SPORE PRINTS

BULLETIN OF THE PUGET SOUND MYCOLOGICAL SOCIETY
Number 540 March 2018

BRIDLE TRAILS FUNGA STUDY UPDATE

Daniel Winkler & the BTSP Team

In early January the Bridal Trails Study group met to inventory all specimens collected in 2016 and 2017, and the total number is almost 250 (not all unique species). We made sure they were all entered on our master list, a spreadsheet. We checked that all our collection numbers match our dried specimens and that we actually have all specimens in one location. Currently we are correlating our images to specimens in the master list. In the past we uploaded all our pictures onto the project's Google drive, a site all group leaders and photographers have access to.

From 2018 onward, however, we want upload all our collections to iNaturalist for a range of reasons. Our study, under the title "PSMS Bridle Trails Mushroom Survey Project," is already set up there, and contains 45 observations of 30 species uploaded by six participants. One key reason for using iNaturalist is that we can enter a new "observation" and upload its picture while still in the field! If you don't want to impact your data limit, you can set up the process so that the image will be uploaded when your cell phone is using WiFi, very considerate! The main drawback is that cell phone pictures do not have the same quality—and details are important for taxonomy—as do more sophisticated cameras many of us prefer for documentation. However, we can add more images to the entries later on.

On Sunday, February 4, group leaders for the Bridle Trail Funga Study met in the state park to test the new technology. We were all excited to see how we can create observations from the field that include collection number, photo, and precise location thanks to the GPS capacity of regular cell phones. One highlight of the trip was when Derek Hevel found a rare, unusual gilled mushroom in the genus *Metteomyces*.

So before we start a new year, we are trying to catch up with creating iNaturalist observations for the 2016/2017 collections and uploading their images. Unfortunately, that is a bit time consuming, so if anyone wants to help in this process, please let us know (contact Paul at parehill1@gmail.com). It does not require mycological knowledge, and the actual process can be done from any computer and takes minimum computer knowledge.

Hopefully the next update will be the dates for the spring mushroom season study days. We gladly invite the membership to participate and use that great opportunity to learn about mushrooms from knowledgeable fellow club members in our local 450 acres forest just NE of the I-405/ Hwy 520 intersection in South Kirkland.

Derek Hevel

Mystery Metteomyces sp. discovered at Bridle Trails StatePark.

FOSSIL POOP REVEALS CRITICAL ROLE OF GIANT BIRDS IN NEW ZEALAND'S ECOSYSTEM

Elizabeth Pennisi

www.sciencemag.com, Feb. 12, 2018

Artist's rendition of ancient moas in New Zealand.

When the first humans landed on what is now known as New Zealand 700 years ago, they didn't find mammals. Instead, they discovered giant birds called moas, as well as a host of other indigenous bird species. Soon, they had eaten many of them into extinction.

Now, by deciphering ancient DNA found in fossilized bird droppings, researchers have a better idea of the toll those extinctions took on New Zealand's forests and shrublands. The study shows that mushrooms and other fungi were important to the extinct birds' diets and suggests moas had a strong hand in shaping New Zealand's native landscape by helping fungi spread, says coauthor Alan Cooper, an ancient DNA specialist at The University of Adelaide in Australia. Now that the moas are gone, "The forest has potentially lost a potentially major way to spread."

"This paper is a clear example of the great potential of ancient DNA-based techniques," says Melania Cristescu, an ecological geneticist at McGill University in Montreal, Canada, who was not involved in the work. Cristescu says she was surprised by how much information the DNA contained. "The authors were able to identify a wide variety of species and to reconstruct the ecology of an extinct species."

Over the past decade, Jamie Wood, a paleoecologist at Landcare Research in Lincoln, New Zealand, has found hundreds of fossilized bird droppings, or coprolites, well preserved in caves and shallow sediments across the country. Earlier, Cooper and others had done some rudimentary DNA studies that showed that many coprolites came from five extinct species of moas and the kakapo (*Strigops habroptilus*), a critically endangered parrot. But the data provided few details about what these birds ate.

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CALENDAR

Mar. 10	Survivors' Banquet, 7:00 pm, CUH
Mar. 19	Board meeting, 7:30 pm, CUH board room
Mar. 20	*Spore Prints* deadline

CONTAMINANTS IN MOST KENYA HERBAL MEDICINES SICKEN, OR WORSE

John Muchangi

https://www.the-star.co.ke/, Feb. 16, 2018

Most herbal medicines in the Kenya market are contaminated with dangerous fungi, exposing users to risky diseases including meningitis, say scientists at the Kenya Medical Research Institute (Kemri).

Researchers bought the medicines from the shops and streets in Eldoret and Mombasa and took samples to Kemri laboratories in Nairobi for testing. Only 31 percent were found safe for human consumption while the rest were contaminated with fungi. Eighty eight percent of the herbal powders and 64.3 percent of the herbal liquids from Eldoret were contaminated while oils had no contamination. Herbal powders from Mombasa were more contaminated at 84.2 percent followed by liquids and tablets at 66.7 percent; again, oils and capsules were not contaminated.

Some of these contaminates can poison the lungs and the brain leading to death. Scientists were particularly alarmed after finding a dangerous fungus known as *Cryptococcus neoformans*.

PSMS SURVIVORS' BANQUET

Saturday, March 10, at 7:30—9:30 pm at the Center for Urban Horticulture, 3501 NE 41st Street, Seattle, WA 98105 (doors open at 7:00 pm for the social hour). This replaces our March general membership meeting.

It's time again to gather and congratulate each other for making it through another season of finding, cooking, and eating mushrooms. Sign up online on the PSMS website, psms.org. Seating will be limited, so you must be registered early to attend. The cost is $5/person to cover incidentals. Sorry, no refunds. As in previous years, the event will be a potluck dinner for PSMS members only, but if your significant other or dinner partner is not a member, you may still include them. We will have a banquet permit, so bring your favorite wine or beer, but no hard liquor, please!

Our banquet theme this year is "Pesco-Vegetarian," but all potluck contributions are welcome. We encourage you to bring your best dishes, especially those featuring mushrooms, wild or cultivated. Please label your contributions with the ingredients and species of mushrooms, if any. We will have a short presentation or two, introduce the newly elected officers and board members for 2018–2020, announce the winner of the 2018 Patrice Benson Golden Mushroom Award for outstanding service to our society, and hand out a few door prizes. This promises to be a fun evening with friends and family, so come join us!

We will have a silent auction with some interesting items. Funds raised will benefit the Ben Woo Scholarship Fund!

EUROPEAN COURT BACKS OPPONENTS OF LOGGING IN PRIMEVAL POLISH FOREST

Erik Stokstad

http://www.sciencemag.org/, Feb. 20, 2018

One of the hottest environmental conflicts in the European Union—the logging of a primeval forest in Poland—may be nearing an end. The European Court of Justice (ECJ) today issued a legal opinion that the controversial logging, which had been defended by Poland's government, is illegal. Poland's minister for the environment indicated that he will accept the court's final ruling, which is expected next month.

The Białowieża Forest in eastern Poland is the largest remnant of forest that once covered lowland Europe and has been named a UNESCO World Heritage Site. In addition to wolves, bison, and a rich array of birds and beetles, the forest contains many species of fungi found nowhere else. In 2016, Jan Szyszko, then the minister for the environment, approved a tripling of logging, saying that it was necessary to fight an outbreak of spruce bark beetles.

Environmental groups argued that the logging wouldn't defeat the beetle and would cause more harm than good. Most scientists agreed and felt that the old-growth forest should be left largely unmanaged. ClientEarth, an environmental group headquartered in London, and other groups filed a complaint with the European

Commission, which took the case to the ECJ, charging that Poland was in violation of EU laws to protect habitat and birds.

The advocate general of the ECJ, Yves Bot, issued a legal opinion today finding that Poland had not followed the EU laws, nor had it adequately assessed the impact of the logging. He also concluded that logging would harm breeding sites of protected species. The opinion is not binding, but the court follows the recommendation of the advocate general in almost all cases.

Szyszko was fired in early January as part of a Cabinet reshuffle intended to improve relations with the European Union. His replacement, Henryk Kowalczyk, issued a statement today that the ministry was reviewing the opinion, but would abide by the court's decision: "I can confirm that Poland will comply with the final judgment of the Tribunal regarding the Białowieża Forest."

Jan A. Nicolas

Activists protest logging in the Białowieża Forest in early 2017.

MAGIC MUSHROOM USERS EAGER TO TALK

Deborah Wilson

CBC News, Feb. 13, 2018

For University of Victoria masters student Lindsay Shaw, finding subjects to interview for her research project has been easy.

Shaw wants to know how and why people use magic mushrooms—the hallucinogenic fungi that grow wild in fields and lawns of coastal British Columbia but are illegal to possess.

The second-year masters student at UVic's Canadian Institute for Substance Use Research has found no shortage of people who want to talk about their experiences with *Psilocybe semilanceata.*

When she put out a request for volunteers to answer a survey about their use of magic mushrooms, her email inbox filled with more than 300 responses in just over a day.

Jonathan Woods

Masters student Lindsay Shaw wants to know how and why people use magic mushrooms—the hallucinogenic fungi that grow wild in West Coast fields and lawns, as well as home grow-kits.

People strike up conversation in the grocery store when they learn the subject of her research, and she has been contacted by people from around the world who are eager to share their stories.

Shaw became curious about the topic after reading surveys of university-age recreational substance users that said 93 percent had taken magic mushrooms at least once. As well, 27 percent said they used them in the previous month.

"When I was reading these results they seemed relatively high," Shaw told *On the Island* host Gregor Craigie.

Few Other Studies

But despite its apparent popularity, she found specific research on recreational magic mushroom use was scarce.

"There have been reports of people using them in therapeutic and medicinal ways, perhaps micro-dosing…to treat anxiety or headaches," she said. Others might use them for party drugs or in an outdoor setting.

"But we actually don't know what the users are using these recreational substances for," Shaw said.

Transformative Experiences Recounted

Shaw expects to have results of her survey within a few months, but she has been struck by the overwhelming positive and sometimes transformative experiences with magic mushrooms that people have described to her.

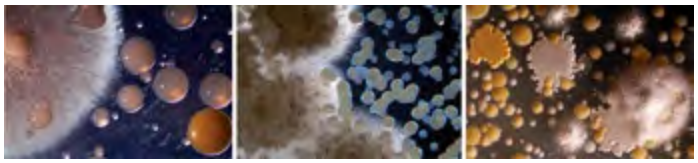
"I think it was presenting a unique opportunity for a lot of people," Shaw said of her study. "I think it says something to me about the prevalence and also there aren't venues for people to talk about their magic mushroom use."

HOW FUNGI AND BACTERIA TEAM UP FOR A TASTIER CHEESE RIND

Menaka Wilhelm

npr.org, Jan. 2018

via *The Spore Print*, L. A. Myco. Soc., Feb. 2018



Benjamin Wolfe

Colonies of microbes from different cheese rinds. From right to left, Comte, Robiola, and blue cheese.

It was the tiny streams of slime that stood out. As a microbiologist who studies the rinds of cheeses like Stilton, Gruyere, and Taleggio, Benjamin Wolfe had done plenty of experiments on bacteria, yeast, and mold. But he'd never seen anything like this. He wasn't actually running a lab test when he noticed those slimy streams—he was working with a photographer to document the microbes of a Saint-Nectaire rind. He expected to show the photographer what he normally saw from cheese microbes: fungal molds that branched out in many directions, like a plants' roots, and bacterial colonies camped out in dots and blobs. But there was something else, too: little rivulets running along the branches of a swath of fungus.

Maybe swimming bacteria were creating the streams, but he couldn't be sure. Inspired by the photo shoot, Wolfe, an assistant professor at Tufts University, went back to his cheese rinds with

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A NEW SOURCE FOR CULINARY TRUFFLES?

A. Sieger

Eklekto

Bringing the truffle back to Greece.

With the increasing shortage of French and Italian truffles, and resulting astronomic prices, Greek entrepreneurs Peter Weltman and George Athanas saw an opportunity to export pricey truffles from Greece, leading to their new company Eklekto.

The Eklekto website advertises the following fungal treasures now associated mainly with France and Italy:

Black Summer Truffles, *Tuber aestivum Vitt*, May–Sept.,
Black Autumn Truffles, *Tuber uncinatum*, Sept.–Dec,
Black Winter Truffles, *Tuber melanosporum*, Nov.–Feb.,
White Spring Truffles, *Tuber borchii,* Feb.–May,
White Winter Truffles, *Tuber magnatum pico,* Sept.–Jan.

In 2004, molecular analysis showed that *T. aestiv*um (also called the burgundy truffle) and *T. uncinatum* are actually one species, although differences in appearance and pungency result in a difference in price.

The following article published February 20 in *Bloomberg Pursuits* describes Eklekto, the introduction of their products by Weltman in San Francisco in 2016, and the reaction of top U.S. chefs.

YOUR NEXT TRUFFLE MAY BE COMING FROM GREECE

Larissa Zimberoff

https://www.bloomberg.com/, Feb. 20, 2018

Skyrocketing prices in Italy and counterfeit versions from Eastern Europe are driving chefs to a new source.

So you're dining at a fancy restaurant and choose to splurge on some truffles to top off your repast. The server steps up and presents the vaguely ugly tuber. As the pungent slices rain down on your main course, the waiter announces that these truffles didn't come from Italy, the traditional provenance of this decadent garnish. They hail from Greece.

Don't be shocked—be glad. Italians have successfully positioned their product as the most luxurious under the forest floor. But white Alba truffles—*Tuber magnatum pico*—also grow magnificently well in Greece. Even Aristotle mentions them in his writings, but they never made it into the local cuisine. Unlike Italy's truffles, which have been dug up and eaten for centuries, Greece's truffles have remained largely undisturbed. At least they did until the Athens-based culinary exporter Eklekto saw their potential for the U.S. market.

But there's an additional reason to embrace Greek truffles. Usually, countless middlemen touch an Italian truffle before it makes it to market, increasing the consumer's chances of getting a counterfeit version. Eklekto partners Peter Weltman and George Athanas say they work only with a small group of Greek foragers and know exactly where the product is from. Apart from the forager working with his trusty dog, Weltman and Athanas are the only people that touch the truffles before export, the company says.

Initially, it was mutual interest in Greek wine that brought Weltman and Athanas together, but a mutual friend and respected mycologist (a studier of fungi) pointed them to truffles. Bitten by the Greek truffle bug, Weltman—a trained chef and sommelier—brought a cache of tubers back with him to San Francisco-area restaurants in 2016, jamming a pile of Greek Burgundys (also called black summer truffles) into a stinky backpack. "You bring in caper leaves and it's one thing," he says of these sales calls. "But truffles are a whole other ballgame." Everywhere Weltman went, the kitchen staff gathered around to peer into his Tupperware. They loved the scent: more buttery and saltier than the smokier French version and different from the Perigords—*Tuber melanosporum*—that he had later, which were more fruity, earthy, and pungent. Still, they were sent off without a sale.

Eklekto

Harvest of black Greek Peloponnese truffles.

In 2017, Eklekto's foragers began unearthing the prized white truffle that, in addition to Italy and Greece, also comes from Slovenia and Macedonia. More than a few Italian truffles have a good chance of actually hailing from these countries, given the premium prices they command and the ease of exporting them. At Urbani, which controls 70 percent of the world's truffle market, Vittorio Giordano, vice president of the U.S. and Canada division, says he's paying close attention to his Alba sources.

Eklekto

Greek white truffles, Tuber magnatum pico.

"As a truffle company, we have to keep an eye on the product," he says. "If there are other areas producing the same truffle, we definitely have to pay attention."

Nevertheless, with Alba prices climbing because of drought, the timing for Greek truffles was perfect. Last year, Italian truffles jumped to $3,500 a pound wholesale. Greek truffles were slightly cheaper, going for $3,150 a pound. Equally delicious, but not as rare, Perigords fetched $840 a pound.

The same species as the Alba, Eklekto's Greek white truffle smells and tastes just as delicious. One convert is chef Michael Tusk at San Francisco's Quince restaurant. Tusk is a prodigious user of the luxury ingredient. "People are paying a lot of money," Tusk says of his dinners. Because of this, sometimes he would take over in the dining room for any cautious captains. "I was never really fond of conservative shaving. It was either go big or go home." During his annual, eight-night, white truffle festival, he uses about two kilograms a day. In peak season, Tusk will spend around $100,000 on truffles.

When Weltman first pitched his burgundy truffles to Tusk in 2016, the chef didn't believe another country's product could rival Italy's. But after a year of soaring overhead, he reconsidered. "It was a brutal year of expense and I thought I'll at least take a look," says Tusk. He began adding them to his risotto with tartufo bianco, a dish that includes both cultured white truffle butter and a generous shaving of truffles at the table, and agnolottini di fonduta, molten cheese-stuffed pasta with white truffles. "The flavor was really good," he says.

Matt Morris

Last October, when Quince was awarded three Michelin stars, he requisitioned truffles to celebrate. He called up Far West Fungi—a wholesale and retail shop that carries the largest variety of truffle species in the Bay Area and which just received a large shipment of white tubers from Eklekto. General Manager Naomi Wolf delivered the goods personally. "I think it was three pounds, a ludicrous amount," Wolf says.

George Chen, chef and owner of China Live and Eight Tables in San Francisco, first started using black truffles in 2007 at Roosevelt Prime, a steakhouse in China. He continued to use them until 2010, when the market began to be flooded with inferior products. He started searching for alternatives.

"I heard that Greece had truffles, but I had never seen one," says Chen. Weltman showed up one day with large, bright, white truffles. They had few indentations, allowing for beautiful oval pieces when shaved. But that wasn't the real test. "The smell and the taste were absolutely every bit as good as anything I got from Alba," Chen says. He began using them on his velvet chicken with roasted truffle veal jus and, in a riff on broccoli beef, seared wagyu finished with shaved white truffles.

Taking a chance on a supplier with a new ingredient, especially an expensive one, is a risk many don't want to take. However, for this southern European country whose economy has problems, it's a potential jackpot. Lefteris Lahouvaris, a Greek mycologist who works with Eklekto, estimates that Greece could export as many as three tons of truffles annually, translating into millions of dollars at wholesale prices in the U.S.

Many have yet to be convinced. Chefs Yotam Ottolenghi and Alice Waters, both of whom showed interest, eventually passed on Greek truffles. At Far West, co-owner Ian Garrone says he will continue to carry the Greek truffles as long as they're consistent. "It's going to be determined by a few good seasons," he says. "I'm thinking it's going to be an early white truffle season. If it can get in the market before Italian [truffles] get established, it has a really wonderful chance of being a mainstay."

FUNGUS UNKNOWN TO SCIENCE FOUND ON SOUTH DOWNS IN ENGLAND

Sara Page

https://www.midsussextimes.co.uk/, Feb. 15 2018

The ground-breaking discovery of the dark blue *Entoloma atromadidum* was made by a group studying fungi on National Trust land at Wolstonbury Hill.

What was thought to be one species, Big Blue Pinkgill—*Entoloma bloxamii*—has now been proven by experts to be at least four different species.

Mycologists had suspected Big Blue Pinkgills comprised more than one species, but lacked evidence. The find at Wolstonbury Hill—a South Downs landmark with a rich history—means their suspicions can now be confirmed in the record books.

Kew Gardens mycology research leader Dr. Martyn Ainsworth said: "After more than a year of detective work and DNA sequencing at Kew we finally reached a position where we could confidently describe and name this new species in a publication.

"This work could not have happened without the keen eyes of many volunteers searching sites such as Wolstonbury for suitable specimens to analyze as part of our Lost & Found Fungi Project.

"It is always exciting to add a new name to the fungal kingdom and I'm still amazed that, even in a well-studied country such as ours, there are still fungi such as this very striking blue mushroom to be discovered."

National Trust ranger Graham Wellfare, who looks after the land around Wolstonbury, said: "Fungi are a bit of a neglected kingdom, but they are fascinating organisms and among the oldest on our planet. These days, we're able to unearth hidden truths about them through modern science and technology, and there's so much potential to discover even more."

Martin Allison, fungus recorder for Sussex, said: "It sometimes happens that a rare or unusual fungus is identified during a study day, but to find a newly described species is a very special event indeed."

The four species of Big Blue Pinkgill now recorded are *Entoloma atromadidum*, *Entoloma bloxamii*, *Entoloma madidum*, and *Entoloma ochreoprunuloides*.

The find at Wolstonbury Hill was not the only major discovery of fungi at National Trust places in recent months. During a count of grassland fungi on the Longshaw Estate in Derbyshire, a group came across another UK first in the shape of the Ermine Bonnet—*Mycena erminia*—a slender white toadstool usually found only in The Netherlands and Denmark.

Last autumn, volunteers at the Trust's Clumber Park in Nottinghamshire discovered the extremely rare Powdercap strangler, a parasitic toadstool that body-snatches another grassland fungus.

Big Blue Pinkgill, Entoloma atromadidum, discovered on the South Downs.

Fungi, bacteria, and cheese rinds, *cont. from page 3*

new questions. What, exactly, was traveling along the fungus, and how was it moving?

He had read about bacteria moving along fungi in soil. The microscopic, branched tendrils that fungi use to bring in nutrients—their hyphae—functioned as a specialized microbial highway. "Bacteria can swim through liquids, and the fungi, these hyphae, have a thin layer of liquid on the outside of them," Wolfe says. Soil bacteria were known to hop into this lazy river for travel.

In the fungus he saw, even a tiny channel of water outside fungal branches would leave a bacterium plenty of room to swim. But it was also possible that he'd just seen bacteria hitching a ride as the fungus grew instead of swimming on their own.

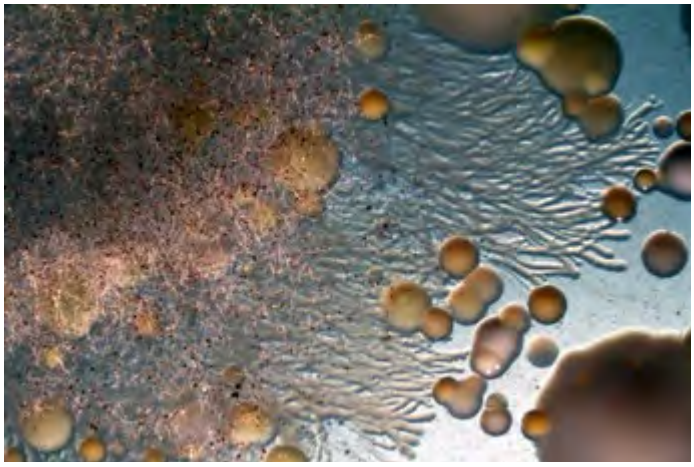
So he and his students scraped samples off cheese rinds and chose microbes for experiments, which they published recently in *Nature Communications*. They picked a swimming bacteria and a few molds that grew at different speeds, hoping to see if the bacteria were moving or if the fungi did all the pushing. One mold grew quickly and spread out wide, like a microbial Los Angeles, while another grew slowly, knitting itself into dense networks, more like a fungal Tokyo.

These are cheese rind microbes, so many bring a special flavor to the table. Their choice of bacteria, *Serratia proteamaculans*, gives a cheese a nice note of cooked cabbage. The slow-growing fungal mold, a strain of *Penicillium*, tastes earthy, like mushrooms with a hint of damp basement, Wolfe says.

Another mold they studied, *Galactomyces geotrichum*, contributes a strong, unique flavor profile suited for stinky cheese lovers. "The best way to describe it is sweet, buttery flatulence," Wolfe says. He meant that as a compliment. Sure enough, when Wolfe and his students left bacteria to grow alongside fungal molds, the colonies spread farther than bacteria alone. As the mold branched outward, it seemed, it gave nearby bacteria a boost. And at closer zoom, the bacteria were clearly swimming along the hyphae, just like the streams Wolfe noticed during that first surprising photo shoot. From a cheese-making perspective, it's a really nice idea that fungal molds would help bacteria spread out and grow. Both entities imbue their surroundings with different flavors, so their intermingling creates a complex, tasty cheese. But from a microbial standpoint, it doesn't make perfect sense that fungi and bacteria would cooperate.

That's because all these microbes need the same ingredients to survive—water and nutrients—and when resources are scarce, they've got tricks for making sure the competition isn't friendly. Fungal molds create chemicals specialized to burst bacteria open, which we've co-opted for antibiotics like penicillin. Bacteria have specialized enzymes, called chitinases, that liquefy fungi, reducing them to a slurpable smoothie of carbon and nitrogen. "People have looked at fungal hyphae and bacteria just as antagonists," says Lukas Wick, a microbiologist at the Helmholtz Centre for Environmental Research. "And this is certainly part of the story, but it's a really complex story."

Despite those unfriendly adaptations, bacteria stand to gain a lot from fungal networks. Fungi pump water and nutrients around their hyphae, so any bacteria along for the ride also have access to those resources. "They are a logistic network themselves—it's a type of supply chain," says Wick. For a bacterium, hyphae are the opposite of a lonely state highway that stretches for miles without a gas station or drive-thru in sight. Not all bacteria can swim, so the fungal network can only take some bacteria so far. And unfortunately, many toxic bacteria can hop onto the hyphae highway. *Escherichia coli* grows better in foods that contain certain fungi. *Listeria*, which can infect the cheeses Wolfe studies, is also known to travel via fungal network. But ideally, as the picture of how specific fungi affect certain bacteria gets clearer, cheese mongers will be able to tweak the microbial communities of their cheese rinds to maximize precise flavors and minimize contamination. One day, cheese makers might cultivate a fungus that deters dangerous bacteria, ferrying only the flavorful microbes along.



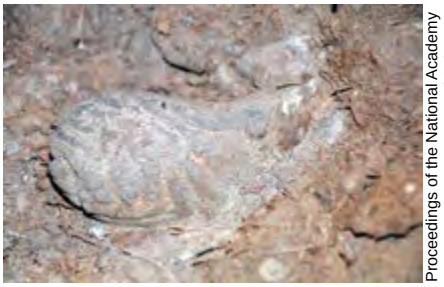
Benjamin Wolfe

Microbes cultured from the rind of Saint-Nectaire cheese. The branched hyphae of a fungal mold coexist with the blobs of bacterial colonies. Note the transparent mycelium growing through the substrate.

Moas and beech trees, *cont. from page 1*

Since then, other studies have shown that more extensive, high-throughput sequencing of DNA found in poop has the potential to reveal much more information. Researchers used it for an in-depth study of the gut bacteria of ancient Americans, for instance, and to catalog the diets of mammoths. So Cooper, Wood, and graduate student Alexander Boast of The University of Auckland in New Zealand decided to study in greater detail the DNA from 23 coprolites collected from eight beech forests and shrublands across New Zealand's South Island. The droppings ranged in age from 124 to 1557 years old. For comparison, they also sequenced poop DNA from living kiwis, ostriches, and several mammals.

They found a staggering variety of DNA from plants, mosses, fungi, and parasites, whose distribution indicated that each species had its own diet and its own set of parasites, the researchers report today in the *Proceedings of the National Academy of Sciences*. There was more variety in the poop from what were once beech forests than from scrubland coprolites.



Proceedings of the National Academy of Sciences

A moa coprolite in the sediment that buried and preserved it.

Two species, the upland moa and the South Island moa, had mosses and ferns in their diets, the researchers report, whereas the others did not. The upland moa also carried a parasite that it could have only obtained by eating pond snails or aquatic plants, suggesting this relatively small species focused on foods larger moas ignored. It probably searched for food in alpine areas, where aquatic life thrived in high elevation lakes, even though that's not where coprolites are found.

Surprisingly, fungal DNA was among the most common type of DNA, particularly in poop from species living in beech forests. Among the fungus species that researchers found were bracket fungi, puffballs, and true mushrooms, many of which are brightly colored to look like flowers and attract animals that help spread fungal spores in their droppings. Until these findings, "The role of fungi in the diet of New Zealand's extinct birds has been largely speculative," says Landcare Research paleoecologist Janet Wilmshurst, who was not involved with the work.

The fungi found in coprolites are essential to the survival of beeches, and Cooper thinks moas played an important role in helping beech trees expand across New Zealand. Beech forests are well established in the country, but natural disasters have wiped out the trees in some patches, and they haven't returned; that might be because they lacked the moas' help, Cooper says. "Reconstructing even some of the major interactions can provide guidance" about how the flora, fauna, and landscape are connected—and how they may be preserved, he points out. Foresters may want to find new ways to spread these fungi as well as plant new seedlings in places where the beeches have disappeared, for instance.

RESEARCHERS QUANTIFY NUTRITIONAL VALUE OF SOIL FUNGI TO THE SERENGETI FOOD WEB

Kerry Bennett

Northern Arizona University, Feb. 14, 2018

The complex Serengeti ecosystem, which spans 12,000 square miles extending from northern Tanzania into southwestern Kenya, is home to millions of animals, including 70 species of large mammals. It is a hotspot for mammal diversity—including herbivores such as wildebeest, zebra, and gazelles that graze on grasses and trees, as well as lions, crocodiles, leopards, and hyenas that survive by preying on the grazing herbivores.

A new study published in the *Journal of Ecology* by a team of Northern Arizona University researchers shows the food web supporting this remarkable variety of wildlife would appear very different without the nutrients supplied by arbuscular mycorrhizal (AM) fungi. The interdisciplinary study, authored by graduate students in NAU's School of Earth Sciences and Environmental Sustainability—Bo Stevens, Jeffrey Propster, Andrew Abraham, and Chase Ridenour—along with assistant professor of informatics, computing, and cyber systems Christopher Doughty and Regents' Professor of Earth Sciences and Environmental Sustainability Nancy Johnson, quantifies the importance of AM fungi in the soil of the Serengeti National Park in Tanzania.

AM fungi, a type of mycorrhizal fungi, penetrate the roots of grasses and other plants native to the Serengeti. Considered natural biofertilizers, AM fungi provide their host plants with water, nutrients, and pathogen protection in exchange for photosynthesis. The symbiotic relationship between AM fungi and plants, which has evolved for millions of years, is critical for the uptake of essential plant nutrients such as phosphorus. In turn, the nutritional quality of the plains' grasses and trees influences the biomass of the herbivores and their predators.

By creating an ecosystem simulation that enabled the researchers to measure the biomass of AM fungi across a natural soil fertility gradient and estimate the contribution of mycorrhizal symbioses to the biomass of all plants and animals in the Serengeti, the researchers were able to estimate the animal biomass that results from phosphorus supplied to plants through AM fungi.

This study shows that the contribution of mycorrhizal symbioses to the growth and nutritional quality of grasses cascades through the biomass of large grazing mammals and their predators. Although AM fungi amount to less than 1 percent of the overall living biomass in the Serengeti, their predicted nutrient inputs into the food web doubled animal biomass.

"It's really surprising that a small group of microbes can have such a large impact on an entire ecosystem," said Stevens, lead author of the study. "We always knew that mycorrhizal fungi were important for grass nutrition in the Serengeti. Now we can say how important they are for the nutrition of animals up the food chain, from zebras to lions."

FOOT FUNGUS MAY BE CLONING ITSELF

Kate Sheridan

http://www.newsweek.com/, Feb. 23, 2018

The fungus responsible for toenail infections and athlete's foot may reproduce by making clones of itself. According to a new paper published Wednesday in *Genetics,* the genome of *Trichophyton rubrum*, the fungus responsible for these irritating conditions, shows some telltale signs of asexual reproduction—which could be good news for people who want to develop new drugs to stop it.

"Most organisms are sexual reproducing," Duke researcher Dr. Joseph Heitman told *Newsweek*—and that includes most fungi. "The conventional evolutionary theories are that asexual organisms are doomed to extinction." But the fungus might want to keep things exactly as they are—after all, it's gotten very good at infecting human skin.

To figure out exactly what these fungi are doing, scientists have a few options. They can look for physical evidence—but that's easier said than done. "It's often hard to catch them in the act in laboratory conditions," Heitman said. So after he and his colleagues failed to find the fungus *in flagrante*, they looked for genetic evidence, too.

Fungi don't have X and Y chromosomes like humans, but they do have something similar, called the mating type locus. "It serves a similar function, in that there are typically two mating types," Heitman said. "For *Trichophyton rubrum*, they're essentially all of one mating type." (Of the 135 fungi included in the paper, 134 had the same mating type.)

But just because the fungi are mostly of one mating type doesn't mean that they can't still mix it up, genetically. So Heitman and his colleagues also looked for signs that genes have been recombining as they would in sexual reproduction—which did not exist.

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PAPPARDELLE WITH MIXED WILD MUSHROOMS

Jamie Oliver

Ingredients

9–11 oz. wild mushrooms (buy around 14 oz., as you have to trim a bit off)

3 TBs olive oil

1 clove of garlic, finely chopped

1–2 small dried red chilies, pounded or very finely chopped

Salt and freshly ground black pepper

Juice of 1/2 lemon

1 lb pappardelle

A small handful of grated Parmesan cheese

1 handful of fresh flat-leaf parsley, roughly chopped

2 oz. unsalted butter

Directions

Brush off any dirt from the mushrooms with a pastry brush or a dish towel. Slice the mushrooms thinly, but tear girolles, chanterelles, and blewits in half. Put the olive oil in a very hot frying pan and add the mushrooms. Let them fry fast, tossing once or twice, then add the garlic and chili with a pinch of salt (it is very important to season mushrooms lightly, as a little really brings out the flavor). Continue to fry fast for 4–5 minutes, tossing regularly. Then turn the heat off and squeeze in the lemon juice. Toss and season to taste.

Meanwhile cook the pasta in boiling salted water until *al dente*. Add to the mushrooms, with the Parmesan, parsley, and butter. Toss gently, coating the pasta with the mushrooms and their flavor. Serve, scraping out all of the last bits of mushroom from the pan, and sprinkle with a little extra parsley and Parmesan.

Foot fungus*, cont. from page 7*

Genes that the fungi need to sense and respond to pheromones that trigger the sexual cycle did still exist. So there could still be toenail fungi that are reproducing sexually. “It’s very hard to prove that something is strictly asexual,” Heitman said. “I think it is important to note that this is a hypothesis. There are certainly further and additional studies that need to be conducted.” But based on the work he’s done, the fungus does seem to be just producing clones of itself.

If other studies come to similar conclusions, it could mean that drug companies should have a look at the genome to see if there are any useful hints for making more effective drugs. “It’s extremely hard to get rid of it,” Heitman said. But in theory, knowing more about the way the fungus works could reveal new pathways to target. “Having the genomic blueprint for the organism is the starting point.”

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