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The myxobiota of the Serra de Caldas Novas State Park (PESCAN), Goiás, Brazil, with new records for the Central-West region and the Cerrado biome (Brazilian Savanna)

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Abstract

A myxomycetes species inventory was carried out in the Serra de Caldas Novas State Park (PESCAN), Goiás, Brazil to increase the knowledge of the myxobiota of the Central-West region and the Cerrado biome (brazilian Savanna), including ecological aspects. We found 18 species, distributed into nine genera and seven families. Among these occurrences, four are new records for the Cerrado, nine for the Central-West region and all are new for the state of Goiás. Of the species found, 56% were classified as occasional. The richness and diversity estimated for the area, according to Shanonn (H' 2.6), Chao1 (22.1) and Jack1 (22.9) indices, showed that this environment act as an important refuge for the development of myxomycetes, with high taxonomic diversity (S/G 2.2). Thus, the results reinforce the importance of the park as a conservation unit of myxobiota.

Key words – Biodiversity – Geographic distribution – Myxomycetes – New occurrences

Introduction

The knowledge of the Myxobiota in Brazil concentrates, mainly, in Northeast and Southeast regions. The Central-West region that comprises the states of Goiás, Mato Grosso, Mato Grosso do Sul and the Federal District is the less studied region regarding myxomycetes, comprising, so far, 39 species records, where 26 were found in the Distrito Federal, 12 in Goiás and three in Mato Grosso (Gottsberger 1968, Maimoni-Rodella 2002, Bezerra et al. 2009, Bezerra & Cavalcanti 2010, Carvalho et al. 2011, Araújo et al. 2012, 2015, Calaça & Araújo 2015, Agra et al. 2018).

The first record of myxomycetes for the state of Goiás was *Physarum alvoradianum* Gottsb., collected by Gottsberger (1968), in the municipality of Alvorada do Norte. Only after 44 years, new records were found in the state, by the study of Araújo et al. (2012), which reported the occurrence of nine species on mango tree waste in the municipalities of Anápolis and Pirenópolis. Afterwards, two new occurrences were reported, *Perichaena calongei* Lado, D. Wrigley & Estrada, in the municipality of Silvânia (Araújo et al. 2015) and *Physarum notabile* T. Macbr. in the municipality of Anápolis (Calaça & Araújo 2015). This demonstrates the scarcity of knowledge and the need for systematized inventories and surveys for the region, especially in protected areas.

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The state of Goiás is filled almost exclusively by the Cerrado biome (Brazilian Savanna), which is characterized as a mosaic of vegetation, consisted of different physiognomies, ranging from forest and savannas to grassland formations (Ribeiro & Walter 2008). The Cerrado is the third biome with the lowest number of records of myxomycete species, totaling 91 occurrences, only more than the Pampa with 57 records and the Pantanal, which has no records (Moreira 2016, Lima & Cavalcanti 2017).

This study aimed to contribute to the taxonomic and ecological knowledge of the myxobiota of the Central-West region of the state of Goiás and Cerrado, through the species inventory of the Serra de Caldas Novas State Park (PESCAN) and its surroundings, highlighting some ecological aspects.

Materials & Methods

Study area

Located in the Central-South region of Goiás, between the municipalities of Caldas Novas and Rio Quente (Fig. 1), the PESCAN constitutes one of the most representative Conservation Units of the Cerrado in Goiás. Comprising an extension of approximately 125 km², the park is an important recharge area for hydrothermal aquifers in the region. It presents a rainy tropical climate, hot and humid, with summer rains, being classified in the classification of Köppen (1948) (Almeida & Sarmento 1998).

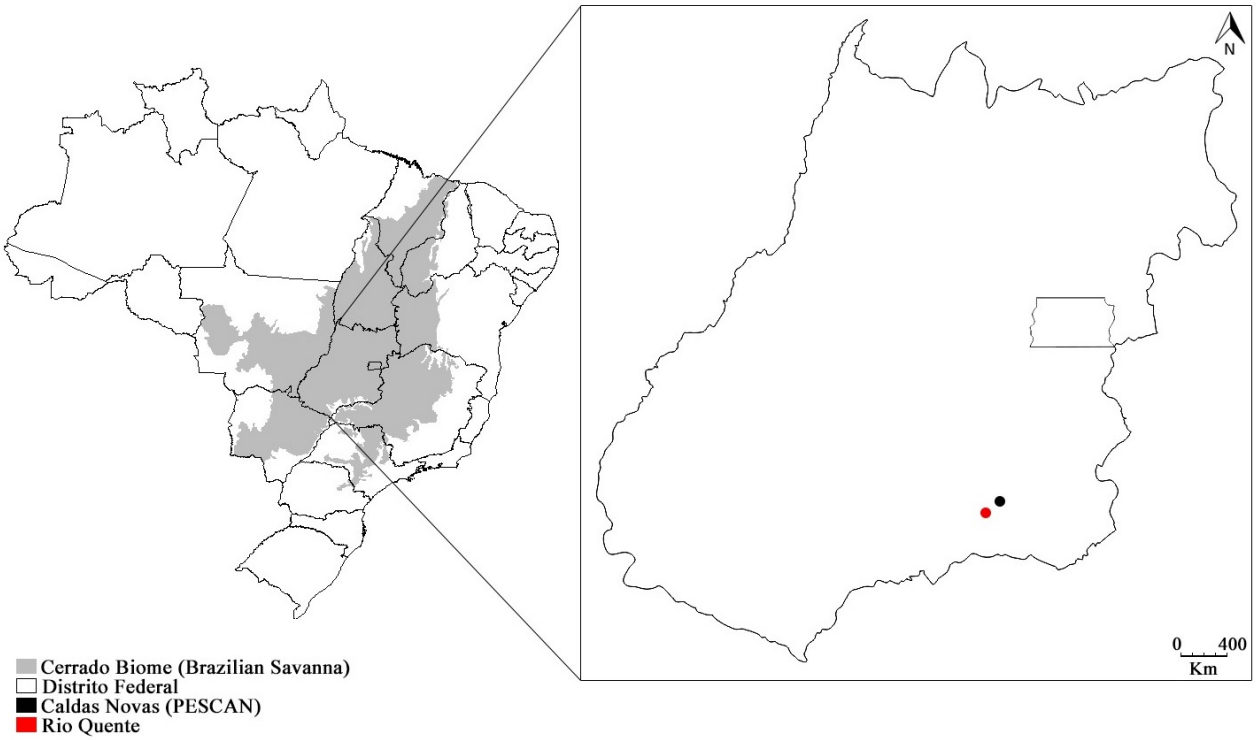

Fig. 1 – Location of the Serra de Caldas Novas State Park (PESCAN) in Brazil. In gray, the distribution área of the Cerrado biome in the Brazilian territory and, zooming in the State of Goiás with the municipalities of Caldas Novas and Rio Quente (that host the park).

The park area is characterized by the phytophysiognomies *cerrado rupestre* (rocky montane savanna), *campo-cerrado* (savanna woodland), enclave of deciduous forest, *campo úmido* (wet grassland), *campo limpo* (grassland), *campo sujo* (shrub savanna), *vereda* (palm swamps) and savanna formations, most of which is represented by savanna and grassland formations. In the upper part of the hill, it prevails the cerrado *stricto sensu* areas and in the areas located in the park

surroundings prevails the vegetation of cerrado *stricto sensu* and *cerradão* (tall woodland), besides fragments of semideciduous seasonal forest, with gradual fragments of gallery forests (Almeida & Sarmento 1998, Antunes & Benvenutti 1998).

Created in 1970, the main purpose of the park was to protect the rainwater catchment systems that supplies the thermal water table. This water table is the main reason for the extensive tourism and leisure development that has been established in the region (Almeida & Sarmento 1998).

Study procedures

A total of 13 samplings were carried out between 2007 and 2015, during which sporocarps and plasmodia visualized in the field were collected, as well as substrate samples without the apparent presence of myxomycetes, for the preparation of moist chamber. The collected material was packed in boxes and/or paper bags, duly identified and taken to the laboratory. The collected sporocarps were dried at room temperature and the other substrates were incubated in moist chamber and periodically monitored for the onset of myxomycetes for up to three months.

The taxonomic determination of the species was based on macro and micromorphological characters. Were used relevant bibliographies, such as Farr (1976), Martin & Alexopoulos (1969), Poulain et al. (2011) and comparison with herbarium specimens. Descriptions and illustrations of the species were based on the material studied. The taxonomic nomenclature and the abbreviation of the authors' names followed the pattern of nomen.mix (Lado 2005-2019). The geographic distribution of the species was based on data published in periodicals. All the collected samples were identified up to the species level and deposited in the HUEG Herbarium, located at the Universidade Estadual de Goiás (UEG), Campus Anápolis de Ciências Exatas e Tecnológicas (CCET).

For each species, the relative frequency (FR) and the frequency class were calculated according to Schnittler et al. (2002), Cavalcanti & Mobin (2004) and Gotelli (2009). According to Schittler et al. (2002), the species were considered rare, those species represented by a frequency less than 1.5%; occasional, those with a frequency between 1.5 and 3.5%; common, those with frequencies between 3.5 and 6.5% and abundant, those with frequency above 6.5%.

The species richness was estimated by the Chao1 and Jack1 indexes (Chao 1984, Barros 2007, Gotelli 2009, Provete et al. 2011) and diversity by the Shannon-Wiener index (H') (Shannon 1948, Magurran 1988). The index of taxonomic diversity was calculated using the number of species per genus (S/G), according to Simberloff (1970) and Stephenson et al. (1993), who consider that the community in which the species are distributed in several genera is more diverse than that in which many species belong to the same genus, so a low value for S/G implies a high diversity. In order to verify sample adequacy and determine species/area ratio, the collector curve or curve of species accumulation was plotted, according to Colwell & Coddington (1994).

Results

We found 18 species of myxomycetes, distributed into nine genera and seven families. The most frequent families were: Trichiaceae with 20% of occurrences and Physaraceae with 17% (Table 1) and the most frequent species were: *Hemitrichia serpula*, with 17% of occurrences, *Ceratiomyxa fruticulosa* (13%), *Lycogala epidendrum* and *Didymium squamulosum* (with 10% each).

The species *Didymium iridis*, *D. squamulosum*, *Physarum conglomeratum* and *P. polycephallum* has been found for the first time in the Cerrado. *Diachea bulbillosa, Didymium iridis, D. squamulosum, Physarum album, P. bogoriense, P. conglomeratum, P.* cf. *javanicum, P. polycephalum* and *P. tenerum* are new records for the Central-West region and all species sampled in the area are new for the state of Goiás (Table 1).

About 56% of the species were classified as occasional, 33% abundant and 11% common. None of the species evaluated were considered rare (Table 1). The greatest abundance of myxomycetes was observed on dead wood (71%), the rest occurred on dead leaf (16%), fruiting bodies of macrofungi (5%), live tree (5%) and live leaf (3%).

Although the accumulation curve shows that the number of species may increase as new collections are performed (Fig. 2), the diversity showed by the Shannon-Wiener index was H' = 2.6 and Hmax = 2.9, the richness estimators Chao1 and Jack1 presented values of 22.1 and 22.9, respectively, and the taxonomic diversity S/G = 2.2.

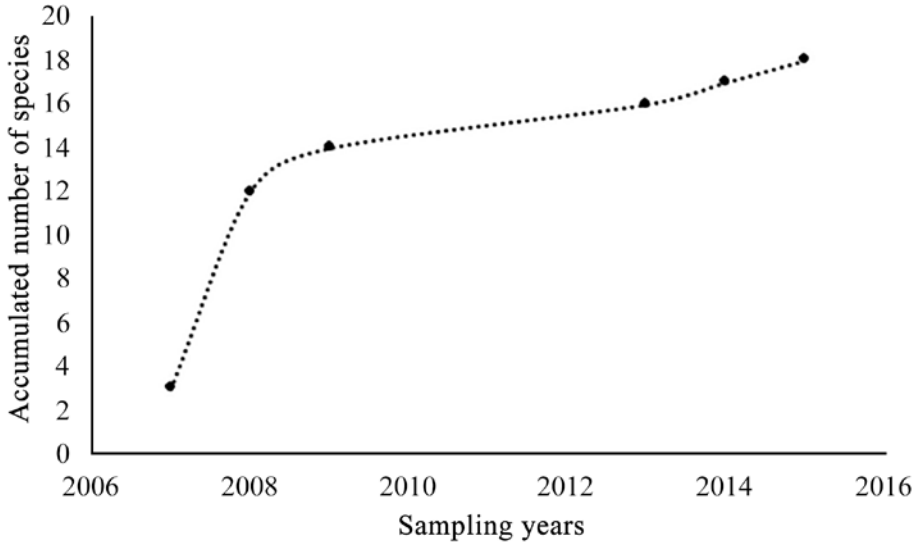

Fig. 2 – Species accumulation curve of myxomycetes of the Serra de Caldas Novas State Park (PESCAN), Goiás, Brazil, throughout the sampling years.

Discussion

Our results showed a high taxonomic diversity in the studied area, with prevalence of species with wide distribution in neotropical regions. Similar result was observed in a survey carried out in the IBGE Ecological Reserve, an area of Cerrado located in Brasília, Federal District, 26 species were inventoried, they are distributed into 15 genera and eight families. Among these, Trichiaceae, with 38%, and Stemonitidaceae, with 22%, were the most frequent, and *H. serpula* was the second most abundant species (9%), behind *H. calyculata* (17%) (Carvalho et al. 2011). In other studies, carried out in Cerrado areas of the Northeast and Southeast regions, the most frequent species were: *Comatricha meandrispora* (Mobin & Cavalcanti 2000); *Hemitrichia serpula* var. *serpula* and *Comatricha meandrispora* (Cavalcanti & Mobin 2004) and *Stemonitis fusca* (Maimoni-Rodella & Gottsberger 1980).

Bezerra et al. (2008) in a diversity study of Physarales in wet forests and neotropical forests, in the Serra do Itabaiana National Park, Sergipe, Brazil, observed that 50% of the species were rare, 23% were occasional, 15% were common, and 12 % abundant. In the present study, 89% of the species of Physarales were considered occasional and 11% were abundant. However, the high index of occasional species should be evaluated with caution, since sampling effort and substrate specificity may influence this classification.

The predominance of dead wood substrate was also observed by Bezerra et al. (2008) and Tenório et al. (2009) in forest areas of the Serra de Itabaiana National Park. The myxomycetes that occur on wood are called lignicolous and are generally the best known, because these species present larger fruiting bodies and therefore, they are more easily detected with the naked eye (Ing 1994, Martin & Alexopoulos 1969, Rufino & Cavalcanti 2007). This ecological group includes the largest number of species among the myxomycetes and are widely distributed in tropical regions (Rufino & Cavalcanti 2007, Rojas et al. 2014).

The Shannon-Wiener index showed that the area presents a great diversity. Considering that this index informs the degree of uncertainty that exists in predicting which species belongs to a randomly chosen individual in a community, then the greater the uncertainty, the greater the index value and thus, the greater the sample diversity. According to Magurran (1988), the values assumed

for this index are between 1.5 and 3.5, so it will assume its maximum value when all existing species present the same frequency. Therefore, the data found here may change when increasing new species occurring only once, with H' still not reaching the maximum value.

Table 1 Myxomycetes sampled in the PESCAN according to taxonomy, Absolute frequency (FA), Relative frequency (FR), frequency class (CF): abundant (A), common (C), occasional (O), rare (R) and geographic distribution in Brazil. * new records for the Cerrado, [+] new records for Central-West region. All listed species are new records for the state of Goiás. AC = Acre, AL = Alagoas, AM = Amazônia, AP = Amapá, BA = Bahia, CE = Ceará, DF = Distrito Federal, ES = Espírito Santo, MA = Maranhão, MG = Minas Gerais, PA = Pará, PB = Paraíba, PE = Pernambuco, PI = Piauí, PR = Paraná, RJ = Rio de Janeiro, RN = Rio Grande do Norte, RO = Rondônia, RR = Roraima, RS = Rio Grande do Sul, SC = Santa Catarina, SE = Sergipe, SP = São Paulo.

Order	Family	Species	FA	FR (%)	CF	Geographic Distribution in Brazil
Protesteliales	Ceratiomyxaceae	*Ceratiomyxa fruticulosa* (O. F. Müll.) T. Macbr	8	13.5	A	AC, AL, AM, AP, BA, CE, DF, PA, PB, PE, PI, RN, RO, RR, RS, SC, SE, SP
Liceales	Cribrariaceae	*Cribraria cancellata* (Batsch) Nann. - Bremek	5	8.5	A	AL, AM, BA, CE, DF, MG, PB, PE, PI, PR, RJ, RR, SC, SE, SP
	Reticulariaceae	*Lycogala epidendrum* (L.) Fr.	6	10.1	A	AL, AC, AM, BA, DF, MA, PB, PE, PI, PR, RJ, RN, RR, RS, SC, SE, SP
	Didymiaceae	*[+] *Didymium iridis* (Ditmar) Fr.	1	1.7	O	BA, CE, ES, MA, MG, PB, PE, RJ, SC, SP
		*[+] *D. squamulosum* (Alb. & Schwein.) Fr. & Palmquist	6	10.1	A	AL, BA, PE, RN, SC, SP
Physarales	Physaraceae	[+] *Physarum album* (Bull.) Chevall.	2	3.4	O	AL, AM, BA, CE, ES, MA, MG, PB, PE, PI, PR, RJ, RN, RR, RS, SC, SE, SP
		[+] *P. bogoriense* Racib	1	1.7	O	AL, BA, PB, PE, PI, MG, RS, SC, SE, SP
		*[+] *P. conglomeratum* (Fr.) Rostaf.	1	1.7	O	SE
		[+] *P.* cf. *javanicum* Racib	1	1.7	O	BA, SP
		P. nucleatum Rex	2	3.4	O	AL, AM, CE, DF, PB, PE, PI, PR, RR, SE, SP
		*[+] *P. polycephalum* Schwein	2	3.4	O	BA, PE, RS, SC, SP
		[+] *P. tenerum* Rex	1	1.7	O	AM, BA, CE, PE, RS, SE, SP
		[+] *Diachea bulbillosa* (Berk. & Broome) Lister	1	1.7	O	PI
Stemonitales	Stemonitaceae	*Stemonitis fusca* Roth	3	5.1	C	AL, AM, BA, DF, ES, PA, PB, PE, PI, PR, RJ, RN, RO, RR, RS, SC, SE, SP
Trichiales	Arcyriaceae	*Arcyria cinerea* (Bull.) Pers.	4	6.8	A	AC, AL, AM, BA, CE, DF, MG, PA, PB, PE, PI, PR, RJ, RN, RO, RR, RS, SC, SE, SP
		A. denudata (L.) Wettst.	2	3.4	O	AL, AM, AP, BA, CE, DF, PA, PB, PE, PI, PR, RJ, RN, RO, RR, RS, SC, SE, SP
	Trichiaceae	*Hemitrichia calyculata* (SPeg.) M.L. Farr	3	5.1	C	AC, AL, AM, BA, CE, DF, MA, MG, PB, PE, PI, PR, RJ, RN, RS, RR, SC, SE, SP
		H. serpula (Scop.) Rostaf. Ex Lister	10	17	A	AL, AM, AP, BA, CE, DF, MT, PA, PB, PE, PI, PR, RJ, RN, RR, RS, SC, SE, SP

The richness estimators Chao1 and Jack1 make it possible to estimate the total number of species in a given community (Barros 2007, Gotelli 2009, Provete et al. 2011), so it can be observed that the area studied, which has an n = 18, has not yet reached the maximum number of species. This can be observed by the large number of species with a single occurrence, because the larger the sampling of species occurring once, the higher the estimate for the total number of species present in the community (Gotelli 2009, Provete et al. 2011).

The myxobiota recorded in the PESCAN showed a high taxonomic diversity, compared to the study of Ferreira & Cavalcanti (2010) carried out in three conservation units of Atlantic Forest, located in the state of Pernambuco (S/G = 1.5). According to Stephenson et al. (1993), the greater the number of genera in which species are distributed into, the greater the diversity. Stephenson et al. (2001) report that values of S/G found in temperate and tropical regions may vary between 2.2 and 4.6.

This study allowed the inventory of myxomycete species of the Serra de Caldas Novas State Park, in addition to expanding the knowledge of the myxobiota for the Cerrado, the Central-West region and the state of Goiás, increasing in four, nine and 18 species known for each of these locations, respectively. There was a predominance of lignicolous species (71%) and 33% were considered as occasional.

The data presented showed a high taxonomic diversity in the studied area and considering that the Cerrado has been suffering a reduction of its diversity due to intense anthropogenic activity, these results provide a basis for the elaboration of conservation practices and reveal the importance of the park as a conservation unit of the Cerrado myxobiota.

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