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# Marine Fungi on *Avicennia* sp. from Kadalundi Estuary, Kerala, India

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**A B S T R A C T**

Marine fungi play a vital role in the decomposition of lignocellulosic materials and nutrient cycling in mangrove ecosystems. This study investigates the diversity of marine fungi associated with the wood samples of *Avicennia* sp. collected from the estuary of Kadalundi, Kerala, South India. A total of 27 marine fungal species were isolated from the host plant, comprising 16 Ascomycetes and 11 Mitosporic fungi. The occurrence and frequency of each species were determined to understand the fungal composition of the mangrove wood substrate. Among the Ascomycetes, *Aniptodera chesapeakensis*, *Savoryella lignicola*, and *Marinosphaera mangrovei* were the most frequently occurring species, indicating their strong adaptation to the mangrove wood environment. In the Mitosporic fungi group, *Periconia prolifica* and *Zalerion maritimum* showed the highest frequency of occurrence, reflecting their ecological significance in wood degradation. The study highlights the species richness and composition of marine fungi associated with *Avicennia* wood, providing insights into their ecological roles in the estuarine ecosystem. These findings contribute to understanding fungal biodiversity in mangroves and offer baseline data for future studies on marine fungal ecology, bioprospecting, and potential applications in biotechnology, particularly in lignocellulose degradation and natural product exploration.

## Introduction

Kadalundi was declared as Kerala's first community reserve by the Kerala government in 2007 for protecting flora and fauna, traditional or cultural heritage or values in the interests of an individual or society. This bird sanctuary is a natural habitat of many mangrove genera like *Avicennia, Acanthus, Excoecaria, Bruguiera, Rhizophora* and *Sonneratia.* As diverse vegetation exists in mangroves, it is considered as a major ecosystem of marine fungi. Marine fungi represent an ecological group of approximately 1, 500 species (excluding lichens) (Wijayawardene *et al.,* 2022). They are classified as either obligate (growing exclusively in marine/estuarine habitats) or facultative (originating from terrestrial/freshwater sources but capable of marine growth). These fungi are microscopic (with the largest known fruiting body, *Amylocarpus encephaloides*, being less than 3 mm (Kohlmeyer and Kohlmeyer, 1979)) and colonize diverse substrates, including wood, sediments, and decaying mangrove leaves. Marine fungi are economically and ecologically important. Their ability to survive in extreme conditions yields valuable secondary metabolites for medical use (e. g., antimicrobials and anti-cancer agents) and they produce lignin-degrading enzymes used for industrial effluent treatment (Pointing *et al.,* 1998; Blunt *et al.,* 2008). Furthermore, their presence can be linked to heavy metal concentration in estuaries (Babich and Stotzky, 1983).

Despite their role as critical decomposers in marine ecosystems, research into their distribution and diversity

significantly lags behind that of terrestrial and freshwater fungi (Sarma, 2019). This paper aims to bridge that gap by examining the distribution and diversity of marine fungi specifically on organic matter of *Avicennia* from Kadalundi estuary.

## Materials and Methods

### Collection and processing of wood samples

Decaying woody substrates of *Avicennia* was collected from mangrove forest of Kadalundi estuary (Kerala) during June 2023 - October 2024. The samples were washed thoroughly, packed in sterile polythene bags, and transported to the laboratory. After screening for marine fungus with a stereomicroscope, the wood samples were incubated at room temperature. Periodical isolation of marine fungi from these wood samples were carried out for six months. Identifications of marine fungi were done using taxonomic keys by Kohlmeyer and Kohlmeyer, (1979), Kohlmeyer and Kohlmeyer (1991), Hyde *et al.,* (2000), Raveendran and Manimohan (2007), Nambiar and Raveendran (2012), and Borse B. D. *et al.,* (2012). The marine fungi thus identified were tabulated and recorded in Table No. 1.

**Table.1** Marine fungi isolated from *Avicennia*

| **Name of Fungi** | **% FO** |
|---|---|
| Ascomycetes | |
| *Aigialus grandis* Kohlm et Schatz | 7.25 |
| *Aigialus parvus* S. Schatz & Kohlm | 3.03 |
| *Aniptodera chesapeakensis* Shearer et Miller | 10.18 |
| *Aniptodera haispora* Vrijmoed, Hyde et Jones | 0.75 |
| *Aniptodera mangrovei* K.D. Hyde | 0.44 |
| *Arenariomyces majusculus* Kohlm. & Volkm.-Kohlm | 1.70 |
| *Biatriospora marina* Hyde et Borse | 5.10 |
| *Corollospora gracilis* Nakagiri & Tokura | 2.30 |
| *Corollospora quinqueseptata* Nakagiri | 1.58 |
| *Corollospora pseudopulchella* Nakagiri & Tokura | 1.90 |
| *Halorosellina oceanica* (Schatz) Whalley, Jones, Hyde et Laessoe | 2.20 |
| *Leptosphaeria avicenniae* Kohlm. & E.Kohlm | 3.67 |
| *Marinosphaera mangrovei* Hyde | 7.69 |
| *Saagaromyces abonnis* (Kohlm.) K.L. Pang & E.B.G. Jones | 0.86 |
| *Savoryella lignicola* Jones et Eaton | 8.51 |
| *Verruculina enalia* (Kohlm) Kohlm et Kohlm | 5.90 |
| **Mitosporic Fungi** | |
| *Bactrodesmium linderii* (J.L. Crane & Shearer) Palm & Stewart | 2.30 |
| *Cirrenalia macrocephala* (Kohlm.) Meyers | 0.75 |
| *Cirrenalia pygmea* Kohlm | 1.30 |
| *Cirrenalia tropicalis* Kohlm. | 1.15 |
| *Cirrenalia fusca* I. Schmidt | 0.86 |
| *Dendryphiella salina* (G.K. Sutherl.) Pugh & Nicot. | 2.10 |
| *Periconia prolifica* Anastasiou | 5.91 |
| *Trichocladium achrasporum* (Meyers & Moore) Dixon in Shearer & Crane | 2.02 |
| *Trichocladium alopallonellum* (Meyers et Moore) Kohlm et V. Kohlm | 1.15 |
| *Trichocladium melhae* E.B.G. Jones, Abdel-Wahab and Vrijmoed, sp. novo. | 2.16 |
| *Zalerion maritimum* (Linder) Anastasiou | 2.70 |

**Presentation of data**

* Percent frequency of occurrence (FO) = Number of isolates of a particular species obtained from *Avicennia* divided by number of *Avicennia* organic samples (138) x 100.

On the basis of percentage occurrence, the marine fungi were classified as most frequent (occurring in > 10 % samples), frequent (in 7-10 % samples), occasional (in 5-7 % samples) and rare (in < 5 % samples).

## Results and Discussion

In this study a total of 27 species of marine fungi were recorded from decayed wood samples of *Avicennia sp* from Kadalundi estuary. Out of 190 decayed samples of *Avicennia* sp examined, 138 samples were found to support marine fungi. Of the total 27 higher marine fungi, Ascomycetes include 16 species and Mitosporic fungi include 11 species. In terms of percent frequency of occurrence *Aniptodera chesapeakensis* (10. 14 %) and *Savoryella lignicola* (8. 69%) were the most frequent species encountered. The percentage colonisation of marine fungi on *Avicennia* was 83%.

The dominant and most frequently isolated fungus *Aniptodera chesapeakensis* occurs at a frequency nearly 2% higher than the next closest species, *Savoryella lignicola*. High frequency group include fungi like *Savoryella lignicola*, *Marinosphaera mangrovei*, and *Aigialus grandis* also show high occurrence, suggesting they are major contributors to the decomposition or ecological processes in the *Avicennia* mangroves of the Kadalundi estuary.

Low frequency group include species like *Aniptodera haispora* (0. 75%), *Aniptodera mangrovei* (0. 44%), and *Saagaromyces abonnis* (0. 86%) were isolated very infrequently. Several species names directly reference their habitat (e. g., *Aniptodera mangrovei*, *Marinosphaera mangrovei*, *Leptosphaeria avicenniae*), confirming their association with the mangrove environment considered as mangrove association.

It was reported that Ascomycetes were the most common taxonomic group in the mangrove species. In the present study, more than 59% of the collected species were ascomycetes and indicates their importance in the mangrove habitat. The Ascomycetes, led by *Aniptodera chesapeakensis*. The top four species (*A. chesapeakensis*, *S. lignicola*, *M. mangrovei*, and *A. grandis*) are likely the primary agents of wood and organic matter decomposition in the *Avicennia* roots and submerged wood. *Aniptodera mangrovei* and *Saagaromyces abonnis* were found at the lowest frequencies, suggesting they are either rare, highly selective, or transient species in the studied habitat. Species names such as *Leptosphaeria avicenniae* and *Marinosphaera mangrovei* confirm the specialized nature of these fungi to the mangrove host. The consistently high frequency of species like *Aniptodera chesapeakensis*, *Savoryella lignicola*, and *Marinosphaera mangrovei* suggests these are the core fungal decomposers responsible for processing the *Avicennia* detritus in this specific estuary.

The differences in the percentage colonization, species diversity and average number of fungi per sample in the present study and those reported from the literature could be attributed to several ecological factors like physical and chemical parameters, age of host plant, origin and nature of substrata , presence or absence of bark, location of the mangrove site studied, number of samples examined, the incubation period of the wood sample in the laboratory and micro habitats like salinity, temperature, humidity, pH inside the mangrove etc.

*Periconia prolifica* is by far the most dominant mitosporic fungus, occurring at 5. 91%, which is more than double the frequency of the next highest species. Its frequency is nearly matching the ascomycetes species *Verruculina enalia. Bactrodesmium linderii* shows a mid-range frequency (2. 16%). The genera *Cirrenalia* (with four species) and *Trichocladium* (with three species) show significant diversity, though their individual frequencies are relatively low (ranging from 0. 75% to 2. 16%). Mitosporic fungi are often important in the initial stages of lignocellulose decomposition (breaking down wood and plant matter) in marine environments. Their presence, especially the high frequency of *Periconia prolifica*, highlights their crucial role in nutrient recycling within the *Avicennia* habitat. The dominance of ascomycetes among the isolated fungi is consistent with their known prevalence in marine environments. The mangrove genus *Avicennia*, in particular, supports a high diversity and abundance of marine fungi due to several factors intrinsic to its environment. Mangrove ecosystems, characterized by high salinity, fluctuating water levels, and rich organic matter, provide an ideal habitat. Specifically, *Avicennia*'s complex root system offers an extensive surface area for fungal colonization. Furthermore, the abundant organic matter (decaying leaves and roots) produced by the mangroves serves as a primary nutrient source.

Some marine fungi also form symbiotic relationships with the roots, potentially aiding nutrient uptake and offering pathogen protection. Ultimately, the fungi in

these mangroves have adapted to the dynamic and stressful conditions, allowing them to thrive in *Avicennia* and similar ecosystems.

The average number of fungi per sample is a critical metric for comparing different marine habitats or substrates (Maria and Sridhar, 2002). This yardstick is informed by published data on the frequency of marine fungi in mangrove ecosystems from around the world. Specific Indian studies include Sarma and Vittal (2001), Maria and Sridhar (2003), Raveendran and Manimohan (2007), Nambiar and Raveendran (2009), and Devadatha *et al.,* (2021). International research contributing to this field includes work by Alias *et al.,* (2010), Leong *et al.,* (1991), and Jones *et al.,* (1998).

The dominant fungal species identified in this study were *Aniptodera chesapeakensis, Savoryella lignicola, Marinosphaera mangrovei, Aigialus grandis,* and *Periconia prolifica*. The earlier work of Raveendran and Manimohan (2007) recorded *Halocyphina villosa, Aniptodera chesapeakensi Marinosphaera mangrovei Lulworthia grandispora* and *Savoryella lignicola* on Avicennia species from Kadalundi estuary.

Based on Kohlmeyer and Kohlmeyer's (1979) definition, all fungi found in the current work are classified as typically marine. The distribution and frequency of marine fungi are influenced by many complexes, interacting factors, making it impossible to attribute their presence to a single cause. However, several factors are considered key elements: availability of substratum, temperature, water salinity, and geographical location (Booth and Kenkel, 1986; Jones, 2000). Due to the study's short incubation period and duration, only a limited number of species were ultimately encountered.

In conclusion, this study found a wide diversity of marine fungi on Avicennia mangroves in the Kadalundi estuary, Kerala. Understanding the types and locations of these fungi is key to figuring out their ecological functions and how they might be used in modern science. Future research should focus on exploring the specific roles of these isolated fungi. Testing their potential for practical applications like bioremediation, waste management, natural pest management, and discovering new useful compounds. Sustained, long-term monitoring of fungal communities in mangroves and beaches is necessary to accurately assess ecosystem health and resilience, as their composition provides key indicators for gauging the ecosystem's overall well-being and ability to recover from disturbances. To gain valuable long-term data on ecosystem health and resilience, future studies should establish consistent monitoring programs for fungal communities in both mangrove and beach habitats.

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## Author Contributions

N. Sudheesh Kumar: Conceived the original idea and designed the model the computational framework and wrote the manuscript; Gayatri R. Nambiar: Formal analysis, writing review and editing.

## Declarations

**Ethical Approval** Not applicable.

**Consent to Participate** Not applicable.

**Consent to Publish** Not applicable.

**Conflict of Interest** The authors declare no competing interests.

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