Review

STATUS OF THE MYXOMYCETE COLLECTION AT THE UPLB-MUSEUM OF NATURAL HISTORY (UPLB-MNH) MYCOLOGICAL HERBARIUM

THOMAS EDISON E. DELA CRUZ[1*], RUDOLF V. KUHN[1], ANTON OLIVER M. JAVIER[1], CHRISTIAN M. PARRA[1] AND TRICITA H. QUIMIO[2]

[1]Department of Biological Sciences, College of Science
University of Santo Tomas, España 1015 Manila, Philippines
[2]UPLB-MNH Mycological Herbarium,
University of the Philippines-Los Baños, College 4031 Laguna, Philippines
Email: tedelacruz@mnl.ust.edu.ph

ABSTRACT

The Philippines is considered one of the world's megahotspots of biodiversity. Among the country's fungal species, about 4,698 species belonging to 1,031 genera are currently known or described, of which only a small number of myxomycetes were included. At the UPLB-MNH Mycological Herbarium, one of the country's premier depository institutions of fungal collections, only about 446 myxomycete specimens were recorded. In this review paper, progress made in myxomycete diversity in the Philippines is reported. The conservation status of the myxomycetes specimens deposited at the UPLB-MNH Mycological Herbarium is also assessed. Furthermore, hindrances to the discovery of new myxomycete species and challenges encountered by local researchers are also discussed.

Keywords: *myxomycetes, slime molds, biodiversity, conservation*

INTRODUCTION

The Philippines is a vast archipelago of 7,107 islands located in the Southeast Asian region. Some 50 million years ago, the islands rose from the tectonic plates in the Pacific. Its coastlines now can be up to 17,500 km. Only the island of Palawan is believed to be previously connected to Mainland Asia (Vesilind, 2002). Thus, many species living within the islands and islets of the country virtually evolved in isolation. It is thus not surprising that the Philippines, with its almost 300,000 km^2 land mass, is considered to be as one of the world's megahotspots of biodiversity.

The geographic isolation of the many islands in the Philippines resulted in a number of unique flora and fauna. In the country's various habitat types of lowland rainforests and montane forests, about 65 % of its more than 9,000 plants and about 1,100 land vertebrate species are endemic. That simply means the country harbours about 6,091 endemic species of plants, 102 endemic species of mammals, 186 endemic species of birds, 160 endemic species of reptiles, 76 endemic species of amphibians and 67 endemic species of freshwater fishes. Along its mangrove coasts and pristine coral reefs, more than 500 coral species as well as 34 kinds of fishes are also only found here (http://www.biodiversityhotspots.org). Indeed, everyday, new plant and animal species from less explored places and areas contributes to the continuous rise in the number of species in the country. So, it is not surprising that the Philippines is listed as second most diverse country in the world in terms of the number of endemic species per land area, second only to Madagascar.

Fungal Diversity in the Philippines

The Philippine biodiversity is not only limited to the so-called multicellular "higher life forms". As early as 1906, the American botanist Ricker looked at the fungal flora of the country and reported 156 species from 71 genera. About a decade after, Baker in 1914 reported a higher record, i.e. about 638 fungal species belonging to 215 genera (Quimio, 2002). One of the early Filipino mycologists, Nicanor Teodoro (1937), in his book "Enumeration of Philippine Fungi", credited the country with 2,979 fungal species from 620 genera. Mostly were ascomycetes and basidiomycetes which comprised almost 79 % of the described species.

Teodoro's Enumeration of Philippine Fungi, however, did not include most of the lower fungi. Dogma (1975) listed 221 species of these microorganisms which included 46 species of myxomycetes, 66 species of chytrids and 61 species of oomycetes. Further enumeration by Dogma (1986) of Philippine zoosporic fungi yielded 118 species belonging to 60 genera and 10 orders. Of these, 75 were common and widespread while 57 were economically important. Furthermore, 43 species were rare and 9 species were endemic. Majority of the zoosporic fungi were also new to the Philippines and nine were even new to science.

Recent enumeration of Philippine fungi by Quimio (2002) reported 4,698 fungal species belonging to 1,031 genera. But, with about 75,000 species known worldwide and an estimated 1.5 million species present (Hawksworth, 2001), the number of fungal species found in the Philippines is indeed low for a tropical country. From the earlier works of Teodoro (1937) until the present list by Quimio (2002), the number of fungal species credited to the country increased only by 36 % for the past 65 years or with an average discovery rate of 26 species per year. This number though may increase with the publications of new or misidentified species and with extensive surveys of published literatures or symposium proceedings.

The Philippines' Myxomycete Flora

One of the less explored microbial flora in the country are the myxomycetes. Myxomycetes or slime molds are a small, morphologically diverse, but relatively homogenous group of eukaryotic organisms. They exists as thin, free-living, acellular mass of naked protoplasm with no cell wall, referred to as plasmodium. The plasmodium may be viscous and slimy, white or brightly colored, e.g. different shades of yellow, orange and red, and may change form as it creeps slowly over the substrate upon which it occurs (Stephenson & Stempen, 1994). At this stage of their life cycle, the myxomycetes typically thrive on decaying woods, leaves, twigs or on dead barks of living trees in cool, shady and moist places where they generally feed on bacteria and/or protozoa by engulfing them, an animal-like feature. After a period of feeding and growth, the plasmodium moves out of its habitat and into a drier, more exposed location where it forms one or more, minute in size fruiting bodies. The fruiting bodies exhibit remarkable and intricate structure and each contains numerous spores. Spores of myxomycetes can be dispersed by wind, and under suitable conditions, will germinate and develop again into a plasmodium (Stephenson & Stempen, 1994). This remarkable transformation from an animal-like to a fungus-like form fascinated many scientists and made myxomycetes an ideal model system to study cellular development in lower life forms. At present, about 923 species of myxomycetes are known worldwide with most species belonging to the Order Physarales, Stemonitales and Trichiales.

In the Philippines, very little is known of its myxoflora. Uyenco (1973) reported to have published the first report on Philippine myxomycetes. From her collection of 341 specimens from various places in Luzon, Zamboanga and Basilan (1961-1973), she reported 18 species belonging to 10 genera. Dogma (1975), however, noted that Martin and Alexopoulous' *The Myxomycetes*, published in 1969, credited already the country with 22 species of myxomycetes. Dogma then listed 46 species of myxomycetes belonging to 20 genera for our country. But perhaps, the most extensive list of Philippine myxomycetes was done by Reynolds (1981). He reported an annotated list of 107 species, 53 of which were new records for the country. Included in the list were species of *Arcyria* (8), *Badhamia* (1), *Ceratiomyxa* (1), *Clastoderma* (1), *Comatricha* (5), *Craterium* (3), *Cribaria* (5), *Diachea* (4), *Dictydium* (1), *Diderma* (4), *Didymium* (10), *Echinostelium* (1), *Fuligo* (1), *Hemitrichia* (4), *Lamproderma* (3), *Licea* (1), *Lycogala* (2), *Metatrichia* (1), *Perichaena* (5), *Physarella* (1), *Physarum* (26), *Stemonitis* (6), *Trichia* (5) and *Tubifera* (3). Most of these myxomycetes were collected from substrates obtained from several sites in the country (Fig. 1). The list also corresponded to 25 % of world's known species of myxomycetes at that time and to 60% of the estimated total number of Philippine myxomycete flora (Reynolds, 1981).

Recently, in the checklist and database of Philippine fungi, Quimio (2002) listed only 118 species of myxomycetes, and included species

belonging to the Orders Ceratiomyxales (1), Liceales (17), Stemonitales (22), Trichiales (23) and Physarales (55). At the University of Santo Tomas – College of Science, a research study was conducted by undergraduate students on the myxomycetes found in selected highlands of Luzon and in selected islands of Hundred Islands and Anda Island in Pangasinan (Corpuz *et al*., 2009). A total of 25 species was observed in selected highlands whereas 25 – 30 species were recorded in different islands in Pangasinan. Abundant species belong to the genera *Arcyria, Comatricha, Craterium, Diderma, Physarum* and *Stemonitis*. Four species were new records for the Philippines: *Elaeomyxa miyazakiensis, Lepidoderma tigrinum, Perichaena pedata* and *Physarum decipiens*. One specimen belonging to the genus *Craterium* was obtained from one of the islands and is believed to be a novel species.

Myxomycete Collection at the UPLB-MNH Mycological Herbarium

In the early 1960's, mycologist Don Reynolds together with his students, T. H. Quimio included, made extensive fungal collections in the country, from the islands of Batanes to the islands of Sulu. The growing collections of fungal specimens led to the establishment of the G. O Ocfemia Memorial Herbarium, named after the first Filipino chair of the Department of Plant Pathology at the University of the Philippines in Los Baños, Laguna (Quimio, 2001a). In 1965, the herbarium was formally recognized (Quimio & Quimio, 1965) and was subsequently listed at the Index Herbariorum in 1968 as CALP (College of Agriculture, Laguna, Philippines). Since then, the herbarium has evolved to what is now known as the University of the Philippines Los Baños - Museum of Natural History (UPLB-MNH) Mycological Herbarium, one of the country's premier depository institutions of fungal collections.

Owing its existence to T. H. Quimio and D. Reynolds, it is not therefore surprising that earlier collections at the UPLB-MNH Mycological Herbarium included myxomycetes. At present, about 446 specimens of myxomycetes were recorded in the herbarium. Deposited mainly by Reynolds, Dogma and Quimio, only 128 strains were identified up to species level. Majority (282) of the deposited myxomycete specimens were identified only up to the genus level. Myxomycetes found mainly belong to the following genera: *Arcyria*, *Ceratiomyxa*, *Cienkowskiella*, *Clastoderma, Comatricha, Craterium, Cribaria, Diachea, Dictydium, Diderma, Didymium, Fuligo, Hemitrichia, Lamproderma, Lycogala, Perichaena, Physarella, Physarum, Stemonitis, Trichia* and *Tubifera*, which could later be grouped into several families (Fig. 2.0). Specimens identified to the species level included seven species of *Arcyria* and *Trichia*, five species of *Physarum*, four species of *Stemonitis*, three species of *Hemitrichia* and two species for each of *Comatricha, Diachea, Didymium, Lamproderma* and *Lycogala* (Table 1).

Majority of the myxomycetes deposited at the UPLB-MNH Mycological Herbarium was collected from Laguna (96), Iloilo (58), Davao (46), Mountain

Province (45) and Palawan (45). Very few specimens were collected from Albay (6), Bataan (6), Quezon (4), Leyte (1), Zamboanga (1), Ilocos Norte (1) and Quezon City in Manila (1). Most of the specimens were also collected and deposited in 1963 (168 specimens) and 1964 (161 specimens). Interestingly, several specimens deposited at the herbarium included those that were collected from the USA (20), Ecuador (1) and Costa Rica (1), perhaps sent or brought to the Philippines by early mycologists. Some of the specimens deposited even dated as early as 1900's up to the pre-World War II time, i.e. from 1888 to 1939.

Assessment of the conservation status of the specimens deposited at the herbarium showed that majority of the specimens was in good condition (Table 2). Only 19 specimens previously listed in the UPLB-MNH Mycological Herbarium database (Quimio, 2001b) were found missing. Unfortunately, many herbarium boxes (155) contained no fruiting bodies at all or specimens that have already deteriorated. In some boxes (70), only the stalk or stipe of the myxomycetes remained. But still, many herbarium boxes or specimens (201) survived the ravages of time and the conditions of the herbarium. These specimens had 2 or more fruiting bodies, all of which were in very good and well-conserved conditions. Remarkably, some specimens, more than a hundred year old, remained in excellent condition at the UPLB-MNH Mycological Herbarium (Fig. 3). *Trichia pusilla* (Accession No.: 8289), *Hemitrichia clavata* (Accession no.: NA) and *Trichia botrytis* (Accession No.: 8296) were collected from the USA in 1888, 1889 and 1890, respectively. Truly, the UPLB-MNH Mycological Herbarium offers many specimens with their very own history.

Problems and Challenges in Myxomycete Biodiversity Research

In spite of the high endemicity of the flora and fauna of the country, still limited progress has been made on Philippine fungal biodiversity research, particularly on Philippine myxomycetes. Dogma (1975) credited this little progress on a combined result of academic apathy, economic orientation and problems similarly felt in most developing countries. He listed also several points or possible reasons in his paper. Until today, we believed that Dogma's observations remained true and valid. Our little progress in myxomycete biodiversity research could also be attributed to the following points as previously discussed by Dogma:

Personnel. Still, very few are equipped to pursue a career in mycology, particularly in myxomycetes. Very few people have undergone trainings that will allow them to conduct research studies on myxomycetes. The lack of personnel is also reflected in the lack of appreciation for myxomycetes and mycology in general in the science curricula of most local universities and colleges as first observed by Dogma (1975). Courses on these fields were limited only to the graduate level or to those subjects with practical

applications, e. g. plant pathology, biotechnology, etc. Thus, there is an urgent need to train young people in the field who can and will explore our unexplored areas for myxomycetes. The challenge now will be to motivate young minds to pursue careers in mycology and to conduct biodiversity research on myxomycetes.

Herbarium. Myxomycete research requires herbaria as depository institutions for safe keeping of described species or collected specimens. These herbaria must be easily accessible for specimen retrieval or any comparative studies. In the Philippines, the Philippine National Museum as mandated by our Constitution serves as the official repository of all flora and fauna collected and discovered in the country. Its Mycology Section at the Botany Division, however, holds very few specimens of myxomycetes. The UPLB-Museum of Natural History Mycological Herbarium (UPLB-MNH) serves also as one of the country's premier depository institutions for fungal collections. Included in their list are several species and specimens of myxomycetes collected over the century. Still, the UPLB-MNH is not sufficient to hold in storage and for safe keeping all those specimens within the country, and necessitates the establishment of more local and/or university-based herbaria.

Literature. Several local journals can now be a place for publishing research in myxomycete biodiversity. With easy access to Internet, even international scientific journals can serve as venue for disseminating information on new species of myxomycetes collected in the country or on new results on myxomycete biodiversity.

Loss of Natural Resources. Perhaps the most influential factor that hinders or slows us in our search for new species of myxomycetes is the continuous loss of our natural resources. In the 1960s, almost 90% of our archipelago is carpeted by natural, primary forest. In 1992, it is estimated that only 15 % remained. With an annual deforestation rate of 1.5 % or equivalent to 2,000 km^2 (Catibog-Sinha & Heaney, 2006), it is believed that numerous species of plants and animals, even myxomycetes, may have gone extinct. It is therefore of urgent need to conserve and protect our fast vanishing natural resources. Baseline studies on biodiversity on these remaining forests are again of urgency.

In summary, the number of Philippine myxomycetes is still considered to be small, indicating that still many more myxomycete species remained undiscovered and a vast tract of the country's tropical habitats are still to be explored. The myxomycete collection at the UPLB-MNH Mycological Herbarium holds in its hall many specimens collected by well-known mycologists in the country. However, the herbarium is not enough to keep all specimens found in the country. The list of specimens here also reflects the low number of collected species and raises the need to explore and learn more

of our biodiversity. This is a challenge that this review paper aims to convey to our researchers and young, future scientists.

ACKNOWLEDGEMENT

The authors would like to thank Mr. Manuel M. Baldovino for his technical assistance.

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Table 1. List of identified myxomycetes deposited at the UPLB-MNH Mycological Herbarium.

Genera	Species
Arcyria	*A. cinerea, A. denudata, A. glauca, A. globosa, A. incarnate, A. insignis, A. nutans*
Ceratiomyxa	*C. fruticolosa*
Clastoderma	*C. debaryanum*
Comatricha	*C. pulchella, C. typhoides* (syn. *Stemonitopsis typhina*)
Craterium	*C. minutum*
Cribraria	*C. microcarpa*
Diachea	*D. bulbillosa, D. leucopodia*
Dictydium	*D. cancellatum* (syn. *Cribraria cancellata*), *D. thaliuplumbeum*
Diderma	*D. montanum*
Didymium	*D. farinaceum* (syn. *D. melanospermum*), *D. squamulosum*
Fuligo	*F. septic*
Hemitrichia	*H. clavata, H. serpula, H. stipitata* (syn. *Hemitrichia calyculata*)
Lamproderma	*L. columbinum, L. scintillans*
Lycogala	*L. epidendrum , L. exiguum*
Perichaena	*P. depressa*
Physarella	*P. oblonga*
Physarum	*P. compressum, P. nutans* (syn. *Physarum album*), *P. pezizoideum, P. pusillum, P. roseum*
Stemonitis	*S. corolinensis, S. flavogenita, S. fusca, S. splendens*
Tilmadoche	*T. compacta* (syn. *Physarum spellatum*)
Trichia	*T. botrytis, T. erecta, T. fallax* (syn. *T. decipiens*), *T. favoginea,* *T. floriformis* (syn. *Metatrichia floriformis*), *T. pusilla* (syn. *Oligonema schweinitzii*), *T. scabra*
Tubifera	*T. ferruginosa* (syn. *Tubulifera arachnoidea*)

Table 2. Conservation status of the myxomycete specimens deposited at the UPLB-MNH Mycological Herbarium (as of December 2008).

Status	State of Conservation	No. of Herbarium Specimen
0	herbarium missing	19
1	no fruiting body found	103
2	fruiting bodies deteriorated	52
3	only stipes/stalks present	70
4	one or two fruiting bodies present	23
5	numerous, well-conserved fruiting bodies present	178
ND	could not be determined	1
Total		**446**

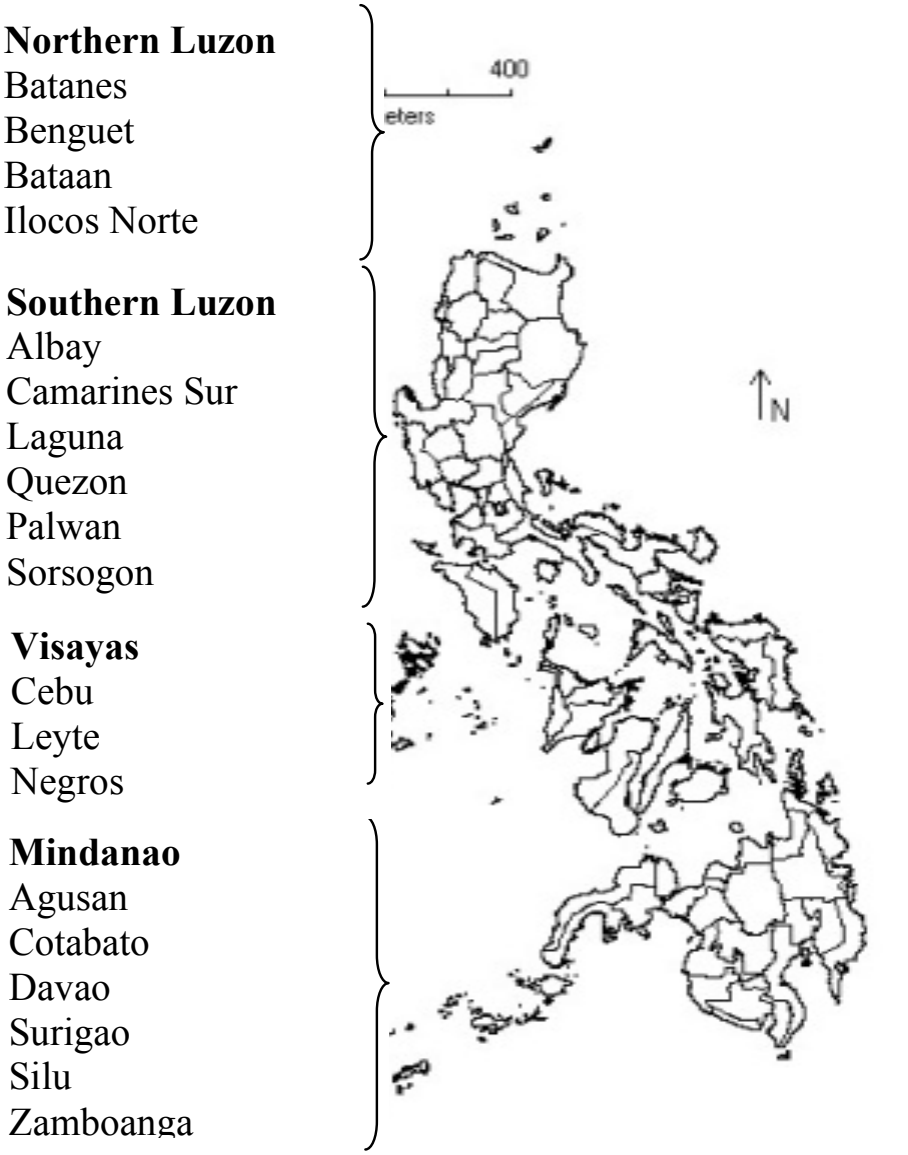


Figure 1. Geographic origin of published and described Philippine myxomycetes (adapted from Reynolds, 1981 & Quimio, 2001).

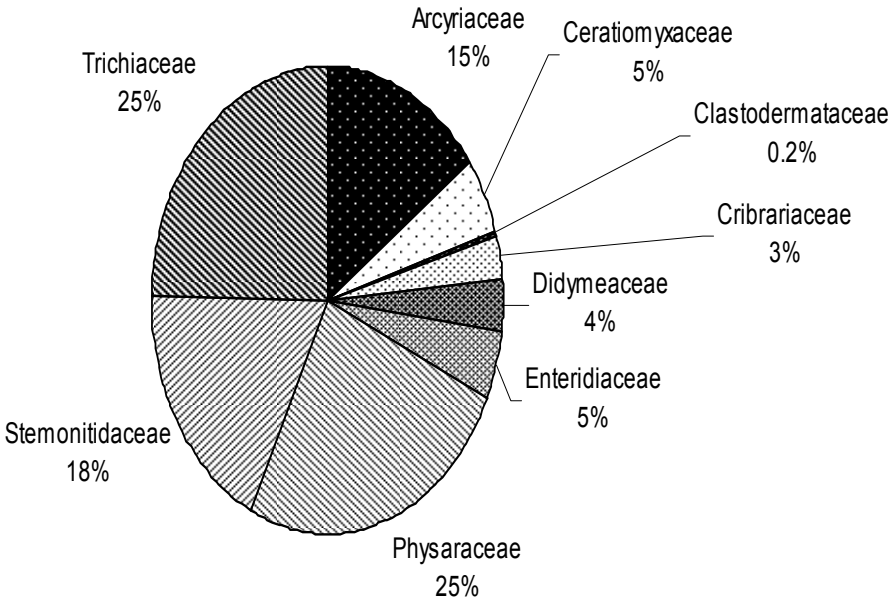
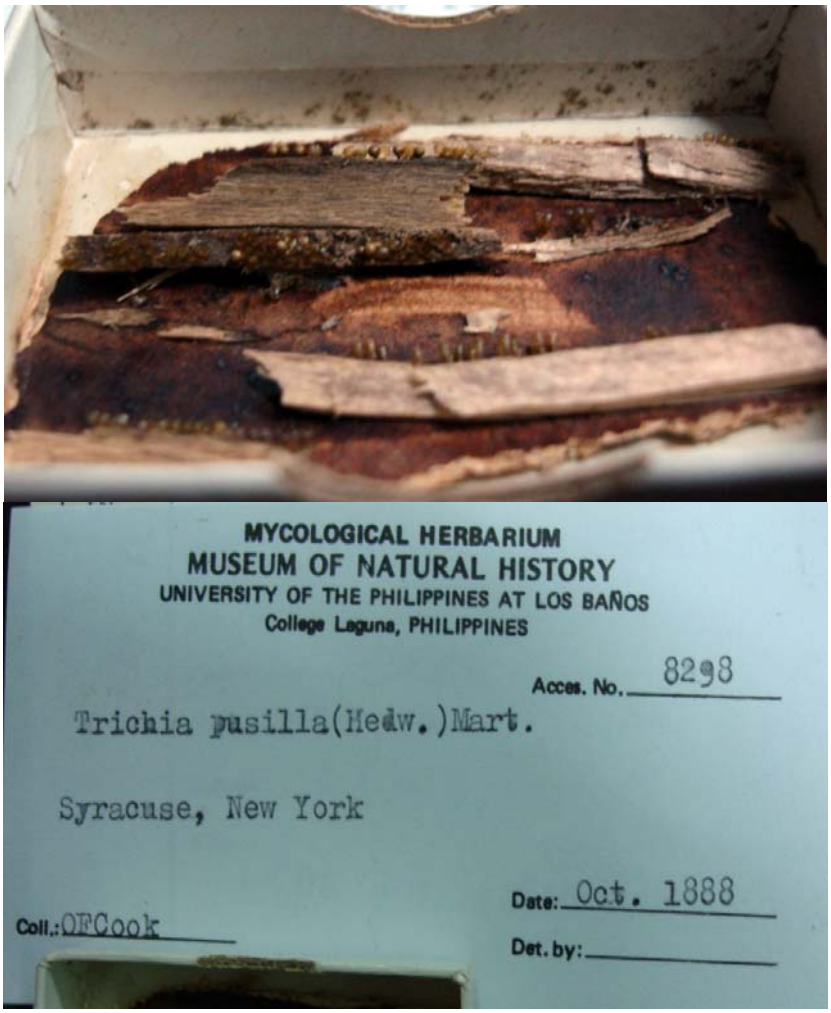
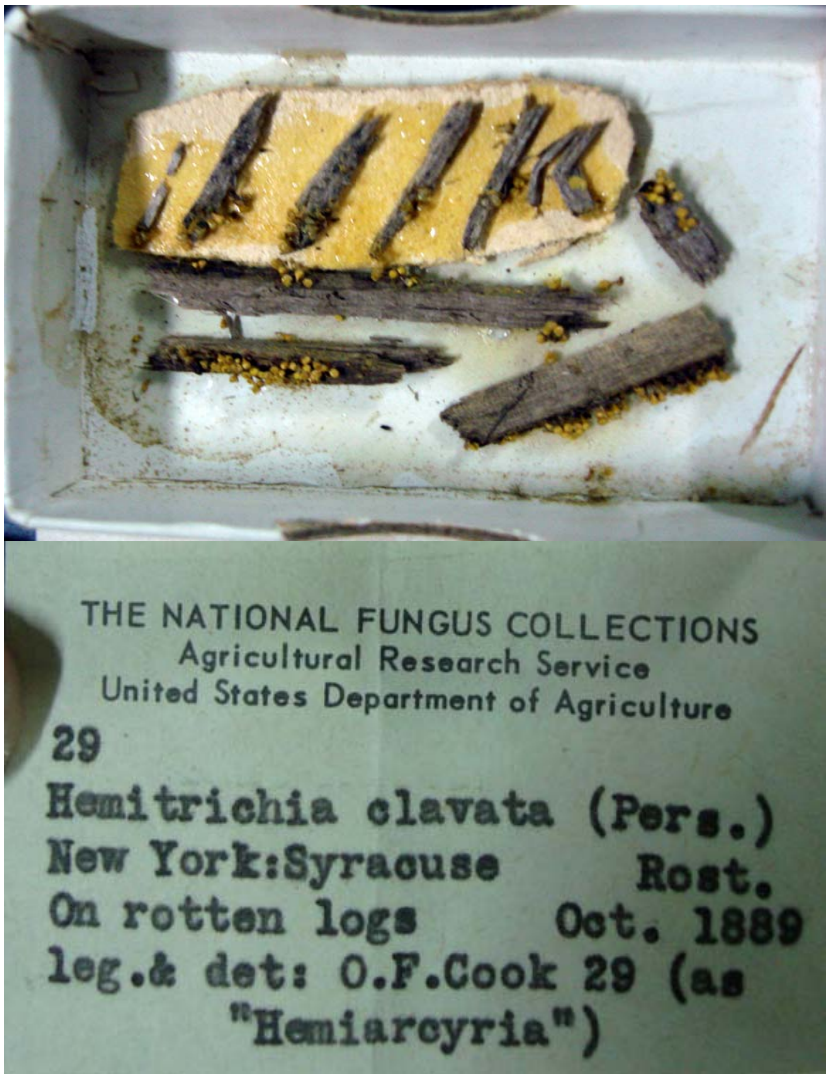


Figure 2. Number of myxomycete specimens deposited at the UPLB-MNH Mycological Herbarium (adapted from Quimio, 2001).



A *Trichia pusilla* (Acces. No.: 8289): Date & Place of Collection: 1888, Syracuse, New York



B *Hemitrichia clavata* (Acces. No.: NA): Date & Place of Collection: 1889, Syracuse, New York

b

C *Trichia botrytis* (Acces. No.: 8296): Date & Place of Collection: 1890, Tully, New York

Figure 3. Specimens of myxomycetes deposited at the UPLB-MNH Mycological Herbarium. Herbarium labels on the right side were original labels for each of the specimen.