Africa fungus day 25 th of May 2022

Influence of host plants and edaphic factors on the diversity and distribution of EcM fungi In Congolese forests

By Héritier MILENGE KAMALEBO, Ph.D

Département de Biologie,
ISP de Bukavu/D R Congo

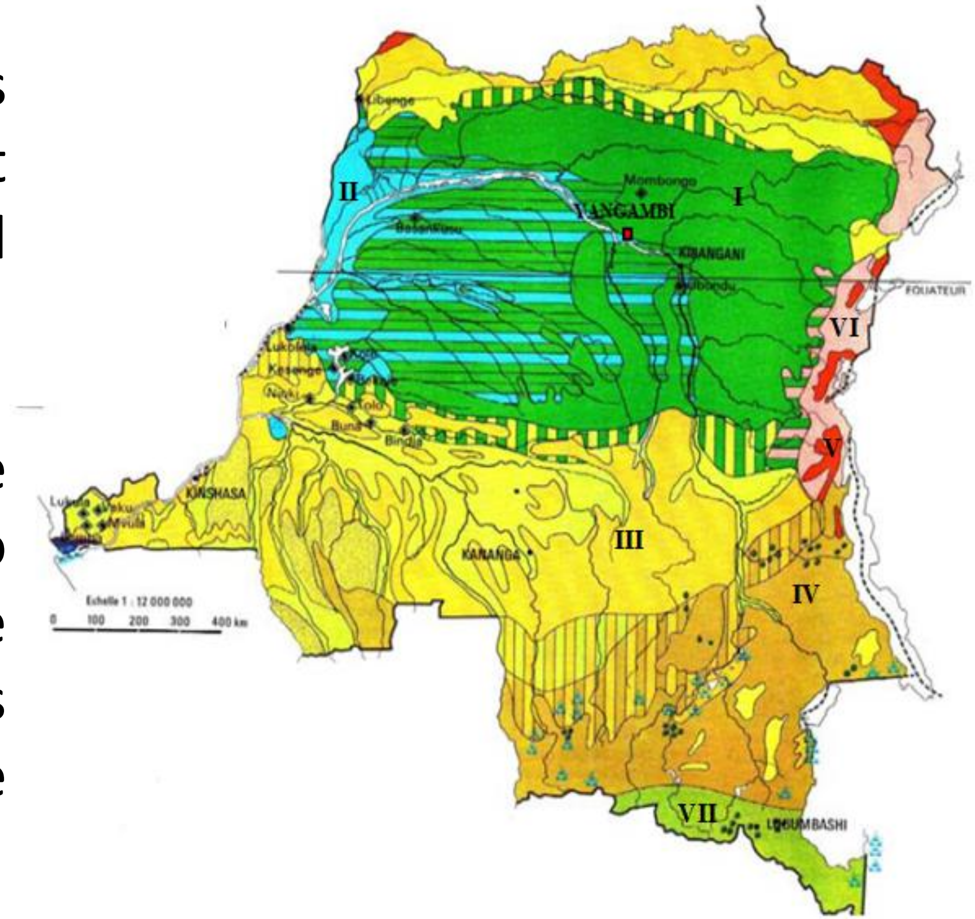
Outline

- Distribution of EcM fungi in tropical African forests
- Fungi hotspots and collections in D R Congo
- Main fungal collections
- Fungal species assemblages and indicator species
- Soil properties promoting EcM fungi and their host plants
- Fungal knowledge gaps
- Conclusion and recommandation

Fungi hostspots and collections in the D R Congo

- The EcM fungal communities constitute an important component of many tropical African forests

- In D R Congo, EcM fungi are mainly distributed in the Congo basin rainforests, in the Zambezian Miombo woodlands of Katanga region, and in the Sudanian savannah woodlands



Vegetation and fungi in the region of Katanga

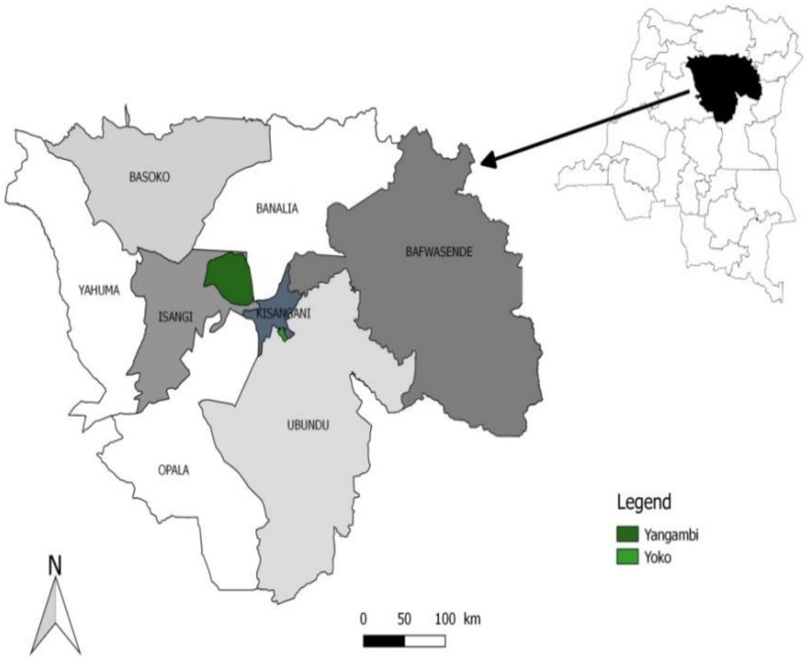
- The region of Lubumbashi (Upper Katanga) characterized by its miombo vegetation.

- These open forests are dominated by trees (Caesalpiniaceae, Phyllanthaceae and some Dipterocarpaceae) that associate with a great number of ectomycorrhizal fungi.
- Most of the type specimens of *Cantharellus*, *Russula*, Boletales, and milk caps (*Lactarius* and *Lactifluus*)

Tshopo as a hotspot of fungi diversity

Vegetation in this region is particularly rich in both saprotrophic and ectomycorrhizal fungi and consist in monodominant forests of:

- *Gilbertiodendron dewevrei*,
- *Brachystegia laurentii*, and
- gallery forests with *Uapaca guineensis*.



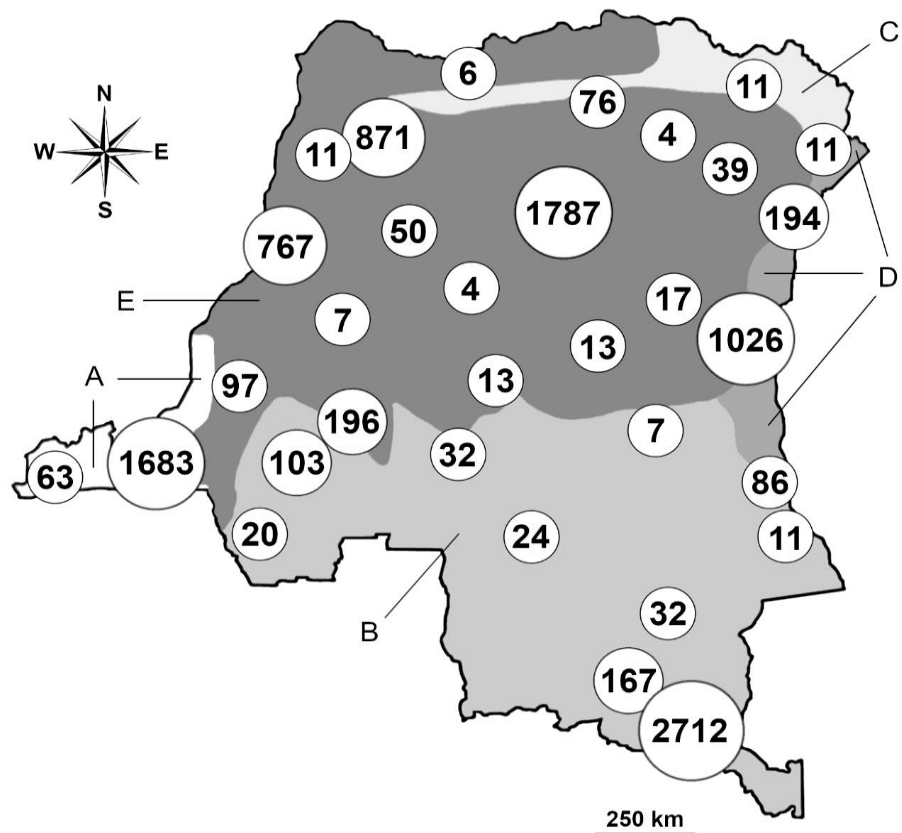
The mixed forests host several ectomycorrhizal trees

FAMILY	EcM Trees
Fabaceae	Afzelia bipindensis Harms
	Anthonotha macrophylla P. Beauv
	Aphanocalyx cynometroides Oliver
	Berlinia grandiflora (Vahl) Hutch. & Dalz.
	Brachystegia laurentii (De Wild.) Louis
	Gilbertiodendron dewevrei (De Wild.) J. Léonard
	Julbernardia seretii (De Wild.) Troupin
	Paramacrolobium coeruleum (Taub.) J. Léonard
	Paramacrolobium sp.
	Pericopsis elata (Harms) Van Meeuwen
Phyllanthaceae	Uapaca guineensis Mull. Arg
	Uapaca heudelotii Baillon

Main fungal collections in the D R Congo

On the basis of the collection kept at Meise Botanic Garden (BR, Belgium) With 10,152 specimens and 825 type specimens collected in DRC (95% of all collections and 97% of the type specimens):

- 1°) dense forests from the Congo basin, followed by
- 2°) the wooded savannas and miombo woodlands of the Zambezian region.



Milenge et al., 2021., Geo-Eco-Trop., 2021, 45, 3 : 417-434

ORIGINAL ARTICLE

WILEY African Journal of Ecology

Host plants and edaphic factors influence the distribution and diversity of ectomycorrhizal fungal fruiting bodies within rainforests from Tshopo, Democratic Republic of the Congo

Héritier Milenge Kamalebo[1,2] | Hippolyte Nshimba Seya Wa Malale[1] | Cephas Masumbuko Ndabaga[3] | Léon Nsharwasi Nabahungu[4] | Jérôme Degreef[5,6] | André De KeseL[5]

[1]Faculté des sciences, Université de Kisangani, Kisangani, D R Congo

[2]Centre de Recherches Universitaires du Kivu (CERUKI)/ISP, Bukavu, D R Congo

[3]Faculté des sciences, Université Officielle de Bukavu, Bukavu, D R Congo

[4]International Institute of Tropical Agriculture, IITA-Kalambo, Bukavu, D R Congo

[5]Meise Botanic Garden, Meise, Belgique

[6]Fédération Wallonie-Bruxelles, Service Général de l'Enseignement Supérieur et de la Recherche Scientifique, Brussels, Belgium

Correspondence
Héritier Milenge Kamalebo, Faculté des sciences, Université de Kisangani, Kisangani, D R Congo.
Email:kamaleboheritier@gmail.com

Funding information
Centre for International Forestry Research; Belgian Federal Science Policy Office

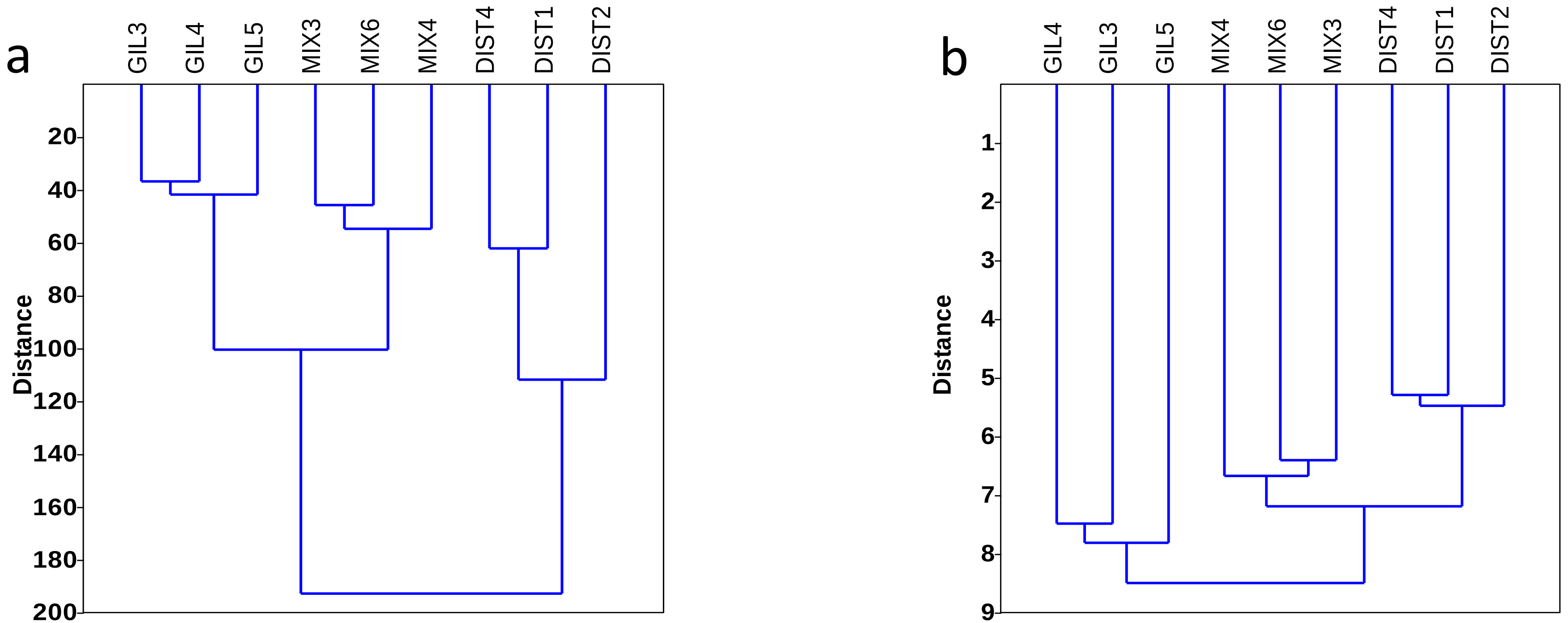
Abstract

Ectomycorrhizal fungi constitute an important component of forest ecosystems that enhances plant nutrition and resistance against stresses. Diversity of ectomycorrhizal (EcM) fungi is, however, affected by host plant diversity and soil heterogeneity. This study provides information about the influence of host plants and soil resources on the diversity of ectomycorrhizal fungal fruiting bodies from rainforests of the Democratic Republic of the Congo. Based on the presence of fungal fruiting bodies, significant differences in the number of ectomycorrhizal fungi species existed between forest stand types ($p < 0.001$). The most ectomycorrhizal species-rich forest was the *Gilbertiodendron dewevrei*-dominated forest (61 species). Of all 93 species of ectomycorrhizal fungi, 19 demonstrated a significant indicator value for particular forest stand types. Of all analysed edaphic factors, the percentage of silt particles was the most important parameter influencing EcM fungi host plant tree distribution. Both host trees and edaphic factors strongly affected the distribution and diversity of EcM fungi. EcM fungi may have developed differently their ability to successfully colonise root systems in relation to the availability of nutrients.

Fungal species assemblages and indicator species

- The composition of vascular plants prominently influenced EcM fungi species assemblages and composition.

- Clustering of plots based on EcM fungi (a) is strongly correlated with forest stand types and their composition in vascular plants (b)



Indicator EcM species

- The highest number of indicator species was demonstrated for the *Brachystegia laurentii* dominated forests

N°	Indicator EcM species	Probability		Indicator value (Indval)	
		Fidelity	Occurrence	Indval	p-value
	Brachystegia laurentii dominated forest				
1	Cantharellus ruber	1.0000	1.000	1.000	**
2	Cantharellus rufopunctatus	1.0000	1.000	1.000	**
3	Russula roseostriata	1.0000	1.000	1.000	**
4	Thelephora palmata	1.0000	1.000	1.000	**
5	Russula meleagris	0.8333	1.000	0.913	**
6	Russula sese	0.8333	1.000	0.913	**
7	Cantharellus miniatescens	0.7500	1.000	0.866	*

Indicator EcM species

- The all four indicator species of *Gilbertiodendron dewevrei* dominated forest were exclusively faithful (100% fidelity) and demonstrated strong preference (100% occurrence).

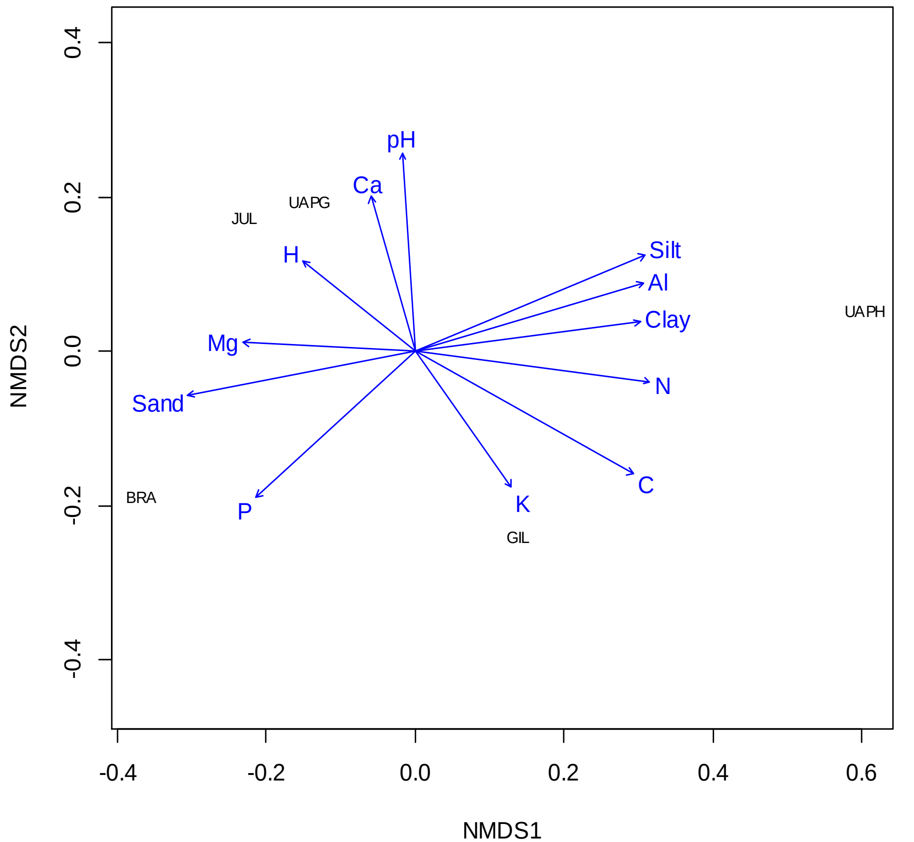
N°	Indicator EcM species	Probability		Indicator value (Indval)	
		Fidelity	Occurrence	Indval	p-value
Uapaca heudelotii dominated forest					
1	Lactifluus heimi	1.00	1.00	1.000	**
Gilbertiodendron dewevrei dominated forest					
1	Cantharellus congolensis	1.000	1.000	1.000	**
3	Rubinoboletus luteopurpureus	1.000	1.000	1.000	**
4	Strobilomyces echinatus	1.000	1.000	1.000	**
5	Tylopilus beeli	1.000	1.000	1.000	**

Soil types preference

- The diversity of each forest stand and associated EcM fungal community are differently influenced by soil properties.

- *B. laurentii* dominated forest and associated EcM fungi are mainly promoted by sand soil, content in extractable P and available Mg

- Silt and clay particles, Al and N are the most important edaphic parameters influencing the presence of EcM fungi associated with *U. heudelotii*

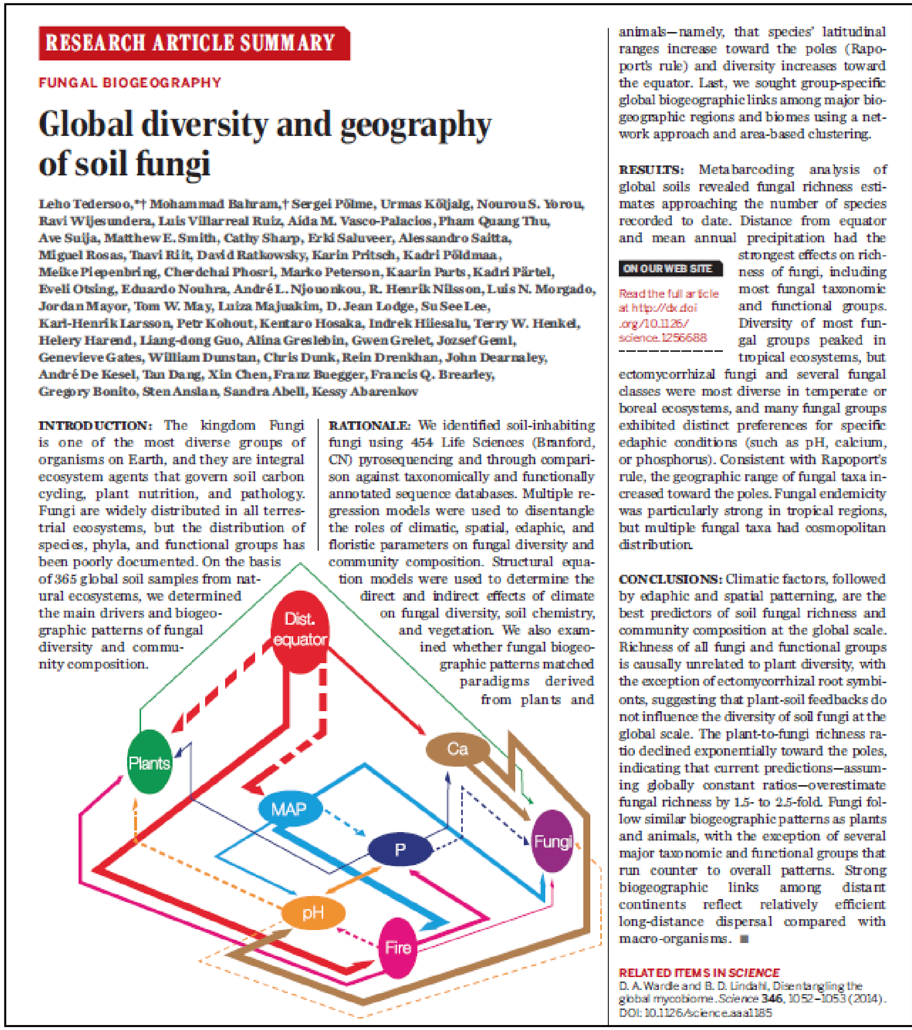


Milenge et al., 2019. *Afr J Ecol.* 2019;1–13.

Fungal knwoledge gaps

- Due to lack of experts and adequate equipment, the dense forests of the Congo Basin are clearly understudied and could reveal many new taxa.

- Only one study using below ground samples exists (Tedersoo et al. 2014).


RESEARCH ARTICLE SUMMARY

FUNGAL BIOGEOGRAPHY

Global diversity and geography of soil fungi

Leho Tedersoo,*† Mohammad Bahram,† Sergei Põlme, Urmas Kõljalg, Nourou S. Yorou, Ravi Wijesundera, Luis Villarreal Ruiz, Aída M. Vasco-Palacios, Pham Quang Thu, Ave Suija, Matthew E. Smith, Cathy Sharp, Erki Saluveer, Alessandro Saitta, Miguel Rosas, Taavi Riit, David Ratkowsky, Karin Pritsch, Kadri Põldmaa, Meike Piepenbring, Cherdchai Phosri, Marko Peterson, Kaarin Parts, Kadri Pärtel, Eveli Otsing, Eduardo Nouhra, André L. Njouonkou, R. Henrik Nilsson, Luis N. Morgado, Jordan Mayor, Tom W. May, Luiza Majuakim, D. Jean Lodge, Su See Lee, Karl-Henrik Larsson, Petr Kohout, Kentaro Hosaka, Indrek Hiiesalu, Terry W. Henkel, Helery Harend, Liang-dong Guo, Alina Greslebin, Gwen Grelet, Jozsef Geml, Genevieve Gates, William Dunstan, Chris Dunk, Rein Drenkhan, John Dearnaley, André De Kesel, Tan Dang, Xin Chen, Franz Buegger, Francis Q. Brearley, Gregory Bonito, Sten Anslan, Sandra Abell, Kessy Abarenkov

INTRODUCTION: The kingdom Fungi is one of the most diverse groups of organisms on Earth, and they are integral ecosystem agents that govern soil carbon cycling, plant nutrition, and pathology. Fungi are widely distributed in all terrestrial ecosystems, but the distribution of species, phyla, and functional groups has been poorly documented. On the basis of 365 global soil samples from natural ecosystems, we determined the main drivers and biogeographic patterns of fungal diversity and community composition.

RATIONALE: We identified soil-inhabiting fungi using 454 Life Sciences (Branford, CN) pyrosequencing and through comparison against taxonomically and functionally annotated sequence databases. Multiple regression models were used to disentangle the roles of climatic, spatial, edaphic, and floristic parameters on fungal diversity and community composition. Structural equation models were used to determine the direct and indirect effects of climate on fungal diversity, soil chemistry, and vegetation. We also examined whether fungal biogeographic patterns matched paradigms derived from plants and animals—namely, that species' latitudinal ranges increase toward the poles (Rapoport's rule) and diversity increases toward the equator. Last, we sought group-specific global biogeographic links among major biogeographic regions and biomes using a network approach and area-based clustering.

RESULTS: Metabarcoding analysis of global soils revealed fungal richness estimates approaching the number of species recorded to date. Distance from equator and mean annual precipitation had the strongest effects on richness of fungi, including most fungal taxonomic and functional groups. Diversity of most fungal groups peaked in tropical ecosystems, but ectomycorrhizal fungi and several fungal classes were most diverse in temperate or boreal ecosystems, and many fungal groups exhibited distinct preferences for specific edaphic conditions (such as pH, calcium, or phosphorus). Consistent with Rapoport's rule, the geographic range of fungal taxa increased toward the poles. Fungal endemicity was particularly strong in tropical regions, but multiple fungal taxa had cosmopolitan distribution.

ON OUR WEB SITE

Read the full article at http://dx.doi.org/10.1126/science.1256688

CONCLUSIONS: Climatic factors, followed by edaphic and spatial patterning, are the best predictors of soil fungal richness and community composition at the global scale. Richness of all fungi and functional groups is causally unrelated to plant diversity, with the exception of ectomycorrhizal root symbionts, suggesting that plant-soil feedbacks do not influence the diversity of soil fungi at the global scale. The plant-to-fungi richness ratio declined exponentially toward the poles, indicating that current predictions—assuming globally constant ratios—overestimate fungal richness by 1.5- to 2.5-fold. Fungi follow similar biogeographic patterns as plants and animals, with the exception of several major taxonomic and functional groups that run counter to overall patterns. Strong biogeographic links among distant continents reflect relatively efficient long-distance dispersal compared with macro-organisms. ■

RELATED ITEMS IN *SCIENCE*
D. A. Wardle and B. D. Lindahl, Disentangling the global mycobiome. *Science* **346**, 1052–1053 (2014). DOI: 10.1126/science.aaa1185

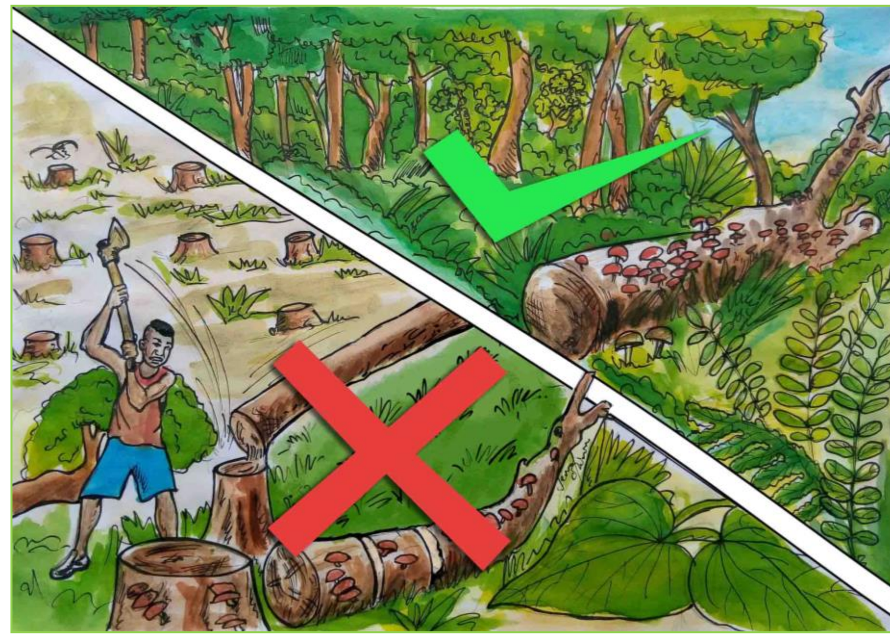
Fungal knwoledge gaps

- Numerous habitats are hardly or not at all screened for fungi. Only very few “complete” inventories of fungi exist in some specific sites.

- Adequate mycological information is also lacking for several ecoregions, the case of the forests dominated by dominated by *Michelsonia microphylla* and *Staudtia stipitata*.

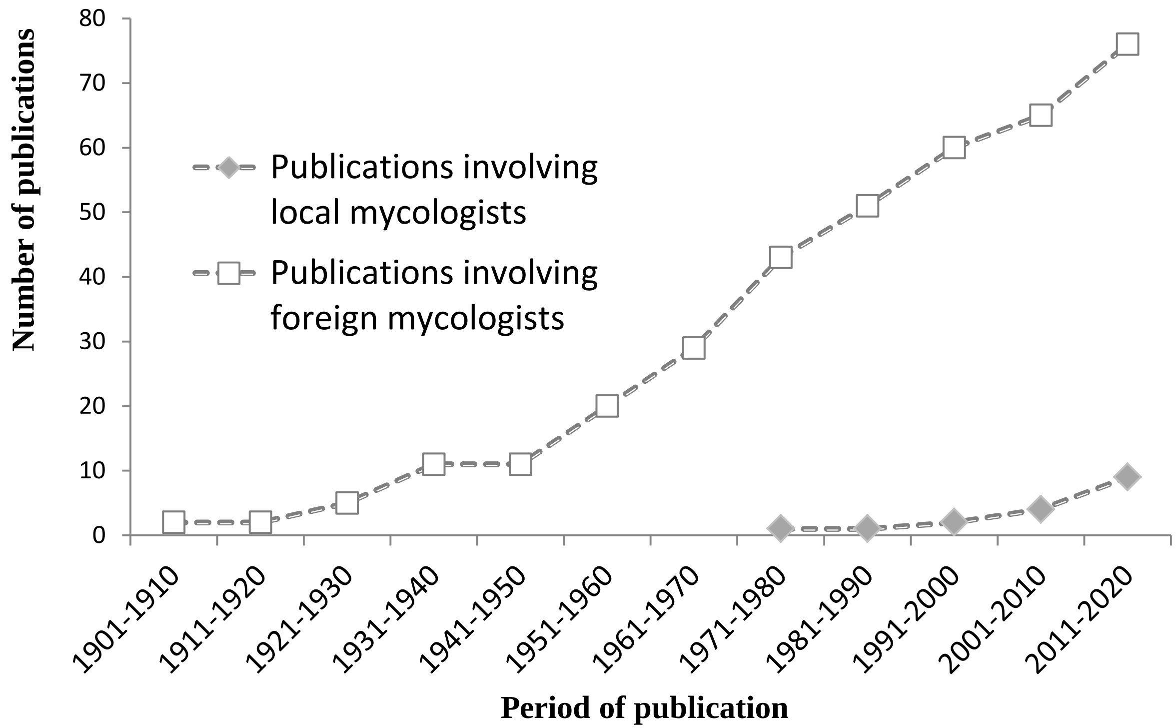
Michelsonia microphylla

- **Red List category** – Vulnerable: VU B2ab(i,ii,iii,iv),
- **The habitat**: threatened by slash and burn agriculture, mining activities and growing human populations



(Reference: Sosef et al., 2021, Red List of the endemic and subendemic trees of Central Africa (Democratic Republic of the Congo - Rwanda - Burundi), Meise Botanic Garden, Nieuwelaan 38, 1860 Meise, Belgium.

Most of the pioneering mycological investigations in DRC were done by explorers and/or mycologists working with/at Meise Botanic Garden



Fungal knwoledge gaps

- There is little doubt that many fungal species are still undescribed (new for science);

- Several species showing an abnormally wide distribution and host range may actually represent species complex, i.e. grouping different sibling species

EcM fungi: source of ecosystem services

- Sub-Saharan tropical Africa (without South Africa) counts 150 edible ectomycorrhizal taxa, 99 (66 %) of which occur in DR Congo.

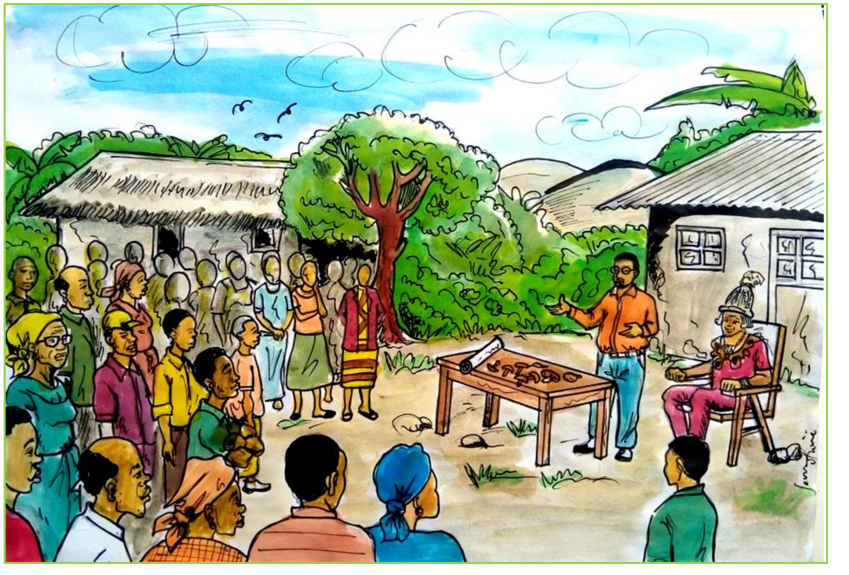
- In fact, since the last complete review from 1994 (Rammeloo & Walleyn 1993, Walleyn & Rammeloo 1994), the number of edible ECM fungi, known from tropical Africa, has increased from 81 to 150 (+69, 85% increase) taxa, and the ones from DR Congo from 55 to 99 taxa (+44, 80% increase).

How to promote EcM fungi ?

- Assessing natural productivity of edible EcM fungi

- Raising local people awareness for the conservation EcM fungi habitats

- Knowing the actual measured interest for local people.



Conclusion

- Due to this severe taxonomic impediment (lack of literature, experts and a very high percentage of undescribed taxa), adequate identification tools are lacking for the majority of species

- Contributing to a better understanding of ecosystem services delivered by useful fungi and proposing science-based solutions for conservation, fully complies with the goals of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

- Equipping local laboratories for both microscopical and molecular analysis of fungi, as well as the reinforcement of the north-south scientific collaboration, would be ideal for promoting mycology in many African countries.

Thank you so much