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Fungi in Focus: Coral Fungus

In This Issue:

William Needham
MAW President

Common Name: Coral Fungus – The branching of the fungal thallus resembles the calcium carbonate structure of ocean corals. Other common names are applied to differentiated shapes, such as worm, club, or tube fungi for those lacking side branches and antler fungi for those with wider, flange-like appendages. An extreme is cauliflower fungus which looks nothing like coral but is usually included in the coral-like category in field guides. For the common Crown-tipped coral (photo upper right) the ends of the coral segments have tines like miniature crowns.

Scientific Name: *Clavariaceae* – The family name for the coral fungi is derived from *clava*, the Latin word for "club;" the type-genus is *Clavaria*. The coral fungus pictured above was originally *Clavaria pyxidata*, became *Clavicorona pyxidata*, and is now *Artomyces pyxidatus*. Pyx is from the Greek word *pyxos* meaning "box tree" from which boxes were made (and the etymology of the word box – a pyx is a container for Eucharist wafers). The implication for its use as a name for this species is "box-like."


Crown-tipped Coral mushroom. Photo: William Needham

Potpourri: Coral fungi look like coral. The verisimilar likeness can be so convincing that it seems plausible that they were uprooted from a seabed reef and planted in the woods for decoration. The delicate ivory and cream-colored branches rising in dense clusters from a brown-black dead log are one of the wonders of the wooded paths sought by those who wander there. There is an abiding benefit to have some knowledge of the things that nature has created and coral fungi is a good collective mnemonic to apply to the group that surely must be closely related. And so it is for the traditionalists steeped in the lore of musty mushroom field guides who are referred to collectively as the "lumpers." The new world order of DNA has taken the science of biology on a wild ride with many hairpin turns and dead ends; in the case of mycology, the train has left the tracks more than once. Coevolution … that which created a marsupial mouse in Australia unrelated to the placental house mouse everywhere else … globally demonstrates Darwin's vision. Fungi that branch is a natural evolutionary path for two individual organisms that started at different places and times. The diaspora of species from one genus to another…

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Fall MAWDC Events Recap

Annie Greene
MAW Newsletter Editor

Now that effective COVID-19 vaccines are widely accessible to the American public and many venues are back open for hosting events, MAWDC was able to hold two cornerstone events this year: the annual Sequanota retreat and the mushroom fair at Brookside Gardens. The Sequanota retreat featured speakers and foray leaders Thomas Roehl and Django Grootmeyers. Since the event was cancelled last year due to COVID-19 concerns, attendees surely made up for lost time; foraging baskets were full of a variety of mushrooms, including the crowd-pleasing Chicken of the Woods. Attendees' wide smiles said it all - they were happy to be back at Sequanota!

The Mushroom Fair, held at Brookside Gardens this fall, was also well attended. As usual, MAWDC set up educational displays for attendees to peruse. The pandemic has sparked (or rekindled) many peoples' love for the outdoors, and many are beginning to learn about how fascinating fungi really are. We hope they learned something at the Mushroom Fair!

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Mushrooms

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in search of a home on the genetic tree of life has exploded the coral fungi into fragments. This is the realm of the "splitters," the subdividers for whom a bar code will become the only true arbiter of species. There is of course a hybrid middle ground, acknowledging the latter but practicing the former, the province of most mushroom hunters.

Like all epigeal fruiting bodies extending upward above the ground from the main body of a fungus, which is hypogeal or below ground, the branching arms of coral fungi function to support and project the spore bearing reproductive components called basidia. Gilled or pored mushrooms maximize the number of spores they can disperse by creating as much surface area as possible in the limited space beneath the cap or pileus. Similarly, coral fungi branch again and again or extend myriad singular shafts to get as many fingers of spore bearing surface into the air as possible. The topology of using multiple extensions into a fluid medium is one of the recurring themes of evolution — coevolution. In this case, it has nothing to do with fungi per se. They look like coral because real coral is doing essentially the same thing; the namesake polyps secrete a type of calcium carbonate called aragonite to form protective exoskeletons in reefs that extend outward into the water where their food floats by. To extend the analogy to the rest of biology is a matter of observation. Trees send branches covered with photosynthesizing leaves toward the sun and roots toward the water and minerals of the earth where they encounter the branching mycelia of fungi.

Fungi have evolved to distribute reproductive spores with different mechanisms that could only have been naturally selected by the variations in form and function of random mutation. Among the more creative methods are the puffing of puffball spores out a hole in the top by the impact force of raindrops, the odorous spore-laden goo of stinkhorns that attracts insects, and the redolence of truffles sought by burrowing or digging animals as food digested, their spores excreted intact. Coral fungi are among the most primitive of all basidiomycete fungi in having their club-shaped spore bearing basidia positioned along the upper reaches of each prong so that they can be carried away by either wind or water. Having more fruiting bodies with more branches creates more spores, which is why coral fungi are frequently found growing saprophytically in dense clusters on dead tree logs or growing in mycorrhizal clusters on the ground. Simply sticking indistinguishable club shapes into the air with a bunch of short rods with spores attached to the end is the most straightforward way to disperse them for germination. The phylogenic diversity of the coral fungi belies their similar ramified appearance. Historically, structure was thought to be the basis for taxonomic classification, an assumption that works reasonably well with plants and animals but not with fungi. The delicate and colorful appearance of the coral fungi brought them to the attention of the earliest naturalists, who grouped them according to shapes. Since fungi were then considered members of the Plant Kingdom (Subkingdom Thallophyta), this was consistent with practice. The French botanist Chevallier placed them in the order Clavariées in 1826 with only two genera, *Clavaria* and *Merisma* noting that "se distingue du premier coup d'oeil" – they can be identified with a fleeting glance in having "la forme d'une petit massue" – the form of a little club. The assignment of fungi to families according to form lasted for over a hundred years until the nuances in microstructure and spore appearance initiated cracks in the biological foundation. Toward the end of the last century, fungi were recast as one of five different kingdoms, the foundational genus *Clavaria* was dissected into six genera with derivative names like *Clavulina* (little club) and

Upcoming Events

The events listed below may change, so read MAW emails and check our website at **http://mawdc.org** for up-to-date information on events.

Upcoming Scheduled Programs

Feb 1 **Monthly Meeting** featuring author and scientist Suzanne Simard, a pioneer in mycorrhizal fungi research and author of the book "Finding the Mother Tree." Tom McCoy will also speak about orchids.

Mar 1 **Monthly Meeting** featuring Elinoar Shavitz who will speak about fungi in amber and copal - a unique topic that you won't want to miss!

Apr 5 **Monthly Meeting** featuring a presentation by Jacob Kalichman called "Mushroom Macromacromorphology", where he will will demystify some mycology jargon. MAWDC's Science Advisor Megan Romburg will also enlighten us about rust fungi and the ancient festival of Robigalia.

For the time being, monthly meetings will be held on the first Tuesday of the month at 7:00 PM online via Zoom (www.zoom.us). Links will be emailed to members before each meeting, posted on the club's Facebook page, and can also be found on the MAWDC website. Members of the public are welcome to attend. To participate in the virtual mushroom ID session, email pictures of mushrooms ahead of time to forays@mawdc.org.

Clavariadelphis (brother of *Clavaria*), which is how they appear in the most popular fungi field guides.

Despite the distinctive shape that suggests a unique origin, coral fungi are agarics, the historical group name for almost all gilled fungi. What is now the order Agaricales is comprised of over 9,000 species, containing over half of all known mushroom-forming macrofungi assigned to one of 26 families with about 350 genera that range from *Amanita* to *Xerula*. Carl Linnaeas, who established the first taxonomic structure in biology with the publication of *Systema Naturae* in the 18th century, placed all gilled mushrooms in a single genus that he named *Agaricus*. One hundred years later, Elias Fries published *Systema Mycologicum*, which separated the agarics into twelve genera based on macroscopic features such as the structure of the spore-bearing surface or hymenium (e.g. gills, pores, teeth, ridges, vase-shaped) and spore color (white, pink, brown, purple-brown, or black). Six groups of basidiomycetes were recognized based on the shape of the sporocarp or fruiting body — "coral-like fungi" was one of them. While there was some expansion of genera over the ensuing decades, the so-called Friesian approach to gilled mushroom identification has persisted and is what is still generally in use, spore print color and all. The use of field characteristics is crucial to the practical application of mycology that serves the community of foragers looking for edible species and other aficionados who enjoy their company.

Over the last several decades, the use of DNA to map out the true phylogenetic relationships has upended the traditional taxonomy based on macroscopic structure and spore color. Unravelling the complex weave of evolutionary threads from one species to its predecessor is a monumental task that is just now gaining momentum. The goal is to determine the real or cladistic family tree so that a clade, the term adopted to refer to all species with a common ancestor, can be established with certainty. In one analysis, the agarics fell into six major clades, or single-ancestor groupings named Agaricoid, Tricholomatoid, Marasmioid, Pluteoid, Hygrophoroid and Plicaturopsidoid. The coral fungi are in the latter, which diverged from all the other agarics at the earliest evolutionary branching in the Cretaceous Era some 125 million years ago. It is not unreasonable to conclude from this analysis that the coral fungi evolved a reliable and efficient method of spore dispersal early on and have thrived ever since, branching out to form new species all using the same technique. It is now evident that the shape of a fungus does not necessarily establish its proper branch in the family tree. The agarics, now the Eugarics Clade, not only has fungi shaped like mushrooms and coral, but also puffballs like Calvatia and Lycoperdon. Likewise, shapes extend across multiple clades. For example, coral-shaped fungi also appear in the Russuloid Clade (Russulas) like Artomyces as pictured on Page 1, and Sparassis as pictured below in the Polyporoid Clade (Polypores).

This is then the dichotomy between the taxonomists of the old school steeped in the Linnaean traditions of field identification and the DNA systematists of the new school for which only the laboratory will do.

Sparassis (common name: cauliflower mushroom). Photo: William Needham

MAW Board of Directors

Mushrooms

The new biological life history of coral fungi is still subject to the findings of the most recent research paper devoted to the group and it may be decades before a settled taxonomy emerges. As a brief and incomplete history, in 1999 "four lineages containing cantharelloid and clavarioid fungi were identified," with the clavarioid containing most of the corals, but also noting that "Clavicorona is closely related to Auriscalpium, which is toothed, and Lentinellus, which is gilled." In 2006, it was acknowledged that coral shaped fungi must have evolved at least five times over the millennia and that the "evolutionary significance of this morphology is difficult to interpret because the phylogenetic positions of many clavarioid fungi are still unknown." The new genus *Alloclavaria* was added to accommodate the unique fungus *Clavaria purpurea* "not related to *Clavaria* but derived within the hymenochaetoid clade," which consists mostly of bracket fungi. Seven years later, the coral fungus family was found to consist of four major clades: Mucronella, Ramariopsis-Clavulinopsis, Hyphodontiella, and Clavaria-Camarophyllopsis-Clavicorona. This thorough phylogenic analysis of 47 sporocarp sequences merged with 243 environmental sequences concluded that "126 molecular operational taxonomic units can be recognized in the Clavariaceae … an estimate that exceeds the known number of species in the family." Phylogenic studies are continuing. Returning to the more mundane walk through the woods looking for coral fungi, the two most pressing questions concern edibility and toxicity. Neither of these subjects is broached in the scientific literature, and, like most fungi, data points are empirical, relying on random trial and error anecdote. For coral fungi, this is complicated by the fact that most are small and delicate and therefore rarely sampled by those seeking massive brackets of Chicken-of-the-woods and yellow clusters of chanterelles. Edibility has been a question ever since Chevalier first singled them out in 1826, noting that "Presque tout les clavaires fournissent a l'homme une nouriteure saine, on mange ordinarements les plus grosses" – almost all are good to eat but only pick the big ones, and "Elles n'ont aucune qualité vénéneuses; quelques-une ont une saveur amère" – none are poisonous but some are bitter. This sweeping assurance cannot have been the result of a thorough assessment, as there are good and bad corals. Modern guides are more circumspect, offering a range of information about edibility from choice to poisonous with caveats about having a laxative effect on some people and causing gastrointestinal distress in others. Many are of unknown edibility and likely to remain so. There is one standout worth noting that has the hallmarks of broad acceptability. The Cauliflower Mushroom (*Sparassis americana* – formerly *crispa*) is large, unusual, and common. It neither tastes nor looks much like a cauliflower. The "Elizabethan ruff of a mushroom" is hard to miss and there is no doppelganger to fool the hapless hunter.

References available upon request.

Left: *Clavinulopsis fusiformis* (common name: golden spindles).
Photo: Annie Greene

Fall 2021 Events

Above: Marisol Perez and friend pose in front of an impressive Chicken-of-the-Woods find at the Sequanota retreat.

Right: A foraging basket from a Sequanota attendee showing a bountiful variety of mushrooms

Above: A hearty crowd gathered for the Mushroom Fair at Brookside Gardens.

Below: Attendees admire an educational display.

Fungi in the News

Marisa Bello
MAW Member

Editor's Note: This article contains summaries of notable fungus-related news from July through November 2021. Visit the URL following each topic below for a closer look.

Study finds that birds, not just mammals, hunt for truffles

While humans enjoy a handful of species of truffles as a luxurious delicacy, there are hundreds of fungal species that associate with tree roots and form underground truffles. These fungi rely on other animals to eat the truffles and spread their spores. While scientists previously thought solely mammals consumed truffles, a study at the University of Florida says otherwise. Researchers found truffle DNA and even viable truffle spores in the feces of two bird species in Patagonia: chucao tapaculo and black throated huet-huet. Not only were the birds eating the truffles, but they were actively hunting for them, too. Some researchers even go as far to say that the truffles themselves are attracting birds by appearing like brightly colored berries. Read more here at: https://www.sciencedaily.com/releases/2021/10/211028120347.htm

Researchers at Oregon State University discover the oldest parasitic fungus specimen on a 50-million-year-old ant

When George Pointar Jr. discovered a fossilized ant with a mushroom growing from it, he did not know he was looking at the oldest specimen of a fungus parasitizing an ant. The ant in question is a carpenter ant, a species vulnerable to parasitic fungi, especially those from the genus *Ophiocordyceps*. Fungi in the genus *Ophiocordyceps* force the ant to attach to climb plants, then the mushroom fruiting body erupts from the ant's head in order to enable easy spore release. There are many similarities between *Ophiocordyceps* species and the mushroom growing from the fossilized carpenter ant. However, the fossilized mushroom protrudes from the ant's abdomen, which is unusual for the *Ophiocordyceps*- meaning that it is a new species of parasitic fungus, which its discoverers named *Allocordyceps baltica*. Scientists will study the relationship between ants and parasitic fungi further, as well as the origin of this specific relationship. Read more here: https://scitechdaily.com/mushroom-growing-out-of-50-million-year-old-fossilized-ant-reveals-new-species-of-fungal-parasite/

Adriana L. Romero-Olivares delves into a new field of fungi-based research

As the impacts of climate change have grown increasingly evident in almost all areas of the natural world, the impact on fungi has been left out. Romero-Olivares, a microbiologist from New Mexico State University, discovered that fungi's key role in an ecosystem (as a decomposer that provides vital nutrients to other organisms) becomes hindered with the effects of climate change. By simulating warming environments, Romero-Olivares found that in higher temperatures, fungi focus their energy on metabolism and processes to survive, rather than decomposing. Because less energy is focused on decomposing, the fungus cannot provide nutrients such as nitrogen to the ecosystem. Further, the way the fungi processed carbon changed, too. Under rising temperatures, fungi switch to decomposing recalcitrant carbon (carbon stored deep underground). Because of this switch, the soil cannot store carbon as well as it could with the recalcitrant carbon, meaning carbon emissions increase. Finally, Romero-Olivares expanded her research to the genetics of fungi. She noted that the effects of climate change will increase the number of species with nitrogen-uptake genes, which include yeasts and animal pathogens. Read more at: https://www.the-scientist.com/scientist-to-watch/adriana-l-romero-olivares-tracks-fungi-s-response-to-climate-change-68817

Correction

Editor's note: In the printed version of the last Sporophore issue (published July 2021), the comic's title and author name were cut off due to a printing error. The series title is "Tales of the Fun Guy", the author is Loretta E. Chi, and the caption at the top should have read "How it all began". My apologies for this error.

Crown-Tipped Coral Parmesan Crackers

Recipe from The Forager Chef, photo instructions available at: https://foragerchef.com/crown-tipped-coral-croutons/

Reminder: when planning to eat any foraged mushrooms, be 100% sure of its identity before consumption. Consult your local field guide or an expert identifier. When in doubt, don't eat it!

Ingredients:

4 oz crown-tipped coral clusters, trimmed of bark and picked over for debris and insects
1 pinch kosher salt
1.5 oz (about 3 Tablespoons) freshly grated parmesan cheese
2 Tablespoons all-purpose flour or gluten-free flour
Flavorless cooking oil in a spray bottle

Instructions:

1. Preheat an oven to 325°F
2. Toss coral mushrooms, parmesan, pinch of salt, and flour together in a mixing bowl. Make small mounds roughly the size of ¼ cup on a baking sheet.
3. Flatten mounds lightly, then spray or drizzle lightly with oil and bake for 30-45 minutes. Flip halfway through baking time, pressing down on any raised parts to ensure even crispness.
4. Bake until the mushrooms have wilted and the cheese and flour are very crisp. The cheese should be golden and the crackers evenly crisp, but not burnt.
5. Remove the crackers to a cooling rack or towel to weep any excess oil, then tore in a container with a tight-fitting lid at room temperature for 2 days, or refrigerate and toast slightly to re-crisp, then cool, before eating.

Tales of the Fun Guy

by Loretta E. Chi