

The Toadstool Review

OFFICIAL NEWSLETTER OF THE MMS, A SOCIETY FOR THE STUDY OF MUSHROOMS AND OTHER FUNGI

PRESIDENT'S MESSAGE



By
John Lamprecht

The club has done fabulous things and has much to be proud of. I thank you all for the confidence in re-electing me. In my first message last year I highlighted four goals. I will spend this message looking back at how we did and what we have yet to do with those goals and other challenges.

The first goal was “to continue to ensure positive value for new as well as existing members.” The MMS remains one of the biggest bargains out there. We once again provided a full slate of foray opportunities to our members and guests, and filled our meetings with educational content. We hosted a fabulous cooking demo from a highly regarded Twin Cities chef, and were honored to have both our scientific advisors, noted mycologist Dr. Tom Volk from the University of Wisconsin, Lacrosse, and Dr. Scott Bates from the University of Minnesota, give presentations. We held another fabulous photo contest and presented at Da Vinci Fest and the State Fair, giving many of our members the opportunity to assist in presenting to the general public. I would like to expand this going forward by establishing a list of our members interested in giving mushroom talks and presentations, and assisting them in getting started. Many requests come to our society each year for speakers, reflecting the interest the general public now has in foraging and natural foods. Every presentation or demonstration we participate in should give us a sense that we have provided a meaningful service to the public. One further enhancement for our members is our new website (www.minnesotamycologicalsociety.org). It will eventually allow on-line renewals, and will be an informative and helpful site we can all be proud of!

Second, “strengthen our relationship with the University of Minnesota.” The issue of room access in the face of heightened security was a challenge, but has been solved. We have great meeting facilities available. Within the next few weeks we will be selecting the recipient of our first scholarship to aid a graduate student in the field of mycology at the U. We provided assistance as requested by our advisor to track down a new voucher specimen, and we can go beyond that in the future in working with the herbarium/fungarium project at the Bell Museum to provide more vouchered specimens.

Third, “reinforce, protect and expand our foray sites.” Lee Moellerman scheduled a fabulous assortment of forays and 2014 was a good year. We still need to be on the lookout for additional sites, especially private property where we can not only forage for the table, but also survey what degree of fungal diversity there is in our state. Some effort was taken to encourage and educate members to use ID or voucher slips and gather lists of what we find on our forays. This ties into our other goals. Forays are a major opportunity to add to our list and provide voucher specimens, but so are our ID sessions and having individual foragers bring their finds for identification. Finding private lands and working with local agencies to refine rules will open access. A request for such refinement was sent to the board of commissioners at Dakota County.

Finally, “spread out the work and encourage broader involvement by our members.” We still have some work to do in this area, but it is getting better. The State Fair effort benefitted from new members helping in various aspects. As I mentioned before, I also want to develop a list of presenters to spread out this opportunity. Our recent election is bringing a couple of new faces to the Board, and several committees are being formed that will rely on members to assist with the work in those groups (check our website for updates). We need you!

**MINNESOTA MYCOLOGICAL
SOCIETY**

President: John Lamprecht
jml313@aol.com
952-890-8744

Past President: Barry Beck
Beck.Barry@comcast.net
612-720-7953

VP/State Fair Chair: Betty Jo Fulgency
952-920-9311

Treasurer: Claudette Lamprecht
claudie1352@aol.com

Corresponding Secretary: Richard Pizarro
rpmush@gmail.com

Recording Secretary: Howard Goltz
Goltz.howard@gmail.com

Newsletter & Website: Janet Contursi
jancontursi@msn.com

Member at Large: Kathy Yerich
kathy.yerich@gmail.com

Member at Large: Marek Turowski
maturow@yahoo.com

Membership Support: John Lamprecht
jml313@aol.com

Forays: Lee Moellerman
chagalee@msn.com
763-434-3354

ID Committee Chair: Ron Spinosa
ronspin@juno.com

MMS Store: Delia Lam
slowlorus@gmail.com

Collections & Vouchers: Adele Mehta
952-884-7362

General Counsel: Bob Fulgency
robjoful@comcast.net
952-920-9311

NAMA Trustee: Peggy Laine
plaine1@juno.com

Scientific Advisor:
Dr. Tom Volk, U of WI
tvolk@uwlax.edu
608-787-0501

WINTER 2015

UPCOMING MMS FORAYS...

March 28-29: Annual Chaga Foray

Save the date! Details will be sent to members in a special email.

UPCOMING MMS MEETINGS & EVENTS...

January:

Jan. 10, 1-5 p.m. Annual Da Vinci Fest. Stillwater Area High School
MMS will again participate in this arts & science event that features educational exhibits and special presentations by science and art organizations. MMS members are needed to assist with setup. If you can help with this event, contact John Lamprecht (952-890-8744, jml313@aol.com) or Ron Spinosa (651-224-5274, ronspin@juno.com) See more info on page 5.

Jan. 12, 7:15 p.m. MMS Meeting. 110 Green Hall, U of M St Paul Campus
Nick Jordan will give a presentation on the genus Amanita, followed by Ron Spinosa who will talk about "Santa Amanita," providing a different take on the subject. Treats, raffles, auctions and the MMS Store.

February:

Feb. 9, 7:15 p.m. MMS Meeting. 110 Green Hall, U of M St Paul Campus
Members who attended the NAMA national foray will give a show and answer questions about NAMA. We will also talk about Chaga and preview our winter Chaga Foray. As with most of our meetings, the public is welcome.

Feb. 21, 1-4 p.m. MMS Annual Awards Banquet, Dragon House Restaurant, Columbia Heights

This is a special occasion to recognize MMS members who have made a significant contribution to our association. There is a limit of 60 reservations, so sign up now! (Menu and reservation form on page 7)

March:

Mar. 9, 7:15 p.m. MMS Meeting. 110 Green Hall, U of M St Paul Campus
Betty Jo Fulgency will talk about renowned mycologist Cathy Cripps who was featured at our State Fair display last August. A discussion and presentation about Chaga and other medicinal mushrooms will follow.

Mar. 28-29, Annual Chaga Foray (see above)

April:

Apr. 13, 7:15 p.m. MMS Meeting. 110 Green Hall, U of M St Paul Campus
Cindy Buschena from the University of MN Forestry Department will talk about the mycorrhizal relationship between fungi and trees. Cindy did her Masters research on ectomycorrhizal fungi.

Apr. 27, 7:15 p.m. MMS Meeting. 110 Green Hall, U of M St Paul Campus
Morels!

MMS Election Results

Officers and New Board Members for 2015:

President: John Lamprecht
Vice President: Betty Jo Fulgency
Treasurer: Claudette Lamprecht
Corresponding Secretary: Richard Pizarro
Member-at-Large 1: Kathy Yerich
Member-at-Large 2: Marek Turowski
Recording Secretary: Howard Goltz

Time to renew your MMS membership!

Renew now — don't lose your MMS membership benefits!

MMS membership runs from January to January. Unless you signed up at the 2014 State Fair or after Oct. 1, 2014, your membership will expire in January 2015.

We'll have forays, pot lucks, banquets and events you won't want to miss. Use the form on Page 9, and renew your membership now!

The Toadstool Review is the newsletter of the MN Mycological Society. The newsletter is published in January, April, July and October. The newsletter keeps members informed about club meetings, forays and other events, and includes articles and mycological information for educational purposes. The newsletter staff does not advocate or advise any specific use of wild mushrooms and assumes no responsibility for the consequences thereof. Submissions from members are welcome—see Article and Photo Guidelines below.

Article and Photo Guidelines

1. General articles and foray reports should be around 500 words or less. Add a brief (2-3 sentences) author bio and submit as a Word file. If accompanied by photos, see photo dimensions below.
2. Photos must be jpg, no more than 75kb, and sized for the web (320x240). If you need to resize your photos before sending them, here is a free program: <http://ipiccy.com/> If you cannot resize photos, send them as-is and I'll resize.
3. All photos of fungi must be accompanied by:
 - Correct identification and spelling of genus and species
 - Photographer's full name
4. All articles and photos taken from another source must have permission for reprinting. If you see an article/photo you think will be of interest, send me the link/title, and I'll request permission to reprint.
5. If you are writing an original scientific article, including articles about medicinal mushrooms, please observe the following guidelines:
 - Data should be based on the latest credible sources/studies;
 - Include a list of references cited;
 - Make clear in the article the types of studies you are basing your information on (e.g., in vitro, animal, human, clinical trials, review articles, etc.).

Please email your submission to the editor: jancontursi@msn.com Deadline for submissions is the 15th of the month preceding publication: December 15, March 15, June 15 and September 15.

Whats for dinner?

Rapidly identifying undescribed species in a commercial fungi packet

For lovers of wild foods, autumn harks a season of bounty. Fungi of dizzying variety erupt from wood and soil, luring intrepid collectors to woodlands in search of elusive but delectable wild mushrooms. Part of their appeal lies in the allure of the treasure hunt, and their mysterious not-quite-meat, not-quite-vegetable qualities that belie an almost otherworldly existence. But are the mushrooms you are eating known to science?



Samples of the new species in the original packet. Image credit: Bryn Dentinger

The Fungi Kingdom is enormously diverse yet vastly underdocumented – although some estimates range up to 10 million species, only about 100,000 species have been described. Mushrooms are one of the most conspicuous and well known groups of Fungi and make up around 16,000

named species, but only a handful of these species are well documented. With estimated rates of Fungi extinction exceeding current rates of description, the enormity and urgency of the task of accurate identification cannot be overstated. New approaches that accelerate the documentation and description of new species are desperately needed before it is too late.

So how well do we really know the mushrooms? In an article published in *PeerJ*, mycologists Bryn Dentinger and Laura Martinez-Suz from the Royal Botanic Gardens, Kew in London, set out to ask this question by using DNA-based taxonomy. But instead of venturing into the wild in search of never before seen species, they simply went to a local grocer and bought a packet of dried porcini whose intended destiny was more likely a rich risotto than a DNA sequencer.

Some of the most sought-after of wild mushrooms are the sweet and nutty *Boletus edulis* and allies, often referred to by the Italian common name porcini. Dentinger has been studying porcini for over 10 years and knew that if the porcini in this packet originated in China, they were likely to be made up of unnamed species. But how many species could be detected in the packet, and how quickly could diagnosing and describing them be accomplished?

Drs. Dentinger and Suz arbitrarily selected 15 pieces of mushroom from the packet and sequenced the fungal DNA barcode region for each. They then compared these sequences to sequences in the International Nucleotide Sequence Database and classified them based on evolutionary relationships. This revealed three distinct species, none of which were known to science or had scientific names. To expedite the formal naming process required by the International Code of Nomenclature for algae, fungi and plants, the researchers used a rapid e-publishing tool that facilitates immediate name registration and species diagnosis to satisfy the rules of the Code.

"This study demonstrates that the whole procedure, from unknown mushrooms to names, can be done rapidly – we did this in under a week, but if push came to shove, it could be done in a day" said Dr. Dentinger.

Hundreds of thousands of tons of porcini are collected from the wild and sold around the world every year, most of it ending up in Europe and North America. Although typically composed of five well-known species native to these regions (*B. aereus*, *B. edulis*, *B. pinophilus*, *B. reticulatus*, *B. rex-veris*), around half of all porcini traded in Europe originates in China. These porcini, typically collected from the wild in Yunnan province, have been exported to Europe since the 1970s, yet until last December, none of them had scientific names. The researchers named them with Chinese epithets referring to local common names for porcini (*Boletus meiweiniugan*, *Boletus bainiugan*) and the Chinese word for 'edible' (*Boletus shiyong*). As Dr. Dentinger put it, "our results demonstrate just how ubiquitous unknown fungal diversity is – it can literally be found right under our noses." [cont'd on pg. 8]

2015 Da Vinci Fest

On January 10, the MMS will once again participate in the annual Da Vinci Fest in Stillwater. The Da Vinci Fest is a popular arts, science and creativity event open to all 4th through 12th grade students who live within the boundaries of Stillwater Area Public Schools. Every year, the Da Vinci Fest invites businesses and groups to present interactive and hands-on science, technology and art exhibits to inspire and motivate K-12 students. The exhibitor booths complement the student projects and provide a unique glimpse at how science, art and technology apply in the real world. The MMS will maintain a booth at the Fest.

Da Vinci is open to the public from 1 to 5 p.m., followed by an Awards Ceremony at 5:30. Interested MMS members could either come at 11:30 a.m. to help set up our exhibit, or come anytime to see our exhibit and interact with the public.

When:

Saturday, January 10, 2015

Where:

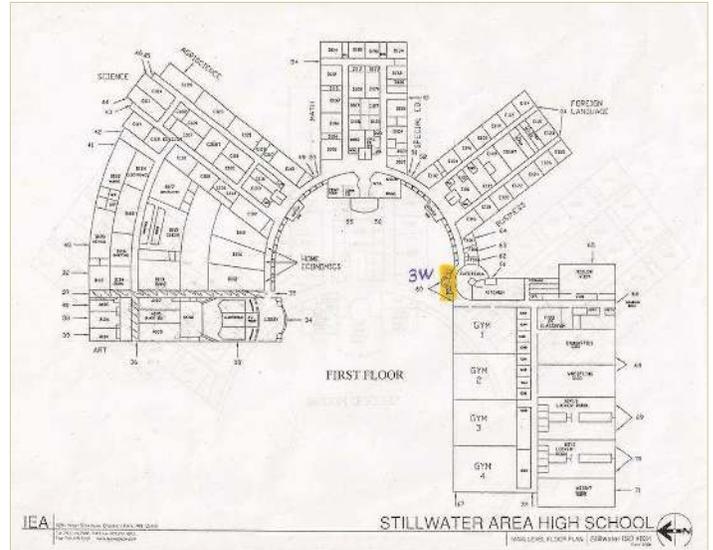
Stillwater Area High School
5701 Stillwater Blvd. N.
Stillwater, MN 55082

Google map link here: <http://g.co/maps/3uvmw>

For further information, contact:

John Lamprecht: 952-890-8744, jml313@aol.com

Ron Spinosa: 651-224-5274, ronspin@juno.com



Stillwater HS map: Enter near the 3W entrance doors (yellow).

2014 October MMS Potluck



My First Annual NAMA Foray & Conference

By Howard Goltz



Watercolor painting by Howard Goltz.
[Image credit: Howard Goltz]

The Conference's base of operations was the Salvation Army's Camp Arnold, 650 pristine wooded acres with a spectacular view of Mount Rainier, offering ample room for quick forays on-site. Off-site forays departed twice daily. The Camp included an auditorium, break-out spaces for classes, lectures and displays, camping facilities, "rustic" bunk-style lodging (ear-plugs were provided in each welcome bag) and a dining hall.

Janet and I arrived Wednesday to attend Alexander (Sasha) Viazmen-sky's pre-conference class: "Mushroom Watercolor Painting." He is recognized as one of the world's finest mushroom watercolorists, and MMS members may recall his presentation at one of our meetings two years ago. His watercolors, "Portraits of Mushrooms," depict each subject's unique personality, flaws and all.

Sasha provided a basket of mushrooms that he had collected for our class of 10 as "models" for our paintings. It's the longest amount of time I've ever looked at a single mushroom — six hours examining every detail, color, shape and blemish. With Sasha's demonstration and critiques, everyone completed at least one mushroom watercolor.

With only registration and an evening program on Thursday, we decided to spend this day circumnavigating Mount Rainier by car. The "locals" generously suggested foray sites for us. Sasha and Ron Spinosa were also free that day and joined us for a 10-hour introduction to the lush habitats surrounding the mountain. It was a memorable day that included four forays where mushrooms were rarely out of sight. [cont'd on pg. 8]

Last October Janet and I were fortunate to be among the 300 mushroom enthusiasts from around the world (including 14 MMS members) who ascended into the lush, temperate rainforest foothills of Mount Rainier National Park for the 2014 Patrice Benson Memorial NAMA Foray in search of fungi and fungal enlightenment. The forest capitulated with a promiscuous abundance of mushrooms.

Attendees selected from two pre-conference workshops, 11 organized group forays and 27 diverse educational programs. While each attendee had different experiences, all would agree it was a rewarding venture, with collegial participants, a beautiful environment, prominent mycology educators, diverse mushroom cuisine and a bounty of fungi to be found.



Watercolor paintings by Janet Goltz.
[Image credit: Howard Goltz]

The Minnesota Mycological Society's Annual Awards Banquet

Saturday, February 21, 1-4 p.m.

The Dragon House Restaurant

3970 Central Ave. NE, Columbia Heights, MN

763-781-8884

[Free parking in the municipal lot at the rear of the restaurant]

Highlights of the banquet:

- Slide show of the winning photographs from the 2014 MMS Photo Contest and presentation of awards to the winners in each category
 - Presentation of the 2014 Golden Chanterelle Award
 - Presentation of the 2014 President's Awards
- The Gift Exchange (if you wish to participate in the Gift Exchange, please bring a wrapped, inexpensive, mushroom-type gift. If you have something for the raffle or silent auction, or have any questions, please contact Betty Jo Fulgency at: 952-920-9311.

Banquet menu:

BBQ Ribs
Veggie Mushroom Wraps
Cream Cheese Wontons
Egg Rolls
Vegetable Spring Rolls
Veggie Marinade with Portobello Mushrooms
Hunan Vegetable with Hen of the Woods
Curry Vegetable with Chanterelles
Vegetable Lo Mein with Chicken Mushrooms
General Tsao's Chicken with Button Mushrooms
Chicken Chow Mein
Vegetable Fried Rice with Portobello Mushrooms
Egg Foo Young with Shitake gravy
Broccoli bean sprout with King Oyster over Rice Noodle

"All You Can Eat Buffet." Cost is \$28.00 per person (includes tax and tip).

Coffee, soda and tea will be available for an additional fee of \$1.50 (collected at time of order).

The club will make wine available for a donation.

Registration Form

Name: _____

Address: _____

Telephone: _____

Number of persons: _____ @ 28.00 each. Amount Enclosed: \$ _____

IMPORTANT!

Mail registration and check, made out to the Minnesota Mycological Society, by **February 12th** to: Betty Jo Fulgency, 5620 Code Avenue, Edina, MN 55436. **The Banquet is limited to 60 people.**



Janet Goltz's hidden find Violet Chanterelle (*Gomphus clavatus*). [Image credit: Howard Goltz]

Janet & I spent Friday morning in Rob and Ann Simpson's seminar, "Photography One: Fungi, Fun, and Photography." Rob and Ann are professional biologists, photographers and artists who have spent years researching and interpreting our national parks, and have articles published in *National Geographic*, *Time*, and *National Wildlife*. They shared their fundamental techniques in getting great mushroom photographs.

Our afternoon class was "The Identification of Common Macrolichens in Western Washington," by Katie Glew (Associate Curator of Lichens and Bryophytes at the University of Washington Herbarium) and Fred Rhoades, Ph.D. (trained in mycological and lichenological ecology). We learned that lichens are fungi allied with photobionts — algae or cyanobacteria — wherein the fungi give the lichen its shape and

structure (its home), and the photobiont provides nutrition (energy) to the fungus. The 2-hour intensive classroom introduction to lichenology was followed by a lichen foray. It was an amazing introduction to the beauty and diversity in what is frequently overlooked in the world of mycology.

Saturday started with another private foray to some likely spots we passed earlier, this time accompanied by Steve Netzman and Ron Spinosa. Finds included Ron's first slime-laden Cowboy's Handkerchief Mushroom (*Hygrophorus eburneus*) and several Cat's Tongue Mushrooms (*Pseudohydnum gelatinosum*). Janet found a near-perfect Violet Chanterelle (*Gomphus clavatus*) that the rest of us had bypassed — twice. Steve spotted a roadside Lobster that led to a hillside covered with dozens of the orange beauties.

Back at camp, we toured the collection building where thousands of mushrooms were sorted into 500 documented species, with select specimens to be dried as part of NAMA's over-3,000-specimen database in the Field Museum of Natural History, in Chicago. This was a full time job for students and professionals, with the MMS's Adele Mehta entering each voucher into NAMA's database.

Fifteen species of edible mushrooms were cooked for sampling in an open air pavilion and in the auditorium building after the evening program. Candy Cap Marshmallows (*Lactarius rubidus*) for dessert anyone?

Saturday evening's program concluded with Ron Spinosa's "grand" introduction of the keynote speaker, Paul Stamets, who presented "Powerful Polypores: Novel Discoveries," a tremendous close to the event.

Finally, the location of the NAMA Fall 2015 Annual Foray and Conference was announced to be the Tennessee Appalachian mountains. Hope to see you there!

[What's for dinner?—cont'd from pg. 4]

The researchers hope that by demonstrating the rapid identification and naming of new Fungi species in this way, others in the community will be inspired to continue the important work of identifying new Fungi species before they disappear.

Journal Reference:

Bryn T.M. Dentinger, Laura M. Suz. What's for dinner? Undescribed species of porcini in a commercial packet. PeerJ, 2014; 2: e570 DOI: 10.7717/peerj.570

The full article can be found at: <https://peerj.com/articles/570/>

MMS MEMBERSHIP APPLICATION / RENEWAL FORM

Name _____

Name _____

Address _____

City _____ State _____ Zip _____

Phone (____) _____

Email _____

New Member _____ Renewal _____

Individual (\$20) _____ Family (\$25) _____ Student (\$15) _____

Send newsletter via email _____ postal mail _____
(Make check payable to MMS)

RELEASE

I (We) realize that when engaged in wild mushroom activities, serious physical injury and personal property damage may accidentally occur. I (We) further realize that there is the possibility of having an allergic reaction to, or being poisoned by eating wild mushrooms, and that the adverse reactions to eating wild mushrooms range from mild indigestion to fatal illness.

Knowing the risks, I (We) agree to assume the risks, and agree to release, hold harmless and indemnify the Minnesota Mycological Society, and any officer or member thereof, from any and all legal responsibility for injuries or accidents incurred by myself or my family during, or as a result of any mushroom identification, field trip, excursion, publication, meeting, dining or any other activity sponsored by the MMS.

Signature: _____

Date: _____

Signature: _____

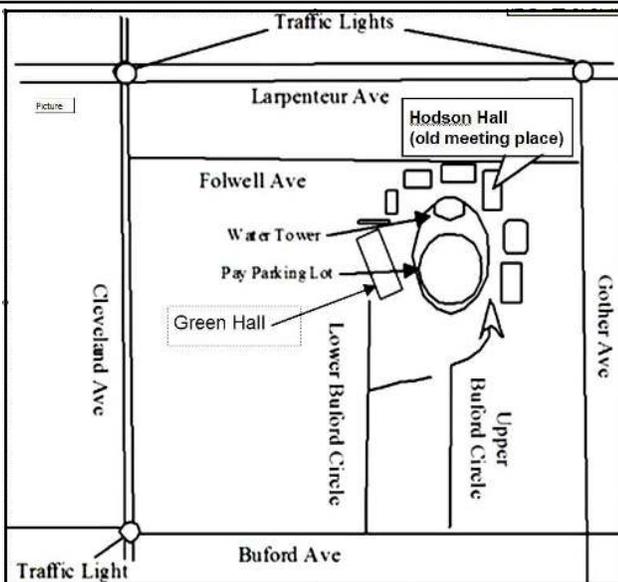
Date: _____

Optional: I also want to join NAMA and receive NAMA's newsletter at the special MMS member- affiliated rate of:

\$25.00 Individual w/electronic newsletter _____

\$40.00 Individual or family w/hard copy newsletter _____
(Include a separate check payable to NAMA)

Send application form, check(s) and release to:
Minnesota Mycological Society
P.O. Box 211444
Eagan, MN 55121



The Minnesota Mycological Society meets the second Monday of the month in Room 110 Green Hall, on the St. Paul Campus of the University of Minnesota (unless otherwise noted). Meeting time is 7:15 p.m.

Identification of an *Alnicola* species from a bog in Chisago County, MN

Jillian E. Reilly* and Anna Gerenday



Figure 1: An *Alnicola* species, *Alnicola sphagneti*, from Bernie's Bog, Warner Nature Center in Washington County. [Image credit: Anna Gerenday]

The genus *Alnicola* (family *Cortinariaceae*) is an assemblage of small brown, brown-spored mushrooms, frequently associated with alder and willow (Rochet et al. 2011). The genus has been studied in Europe and Asia. In North America the species name *Alnicola scolecina* occasionally appears on fungal lists, but the genus has not been the subject of serious taxonomic studies. We encountered *Alnicola* species growing under alder in two different bogs in Minnesota, one in Washington County and one in Chisago County. Our collection from Chisago County is the subject of this article. We have earlier collections of *Alnicola sphagneti* (Figure 1) from Washington County, but the Chisago County collection appeared different, and we decided to subject it to closer taxonomic scrutiny.

We recognized the collection in the field as belonging to the genus *Alnicola* by its relatively small size, its red-brown colors and by its association with alder. In the lab we examined it microscopically. Our collection had the warty spores and the sterile gill edges (lacking basidia) lined with flask-shaped cystidia with elongated necks (Figure 2), characteristic of the genus. The size of the cystidia measured on the average 37.0 x 8.0 x 2.0 microns; the size range of spores were 10.5 - 12 x (4.5-) 5 - 6 microns averaging 11.0 x 5.0 microns; Q range (length ÷ width) = (1.8) 1.9 - 2.4; Q average = 2.1 (see notes on measurements below).

With all this information, the species keyed to *A. umbrina*. To confirm this, we decided to sequence the barcode, also known as the ITS region of the ribosomal DNA (Schoch et al. 2012). Our sequences matched 11 sequences annotated as *Alnicola umbrina* in GenBank. They had ≥99% identities with at least 98% query cover. Interestingly, all the sequences in GenBank originated from Europe or Asia. We found no digital record on MycoPortal, suggesting that this species has not yet been recorded from North America. Hence, our collection of *Alnicola umbrina* might represent a new record from North America, but further studies will be required to authenticate our finding. The genus is polyphyletic, and is currently undergoing taxonomic revision (Moreau, 2005). It will be interesting to know how our *Alnicola umbrina*, as well as our other *Alnicola* collections, compares phylogenetically with the currently known European and Asian species.

Notes on microscopic characters and their measurements:

Cystidia are sterile cells, i. e. they do not produce spores, as opposed to **basidia**, the spore bearing cells. When the **cystidia** occur on the gill edge, they are called **cheilocystidia**. Sterile edge means that the **cheilocystidia** cover the entire gill edge; there are no intervening **basidia**. We made three measurements on the **cheilocystidia**: length, width of the swollen base, and thickness of the neck. Spores are measured in profile view; length and width are given. Ten to 50 spores are measured, depending on the spore source, which may be a spore print, apex of the stipe or a gill section. **Q value** is a way of describing the shape of the spores: a **Q value** of 1 is spherical; a **Q value** of 2 or higher is cylindrical; **Q values** in between indicate variously elongated spores.

References:

- Moreau, P-A.** 2005. A nomenclatural revision of the genus *Alnicola* (*Cortinariaceae*). *Fungal Diversity* 20: 121-155.
- Rochet, J., et al.** 2011. Comparative phylogenies and host specialization in the alder ectomycorrhizal fungi *Alnicola*, *Alpova* and *Lactarius* (Basidiomycota) in Europe. *BMC Evol. Biol.* 11, 1-14.
- Schoch, C. L., et al.** 2012. Nuclear ribosomal internal transcribed spacer (ITS) region as a universal DNA barcode marker for *Fungi*. *PNAS* 109 (16) 6241-6246.

*This study was carried out by Jillian Reilly as part of her undergraduate research project at the University of MN.



Figure 2. Microscopic images of *Alnicola* cf. *umbrina* from Chisago County. A: Microphotograph of cheilocystidia at 1000x magnification, rehydrated in 5% KOH and stained with Congo red. B: Spores in face view in 5% KOH at 1000x magnification. [Image credit: Jillian Reilly]

Zombie ant fungi 'know' brains of their hosts

By Chuck Gill

A parasitic fungus that reproduces by manipulating the behavior of ants emits a cocktail of behavior-controlling chemicals when encountering the brain of its natural target host, but not when infecting other ant species, a new study shows.

The findings, which suggest that the fungus "knows" its preferred host, provide new insights into the molecular mechanisms underlying this phenomenon, according to researchers.

"Fungi are well known for their ability to secrete chemicals that affect their environment," noted lead author Charissa de Bekker, a Marie Curie Fellow in Penn State's College of Agricultural Sciences, and Ludwig Maximilian of the University of Munich. "So we wanted to know what chemicals are employed to control so precisely the behavior of ants."

The research focused on a species from the genus *Ophiocordyceps* — known as "zombie ant fungi" — which control their

ant hosts by inducing a biting behavior. Although these fungi infect many insects, the species that infect ants have evolved a mechanism that induces hosts to die attached by their mandibles to plant material, providing a platform from which the fungus can grow and shoot spores to infect other ants.

To study this mechanism, the researchers combined field research with a citizen-scientist in South Carolina, infection experiments under laboratory conditions and analysis using metabolomics, which is the study of the chemical processes associated with the molecular products of metabolism.

The scientists used a newly discovered fungal species from North America — initially called *Ophiocordyceps unilateralis sensu lato* while it awaits a new name — that normally controls an ant species in the genus *Camponotus*. To test whether a species of fungus that has evolved to control the behavior of one ant species can infect and control others, they infected non-target hosts from the same ant genus and another genus (*Formica*).

They found that this obligate killer can infect and kill non-target ants, but it cannot manipulate their behavior. "The brain of the target species was the key to understanding manipulation," de Bekker said.

The researchers next removed ant brains, keeping the organs alive in special media. The fungus then was grown in the presence of brains from different ant species to determine what chemicals it produced for each brain.

"This was 'brain-in-a-jar' science at its best," said co-author David Hughes, assistant professor of entomology and biology, Penn State. "It was necessary to reduce the complexity associated with the whole, living ant, and just ask what chemicals the fungus produces when it encounters the ant brain.

"You don't get to see a lot of behavior with fungi," he said. "You have to infer what they are doing by examining how they grow, where they grow and most important, what chemicals they secrete." [cont'd on pg. 12]



A dead ant manipulated by a species of so-called "zombie ant fungus" clings to a twig in a South Carolina forest. Newly published Penn State research represents the first extensive study of zombie ants in North America. [Image credit: Hughes Lab, Penn State]

[Zombie ant fungi —cont'd from pg. 11]

He explained that fungi are nourished via osmotrophy, by which they secrete compounds that degrade the bigger molecules in their environment into smaller ones that then can be taken up by the fungus. Using metabolomics, the researchers could determine precisely the chemical crosstalk between the fungus and the ant brain it grew alongside.

"We could see in the data that the fungus behaved differently in the presence of the ant brain it had co-evolved with," said de Bekker, whose Penn State co-authors also included Andrew Patterson, assistant professor of molecular toxicology, and Phil Smith, director of the Metabolomics Core Facility.

The researchers found thousands of unique chemicals, most of them completely unknown. This, according to Hughes, is not surprising, since little previous work has mined these fungi for the chemicals they produce.

But what did stand out were two known neuromodulators, guanobutyric acid (GBA) and sphingosine. These both have been reported to be involved in neurological disorders and were enriched when the fungus was grown in the presence of brains of its target species.

"There is no single compound that is produced that results in the exquisite control of ant behavior we observe," de Bekker said. "Rather, it is a mixture of different chemicals that we assume act in synergy.

"But whatever the precise blend and tempo of chemical secretion," she said, "it is impressive that these fungi seem to 'know' when they are beside the brain of their regular host and behave accordingly."

Noted Hughes, "This is one of the most complex examples of parasites controlling animal behavior because it is a microbe controlling an animal — the one without the brain controls the one with the brain. By employing metabolomics and controlled laboratory infections, we can now begin to understand how the fungi pull off this impressive trick."

The research also is notable, the scientists contend, because it is the first extensive study of zombie ants in North America. Typically assumed to be a tropical phenomenon, they exist in temperate habitats but can be hard to find.

"This whole project has been made possible by Kim Fleming, a resident of Donalds, South Carolina, an avid nature photographer who found the original samples and posted pictures of them online," said Hughes.

"It has been a joy to work with Kim, who has become an integral part of our team taking thousands of photos of the zombie ant fungi during her daily walk in the woods."

He noted that the newly discovered species of zombie ant fungus will be named after Fleming, who is a co-author on the study.

"Through Kim, we have been able to engage with the wider community in South Carolina, including the biology program at Erskine College," said de Bekker. "It's been a great way to share our science with the public."

The research, which was supported by Marie Curie Actions and Penn State, was published in BMC Evolutionary Biology.

Journal Reference:

Charissa de Bekker, Lauren E Quevillon, Philip B Smith, Kimberly R Fleming, Debashis Ghosh, Andrew D Patterson, David P Hughes. Species-specific ant brain manipulation by a specialized fungal parasite. BMC Evolutionary Biology, 2014; 14 (1)

Amateur mycology and the dwindling taxonomists problem

By Todd Osmundson

Reprinted from: *Mycena News*, Mycological Society of San Francisco, October, 2011, vol. 63:02

My electronic social circle has been abuzz recently about an article in the *Wall Street Journal* entitled “The Fungus Among Us Multiplies As Mycological Taxonomists Wither [1].” Granted, one discussion was mostly about the need for some new mycological puns, but mycological colleagues both amateur and professional have taken note that the mycological “taxonomy gap” is being recognized in the mass media sphere.

The *WSJ* article – which includes interviews with mycologist Roy Watling and entomologist (and outspoken defender of taxonomy) Quentin Wheeler – decries the dwindling number of professional taxonomists amidst the growing threat that many species may go extinct before they have even been discovered. As encouraging as it is that a well-respected, wide-circulation, non-science-specialist news source is discussing this issue, they have unfortunately taken too narrow a scope in defining the cause of the problem. The *WSJ* article states that the number of taxonomists is dwindling primarily because would-be taxonomists are being lured away by fields perceived as more modern or fashionable, such as molecular biology. Though there is certainly an element of truth to this notion, I have personally seen enough evidence to the contrary to be unconvinced that this is the major cause of the decline. Several times over the past several years I have seen excellent taxonomic projects, including surveys of geographical regions that are terra incognita mycologically-speaking, or revisions of diverse taxonomic groups – proposed by some of the best-respected scientists in U.S. mycology – go unfunded through 2, 3, or more rounds of funding competition. I have also seen several Ph.D.s trained in mushroom taxonomy move into other fields due to the realities of the job market during that time. So, I’m convinced that, in terms of professional positions for mushroom taxonomists, the problem is more one of funding and giving prominence to the field rather than demand for its services.

Even in the best of times, professional taxonomists never were plentiful enough to cover all areas at all times. With their greater numbers and geographical representation, amateur mycologists have the potential to cover much more ground in the effort to document fungal biodiversity and discover species new to science.

Given these numbers, it is clear that alternative models of filling the “taxonomy gap” will be needed if we are to achieve a reasonably full accounting of present levels of fungal diversity before extinction claims its victims. One suggestion circulating in my cybersphere, as well as an activity undertaken and mentioned by Dr. Watling in the *WSJ* article, is to harness the numbers and talents of amateur mycologists to do the work currently done by the shrinking number of professional taxonomists. I should note that I here use the words “professional” and “amateur” to denote one who works in mycology as a primary employment and one who does not, respectively, rather than in the sense of relative levels of skill – indeed, as pointed out by Watling [2], many of the giants in the history of fungal taxonomy were amateurs in the economic, but certainly not in the capability, sense of the word. As currently practiced in the United States, however, professional and amateur mycology are often (but not always) accompanied by a difference in strategy and outlook. This difference in many ways mirrors the difference between the way that science is taught – up to, and including, the college level – and the way that it is practiced. The way that science is often taught is as a package of textbook “facts” that have to be learned or memorized in an uncritical fashion. The practice of science – posing questions and assessing their possible answers based on the strength of evidence – is so different from the classroom version as to almost constitute another activity altogether. The ability to learn and identify mushrooms based on existing knowledge (field guides and even technical literature) – a skill possessed in great abundance by a number of amateur mycologists – is akin to the learning of existing knowledge. Scientific mycology is, in contrast, focused on the generation of new knowledge. The former is a necessary prerequisite, rather than an adequate substitute, for the latter.

What does this activity of generating new knowledge entail? Three of the primary types of work undertaken by scientific mycological taxonomists are the description of new species, classification and the description of higher taxa, and documentation of biodiversity and geographical distributions. [cont’d on pg. 14]

[Amateur mycology —cont'd from pg. 13]

The description of new species requires a detailed analysis of characters between a species of interest and those species that are suspected to be closely related. These characters can be macroscopic, microscopic, submicroscopic (requiring scanning or transmission electron microscopes), biochemical, physiological, ecological, and/or genetic. A specialist must have not only an eye for detail, but a good sense of the variability found within as well as between species (gained through examining numerous individuals), and a strong command of the technical literature on the relevant group(s) of fungi in order to avoid the mistakes of either applying an existing name to a distinct species or applying a new name superfluously. A well-conducted study of a single species can therefore take months to carry out and write; a study of a genus or larger group can take years or a lifetime. In *Describing Species* (recommended reading for persons interested in doing taxonomic studies), Judith E. Winston [3] describes many of the activities undertaken by taxonomists. Drawing from this book as well as personal experience, I would recommend the following as a minimal to-do list for any amateur mycologist committed to carrying out serious taxonomic studies:

- Acquire the necessary material tools – specimen dryer (food dehydrator), macrochemical reagents, and a microscope. A color guide is also a highly recommended tool for standardizing the use of color names in descriptions.
- Learn procedures and technical terms for accurate field description of specimens, noting that important characters that must be observed are different for different groups (for example, the macrochemical field tests important for identifying boletes are different than those used for *Russula*, and *Inocybe* specimens should be examined to determine how much of the stipe, if any, is covered by pruinose hairs; the importance of this latter character also determines how specimens must be collected, since handling them by the stipe can obliterate evidence of pruinosity).
- Keep voucher specimens. As knowledge about a taxonomic group, as well as the availability of technological tools, increases, it is essential that other researchers can examine specimens from earlier studies.
- Become an expert on a group of interest, including knowing the organisms themselves – including the range in variation in traits found within a species – and the technical literature on that group.
- Learn the tools of taxonomy, including rules of nomenclature and synonymy, use of herbarium collections, literature searching, and writing taxonomic keys.

The description of species makes up just a part of what a professional taxonomist (or systematist) does, however. The description of, and placement of species in higher taxa (genus, family, order, class, etc.) is also a critical part of the job, constituting the activity of classification. Systematists are in unity in the belief that the type of classification system with the highest information content is one that reflects genetic relatedness or, more accurately, patterns of evolutionary descent (a phylogenetic system). A rigorous classification is built through careful comparative analyses of multiple characters of the organisms, using the standardized methodologies of phylogenetic systematics. Given the goal of constructing a classification system that reflects patterns of genetic relatedness, the ability to analyze genetic information (DNA sequence data) directly is of great value, and is so widespread as to be considered indispensable to current systematics. However, while the study of DNA (genotypic) data can reveal patterns of genetic relatedness, the study of morphological and other phenotypic data reveals the patterns of distribution and origin of those traits that make the study of organisms and the conservation of biodiversity fascinating and worthwhile pursuits. Both genotypic and phenotypic data therefore play an important role in systematics (their use in mushroom classification is discussed in more detail in [4]), and the professional systematist is responsible for developing and refining classifications that reflect new (or newly collected) data.

The third activity undertaken by most professional taxonomists is the discovery and documentation of biodiversity and biogeography. This activity incorporates the techniques of both of the previous two, and involves specimen identification, description, classification, and the computational analysis of the patterns of geographical distribution of traits and organismal groups.

In the *WSJ* article, Dr. Watling is quoted as saying “I wouldn't say there's a shortage of mycological taxonomists in the U.K. There ain't any.” While this statement does not take into account those taxonomists that use molecular as well as morphological data (of which there are a number in the U.K.), it does highlight the seriousness of the current decline in the numbers of professional mushroom specialists, a situation mirrored across most – if not all – taxonomic disciplines. Even in the best of times, professional taxonomists never were plentiful enough to cover all areas at all times.

[cont'd on pg. 15]

[Amateur mycology —cont'd from pg. 14]

With their greater numbers and geographical representation, amateur mycologists have the potential to cover much more ground in the effort to document fungal biodiversity and discover species new to science. So, can the taxonomy gap be filled by amateur mycologists? Certainly to some degree and in some respects, especially in the task of describing species, documenting geographical distributions, and observing phenotypic traits; as in the history of fungal taxonomy, today we are fortunate to have a number of expert specialists that are not primarily employed in mycology. However, we shouldn't let ourselves believe that the task is an easy one. It demands a commitment to serious scholarship, and requires focused effort, careful and purposeful collecting and observation, and the acquisition of a set of necessary technical skills. Above all, it must be noted that a commitment to identification and naming is not enough; serious taxonomic study must include the generation of new knowledge. It must also be acknowledged that the work of a professional systematist has many facets in addition to describing species; these facets – especially pertaining to the science of character analysis and species classification – require additional specialized knowledge and tools. In addition, current efforts to meet the challenges of the biodiversity crisis, including broad-scale data dissemination and facilitating rapid survey studies of the planet's most biodiverse, tropical habitats, require both large-scale collaborations and institutional resources [5]. Therefore, the role of the professional taxonomist remains essential, and the decline in their ranks remains alarming.

So, can the taxonomy gap be filled by amateur mycologists? Certainly to some degree and in some respects... . However, we shouldn't let ourselves believe that the task is an easy one. It demands a commitment to serious scholarship, and requires focused effort, careful and purposeful collecting and observation, and the acquisition of a set of necessary technical skills.

Reduced numbers of professional taxonomists on one hand, and the need for a high degree of specialized knowledge and training on the other, make collaboration between amateur and professional mycologists critical if we are to meet the goal of discovering Earth's fungal diversity. Among the roles of professional mycologists in such collaborations could be to improve access to literature and herbarium collections to serious amateur taxonomists; conduct phylogenetic analyses of phenotypic and molecular characters; generate scientifically and statistically rigorous study designs for field surveys, and teach proper field and laboratory techniques. Among the roles of amateur mycologists can be to acquire expertise in particular taxonomic groups, document diversity and species occurrence in a wide variety of geographic localities; and collect, provide field descriptions for, photograph and voucher specimens. In the Bay Area we are fortunate to have both active professional and amateur mycology communities, making directly collaborative projects possible. I had the opportunity to participate last year in a one such field trip, and the synergy of the specimen processing and identification pipeline produced during this trip, as well as the camaraderie of the participants, offer proof that this collaborative model can work. Given the magnitude of the challenges that we face in addressing the crisis of declining biodiversity, and the critical role of taxonomy in discovering – and hopefully conserving – this biodiversity, amateurs and professionals should form an additional collaboration as well: joining together in advocating for increased public attention and funding for taxonomy and biodiversity research.

About the Author: Todd Osmundson, Ph.D. is a postdoctoral researcher in the Garbelotto (Forest Mycology and Pathology) laboratory at the University of California-Berkeley. His research interests are in the systematics, biodiversity, evolution, ecology and conservation of fungi, especially ectomycorrhizal, endophytic and plant-pathogenic species. Current research projects include surveys of fungal biodiversity on the French Polynesian island of Moorea and phylogenetic studies of burn mounds.

References:

- [1] Naik G. The fungus among us multiplies as mycological taxonomists wither. *Wall Street Journal*, September 7, 2011. <http://online.wsj.com/article/SB10001424053111904716604576544373054363118.html>.
- [2] Watling R. 1998. The role of the amateur in mycology—what would we do without them! *Mycoscience* 39(4): 513-522. DOI: 10.1007/BF02460913
- [3] Winston JE. 1999. *Describing Species: Practical Taxonomic Procedure for Biologists*. New York: Columbia University Press. 512 pp.
- [4] Osmundson, TW. 2010. Phylogeny, natural selection and the state of mushroom classification. *McIlvainea* 19. <http://www.namyc.org/publications/mcilvainea/v19/phylogeny.html>.
- [5] Wheeler QD. 2008. Introductory: Toward the New Taxonomy. pp. 1-17 in Q.D. Wheeler, ed. *The New Taxonomy*. The Systematics Association Special Volume Series 76. Boca Raton, FL: CRC Press.

The Minnesota Mycological Society

Inside this issue:

- 1 — President's message
- 2 — Forays, MMS meetings & events
- 3 — MMS election results & membership renewal reminder
- 4 — "What's for dinner?"
- 5 — 2015 Da Vinci Fest & 2014 potluck photos
- 6 — "My first NAMA foray and conference" by Howard Goltz
- 7 — MMS Awards banquet menu & registration form
- 9 — MMS membership application & renewal form
- 10 — "Identification of an Alnicola species" by Jillian Reilly & Anna Gerenday
- 11 — "Zombie ant fungi" by Chuck Gill
- 13 — "Amateur mycology and the dwindling taxonomists problem" by Todd Osmundson



Minnesota Mycological Society

**PO Box 211444
Eagan, MN 55121**