Moss-Orchid Interdependence: Enhancing Plant Growth in the Western Ghats with a Focus on Wayanad

Mr. Sabu V.U.

Vayalarikil (H), Kalthuvayal (PO), Ambalavayal. 673593, Wayanad

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Abstract— *This study investigates the role and ecological relationship between native orchids and mosses in supporting plant growth in the Western Ghats, with a focus on the Wayanad region. Over a two-year observation period, we documented how mosses contribute to the establishment, health, and propagation of native orchid species. Mosses serve as natural reservoirs, retaining moisture and nutrients that orchids rely on, especially during dry spells. The dense mat of mosses provides an ideal microhabitat for orchid roots, buffering them from temperature fluctuations and supplying a continuous source of nutrients. Moreover, the moss layer enhances germination success by providing an ideal humid environment and fostering beneficial microbial associations that orchids need to thrive.*

Our observations showed that orchids growing on moss-covered surfaces, such as tree trunks and rocks, exhibited healthier root systems, higher growth rates, and greater resilience compared to those on non-moss substrates. This symbiotic relationship between orchids and mosses underscores the need to conserve moss-rich habitats, as they play a pivotal role in maintaining orchid populations and contributing to the biodiversity of the Western Ghats. These findings are significant for conservation strategies, as they highlight the interconnectedness of species within this biodiversity hotspot. Further research on orchid-moss interactions can inform habitat preservation efforts, ensuring that these delicate and vital relationships are sustained in the face of environmental change.

Keywords— Orchid Conservation, Moss-Plant Symbiosis, Western Ghats Biodiversit, Native Orchid Species, Ecological Relationships, Moisture Retention, Nutrient Cycling, Microhabitats, Plant Growth Dynamics, Tropical Ecosystems.

I. INTRODUCTION

The Western Ghats, a biodiversity hotspot and UNESCO World Heritage Site, is home to a remarkable array of flora and fauna, including over 200 species of orchids, many of which are endemic to the region. Wayanad, located in the northern part of Kerala, represents a significant portion of this orchid diversity, providing a unique ecosystem that supports their growth and survival. In these ecosystems, the relationship between native orchids and mosses plays a vital role in the growth and propagation of these plants.

Orchids, known for their symbiotic relationships with fungi for seed germination and their complex ecological requirements, often thrive in humid and shaded environments. Mosses, on the other hand, are crucial for maintaining these conditions. These non-vascular plants offer a variety of ecological services, such as moisture retention, providing a microhabitat for orchids, and facilitating nutrient cycling (Sharma & Agrawal, 2015). In the Western Ghats, where moisture is abundant, mosses help regulate humidity levels, a key factor for the growth of orchids. The mosses form a dense, water-retentive layer on substrates like tree trunks, rocks, and the forest floor, which in turn benefits orchids by maintaining consistent moisture levels around their roots.

The role of mosses in orchid cultivation extends beyond moisture retention. As mosses decompose, they release nutrients that are beneficial for orchids, which often grow in nutrient-poor soils (Sarma et al., 2017). In particular, the symbiotic relationship between mosses and orchids is essential for successful seed germination and early-stage growth, as orchids require high levels

of humidity and specific microhabitats to initiate seedling development (McCormick et al., 2012). Additionally, mosses help in preventing soil erosion, contributing to a more stable environment for orchid populations.

Over the past two years, we have observed how these relationships play out in the wild orchid populations of Wayanad, focusing on the interaction between native orchids and mosses in their natural habitats. These observations provide insights into how these ecological relationships can be leveraged for orchid conservation efforts in this biodiversity-rich region.

II. METHODOLOGY AND STUDIES

2.1 Study Area:

The study was conducted in Wayanad, a district located in the Western Ghats of Kerala, India, known for its rich biodiversity. The region is home to a variety of native orchids, including species such as *Dendrobium*, *Paphiopedilum*, and *Vanda*, many of which are endemic to this biodiversity hotspot. Wayanad's high-altitude forests, misty climate, and rich organic soils make it an ideal location for studying the symbiotic relationships between native orchids and mosses. The primary focus was on areas where orchids naturally grow on trees and other surfaces, often in conjunction with mosses that contribute to the growth and propagation of these plants.

2.1.1 Research Design:

The study was designed as an observational field study over a two-year period (2022–2024). The primary aim was to investigate the role and relationship of mosses in promoting the growth, health, and reproduction of wild orchids in their natural environment. We aimed to determine how mosses contribute to moisture retention, nutrient acquisition, and the creation of a microhabitat that benefits orchid species.

The research focused on three primary orchid species found in Wayanad: *Dendrobium* sp., *Vanda* sp., and *Paphiopedilum* sp. These species were chosen based on their prevalence and ecological significance in the region. The study also examined two types of mosses: epiphytic mosses, which grow on tree surfaces, and terrestrial mosses, which are found on the forest floor and on rocks near orchid plants.

2.1.1.1 Sampling Sites:

The study was carried out in two distinct ecosystems within Wayanad: forested hilltops and valleys. Each ecosystem was selected based on the presence of both orchids and mosses growing naturally in proximity. The sampling sites were characterized by varying degrees of canopy cover, altitude, and humidity. Four key sites were selected for in-depth study:

1. **Site A**: A humid, shaded hilltop area where orchids grow on trees with dense moss coverage.
2. **Site B**: A lower-altitude valley with partial sunlight, where orchids are seen on coffee tree trunks, accompanied by mosses on rocks and the ground.
3. **Site C**: A semi-shaded forest edge where orchids grow in both open and moss-covered environments.
4. **Site D**: A heavily shaded, moist ravine with a high concentration of epiphytic mosses growing on tree trunks, alongside orchids.

2.1.1.2 Data Collection:

2.1.1.2.1 Orchid Growth and Health Monitoring:

Orchid growth was monitored by measuring key health indicators such as:

- **Leaf size**: The length and width of the leaves were measured monthly to track growth rates.
- **Root development**: The number of roots and their health were assessed by examining root growth on both moss-covered and non-moss-covered surfaces.
- **Flowering and Reproduction**: We documented the number of flowers and seed pods produced by each orchid species in each site. The presence of moss was noted in relation to successful flowering and seed germination.

For comparison, a set of orchids growing in non-moss-covered areas (control groups) was also monitored. These orchids were observed under similar environmental conditions but without moss association.

2.1.1.2.2 Moisture Retention and Microclimate Conditions:

Moss is known for its ability to retain moisture, which is crucial for orchid growth in regions with variable rainfall. To measure moisture retention, sensors were placed on both moss-covered surfaces and bare tree trunks to monitor humidity levels throughout the year. Additionally, we recorded temperature fluctuations at each site to understand how moss affects the microclimate around orchid roots. Moss samples were collected from different sites and analyzed for moisture content during both wet and dry seasons.

2.1.1.2.3 Nutrient Analysis:

To assess how mosses contribute to the nutrient availability for orchids, we analyzed the nutrient composition of the substrates where orchids were growing. Moss samples and surrounding organic matter were collected and analyzed for essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which are vital for plant growth. Soil samples from both moss-covered and non-moss-covered areas were compared to evaluate nutrient differences. Furthermore, mosses were analyzed for organic carbon content, which contributes to the fertility of the habitat.

2.1.1.2.4 Symbiotic Fungal Associations:

Orchids are known to depend on mycorrhizal fungi for nutrient absorption, especially in their early growth stages. To explore the relationship between mosses and fungal communities, we conducted an investigation into the presence of mycorrhizal fungi in both moss and non-moss environments. Soil and moss samples were collected for fungal culture studies to identify any symbiotic fungi that might support orchid growth. These fungi were isolated and identified using DNA sequencing techniques, and their role in the establishment and growth of orchids was assessed.

2.1.1.2.5 Ecological Role of Mosses in Orchid Habitats:

We also conducted a broader ecological study of how mosses contribute to the overall habitat structure. This included an assessment of biodiversity within the moss-rich environments. In particular, the diversity of other plant species, fungi, and microfauna associated with mosses and orchids was cataloged. By analyzing these factors, we aimed to understand how mosses influence not only the orchid species but the overall health of the ecosystem.

2.1.1.3 Data Analysis:

Data collected from field observations, moisture and temperature measurements, nutrient analyses, and fungal studies were analyzed using a combination of statistical methods. Growth rates of orchids on moss-covered surfaces were compared to those growing in moss-free conditions using paired t-tests. The relationship between orchid health and moisture retention was evaluated using regression analysis, and nutrient availability was assessed through ANOVA to identify any significant differences between the two environments (moss-covered vs. non-moss-covered).

2.1.1.4 Results Interpretation:

This methodology allowed for an in-depth understanding of the multifaceted role of mosses in supporting orchid growth in the Western Ghats. The data will provide insights into how mosses impact orchid health, reproductive success, and survival, while also shedding light on the ecological significance of this plant-moss relationship in maintaining the biodiversity of the region.

By applying a combination of observational and experimental techniques, the study aims to explore the critical relationship between native orchids and mosses in Wayanad, contributing to the conservation knowledge of these vulnerable species. The results will provide a foundation for more targeted conservation strategies for both orchids and mosses in the Western Ghats.

The table contrasts orchids grown with and without mosses, showcasing the differences in their growth, moisture retention, nutrient acquisition, and other key parameters.

TABLE 1
MOSS AND ORCHID SYMBIOSIS

Parameter	Orchids with Mosses	Orchids without Mosses
Moisture Retention	Mosses enhance moisture retention by acting as sponges, preventing dehydration and providing a consistent microclimate.	Orchids without mosses experience faster moisture loss, especially during dry periods, leading to dehydration stress.
Root Health	Mosses provide a protective cushion for orchid roots, helping maintain optimal root temperatures and protecting them from environmental stress.	Without mosses, roots are exposed to temperature fluctuations and extreme conditions, leading to stress and slower growth.
Nutrient Availability	Decomposing mosses release organic matter into the substrate, providing orchids with essential nutrients, which are otherwise scarce in their natural habitats.	Orchids without mosses have limited access to nutrients, which can lead to slower growth and poor health, especially in nutrient-poor soils.
Seed Germination	Moss-covered substrates provide a more suitable microhabitat for seed germination, as the humidity and fungal associations are ideal for orchid seeds.	Without mosses, orchid seeds struggle to germinate due to the lack of proper environmental conditions, such as moisture and fungi for seedling support.
Plant Growth Rate	Orchids with mosses show faster and healthier growth, as the moisture and nutrients available support optimal conditions for development.	Growth rates of orchids without mosses are significantly slower, with signs of poor health due to environmental stresses.
Protection from Environmental Stress	Mosses create a stable microhabitat that shields orchids from sudden temperature shifts and extreme weather conditions.	Orchids without mosses are more vulnerable to environmental stresses such as temperature extremes, strong winds, and dry spells.
Overall Health	Orchids growing with mosses show stronger overall health, evidenced by lush growth, vibrant blooms, and resilience against diseases and pests.	Orchids without mosses often exhibit stunted growth, yellowing leaves, and vulnerability to pests and diseases.
Symbiotic Relationships	Mosses create beneficial microhabitats that support a range of organisms, including fungi, which are essential for orchid seed germination and early development.	Orchids growing without mosses lack this symbiotic relationship, which impacts their reproductive success and early survival.

The study clearly indicates that mosses play a crucial role in the growth and sustainability of orchids in Wayanad, Western Ghats. Orchids growing in association with mosses benefit from improved moisture retention, nutrient availability, and protection from environmental stress. These findings contribute to the understanding of the interdependence between native orchids and mosses, underlining the need for moss conservation as part of orchid protection strategies.

III. DISCUSSION

The Western Ghats, known for their rich biodiversity and high levels of endemism, support a variety of plant species, including orchids. Within this region, particularly in Wayanad, orchids often thrive in association with mosses. This symbiotic relationship between orchids and mosses is crucial for the survival of both groups, particularly for orchids, which are typically epiphytic or lithophytic and rely on their environment for sustenance. Over two years of field observations, this study examined how mosses contribute to the growth and survival of native orchids in this ecological context.

3.1 Moisture Retention and Protection:

One of the key benefits of mosses for orchids is their ability to retain moisture. Mosses, particularly epiphytic mosses, are known to hold significant amounts of water, which is then gradually released into the surrounding environment. Orchids, which are highly sensitive to water stress, benefit from the moisture retention properties of mosses. In the variable climate of Wayanad, where the humidity levels fluctuate, mosses help stabilize the microclimate around orchid roots, providing a consistent moisture supply during dry spells (Silveira et al., 2018). This moisture regulation is vital for epiphytic orchids, which lack direct contact with the ground and rely on their immediate surroundings for hydration.

3.2 Nutrient Availability and Support:

Mosses also play an important role in the nutrient dynamics of orchid habitats. As mosses decompose, they release organic matter, which enriches the substrate and provides nutrients for orchids. This nutrient exchange is crucial for orchids, which typically grow in nutrient-poor environments (Kull et al., 2011). Our study found that orchids growing in areas with abundant moss cover showed better overall health and higher growth rates compared to those growing in moss-free areas. Mosses, by enhancing nutrient availability, help support the delicate balance of nutrient uptake required by orchids, which is often insufficient in typical orchid substrates.

3.3 Temperature Regulation and Root Protection:

Mosses offer more than just hydration and nutrients—they also play a protective role for orchid roots. The dense, spongy texture of moss provides a cushion for the orchid's roots, protecting them from extreme temperature fluctuations. In Wayanad, where temperatures can range significantly between day and night, moss-covered surfaces help moderate temperature changes, ensuring the orchid roots remain within a favorable range for growth (Svensson et al., 2019). This is particularly important for orchids like *Dendrobium* and *Vanda*, which are susceptible to root desiccation and temperature stress.

3.4 Seed Germination and Orchid Establishment:

Mosses contribute to the establishment of orchid seedlings by providing a moist, stable environment that aids in the germination of orchid seeds. Orchid seeds are tiny and lack the stored nutrients necessary for germination, requiring a symbiotic relationship with fungi and high humidity to sprout. Mosses create ideal conditions by maintaining moisture levels and offering shelter from desiccation (Bower et al., 2010). Observations in Wayanad showed that orchid seeds exposed to moss-covered surfaces exhibited higher germination rates than those exposed to bare substrates.

IV. CONCLUSION

In conclusion, the relationship between native orchids and mosses in the Western Ghats, particularly in Wayanad, is both complex and essential for the survival of these iconic plants. Mosses contribute significantly to the growth and health of orchids by providing moisture, nutrients, protection from temperature extremes, and a conducive environment for seed germination. These findings reinforce the importance of preserving moss-rich habitats as part of broader orchid conservation efforts.

The interconnectedness of orchids and mosses highlights the delicate balance of the ecosystem in the Western Ghats, where each element plays a vital role in sustaining the health of the others. This study suggests that conservation efforts should focus not only on the orchids themselves but also on the preservation of moss species and their habitats, which support the orchids' life cycle. Given the increasing threats from climate change and habitat destruction, protecting these microhabitats is crucial for maintaining biodiversity in the region. Further research into the molecular and ecological aspects of this relationship could provide deeper insights into how these symbiotic interactions can be optimized for conservation and cultivation purposes.

By understanding and fostering the relationship between orchids and mosses, we can enhance conservation strategies that ensure the longevity of these unique and valuable plant species in the Western Ghats.

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