



*“Mushrooms, humans and nature  
in a changing world”*

**IWEMM9** Proceedings  
**MEXICO**

Jesús Pérez-Moreno  
Alexis Guerin-Lagette  
**Editors**



# **Mushrooms, humans and nature in a changing world**

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**Cover:** Rosaura Hernández-Mejía a Mixtec girl gathering wild mushrooms in Oaxaca, México; and clockwise pictures of *Laccaria laccata*, *Tuber melanosporum*, *Tricholoma magnivelare* and *Boletus edulis* s.l. (**Photos:** *Jesús Pérez-Moreno and Faustino Hernández-Santiago*)

**Back:** Stylized Aztec motifs; Mexican offering with edible wild mushrooms, corns and beans (Photo courtesy of **Lucila Aragon-Carrillo**)

Technical support: PhD Magdalena Martínez-Reyes  
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# Preamble

Currently, we live a ubiquitous world-wide crisis, which includes an environmental crisis, an unequal economic distribution, a bio-cultural erosion - at a speed never seen before in our history - of the traditional knowledge that was generated during millennia, a destruction of unique ecosystems including their biodiversity, and a severe obvious climate change. Our planet, also called *Gaia* by the British geo-physiologist James Lovelock and the American microbiologist Lynn Margulis is a super-organism, which is alive and has its own homeostatic mechanisms to survive. We have to recognize the perspective that all living being, and the abiotic factors of the earth are inexorably linked and mutually affected. If *Gaia* is a living being which is sick, then its disease is humankind. We have destroyed and transformed into industrial areas, cities or crop fields more than 70% of the surface of the earth. Currently there is no point on earth which has not been affected by our existence. The future between the relationship between humankind and earth includes three possible scenarios: i) the patient dies, in this case we as human beings will disappear along with the earth; ii) the patient gets cured, in this case we as human beings will disappear and the earth will survive; and iii) there is an equilibrium between disease and patient. In this case, we as human beings survive and the earth survives as well. To develop this third option we need a change of conscience, a change of appropriation of natural resources and a radical change in the way we are living, acting and thinking. Can the scientific knowledge and technical development of edible ectomycorrhizal fungi contribute to the development of a better environment? Can it lead to social rural development, to a fair trade for poor communities, and therefore attenuate the biodiversity and cultural erosion, and contribute to mitigate climate change? There are two positions, the first one; called realistic by some people is that this is not possible. The second one called utopic by some people is that this is completely feasible. Behind the IWEMMs, we have observed and contributed to this dream, even showing in several cases that making a difference through research on edible mycorrhizal fungi is completely possible. Edible ectomycorrhizal mushrooms are an important ecological, social, cultural

and economic component of the ecosystems of the world. The sustainable use of this non-timber forest product has shown to be a boost to rural development. We need to take quick actions, innovate, and use the scientific and technological advances to contribute to solve worldwide problems of paramount importance. It is not only our responsibility as a generation but also our privilege to dream and to work for the construction of a better world. IWEMM9 welcomes the presentation of 127 research works, presented by authors from more than 20 countries from five continents, in *Colegio de Postgraduados, Mexico* from July 10 to 14, 2017. Hoping you have a pleasant stay, receive a very warm welcome from one of the largest genetic centers of biological, mycological and cultural diversity worldwide.

*The Editors*

***Texcoco, Mexico and Christchurch, New Zealand  
Summer, 2017***

## Topics

- ❖ Biodiversity
- ❖ Global climate change
- ❖ Cultivation
- ❖ Food security and health
- ❖ Biotechnology
- ❖ Ecology
- ❖ Molecular biology
- ❖ Genomic sciences
- ❖ Bioactive compounds
- ❖ Biocultural importance
- ❖ Conservation
- ❖ Sustainability
- ❖ Taxonomy
- ❖ Evolution and genetics
- ❖ Traditional knowledge
- ❖ Economic importance

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# SPONSORS

We deeply appreciate the generous support from our sponsors from 3 continents; without them our conference would not have been possible. From the bottom of our hearts we express them our sincere gratitude. We wish you all the best in your personal and professional life!

*Colegio de Postgraduados*

Mexican Council of Science and Technology (CONACyT)

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Climate Change Commission, Cámara de Diputados LXIII Legislatura, **(Mexico)**

The logo of IWEMM9 is courtesy of the prestigious Mexican artist and scientist Professor J. Cruz García Albarado (Cruzgaali).

It was based on ancient Mexican pictographic representations of two mushrooms from the *Mixtec Codex Yuta tnoho* dated from the XV century; a tree from the *Mendoza Codex* made by the Aztecs in 1540; and a human representation in a cave painting made three thousand years ago in western Mexico.



The result is a contemporaneous fascinating mixture of color, movement and Mexican identity representing the motto of the IWEMM9:

*“Mushrooms, humans and nature in a changing world”*



### Woman with mushroom

- Fired clay modeling
- Classic Colima
- Dated from AD 100 to 700
- 44.5 x 22.5 cm
- University of Colima collection, *Museum Alejandro Rangel Hidalgo*





## PROGRAM

### Monday July 10

Time	Activity	Place
14:00-18:00	Registration	Hotel Santa Bertha Hall in Texcoco

### Tuesday July 11

Time	Activity	Place
09:50-10:05	Introductory welcome and presentation of the Presidium by the IWEMM9 Chairman, <b>Dr. Jesus Pérez Moreno</b> from <i>Colegio de Postgraduados</i>	
10:05-10:15	Speech by the International Secretary of the IWEMM9, <b>Dr. Alexis Guerin-Laguette</b> from the <i>New Zealand Institute for Plant and Food Research</i>	
10:15-10:30	Acknowledgements of the IWEMM9 Sponsors	Lecture Hall
10:30-10:45	Video " <b><i>Mushrooms, People and nature in a Changing World</i></b> " produced by the Mexican film maker <b>Jaime Kuri</b>	
10:45-10:55	Video of the <i>IWEMM9</i> logo courtesy of the Mexican Scientist <b>Dr. Cruz García Alvarado</b> (Cruzgaali)	
10:55-11:10	Official Opening Ceremony by a Mexican authority	



11:10-11:30	Coffee break and performance of Mexican <i>charros</i>	Garden of Colegio de Postgraduados
11:30-11:45	Move to the Lecture Hall	
11:45-12:45	<p><b>Opening Keynote Lecture</b></p> <p><i>Networks of power and influence: the role of ectomycorrhizal mycelia in the growth of forest trees and the support of fungal fruitbody production</i></p> <p><b>Prof. Sir David J Read</b></p> <p>Department of Animal and Plant Sciences, University of Sheffield, <b>England</b></p>	Lecture Hall
12:45-14:15	<p><b>Oral presentations-Session 1</b></p> <p><b>Diversity, Taxonomy and Ecology</b></p>	Lecture Hall
12:45-13:00	<p>Diversity and community structure of ectomycorrhizal fungi from Mexican neotropics, with notes on edible mushrooms</p> <p><b>GARIBAY-ORIJEL Roberto <i>et al.</i> (Mexico)</b></p>	
13:00-13:15	<p>Observations on edible mycorrhizal mushrooms (EMMs) with a giant natural wealth and truffle plantations with a great development potential in China</p> <p><b>LIU Pei-Gui <i>et al.</i> (China)</b></p>	
13:15-13:30	<p>Soil mesofauna and sporomes of edible ectomycorrhizal mushrooms: an approach of the interaction</p> <p><b>DÍAZ-AGUILAR Irma and PÉREZ-MORENO Jesús (Mexico)</b></p>	



13:30-13:45	Phylogenetic positions of Caesar's mushrooms in Guatemala <b>KODAIRA Miyuki <i>et al.</i> (Japan and Guatemala)</b>	Lecture Hall
13:45-14:00	Ecology and taxonomy of the desert truffles in the North of Africa <b>KHABAR Lahsen (Morocco)</b>	
14:00-14:15	Soil conditions of Japanese truffles <b>FURUSAWA Hitomi <i>et al.</i> (presentation by <u>YAMANAKA Takashi</u>) (Japan)</b>	
14:15-14:30	Milkcaps, now <i>Lactarius</i> , <i>Multifurca</i> and <i>Lactifluus</i> : New insights in the phylogeny and systematic position of the edible taxa <b><u>VERBEKEN Annemieke</u> and <u>DE CROP Eske</u> (Belgium)</b>	
14:30-15:45	Lunch	Garden of <i>Colegio de Postgraduados</i>
15:45-17:00	<b>Oral presentations-Session 2 Sustainability, Traditional Knowledge, Conservation and Economic importance</b>	Lecture Hall
15:45-16:00	Truffles as food and medicine in China <b>TAN Xinpei and <u>WANG Bin</u> (China)</b>	
16:00-16:15	European Grouping of Territorial Cooperation (EGTC) for sustainable management and valorization of wild edible mushrooms under global change <b>MARTÍNEZ-PEÑA Fernando <i>et al.</i> (Spain and France)</b>	



16:15-16:30	<p>Traditional ethnomycological knowledge and change process in Mapuche-Creole communities: a study on wild edible fungi from Patagonian <i>Nothofagus</i> forests, Argentina</p> <p><b>TOLEDO Carolina V. et al.</b>  <b>(presentation by <u>BARROETAVERÑA Carolina</u>) (Argentina)</b></p>	Lecture Hall
16:30-16:45	<p>Edible wild mushrooms of Ethiopia: neglected non-timber forest products</p> <p><b>DEJENE Tatek et al. (presentation by <u>MARTÍN-PINTO Pablo</u>) (Ethiopia and Spain)</b></p>	
16:45-17:00	<p>Mycotourism as a driver of rural development</p> <p><b>LATORRE Joaquin et al. (Spain)</b></p>	
17:00-17:15	Break	Lobby of Lecture Hall
17:15-18:30	<p><b>Oral presentations-Session 3  Food Science and Health and  Biocultural importance</b></p>	Lecture Hall
17:15-17:30	<p>Introducing mushroom fruiting patterns from the Swiss National Poisons Information Centre</p> <p><b>EGLI Simon et al. (Switzerland and United Kingdom)</b></p>	
17:30-17:45	<p>Mushroom-stones of Guatemala: origin, diversity and new discoveries</p> <p><b>FLORES ARZÚ Roberto (Guatemala)</b></p>	



17:45-18:00	Edible Ascomycetes in Mesoamerica: a review  <b>MEDEL ORTIZ Rosario et al.</b> <b>(Mexico, Guatemala, El Salvador and Honduras)</b>	Lecture Hall
18:00-18:15	It is never too late to learn. On the (recent) transition from mycophoby to mycophily in Sardinia  <b>COMANDINI Ornella and RINALDI Andrea C. (Italy)</b>	
18:15-18:30	Edible ectomycorrhizal mushrooms, nature and humans in a changing world: a Mexican perspective  <b>PÉREZ-MORENO Jesús et al.</b> <b>(Mexico)</b>	

### Wednesday July 12

Time	Activity	Place
10:00-11:00	<b>Keynote Lecture</b>  <i>Cultivation of truffles: history, technology and challenges</i>  <b>Pierre Sourzat</b> <i>Truffle Expert, Bel Air, 46240, Ussel,</i>  <b>France</b>	Lecture Hall
11:00-11:30	IWEMM9 official photography by Studio Azul Texcoco	Library Entrance of Colegio de Postgraduados



11:30-12:30	<b>Oral presentations-Session 4 Cultivation Part A</b>	Lecture Hall
11:30-11:45	Advances on spawn production and strain conservation of edible ectomycorrhizal mushrooms in Eastern Mexico  <b>MATA Gerardo (Mexico)</b>	
11:45-12:00	Monitoring pests in summer truffles ( <i>Tuber aestivum</i> ) during 2016-2017  <b>DANAY Ofer et al. (Israel)</b>	
12:00-12:15	Development of edible desert truffles as new crops in Israel: characterization of morphology, molecular markers, volatile profiles, and agrotechnologies  <b>KAMLE Madhu et al. (presentation by SITRIT Yaron) (Israel and United States of America)</b>	
12:15-12:30	Advances in desert truffle cultivation in Spain  <b>MORTE Asunción et al. (Spain)</b>	
12:30-12:45	<b>International Photography exhibition “Mushrooms of the World”</b>	Lobby of Lecture Hall
12:45-14:00	<b>Poster presentation Session</b>	Lecture Hall outdoors
14:00-16:00	Lunch	Garden of <i>Colegio de Postgraduados</i>



16:00-17:15	<b>Oral presentations-Session 5 Cultivation Part B</b>	Lecture Hall
16:00-16:15	Cultivation of edible ectomycorrhizal mushrooms in China  <b>FU-QIANG Yu <i>et al.</i> (China and New Zealand)</b>	
16:15-16:30	Advances in the cultivation of truffles in Canada  <b>BERCH Shannon (Canada)</b>	
16:30-16:45	Trials for the cultivation of <i>Tricholoma matsutake</i> in Nagano prefecture, Japan  <b>FURUKAWA Hitoshi <i>et al.</i> (Japan)</b>	
16:45-17:00	How is <i>Tricholoma matsutake</i> mycorrhization affected by potentially competing microorganisms?  <b>YAMADA Akiyoshi <i>et al.</i> (Japan)</b>	
17:00-17:15	Advances in the cultivation of Saffron milk cap in New Zealand  <b>GUERIN-LAGUETTE Alexis <i>et al.</i> (New Zealand)</b>	
17:15-17:30	Get on the transport to Mexico City	Parking lot of <i>Colegio de Postgraduados</i>
17:30-19:30	Transportation to Mexico City	Texcoco-Mexico City road



20:00-22:00	International performance of Mexican Folkloric Ballet of <i>Amalia Hernández</i>	Palace of Fine Arts, Mexico City
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### Thursday July 13

Time	Activity	Place
08:00-18:00	<ul style="list-style-type: none"> <li>• Mycological trail in oak, pine and fir forests nearby Texcoco with local mushroom gatherers (<b>Option 1</b>)</li> <li>• Visit to the ancient city of <i>Teotihuacan</i> (<b>Option 2</b>).</li> </ul>	<p>Forests nearby Texcoco</p> <p>Ancient City of <i>Teotihuacan</i></p>

### Friday July 14

Time	Activity	Place
09:00-9:30	Photography of people wearing International or Mexican Typical Clothing by Studio Azul Texcoco	Library Entrance of <i>Colegio de Postgraduados</i>
09:00-14:00	<p><b>Biocultural Fair</b></p> <p>Fresh mushroom Exhibition; Museographic exhibition "<b>Codices and Mushrooms</b>"; Ludic activities for children and adults; Handicraft exhibition; Mycogastronomy taste by Mexican ethnic groups; Typical Mexican and International clothing; IWEMM9 exhibitors.</p>	Garden of <i>Colegio de Postgraduados</i>
14:00-15:30	Lunch	Garden of <i>Colegio de Postgraduados</i>



15:30-16:45	<b>Oral presentations-Session 6</b>	Lecture Hall
	<b>Climate Change, Molecular Biology and Genomic Sciences</b>	
15:30-15:45	Expanding truffle growth: climate change induced shifts in latitudinal distribution of <i>Tuber melanosporum</i> cultivation	
	<b>PAUL Thomas and BÜNTGEN Ulf (United Kingdom, Switzerland and Czech Republic)</b>	
15:45-16:00	Do climate changes affect the fruiting timing of wild mushroom populations in Israel?	
	<b>LEWINSOHN Dalia (Israel)</b>	
16:00-16:15	How does management affect <i>Boletus edulis</i> extra-radical soil mycelium and sporocarp production? A case study in <i>Cistus ladanifer</i> scrublands	
	<b>MEDIAVILLA Olaya et al. (Spain)</b>	
16:15-16:30	Soil mycelium and sporocarp dynamics of <i>Boletus edulis</i> in managed <i>Pinus sylvestris</i> stands	
	<b>PARLADÉ Xavier et al. (Spain)</b>	
16:30-16:45	The comparative genomics of <i>Laccaria trichodermophora</i> towards the understanding of the wide ecological range of the genus	
	<b>ÁNGELES-ARGÁIZ Rodolfo Enrique et al. (Mexico)</b>	



16:45-17:45	<p><b>Closing Keynote Lecture</b></p> <p><i>Life and mushrooms - Time through 20 years of IWEMM</i></p> <p><b>Dr. Wang Yun</b></p> <p><i>Kunming Institute of Botany, Academia Sinica, Kunming; Biotechnology and Germplasm Resources Institute, Yunnan Academy of Agricultural Sciences, Kunming, China; Plant and Food Research, New Zealand 15 Lynfield Ave. Ilam, Christchurch, New Zealand.</i></p> <p><b>China and New Zealand</b></p>	Lecture Hall
17:45-18:00	Conclusions of IWEMM9 by Drs. Alexis Guerin-Laguette and Wang Yun	Lecture Hall
18:00-18:15	Tribute to previous IWEMMs	
18:15-18:30	International and Mexican student award ceremony	
18:30-18:35	Poster and Photography award ceremony	
18:35-19:00	<b>IWEMM10</b> Voting session	
19:00-19:05	Announcement of the Venue of the <i>International Conference on Mycorrhiza 10</i> (ICOM10) by Dr. Roberto Garibay Orijel	
19:05-19:10	Closing Ceremony of the IWEMM9	Lecture Hall
19:10-20:30	Transportation to the Hotel and from there to the <i>Hacienda Pintoraco</i>	
20:30-24:00	Gala dinner and <b>Mexican Fiesta</b>	<i>Hacienda Pintoraco</i>



# Keynote Lectures





## **NETWORKS OF POWER AND INFLUENCE: THE ROLE OF ECTOMYCORRHIZAL MYCELIA IN THE GORWTH OF FOREST TREES AND THE SUPPORT OF FUNGAL FRUITBODY PRODUCTION**

David J Read

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**Keywords:** Fruit body production, photosynthate supply, ectomycorrhiza, vegetative mycelium, carbon flow, mineral nutrient capture

The majority of edible mushrooms are formed by ectomycorrhizal associations with forest trees. If we are to understand, perhaps even manage, their production we need to learn more about the structural, physiological and ecological factors involved in their formation. This lecture first examines the development of novel techniques enabling the non-destructive analysis of the vegetative mycelium that sustains fruit body production. It then identifies the photosynthetic partner, the tree, as the primary source of the carbon required for fruit body production and explores the pathways through which the necessary sugars are transferred from the host tree to distal parts of the mycelial network where fruit body initiation takes place. The processes whereby the vegetative mycelium, in turn, explores the soil to facilitate capture of the mineral nutrients necessary to sustain photosynthesis of the host plant are described, and the possible consequences of nutrient ‘sharing’ within the forest ecosystem are considered. The vital roles played by the fungal mycelium in mobilisation of nitrogen and phosphorus from complex organic sources is stressed, and some quantification of the dimensions of ‘the wood-wide web’ formed by mycelial networks in soils is provided.

**Topic:** Plant and fungal nutrition



## CULTIVATION OF TRUFFLES: HISTORY, TECHNOLOGY AND CHALLENGES

Pierre Sourzat

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**Keywords:** *Tuber*, mycorrhized plant, calcareous soil, watering, tree pruning fungal contamination, global warming

The cultivation of the truffle was invented in France at the beginning of the 19th century by planting seeds of acorns in suitable limestone areas. The truffle production of *Tuber melanosporum* continued to increase in France during the nineteenth century until the Great War of 1914-18. The destruction of the European vineyard by the Phylloxera aphid in 1870-80 made available great spaces for truffle cultivation. The decline in the production of truffles increased in France after the First World War until the 1970s. Truffle growers then organized themselves into unions and federations to stop this decline. In 1973, following the work of INRA (French acronym of the National Institute of the Agronomic Research) in collaboration with Italian scientists, the first controlled mycorrhized plants were marketed. Since then, many plantations have been carried out with public subsidies to increase the production of *Tuber melanosporum*. The cultivation of *Tuber uncinatum* / *aestivum* is less developed than those of *Tuber melanosporum*. The Italians are very motivated by the production of different *Tuber* species, especially by *Tuber magnatum*. In Spain, plantations with *Tuber melanosporum* have spread considerably since the 1980s with very good results currently. Technically, the success of black truffle production depends on 4 main factors: 1) a well mycorrhized plant, 2) a calcareous, aerated, draining soil with good biological activity, 3) a temperate climate, and 4) appropriate cultural and crop management techniques. Cultivation techniques mainly concern tillage, watering and tree pruning. The field of techniques has recently been expanded with the "truffle traps" and control of "the pressure of fungal contamination". With the "truffle traps", one is supposed to reinforce the truffle potential and to ensure the presence of the two sexual types. For the control of fungal contamination, "truffle bastions" are recommended on large plantations with the creation of sanitary perimeters. The reliability of the plantations and the regularity of the results currently constitute the challenge of truffle cultivation. The first limiting factor is the drought due to global warming. The second one is fungal contamination by competing mycorrhizal fungi, in particular *Tuber brumale* against *Tuber melanosporum*. The third one is a better understanding of the nutritional requirements and sexual reproduction of truffles. A better understanding of the ecological conditions of natural truffles and highly productive plantations should help us to address these challenges. Finally, the conditions for the production of different *Tuber* species outside Europe (Australia, New Zealand, Asia, America and Africa) can help us to a better understanding of the truffle cultivation in general.

**Topic:** Cultivation



## LIFE AND MUSHROOMS - TIME THROUGH 20 YEARS OF IWEMM

Yun Wang

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**Keywords:** IWEMM, history

A consensus to have an independent international meeting on edible mycorrhizal mushrooms (EMMs) was proposed at the EMMs Workshop of the 1<sup>st</sup> International Conference on Mycorrhizae (ICOM1), 4-9 Aug 1996, Berkeley, USA. After discussion, the decision was made to have the 1<sup>st</sup> IWEMM aligned with the ICOM2, Uppsala, Sweden, 1998. The IWEMM1 was still run as a workshop with 82 participants. The 2<sup>nd</sup> and 3<sup>rd</sup> IWEMM were aligned in time (year) with the 3<sup>rd</sup> and 4<sup>th</sup> ICOM, respectively, but at different locations. The 2<sup>nd</sup> IWEMM was held in Christchurch, New Zealand, 4 days before the 3<sup>rd</sup> ICOM in Adelaide, Australia, 8-13 July 2001. The 3<sup>rd</sup> IWEMM was held in Victoria University, Canada, 3 days after the 4<sup>th</sup> ICOM in Montréal, 8-13 Aug 2003. The topics of these two meetings focused on the cultivation of EMMs. The 4<sup>th</sup> IWEMM was held in Murcia, Spain, 28 Nov-2 Dec 2005 with over 120 participants from 20 countries and thoroughly separated from the ICOM5 (Granada, Spain, July 2006). The meeting emphasized on rural development. Since then the IWEMM has become an independent international conference, however, we continue the tradition of using “Workshop” for our meeting. The 5<sup>th</sup> IWEMM was held in Chuxiong, China, 20-29 Aug 2007 with over 300 participants from more than 20 countries. This was the 1<sup>st</sup> time an IWEMM was organized in a developing country. The huge diversity of EMM resources in Yunnan was stunning, which are an important livelihood for locals. Scientific exploitation and protection of these precious resources are urgent tasks. Proceedings were produced as a Supplement of Acta Botanica Yunnanica, Suppl. XVI, 2009. The 6<sup>th</sup> IWEMM was to be held in Chile in 2009. Unfortunately the big quake in Chile made the workshop cancelled finally. Thankfully, Prof. Lahsen Khabar organized the IWEMM6 in Rabat, Morocco, 6-10 April 2010 urgently but successfully.



The 7<sup>th</sup> IWEMM was held in La Antigua, Guatemala 29 July – 3 Aug 2013 with over 100 participants. The rich and long history of mushroom cultures including Maya culture deeply captivated all participants. The Proceedings was produced with lovely photos. The 8<sup>th</sup> IWEMM was held in Cahors, France, 10-17 Oct. 2016. The large audience (over 110 abstracts from 25 countries), the long history and great knowledge of using and growing truffles, along with the wonderful French food and wine culture, has made this workshop so successful that we will never forget it. I was very lucky to attend all the IWEMMs including the seminal workshop in Berkeley in 1996. It is a privilege and a true happiness to recall the IWEMM memories at the 9<sup>th</sup> IWEMM in Texcoco, Mexico, 10-14 July 2017.

**Topic:** IWEMM history



# Oral presentations





## DISTRIBUTION OF EDIBLE ECTOMYCORRHIZAL MUSHROOMS IN GUATEMALA: ECTOMYCORRHIZAL GENERA AND ENDEMIC SPECIES COLLECTED FROM 1980 TO 2016

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**Keywords:** Neotropic, endemism, pine-oak forest, hot spots, topography

In this study, we present a revision of the diversity of ectomycorrhizal mushrooms collected in Guatemala by the research staff of UBIOTAH, since 1980s to 2016. The information was obtained from the database of *Micoteca Rubén Mayorga Peralta – MICG–*, from which we proceeded to elaborate an updated list of genera and species of ectomycorrhizal mushrooms reported for the country, considering the number of individuals for each genus, date of sample and location of collected specimens. The list enabled us to create a map that illustrates the main localities and specific sites of sampling of ectomycorrhizal mushrooms over the last decades. We also present a list of the ectomycorrhizal genera found to date and a list of species consumed by local people, especially from the genera *Amanita*, *Boletus*, *Cantharellus*, *Laccaria*, *Lactarius*, *Ramaria* and *Russula*. Graphics illustrate sampling every five year period and by altitude in the country. The highly variable topography and the diversity of ecosystems in Guatemala contribute to the wide range of distribution of ectomycorrhizal mushrooms and to their frequent endemism. The latter point will be illustrated with pictures of endemic species.

**Topic:** Biodiversity



## DIVERSITY OF ECTOMYCORRHYZAL FUNGI ASSOCIATED WITH *Pinus maximartinezii* AN ENDANGERED ENDEMIC SPECIES OF MEXICO

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**Keywords:** ectomycorrhizae; endemic species, endangered pines, conservation, blue pine

Conifers constitute approximately 60% of the total number of gymnosperms distributed world-wide and they are mainly composed by species of the genus *Pinus*. *P. maximartinezii* Rzedowski is endemic to Mexico and is characterized by a large size of strobos; and seeds which can be up to 3 cm long and are edible and highly nutritious. The species is highly appreciated as ornamental and an alternative to recover degraded areas. However, due to its geographically limited distribution to two small areas of northern Mexico; and therefore a low genetic variability, it is classified as endangered in the Red List of Threatened Species (IUCN). Despite the importance of the species, conservation efforts have been scarce. Additionally the naturally associated mycorrhizal fungi are lacking. The present work evaluated the diversity of ectomycorrhizal fungi associated with *P. maximartinezii* from a Neartic forest in the state of Zacatecas, Mexico. Ectomycorrhizae were obtained using the permanent square method to collect roots of adult trees in their natural habitat; macro and micromorphological characterization of the morphotypes was performed. Sampling was carried out during the dry season. The results showed that about 70% of the mycorrhizal roots were dead and that the diversity of live ectomycorrhizal fungi was represented by eight morphotypes, of which two represented more than 50% of the total relative abundance. The low intra-generic diversity found may be a safety mechanism to maintain the productivity of the forest under conditions of stress, caused by factors such as low fertility and drought. This is the first report describing the diversity of morphotypes associated with *P. maximartinezii* in its natural distribution areas. Financial support from the project CONACyT 246674 is acknowledged.

**Topic:** Conservation



## INFLUENCE OF TWO ECTOMYCORRHYZAL FUNGI ON THE BACTERIAL DIVERSITY OF MICROBIOME OF *Pinus greggi* MYCORRHIZOSPHERE

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**Keywords:** Metagenomic, microbiome, ectomycorrhizal symbiosis, biodiversity

In forest ecosystems plant roots are associated with a vast community of microorganisms, which play key roles in soil fertility, nutrition and plant health. Ectomycorrhizas changes the characteristics of the surrounding soil and creates an environment called ectomycorrhizosphere where microbial communities differ from those of the surface of soil and rhizosphere. This work evaluated the influence of two edible ectomycorrhizal fungi *Laccaria laccata* and *Hebeloma mesophaeum*, inoculated alone or in combination with the N<sub>2</sub>-fixing bacteria *Azospirillum brasiliense*, on the composition of the bacterial community of *Pinus greggi* microbiome grown in greenhouse. Root and surrounding soil samples were collected from one-year-old plants, which showed evidence of ectomycorrhization and a positive effect on plant growth. Genomic libraries of the 16S rDNA gene were generated. The DNA was extracted with Soil DNA Isolation Kit from MoBio Laboratories Inc. The 16S gene was amplified by the polymerase chain reaction (PCR) and the sequencing of the PCR products was performed with the Illumina sequencer. In the 12 analyzed samples a total of 820,982 sequences were obtained, in which each bookstore had from 41,967 to 97,512 readings. A total of 943 Operational Taxonomic Units (OTUs) were differentiated, which were grouped in 32 bacterial phylogenetic groups. Phyla with the highest relative abundance were Proteobacteria (67%) and Actinobacteria (21.7%), the first one was dominated by Alphaproteobacteria (58.7%) and to a lesser extent by Betaproteobacteria (5.4%), as well as Gamma-, Delta- and Epsilon- Proteobacteria (2.9%). Other less abundant Phyla, with more presence in soil than in root, were Chloroflexi, Bacteroidetes, Firmicutes, Acidobacteria, Saccharibacteria and Gemmatimonadetes. Bacterial communities were more diverse in soil than in root, with Shannon-Weaver (H') indices of 4.21 and 3.63, and Simpson (1 / D) inverse of 33.7 and 16.7. In the root, the diversity of bacteria decreased with the presence of the inoculated endophytes, while in the soil the opposite occurred with *Laccaria* and *Hebeloma* + *Azospirillum*. The species shared with the control group decreased in the following order: *Azospirillum* > *Laccaria* > *Hebeloma*. *Laccaria* had more unique species and greater abundance of *Pseudomonas* and *Actinoplanes* than the other treatments. The Sorensen Similarity Index (CC) had high values for *Laccaria* compared with *Laccaria* + *Azospirillum* and *Hebeloma* with *Hebeloma* + *Azospirillum*, both in root and soil. It is concluded that *L. laccata* and *H. mesophaeum* modified the structure and composition of the bacterial community, whereas *A. brasiliense* had a minor influence on the ectomycorrhizal microbiome. Financial support from the Project CONACyT 246674 is acknowledged.

**Topic:** Molecular Biology



## EDIBLE BOLETALES (BASIDIOMYCOTA) FROM THE REGIONS OF NORTHERN MOUNTAIN RANGE AND CENTRAL VALLEYS OF OAXACA STATE, MEXICO

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**Keywords:** potential use, boletes, wild edible mushrooms, hosts, *Quercus*, *Pinus*, ectomycorrhizal

Edible wild Boletales are non-timber forest resources whose sustainable use depends on the knowledge of the distribution and productivity of their basidioma. In Mexico this resource is not used to its full potential, especially in the state of Oaxaca, where some of the species are currently being use in some communities of the *Sierra Juárez*. Twelve explorations were carried out in three rainy seasons, from June to December over a two year period from 2014 to 2016 in the regions of Sierra Norte and Valles Centrales. An opportunistic sampling was conducted and the MEXU-UNAM and the ITCV herbarium were reviewed. Also the hosts of the fungi of the order Boletales were determined. A total of 125 specimens of edible wild Boletales, located in three families (Boletaceae, Calostomataceae and Suillaceae), 15 genera and 23 species were identified including *Aureoboletus auriporus*, *Calostoma cinnabarina*, *Boletus variipes*, *Boletus reticulatus*, *Boletellus russellii*, *Boletellus ananas*, *Exsudoporus frostii*, *Fistulinella wolfeana*, *Harrya chromapes*, *Heimioporus betula*, *Leccinellum albellum*, *Leccinum holopus*, *Leccinum rugosiceps*, *Pulveroboletus ravenelii*, *Strobilomyces confusus*, *Strobilomyces spp*, *Sutorius eximius*, *Suillus granulatus*, *Suillus decipiens*, *Suillus spraguei*, *Suillus subluteus* and *Xerocomus illudens*. These species were associated with *Quercus scytophylla*, *Q. laurina*, *Q. liebmanii*, *Q. urbanii*, *Q. rugosa*, *Q. martinezii*, *Q. elliptica*, *Pinus chiapensis* and *Pinus oocarpa*. This is the first work that records the diversity of edible boletes from the state of Oaxaca, and it show the great economic and social potential of this resource in the studied area.

**Topic:** Taxonomy, sustainable, and ecology



## TRADITIONAL KNOWLEDGE OF WILD EDIBLE FUNGI IN THE CENTRAL REGION OF THE MUNICIPALITY OF SANTA ANA JILOTZINGO, STATE OF MEXICO

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**Keywords:** Macrofungi, ethnomycology, edible mushrooms

In Mexico the use of wild edible fungi (WEF) is a part of the national culture, its knowledge and use is very important for domestic consumption and marketing. However, most of the studies are centered in native groups, and there are only few researches based on mestizo communities, as is the Municipality of Santa Ana Jilotzingo in central Mexico. To document aspects of traditional knowledge in this area, during the rainy periods from 2013 to 2016, local people were selected using the snowball technique in order to collect edible fungi. At the same time, informal and unstructured and semi-structured interviews were carried out and information related to the traditional names of fungi, data on phenology, biology, ecology, morphology, fungus concept and culinary practices were recorded. The specimens were determined based on their macro and microscopic characteristics using specialized taxonomic keys. Approximately 350 edible specimens were collected and 62 species were identified. A total of 64 local names were recorded, which were based on morphological characteristics, type of vegetation where the mushrooms grow and habitats. The most popular fungi were *Amanita* sect. *caesarea*, *Lyophyllum decastes*, *Cantharellus cibarius* and different species of the genera *Morchella* and *Ramaria*. The gathering of WEF is predominantly used for self-consumption. Traditional knowledge related to WEF in general shows dynamics similar to those of other native communities, highlighting particular characteristics such as the absence of speakers of indigenous languages, as well as the excessive growth of the population that has brought many changes in the locality. Despite these facts, it was recorded that traditional knowledge related to WEF still persists in the studied community.

**Topic:** Traditional knowledge



## ECTOMYCORRHIZAL FUNGAL COMMUNITY IN HIGH MOUNTAIN FOREST: LAST CHANCE TO MITIGATE CLIMATE GLOBAL CHANGE?

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**Keywords:** Ectomycorrhizae, Mexico, Neotropic, Russulaceae, diversity

Forest ecosystems in Mexico are vulnerable to the threat of global climate change. *Pinus hartwegii* is a conifer restricted to the mountains of the Transverse Neovolcanic Axis and its distribution makes it a priority species for its conservation. Plants and ectomycorrhizal fungi (ECMF) may respond particularly to climate change and the soil factors directly influence on the community structure. The objective of this study was to document the diversity of ECMF associated with conifers in high mountain areas of Mexico. A total of 22 ectomycorrhizal taxa were identified, of which *Cortinarius mucosus*, *C. diasemospermus* and *Russula betularum* are new records for Mexico. In addition *R. betularum*, *R. sp.1* and *Sistotrema confluens* were identified as native species of the Neotropics. We found a positive correlation between the inorganic nitrogen ( $\text{NH}_4 + \text{NO}_3$ ), extractable P and exchangeable K contents with some species such as *Byssocorticium sp.*, *Clavulina sp.* *Cortinarius mucosus*, *C. sp. 2* and *C. sp. 3*, *Hygrophorus sp.* and *P. olivaceum*. However, species such as *Cortinarius sp. 1*, *Piloderma sp. 1*, *Russula betularum* and *Sistotrema confluens*, were negatively correlated with organic matter and Ca. This work shows that the strong effect of edaphic variables on each species would depend on the host composition and resilience capacity of fungal-plant communities.

**Topic:** Climate change



## COINOCULATION OF AN EDIBLE ECTOMYCORRHIZAL MUSHROOM AND MYCORRHIZAL HELPER BACTERIA IN THE PHYSIOLOGICAL ENHANCEMENT OF *Pinus montezumae*

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**Keywords:** Mycorrhiza, photosynthetic rate, chlorophyll contents, forest biotechnology.

The ectomycorrhiza and the mycorrhizal helper bacteria (MHB) are fundamental in the functioning of forest ecosystems by improving the physiological quality of the associated trees. In this work the effect of the inoculation with the edible ectomycorrhizal mushroom *Hebeloma mesophaeum* (*Hm*) alone or coinoculated with the MHB *Cohnella* sp. (*C*) or *Azospirillum brasilense* (*Ab*) on the ecophysiological quality of plants of *Pinus montezumae* Lamb was studied. Growth, photosynthetic rate, transpiration, a, b and total chlorophyll and carotene contents, SPAD units, root colonization and plant contents of N, P and K were evaluated. Increases in terms of growth, photosynthetic rate and nutrient content of inoculated plants with the edible ectomycorrhizal mushroom alone or coinoculated with MHB was recorded. In contrast, there were no differences when the MHB were inoculated alone. Increased shoot respiration was observed only in the treatments inoculated with *Hm* and *Hm + C*. Inoculation with *Hm* increased the concentration of chlorophyll a, while the co-inoculation with *Hm + C* increased the concentration of chlorophyll a, b, total and carotenes. Colonization percentages in inoculated plants were always above 68%. There was a synergism in plants inoculated with *Hm + Ab* in terms of shoot and total N content compared to plants inoculated exclusively either with *Hm* or *Ab*. The biotechnological potential of co-inoculation with *Hm*, *C* and *Ab* in the production of plants of *P. montezumae*, which has a great importance in reforestation and soil restoration programs in Mexico, is demonstrated for the first time.

**Topic:** Biotechnology



## **PATAGONIA FUNGI trails and tastes: NOVEL USES OF NOVEL WILD EDIBLE FUNGI FROM PATAGONIAN FORESTS, ARGENTINA**

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**Keywords:** ecotourism, gastronomy, non-wood forest products, *Ramaria patagonica*, *Cyttaria*, *Grifola gargal*, *Fistulina antarctica*

The western region of Patagonia (Argentina) has a wide strip of native forests dominated by *Nothofagus* spp., home to numerous species of edible fungi although very little is known. To the east, in the forest–steppe ecotone area, plantations with exotic conifers have been established, which also offer other edible fungal species. The scientific-technical approach to the study of these fungal species has been developed together with the dissemination and transfer of the results to harvesters and to the gastronomic sector as demanders of the product. A number of field manuals have been published to provide a guide for edible fungi recognition, harvest and use, and to document accessible and specific material for the lectures, workshops and courses offered on the subject. Successful use of these non-wood resources will depend to a great extent on generating a strategy to promote novel uses of medicinal species (nutraceuticals), mycogastronomy and mycotourism. In this sense, since the recent initiative *PATAGONIA FUNGI trails and tastes*, work is being done on the direct dissemination to consumers, on the development of new recipes with chefs, and on a proposal of mycotourism trails for the region. Edible wild mushrooms are one of the most diverse and abundant "non-wood forest products". Patagonia has the opportunity to use these novel products for a particular and exclusive offer of regional mycogastronomy. In addition, they can be incorporated into ecotourism activities such as foraging, reconnaissance, photography and/or harvesting of specimens for tasting. These activities involve the multiple uses of Patagonian forest environments, favoring their appreciation and conservation.

**Topic:** Economic importance, conservation



## THE DEATH CAP MUSHROOM (*Amanita phalloides*) MOVES TO A NATIVE TREE IN VICTORIA, BRITISH COLUMBIA

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**Keywords:** ectomycorrhiza, death cap mushroom, *Amanita phalloides*, *Quercus garryana*

*Amanita phalloides*, the Death Cap mushroom, is an invasive ectomycorrhizal fungus in North America that was inadvertently introduced from Europe. Death Cap mushrooms have caused three recorded poisonings in British Columbia (BC), including one recent death. In BC, these mushrooms fruit mostly in major urban areas, including Vancouver and Victoria, under planted exotic broadleaf trees. In California, *A. phalloides* was demonstrated to also form ectomycorrhizas with a native oak species, *Quercus agrifolia*. Here we report that *A. phalloides* also forms ectomycorrhizas with *Quercus garryana*, BC's only native species of oak, and can fruit in association with this tree host. Native *Q. agrifolia* is already the dominant host in California for death caps, while ours is the first report with *Q. garryana*. If Death Cap mushroom takes hold in Pacific Northwest Garry oaks and expands to fully exploit both *Q. garryana* and *Q. agrifolia* habitats, which overlap in the San Francisco area, the risk for serious mushroom poisoning will increase and mushroom harvesters, the medical community, and forest and park managers need to be aware of this increased risk.

**Topic:** Ecology



## DIVERSITY AND MANAGEMENT OF WILD EDIBLE MUSHROOMS OF HIGH MOUNTAIN IN THE STATE OF MEXICO: WITH EMPHASIS ON ECTOMYCORRHIZAL SPECIES

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**Keywords:** *Abies religiosa*, *Helvella*, Amanalco, sustainable

Wild edible mushrooms (WEM) are resources of ecological, cultural and economic importance for rural communities. Most studies on WEM have been made from the biological, ecological or ethnomycological perspectives, but few examples exist where the integration of information to generate management strategies have been used. For this reason, the aim of the present work was to assess the diversity, ecological availability and traditional knowledge, as well as their integration into a GIS to develop a model from WEM management. Results showed an inventory of 96 WEM, 38 of which were sold at the markets. In the ecological study, we studied the presence of WEM in vegetation of *Abies*, *Abies-Pinus*, *Pinus*, *Pinus-Quercus* and *Quercus*. The *Pinus-Abies* forest had the highest diversity with 80 species. The most abundant species were *Clavulina cinerea*, *Clitocybe gibba* and *Russula brevipes*. The species with the highest ecological importance were *Clavulina cinerea*, *Clitocybe gibba* and *Russula brevipes*. The species with the highest cultural importance were “gachupines” (*Helvella* spp.) “tecomates” (*Amanita* sect. *caesarea*) and “clavitos” (*Lyophyllum decastes*). Using GIS, we made an analysis for the above mentioned WEM. By classifying these species, we obtained potential distribution maps, we extracted information from the environmental variables in which those species are developed, analyzed the relationship between the inhabitants of the localities and the feasible species to exploit as well as the effects of harvest on the species abundance. The analysis of these variables allows to develop strategies for the management of the WEM by communities in the region and will contribute to a sustainable exploitation of WEM in Mexico.

**Topic:** Sustainability



## DISTRIBUTION OF ECTOMYCORRHIZAL FUNGI IN BUSHY OAK SPECIES OF THE HIGH PLATEAU POTOSINO-ZACATECANO IN NORTHERN MEXICO

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**Keywords:** semi-arid regions, *Quercus*, *Astraeus hygrometricus*, *Cenococcum geophilum*.

Mexico has the greatest diversity of oaks (*Quercus*) worldwide; in the semi-arid region of the high plateau *Potosino-Zacatecano* in the North of Mexico, there are several species of this genus. However, due to high anthropogenic pressures, in these areas there are only remnants of different species of *Quercus*, which usually had bushy growth habit. In this scenario, it is urgent to study the ectomycorrhizal fungi (ECMF) associated with these species of *Quercus* spp. We studied the ECMF associated with *Q. tinkhamii*, *Q. potosina* and *Q. striatula* in the localities of *Cerro Peñón Blanco*, *Sierra de Guanamá* and *Sierra La Mojonera*, in the states of San Luis Potosi and Zacatecas, in northern Mexico. Identification of morphotypes, was performed using DEEMY. It was found that *Quercus tinkhamii* was associated with *Astraeus hygrometricus*, which is an edible species in southeastern Asia, particularly appreciated in Thailand. *Q. tinkhamii* plants were inoculated with spores of this fungus and the establishment of ectomycorrhization was demonstrated for the tree host. Additionally, six species of ECMF were found and identified associated with six species of oaks. We register for the first time the ECM symbiosis between *Cenococcum geophilum* and *Q. potosina* and *Q. striatula*. The abundance of ectomycorrhizal colonization associated with relicts of oaks of semi-arid areas demonstrated in the present work, shows the importance of this symbiosis, for the survival of the trees in the strongly disturbed conditions subject to severe drought existing in all of the studied areas.

**Topic:** Biodiversity



## SYMBIOTIC PROPAGATION OF THREE SPECIES OF PINES IN THE COMMUNITY *FRESNO NICHÍ*, *SAN FELIPE DEL PROGRESO* IN THE STATE OF MÉXICO

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**Keywords:** Ectomycorrhiza, pine forests, native species, biotechnology, anthropogenic factors

In Mexico, one of the ecosystems with the greatest diversity of associated species is the pine forest. In addition, it offers multiple ecosystem services such as contributing to atmospheric humidity, rainfall regulation, and reduction of soil erosion. Additionally, they provide multiple non-timber forest products, including edible wild fungi which are part of the culture of indigenous and rural communities. In the State of Mexico these ecosystems have a high geographical distribution, unfortunately they have been lost by the change of land use, agriculture, fires and deforestation. A biotechnological alternative for the conservation of native species is the use of ectomycorrhiza due to the fact that this symbiosis is obligatory for pines. Therefore the general objective of this work was to carry out the symbiotic propagation of three pine species native to the community of *Fresno Nichi*, *San Felipe del Progreso* in the State of Mexico. Soil from *Pinus montezumae*, *P. patula* and *P. pseudostrobus* was collected and inoculated for germination of trees; spores were selected from three species of wild fungi *Amanita* sect. *caesareae*, *Morchella* sp. and *Lacaria lacata*. The experimental design was completely randomized with eight treatments, with approximately 60 plants per species, with a total of 400 units. After six months, survival, growth, mycorrhizal inoculum and aerial biomass were evaluated, showing differential effects according to the evaluated species in comparison with non-inoculated trees.

**Topic:** Biotechnology



## FIELD SURVIVAL OF TWO NEOTROPICAL PINES MYCORRHIZED WITH *Suillus pungens* AND *Thelephora terrestris* IN THE PRESENCE OF ALLELOPATHIC TREES

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**Keywords:** field experiments, allelopathy, ectomycorrhizal fungi, *Eucalyptus*

The absence of plant mycorrhization and the low soil fertility are some of the main problems related to the low survival rate of planted pines in the field in Mexico. Therefore, the objective of this research was to evaluate the survival and growth of pines inoculated with ectomycorrhizal fungi, in areas with the presence or absence of allelopathic plants. Two-year-old pines with more than 80% of mycorrhizal colonization were transplanted in the National Park *Molino de Flores*, Texcoco, Mexico. The experiment was carried out in two areas: one with the presence of mature trees of *Eucalyptus camaldulensis* and the other with the absence of this tree species. In each zone, 3 bioassays were established: i) *Pinus greggii* mycorrhized with the edible mushroom *Suillus pungens* and non-mycorrhizal plants; ii) *Pinus patula* mycorrhized plants with *S. pungens*, *Thelephora terrestris* and non-mycorrhizal plants and, iii) *P. greggii* mycorrhized with *T. terrestris* and non-mycorrhizal plants. In total 98 experimental units were evaluated, 48 in the eucalyptus area and 48 in the area without eucalypts. The stem diameter, height and survival were evaluated every two months for one year after transplantation. Field survival differences assessed by the log-rank test, using the Kaplan-Meier method showed that two-year old mycorrhizal plants had higher survival rates compared to non-mycorrhizal plants. At the end of the experiment, *P. patula* inoculated, or not inoculated, were not able to survive, in most treatments, except those plants inoculated with *S. pungens* which have a 14% survival rate in both areas. *P. greggii* plants mycorrhized with *T. terrestris* were able to mitigate the allelopathic effect of eucalypts. We conclude that therefore, including the appropriate ectomycorrhizal fungi significantly might increase the survival of *P. greggii* in the field and its tolerance to the allelopathy to *Eucalyptus camaldulensis*. Financial support from the Project CONACYT 246674 is acknowledged.

**Topic:** Biotechnology



## METAGENOMIC CHARACTERIZATION OF THE MICROBIOMA ASSOCIATED WITH ECTOMICORRHIZAE OF TWO NEOTROPICAL PINES

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**Keywords:** Metagenomic, microbiome, ectomycorrhizal symbiosis, Neotropics

The ectomycorrhiza is a mutualist symbiosis established between more than 20,000 fungal species and around 5,000 plant species. Ectomycorrhizal roots are associated with bacterial and fungal communities that play an important role in the survival and growth of forest species. There have been few studies related to the factors that modify these microbial communities associated with ectomycorrhizae, mainly in the Neotropics. This work evaluated the influence of two phytobionts (*Pinus patula* and *Pinus greggii*) and two mycobionts (the edible ectomycorrhizal mushroom *Suillus pungens* and *Thelephora terrestris*) on the composition of the microbiome associated with its ectomycorrhizae. Also the microbiome of two microhabitats was studied for each ectomycorrhizal combination: in the case of non-mycorrhizal plants the root and rhizosphere were evaluated; and for mycorrhizal plants the ectomycorrhizal root and the ectomycorrhizosphere were surveyed. For the 16S region, a total of 3'132,496 initial sequences were counted, of which finally 90,927 unique sequences were left at the end. For the 18S region, a total of 1'271,750 initial sequences were counted, of which 22,616 unique sequences were left at the end. In the bacterial community we observed the presence of 8 dominant OTUs that occupied about 90% of the total relative abundance, including: Bacillales, Gemmatimonadales and 6 non-classified groups. For the fungal community, 95% of the relative abundance was composed of 3 OTUs: Hypocreales, Sordariales and Eurotiales. We identified 79 OTUs at the family level for bacteria and 32 OTUs for fungi, which had a relative abundance greater than 1% in at least one of the treatments. In general, a greater bacterial diversity was observed in *Pinus greggii* than in *Pinus patula*, whereas in the fungal diversity an opposite trend was observed. Mycobionts showed differences when associated with phytobionts, *Suillus pungens* increased microbial diversity in *Pinus greggii*, while *Thelephora terrestris* favored that of *Pinus patula*. This work demonstrates that the structure of bacterial and fungal communities associated with Neotropical ectomycorrhizae is influenced by phytobionts, mycobionts and microhabitats.

**Topic:** Molecular Biology



## POTENTIAL OF *Pinus greggii* AND THE EDIBLE ECTOMYCORRHIZAL MUSHROOM *Suillus brevipes* FOR REFORESTATION OF HIGHLY DEGRADED SOILS

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**Keywords:** ectomycorrhiza, *Pinus*, mushroom edible, reforestation

One of the challenges for reforestation in Mexico is decreasing the high mortality rates of forest species when they are transplanted from nurseries to the field; the historical mean survival rate of pines varying between 0 to 20%. Some of the possible solutions to this problem is to guarantee that the trees have their appropriate natural symbionts, to face adverse situations, before to plant them in the field. It is also necessary to choose the appropriate tree-ectomycorrhizal combination according to soil conditions to ensure plant establishment. In the present work, *Pinus greggii* seedlings were inoculated in the nursery with an edible ectomycorrhizal species which has a great social, cultural and economic importance in Central Mexico, *Suillus brevipes*. The inoculation with fresh or dry hymenia in slurries originated high colonization rates. Each plant received a dose of spores from  $10^6$  to  $10^7$  spores of this mushroom. The estimated percentage of external mycelium which covered the external area of the root systems extracted from their containers varied from 30 to 90%. After maintaining the trees during three years in greenhouse, fifty trees selected due to its high colonization rate, were transplanted to a highly degraded soil, with very low fertility conditions, in order to evaluate the percentage of tree survival. The survival rate in field conditions after a year was of 80%. This work shows the great potential of the association *P. greggii* and *Suillus brevipes* for successful establishment in a soil highly degraded in Central Mexico.

**Topic:** Ecology



## FIRST RECORD OF SYNTHESIS BETWEEN THREE ECTOMYCORRHIZAL EDIBLE MUSHROOMS AND *Pinus maximartinezii* A MEXICAN ENDANGERED NATIVE SPECIES

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**Keywords:** ectomycorrhizal symbiosis, endemic, blue pine, edible mushrooms, inoculation

Mexico holds the greatest diversity of species of the genus *Pinus* worldwide, with 72 taxa of which 50% are native to the country, as *Pinus maximartinezii* Rzedowski, an endangered species. This pine has blue colored needles in different shades, a strobile weighing up to 3 kg and 40 cm long and 20 cm wide. The seeds are marketed as food because of their high nutritional and medicinal value, which is why the species is in danger of extinction. The objective of this work was to evaluate the effect of inoculation with three species of ectomycorrhizal wild edible mushrooms in *P. maximartinezii*. The research was carried out at the *Colegio de Postgraduados*, state of Mexico. The seeds were collected in the community of the *Nochixtlán Assumption*, in the state of Oaxaca, Mexico. Sowing was carried out on a sterile substrate; and dehydrated and ground pilea of *Hebeloma alpinum*, *Laccaria proxima* and *Suillus pseudobrevipes* containing spores were applied. Mycorrhizae were successfully synthesized with the three evaluated mycobionts evaluated and a morphoanatomical analysis of the ectomycorrhizal roots was carried out for the three different combinations. This study reports for the first time, the synthesis of ectomycorrhiza between identified mycobionts and the Mexican blue pine, which obligatorily requires the establishment of the ectomycorrhizal symbiosis in its roots. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Biotechnology



## TRAPPING FUNGAL SPORES TO STUDY AIRBORNE DISPERSION AND MUSHROOM EMERGENCE

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**Keywords:** ectomycorrhizal, DNA barcoding, molecular identification, dispersion, *Lactarius*, Next Generation Sequencing, qPCR

Mushrooms monitoring face many challenges from an economical and logistical perspective: samplings demand extensive field work and sample identification require expertise of experienced taxonomists. Simultaneously, the study of fungal dispersal has been constrained by technological limitations. Thus, new tools to assess fungal diversity and to address spore dispersal are needed. By using simple spore traps (filter and funnel traps) together with qPCR and NGS techniques, we have identified the spores from the fruiting body community in plots where mushroom production was determined weekly. Filter traps were more effective capturing both saprotrophic and ectomycorrhizal spores than funnel traps. Spores from 37 fungal species out of 71 producing fruiting bodies were identified, whereas 13 fungal species could not be found because they did not have any published rITS sequences at UNITE or at INSD databases. Spore community composition changed considerably over time due to the emergence of ephemeral fruiting bodies and rapid spore deposition (lasting from 1 to 2 weeks), which occurred in the absence of rainfall events. For many species producing ephemeral fruiting bodies, the spore peak occurred one week after fruiting body emergence. There were significant positive relationships between fruiting body yields and spore abundance in time for five out of seven fungal species. However, there was no relationship between fruiting body yields and their spore abundance at plot level, suggesting that many spores captured were arriving from surrounding areas. Spore trapping coupled with NGS techniques are promising approaches to study mushroom emergence and fungal dispersal.

**Topic:** Ecology



## EDIBLE AND ECTOMYCORRHIZAL MUSHROOMS FROM MILPA ALTA, MEXICO CITY

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**Keywords:** inventorying, ectomycorrhiza, edible wild mushrooms

*Milpa Alta* is located in the southern part of Mexico Basin; it was formally considered, along with other areas from the south-western part of Mexico City, as Ecological Conservation Areas in 1987. Within the delegation *Milpa Alta* there is a Community Ecological Conservation Area which covers around 5000 ha and includes several forests where management, use and conservation of different resources are carried out by local “*comuneros*” (people who works in communal lands). This area is crucial for the sustainability of the great metropolis covered by Mexico city, one of the largest population centers of the planet. Mexico city possess an area of 1485 km<sup>2</sup> and its land is administratively divided into two types: urban and preserved. The preserved land category covers 59% of the total area. Currently the mycological knowledge in Mexico City is insufficient. So far 257 species of macromycetes have been registered in Mexico City. Explorations were conducted during the rainy season from June to October of 2008 to 2016. The specimens were collected from 10 localities following the techniques proposed by Cifuentes and collaborators in 1986. Three hundred and fifty specimens were collected, of which 35 species of mycorrhizal fungi and 15 species of edible mushrooms were identified. Among them five new records for Mexico City were found. It is necessary to continue with this type of basic mycological studies. Unfortunately the study of inventorying and monitoring the biodiversity in Mexico currently has had a decreased support by the national institutions.

**Topic:** Taxonomy



## DIVERSITY OF BIOLUMINESCENT MUSHROOMS (AGARICALES) FROM MOIST MOUNTAIN CLOUDY FOREST FROM VERACRUZ, MEXICO

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**Keywords:** Ecology, subtropical forest, macromycetes, taxonomy, bioluminescence

Most studies on bioluminescent macromycetes have been focused on taxonomic and phylogenetic approaches. In Mexico, several species belonging to genera reported with this characteristic have been cited in fungal checklists, without highlighting it. In this work the diversity and distribution of bioluminescent fungi were evaluated in three sites with different structure and diversity of woody species in moist montane cloudy forests (MMCF) located in the central part of Veracruz, Mexico. Ten plots of 10 x 10 m were established, woody species were identified and their diameter, height, canopy cover, inclination and slope orientation were measured. The collections of bioluminescent basidiomata or mycelium were carried out by free sampling of 4 hours. For each site, temperature and humidity of the environment were registered at each collection point. Bioluminescence was recorded with long exposure photographs and in complete darkness. We identified 18 taxa distributed in the genus *Mycena*, *Panellus* and *Roridomyces*. Chao-Jaccard and alpha diversity indexes were estimated, the effect of explanatory variables on macromycete wealth was determined with regression trees and their distribution with respect to these variables was evaluated with a principal components analysis (PCA). This work contributed to the knowledge of the MMCF bioluminescent fungi as well as to the understanding of their relationships with the tree species in the subtropical forests.

**Topic:** Ecology

**Note of the Editors:** Bioluminescent mushrooms are usually saprotrophic; however we decided to include this abstract due to the attraction of the Topic to a general audience.



## **BIODIVERSITY AND POTENTIAL USE OF THE MYCOLOGICAL RESOURCE, INCLUDING ECTOMYCORRHIZAL MUSHROOMS, IN THE LOW DECIDUOUS FOREST OF TIERRA CALIENTE, GUERRERO, MEXICO**

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**Keywords:** macromycetes, conservation, ecology, biotechnology

Guerrero is a state of Mexico which ranks fourth in the country in terms of biodiversity. Due to its great abiotic conditions, plant diversity and types of vegetation, there is a great diversity of wild mushrooms. However, the mycological resource has been largely unexplored in the low deciduous forests worldwide. The present study aimed to generate information on the diversity and potential use of the macromycetes of this type of vegetation in the region of *Tierra Caliente*, state of Guerrero, located in the dry tropical region of southeastern Mexico. Mushrooms were collected from 2013 to 2016 and voucher collections were kept in the herbarium of the *Instituto Tecnológico de Ciudad Altamirano*, in some representative localities of the *Tierra Caliente* region. Sampling was carried out during the months of greatest mushroom production, which goes from early August to late September. A total of 34 families were registered, 69 genera and 87 species, indicating that there is a significant fungal diversity of this region. This is a pioneer study of the fungal diversity in this dry tropical region. The presence of a great diversity of wild mushrooms includes the potential use as medicine (e.g. *Ganoderma lucidum*, *Coprinus comatus*, *Pycnoporus sanguineus*, and *Geastrum triplex*) and food (e. gr. *Pleurotus djamor*, *P. ostreatus* and *Auricularia* spp.). In addition, there is a biotechnological potential to inoculate native trees with some ectomycorrhizal species included in the genera *Ramaria*, *Tremellodendron* and *Tylopilus*. However, the use of these species is practically invisible, since the inhabitants of the region do not have a mycophilic cosmopolitan vision. Therefore, the importance of the present study relies on the generation of the knowledge and diffusion of the ecological, social and economic importance and potential benefits of the macromycetes in the studied region. With the information generated to date, it is intended to propose strategies of use, management and conservation of the mycological resource in this tropical region.

**Topic:** Biodiversity



## ENDEMIC EASTERN MEDITERRANEAN OAK SPECIES AS HOSTS OF BLACK TRUFFLES

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**Keywords:** *Quercus ithaburensis*, *Quercus boissieri*, *Tuber aestivum*, *Tuber melanosporum*

Five endemic oak species grow in Israel. The most common is Kermes oak (*Quercus calliprino*), the second is the Tabor oak known also as the Valonia oak (*Quercus ithaburensis*), the largest and most impressive among oak species that grow in Israel, reaching height of 20 meters or more. Tabor oak grows in areas with annual precipitation above 250 mm in most regions of the country. Aleppo oak (*Quercus boissieri*) trees reach a height of 15 m and grow on high mountains at 500 m a.s.l. The Turkey oak (*Quercus cerris*) and the Hermon oak (*Quercus look*) are rare and grow only in higher altitudes (1550-1900 m a.s.l.). In an attempt to introduce truffles into northern Israel we examined the possibility of using the Tabor oak and Aleppo oak to host the black truffle (*Tuber melanosporum*) and summer truffle (*Tuber aestivum*), in comparison with oak species that are commonly used in other Mediterranean regions. Since 2015 seeds were collected from an adult grove. The seeds were disinfected and sown in a heat sterilized substrate. About two months after germination, the seedlings were inoculated with the same quantity of truffle spores and were grown in a greenhouse. After six months, the roots were analyzed to assess mycorrhizal formation and mycorrhization rate. The seedlings were also checked for height and diameter. In the examination of the suitability of local oaks to serve as hosts trees for the black truffle (*T. melanosporum*), it was found that the Tabor oak inoculated seedlings reached a higher height and larger stem diameter than the control, but the mycorrhization rate with black truffle was negligible. On the other hand, the growth of the Aleppo oak inoculated seedlings was also stimulated and they reached a high level of mycorrhization rate, similar to Grayish oak (*Quercus pedunculifora*) seedlings, featuring better parameters than the commonly used Holm oak (*Quercus ilex*). In the examination of the suitability of local oaks to serve as hosts trees for the summer truffle (*T. aestivum*), it was found that the Tabor oak seedlings were higher and reached larger diameter, but the mycorrhization rate was negligible, in comparison with the Aleppo oak. In the coming years, we will try to monitor the development of the Tabor oak and Aleppo oak seedlings and the mycorrhization rates under field conditions in different climatic zones.

**Topic:** Cultivation



## TWO NEW SPECIES OF THE ECTOMYCORRHIZAL GASTEROID MUSHROOM *Calostoma* (Boletales) USED AS FOOD AMONG MIXE PEOPLE FROM SOUTHERN, MEXICO

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**Keywords:** Boletales, Oaxaca, scanning electron microscopy, phylogeny

*Calostoma* is an ectomycorrhizal genus within the order Boletales, which contains 26 species, of which five have been reported from Mexico. Some species have been registered in the world as edible, e.g. *Calostoma* cf. *fuscum* (Berk.) Massee consumed in Malaysia. In Mexico, in 2009 *Calostoma cinnabarina* was reported as formerly edible among nahuatl people in the state of Hidalgo. The Mexican ethnic group Mixe with prehispanic origin is currently constituted by 130,037 inhabitants, whose origin goes back more than 2000 years and is located in the mountain ranges of the states of Oaxaca and Veracruz. Among the mixes the use of fungi has been maintained by oral tradition, and traditionally inherited and conserved by means of geographical and cultural hermetism. However, they are now aware of the influence that globalization can have on the deterioration of their traditional knowledge and, conversely, the ways in which globalization can take advantage of their ancestral wisdom, such as the plagiarism of their designs by the foreign designer Isabel Marant who in 2015 profited by trading their designs with a commercial brand. For these reasons the community has accepted the opening and registration of their knowledge to young people with formal studies belonging to the same community; an example of this is the pride of their music, extolled mostly by the women of this group. In the present work, one of the coauthors is a native speaker and member of the Mixe people, which allows the domestic and international registration of traditional knowledge belonging to the Mixe ethnic group or *Ayuukja'äy*. The present work describes two new species of the genus *Calostoma* which are part of the diet of the Mixe people. For the identification of these species, macro- and micromorphological, molecular and phylogenetic identification techniques were used, with the amplification of the ITS region using the ITS4 and ITS5 primers and their analysis determining the bootstrap values and the distance matrix using both UPGMA and the maximum likelihood. Additionally, emphasis is given to the importance of scanning electron microscopy to distinguish species in this genus; since the spore reticulum in the new species described in the present work is clearly different compared to those described so far. The ethnotaxa consumed is called in Mixe language *Naax tututs* (*naax* = earth, *tututs* = egg), it grows in forests dominated by *Quercus obtusata*, and is constituted at least, by the two new species described here, named *C. naaxtututs* and *C. tootei* (*töö* = rain, *tei* = foot). Both species are consumed by the mixes as a “snack mountain”, only removing the gelatinous outer layer. This paper documents the importance of the study of fungi with biocultural importance among the Mixe group in Mexico, which has scarcely been studied; and the importance of the use of multiple scientific tools for the precise knowledge of edible ectomycorrhizal mushrooms. We acknowledge the financial support from the Project CONACyT 246674.

**Topic:** Biodiversity, Biocultural importance



***Amanita ayuukjaay* A NEW EDIBLE SPECIES OF THE CAESAR'S MUSHROOM COMPLEX, WITH BIOCULTURAL IMPORTANCE AMONG AYUUKJÄ'ÄY PEOPLE FROM OAXACA, MEXICO**

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**Keywords:** phylogeny, mixe, molecular biology, morphology, taxonomy

One of the edible ectomycorrhizal fungi most appreciated worldwide since ancient times is the complex of species currently classified in the *Amanita* section *caesareae*. This taxon was valued by the upper social classes among the Greek and Roman societies giving rise to their name due to the high appreciation by the Caesar in ancient Rome. Currently, it remains as a highly appreciated taxon worldwide, in all continents. The Mixe ethnic group, located in the eastern part of the northern mountain range in the state of Oaxaca called also the *Sierra Mixe*, is constituted by a pre-Hispanic community which is older than 2500 years. Among the ancestral knowledge inherited orally, is possible to still find the use of diverse species of fungi, emphasizing the consumption of representatives of the *Amanita* sect. *caesarea* including for example *Amanita jacksonii* Pomerl. The genus *Amanita* contains about 868 described species, in which the presence of cryptic species is highly probable. In this work the taxonomic identification of a new species of the *Caesareae* section was made, which was named *A. ayuukjaay*. The proposal of this new species is based on macro- and micromorphological characterization, as well as on molecular identification by sequencing the DNA region with the specific primers ITS4 and ITS5. In addition, the phylogenetic relationships established among the collected individuals and with other species of the same section were generated using the PHYLIP software for bootstrap analysis and the distance matrix that was performed with both UPGMA and maximum likelihood. The name of *A. ayuukjaay* is proposed for this new species because this is how the Mixe ethnic group called themselves; originating from the following roots *a* = language; *yuuk* = flowery; *jä'äy* = people, literally the "people of the flowery language". Among the mixe culture, the proposed new species is consumed roasted, with a little lemon and salt and it is highly appreciated as a very special delicacy. This work shows that the diversity of species of the group *Amanita* sect. *caesareae* is far to be complete and still requires further exploration and deeper comprehensive studies for its more precise understanding.

**Topic:** Biocultural importance



## UNDERSTANDING THE ECOLOGICAL INTERACTIONS BETWEEN MITES AND COLLEMBOLANS WITH MORELS (*Morchella* spp.)

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**Keywords:** Collembola, Acari, ascocarp, ascospores, feeding associations

Wild edible morels included in the genus *Morchella* occur in diverse forested ecosystems and habitats being highly valued in North America and Europe. Morels are appreciated worldwide for their savory flavor and nutritional composition as well as for their antioxidant and immune-stimulatory bioactivities. Despite the high demand and their increasing economic importance, their ecological interactions have been scarcely studied, including those related to the associations of morels with soil mesofauna (Collembola and Acari). Mesofauna are soil and litter dwellers and Collembola are commonly known by their grazing and gathering behavior. Most of these species feed on fungi contributing to their dispersion by grazing hyphae and dispersing spores. Acari are traditionally subdivided into Oribatida, Prostigmata and Mesostigmata based on their morphological characteristics, playing an important role in different soil biological functions. Oribatid mites are the most important decomposers carrying out organic matter turnover. In contrast, Mesostigmata and Prostigmata are the predators that regulate the population sizes of other soil organisms. In this study, we examined the ecological morel-mesofauna associations present in ascocarps collected in forests of the Sierra Nevada, Mexico. Fresh ascocarps were collected in *Abies religiosa* and *Pinus hartwegii* forests of San Pablo Ixayoc, Texcoco and in the temperate forests of Iztaccíhuatl volcano. Mesofauna were separated and identified to level of order and suborder and their abundances were counted. Because of abruptly conical caps with ridges and pits, morels are an attractive habitat to mesofauna for containing diverse assemblages of collembolans and mites. Rarefaction curves indicated that *Morchella* aff. *esculenta* had the highest richness and that *Morchella* aff. *conica* had the lowest richness of mesofauna. Differences in the abundance of Collembola were observed in the two sampling sites. For instance, on the ascocarps of *M.* aff. *conica* Poduromorpha tended to be highest in the forests of Iztaccíhuatl and Entomobryomorpha showed to be most abundant in the forest of Monte Tlaloc. Mites and collembolans had feeding preferences for morels and also the presence of ascospores in the gut contents was abundantly recorded. We showed that the relationships between morels and mesofauna are more complex than previously believed. We acknowledge the financial support from the Project CONACyT 246674.

**Topic:** Ecology



## INOCULATION OF *Casuarina equisetifolia* WITH TWO EDIBLE ECTOMYCORRHIZAL ALLOPATRIC SPECIES NATIVE FROM MEXICO

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**Keywords:** mycorrhiza, *Hebeloma mesophaeum*, *Laccaria proxima*

The inoculation of trees of forest importance with ectomycorrhizal fungi (ECMF) represents an important tool in the production of plants in greenhouse. A selection criterion for ECMF, which has become increasingly important in recent times, is its edibility. In Mexico, one the largest diversities known worldwide of ectomycorrhizal edible mushrooms are collected for self-consumption or sale in the markets. They are indispensable for the establishment and functioning of temperate forests, as they favor growth, as well as nutritional transfer and field survival of trees with forest importance. Due to the ecological and physiological importance of ECMF, the present study evaluated the effect on growth, stem diameter, dry weight and percentage of colonization of *Casuarina equisetifolia* L., which is a species native to Australia, widely used in reforestation in Mexico, by inoculating *Hebeloma mesophaeum* and *Laccaria proxima*. The experiment was carried out in a greenhouse on a sterile substrate. The most dramatic effects were detected 90 days after inoculation, since 100% of the non-inoculated plants died, whereas there was a 100% of survival in plants inoculated with any of the two evaluated fungi; showing a high mycorrhizal dependence for the studied tree species. In addition, 180 days after inoculation, the inoculated plants showed a higher growth and development, independently of the inoculated ectomycorrhizal fungus. It can be concluded that the evaluated ECMF have great potential of biotechnological application in the production of plants of *C. equisetifolia*. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Biotechnology



## INOCULATION WITH TWO EDIBLE ECTOMYCORRHIZAL MUSHROOMS IN *Pinus greggii* PLANTS GROWN IN CONTAINERS WITH DIFFERENT VOLUMES

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**Keywords:** Neotropical pines, edible wild mushrooms, container size

One of the most important criteria currently used worldwide in the selection of ectomycorrhizal fungi for the inoculation of trees is their edibility. *Laccaria proxima* and *Suillus pseudobrevipes* are widely consumed in Central Mexico where they have a great cultural, social and economic importance. In the present work the effect of these mushrooms was evaluated in terms of growth, and percentage of colonization in *P. greggii*, a species which is native from Mexico, where it has a great interest in reforestation and establishment of commercial plantations. Trees were inoculated with  $10^6$  to  $10^7$  spores per plant. Trees were grown during the first year in plastic containers with a volume of  $140 \text{ cm}^3$ . After that, they were transferred to pots with two different volumes,  $1800 \text{ cm}^3$  and  $3600 \text{ cm}^3$ . After 240 days of inoculation, there was a beneficial effect on the growth of the forest species evaluated as a result of inoculation in terms of stem height and diameter compared to non-inoculated plants. The best results were obtained in plants in  $3600 \text{ cm}^3$  containers compared to the smaller containers. Regardless of the volume of the container used, *Laccaria proxima* produced better results in terms of plant growth and ectomycorrhizal colonization. It can be concluded that ectomycorrhizal edible fungi evaluated have great potential for use in the production of plants of *P. greggii* in greenhouse or nursery and that the size of the container have a strong influence in the mycorrhizal colonization and the growth of the trees. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Biotechnology



## CYTOTOXIC ACTIVITIES OF EIGHT EDIBLE FUNGI IN THE MARKET AND CHEMICAL CONSTITUENTS IN THE FRUITING BODIES OF *Sarcodon imbricatus*

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**Keywords:** *Sarcodon imbricatus*; cytotoxic activity; chemical constituents; *p*-terphenyl

In this study, *in vitro* cytotoxic activities of eight common edible fungi in the market were determined. *In vitro* cytotoxic activities of the ethanol extracts from *Armillaria* sp1 and sp2, *Sarcodon* sp1 and sp2, *Lactarius* sp, *Lactarius piperatus*, *Cortinarius* sp and *Tricholma bakamatsutake* on Leukemia HL-60, lung cancer A-549, hepatocellular carcinoma SMMC-7721, breast cancer MCF-7 and colon cancer SW480 were determined. The results showed that the two *Sarcodon* extracts have moderate inhibitory activities on lung cancer A-549, and also have higher inhibitory activities on hepatocellular carcinoma SMMC-7721 with the IC<sub>50</sub> values of 25.96 µg/mL and 23.01 µg/mL, respectively. Using DNA identification methods, the *Sarcodon* sp1 was identified as *S. imbricatus*. In addition, the isolation and structural identification of the chemical constituents from dried fruiting bodies of *S. imbricatus* were carried out. Nine compounds (**1-9**) were isolated from the ethanol extract of the dried fruiting bodies by chromatographic techniques, such as silica gel and spectroscopic analyses (1H-NMR, 13C-NMR, 2D NMR, ESI-MS, HR-ESI-MS, UV, IR). Their chemical structures were identified as B1-V (**1**), *p*-hydroxybenzoic acid (**2**), 2', 3'-diacetyl- 3, 4, 5', 6', 4''-pentahydroxy-*p*-triphenyl (**3**), 2', 3'-diacetyl-3, 4, 5', 6', 3'', 4''-hexahydroxy-*p*-triphenyl (**4**), asperamide B (**5**), adenosine (**6**), uridine (**7**), 1-ethyl-β-D-glucopyranoside (**8**) and D-allitol (**9**). Compound **4** is a new *p*-terphenyl.

**Topic:** Bioactive compounds



## MYCORRHIZATION OF *Pinus pseudostrobus* AND *P. greggii* USING SLURRIES OF TWO QUALITIES OF *Suillus pseudobrevipes*

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**Keywords:** short shelf-life, ectomycorrhizal symbiosis, inoculum quality

Mycorrhizae are mutual symbiotic associations between plant roots and the fungal mycelium. Conifers of the genus *Pinus* establish associations with ectomycorrhizal fungi naturally in the forests. *Suillus pseudobrevipes* A. H. Sm. & Thiers is a species of edible ectomycorrhizal wild edible fungus, with short shelf life, so it is not ideal for sale in traditional markets, despite being very abundant in pine forests in Mexico. In this scenario, the objective of this work was to evaluate the effect of slurry inoculation with *S. pseudobrevipes* basidiomata of two qualities, on the growth and ectomycorrhizal colonization of *P. pseudostrobus* Lindl and *P. greggii* Englem in nursery. The first quality inoculum came from mature basidiomata in an excellent state of preservation and in the case of the second quality inoculum the basidiomata had a higher degree of maturity. In both cases the stipe was cut from the pileum and the hymenium was carefully separated. This hymenium was ground with sterile distilled water in a 1:1 ratio. As a result of the ectomycorrhizal inoculation, there was a beneficial effect on growth, dry weight and percentage of mycorrhizal colonization. In the case of *P. pseudostrobus* the colonization was 32% and 48% for inoculum of first and second quality, respectively. Similarly, in the case of *P. greggii* colonization was 47% and 48%, respectively. Morphotyping showed the typical morphoanatomical structures of *S. pseudobrevipes* colonization. This work demonstrates the potential of *S. pseudobrevipes* to establish ectomycorrhizal synthesis with *P. pseudostrobus* and *P. greggii*, regardless of the inoculum quality, which would represent a biotechnological potential of this mycological resource underutilized as a food because of its short shelf life. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Biotechnology



## COINOCULATION WITH ECTOMYCORRHIZAL AND ARBUSCULAR FUNGI IN TWO NEOTROPICAL PINE SPECIES

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**Keywords:** Pinaceae, consortium, inoculation, reforestation, coinoculation.

Mexico has one of the highest rates of deforestation rates at the international level, so it is urgent to develop strategies for successful reforestation. Although the roots of Pinaceae are usually colonized by ectomycorrhizal fungi (ECMF), there are also some reports which have registered the presence of arbuscular mycorrhizae (AM). The objective of the present work was to evaluate the effect of HMA and the edible ectomycorrhizal fungus *Laccaria proxima* on the growth and nutritional content of *Pinus patula* and *P. greggii*, two species of native pine trees of Mexico with great economic, ecological and forest importance. An evident translocation of macro and micronutrients was observed in plants inoculated with the evaluated consortia, mainly Mg and Mn. Similarly, the presence of hyphae, vesicles and arbuscles in *P. greggii* roots inoculated with the AM consortia was recorded. In addition, an increase in the photosynthetic rate and chlorophyll content a and b in *P. greggii* inoculated with either symbiont was recorded. The results obtained allow us to conclude that *P. greggii* increases its development in early stages when it is inoculated with AM, ECMF or the combination of both. In contrast, in *P. patula* we observed less evident results; therefore it is important to select the appropriate mycorrhizal endophyte depending on the phytobiont species, to carry out restoration and reforestation activities using Mexican pines. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Biotechnology



## TEMPERATURE, pH AND *in vitro* GROWTH OF EDIBLE ECTOMYCORRHIZAL MUSHROOMS ASSOCIATED WITH *Pinus radiata* PLANTATIONS IN CHILE

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**Keywords:** *Rhizopogon*, *Suillus*, biomass, pure culture, radial growth rate

Growth differences of fungi under *in vitro* culture conditions have been shown to be a guide for preselection of potential fungal species (strains or ecotypes) to be used in nursery mycorrhization programs. In this study we compared *in vitro* growth of *Rhizopogon luteolus*, *Suillus granulatus* and *S. luteus* under different temperatures and pH. Fungal material was collected in adult *Pinus radiata* plantation. Isolation of the strains was performed on potato dextrose agar medium and the evaluation of the radial growth rate and the increase in mycelial biomass was performed on the Melin Norkrans Modified growth medium. Temperature (24, 28 and 32° C) and pH (4.8, 5.3, 5.8, 6.3 and 6.8) effects of the growth medium were tested for the three fungal species in two independent assays. The results indicate that the temperature had a significant effect on the radial growth rate (RGR) and mycelial biomass increase (MBI) in all of the evaluated fungal species. The highest RGR and MBI were recorded in *R. luteolus*, and the lowest values for these variables were registered in *S. luteus*. *R. luteolus* had the highest sensitivity to pH changes. Meanwhile, under the evaluated culture conditions, which did not include the addition of a biological buffer, there was not a pattern in *S. granulatus* and *S. luteus* growing under different pH conditions. When cultivated *in vitro*, the three studied species of ECMF presented exponential, declination and stationary growth phases. The *in vitro* growth responses recorded in the present study showed the potential of *R. luteolus* to be used in programs using mycorrhizal inoculation in the production of *Pinus radiata* in nurseries in Chile.

**Topic:** Biotechnology



## MYCORRHIZATION OF THE ENDANGERED SPECIES *Pinus maximartinezii* WITH WILD EDIBLE FUNGI IN A TRADITIONAL FOREST NURSERY

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**Keywords:** mycorrhizal colonization, morphotyping, endangered species

Mexico has 49 of the approximately 120 species of the genus *Pinus* known worldwide. *Pinus maximartinezii* is a pine species native from in Mexico in danger of extinction, which germinates less than 3% naturally and survives less than 3% in the field. For these reasons, the biotechnological development of inoculation with ectomycorrhizal fungi is an urgent need, as this biotechnology contributes to the development, growth and survival of the inoculated tree species. The present research evaluated the effect of inoculation with edible ectomycorrhizal mushrooms on the growth of *P. maximartinezii* in a traditional nursery. A completely randomized experimental design was performed with three treatments: i) plants inoculated with *Laccaria proxima*, ii) plants inoculated with *Suillus tomentosus*; and iii) plants not inoculated. After 7 months from sowing, evaluations of the percentage of ectomycorrhizal colonization were performed. The data of the evaluated variables were then analyzed using ANOVA and means comparison using Tukey test ( $\alpha = 0.05$ ). Different percentages of colonization between treatments were observed. Plants inoculated with *S. tomentosus* presented the highest percentage of colonization (69.8%), whereas those inoculated with *L. proxima* had only 46.8%. There was a positive response to the mycorrhizal colonization from *P. maximartinezii* with the inoculum used in terms of plant growth. Mycorrhization in a traditional forest nursery was successful, demonstrating that this technology might be effective in a range of nurseries, including those highly technified and also the traditional ones. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Conservation



## GROWTH OF TWO MYCORRHIZAL MUSHROOMS FROM SIERRA TARAHUMARA OF CHIHUAHUA, MEXICO UNDER TWO pH CONDITIONS AND SIX GROWING MEDIA

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**Keywords:** Mycelium, inoculation, colonial morphology, nutritive mediums, pH

*Astraeus hygrometricus* is an ectomycorrhizal mushroom that is found mainly in juvenile forests and is considered as a disturb indicator species of disturb in Chihuahua, Mexico. *Pisolithus tinctorius* is frequently used in the inoculation of plants with forest importance, however there are only few studies of its mycorrhizal efficiency with *Pinus arizonica*, one of the pine species with the highest economic interest in Chihuahua. In the present work, the growth of two mushrooms were evaluated in six growing media (Potato dextrose agar (PDA), Melin-Norkrans (MN), oats (AV), corn (MZ), trypticase soy (ATS) y dextrose sabouraud (ADS)), with the purpose of establishing the best growing conditions, as part of the first stage of investigation related to mycorrhization with *P. arizonica*. Mycelial development was carried out from spores planted in PDA medium until pure mycelium was obtained. Then mycelial fragments (1 cm<sup>2</sup>) were transferred into the the six growing media under two pH conditions (4.8 and 5.8) with four replicates per treatment. Colonial morphology was determined taking into account the macromorphological characteristics, growing media and pH. The highest colonial diameter for *A. hygrometricus* was obtained in ADS medium at pH 5.8 (8 cm) where it was observed the highest growing speed (16 mmd<sup>-1</sup>) after seven days of incubation. The highest values for *P. tinctorius* occurred in MN medium at pH 5.8 (8 cm) after seven days of incubation. However, AV at pH 4.8 was the medium where the highest growing speed was reached (12 mmd<sup>-1</sup>). The colonial morphology of *A. hygrometricus* was particularly different in each medium.

**Topic:** Biotechnology



## IMPACT OF FOREST MANAGEMENT ON THE ECTOMYCORRHIZAL FUNGI DIVERSITY IN A CONIFER FOREST IN THE REGION CHIGNAHUAPAN, PUEBLA, MEXICO

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**Keywords:** Diversity, ectomycorrhizae, ITS, silvicultural development method

Silvicultural method development (MDS) is a forest management program used in temperate forests of central Mexico. However, it is unknown whether the MDS modifies the species diversity. In particular, the effect of this type of management in the communities of ectomycorrhizal fungi (ECMF) associated to the trees that are harvested. The objective of this work was to evaluate the impact of the MDS on the diversity of ECMF in a conifer forest in *Ejido de Llano Grande* in Chignahuapan, Puebla, Mexico. This was achieved by collecting samples of mycorrhizal roots in three stages of MDS management and using molecular biology techniques, amplifying and sequencing the ITS region. Taxonomic assignment of the sequences was done using the database GenBank. In Russulaceae a total 3405 ectomycorrhizae were collected, corresponding to 47 morphotypes. A molecular analysis of 380 ectomycorrhizae was performed, obtaining 67 molecular operational taxonomic units (MOTU's). The ECMF community was represented by 12 families, the most diverse were Inocybaceae, Russulaceae and Thelephoraceae. The species correspond to 23 genera; the most diverse were *Inocybe* (13), *Tomentella* (11) and *Russula* (9). The results indicate that the ECMF diversity is related to the cycle stage in the MDS. In the first phase where all the trees were cut, the diversity was low (1.09) and increased in the following stages as the age of the trees increased (3.71). This is indicative that the MDS does not affect the resilience of the forest, being a sustainable method for the approach of temperate forests.

**Topic.** Biodiversity, Conservation



## NUTRITIONAL VALUE AND TOTAL PHENOLICS COMPOUNDS CONTAINED IN WILD AND CULTIVATED EDIBLE MUSHROOM, INCLUDING ECTOMYCORRHIZAL SPECIES

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**Keywords:** edible mushroom, phenolics contain, nutritional potential

The fast deforestation rates occurring in Mexico is originating a great loss of biodiversity including symbiotic and saprophytic macrofungi. This implies a loss of fungal genetic biotic resources, which have not been fully studied in terms of their nutritional, nutraceutical and biotechnological potential. The aim of this study was to analyze its chemical composition and total phenolic content of edible wild mushrooms and its comparison with cultivated mushrooms. Wild mushrooms were gathered in Zirahuén, Ciudad Hidalgo and Paracho, all of them municipalities of Michoacán state, Mexico and the cultivated mushrooms were purchased in a local market. The mushrooms *Hypomyces lactiflorum*, *Bolletus* sp., *Ramaria fennica*, *Russula brevipes*, *Clitocybe gibba*, *Morchella elata*, *Lentinus edodes* and *Pleurotus ostreatus* were analyzed. The percentage of dry matter, moisture, total carbohydrate content, protein, fat, ash and total phenolics were determinate. Our findings shown that wild edible mushrooms vary on dry matter, fat, protein and phenolic compounds contain. *Bolletus* sp. had the highest fat content compared with the other analyzed fungal species; and total phenolic compounds (three times higher than the shiitake and five times higher than *Pleurotus*). *Ramaria fennica* presented a high content of total phenolic compounds (twice than shiitake). Regard to the content of protein, *Morchella elata* and *Clitocybe gibba* had comparable levels to shiitake and *Pleurotus*. In general, edible wild mushrooms have a high nutritional and nutraceutical value (phenolic compounds), which equal or exceed commercial the mushrooms shiitake and *Pleurotus*.

**Topic:** Food security and health



## ECOLOGICAL ASPECTS OF ECTOMICORRHYZAL FUNGI COLLECTED ON WOOD OF *Abies religiosa* IN CENTRAL MEXICO, INCLUDING EDIBLE SPECIES

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**Keywords:** ectomycorrhizal macromycetes, rotten logs, *Abies religiosa*

In recent years different studies have been conducted around the world to determine the characteristics of dead wood which influence the distribution patterns of the macromycetes that inhabit and disintegrate this abundant substrate in natural forests. In Mexico, information related to the ecology of these fungi, which have a very high importance in the disintegration of lignocellulose from wood in ecosystems, is scarce. Different species of ectomycorrhizal mushrooms, including edible species have been found growing in this substrate in fir forests worldwide. However, their biodiversity and their possible intervention in the process of wood rot have not been fully understood. In this work, the relationship between richness and abundance of macromycetes; and the volume, density, moisture content and carbon/nitrogen (C/N) ratio in *Abies religiosa* rotten logs was studied. A total of 43 trunks were evaluated; we found 43 different genera of macromycetes, 11 of them being ectomycorrhizal. No ectomycorrhizal genera were found inhabiting trunks, always they were observed growing on decaying wood. *Ramaria* spp., *Entoloma* sp., *Phaeoclavulina* spp. and *Clavulina coralloides* had more than one sporome. Ectomycorrhizal species of *Ramaria*, *Phaeoclavulina* and *Clavulina* are widely consumed in Mexico. The other genera were represented by a single sporome. The relationship of the ectomycorrhizal macromycetes with the wood characteristics was of the negative exponential distribution: volume and richness ( $r^2=0.98$ ), volume and abundance ( $r^2=0.88$ ), moisture and abundance ( $r^2=0.99$ ), density and richness ( $r^2=0.71$ ), density and abundance ( $r^2=0.99$ ), C/N and richness ( $r^2=0.98$ ), C/N and abundance ( $r^2=0.97$ ). Richness and abundance are higher in the case of volume, moisture, density and C/N ratio present low values.

**Topic:** Ecology



## ECTOMYCORRHIZAL FUNGI FROM *COFRE DE PEROTE* NATIONAL PARK: WITH EMPHASIS ON EDIBLE MUSHROOMS

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**Keywords:** Symbiosis, *Abies religiosa*, EMF, sporome, Russulaceae

According to FAO in 2005, more than 220 genera and 2000 species of mushrooms have been reported as edible worldwide. Many species of ectomycorrhizal fungi (EMF) produce conspicuous edible sporomes consumed by local people of the forest communities in Mexico. These ectomycorrhizal species have also a paramount importance for the nutrient exchange and the maintenance of forest ecosystems. In the *Cofre de Perote* National Park, Veracruz, Mexico, there are monospecific forests of *Abies religiosa*, an endemic species with a distribution restricted by altitudinal level from 3200 to 3600 m a.s.l. Many studies have been focused on fungal inventories and few have dealt with EMF. In recent studies, we have reported 25 taxa of EMF, 15 of which are edible. Currently we have morphological and molecular characterizations of different EMF and their respective ectomycorrhizal roots including *Sarcodon imbricatus*, *Turbinellus floccosus* and *Tricholoma equestre*. *Turbinellus floccosus* is a highly consumed species in the study area. The molecular approach allow to strengthen the biodiversity studies of EMF, because with a combination of morphological descriptions of sporomes and their associated ectomycorrhizal root-tips the identity of the specimens can be determined with precision.

**Topic:** Biodiversity



## SELECTION OF RHIZOBACTERIAL STRAINS CAPABLE OF PROMOTING THE MYCELIAL GROWTH OF THE EDIBLE ECTOMYCORRHIZAL FUNGUS *Suillus* sp.

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**Keywords:** mycorrhizal helper bacteria, phosphate solubilization, auxins, forest nurseries

In the rhizosphere many microorganisms establish symbiotic interactions with plants and other microorganisms. One of these microbial groups is the rhizobacteria, which through different mechanisms (e.g. phosphate solubilization, plant hormone production and nitrogen fixation) promote growth and improve plant nutrition. When these rhizobacteria grow in the mycorrhizosphere might enhance the symbiotic relationship between mycorrhizal fungi and plants, in addition to their direct effect on plant growth and nutrition. The objective of this research was to select strains of rhizobacteria with promoting abilities of the mycelial growth in the ectomycorrhizal fungus *Suillus* sp. About 98 strains of rhizobacteria were isolated from ectomycorrhizal fungus sporomes in forest ecosystems of Mount Tlaloc in Central Mexico. The results show that in the forest there is a large reservoir of rhizobacteria with high capacity to solubilize phosphates (42%), to produce auxins (52%) and to positively induce mycelial growth (23%). The biotechnological potential of mycorrhizal helper rhizobacteria is high, as they can be propagated in culture media and used as microbial inoculants to increase mycelial growth of ectomycorrhizal fungi in the biofertilizer industry or to increase mycorrhizae in forest nurseries.

**Topic:** Biotechnology



## MYCORRHIZAL COLONIZATION AND HYDRAULIC CONDUCTIVITY OF *Pinus leiophylla* IN FLOODING CONDITIONS

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**Keywords:** Climate change, inoculum, waterlogging, mycorrhiza, stress

Forest species, depend on partnerships established with ectomycorrhizal fungi to face stress conditions and achieve optimal development. Some deforested sites have problems with temporary waterlogging, which is a factor that negatively affects the reforestation success. Waterlogging alters the close ecological and physiological relationship between fungus and the plant. Additionally, it has been predicted that one of the possible scenarios with climate change, it is a possible change of rainfall patterns; and therefore excessive rainfall during some periods of time might result in extensive flooding in some forests. However, how do the waterlogging affects the ectomycorrhizal symbiosis has been scarcely studied. In this study, the effect of waterlogging in the survival, growth, biomass, hydraulic conductivity of the roots, mycorrhizal colonization and nutrient content in *Pinus leiophylla* was determined. Plants were germinated in a sterilized substrate (peat-moss, agrolita and vermiculite; 2:1:1). Three sources of inoculum were used: A) native soil from forest floor, B) mycorrhizal roots from a natural waterlogging area; and C) mycorrhizal roots from a seed *P. leiophylla* orchard plantation. Additionally a treatment with non-mycorrhizal plants was considered. Trees were maintained during 7 months in greenhouse conditions. After that they were treated with two levels of waterlogging, presence or absence, during 60 days; under a randomized complete block design, and a 2 x 4 factorial arrangement. The plants without waterlogging had greater dry weight, root volume and percentage of colonization, and the highest percentage of colonization was recorded in the plants with the inoculum B, followed by A. Meanwhile, the percentage of colonization was smaller in flooded plants, being first the inoculum A followed by B. An increase of hydraulic conductivity was recorded in mycorrhizal plants, independently of the inoculum source, compared to non-inoculated plants. This seminal work demonstrates for the first time that the ectomycorrhiza is a factor which allows *P. leiophylla* to increase its tolerance to waterlogging by increasing the hydraulic conductivity of the trees.

**Topic:** Global climate change



**BIOCHEMICAL, MORPHOLOGICAL AND GENETIC  
APPROXIMATION OF THE ECTOMYCORRHIZAL MUSHROOM  
*Amanita rubescens* COMPLEX IN MEXICO**

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**Keywords:** *Amanita*, edible, ITS, toxic, phylogenetic

Wild edible fungi are a non-timber forest product of ecological, cultural and economic importance. Mexico has a great diversity of edible fungi, although there are problems of mycetismus by confusion or natural variation in the species. The genus *Amanita* Pers. : Fr. includes edible and poisonous mushrooms distributed throughout the world. There are few biochemical, genetic and taxonomic studies that support the identification of *Amanita* species. The *Amanita rubescens* complex is considered edible in Europe, the United States and parts of Africa and Asia. In Mexico there are regions where it is consumed and others where they are considered toxic. Therefore, it is necessary to determine the genetic identity of Mexican species, if they contain toxins and their morphological differences. So far, preliminary results of the ITS1F and ITS4 sequences of 35 previous samples of the municipalities of *Pachuca de Soto*, *Omitlán*, *Acaxochitlán*, *Mineral del Chico* and *Huasca* in the state of Hidalgo have been obtained: A Bayesian inference analysis was performed in which two groups were generated: 1) Eurasian specimens considered as *A. rubescens* sensu stricto, coming from Europe and the external groups; and 2) specimens which includes only accessions from the state of Hidalgo. The toxin and morphological results are in process, and we are collecting more samples from other parts of Mexico. The present work will contribute to the knowledge of the morphological, biochemical and genetic variation of the populations of the *A. rubescens* complex in the country.

**Topic:** Biodiversity



## MORPHOLOGICAL AND GENETIC CHARACTERIZATION OF THE ECTOMYCORRHIZA FORMED BY *Rhizopogon roseolus* AND A NEOTROPICAL PINE FROM SOUTHWESTERN MEXICO

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**Keywords:** Mycorrhizae, *Pinus oaxacana*, symbiotic association, bioinoculants.

Ectomycorrhizal fungi have a beneficial effect on the associated plants, increasing the absorption of nutrients and in return, the fungi receive carbon from them. Species of the genus *Pinus* have an obligatory dependence on the ectomycorrhizal symbiosis for their growth and survival under natural conditions. However, despite the importance of ectomycorrhiza, the available morphological descriptions of these associations in Mexico are limited. *Pinus oaxacana* Mirov. is an important component of the great diversity of the coniferous forests of Mexico and, from the ecological point of view, plays a fundamental role in terms of environmental services due to its relatively large distribution in Mexico. In the present work the morphological, macroscopic, microscopic and genetic characterization, of the ectomycorrhizae established between *Rhizopogon lutescens* and *Pinus oaxacana* were performed. Synthesis of the studied ectomycorrhizae was carried out by inoculation with spores in a sterile substrate, keeping the plants under greenhouse conditions during four years. The taxonomic identity of the ectomycorrhiza morphotypes was determined by the phylogenetic affinity of their consensus sequences compared with those in the GenBank databases. *Rhizopogon roseolus* presented dichotomous tips, with short, simple, coraloid or head-shaped branches, white at the beginning and light brown at maturity. External and internal mantle of plectenchimatic type covered homogeneously the ectomycorrhizal roots. The presence of abundant rhizomorphs with adherent hyaline crystals was frequently observed. The combination of morphoanatomical and genetic characterization of ectomycorrhizae allows an adequate identification; which is crucial for the selection of mushrooms with potential use as bioinoculants in the production of plant species of forest and economic relevance in Mexico. Financial support from the Project CONACyT 246674 is acknowledged.

**Topic:** Taxonomy



## INTERACTION BETWEEN THE SOIL MESOFAUNA (ACARI AND COLLEMBOLA) AND EDIBLE ECTOMYCORRHIZAL MUSHROOMS IN THE MIXTEC REGION, OAXACA, MEXICO

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**Keywords:** Sporome, Poduromorpha, Oribatida, Hypogastruridae, mites, springtails.

The soil is a living, complex and dynamic ecosystem, in which vital processes develop for the functioning of terrestrial ecosystems. The nutrient cycles are closely associated with the decomposition of organic matter, and the communities of edaphic fauna are important components of most of the soil transformations. An important part of the diet of the most important groups of edaphic fauna are constituted by the hyphae and spores of a great diversity of fungi, fulfilling functions as vectors of spores and indicators of the ecological conditions of the soil and the ecosystem. In the present study the mesofauna associated to edible ectomycorrhizal mushrooms (EEM) collected in a chronosequence of 25, 42, 73 years old; and older than 90 years *Quercus magnoliifolia* forests was evaluated. Based on their morphological characteristics, richness of orders and suborders of mites and springtails between EEM were identified, counted and compared. A total of 4,692 individuals of springtails and mites were obtained, with Collembola (97.91%), Poduromorpha (96.06%) and morphospecies of the family Hypogastruridae (87.5%) being the most abundant. The Acari subclass represented only 2.09% of the total, including species of Mesostigmata and Oribatida. The highest estimated richness of springtail and mites was registered in *Russula mexicana* and the lowest in *Lactarius volemus*. Meanwhile the lower abundances were observed in *Ramaria* aff. *fennica*, *Amanita* aff. *basii* and *Cantharellus cibarius* s.l., indicating a strong food preferences of the mesofaunal component for certain species of EEM. Financial support from the Project CONACyT 246674 is acknowledged.

**Topic:** Ecology



## THE MUSHROOMS AND THE FIRST SUNRISE ACCORDING TO THE MIXTEC PREHISPANIC CODEX *YUTA TNOHO* DATED FROM EARLY FIFTEENTH CENTURY

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**Keywords:** Cultural identity, Mesoamerica, Oaxaca, wild mushrooms, *Psilocybe, ñuu savi*

In Mexico, wild mushrooms play a fundamental role in the regulation of terrestrial ecosystems, influencing the productivity, diversity and structure of plant communities. They also have enormous cultural importance linked to our national identity. Historically wild mushrooms have been a source of food, medicine and ceremonial and ludic use, fundamental for the survival of diverse ethnic groups. When the Spaniards arrived, at the beginning of the sixteenth century, the mycological knowledge was profuse, varied and enormously exact as evidenced by linguistic and archaeological evidence; which is documented in diverse pre-Hispanic codex and colonial writings. The document described in the present work is one of the most fascinating, and paradoxically little known, and non-properly analyzed in Mesoamerica. It contains the worldview of the Mixtec group or "*ñuu savi*" of the birth of the first sun and its relation to a mushroom sacred ceremony. The story which is analyzed in detail in the present work is based on the pictograms that appear in folios 24 and 25 of the prehispanic codex of Mixtec origin called the *Codex Yuta Tnoho* or *Codex Vindobonensis Mexicanus I*. The codex was elaborated on deer skin and is currently deposited in the National Library of Austria in Vienna. The story of the first dawn and the association of different deities with the mushrooms, reveals the importance of this group of organisms from a ritual perspective for the Mixtec people since pre-Hispanic times. This evidence constitutes a unique piece of the cultural and ceremonial importance of fungi for the Mixtec group, which currently survives in geographically close groups such as Mixe, Mazatec, Chinanted and Zapotec people. Financial support from the Project CONACyT 246674 is acknowledged.

**Topic:** Traditional knowledge



## EDIBLE ECTOMYCORRHIZAL MUSHROOMS FROM THE MONTANE CLOUD FOREST FROM *EL CIELO* BIOSPHERE RESERVE, TAMAULIPAS, MEXICO

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**Keywords:** Mycorrhiza, edible mushrooms, macrofungi, subtropical forest, taxonomy

Montane cloud forest at *El Cielo* biosphere reserve houses a high diversity of ectomycorrhizal edible mushrooms mainly associated with *Fagus*, *Pinus* and *Quercus* species. This work was conducted in this forest, which mainly had members of Altingiaceae, Magnoliaceae, Fagaceae and Pinaceae species. Mycological explorations were conducted on September and October at the localities: *San José*, *Alta Cima*, *Valle del Ovni* and *La Gloria*. Sampling macrofungi was conducted according Lodge and collaboration in 2004. Supplementary samples from ITCV herbarium were also examined. One hundred and eighty specimens were obtained among which members of 16 families, 29 genera and 70 species were identified including *Amanita jacksonii*, *A. aff. caesarea*, *Boletus variipes*, *B. paulae*, *Hortiboletus rubellus*, *Boletellus ananas*, *B. russellii*, *Craterellus fallax*, *Craterellus cornucopioides*, *Cantharellus cibarius*, *C. minor*, *C. cinnabarinus*, *C. lateritius*, *Exsudoporus frostii*, *Suillus granulatus*, *S. tomentosus*, *S. cothurnatus*, *Laccaria laccata*, *L. amethystina*, *Lactarius volemus*, *L. hygrophoroides*, *L. deliciosus*, *L. indigo*, *Leccinellum albellum*, *Hydnum umbilicatum*, *Gomphus clavatus*, *Sarcodon imbricatus*, *Ramaria flava* and *Strobilomyces strobilaceus*. This is the first work focused on the study of wild edible ectomycorrhizal fungi in the montane cloud forest at *El Cielo* biosphere reserve. We show the potential use of edible ectomycorrhizal fungi as a resource that can be used by local communities.

**Topics:** Taxonomy, Ecology



## ANALYSIS OF ECTOMYCORRHIZAL AND BACTERIAL COMMUNITIES IN THE FORMATION OF SOIL AGGREGATES THROUGH THIN SECTIONS OF GIGA-IMAGES

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**Keywords:** Thin sections, soil aggregation, *Suillus* sp., *Laccaria proxima*, *Hebeloma leucosarx*, pines.

Usually it has been generalized that ectomycorrhizal fungi (ECMF) form soil aggregates by connecting particles through its mycelium. However this generalization is based on studies carried out in modified samples or individual microscopic images. In this study it is proposed the use of thin sections of Giga-images and thematic maps to evaluate the formation of *in situ* aggregates by the interaction of different phytobionts (*Pinus patula* and *P. greggii*), mycobionts (*Suillus* sp., *Laccaria proxima*, *Hebeloma leucosarx* and non-inoculated trees) and bacterial communities. Pine seeds were sowed in tubes containing a mixture of sand-bark-soil (andisol), in a 2:2:1 proportion with a scoria basis (2-3 mm of diameter) called *tezontle*. After that ectomycorrhizal inoculation was carried out. After 24 months of growth, the substrate was coated with resin polyester. The thin sections (2 x 5 cm x 30 µm of thickness) were prepared and dyed with white Calcoflour. Sequential and digital images were taken with an optic microscope, ultraviolet light and petrographic microscope under different types of light (PPL and XPL), constructing a mosaic of images. Images were superimposed with the algebra of the maps to stand the components out and to elaborate thematic maps. The results show that the plant-edible ectomycorrhizal fungi interactions act in a different way in the aggregation process of the soil. *P. patula* (not inoculated) presented bacterial communities in the aggregates or forms macro-aggregates with *Suillus* sp. or *H. leucosarx*; while *P. greggii* only form aggregates in the presence of associated mycobionts. In the case of the relationship between mycobionts and aggregate size, the macro-aggregates were observed only with *Suillus* sp. (in-capsule particles) and with *H. leucosarx* (jointed particles); whereas micro-aggregates were observed only with *L. proxima*. It is important to point out that this might be related with the type of the mycobiont mycelium, due to the fact that the first two fungi are even able to form evident rhizomorphs, while *L. proxima* only has gelatinous mycelium. Finally, bacterial hotspots were observed only in the macro-aggregates surrounded by mycelium of *Suillus* sp. Probably this could generate conditions of protection favoring the development of the aggregates. The present study presents evidence that ECMF, host plants and bacterial communities differentially influence the formation and size of soil aggregates.

**Topic:** Ecology



## USES, ECOLOGICAL AND BIOCULTURAL IMPORTANCE OF WILD FUNGI IN THE SIERRA NORTE OF OAXACA, MEXICO

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**Keywords:** Ethnomycology, edible ectomycorrhizal mushrooms, reforestation

Wild mushrooms are a non-timber forest resource with enormous ecological and physiological importance in forest ecosystems. In this work we analyze several advances of three years of research in the *Sierra Norte* of Oaxaca, Mexico developed in the *Universidad de la Sierra Juárez*. The mycological works developed have included studies related to biodiversity, ecology, ethnomycology, biocultural importance and biotechnology in cloud mountain, oak and pine forests of the mushrooms in the region. The biodiversity of macromycetes in the cloud mountain forests and the cultural importance of edible wild mushrooms were studied in the chinantec community of *Santiago Comaltepec* and the zapotec municipality of *Ixtlán de Juárez*. In the cloud mountain forest 168 morphospecies were identified, of which 67% were saprobic, 28% ectomycorrhizal and 5% parasitic. The genera with the highest number of ectomycorrhizal fungi were *Cortinarius*, *Lactarius* and *Russula* with 12, 7 and 6 morphospecies, respectively. The wild fungi that presented the highest index of cultural importance for zapotec and chinantec people were *Cantharellus cibarius*, *Amanita jacksonii*, *Amanita laurae*, *Amanita basii* and *Neolentinus lepideus*. These ethnic groups still maintain their traditional knowledge and have used wild mushrooms with different uses, including edible, medicinal, recreational and economic purposes. Finally, it was demonstrated that pine plants inoculated mainly with *Suillus granulatus* reached a higher increase in height, diameter, biomass, nutrient content and ectomycorrhizal colonization with respect to non-inoculated trees. Research carried out over the past three years has shown conclusively that there is: (i) a large biodiversity of ectomycorrhizal edible fungi in the ecosystems of the region; (ii) a great traditional knowledge in the studied communities; (iii) an enormous biocultural importance, with potential for application in activities of economic and social local importance such as mycotourism; or added value to native fungi through conservation methods for domestic or international commercialization; and (iv) an enormous biotechnological potential of various species in the production of native trees for reforestation or commercial plantations.

**Topic:** Biocultural importance



## DIVERSITY OF ECTOMYCORRHIZAL FUNGI ASSOCIATED TO *QUERCUS GLAUCOIDES* AND *Q. POTOSINA* IN A TEMPERATE FOREST IN CENTRAL MEXICO

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**Keywords:** Ectomycorrhiza, oaks, biodiversity, conservation

The oak forests are communities of great ecological importance; where a wide variety of organisms interact with each other. Such is the case of ectomycorrhizal fungi (ECMF) and the roots of the trees that form ectomycorrhizae which is a mutualist interaction that plays an important role in the maintenance of these ecosystems. However, there is little knowledge related to the diversity of ECMF associated with the oak roots. Therefore, the objective of this study was to determine the diversity of ECMF associated with roots of *Q. glaucoides* M.Martens & Galeotti and *Q. potosina* Trel. in temperate forests of Central Mexico. Mycorrhizae were obtained by sampling directly at the root of the two oak species. The macro and micro-morphological characterization of ectomycorrhizae was performed. In addition, the ITS region of ribosomal DNA was sequenced. The taxonomic identity of the sequences was made using the GenBank database. We found 29 different morphotypes, 17 specific for *Q. glaucoides*, 3 for *Q. potosina* and 9 morphotypes were present in both species. Molecular analysis of 380 ectomycorrhizae was performed; obtaining 9 molecular operational taxonomic units (MOTU's) grouped in 5 genera. The genus with the highest number of species was *Tomentella* with 3, followed by *Inocybe* and *Russula* with 2 species each one and *Sebacina* and *Tuber* with one species. Only *Sebacina epigaes* and *Tuber castilloi* coincided with 97% similarity to those reported in GenBank, the remaining species might be new records for science. The results obtained are indicative of the importance of studies of ectomycorrhizal diversity in oak forests.

**Topic:** Biodiversity



## SUSTAINABLE DEVELOPMENT OF THE TERFESS SECTOR

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**Keywords:** Terfess, chain, sustainable development, valorization, economy

In Morocco, as in other countries, we continue to face a number of problems causing the Terfess production to fall. This decline in production is strongly linked to unregulated exploitation, overexploitation, overgrazing in addition to climate change such as warming and negative fluctuations in rainfall, etc. On this occasion, the team "*Mycologie Forestière et Trufficulture (Mycotruf)*" of Mohammed V University of Rabat of Morocco in collaboration with the Wageningen Truffle Center (WTC) of the Netherlands organized a Meeting in the form of a round table on the theme of "development of the Terfess sector" to raise public awareness of the importance of Terfess both for the sustainable development of the Terfess sector and for their role in combating desertification. The two partners have invited students from "International Food and Agribusiness of the University of Applied Sciences (HAS) Den Bosch" from the Netherlands and students from the Faculty of Sciences of Mohammed V University Rabat (FSR, UM5) to participate in the round table. The main objective of this meeting is to discuss, talk over, address these problems and try to find solutions. The discussions focused on the valorization of the product, its packaging and its transformation to develop the chain. At the end of this working session, the participants set out the framework for the sustainable development of the "Terfess" sector.

**Topic:** Sustainability, Economic importance



## TWO CRYPTIC SPECIES ARE PRESENT IN THE JAPANESE *Amanita caesareoides* POPULATION

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**Keywords:** *Amanita*, edible mushrooms, phylogeny, molecular, multi-marker analysis

East Asian *Amanita caesareoides* Lj.N. Vassiljeva, one of the Caesar's mushrooms, is relative to European *A. caesarea*, North American *A. jacksonii* and Central American *A. basii*. Japanese common name of *A. caesareoides* is '*Tamagotake*' which is known as a delicious wild edible mushroom. '*Tamagotake*' formerly identified as *A. hemibapha* was recently corrected to the Latin name *A. caesareoides* by morphological and phylogenetic analyses. However, as the Japanese '*Tamagotake*' population has morphological variation, it is suggested that there possibly are two different groups in the population. In this study, we aimed to clarify a working hypothesis that '*Tamagotake*' consists of two cryptic species by multi-locus phylogenetic analyses: targeted 6 sites were ITS and IGS1 regions of rRNA, *tef1*, *rpb2*, *atp6* and *cox3* genes. Fungal DNA was extracted from 20 dry materials of *A. caesareoides* and red- to orange-cap relatives in the section *Caesareae*, and the targeted sites were amplified by PCR and the obtained nucleotide sequences were used for phylogenetic analyses. As a result, '*Tamagotake*' was divided into two phylogenetic clades based on 5 sites data (IGS1, *tef1*, *rpb2*, *atp6* and *cox3*). Each phylogroup differed its climatic habitat, i.e. temperate or subalpine zone. These results suggest that '*Tamagotake*' consists of true *A. caesareoides* and an undescribed cryptic *Amanita* species. Now, it is necessary to characterize these two species morphologically.

**Topic:** Taxonomy



## DIVERSITY OF MICRO-FAUNA IN GLASSHOUSE MYCORRHIZAL SEEDLINGS RESPONSIBLE FOR MYCORRHIZA GRAZING?

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**Keywords:** Insect, *Bradysia impatiens*, grazing, mycorrhizal seedlings, glasshouse

Micro-fauna pests damaging mycorrhizal seedlings can seriously impact the outcome of mycorrhizal synthesis. Insect larvae can not only eat mycorrhizae, but also spread pathogenic bacteria, which may cause further harm to mycorrhizal seedlings. In 2016, while carrying out a large-scale mycorrhiza synthesis in glasshouse between several species of *Pinus* and *Lactarius* (section *Deliciosi*), we observed considerable grazing of mycorrhizae by small animals. The focus of this work was to identify and quantify the animal species present in the glasshouse cells and to speculate what were the main groups involved in mycorrhiza grazing. We classified and counted the adult animals caught on colored sticky traps hanged in the glasshouse for 3 to 5 months. Animals were identified using morphological characters and mitochondrial cytochrome *c* oxidase DNA sequences. A total of 1976 adults, belonging to 16 species and seven orders were identified, of which 84.5 % were *Bradysia impatiens* (Diptera, Sciaridae), by far the most abundant insect species, followed by *Hymenoptera* sp. (9.4 %). Spiders (Araneae) were also found, potentially acting as insect predators. Larvae of *B. impatiens* were found foraging pine roots and were suspected to be the main mycorrhiza pests. More information is required to prove this conjecture. Identifying mycorrhiza grazing animals will assist developing sustainable strategies for pest control.

**Topic:** Biodiversity



## ***Tricholoma matsutake* AFFECTS MICROBIAL COMMUNITIES ASSOCIATED WITH *Quercus semecarpifolia***

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**Keywords:** *Tricholoma matsutake*, endophytic, microbial communities, plant, host

*Tricholoma matsutake* (S. Ito et Imai) is an ectomycorrhizal basidiomycete associated with Pinaceae and Fagaceae trees in the Northern Hemisphere. It's well known that fungal symbiont and host plant can benefit from the symbiotic relationship between them. The fungal hyphal network aids in water and nutrient uptake helping the host plant to survive adverse conditions, and in exchange, the fungal symbiont is provided with access to carbohydrates. But whether the presence of ectomycorrhizal fungi can affect the endophytes of host plant is still unknown. In this paper, we studied the endophytic microbial communities (endophytic fungi and bacteria) of different *Quercus semecarpifolia* tissues (root, stem, leaf) with or without *T. matsutake* partner using high throughput sequencing. We found that the endophytic community structure and dominant species changed in *Q. semecarpifolia* with or without *T. matsutake* partner and some species were enriched in *Q. semecarpifolia* with *T. matsutake* partner, which may lay a foundation for revealing the material exchange and interactions between ectomycorrhizal fungi and plant host.

**Acknowledgment:** This study was financed by Sichuan Academy of Agricultural Sciences (2015LWJJ-005).

**Topic:** Biotechnology



## ***Scleroderma meridionale* ECTOMYCORRHIZAE WITH *Halimium halimifolium*: EXPANDING THE MEDITERRANEAN SYMBIOTIC REPERTOIRE**

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**Keywords:** Confocal laser scanning microscopy, molecular phylogeny, maquis, *Cistaceae*, *Sclerodermataceae*, *Boletales*

*Scleroderma* is a gasteromycete genus in the Boletales (Basidiomycota), with a cosmopolitan distribution. Species of *Scleroderma* establish ectomycorrhizal (ECM) symbiosis with a range of coniferous and non-coniferous trees and shrubs, both in temperate and tropical regions, with little tendency to host specificity, a feature that might have facilitated the wide distribution of the genus. With the contribute of confocal laser scanning microscopy, we describe the morpho-anatomical features of the ectomycorrhizae formed by *Scleroderma meridionale* on *Halimium halimifolium*, a cistaceous plant belonging to a small group of woody shrubs occurring in open vegetation types in the Mediterranean region. The mycobiont and host plant identity in ECM was verified through molecular tools. Mycorrhizal system is very small, up to 1.9 mm, mostly coralloid to irregularly pinnate. The mantle surface is felty, whitish with silver patches. Compact rhizomorphs are frequent. Mantle surface is characterised by a network of branched hyphae organized in hyphal bundles. Hyphae are frequently covered by granules or warts. These characters, except for the presence of granules, are similar to those reported for the only two natural *Scleroderma* ECM described so far, i.e. *S. bovista* on *Populus* and *S. citrinum* on *Betula* and *Pinus*. On the other side, the peculiarity of *S. meridionale* + *Halimium* ECM is the particularly small dimension of mycorrhizal system, a character shared with ECM formed by *Cistaceae*. At the best of our knowledge, this is the first description of an ectomycorrhiza on *Halimium*, a plant whose mycorrhizal biology deserves to be explored in greater detail.

**Topic:** Biodiversity; Ecology



## TRADITIONAL KNOWLEDGE OF WILD FUNGI BETWEEN THE CHINANTEC PEOPLE OF SANTIAGO COMALTEPEC, OAXACA, MEXICO

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**Keywords:** Macromycetes, northern mountain range, traditional knowledge

Wild fungi, including a big number of ectomycorrhizal species, are a non-timber forest resource which has a great cultural importance for Chinantec people of *Santiago Comaltepec*, Mexico. Chinantec people are a pre-Hispanic group that lives in the state of Oaxaca in southeastern Mexico. Constituted by 138,000 inhabitants, they call themselves *tsa ju jmi*, which means "people of ancient word". Mycological studies in the group have been very scarce. In the present work, unstructured and semi-structured interviews were carried out using the snowball technique, in order to know the biodiversity, use and importance of the fungal species used by this ethnic group. Thirty three taxa were identified, of which 29 are used in Chinantec cuisine, two are used in traditional medicine, and two are used with ritual-ceremonial purposes. All identified species maintain names in Chinantec language, which are assigned according to homologies and particular elements of the Chinantec cosmovision. Frequently, the mushroom gathering is made by adult males of the community, in the rainy months from April to October. All edible fungi harvested are used for self-consumption; however, sometimes they are marketed within the community or given to friends as a gift. These last attitude strengths the cultural links among the members of the community. Seven forms of preparation of edible wild mushrooms were recorded, of which the dish known as "*amarillo*" of mushrooms is the most appreciated by the inhabitants of the studied community. Medicinal mushrooms are used in religious sessions or special rites, for example the so-called divine consultation, or renewal of energy; while some fungi have recreational use, since in their hymenium Chinantec people draw landscapes and animals of the region. The importance and uses of wild mushrooms can be used as part of models of sustainable development in the communities, if the local cosmovision is taken into account.

**Topic:** Biocultural importance



## QUANTITATIVE ETHNOMYCOLOGY OF WILD FUNGI: A STUDY CASE IN SANTIAGO COMALTEPEC IN SOUTHEASTERN MEXICO

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**Keywords:** Biocultural importance, native groups, ethnomycological indexes

Mexico is one of the world's megadiverse countries and a one of the greatest mycological reservoirs. In addition, it holds a large number of ethnic groups with ancient mycological knowledge generated during millennia related to the importance and use of this natural resource. Currently there is a trend to use tools such as numerical ethnomycology in order to generate a more accurate understanding of the biocultural importance of mushrooms in ethnic groups. This study determined the Index of Cultural Importance of Wild Mushrooms (ICIWM) in the *Santiago Comaltepec* community, Municipality of Ixtlán located in Oaxaca, Mexico. THE ICIWM was calculated using eight sub-indices: (i) local nomenclature; (ii) mention; (iii) abundance perception; (iv) frequency of consumption; (v) multi functionality as food; (vi) preference of consumption; (vii) recognition of edibility; and (viii) economic importance. Additionally, the index of mention order was calculated as a variable of cultural importance. A multivariate analysis was performed using the maximum distances method to study the relationship between the different species of mushrooms, taking into account the previously estimated sub - indexes. In addition, Pearson's correlation analysis was used to study the possible relationship between significance indexes. There were 22 names in Chinanteco corresponding to 33 taxa. *Cantharellus cibarius* was the mushroom with the highest ICIWM value, followed by *Amanita* spp. and *Amanita jacksonii*. Meanwhile *Cantharellus cibarius* presented the highest value in the index of order of mentioning. The dendrogram of maximum distance showed three clusters that included different species of mushrooms. The index of order of mentioning had a high correlation ( $r = 0.929$ ) with respect to the ICIWM. These indexes reflect the most well-known or culturally important species in the studied community. This study might be a valuable tool for the sustainable use and economic potential commercialization of wild edible fungi among the Chinantec ethnic group

**Topic:** Biocultural Importance



## INOCULATION OF *Pinus pringlei* SHAW A NEOTROPICAL SPECIES WITH A RESTRICTED DISTRIBUTION WITH ECTOMYCORRHIZAL MUSHROOMS

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**Keywords:** Biotechnology, plant quality, survival, edible ectomycorrhizal mushrooms

All of the Pinaceae require the ectomycorrhizal interaction to survive under field conditions. However, their use has not traditionally been considered in the production of forest plants, mainly in Neotropical areas. Therefore, the objective of this research was to evaluate the effect of the ectomycorrhizal inoculation in the growth, nutrient contents and survival in the field of *Pinus pringlei* with three ectomycorrhizal fungi (ECMF). *P. pringlei* plants were inoculated with the ECMF: i) *Hebeloma alpinum* (*Ha*); ii) *Laccaria trichodermophora* (*Lt*); and iii) *Thelephora terrestris* (*Tt*). The first two species being highly appreciated as food in Central Mexico. In greenhouse, the three inoculated ECMF originated increases in terms of growth and nutrient content in *P. pringlei* plants. A significant nutritional mobilization mainly of K, Fe and Zn was registered. Molecular analysis showed that the inoculated ECMF abundantly colonized the roots of the pines. Pearson correlation analysis showed strongly positive correlations between macro and micronutrients, mainly in mycorrhizal plants compared to non-mycorrhizal plants. Survival differences under field conditions, between treatments assessed by the log-rank test, using the Kaplan-Meier method showed that two-year old plants inoculated mainly with *Ha* and *Tt* had higher survival rates in the field compared to non-inoculated plants. The beneficial effect of ECMF on growth, nutritional mobilization, and increases in field survival rates in *P. pringlei*, a species native to Mexico with a restricted geographical distribution, is reported for the first time. It can be concluded that the evaluated ECMF, including two edible species, had a high potential as useful sources of ectomycorrhizal inoculants for the production of high quality *P. pringlei* plants. Financial support from the Project CONACyT 246674 is acknowledged.

**Topic:** Biotechnology



## PRELIMINARY STUDY OF THE GENERA *Ramaria* AND *Phaeoclavulina* IN TEMPERATE FORESTS OF THE DISTRICT OF IXTLÁN DE JUÁREZ, OAXACA, MEXICO

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**Keywords:** Taxonomy, Basidiomycota, clavarioid fungi

The district of Ixtlán de Juárez, is in the Sierra Norte of Oaxaca (2030 masl 17° N 20° N and 96° N 29° W). In this district there are several types of vegetation including temperate forest of *Pinus*, *Quercus* or *Pinus-Quercus*, cloud forest and low deciduous forest. The presence of different plant communities and climatic conditions could lead to a great diversity of fungi. Some studies included of macro fungi in the same area have focused in produce inventories, which included six taxa of the genus *Ramaria*. However, taxonomic studies focused on clavarioid fungi are still lacking. As a part of a broader work that includes the study of clavarioid fungi in the district of Ixtlán, we report preliminary results from some collections made between 2014 and 2016. The preliminary results were generated from macro and micromorphological characterization of the specimens and showed nine morphotypes, of which three corresponded to *Phaeoclavulina* (*P. aff. roellini*, *P. aff. flaccida* and *Phaeoclavulina* sp.1) and six to genus *Ramaria* (*R. aff. cyaneigranosa* var. *persicina*, *R. concolor* f. *marri*, *R. suecica*, *R. rubella* f. *rubella*, *Ramaria* sp. 1 and *Ramaria* sp. 2). With these new additions we can infer that the diversity of clavarioid fungi in the district of Ixtlán could be high. Also, is essential to perform a good characterization of macro and micromorphological data for a favorable species determination.

**Topic:** Taxonomy



## INFLUENCE OF THREE CULTURE MEDIA AND pH IN THE *in vitro* MYCELIAL GROWTH OF THE EDIBLE ECTOMYCORRHIZAL MUSHROOM *Hebeloma mesophaeum*

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**Keywords:** *Pinus montezumae*, *Abies religiosa*

It has been estimated that the genus *Hebeloma* includes between 124 and 150 species worldwide. The term name of *Hebeloma* comes from the ancient Greek word *Hebe*, meaning 'youth' or 'puberty,' and the suffix - *loma*, meaning 'a fringe' or 'youthful veil,' in reference to the fungal veil that is only seen in immature stages of basidiomata of this genus. The species of this genus have a great potential for use in nursery-based plant inoculation programs because they include pioneering species that thrive in low fertility conditions and that are associated with a wide range of host trees. In general, the species of *Hebeloma* are considered poisonous. However, in Mexico there are several species of the genus that are widely consumed and have a cultural, social and economic value mainly in Central Mexico. The most abundant of them is *Hebeloma mesophaeum* s.l. The objective of the present work was to study the effect of culture media and pH on the growth of this fungus. Isolations were carried out from the context of the upper part of the pileum of specimens collected in ecotones of *Pinus montezumae* and *Abies religiosa*. Growth was measured *in vitro* in three culture media at 28 ° C and five different pH. The culture media used were modified Melin Norkrans (MMN), potato dextrose agar (PDA) and malt extract (ME); and the pH evaluated were 4, 5, 6, 7 and 8. Radial growth was evaluated for 35 days at 8 day intervals. Identification of the strain was corroborated by molecular identification. The best growth was observed in the PDA medium at pH 5 and 6 with an average growth per day of 23 mm. In contrast, the lowest growth was observed in ME at pH 8 with 5 mm per day. This agrees with the soil pH at which this mushrooms grows in the studied forest areas, which varies from 5.7 to 6.3. Depending on the culture medium, morphological differences were observed, mainly the presence of concentric rings in ME and MMN and abundance of mycelium immersed at pH 4 in the three culture media. Culture was also carried out in liquid medium and acidification of the medium from an initial pH of 5.7 to 2.9 after 30 days of growth was recorded in the MMN solution. This study demonstrates that pH and solid culture media influence the *in vitro* growth of *H. mesophaeum*. This information is useful for scaling production of ectomycorrhizal inoculum to of forest interest.

**Topic:** Cultivation



## EFFECT OF RHIZOBACTERIAL FILTRATES ON MYCELIAL GROWTH OF THE EDIBLE ECTOMYCORRHIZAL FUNGUS *Suillus* sp.

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**Keywords:** Climate change, helper bacteria, mycelial growth, microorganisms

The interaction ectomycorrhizal fungus – host plant is influenced by microbial communities growing in the mycorrhizosphere and by environmental factors, so that if changes in these two biotic components originate modifications in the functioning of the ectomycorrhizal symbiosis. It has also been registered that the mycorrhizal helper bacteria favor the fungal colonization and its adaptation to different temperature conditions. The objective of this study was to evaluate the effect of rhizobacterial filtrates on the mycelial growth of *Suillus* sp. at *in vitro* level and under three temperatures regimens. An experiment using filtrates from bacterial strains was established. Four rhizobacterial strains (B1, B2, B39 and B68) were cultured in potato dextrose broth for 72 h under shaking conditions at 28°C. Each bacterial filtrate was mixed with Melin-Norkrans medium to obtain filtrate concentrations of 30 and 70% in the medium; a control with no filtrate was included. A mycelial disc of *Suillus* sp. was placed at the center of these filtrate plates. The fungal cultures with the rhizobacterial filtrates were incubated under three temperatures: 15°C, 23°C and 28°C. The diameter of the fungal growth was measured periodically. It was found that the bacterial filtrates stimulate the radial growth of *Suillus* sp., but this depended on the temperature. The filtrate from the strain B1 promoted at all three temperatures the mycelial growth at all evaluated temperatures, however the greatest growth promotion was registered at 28°C. These bacterial filtrates have a biotechnological potential in the production of biofertilizers and could be used to stimulate the growth of ectomycorrhizal fungi, although trials are needed in plants at nursery level.

**Topic:** Biotechnology



## ECTOMYCORRHIZAL ABILITY OF *Pinus eldarica* TO ESTABLISH SYMBIOSIS WITH THREE SPECIES OF MACROMYCETE MUSHROOMS OF THE SIERRA TARAHUMARA, FROM NORTHERN MEXICO

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**Keywords:** Ectomycorrhizal fungi, pine, mycorrhiza, inoculation, morphological characterization

*Pinus eldarica* is considered a desert species that is not a native from Mexico and it has been introduced to Ciudad Juárez, Chihuahua in northern Mexico by means of reforestation. Despite the reported dependency of all pine trees with ectomycorrhizal fungi, there is very few information of the ability of *P. eldarica* to establish mycorrhizal associations. In the present study, this ability was evaluated with three different species of ectomycorrhizal fungi (*Astraeus hygrometricus*, *Laccaria laccata* and *Pisolithus tinctorius*), that were collected from a forest in Creel, Chihuahua. The inocula were prepared using distilled water and the root trees were inoculated using a factorial design of 3x2. Monthly measurements were taken in the following morphometric variables: foliage length, stem length, foliage width, total length of the seedlings and the percentage of ectomycorrhizal for each treatment. We found that the fungi that increased the growth of *P. eldarica* were *A. hygrometricus* and *L. laccata* for all measured variables. The macroscopic and microscopic morphological characterization of the ectomycorrhizal roots was performed only for *L. laccata*. It was registered the presence of the mantle, Hartig net and emanating hyphae. The ectomycorrhizal morphotypes showed a coralloid ramification type with a length of 1.5-4.8 mm with straight ends, up to 0.2-2.6 mm in length and 0.2-0.7mm in diameter. They showed a yellowish coloration with the presence of hyphal mantle and mycelial strands. It was demonstrated that the inoculation with ectomycorrhizal fungi might help the survival and growth of *Pinus eldarica*, having therefore a biotechnological potential in the production of this tree species.

**Topic:** Biotechnology



## BASIDIOMATA FORMATION OF TWO EDIBLE ECTOMYCORRHIZAL MUSHROOMS IN ASSOCIATION WITH TWO NEOTROPICAL PINES IN GREENHOUSE

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**Keywords:** Pinaceae, wild edible fungi, sporal inoculum, spore production, early colonizers

Mycelium of Agaricales, has typically been used in the inoculation of edible ectomycorrhizal fungi in forest plants, but the efficiency of the use of dried pilea of basidiomata as inoculum source has received little attention. In the present study, *Pinus greggii* Engelm and *P. montezumae* Lamb. plants were inoculated with ground dehydrated basidiomata of *Laccaria laccata* s.l. and *Hebeloma mesophaeum* s.l. After 284 and 392 days post-inoculation, respectively, the first appearances of basidiomata of the inoculated species were recorded. After 421 days post-inoculation, a total of 66 mature basidiomata of *L. laccata* and 2 of *H. mesophaeum* had formed. Most (74%) of the basidiomata of *L. laccata* were associated with *P. montezumae*, and only 26% were associated with *P. greggii*. The two pine species showed high percentages of ectomycorrhizal colonization (ranging from 80% to 84%) when the fungal species were inoculated individually. Molecular analysis proved that the inoculum had a correspondence with the ectomycorrhizal roots and the formed basidiomata for both evaluated species. Additionally, the ontogeny of the basidiomata formation in the two species of fungi is described. Differences in the development of *L. laccata* and *H. mesophaeum* were observed, primarily in the early formation of the pilea. In the case of *L. laccata*, eight ontogenetic stages were characterised, and the formation of mature sporocarps and spore clusters was recorded. Previous studies have documented the appearance of basidiomata of *Laccaria* or *Hebeloma* at 45 to 180 days after inoculation using mycelia as the source of inoculum in the presence of a host. Here, using dehydrated basidiomata, the first basidioma was recorded more than 9 months after inoculation. The present study suggests that under equivalent environmental conditions, the host species has an influence on the formation of ectomycorrhizal basidiomata.

**Topic:** Biotechnology



## PLANT DEVELOPMENT OF *Quercus castanea* INOCULATED WITH *Hebeloma mesophaeum* AND IRRIGATED WITH ALLOTROPIZED WATER IN A GREENHOUSE: AN EXPLORATORY STUDY

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**Keywords:** *Quercus castanea*, *Hebeloma mesophaeum*, allotropized water, greenhouse, ectomycorrhizal fungi, Mixteca Alta, Oaxaca.

*Quercus castanea* Née (*encino capulincillo*) is a Mexican species of oak deciduous tree in the Fagaceae family. Its distribution area ranges from northwestern to southeastern Mexico and northern Central America. For this work, seeds of this species were collected in the *Mixteca Alta* in the north of Oaxaca State, Mexico. Fourteen 5 year old plants of *Q. castanea* mycorrhized with *Hebeloma mesophaeum* (Pers.) Quél. grown in pots, in a soil with a pH of 7.3, were facilitated by a research colleague (Dr. Faustino Hernández-Santiago) for an exploratory study in greenhouse conditions at the eastern of Mexico City. A completely randomized design was used, with two treatments: i) plants irrigated with allotropized water and ii) plants irrigated with tap water. Seven replicates were used for each treatment. Weekly, for 56 days, plant height, mature leaves, young leaves, meristems and coverture were registered. Allotropized water was produced with a 4 commercial allotropic cylindrical cells made of brass metal (12 cm long and 2.5 cm diameter) in a 200 L water tank; the cells develop an electrochemical reversible reaction (Zn-Cu) inside, generating a weak electromagnetic field that enhances salt solubility and water uptake by the plants. The results show no statistical differences in any plant variable at the end of the study. However, time registration of plant development was very short. It is concluded that is necessary to growth plant species with and without mycorrhizal inoculation for at least one annual period in order to test the influence of allotropized water on plant development. Financial support from the project UNAM-PAPIIT IN218317 is acknowledged.

**Topic:** Ecology



## ECTOMYCORRHIZAL MORPHOTYPES OF *Pinus pringlei* IN A PRESERVED AREA OF NATURAL FORESTS IN GUERRERO, MEXICO

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**Keywords:** Forest conservation, native pines, pringle's pine, endemic species.

Temperate forests are part of the great biological diversity of Mexico, which produce timber, non-timber forest resources and environmental services. Ectomycorrhizae are important components for the functioning of the forests, increasing the area of root absorption which favors the tree growth. This work evaluated the richness of ectomycorrhizal morphotypes of *Pinus pringlei* Shaw natural forests located at *El Huizteco*, Taxco, Guerrero, Mexico. This pine species is only found in Mexico, where it has a restricted distribution. The evaluation included trees of different sizes: adults, juveniles and young seedlings. During the rainy season of 2015 four soil blocks of 20x20x20 cm were collected adjacent to pine stems and all the morphotypes of the mycorrhized roots were obtained. In addition, the sporomes of ectomycorrhizal fungi in the same studied area were identified. As a result, 14 different morphotypes were obtained, both tuberculate and simple. Some morphotypes belonged to the genera of *Cenococum* and *Helvella*; as far as we know this is the first report of such ectomycorrhizal genera associated with *P. pringlei* in natural forests. In the conserved area 11 morphotypes were found associated with adult trees, 7 with juveniles and 9 with young seedlings. The identified fungi belonged to the genera *Amanita*, *Boletus*, *Lactarius*, *Leccinum*, *Ramaria* and *Russula*. This is one of the few studies of the morphotypes and basidiomata associated with this endemic pine species of Mexico under natural conditions.

**Topic:** Conservation



## PERCENTAGE OF ECTOMYCORRHIZAL COLONIZATION IN *Pinus greggii* ORIGINATED BY THE INOCULATION WITH DIFFERENT DOSES OF THE EDIBLE MUSHROOM *Laccaria proxima*

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**Keywords:** Mycorrhizae, climate change, deforestation, reforestation, plant survival

Mycorrhizae are mutualistic associations between the roots of plants and certain groups of fungi. Particularly, ectomycorrhizae have ecophysiological importance in the forests due to the fact that the external ectomycorrhizal mycelium plays a role as an extension of the roots and increase of the absorption area. The main benefit in this symbiosis is the exchange of nutrients. On the other hand, deforestation is a factor which contributes to climate change and an important activity to reverse this damage is the reforestation. However, this is a complex process in Mexico, which includes, among other technical limitations, a low survival rate of pines in the field. One of the reasons which explain this low survival is the lack of ectomycorrhizal symbionts in the roots of most pine species produced in nurseries, whose presence is obligatory under natural conditions. However, in Mexico the development of a biotechnology using edible ectomycorrhizal mushrooms is in its infancy. The objective of the present study was to evaluate the effect of inoculation with three doses (1, 2 and 3 g per plant) each gram containing  $10^6$  to  $10^7$  spores of the edible mushroom *Laccaria proxima* on the growth and percentage of ectomycorrhizal colonization in *Pinus greggii* plants. Two hundred and forty days after sowing, the plants inoculated with a dose of 2 g presented better results in terms of growth, biomass and percentage of colonization. The percentage of colonization at this time was of 28, 44 and 40%, in plants inoculated with 1, 2 and 3 g of spore inoculum, respectively. Meanwhile in non-inoculated plants there was no mycorrhization. Additionally, a morphological characterization of the mycorrhizae was performed to confirm the colonization of *L. proxima* in the evaluated host plant, and the observed morphotypes were those characteristic of this mycobiont. This work then gives some light of the optimal dose of *L. proxima* inoculum which should be used in the plant production of *P. greggii*. It can also be concluded that *L. proxima* represents an important potential source for the successful biotechnological inoculation of *P. greggii* which is a forest species with great economic relevance in Mexico. Financial support from the Project CONACyT 246674 is acknowledged.

**Topic:** Biotechnology



## EFFECT OF *T. melanosporum* ON SURROUNDING SOIL MYCOLOGICAL DIVERSITY

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**Keywords:** fungal biodiversity, soil colonization, fungal interspecific interaction, *Tuber melanosporum*, *Quercus ilex*.

The capacity of *T. melanosporum* to colonize a new site is a big unknown. In the early days of truffle cultivation research, there was a lot of effort in making a substrate as depleted as possible of propagules of other fungi so that the truffle mycelium could grow. Lately, we are observing that *T. melanosporum* has the capacity to colonize quickly the soil where it is introduced with a seedling, and remain there for a long time. We wanted to understand better whether the competitive interactions between the truffle fungus and other fungi when planted in a wild site, where we would expect to find a wide array of fungi including VAM and ectomycorrhizal. We planted *T. melanosporum* inoculated seedlings in a small abandoned pasture surrounded by *Quercus ilex* forest. Five years later we selected a subset of 30 seedlings, sampled soil 40 and 80 cm apart from the stem, and extracted DNA to perform PacBio fungal-specific amplicon sequencing to identify the fungal species present in the soil samples. We observed larger amounts of *T. melanosporum* mycelium close to the tree, but this apparent dominance did not translate into a strong impact on the composition of the community of other fungi surrounding the plant. On the other hand, trees of larger diameter did have a distinct mycological community around them from that of thinner trees. Of particular interest was the distance effect on an OTU identified as *Glomeraceae* sp that was a lot less abundant close to the seedlings where *T. melanosporum* was dominant. Only the relative proportions of a *Suillus* species and *Rhizopogon roseolus* were positively, but marginally, correlated with *T. melanosporum* dominance. Initial root colonization of inoculated seedlings may be more important than fungal competitors to predict future success of *T. melanosporum* mycelial expansion.

**Topic:** Ecology



## IMPORTANCE OF THE STUDY OF THE MYCOLOGICAL RESOURCES FOR SUSTAINABILITY AND TRADITIONAL KNOWLEDGE IN THE STATE OF MEXICO

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**Keywords:** Macromycete, traditional knowledge, native communities, sustainable development

The Intercultural University of the State of Mexico (which acronym is UIEM in Spanish) started its activities in September 2004; having as a function to meet the social demand to offer teaching with a new approach, directed both to indigenous groups, and to urban population. One of the goals was the promotion of an innovative way of teaching, integrating the worldview of the Mazahua, Otomí, Matlazinca, Nahuatl and Tlahuica people with the clear intention of preserving the biocultural heritage of these indigenous people. The University offers three majors: Language and Culture, Intercultural Communication and Sustainable Development (SD). Thus, the bachelor's degree in SD arises from the need to look for alternative model of development, involving social, economic, cultural and environmental aspects promoting the sustainable management of natural resources including non-timber forest products, among which fungi are of paramount importance in the area of influence of the University. Undergraduate students learn to characterize the mushrooms with biocultural importance in their native groups, and learn to identify them by using specialized guides and web pages. This is complemented with explanations of the mycological principles and function. The collected specimens are herborized, and the students learn, in practical terms, the importance of wild mushrooms, including the use of ectomycorrhizal species in the potential development of strategies for sustainable development. There has been a particular interest in the biotechnological application and development using wild mushrooms. The mycological diversity of some Mazahua communities, the names in the original language and their linguistic roots has been formally documented. There have been three B.Sc. thesis, the publication of a book and five works more are in process. The development of mycological studies, is one of the research lines which is being develop in this University which in linked with the native groups of the State of Mexico located in Central Mexico.

**Topic:** Traditional knowledge



## HYPOGEOUS FUNGI FROM THE PROTECTED NATURAL AREA CUENCA DE LA ESPERANZA IN GUANAJUATO, MÉXICO

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**Keywords:** *Quercus*, hypogeous fungi, Guanajuato

Knowledge on the hypogeous fungi of Mexico is limited. There are no reports of hypogeous fungi from Guanajuato state located in eastern Mexico. *Cuenca de la Esperanza* is a protected natural area, which has a wet and temperate climate, covers 1832 ha and is located in the mountain range of Santa Rosa, in the state of Guanajuato. It has as dominant vegetation of oak forests with 15 species of *Quercus*, associated with *Arbutus* sp. and *Arctostaphylos pungens*. We tested the hypotheses that there were hypogeous fungi associated to the *Quercus* forests in this natural area and that some of these species were potential edible. Thus, the objective of the present work was to contribute to the taxonomic knowledge of the hypogeous fungi from the mountain range of Santa Rosa, Guanajuato. The fruit body search was carried out by randomly selecting oak trees and then digging in the upper soil layer, down to 15 cm deep, in the area surrounding the trunk bases. All the fruiting bodies found were photographed fresh. After that, they were dried at 50°C and voucher collections were deposited in the mycological collection *José Castillo Tovar* (ITCV) at the Technological Institute of *Ciudad Victoria*, Mexico. Twenty nine field trips were carried out, in which more than 98 specimens of hypogeous fungi were collected associated with native oaks. The hypogeous fungi found belong either to Ascomycota, i.e. *Hydnobolites*, *Pachyphloides* and *Tuber*; or to Basidiomycota, i.e. *Aroramyses*, *Hymenogaster*, *Hysteranguim*, *Macowanites* and *Melanogaster*. At least 11 species of hypogeous fungi were collected, among which two *Tuber* species are potentially edible.

**Topic:** Taxonomy



## POTENCIAL USE AND DISTRIBUTION OF SPECIES OF *Boletus* IN MEXICO

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**Keywords:** Boletales, richness, edible, toxic, medicinal

Considering that the species included in the genus *Boletus* are edible, and have a very important international market, a bibliographic search in different scientific journals including for example *Boletín Informativo de la Sociedad Mexicana de Micología*, *Boletín de la Sociedad Botánica de México*, *Revista de Micología Neotropical Aplicada*, *Hongos del Estado de Querétaro*, *Die Röhrling I-II*, was conducted in order to know the species registered in Mexico. As a result, it was found that a total of 38 species have been cited in the genus *Boletus* s.l. however currently some of them are now included in other genera including *Suillus* (3 species), *Gyrporus* (1 species), *Xerocomus* (4 species) and *Pulveroboletus* (2 species). Most of the registered species are edible and they are considered of high quality. Few species have a very bitter taste which originates gastrointestinal distress. The economic value of the species of the genus *Boletus* varies from year to year, i.e. in 2009 its price was 60 american dollars; in Mexico these mushrooms are sold by measure of either a small pile or a small basket costing no more than 80 Mexican pesos. No precise data were found on the precise amounts of *Boletus* spp. which are exported from Mexico to international markets, and whether the mushroom species of *Boletus* are mixed with other genera, or exported separately. We discuss the species that were found to have a large distribution across the country. An interesting historical data is constituted by the fact that the first thesis related with species within this genus was directed by one of the authors of the present contribution Dr. Teófilo Herrera in 1958 by the student Monserrat Gispert which was entitled “Species of genus *Boletus* in the Mountain range of las Cruces and the Desert of the Lions, Mexico City”. Afterwards, this contribution was published in the Bulletin of the Mexican Botanical Society.

**Topic:** Taxonomy, Biodiversity



## INOCULATION WITH TWO ECTOMYCORRHIZAL EDIBLE FUNGI IN *Pinus cembroides* subsp. *orizabensis* A DROUGHT-RESISTANT SPECIES

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**Keywords:** pine nuts, restauration, hydric stress

In Mexico, the inadequate use of forest resources has originated environmental problems of great impact including conspicuous soil degradation. *Pinus cembroides* subsp. *orizabensis* is the main native pine tree species of Mexico that produce pine nuts known as *piñones* in Spanish. It also has a great adaptive potential to grow in adverse conditions including severe drought. On the other hand, *Laccaria proxima* and *Hebeloma mesophaeum* are ectomycorrhizal edible species of great cultural and economic importance in Mexico. The objective of this work was to evaluate if the fungi *L. proxima* and *H. mesophaeum* were able to form ectomycorrhizae with *P. cembroides*; as well as to analyze if the inoculation with these fungi increased the growth of this plant tree. Significant differences in height and colonization were found in plants inoculated with both fungi, alone or in combination with respect to non-inoculated plants. Colonization rates from 25 to 33% were recorded in the inoculated plants. The mycorrhizae of *H. mesophaeum* were dichotomous, from 2 to 5 mm in length and 0.5 mm in diameter. They were white when young and have cream color in older stages, with presence of white mycelial cords. The ectomycorrhizae of *L. proxima* were simple and sometimes dichotomous, 2 to 8 mm in length and 0.2 mm in diameter, light brown when young and ocher brown in older stages, with light brown apex and abundant gelatinous hyphae. The formation of mycorrhizae between *L. proxima* and *H. mesophaeum* and *P. cembroides* is recorded for the first time. Additionally, this work demonstrates the potential of the evaluated fungi in the production of a pine species that is highly tolerant to drought and has a relevant economic importance in pine nut production. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Biotechnology



## BIOTECHNOLOGICAL APPLICATION OF PLANT GROWTH PROMOTING BACTERIA AND *Laccaria laccata* IN THE GROWTH OF *Pinus patula*

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**Keywords:** ectomycorrhiza, inoculation, pines, N-fixing bacteria, fosfate solubilizing bacteria

There is a high percentage of mortality which occurs in pine plants when transplanted from nursery to field due to problems of adaptation to the environment. In Mexico, this percentage of mortality reaches up to 80%. The application of beneficial bacteria and ectomycorrhizal fungi that facilitate the absorption of nutrients, the capture of water and the stimulation of the plant growth can be very helpful. The objective of the present work was to apply inoculants formulated with nitrogen fixing bacteria (NFB), phosphate solubilizing bacteria (PSB) and with an edible ectomycorrhizal mushroom *Laccaria laccata*, in the development of *Pinus patula* plants. Three month old pines were inoculated with microbial formulations and the inoculation was repeated once a month in both fertilized and unfertilized treatments. The shoot height, the stem diameter and the total dry mass, as well as ectomycorrhizal and non-mycorrhizal roots were evaluated. One hundred and eighty days after inoculation an increase in plant growth was observed. In the fertilized treatments there were increases in relation to non-inoculated plants of 27.4 and 20.4% in the height of plants inoculated with BSF + *L. laccata*; and with BFN + *L. laccata*, respectively; of 28.4 and 23% in the dry mass of the shoots of plants inoculated with *L. laccata* + BSF and of 107.6 and 46.2% in plants inoculated with BSF and BSF + BFN, respectively. Meanwhile in the treatments without fertilization there were also increases, compared with non-inoculated plants of 11.04% in the height of plants inoculated with *L. laccata*; of 34.4% in the dry mass of the shoots of plants inoculated with BFN + *L. laccata*; of 67.9% in the roots of plants inoculated with BSF + *L. laccata*. The highest percentages of mycorrhization were recorded in the treatments of *L. laccata* + BFN and *L. laccata* + BSF. This work demonstrates the importance of co-inoculation between phosphate-solubilizing and nitrogen-fixing bacteria with the edible ectomycorrhizal fungus *L. laccata* in the production of *P. patula* plants.

**Topic:** Biotechnology



## SEASONAL DYNAMICS OF EXTRARADICAL MYCELIUM AND MYCORRHIZAS IN A BLACK TRUFFLE (*Tuber melanosporum*) PLANTATION

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**Keywords:** Black truffle, *Tuber melanosporum*, mycelium quantification, real-time PCR, ectomycorrhizal diversity

Seasonal dynamics of black truffle (*Tuber melanosporum* Vitt.) extraradical mycelium as well as the composition of the associated mycorrhizal community have been evaluated in a 16-year-old plantation with productive and non-productive trees. Mycelium biomass of *T. melanosporum* was seasonally quantified by real-time PCR over two consecutive years and the correlation with environmental variables explored. Extraradical mycelium biomass varied seasonally and between the two consecutive years, being correlated with the precipitation that occurred one month before sampling. In addition, productive trees had more mycelium in the brûlé area than non-productive trees. The ectomycorrhizal community composition inside the brûlé areas was seasonally evaluated during a year. Ten mycorrhizal morphotypes were detected; *T. melanosporum* was the most abundant in productive and non-productive trees. Black truffle mycorrhizas were more abundant (mycorrhizal tip per constant volume of soil) in productive trees and no seasonal variation was observed in mycorrhizal abundance during the first year. The occurrence of black truffle mycorrhizas was significant and positively correlated with the extraradical mycelium biomass. The mycorrhizal composition within the brûlé areas was significantly different between productive and non-productive trees, and no variation was detected between seasons. The assessment of the fungal vegetative structures in a mature plantation is of paramount importance to develop trufficulture methods based on knowledge of the biological cycle of the fungus and its relationships with the associated ectomycorrhizal communities.

**Topic:** Biodiversity



## ETHNOMYCOLOGY OF THE *TLAHUICA-PJIEKAKJOO* CULTURE OF THE STATE OF MEXICO

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**Keywords:** Cultural erosion, original cultures, tradicional knowledge

Mexico is a country with an enormous biocultural importance; it holds a large biological diversity which includes around 10% of the known biological diversity and also 68 ethnic groups. As a consequence of these biological and cultural diversities, in the country more than 450 species of wild edible mushrooms (WEM) are consumed, one of the greatest genetic diversities known world-wide. The *Tlahuica-Pjiekakjoo* culture, located in the municipality of Ocuilan, state of Mexico, possesses an enormous, precise and exact knowledge of their WEM. The mycological resource has been part of their culture since pre-Hispanic times and has constituted part of their diet ancestrally. However, their fungi have been scarcely studied. In addition, this original group is part of the Mexican cultural heritage, which, like other cultures, shares accelerated cultural erosion and the loss of its traditional ancestral knowledge. Therefore, as an effort to contribute to the conservation of the *Tlahuica-Pjiekakjoo* biocultural heritage, an ethnomycological study was carried out, documenting the WEM species and the traditional knowledge associated with these organisms. As a result of the study, 160 species of WEM were recorded to be consumed and distinguished by the *Tlahuica-Pjiekakjoo*. This figure is one of the highest in Mexico for a single ethnic group in Mexico. Also 79 names in *Tlahuica-Pjiekakjoo* language and 130 common names in Spanish were registered. In addition, we identified 117 ectomycorrhizal species with biotechnological potential for the production of trees with forest importance in the studied area. The present study concludes that the traditional knowledge related with the WEM remains in the study area, being extremely diverse and accurate in terms of identification, use and cultural importance. In addition, the mycological resource represents an opportunity for local development and conservation of its ecosystems, through the development of activities, such as mycotourism. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Ethnomycology



## MYCORRHIZAL SYNTHESIS OF *Tuber* SPP. AND INDIGENOUS HOSTS IN SOUTHWESTERN CHINA

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**Keywords:** truffle, cultivation, inoculation, mycorrhizal synthesis

Edible truffles originating from Asia are gaining increased recognition internationally. We initiated the cultivation of truffle trees in Yunnan and Guizhou provinces. The first step consisted in attempting artificial syntheses of mycorrhizae between candidate truffle and tree species. Containerized seedlings of *Quercus franchetii*, *Q. variabilis*, *Q. fabrei*, *Q. mongolica*, *Q. longispica*, *Cyclobalanopsis glauca* and *Corylus yunnanensis* were sourced from China and inoculated with aqueous spore suspensions of *Tuber indicum*, *T. sinoaestivum* and *T. pseudoexcavatum*. In addition, *T. melanosporum* and *T. borchii* were sourced from Europe and inoculated onto the above indigenous trees. Truffles were identified using morphological characters and ITS sequences. The inocula consisted of spore slurries, i.e. chopped ascorcarps were crushed with a blender and spore concentration was measured with a haemocytometer. Each seedling received the same quantity of spores regardless of the truffle species. Non-inoculated control seedlings were included. Mycorrhizae began to form 5 months after inoculation and were harvested at 9 months. The ITS sequences of mycorrhizae obtained were identical to those of the source ascorcarps. Mycorrhiza formation either stimulated or did not affect the host plants' growth compared to control seedlings. We synthesized mycorrhizae between 14 distinct combinations of plant/truffle species, two of which, i.e. *T. melanosporum* associated with either *Q. mongolica* or *Q. longispica* have not been reported yet. The comparative quantification of mycorrhizae obtained for different combinations has not been attempted. Our next step is to further document the outcome of the mycorrhization process and to set-up the first trial plantations with these combinations.

**Topic:** Cultivation



## MYCORRHIZAL COLONIZATION AND MORPHOTYPE RICHNESS ASSOCIATED WITH THE GROWTH OF *Abies religiosa* IN THREE SUBSTRATES

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**Keywords:** ectomycorrhiza, organic matter, vermicompost, plant production

*Abies religiosa* (Kunth) Schltdt et. Cham. is distributed in Mexico, between 2800 and 3500 m a.s.l. This species is commonly called *oyamel*, which comes from the nahuatl, which was the language spoken by the Aztecs. The *oyamel* can be used as a Christmas tree and its wood is used to make coal and furniture. Due to their high economic value, the forests of this species suffer strong social pressure for clandestine exploitation. To solve this problem reforestations are carried out, which are not always successful, and therefore it is required the inoculation with ectomycorrhizal fungi. In the present research, ectomycorrhization in *A. religiosa* was evaluated in plants grown in three substrates: i) 80% of sawdust and 20% of vermicompost; ii) 90% of sawdust and 10% of vermicompost; and iii) 40% of bark, 40% of forest soil and 20% of sand, termed "*colpos*" substrate. Native soil and ectomycorrhizal roots from natural forests of *A. religiosa* was used as inoculum in each treatment, constituted by each substrate, and after 15 months the plant growth and richness composition of morphotypes, was analyzed. In the so-called *colpos* substrate the highest values of stem diameter and height, as well as the highest percentages of mycorrhization, which reached up to 81% on average, were recorded. In this substrate, and in that which contained 10% of compost, only 2 morphotypes were found. Meanwhile, in the substrate containing 20% of vermicompost, the morphotype richness was twice as high. Morphotypes 1 and 2 were found on all evaluated substrates, while morphotypes 3 and 4 were exclusive to the first substrate. This work demonstrates that the physical and chemical properties of each substrate influence the colonization and richness of ECM morphotypes associated with *Abies religiosa*.

**Topic:** Biotechnology



## **INOCULATION OF TWO EDIBLE FUNGI AND NATIVE SOIL IN *Pinus hartwegii*, GROWTH AND MYCORRHIZATION**

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**Keywords:** *Abies religiosa*, *Laccaria proxima*, *Amanita rubescens*

*Pinus hartwegii* Lindl. is a native species of Mexico and Central America, where it grows in the altitudinal limits of the tree vegetation, as high as 4300 m a.s.l. Currently, it has suffered a dramatic reduction in its normal distribution originated by the global temperature increase. In the present work, the effect on growth and ectomycorrhizal colonization of *P. hartwegii* of the addition of liquid inoculum of *Laccaria proxima* or *Amanita rubescens*, two edible fungi of great cultural importance in Mexico, and of two native inocula constituted by ectomycorrhizal roots and soil from natural forests of *P. hartwegii* and *Abies religiosa* (Kunth) Schltdl. et Cham. was evaluated. This latter treatment was established because *A. religiosa* might displace the natural distribution of *P. hartwegii*. Additionally, there was a fifth treatment consisting of non-inoculated plants. The highest height was observed in plants inoculated with *A. rubescens*, while the best stem diameter was recorded in plants inoculated with native soil and ectomycorrhizae from fir. The highest percentage of mycorrhization in the pines was recorded in plants inoculated with soil and ectomycorrhizal roots of natural forests of *P. hartwegii*. This work demonstrates that the ectomycorrhizal inoculum constituted by soil and mycorrhizal roots from fir forests could enhance the survival of *P. hartwegii* against its reduction of distribution. In addition, it demonstrates the biotechnological potential of *L. proxima* and *A. rubescens* in the nursery plant production of this forest species.

**Topic:** Biotechnology



## CULTURAL IMPORTANCE OF NON-EATING FUNGI IN TWO COMMUNITIES OF LA MALINTZI VOLCANO TLAXCALA, MÉXICO

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**Keywords:** Toxic mushrooms, local knowledge, recognition criteria, ethnotaxa, *Amanita*, *Russula*, *Boletus*, *Clitocybe*

Recognizing the role that mushrooms play in human cultures has been a recurring topic in ethnomycology. However, currently there has not been a study focused on non-edible mushrooms. This research has the objective of determining which mushrooms are deemed non-edible, what their cultural significance is, and the criteria used for such significance. The study sites were the communities of *Francisco Javier Mina* and *San Isidro Buensuceso*, both located in the National Park *La Malintzi*, Tlaxcala, Mexico. Mushroom specimens were obtained in 13 ethnomycological walks and seven requests for collection. They were collected, described, and determined using standard biological methods. Ninety-one free listings and 81 semi-structured interviews were applied. One hundred and three species of mushrooms belonging to 45 genera were identified. The most diverse genera were *Amanita*, *Cortinarius*, *Russula*, *Boletus*, and *Clitocybe*. People build knowledge related to non-edible mushrooms by comparing them to edible species. In general people consider that all non-edible mushrooms are poisonous; they represent a group of organisms with “no use”, but with some “interest”. The common names, both in Spanish and in Nahuatl, are assigned in reference to their edible look-alike. A hundred and one specific recognition criteria used according to each ethnotaxon were found; these were proved to have consensus in the most significant taxa. *A. muscaria* obtained the highest values for most of the indicators used to calculate cultural significance. We propose that ethnotaxa with the highest values for cultural significance indicators are those that are attributed with a set of clear and precise features, which define them and allow them to be grouped by names in specific ethnotaxa.

**Topic:** Ethnomicology



## ETHNOMYCOLOGICAL STUDY OF THE MAZAHUA COMMUNITIES NEARBY XOCOTÉPETL MOUNTAIN, MUNICIPALITY OF JOCOTITLÁN IN THE STATE OF MEXICO

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**Keywords:** Edible fungi, macromycetes, traditional knowledge, Ascomycota, Basidiomycota, native communities

Mexico has the tradition of being mycophagous since pre-Hispanic times. However the macromycetes, began to formally being studied in the country only until the second half of the last century. The main topics have being the taxonomic, ecological and economic approaches. However, the study of the mycological resource is far to be complete. In the present study the mycological diversity growing in the Xocotépetl Mountain, in the Municipality of Jocotitlán, State of Mexico was studied. This area is considered a state reserve, which has allowed it to maintain an important forest mass and it is visited for the mushroom gathering by several communities. Mushrooms are used either for self-consumption or they are marketed. Thus, the present research aimed to carry out an ethnomycological study of the Mazahua communities near the Xocotépetl Mountain. This work was carried out in the rainy season of 2013 during July to October, when the highest historical rainfall was recorded. For the collection of fungal diversity, 8 field trips were carried out every 15 days, carrying out random walks with a duration of 10 hours. The study was carried out in three localities: Barrio la Venta, Cabecera municipal and Huemetla, selected for their proximity to the Xocotépetl Mountain and for having a mazahua population. Sixty three rural family systems were interviewed. One hundred specimens of macromycetes were collected. The Mazahua population of the studied area consumes 34 species, of which 11 are commercialized, including ectomycorrhizal mushrooms. The population use 26 local names in Spanish and 15 names in Mazahua language. This seminal study shows that a local knowledge still survives in the studied region.

**Topic:** Traditional knowledge



**FIRST RECORD OF THE ECTOMYCORRHIZAL SYNTHESIS  
BETWEEN *Laccaria proxima* AND *Quercus uxoris* A VULNERABLE  
SPECIES OF THE MOIST MONTANE CLOUDY FOREST  
OF THE MAZATEC REGION, MEXICO**

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**Keywords:** endemic species, endangered oaks, inoculum, basidiomata formation

Mexico holds the highest diversity of oaks worldwide with more than 170 species, of which 109 are endemic. *Quercus uxoris* McVaugh recently found in the mazateca region in the state of Oaxaca, Mexico is known as *oi'en* (oak) in Mazatecan language. This is a species which grows only in Mexican moist montane cloud forest classified and has been classified as vulnerable by the International Union for Conservation of Nature and the Red List of Threatened Species. The objective of this work was to evaluate the effect of the inoculation with the edible ectomycorrhizal fungus *Laccaria proxima* on *Q. uxoris*. The experiment was conducted at *Colegio de Postgraduados*, with a completely random experimental design. Acorns 40 mm long by 28 mm wide were collected in the municipality of San Antonio Eloxochitlán in Flores Magón, Oaxaca; The inoculum was obtained from the *L. proxima* pellets dehydrated at 35 ° C and ground. The synthesis of the edible ectomycorrhizal fungus *L. proxima* with *Q. uxoris* is recorded for the first time. The establishment of the symbiosis was confirmed with the appearance of a sporome of *L. proxima* at 432 days after planting and inoculating the plants under nursery conditions. The sporome was able to produce spores. Ectomycorrhizae were simple, 2 to 6 mm long, light brown color, constricted between the oldest and youngest parts, with whitish globose tips, without presence of rhizomorphs, plectenchimatous mantle and with some semitransparent mycelium. Currently, there were no studies showing that *Q. uxoris* was able to establish ectomycorrhizal symbiosis, thus this work shows the great potential of this symbiosis in the production of plants of this vulnerable species. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Conservation



## ***Eremiomyces innocentii*, A NEW DESERT TRUFFLE FROM THE CANARY ISLAND**

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**Keywords:** Desert truffle, hypogeous, mycorrhizal fungi, Pezizaceae

The genus *Eremiomyces* was established by Ferdman et al. (2005) to accommodate *E. echinulatus*, a southern African desert truffle originally described as *Choiromyces echinulatus* from the Cape Province in South Africa by Marasas & Trappe (1973). The genus *Eremiomyces* has two accepted species, *E. echinulatus* also collected in the Kalahari Desert of Botswana and Namibia (Ferdman et al. 2005, Trappe et al. 2008, 2010), and *Eremiomyces magnisporus*, collected in semi-arid hills around Alcalá de Henares, central Spain (Alvarado et al. 2011). In the present work, a new species of *Eremiomyces* is described from the Canary Islands based on morphological observations and comparison of ITS DNA sequences. *Eremiomyces innocentii* Ant. Rodr. & Bordallo is proposed to accommodate two collections found in February 2006 in alkaline soil of Tenerife Island and named after Mauro Innocenti, for his outstanding contribution to the knowledge of hypogeous fungi of the Canary Islands. *Eremiomyces innocentii* is the first *Eremiomyces* species described with amyloid asci. *Eremiomyces magnisporus* was described from a single ascoma where asci could not be found due to the advanced maturity of the sample. However, it differs from all other *Eremiomyces* spp. by its amyloid asci with larger spores (16–18 µm) than *E. echinulatus* (10–14 µm) and *E. magnisporus* (14–17 µm), excluding the ornamentation. This species is located in arid zones of Tenerife (Canary Islands), in calcareous sandy soils, associated with *Helianthemum canariense*. The annual rainfall is about 50–300 mm in the lower levels (Inframediterranean), specifically around 200 mm in the study area. Rainfall can be high in a short period of time in the case of storms from the west or the south of the islands, reaching 200 mm or more in 3–4 d. Financial support from the Projects CGL2016-78946-R (AEI/FEDER, UE) and 19484/PI/14 (FEDER/ Fundación Séneca-Agencia de Ciencia y Tecnología de la Región de Murcia, Spain) is acknowledged.

**Topic:** Taxonomy



## GERMINATION AND GROWTH OF *Abies religiosa* SEEDLINGS INOCULATED WITH TWO ECTOMYCORRHIZAL MUSHROOMS

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**Keywords:** germination rate, ectomycorrhizal association, spore solution, commercial inoculum

Survival success of forest species relies on the interaction of physical, chemical and microbiological variables in their habitat. Particularly, plant-fungus interaction allows nutrient exchange between both organisms. This contribution provides information about some endangered species such as *Abies religiosa* to solve its establishment and germination problem. The aim of this work was to estimate the germination rate and seedling's growing after being inoculated with 2 ectomycorrhizal fungi. In a greenhouse experiment, we inoculated with a spore solution of *Russula brevipes* (a wild edible ectomycorrhizal mushroom) and a commercial inoculum of *Pisolithus tinctorius*; then its effectiveness was measured by comparing some variables: mycorrhizal percentage in roots, height, diameter, biomass (foliage, roots and stem) on fir seedlings after 4 months, which is considered a critical time for plant establishment. Also germination rate was registered by counting the number of germinated seeds. Germination results showed that 33% of the seeds developed after 40 days after sowing, with an average temperature of 19.3° C and a daily humidity of 23%. Seedling diameter inoculated with *P. tinctorius* and the control had no significant differences ( $\alpha=0.05$ ) between months, but in *R. brevipes* there was a difference ( $\alpha=0.05$ ) on the second month (0.17cm). Height values showed significant differences ( $\alpha=0.05$ ) in both treatments, 6.3 cm for *P. tinctorius* and 6.5 for *R. brevipes*. There were no significant differences in terms of dry biomass between both treatments ( $\alpha=0.05$ ). Although mycorrhizal association was not found in the treatments after four months, it is important to consider that evaluations during longer periods of time might be necessary, and also that is necessary to follow the overall plant growth to register the ectomycorrhizal fungal establishment; which is critical for successful reforestation.

**Topic:** Biotechnology



## MYCORRHIZATION OF *Pinus montezumae* WITH SYMPATRIC AND ALLOPATRIC EDIBLE ECTOMYCORRHIZAL SPECIES OF *Laccaria* spp.

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**Keywords:** Mexico, inoculum, *Laccaria trichodermophora*, *L. vinaceobrunnea*, *L. laccata* var. *laccata*, *L. bicolor* s.l.

The acquisition of resources and health of plants is influenced by the establishment ectomycorrhizal symbiosis, which improves the adaptation and interaction of the host and its environment when the participants are sympatric. However, frequently in practical terms, in commercial production of forest trees mycorrhizal inoculum includes typically exotic or allopatric species. In order to evaluate the effect of mycorrhization with sympatric species, the effect of native and sympatric fungi with the host was evaluated. *Pinus montezumae* was inoculated with two species with which it shares natural habitats: *Laccaria trichodermophora* and *L. bicolor* s.l.; and with two allopatric species: *L. laccata* var. *laccata* and *L. vinaceobrunnea*. It was expected a better growth and nutrient plant contents with sympatric than with allopatric inoculated mycobionts. The efficiency in the percentage of mycorrhization varied from 93.5% to 98.5% in all treatments. The most efficient treatments ( $p = 0.05$ ) in height, stem diameter, root dry weight, total weight, K total content and in shoots were registered in those plants inoculated with *L. bicolor* s.l., followed by *L. trichodermophora*. This is the first work that demonstrates experimentally the need to use host species inoculated with sympatric ectomycorrhizal fungi which are genetically predisposed to mycorrhization and naturally adapted to local environmental and edaphic conditions. The appropriate selection of fungi with the host plants guarantees mycorrhizal success, which is reflected in the quality of the plant in terms of growth and nutrition.

**Topic:** Ecology



## TRADITIONAL ETHNOMYCOLOGICAL KNOWLEDGE AMONG THE MEXICAN ETHNIC GROUP *HIÚ HU* OR *OTOMÍ* IN THE COMMUNITIES OF HUIXQUILUCAN, MEXICO

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**Keywords:** Mexico, ethnomycology, ectomycorrhizal mushrooms, biocultural importance

Mexico presents a great cultural diversity which includes 68 ethnic groups. Among different Mexican ethnic groups wild edible mushrooms are included as part of their cultural millenarian heritage; as a result more than 360 taxa are consumed in the country. One of the oldest ethnic groups in the Mexican highlands are the Otomí people or "flechadores de pájaros" ("bird archers"), who are characterized by their ability to work with very complex and refined weaving techniques. The community of Huixquilucan, state of Mexico, is of Otomí origin, and mushroom gathering is a very important complementary activity for their inhabitants. The term used to refer to mushrooms among otomí people is *llacjó*, and different words are used to refer for the different parts of the mushrooms: *lláhiúis* which means root or trunk refers to mushroom stipe, *rásxefí* which means hat is used to refer to the pileum and *rángué* which means pulp or meat refers to context. The ectomycorrhizal species more frequently used as food are: *llaguá sxunxú*=*Clavulina coralloides* (little bird legs), *Phaeoclavulina abietina* (yellow leg), *Ramaria aurantiiscescens* (bird leg), *R. aff. sanguinea* (yellow bird leg); *llacjé sxapó*=*Helvella lacunosa* (blackies), *H. elastica* (little soldiers, little matches), *H. pithiophyla* (white gachupín or blond little guy); *llaché shcucjó*=*Gyromitra infula* (pipilitas); *llacjé boshu*=*Russula aff. brevipes* (pig's ear); *llacjó sxefí*=*Boletus aff. luridiformis* (galambo); *Llamó jicjó*=*B. edulis s.l.* (cema de oyamel); *llaje itdá*=*Morchella elata s.l.*, *M. esculenta s.l.* (pancitas or cob corn); and *llajé nanni*=*Lactarius cf. sanguifluus* (enchilados). The representative dish in all communities is called "casamiento", which is a stew used for the celebration of otomis marriages. This work shows that the traditional knowledge currently persists among otomí people, reflecting the importance of this natural resource in the current life of the local people.

**Topic:** Traditional knowledge



## DIVERSITY OF EDIBLE, MEDICINAL AND TOXIC MUSHROOMS IN ATATLAHUCA AND CUQUILA, FROM CENTRAL VALLEYS OF OAXACA, MEXICO

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**Keywords:** Ethnoecology, wild mushrooms, original cultures, cosmovison

The traditional knowledge of the original cultures native to Latin America, particularly in Mesoamerica, is important to study due to its multiplicity and deepness. From February 2013 to December 2015, the present investigation was carried out in the rural communities of *Atatlahuca* and *Cuquila*, in the Central Valleys of the state of Oaxaca. Mushroom gathering was conducted along with local collectors. Additionally, structured and semi-structured interviews; and purchase of mushrooms was carried out. Thirty nine species of edible mushrooms were recorded, among which 23 species are consumed in *Atatlahuca*. The most appreciated mushrooms in this community were *Tricholoma magnivelare* (avocado fungus), *Amanita laurae* (egg yolk), *Sparassis crispa* (trembling fungus), *Neolentinus lepideus* and *Neolentinus ponderosus* (pine fungi). In the case of the community of *Cuquila* 15 species were registered as edible; and the ones with the highest preference were *Neolentinus lepideus* (the lent mushroom), *Helvella crispa* (cat ear fungus) and *Amanita laurae* (egg yolk). *Astraeus hygrometricus* (the star fungus) is used as a medicine along with the plant *Pinguicola moranensis* (ear of coyote). Local people identified 8 toxic among which the most important were *Amanita muscaria*, *Amanita verna*, *Amanita pantherina*, *Amanita phalloides*, *Boletus frostii* and *Boletus russelii*. We conclude that the knowledge that the original communities have in the two studied communities varies, with a higher number of species consumed in *Atatlahuca* compared to those consumed in *Cuquila*. This work demonstrates that in the studied communities there is still a traditional knowledge in the use of wild fungi, including ectomycorrhizal edible and toxic species.

**Topic:** Traditional knowledge



## MYCOGASTRONOMY AND NUTRITIONAL CONTENTS OF EDIBLE ECTOMYCORRHIZAL MUSHROOMS AND ITS IMPORTANCE IN THE CONSERVATION OF MONTANE CLOUD FOREST IN MEXICO

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**Keywords:** subtropical forests, coral mushrooms, Caesar mushrooms, chanterelles

The tropical montane cloud forest is an ecosystem which is distributed in small fragmented areas mainly in the Neotropic, and also in some regions of Africa and Southeast Asia. It is the ecosystem that hosts the greatest diversity of plants and animals relative to its area, along with a huge number of endemic organisms, many of them threatened or endangered. Their preservation is a complex problem because of the strong social pressure of human groups inhabiting the surrounding areas. One strategy that has gained enormous international significance related to their preservation is the sustainable management of non-timber forest resources, including their wild edible fungi. Despite these efforts, there have been no studies to date on the nutritional properties of edible fungi of the montane cloud forest. Selection and evaluation of the nutritional content was conducted on species of major economic, cultural and social importance in areas of this type of vegetation in the centre of the state of Veracruz, in eastern Mexico. The proximate compositions of 7 species of major regional importance were assessed, along with their contents of vitamin C, thiamine, riboflavin and niacin and the minerals Na, Fe, Ca, K, Se and P. Nutritional characterization is presented for the first time for the edible fungal species *Amanita jacksonii*, *A. basii*, and *Ramaria fennica*, species of great abundance and economic, cultural and social importance in the study areas. In general, evaluated fungi showed high protein content, particularly *Amanita basii*, and low fat content, especially *Ramaria fennica*. Vitamin concentrations varied among species but were higher than those reported for cultivated fungi. In particular, *Cantharellus odoratus* and *Amanita jacksonii* proved to be good sources of vitamin C and riboflavin, respectively. Additionally, *Ramaria fennica* proved to be a good source of Se, which possesses antioxidant activities. Further, the importance of the sustainable management of wild edible fungi and the development of mycogastronomy in the preservation of the montane cloud forest is discussed. This work documents the nutritional importance of wild edible fungi in one of the most fragile ecosystems on the planet and its potential significance to their preservation. We acknowledge the financial support from the Project CONACyT 246674.

**Topic:** Food security and health



## ECTOMYCORRHIZAL MUSHROOMS: TASTY FOOD FROM SAN MIGUEL AJUSCO, TLALPAN, MEXICO CITY

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**Keywords:** ectomycorrhiza, ethnomycology, wild edible mushrooms

*San Miguel Ajusco* is a town located in the southern part of the Mexican capital city. Mexico City has urban and preserved soils, covering an area of 1485 km<sup>2</sup>, the latter covering 59% of its surface. San Miguel Ajusco has an extension of 7619 hectares managed as communal property since 1948 and considered preserved land. In these areas we can find coniferous forests, grasslands and agricultural fields. The people who inhabit these areas are characterized by a mestizo culture which is reflected in their festivals, traditions and gastronomy. Wild mushrooms being an important cultural element in this region of Mexico. Eighty eight edible mushroom species have been recorded through semi-structured interviews using the "snowball" method. Fresh mycological material was collected and photographed in order to support this research. Among the 88 identified morphospecies; 14 genera of ectomycorrhizal macromycetes were found including species belonging to *Amanita*, *Boletus*, *Lyophyllum*, *Helvella*, *Ramaria*, *Russula* and *Turbinellus*. The current knowledge of wild edible mushrooms, which has been transferred for generations, currently remains in *San Miguel Ajusco* despite the close contact, and geographic proximity, of the inhabitants of this town with those that live in Mexico City, one of the largest cities on earth. The villagers of this town accurately recognize and safeguard their common names, form of use and taxonomic and ecological traditional knowledge.

**Topic:** Traditional knowledge



## GROWTH AND NUTRIENT CONTENT OF *Pinus ayacahuite* INOCULATED WITH *Suillus granulatus* IN THE NORTHERN MOUNTAIN RANGE OF OAXACA, MEXICO

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**Keywords:** Ectomycorrhizal inoculum, edible wild mushrooms, reforestation, conifers

Ectomycorrhizal fungi are responsible for the translocation of nutrients to plants and they have a paramount importance in the functioning of forest ecosystems. *P. ayacahuite* Ehrenb. ex Schltdl. is a native species of Mexico, Guatemala, El Salvador and Honduras, and it has a great economic importance as Christmas tree. However, studies of the ectomycorrhizal symbiosis related to this species have been scarce to date. In this study we evaluated the effect of inoculation with *Suillus granulatus* (L.) Roussel on the growth and nutrient contents of *P. ayacahuite* native of the Northern Mountain Range of Oaxaca, Mexico. Six months after germination, the pines were transplanted and inoculated twice with  $10^6$  spores per plant. A completely randomized experimental design was established with inoculated and non-inoculated plants, with 10 replicates. Four hundred and sixty two days after inoculation growth, biomass and ectomycorrhizal percentage were evaluated. The contents of macro- and micronutrients in the root and shoots were also determined. A comparison of means was carried out including an analysis of variance, evaluating the significant differences ( $P \leq 0.05$ ) with the Tukey test for the data that fulfilled the normality assumption and for those that did not meet the normality criteria the Kruskal-Wallis test was used. The morphoanatomic characteristics of ectomycorrhizae were also described, and they corresponded to *S. granulatus*. The height, dry shoot weight, root dry weight and total N, P, K, Ca, Mg, Fe, Zn, Mn and B content were significantly higher in inoculated plants than in non-inoculated plants. This work demonstrates for the first time that the application of *S. granulatus* has a positive effect on *P. ayacahuite* growth, indicating that the use of this fungal species might have a biotechnological potential in plant production in greenhouse and nurseries.

**Topic:** Biotechnology



## DIVERSITY OF HYPOGEOUS FUNGI IN CHINA

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**Keywords:** Classification, diversity, hypogeous fungi, phylogeny, truffle

Hypogeous fungi, some of which are high prized truffles, include ectomycorrhizal fungi associated with ecologically important tree species. Although hypogeous fungi are widely distributed in the world, we know little about their phylogeny and diversity in China. We have collected more than 800 hypogeous samples in China over a 4-yr period. The identities and phylogenies of the samples were analyzed using sequences of four nuclear loci, i.e. internal transcribed spacer (ITS) and large subunit (LSU) regions of rDNA, elongation factor 1 alpha (EF1- $\alpha$ ) and RNA polymerase II large subunit (rpb2) genes. Based on molecular and morphological analyses, we identified 69 hypogeous species which belong to 23 genera, 18 families, 8 orders and 2 phyla. Results revealed that truffles are abundant with at least 50 *Tuber* species present in China, including 12 new species and 1 first reported species. Detailed molecular phylogeny within individual *Tuber* phylogroups revealed the existence of phylogeographic structures among different regions. We also identified new or known hypogeous species of Ascomycota in China within genera *Elaphomyces*, *Genea*, *Hydnobolites*, *Pachyphlodes*, *Hydnotrya* and *Choiromyces*. In Basidiomycota, we found species belonging to *Rhizopogon*, *Chamonixia*, *Chondrogaster*, *Hysterangium*, *Hymenogaster*, *Melanogaster*, *Truncocolumella*, *Octaviania*, *Rossbeevera*, *Gautieria*, *Scleroderma*, *Astraeus*, *Macowanites* and *Thichaster*. Forty of the species formed separate clades within individual major phylogroups and deserve to be proposed as new species. Although our findings substantially advance the current understanding of hypogeous fungi diversity and phylogeny in China, comparative richness estimation and studies on multilocus phylogeny, are necessary to unequivocally address global patterns of hypogeous fungi diversity and evolution mechanisms.

**Topic:** Biodiversity



## **EDIBLE *Cortinarius* MUSHROOMS IN GUATEMALA: DESCRIPTION OF SPECIES SOLD IN RURAL MARKETS OF CENTRAL GUATEMALA**

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**Keywords:** Food, low-price product, oak forests, endemic species, ethnomycology

This study presents data about macroscopic and microscopic features of four potentially new species of the genus *Cortinarius*, all collected from local markets in different departments of central Guatemala. We describe the characteristics of the specimens, deposited at the *Micoteca Rubén Mayorga Peralta* (MICG), which were collected in 2012 at the markets of San Juan Sacatepéquez (department of Guatemala), San Juan Comalapa, San Martín Jilotepeque and Tecpán (Department of Chimaltenango), and locally recognized under the name *Coyote Head*, and collected in oak or pine-oak forests. Sale and consumption of *Cortinarius* species has become more notorious in those communities during the last years, with prices declining in comparison with those of other edible and well known species, such as *Cantharellus lateritius* or *Lactarius indigo*. We have found at least four species sold in these markets, some close to North American descriptions, but phylogenetic-molecular analyses are necessary to identify them accurately and to determine their phylogenetic position. Because of the rarity of edible species within *Cortinarius*, these locally consumed mushrooms constitute an interesting research Topic, especially with regards to the health of consumers, the chemical composition of mushrooms and the diversity of the genus in Central America.

**Topic:** Traditional knowledge



## SAPROTROPH AND ECTOMYCORRHIZAL SPECIES IN MIXED FORESTS IN THE MUNICIPALITY OF VILLAPINZÓN, IN CUNDINAMARCA, COLOMBIA

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**Keywords:** Oyster mushrooms, Villapinzón, *Suillus luteus*, Cultivation, pine plantations

For many decades, interest in the commercial harvesting of wild edible fungi has increased considerably worldwide, as an alternative for providing incentives and opportunities for people living in marginal rural areas. In Colombia, the knowledge in wild edible fungal species is low. People in the Municipality of Villapinzón, located in the Department of Cundinamarca, uses potato as the main nutrition and food source. However, recently the teaching of oyster mushrooms cultivation in the municipality has shown a positive impact in the region: the cultivation has an initial inversion accessible to rural farmers, it is an easy species to grow, and people are flexible in incorporating the fungal alternative in their diet to compensate for the lack of nutritive food and to potentially improve their economic situation. Following these preliminary findings, we proposed the recognition of fungal species found in mixed forests in the Municipality of *Villapinzón*. We report, 4 species documented as edible and 10 reported as toxic or unknown. The edible species *Suillus luteus* associated with *Pinus* spp. plantations was very abundant in the region. In an attempt to propose potential species to be cultivated with local available resources, we obtain an initial “seed” for a saprotrophic *Agaricus* sp. 1, which grows well in barley and rice grains colonizing the substrate (500 gr) in 20-24 days in a temperature ranging from 16-19 °C. The knowledge on the local fungal diversity (edible and toxic species) is an essential step to establish some of them as potential forest products that can be used by the community; this is a way of diversification of local products and to choose which are the potential fungal species subject to cultivation.

**Topic:** Cultivation



## SOCIALIZING CONSERVATION ASPECTS OF MACROFUNGI IN OAK FORESTS

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**Keywords:** Fungal conservation, sustainable harvest, Boyacá, non-wood forests products, *Quercus humboldtii*

Given that ecosystems gives non-timber forests products and services its maintenance and protection is vital. In countries such as United States, and some European, conservation activities have been proposed based on the observation of edible fungi populations declining after harvesting throughout years. In Colombia, this practice is not common; however in some departments including Boyacá, people use traditional knowledge to practice harvesting of wild mushrooms. The booklet presented here is intended for local people living nearby oak forests (*Quercus humboldtii*) in Boyacá, gradually creating awareness of the fungal source conservation. The information provide in this booklet is aimed to provide people with valuable information based on the important functions of the macrofungi in the ecosystems and some recommendations to perform a sustainable harvest. Moreover, recommendations to help reducing the spread of *A. muscaria* are given particularly for communities developing their activities between plantations and native oak ecosystems.

**Topic:** Conservation



**RAPID ASSESSMENT OF MACROFUNGAL DIVERSITY  
(PHYLA BASIDIOMYCOTA AND ASCOMYCOTA) IN ECOSYSTEMS  
OF EL PEÑÓN, SANTANDER, COLOMBIA**

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**Keywords:** Ectomycorrhizal fungi, saprotrophic fungi, *Quercus humboldtii*, sub-Andean forest, species richness

Oak-dominated forests harbor a wide variety of organisms. Within them macrofungi represent a great variety of species with diverse morphologies and ecologies (saprotrophs, symbionts, parasites, etc.) that play a vital role in these ecosystems. In Colombia, a large number of fungal species have been reported in ectotrophic oak forests dominated by the species *Quercus humboldtii*. During the field trips in the municipality of *El Peñón* (Department *Santander*), 10 forests were sampled corresponding to 7 fragments of oak forest *Q. humboldtii* above 2400 m a.s.l., and 2 sub-Andean forests between 1800-2400 m a.s.l. A total of 109 fungal species belonging to the Phyla Basidiomycota and Ascomycota were collected: 59 saprotrophic species, 46 putative ectomycorrhizal symbionts and 4 parasitic species. The families with the highest number of species were the Russulaceae family of the order Russulales, followed by the family Cortinariaceae, Omphalotaceae, and Amanitaceae of the order Agaricales. Species of ectomycorrhizal genera were found only in oak forests, and saprotrophic species predominated in the sub-Andean forests. We included new 31 regional, 9 national reports and two potential new species from the genera *Amanita* and *Cantharellus*.

**Topic:** Biodiversity



## INOCULATION OF *Pinus oocarpa* WITH SLURRIES OF THREE ECTOMYCORRHIZAL EDIBLE FUNGI FROM MEXICO

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**Keywords:** slurries, edible wild mushrooms, ancestral pines, inoculum

Mexico has about 47 species, 3 subspecies and 22 varieties of pines; approximately 55% of these taxa are considered endemic and therefore it has been estimated that the country has 42% of the species existing worldwide. *Pinus oocarpa* is a native species of Mexico with great ecological and economic importance. This pine is distributed from northern Mexico to northeastern Nicaragua. In the present study, *Pinus oocarpa* plants were inoculated with fresh ground sporomes of three species of edible ectomycorrhizal fungi: *Helvella lacunosa*, *Amanita rubescens* and *Laccaria laccata*. These species of wild edible fungi have great economic, cultural and social importance in Mexico. In the present study we evaluated the effect in terms of growth; stem diameter and mycorrhizal colonization when inoculating the three fungal species to *P. oocarpa* plants. The experimental design used was completely randomized, with 47 replicates per treatment. There were four treatments: three included inoculated plants with each of the three evaluated fungi and the fourth treatment consisted of non-inoculated plants. Two hundred and forty days after inoculation, there was an evident beneficial effect on the growth of inoculated plants in terms of height and stem diameter compared to non-inoculated plants. Differences were also observed in terms of macro and micronutrient contents in shoots and roots. Ectomycorrhizal colonization varied from 25 to 70% depending on the inoculated fungi. This work demonstrates that the three evaluated fungi have a great biotechnological potential in the production of mycorrhizal plant of *Pinus oocarpa*, which has been considered the progenitor (ancient) species of Mexican pines. Financial support from the CONACyT Project 246674 is acknowledged.

**Topic:** Biotechnology



## TYPE OF LIGHT, BASIDIOMATA FREQUENCY AND DEVELOPMENT OF TWO SPECIES OF EDIBLE ECTOMYCORRHIZAL MUSHROOMS ASSOCIATED WITH NEOTROPICAL PINES

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**Keywords:** edible wild mushrooms, fertile basidiomata formation, red light

Inoculation with ectomycorrhizal fungi, particularly edible species, has gained enormous relevance in production of forest trees with economic importance. However, due to technical difficulties for the cultivation of ectomycorrhizal basidiomata associated with their host trees, factors influencing such basidiomata formation have not been fully understood. This study evaluated the effect of two light wavelengths on the production of basidiomata of two edible ectomycorrhizal mushroom species (*Hebeloma leucosarx* and *Laccaria bicolor*) associated with two neotropical trees, *Pinus montezumae* and *Pinus greggii*. The two fungal species evaluated are widely used as food and sold in traditional markets in Mexico. In general, the type of light differentially influenced the basidioma formation of those mushrooms in the association with host seedlings in greenhouse during six years. Increased basidioma formation of *H. leucosarx* was observed associated with trees growing in pots covered with filters with a wavelength of ~590 nm compared with those covered with filters with a wavelength of ~660 nm. Meanwhile, the opposite trend was observed in basidiomata of *L. bicolor*. The host tree species influenced the formation of basidiomata. Basidiomata formation of *H. leucosarx* increased in the association with *P. montezumae* than with *P. greggii*. In addition, a description of basidiomata formation from very young stages to senescence, for both studied mycobionts, is provided. To our knowledge, this is the first record of the effect of light wavelengths on the production of basidiomata of edible ectomycorrhizal mushrooms, demonstrating that this phenomenon is more complex than previously believed. We acknowledge the financial support from the Project CONACyT 246674.

**Topic:** Ecology



## HOW CHINESE BLACK TRUFFLE (*TUBER INDICUM*) ECTOMYCORRHIZAE REJECT SPECIFIC MATING TYPES ?

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**Keywords:** *Tuber indicum*, ectomycorrhizae, mating types, MAT1-1-1, MAT1-2-1.

The unbalance distributions of mating types of *Tuber melanosporum* were widely reported, the same situation were found in *Tuber indicum* in our study. We quantified the two mating type genes of ectomycorrhizae from 15 one-year-old *T.indicum-pinus* seeding using real-time PCR. Although the amplification efficiency of samples was different from each other, the sum of two mating type gene copy number range from 254 to 36429. The data showed not only the unbalanced distribution of two mating type gene copy numbers in all ectomycorrhizae from the same seeding. Moreover, although all seeding were separately planted in different pots, 14 of them present the same dominant mating type (MAT1-2-1). Furthermore, the differences of two mating type gene numbers were dramatic in same seeding. MAT1-2-1 was dozens of times that of MAT1-1-1 in most samples. This results rise the question that how *Tuber indicum* ectomycorrhizae reject specific mating types. Is specific *Tuber indicum* mating type more competitive to some specific environment than the other one? Or if *Tuber indicum* ectomycorrhizae are able to communicate with each other to reject the specific mating types regardless that they live underground?

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**Topic:** Genetics



**DESERT TRUFFLES NATURAL MYCORRHIZAL ASSOCIATION  
WITH *Helianthemum lippii* AND *Helianthemum ledifolium* IN THE  
PROVINCE OF FIGUIG IN EASTERN MOROCCO**

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**Keywords:** Desert truffle, mycorrhiza, ectomycorrhiza, *Helianthemum*, host plant

In the East and the South of Morocco, five desert truffles (*Tirmanianivea*, *Tirmania pinoyi*, *Terfeziaboudieri*, *Terfeziacaveryi*, *Picoajuniperi*) are associated to the genus *Helianthemum* host plants. On the field located, the roots of host plants *Helianthemum lippii sessiliflorum* (Desf.) Pers. and *Helianthemum ledifolium* were collected in the proximity of different species of truffles from the Moroccan eastern pilot productive sites in the province of Figuig. Staining and observation of mycorrhizal roots allowed us to reveal a total ectomycorrhiza presence for the herbaceous *Helianthemum ledifolium* and the perennial *Helianthemum lippii* without fungal mantle and with Hartig net surrounding the plant cells and hyphal anastomosis with 100% of mycorrhizal colonization. And the presence of desert truffles primordia in 92% of the root sampled. This kind of mycorrhiza is due to low levels of phosphorus in the soil and a short stress period. This study is primordial as a reference for *Helianthemum* sp. mycorrhiza plots under controlled conditions in greenhouse.

**Topic:** Biodiversity



## CO-INOCULATION OF AN EDIBLE ECTOMYCORRHIZAL FUNGUS AND A MYCORRHIZAL HELPER BACTERIA IN THE GROWTH AND PHYSIOLOGY OF *Pinus cembroides* IN THREE SUBSTRATES

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**Keywords:** drought, *Laccaria proxima*, *Cohnella*

The inoculation of forest trees with ectomycorrhizal fungi represents an important tool in the production of plants, and their subsequent survival in the field. The main benefit for both symbionts is the nutritional exchange and protection of environmental stresses. An additional beneficial factor is the inoculation with bacteria that mycorrhizal helper bacteria. *Pinus cembroides* Zucc. is a species native to Mexico, tolerant to drought, which is used in reforestation programs and whose seed is edible and it has a high nutritional value. In the present work a bioassay was performed with *P. cembroides* plants grown on three different substrates, inoculated or not with the bacterium *Cohnella* and the edible ectomycorrhizal fungus *Laccaria proxima*. Growth, photosynthetic rate and transpiration measured with a PPSYSTEM CIRAS-3 were evaluated. The substrates that best promoted plant growth were sawdust, bark, and compost at 10 and 20%; so that there was a positive effect of organic matter in plants co-inoculated with *Cohnella* and *L. proxima*, showing values of 2.5 cm and 7.0 cm in non-inoculated and co-inoculated plants, respectively. In contrast, there were no differences when the plants were exclusively inoculated with either *Cohnella* or *L. proxima*. The photosynthetic rate of the non-inoculated plants varied from 0.058 to 0.071  $\mu\text{molm}^{-2}\text{s}^{-1}$ , depending on the substrates, whereas in the co-inoculated treatments the values were increased five-fold. The rate of transpiration in non-inoculated plants had values of 0.174 and 0.258  $\mu\text{molm}^{-2}\text{s}^{-1}$ ; while in the co-inoculated treatments the values increased six-fold. These data show the importance of co-inoculation with the ectomycorrhizal edible fungi *L. proxima* and the bacteria *Cohnella* in the growth and physiology of *P. cembroides*. Financial support from the project CONACyT 246674 is acknowledged.

**Topic:** Biotechnology



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## ICOM 10 in Mérida, Mexico, 2019

### *Mycorrhizae for a Sustainable World*

The challenge of a sustainable world requires, besides knowledge, creativity and a holistic perspective to realize the conservation and best possible use of natural resources. We mycorrhizologists ought to take up this challenge and contribute to the preservation and careful management of resources, generating knowledge that is not only novel but also connected to the goals of sustainability and human well-being. In ICOM 10 we wish to encourage innovation in order to generate basic and applied knowledge in a different way, a way committed to sustainable development. This is why we are inviting you all to Mexico, to Merida, in the heart of ancestral Mayan culture, a culture with an astounding development of abstract knowledge and knowledge of nature.



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Chair: Javier Álvarez-Sánchez  
Co-chair: Mayra Gavito Pardo

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**ADDENDUM: SUMMARY OF THE POSTER NUMBER 128**

**BIODIVERSITY AND ETHNOMYCOLOGICAL KNOWLEDGE OF THE  
MACROMYCETE FUNGI OF THE CLOUDY MOIST MONTANE  
FOREST AND ITS IMPORTANCE IN THE CENTRAL PART OF STATE  
OF VERACRUZ, MEXICO**

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**Keywords:** Moist montane cloudy forest, biodiversity, ethnomycological, macromycetes

There is in Mexico a big variety of fungi, due to the great floristic and climatic diversities. Guzmán in 1994 and in 1995 calculated that in the country there are between 12,000 and 14,000 species of fungi, of which currently only approximately 6% is known. This author considered that the state of Veracruz, has one of the richest fungal diversities and that it is probable that more than 11,000 species exist. On the other hand, the moist montane forest, as considered by Guzmán in 1996 and in 1998; and Chacón and Medel in 1993, is one of the richest types of vegetation in fungal terms. They register more than 600 species, from which 60% are endemic of such forests. In the present work, 59 species belonging to the Basidiomycetes were identified. The studied material was gathered from the central region of the state of Veracruz, which presents different areas with moist montane forests. The identified species were identified from more than 1200 collections carried out by the authors of the present work. These species have an ethnomycological importance for local inhabitants in the region where they were collected: and also they play a very important ecological role in the cloudy forests. Also, we present some new records for the state of Veracruz and also some records of species that had not been collected since their original collection more than 80 years. This work shows that the study of the fungi from the moist montane forest is currently far from being complete.

**TOPIC:** Diversity



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