
Review Article

***Cycas beddomei* Dyer (Cycadaceae): an endangered endemic cycad of India**

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Abstract: *Cycas beddomei* Dyer, is a narrowly endemic cycad confined to the southern Eastern Ghats of Andhra Pradesh, India, and represents one of the most evolutionarily significant gymnosperms of the Indian flora. Owing to its restricted distribution, habitat degradation, illegal harvesting, low natural regeneration and fragmented populations, the species has become a major focus of conservation research. This review synthesizes the available literature on the taxonomy, nomenclature, distribution, ecology, reproductive biology, phytochemistry, physiology, molecular diversity, pharmacological potential and conservation status of *C. beddomei*. Recent taxonomic revisions and lectotypification have clarified its nomenclatural status, while field surveys have improved understanding of its geographical distribution and population structure. Molecular studies employing Inter Simple Sequence Repeat (ISSR) markers have revealed appreciable genetic variation among remnant populations, providing valuable information for conservation planning and germplasm management. Phytochemical investigations have identified bioactive constituents, including biflavanones, which contribute to the

species' antioxidant and potential anticancer properties. Physiological studies have further enhanced understanding of its photosynthetic adaptations under natural environmental conditions. Despite these advances, substantial knowledge gaps remain regarding reproductive ecology, population genetics, climate resilience, *ex situ* propagation and long-term monitoring. Effective conservation of *C. beddomei* requires integrated strategies encompassing habitat protection, population restoration, community participation, molecular-assisted conservation and strengthened implementation of national and international conservation policies. Consolidation of current knowledge and identifying future research priorities, present review provides a comprehensive scientific resource to support the conservation, sustainable management, and further investigation of this endangered and evolutionarily distinct cycad.

Keywords: Antioxidant activity, gymnosperm, phytoconstituents

Introduction

Cycads are among the oldest extant seed plants, representing a lineage that originated more than 280 million years ago and has survived multiple episodes of global environmental change. Their distinctive morphology, slow growth, dioecious reproductive system, and ecological specialization make them invaluable for understanding the evolution of gymnosperms and the history of terrestrial vegetation. Despite their evolutionary significance, cycads are among the most threatened groups of plants worldwide due to habitat destruction, overexploitation, low reproductive success and restricted geographic distributions. Consequently, conservation of cycad diversity has become a global priority. *Cycas beddomei* Dyer (Cycadaceae) is one of the most remarkable cycads of the Indian subcontinent. It is a narrow endemic species restricted to the southern Eastern Ghats, particularly the Tirupati–Kadapa hill ranges of Andhra Pradesh, India (Rao et al., 2010; Rao et al., 2015). The species inhabits dry deciduous forests, rocky hill slopes, and scrub forests, where it grows under harsh environmental conditions. Owing to its limited distribution, fragmented populations, and continuous decline in habitat quality, *C. beddomei* has attracted considerable attention from botanists, conservation biologists, and forest managers. Recent surveys have reported additional sub-populations within its native range; however, the overall extent of occurrence remains highly restricted, emphasizing the urgent need for effective conservation measures (Rao et al., 2015). The taxonomic history of *C. beddomei* has been the subject of extensive discussion because of its close morphological resemblance to several Indian species of *Cycas*. Advances in systematic studies have improved understanding of its diagnostic characters, phylogenetic relationships, and nomenclatural status. A significant contribution was the lectotypification of the species by Khuraijam et al. (2018), which clarified the application of the name and resolved historical ambiguities associated with its taxonomy. More recently, Nethaji et al. (2022) comprehensively reviewed the taxonomy and allied issues of *C. beddomei*, highlighting its distinctive morphological features, distribution, and systematic position within the genus. Such taxonomic clarification is essential for accurate identification, biodiversity documentation and conservation planning. The ecological importance of *C. beddomei* extends beyond its status as a rare endemic species. As a long-lived gymnosperm adapted to nutrient-poor rocky habitats, it contributes to

ecosystem stability and serves as an important component of the dry deciduous vegetation of the Eastern Ghats. However, natural populations face numerous anthropogenic and environmental threats, including habitat degradation, forest fires, mining activities, grazing, road construction and illegal collection of plants for ornamental and commercial purposes (Rao et al., 2010; Rao et al., 2015). These pressures have resulted in fragmented populations with poor natural regeneration, thereby increasing the risk of local extinction. Conservation of *C. beddomei* requires not only habitat protection but also a thorough understanding of its genetic diversity and population structure. Molecular markers have become indispensable tools for assessing genetic variation in threatened plant species. Rout et al. (2014) employed Inter Simple Sequence Repeat (ISSR) markers to evaluate the genetic diversity of *C. beddomei* populations and demonstrated considerable genetic polymorphism among sampled individuals. Their study provided baseline molecular information that can facilitate germplasm conservation, ex situ propagation, and population management. Such genetic investigations are increasingly recognized as fundamental components of evidence-based conservation programmes. With its ecological and evolutionary significance, *C. beddomei* has attracted scientific interest because of its phytochemical composition and medicinal potential. Phytochemical investigations have led to the isolation of a novel biflavanone from the species, indicating that it is a valuable source of biologically active secondary metabolites (Jayaprakasam et al., 2000). Subsequent pharmacological studies have demonstrated antioxidant activity (Baggiya and Sundararajan, 2015) and reported promising antitumour properties in experimental models (Hari et al., 2022). Although these findings are preliminary, they suggest that *C. beddomei* possesses considerable pharmaceutical potential while simultaneously underscoring the need for sustainable utilization that does not compromise wild populations. Physiological investigations have also contributed to understanding the adaptive biology of the species. Prabhakar and Rao (1981) examined photorespiration in *Cycas beddomei* and *Cycas circinalis*, providing early insights into the physiological characteristics of Indian cycads. Such studies enhance our understanding of the environmental adaptations that enable this species to survive under the dry climatic conditions of the Eastern Ghats and provide a foundation for future ecophysiological research. Although considerable progress has been made in taxonomy, ecology, phytochemistry, molecular biology, and conservation, information on *C. beddomei* remains scattered across diverse scientific publications. Furthermore, emerging issues such as climate change, habitat fragmentation, reproductive ecology, assisted propagation, restoration ecology, and long-term population monitoring require greater scientific attention. A comprehensive synthesis of existing knowledge is therefore essential to identify research gaps and support evidence-based conservation strategies. The present review aims to compile and critically evaluate the available literature on *Cycas beddomei* with emphasis on its taxonomy, distribution, ecology, reproductive biology, phytochemistry, physiology, molecular diversity, pharmacological importance, and conservation status. By integrating findings from classical botanical studies with recent molecular and conservation research, this review seeks to provide a comprehensive reference for researchers, conservation practitioners, forest managers and policymakers engaged in the protection and sustainable management of this evolutionarily significant and endangered Indian cycad.

Taxonomy and nomenclature

Cycas beddomei Dyer belongs to the family Cycadaceae and is one of the few cycad species endemic to India. The species was first described by Dyer and is distinguished from other Indian members of the genus by its compact habit, narrow and rigid leaflets and characteristic reproductive structures. Taxonomic confusion has existed because of morphological similarities with allied species such as *Cycas circinalis*. To stabilize the nomenclature, Khurajam et al. (2018) designated a lectotype for *C. beddomei*, thereby resolving historical ambiguities associated with the application of its scientific name. A comprehensive review by Nethaji et al. (2022) further clarified the taxonomy, diagnostic characters, and systematic position of the species, emphasizing its distinct identity and importance for floristic and conservation studies.

Distribution, habitat and ecology

Cycas beddomei is a narrow endemic species confined to the Tirupati–Kadapa hill ranges of the southern Eastern Ghats in Andhra Pradesh, India. It typically occurs on rocky hill slopes, open scrub forests, and dry deciduous forests growing on shallow, well-drained soils under semi-arid climatic conditions. The species is adapted to nutrient-poor substrates and survives in fragmented habitats where seasonal drought is common. Field investigations have identified additional sub-populations, but the overall geographic range remains highly restricted and fragmented. Habitat degradation, forest fires, grazing, mining activities and illegal collection have significantly reduced the quality and continuity of its natural habitats, posing serious threats to its long-term survival (Rao et al., 2010; Rout et al., 2014; Rao et al., 2015).

Morphology and reproductive biology

C. beddomei is a slow-growing, dioecious gymnosperm characterized by an unbranched stem crowned with pinnately compound leaves. The leaves possess narrow, coriaceous leaflets with revolute margins, while male plants bear cylindrical cones and female plants produce loosely arranged megasporophylls carrying ovules along their margins. Like other cycads, the species depends on successful pollination and seed development for natural regeneration, which is generally slow in wild populations. Limited seedling establishment, coupled with habitat disturbance and anthropogenic pressures, contributes to poor population recruitment. The reproductive biology of *C. beddomei* remains insufficiently understood, although available studies indicate that its restricted distribution and low regeneration make reproductive ecology an important priority for future research (Nethaji et al., 2022)

Phytochemistry

Phytochemical investigations have demonstrated that *C. beddomei* contains biologically active secondary metabolites with potential medicinal value. Jayaprakasam et al. (2000) reported the isolation and structural characterization of a novel biflavanone from the leaves of the species, representing one of the earliest detailed phytochemical studies on this endemic cycad. The occurrence of flavonoids and related phenolic compounds suggests that the species possesses significant antioxidant properties and

may serve as a valuable source of natural bioactive molecules. Although phytochemical research on *C. beddomei* remains limited compared with many medicinal plants, the available evidence indicates considerable potential for the discovery of pharmacologically important compounds through advanced metabolomic and phytochemical investigations.

Physiological studies

Physiological information on *C. beddomei* is limited, with photorespiration representing one of the earliest aspects investigated. Prabhakar and Rao (1981) compared photorespiratory characteristics of *C. beddomei* and *C. circinalis* and demonstrated that the species exhibits physiological features typical of C_3 plants. Their findings contributed to understanding carbon metabolism and photosynthetic performance in cycads and highlighted the adaptive mechanisms that enable the species to survive under the dry environmental conditions of the Eastern Ghats. Nevertheless, studies on photosynthesis, water-use efficiency, nutrient dynamics and responses to environmental stress remain scarce and warrant further investigation.

Molecular diversity and DNA profiling

Molecular characterization has become an essential tool for assessing genetic diversity in threatened plant species. Rout et al. (2014) evaluated the genetic diversity of *C. beddomei* using Inter Simple Sequence Repeat (ISSR) markers and detected substantial levels of polymorphism among sampled individuals. The study generated 86 amplified DNA fragments with a high proportion of polymorphic loci, indicating appreciable genetic variability despite the species' restricted distribution. Cluster analysis grouped the sampled populations into distinct genetic clusters, providing valuable baseline information for germplasm conservation, population management, and future breeding programmes. These molecular findings support the integration of genetic information into conservation planning for this endangered endemic species.

Pharmacological and antioxidant potential

Recent investigations have highlighted the pharmacological significance of *C. beddomei*. Extracts of the species have demonstrated appreciable antioxidant activity, suggesting the presence of phenolic and flavonoid constituents capable of scavenging free radicals (Baggiya and Sundararajan, 2015). Furthermore, Hari et al. (2022) reported promising antitumour activity of plant extracts in experimental studies, indicating their potential as sources of bioactive compounds for pharmaceutical development. Although these findings are encouraging, further studies involving compound isolation, toxicity evaluation, mechanism of action and clinical validation are necessary before therapeutic applications can be established.

Conservation status and threats

C. beddomei is recognized as one of India's most threatened gymnosperms because of its narrow distribution, fragmented populations, and continuous decline in habitat quality. Rao et al. (2010) reassessed its conservation status and emphasized that illegal collection for horticultural trade, habitat

destruction, forest fires, grazing, mining activities and poor natural regeneration constitute the principal threats to its survival. Subsequent field surveys documented additional sub-populations but confirmed that the species remains highly vulnerable because of its restricted extent of occurrence and continuing anthropogenic pressures (Rao et al., 2015). These findings underscore the urgent need for scientifically informed conservation strategies to prevent further population decline.

Current conservation initiatives

Conservation efforts for *C. beddomei* focus on habitat protection, population assessment, legal protection, and ex situ conservation. Updated distribution mapping and Red List reassessments have provided important information for conservation planning and prioritization (Rao et al., 2015). Molecular studies have contributed genetic information useful for germplasm conservation and restoration programmes (Rout et al., 2014), while recent reviews have emphasized the importance of integrating taxonomic clarification, ecological monitoring, propagation techniques, and community participation into long-term conservation strategies (Nethaji et al., 2022). As an endemic species of high conservation significance, *C. beddomei* also benefits from national biodiversity conservation initiatives and international attention directed toward cycad conservation.

Research gaps and future prospects

Despite considerable advances in taxonomy, conservation biology, molecular genetics, phytochemistry, and pharmacology, significant knowledge gaps remain regarding *C. beddomei*. Comprehensive studies on reproductive ecology, pollination biology, seed germination, population genetics using high-resolution molecular markers, climate change impacts, tissue culture, and restoration ecology are still lacking. Long-term ecological monitoring and genomic approaches would improve understanding of adaptive variation and population resilience. Future research should also focus on sustainable propagation protocols, metabolomic profiling, validation of medicinal properties, and community-based conservation programmes to ensure the long-term survival of this evolutionarily important endemic species. Integrating multidisciplinary research with effective habitat management will be essential for conserving *C. beddomei* in its natural environment (Rao et al., 2015; Nethaji et al., 2022; Rout et al., 2014).

Conclusion

C. beddomei is an evolutionarily significant and narrowly endemic gymnosperm that represents an invaluable component of India's botanical heritage. The available scientific evidence demonstrates that this species possesses considerable ecological, taxonomic, genetic, phytochemical and pharmacological importance. Research conducted over the past several decades has enhanced our understanding of its taxonomy, distribution, habitat preferences, physiological adaptations, molecular diversity, and medicinal potential, thereby providing a strong foundation for future scientific investigations and conservation planning. Despite these advances, the species continues to face serious challenges due to its restricted geographical distribution, habitat fragmentation, anthropogenic disturbances, illegal collection and poor natural regeneration. These factors have contributed to

declining populations and increased the risk of local extinction, emphasizing the need for immediate and sustained conservation efforts. An integrated conservation approach involving habitat protection, *ex situ* conservation, ecological restoration, scientific monitoring and community participation is essential to ensure the long-term survival of this endangered cycad. Future research should focus on reproductive ecology, pollination biology, population genetics, climate change resilience, tissue culture, genomics, metabolomics and large-scale restoration programmes. Such multidisciplinary studies will not only improve our understanding of the species but also facilitate the development of effective conservation and sustainable utilization strategies. Conserving *C. beddomei* is of paramount importance, not only for preserving one of the world's oldest lineages of seed plants but also for safeguarding the unique biodiversity of the Eastern Ghats and the valuable genetic resources it represents for future generations.

References

- Baggiya SD and Sundararajan R. (2015). *In-vitro* antioxidant activity of *Cycas beddomei*. International Journal of Phytomedicine. 7(4): 468-467. <https://ijp.arjournals.org/index.php/ijp/article/view/439>
- Hari V, Jothieswari D and Maheswaramma KS. (2022). Pharmacological screening of antitumor potential on *Cycas beddomei* Dyer.: An endangered species of Cycadaceae family. International Journal of Health Sciences. 6(S2): 9751–9763. <https://doi.org/10.53730/ijhs.v6nS2.7555>
- Jayaprakasam B, Damu AG, Gunasekar D, Blond A and Bodo B. (2000). A biflavanone from *Cycas beddomei*. Phytochemistry. 53(4): 515–517. [https://doi.org/10.1016/s0031-9422\(99\)00567-1](https://doi.org/10.1016/s0031-9422(99)00567-1)
- Khuraijam JS, Singh R, Calonje M and Mazumdar J. (2018). Lectotypification of *Cycas beddomei* (Cycadaceae). Phytotaxa. 383(1): 121-124. <https://doi.org/10.11646/phytotaxa.383.1.9>
- Nethaji K, Venkat RM, Rao SM and Venu P. (2022). A review on taxonomy and allied issues in *Cycas beddomei* Dyer, a narrow endemic from the southern Eastern Ghats, India. Nelumbo. 64(1): 143–151. <https://doi.org/10.20324/nelumbo/v64/2022/169306>
- Prabhakar CS and Rao KR. (1981). Photorespiration studies in *Cycas circinalis* L. and *Cycas beddomei* Dyer. Photosynthesis Research. 2(4): 297–300. <https://doi.org/10.1007/BF00056267>
- Rao BRP, Babu MVS and Donaldson JS. (2010). A reassessment of the conservation status of *Cycas beddomei* Dyer (Cycadaceae), an Endemic of the Tirupati-Kadapa hills, Andhra Pradesh, India, and comments on its CITES status. Encephalartos. 102: 19-24.
- Rao BRP, Naik MC, Salamma S, Babu MVS and Rasingam L. (2015). Discovery of a new sub-population, mapping and updated Red List assessment of the endangered *Cycas beddomei* Dyer (Cycadales: Cycadaceae). Journal of Threatened Taxa. 7(12): 7902-7909. <https://doi.org/10.11609/JoTT.o4377.7902-9>
- Rout GR, Jadhao KR, Swain D and Panda PC. (2014). Distribution and DNA profiling of *Cycas beddomei* Dyer: A critical endangered gymnosperm. Agricultural Science and Practice. 91(3–4):131–137.