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Myxomycetes of Vietnam: A Systematic Review

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Abstract: Myxomycetes, often known as plasmodial slime molds or myxogastrids, are fungus-like protists often found in high abundance in terrestrial habitats. However, myxomycetes are still the subject of relatively limited research in Vietnam. This systematic review updates a total of 173 myxomycetes which includes the enumeration of six new species that have been discovered in this country since its very first myxomycetes research that started in 2009. The article also suggests future directives, challenges, and the opportunities for budding myxomycete research in Vietnam.

Keywords: biodiversity, paleotropics, PRISMA guideline, research, slime molds.

Introduction

Like other countries in Southeast Asia, studies about myxomycetes in Vietnam, although started quite very late, have also grown rapidly over the last decades. With the unique topography and climatic variations from Northern to Southern Vietnam, the country offers unique terrestrial vegetation types ranging from tropical rainforests to high montane forests (Nguyen et al. 2020) that harboured many new reported species of myxomycetes. For the record, the first report for myxomycetes in Vietnam begun only in 2009 when Van Hooff published in *Boletin de la Sociedad Micologica* 23 new records for the country including one (*Cribraria tecta)* new species at that time.

After five years, two papers about myxomycetes in Vietnam have been subsequently published in the journal *Mycosphere*. The first is the paper of Novozhilov et al. (2014) wherein two new species of *Diderma* were reported from intensive surveys conducted in the lowland dense monsoon semideciduous forest of Cat Tien National Park. This is then followed by another paper from Tran et al. (2014) that utilized the moist chamber culture technique and samples of dead plant materials collected haphazardly from forests of Cuc Phuong, Bu Gia Map, and Nam Cat Tien National Parks. From this study, a total of 57 myxomycetes records for Vietnam have been updated. Novozhilov et al. (2017) reported a systematic survey of myxomycetes in lowland monsoon tropical forests of Dong Nai Biosphere Reserve, where 69 out of 107 recorded myxomycetes were considered new for the country.

Studies of myxomycetes in Northern Vietnam followed in the next years wherein, Redeña-Santos et al. (2018) first reported the occurrence of 20 species from three agroecosystems (*Camelia sinensis, Dimocarpus longan*, and *Psidium guajava*) of Thai Nguyen Province. This was followed by another comprehensive study that assessed litter from protected and unprotected plantation forest in Thai Nguyen City, wherein a total of seven new records (Redeña-Santos et al. 2018) was accounted for Vietnam. On the same year, synecological studies about myxomycetes in Southern Vietnam were reported by Novozhilov et al. (2018) and have observed similarities of myxomycetes composition in Vietnam with that of the common myxomycetes found in the temperate and in the boreal areas of the world. For 2019, myxomycetes surveyed from Dalat Plateau, Southern Vietnam, specifically in the tropical forest region of Nui Ba and Chu Yan Sin National Park added 40 new records (Novozhilov et al. 2019). Moreover, published also that year was the new species, *Diderma dalatense* that was first reported in Bidoup Nui Ba National Park (Novozhilov et al. 2020). Nguyen et al. (2020) conducted another synecological investigation of myxomycetes on leaf litter collected from the forests of Northern and Central Vietnam (Ha Noi, Thai Nguyen, and Da Nang of Vietnam). Synecological studies about myxomycetes in the Nature Reserve Phia Oắc-Phia Den was reported by Fedorova et al. (2020, 2021), in this reserve eleven taxa were recorded for Vietnam for the first time, and all taxa were new for the nature reserve. Recently, another new species, *Lamproderma vietnamense*, was reported for the country and was discovered in the aforementioned nature park in Northern Vietnam (Novozhilov et al. 2022).

These published peer-reviewed reports and the many other ongoing studies about myxomycetes in Vietnam seem to point out that the country cradles to become a hotspot of myxomycete biodiversity in Southeast Asia. Hence, this extensive systematic literature review is conducted to (1) update the current status of records for Vietnam and (2) comprehensively discuss the status and challenges of myxomycete research in the country.

Materials and Methods

General study area

The location of Vietnam is in the Indochina region with S-shaped land that has over 331 690 square kilometers. The particular topography is small and narrow, extending from north to south with terrain that is mostly mountainous, which accounts for three-quarters of the land area. Because the country is in Southeast Asia, hence a tropical climate is the most common with the annual average temperature across the country from 22 to 27 degrees Celsius (Unknown author 2022). There are two distinct seasons, the dry and cold seasons (from November to April next year), and the hot rainy season (from May to October); however, due to the effects of cold fronts in the Northern provinces, the climate changes to four seasons: spring, summer, autumn, and winter.

Systematic review based on PRISMA guidelines

This study begins with keying the word " Myxomycetes of Vietnam" in the Google Scholar engine, which accounted a total of 330 literature hits. However, after the screening method for duplication in title, 19 literature hit results were removed. The next round of more stringent screening removed 292 literature hits because the information is not related or eligible to the topic of Vietnam myxomycetes. One more literature hit was removed since this was not a peer reviewed paper. From the 18 literature sources were screened using the PRISMA guideline (see Fig. 1 for the schematic flow of this literature selection), an additional two papers from the last author that were not generated during the search flowchart was included in this review, making this systematic review to utilize 20 literatures tackling different themes (ecology, genetics, taxonomy) of Vietnam myxomycetes.

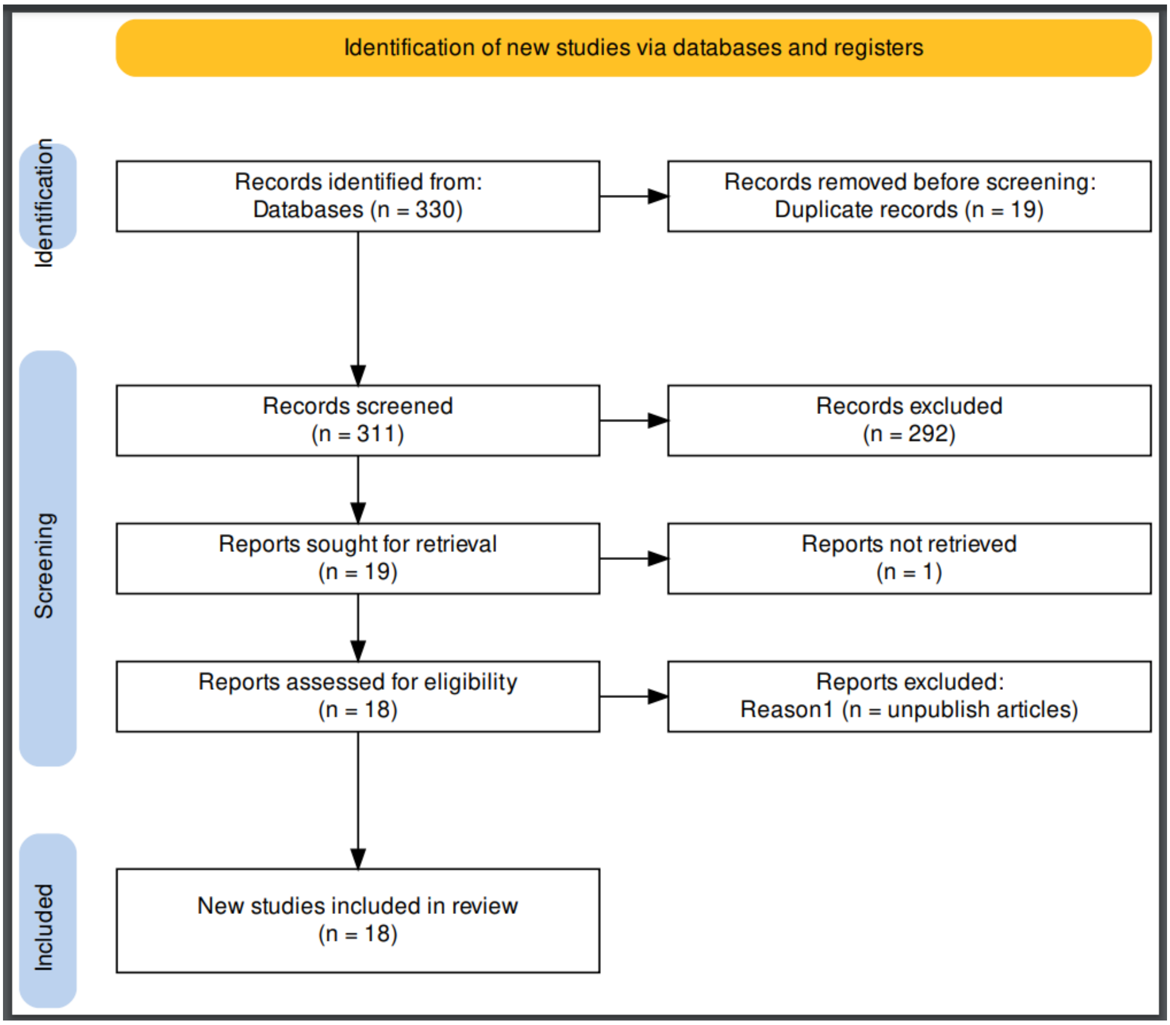

Figure 1. The PRISMA flowchart used in the present study during the bibliographic review of literature.

Results and Discussion

A number of papers that reported records of myxomycetes in Vietnam have already been accounted for the past decade since the study of myxomycetes in the country started; however, the total valid number for myxomycetes in the country is still vague. Hence for this study, we reviewed 18 taxonomic and ecological papers that tackled myxomycetes in Vietnam to updated the current status of myxomycetes studies in the country.

Where in Vietnam myxomycetes have been surveyed?

Many National Parks have been surveyed for myxomycetes but the most common landscape where most collections for these national parks were conducted are the lowland mountainous landscapes (Fig. 2). Similar on other countries in Southeast Asia (Philippines – Dagamac et al. 2017b; Bernardo et al. 2018; Thailand – Ko Ko et al. 2011; Laos – Ko Ko et al. 2012), where lowland forests have been the most surveyed, besides of the accessibility and practicality reasons, tropical rainforests is the most favorable environment for the growth of myxomycetes in nature (Stephenson et al. 2007; Novozhilov et al. 2017, Dagamac et al. 2017a). In comparison, forest natural parks from the South are much better studied than from the North and Central parts of Vietnam. The area of Southern Vietnam with the southern border of Bach Ma mountain towards the south is the place that has nuances of the sub-equatorial monsoon climate. In terms of the places where surveys for myxomycetes have been carried out, the earliest field studies conducted in the South came from the works of Tran et al. (2014) in the lowland forested areas of national parks of Southern Vietnam accounting to 43 taxa. But perhaps, the most comprehensive diversity studies in the southern part of Vietnam are done in lowland forest of Cat Tien National Park and Vinh Cuu Nature Reserve where the most diversity of myxomycetes with 107 taxa from 27 genera was accounted (Novozhilov et al. 2017) and in the mountain tropical forests of Dalat Plateau with 105 taxa from 28 genera (Novozhilov et al. 2019b).

Unlike the more systematic and comprehensive synecological studies conducted in the lowland forest in the South, the first papers in Northern Vietnam about myxomycetes focused mainly on litter samples randomly collected in Hanoi (Van Hooff 2009). Perhaps, the most important diversity assessments for myxomycetes in the north was initiated by the comparative study in the lowland plantation forests (Redeña-Santos et al. 2018) and agroecosystems (Redeña-Santos et al. 2017) of Thai Nguyen Province where 54 taxa and 20 taxa were accounted respectively. So far, there is only one National Park (Ba Vi National Park) in the North that is explored for myxomycetes and only paper so far that sampled from the lowland areas of Central Vietnam is attributed from the rapid assessment of litters in Da Nang City (Nguyen et al. 2020). With these studies, a clear imbalance in terms of myxomycete surveys have been done for the whole Vietnam and calls for exploring the other terrains and National Parks in Northern and Central Vietnam.

How many total number of myxomycetes species are known thus far from Vietnam?

The list of species presented in Table 1 counted a total of 173 valid names (including species identified as taxonomic variety) for the country. This includes the 23 records first reported from Van Hooff (2009), 32 from Tran et al. (2014), four new species reported by Novozhilov et al. in their papers in 2014 (Novozhilov et al. 2014a; Novozhilov et al. 2014b, Novozhilov et al. 2014c), one from Redeña-Santos et al.(2017), one new species reported by Novozhilov et al. (2019b), 11 by Fedorova et al. (2020) and another one new species by Novozhilov et al., (2022). After cross matching with the other literatures, only six (out of seven), 61 (out of 69) and 34 (out of 42) number of myxomycetes were included from the synecological papers in 2018 of Redeña-Santos, 2017, 2019 of Novozhilov et al. and 11 of Fedorova et al. (2020) , respectively. We have removed some species from the list because of the following: (1) synonyms, wherein basing from the updated nomenclature of myxomycetes (Lado 2000–2023, www.nomen.eumycetozoa.com), *Stemonitis axifera* is now the accepted name for *Stemonitis smithii;* (2) incomplete taxonomic nomenclature, this includes names that only presents the genus name and without any specific epithet; (3) duplicates, species that were previously reported as new species on earlier publications was not treated as an additional record already to avoid duplication in the count of records.

These 173 records of myxomycetes in Vietnam seem to be slowly catching up with the number of myxomycetes in neighboring countries. But with the number of other surveys that can be conducted in other forested areas in Vietnam that have not been surveyed yet but shows promising areas for collection such as (i) Ba Be National Park in Bac Khan Province, (ii)Tam Dao National park in Vinh Phuc province, (iii) Hoang Lien National Park in Lai Chau Province, (iv) Pu Mat National Park in Nghe An Province, (v) Bach Ma National Park in Thua Thien Hue Province, (vi) Phu Quoc National Park Kien Giang Province, we expect that these numbers can grow drastically perhaps in the next years.

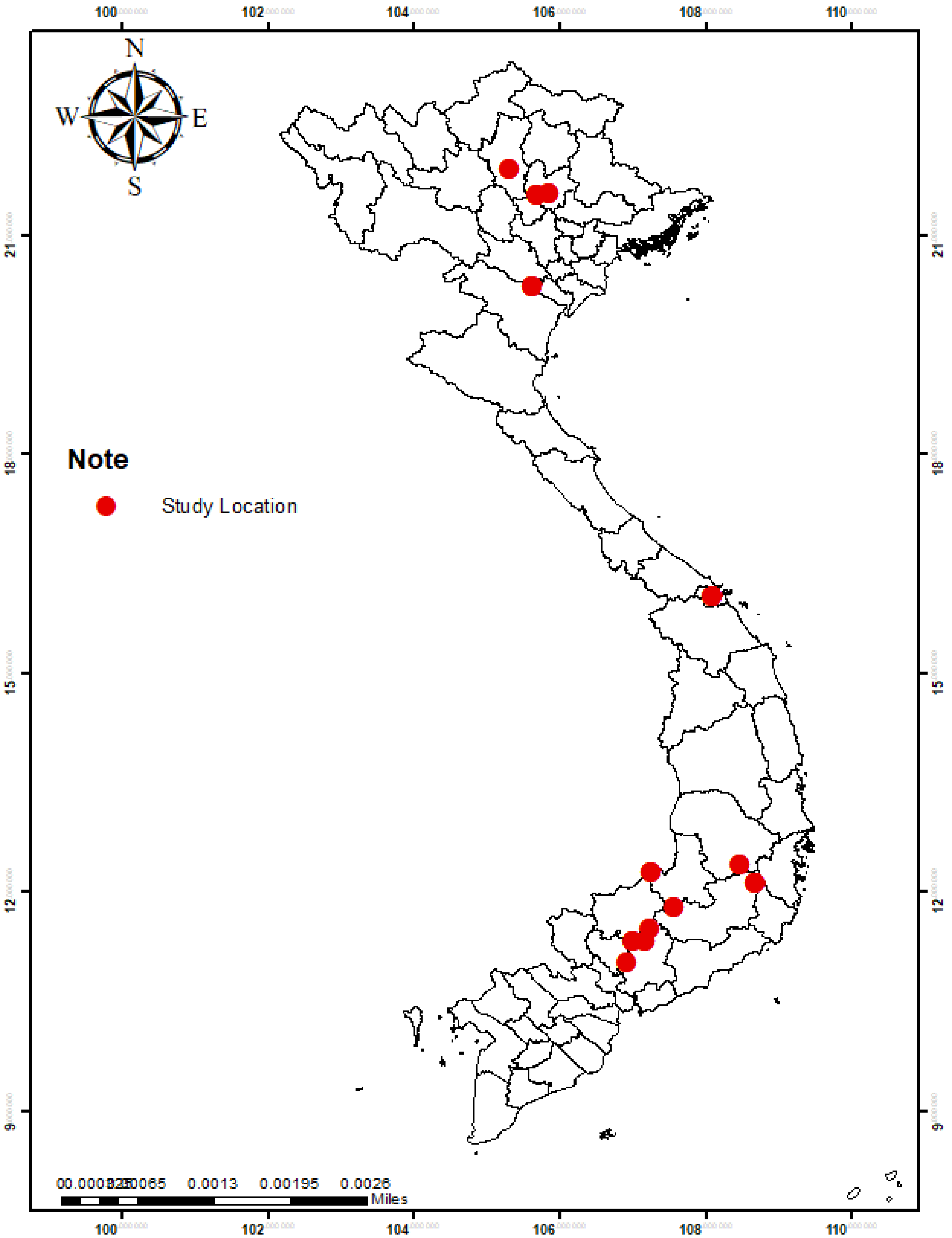

Figure 2. Location of studies conducted in Viet Nam are represented by the red circles.

What do these myxomycete records tell us about Vietnam's biodiversity?

From the 173 myxomycetes records, six of them are perhaps even endemic and new species to science, namely, *Diderma cattiense* and *Diderma pseudotestaceum* (Novozhilov et al. 2014a), *Comatricha spinispora* (Novozhilov et al. 2014b), *Perichaena echinolopospora* (Novozhilov et al. 2014c), *Diderma dalatense* (Novozhilov et al. 2019) and *Lamproderma vietnamense* (Novozhilov et al. 2022). The first five species all came from the extensive surveys conducted in the southern part of Vietnam while the last species came from the northern part. In fact, the largest number of new myxomycetes species for the last decade being described in Southeast Asia are all coming from these extensive studies in Vietnam. Just by merely looking at this number this clearly points out the diversity of myxomycetes and perhaps the hidden diversity of many more, that awaits discovery in the country.

All of these new species were described to be isolated from National Parks where there are strong environmental policies in terms of protection (No.29/2004/QH11) and biodiversity conservation (No.20/2008/QH12) in Vietnam. The National Parks in Vietnam organize the management and conservation of natural ecosystem for the country and much are focused on the protection of indigenous flora and fauna. This now entails lesser attention towards implementation of scientific research programs or research activities that looks into the roles of local microbial flora such as the myxomycetes in the country. Myxomycetes are important ecologically since their microbial predation in nature keeps the whole terrestrial ecosystem in balance. Removing them in the equation of food chains and community dynamics in the soil can cause major collapse of macroorganism that most of the biodiversity policies in the country protects, The notion now that myxomycete records for the country are growing steadfastly points to (i) myxomycetes can act as a biological indicator of ecosystem health for many forests in the country as shown by studies done by Redeña-Santos et al. (2017) that compared protected and unprotected plantation forests; (ii) strategies in protecting a natural park should not just be on a species level alone, but looking at protecting them at a landscape or ecosystem level covering now not just the animals or plants that are endangered but also myxomycetes that can be endemic for the country; (iii) exploring and tapping basic research on biodiversity to possibly look at possible cryptic speciation that may occur on myxomycete populations collected in Vietnam.

What is next for studying myxomycetes in Vietnam?

The large extent of research themes conducted in Vietnam about myxomycetes are concentrated on the aspects of taxonomy, biogeography, and ecology. Looking at the authorship of the papers that worked about myxomycetes in Vietnam, most are products of collaborative studies with foreign experts that have initiated and gave their time to explore the diversity of such neglected microbial flora in Vietnam. This now points for the opportunity that more Vietnamese scientist should be trained to become adept to the specialized role of slime molds in Vietnam's rich landscape. Initiatives have been done by some Vietnamese researchers, who aside from working on the ecology of myxomycetes, are also exploring the potential of this microorganism for industrial applications.

Besides that, researches that utilize samples from Vietnam in elucidating potential for barcoding and genetic work have been conducted in recent years. Example for this is the paper of Shchepin et al. (2017) that have employed the plasmodial collections coming from substrates collected in Northern and Central Vietnam to see if DNA barcoding would work on the animal like feature stage of myxomycetes. Samples from Vietnam have also been used in population genetic studies of *Diderma hemisphaericum* (Almadrones-Reyes et al. 2019) and *Hemitrichia serpula* (Dagamac et al. 2017) to prove the complexities of speciation on clear cut morphospecies. Buisan and Dagamac (2021) have enumerated possible sophisticated tools and methods that can be employed for studying slime molds especially in developing country like Vietnam where studies about myxomycetes are still described to be at its infancy.

Table 1. List of myxomycete species recorded for Vietnam. Information is provided on the source(s) of each record where the species was first mentioned, along with some general comments.

No	Myxomycete species	Reference
1	*Arcyria cinerea* (Bull.) Pers.	Van Hooff (2009)
2	*Arcyria denudata* (L.) Wettst.	Tran et al. (2014)
3	*Arcyria incarnata* (Alb. & Schwein.) O.F. Cook.	Novozhilov et al. (2017)
4	*Arcyria insignis* Kalchbr. & Cooke	Tran et al. (2014)
5	*Arcyria marginoundulata* Nann.-Bremek. & .Y Yamam.	Van Hooff (2009)
6	*Arcyria minuta* Buchet	Van Hooff (2009)
7	*Badhamia affinis* Rostaf.	Novozhilov et al. (2017)
8	*Barbeyella minutissima* Meyl.	Novozhilov et al. (2019a)
9	*Calomyxa metallica* (Berk.) Nieuwl.	Tran et al. (2014)
10	*Ceratiomyxa fruticolosa* (O.F. Mull.) T. Macbr.	Tran et al. (2014)
11	*Clastoderma debaryanum* A. Blytt	Tran et al. (2014)
12	*Collaria arcyrionema* (Rostaf.) Nann-Bremek. ex Lado	Tran et al. (2014)
13	*Collaria lurida* (Lister) Nann.-Bremek.	Novozhilov et al. (2017)
14	*C. rubens* (Lister) Nann-Bremek.	Fedorova et al. (2020)
15	Colloderma oculatum (C. Lippert) G. Lister	Fedorova et al. (2020)
16	*Comatricha brachypus* (Meyl.) Meyl.	Van Hooff (2009)
17	*Comatricha alta* Preuss	Tran et al. (2014)
18	*Comatricha elegans var. pallens* G. Lister	Novozhilov et al. (2019a)
19	*Comatricha elegans* (Racib) G. Lister	Novozhilov et al. (2017)
20	*Comatricha laxa* Rostaf.	Fedorova et al. (2020)
21	*Comatricha nigra* (Pers. ex J.F. Gmel.) Schroet.	Redeña-Santos et al. (2018)
22	*Comatricha pulchella* (C. Bab.) Rostaf.	Novozhilov et al. (2017)
23	*Comatricha spinispora* Novozh. & D.W. Mitch.	Novozhilov et al. (2014b)
24	*Comatricha tenerrima* (M.A. Curtis) G. Lister	Van Hooff (2009)
25	*Craterium minutum* (Leers) Fr.	Tran et al. (2014)
26	*Craterium rubronodum* G. Lister	Novozhilov et al. (2017)
27	*Cribraria cancellata* (Batsch.) Nann.-Bremek.	Novozhilov et al. (2017)
28	*Cribraria confusa* Nann.-Bremek. & Y. Yamam.	Novozhilov et al. (2017)
29	*Cribraria intricata* Schrad.	Novozhilov et al. (2017)
30	*Cribraria languescens* Rex	Novozhilov et al. (2017)
21	*Cribraria lepida* Meyl.	Novozhilov et al. (2017)
32	*Cribraria microcarpa* (Schrad.) Pers.	Tran et al. (2014)
33	*Cribraria minutissima* Schwein	Novozhilov et al. (2019a)
34	*Cribraria splendens* (Schrad.) Pers.	Novozhilov et al. (2019a)
35	*Cribraria tecta* Hooff	Van Hooff (2009)
36	*Cribraria tenella var. concinna* (G. Lister) Schrad.	Novozhilov et al. (2017)
37	*Cribraria violacea* Rex	Tran et al. (2014)
38	*Diachea bulbillosa* (Berk. & Broome) Lister	Redeña-Santos et al. (2018)
39	*Didymium difforme* (Pers.) S.F. Gray	Redeña-Santos et al. (2018)
40	*Diachea leucopodia* (Bull.) Rostaf.	Tran et al. (2014)
41	*Diderma floriforme* (Bull.) Pers.	Novozhilov et al. (2019a)
42	*Diderma cattiense* Novozh. & D.W. Mitch.	Novozhilov et al. (2014a)
43	*Diderma chondrioderma* (de Bary et Rostaf.) G. Lister	Fedorova et al. (2020)
44	*Diderma dalatense* Novozh., Prikhodko & Shchepin	Novozhilov et al. (2019b)
45	*Diderma deplanatum* Fr.	Novozhilov et al. (2019a)
46	*Diderma effusum* (Schwein.) Morgan	Tran et al. (2014)
47	*Diderma globosum* Pers.	Tran et al. (2014)

48	*Diderma hemisphaericum* (Bull.) Hornem.	Van Hooff (2009)
49	*Diderma pseudotestaceum* Novozh. & D.W. Mitch.	Novozhilov et al. (2014a)
50	*Diderma rugosum* (Rex) T. Macbr.	Novozhilov et al. (2017)
51	*Diderma saundersii* (Berk. & Broome ex Massee) E. Sheld.	Van Hooff (2009)
52	*Didymium anellus* Morgan	Novozhilov et al. (2017)
53	*Didymium bahiense* Gottsb.	Van Hooff (2009)
54	*Didymium clavus* (Alb. & Schwein.) Rabenh.	Novozhilov et al. (2017)
55	*Didymium columella-cavum* Hochg., Gottsb. & Nann-Bremek.	Novozhilov et al. (2017)
56	*Didymium difforme* (Pers.) Gray	Van Hooff (2009)
57	*Didymium floccoides* Nann.-Bremek. & Y. Yamam.	Novozhilov et al. (2017)
58	*Didymium iridis* (Ditmar) Fr.	Novozhilov et al. (2017)
59	*Didymium leoninum* Berk. & Broome	Novozhilov et al. (2017)
60	*Didymium minus* (Lister) Morgan	Novozhilov et al. (2017)
61	*Didymium nigripes* (Link) Fr.	Tran et al. (2014)
62	*Didymium ochroideum* G. Lister	Novozhilov et al. (2017)
63	*Didymium squamulosum* (Alb. & Schwein.) Fr. & Palmquist	Tran et al. (2014)
64	*Didymium verrucosporum* A.L.Welden	Novozhilov et al. (2017)
65	*Echinostelium apitectum* K.D. Whitney	Novozhilov et al. (2019a)
66	*Echinostelium brooksii* K.D. Whitney	Novozhilov et al. (2019a)
67	*Echinostelium colliculosum* K.D. Whitney & H.W. Keller	Novozhilov et al. (2019a)
68	*Echinostelium elachiston* Alexop.	Novozhilov et al. (2017)
69	*Echinostelium minutum* de Bary	Van Hooff (2009)
70	*Elaeomyxa cerifera* (G. Lister) Hagelst.	Novozhilov et al. (2019a)
71	*Enerthenema papillatum* (Pers.) Rostaf	Novozhilov et al. (2019a)
72	*Fuligo septica* (L.) F.H. Wigg.	Novozhilov et al. (2017)
73	*Hemitrichia calyculata* (Speg.) M.L. Farr	Tran et al. (2014)
74	*Hemitrichia leiotricha* (Lister) G. Lister	Fedorova et al. (2020)
75	*Hemitrichia minor* G. Lister	Novozhilov et al. (2019a)
76	*Hemitrichia pardina* (Minakata) Ing	Novozhilov et al. (2017)
77	*Hemitrichia serpula* (Scop.) Rostaf. ex Lister	Tran et al. (2014)
78	*hysarum oblatum* T. Macbr	Van Hooff (2009)
79	*Lamproderma columbinum* (Pers.) Rostaf.	Novozhilov et al. (2019a)
80	*Lamproderma scintillans* (Berk. & Broome) Morgan	Van Hooff (2009)
81	*Lamproderma vietnamense* Novozh., Prikhodko, Fedorova, Shchepin & Schnittler	Novozhilov et al. (2022)
82	*Lepidoderma tigrinum* (Schrad.) Rostaf.	Novozhilov et al. (2019a)
83	*Licea biforis* Morgan	Novozhilov et al. (2017)
84	*Licea bulbosa* Nann.-Bremek. & Y. Yamam.	Fedorova et al. (2020)
85	*Licea erecta* K.S. Thind & Dhillon	Redeña-Santos et al. (2018)
86	*Licea kleistobolus* G.W. Martin	Novozhilov et al. (2017)
87	*Licea minima* Fr.	Novozhilov et al. (2019a)
88	*Licea operculata* (Wingate) G.W. Martin	Tran et al. (2014)
89	*Licea pygmaea* (Meyl.) Ing	Novozhilov et al. (2017)
90	*Lindbladia tubulina* Fr.	Novozhilov et al. (2019a)
91	*Lycogala epidendrum* (L.) Fr.	Novozhilov et al. (2017)
92	*Lycogala exiguum* Morgan	Novozhilov et al. (2017)
93	*Macbrideola argentea* Nann.-Bremek. & Y. Yamam.	Novozhilov et al. (2017)
94	*Macbrideola cornea* (G. Lister & Cran.) Alexop.	Fedorova et al. (2020)
95	*Macbrideola martinii* (Alexop. & Beneke) Alexop.	Novozhilov et al. (2017)
96	*Macbrideola ovoidea* Nann.-Bremek. & Y. Yamam.	Novozhilov et al. (2017)
97	*Macbrideola scintillans* H.C. Gilbert	Novozhilov et al. (2017)
98	*Metatrichia floriformis* (Schwein.) Nann.-Bremek.	Novozhilov et al. (2019a)

99	*Metatrichia vesparia* (Batsch.) Nann.-Bremek. ex. G.W. Martin & Alexop.	Tran et al. (2014)
100	*Paradiachea caespitosa* (Sturgis) Hertel ex H. Neubert, Nowotny & K. Baumann	Van Hooff (2009)
101	*Paradiacheopsis longipes* Hoof & Nann.-Bremek.	Novozhilov et al. (2019a)
102	*Paradiacheopsis rigida* (Brândza) Nann.-Bremek.	Novozhilov et al. (2017)
103	*Paradiacheopsis solitaria* (Nann.-Bremek.) Nann.-Bremek.	Novozhilov et al. (2019a)
104	*Perichaena echinolophospora* Novozhilov & S.L. Stephenson,	Novozhilov et al. (2014c)
105	*Perichaena liceoides* Rostaf.	Redeña-Santos et al. (2017)
106	*Perichaena chrysosperma* (Curr.) Lister	Tran et al. (2014)
107	*Perichaena calongei* Lado, D. Wrigley & Estrada	Fedorova et al. (2020)
108	*Perichaena corticalis* (Batsch) Rostaf.	Van Hooff (2009)
109	*Perichaena depressa* Lib.	Tran et al. (2014)
110	*Perichaena dictyonema* Rammeloo	Novozhilov et al. (2017)
111	*Ophiotheca pedata* (Lister & G. Lister) García-Cunch., J.C. Zamora & Lado	Novozhilov et al. (2017)
112	*Perichaena reticulospora* H.W. Keller & D.R. Reynolds	Novozhilov et al. (2017)
113	*Gulielmina vermicularis* (Schwein.) García-Cunch., J.C. Zamora & Lado	Van Hooff (2009)
114	*Physarella oblonga* (Berk & M.A. Curtis) Morgan	Novozhilov et al. (2017)
115	*Physarum auripigmentum* G.W. Martin	Novozhilov et al. (2019a)
116	*Physarum album* (Bull.) Chevall	Tran et al. (2014)
117	*Physarum bitectum* G. Lister	Redeña-Santos et al. (2018)
118	*Physarum bivalve* Pers.	Tran et al. (2014)
119	*Physarum bogoriense* Racib.	Tran et al. (2014)
120	*Physarum cinereum* (Batsch) Pers.	Van Hooff (2009)
121	*Physarum citrinum* Schumach.	Novozhilov et al. (2017)
122	*Physarum compressum* Alb. & Schwein	Van Hooff (2009)
123	*Physarum crateriforme* Petch	Tran et al. (2014)
124	*Physarum decipiens* M.A. Curtis	Novozhilov et al. (2017)
125	*Physarum echinosporum* Lister	Tran et al. (2014)
126	*Physarum flavicomum* Berk.	Tran et al. (2014)
127	*Physarum globuliferum* (Bull.) Pers.	Novozhilov et al. (2017)
128	*Physarum gyrosum* Rostaf.	Van Hooff (2009)
129	*Physarum javanicum* Racib.	Novozhilov et al. (2019a)
130	*Physarum lakhanpalii* Nann.-Bremek. & Y. Yamam.	Tran et al. (2014)
131	*Physarum lateritium* (Berk. & Ravenel) Morgan	Novozhilov et al. (2017)
132	*Physarum leucophaeum* Fr. & Palmquist	Novozhilov et al. (2019a)
133	*Physarum leucopus* Link	Novozhilov et al. (2019a)
134	*Physarum melleum* (Berk. & Broome) Massee	Van Hooff (2009)
135	*Physarum murinum* Lister	Novozhilov et al. (2019a)
136	*Physarum nucleatum* Rex	Novozhilov et al. (2017)
137	*Physarum oblatum* T. Macbr	Novozhilov et al. (2017)
138	*Physarum penetrale* Rex	Novozhilov et al. (2017)
139	*Physarum pezizoideum* (Jungh.) Pavill. & Lagarde	Novozhilov et al. (2019a)
140	*Physarum pusillum* (Berk. & M.A. Curtis) G. Lister	Van Hooff (2009)
141	*Physarum roseum* Berk. & Broome	Tran et al. (2014)
142	*Physarum sessile* Brândza	Novozhilov et al. (2017)
143	*Physarum stellatum* (Massee) G.W. Martin	Novozhilov et al. (2017)
144	*Physarum sulphureum* Alb. & Schwein	Novozhilov et al. (2017)
145	*Physarum superbum* Hagelst.	Tran et al. (2014)
146	*Physarum tenerum* Rex	Novozhilov et al. (2017)

147	*Physarum virescens* Ditmar	Novozhilov et al. (2019a)
148	*Physarum viride* (Bull.) Pers.	Tran et al. (2014)
149	*Siphoptychium reticulatum* Leontyev, Schnittler & S.L. Stephenson	Novozhilov et al. (2019a)
150	*Stemonaria fuscoides* Nann.-Bremek. & Y. Yamam.	Van Hooff (2009)
151	*Stemonitis axifera* (Bull.) T. Macbr	Novozhilov et al. (2017)
152	*Stemonitis fusca* Roth	Tran et al. (2014)
153	*Stemonitis herbatica* Peck	Van Hooff (2009)
154	*Stemonitis inconspicua* Nann.-Bremek.	Novozhilov et al. (2019a)
155	*Stemonitis mussooriensis* G.W. Martin, K.S. Thind & Sohi	Novozhilov et al. (2017)
156	*Stemonitis pallida* Wingate	Redeña-Santos et al. (2018)
157	*Stemonitis splendens* Rostaf.	Novozhilov et al. (2017)
158	*Stemonitopsis aequalis* (Peck) Y. Yamam.	Novozhilov et al. (2017)
159	*Stemonitopsis gracilis* (G. Lister) Nann.-Bremek.	Novozhilov et al. (2017)
160	*Stemonitopsis hyperopta* (Meyl.) Nann.-Bremek.	Novozhilov et al. (2019a)
161	*Stemonitopsis typhina* (F.H. Wigg.) Nann.-Bremek.	Novozhilov et al. (2017)
162	*Stemonitopsis typhina* var. *similis* (G. Lister) Nann.-Bremek. & Y. Yamam.	Novozhilov et al. (2017)
163	*Trichia ambigua* Schirmer, L.G. Krieglst & Flatau	Fedorova et al. (2020)
164	*Trichia decipiens* (Pers.) T. Macbr	Novozhilov et al. (2019a)
165	*Trichia decipiens* var. *hemitrichioides* Brandza	Fedorova et al. (2020)
166	*Trichia erecta* Rex	Novozhilov et al. (2019a)
167	*Trichia favoginea* (Batsch) Pers.	Novozhilov et al. (2019a)
168	*Trichia papillata* Adamonyte	Novozhilov et al. (2017)
169	*Trichia persimilis* P. Karst.	Novozhilov et al. (2017)
170	*Trichia scabra* Rostaf.	Novozhilov et al. (2019a)
171	*Trichia verrucosa* Berk.	Novozhilov et al. (2019a)
172	*Tubulifera casparyi* (Rostaf.) Lado	Novozhilov et al. (2017)
173	*Tubulifera microsperma* (Berk. & M.A. Curtis) Lado	Novozhilov et al. (2017)

Hence, there are still many gaps that need to be addressed in the myxomycete profiles of Vietnam. To fill in this the country needs to invest on (i) training talented Vietnamese scientist, (ii) collaborating with experts that can mentor and inspire locals to pursue a career and specialization on myxomycetes, (iii) incorporating these organisms in the science education of the country, and (iv) technologies where both pure and applied topics exploring myxomycetes can be tapped.

Conclusions

Vietnam is a region where biodiversity is the highest on the Earth. For myxomycetes alone, the diversity of the country is considerably a "hotspot" for Southeast Asia. However, in this systematic review, we suggested more potential areas in Vietnam where extensive exploration on myxomycetes should start to fluorish. As such, collaboration is important especially in a country that are just beginning to mark myxomycetes as an important component of the country's biodiversity. Moreover, it is not surprising to observe the rate of species additions of the past decade, Vietnam can eventually reach not only the number from other Southeast Asian country but can really become a hotspot myxomycetes in the world.

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