout the study period; **D**) Monthly rainfall on the Cumbe Trail for the same period but displaced by three months (January ➔ April, etc.); **E**) Monthly rainfall on the Boa Vista Trail throughout the study period; **F**) Monthly rainfall on the Boa Vista Trail for the same period but displaced by three months (January ➔ April, etc.)

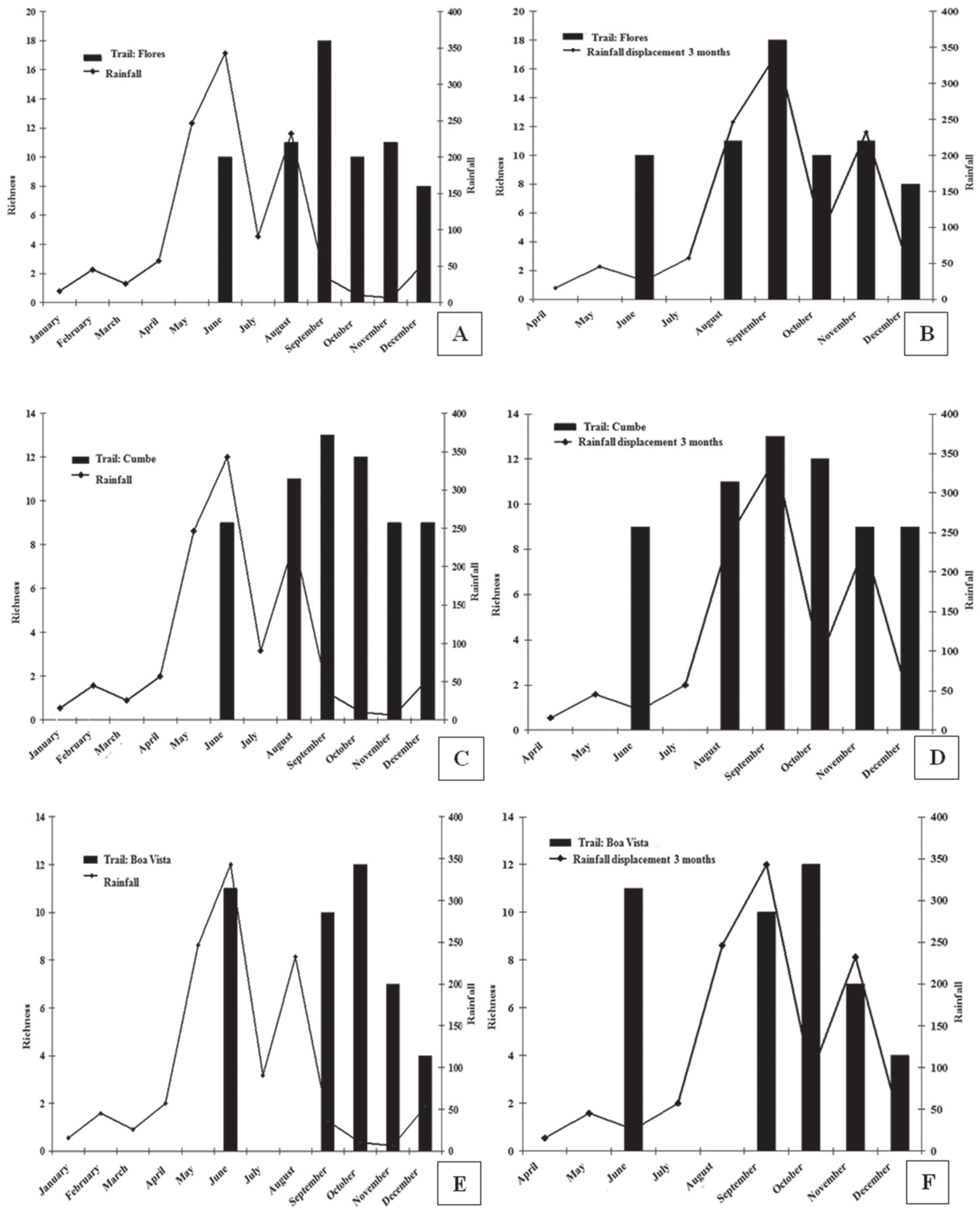

Figure 6. Monthly rainfall and myxomycete species richness in the Pau-Ferro Forest Environmentally Protected Area, in the municipality of Areia, located in the state of Paraíba, in northeastern Brazil. **A**) Monthly rainfall on the Flores Trail throughout the study period (2005); **B**) Monthly rainfall on the Flores Trail for the same period but displaced by three months (January ➔ April, etc.); **C**) Monthly rainfall on the Cumbe Trail throughout the study period; **D**) Monthly rainfall on the Cumbe Trail for the same period but displaced by three months (January ➔ April, etc.); **E**) Monthly rainfall on the Boa Vista Trail throughout the study period; **F**) Monthly rainfall on the Boa Vista Trail for the same period but displaced by three months (January ➔ April, etc.)

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