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Xylaria: Nature's Silent Decomposer and Bioactive Powerhouse

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The genus *Xylaria* is one of the most diverse and ecologically important fungal groups in forest ecosystems. It belongs to the family Xylariaceae under the order Xylariales, class Sordariomycetes, phylum Ascomycota, and kingdom Fungi. The genus comprises more than 500 recognized species distributed across tropical and temperate regions worldwide. *Xylaria* species are primarily known as wood-decomposing fungi that play a significant role in lignocellulose degradation and nutrient cycling in forest ecosystems. Many species also occur as endophytes within living plant tissues, demonstrating ecological versatility. In addition to their environmental importance, *Xylaria* species produce diverse bioactive secondary metabolites, making them valuable in biodiversity research, biotechnology, and pharmaceutical studies (Zeng *et al*., 2024). Among the most well-known species are *Xylaria polymorpha* ("dead man's fingers") and *Xylaria hypoxylon* ("candlestick fungus"), both recognized for their distinct stromatal morphology and ecological roles (Koyani *et al*., 2016).

Habitat and Distribution

Xylaria species are predominantly associated with forest ecosystems, particularly in tropical and temperate climates. Their principal habitat is decaying hardwood, including fallen logs, stumps, and dead branches. Some species act as early colonizers of freshly fallen timber, whereas others prefer well-decomposed or water-soaked wood. Beyond woody substrates, certain species are specialized to grow on seeds, fruits, petioles, and fallen leaves, often displaying host specificity. In tropical regions, some species are also found in association with abandoned termite or ant nests. Although *Xylaria* has a global distribution, species diversity is especially high in tropical forests.

Morphological Characteristics

Species within the genus are distinguished by their upright, stipitate, and charred stromata, characterized by perithecia that are entirely immersed, and often dark brown to black at maturity. It may grow singly or in clusters on decaying wood. Young stromata can appear whitish or gray due to a powdery coating of asexual spores, but they become hard and carbonaceous as they age. Embedded within the stromatal tissue are numerous flask-shaped perithecia, each containing cylindrical asci with eight ascospores arranged in a single row. The ascospores are generally brown to black, smooth, ellipsoid to fusiform, and possess a distinct germ slit, which is an important diagnostic feature of the genus (Rogers *et al.*, 2000).

Biodiversity of *Xylaria*

Xylariaceae exhibits remarkable diversity worldwide, particularly in tropical and subtropical ecosystems where climatic conditions and plant diversity support fungal proliferation. The diversity of *Xylaria* is strongly influenced by habitat type, host specificity, altitude, and climatic factors (Zeng *et al*., 2024). Tropical forests in Southeast Asia, Africa, and South America are considered biodiversity hotspots for *Xylaria*. Numerous new species and records continue to be reported from these regions, indicating that the genus remains underexplored. Endophytic isolates of *Xylaria* obtained from diverse host plants further contribute to its hidden biodiversity. Studies have shown that plant diversity and proximity to natural forest habitats significantly affect the frequency and diversity of *Xylaria* species isolated from plant tissues (Koyani *et al*., 2016).

A B C

Figure 1. Fruiting bodies of *Xylaria* species: (A) *Xylaria hypoxylon*; (B) *Xylaria apiculata*; (C) *Xylaria polymorpha* ("dead man's fingers").

Ecological Importance

Ecologically, *Xylaria* plays a vital role as a saprophyte by degrading lignin and cellulose in woody tissues. This process contributes to nutrient recycling and carbon cycling in forest ecosystems, preventing the accumulation of dead organic matter and enriching soil fertility. As endophytes, certain species may enhance host resistance to environmental stress or pathogens, demonstrating ecological adaptability and functional diversity. Studies showed that the isolation of compounds such as piliformic acid and cytochalasin D, showed 51.33% and 38.76% inhibition of mycelial growth of *C. gloeosporioides*, respectively. These compounds were isolated with EtOAc extracts from strains 249 and 214 of *Xylaria*, had shown antifungal activity better than the fungicide like captan (Elias *et al*., 2018). In addition, diverse antimicrobial and antifungal secondary metabolites produced by *Xylaria* species provided a biochemical basis for their inhibitory activity (Chen *et al*., 2024). Compounds produced by *Xylaria* fungi have the ability to inhibit the growth of harmful bacteria. Type A xylapeptides with antibacterial activity against *Bacillus subtilis* and *Bacillus cereus* had been reported, exhibiting a minimum inhibitory concentration (MIC) of 12.5 µg/mL (Xu *et al*., 2017). Similarly, xylarcalasin B isolated from plants colonized by *Xylaria* sp. strain GDGS-77B demonstrated antibacterial effects against *B. subtilis*, with MIC values of 25 µg/mL (Zhao-Long *et al*., 2022). Together, these findings confirm that *Xylaria* not only contributes to wood decomposition but also plays a significant role in microbial competition and plant pathogen suppression. Species of *Xylaria* produce a wide array of structurally diverse secondary metabolites, including terpenoids, polyketides, alkaloids, and cytochalasins. These compounds exhibit antibacterial, antifungal, anticancer, anti-inflammatory, and antimalarial activities. Many metabolites show promise as potential pharmaceutical leads, attracting significant research interest (Chen *et al*., 2024).

Conclusion

In summary, *Xylaria* is a diverse and ecologically significant genus within the Ascomycota. It contributes substantially to wood decomposition, nutrient cycling, and forest ecosystem stability. Its remarkable biodiversity, particularly in tropical ecosystems, highlights its ecological adaptability and evolutionary success. Furthermore, its ability to produce bioactive secondary metabolites and industrially important enzymes underscores its importance in biotechnology and medicine. Continued research integrating taxonomy, biodiversity surveys, ecology, and metabolomics will further expand our understanding of this genus and its potential applications.

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