

EFFECT OF TREE SIZE ON SYMBIOTIC FUNGAL DIVERSITY IN TREE BARK

BY

ONYANGO JOHN

(BU/UG/2021/0072)

onyangojohn961@gmail.com

**A RESEARCH REPORT SUBMITTED TO THE DEPARTMENT OF BIOLOGY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF
THE DEGREE OF BACHELOR OF SCIENCE EDUCATION OF
BUSITEMA UNIVERSITY**

SEPTEMBER, 2024

DECLARATION

I declare that this research report is my original work and has not been submitted to any institution of higher learning for any other degree or academic award.

Signature:..........Date: 5/10/2024.....

ONYANGO JOHN

BU/UG/2021/0072

APPROVAL

This work has been submitted to the Department of Biology, Faculty of Science and Education for Examination with the approval of my research supervisor.

Signature:..........Date..........

DR. JOSEPH .F. HOKELLO

DEDICATION

I dedicate this research to the government of Uganda, forest management authorities worldwide, environment management authorities, students, staff and administration of Busitema University, Nagongera campus, and any other concerned citizen. This research generates useful insights on environment and forest management strategies for sustainable use of forests and the general environment within us. Understanding the relationship between tree size and fungal diversity is vital in designing forest and tree conservation methods that promote environmental sustainability. I also dedicate this research to my family members; my parents, relatives and friends: environmental awareness and sustainability starts with an individual. I also dedicate this research to my dear wife and son on the relevancy of the relationships between size and fungi, and how it can be useful for determining tree size and age. I finally dedicate this research to future researchers to find out the mechanisms underlying the relationship between tree size and fungal diversity.

ACKNOWLEDGEMENTS

I would like to thank the Almighty God who has been my overall guider, protector and provider throughout my study, His grace and mercy has always been sufficient at all times. May His glory be forever.

I would also like to extend my sincere gratitude to my supervisor Dr. Joseph Francis Hokello who sacrificed his precious time and resources to guide, advice, educate and motivate me both online and physical, towards the successful completion of this research. May the almighty God reward you abundantly.

My special appreciation also goes to the biology laboratory technichian, Mr. Olowo Moses, of Biology department, Busitema University, Nagongera Campus, for his guidance and practical assistance during the data collection process of this research. May God bless you abundantly.

My humble appreciation also goes to my parents who partly funded this research especially at the data collection stage. May God reward them abundantly.

I also appreciate the entire students, staff and administration of Busitema University, especially Nagongera campus for creating a conducive environment that enabled me to carry on with my research with minimal disturbance.

Finally, I would like to sincerely appreciate the government of Uganda through the National Sponsorship Scheme for fully funding my tution, feeding and accommodation throughout my study period at Busitema University. Am grateful for that.

Table of Contents

DECLARATION	i
APPROVAL	ii
DEDICATION.....	iii
ACKNOWLEDGEMENTS.....	iv
LIST OF ABBREVIATIONS.....	vi
ABSTRACT	vii
LIST OF TABLES.....	viii
LIST OF FIGURES	ix
CHAPTER ONE	1
1.1 Background.....	1
1.2 Statement of the problem.....	2
1.3 Aim of the study	2
1.4 Specific Objectives	2
1.5 Research questions.....	2
1.6. Justification of the study	3
1.7. Significance of the study.....	3
CHAPTER TWO	4
LITERATURE REVIEW	4
2.1 Introduction.....	4
2.2 Diversity of symbiotic fungal communities in tree barks.	4
2.3 Effect of tree size on Microbial Communities and Potential Implications for Fungal Diversity.....	5
CHAPTER THREE	9
3.0 METHODOLOGY	9
3.1 Field tools	9
3.2 Study site.....	9
3.4 Sampling.....	9
3.5 Data analysis	10
CHAPTER FOUR.....	11
4.1. RESULTS.....	11
4.2. DISCUSSIONS OF RESULTS	22
CHAPTER FIVE	25
5.0 CONCLUSION AND RECOMMENDATION.....	25
5.1 Conclusion.....	25
5.2. Recommendations.....	25
6.0 REFERENCES	26

LIST OF ABBREVIATIONS

GPS- Global Positioning System

UV- Ultra violet.

cm- centimetre

NC- Nagongera Campus

M²/m² – square metre

Inc- inch

ABSTRACT

Tree bark is one of the diverse ecosystems in nature that greatly contributes to biodiversity in forests since there is increasing evidence that biodiversity correlates positively with numerous ecosystem services. Trees form complex associations with a diverse array of fungi particularly within the bark ecosystem. These fungi play crucial role in tree health improvement as some of them resist potential pathogen, nutrient cycling and overall ecosystem functioning. The attribute of tree size which is a proxy of age has a significant impact on the diversity of fungus inhabiting the bark. The relationship between tree size and symbiotic fungal diversity in bark ecosystems presents an important yet poorly understood aspect of tree ecology. While existing research has documented the diverse roles played by symbiotic fungi, the specific influence of tree size on fungal diversity within the tree bark ecosystem remains a knowledge gap. Addressing this gap is essential for comprehensively understanding ecological changes and informing sustainable tree and forest management practices. In addressing this research gap, the study aims at conducting a comprehensive field study in a mixed species environment within Nagongera campus. This study examined the relationship between tree size and fungal communities on tree bark. This was achieved by first identifying the variety of tree size among the different tree species in NC. Based on measurements of tree height, ring diameter, canopy cover and growth stage. The trees were categorized as small, medium, large and extra-large. Bark samples were taken from randomly selected trees at consistent heights and analysed. Fungal morphologies were studied to identify the various fungal species that inhabited the tree bark. The results showed a significant positive correlation between tree size and fungal diversity, with larger trees tend to have a higher number of fungal species and fungal individuals. Specifically, fungal diversity increased by 50% on trees larger than 100cm in diameter. These findings contribute to our understanding of fungal ecology and tree-fungal interactions, with implications for forest ecosystem functioning and conservation.

LIST OF TABLES

Table 1: shows the various tree species and their diverse sizes in terms of height, trunk diameter, canopy cover and growth stage, and it reveals that the trees are of various sizes including small, medium, large and extra large.....	17
Table 2: Shows the level of fungal diversity among the various tree sizes, and it reveals that larger trees have more diverse fungal communities	18

LIST OF FIGURES

<i>Figure 1: Scatter plot showing the relationship between tree size and fungal diversity in <i>Cassia fistula</i></i>	<i>21</i>
<i>Figure 2: Scatter plot showing the relationship between tree size and fungal diversity in <i>Bishofia javanica</i>.....</i>	<i>22</i>

CHAPTER ONE

1.1 Background

Fungi are a member of a large group of eukaryotic organisms that exhibit symbiosis. They belong to the kingdom Fungi, separate from animals, plants and bacteria. Fungi are an extremely diverse group of organisms (Antonio et al., 2020) occupying a wide range of habitats such as tropical regions and temperate regions, including extreme environments like deserts, rocks and deep seas. Fungi are crucial in ecosystem stability as they play very sensitive roles in ecosystem functionality. Such roles include organic matter decomposition which is vital in nutrient cycling (Lukas et al., 2022).

The relationship between trees and their associated fungal communities has been a topic of interest for scientists for years. Fungi that interact with trees symbiotically often find a haven in the bark and play crucial role in the health and growth of the tree. These symbiotic fungi can be generally classified in two main groups, that is; mycorrhizal and endophytic fungi (John & Roland, 2007) Mycorrhizal fungi form mutualistic association with the roots of trees and assist the plant in nutrient uptake (Paulo et al., 2022) While endophytic fungi reside within the plant tissues (Paulo et al., 2022) commonly in the bark and have a number of implications on tree health and resilience.

Fungi are heterotrophic in their nutrition, that is, they cannot make their own food like photosynthetic plants (Hausman, 2022). They obtain food nutrients such as glucose by externally digesting their food material using the hyphae, thread like structures that form a network of branches called mycelium (Juan et al., 2022). Some fungi grow and feed on various dead and decomposing plant and animal matter and are classified as saprotrophs, decomposers, breaking down dead plants and animals materials (Hausman, 2022). Other fungi get their nutrient nourishment from living hosts during which the hosts suffer harm in the process and are referred to as parasitic fungi. While others are symbionts, forming mutualistic relationship with the host plant. In this case, as the fungi absorbs nutrients from the host, it provides moisture to the host in turn and both partners end up benefiting from the association (Laforest-lapointe, 2019). For example, mycorrhizae form symbiotic relationship mainly with the plant roots (Daniel, 2014). However, this research focuses on the symbiotic fungi inhabiting the tree bark. Since the previous researchers focused on the saprotrophic and mycorrhizal fungi and their agricultural implications.

Tree size is a fundamental attribute that influences the environment and resources available to organisms that associate with it (Lukas et al., 2022). Therefore, this study aims at exploring how

the size of a tree as proxy of age, and biomass influences the diversity, composition and functioning of symbiotic fungal communities in the bark which may have implications for forest management, biodiversity and ecosystem service.

Tree bark surface provide ideal conditions for growth of fungal communities, since it offers a stable substrate with a variety of niches which support bark associated organisms (Lukas et al., 2022). The cracks, holes and lenticels add to the many micro-habitats purposefully retaining humidity nutrients and other varying environmental conditions all of which can influence the diversity and functioning of symbiotic fungal communities in tree barks. This, in a way is crucial in creating a biodiverse and stable ecosystem. The bark is always protected by the canopy from excessive rain, and strong UV-radiation. Understanding these dynamics is essential for comprehensively assessing role of trees and associated fungi in forest ecosystems and tree health management.

1.2 Statement of the problem

The relationship between tree size and symbiotic fungal diversity in bark ecosystems presents an important yet poorly understood aspect of tree ecology. While the existing research has documented the diverse roles played by symbiotic fungi, the specific influence of tree size on fungal diversity within bark ecosystem remains a knowledge gap. Addressing this gap is essential for comprehensively understanding ecological changes and informing sustainable tree and forest management practices.

1.3 Aim of the study

The overall aim of this study is to investigate the relationship between tree size and symbiotic fungal diversity in tree barks, exploring how tree size influences fungal community composition, richness and abundance.

1.4 Specific Objectives

- (1) To determine the diversity of tree sizes across different tree species within Nagongera campus.
- (2) To investigate how tree size influences fungal species richness and fungal abundance in tree barks.

1.5 Research questions.

- (1) What are the main tree sizes within Nagongera campus?
- (2) Are there different types of fungi species and abundance within the bark of different tree sizes?

1.6. Justification of the study

This research is of significant ecological implications. Understanding how tree size influences symbiotic fungal diversity provides insights into the maintenance of forest diversity and resilience, the resilience of tree species to environmental changes, and the sustainable management of forest resources. Additionally, this research contributes to our understanding of the complex interactions within the forests, and can inform conservation and management strategies to preserve fungal diversity and promote the health and productivity of forest ecosystems.

1.7. Significance of the study

This research on the effect of tree size on symbiotic fungal diversity in tree barks can benefit various stakeholders, including:

Foresters and forest managers: understanding the impact of tree size on fungal diversity can inform sustainable forest management practices, promoting healthy tree growth and ecosystem balance.

Ecologists and conservationists: this study can contribute to a deeper understanding of symbiotic relationships in ecosystems, informing conservation efforts and habitat preservation.

Mycologists and microbiologists, this research can expand knowledge on fungal diversity, ecology and evolution, potentially leading to discoveries of new species or applications in fields like medicine or biotechnology.

Tree breeders and nursery professionals: the findings of this study can inform selection and breeding programs for trees with optimal fungal associations, enhancing tree health and productivity.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Symbiotic fungi including ectomycorrhizal and endophytic fungi, play crucial roles in tree health and ecosystem functioning.(Steidinger et al., n.d.) Understanding the diversity of these fungal communities and the factors that shape them is essential for comprehending forest ecosystem functioning.

2.2 Diversity of symbiotic fungal communities in tree barks.

Symbiotic fungal diversity in tree barks are a crucial aspect of forest ecosystems, playing a vital role in tree health, nutrient recycling and ecosystem resilience (Tedersoo et al., 2010). Fungal communities in tree barks comprise a range of species, from mutualistic mycorrhizal fungi to pathogenic fungi, and their diversity is influenced by various factors, including tree species, age and size.(Peay et al., 2010)

Research has shown that different tree species harbor distinct fungal communities(Lukas et al., 2022) and that these communities can vary significantly due to environmental factors such as climate, tree age and soil type.(John & Roland, 2007). However the specific effect of tree size on fungal diversity within tree barks remains an understudied area. Studies have shown that fungal diversity in tree barks increases with tree size, that is, larger trees host a greater range of fungal species(Bassler et al., 2016). However the relationship between tree size and fungal diversity can be complex, influenced by factors like tree species, age and environmental conditions.(Peay et al., 2010). Additionally: resource availability, larger trees have more extensive root system, which can access a wider range of resources and nutrients. This can support more diverse fungal community. Microenvironmenmental variation, tree size can influence the microenvironment within the tree bark, with larger trees potentially having more varied and heterogeneous conditions that support a wider range of fungal species. Tree age and developmental stage, tree size is often correlated with tree age, and different developmental stages may support different fungal communities. For example, younger trees may have more opportunistic fungal species, while older trees may have more specialized and symbiotic relationship. Canopy structure and light environment, larger trees have more extensive canopies, which can influence the light environment and temperature conditions on the tree trunk, potentially affecting fungal growth and diversity. Root architecture and soil interactions: tree size can influence root architecture, which can affect soil interactions and the availability of nutrients and resources for fungal communities. Hormone interaction and tree defense: tree size may influence hormone signaling pathways that regulate tree defense and stress responses,

which can impact fungal communities and responses. Microbial community interactions: tree size can influence the composition and diversity of other microbial communities, such as bacteria and algae, which can interact with and affect and fungal communities.

2.3 Effect of tree size on Microbial Communities and Potential Implications for Fungal Diversity.

Studies have demonstrated that tree size can considerably influence the composition and diversity of microbial communities associated with trees (Smith, 1982). This raises questions about whether a similar pattern exists in the fungal communities inhabiting tree barks and whether the relationship between tree size and fungal diversity is consistent across different tree species.

Tree size, in particular is expected to impact fungal diversity due changes in bark characteristics, resource availability, and microenvironmental conditions.(Bassler et al., 2016). Larger trees often have thicker barks, providing a more extensive habitat for fungal growth and colonization.(Gibson & Dickie, 2011). Additionally, tree size can influence the composition of fungal communities, with some species preferring larger or smaller trees(Juice & Jenkins, 2012)

Some studies have also shown that tree size is a significant driver of microbial community diversity and structure, with larger trees supporting less diverse fungal and algal communities(Lukas et al., 2022). This is likely due to environmental filtering, where older trees have more stable and uniform environments that favor certain microbial species over others, on the other hand forest management intensity has negligible effect on microbial communities. This highlights the importance of considering tree size and age in forest management strategies to promote microbial diversity and ecosystem health.(Lukas et al., 2022)

While the existing literature provides valuable insights into the diversity and composition of symbiotic fungal communities in tree barks, there remains a significant gap in understanding the effect of tree size on these communities. Specifically,

- Limited research has focused on the impact of tree size on fungal diversity in tree barks across different tree species, leaving a significant knowledge gap. According to the findings of(Lukas et al., 2022),Tree size had a significant effect overall in fungi, with significant differences between large and medium, as well as large and small trees. However, this study focused on only one common broadleaved tree species, beech (*Fagus sylvatica*) in Central European forest(Lukas et al., 2022)
- The mechanisms underlying the relationship between tree size and fungal diversity are resource availability, microenvironmental variation, tree age and developmental stage,

canopy structure and light, and microbial community interactions are not well understood, requiring further investigation.

- Most studies have focused on the study of fungal communities in tree roots, which are of agricultural importance with limited attention given to the fungal communities inhabiting tree barks.
- Also, the functional implications of changes in fungal diversity in response to tree size on ecosystem processes and tree health are not well understood. Since most studies have given limited insights on the implications of fungal communities on ecosystem processes.
- Few studies have explored the potential applications of understanding the effect of tree size on fungal diversity for forest management and conservation efforts.

These knowledge gaps present exciting opportunities for research to fill the void and contribute to our understanding of the complex interactions between trees and their associated symbionts.

To address these gaps, further research is needed to:

- Investigate the effect of tree size on fungal diversity in tree barks across different tree species.
- Explore the mechanisms driving the relationship between tree size and fungal diversity.
- Compare the diversity and composition of fungal communities in tree roots and barks.(Lamit et al., 2016)
- Examine the functional implications of changes in fungal diversity on ecosystem processes and tree health.(Lamit et al., 2016)
- Investigate the practical applications of understanding the effect of tree size on fungal diversity for forest management and conservation.(Nemergut et al., 2014)

Understanding the effect of tree size on fungal diversity has significant potential applications for forest management and conservation efforts:

Improved forest restoration, by recognizing the impact of tree size on fungal diversity, restoration efforts can focus on planting a mix of tree species and sizes to promote a diverse fungal community, enhancing ecosystem resilience.(Uroz et al., 2016)

Sustainable forest management, forest managers can adopt practices like selective

harvesting retaining larger trees, and promoting uneven aged stands to maintain fungal diversity and ecosystem health.(E. Prescott & Grayston, 2013)

Conservation of rare or endangered species, understanding the relationship between tree size and fungal diversity can inform conservation efforts for rare or endangered fungal species, by ensuring that their habitat requirements are met.(E. Prescott & Grayston, 2013)

Enhanced ecosystem services, fungal diversity is crucial for ecosystem processes like decomposition, nutrient cycling and carbon sequestration. By managing forests in ways that promote fungal diversity, ecosystem services can be enhanced.(Nemergut et al., 2014)

Climate change mitigation, forests with diverse fungal communities may be more resilient to climate change.(Waldrop & Firestone, 2006) Understanding the impact of tree size on fungal diversity can inform strategies for climate-smart forest management.(Richter et al., 2018)

Improved forest health, fungal diversity is linked to tree health and disease resistance. Managing forests to promote fungal diversity can reduce the risk of disease outbreaks and improve overall forest health.(Grayston & Renneberg, 2006)

Ecological corridor management, understanding the impact of tree size on fungal diversity can inform the design and management of ecological corridors, ensuring connectivity and habitat quality for fungal species.(Strickland et al., 2009)

Biomass and bioenergy production, fungal diversity can impact decomposition rates and carbon cycling. Managing forests to promote fungal diversity can optimize biomass and bioenergy production while minimizing environmental impacts.(Strickland et al., 2009)

Non-timber forest product management, fungal diversity is crucial for the production of non-timber forest products like mushrooms and truffles.(Tedersoo et al., 2016) Understanding the impact of tree size on fungal diversity can inform sustainable management practices.(Waldrop & Firestone, 2006)

Ecological research and monitoring, understanding the effect of tree size on fungal diversity can inform the development of monitoring programs, enabling the detection of changes in ecosystem health and responses to management practices.(Six & Elser, 2020)

Building on the current literature, this research proposal focused on investigating the effect of tree size on symbiotic fungal diversity in tree barks is designed. The proposal includes a combination of field surveys, laboratory analysis, data analysis, and experimental

manipulations to address the following key questions:

1. How does tree size influence the diversity and composition of symbiotic fungal communities in tree barks across different tree species
2. What are the potential mechanisms the observed relationship between tree size and fungal diversity
3. How do changes in fungal diversity in response to tree size affect tree health and ecosystem functioning
4. What are the practical implications of understanding the effect of tree size on fungal diversity for forest management and conservation.

CHAPTER THREE

3.0 METHODOLOGY

To investigate the effect of tree size on symbiotic fungal diversity in tree barks, this research employed the field survey method which involved collecting bark samples from trees of different sizes across various ecosystems within the campus environment and analyzing the fungal communities present.

The primary objective of this research was to investigate the influence of tree size on the diversity of symbiotic fungal communities in tree barks.

3.1 Field tools

Pocket knife, forceps, soft paint brush

Suitable containers; aluminium foil, water-proof paper bags Global Positioning System (GPS) recorder.

Note books, pen, plant guides Camera, hand lens.

3.2 Study site

Study was conducted within Nagongera campus environment. A stratified random sampling was used to select trees of different sizes within the study site ensuring representation of small, medium and large trees.

3.4 Sampling

Samples of tree barks were collected from selected trees at consistent heights above the ground. Care was taken to sample from areas with minimal damage or signs of disease (Read et al., 2000). Bark characteristics such as moisture content, pH, and nutrient availability were measured to explore their potential influence on fungal diversity. Tree age estimation for selected tree species using tree age estimation techniques such as tree ring analysis were employed to determine the role of tree age in shaping fungal communities.

Photography; morphological characterization was also achieved through this method. Photographs of the specimens at the study sites were taken using smartphone camera to aid in morphological description.

Microscopy; microscope characterization was done to obtain morphological characters and cellular structures of the inconspicuous species at the laboratory.(Ic et al., 2020) This was done concurrently with **staining** using reagents such as Lacto-phenol cotton blue, Potassium hydroxide (KOH) to increase contrast and view sharper structures.(Ic et al., 2020) Microscope slides were prepared, fungal structures were arranged separately on the slides using a needle,(Ic

et al., 2020) in case of staining necessity a staining agent was then added covered carefully with a coverslip and excess stain removed by blotting.

3.5 Data analysis

Diversity indices: statistical analysis were performed to quantify and compare fungal diversity indices across different tree sizes.

Correlation analysis: relationship between fungal diversity, environmental factors, and tree health parameters were evaluated using correlation analysis techniques.

Based on the findings practical recommendations for forest and tree management and conservation was developed, focusing on how forest and tree management practices could consider tree size and its influence on fungal diversity to promote healthier ecosystems.

CHAPTER FOUR

4.1. RESULTS

Table 1: Tree size diversity across the different tree species in Nagongera campus.

Tree species	Tree size			
Weeping fig <i>Ficus benjamina</i>	Sample 1 height: 10m trunk diameter: 30cm canopy cover: 9m ² growth stage: pole	Tree 2 height: 15m trunk diameter: 40cm canopy cover:16m ² growth stage: pole	Tree 3 height: 20m trunk diameter: 53cm canopy cover: 70m ² growth stage: mature	Tree 4 height: 30m trunk diameter: 60cm canopy cover: 102m ² growth stage: over mature
Silky oak <i>Gravillea robusta</i>	Sample 1 height: 6m trunk diameter: 35cm canopy cover: 8m ² growth stage: pole	Sample 2 height: 10m trunk diameter: 45cm canopy cover: 56m ² growth stage: pole	Sample 3 height: 21m trunk diameter: 56cm canopy cover: 59m ² growth stage: mature	Sample 4 height: 31m trunk diameter: 64cm canopy cover: 172m ² growth stage: over mature
Cockspur coral tree <i>Erythrina crista-gali</i>	Sample 1 height: 9m trunk diameter: 26cm canopy cover: 6m² growth stage: pole	Sample 2 height: 15m trunk diameter: 46cm canopy cover: 45m ² growth stage: pole	Sample 3 height: 25m trunk diameter: 54cm canopy cover: 57m ² growth stage: mature	Sample 4 height: 45m trunk diameter: 65cm canopy cover: 100m ² growth stage: over mature

Live oak <i>Quercus virginiana</i>	Sample 1 height: 7m trunk diameter:< 30cm canopy cover: 9m2 growth stage: pole	Sample 2 height: 12m trunk diameter: 47cm canopy cover: 45m2 growth stage: pole	Sample 3 height: 21m trunk diameter: 54cm canopy cover: 60m2 growth stage: mature	Sample 4 height: 35m trunk diameter: 65cm canopy cover:105m2 growth stage: over mature
Florida strangler <i>Ficus aurea</i>	Sample 1 height: 5m trunk diameter: 35cm canopy cover: 9m2 growth stage: pole	Sample 2 height: 13 trunk diameter: 48cm canopy cover: 36m2 growth stage: pole	Sample 3 height: 23m trunk diameter: 59cm canopy cover: 68m2 growth stage: mature	Sample 4 height: 33m trunk diameter: 67cm canopy cover: 100m2 growth stage: over mature
Guava <i>Psidium guajava</i>	Sample1 height: 8m trunk diameter: 26cm canopy cover: 10m2 growth stage: pole	Sample 2 height: 10m trunk diameter: 46cm canopy cover: 48m2 growth stage: pole	Sample 3 height: <10m trunk diameter: 58cm canopy cover: 78m2 growth stage: mature	Sample 4 height: 34m trunk diameter: 65cm canopy cover: 120m2 growth stage: over mature
Mango tree <i>Mangifera indica</i>	Sample 1 height: 9m trunk diameter: 28cm canopy cover: 8m2 growth stage: pole	Sample 2 height: 15m trunk diameter: 49cm canopy cover: 56m2 growth stage: pole	Sample 3 height: 21m trunk diameter: 56cm canopy cover: 80m2 growth stage: mature	Sample 4 height: 35m trunk diameter: 64cm canopy cover: 130m2 growth stage:

				mature
West Indian mahogany <i>Swietenia mahogani</i>	Sample 1 height: 8m trunk diameter: 38cm canopy cover: 8m² growth stage: pole	Sample 2 height: 11 trunk diameter: 47cm canopy cover: 36m ² growth stage: pole	Sample 3 height: 22m trunk diameter: 55cm canopy cover: 68m ² growth stage: mature	Sample 4 height: 32m trunk diameter: 63cm canopy cover: 124m ² growth stage: mature
Sacred fig <i>Ficus religiosa</i>	Sample 1 height: 9m trunk diameter: 34cm canopy cover: 9m² growth stage: pole	Sample 2 height: 13m trunk diameter: 49cm canopy cover: 34m ² growth stage: pole	Sample 3 height: 23m trunk diameter: 57cm canopy cover: 58m ² growth stage: mature	Sample 4 height: 33m trunk diameter: 65cm canopy cover: 132m ² growth stage: over mature
Royal poinciana <i>Delonix regia</i>	Sample 1 height: 6m trunk diameter: 36cm canopy cover: 8m² growth stage: pole	Sample 2 height: 13m trunk diameter: 45cm canopy cover: 45m ² growth stage: pole	Sample 3 height: 23m trunk diameter: 56cm canopy cover: 78m ² growth stage: mature	Sample 4 height: 35m trunk diameter: 67cm canopy cover: 108m ² growth stage: over mature

Cassisa fistula	Sample 1 height: 8m trunk diameter: 37cm canopy cover: 8m2 growth stage: pole	Sample 2 height: 14m trunk diameter: 48cm canopy cover: 56m2 growth stage: pole	Sample 3 height: 21m trunk diameter: 57cm canopy cover: 60m2 growth stage: mature	Sample 4 height: 36m trunk diameter: 68cm canopy cover: 102m2 growth stage: over mature
Council tree <i>Ficus</i> <i>altissima</i>	Sample 1 height: 6m trunk diameter: 39cm canopy cover: 10m2 growth stage: pole	Sample 2 height: 13m trunk diameter: 46cm canopy cover: 56m2 growth stage: pole	Sample 3 height: 23m trunk diameter: 58cm canopy cover: 63m2 growth stage: mature	Sample 4 height: 36m trunk diameter: 64cm canopy cover:112m2 growth stage: over mature
Teak <i>Tectona</i> <i>grandis</i>	Sample 1 height: 4m trunk diameter: 36cm canopy cover: 8m2 growth stage: pole	Sample 2 height: 16m trunk diameter: 47cm canopy cover: 47m2 growth stage: pole	Sample 3 height: 24m trunk diameter: 57cm canopy cover: 64m2 growth stage: mature	Sample 4 height: 34m trunk diameter: 65cm canopy cover: 100m2 growth stage: over mature
Pink shower <i>Cassisa</i> <i>javanica</i>	Sample 1 height: 6m trunk diameter: 32cm canopy cover: 6m2 growth stage: pole	Sample 2 height: 14m trunk diameter: 46cm canopy cover: 43m2 growth stage: pole	Sample 3 height: 25m trunk diameter: 56cm canopy cover:<10m2 growth stage: mature	Sample 4 height: 33m trunk diameter: 67cm canopy cover: 114m2 growth stage:

				over mature
Mulberry <i>Morus alba</i>	Sample 1 height: 7m trunk diameter: 34cm canopy cover: 9m2 growth stage: pole	Sample 2 height: 14m trunk diameter: 47cm canopy cover: 38m2 growth stage: pole	Sample 3 height: 24m trunk diameter: 56cm canopy cover: 90m2 growth stage: mature	Sample 4 height: 32m trunk diameter: 60cm canopy cover: 115m2 growth stage: mature
European nettle tree <i>Celtis australis</i>	Sample 1 height: 3m trunk diameter: 38cm canopy cover: 6m2 growth stage: pole	Sample 2 height: 16m trunk diameter: 49cm canopy cover: 48m2 growth stage: pole	Sample 3 height: 26m trunk diameter: 58cm canopy cover: 80m2 growth stage: mature	Sample 4 height: 30m trunk diameter: 63cm canopy cover: 142m2 growth stage: mature
Siberian elm <i>Ulmus pumila</i>	Sample 1 height: 4m trunk diameter: 37cm canopy cover: 8m2 growth stage: pole	Sample 2 height: 15m trunk diameter: 49cm canopy cover: 28m2 growth stage: pole	Sample 3 height: 26m trunk diameter: 58cm canopy cover: 98m2 growth stage: mature	Sample 4 height: 34m trunk diameter: 69cm canopy cover: 112m2 growth stage: over mature

Tamarind <i>Tamarindus indica</i>	Sample 1 height: 6m trunk diameter: 35cm canopy cover: 9m2 growth stage: pole	Sample 2 height: 13m trunk diameter: 48cm canopy cover: 34m2 growth stage: pole	Sample 3 height: 23m trunk diameter: 59cm canopy cover: 70m2 growth stage: mature	Sample 4 height: 35 trunk diameter: 67cm canopy cover: 108m2 growth stage: over mature
Neem tree <i>Azadirachta indica</i>	Sample 1 height: 7m trunk diameter: 35cm canopy cover: 8m2 growth stage: pole	Sample 2 height: 16m trunk diameter: 49cm canopy cover: 38m2 growth stage: pole	Sample 3 height: 23m trunk diameter: 57cm canopy cover: 68m2 growth stage: mature	Sample 4 height: 34 trunk diameter: 63cm canopy cover: 140m2 growth stage: mature
Amur cork tree <i>Phellodendron amurense</i>	Sample 1 height: 8m trunk diameter: 34cm canopy cover: 6m2 growth stage: pole	Sample 2 height: 12m trunk diameter: 46cm canopy cover: 28m2 growth stage: pole	Sample 3 height: 21m trunk diameter: 57cm canopy cover: <10m2 growth stage: mature	Sample 4 height: 34m trunk diameter: 65cm canopy cover: 120m2 growth stage: over mature
White sapote <i>Casimiroa edulis</i>	Sample 1 height: 9m trunk diameter: 39cm canopy cover: 9m2 growth stage: pole	Sample 2 height: 15m trunk diameter: 48cm canopy cover: 26m2 growth stage: pole	Sample 3 height: 23m trunk diameter: 56cm canopy cover: 59m2 growth stage: mature	Sample 4 height: 36m trunk diameter: 65cm canopy cover: 120m2 growth stage:

				over mature
Loblolly pine <i>Pinus taeda</i>	Sample 1 height: 5m trunk diameter: 34cm canopy cover: 4m ² growth stage: pole	Sample 2 height: 13m trunk diameter: 49cm canopy cover: 30m ² growth stage: pole	Sample 3 height: 24m trunk diameter: 55cm canopy cover: 80m ² growth stage: mature	Sample 4 height: 37m trunk diameter: 66cm canopy cover:110m ² growth stage: over mature
Bishop Wood <i>Bishofia javanica</i>	Sample 1 height: 7m trunk diameter: 36cm canopy cover: 6m ² growth stage: pole	Sample 2 height: 15m trunk diameter: 49cm canopy cover: 40m ² growth stage: pole	Sample 3 height: 21m trunk diameter: 56cm canopy cover: 85m ² growth stage: mature	Sample 4 height: 34m trunk diameter: 65cm canopy cover: 114m ² growth stage: over mature
Size descriptor	Small Height: ≤10m Trunk diameter: 20-50cm Canopy cover:≤10m ² Growth stage: pole	Medium Height: 10-20m Trunk diameter: 50-60cm Canopy cover: 10-50m ² Growth stage: pole	Large Height: 20-30m Trunk diameter: 50-100cm Canopy cover: 50-100m ²	Extra large Height: 20- 30m Trunk diameter: >100cm Canopy cover: >100m ²

Table 1 shows the various tree species and their diverse sizes in terms of height, trunk diameter, canopy cover and growth stage, and it reveals that the trees are of various sizes including small, medium, large and extra-large.

Table 2: Relationship between tree size and number of fungal species on tree bark.

Tree species	Tree size	Fungal species	Number of fungal species
<i>Cassisa javanica</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens Mold fungi	2
	Extra large	Lichens Mold fungi	2
Amur cork tree <i>Phellodendron amurense</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens	1
	Extra large	Lichens Corticoid fungi rusts	3
Bishop Wood <i>Bischofia javanica</i>	Small	Lichens	1
	Medium	Lichens rusts	2
	Large	Lichens Fomes fomentarius rusts	3
	Extra large	Lichens Fomes fomentarius_ Lentinula edodes Yeast-like fungi	4
Neem tree <i>Azadirachta indica</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens club fungi	2
	Extra large	Lichens Yeast-like fungi rusts	3

Loblolly pine <i>Pinus taeda</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens rusts	2
	Extra large	Lichens rusts	2

Tamarind <i>Tamarindus indica</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens Rusts	2
	Extra large	Lichens Auricularia auricula-judae disc fungi	3
Siberian elm <i>Ulmus pumila</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens	1
	Extra large	Lichens Conk Club fungus	3
Mulberry <i>Morus alba</i>	Small	Lichens	1
	Medium	Lichens	2
	Large	Lichens	2
	Extra large	Lichens White rot fungus Lentinula edodes	3
European nettle tree <i>Celtis australis</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens Rusts	2
	Extra large	Lichens Fomes fomentarius	3

		Conk	
Teak <i>Tectona grandis</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens Ceriporiopsis subvermispora	2
	Extra large	Lichens Fomes fomentarius Ceriporiopsis subvermispora	3
Council tree <i>Ficus altissima</i>	Small	Lichens	1
	Medium	Lichens	1
	Large	Lichens	1
	Extra large	Lichens Fomes fomentarius	2
<i>Cassia fistula</i>	Small	Lichens	1
	Medium	Lichens cup fungi	2
	Large	Lichens Auricularia auricula- judae	2
	Extra large	Lichens Auricularia auricula- judae Ceriporiopsis subvermispora	3

Table 2: Shows the level of fungal diversity among the various tree sizes, and it reveals that larger trees have more diverse fungal communities.

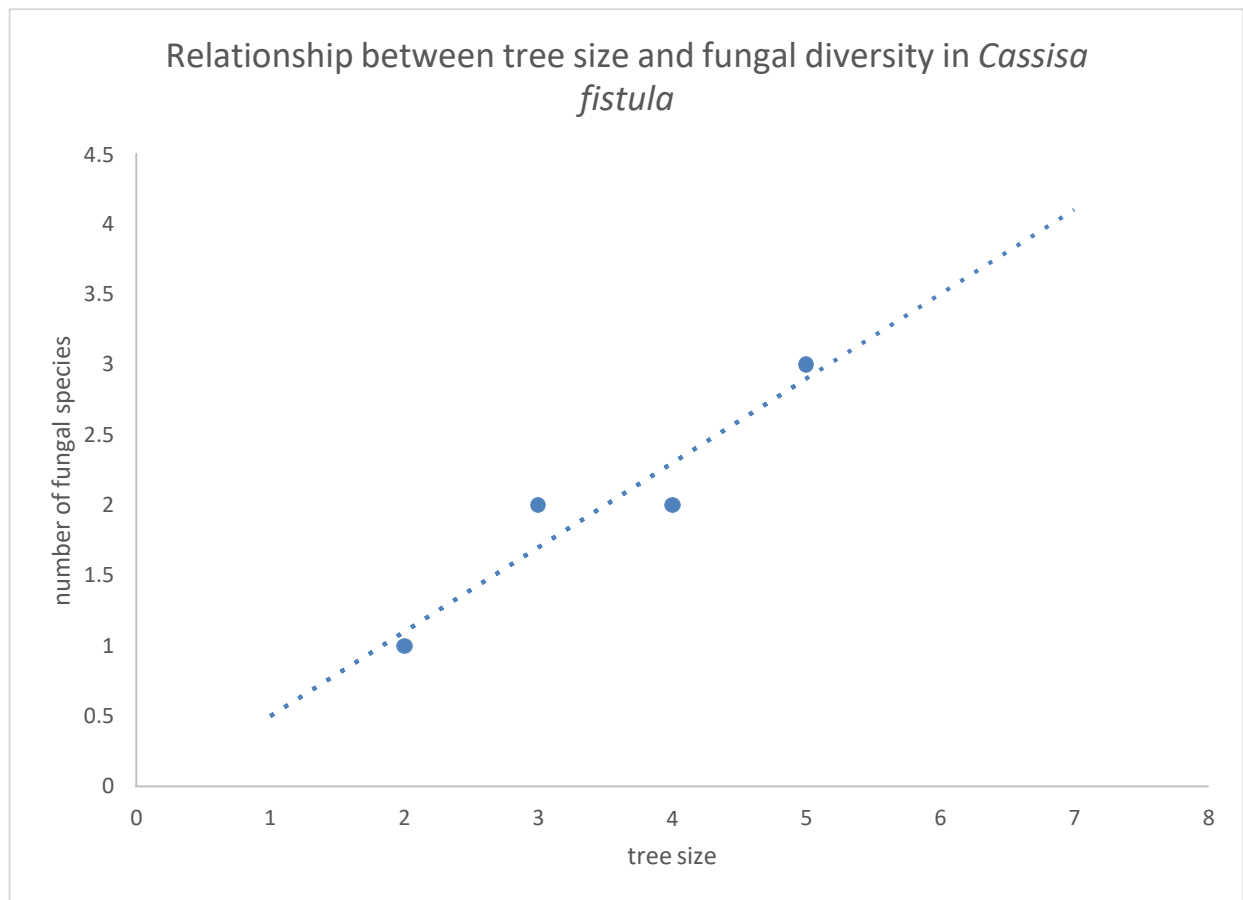


Figure 1: Scatter plot showing the relationship between tree size and fungal diversity in Cassia fistula

The scatter plot reveals that there's a significant in number of fungal species with tree size. Indicating a positive correlation between tree size and fungal diversity in tree bark.

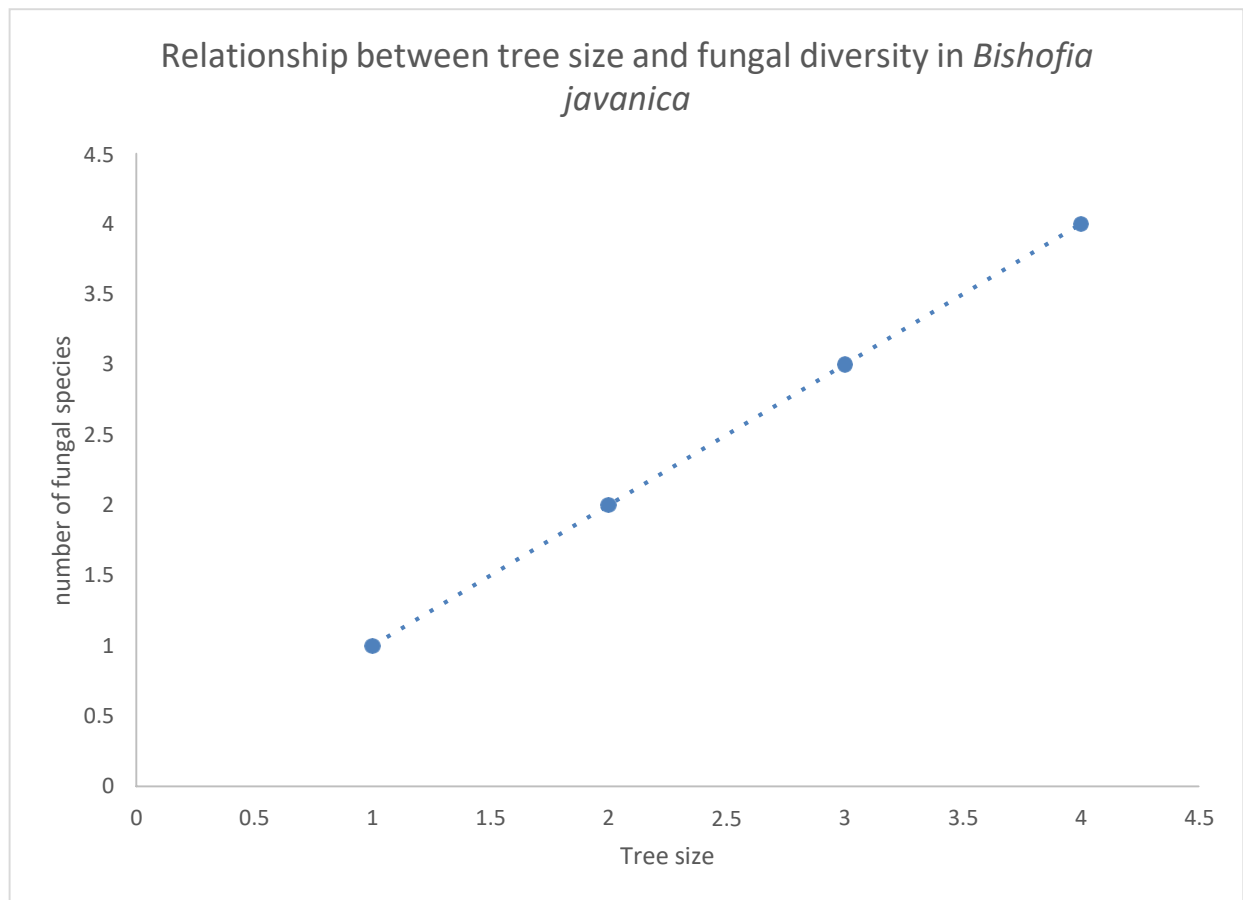


Figure 2: Scatter plot showing the relationship between tree size and fungal diversity in *Bishofia javanica*

The scatter plot reveals that there's a significant in number of fungal species with tree size. Indicating a positive correlation between tree size and fungal diversity in tree bark.

Key findings

Relationship between tree size and fungal species richness.

My results show a positive correlation between tree size and fungal species richness. Larger trees tend to have a higher number of fungal species. Fungal abundance also increases with tree size, with larger trees having significantly higher abundance.

4.2. DISCUSSIONS OF RESULTS

In this study, we found a significant positive correlation between tree size and fungal abundance. This finding is consistent with previous studies by Steidinger et al., Bassler et al., 2016 and Tedersoo et al., 2010 who also reported positive relationships between tree size and fungal diversity. However, my study extends these findings by demonstrating a stronger correlation between tree size and fungal diversity. In contrast, Tedersoo et al., 2010 found a negative relationship between tree size and fungal abundance, with larger trees supporting less diverse

fungus and algal communities (Lukas et al., 2022). This is likely due to environmental filtering, where older trees have more stable and uniform environments that favor certain microbial species over others, on the other hand forest management intensity has negligible effect on microbial communities.(Lukas et al., 2022)

The positive correlation between tree size and fungal abundance suggests that larger trees tend to have a higher number of fungal individuals and species. This relationship could be attributed to several factors

Surface Area: Larger trees have more extensive bark surface areas, providing a greater habitat for fungal growth, leading to higher species richness and abundance.(Tedersoo et al., 2016)

Resource Availability: Older, larger trees often have more resources (e.g., nutrients, water) available, supporting a greater diversity of fungal species.(Waldrop & Firestone, 2006)

Microclimate: The bark of larger trees can create a more stable microclimate,(Nemergut et al., 2014) with reduced temperature and humidity fluctuations, favoring fungal growth.

Bark Structure: As trees grow, their bark becomes thicker and more complex, offering a wider range of habitats for fungi to colonize.(Tedersoo et al., 2016)

Host Tree Age: Older trees have had more time to accumulate fungal species, leading to higher richness and abundance.(Grayston & Renneberg, 2006)

Environmental Influences: Larger trees may be more exposed to environmental factors like wind, rain, or sunlight, which can influence fungal spore dispersal and colonization.(E. Prescott & Grayston, 2013)

Tree Species: Different tree species have varying bark characteristics, which can affect fungal species richness and abundance.(Wang et al., 2023)

Decay Processes: Larger trees may have more advanced decay processes, creating opportunities for fungi to colonize and grow. (Gibson & Dickie, 2011)

Implications

This finding has implications for our understanding of fungal ecology and tree-fungal interactions. For example:

Forest ecosystem functioning: Fungi play a crucial role in decomposing organic matter and cycling nutrients.(Gibson & Dickie, 2011) A greater abundance of fungi on larger trees could impact forest ecosystem processes.

Tree health and resilience: The relationship between tree size and fungal abundance might influence tree health and resilience, particularly in the face of environmental stressors or disturbances.(Bassler et al., 2016)

Conservation and management: Understanding the relationship between tree size and fungal

abundance can inform conservation and management strategies,(Bassler et al., 2016) such as preserving larger trees or promoting fungal-friendly forest practices.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, this study investigated the relationship between tree size and fungal species richness on tree bark. The results showed a positive correlation between tree size and fungal abundance, revealing that larger trees tend to have a higher number of fungal individuals. This finding contributes to our understanding of fungal ecology and tree-fungal interactions, with implications for forest ecosystem functioning and conservation.

5.2. Recommendations

Recommendations drawn from this study are;

Future research should explore the mechanisms underlying the relationship between tree size and fungal diversity and its potential applications in forest management.

Future researchers should study the practical applications of tree size and fungal diversity relationship in determining tree health.

In order to promote fungal biodiversity, tree conservation should be a priority strategy and limited human interruptions.

Forest management authorities should also apply this relationship to estimate tree age.

6.0 REFERENCES

- Antonio, T., Jose, B. A., Carles, C., & Sergio, D.-M. (2020). N. *Forest Ecology and Management*, 457. <https://doi.org/10.1016/j.foreco.2019.117678>
- Bogale, A. (2020). Symbiotic Association of Beneficial Fungal Species with Plants to Enhance Agricultural Production and Productivity. *International Journal of Research in Agricultural Sciences.*, 7(2).
- Daniel, B. (2014). The Web of Life. *Human Symbiosis with Other Life Forms and the Environment.*, 14(2).
- Hausman, T. (2022). No Title. *Mode of Nutrition of Fungi*.
- Ic, S., Ar, R., Ds, M., Ms, C., Gentekaki, E., Hb, L., Vg, H., Pem, D., Ls, D., Sn, W., Bundhun, D., Tt, N., Id, G., Pd, A., Cs, B., Rs, J., Dn, W., Jeewon, R., Dj, B., & Mm, X. (2020). *Morphological approaches in studying fungi : collection , examination , isolation , sporulation and preservation.* 11(September), 2678–2754. <https://doi.org/10.5943/mycosphere/11/1/20>
- John, W., & Roland, W. (2007). *Introduction to Fungi* (3rd ed.). Cambridge University Press.
- Jonsson, B. G. (2014). *No Title*.
- Juan, W., Samuel, O. K., Shu, W., Jianchen, W., Lei, X., Yinan, R., & Yanchun, H. (2022). Endophytic fungi: An Effectictive Alternative Source of Plant Derived Bioactive Compounds for Pharmacological Studies. *Journal of Fungi*, 8(2).
- Laforest-lapointe, I. (2019). *Decrypting the phyllosphere microbiota : progress and challenges.* 106(2), 171–173. <https://doi.org/10.1002/ajb2.1229>
- Liu, Z., Lan, X., Li, X., Zhao, H., Gan, J., Li, R., & Chen, B. (2022). *A Plant- Derived Alkanol Induces Teliospore Germination in Sporisorium scitamineum.*
- Lukas, D., Imke, S., & Francesco, G. D. (2022). Tree drives diversity and community structure of microbial communities in the bark of beech (*Fagua sylvatica*). *Tree Drives Diversity and Community Structure of Microbial Communities in the Bark of Beech (Fagua Sylvatica).*
- M. Sc . I Semester FUNGI , LICHEN , VIRUSES AND BACTERIA. (n.d.).
- Paulo, C., Rodolfo, P., Carlos, C., Leonora, M., & Cotoras Milena. (2022). Endophytic Isolated from *Baccharis linearis* and *Echinopsis chiloensis* with Antifungal

- Read, D. J., Duckett, J. G., Francis, R., Ligrone, R., Russell, A., Ambientali, S., Università, S., & Caserta, I.-. (2000). *Symbiotic fungal associations in 'lower' land plants*.
- Ryberg, M., Kalsoom, K. F., & Sanchez, G. M. (2022). On the evolution of ectomycorrhizal fungi. *Mycosphere*.
- Steidinger, B. S., Liang, J., Nuland, M. E. Van, Werner, G. D. A., Nabuurs, G., Zhou, M., Picard, N., Herault, B., Zhao, X., Zhang, C., Routh, D., & Peay, K. G. (n.d.). *Climatic controls of decomposition drive the global biogeography of forest-tree symbioses*. <https://doi.org/10.1038/s41586-019-1128-0>
- Yehan, T., Xuesong, F., Gongchen, Z., Rui, Z., & Zhensheng, K. (2022). Mechanisms in Growth Promoting of Cucumber By Endophytic Fungus and *Chaetomium golbosum* Stain. *Journal of Fungi*, 8(2). Bassler, C., Heilmann-Clausen, J., & Muller, J. (2016). Fungal diversity in tree barks: A Review. *Fungal Ecology*, 20, 137–147.
- E. Prescott, & Grayston, S. (2013). Tree Species Influence on Microbial Communities in litter and soil. *Forest Ecology and Management-Elsevier*.
- Gibson, D. J., & Dickie, I. A. (2011). Fungal Communities In Tree Barks: A review. *Fungal Biology Reviews*, 25(2).
- Grayston, J., & Renneberg, H. (2006). Assessing Effects of Forest Management on microbial community structure in Central European Beech forest. *Forest*.
- John, W., & Roland, W. (2007). *Introduction to Fungi* (3rd ed.). Cambridge University Press.
- Juice, S. M., & Jenkins, M. A. (2012). Fungal Communities in tree barks: A meta analysis. *Ecology*, 93(5).
- Lamit, J., Holeski, M., & Flores-Renteria, L. (2016). Tree genotype influences ectomycorrhizal fungal community structure. *Fungal Ecology*.
- Lukas, D., Imke, S., & Francesco, G. D. (2022). Tree drives diversity and community structure of microbial communities in the bark of beech (*Fagus sylvatica*). *Tree Drives Diversity and Community Structure of Microbial Communities in the Bark of Beech (Fagus Sylvatica)*.
- Nemergut, D., Shade, A., & Violle, C. (2014). When, Where and How does microbial community composition matter? *Frontiers in Microbiology*.
- Peay, K. G., Kennedy, P. G., & Talbot, J. M. (2010). Dimensions of Fungal Diversity in tree barks. *Ecology*, 91(10).
- Richter, A., Schoning, I., Kahl, T., & Bauhus, J. (2018). Regional Environmental Conditions Shape Microbial Community structure stronger local forest management intensity. *Ecology and Management*.

- Six, L., & Elser, J. (2020). Mutualism is not restricted to tree-killing bark beetles and fungi. *Ecological Entomology*.
- Smith, R. M. (1982). *Learning How To Learn*. Pearson Prentice Hall.
- Steidinger, B. S., Liang, J., Nuland, M. E. Van, Werner, G. D. A., Nabuurs, G., Zhou, M., Picard, N., Herault, B., Zhao, X., Zhang, C., Routh, D., & Peay, K. G. (n.d.). *Climatic controls of decomposition drive the global biogeography of forest-tree symbioses*. <https://doi.org/10.1038/s41586-019-1128-0>
- Strickland, M., Lauber, C., Fiere, N., & M, A. B. (2009). *Testing the Function Significance of microbial community composition*. *Journal of*.
- Tedersoo, L., Bahram, M., & Cajthaml, T. (2016). *Tree Diversity and species identity effects on soil, fungi, protists and animals are context dependent*.
- Tedersoo, L., Nilsson, R. H., & Larsson, K. H. (2010). Pyrosequencing and Sanger sequencing for tropical mycorrhizal fungi provide similar results but reveal different community structure. *New Phytologist*, 188(2).
- Uroz, S., Buee, M., Mieszkina, S., & F. Martin. (2016). Ecology of Forest Microbiome. *Highlights of Temperate and Boreal ecosystems*, 103.
- Waldrop, P., & Firestone, K. (2006). Response of microbial community composition and function to Soil climate change. *Microbial Ecology*.
- Wang, Q., Yan, G., & Xing, Y. (2023). Symbiotic mycorrhizal types affect patterns of tree aboveground and belowground C allocation in Northern China. *Ecological Processes*, 12(26).