Rainforest Biodiversity in Ecuador 2017-2018

A Descriptive Survey of the Roles and Patterns of Fungi near the Shiripuno Field Station in the Yasuni National Park of Ecuador

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Abstract

This project intends to describe findings related to various roles and patterns of fungi in the Shiripuno Field Station trails of the Yasuni National Park in Ecuador. A Sony A6000 mirrorless camera and a Rite in the Rain waterproof notepad and pen were used to record data and capture these findings. The results indicate a large variety of fungi growth in the Yasuni National Park and intricately-woven symbiotic behaviors with other rainforest beings. In the end I discuss some of the previously researched symbiotic behaviors found along the trails and at the Shiripuno Field Station.

Introduction

The Yasuni National Park in Ecuador is one of the world's most biodiverse hotspots[1]. Many factors allow for such a phenomenon to occur, such as abundant rain, intense species competition, and a relatively stable climate. The field project intends to demonstrate the prominent roles of fungi in the rainforest ecosystem of the Yasuni National Park near the Shiripuno Field Station through an investigation of fungi found throughout the nearby hiking trails.

Prior research reveals a significant role played by fungi in the ecosystem of natural landscapes, and the tropical rainforest of the equator is no exception. Where rain and humidity are plentiful, a plethora of fungi species can be found. Fungi are known to help maintain species biodiversity and decompose organic waste, further enabling the Yasuni to claim its title as one of the world's most biodiverse hotspots.

The objectives of the field project are to 1) find, observe, and photograph fungi along the daily and nightly hikes and canoe rides, 2) check for patterns in fungi findings, and 3) discover, through possible patterns, the prominent roles of fungi near the Shiripuno Field Station in the rainforest of the Yasuni National Park. While books on tropical bird species are aplenty, observations of fungi in the equatorial regions are rare and few. Thus, the fieldwork observations were expected to provide unique findings, with potential for new species to be discovered.

Expected outcomes for the field project included 1) a comprehensive catalog of tropical fungi photographs, 2) observations of rare fungi endemic to the region, and 3) a deeper understanding into the life of fungi near the Shiripuno Field Station in the rainforest of the Yasuni National Park.

Materials and Methods

In the beginning of the field project, I set out to explore the existence of fungi in the rainforest trails near the Shiripuno Field Station. The Field Station is in the Yasuni National Park of Ecuador. It is a very dense lowland tropical rainforest. The Shiripuno River flows through the forest, after breaking off from the Napo River. To get to the Field Station, we drove from Quito to Coca and then to the river checkpoint. After getting our passports checked, we boarded a motorized canoe for approximately five hours, and head downstream towards the Field Station, with the coordinates 1° 6’ 16.8”S and 76° 45’ 54.2”W.

The first part of the field project developed a certain path that the project can follow. This was accomplished during the first day at Shiripuno. We set out on three hikes that day, enabling me to explore the world of fungi in the rainforest trails of Shiripuno. The world I stumbled into was a rich atmosphere of rain and humidity, which are very suitable for fungi. After the initial hikes, I recognized a pattern in the various roles of fungi in the area: fungi-plant symbiosis, and the promotion of species biodiversity through the decomposition of organic matter.

I. Fungi-plant symbiosis: in the backyard of the Shiripuno Field Station, lodge owner Jarol ‘Fernando’ Vaca keeps a garden of over 400 specimens of orchids. Orchids are epiphytes and do not require soil to survive – just a healthy amount of humidity and rain. The orchids’ roots contain an essential fungus that provides a substrate for the orchid to receive its nutrients. Fernando’s experiment is to strip away the layer of fungus from the roots of some orchid specimens in order to observe the relationship between the fungus’ presence and the growth quality of the orchids. The methods used for this role of fungi in the rainforest was observing the orchid specimens throughout the backyard of the Shiripuno Field Station and asking Fernando questions about the experiments and the observations collected. The materials used to record the information are a Right in the Rain notepad and pen and a Sony A6000 mirrorless camera.

II. Sightings and Patterns: after several hikes, it seemed a recurring pattern that fungi love growing on decaying tree trunks and branches, which are plentiful in the ever-changing environment of the rainforest. For this section of data, the methods in use were photographing rarely-seen fungi and clusters of fungi families living on wood as a substrate, and drawing the findings in the Rite in the Rain notepad, along with the hike details and any landscape observations. Then, once we returned back to the field station, I would attempt to identify the fungi using a printed guide of Amazonian fungi from Daniel Winkler's Mushroaming.com and the fungi pictures from Paul Stamets' "Psilocybin Mushrooms of the World".

Materials and Methods: Criticism

Had I the amount of experience and knowledge pertaining to the project, the trails of Shiripuno, and the flow of activities in the rainforest, I would alter the materials and methods for a future project. Here I discuss what I would do differently:

I. Taking a measurement of the temperature and humidity of each day at the same place in the field station, three times per day. A sample in the morning after breakfast, a sample in the afternoon after lunch, and a sample in the evening after dinner. By taking these samples, a recognition of patterns in fungi growth can be increased, as well as other observations.

II. Recording the GPS coordinates of prominent fungi finds.

III. Tracking our trails across Shiripuno using a GPS application on a phone in order to map the fungi species observed, so that others interested in neo-tropical fungi in the future know where they may find the fungi.

IV. Taking spore-prints of the fungi. This can only be possible through an agreement of Ecuador and United States officials, since bringing spores into another country requires special permission. I would need research and collecting permits from Ecuador and import permits for the United States.

V. Photographing the *Cordyceps* species more often. This entails carrying the camera more often.

Results

Fungi-Plant Symbiosis:

Fernando's Orchid Garden in the backyard of the Shiripuno Field Station contains over 400 specimens of orchids. As Fernando walks the trails of Shiripuno and canoes down the river, he comes across different species of orchids. Orchids are epiphytes, and their endophytes are rather unique; they have an "ancestral relationship with Rhizoctonia-like fungi"[2]. These 'air-growing' plants cannot do it all alone, so they grow along with a mycorrhizal group in their endophytes.

Figure 1: From Fernando's Orchid Garden

For the past several years, Fernando collects orchid specimens that he comes across along the trails and rivers. He brings them back to the Field Station and hangs them up on a chord that stretches from tree to tree behind the main cabin. From there, the orchids are separated into species. Then, Fernando tests his hypothesis with the following variables:

- If the roots of the orchids are bare naked, they struggle to grow.
- If the roots of the orchids have a community of fungus with substrate for nutrients, they thrive.

Fernando led me around his lively experiment, and demonstrated that his hypothesis is, so far, true. The four-hundred specimen sample clearly shows that the orchids whose roots are stripped bare naked struggle to grow. Due to the tropical climate, these epiphytes manage to grow, but not as well as the other orchids, whose fungi substrate help them thrive in the tropical region.

Although the hypothesis may be true thus far, the observations in the growth of the orchids may be due to the plants being injured. Since their fungus substrate is removed, the action may lead to the plant being injured, and this may be the cause for struggle in the plants' ability to grow and thrive. Therefore, we must be wary of coming to conclusions, and a more thorough experimental standard must be applied.

Fernando hopes that research may benefit from the wide sample range in the Orchid Garden. He remains open and inviting to the idea for a researcher of orchids and epiphytes to stay at his Field Station as research is conducted.

Sightings and Patterns:

In the humid climate of the Yasuni National Park, we came across many fungi, both individual sprouts and in collective families, throughout the trails carved by Fernando and company. The following table demonstrates the recorded temperature and relative humidity of seven consecutive days. All the recordings were taken between 0700 and 0900 in the main cabin of the field station.

Date	**Temperature (C)**	**Relative Humidity**
12/31	25.3	95%
1/1	21.7	97.7%
1/2	21.4	99.9%

1/3	24.6	99.9%
1/4	24.7	99.9%
1/5	21.6	99.9%
1/6	20.8	99.9%
Mean	22.9	98.9%

Observationally, the high humidity and plentiful water levels in the soil enabled fungi to thrive. On the night hike of January 3rd, I observed a fungus spanning around 56 cm across and 24 cm wide. Using Daniel Winkler's "Amazing Amazon Mushroom" identification pictures, the fungal giant probably belongs to the *Amauroderma* genus[3].

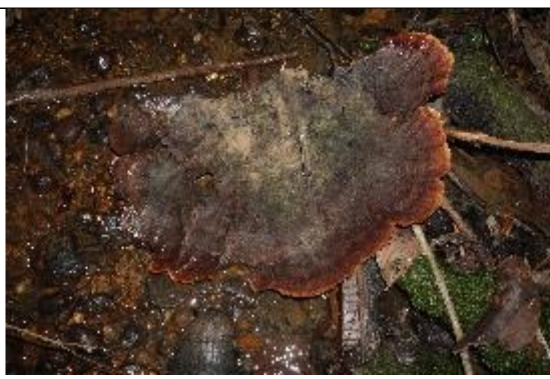

Figure 2: The giant Amauroderma, top

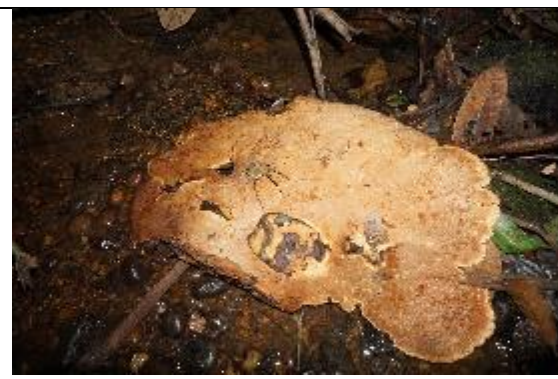

Figure 3: The giant Amauroderma, bottom

The night hikes provided for the discovery of a vast range of sightings, especially the *Cordyceps* family of fungi. The *Cordyceps* preys on insects and decomposes their bodies in order to produce fruit-bodies to sporulate so that the cycle of preying on insects can persist. Sight of a *Cordyceps* feasting upon an insect, such as a moth, is a chilling and mystifying phenomenon.

The *Cordyceps* fungus is highly medicinal, and this is due to the manner in which it grows. At first, its spores reach a host insect. In an example of an ant, the spores enter the body of the ant, and the ant begins exhibiting symptoms of illness. Its fellow ant colony members are trained to recognize the symptoms, and carry the ant far away from the colony to die on its own and reduce the risk of further colony contamination by the fungus. The mind of the ant is then controlled by the fungus, and the ant walks up a tree or goes to the underside of leaves and holds on. The fungus then decomposes the ant from the inside and a fruit-body emerges from the head and other appendages of the ant. This way, the spores are released into the air to be carried far in the distance so that the fungus can continue this cycle. Many cultures recognize the *Cordyceps* as highly medicinal, and this is due to the process that takes place as the fungus decomposes its insect host. As the insect is decomposed, viruses, bacteria, and other miniscule organisms attempt to decompose the insect. In response to these outsiders, the *Cordyceps* creates the anti-viral, anti-bacteria, and anti-fungal chemicals that are heralded by the scientific community as some of the most potent anti-cancer and anti-aging properties[11].

	
Figure 4: Cordyceps feasting on a moth	*Figure 5: Cordyceps feasting on a flying critter*

The cup fungus is a fantastic-looking mushroom – some of them even have eyelashes, as is apparent in these photos. We came across the *Cookeina tricholoma* on two separate occasions, once in the nighttime and once in the daytime[3].

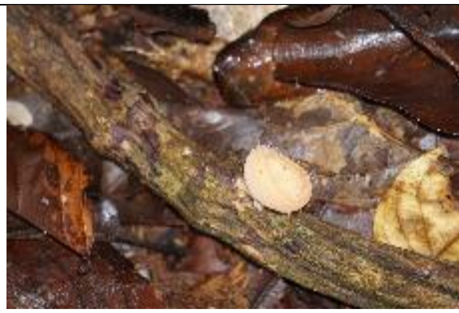	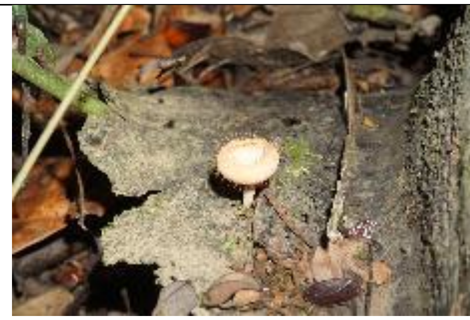
Figure 6: Cookeina tricholoma	*Figure 7: Cookeina tricholoma*

Another rare fungus that is endemic to the tropics of Ecuador was found on the 31 of December. Using Daniel Winkler's photos, it could probably be the *Staheliomyces cinctus*[3]. This 'phallic-looking' fungus reached its full erection around 0900 of December 31, and by 1500, ants began taking advantage of the *Staheliomyces cinctus'* death. The *Staheliomyces cinctus* is part of the stinkhorn family. It if found only in Central and South America, and the top of the stalk is covered with an unpleasant-smelling slimy spore mass that attracts insects like the stingless bees that help disseminate the spores[10].

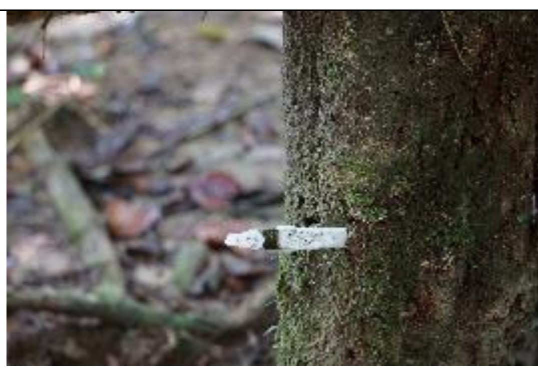	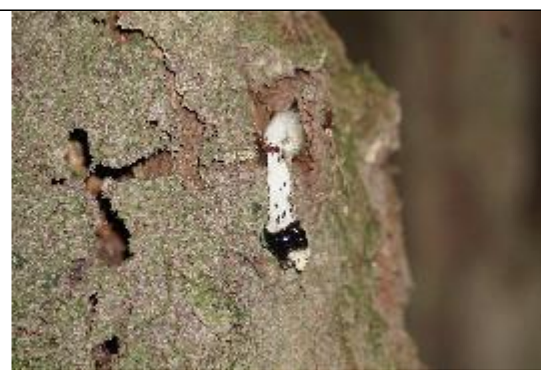
Figure 8: Staheliomyces cinctus at around 0900	*Figure 9: Staheliomyces cinctus at around 1500*

I observed fungi growing solitarily and in large groups. With the exception of perhaps the *Cordyceps*, which lives in and on insects, and one other fungus fruit-body, most of the fungi observed lived on wood and leaves. The fungus in exception of the rule was found growing on a termite mound.

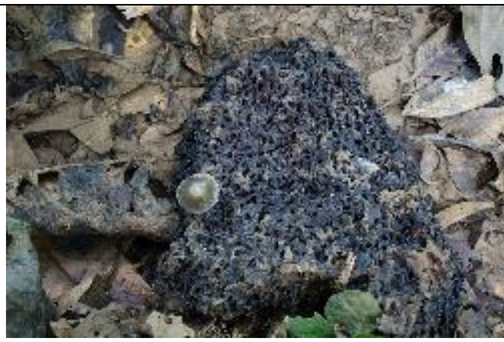

Figure 10: gilled mushroom on termite round

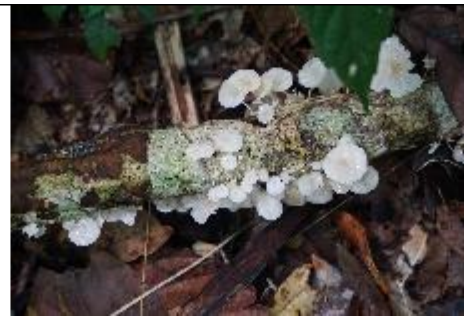

Figure 11: family cluster growing together

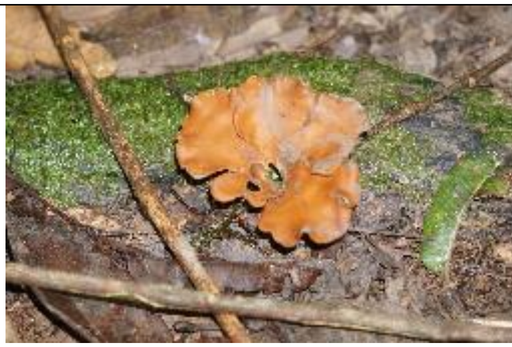

Figure 12: Single fungus growing

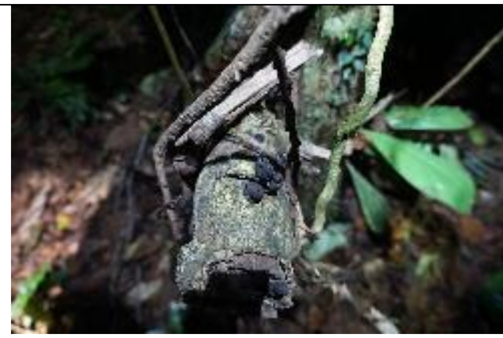

Figure 13: Black club-like fungi

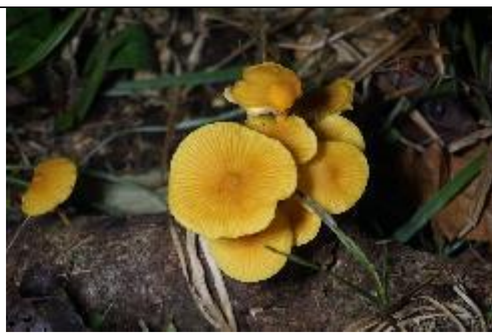

Figure 14: Gilled mushroom family

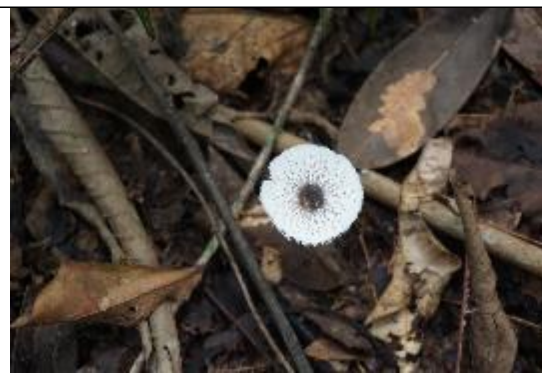

Figure 15: a unique fungus growing alone

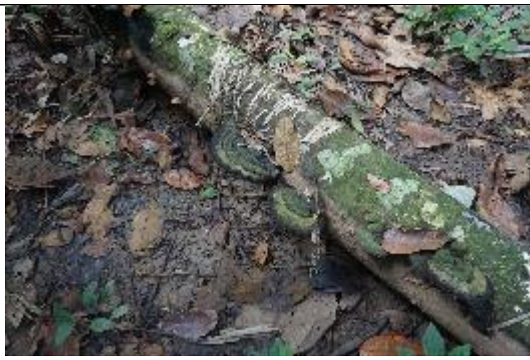	
Figure 16: polypores decomposing wood	*Figure 17: more polypores decomposing a log*
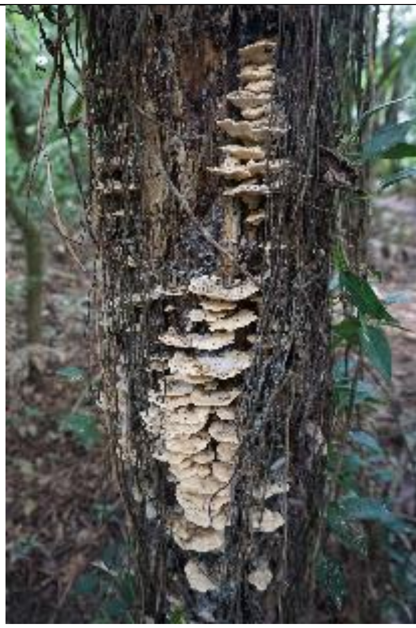	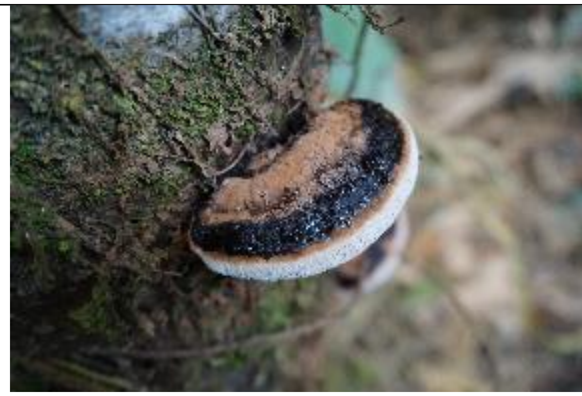
Figure 18: a family of polypores ascending great heights	*Figure 19: a true polypore*
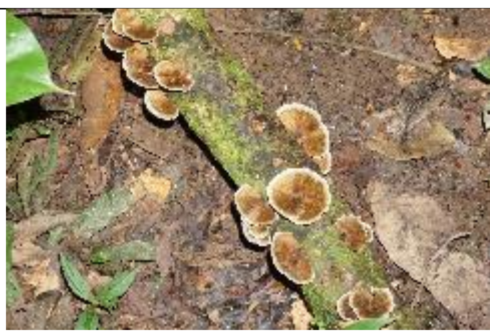	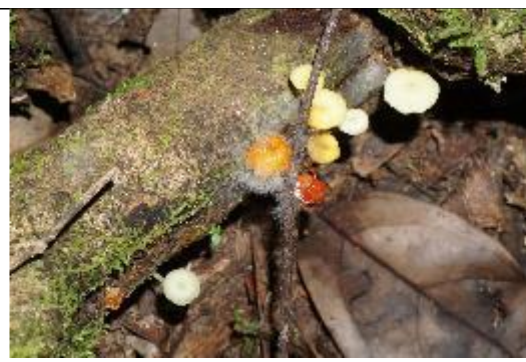
Figure 20: polypore-looking fungi	*Figure 21: a colorful display by these gilled fungi*

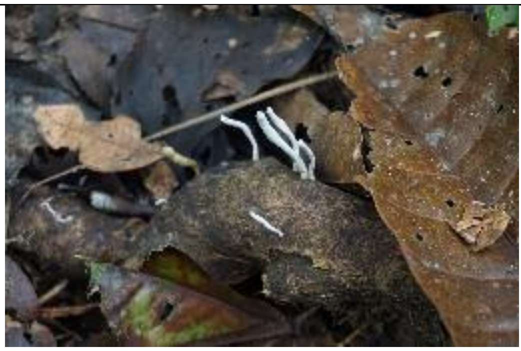

Figure 22: club fungi reaching for the heavens

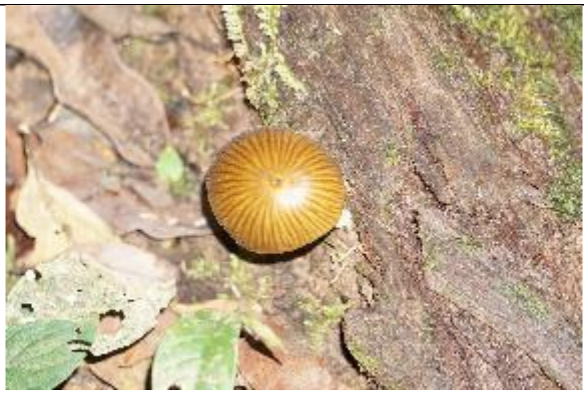

Figure 23: a unique gilled fungus growing alone

Figure 24: large polypores taking over a log

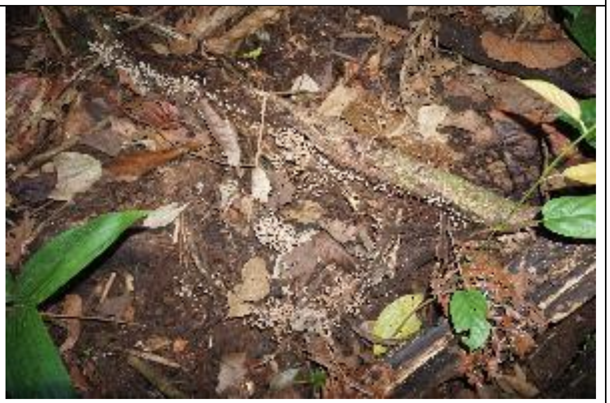

Figure 25: a colony of tiny mushrooms in their youth

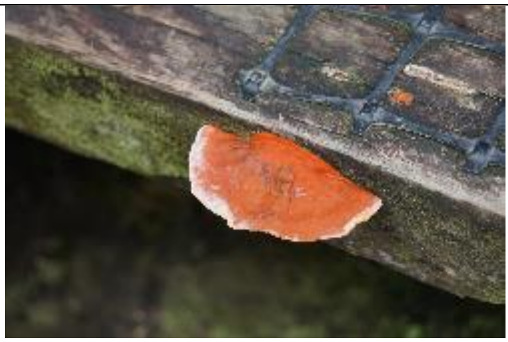

Figure 26: a polypore that lived for the entire week we were at the Lodge

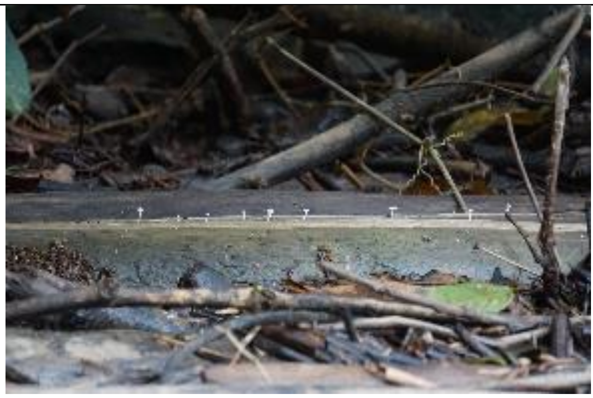

Figure 27: tiny gilled mushrooms lining up

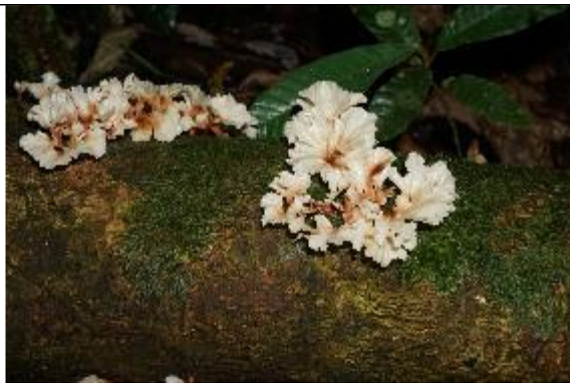	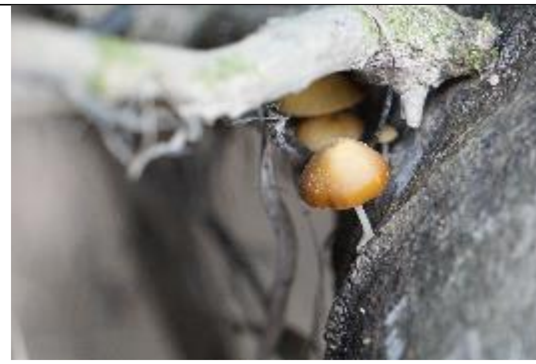
Figure 28: jelly-like fungus	*Figure 29: the classic gilled mushroom*
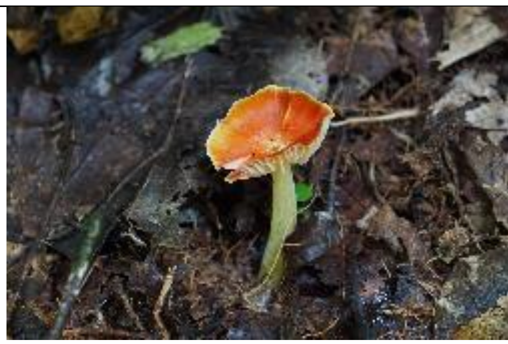	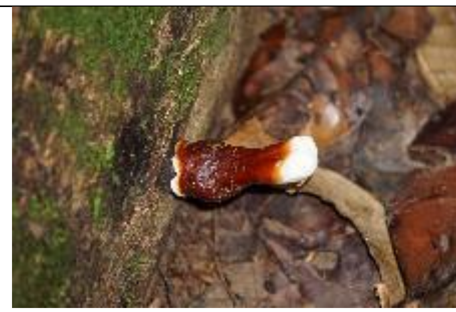
Figure 30: a unique red fungus at its end of life	*Figure 31: a unique mahogany club-like fungus*

For the last night of hiking, Fernando led the students some ten minutes down the trails to a magical sighting: the bioluminescent fungus. We turned our flashlights off, and waited for our eyes to adjust to the natural lighting. The fungi illuminated the floor in little specks. It was like looking upwards at the sky on a cloudless and moonless night, with the stars speckling. We bunched up the leaves with bioluminescent fungus on them, and using the Sony A6000 mirrorless camera, I took a 30-second time-lapse photo.

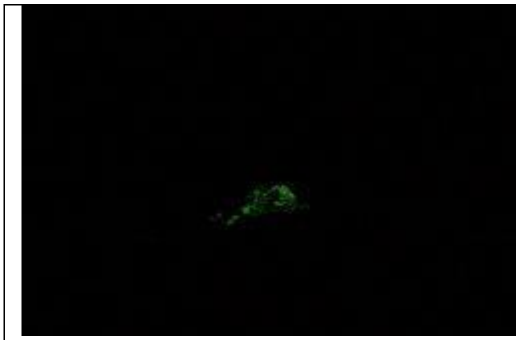

Figure 32: Bioluminescent fungus, long exposure

Discussion

Fungi-Plant Symbiosis:

From Fernando's experiment, we learn that the orchids thrive when paired with their natural fungi mycorrhiza, while the orchids whose fungi is removed tend to struggle in growth. In other experiments performed by other teams of scientists, similar results present a similar conclusion. According to Smith and Smith in *Arbuscular Mycorrhizas and Plant Growth*, the "hidden mycorrhizal benefits related to nutrition, avoidance of toxins, increased competitive ability, together with other non-nutritional advantages such as increased plant tolerance to drought and to some diseases will result in increased plant success"[4]. Further, in a review paper of the *Studies of Mycorrhizal Fungi of Chinese Orchids and Their Role in Orchid Conservation in China*, the authors report an "enhanced survival rate of seedlings and a promotion of seedling growth, with the effects of the fungal elicitors on stimulating seedling growth confirmed."[5]

The orchids thrive with the fungi due to the mycorrhizal ability to transfer nutrients. Mycologist Paul Stamets presents these findings in his book *Mycelium Running.* He claims, based off others' research, that "the mycelium extends the plant's range for absorbing nutrients and water while conferring a fungal defense against invasive diseases"[6]. This may occur since the surface area of the mycorrhizal fungi may be 10 to 100 times than the surface area of the plant leaves, allowing the growth of the plant partners to accelerate. In return, the fungi benefit from access to plant-secreted sugars. The symbiosis of plants and fungi is a stellar partnership in the natural world, as both sides benefit from the exchange, while those who refrain from the partnership struggle growing in comparison to those in symbiotic partnership.

Though the results of the orchid experiment show interesting findings, we must scrutinize the findings due to the manner in which the experiment is conducted. I do not really know if the orchids fail to thrive because their fungi mycorrhiza are removed, or if this because the orchid plant is injured in the process of its fungi mycorrhiza removal. In order to make the findings of this experiment more conclusive, we may consider a different means of separating the orchids from their mycorrhiza. For example, using an incision knife to cut the fungi mycorrhiza from the orchid roots in a precise manner may provide us with more meaningful results to interpret.

Bioluminescent Fungi:

The bioluminescent fungi observed during the final night hike at the Shiripuno Field Station uniformly raised an interesting question: *why* is the fungus (which could potentially be bacteria) exhibiting bioluminescent properties? Some creatures, such as the fireflies, use their bioluminescence to attract mates[7]. The deep-sea fish use their light to be able to find mates and food. The squid, shrimp, and lanternfish use bioluminescence to keep their schools together in the dark ocean waters. The angler fish uses its dorsal fin to lure its prey. And others, such as the bioluminescent stinkhorn fungi, use light to attract insects. According to Jones, this 'foxfire' fungus emits a yellow-green glow that is visible from several meters, and the light attracts the flies that pick up fungi spores and inadvertently disperse them throughout the woods[7]. The bioluminescent properties of the fungi and the other creatures mentioned occur in similar means – a luciferin enzyme with a luciferase substrate, leading to oxidized luciferin using a light emitter, with the final product called oxyluciferin[9].

We see a similar theory postulated by Lloyd. Since the bioluminescent chemical reaction uses energy, Lloyd states that "one is prompted to speculate on the adaptive significance of this phenomenon"[8]. The speculation is that the "fungal light may attract insects that perform some service for the fungi”, the same service postulated by Jones: the insect may eat the fungi spores and later deposit them elsewhere in the feces.

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