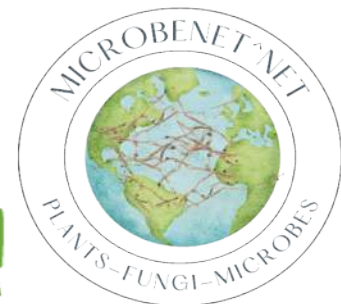


# Arbuscular Mycorrhizal Fungi: Diversity, Interactions, and Their Impact on Plant Symbioses.

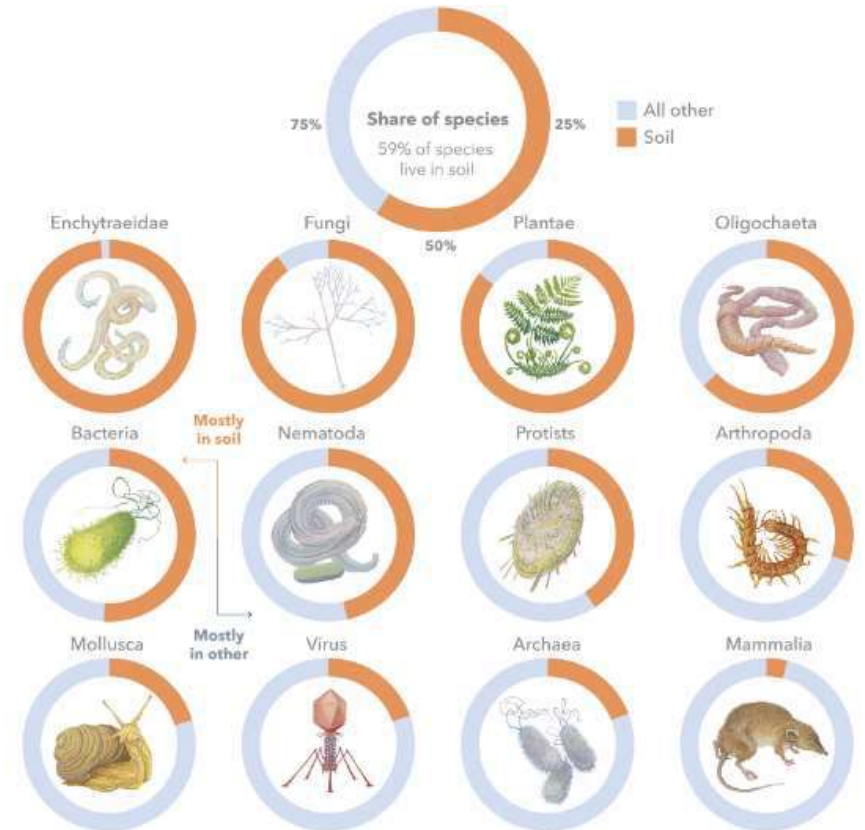
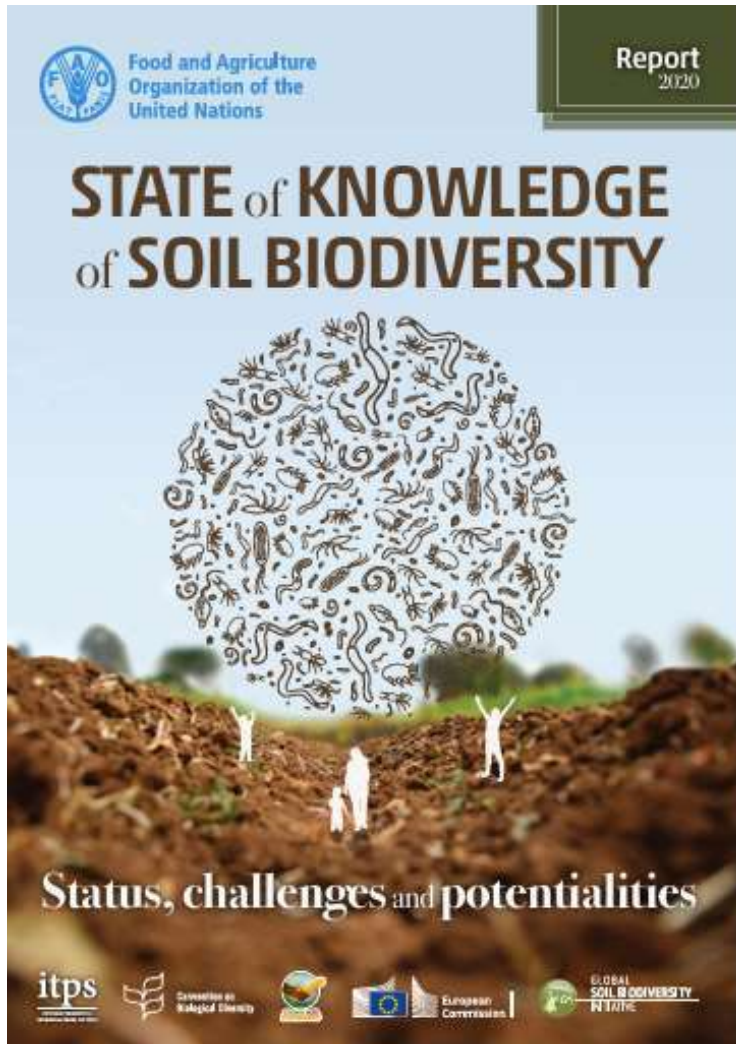
PhD. María Victoria Vignale

Researcher

Instituto de Biología Subtropical (IBS), Puerto Iguazú (CONICET-UNAM), Argentina.



# Soil is the habitat of 59% of the planet's biodiversity.



**PNAS**

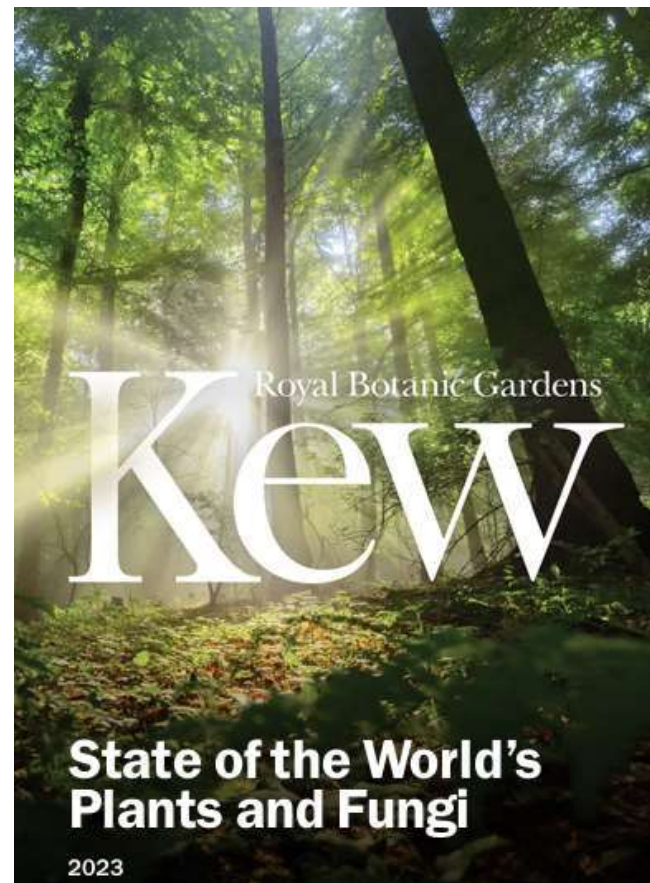
RESEARCH ARTICLE | ECOLOGY

## Enumerating soil biodiversity

Mark A. Anthony<sup>a,b,1</sup>, S. Franz Bender<sup>a,c</sup>, and Marcel G. A. van der Heijden<sup>a,c,1</sup>

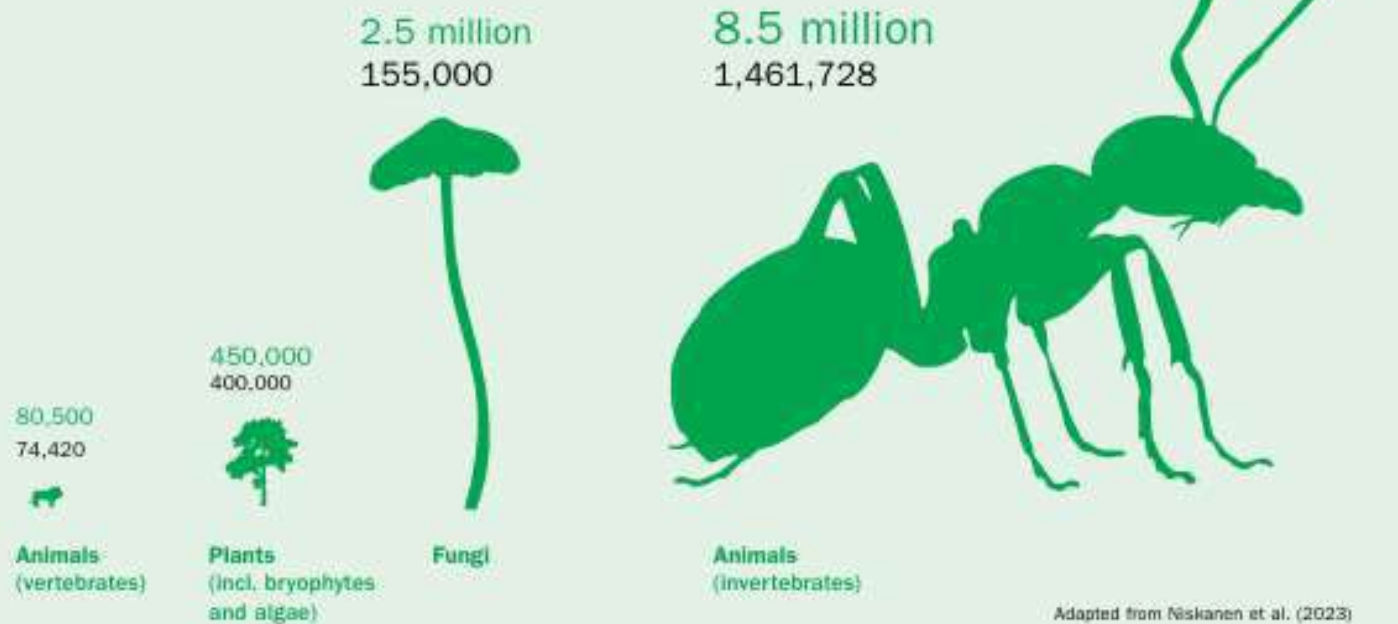
2023

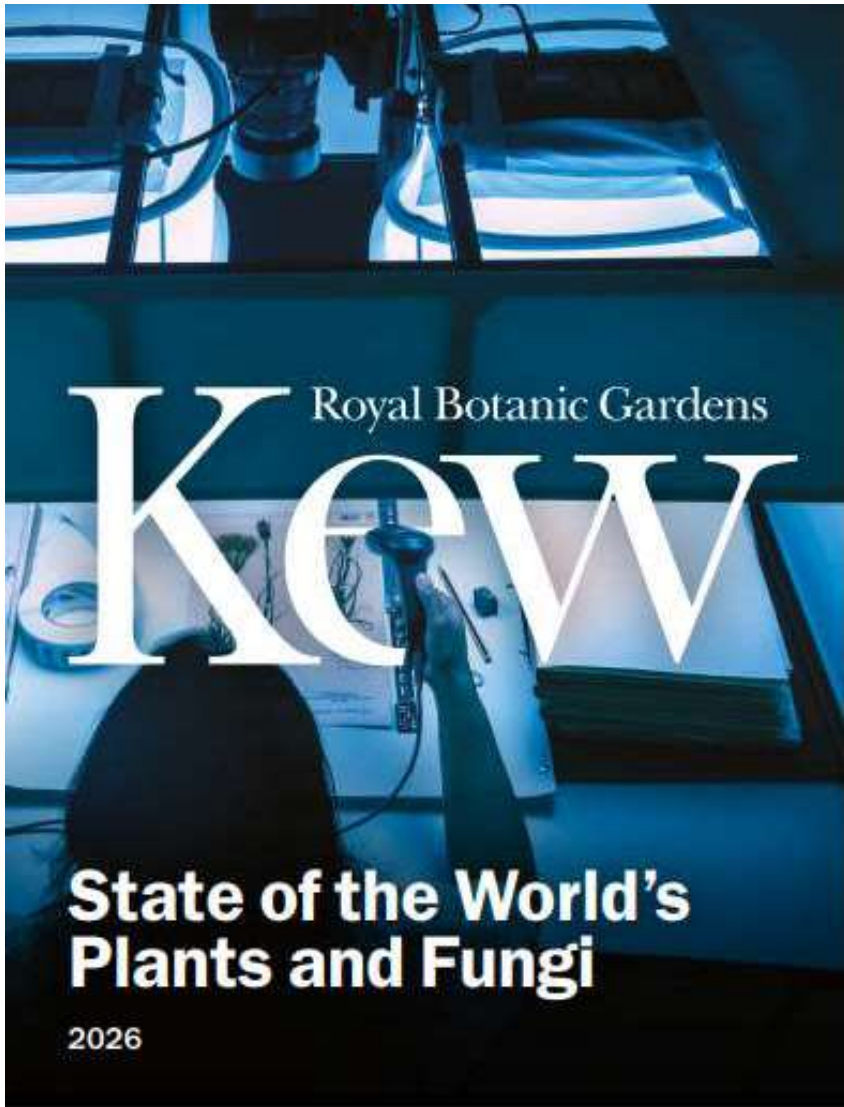
# Much remains to be understood.



**FIGURE 1: How species diversity differs between animals, plants and fungi**

An updated estimate confirms fungi as second only to invertebrate animals with regards to species diversity. Here, the total estimated number of species for four major groups is shown in green, and the current number of scientifically described species is shown in black.

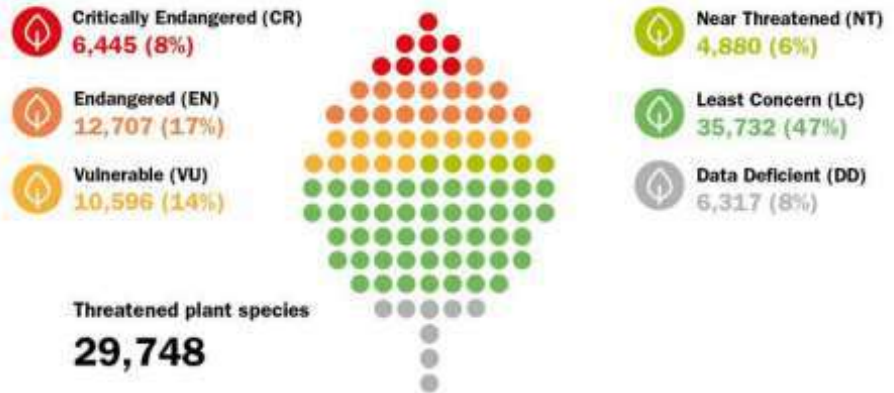




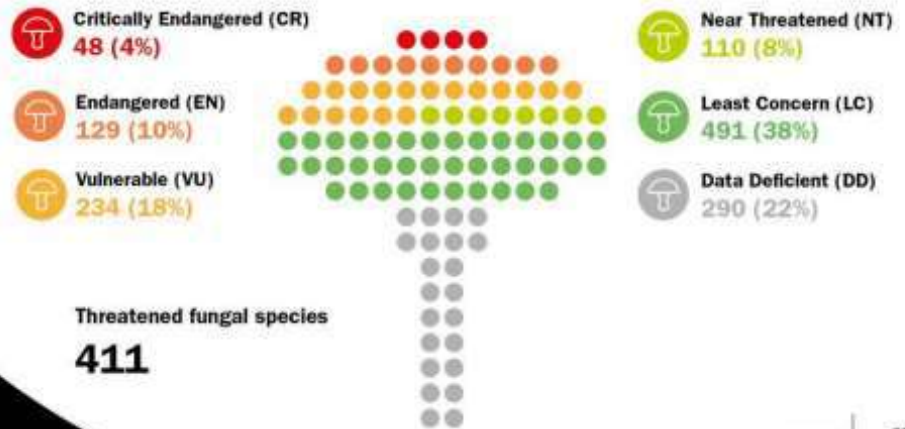
### How many species are at risk?

Number of species in six of the nine IUCN Red List categories (excluding Extinct, Extinct in the Wild and Not Evaluated) and the corresponding percentages.

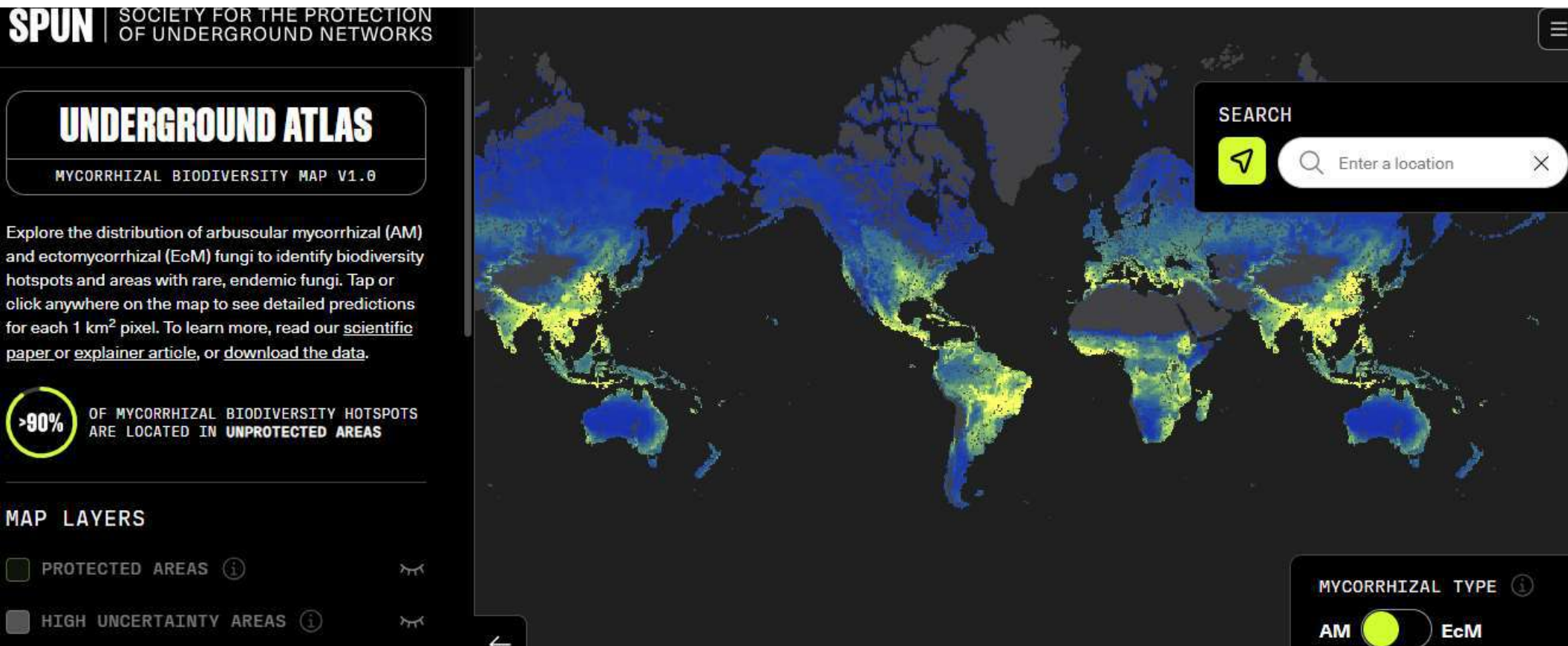
#### Plants



#### Fungi



# Massive underground network of fungi



70% of belowground biodiversity hotspots remain unprotected (Guerra et al., 2022).



FAUNA

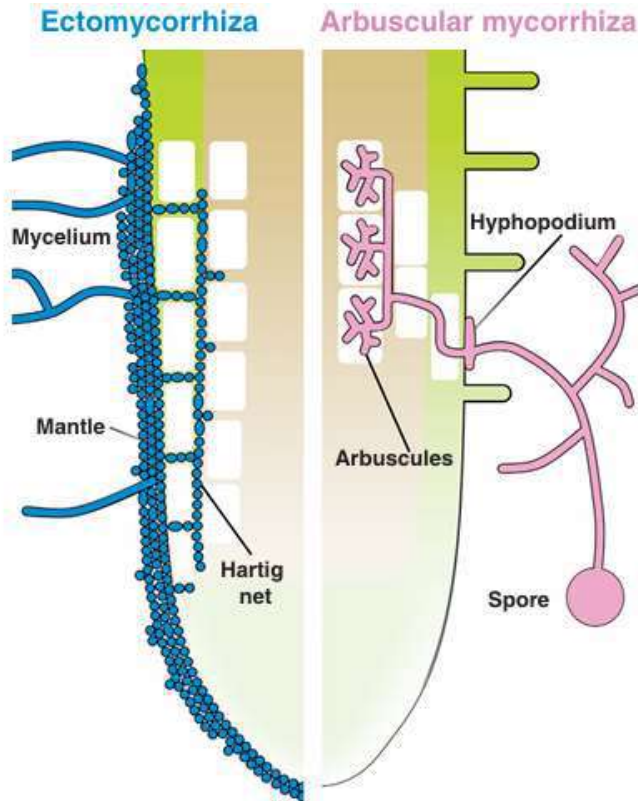


FLORA



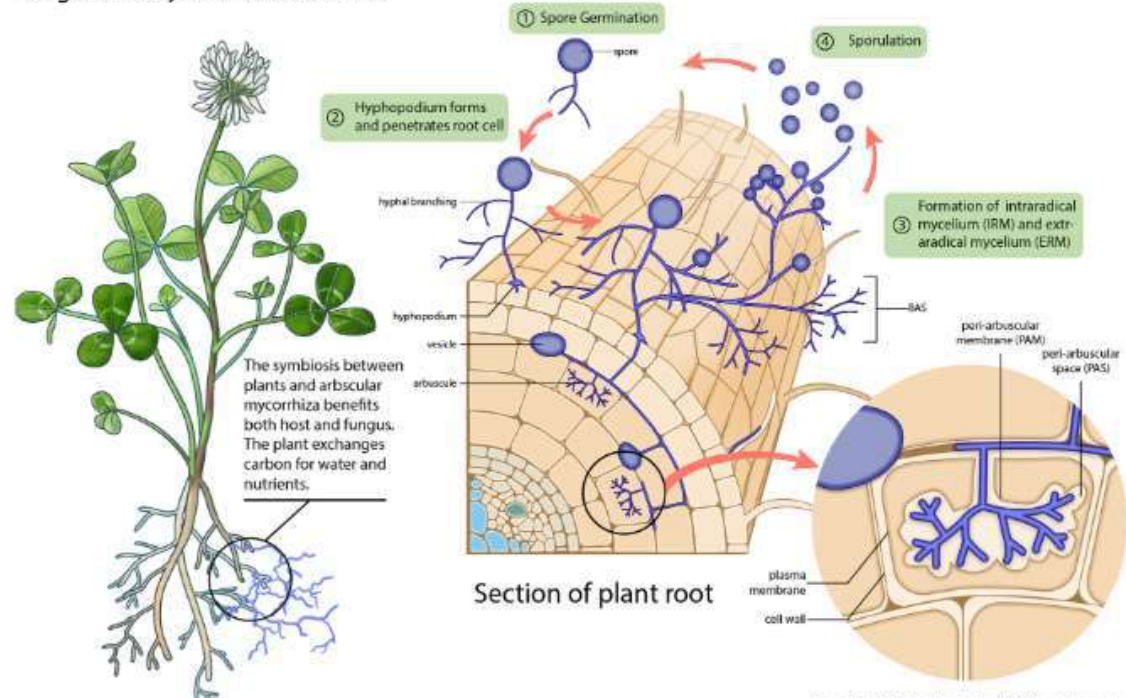
FUNGA

# What Is a Mycorrhiza? Main types



## Arbuscular Mycorrhiza

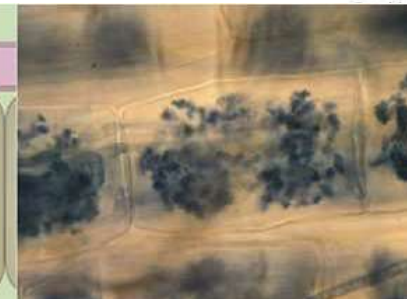
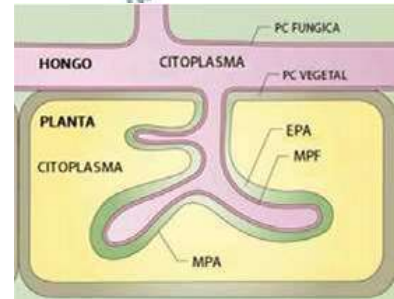
Fungus Life Cycle and Structures



by Madelyn Neufeld (madyrose.com)



150 m years



470 m years

# Arbuscular mycorrhizal fungi

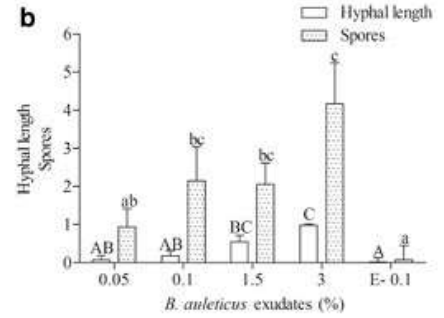
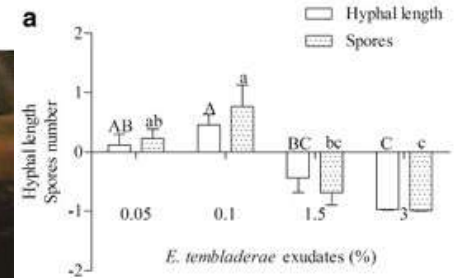
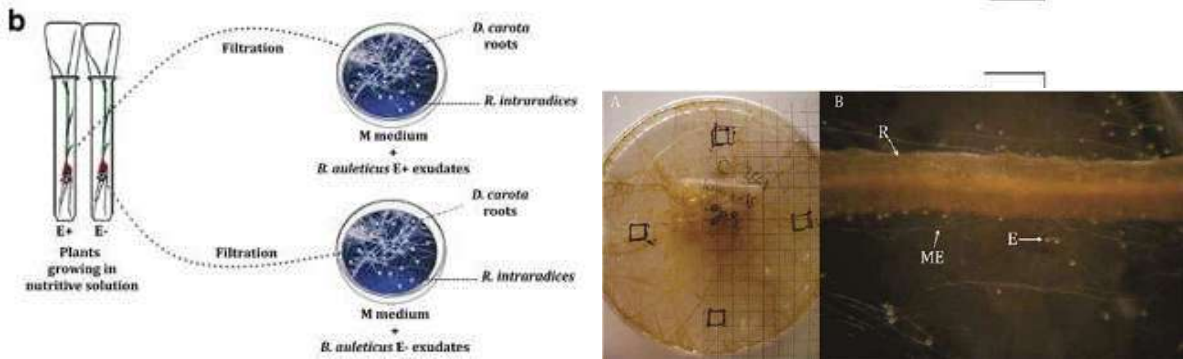
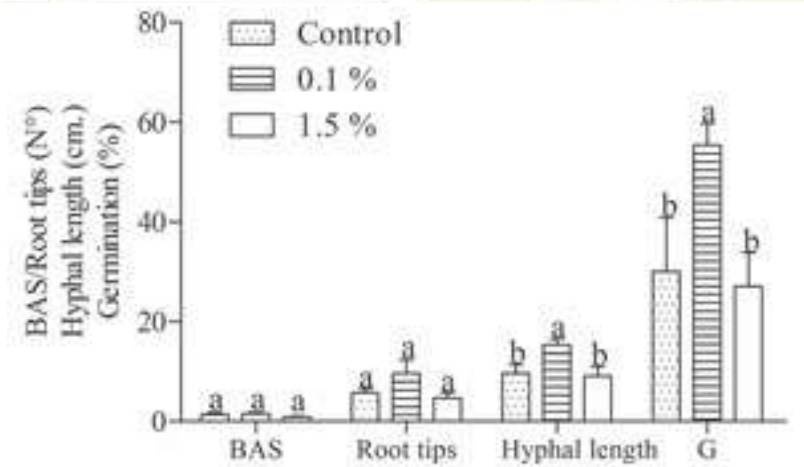
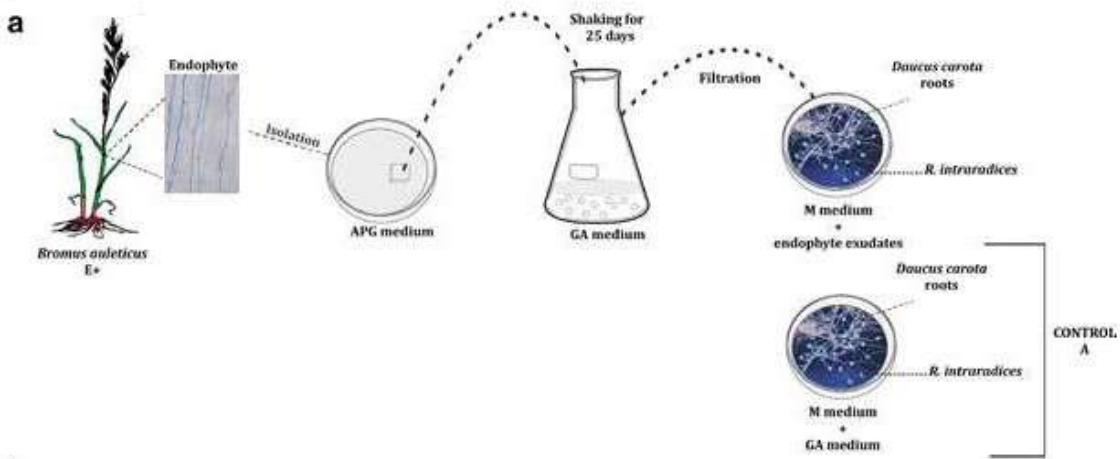
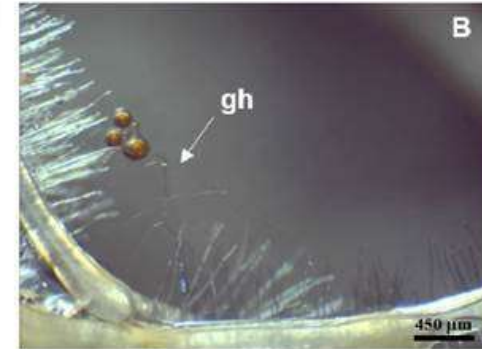
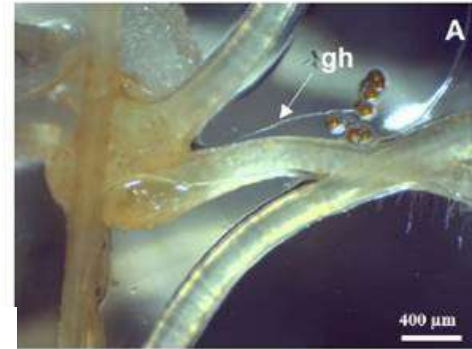
- Belong to the phylum Glomeromycota
- Helped plants colonize land approximately 475 million years ago
- Obligate biotrophs
- Form associations with more than 80% of terrestrial plant species
- Around 370 species have been described morphologically (more than 1,000 molecular taxa), with high genetic and functional diversity
- Asexual reproduction (including hyphal anastomosis)
- Microscopic organisms (spores up to 0.05 mm in diameter)



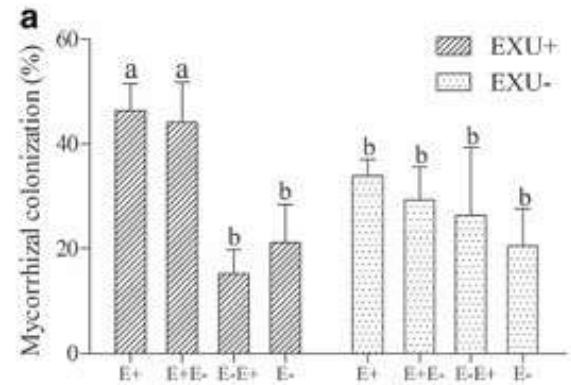
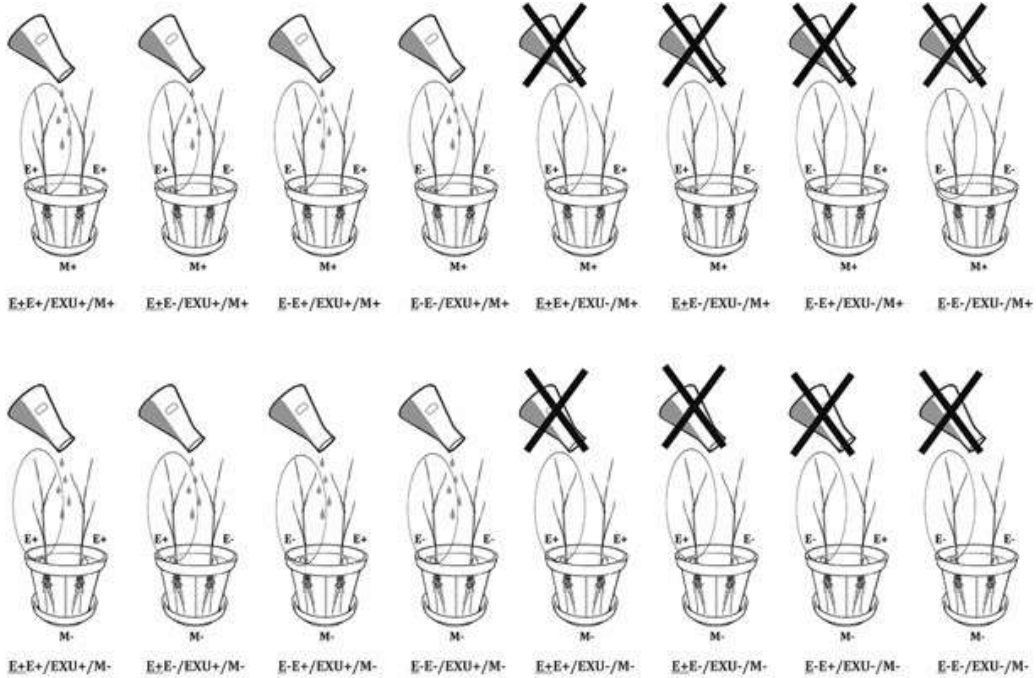
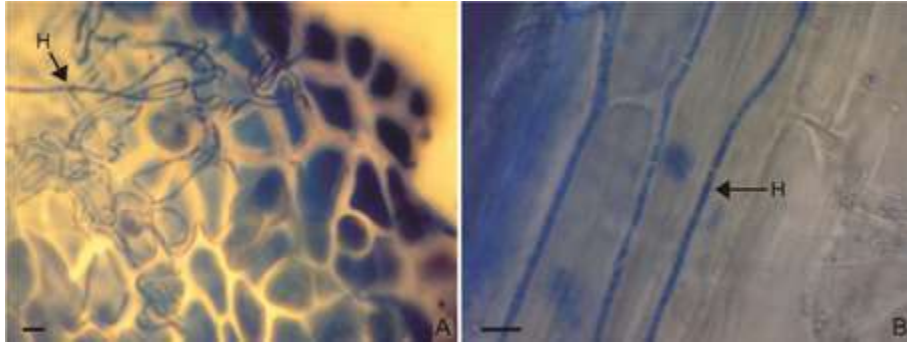
# *Epichloë* exudates promote in vitro and in vivo arbuscular mycorrhizal fungi development and plant growth

M. Victoria Vignale · Leopoldo J. Iannone ·  
 J. Martín Scervino · M. Victoria Novas

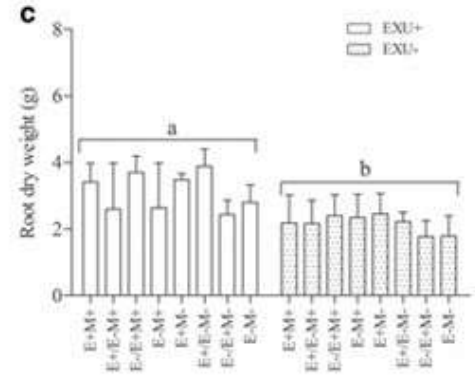
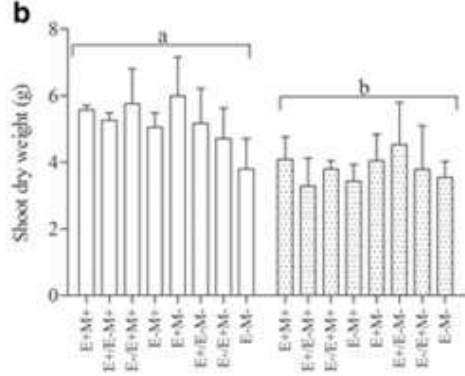
*In - vitro*



**In – vivo (pots)**



Mycorrhizal colonization and plant growth were enhanced by the endophytes and their exudates.



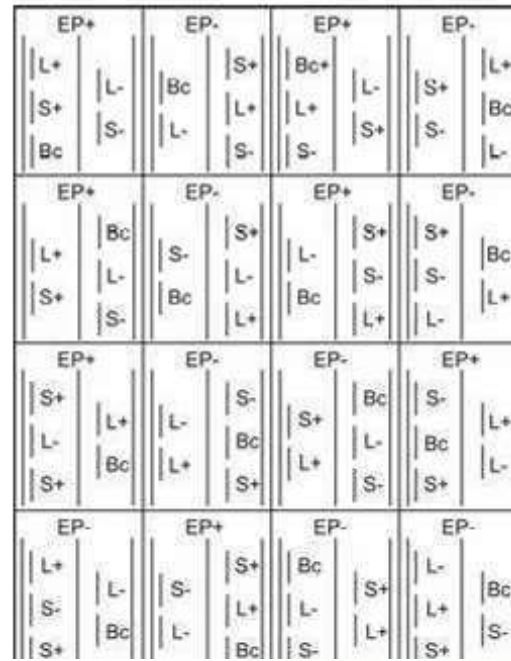


*Epichloë* endophytes of a wild grass promote mycorrhizal colonization of neighbor grasses

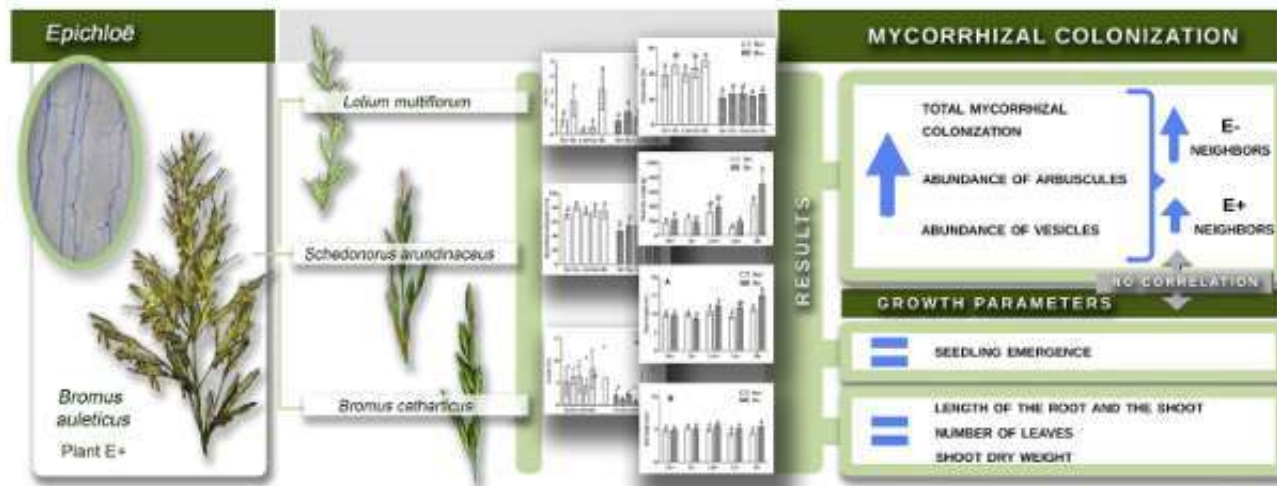
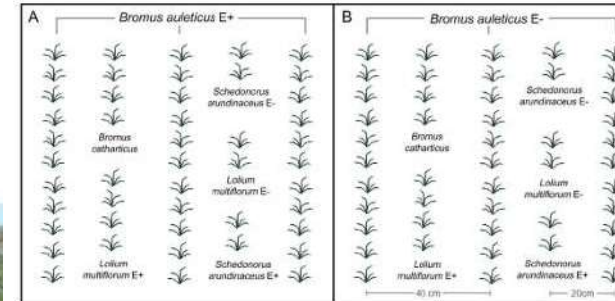
M. Victoria Vignale <sup>a, b</sup>, Leopoldo J. Iannone <sup>a, b, c</sup>, M. Victoria Novas <sup>a, b, \*</sup>

**Field experiment**  
**EEA INTA C del Uruguay**

Neighboring plants: three agronomically important grass species.



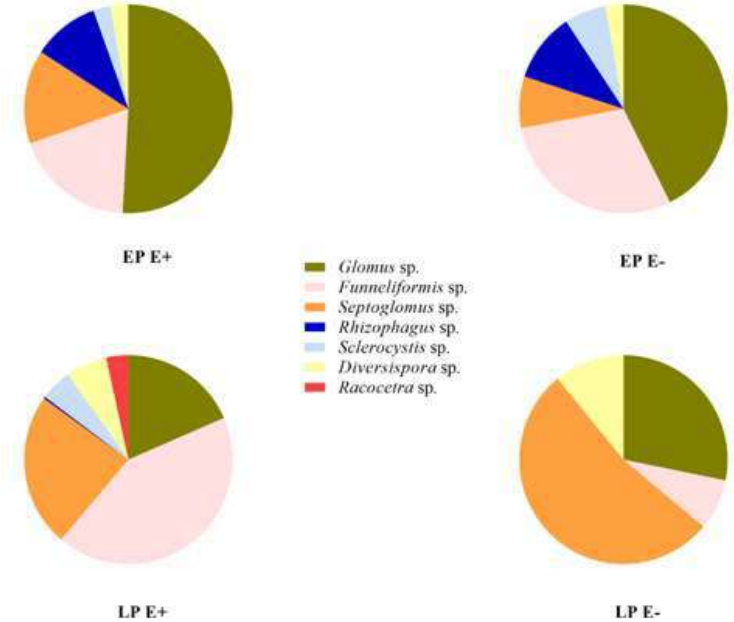
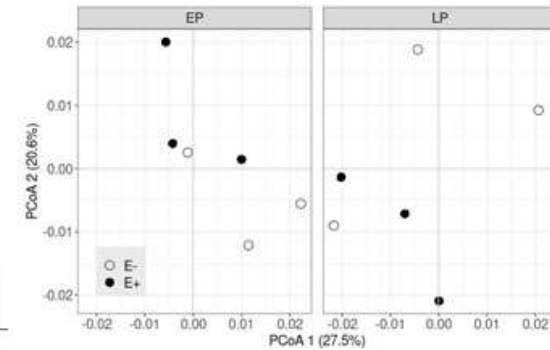
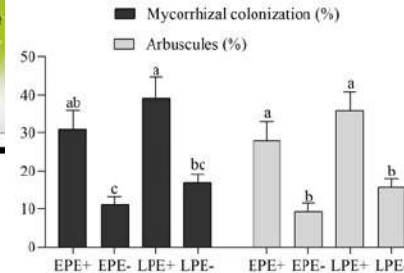
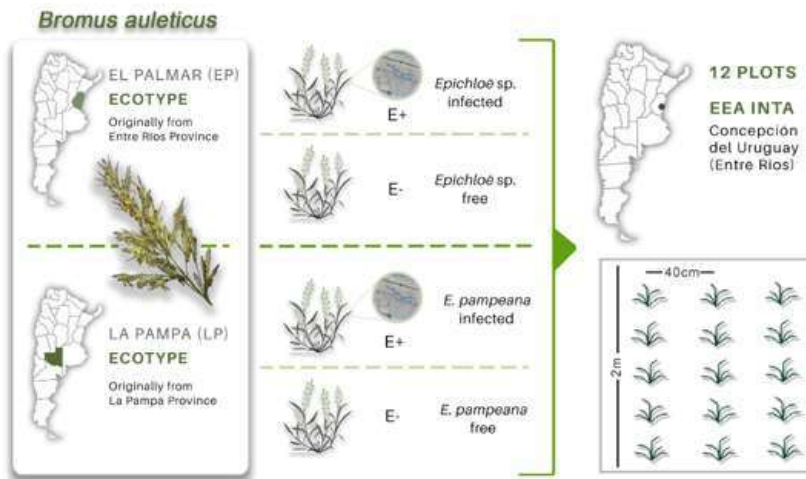
SCHEMATIC REPRESENTATION OF ONE BLOCK (4 IN TOTAL)










## Ecotype and fungal endophyte status differentially affect soil arbuscular mycorrhizal community of the native grass *Bromus auleticus*

M. Victoria Vignale<sup>a,b,1</sup>, Lucía Ortiz Rocca<sup>c</sup>, Marcelo Soria<sup>c,d</sup>, Leopoldo J. Iannone<sup>a,b</sup>,  
M. Victoria Novas<sup>a,b,\*</sup>



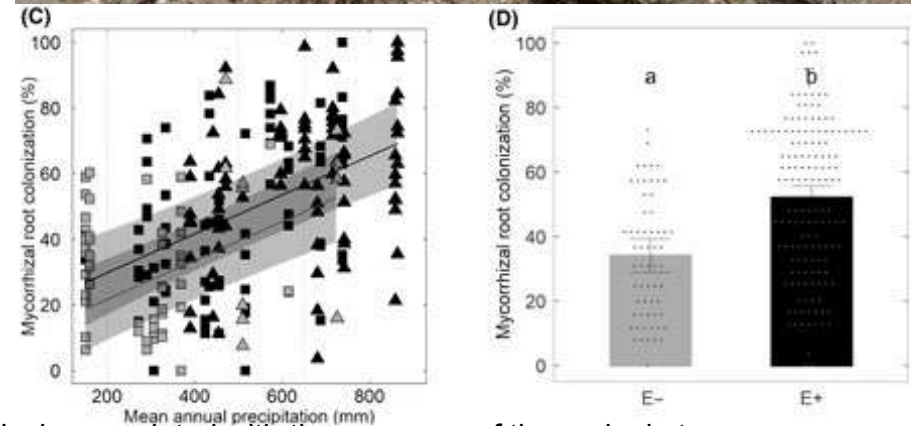
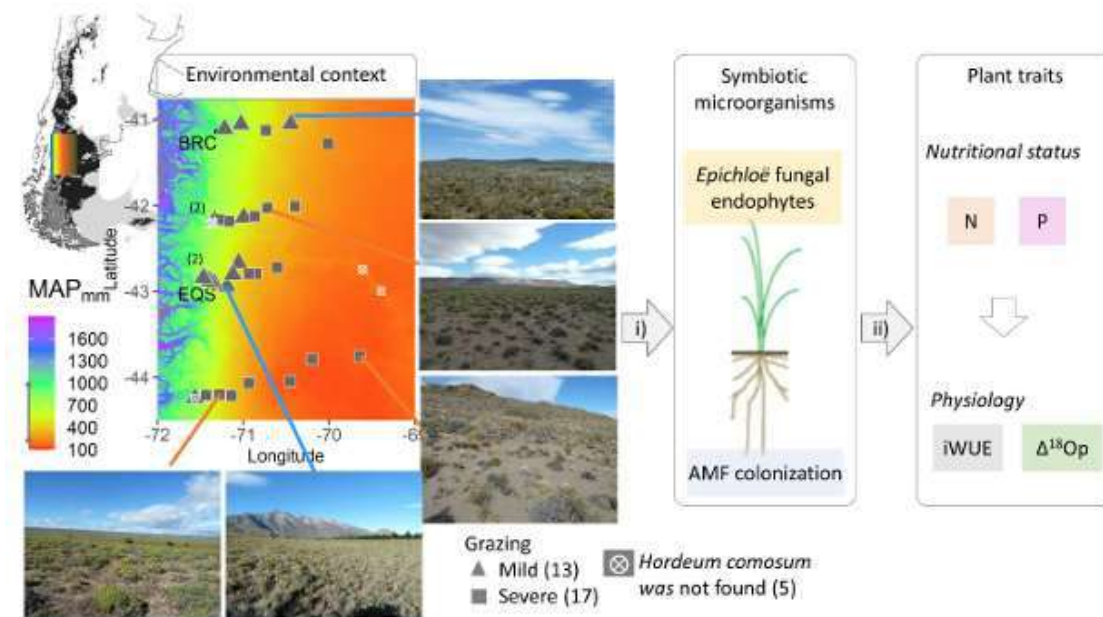
- Mycorrhizal colonization was higher in E+ plants than in E- plants.
- Differences in AMF richness and community composition were observed among ecotypes.
- No differences were detected in soil AMF communities between E+ and E- plants.

# Loss of fungal symbionts at the arid limit of the distribution range in a native Patagonian grass—Resource eco-physiological relations

Cecilia Casas<sup>1,2,3</sup>  | Pedro E. Gundel<sup>2,4</sup>  | Eluneý Deliens<sup>1</sup>  | Leopoldo J. Iannone<sup>5,6</sup>  | Guillermo García Martínez<sup>7</sup> | María V. Vignale<sup>5,6,8</sup>  | Hans Schnyder<sup>3</sup> 



The study was highlighted as a featured paper by the prestigious journal *Nature Climate Change* (Armarego-Mariott, 2022).



- Mycorrhizal colonization was positively associated with the presence of the endophyte.
- Mycorrhizas can regulate stomatal aperture in response to environmental moisture conditions, thereby optimizing intrinsic water-use efficiency

# Interaction between Arbuscular Mycorrhizas and *Trichoderma* in *Ilex paraguariensis*: Effects on Plant Development and Drought Tolerance



1. The diversity and colonization of arbuscular mycorrhizal fungi in yerba mate plantations are influenced by management practices.

2. Co-inoculation with arbuscular mycorrhizal fungi and *Trichoderma* promotes the growth and development of *Ilex paraguariensis* seedlings.

3. Co-inoculation with arbuscular mycorrhizal fungi and *Trichoderma* enhances drought tolerance in *Ilex paraguariensis* seedlings.

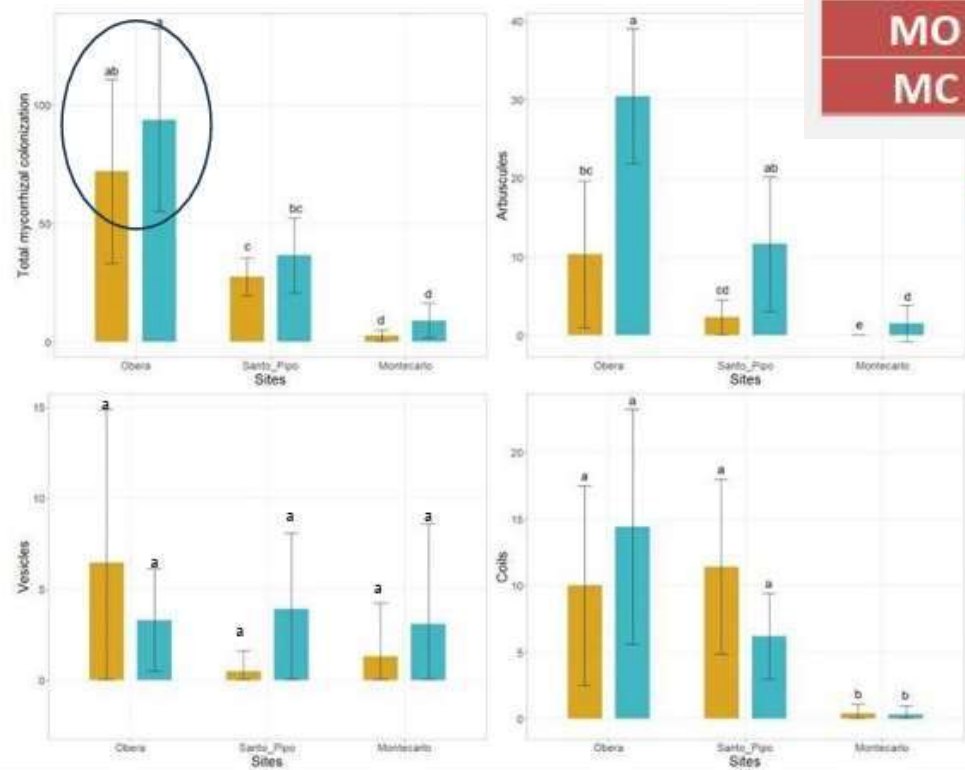
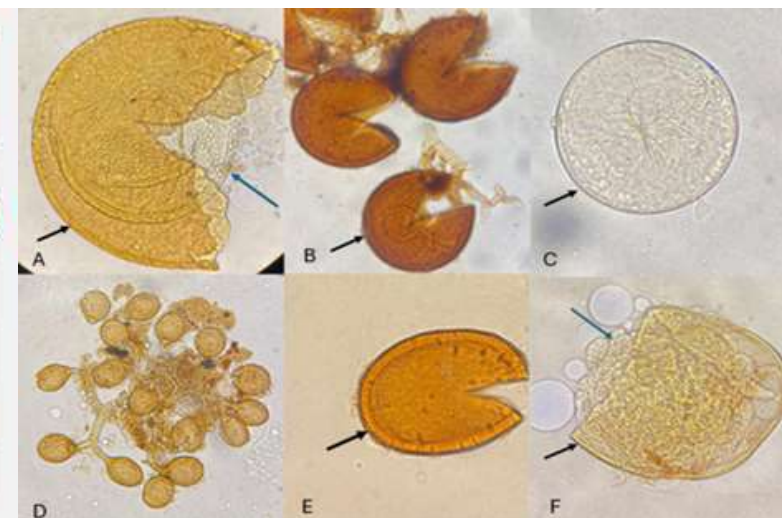
ORGANIC

CONVENTIONAL

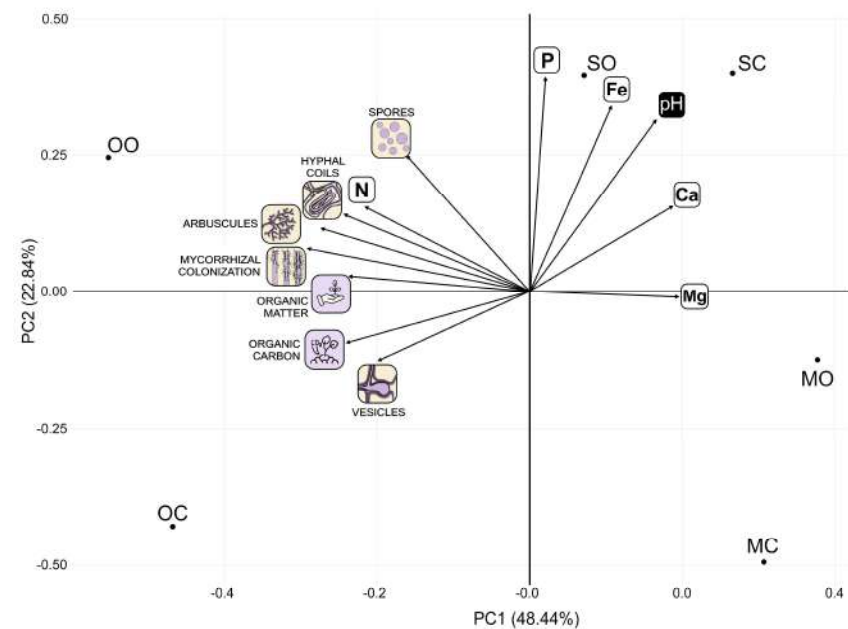


Sampling and characterization of arbuscular mycorrhizal fungi (AMF) from yerba mate plantations under different cultural management practices.

Sitio de muestreo	Número de esporas
OO	1450
OC	443
SO	782
SC	598
MO	671
MC	354



Agricultural practices  
■ Conventional  
■ Organic





# Ensayo de desarrollo de plantas juveniles de *Ilex paraguariensis* co-inoculadas con HMA y *Trichoderma*



## DISEÑO EXPERIMENTAL



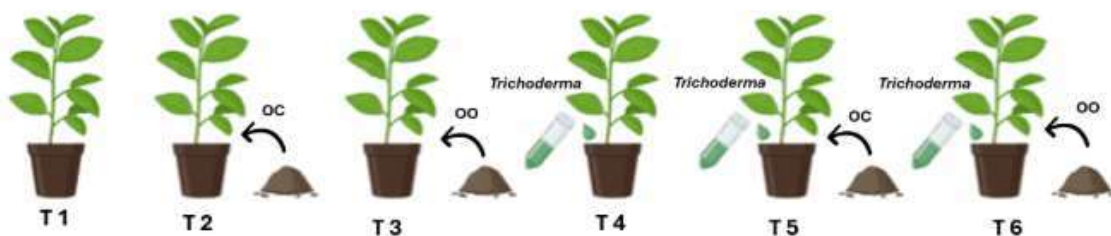
Se realizaron 6 tratamientos con 20 plantas juveniles cada uno provenientes del vivero VyO (Oberá, Misiones).



Se utilizó como inóculo 20 g de suelo provenientes de los sitio Oberá con manejo orgánico, Oberá con manejo convencional y *Trichoderma asperelloides* LBM193.

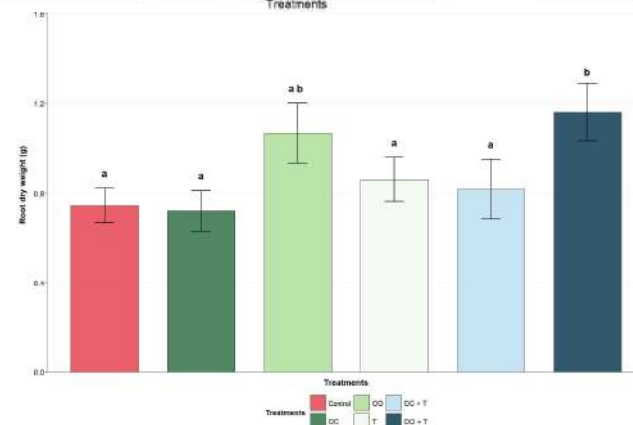
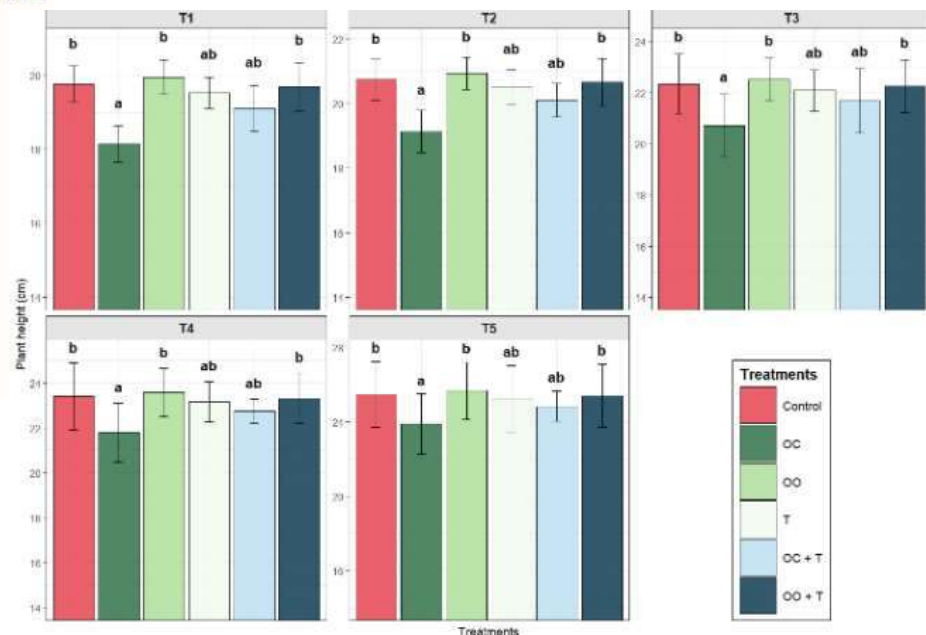


El esquema de tratamiento fue el siguiente:



### Parámetros evaluados:

- ✓ Altura del vástago
- ✓ Número de hojas
- ✓ Diámetro de la planta a la altura del cuello
- ✓ Peso fresco y seco de parte aérea y radicular
- ✓ Porcentaje de micorrización en raíces
- ✓ Volumen radicular
- ✓ Contenido de clorofila





**Molecular and morphological characterization and comparison between populations of AMF in yerba mate (*Ilex paraguariensis*) plantations with different types of management (Organic vs Conventional).  
James Bever's Lab – University of Kansas**



## Objective 1

Activity 1. Extraction of DNA from soil, make library prep for Illumina sequence and analyse.

Activity 2. Spores extraction, DNA extraction from individual spores.

Activity 3. Morphological ID of spores.

Activity 4. Trap cultures and cone-tainers with single species cultures.

## Objective 2

Activity 1. Training in the development and maintenance of an AMF culture collection (INVAM)



The International Collection of (Vesicular) Arbuscular Mycorrhizal Fungi  
**INVAM**



## Objective 2

### Activity 1. Training in the development and maintenance of an AMF culture collection.

- **Planting**



- **Organizing**



- **Counting spores per g/soil**
- **Extraction of INVAM spores and observation of many different species**

- **Harvesting**



- **nursery plant maintenance**

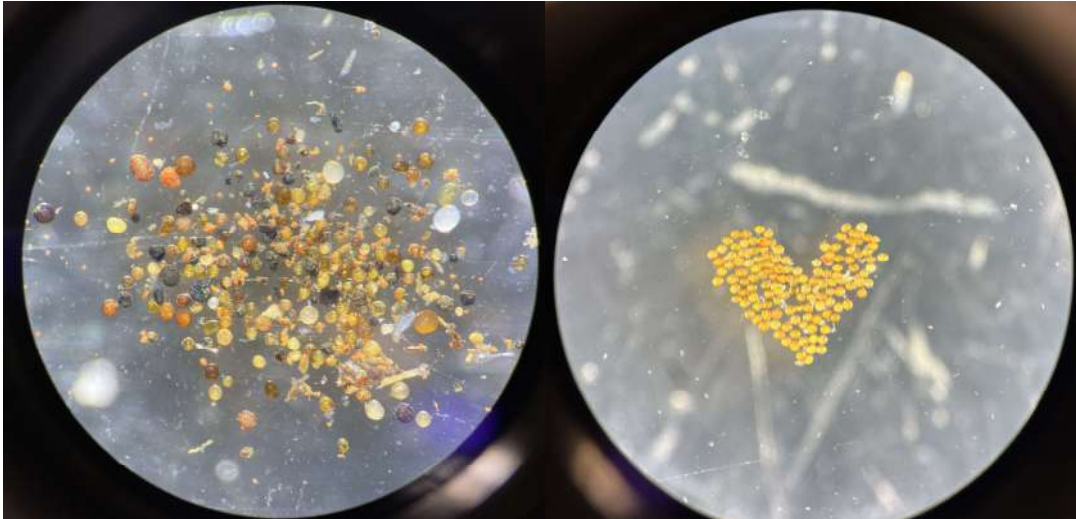


# Results

## ➤ Objective 1

Activity 2. Spores Extraction (slides, measurements, photographs, DNA extraction from individual spores and cultures)

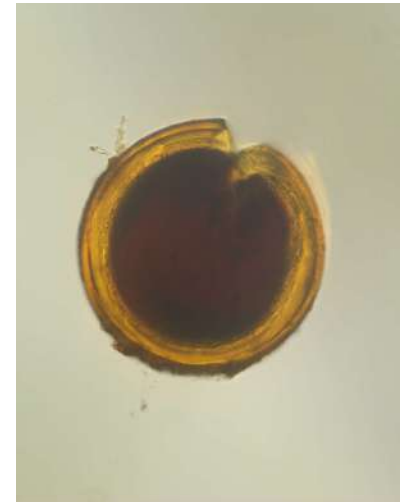
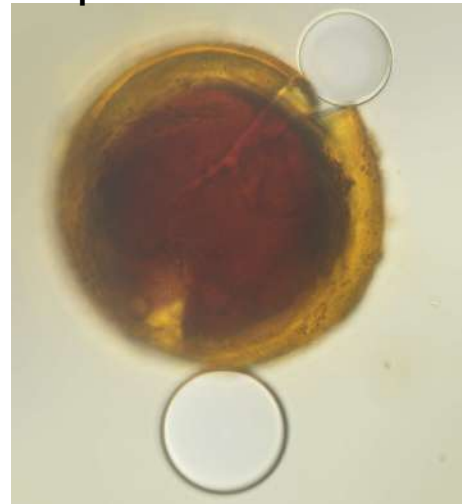
### Extraction of spores



# Spores

► Objective 1

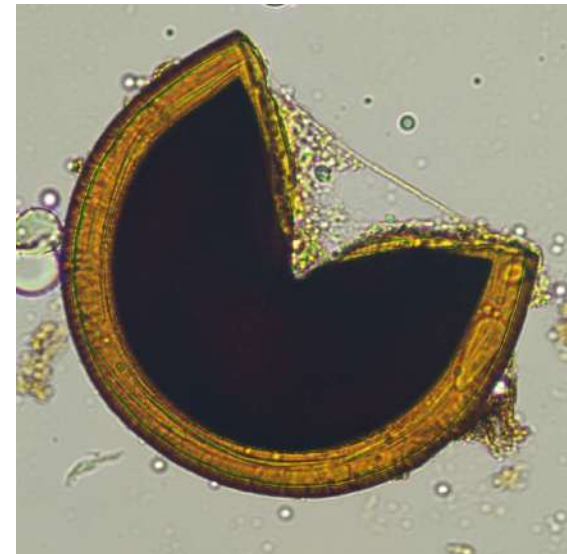
Activity 3. Morphological ID of spores



*Acaulospora* sp.

## DNA EXTRACTED

We created a step-by-step protocol for extracting DNA from spores.



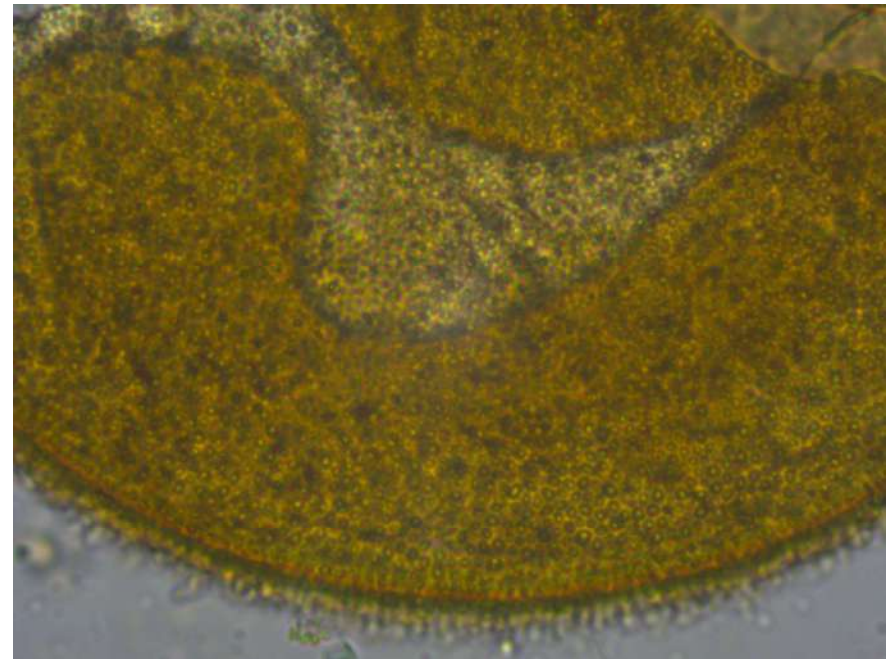
# Spores

*Acaulospora scrobiculata*



# Spores

*Entrophospora infrequens*



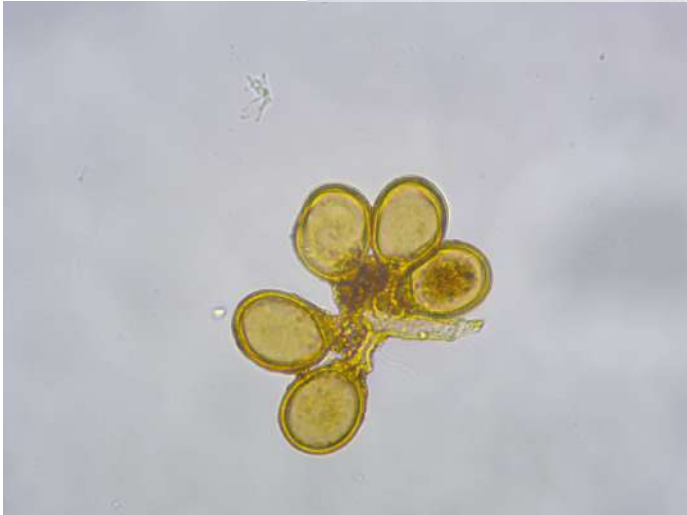
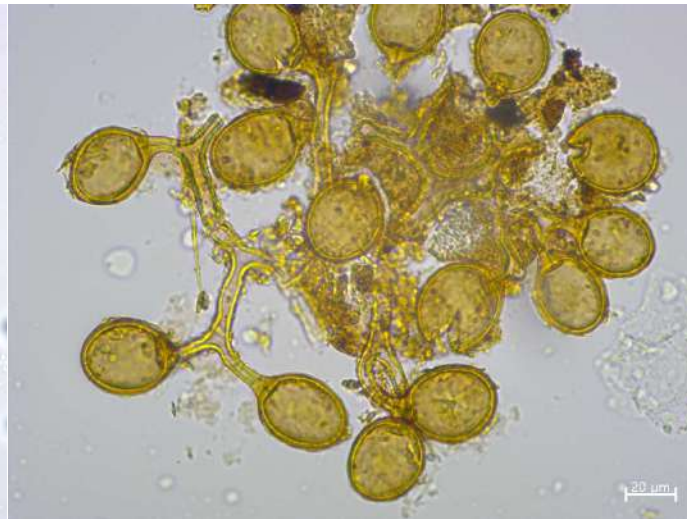
# Spores/sporocarps

*Glomus clavisporum*

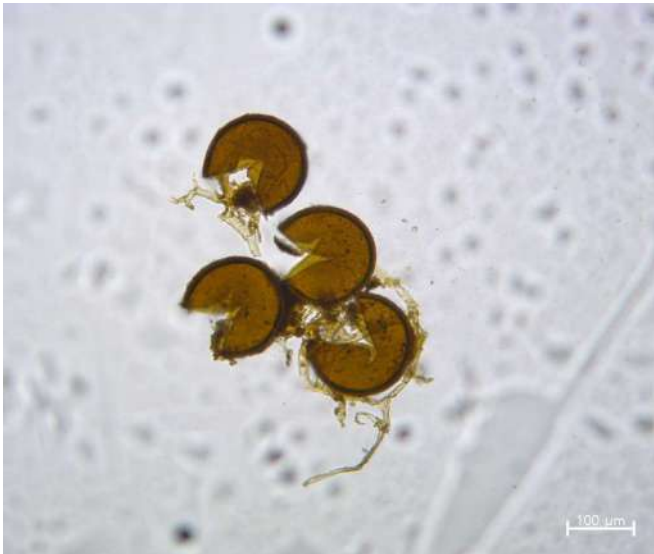


# Spores/sporocarps

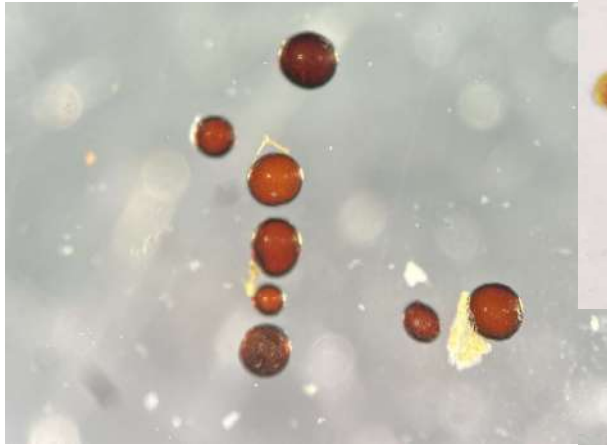
*Sclerocystis rubiformis*



# Spores/sporocarps



More spores...

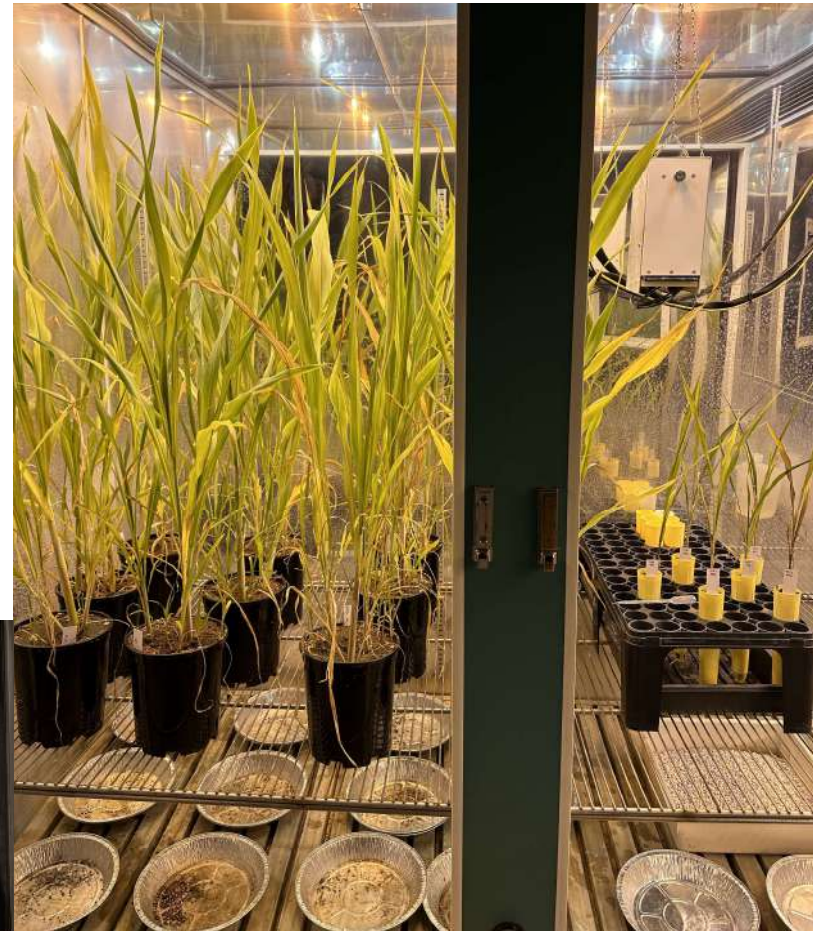


**In general**, I see more diversity in organic crops compared to conventional ones, while in conventional crops, there is a higher number of spores of the same species. In the native forests there are few spores.

# Results

## ► Objective 1

### Activity 4: Trap cultures and cone-tainers with single species cultures



#### PROGRAM SETTING

##### CHAMBER 1

00.00 22 °C - 000Mmol  
08.00 26 °C - 800  
12.00 30 °C - 1000  
20.00 26 °C - 800

70% HUMIDITY  
300 ppm CO<sub>2</sub>

7/20: 12 trap cultures  
8/20: Fertilization 70 ml.

**4 months in 11/20**

Row	Time	Temp (°C)	%RH
01	00 : 00	22.0	0070
02	08 : 00	26.0	0070
03	12 : 00	30.0	0070

# Others

## Visit to the KU Experimental Station



## New Roots for restoration meeting



## Mushroom Foray near Topika







## UPCOMING PROJECT

Mycorrhizal communities associated with ferns as indicators of successional gradients and ecological maturity in subtropical forest environments.

**SPUN** ATLAS SUBTERRÁNEO HONGOS MICORRÍZICOS CIENTÍFICOS EXPEDICIONES INVESTIGACIÓN EXPLORADORES SUBTERRÁNEOS PRENSA ACERCA DE CONSEGUIR IMPLICADO DONAR ES

We're Hiring! CAREERS →

# PROTEJAMOS LAS REDES SUBTERRÁNEAS

Los hongos sustentan gran parte de la vida en la Tierra. SPUN es una organización de investigación científica fundada para mapear las comunidades de hongos micorrízicos y abogar por su

An aerial photograph of a dense, lush green forest covering a mountain range. The forest is thick with trees, and the mountains in the background are partially obscured by a light mist or haze. The sky is overcast with soft, grey clouds. The overall scene is a vast, natural landscape.

# WOOD-INHABITING AGARICOMYCETES OF THE ARGENTINE ATLANTIC FOREST

COMMUNITY COMPOSITION AND ITS INFLUENCE IN  
NATURAL AND FORESTED ECOSYSTEMS

PhD STUDENT: LIC. BATISTA ADRIANA JUDIT  
SUPERVISOR: PhD. NIVEIRO NICOLAS  
CO-SUPERVISOR: PhD. VIGNALE MARÍA VICTORIA



## GENERAL AIM

To study wood-inhabiting Agaricomycete communities in native and forested environments of the Argentine Atlantic Forest (AAF), assessing their occurrence and ecological roles as pathogens and saprotrophs.

## PARTICULAR AIMS

1

To document, identify, and describe wood-inhabiting Agaricomycete species present in native and planted environments of the Argentine Atlantic Forest.

2

To analyze and compare the composition of wood-inhabiting Agaricomycete communities in native environments of the Argentine Atlantic Forest (SAA) and pine plantations.

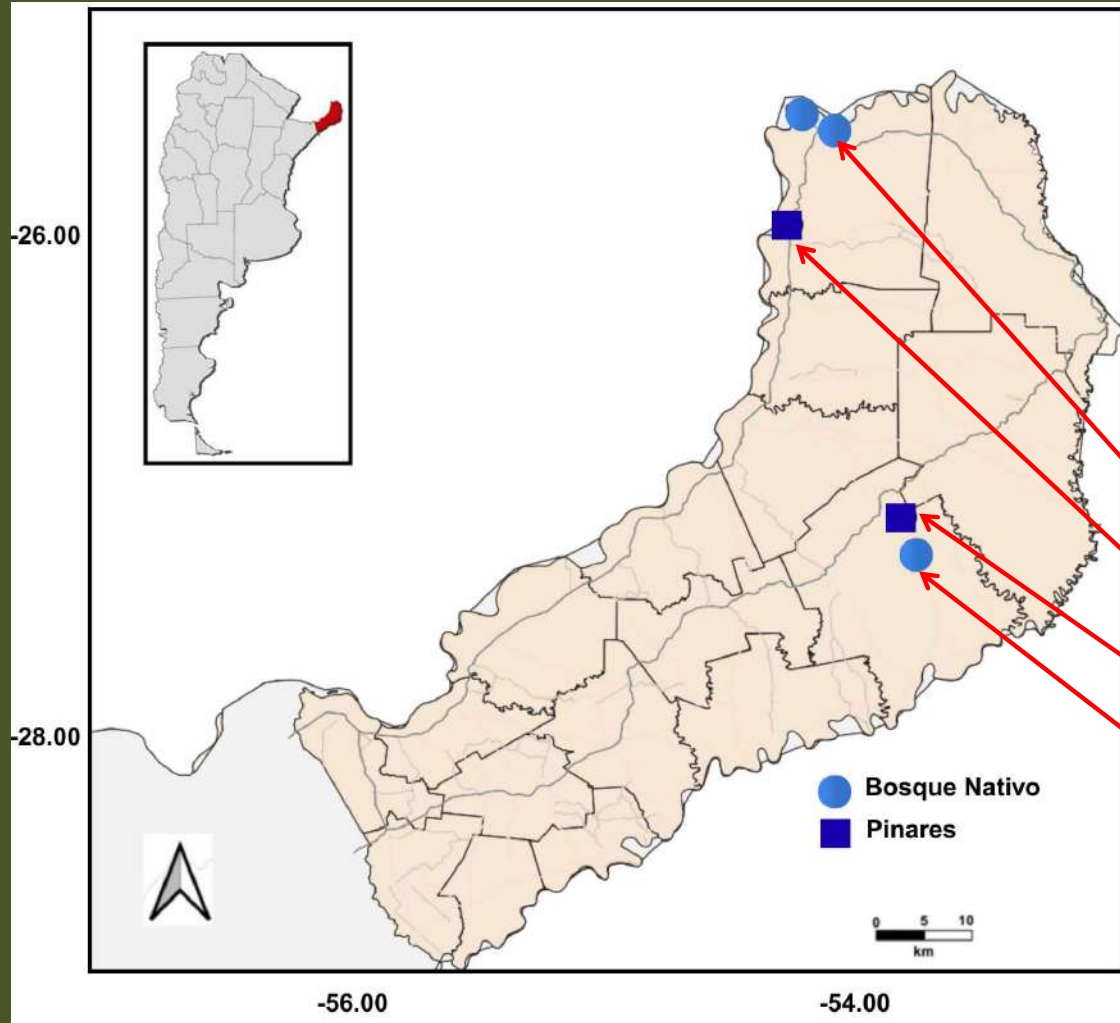
3

To identify the pathogenic fungal species affecting native and planted trees.

4

To analyze substrate specificity of pathogenic and saprotrophic species.

# METHODOLOGY



## Study Area

- Iguazú National Park
- Pine plantation
- Pine plantation
- Reserva de Usos Múltiples Guaraní  
(Permanent Sampling Pots)

Autumn-Spring 2025  
Autumn-Spring 2026

○

# Pine plantations



# Iguazú National Park



# Reserva de Usos Múltiples Guaraní (RUMG)





# GEO-TREES: high-accuracy ground data for satellite-derived biomass mapping

ENTER ADDRESS X

FILTER BY COMPLETED 0 ONGOING 50 PLANNED 12

**ARGENTINA**

## MISIONES

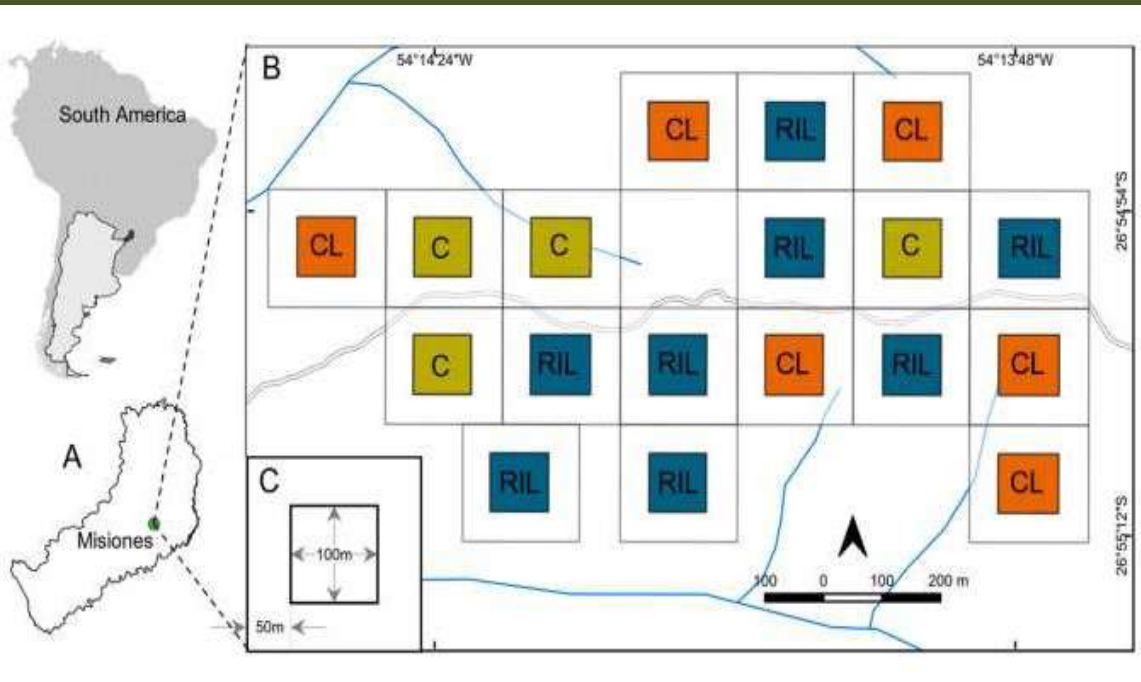
LATITUDE : -26.92 LONGITUDE : -54.23

The Misiones site is located within the Guaraní Multiple Use Reserve (RUMG, Faculty of Forestry Sciences - National University of Misiones). The site includes 18 forest inventory plots, 1 ha size each with all trees, palms and lianas  $\geq 10$  cm included. Of these, there are 4 control plots, 8 plots with reduced-impact logging, and 6 with conventional logging (first measurement: 1998; logging date: 1999). Lowland (350-500 m a.s.l.) subtropical semideciduous forest. TmFO Site.

Completed measurements :

- Forest plot inventory
- ALS

# RUMG - 30 years of monitoring data



Control

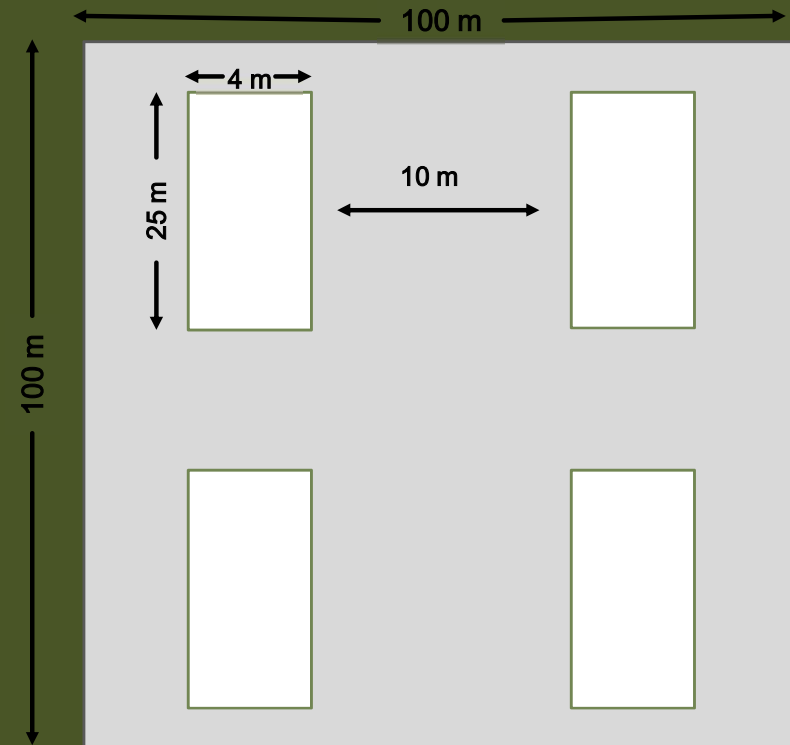
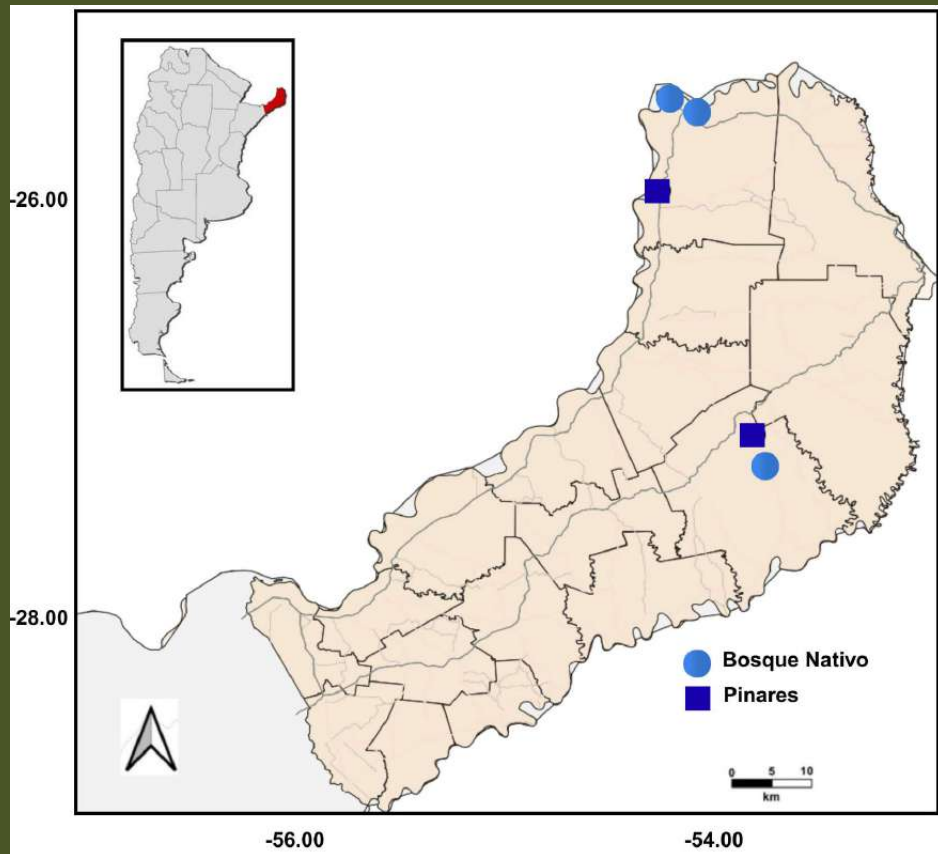
Conventionally  
Logged plots (CL)

Reduced impact  
Logging plots (RIL)



# Experimental design

Modified from Gates *et al.* (2011)



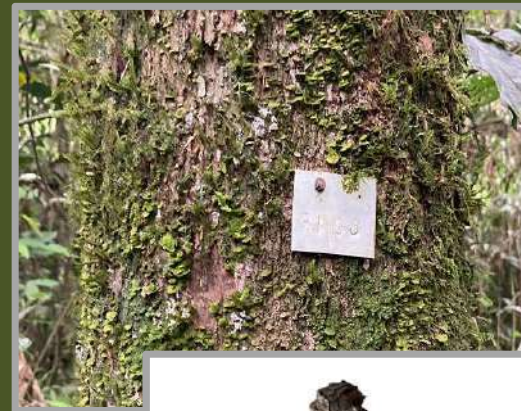
4 Plots in each area (1 ha each)

4 subplots (25 x 4 meters)

# Experimental design

Huhndorf *et al.* 2004)

- **Decay class 1:** Newly fallen wood, generally retaining its bark.
- **Decay class 2:** Intermediate decay; bark detached; a knife can penetrate up to 2 cm into the wood without applying excessive pressure.
- **Decay class 3:** Advanced decay; a knife can penetrate the wood easily without applying much pressure, and the wood can be partially crumbled by hand.



# Morfological ID

In a first step, orders and/or families were determined based on the analysis of macro- and microscopic characters of taxonomic relevance, using specialized literature.

Colección BAH (Briófitos, Algas y Hongos) – Herbario CTES

UNIVERSIDAD NACIONAL DE CÓRDOBA  
Facultad de Ciencias Exactas, Físicas y Naturales

NOVEDADES SOBRE “CORTICIOIDES” Y “POLÍPOROS”  
(BASIDIOMYCETES) XILÓFILOS  
DEL NORDESTE ARGENTINO Y PARAGUAY

Lic. Orlando Fabián Popoff

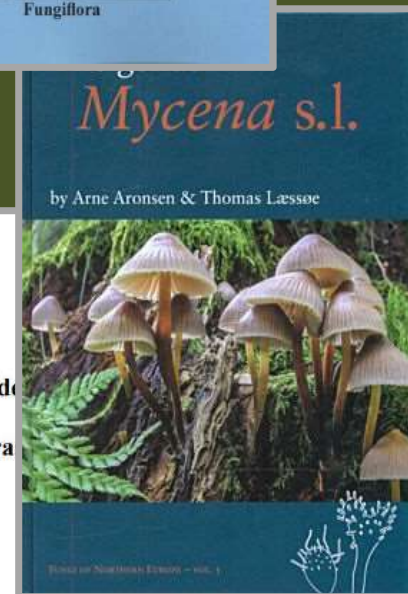
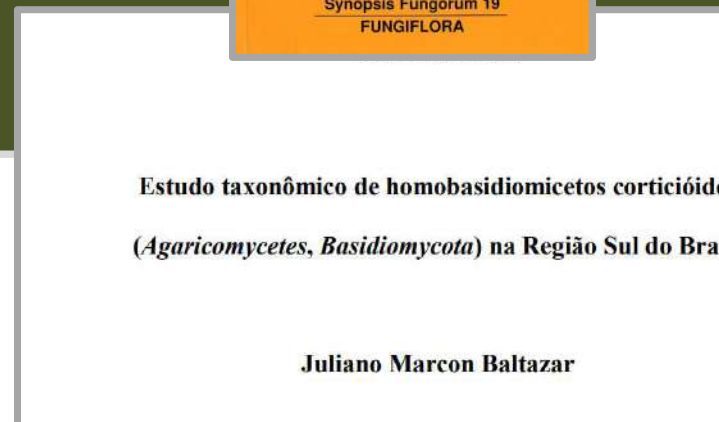
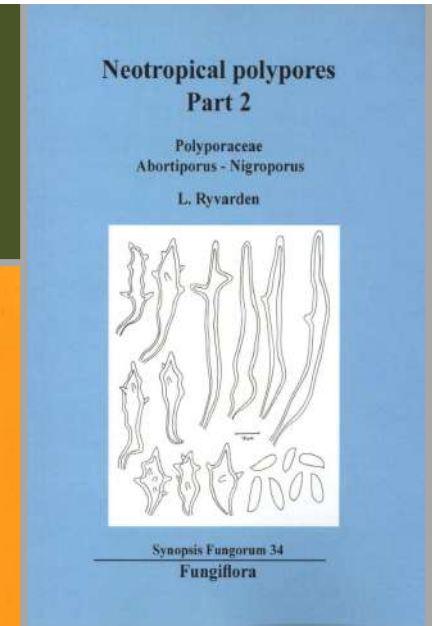
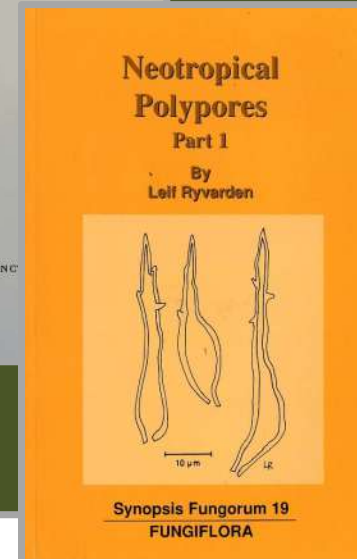
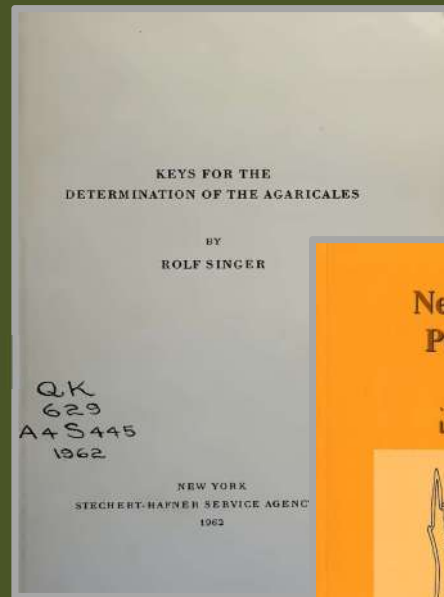
Lilloa 51 (1): 74-86, 2014

74

## Hongos agaricoides de las Yungas argentinas. Clave de géneros

Niveiro, Nicolás<sup>1\*</sup>; Paola Zuliani<sup>1</sup>; Natalia A. Ramirez<sup>1</sup>;  
Orlando F. Popoff<sup>1</sup>; Edgardo O. Albertó<sup>2</sup>

<sup>1</sup> Instituto de Botánica del Nordeste, IBONE (UNNE-CONICET). Sargento Cabral 2131, CC 209, (3400) Co-





# Molecular ID



Finnish Museum of Natural History (Helsinki, Finland)  
PhD. Slava Spirin  
PhD. Ilya Viner

80 samples

“White corticioids”



“jelly fungi”

“black stipe polypores”



## Substrate volume

All woody substrates with a diameter  $> 10$  cm intersecting the 25 m transect.



# Substrate volume

$$V = L/3 \times (A_1 + \sqrt{A_1 \times A_2} + A_2)$$

V = volumen de la pieza  
 L = longitud de la pieza  
 A<sub>1</sub> = área basal  
 A<sub>2</sub> = área distal



**Tocones**



**Ramas caídas**



**Troncos caídos**

FWD = 5 - 9 CM

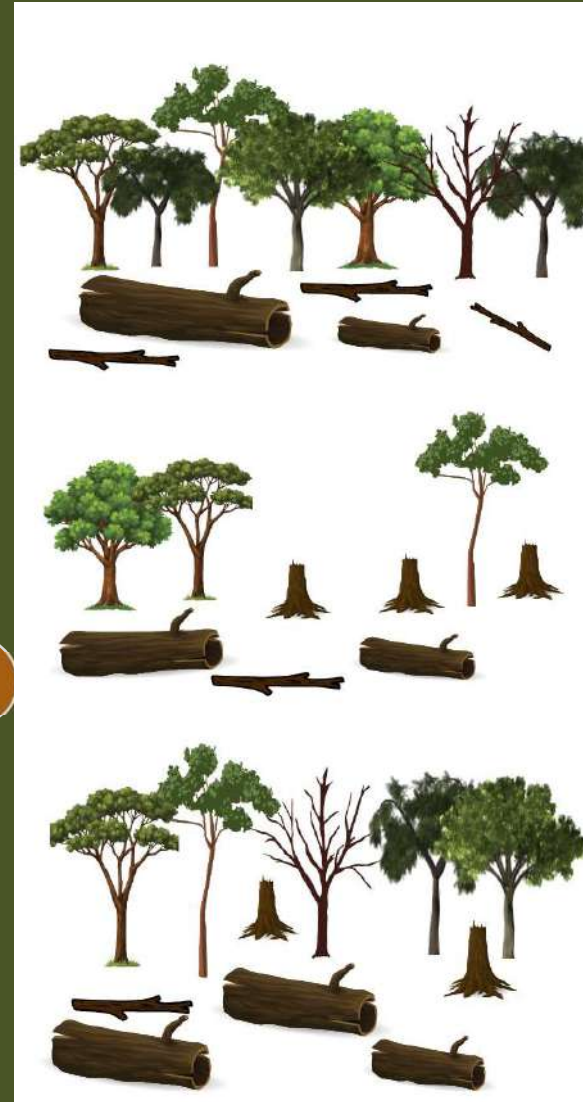
CWD ≥ 10 CM



Tratamiento:

ID subparcela: GP \_\_\_\_\_ S \_\_\_\_\_

Nº pieza	Tipo	D1 ancho (cm)	D2 angosto (cm)	Longitud (m)	Descomposición (1,2,3)
1					
2					
3					
4					
5					



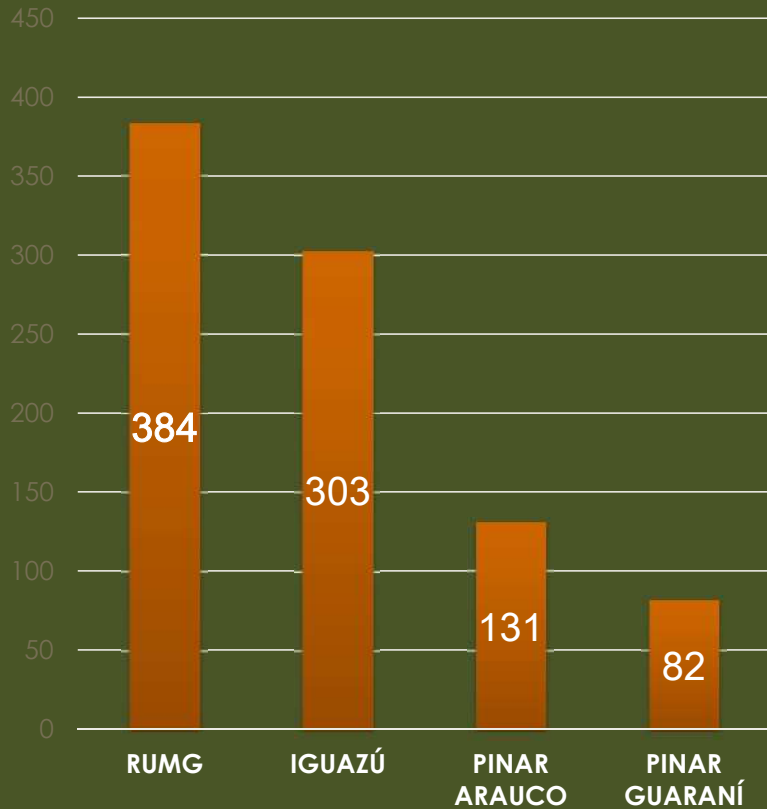
# RESULTS

3 of the 4 sampling campaigns:

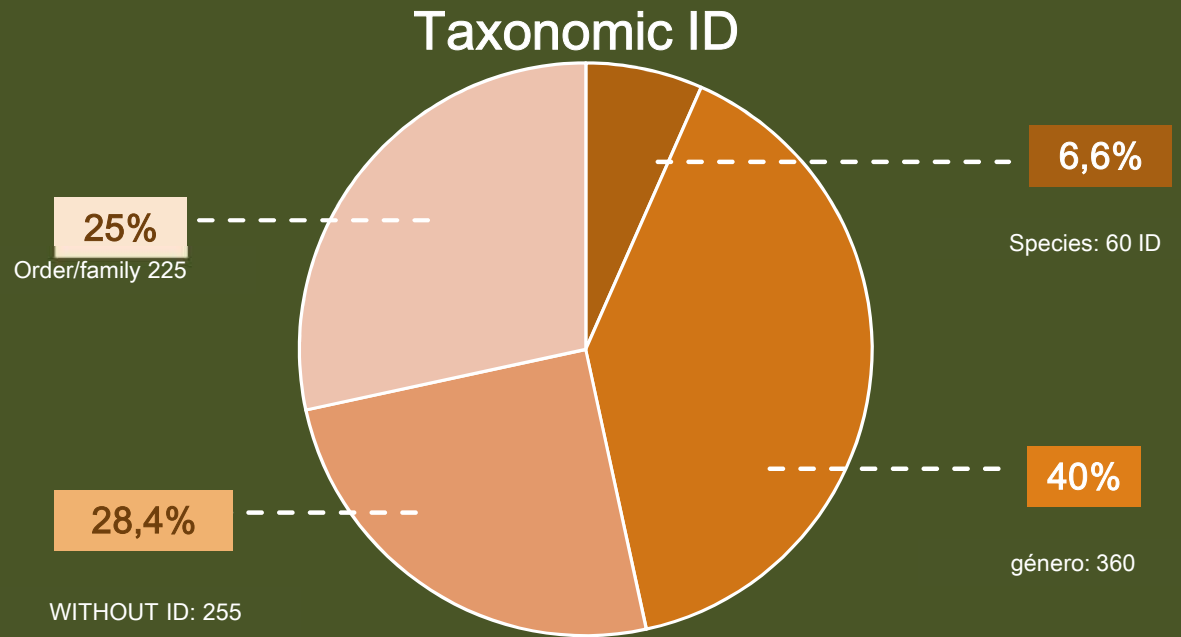
1. Autumn 2025
2. Spring 2025
3. Autumn 2026



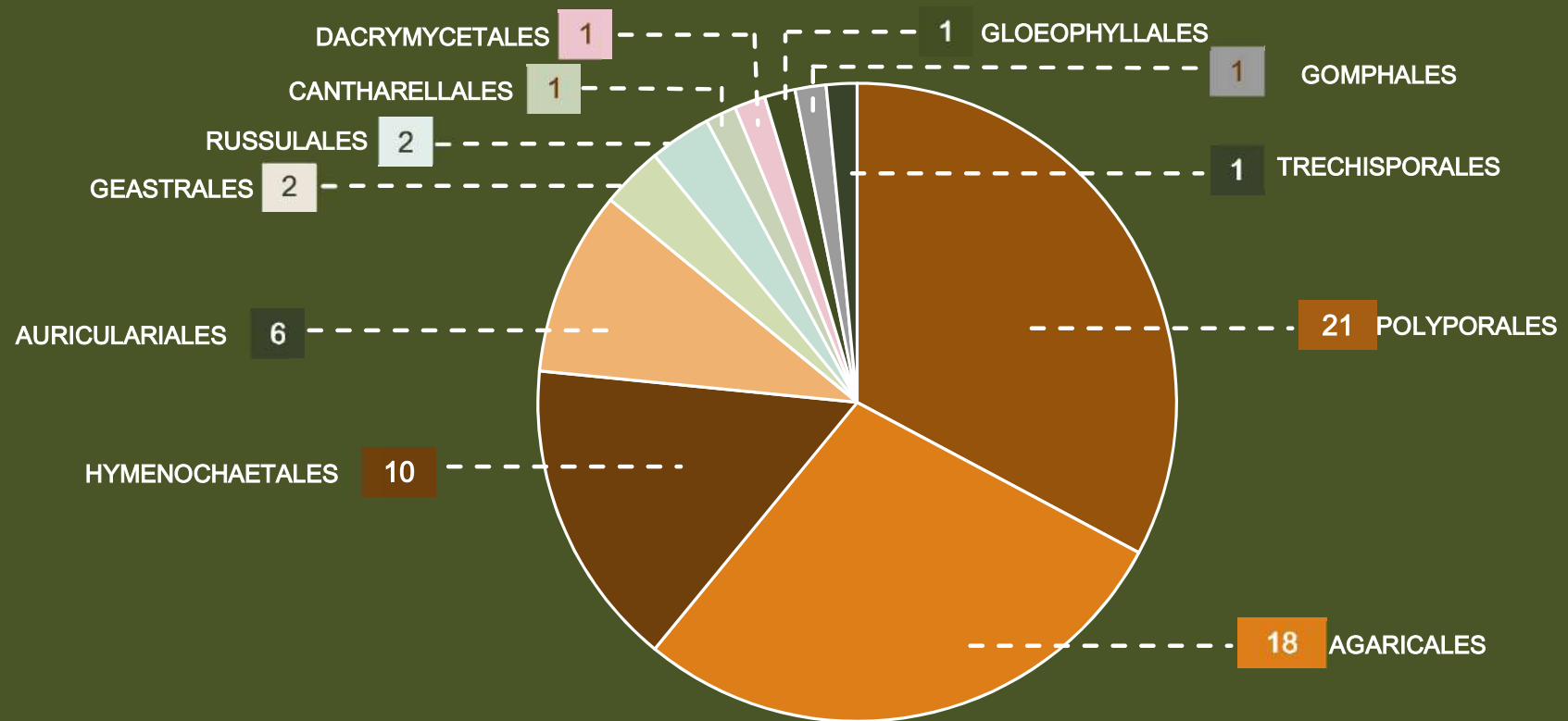
# RESULTS



During the first year of sampling (autumn and spring 2025), 900 Agaricomycetes specimens were collected.

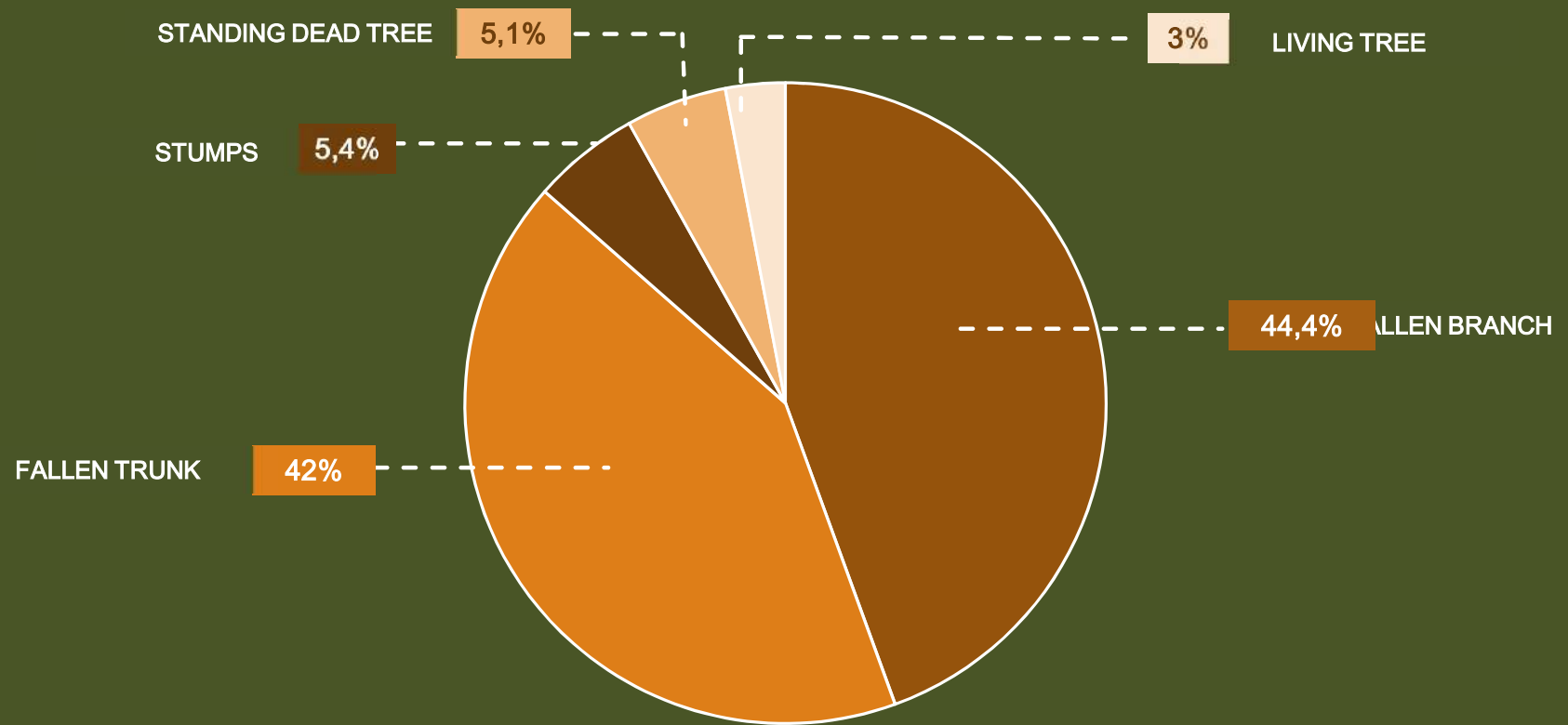


# RESULTS



# RESULTS

## Substrates



*Filoboletus  
grassilis*



*Rigidoporus  
crocatu*



*Perenniporia  
marius*



*Polyporus leprieurii  
s.l.*



*Meripilus brasiliensis*



*Fomes  
fasciatus*



*Inocutis jamaicensis*



*Elmerina  
santanensis*



*Clitocybe aff  
asema*



*Peniophorella rudis  
s.l.*



*Scytinostroma  
auriusculum s.l.*



*Hyphoderma  
setigerum s.l.*



*Ganoderma  
aplannatum*



*Galerina  
velutipes*



*Perenniporia*



*Hymenochaete*



*Leucocoprinus*



*Mycena  
paraguariensis*



# RESULTS

6 *Auricularia* species

*A. brasiliiana*



*A. fuscosuccinea*



*A. protracta*



*A. cornea*



*A. nigricans*



*A. tremellosa*



The identity of additional specimens was confirmed *Polyporus wrightii*, *P. subelegans*, *Lyomyces boquetensis*, *Xylodon rickii*, *Phanerochaete* sp., *Steccherinum perparvulum*, *Perenniporia paraguayensis* y *Elmeerina santanensis*.

**Estudio preliminar sobre el género *Amanita* en el nordeste de Argentina**  
**Preliminary study on the genus *Amanita* in northeastern Argentina**

Vignale M. V.<sup>1,2</sup>, Ramirez N. A.<sup>3</sup>, Grassi E. M.<sup>3,4</sup>, Niveiro N.A.<sup>4</sup>

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<sup>2</sup>Instituto Misionero de Biodiversidad (IMIBIO) - CONICET, CP 3400, Misiones, Argentina.  
<sup>3</sup>Instituto de Botánica del Nordeste (IBONE - CONICET), Sargento Cabral 2131, CP 3400, Corrientes, Argentina.  
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**Introducción**

El nordeste argentino (NEA) posee una gran variedad de ambientes naturales (selvas húmedas, bosques xerófilos, pastizales, pajonales, etc.), además de tener una importante superficie forestada con especies introducidas, esto facilita las condiciones para la aparición de especies de hongos asociadas, sobre todo micorrízicas, como las amanitas. Este es un género que presenta algunas grandes, vistosas, con laminillas blancas, limbo, y estipe con anillo y volva basal. Si bien es un grupo ampliamente estudiado en muchos lugares del mundo, su gran diversidad hace que la identificación de sus especies no sea sencilla, y hasta la fecha, no se han trabajado sobre este género en el norte de Argentina. El objetivo de este trabajo es estudiar a las especies de *Amanita* que fueron registradas en el NEA, en ambientes naturales y forestados, en base a colecciones realizadas durante los últimos años y contribuir al conocimiento de la flora de la región.

**Materiales y Métodos**

Las especímenes colectados fueron fotografiados y descritos macroscópicamente "in situ", y analizados microscópicamente mediante las técnicas habituales para el estudio del grupo en cuestión. El material colectado fue depositado como herbario en los herbarios del Instituto de Botánica del Nordeste (CTES) y el Instituto Misionero de Biodiversidad (IMB).

**Resultados y Discusión**

Se registraron un total de siete especies, 2 asociadas a ambientes naturales y 5 a ambientes forestados. De las especies nativas, se registra por primera vez para el NEA a *A. muscaria* (sección *lepidaria*) y *A. muscaria* (sección *lepidaria*). Respecto a las especies asociadas a cultivos forestales, se registraron: *A. muscaria* (sección *Casaregola*), *A. muscaria* (sección *lepidaria*), *A. muscaria* (sección *lepidaria*), *A. muscaria* (sección *lepidaria*) y *A. muscaria* (sección *lepidaria*). La diversidad de especies encontradas fue mayor a las esperadas, esto se debe a la gran variedad de especies introducidas asociadas a los bosques de pino. Este registro es el primer registro de *A. muscaria* en esta zona de la provincia de Misiones.



Fig. 1. Aspecto general de las especies de *Amanita* del NEA: A-B. *Amanita muscaria*; C-A. *A. muscaria*; D. *A. muscaria*; E. *A. muscaria*; F. *A. muscaria*; G. *A. muscaria*. Las fotos de las especies de cada uno de los registros fueron tomadas en ciertos de laminillas tratadas con el reactivo de  $FeSO_4$ , observándose en todas las especies reacción azulada salvo en D.



Fig. 2. Mapa mostrando las colecciones realizadas.

**Referencias**



DARWINIANA, nueva serie 13(2): xxx-xxx: 2025  
 Versión de registro, efectivamente publicada el xx de septiembre de 2025  
 DOI: 10.14522/darwiniana.2025.131.1289

**EL GÉNERO AMANITA (AMANITACEAE, AGARICALES, BASIDIOMYCOTA)  
 ASOCIADO A CULTIVOS FORESTALES DE PINO  
 EN LA MESOPOTAMIA ARGENTINA**

A. Judit Batista<sup>1,2\*</sup>, Alex E. Somrau<sup>1</sup>, Natalia A. Ramirez<sup>1,2</sup>, Emanuel M. Grassi<sup>3</sup>,  
 M. Victoria Vignale<sup>3,4</sup> & Nicolás Niveiro<sup>1,2</sup>



**Nuevo registro de *Morchella esculenta* (Ascomycota, Pezizales) para la selva paranaense**

New record of *Morchella esculenta* (Ascomycota, Pezizales) for the Paranaense forest

Vignale, M. Victoria<sup>1,2\*</sup>; Felipe Sodrê Mendes Barros<sup>1,3</sup>; Emanuel M. Grassi<sup>1,4</sup>

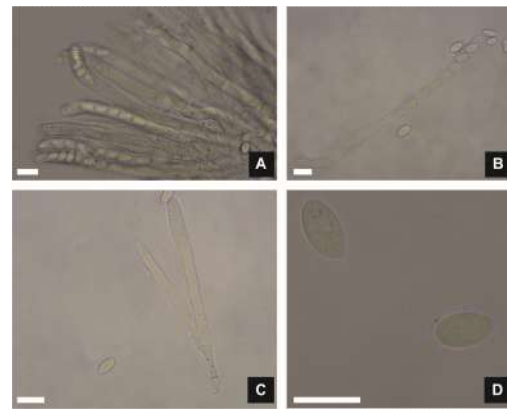
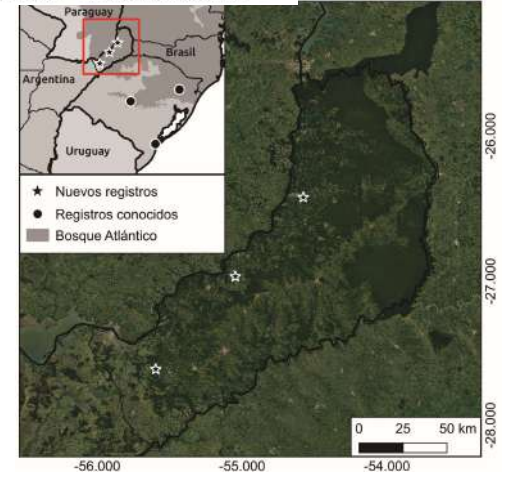


Fig. 3. Aspecto microscópico de *Morchella esculenta*: A y B. Hifas con setas; C y D. Detalles de la estructura de la setina.

# Workshops on mushroom identification and collection



OBERÁ



Emanuel Grassi | Paula Álvarez | Victoria Vignale



CAPIOVÍ



APÓSTOLES



IGUAZÚ



EL SOBERBIO

**LET'S BE MORE LIKE  
MYCORRHIZAL FUNGI**

**COLLABORATE**

**BUILD NETWORKS**

