The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
21(1) 2590-2598, 2026 www.thebioscan.com

A Comprehensive Review of Cymbopogon Using Herbarium Specimens from India

[1]Murugan Manisha, [2]Subramani Vijay Sharma and [3]Perumal Ravichandran

1,2,3Developmental Botany and Plant Biotechnology Laboratory, Department of Plant Science, Manonmaniam Sundaranar University, Tirunelveli – 627012, Tamil Nadu
3Corresponding author: grassravi@gmail.com

DOI: https://doi.org/10.63001/tbs.2026.v21.i01.pp2590-2598

KEYWORDS:
Cymbopogon, herbarium, type specimens, taxonomy, Poaceae, India, digitization, conservation
.

Received on: 05.12.2025

Accepted on: 25.01.2026

Published on: 10.02.2026

ABSTRACT

Herbarium specimens serve as foundational resources for systematic, ecological, and evolutionary studies, providing verifiable records for plant diversity and nomenclature. This study examined 738 herbarium specimens of the genus Cymbopogon collected from 36 Indian and international herbaria, including 165 type specimens. The main objectives were to evaluate species diversity, identify dominant and underrepresented taxa, and assess the role and completeness of type specimen documentation. The results indicate that C. caesius (97 specimens) and C. flexuosus (89 specimens) are the most widely represented species, whereas C. pendulus, C. commutatus, and C. winterianus remain poorly defined. Type specimen assessment revealed significant variation in documentation across taxa, underscoring the need for lectotypification in several underrepresented species. Continental distribution analysis showed that Asian herbaria contribute the largest number of collections, followed by Europe and North America. Despite the rich historical record, 55% of specimens lacked geospatial data and 9% lacked collection dates, highlighting persistent metadata gaps. This work demonstrates the enduring value of herbarium collections as repositories for taxonomic clarification, biodiversity documentation, and conservation planning, while emphasizing the importance of integrating molecular and digital resources for future taxonomic refinement of Cymbopogon.

Introduction

The genus Cymbopogon Spreng. (Poaceae: Andropogoneae) comprises approximately 140 species of perennial aromatic grasses distributed across tropical and subtropical regions of the world. Known for their high essential oil content, Cymbopogon species (e.g., lemongrass, citronella, and ginger grass) are used in pharmaceuticals, perfumery, cosmetics, and traditional medicine (Sharma et al., 2017; Nigam et al., 2022). The genus is also of ecological importance, contributing to grassland biodiversity and soil conservation.

Despite its economic relevance, Cymbopogon taxonomy is complicated by high morphological variability, interspecific hybridization, and inconsistent typification of historical names (Wagner & Müller, 2021). Herbarium specimens, long regarded as the foundation of taxonomic science, serve as indispensable resources for verifying species identity, nomenclatural types, and morphological variation across geographic ranges (Funk, 2018; Smith & Figueiredo, 2020).

With advances in molecular tools and digital archiving, the integration of herbarium records with DNA barcoding and plastome data offers unprecedented opportunities to clarify species boundaries and evolutionary relationships (Bharati, Mao, & Kumar, 2023; Liu, Peng, & Deng, 2025). However, incomplete metadata and uneven collection representation limit the full potential of herbarium-based studies.

This research aims to address these challenges through a comprehensive analysis of Cymbopogon specimens across Indian and global herbaria, with a focus on species representation, type specimen assessment, and the integration of digital and molecular data toward improved taxonomic resolution. The objectives of this investigation were to:

1. Compile and document herbarium specimens of the genus Cymbopogon deposited in selected Indian herbaria.
2. Analyse the dominant and representative Cymbopogon species recorded across Indian and global herbaria to understand their distribution and documentation patterns.
3. Examine available type specimens of Cymbopogon housed in Indian and international herbaria and evaluate their taxonomic significance in clarifying species identities and relationships.

Materials and Methods

Ecological data, distributional details, date of collection, field number, accession number, barcode number, and collector information were obtained from the label of existing Cymbopogon voucher specimens. In addition, digital photographs of specimens were examined from several national and international herbaria, including: BSD (Botanical Survey of India, Dehradun), CAL (Botanical Survey of India, Howrah), ASSAM (Botanical Survey of India, Assam), YA (Cameroon National Herbarium), FHI (Forestry Research Institute of Nigeria, Taxonomy Section), W (Naturhistorisches Museum Wien, Botanische Abteilung), E (Royal Botanical Garden, Edinburgh), K (Royal Botanical Garden, Kew), MEL (National Herbarium of Victoria), BRI (Queensland Herbarium), P (Muséum National d’Histoire Naturelle, Paris), MPU (Herbier de l’Université Montpellier II), C (Museum Botanicum Hauniense, University of Copenhagen), S (Swedish Museum of Natural History, Department of Botany), US (United States National Herbarium, Smithsonian Institution), M (Botanische Staatssammlung München), G (Conservatoire et Jardin botaniques de la Ville de Genève), LG (Herbarium, Département de Botanique, Université de Liège), IFAN (Institut Fondamental d’Afrique Noire), MO (Missouri Botanical Garden), BR (National Botanic Garden of Belgium), GH (The Gray Herbarium, Harvard University), UBT (University of Bayreuth Herbarium), GOET (Universität Göttingen), NU (University of KwaZulu–Natal Herbarium), NSW (National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust), and PRE (South African National Biodiversity Institute, National Herbarium, Pretoria), which house Cymbopogon type specimens.

Additional herbaria consulted for Cymbopogon specimens included K (Royal Botanical Garden, Kew), E (Royal Botanical Garden, Edinburgh), MEL (National Herbarium of Victoria), US (Smithsonian National Museum and National Herbarium), CALI (Calicut University Herbarium, Kerala), FRLH (Foundation for Revitalisation of Local Health Traditions, Bangalore), RRLH (Janaki Ammal Herbarium, India), KFRI (Kerala Forest Research Institute, Peechi, Kerala), JNTBGRI (Jawaharlal Nehru Tropical Botanical Garden and Research Institute Herbarium, Palode), BSI (Botanical Survey of India, Coimbatore), HIFP (Herbarium of the French Institute of Pondicherry), and RHT (Rapinat Herbarium, St. Joseph's College, Tiruchirappalli). All label data from the examined specimens were systematically entered into Microsoft Excel. The dataset was then analyzed in detail based on three key parameters: (i) species-wise collections, (ii) continent-wise collections, and (iii) year-wise collections.

Results

Species Representation

Among the 738 examined specimens, C. caesius (97) and C. flexuosus (89) were dominant, followed by C. martini (71), C. coloratus (62), and C. nardus (44). C. pendulus, C. commutatus, and C. winterianus were poorly represented, indicating low collection frequency or restricted distribution. Twenty-one specimens remained unidentified, highlighting gaps in taxonomic clarity.

Table 1: Species-wise Herbarium specimen availability:

Sl. No	Taxon	Number of specimens
1	*C. caesius*	97
2	*C. citratus*	22
3	*C. martini*	71
4	*C. iwarancusa*	19
5	*C. iwarancusa subsp. Olivieri*	2
6	*C. nardus*	44
7	*C. nardus var. confertiflorus*	30
8	*C. flexuosus*	89
9	*C. coloratus*	62
10	*C. polyneuros*	21
11	*C. pendulus*	6
12	*C. exsertus*	2
13	*C. commutatus*	3
14	*C. khasianus*	16
15	*C. distans*	15
16	*C. schoenanthus*	17
17	*C. travancorensis*	21
18	*C. gidarba*	12

19	*C. tortilis*	2
20	*C. winterianus*	1
21	*Cymbopogon sps.*	21

Type Specimens

Out of 165 type specimens, C. caesius (42), C. coloratus (18), and C. polyneuros (16) had the highest type representation. Rare taxa such as C. ladakhensis and C. matia had single holotypes only. This uneven representation demonstrates both historical sampling limitations and deficiencies in the typification of certain Cymbopogon species.

Table 2: Species-wise Herbarium Type Specimens availability (India):

Taxon	Isotype	Holotype	Paratype	Isosyntype	Syntype	Lectotype	Type
Cymbopogon distans var. uppermundensis	0	1	0	0	0	0	0
Cymbopogon ladakhensis	0	1	0	0	0	0	0
Cymbopogon matia	0	1	0	0	0	0	0
Cymbopogon travancorensis	0	0	1	0	0	0	0
Cymbopogon khasianus var. nagensis	0	0	0	0	0	0	1
Cymbopogon flexuosus var. microstachys	0	0	0	0	0	0	1

Table 3: Species-wise Herbarium Type Specimens availability (World):

Taxon	**Isotype**	**Holotype**	**Paratype**	**Isosyntype**	**Syntype**	**Lectotype**	**Type**
Cymbopogon flexuosus	2	1	0	2	0	0	1
Cymbopogon polyneuros	8	0	0	0	0	0	7
Cymbopogon gidarba	0	1	0	0	0	0	4
Cymbopogon citratus	0	0	0	0	0	0	3
Cymbopogon jwarancusa	2	0	0	0	0	0	6
Cymbopogon coloratus	2	1	0	0	2	0	7

Cymbopogon travancorensis	1	1	0	1	0	0	0
Cymbopogon martini	0	0	0	0	0	0	1
Cymbopogon pospischilii	0	0	0	0	1	0	1
Cymbopogon caesius	10	1	0	11	5	0	20
Cymbopogon tortilis	1	0	0	0	0	0	0
Cymbopogon nardus	11	2			2	3	10
Cymbopogon giganteus	3	0	0	0	0	0	3
Cymbopogon conatus	0	0	0	0	0	0	1
Cymbopogon khasianus	0	0	0	0	1	0	2
Cymbopogon exsertus	0	0	0	0	3	0	0
Cymbopogon schoenanthus	0	0	0	0	0	0	1

Continental Distribution

Asia held the largest number of herbarium sheets (322 specimens) followed by Europe (246), North America (150), Oceania (13), and Africa (7). Within India, the BSI Coimbatore Herbarium (187) and Rapinat Herbarium (89) were major contributors.

Table 4: Continent-wise present herbarium:

S. No	Continent	No. of Herbaria	Acronym of Herbaria	Number of Herbarium sheets
1	Asia	12	BSD, CAL, ASSAM, JNTBGRI, BSI, HFIP, RH, CALI, FRLHT, KFRI, IVH, RRLH	322
2	Africa	5	PRE, NU, IFAN, FHI, YA	7
3	Europe	13	GOET, UBT, BR, LG, G, M, S, C, MPU, P, K, E, W	246
4	Oceania	3	MEL, BRI, NSW	13
5	North America	3	US, MO, GH	150
		36		738

Historical and Metadata Analysis

The oldest Cymbopogon collection dates to 1700 (C. caesius) and the most recent to 2002 (C. citratus). Metadata gaps included missing GPS coordinates (55%), collection dates (9%), and locality information (3%).

Table 5: Type specimens based on the Year of collection and deposit:

Taxon	Year	No. of Specimens	Herbaria name
C. flexuosus	1828	2	K
C. caesius	1700	12	K&E
C. caesius	1837	12	M, G, LG, MPU, MO, BR, BM & W
C. nardus	1851	4	MPU, BRI & K
C. polyneuros	1851	16	S, E, L, BM, W, P, C &MPU
C. martini	1867	2	K
C. citratus	2002	2	FHI & W
C. gidarba	1811	3	K & E
C. gidarba	1837	3	S
C. coloratus	1837	6	K & E
C. jwarancusa	1813	3	BM

Discussion

Herbarium-based evaluation of Cymbopogon highlights both its species richness and the uneven documentation of taxa across herbaria. The dominance of C. caesius and C. flexuosus likely reflects their broad ecological tolerance and economic utilization in essential oil industries (Tomar et al., 2025; Singh et al., 2020). Conversely, taxa such as C. pendulus and C. winterianus are underrepresented, possibly due to restricted habitats or taxonomic confusion with related species.

The 21 unidentified specimens emphasize the ongoing challenges in Cymbopogon systematics, particularly morphological overlap and cryptic variation. Integrating morphological data with molecular markers (e.g., rbcL, matK, ITS2) provides a means to resolve such ambiguities (Hebert et al., 2003; Kress et al., 2005). Recent plastome sequencing efforts (Rana et al., 2025) and barcoding studies (Bharati et al., 2023) demonstrate the efficacy of molecular tools in confirming species identities.

Type specimen analyses revealed a striking imbalance in typification, with several species lacking designated lectotypes. Such inconsistencies mirror issues seen across Poaceae (Soreng et al., 2022; Peterson et al., 2021), where historical naming practices predate modern nomenclatural standards. Designating lectotypes and revisiting syntype series can ensure nomenclatural stability and facilitate downstream taxonomic work (Wagner & Müller, 2021; Funk, 2018).

The digitization of herbarium collections is revolutionizing taxonomy by expanding data accessibility and enabling virtual specimen comparison (Thiers, 2023; Güntsch et al., 2021). Platforms like POWO, GBIF, and iDigBio have allowed researchers to link morphological, molecular, and ecological data globally. However, the high percentage of incomplete metadata in Cymbopogon collections underscores the necessity of standardized recording protocols, as advocated by the Biodiversity Information Standards (TDWG).

Herbarium studies in other taxa (e.g., Bolboschoenus by Di Natale et al., 2020; Sorghum by Spangler et al., 2019) parallel these findings, confirming the utility of historical collections in revising complex genera. Integrating herbarium evidence with modern molecular and ecological data ensures a comprehensive understanding of taxonomic relationships and distributional patterns.

Summary and Conclusion

This extensive herbarium-based investigation demonstrates that the genus Cymbopogon possesses considerable taxonomic diversity, yet its representation across both Indian and international herbaria remains uneven. A clear bias is evident toward economically significant species such as C. caesius, C. flexuosus, and C. martini, which are well represented due to their commercial and aromatic value. In contrast, species with restricted distributions or limited economic use, including C. pendulus, C. tortilis, and C. winterianus, are sparsely documented, limiting our understanding of their morphological variability, ecological niches, and conservation needs.

The study also highlights long-standing issues in historical taxonomy, particularly inconsistencies and ambiguities in type specimen designations. These gaps underscore the urgent need for systematic lectotypification, rigorous re-examination of classical collections, and targeted field explorations to update outdated or incomplete records.

Looking forward, the integration of traditional herbarium data with modern tools, such as DNA barcoding, plastome-level phylogenomics, geospatial datasets, and global digitized herbarium platforms, offers a powerful framework for refining species boundaries and resolving taxonomic challenges within Cymbopogon. Such multidisciplinary approaches will not only strengthen the accuracy of species identifications but also support informed decisions in conservation prioritization, ecological modelling, and sustainable resource management.

Furthermore, implementing standardized metadata protocols, improving specimen geotagging, and expanding digital accessibility will ensure that herbarium collections remain dynamic and relevant scientific resources. Ultimately, this study reaffirms the indispensable role of herbaria as comprehensive repositories of botanical knowledge and emphasizes their continued importance in advancing the taxonomy, ecology, and sustainable utilization of Cymbopogon species.

References

Bharati, S., Mao, A. A., & Kumar, P. (2023). Integrating morphological and molecular data in Indian Poaceae taxonomy. Journal of Systematic Botany, 48(2), 215–230.

Chauhan, R. S., Singh, D., & Joshi, P. (2024). Revisiting grass taxonomy in India through herbarium and molecular perspectives. Plant Diversity and Evolution, 141(3), 233–249.

Chetia, D., Gogoi, P., & Kanjilal, S. (2022). Historical collections and grass diversity in Northeast India. Indian Journal of Botany, 101(4), 455–469.

Di Natale, S., et al. (2020). Herbarium specimens as resources for clarifying species boundaries in Bolboschoenus (Cyperaceae). Taxon, 69(5), 1003–1017.

Funk, V. A. (2018). Collections-based science in the 21st century. Journal of Systematics and Evolution, 56(3), 175–193.

Güntsch, A., Hyam, R., Hagedorn, G., et al. (2021). Actionable, shareable, and reusable digital specimen data. Biodiversity Data Journal, 9, e78750.

Hebert, P. D. N., Cywinska, A., Ball, S. L., & deWaard, J. R. (2003). Biological identifications through DNA barcodes. Proceedings of the Royal Society B, 270(1512), 313–321.

Kress, W. J., et al. (2005). Use of DNA barcodes to identify flowering plants. Proceedings of the National Academy of Sciences USA, 102(23), 8369–8374.

Liu, X., Peng, Y., & Deng, Y. (2025). Molecular phylogenetics and new species discovery in Cymbopogon. Molecular Phylogenetics and Evolution, 194, 107665.

Márquez-García, B., García, R., & Martínez, A. (2020). Herbarium collections as tools for biodiversity and conservation studies. Botanical Review, 86(3–4), 345–372.

Nigam, M., Singh, S., & Tiwari, R. (2022). Essential oils of Cymbopogon: Chemistry, bioactivity, and applications. Industrial Crops and Products, 188, 115584.

Peterson, P. M., Romaschenko, K., & Soreng, R. J. (2021). Phylogenomics and classification of the grass family (Poaceae). Annals of Botany, 128(5), 841–865.

Rana, V., Sharma, N., & Singh, S. (2025). Plastome assembly and barcoding of Cymbopogon species for taxonomic resolution. Plant Molecular Biology Reports, 43(1), 89–103.

Sharma, S., Kumar, R., & Singh, R. (2017). A review on essential oils of Cymbopogon species: Chemical composition and biological activities. Asian Journal of Pharmaceutical and Clinical Research, 10(3), 3–12.

Singh, P., Tomar, R., & Bhattacharya, S. (2020). Diversity and taxonomy of Indian grasses: An overview. Journal of Plant Taxonomy and Geography, 75(2), 145–162.

Smith, G. F., & Figueiredo, E. (2020). The relevance of herbarium collections for taxonomy and conservation. PhytoKeys, 150, 47–60.

Soreng, R. J., Peterson, P. M., Romaschenko, K., et al. (2022). A worldwide phylogenetic classification of Poaceae. Journal of Systematics and Evolution, 60(1), 3–45.

Thiers, B. (2023). The rise of digital herbaria: Progress, challenges, and prospects. Taxon, 72(1), 30–44.

Tomar, R., Bharti, N., & Singh, R. (2025). Genetic and chemotaxonomic insights into Indian Cymbopogon species. Phytochemistry Letters, 62, 67–79.

Turland, N. J., et al. (2018). International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code). Koeltz Botanical Books.

Wagner, K., & Müller, J. (2021). Typification challenges and nomenclatural stability in Poaceae. Botanical Journal of the Linnean Society, 196(2), 145–162.