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# Diversity of Gymnosperms in Acharya Jagadish Chandra Bose Indian Botanic Garden, Howrah, West Bengal, India

S.P. Panda<sup>1</sup>\*, S.S. Hameed<sup>2</sup> and M.U. Sharief<sup>2</sup>

<sup>1</sup>A.J.C. Bose Indian Botanic Garden, Botanical Survey of India, Howrah (West Bengal), India. <sup>2</sup>Botanical Survey of India, Southern Regional Centre, Coimbatore (Tamil Nadu), India.

(Corresponding author: S.P. Panda\*) (Received: 13 February 2024; Revised: 06 March 2024; Accepted: 26 March 2024; Published: 15 April 2024) (Published by Research Trend)

ABSTRACT: The present paper deals with the documentation of the gymnosperm diversity of Acharya Jagadish Chandra Bose Indian Botanic Garden (AJCBIBG) along with their habit, global distribution, local name, coning period and IUCN categories. The study revealed 43 species of gymnosperms found in AJCBIBG under 15 genera, belonging to 08 families. Furthermore, it was observed that out of 43 species, majority of them were from the Cycadaceae with maximum 12 species of *Cycas* followed by Zamiaceae with 8 species of *Zamia*. Further, it was also observed that among the enlisted species, 6% of species were critically endangered and 26% of them have acquired endangered status according to IUCN criteria.

Keywords: Diversity, Gymnosperm, AJCBIBG, Cycadaceae, Zamiaceae.

# **INTRODUCTION**

Gymnosperms are one of the most primitive groups of vascular plants, as they have said to be in existence since the late Paleozoic era (ca. 265 million year ago) (Uniyal and Awasthi 2000). This primitive group of plants was originally defined by the nature of their female reproductive organ, in which the seeds are naked in the carpel. Globally, gymnosperms are distributed in all continents except Antarctica, of which two-thirds are conifers, a group that constitutes over 39% of the world's forests (Armenise et al., 2012). They are represented by 12 families, 83 genera (Christenhusz et al., 2011), and about 1000 species including, ca. 297-331 species of cycads in 10 genera, one extant ginkgophyte, 80-100 geophytes in three genera, and ca. 614 species of conifers in 69 genera (Farjon, 2010; Christenhusz et al., 2011). Among these genera, 34 (40.96%) are monotypic, 22 (26.5%) have only two to five species, and only three (Cycas, Pinus and Podocarpus) comprise near or more than 100 species. It is interesting to note that half (45) of the genera occur in Asia and 31 in Australia (continent), and the majority of the monotypic genera are found in these two continents. Moreover, beautiful reproductive cones, gregarious foliage, heavy trunks and perennial growth make it the perfect ornamental plant for Garden and plant lovers. Gymnosperms can be differentiated from angiosperm as gymnosperms are soft wood plant as compared to angiosperms which are usually hardwood (Chamberlain, 1935; Dutta, 1973). The Acharya Jagadish Chandra Bose Indian Botanic Garden serves as a living repository of many native and exotic species of gymnosperms which are conserved in different divisions of the garden. Some species, such as

Cycas rumphii Miq. and Cycas circinalis L. have been conserved from almost 200 years in AJCBIBG and are assumed to be planted during the tenure of Dr. William Roxburgh (1793-1814) who served as the first salaried superintendent of this garden, which was earlier known as Company Bagan or Calcutta Royal Botanic Garden. It was established in 1787 by Col. Robert Kyd, as one of the best landscaped Gardens spreading across an area of 273 acres with 24 lakes and 25 division and having numerous fauna species like birds, insects, reptiles and mammals which develops a perfect ecosystem in the heart of the city. Different divisions of the garden are dedicated for conserving various rare and endangered species not only from India but from different parts of the world. The garden has a very rich history of plant introduction and multiplication of many exotic species that have now been commercialized such as Tea, Coffee, Rubber, Mahogany, Indigo etc. The successors of Dr. William Roxburgh like Nathaniel Wallich (1817–1846), William Griffith (1842–1845), CB Clarke (1869-1871), Sir George King (1871-1897) and many more introduced many exotic species of plants from various regions of the world. At present, the garden holds the privilege of conserving almost 1400 species of plants belonging to different families and genera. A dedicated section of cycad plants at AJCBIBG conserves almost 22 species belonging to 12 genera of cycas. Several species of pine are also maintained and conserved in the pinetum like Pinus roxburghii Sarg., Podocarpus neriifolius D. Don and some species of Ephedra, Araucaria, Juniperus and Thuja. Keeping in mind, the ornamental as well as taxonomic importance of gymnosperms, a study was undertaken at AJCBIBG to survey, identify and document the gymnosperm diversity.

#### MATERIALS AND METHODS

The current study was based on an extensive division wise survey of gymnosperms in Cycad, Pinetum and other sections of AJCBIBG. Since the inception, several works have been carried out to document the floral diversity of the garden but no attempts was made to study the gymnosperm diversity. Therefore, considering this issue, the present work was carried out to document the gymnosperms of the garden along with their family, local name, global distribution, coning time, and IUCN status where ever available. The plants were identified in consultation with floras, monographs, and relevant literatures available.

## ENUMERATION

#### ARAUCARIACEAE

1. Agathis alba (Rumph. ex Valmont) Foxw. Tree Common Name: Dammar Pine (Eng.) Distribution: Philippines; Indonesia: Sumatra, Java, Borneo, Celebes, Moluccas Cone Formation Time: March - July IUCN Status: Vulnerable 2. Agathis lanceolata Warb. Tree Common Name: Koghis Kauri Distribution: New Caledonia Cone Formation Time: January - March IUCN Status: Vulnerable 3. Araucaria bidwillii Hook. Tree Common Name: Bunya Pine (Eng.) Distribution: Australia: Queensland Cone Formation Time: April - October (Male cone), December - March (Female cone) IUCN Status: Least Concern 4. Araucaria columnaris (G. Forst.) Hook. [Araucaria cookii R. Br. ex Endl., Araucaria excelsa (Lamb.) R. Br.] Tree Common Name: Christmas Tree (Eng.) Distribution: New Caledonia Cone Formation Time: February - May IUCN Status: Least Concern 5. Araucaria cunninghamii Mudie Tree Common Name: Hoop Pine (Eng.) Distribution: Australia: Coastal tropical and subtropical rainforests from northern Queensland to Coffs Harbour in New South Wales Cone Formation Time: Not seen IUCN Status: Least Concern CUPRESSACEAE 6. Cupressus pendula Thunb. (*Cupressus funebris* Endl.) Tree Common Name: Chinese Weeping Cypress (Eng.) Distribution: Vietnam and China Cone Formation Time: December -October; Female cone initiates in early July IUCN Status: Data Deficient 7. Cupressus torulosa D. Don ex Lamb. Tree

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Common Name: Himalayan Cypress (Eng.) Distribution: W. Himalaya, China and Vietnam Cone Formation Time: February- December IUCN Status: Least Concern 8. Juniperus chinensis L. Shrub or Tree Common Name: Chinese Juniper (Eng.) Distribution: China, Japan, Korea Cone Formation Time: November - May IUCN Status: Least Concern 9. Juniperus recurva Buch.-Ham. ex D. Don Shrub or Tree Common Name: Drooping Juniper (Eng.) Distribution: India: Arunachal Pradesh, Assam, Uttar Pradesh; Nepal, Bhutan, Myanmar, China Cone Formation Time: June-July; Female cones ripen in July-October of next year IUCN Status: Least Concern 10. Thuja occidentalis L. Tree Common Name: American arborvitae (Eng.) Distribution: Canada, USA Cone Formation Time: June - October IUCN Status: Least Concern 11. Platycladus orientalis (L.) Franco (Thuja orientalis L.) Shrub or Tree Common Name: Oriental thuja (Eng.), Morpankhi (Hindi) Distribution: Korea, E. Russia, and China Cone Formation Time: End of July - October IUCN Status: Near Threatened 12. Taxodium distichum (L.) Rich. Tree Common Name: Bald Cypress (Eng.) Distribution: India: Introduced, Jammu & Kashmir, Planted in West Bengal (AJCBIBG, Howrah); Native of United States Cone Formation Time: August onwards IUCN Status: Least Concern 13. Taxodium mucronatum Ten. Tree Common Name: Montezuma Cypress (Eng.) Distribution: India: Introduced, Uttar Pradesh (Allahabad, Lucknow), Uttarakhand (Dehradun), Sikkim (Gangtok); Native of Guatemala & Mexico Cone Formation Time: February IUCN Status: Least Concern CYCADACEAE 14. Cycas revoluta Thunb. Tree Common Name: Sago Palm Distribution: China, Japan, Taiwan, Throughout India Cone Formation Time: Cone Formation Time: Not seen IUCN Status: Least Concern 15. Cycas pectinata Buch.-Ham. Tree Common Name: Nepal Cycas Distribution: India: North-eastern states, Nepal, Bhutan, Thailand, Bangladesh, Myanmar Cone Formation Time: November-January **IUCN Status: Vulnerable** 16. Cycas beddomei Dyer

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Tree Common Name: Beddome's cycas Distribution: India (Andhra Pradesh) Cone Formation Time: November-May IUCN Status: Endangered 17. Cycas pschannae R.C. Srivast. & L.J. Singh Shrub or Tree Distribution: Andaman & Nicobar Islands Cone Formation Time: December-July IUCN Status: Not Evaluated 18. Cycas zevlanica (J. Schust.) A. Lindstr. & K.D. Hill Shrub or Tree Common Name: Maha-madu (in Sri Lanka) Distribution: Andaman & Nicobar Islands, Kerala, Sri Lanka Cone Formation Time: Not seen IUCN Status: Critically Endangered 19. Cycas circinalis L. Shrub or Tree Common Name: Queen Sago Distribution: India (West Peninsula) Cone Formation Time: February-October **IUCN Status: Endangered** 20. Cycas darshii R.C. Srivast. & Jana Shrub or Tree Distribution: Andaman Island Cone Formation Time: Not seen IUCN Status: Data Deficient 21. Cycas orixensis (Haines) Rita Singh & Khuraijam (Cycas circinalis var. orixensis Haines) Tree Distribution: Odisha, North Eastern Ghats Cone Formation Time: Not seen **IUCN Status: Endangered** 22. Cycas indica A. Lindstr. & K.D. Hill Tree Distribution: India (Karnataka) Cone Formation Time: Not seen IUCN Status: Not Evaluated 23. Cycas sphaerica Roxb. Tree Common Name: Spherical Sago (Eng.) Distribution: India (Odisha, Andhra Pradesh) Cone Formation Time: August-October IUCN Status: Endangered 24. Cycas clivicola K.D. Hill Shrub or Tree Common Name: The Cliff Cycad (Eng.) Distribution: Cambodia, Malaya, Thailand, Vietnam Cone Formation Time: Not seen IUCN Status: Least Concern 25. Cycas rumphii Miq. Tree Common Name: Queen Sago, Bread Palm (Eng.) Distribution: India (Andaman & Nicobar Islands: Cultivated almost throughout India), Java, New Guinea Cone Formation Time: December-January, Plants with ovules seen almost throughout the year IUCN Status: Near Threatened ZAMIACEAE 26. Dioon spinulosum Dyer ex Eichl. Tree Common Name: Gum Palm (Eng.) Panda et al., Biological Forum – An International Journal 16(4): 203-211(2024)

Distribution: Mexico Cone Formation Time: May IUCN Status: Endangered 27. Dioon edule Lindl. Shrub Common Name: Chestnut Dioon (Eng.) Distribution: Mexico Cone Formation Time: June-July IUCN Status: Near Threatened 28. Zamia fischeri Mig. ex Lem. Shrub Common Name: Fischer's Zamia (Eng.) Distribution: Northeast Mexico Cone Formation Time: Not seen **IUCN Status: Endangered** 29. Zamia furfuracea L.f. ex Aiton Shrub Common Name: Cardboard Palm (Eng.) Distribution: Mexico Gulf Cone Formation Time: Not seen IUCN Status: Endangered 30. Zamia pumila L. Shrub Common Name: Florida Arrowroot (Eng.) Distribution: Cuba, Dominican Republic, Jamaica, Puerto Rico Cone Formation Time: Not seen IUCN Status: Vulnerable 31. Zamia angustifolia Jacq. Shrub Common Name: Eleuthera Coontie Distribution: Bahamas, Cuba Cone Formation Time: Not seen **IUCN Status: Vulnerable** 32. Zamia standlevi Schutzman Shrub Common Name: Camotillo (Spanish) Distribution: Guatemala, Honduras Cone Formation Time: Not seen IUCN Status: Least Concern 33. Zamia inermis Vovides, J.D. Rees & Vázq. Torres Shrub Distribution: Mexico Gulf Cone Formation Time: Not seen IUCN Status: Critically Endangered 34. Zamia variegata Warsz. Shrub Common Name: Speckled Zamia (Eng.) Distribution: Belize, Guatemala, Mexico Southeast Cone Formation Time: Not seen IUCN Status: Endangered 35. Zamia loddigesii Miq. Shrub Distribution: Belize, Mexico Cone Formation Time: Not seen IUCN Status: Near Threatened PINACEAE 36. Pinus roxburghii Sarg. Tree Common Name: Chir pine (Eng.), Chir (Hindi) Distribution: India: Uttrakhand to Arunachal Pradesh; Outer Himalayan Ranges, Pakistan, Bhutan, Afghanistan 205

Cone Formation Time: February - May IUCN Status: Least Concern PODOCARPACEAE 37. Afrocarpus gracilior (Pilg.) C.N. Page (Podocarpus gracilior Pilg.) Tree Common Name: Fern Pine (Eng.) India: Uttarakhand Distribution: (Dehradun), Meghalaya (Shillong), Sikkim (Gangtok); Sao Tome, Ethiopia to S. Africa. Native of Abyssinia, Uganda and Keniva (Planted) Cone Formation Time: April - May IUCN Status: Least Concern 38. Podocarpus macrophyllus (Thunb.) Sweet (Taxus *macrophylla* Thunb.) Tree Common Name: Southern Yew (Eng.) Distribution: India: Planted; S. China to N. Myanmar, Taiwan, Japan Cone Formation Time: April - May IUCN Status: Least Concern 39. Podocarpus neriifolius D. Don Tree Common Name: Brown Pine (Eng.), Halis (Hindi) Distribution: India (Andaman Islands, North East India, Eastern Himalaya Region upto 900 m.); Bhutan, Cambodia, China, Indonesia, Laos, Malaysia, Myanmar, Nepal, Papua New Guinea, Philippines, Thailand, Vietnam Cone Formation Time: July – February

IUCN Status: Least Concern

40. Podocarpus polystachyus R. Br. ex Endl.

Tree Common Name: Sea Teak (Eng.) Distribution: Borneo, Malaya, Maluku, Philippines, Sulawesi, Sumatera, Thailand Cone Formation Time: Not seen IUCN Status: Vulnerable 41. *Podocarpus* macrophyllus var. maki Siebold &Zucc. Tree Common Name: Buddhist Pine Distribution: India: Introduced: China South-Central, China Southeast, Japan, Myanmar, Taiwan Cone Formation Time: Not seen IUCN Status: Near Threatened GINKGOACEAE 42. Ginkgo biloba L. Tree Common Name: Maidenhair Tree (Eng.) Distribution: India: West Bengal (Full grown trees are seen in Kalimpong), Planted in most of the Botanic Gardens in India; Eastern China Cone Formation Time: April – June IUCN Status: Endangered **EPHEDRACEAE** 43. Ephedra foliata Boiss. ex C.A. Mey. (Ephedra ciliata Fisch. & C.A. Mey.) Shrub Common Name: Horsetail Shrub (Eng.) Distribution: India (Punjab, Rajasthan), Afghanistan, Pakistan, Egypt, Iran Cone Formation Time: January – May

IUCN Status: Least Concern



BOLD NOS. (1-25) - DIVISION NOS. OF THE GARDEN

Locations of Acharya Jagadish Chandra Bose Indian Botanic Garden (AJCBIBG) with Higher Concentration of Gymnosperm



Plate 1: A. Cycas circinalis L., B. Newly developed megasporophyll (C. circinalis), C. Immature ovule (C. circinalis), D. Mature ovule (C. circinalis),
E. New leaf formation (C. circinalis), F. Cycas indica A.Lindstr. & K.D.Hill,
G. Cycas revoluta Thunb.



Plate 2: A. Cycas pectinata Buch.-Ham., B. Newly developed buds (C. pectinata), C. Immature ovule (Cycas sainathii R.C.Srivast.), D. Cycas sainathii R.C.Srivast., E. Formation of leaves from buds (C. sainathii).



Plate 3: A. Cycas rumphii Miq., B. Bark (C. rumphii), C. Leaf (C. rumphii), D. Zamia furfuracea L.f. ex Aiton, E. Leaf (Z. furfuracea), F. Female cone (Z. furfuracea), G. Zamia angustifolia Jacq., H. Female cones (Z. angustifolia).



Plate 4: A. Zamia inermis Vovides, J.D.Rees & Vázq.Torres, B. Zamia standleyi Schutzman, C. Zamia fischeri Miq. ex Lem., D. Male cone (Z. fischeri), E. Zamia loddigesii Miq., F. Female cone (Z. loddigesii), G. Bark (Platycladus orientalis (L.) Franco) H. Platycladus orientalis (L.) Franco, I. Leaf (P. orientalis).



Plate 5: A. & C. Dioon edule Lindl., B. & D. Dioon spinulosum Dyer ex Eichl., E. Leaf (Podocarpus neriifolius D.Don), F. Podocarpus neriifolius D.Don, G. & K. Leaf (Agathis alba (Rumph. ex Valmont) Foxw.), H. Agathis alba (Rumph. ex Valmont) Foxw., I. Bark (P. neriifolius), J. Bark (A. alba).



Plate 6: A. Bark (Araucaria cuminghamii Mudie), B. Bark (Pinus roxburghii Sarg.), C. Araucaria cuminghamii Mudie, D. Leaf (A. cuminghamii), E. Araucaria columnaris (G.Forst.) Hook., F. Taxodium distichum (L.) Rich., G. Pinus roxburghii Sarg., H. Cypress knee roots (T. distichum).



Plate 7: A. Leaf (Taxodium distichum (L.) Rich.), B. Taxodium mucronatum Ten., C. Juniperus chinensis L., D. Bark (J. chinensis), E. Leaf (J. chinensis), F. Ephedra ciliata Fisch. & C.A.Mey., G. Cones (E. ciliata), H. Afrocarpus gracilior (Pilg.) C.N.Page.

#### **RESULTS AND DISCUSSION**

The documentation of gymnosperms revealed, 43 species belonging to 15 genera under 8 families introduced at different times in the AJCBIBG from different regions of India and other parts of the globe. Of these 43 gymnosperms, the dominant families are found to be Cycadaceae (12 species), Zamiaceae (10 species), followed by Cupressaceae (08 species), Araucariaceae (05), whereas 3 families (Ephedraceae, Ginkgoaceae, Pinaceae) are represented by single species each (Fig. 1). Moreover, the monotypic genus Cycas in the family Cycadaceae have maximum 12 species, followed by Zamia with 8 species. The genus Araucaria and Podocarpus have 3 species each, while the genus Taxodium, Dioon, Juniperous, Cupressus, and Agathis have 2 species only (Fig. 2). In a previous report, Srivastava (2006) listed 101 taxa (indigenous and exotic) of gymnosperms from India, while Singh and Srivastava (2013) revised the check list and published the occurrence of 146 species and 07 varieties of gymnosperms in India with extensive details of exotic/introduced species. Moreover, out of these 43 introduced species being conserved at AJCBIBG, 55% of them are under least concern category, whereas 26% are of endangered status where as 6% are critically endangered and 13% are under near threatened category (Fig. 3).

The species enumerated in this communication are not only interesting from taxonomic point of view but also have both the socioeconomic and horticultural importance. This current documentation will pave the way for further introduction and conservation of other gymnosperms, along with development of propagation techniques, study on phenology as well as reproductive biology of the gymnosperms.



Fig. 1. Family- wise diversity of Gymnosperms in AJCBIBG.



Fig. 2. Species -wise diversity of Gymnosperms in AJCBIBG.



Fig. 3. IUCN Status of Gymnosperms in AJCBIBG.



**Fig. 4.** Month wise cone formation percentage of several Gymnosperms in AJCBIBG.

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