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# A comprehensive review on threats and conservation status of orchids

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**ABSTRACT**

Orchids are the most diverse and valuable plants in the world. These are the major constituents of traditional Chinese medicine. Horticulturists and collectors highly value them due to their esthetic appeal and cultural significance. However, many orchids risk extinction due to habitat loss, over-collection, and other human activities. To address this issue, various conservation strategies have been developed and implemented. This review paper focuses on the orchids' conservation status, threats, and conservation measures. Habitat conservation allows the long-term existence of life on Earth. The conservation efforts involve a combination of *in situ* and *ex situ* measurements. The *in situ* maintenance involves protecting the natural habitats where orchids grow, such as establishing protected areas and restoring degraded habitats. The *ex situ* measures include cultivating and preserving orchids outside their natural habitats, such as botanical gardens, seed banks, and cryopreservation.

## ARTICLE HIGHLIGHTS

- Orchidaceae is the largest family of flowering plants facing threats due to habitat destruction, forest fires, over collection etc.
- Alkaloids, carbohydrates, flavonoids, glycosides, and other phytochemicals found in orchids play an important role in pharmaceutical and cosmetology sector.
- There is an immediate need by public, private sectors and research universities/institutes to conserve these precious species which can be made possible via public awareness programs and various conservation techniques like plant tissue culturing.

## 1. INTRODUCTION

*Orchidaceae* is a large, diverse family of angiosperms known for its distinctive flower morphologies. Worldwide, there are approximately 28,484 species and 850 genera of orchids [1]. Orchids grow in various habitats, including lithophytic, epiphytic, or terrestrial. Among them, 25% are terrestrial, and approximately 70% are epiphytic or lithophytic [2]. Orchids are cultivated for their ornamental value due to their exotic beauty and high durability [3,4]. Chinese was the first researchers to discover and develop orchids with therapeutic properties [5]. Orchids contain a wide range of bioactive substances that have been utilized to treat various diseases [6]. The bioactive components extracted from orchids include alkaloids, dactylorhins, sinensols, and spiranthols. These diverse metabolites found in different orchid species provide benefits in the treatment of conditions such as rheumatoid arthritis, bacterial infections, inflammation, neuroprotection, anti-carcinogenesis, diuretic effects, anti-aging properties, wound healing, hypoglycemia, and anti-tumor activities in humans as mentioned in Table 1 [7-10]. Orchids also hold cultural value in various nations and tribes worldwide, where they are used as food and herbal medicines [11].

Globally, orchids are flowering plant species at risk of extinction. It is important to promote conservation efforts for the diverse and significant plant family *Orchidaceae* [12]. In many regions, the number of orchids with medicinal and horticultural significance is declining due to habitat destruction, overexploitation, and climate change and is classified as rare, endangered, or threatened in the international union for conservation of nature (IUCN) Red List [13,14]. There is an urgent need to preserve these orchids and different conservation methods have been developed to safeguard their biodiversity. The different *in vitro* strategies such as micropropagation, synthetic seed formation, and cryopreservation are highly valuable techniques in preserving these plants from extinction [15]. According to the orchid conservation alliance, preserving natural orchid habitats is essential for the survival of orchids [16]. This review aims to narrate the threats, *in situ* and *ex situ* conservation measures employed to protect the orchids.

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**Table 1:** Medicinal uses of some orchids.

| Botanical name | Medicinal uses | References |
|---|---|---|
| *Aerides multiflora* Roxb | The leaf paste is used to treat rheumatism. | [8] |
| *Calanthe tricarinata* Lindl | The paste of the leaf is used to treat sores and eczema. | [6] |
| *Coelogyne cristata* Lindl | Treat wounds, burns, and skin disease. | [9] |
| *Coelogyne prolifera* Lindl | Headache and fever relief using the paste of pseudobulbs. | [9] |
| *Dendrobium amoenum* Wall. ex Lindl. | The whole plant powder is employed to treat burnt skin and broken bones. | [9] |
| *Eulophia dabia* (D.Don) Hochr | Rhizome paste is used to treat cough and cold. | [9] |
| *Habenaria furcifera* Lindl | The plant is used for wound healing. | [9] |
| *Liparis odorata* (Willd.) Lindl. | The leaf paste is used for diabetic ulcer. | [8] |
| *Pholidota imbricata* Hook | Pseudobulb with mustard oil is used to treat joint discomfort. | [8] |
| *Rhynchostylis retusa* (L.) Blume | The juice of leaf is used to treat constipation. | [8] |
| *Spiranthes sinensis* (Pers.) Ames | The root and stem paste is used for curing sores. | [9] |
| *Vanda cristata* Wall. ex Lindl. | Fresh juice is consumed as a tonic to promote body growth and treat cough and cold. | [10] |

## 2. CONSERVATION STATUS AND THREATS

According to the APG III classification system (2009), *Orchidaceae* is divided into five subfamilies, namely, *Apostasioideae*, *Cypripedioideae*, *Vanilloideae*, *Epidendroideae*, and *Orchidoideae* [17]. In present, there are 28,484 recognized and accepted species within the family [18]. These plants are highly sensitive to pollution in their habitats and require special attention to ensure their survival [19]. The entire group of orchids faces threats due to the severe reduction of forest areas. In addition, habitat degradation and various human activities have led to a decline in a number of certain orchid species in India [20]. According to reports, over 50% of orchid species face threats due to their extensive use in traditional medicine. Primarily due to habitat degradation and extensive collection, approximately 90% of *Cypripedioideae* species (slipper orchids) in the Global Red List are declared as threatened [21]. Appendix I of the Red List includes *Renanthera imschootiana* (commonly known as "Red Vanda" in Manipur), and approximately ten species of *Paphiopedilum*. The *Liparis olivacea* has become extinct and *Dactylorhiza hatagirea* (Himalayan medicinal orchid) is critically endangered listed in Appendix I of convention on international trade in endangered species (CITES) [22,23]. Many orchid species are classified as endangered, rare, and included in Appendix II of CITES due to natural and human-induced threats. The Appendix II lists 1295 species from 179 genera found in India, including *Aerides*, *Acampe*, *Androcorys*, *Bulbophyllum*, *Ceratostylis*, *Cymbidium*, *Dactylorhiza*, *Epipactis*, *Gastrochilus*, *Goodyera*, *Habenaria*, *Herminium*, *Liparis*, *Malaxis*, *Nervilia*, *Ornithochilus*, *Peristylis*, *Pholidota,* and *Rhynchostylis retusa* [24]. By the end of 2017, 948 orchid species had been mentioned in the IUCN Global Red List, with approximately 56.5% classified as threatened [25]. Therefore, to prevent these rare plants continued extinction, their protection and conservation must be given the highest priority.

## 3. CONSERVATION MEASURES

The legislative measures, *in situ* preservation in sanctuaries/reserves and *ex situ* preservation in orchidaria/botanical gardens are the three primary approaches for safeguarding the genetic resources of orchid species [26].

### 3.1. Governmental Action

The IUCN maintains a protection program for CITES of wild plants and animals. Orchids are recognized as threatened species under this agreement. The endangered and extinct species are listed in Appendix I, where the trade of wild plants is strictly prohibited. However, the trade of cultivated and artificially propagated plants is allowed with proper authorization. The species listed in Appendix II may be at risk if trade is not carefully regulated. Almost, all members of the *Orchidaceae* family are listed in Appendix II. In India, the Wildlife Protection Act (1972) enacted by the government includes *R. imschootiana* (Red Vanda) and *Vanda coerulea* (Blue Vanda) in Schedule VI. The laws have played a crucial role in illegally collecting orchids from the wild [27].

### 3.2. *In situ* Conservation

*In situ* conservation aims to protect all living things, particularly wild flora, fauna, and threatened species within their natural environment. Turkey is the first to have a national strategy for preserving genetic diversity in its natural habitat [28]. Examples of *in situ* preservation include biosphere reserves, sanctuaries, and national parks. A biosphere reserve is a large protected area for the preservation of plant and animal resources where certain activities such as plantation, agriculture, grazing, tree cutting, hunting, and poaching are strictly prohibited. The "Man and Biosphere" initiative, proposed by United Nations educational, scientific, and cultural organization (UNESCO), introduced the concept of biosphere reserves in 1971. The first biosphere reserve in the world was established in 1979 [27]. At present, there are 738 biosphere reserves in 134 countries, including 22 transboundary locations. In India, there are 18 biosphere reserves, namely, Agasthyamalai, Kachchh, Cold Desert, Great Nicobar, Manas, Sunderbans, Similipal, Dibru-Saikhowa, Panna, Seshachalam hills, Achanakmar Amarkantak, Nanda Devi, Nilgiri, Nokrek protecting rare, endangered, and vulnerable orchid species. Similipal is the ninth biosphere reserve in India, containing 96 orchid species listed by UNESCO. It serves as a reservoir for epiphytic and terrestrial orchids in Odisha. *Eria meghasaniensis* and *Tainia hookeriana* are endemic orchids found exclusively in Similipal Biosphere Reserve [29].

A national park is a highly significant area with stunning landscapes protected and maintained by the government to conserve flora and fauna. The human activities such as mining, hunting, and fishing are prohibited in national parks to preserve their natural areas. The Jim Corbett National Park, established in 1936, was the first national park in India. At present, there are 106 active national parks in India, including Rani Jhansi Marine, Mount Harriett, Papikonda, South Button Island, Indravati, Khirganga,

and Great Himalayan, which collectively cover an area of 44,402.95 km$^2$ (National Wildlife Database 2023). Ninety-Six different orchid species inhabit the Similipal National Park in Odisha, while the Buxa Tiger Reserve in West Bengal has 150 different orchid species [27]. The Kaziranga Orchid National Park is the largest orchid national park having approximately 600 types of wild orchids collected from North-east India.

Sacred groves are small areas holding religious importance to preserve various plants and animal species useful for food, medicine, and other purposes [30]. The various states of India, including Himachal Pradesh, Karnataka, Maharashtra, West Bengal, and Chhattisgarh are well-known for their sacred groves. There are 13,270 known sacred groves in India, and 5627 are located in the Indian Himalayan area. In Arunachal Pradesh, Sessa Orchid Sanctuary is the first and only protected area in the country for the preservation of naturally growing orchids. Hadimba Devi (Kullu District of Himachal Pradesh) recorded *Calanthe tricarinata*, *Epipactis helleborine*, and *Herminium lanceum*, while Rupasana Devi reported *E. helleborine*, *Habenaria edgeworthii*, and *H. lanceum*. The sacred groves of Jamdagni Rishi are inhabited by *H. edgeworthii*, *Goodyera repens*, *E. helleborine*, and *Spiranthes sinensis* while *C. tricarinata*, and *H. edgeworthii* are found in the sacred groves of Shangchul Rishi [31].

### 3.3. *Ex situ* Conservation

*Ex situ* conservation is a method of protecting species (plants or animals) outside their original environment. It involves relocating genetic material from its native location, allowing for easy access to germplasm for research and utilization. It is considered the most practical, cost-effective, and widely practiced form of conservation. In India, the Botanical Survey of India maintains three National Orchidaria and Experimental Gardens, located in Yercaud, Howrah, and Shillong. The State Forest Research Institute of Arunachal Pradesh carries out *ex situ* conservation by preserving a variety of orchid species in the Orchid Research Centre situated in Tipi, Itanagar, Dirrang, Jenging, and Sessa [27].

The most popular *ex situ* conservation techniques include a botanical garden, *in vitro* propagation, cryopreservation, gene banks, and seed storage. A botanical garden, also referred to as a botanic garden, is a collection of living plants and plays a key role in conservation. Organizations like the New York Botanical Garden and Royal Botanic Garden (Kew) maintain living orchid collections, and conduct ongoing research initiatives [31]. In India, there are currently 13 botanical gardens that preserve various orchid species. The Lloyd Botanical Garden in Darjeeling, West Bengal, has 43 collected orchid species [27]. The Botanical Garden and National Orchidarium, located near Umiam Lake in Barapani, is approximately 22 km from Shillong has 419 orchid species from 94 genera collected from various states in North-east India. Each species is documented with its botanical name, place of collection, flowering-fruiting season, habitat, and IUCN status. The major orchid genera preserved in the garden include *Bulbophyllum*, *Dendrobium*, *Coelogyne*, *Cymbidium*, *Liparis*, *Oberonia*, and *Paphiopedilum*. In addition, the orchidarium recorded other fascinating genera such as *Anoectochilus brevilabris*, *Acanthephippium sylhetense*, *Armodorum senapatianum*, *Bulbophyllum rothschildianum*, *Cymbidium dayanaum*, *Neogyna gardneriana*, *Paphiopedilum venustum*, and *R. imschootiana*.

A seed bank is designed to preserve and protect the genetic diversity of seeds. The largest seed bank is the Millennium Seed Bank, located in Sussex, which is operated and supervised by the Royal Botanic Gardens, Kew. Orchids produce numerous seeds within a single capsule. However, these seeds lack a viable endosperm under natural conditions and require a specific mycorrhizal association for germination. As a result, the germination rate of orchid seeds is typically low. The orchid seeds (*Dactylorhiza*, *Dendrobium*, *Eulophia*, and *Paphiopedilum*) are preserved at −70°C to maintain their high viability. These seeds have shown excellent potential for long-term storage at low temperatures [27].

Cryopreservation is a technique used to preserve plant organs and reproductive components by storing them in liquid nitrogen at a temperature of −196°C. Cryopreservatives are particularly useful for preserving seeds with high moisture content. The orchid tissues and explants can be successfully cryopreserved in liquid nitrogen cylinders by treating them with cryoprotectants and plant vitrification solutions. In India, Cryobank facilities have been established by the national bureau of plant genetic resources, which preserves 2.5 lakh germplasm lines [27]. This technique has become an affordable method for preserving endangered species.

The *in vitro* technique is a biotechnology method used for secondary metabolite production, virus eradication, and mass propagation [32]. The various types of explants, including seeds, shoots, roots, leaf apexes, nodal segments, rhizomes, and pseudobulbs have been commonly used to micropropagate different orchid species [33]. This technique enables the production of healthy and disease-free plants on a large scale. It is highly effective for conserving the gene pool and biodiversity. The *in vitro* culture is the only viable method to preserve and reintroduce threatened genetic material into the environment. It is considered the best technique for conserving rare or endangered orchids with ornamental and medicinal significance [34].

## 4. CONCLUSION AND FUTURE PERSPECTIVES

The conservation of orchids is a critical task that demands immediate attention and action. By implementing effective conservation strategies, we can secure the survival of orchid species and preserve the benefits they provide to the environment and society. It is vital to prevent the extinction of orchids and safeguard their ecological and cultural significance. These strategies should encompass habitat preservation, particularly in areas abundant with orchids, and regulation of harvesting practices. The local people should be made aware to protect the wild orchids in their area. Hence, public awareness can play a significant role in promoting orchid conservation. Overall, orchid conservation necessitates collaborative efforts from governments, organizations, scientists, and the general public to preserve these exquisite and ecologically significant medicinal plants for future generations.

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All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agreed to be accountable for all aspects of the work.

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## APPENDIX

**Appendix I**

| Botanical name | IUCN Status |
|---|---|
| *Renanthera imschootiana* (Rolfe) | Endangered |
| *Paphiopedilum charlesworthii* (Rolfe) | Endangered |
| *Paphiopedilum druryi* (Bedd.) Stein | Critically Endangered |
| *Paphiopedilum fairrieanum* (Lindl.) Stein | Critically Endangered |
| *Paphiopedilum hirsutissimum* (Lindl. ex Hook.) Stein | Vulnerable |
| *Paphiopedilum insigne* (Wall. ex Lindl.) Pfitzer | Endangered |
| *Paphiopedilum spicerianum* (Rchb. f.) Pfitzer | Endangered |
| *Paphiopedilum venustum* (Wall. ex Sims) Pfitzer | Endangered |
| *Paphiopedilum villosum* (Lindl.) Stein | Vulnerable |
| *Paphiopedilum wardii* Summerh | Endangered |
| *Liparis olivacea* Lindl. | Extinct |
| *Dactylorhiza hatagirea* (D. Don) Soo | Critically Endangered |

**Appendix II**

| Botanical name | IUCN Status |
|---|---|
| *Aerides odorata* Lour | Endangered |
| *Acampe praemorsa* (Roxb.) Blatt. & Mc Cann | Least Concern |
| *Androcorys angustilabris* (King & Pantl.) | Near threatened |
| *Bulbophyllum helenae* (Kuntze) J.J. Sm | Endangered |
| *Ceratostylis subulata* Blume | Near threatened |
| *Cymbidium iridioides* (D. Don) | Near threatened |
| *Dactylorhiza hatagirea* (D. Don) Soo | Critically endangered |
| *Epipactis helleborine* (L.) Crantz | Threatened |
| *Gastrochilus calceolaris* (Buch.-Ham. ex Sm.) D. Don | Critically endangered |
| *Goodyera repens* (L.) R.Br. | Near threatened |
| *Habenaria intermedia* D. Don | Endangered |
| *Malaxis acuminata* D. Don | Endangered |
| *Liparis odorata* (Willd.) Lindl. | Near threatened |
| *Nervilia crociformis* (Zoll. ex Moritzi) Seidenf | Near threatened |
| *Ornithochilus difformis* (Wall. ex Lindl.) Schltr | Near threatened |
| *Pholidota pallida* Lindl. | Near threatened |
| *Peristylis lacertiferus* (Lindl.) | Endangered |
| *Peristylis lacertiferus* (Lindl.) J.J. Sm. | Endangered |
| *Rhynchostylis retusa (L.)* | Endangered |