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New records of myxomycetes (Amoebozoa) from Colombia

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ABSTRACT

Colombia is located in one the megadiverse regions of the world. However, the number of known species of myxomycetes for this territory is low when compared to similar countries in the same region. The most important reason for such pattern is the systematic undersampling of ecosystems in that part of the world. For that reason, efforts to document the myxobiota of Colombia were set in place as part of collaborative initiatives among academic institutions in the region. Surveys focusing both on field collections and material for moist chamber cultures during the period between 2019-2021 as well as a search of vouchers in recognized herbaria yielded a total of 28 new records of myxomycetes for Colombia, most of which belong to the genera *Arcyria*, *Physarum* and *Stemonitopsis*. These results have increased the number of recognized myxomycetes in Colombian territories from 106 to 134, with an associated increment of about 26% directly related to the latest efforts. Similar surveys in different ecosystems in Colombia and more exploration of Colombian collections will likely increase the number of recognized species of myxomycetes even more, but the present study highlights the importance of establishing a baseline of research in one territory as a strategy to document its biota.

Key words: myxogastrids, northern Andes, South America, slime molds.

INTRODUCTION

Colombia is a megadiverse country (Arbeláez-Cortés 2013). The variety of conditions for the establishment of life in this part of the world allow for a wide diversity of life strategies to coexist in this territory. High biodiversity values have been commonly associated with Colombian territories (Brummitt & Nic Lughadha 2003), even though most of these quantifications are based on macroscopic forms that do not represent the most species-rich groups. In this manner, microbial diversity in Colombia, in a similar manner to other countries (Wilson et al. 2007), has not been documented with the same effort and intensity as more popular groups of organisms.

In addition, the high load of paperwork and general bureaucracy to conduct biodiversity research in Colombia has been a recent impediment to generate updated figures associated with many taxonomic groups (Fernández 2011). In fact, it is acknowledged that for the same contextual reasons the genomic diversity associated with life forms in Colombia is currently more incomplete than comparable data from other Latin America countries (Noreña-P et al. 2018). These limitations do not facilitate research on microorganisms that do not have commercial or applied value and have consequences on the understanding of global microbial ecology (Gibbons & Gilbert 2015).

Myxomycetes, a group of fruiting amoebae found worldwide in association with decayed plant parts (Keller et al. 2021) has been timidly studied in Colombia. For instance, G.W. Martin mentioned only 34 species almost 90 years ago (Martin 1934), and M. L. Farr (1976) updated such figure, 42 years later, to 57 species. In his review of Colombian myxomycetes, Uribe-Meléndez (1995) increased the number up to 96 species and some years later Rojas et al. (2012) provided a total value of 108 species. The last publication, ten years ago, represents the most updated reference to the biodiversity of myxomycetes in Colombia. However, the value provided therein is still today – using the words of G W. Martin in the 1930s – "absurdly incomplete for so large a country with such varied topography and climate". For comparison, Costa Rica, 22 times smaller than Colombia has 242 species of myxomycetes reported (Lado & Rojas 2018).

Colombia must have a larger myxobiota and even the most recent values of myxomycete biodiversity are certainly the product of undersampling. Similar to the case of other groups of organisms, it has been difficult for both local and foreign researchers to conduct biodiversity research in Colombia in recent decades (Clerici et al. 2016). For that reason, results from any efforts to do so should be properly documented. The present study has been carried out as part of explorations to document ecological patterns of myxomycetes in urban areas across the Neotropics and its objective is to communicate a series of previously unrecorded species of myxomycetes for Colombian territory. Such information, in the context of similar regional data, increases the robustness of analyses and interpretations on microbial diversity, ecology and distribution.

MATERALS AND METHODS

To alleviate the disparity of available information on myxomycetes between Mesoamerica and the Tropical Andes biodiversity hotspot regions, a collaborative effort was established in 2019. As part of this effort, a series of surveys to document myxomycetes were established in a) Cartagena, b) The Metropolitan Area of the Aburrá Valley and c) the region West of the Aburrá Valley within the Department of Antioquia.

Cartagena, in the northern Caribbean, is located within a region of tropical dry forests, at just 2 m of elevation, with an average yearly temperature of 27°C and an annual precipitation of about 1100 liters per square meter. In contrast, the other two studied areas are located in the central Andes, between 500-1500 m in elevation, and represent premontane moist forests with an average yearly temperature of 21°C and an annual precipitation of about 1700 liters per square meter.

In all surveys, dead plant material was collected and used to set up moist chamber cultures in the manner described by Stephenson & Stempen (1994). With this protocol, the collected material was placed in petri dishes previously lined with filter paper and abundant water was added in order to stimulate myxomycete propagules. After 24 h, water was discarded, pH was measured, and the culture was examined during a period of approximately two months.

When either plasmodia or fruiting bodies of myxomycetes were observed, they were recorded and in the case of the last ones, they were extracted with fine forceps and glued to pasteboard boxes for scientific storage. In the Metropolitan Area of the Aburrá Valley, field collections were also obtained in the Campus of the University of Antioquia. All specimens were identified with appropriate monographs (e.g., Martin & Alexopoulos 1969, Poulain et al. 2011) using basic microscopical techniques, and deposited in the Myxogastrid Biorepository of the University of Costa Rica and the HUA herbaria from the University of Antioquia. The nomenclature used was that of Lado (2005-2022).

In addition to the surveys, deposited vouchers and confirmed observations of myxomycetes from Colombia in either recognized herbaria or repositories in the United States were examined via the Mycology Collections Portal (MyCoPortal 2022). When myxomycetes from Colombia were found, collections were checked for inconsistencies (e.g., doubtful identifications, wrong geolocation) and only records with fully valid information and confirmatory images were used to complement the survey efforts.

The list of new records for Colombia provided herein contains the month of collection, the approximate locality and the substrate upon which the specimen was found. The collection number assigned to the deposited vouchers and institutional secondary numbers in the case of unreported species in American herbaria are provided as well. For all the latter, the Ro acronym is from the Myxogastrid Biorepository at the University of Costa Rica, BPI is from the US National Fungus Collections, NYBG from the New York Botanical Garden, ILLS from the Illinois Natural History Survey Herbarium and MUOB from the Mushroom Observer Repository (Wood 2008). In all cases, the known distribution of the species in neighboring countries was provided.

RESULTS

A total of 28 species of myxomycetes that had not been previously communicated for Colombia were recorded during the surveys. That result brought the total number of myxomycetes in Colombian territories to 134. The genus *Ceratiomyxa*, a sister group to the myxomycetes and considered in all previous reports, was excluded in these calculations. Those 28 new species for Colombia represented an increment of 26.4% with respect to the last published value of 106 (108 considering the two *Ceratiomyxa* species).

In this manner, the ratio of species to genera (known in the myxomycete literature as the taxonomic diversity index) changed from 4.07 to 4.62 implying that the currently documented intrageneric diversity increased. Of the 134 species, 42 were associated with the phylogenetically stable "bright-spored clade" and 92 species belonged to the "dark-spored clade" and the number of new species within each group represented

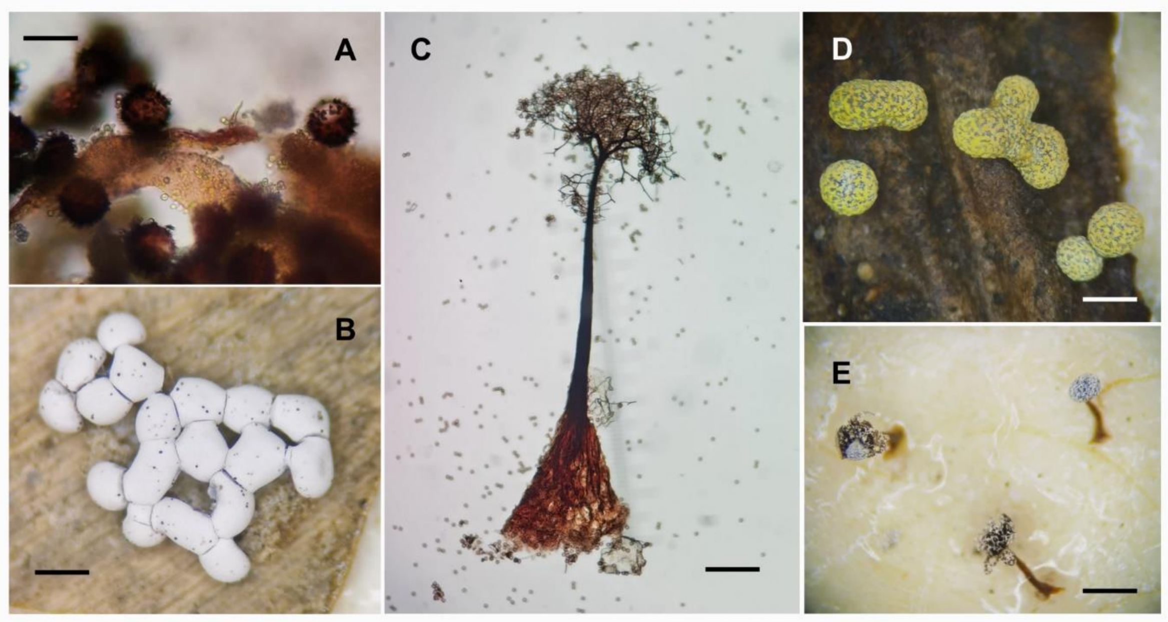

Fig. 1. *Diderma acanthosporum* Ro-9953, A. Spores under transmitted light – scale bar=20 μm, B. General appearance – scale bar = 1 mm. C. Sporocarp of *Paradiacheopsis solitaria* Ro-9611 under transmitted light – scale bar=100 μm. D. Sporocarps of *Physarum decipiens* Ro- 9816 – scale bar=1 mm. E. Sporocarps of *Badhamia melanospora* Ro- 9748 – scale bar=1 mm.

about 23% in the former and 19% in the latter implying that species in the bright spore group were recorded at a higher rate during the present effort.

From the newly communicated species for Colombia, the most common genera were *Physarum*, *Arcyria* and *Stemonitopsis*, with six, four and three species, respectively. The genera *Metatrichia* and *Paradiacheopsis* were communicated for the first time in Colombia. Of the records observed in the surveys, 6 were associated exclusively with ground litter, 5 with twigs and 4 with bark. Eight records were observed in more than one substrate.

List of new records of myxomycetes for Colombia:

1. *Arcyria afroalpina* Rammeloo – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On ground litter. Ro-9770, 9898, 9989, 10003 and 10033. Known from Panama and Costa Rica.
2. *Arcyria magna* Rex – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On twigs. Ro-9906. Known from Panama and Costa Rica.
3. *Arcyria minuta* Buchet – April 2019, from Campus of the University of Antioquia, Medellín, Antioquia, Colombia. On ground litter. Ro-10049 (Deposited in HUA). Known from Panama and Costa Rica.
4. *Arcyria occidentalis* (T. Macbr.) G. Lister – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On twigs. Ro-10016. Known from Mexico.
5. *Badhamia melanospora* Speg. – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On both ground litter and twigs. Ro-9748, 9754, 9877 and 9995. Fig 1E. Known from Panama, Ecuador and Costa Rica.
6. *Badhamia populina* Lister & G. Lister – July 1978, from Sibundoy, between Pasto and Mocoa, Putumayo, Colombia. On moss. KP Dumont 9581 (BPI 743914/NYBG 02678164). Known from Chile.
7. *Collaria arcyrionema* (Rostaf.) Nann.-Bremek. ex Lado – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On ground litter. Ro-9720. Known from Panama, Ecuador and Costa Rica.
8. *Collaria rubens* (Lister) Nann.-Bremek. – March 2022, from Medellín. Antioquia, Colombia. On bark of living trees. Ro-9612, 9630. Known from Costa Rica.
9. *Comatricha nigra* (Pers. ex J.F. Gmel.) J. Schröt. – March 2022, from both the region West of the Aburrá Valley and Medellín, Antioquia, Colombia. On ground litter, twigs and bark of living trees. Ro-9565, 9568, 9571, 9631, 9650, 9651, 9653, 9654, 9684, 9711, 9717, 9722, 9728, 9730, 9733, 9738, 9741, 9743, 9765, 9771, 9775, 9778, 9780, 9786, 9790, 9795, 9796, 9811, 9854, 9897, 9925, 9931, 9933, 9942, 10030 and 10044. Known from Panama, Ecuador and Costa Rica.
10. *Cribraria violacea* Rex – March 2022, from both the region West of the Aburrá Valley and Medellín, Antioquia, Colombia. On ground litter, twigs and bark of living trees. Ro- 9575, 9657, 9660, 9667,

9815, 9846, 9945, 9959, 9961, 9971 and 9998. Known from Panama, Ecuador, Venezuela and Costa Rica.

11. *Diderma acanthosporum* Estrada & Lado – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On ground litter. Ro-9953 and 9955. Figs. 1A and 1B. Known from Mexico.
12. *Diderma deplanatum* Fr. – January 1976, from the Bogotá-Villavicencio Road, via Cáqueza, Cundinamarca, Colombia. On bamboo. K.P: Dumont 2215 (ILLS 50343). Known from Costa Rica.
13. *Fuligo septica* (L.) F.H. Wigg. – July 2015, from Valle del Cauca, Calí, Colombia. On decayed wood. MUOB 170497, 208496, 210650, 218267 and 224909. Known from Known from Panama, Ecuador, Venezuela and Costa Rica.
14. *Macbrideola scintillans* H.C. Gilbert – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On twigs. Ro-9912. Known from Costa Rica.
15. *Paradiacheopsis solitaria* (Nann.-Bremek.) Nann.-Bremek. – March 2022, from Medellín. Antioquia, Colombia. On bark of living trees. Ro-9611. Fig. 1C. Known from Costa Rica.
16. *Perichaena corticalis* (Batsch) Rostaf. – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On both ground litter and twigs. Ro-9687, 9692, 9696, 9701, 9707, 9807, 9825, 9850, 9984, 9994, 10011, 10020, 10032 and 10042. Known from Panama, Ecuador and Costa Rica.
17. *Perichaena vermicularis* (Schwein.) Rostaf. – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On both ground litter and twigs. Ro-9681, 9708, 9826 and 9966. Known from Panama, Ecuador and Costa Rica.
18. *Physarum decipiens* M.A. Curtis – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On twigs. Ro- 9816, 9821, 9828, 9835, 9838, 9841, 9845, 9851 and 9957. Figure 1D. Known Costa Rica.
19. *Physarum crateriforme* Petch – from both the region West of the Aburrá Valley and Medellín, Antioquia, Colombia. On both ground litter and bark of living trees. Ro-9608. Known from Ecuador and Costa Rica.
20. *Physarum nudum* T. Macbr. – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On both ground litter and twigs. Ro-9856 and 9874. Known from Belize.
21. *Physarum polycephalum* Schwein. – March 2022, from Medellín. Antioquia, Colombia. On bark of living trees. Ro-9606. Known from Costa Rica.
22. *Physarum serpula* Morgan – April 2019, from Cartagena, Bolivar, Colombia. On ground litter. Field observation. No voucher collected. Known from Panama, Ecuador and Costa Rica.
23. *Physarum virescens* Ditmar – March 2022, from the region West of the Aburrá Valley, Antioquia, Colombia. On ground litter. Ro-9891 and 10001. Known from Venezuela and Costa Rica.
24. *Stemonitopsis aequalis* (Peck) Y. Yamam. – March 2022, from both the region West of the Aburrá Valley and Medellín, Antioquia, Colombia. On ground litter, twigs and bark of living trees. Ro-9578, 9581, 9585, 9607, 9626, 9633, 9669, 9833, 9844, 9852, 9921 and 9937. Known from Panama and Costa Rica.
25. *Stemonitopsis hyperopta* (Meyl.) Nann.-Bremek. – March 2022, from both the region West of the Aburrá Valley and Medellín, Antioquia, Colombia. On both twigs and bark of living trees. Ro-9587, 9589, 9670, 9682, 9820 and 9911. Known from Panama and Costa Rica.
26. *Stemonitopsis subcaespitosa* (Peck) Nann.-Bremek. – March 2022, from Medellín. Antioquia, Colombia. On bark of living trees. Ro-9583. Known from Costa Rica.
27. *Tubifera corymbosa* Leontyev, Schnittler, S.L. Stephenson & L.M. Walker – April 2019, from Piedecuesta, Santander, Colombia. On decayed wood. MUOB 365522. Known from Costa Rica.
28. *Tubifera ferruginosa* (Batsch) J.F. Gmel. – October 2012, from Valle del Cauca, Calí, Colombia. On decayed wood. MUOB 164907 and 184364. Known from Ecuador, Panama and Costa Rica.

DISCUSSION

Most of the species documented herein are common in the Neotropics. Eleven of them are known from more than 10 countries in the region (Lado & Wrigley de Basanta 2008, Rojas et al. 2018) and with the exception of *Arcyria occidentalis*, *Diderma acanthosporum*, *Badhamia populina*, and *Physarum nudum*, the rest of the species have been documented in Costa Rica, a very well-studied territory (Rojas et al. 2018). Of these exceptions, the first two have been documented in Mexico (Lado & Wrigley de Basanta 2008, Rojas et al. 2010), the third one is known from Chile and Bolivia and the last one has been recorded in Belize (Lado & Wrigley de Basanta 2008). These results simply point out that all species have been previously communicated in the Neotropics and that their presence in Colombia is not extraordinary but expected.

To the best of our knowledge, the surveys where these new records for Colombia were observed have been the most intense recent assessments of myxomycete diversity in that country. Interestingly, more unrecorded species were expected from the tropical dry forests of Cartagena based on previous research in other neotropical areas (Estrada-Torres et al. 2009). It is possible that a number of small forms in such genera as *Echinostelium*, *Licea* or *Macbrideola* were undetected due to the untrained eyes of the students that examined the moist chamber cultures. However, the presence of *Physarum serpula* in Colombian dry forests highlights its occurrence in arid environments as observed in distributional data from other parts of the Neotropics (Rojas et al. 2018).

The premontane forests of the general area associated with the Aburrá Valley (within and neighboring lands) provide adequate conditions for the establishment and reproduction of myxomycetes. The surveys that generated the information presented herein only focused on such substrates as ground litter, twigs and bark. However, previous investigations in similar areas have demonstrated different assemblages of myxomycetes in association with lianas, aerial litter and inflorescences (Wrigley de Basanta et al. 2008, Schnittler & Stephenson 2002). In this manner, it is very likely that the number of species known to the tropical Colombian Andes landscape will increase as more specific surveys are implemented in the future. In the work of Lado & Wrigley de Basanta (2008), they showed very clearly that the number of known species of myxomycetes for different territories in the Neotropics is highly associated with the number of publications for those jurisdictions, a proxy for survey effort (r=0.88, r^2=0.78).

Moreover, given the variety of conditions in Colombia, a series of future surveys in unexplored areas such as highlands, the coastal areas of the Pacific Coast, the eastern plains and the Amazonian forests will inevitably increase the number of known myxomycetes in this part of the world. Such experience has been the norm in other previously unexplored regions in South America such as Chile and Peru (Lado et al. 2013, Lado et al. 2016). However, given the strategic geographical location of Colombia it is possible that new species of myxomycetes for science can be discovered in those campaigns. For instance, in a high-intensity survey in specific locations in Brazil, Costa Rica and Panama, Walker et al. (2019) discovered that a form of stalked *Perichaena* common to Neotropical forests did not quite correspond to the known *P. pedata* and instead was a different species with a similar morphology.

Finally, the presence of online platforms for accessing information on historical biological collections, not available few years ago, has increased the potential of addressing issues related to biodiversity in a different manner than ever before (Monfils et al. 2017). For instance, in the work of Rojas et al. (2012) authors checked for myxomycete collections from Colombia in the herbarium of the United States National Fungus Collection (BPI) but were unaware at that time of the records included herein and of the other records at the New York Botanical Garden and the Illinois Natural History Survey Herbarium. The Mushroom Observer platform was in a very early stage at that time. All these resources allow researchers to synthesize information more properly, at the local or regional levels, and promote higher quality feedback for decision-makers in the fields of conservation and natural resources management. Ultimately, studying nature provides information that should be used for humanity to determine a more responsible future path and efforts to document biodiversity, like the one presented herein, have been conceived with such goal in mind.

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