inoculum

Supplement to
Mycologia
Vol. 62(4)
August 2011

Newsletter of the Mycological Society of America

— In This Issue —

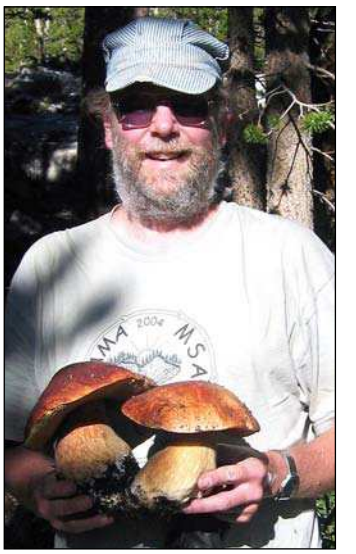
— Important Dates —

September 15, 2011
Deadline for submission to *Inoculum* 62(5)

Editor — Donald O. Natvig
Department of Biology
University of New Mexico
Albuquerque, NM 87131
Telephone: (505) 277-5977
Fax: (505) 277-0304
Email: dnatvig@gmail.com

President's Corner

Working toward a North American Mycobiota for macrofungi — what's stopping us?



Tom Bruns, MSA President

My graduate training was in botany, and as part of this training I took, and helped teach, plant taxonomy courses. My first such course was one called *The Spring Flora of Minnesota*, which was taught by Thomas Morely and was based on a book of the same name that he had authored. The amazing thing about that book was that it contained every vascular plant in the state that flowered before mid June and yet it was small and easy to use. It was the first flora I every owned, but it turned into a gateway drug for others such as Gleason and Cronquist's Manual of the Vascular Plants, The Flora of the Pacific Northwest, and the Jepson Manual. I love these books because they allowed me to learn new plants and to retrieve some basic information about their distributions and their status as a native or introduced species. Florist work also forms the necessary basis for discovering biogeographic patterns.

After moving to Berkeley California from Ann Arbor Michigan I was immediately struck by the impressive differences in mycobiota (i.e., mycoflora, or mycota if you'd rather) in the two regions. Many species and even genera that were common in Michigan were absent or rare in California and unfamiliar genera and species were everywhere. Furthermore many species that are called by the same names in Michigan and California often looked subtlely different in the two regions. Finer scale differences within the California mycobiota were also were obvious. Genera such as *Ramaria and Phaeocollybia* for example seem to increase in species diversity as one moves up the coast, and the Sierra Nevada has its own set of unique species not seen on the coast, including an impressive set of snow melt fungi.

But these observations on mycobiota differences are anecdotal. Where are the data that demonstrate these patterns? Early on in my training I learned that mycobiotas did not exist for North America, or even for any state or region within the continent. Of course there were some field guides to mushrooms, and there were some monographs to particular groups, but the field guides available at the time didn't contain most of the species one would find, and the monographs tended to

Continued on following page

Fig 1. A curation party in which members of the Bay Area Mycological Society, helped to box and label collections from the Pt Reyes "mycoblitz' forays. Not shown are the many people from the Mycological Society of San Francisco, Soma Mycological Association, and the Santa Cruz Fungus Federation, that were responsible for many of the collections and identification.

be expensive, difficult to use, and often out of date. In any case field guides and monographs are not mycobiotas. They generally don't contain the distribution patterns that would reveal what our biogeographic patterns look like. The one exception to these generalities are the lichenized fungi, which do have a beautiful, modern treatment for North America [1], and a website http://www.sharnoffphotos.com/lichens/lichens_home_index.html.

The reasons for the lack of mycobiotas became clear as I began to learn more about mycology: the basic information was not available. Many of the species were still undescribed, or called by European names, and we lacked good images and detailed distribution data even for many well-known species. Existing herbarium records, especially older ones, often erroneously record the presence a particular species simply because the identification tools were primitive at the time of collection, and because collectors are probably always biased toward applying existing names rather than describing new species (e.g., historical records for *Amanita phalloids* [2]). Furthermore the ability to discern species-level differences from dried material is often limited, especially if the material was poorly dried and notes about the original collection are absent or limited. Fungal herbarium records are also strongly biased by collecting patterns; as a result distribution data tend to correlate with the favorite collecting sites of a handful of avid fungal systematists.

Another obvious problem for assembling mycobiota data is that there are very few mycologists versus a large number of fungi. Most of you reading this are aware of aware of Hawksworth's estimates that were originally based on a ratio of six species of fungus for every one vascular plant in Europe [3]. This ratio now looks conservative [4], particularly when tropic region are included [5]. Thus from an organism perspective alone the job of assembling a mycobiota is very conservatively six times more difficult than the job of assembling a flora. But the problem of being outnumbered by the organisms is further exacerbated by the small number of mycologists. To get a rough estimate of the problem I used the 1:5 ratio of mycologist to botantists based on MSA to BSA membership numbers. Combining these two numbers means that we have a ratio of organism to scientists that is about 30 times worst than that of plants and botanists! The problem does get better if we lower our sights to only macrofungi, essentially the mushrooms, polypores, truffles (and false-truffles), corticoid fungi, and Ascomycota with large sporocarps. I hate to suggest this, but I think it is the only practical way to proceed in the short-term. As I will argue below, we are going to need the public for this effort, and I think that requirement will make assembling distribution data on microfungi impractical.

The good news is that three important things have changed since the days I was a student: 1) there are much better field guides (to mushrooms), 2) the internet allows instant access to distributed data and allows one to deposit image-rich descriptions, and 3) cheap, easy, nucleic acid sequences allow us to compare collections in an objective way. With these tools, lots of help from the public, and some coordination, I think we could start to make some real progress on a continental mycobiota at least for the macrofungi. Ultimately, we need some serious funding for this, a point I will return to, but even with minimal funds I think we can get started.

First, we absolutely have to work closely with the informed public, because there are simply not enough professional mycologist to accomplish this task (see above). Other countries, such as the Netherlands, Switzerland, and Germany, [6-9] have already embraced this approach. Here we have the North American Mycological Association (NAMA) and all of its associated local organizations that are already engaged in collecting and identifying. I have no doubts that they would willingly enlist in the goal of producing a North American Mycobiota. These are "citizen scientists" (in NSF lingo), and many of them are highly competent taxonomists. Let's formally enlist them.

Second, this must be a specimen-based effort and specimens must be coupled to at least basic metadata (location, date, habitat, specimen notes). Foray lists, even when supplemented with good photos, are not great evidence for the presence of most species. Dr. Barbara Ertter, who worked on the Jepson Manual (a flora for California), summarized this best when she said: "**without a specimen, it's a rumor**". Specimens provide the necessary ground truth that can be reexamined as species concepts change, without them we stand on weak ground. However, the requirement for specimens adds two additional complexities to the problem: curation and herbarium space. These are respectively time-consuming and in increasingly short supply.

Continued on following page

Third, nucleotide sequencing is a must. Most of our fungal diversity probably resides in difficult species complexes, and it is at this level where regional differences in the mycobiota are likely to be most numerous. The fastest and most objective way to sort out these complexes is with sequence analysis. Deposited sequences are also an easily way for those doing monographic work to screen for collections that might be of special interest. Ideally sequencing would be a multilocus process, but even if we started with a single locus (like ITS) it will greatly aid in the process of sorting out species. Fortunately, there are some really easy DNA sampling, preservation and extraction methods now available **(see** [10]**)** that are very well suited to this goal.

What can we do with little or no funding? We can certainly start to organize, by improving connections between professional mycologists and citizen scientists. We can do this by using existing web technologies such as the Mushroom Observer and Google Docs to help report and coordinate effort within and between groups, and if spare funds are available, we can start to sequence through the collections. My involvement with this approach started when David Rust, a co-founder of the Bay Area Mycological Society (BAMS), approached me and asked what local mushroom clubs could do to contribute to science. His question came on the heals of the Ashville, NC MSA meeting, where the "mycoblitz" of the Great Smoky Mountains National park had occurred. So using the mycoblitz as our model we started a survey of the macrofungi of Pt Reyes National Seashore. This has been an ongoing project for several years and has now expanded to Yosemite National Park. Its been a very rewarding experience that provided me with a great excuse to learn many fungi that I didn't know previously, and it's helped two national parks to start cataloguing their fungi. In Pt. Reyes we have now increased the known number of fungi in the park by over four-fold, and in Yosemite we doubled the number of know fungi in a single year; this says a lot about how little the parks knew, but it also says a lot about what can be done with shoe-string budget and some hardworking volunteers. This work has primarily driven by members of the public, who did most of the collecting and identifying, helped produce web content (see [11]), and helped curate the specimens (Fig 1). We have started to sequence these collections with help from Mike Davis (UC Davis) and with a series of undergraduate projects at Berkeley. The results have revealed many novel fungi even among common species that we thought we knew.

What could we do if the mycological community had funds to produce a North American mycobiota for macrofungi? Here is my short list: 1) digitalize all major fungal herbaria in a way that allows a single search to retrieve records for all available collections; 2) pay for travel for people to collect in different areas of the continent, and to participate in targeted forays; 3) pay for expanding and centralized DNA extraction and sequencing, and give advanced members of the public access to it; 4) pay for training workshops on taxonomically difficult groups; 5) pay for curation of new specimens 6) develop a wiki-style website for the North American Mycobiota that would coordinate the data, display distributions, and provide modern identification tool for all taxa, and 7) begin expanding to other groups of fungi (i.e., microfungi). To do the job right, I think we would need at least 18 million dollars over 15 years[12], with the money being distributed across six regional centers.

Where is this level of funding going to come from? The Consortium for the Barcoding of Life would be a likely source for some of the sequencing, but I think this would represent a relatively small portion of the cost. NSF might pay for some of it. Specifically there seems to be a growing push for the digitalization of collections and I think mycological collections are well positioned to benefit from this initiative. Training and workshop programs are another area where NSF funding might be possible. But at the risk of raising David Minter's ire again (see *Inoculum* 62(1)), I have to say that I don't think it is likely that NSF would ever target 18 million dollars to assemble a North American mycobiota, especially in the current funding climate (ditto USDA, DOE, NIH, EPA, DOD, or any other federal funding agency).

Where does this leave us? It leaves us in the position of doing the best we can with limited funding, while looking for substantial private investment. I have little experience with private funding, but I do see major foundations that have the kind of money necessary, and I think that if we can actually get through the door to make our case we stand a good chance of getting this long overdue project moving more quickly. In the meantime I think we need to get together on this and start to getting organize. I'd be happy to hear from anyone that has experience or idea along these lines.

References

1 Brodo, I. M., Sharnoff, S. D. & S, S. *Lichens of North America*. (Yale University Press, 2001).

2 Pringle, A. & Vellinga, E. C. Last chance to know? Using literature to explore the biogeography and invasion biology of the death cap mushroom *Amanita phalloides* (Vaill. Ex fr. : Fr.) link. *Biological Invasions* **8**, 1131-1144 (2006).

3 Hawksworth, D. L. The fungal dimension of biodiversity: magnitude, significance, and conservation. *Mycol. Res.* **95**, 641-655 (1990).

4 Hawksworth, D. L. The magnitude of fungal diversity: the 1.5 million species estimate revisited. *Mycological Research* **105**, 1422-1432 (2001).

5 Frohlich, J. & Hyde, K. D. Biodiversity of palm fungi in the tropics: are global fungal diversity estimates realistic? *Biodiversity & Conservation* **8**, 977-1004 (1999).

6 anonymous. *Verspreidingsatlas. Kaartenbijlage overzicht van de paddestoelen in Nederland. Deel I. Agaricales.*, (Nederlandse Mycologische Vereniging, 2000).

7 anonymous. *swissfungi online: Verbreitungsatlas der Pilze der Schweiz* http://www.wsl.ch/swissfungi/, 2006).

8 Krieglsteiner, J. G. *Verbreitungsatlas der Grosspilze Deutschlands (West)*. (Ulmer, 1991).

9 Nauta, M. M. & Vellinga, E. C. *Atlas van paddestoelen in Nederland*. (Balkema, 1995).

10 Dentinger, B. T. M., Margaritescu, S. & Moncalvo, J. M. Rapid and reliable high-throughput methods of DNA extraction for use in barcoding and molecular systematics of mushrooms. *Molecular Ecology Resources*. *Molecular Ecology Resources* **10**, 628-633 (2010).

11 Mike Wood, of the Mycological Society of San Francisco, helped design the Pt. Reyes Mycoblitz website, and Debbie Viess of the Bay Area Mycological Society provided text to Pt Reyes National Seashore that is now on that park's website.

12 This number comes from a funding level of $200,000/center/year X 6 centers. This would be enough to hire a postdoc to coordinate the logistics, support training of at least one graduate student, pay for undergradate help with specimen curation, and provide travel and supply money for the project.