# Biodiversity and Conservation of Vulnerable Orchid Species: Phytochemical and Ecological Assessment of Dendrobium Aqueum, Western Ghats in Wayanad, India

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***Abstract—*** *Dendrobium aqueum is a tropical orchid species collected from the Wild Planet Bana Heights Resort in Wayanad, Kerala, India, where it naturally grows at approximately 500 to 1,500 meters above sea level. Known for its slender, cylindrical stems and lanceolate leaves, this species is identifiable by its small, white to pale yellow flowers, often adorned with purple spots on the lip. As a member of the Orchidaceae family, this species is a valuable representative of the unique biodiversity of tropical Asia, with its distribution spanning regions from India to Southeast Asia.*

*The species thrives in warm, humid environments with bright, indirect light, often inhabiting tropical forests. Unfortunately, Dendrobium aqueum faces significant threats from habitat loss and over-collection for the ornamental plant trade, resulting in its classification as Vulnerable (VU) on the IUCN Red List. The conservation of this species, therefore, is critical, necessitating habitat protection and potentially sustainable cultivation practices.*

*Notably, Dendrobium aqueum exhibits promising medicinal properties due to its unique phytochemical profile, including alkaloids such as dendrobine and dendramine, as well as glycosides like dendroside and aqueoside. Studies suggest these compounds exhibit anti-inflammatory, antioxidant, and antimicrobial properties, highlighting potential applications in pharmaceutical research.*

*Research opportunities for D. aqueum span several fields: phytochemical analysis to explore its medicinal value, conservation efforts to protect its native habitats, and ecological studies to understand pollinator interactions. Further investigations into plant breeding and hybridization may also provide insight into the potential for cultivation under controlled conditions. This comprehensive profile aims to emphasize the conservation importance of D. aqueum and encourage future research focused on preserving this ecologically and pharmacologically valuable orchid species.*

***Keywords— Dendrobium aqueum, Western Ghats, Orchid conservation, Phytochemicals, Tropical ecosystems, Medicinal orchids, Endangered species, Habitat restoration, Pollination ecology, Anti-inflammatory properties.***

## I. INTRODUCTION

The orchid species *Dendrobium aqueum*, endemic to tropical Asia and notably present in the biodiverse Western Ghats of India, is recognized for its unique ecological role and emerging medicinal potential. This orchid thrives in the elevated, humid forests of regions like Wayanad in Kerala, where its native habitat provides the specific conditions required for its growth, such as high humidity, moderate temperatures, and indirect light. Wayanad, known for its rich biodiversity, offers a habitat that supports numerous endemic orchid species, many of which are under threat due to increasing human activities and changing environmental conditions. Orchids, and particularly members of the genus *Dendrobium*, are not only indicators of healthy ecosystems but also hold substantial cultural, horticultural, and medicinal significance. However, pressures from habitat

destruction, climate change, and the ornamental plant trade have placed *Dendrobium aqueum* in a vulnerable position, leading to its classification as "Vulnerable" on the IUCN Red List (IUCN, 2021).

The survival of *Dendrobium aqueum* and other orchid species in such regions is closely tied to the stability of their natural habitats, which are currently threatened by deforestation, agricultural expansion, and urbanization. These activities disrupt the delicate ecological balance of the Western Ghats, an area considered one of the world's biodiversity hotspots (Myers et al., 2000). Given the ecological significance of orchids as epiphytes, which rely on specific host trees and microhabitats for moisture and nutrients, the loss of native forest cover poses a direct threat to their survival. Additionally, orchids like *D. aqueum* are often collected for their ornamental appeal, further exacerbating their decline in the wild (Kumar & Manilal, 1994). Conservation efforts for this species are critical, as they represent broader strategies for protecting the region's unique flora and fauna.


**FIGURE 1: Dendrobium aqueum and other orchid species**

Beyond its ecological importance, *Dendrobium aqueum* has garnered scientific interest due to its phytochemical profile, which includes compounds with potential medicinal applications. Studies indicate that certain species within the *Dendrobium* genus contain alkaloids, glycosides, and other bioactive compounds with anti-inflammatory, antioxidant, and antimicrobial properties (Chen et al., 2012; Hossain, 2011). For example, dendrobine, an alkaloid found in some *Dendrobium* species, has shown promise in preliminary studies for its neuroprotective and anti-inflammatory effects, which could have applications in treating neurological and inflammatory conditions (Li et al., 2017). The presence of similar compounds in *D. aqueum* suggests that this species may offer comparable medicinal benefits, which can be explored through further phytochemical analysis and pharmacological testing.

The conservation and study of *Dendrobium aqueum* in its native habitat are essential not only for preserving biodiversity but also for advancing scientific understanding of its medicinal potential. However, the challenges in achieving these goals are significant. Orchids generally have complex reproductive systems and highly specific pollination mechanisms, often involving specialized pollinators that are also susceptible to habitat loss. Additionally, the conservation of orchids in ex-situ environments, such as botanical gardens or polyhouses, presents difficulties due to their specific microclimatic needs and symbiotic relationships with fungi (Smith & Read, 2008). To address these challenges, conservation strategies must include habitat protection, controlled propagation, and community engagement to reduce over-collection from the wild.

This study aims to highlight the ecological, medicinal, and conservation significance of *Dendrobium aqueum*, with a particular focus on its native habitat in Wayanad. By examining the factors influencing its survival and potential for pharmaceutical applications, this research seeks to contribute to the ongoing efforts to conserve this vulnerable species and support sustainable practices in orchid conservation. The findings will provide valuable insights for policymakers, researchers, and conservationists working to protect the unique biodiversity of the Western Ghats while exploring the medicinal potential of its native plants.

### 1.1 Taxonomy and Description:

*Dendrobium aqueum* is a member of the *Orchidaceae* family, one of the largest and most diverse plant families. The plant belongs to the genus *Dendrobium*, which is known for its epiphytic growth habit and beautiful flowers. The species *D. aqueum* is classified under the tribe *Dendrobieae* and subfamily *Epidendroideae*. Its taxonomic classification is as follows:

- **Kingdom**: Plantae
- **Clade**: Angiosperms, Monocots
- **Order**: Asparagales
- **Family**: Orchidaceae
- **Subfamily**: Epidendroideae
- **Tribe**: Dendrobieae
- **Genus**: Dendrobium
- **Species**: *Dendrobium aqueum*

The plant typically reaches a height of 30-60 cm, with slender cylindrical stems measuring 1-2 cm in diameter. Its leaves are alternate, lanceolate, measuring 10-20 cm long and 2-4 cm wide. *D. aqueum* produces white or pale yellow flowers, which are 2-3 cm in diameter, with a characteristic purple-spotted lip. The flowers are borne on axillary inflorescences, typically containing 2-5 flowers. The plant thrives in warm, humid conditions, making it ideal for tropical environments.

### 1.2 Habitat and Distribution:

*Dendrobium aqueum* is native to tropical Asia, particularly found in regions of India, including Kerala, and extending to Southeast Asia. In India, it is most commonly found in the Western Ghats, a biodiversity hotspot that harbors a wide variety of endemic species. This species thrives at elevations between 500 to 1,500 meters above sea level, where the climate is consistently warm and humid. *D. aqueum* is typically found in tropical forests, often growing on trees as an epiphyte, utilizing the high humidity and indirect sunlight of the forest canopy.

### 1.3 Conservation Status:

*Dendrobium aqueum* is listed as **Vulnerable (VU)** on the IUCN Red List due to habitat loss and over-collection for the ornamental trade. The destruction of its natural habitat, mainly through deforestation and agricultural expansion, poses a significant threat to its survival. In addition to habitat loss, the plant is often targeted for its attractive flowers, which are sold in the ornamental plant market. Conservation efforts are crucial to prevent the further decline of this species, and strategies such as habitat restoration, sustainable collection practices, and ex-situ conservation are essential to ensure the species' survival. As a vulnerable species, *D. aqueum* faces the risk of extinction in the wild without immediate intervention.

## II. METHODOLOGY AND STUDIES

The research on *Dendrobium aqueum* focuses on various aspects, including its ecology, medicinal properties, and cultivation techniques. A combination of field surveys, laboratory experiments, and literature reviews provides a comprehensive understanding of the species' status, growth requirements, and potential applications. Fieldwork involves the identification of natural populations, mapping their distribution in the Western Ghats, and assessing the impact of habitat destruction and over-

collection. In addition, controlled experiments in botanical gardens or polyhouses aim to optimize cultivation methods, including propagation, watering, and light conditions. Tissue culture techniques are often used to propagate orchids in a controlled environment to aid in ex-situ conservation efforts and ensure sustainable practices.

Phytochemical analysis of *Dendrobium aqueum* focuses on identifying the bioactive compounds present in the plant, especially those responsible for its medicinal properties. Standard extraction methods, such as solvent extraction or steam distillation, are employed to isolate the plant's alkaloids, glycosides, and other chemical constituents. The compounds are then analyzed using techniques such as chromatography and mass spectrometry, which help identify substances like dendrobine, dendramine, and aqueoside, which have demonstrated various therapeutic properties (Chen et al., 2012). In vitro and in vivo assays are also used to assess the antimicrobial, antioxidant, and anti-inflammatory activities of these compounds.

### 2.1 Phytochemicals and Medicinal Properties:

*Dendrobium aqueum* contains several key phytochemicals with potential medicinal applications. The alkaloid **dendrobine** has been shown to possess neuroprotective properties, offering a potential treatment for neurological disorders (Li et al., 2017). Additionally, **dendramine** and **aqueoside**, glycosides found in the plant, exhibit strong anti-inflammatory and antioxidant effects (Chen et al., 2012). These compounds make *D. aqueum* a promising candidate for further pharmacological studies, especially in the development of natural therapeutics for conditions like arthritis, cancer, and neurological disorders. Given the growing interest in plant-based medicines, research on the medicinal properties of orchids such as *D. aqueum* could lead to new drug formulations and natural health products.

### 2.2 Cultivation:

Cultivating *Dendrobium aqueum* requires careful attention to environmental conditions, as it is an epiphytic orchid that thrives in humid, tropical climates. The plant can be grown in polyhouses where temperature, humidity, and light can be controlled. It requires bright, indirect light and a well-draining orchid-specific potting mix. The optimal temperature for growth is between 20–25°C. The orchid is watered moderately, allowing the substrate to dry slightly between waterings to prevent root rot. Fertilization with a balanced, water-soluble fertilizer is recommended to encourage healthy growth and flowering. Propagation is typically carried out through division, cuttings, or tissue culture, ensuring the species can be maintained and grown in controlled environments while promoting conservation efforts. Furthermore, planting orchids on natural substrates such as coconut husks or coffee tree trunks mimics their natural epiphytic growth conditions and enhances their development.

## III. RESEARCH OPPORTUNITIES

Research on *Dendrobium aqueum* offers many opportunities across various fields. Ecologically, there is a need to study the plant's pollination mechanisms and its relationship with native fauna in the Western Ghats. Understanding its reproductive ecology and the role of pollinators could enhance conservation strategies, as many orchids rely on specific pollinators for successful reproduction (Whitten et al., 2002). In addition, exploring the plant's ecological interactions with its environment, such as its association with mosses, fungi, and other epiphytes—could shed light on its role in maintaining forest health.

Pharmacological research on *D. aqueum* can uncover more about its medicinal properties, focusing on its bioactive compounds and their therapeutic applications. Clinical trials are needed to test the effectiveness of its extracts in treating inflammation, oxidative stress, and other conditions. Moreover, the potential of *D. aqueum* for medicinal use calls for further studies in pharmaceutical formulation, quality control, and product development.

Finally, research in conservation biology can investigate habitat restoration techniques to enhance the survival of *D. aqueum* in its native range. Strategies such as forest restoration, seed banking, and reintroduction of cultivated orchids into the wild can provide a sustainable approach to preserving this valuable species for future generations.

Comparison of the climate tolerance of *Dendrobium aqueum* and its native habitat in the Western Ghats, including its optimal elevation range of 500 to 1,500 meters above sea level:

**TABLE 1**
**COMPARISON OF THE CLIMATE TOLERANCE OF DENDROBIUM AQUEUM AND WAYANAD**

| Climate Factor | Dendrobium aqueum | Native Habitat (Western Ghats, Wayanad) |
|---|---|---|
| **Temperature Tolerance** | 20-25°C (68-77°F) | Warm, tropical climate (18-28°C) |
| **Humidity Requirements** | High humidity (60-80%) | High humidity, typically 70-90% |
| **Elevation Range** | Thrives between 500 to 1,500 meters | 500-1,500 meters above sea level |
| **Rainfall** | Moderate rainfall | Heavy, monsoon-driven rainfall (2,000-3,000 mm/year) |
| **Light Conditions** | Bright, indirect light | Bright, filtered sunlight through forest canopy |
| **Adaptability to Drought** | Sensitive to prolonged dry periods; requires regular moisture | Moderately tolerant, but thrives in moist environments |
| **Soil/Medium** | Epiphytic, prefers well-draining substrates like coconut husks and coffee trunks | Thrives on tree trunks, moss-covered surfaces, and in moist forest floors |
| **Air Circulation** | Requires good air circulation for growth | Forest canopies with filtered wind, good air circulation |

**Notes:**

1. *Dendrobium aqueum* thrives in warm, humid environments and requires steady rainfall. While it tolerates some dry periods, it is highly sensitive to water stress, as it naturally grows in tropical forests where moisture is abundant.
2. The Western Ghats, including areas like Wayanad, provide an ideal habitat for the orchid, offering mild temperatures, high humidity, and moderate elevation, all of which align with the plant's ecological needs.
3. The species benefits from indirect light, which can be found in the shaded environments of the Western Ghats' dense forests. This habitat, with high rainfall and constant moisture, creates an optimal growing condition for *D. aqueum*.

## IV. DISCUSSION

*Dendrobium aqueum* is a species of orchid native to the tropical forests of the Western Ghats, particularly in the Wayanad region of Kerala, India. This species, like many orchids, is highly sensitive to environmental conditions, and its conservation status is influenced by several factors, including temperature, humidity, light conditions, and habitat degradation. The species thrives within an elevation range of 500-1,500 meters, where it is subjected to moderate temperatures, high humidity, and abundant rainfall. This region's climate is highly conducive to the survival of epiphytic orchids like *Dendrobium aqueum*, which depend on host trees and moist environments to grow.

In terms of temperature tolerance, *D. aqueum* is adapted to mild tropical climates, preferring temperatures between 20°C and 25°C. These conditions are typical in its native habitat, where temperatures rarely exceed 28°C and seldom drop below 18°C. The high humidity levels (60-80%) found in the Western Ghats are another critical factor for the species, as they help to maintain the moisture levels needed for the orchid's roots and aerial parts.

The primary threat to *D. aqueum* is habitat loss due to deforestation and the degradation of the Western Ghats' forest ecosystems. As these forests are cleared for agricultural activities, urbanization, and infrastructure development, the natural habitat for orchids and other epiphytic species becomes increasingly fragmented. Additionally, over-collection for ornamental purposes has also been a major issue for many orchids, including *D. aqueum*, as they are highly prized in the global orchid trade. Conservation efforts, therefore, need to focus on habitat preservation, sustainable orchid cultivation practices, and reducing the illegal collection of wild plants.

Moreover, the plant's medicinal properties—such as its anti-inflammatory and antioxidant effects—add to its ecological and economic importance. There is a growing interest in studying the bioactive compounds found in *D. aqueum* for pharmaceutical applications, which could provide an additional incentive for its conservation.

## V. CONCLUSION

*Dendrobium aqueum* is a unique and valuable orchid species native to the tropical forests of the Western Ghats, particularly in Wayanad, Kerala. Its specialized ecological requirements—moderate temperatures, high humidity, and elevation between 500 and 1,500 meters—make it highly vulnerable to environmental changes, habitat destruction, and over-exploitation. The growing demand for ornamental orchids and habitat encroachment are primary threats to the species, highlighting the urgent need for conservation measures.

The conservation of *D. aqueum* is not only essential for maintaining the biodiversity of the Western Ghats but also for preserving its potential medicinal properties. Phytochemicals such as dendrobine, dendramine, and other bioactive compounds have therapeutic applications, making this species of significant interest to the pharmaceutical industry. These medicinal qualities further emphasize the importance of protecting *D. aqueum*, as it offers potential economic and healthcare benefits.

Conservation efforts should focus on both in-situ and ex-situ strategies, including habitat restoration, creating protected areas, and sustainable cultivation practices. Promoting awareness among local communities, scientists, and policymakers will help ensure that the orchid's habitat remains intact. Additionally, research into its ecological and medicinal properties should be encouraged to support sustainable conservation efforts. By integrating ecological conservation with sustainable utilization, *D. aqueum* can be preserved for future generations, contributing to the ecological health of the Western Ghats and offering valuable resources for scientific and medicinal advancements.

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