The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

Indigenous Orchids as a Promising Source of Bioactive Compounds for Pharmaceutical Applications

Dr. Johnnita Tirkey
Assistant Professor, Dept. of Botany
BJB Autonomous College, Bhubaneswar

Abstract

The family Orchidaceae is among the most diverse groups of flowering plants and is increasingly vulnerable to various threats. Habitat loss and climate change have placed many orchid species at risk, while illegal collection for ornamental purposes, traditional practices, food, and medicinal uses further contributes to their decline. This review examines the geographic distribution of rare and endangered orchid species, explores activities associated with their trade, highlights the economic significance of commercially valuable orchids, and discusses existing conservation strategies. The aim is to identify broader approaches that can effectively address these threats while supporting targeted conservation efforts for species facing the greatest risk of extinction.

Keywords: Orchidaceae, Northeast India, Bioactive compounds, Medicinal orchids, Biodiversity conservation, Endemic species, Phytochemical potential

Introduction

Orchidaceae is one of the largest families of flowering plants, comprising about 29,199 species worldwide. India harbors approximately 1,331 orchid species belonging to 186 genera, representing nearly 6% of global orchid diversity. The Eastern and North-eastern Himalayas, North-western Himalayas, Peninsular India, and the Andaman and Nicobar Islands are the major orchid-rich regions of the country.[1][2][3]

North-eastern India is the most important center of orchid diversity in India, supporting around 870 species across 159 genera, which accounts for nearly 73% of the nation's orchid flora.[4][5] The region includes Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and the Darjeeling Himalayas. Favorable climatic conditions, including high humidity and abundant rainfall, provide ideal habitats for diverse orchid species. Arunachal Pradesh, Sikkim, and Meghalaya possess the highest orchid richness in the region.[6][7][8]

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

The region is also characterized by a high degree of endemism and contains several monotypic genera and rare orchid species. Notable genera include *Aerides*, *Bulbophyllum*, *Coelogyne*, *Cymbidium*, *Dendrobium*, *Paphiopedilum*, *Rhynchostylis*, and *Vanda*, many of which are valued for their ornamental and economic importance.[9][10]

Despite their significance, orchids face increasing threats from habitat loss, climate change, and illegal collection. Several species, including *Paphiopedilum* spp. and *Renanthera imschootiana*, [11] are listed under Appendix I of CITES, while the remaining Orchidaceae are protected under Appendix II. [12][13] Therefore, effective conservation strategies, including habitat protection, sustainable utilization, and ex situ propagation, are essential for preserving the rich orchid diversity of Northeast India.[14][15]

Epiphytic orchids in India are especially abundant in the north-eastern region, where they thrive at elevations of up to 2,000 meters above mean sea level.[16] This area is recognized as an important center of orchid diversity and serves as the natural habitat for numerous species with exceptional ornamental value. [17][18][19] Notable orchids native to this region include species of *Aerides*, *Arundina*, *Arachnis*, *Bulbophyllum*, *Calanthe*, *Coelogyne*, *Cymbidium*, *Dendrobium*, *Paphiopedilum*, *Phaius*, *Pleione*, *Renanthera*, *Rhynchostylis*, *Thunia*, and *Vanda*. Many of these orchids are highly prized for their attractive flowers, making them important resources for horticulture, floriculture, and ornamental plant breeding.[20][21]

The Eastern Himalayas and North-eastern India, comprising the Darjeeling region of West Bengal and the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, represent the richest orchid-growing region in the country. [22][23] Characterized by a warm climate, high humidity, and abundant rainfall, this region supports around 870 orchid species belonging to 159 genera, accounting for nearly 73% of India's total orchid diversity.[24][25][26] Among these states, Arunachal Pradesh records the highest orchid richness with 622 species, followed by Sikkim with 543 species and Meghalaya with 389 species. Other states also contribute significantly, including Assam (290 species), Nagaland (246), Mizoram (234), Manipur (215), and Tripura (57). [27]

Orchids in this region occupy a wide range of habitats, extending from tropical forests to alpine ecosystems. They can be found growing on forest trees, secondary vegetation, riverbanks, bamboo and palm groves, forest floors, grassy hillsides, and rocky terrains. Due to their ecological and economic importance, orchids are considered an integral component of farming system research and biodiversity conservation initiatives.[28]

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

Eastern Himalayas and North-Eastern India

A notable feature of the North-eastern region is the presence of several endemic orchid species, many of which are restricted not only to this region but also to specific states and hill ranges such as the Sikkim and Arunachal Himalayas, the Naga and Manipur Hills, the Lushai–Mizo Hills, and the Khasi–Jaintia Hills. Examples include *Dendrobium spatella*, *Dendrobium parciflorum*, and *Luisia macrotis* from Assam; *Vanda coerulea* and *Dendrobium palpebrae* from Arunachal Pradesh; *Renanthera imschootiana* and *Cymbidium tigrinum* from Nagaland; and several species native to Meghalaya, including *Anoectochilus crispus*, *Cymbidium eburneum*, *Habenaria khasiana*, *Paphiopedilum venustum*, and *Tainia khasiana*. [29][30][31][32]. Other state-specific endemic orchids include *Ascocentrum ampullaceum* var. *auranticum* and *Vanda stangeana* from Manipur, *Calanthe whiteana* and *Vanda pumila* from Sikkim, *Renanthera imschootiana* from Tripura, and *Dendrobium palpebrae* from Mizoram. These endemic orchids highlight the exceptional biodiversity and conservation significance of North-eastern India.[33]

North-eastern India is recognized for its remarkable orchid diversity and contains the highest number of monotypic orchid genera in the country. These genera are represented by a single species and include *Anthogonium*, *Arundina*, *Acrochaene*, *Bulleyia*, *Cremastra*, *Cleisocentron*, *Dickasonia*, *Diglyphosa*, *Eriodes*, *Herpysma*, *Jejosephia*, *Mischobulbum*, *Myrmechis*, *Neogyne*, *Ornithochilus*, *Risleya*, *Renanthera*, and *Tipularia*. The presence of these unique genera highlights the evolutionary and ecological significance of the region.[34][35].

The region is also a repository of numerous rare orchid species. Some notable examples include *Acanthephippium sylhetense*, *Anoectochilus grandiflora*, *Bulbophyllum leptanthum*, *Calanthe alpina*, *Coelogyne arunachalensis*, *Cymbidium eburneum*, *Dendrobium chrysotoxum*, *Dendrobium densiflorum*, *Eria fragrans*, *Eulophia candida*, *Galeola cathcarti*, *Habenaria khasiana*, *Liparis acuminata*, *Nervilia scottii*, *Phaius tankervilliae*, *Phalaenopsis mastersii*, *Pleione praecox*, *Tainia khasiana*, *Thunia marshalliana*, and *Vanda parviflora*. These species contribute substantially to the botanical richness and conservation value of North-eastern India.[36][37].

India also supports several highly valuable orchid species that are internationally recognized as threatened and are protected under Appendix I of the Convention on International Trade in Endangered Species (CITES). Among these are species belonging to the genus *Paphiopedilum*, including *Paphiopedilum charlesworthii*, *Paphiopedilum druryi*, and *Paphiopedilum fairrieanum*. [38]. Their

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

inclusion in Appendix I reflects the urgent need for strict conservation measures and regulation of international trade to prevent further population declines in the wild.

Several orchid species found in India are recognized as highly threatened and receive the highest level of international protection under Appendix I of CITES. These include species of *Paphiopedilum* such as *P. charlesworthii*, *P. druryi*, *P. fairrieanum*, *P. hirsutissimum*, *P. insigne*, *P. spicerianum*, *P. venustum*, *P. villosum*, and *P. wardii*, along with *Renanthera imschootiana*. Trade in these species is subject to strict controls because of their high risk of extinction in the wild.[40]

In contrast, Appendix II of CITES covers species that are not currently endangered but could become threatened if international trade remains unregulated. With the exception of the ten *Paphiopedilum* species and *Renanthera imschootiana* listed under Appendix I, the entire orchid family (*Orchidaceae*) is included in Appendix II. [41.] This classification ensures that commercial exploitation does not negatively affect the long-term survival of orchid populations.

India possesses an extraordinary diversity of orchids represented by a large number of genera protected under Appendix II. These include genera such as *Aerides*, *Anoectochilus*, *Arundina*, *Ascocentrum*, *Bulbophyllum*, *Calanthe*, *Cleisostoma*, *Coelogyne*, *Cymbidium*, *Cypripedium*, *Dendrobium*, *Eria*, *Eulophia*, *Gastrochilus*, *Goodyera*, *Habenaria*, *Herminium*, *Liparis*, *Luisia*, *Malaxis*, *Nervilia*, *Oberonia*, and many others. Some genera, including *Bulbophyllum* and *Dendrobium*, are particularly species-rich, each represented by more than one hundred species in the country.[41].

The inclusion of such a vast number of orchid taxa under CITES highlights both their ecological significance and their vulnerability to overexploitation. These international conservation measures play a crucial role in regulating trade, protecting natural populations, and promoting sustainable management of orchid diversity in India.

State	Area (000 km²)	Dense Forest (000 km²)	% Forest Cover	Genera	Species
Arunachal Pradesh	83,743	54,542	65.13	130	600
Assam	78,438	15,842	20.19	101	395
Manipur	22,327	5,309	23.77	90	389

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

Meghalaya	22,429	3,305	14.73	98	352
Mizoram	21,081	4,279	20.29	86	253
Nagaland	16,579	3,531	21.29	108	423
Sikkim	7,096	2,403	38.86	144	561
Tripura	10,488	1,825	17.40	29	39
Odisha	155,207	28,290	33.67	50	160

Table 1. Distribution of orchids under forest cover in Northeast India (modified from GUPTA *et al.: 2024[42]*

Figure 1. Representative medicinal and ornamental orchids of Northeast India: (A) *Dendrobium nobile*, (B) *Vanda coerulea*, (C) *Rhynchostylis retusa*.

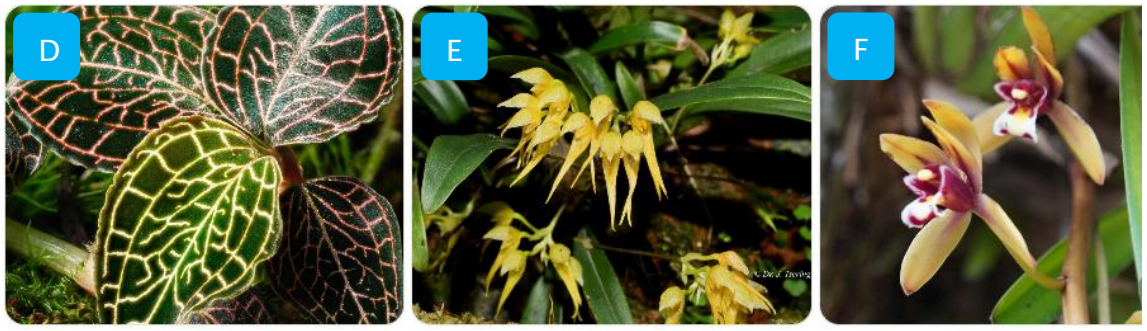

Figure 2. Indigenous orchid species with reported medicinal properties: (D) *Anoectochilus roxburghii*, (E) *Bulbophyllum* spp., (F) *Cymbidium aloifolium*.

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

Figure 3. Selected orchid species known for bioactive compounds and therapeutic potential: (G) *Coelogyne cristata*, (H) *Phaius tankervilleae*, and (I) *Vanda tessellata*.

Orchids from North-eastern India possess considerable medicinal value, particularly species belonging to genera such as *Acampe*, *Bulbophyllum*, and *Dendrobium*. Although research has identified medicinal properties in several orchids, a large proportion of species remain insufficiently studied. [43] Among approximately 145 medicinally important orchid species reported from the region, active bioactive compounds have been documented in only 54 species, suggesting a vast and largely unexplored source of therapeutic substances.[44]

Further investigation is essential to identify, characterize, and validate the pharmacological potential of these orchids. Their rich diversity of secondary metabolites offers significant opportunities for the discovery of novel pharmaceutical compounds. Studies have indicated that certain orchid-derived substances exhibit promising activity against serious health conditions, including cancer, thereby highlighting their potential role in future drug development.[44][45] In addition, orchids with antimicrobial properties may serve as valuable resources for the development of new antibacterial and antifungal agents.

Comprehensive research involving phytochemical analysis, compound isolation, and biological evaluation is needed to fully realize the medicinal potential of these species. Such efforts may lead to the discovery of innovative treatments for diseases including cancer, tumors, neurological disorders, and microbial infections. Detailed information on medicinal orchid species from North-eastern India and their associated bioactive compounds.[46][47]

Orchid Species	Bioactive Compound(s)	Pharmacological Activity

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

Dendrobium nobile	Dendrobine, Dendroxine, Nobilonine	Neuroprotective, anticancer, anti-inflammatory
Dendrobium chrysotoxum	Chrysotoxene, Chrysotoxine, Bibenzyls	Antioxidant, antimicrobial, anticancer
Dendrobium densiflorum	Moscatilin, Gigantol	Antitumor, antioxidant
Bulbophyllum neilgherrense	Phenanthrenes, Flavonoids	Antimicrobial, antioxidant
Bulbophyllum odoratissimum	Bibenzyl derivatives	Anticancer, anti-inflammatory
Vanda tessellata	Alkaloids, Glycosides, β-sitosterol	Anti-inflammatory, analgesic, wound healing
Vanda coerulea	Flavonoids, Anthocyanins	Antioxidant, antimicrobial
Rhynchostylis retusa	Phenolics, Tannins, Flavonoids	Antimicrobial, anti-inflammatory
Aerides odorata	Alkaloids, Phenolics	Antibacterial, antioxidant
Acampe papillosa	Flavonoids, Terpenoids	Antioxidant, antimicrobial
Anoectochilus roxburghii	Kinsenoside, Flavonoids, Polysaccharides	Hepatoprotective, antidiabetic, antioxidant
Anoectochilus formosanus	Kinsenoside	Anti-inflammatory, immunomodulatory
Pholidota articulata	Phenanthrene derivatives	Antioxidant, antimicrobial
Phaius tankervilleae	Phenolics, Flavonoids	Anti-inflammatory, antioxidant
Cymbidium aloifolium	Alkaloids, Glycosides, Triterpenoids	Antimicrobial, wound healing
Cymbidium bicolor	Phenolics, Flavonoids	Antioxidant activity
Coelogyne cristata	Coelogin, Gigantol	Antimicrobial, cytotoxic activity
Calanthe triplicata	Phenanthrenes, Calanquinone	Antioxidant, anticancer
Eulophia nuda	Eulophiol, Phenolic compounds	Anti-inflammatory, antimicrobial
Habenaria intermedia	β-Sitosterol, Phenolics	Adaptogenic, rejuvenating properties

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

Malaxis acuminata	Gigantol, β-Sitosterol	Immunomodulatory, antioxidant
Nervilia aragoana	Flavonoids, Phenolics	Antimicrobial, anti-inflammatory
Vanilla planifolia	Vanillin, Vanillic acid	Antioxidant, antimicrobial

Table 2: bioactive compounds reported from medicinal and indigenous orchids of Northeast India and India

Compound Class	Examples	Biological Activities
Alkaloids	Dendrobine, Nobilonine	Neuroprotective, analgesic
Phenanthrenes	Coelogin, Phenanthrene derivatives	Anticancer, antimicrobial
Bibenzyls	Gigantol, Moscatilin	Antitumor, antioxidant
Flavonoids	Quercetin derivatives	Antioxidant, anti-inflammatory
Terpenoids	Triterpenes, Sesquiterpenes	Antimicrobial, anti-inflammatory
Phenolic Compounds	Vanillic acid, Phenolics	Antioxidant, antimicrobial
Glycosides	Kinsenoside	Antidiabetic, hepatoprotective
Polysaccharides	Orchid polysaccharides	Immunomodulatory

Table 3: Major Classes of Bioactive Compounds Found in Orchids

Discussion

Orchids are among the most diverse groups of flowering plants and have long been recognized for their medicinal importance in traditional healthcare systems. Indigenous orchid species found in Northeast India and other biodiversity-rich regions possess a wide range of bioactive compounds that contribute to their therapeutic properties. These compounds include alkaloids, flavonoids, phenanthrenes, bibenzyls, terpenoids, glycosides, and phenolic substances, many of which have demonstrated significant pharmacological activities.[48]

Among the medicinal orchids, species of *Dendrobium* have received considerable scientific attention because of their rich phytochemical composition. Compounds such as dendrobine, moscatilin, and gigantol have shown promising antioxidant, anti-inflammatory, neuroprotective, and anticancer properties. Similarly, *Anoectochilus* species contain kinsenoside, a bioactive glycoside known for its hepatoprotective, antidiabetic, and immunomodulatory effects. These findings suggest that orchids may

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

serve as valuable sources of novel therapeutic agents for the treatment of chronic and degenerative diseases.[49][50][51]

Phenanthrene and bibenzyl derivatives are among the most important secondary metabolites isolated from orchids. These compounds exhibit strong antimicrobial and cytotoxic activities, making them potential candidates for the development of anticancer drugs.[52] For example, moscatilin isolated from *Dendrobium* species has been reported to inhibit tumor cell proliferation and metastasis. Likewise, gigantol has demonstrated antioxidant and anti-inflammatory activities, highlighting its pharmaceutical significance. The presence of such compounds underscores the importance of orchids as reservoirs of bioactive molecules with potential clinical applications.[53].

Many indigenous orchids also possess antimicrobial properties. Extracts from species such as *Vanda tessellata*, *Rhynchostylis retusa*, and *Aerides odorata* have shown effectiveness against various bacterial and fungal pathogens. In an era marked by increasing antimicrobial resistance, these orchids may provide alternative sources of natural antimicrobial agents. Furthermore, their traditional use in wound healing and infection management supports the need for scientific validation of their medicinal efficacy.[54][55][56].

Despite their immense medicinal value, only a small proportion of orchid species have been subjected to detailed phytochemical and pharmacological investigations. Studies indicate that among the numerous medicinal orchids reported from Northeast India, active compounds have been identified in only a fraction of the species.[57] This gap highlights the vast untapped potential of orchid biodiversity. Comprehensive research involving phytochemical screening, compound isolation, structural characterization, and biological evaluation is essential to discover new bioactive molecules and understand their mechanisms of action.[58]

Conservation of medicinal orchids is equally important because many species are threatened by habitat destruction, overexploitation, illegal collection, and climate change. The growing demand for medicinal and ornamental orchids has placed additional pressure on natural populations. Sustainable harvesting practices, ex situ propagation, tissue culture techniques, and strict implementation of conservation policies are necessary to ensure the long-term survival of these valuable genetic resources.[59][60].

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

Conclusion

Orchids constitute one of the largest and most diverse families of flowering plants, with Northeast India representing a major center of orchid diversity and endemism. The region's favorable climatic conditions, varied topography, and rich forest ecosystems support a remarkable assemblage of orchid species, many of which possess significant ornamental, ecological, medicinal, and economic value. Several rare, endemic, and threatened orchids are found in this biodiversity hotspot, highlighting its importance for conservation and sustainable utilization.

The review of indigenous orchids reveals that these plants are not only valuable components of natural ecosystems but also promising sources of bioactive compounds with potential pharmaceutical applications. Various orchid species contain alkaloids, flavonoids, phenanthrenes, bibenzyls, glycosides, and other secondary metabolites that exhibit antimicrobial, antioxidant, anti-inflammatory, antidiabetic, neuroprotective, and anticancer properties. Species belonging to genera such as *Dendrobium*, *Bulbophyllum*, *Vanda*, *Anoectochilus*, and *Cymbidium* have demonstrated considerable medicinal potential. However, despite the large number of orchid species reported from the region, only a limited proportion has been investigated for their phytochemical composition and biological activities, indicating substantial opportunities for future research.

At the same time, orchid populations face increasing threats from habitat degradation, deforestation, climate change, and unsustainable harvesting for ornamental and medicinal purposes. Many species have become rare or endangered, necessitating urgent conservation measures. Effective strategies should integrate in situ and ex situ conservation approaches, habitat restoration, tissue culture propagation, sustainable utilization practices, and stricter enforcement of regulations governing orchid trade.

Future research should focus on systematic documentation of orchid diversity, isolation and characterization of novel bioactive compounds, pharmacological validation of traditional uses, and development of sustainable cultivation techniques. Such multidisciplinary efforts will not only contribute to biodiversity conservation but also promote the discovery of new therapeutic agents. Therefore, indigenous orchids represent an invaluable natural resource whose conservation and scientific exploration are essential for ecological sustainability, economic development, and advancement of human health.

The Brāhmī, International Multidisciplinary Research Journal
(Peer Reviewed, Referred & Open Access Journal)
Volume: 03 | Issue: 01 | Mar - May, 2026 | ISSN: 3048-9660 (Online) | www.thebrahmi.com

References

1. Chase, M.W., Cameron, K.M., Freudenstein, J.V., et al. (2015). An updated classification of Orchidaceae. *Botanical Journal of the Linnean Society*, 177, 151–174.
2. Govaerts, R., Bernet, P., Kratochvil, K., et al. (2017). World Checklist of Orchidaceae. Royal Botanic Gardens, Kew.
3. Fay, M.F. (2018). Orchid conservation: how can we meet the challenges in the twenty-first century? *Botanical Studies*, 59, 16.
4. Hinsley, A., de Boer, H.J., Fay, M.F., et al. (2018). A review of the trade in orchids and its implications for conservation. *Botanical Journal of the Linnean Society*, 186, 435–455.
5. Gale, S.W., Kumar, P., Hinsley, A., et al. (2018). Orchid conservation: bridging the gap between science and practice. *Botanical Review*, 84, 205–239.
6. Liu, H., Gale, S.W., Kumar, P., et al. (2015). Conservation of orchids. *Nature Plants*, 1, 15074.
7. Bhattacharjee, A. & Chowdhery, H.J. (2019). Orchid diversity and conservation in Northeast India. *Journal of Threatened Taxa*, 11, 14500–14515.
8. Singh, B., Mao, A.A., & Singh, K.P. (2022). Checklist of orchids of Nokrek Biosphere Reserve, Meghalaya. *Journal of Threatened Taxa*, 14, 21660–21695.
9. Gupta, A., Naorem, A., & Khuraijam, J.S. (2024). Medicinally important orchids of Northeast India: traditional knowledge and scientific validation. *Indian Journal of Traditional Knowledge*, 23, 1012–1028.
10. Sarmah, D.S., Gurung, N., Saini, P.S., et al. (2025). Advances in orchid conservation: biotechnology applications and global trade dynamics. *Frontiers in Conservation Science*, 6, 1653827.
11. Teoh, E.S. (2016). *Medicinal Orchids of Asia*. Springer, Cham.
12. Hossain, M.M. (2018). Therapeutic orchids: traditional uses and recent advances. *Journal of Medicinal Plants Studies*, 6, 89–95.
13. Pant, B. (2017). Medicinal orchids and their uses: tissue culture perspectives. *Botanical Research International*, 10, 1–10.
14. Gutiérrez, R.M.P. (2016). Orchids: a review of uses in traditional medicine, phytochemistry and pharmacology. *Journal of Medicinal Plants Research*, 10, 689–701.
15. Singh, A., Duggal, S., & Koul, K.K. (2017). Pharmacological potential of medicinal orchids. *Pharmacognosy Reviews*, 11, 33–40.

16. Chen, Y., Wang, X., & Luo, A. (2018). Bioactive constituents of *Dendrobium* species and their pharmacological activities. *Evidence-Based Complementary and Alternative Medicine*, 2018, 1–15.
17. Ng, T.B., Liu, J., & Wong, J.H. (2019). Review of bioactive compounds from orchids. *International Journal of Biological Macromolecules*, 123, 112–120.
18. He, C.N., Wang, C.L., & Guo, S.X. (2017). Medicinal value and phytochemistry of *Dendrobium*. *Chinese Journal of Natural Medicines*, 15, 721–739.
19. Li, Y., Wang, C., & Wang, Z. (2020). Orchid-derived phenanthrenes and bibenzyls: chemistry and bioactivities. *Phytochemistry Reviews*, 19, 1023–1045.
20. Xu, J., Zhao, W., & Liu, Y. (2021). Secondary metabolites from orchids and their pharmacological activities. *Molecules*, 26, 6710.
21. Pant, B., Raskoti, B.B., & Paudel, M.R. (2019). Traditional uses and medicinal significance of orchids. *Medicinal Plants*, 11, 1–13.
22. Kumar, P., Jalal, J.S., & Rawat, G.S. (2018). Medicinal orchids of the Indian Himalaya. *Journal of Orchid Society of India*, 32, 1–12.
23. Hossain, M.M., Kant, R., & Van, P.T. (2020). Orchid phytochemicals and their medicinal significance. *Biocatalysis and Agricultural Biotechnology*, 24, 101547.
24. Wang, H., Li, J., & Zhao, Y. (2021). Anticancer compounds from orchids: a review. *Frontiers in Pharmacology*, 12, 654321.
25. Mohapatra, P., Pramanik, K., & Jena, C. (2023). Medicinal and economic significance of orchids in India. *Indian Forester*, 149, 123–134.
26. Swarts, N.D., & Dixon, K.W. (2017). Perspectives on orchid conservation in a changing world. *Annals of Botany*, 120, 245–256.
27. Phelps, J. & Webb, E.L. (2017). Invisible trade: the conservation implications of orchid commerce. *Conservation Biology*, 31, 103–112.
28. Hinsley, A., Verissimo, D., & Roberts, D.L. (2016). Heterogeneity in consumer preferences for orchids. *Conservation Letters*, 9, 337–346.
29. Fay, M.F., Pailler, T., & Dixon, K.W. (2017). Orchid conservation and restoration. *Plant Diversity*, 39, 1–5.
30. Singh, B., Mao, A.A., & Singh, K.P. (2021). Orchid diversity of Meghalaya and conservation priorities. *Journal of Threatened Taxa*, 13, 18000–18020.
31. Chowlu, K. (2023). Orchids of Arunachal Pradesh. Botanical Survey of India.

32. Gogoi, K. (2022). Orchid diversity of Assam and conservation strategies. *Pleione*, 16, 45–58.
33. Rao, A.N. & Mani, M. (2020). Endemic orchids of Northeast India. *Indian Journal of Forestry*, 43, 210–219.
34. Estopinan, J., Servajean, M., Bonnet, P., et al. (2024). AI-based mapping of the conservation status of orchid assemblages at global scale. *Biodiversity Informatics*.
35. Singh, A.R. & Prabakaran, N. (2025). Orchid diversity, endemism and future research needs in Andaman and Nicobar Islands. *International Journal of Ecology and Environmental Sciences*.
36. Cardoso, J.C. (2018). Orchid biotechnology and micropropagation. *Plant Cell Culture Protocols*, 45–68.
37. Pant, B. (2018). Orchid micropropagation and conservation. *International Journal of Plant Biology*, 9, 23–31.
38. Teixeira da Silva, J.A. (2017). Advances in orchid tissue culture. *Plant Cell Reports*, 36, 1287–1300.
39. Yam, T.W. & Arditti, J. (2017). History of orchid propagation. *Botanical Review*, 83, 1–53.
40. Hossain, M.M. (2020). In vitro conservation of orchids. *Plant Tissue Culture and Biotechnology*, 30, 1–14.
41. Decruse, S.W. (2018). Cryopreservation techniques for orchid germplasm. *Plant Genetic Resources*, 16, 312–320.
42. Gupta, A., Naorem, A., & Khuraijam, J. S. (2024). *Medicinally important orchids of Northeast India: Traditional knowledge and scientific validation*. **Indian Journal of Traditional Knowledge, 23**(7), 638–654.
43. Sarmah, D.S. et al. (2025). Modern biotechnology for orchid conservation. *Frontiers in Conservation Science*, 6, 1653827.
44. Arditti, J. & Ernst, R. (2016). *Micropropagation of Orchids*. Wiley-Blackwell.
45. UNEP-WCMC (2024). CITES Trade Database for Orchidaceae.
46. CITES Secretariat (2023). *Checklist of Orchidaceae listed under CITES Appendices*.
47. Hinsley, A., Nuno, A., Ridout, M., et al. (2017). Demand reduction strategies for orchid trade. *Conservation Letters*, 10, 444–452.
48. Phelps, J., Carrasco, L.R., & Webb, E.L. (2018). Illegal orchid trade and conservation implications. *Biological Conservation*, 221, 271–279.
49. Verissimo, D., Roberts, D.L., & Hinsley, A. (2019). Consumer behavior in ornamental plant trade. *People and Nature*, 1, 567–578.

50. Bhatt, A. (2020). Orchid diversity and conservation status in India. *Indian Horticulture*, 65, 18–23.
51. Jalal, J.S., Kumar, P., & Singh, R.K. (2018). Orchidaceae of India: diversity and distribution. *Botanical Survey of India Bulletin*, 60, 45–67.
52. Medhi, R.P. & Chakrabarti, S. (2019). Orchids of Northeast India: diversity and utilization. *Floriculture and Ornamental Biotechnology*, 13, 1–15.
53. Devi, M.P., Pramanik, K., & Mohapatra, P. (2024). Conservation priorities for endangered orchids of India. *Indian Journal of Plant Sciences*, 13, 89–101.
54. Kumar, P. & Jalal, J.S. (2021). Endemic orchids of the Indian Himalaya. *Journal of Mountain Science*, 18, 1023–1035.
55. Gogoi, K. & Borah, D. (2020). Rare and threatened orchids of Assam. *Pleione*, 14, 50–62.
56. Singh, B. & Khuraijam, J.S. (2022). Orchid conservation in protected areas of Northeast India. *Journal of Threatened Taxa*, 14, 21000–21015.
57. Mohapatra, P. & Pramanik, K. (2023). Economic importance of orchids in Indian floriculture. *Indian Forester*, 149, 210–219.
58. Gupta, A., Naorem, A., & Khuraijam, J.S. (2024). Bioactive compounds of medicinal orchids from Northeast India. *Indian Journal of Traditional Knowledge*, 23, 1012–1028.
59. Sarmah, D.S., Gurung, N., Saini, P.S., et al. (2025). Global trade dynamics and conservation of orchids. *Frontiers in Conservation Science*, 6, 1653827
60. Hinsley, A., de Boer, H. J., Fay, M. F., Gale, S. W., Gardiner, L. M., Gunasekara, R. S., Kumar, P., Masters, S., Metusala, D., Roberts, D. L., & Veldman, S. (2018). A review of the trade in orchids and its implications for conservation. *Botanical Journal of the Linnean Society*, *186*(4), 435–455. https://doi.org/10.1093/botlinnean/box083