

GRASSES AND SEDGES OF INDIA

Diversity, Ethnobotany and
Ethnopharmacological Aspects

Bhagwati Prashad Sharma

Rajkumari Supriya Devi





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EDITORS

Dr. Bhagwati Prashad Sharma

Department of Botany, Sidharth Government College, Nadaun, Himachal Pradesh, India

Dr. Rajkumari Supriya Devi

Ambika Prasad Research Foundation, Odisha, India

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CONTRIBUTORS

Anjali Jaiswal, Science Educationist, JCPRO Academy, Bangalore, Karnataka, India.

Arun Kumar Mishra, HN-3002, DN Oxy Park, Dumuduma, Bhubaneswar- 751019, Odisha, India.

Bhagwati Prashad Sharma, Department of Botany, Sidharth Government College, Nadaun, Himachal Pradesh, India.

Jaswant Singh, Department of Botany, Punjabi University, Patiala, Punjab, India.

K. V. Bhaskar Rao, Office of the Divisional Forest Officer cum Wildlife Warden, Koraput Forest Division, Koraput, Odisha, India.

Nibedita Jena, Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India.

Parminder Singh Dehar, Department of School Education, GHS Kamalpur, Sangrur, Punjab, India.

Rajesh Kumar Verma, Department of Dravyaguna, Naiminath Ayurvedic Medical College and Research Centre, Agra, Uttar Pradesh, India.

Rajkumari Supriya Devi, Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India.

Sanjeet Kumar, Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India.

Smitaa Basole, Department of Botany, Balbhim College, Beed, Maharashtra, India.

Subhalakshmi Rout, Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India.

Sugimani Marndi, Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India.

Sumalatha BS, Department of Botany, Dr. Manmohan Singh Bengaluru City University, Bengaluru, Karnataka, India.

Sumitra Jethy, Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India.

Sweta Mishra, Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India.

Vijay Kumar Singhal, Laboratory of Biosciences, Mata Sundri University Girls College, Mansa, Punjab, India.



PREFACE

Grasses and sedges form the ecological and cultural backbone of many terrestrial and aquatic ecosystems across the Indian subcontinent. Belonging primarily to Poaceae and Cyperaceae families, they exhibit remarkable diversity, adaptability and utility, ranging from ecological stabilization and fodder resources to medicinal, ritualistic and economic significance. Despite their peculiarity and importance, grasses and sedges have often been under-represented in floristic, ethnobotanical and pharmacological literature when compared to trees, shrubs and various medicinal herbs. Present volume, [Grasses and Sedges of India: Diversity, Ethnobotany and Ethnopharmacological Aspects](#), is an effort to bridge this gap by bringing together region-specific floristic surveys, ecological assessments and phytochemical investigations that highlight the dynamic roles of these plant groups. This book compiles original research and critical updates from diverse ecological landscapes of India, including Himalayan regions, wetlands, urban green spaces, wildlife sanctuaries, sacred groves and aquatic habitats. The chapters collectively address themes such as species diversity and distribution, ecological associations, fodder value for wildlife, traditional knowledge systems, mythological relevance and bioactive potential of selected grass species, particularly *Cymbopogon citratus*. By integrating ethnobotanical wisdom with modern phytochemical and nutritional analyses, this book emphasizes the relevance of grasses and sedges in contemporary research on natural products, sustainable resource use and conservation biology. This particular volume is intended for botanists, ecologists, ethnobotanists, pharmacologists, conservation practitioners, postgraduate students and researchers interested in plant diversity and traditional knowledge systems. It is also expected to serve as a reference for policy planners and educators working in the fields of biodiversity conservation and sustainable utilization of plant resources.

Editors

BACKGROUND

India is one of the world's most biologically diverse countries, with a wide range of climatic zones and ecological habitats that support an extraordinary variety of grass and sedge species. Grasses dominate large tracts of natural and semi-natural landscapes, including grasslands, alpine meadows, forest understoreys, wetlands, agricultural fields and urban green spaces. Particularly in wetlands and aquatic ecosystems, sedges play a crucial role in maintaining hydrological balance, soil stability and habitat structure. Historically, grasses and sedges have been integral to human civilization in the Indian subcontinent. Beyond their well-known role as staple food crops, they have been traditionally used as fodder, thatching material, ritual objects and medicinal resources. Several species are deeply embedded in religious practices, folklore and mythology as well. In recent decades, increasing attention has been directed toward the ethnopharmacological potential of grasses, especially aromatic species like Lemon grass, due to their rich bioactive profiles. Advances in pharmacological screening and nutritional analysis have revealed the presence of several bioactive compounds with antioxidant, antimicrobial, anti-inflammatory and therapeutic properties. Such findings validate traditional knowledge while opening new avenues for drug discovery and functional food research. At the same time, rapid urbanization, habitat fragmentation, climate change and unsustainable land-use practices pose significant threats to grassland and wetland ecosystems. Floristic surveys and ecological studies, such as those presented in this volume, are therefore essential for documenting existing diversity, understanding species–habitat relationships and identifying conservation priorities. By combining floristic diversity studies, ecological accounts, ethnobotanical documentation and phytochemical investigations, this book provides a holistic perspective on the grasses and sedges of India. It emphasizes the need to recognize these overlooked plant groups as vital components of biodiversity, cultural heritage and sustainable healthcare systems.

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A squirrel with grey and brown fur is perched on a tree trunk, holding a nut in its paws and eating it. The background is a lush green forest with many leaves.

Grasses and sedges are the bestower and restorer of
ecological metabolism...

Dr. Bhagwati Prashad Sharma

Understanding grasses and sedges as keystone
resources for sustainable ecosystems and rural
livelihoods...

Dr. Rajkumari Supriya Devi

Chapter 1

Western Himalayan Grasses: An update on species diversity in Uttarkashi, Uttarakhand, India

Jaswant Singh^{1,2*} and Vijay Kumar Singhal¹

¹Department of Botany, Punjabi University, Patiala, Punjab, India

²Laboratory of Biosciences, Mata Sundri University Girls College, Mansa, Punjab, India

*Email-Id: jaswant_rs@pbi.ac.in

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Abstract: The Uttarkashi district in the Western Himalayas embodies a diverse range of plant life thriving across various altitudes and climatic conditions. This unique eco-floristic region is part of the Himalayan biodiversity hotspot, featuring various grasslands characteristic of different climate-driven vegetation types. The authors analyzed specimens from 112 species found in subtropical, temperate, subalpine and alpine vegetation. The current update, with the addition of 76 species recorded in previous expeditions, estimates the species diversity of grasses at 188 species in the Uttarkashi district. This represents 32.30 % of the grass species in the Western Himalayas, 12.28 % in India, and 1.74 % in the global grass flora. Floristically, the genus *Poa* L. is most diverse, encompassing 33 species, including three species endemic to the Western Himalayas.

Keywords: Biodiversity hotspot, biogeography, flora, grass diversity, grasslands, *Poa*

Introduction

The Western Himalayan grasses exhibit the unique species diversity found in the Himalayan biodiversity hotspot, thriving in subtropical, temperate, subalpine and alpine/arctic climate-driven grasslands. Globally, there are 11,506 recognized species and 768 genera (Soreng et al., 2017). The Indian grasslands have 1,531 species and 266 genera (Kellogg et al., 2020; Mao et al., 2022, Mao et al., 2023). The Western Himalayan grasses include 582 species and 143 genera (Tripathi et al., 2020), whereas Uttarakhand grass flora encompasses 485 species and 129 genera (Kandwal and Gupta, 2009). The Uttarkashi district offers grasslands representative of the Western Himalaya. Victor Jacquemont, Werner Hoffmeister and the Schlaginweitt brothers (Jacquemont, 1841; Jacquemont, 1844; Hoffmeister, 1848; Hermann and Schlaginweit, 1862; Grisebach, 1868; Burkill, 1965) initiated the floristic exploration of the grass diversity of the area. Previous taxonomic studies conducted in various areas, particularly in the Bhagirathi, Tons, Nelong, Nila,

Rudra and Yamuna Valleys, have recorded numerous new and endemic species from genera such as *Agropyron* Gaertn., *Andropogon* L., *Cymbopogon* Spreng., *Piptatherum* P.Beauv. and *Poa* L., which were new additions to the grass flora of the world (Hooker, 1897; Duthie, 1906; Bor, 1960; Gupta, 1960; Naithani, 1969; Dabadghao and Shankarnarayan, 1973; Negi et al., 1985; Bir et al., 1987; Gaur and Nautiyal, 1995; Naithani, 1995; Gaur and Nautiyal, 1996; Gaur and Nautiyal, 1997; Nautiyal and Gaur, 1999; Murti, 2001; Rana et al., 2003; Chandran, 2005; Chandola et al., 2008; Kandwal and Gupta, 2009; Pusalkar and Singh, 2012; Nautiyal and Gaur, 2017; Manikandan et al., 2020; Chandrasekar et al., 2022). Dabadghao and Shankarnarayan, (1973) documented 32 species; Negi et al., (1985) noted 10 species; Rana et al., (2003) stated 18 species; Pusalkar and Singh, (2012) reported 95 species; Manikandan et al., (2020) observed 57 species; and Chandrasekar et al., (2022) noted 18 species, altogether resulting in about 155 species across different eco-floristic areas in the district. The authors carried out exploratory studies to investigate the cytological variation in grasses in the Uttarkashi district (Singh, 2022), but they discovered that many grass species were missing from earlier floristic inventories of the region. In order to fill the gap in the documented diversity of grasses and take into account the importance of plant checklists (Victor et al., 2024), they updated the grass species number in the Uttarkashi district, which totals 188 species, including the 76 species previously documented but not collected during the field surveys. This comprehensive checklist also provides new grass distribution records that enrich biodiversity databases.

Methodology

Study area

The Uttarkashi district spans an area of 8016 sq. km. and is located in the Indian state of Uttarakhand (Figure 1). Phytogeographically, the area falls into the major areas/valleys/localities marked as current collection sites in the district area and snow-covered mountains heading to the Bandarpunch glacier biogeographic provinces belonging to the Indian Himalayan Regions, which have unique plant habitats (Kumar et al., 2022). The mountainous areas have varying heights, downturns, valleys and extensive plains. Major rivers, namely Bhagirathi, Jadh Ganga, Tons and Yamuna, together with various tributaries, traverse the mountainous landscape. In northern mountainous areas, the snow-covered tops serve as a water source for rivers and water channels. The subtropical, temperate, subalpine and alpine climates in the area, along with increasing altitude, encourage variation in grass species diversity in grasslands. The study region encompasses four primary forest types, along with several site-specific

subtypes, each characterized by dominant floral constituents (Bir et al., 1987; Pusalkar and Singh, 2012).

1. Himalayan montane subtropical pine forests (600-1800 m)
2. Himalayan montane temperate forests (1800-3300 m)
 - 2.1. Moist temperate 'oak' forests
 - (i) Ban oak forests
 - (ii) Moru oak forests
 - 2.2. Moist deodar forests
 - 2.3. Moist temperate deciduous forests
 - 2.4. Moist-mixed coniferous forests
 - 2.5. Upper West Himalayan temperate broad-leaved forests: kharsu oak forests
3. Sub-Alpine forests (3000-3500 m)
 - 3.1. West Himalayan birch-fir forests
 - 3.2. Riverine blue pine forests
4. Alpine scrub forests/vegetation (above 3500 m)
 - 4.1. Birch/Bhoj scrub forests
 - 4.2. Birch-Rhododendron scrub forests
 - 4.3. Rhododendron scrubs
 - 4.4. Dwarf juniper scrubs
 - 4.5. Alpine meadows/bugyals

The vegetation cover in the district consists of the *Themeda-Arundinella* type (Dabadghao and Shankarnarayan, 1973). We can classify the altitude-specific grasslands into four categories: (a) Himalayan subtropical grasslands (900-1800 m), (b) Himalayan temperate grasslands (1800-3000 m), (c) Alpine meadows, locally referred to as Bugyals (3000-5200 m) and (d) Trans Himalayan steppes (above 4000 m) (Chandran, 2015). In the Western Himalayan highlands, protected areas, including one wildlife sanctuary and two national parks, cover 41.75 % of the district. The mandates for the conservation measures in the protected areas included preserving floral and faunal diversity and assisting in the ecological restoration of various forest

types in the Himalayan biodiversity hotspot area. Established in 1955 to safeguard the biodiversity of Upper Tons Valley, Govind Wildlife Sanctuary, formerly known as Govind Pashu Vihar Wildlife Sanctuary, spans an area of 957.969 sq. km. In 1991, the government declared the northern region, covering 472.08 sq. km., as the Govind National Park. In response to climate shifts, Gangotri National Park has officially declared an area of 2390.02 sq. km. along the Bhagirathi Valley (Gangotri) and above the highland regions, to restore retreating glaciers and protect the native flora and fauna.

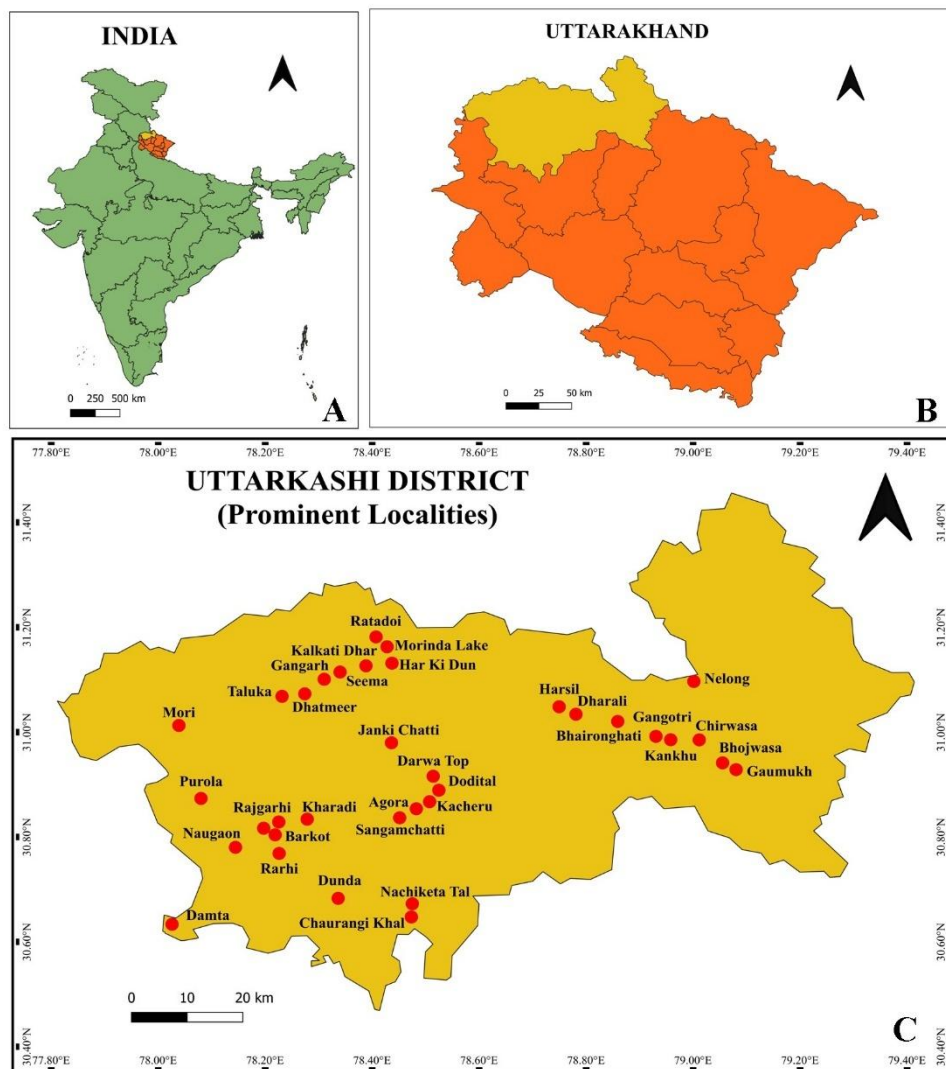


Figure 1: Geographical location of the study area **A.** Western Himalayan Region area falling under Jammu & Kashmir, Himachal Pradesh and

Uttarakhand (starred) states of India. **B.** Geographical location of Uttarkashi district in Uttarakhand state. **C.** Major areas/valleys/localities marked as current collection sites in the study area.

Methods

The exploratory investigations took place from March 2013 to September 2018 ([Figure 2](#)). The following localities like Damta (900-950 m), Dunda (1050 m), Sonaldi (1150 m), Mori (1200 m), Kanseru (1250 m), Barkot (1300 m), Kharadi (1300 m), Purola (1350 m), Rajgarhi (1350 m), Orcha Band (1600 m), Sangamchatti (1650 m), Manpur (1700 m), Sankri (1950 m), Agora (2100 m), Taluka (2100 m), Barsu (2250 m), Bebra (2250 m), Rarhi (2250 m), Chaurangi Khal (2300 m), Barnala Lake (2400 m), Gangarh (2400 m), Dharali (2500 m), Dharkot (2500 m), Harsil (2500 m), Nachiketa Tal (2500 m), Kharsali (2550 m), Seema (2700 m), Bhaironghati (2800 m), Osla (2800 m), Renugaad (2950 m), Dodital (3100 m), Gangotri (3100 m), Kalkati Dhar (3300 m), Yamunotri (3300 m), Devgaad (3500 m), Har Ki Dun (3500 m), Nelong (3500 m), Chirwasa (3600 m), Bhojwasa (3800 m), Darwa Top (3800 m), Morinda Lake (3800 m), Gaumukh (3900 m) and Ratadoi (3900 m) were revisited 3-4 times for the collection of the grass samples ([QGIS, 2024](#)). The geographical coordinates of the visited locations align according to the online data and shapefiles released by the Survey of India, Department of Science and Technology ([SOI, 2024a](#); [SOI, 2024b](#)). The authors followed the taxonomic treatments put forward by Bor, ([1960](#)); Cope, ([1982](#)); Rajbhandari, ([1991](#)); Murti, ([2001](#)); Rana et al., ([2003](#)); Wu et al., ([2007](#)); Chandrasekar and Srivastava, ([2009](#)); Kabeer and Nair, ([2009](#)); Potdar et al., ([2012](#)); Pusalkar and Singh, ([2012](#)); Nautiyal and Gaur, ([2017](#)) and KeyBase, ([2021](#)) to figure out what kind of grass they had collected. They also reviewed the herbaria sheets of grass specimens curated by the Botanical Survey of India (BSD), Northern Circle, Dehra Dun, the Forest Research Institute (DD), Dehra Dun and the Department of Botany (PUN), Punjabi University, Patiala. The accession number(s) of specimens of the species listed in the results section are in accordance with those submitted to the Herbarium (PUN), Department of Botany, Punjabi University, Patiala. The botanical names were based on entries published by the International Plant Names Index ([IPNI, 2024](#)) and synonymies by Plants of the World Online ([POWO, 2024](#)). In order to comprehend the new additions and the occurrence of grass species from past records and our investigation, the authors collected information in [Table 1](#). The results section contains details concerning 112 species, including their botanical name, collection site, distribution pattern, flowering and fruiting period, and essential identification comments concerning new records.

Results

The floristic surveys in the Uttarkashi district identified 112 grass species, representing 51 genera, from various ecozones/localities; 33 of these were new records that contributed to the flora of the district (Figures 3-5).

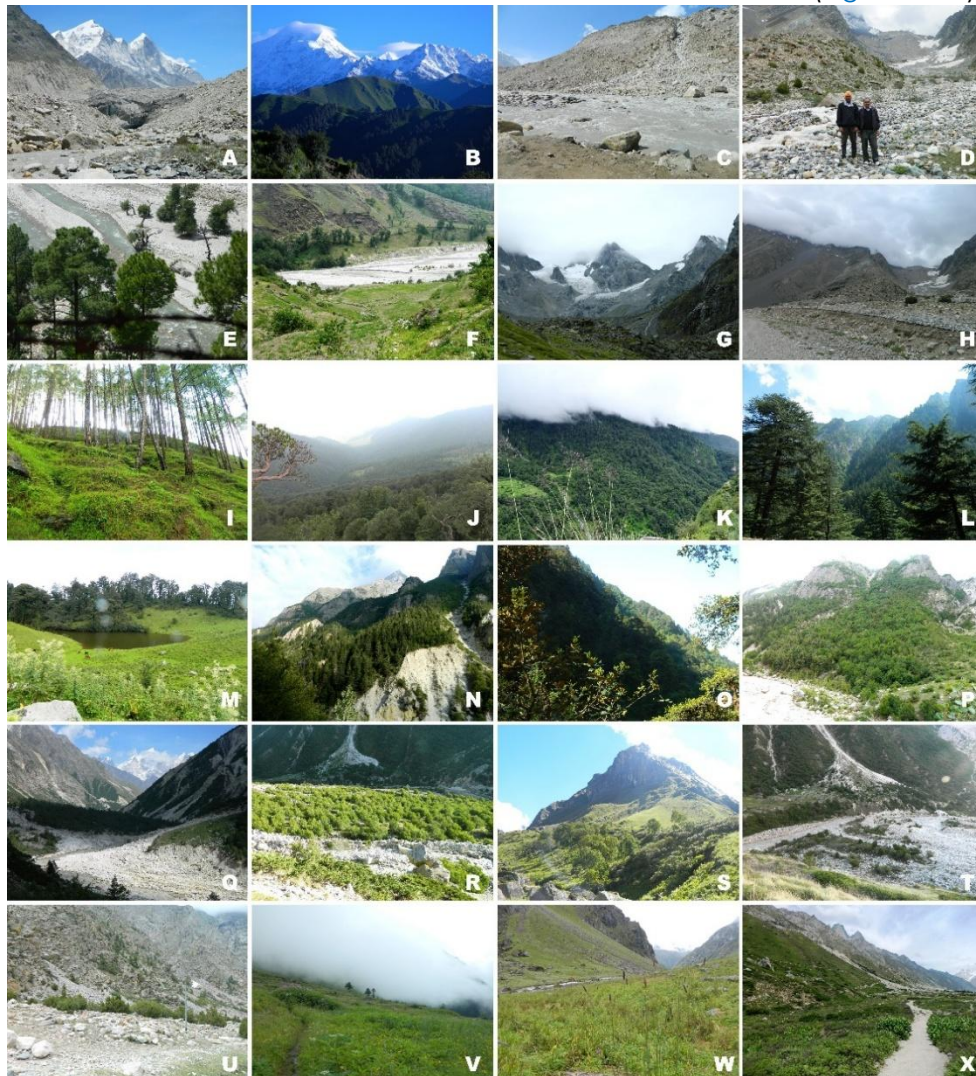


Figure 2: Habitat and vegetation. **A.** Gangotri glacier snout, point of origin of Bhagirathi River. **B.** Snow-covered mountains heading to Bandarpunch glacier. **C.** Bhagirathi River with ice-cold water and sand amalgamation. **D.** A tributary to Jadh Ganga river at Nelong. **E.** Yamuna River bed at Barkot piercing through 'Pine' forest-covered mountains. **F.** River bed of Supin stream, a large tributary of Tons River at Taluka. **G.** Snow-clad mountains/permafrost at Ratadoi. **H.** Cold desert-scrubs at Nelong. **I.** 'Chir' pine forest

cover near Orcha band. **J.** 'Ban oak' forest cover in association with Rhododendron trees at Rarhi Top. **K.** 'Moru oak' forests above Agora-Dodital. **L.** Dense deodar forest (*Cedrus deodara*) cover around Bhaironghati. **M.** Moist Temperate deciduous forest cover on the way to Dayara Bugyal. **N.** Moist mixed Coniferous Forest cover on slopes facing Kankhu. **O.** Upper West Himalayan Temperate broad-leaved forests, Kharsu oak cover above Yamunotri. **P.** West Himalayan Birch-Fir forests around Gangotri. **Q.** Riverine Blue Pine (*Pinus wallichiana*) forest at Chirwasa. **R.** Birch/Bhoj (*Betula utilis*) scrub forests Chirwasa-Bhojwasa (Conserved). **S.** Birch-Rhododendron scrub forests above Har Ki Dun. **T.** Rhododendron scrub patches around Bhojwasa. **U.** Dwarf Juniper scrubs along Jadh Ganga. **V.** Foxtail grass (*Alopecurus arundinaceus*) covered (Alpine) meadow around Morinda Lake-Ratadoi. **W.** Alpine meadows, herbaceous flora along with shrubs. **X.** Panoramic view of study area

The genus *Bromus* L., *Helictotrichon* Besser, *Paspalum* L., *Pennisetum* Rich. and *Setaria* P.Beauv., were each presented by 2 species and others such as *Agrostis* L., *Alopecurus* L., *Arthraxon* P.Beauv., *Capillipedium* Stapf, *Chrysopogon* Trin., *Cymbopogon* Spreng., *Dactyloctenium* Willd., *Echinochloa* P.Beauv., *Eleusine* Gaertn., *Festuca* L., *Glyceria* R.Br, *Microstegium* Nees, *Mnesithea* Kunth, *Oplismenus* P.Beauv., *Panicum* L., *Paspalidium* Stapf, *Phleum* L., *Poa* L., *Rottboellia* L.f., *Sacciolepis* L., *Stipa* L., *Themda* Forssk. and *Tragus* Haller were represented by single species (Table 1).

Table 1: Annotated checklist of species diversity of grasses in the Uttarkashi district area, with name, status of record in present and earlier floristic accounts from different localities/areas/valleys/vegetation zones

Name of taxon	Present Records (Uttarkashi District)	Dabadghao and Shankarnarayan, 1973 (Sandra, Naitwar, Osla, Har Ki Dun)	Negiet al., 1985 (Dodital Area)	Ran et al., 2003 (Tons Valley)	Pusalkar and Singh, 2012 (Gangotri National Park)	Nautilyal and Gaur, 2017 (Areas of Uttarkashi)	Manikandan et al., 2020 (Govind Pashu Vihar Wildlife Sanctuary)	Chandrasekar et al., 2022 (Nelang/Nelong Valley)	New Records
<i>Agropyron thomsonii</i> Hook.f. [= <i>Elymus nayarii</i> Karthik.]	+				+				

<i>Agrostis canina</i> L.	+		+						
<i>Agrostis griffithiana</i> (Hook.f.) Bor	+				+				
<i>Agrostis munroana</i> Aitch. & Hemsl.	+	+			+				
<i>Agrostis pilosula</i> Trin.	+		+		+		+		
<i>Agrostis stolonifera</i> L.					+				
<i>Agrostis vinealis</i> Schreb.	+								+
<i>Alopecurus arundinaceus</i> Poir.	+				+				
<i>Alopecurus nepalensis</i> Trin. ex Steud.	+								+
<i>Andropogon munroi</i> C.B.Clarke [= <i>Andropogon tristis</i> Nees ex Hack.]	+		+		+				
<i>Apluda mutica</i> L.	+	+					+		
<i>Arthraxon lanceolatus</i> (Roxb.) Hochst.	+								+
<i>Arthraxon lancifolius</i> (Trin.) Hochst.	+						+		
<i>Arundinella nepalensis</i> Trin.		+					+		
<i>Arundinella setosa</i> Trin.	+						+		

<i>Arundo donax</i> L.				+	+		+		
<i>Avena fatua</i> L.	+			+					
<i>Avena sativa</i> L.							+		
<i>Brachiaria reptans</i> (L.) C.A.Gardner & C.E.Hubb.	+	+							
<i>Brachypodium distachyon</i> (L.) P.Beauv.					+				
<i>Brachypodium sylvaticum</i> (Huds.) P.Beauv.	+				+		+		
<i>Briza media</i> L.					+				
<i>Bromus catharticus</i> Vahl	+								+
<i>Bromus himalaicus</i> Stapf	+								+
<i>Bromus hordeaceus</i> L.					+				
<i>Bromus inermis</i> Leyss.	+				+			+	
<i>Bromus japonicus</i> Houtt.	+				+		+	+	
<i>Bromus pectinatus</i> Thunb.	+				+				
<i>Bromus ramosus</i> Huds.	+				+		+		
<i>Bromus tectorum</i> L.	+							+	

<i>Calamagrostis emodensis</i> Griseb.	+	+			+			+	
<i>Calamagrostis epigejos</i> (L.) Roth								+	
<i>Calamagrostis lahulensis</i> G.Singh	+				+				
<i>Calamagrostis pseudophragmites</i> (Haller f.) Koeler	+	+			+		+		
<i>Calamagrostis pulchella</i> Griseb.								+	
<i>Calamagrostis scabrescens</i> Griseb. [= <i>Deyeuxia scabrescens</i> (Griseb.) Munro ex Duthie]	+	+			+				
<i>Calamagrostis stolizkae</i> Hook.f.	+				+				
<i>Capillipedium assimile</i> (Steud.) A.Camus	+								+
<i>Chrysopogon fulvus</i> (Spreng.) Chiov.		+		+			+		
<i>Chrysopogon gryllus</i> (L.) Trin.	+			+	+		+		
<i>Chrysopogon serrulatus</i> Trin.	+								+

<i>Cymbopogon distans</i> (Nees ex Steud.) W.Watson	+								+
<i>Cymbopogon martini</i> (Roxb.) W.Watson	+	+					+		
<i>Cynodon dactylon</i> (L.) Pers.	+			+	+		+		
<i>Dactylis glomerata</i> L.	+				+		+		
<i>Dactyloctenium aegyptium</i> (L.) Willd.	+								+
<i>Danthonia cachemyriana</i> Jaub. & Spach [= <i>Tenaxia cachemyriana</i> (Jaub. & Spach) N.P.Barker & H.P.Linder]					+		+		
<i>Danthonia schneideri</i> Pilg. [= <i>Tenaxia cumminsii</i> (Hook.f.) N.P.Barker & H.P.Linder] [= <i>Danthonia jacquemontii</i> Bor]		+			+		+	+	
<i>Dendrocalamus strictus</i> (Roxb.) Nees				+			+		
<i>Deschampsia cespitosa</i>	+	+			+				

(L.) P.Beauv.									
<i>Digitaria ciliaris</i> (Retz.) Koeler [= <i>Digitaria adscenden s</i> (Kunth) Henrard]		+			+				
<i>Digitaria horizontalis</i> Willd.							+		
<i>Digitaria stricta</i> Roth ex Roem. & Schult.							+		
<i>Drepanosta chyum falcatum</i> (Nees) Keng f.				+					
<i>Echinochlo a colona</i> (L.) Link							+		
<i>Echinochlo a crus-galli</i> (L.) P. Beauv.	+								+
<i>Echinochlo a frumentace a</i> Link	+			+			+		
<i>Eleusine coracana</i> (L.) Gaertn.							+		
<i>Eleusine indica</i> (L.) Gaertn.	+								+
<i>Elymus gangotrian us</i> Pusalkar, D.K.Singh & S.K.Srivast.	+				+				
<i>Elymus himalayanu s</i> (Nevski) Tzvelev	+				+				

<i>Elymus jacquemontii</i> (Hook.f.) Tzvelev	+				+				
<i>Elymus longearistatus</i> (Boiss.) Tzvelev [= <i>Elymus canaliculatus</i> (Nevski) Tzvelev; <i>Agropyron canaliculatum</i> Nevski]	+	+			+			+	
<i>Elymus nutans</i> Griseb.	+				+				
<i>Elymus schrenkianus</i> (Fisch. & C.A.Mey. ex Schrenk) Tzvelev	+				+				
<i>Elymus semicostatus</i> (Nees ex. Steud.) Meld	+				+		+		
<i>Eragrostis minor</i> Host					+				
<i>Eragrostis nigra</i> Nees ex Steud.	+			+			+		
<i>Eremopoa persica</i> (Trin.) Roshev. [= <i>Poa persica</i> Trin.]					+				
<i>Eulaliopsis binata</i> (Retz.) C.E. Hubb.	+	+					+		
<i>Festuca alata</i> (Ves) Roshev.	+								+

<i>Festuca gigantea</i> (L.) Vill. [= <i>Lolium giganteum</i> (L.) Darbysh.]	+		+		+				
<i>Festuca kashmiriana</i> Stapf		+							
<i>Festuca lucida</i> Stapf		+							
<i>Festuca ovina</i> L.		+							
<i>Festuca polycolea</i> Stapf					+				
<i>Festuca rubra</i> L.	+		+						
<i>Festuca valesiaca</i> Schleich. ex Gaudin	+				+			+	
<i>Glyceria tonglensis</i> C.B. Clarke	+								+
<i>Helictotrichon asperum</i> (Munro ex Thwaites) Bor [= <i>Trisetopsis aspera</i> (Munro ex Thwaites) Röser & A.Wölk]	+								+
<i>Helictotrichon pratense</i> (L.) Pilg.		+							
<i>Helictotrichon uniyalii</i> Kandwal & B.K. Gupta	+								+
<i>Helictotrichon virescens</i> (Nees ex	+				+				

Steud.) Henrard [= <i>Trisetopsis virescens</i> (Nees ex Steud.) Röser & A.Wölk]									
<i>Heteropogon contortus</i> (L.) P.Beauv. ex Roem. & Schult.,	+						+		
<i>Hierochloë laxa</i> R.Br. ex Hook.f [= <i>Anthoxanthum laxum</i> (Hook.f.) Veldkamp]					+		+		
<i>Imperata cylindrica</i> (L.) P.Beauv.		+		+			+		
<i>Koeleria macrantha</i> (Ledeb.) Schult.	+	+			+				
<i>Melica persica</i> Kunth					+				
<i>Melica scaberima</i> (Nees ex Steud.) Hook.f.	+						+		
<i>Microstegium falconeri</i> (Hook.f.) Clayton							+		
<i>Microstegium nudum</i> (Trin.) A.Camus	+								+
<i>Milium effusum</i> L.	+						+		

<i>Miscanthus nepalensis</i> (Trin.) Hack.							+		
<i>Mnesithea laevis</i> (Retz.) Kunth	+								+
<i>Muhlenbergia duthieana</i> Hack.					+		+		
<i>Muhlenbergia himalayensis</i> Hack. ex Hook.f.					+				
<i>Neyraudia arundinacea</i> (L.) Henrard							+		
<i>Opismenus compositus</i> (L.) P. Beauv.	+								+
<i>Opismenus undulatifolius</i> (Ard.) P.Beauv.	+						+		
<i>Panicum psilopodium</i> Trin.	+								+
<i>Paspalidium flavidum</i> (Retz.) A. Camus	+								+
<i>Paspalum dilatatum</i> Poir.	+								+
<i>Paspalum distichum</i> L.	+								+
<i>Pennisetum alopecuroides</i> (L.) Spreng.	+								+
<i>Pennisetum flaccidum</i> Griseb.					+		+		

[= <i>Cenchrus flaccidus</i> (Griseb.) Morrone]									
<i>Pennisetum lanatum</i> Klotzsch [= <i>Cenchrus lanatus</i> (Klotzsch) Morrone]	+				+			+	
<i>Pennisetum orientale</i> Rich. [= <i>Cenchrus orientalis</i> (Rich.) Morrone]	+	+	+	+			+		
<i>Pennisetum purpureum</i> Schumach.	+								+
<i>Perotis indica</i> (L.) Kuntze				+					
<i>Phacelurus speciosus</i> (Steud.) C.E.Hubb.	+				+				
<i>Phalaris minor</i> Retz.				+	+		+		
<i>Phleum alpinum</i> L.	+	+			+		+		
<i>Phleum paniculatu m</i> Huds.				+			+		
<i>Phleum pratense</i> L.	+								+
<i>Phragmites karka</i> (Retz.) Trin. ex Steud.		+		+			+		
<i>Piptatheru m aequiglum e</i> (Duthie	+				+				

ex Hook.f.) Roshev.									
<i>Piptatheru m gracile</i> Mez	+				+				
<i>Piptatheru m hilariae</i> Pazij								+	
<i>Piptatheru m laterale</i> (Regel) Nevski	+				+				
<i>Piptatheru m munroi</i> (Stapf ex Hook.f.) Mez	+				+			+	
<i>Poa alpigena</i> Lindm.					+	+			
<i>Poa alpina</i> L.		+			+			+	
<i>Poa angustifolia</i> L.					+	+			
<i>Poa annua</i> L.	+	+	+	+	+		+	+	
<i>Poa arnoldii</i> Melderis [= <i>Poa alberti</i> subsp. <i>arnoldii</i> (Melderis) Olonova & G.H.Zhu]					+	+			
<i>Poa attenuata</i> Trin.					+	+			
<i>Poa bactriana</i> Roshev.					+	+			
<i>Poa bulbosa</i> L.						+			
<i>Poa burmanica</i> Bor	+								+

<i>Poa compressa</i> L.								+	
<i>Poa falconeri</i> Hook.f.	+				+	+			
<i>Poa gammieana</i> Hook.f.						+			
<i>Poa glauca</i> Vahl [= <i>Poa litwinowiana</i> Ovcz.]					+				
<i>Poa harae</i> Rajbh. [	+				+	+			
<i>Poa himalayana</i> Nees ex Steud.					+	+			
<i>Poa hirtiglumis</i> Hook.f.					+	+			
<i>Poa jaunsarensis</i> Bor		+			+	+			
<i>Poa kanaii</i> Rajbh.					+	+			
<i>Poa khasiana</i> Stapf					+	+			
<i>Poa koelzii</i> Bor					+	+			
<i>Poa lahulensis</i> Bor [= <i>Poa alberti</i> subsp. <i>lahulensis</i> (Bor) Olonova & G.H.Zhu]					+	+			
<i>Poa mustangensis</i> Rajbh.					+	+			

<i>Poa nemoralis</i> L.			+	+	+		+		
<i>Poa nepalensis</i> (Wall. ex Griseb.) Duthie	+		+			+			
<i>Poa nephelophila</i> Bor [= <i>Poa nepalensis</i> var. <i>nepalensis</i>]	+					+			
<i>Poa pagophila</i> Bor	+	+			+	+			
<i>Poa polycolea</i> Stapf	+				+				
<i>Poa poophagorum</i> Bor [= <i>Poa alberti</i> subsp. <i>poophagorum</i> (Bor) Olonova & G.H.Zhu]	+				+	+			
<i>Poa pratensis</i> L.	+	+			+				
<i>Poa rhadina</i> Bor	+				+	+			
<i>Poa royleana</i> Nees ex Steud.						+			
<i>Poa setulosa</i> Bor	+				+				
<i>Poa sikkimensis</i> (Stapf) Bor					+	+			
<i>Poa stapfiana</i> Bor	+				+	+			

<i>Poa sterilis</i> M.Bieb.	+				+	+		+	
<i>Poa stewartiana</i> Bor	+					+			
<i>Poa supina</i> Schrad.	+				+		+		
<i>Poa tibetica</i> Munro ex Stapf								+	
<i>Poa trivialis</i> L.	+				+				
<i>Poa versicolor</i> Besser	+				+				
<i>Pogonatherum paniceum</i> (Lam.) Hack.				+			+		
<i>Polypogon fugax</i> Nees ex Steud.	+	+			+				
<i>Polypogon monspeliensis</i> (L.) Desf.	+		+						
<i>Rottboellia cochinchinensis</i> (Lour.) Clayton	+								+
<i>Saccharum rufipilum</i> Steud. [= <i>Erianthus rufipilus</i> (Steud.) Griseb.]		+					+		
<i>Saccharum spontaneum</i> L.,							+		
<i>Sacciolepis indica</i> (L.) Chase	+								+
<i>Setaria glauca</i> (L.) P.Beauv.	+								+

<i>Setaria homonyma</i> (Steud.) Chiov.	+								+
<i>Setaria megaphylla</i> (Steud.) T. Durand & Schinz							+		
<i>Setaria pumila</i> (Poir.) Roem. & Schult.	+						+	+	
<i>Sinarundinaria falcata</i> (Nees) C.S.Chao & Renvoize							+		
<i>Spodiopogon dubius</i> Hack.							+		
<i>Stipa jacquemontii</i> Jaub. & Spach [= <i>Achnatherum jacquemontii</i> (Jaub. & Spach) P.C.Kuo & S.L.Lu]					+				
<i>Stipa mongholica</i> Turcz. ex Trin. [= <i>Ptilagrostis mongholica</i> (Turcz. ex Trin.) Griseb.]					+				
<i>Stipa orientalis</i> Trin.					+				
<i>Stipa roylei</i> (Nees) Duthie	+								+

<i>Thamnocalamus spathiflorus</i> (Trin.) Munro							+		
<i>Themeda anathera</i> (Nees ex Steud.) Hack.	+	+					+		
<i>Themeda triandra</i> Forssk.	+								+
<i>Tragus roxburghii</i> Panigrahi	+								+
<i>Tripogon filiformis</i> Nees ex Steud.							+		
<i>Tripogon purpurascens</i> Duthie					+				
<i>Trisetum aeneum</i> (Hook.f.) R.R.Stewart [= <i>Sibirotrisetum aeneum</i> (Hook.f.) Barberá]	+				+				
<i>Trisetum clarkei</i> (Hook.f.) R.R.Stewart	+				+				
<i>Trisetum micans</i> (Hook.f.) Bor					+				
<i>Trisetum spicatum</i> (L.) K.Richt.	+	+			+				
<i>Urochloa villosa</i> (Lam.) T.Q. Nguyen							+		
188 Species	112	32	10	18	95	27	57	18	33

Different populations of *Agropyron thomsonii*, *Andropogon munroi*, *Apluda mutica*, *Brachypodium sylvaticum*, *Dactylis glomerata*, *Elymus semicostatus*, *Melica persica*, *Phacelurus speciosus*, *Stipa roylei* and *Trisetum spicatum* showed different morphological changes depending on their habitat. The following results provide details about the currently examined plant materials:

***Agropyron thomsonii* Hook.f.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Nelong; 31.1064°N, 79.0082°E; alt. 3500 m; 20.06.2015; Jaswant Singh 35201 leg.; PUN 61953.

Distribution: Uncommon, sub-alpine to alpine regions of Bhagirathi, Jadh Ganga (Nelong) and Nila Valleys (Above 3100 m), Uttarkashi.

Flowering and fruiting: May-August.

***Agrostis canina* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dodital; 30.8975°N, 78.5265°E; alt. 3100 m; 31.06.2015; Jaswant Singh 36630 leg.; PUN 63085.

Distribution: Uncommon, sub-alpine to alpine regions of Assi Ganga Valley (3000-3700 m), Uttarkashi.

Flowering and fruiting: June-October.

***Agrostis griffithiana* (Hook.f.) Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Kacheru; 30.8650°N, 78.5102°E; alt. 2700 m; 29.06.2017; Jaswant Singh 35284 leg.; PUN 63045.

Distribution: Common, Assi Ganga (Kacheru, Darwa), Bhagirathi, Chaurangi Khal and Har Ki Dun Valleys (2300-3800 m), Uttarkashi.

Flowering and fruiting: June-September.

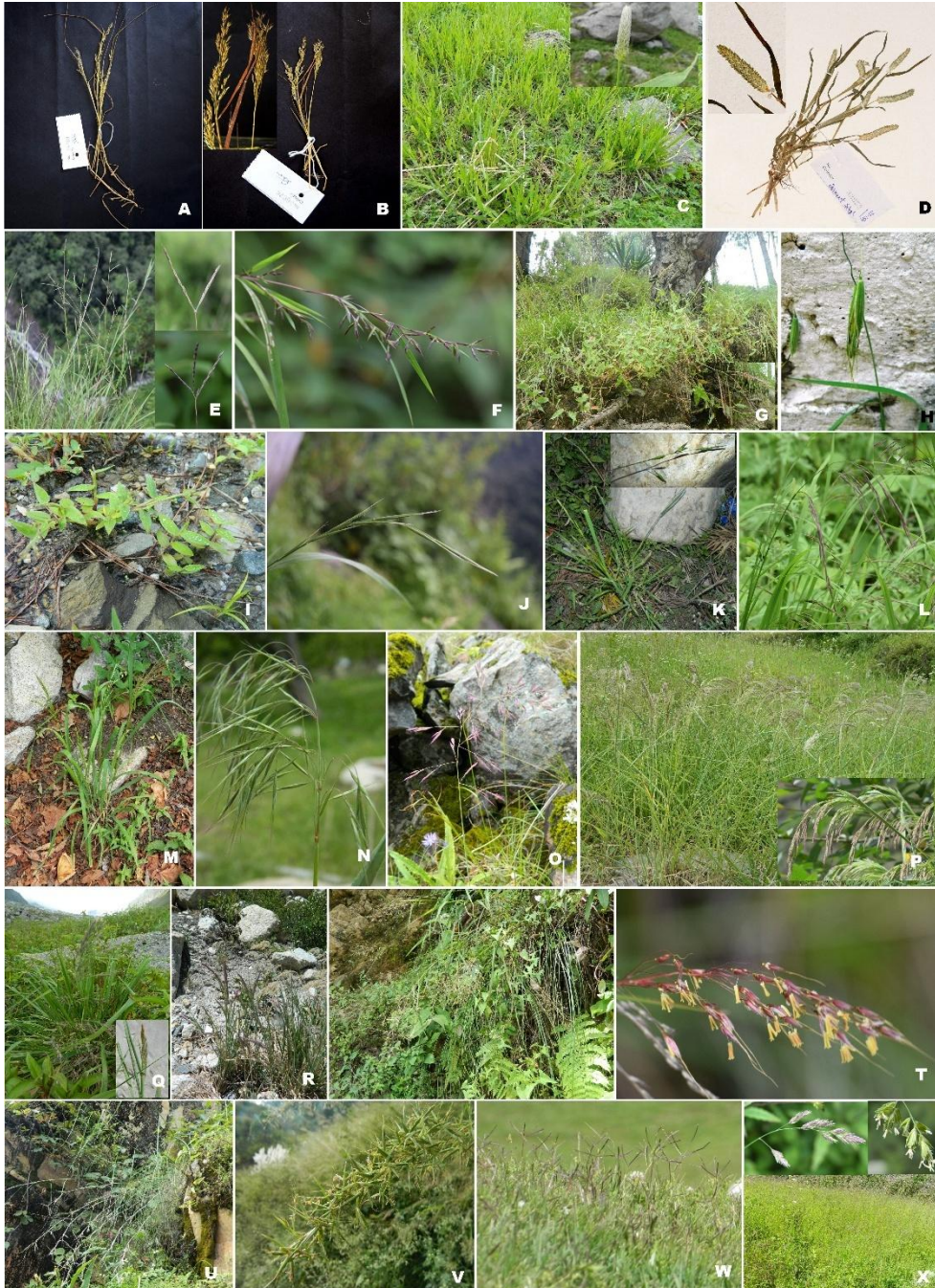


Figure 3: Field/herbarium photographs of grass species. **A.** *Agrostis canina*. **B.** *Agrostis vinealis*. **C.** *Alopecurus arundinaceus*. **D.** *Alopecurus nepalensis*. **E.** *Andropogon munroi*. **F.** *Apluda mutica*. **G.** *Arthraxon lanceolatus*. **H.** *Avena*

fatua. **I.** *Brachiaria reptans*. **J.** *Brachypodium sylvaticum*. **K.** *Bromus catharticus*. **L.** *Bromus himalaicus*. **M.** *Bromus ramosus*. **N.** *Bromus tectorum*. **O.** *Calamagrostis lahulensis*. **P.** *Calamagrostis pseudophragmites*. **Q.** *Calamagrostis scabrescens*. **R.** *Calamagrostis stolizkae*. **S.** *Capillipedium assimile*. **T.** *Chrysopogon serrulatus*. **U.** *Cymbopogon distans*. **V.** *Cymbopogon martini*. **W.** *Cynodon dactylon*. **X.** *Dactylis glomerata*.

***Agrostis munroana* Aitch. & Hemsl.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Morinda Lake; 31.1668°N, 78.4283°E; alt. 3700 m; 01.06.2016; Jaswant Singh 35291 leg.; PUN 63052.

Distribution: Common, alpine regions of Assi Ganga (Darwa), Bhagirathi and Har Ki Dun (Morinda Lake) Valleys (3500-3900 m), Uttarkashi.

Flowering and fruiting: May-September.

***Agrostis pilosula* Trin.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dodital; 30.8975°N, 78.5265°E; alt. 3100 m; 28.07.2017; Jaswant Singh 36509 leg.; PUN 62905.

Distribution: Uncommon, sub-alpine to alpine regions of Assi Ganga (Dodital, Darwa) and Bhagirathi Valleys (3000-3900 m), Uttarkashi.

Flowering and fruiting: May-September.

***Agrostis vinealis* Schreb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Darwa; 30.9139°N, 78.5122°E; alt. 3800 m; 31.06.2015; Jaswant Singh 36626 leg.; PUN 63081.

Identification: Tufted grass, panicle lax, spikelets with 1-floret and laterally compressed, callus not bearded, lemma glabrous, lemma awned below the middle, palea less than half the length of lemma, anthers 1-1.5 mm long.

Distribution: Uncommon, alpine regions of Assi Ganga (Darwa) Valley (3500-3900 m), Uttarkashi.

Flowering and fruiting: July-September.

***Alopecurus arundinaceus* Poir.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Kalkati Dhar; 31.1332°N, 78.3930°E; alt. 3100 m; 19.06.2014; Jaswant Singh 33901 leg.; PUN 60460; • *ibid.*, Morinda Lake, 31.1668°N, 78.4283°E; alt. 3800 m; 01.06.2016; Jaswant Singh 36652 leg.; PUN 63072.

Distribution: Common, sub-alpine to alpine regions of Har Ki Dun (Kalkati Dhar, Morinda Lake) and Nila Valleys (3000-4000 m), Uttarkashi.

Flowering and fruiting: May-September.

***Alopecurus nepalensis* Trin. ex Steud.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dunda; 30.6962°N, 78.3486°E; alt. 1100 m; 29.03.2014; Jaswant Singh 33953 leg.; PUN 60512.

Identification: Annual, tufted; culms geniculate at the base; panicle narrowly cylindrical; spikelets obovate-cuneate; glumes keeled, firm, inflated; lemma minutely awned; anther 0.6 mm long.

Distribution: Uncommon, sub-tropical to temperate regions of Dunda range (900-1200 m), Uttarkashi.

Flowering and fruiting: March-May.

***Andropogon munroi* C.B. Clarke**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Kankhu; 30.9960°N, 78.9553°E; alt. 3150 m; 25.06.2016; Jaswant Singh 33955 leg.; PUN 61001.

Distribution: Common, temperate to alpine zones of Assi Ganga (Agora, Dharkot), Bhagirathi (Kankhu), Har Ki Dun (Kalkati Dhar) and Rarhi Valleys (2000-3400 m), Uttarkashi.

Flowering and fruiting: June-October.

***Apluda mutica* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Sonaldi; 30.8221°N, 78.2060°E; alt. 1200 m; 09.09.2013; Jaswant Singh 33980 leg.; PUN 61026.

Distribution: Common, sub-tropical to temperate regions (Barkot, Chaurangi Khal, Manpur, Nachiketa Tal, Purola, Rarhi, Sonaldi, Taluka) (Up to 2400 m), Uttarkashi.

Flowering and fruiting: May-November.

***Arthraxon lanceolatus* (Roxb.) Hochst.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Purola; 30.8756°N, 78.0786°E; alt. 1300 m; 10.09.2016 Jaswant Singh 36699 leg.; PUN 63035.

Identification: Annual, stoloniferous, culms decumbent, inflorescence composed of 2-4 racemes, spikelets awned and not laterally compressed, lower glume of sessile spikelet 4.5-5 mm long with pectinately toothed base covered with silky cataphylls, lower glume on back flat or slightly convex with strongly marked nerves on the keel from base to apex, anthers 3, 1-2 mm long.

Distribution: Common, sub-tropical to temperate regions (Agora, Purola) (1300-2100 m), Uttarkashi

Flowering and fruiting: May-October.

***Arthraxon lancifolius* (Trin.) Hochst.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Barkot; 31.8077°N, 78.2213°E; alt. 1300 m; 07.09.2013; Jaswant Singh 36545 leg.; PUN 62966.

Distribution: Common, sub-tropical to temperate regions (Barkot, Purola, Rarhi) (1100-2300 m), Uttarkashi.

Flowering and fruiting: May-October.

***Arundinella setosa* Trin.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Agora; 30.8459°N, 78.4862°E; alt. 2100 m; 03.08.2015; Jaswant Singh 36631 leg.; PUN 63086.

Distribution: Common, sub-tropical to temperate regions (Agora, Naitwar and Sankri-Taluka) (1200-2300 m), Uttarkashi.

Flowering and fruiting: July-October.

***Avena fatua* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Purola; 30.8756°N, 78.0786°E; alt. 1300-1350 m; 23.03.2014 Jaswant Singh 35243 leg.; PUN 62416.

Distribution: Uncommon, sub-tropical regions along tons river (Purola) (1100-1400 m), Uttarkashi.

Flowering and fruiting: March-May.

***Brachiaria reptans* (L.) C.A.Gardner & C.E.Hubb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Agora; 30.8459°N, 78.4862°E; alt. 2250 m; 02.08.2015 Jaswant Singh 33929 leg.; PUN 60488.

Distribution: Common, sub-tropical to temperate regions (Agora) (Up to 2400 m), Uttarkashi.

Flowering and fruiting: July-October.

***Brachypodium sylvaticum* (Huds.) P. Beauv.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Orcha Band; 30.8002°N, 78.2376°E; alt. 1600 m; 09.08.2014; Jaswant Singh 35271 leg.; PUN 62444.

Distribution: Common, sub-tropical to alpine montane regions of Uttarkashi (Barkot Band, Orcha Band, Dodital-Darwa, Har Ki Dun) (1200-3500 m), Uttarkashi.

Flowering and fruiting: June-September.

***Bromus catharticus* Vahl**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Naugaon; 30.7812°N, 78.1425°E; alt. 1100-1200 m; 23.03.2014 Jaswant Singh 33939 leg.; PUN 60498.

Identification: Annual, geniculately ascending; spikelets strongly laterally compressed, lemmas awnless or with mucro (1 mm), palea 1/2 lemma length.

Distribution: Uncommon, sub-tropical to temperate regions (Purola, Naugaon) (900-1400 m), Uttarkashi.

Flowering and fruiting: March-May.

***Bromus himalaicus* Stapf**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Darwa; 30.9139°N, 78.5122°E; alt. 3500 m; 28.07.2017 Jaswant Singh 36519 leg.; PUN 62915.

Identification: Perennial herb, panicle drooping, branches simple, spikelets slightly compressed laterally, glumes sub-equal to lower florets, awn stout and as long as lemma, lemma 8-10 mm.

Distribution: Common, alpine regions of Assi Ganga (Dodital-Darwa) and Har Ki Dun (Har Ki Dun) Valleys (3000-3700 m), Uttarkashi.

Flowering and fruiting: May-September.

***Bromus inermis* Leyss.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Harsil; 31.0535°N, 78.7508°E; alt. 2500 m; 24.05.2014; Jaswant Singh 35264 leg.; PUN 62437.

Distribution: Less common, temperate to sub-alpine regions of Bhagirathi Valley (Harsil) (2000-3300 m), Uttarkashi.

Flowering and fruiting: May-September.

***Bromus japonicus* Houtt.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Harsil; 31.0535°N, 78.7508°E; alt. 2500 m; 24.05.2014; Jaswant Singh 33940 leg.; PUN 60499.

Distribution: Common, temperate to alpine regions of Bhagirathi Valley (Chirwasa, Gangotri, Harsil) (2200-3600 m), Uttarkashi.

Flowering and fruiting: May-September.

***Bromus pectinatus* Thunb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangotri; 30.9947°N, 78.9396°E; alt. 3200 m; 15.06.2015; Jaswant Singh 33922 leg.; PUN 60481.

Distribution: Occasional, temperate to sub-alpine regions of Bhagirathi Valley (Gangotri) (2000-3300 m), Uttarkashi.

Flowering and fruiting: May-August.

***Bromus ramosus* Huds.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangotri; 30.9947°N, 78.9396°E; alt. 3200 m; 09.07.2015; Jaswant Singh 35268 leg.; PUN 62441.

Distribution: Uncommon, temperate to alpine regions of Bhagirathi (Chirwasa, Gangotri, Kankhu) and Rudra Ganga Valleys (Up to 3700 m), Uttarkashi.

Flowering and fruiting: June-September.

***Bromus tectorum* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Bhaironghati; 31.0270°N, 78.8676°E; alt. 2800 m; 20.06.2015 Jaswant Singh 35272 leg.; PUN 62445.

Distribution: Common, temperate to sub-alpine regions of Bhagirathi Valley (2200-3300 m), Uttarkashi.

Flowering and fruiting: May-September.

***Calamagrostis emodensis* Griseb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dhatmeer Bridge; 30.0860°N, 78.2681°E; alt. 2100 m; 05.09.2014; Jaswant Singh 36605 leg.; PUN 63100.

Distribution: Common, sub-alpine to alpine regions of Assi Ganga (Dodital), Bhagirathi (Devgaad, Gangotri) and Har Ki Dun (Dhatmeer) Valleys (2000-3700 m), Uttarkashi.

Flowering and fruiting: June-September.

***Calamagrostis lahulensis* G.Singh**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gaumukh; 30.9373°N, 79.0703°E; alt. 3900 m; 24.06.2016; Jaswant Singh 36671 leg.; PUN 63007.

Distribution: Common, alpine regions of Bhagirathi (Bhojwasa, Chirwasa, Gaumukh) and Har Ki Dun (Morinda Lake, Ratadoi) Valleys (3200-4100 m), Uttarkashi.

Flowering and fruiting: June-October.

***Calamagrostis pseudophragmites* (Haller f.) Koeler**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangarh; 31.1007°N, 78.3141°E; alt. 2400 m; 31.06.2015; Jaswant Singh 36571 leg.; PUN 62992.

Distribution: Common, temperate to alpine regions of Uttarkashi (Banas, Bhaironghati, Chirwasa, Dhrasu Band, Gangarh, Gangotri) (1800-3800 m), Uttarkashi.

Flowering and fruiting: May-August.

***Calamagrostis scabrescens* Griseb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Darwa Top; 30.9139°N, 78.5122°E; alt. 3800 m; 31.07.2015; Jaswant Singh 35273 leg.; PUN 62446.

Distribution: Common, alpine regions of Assi Ganga (Darwa), Bhagirathi and Har Ki Dun Valleys (3500-3900 m), Uttarkashi.

Flowering and fruiting: June-September.

***Calamagrostis stolizkae* Hook.f.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gaumukh; 30.9373°N, 79.0703°E; alt. 3900 m; 11.07.2014; Jaswant Singh 36589 leg.; PUN 62935.

Distribution: Uncommon, alpine regions of Bhagirathi (Gaumukh) and Rudra Ganga Valleys (3500-4000 m), Uttarkashi.

Flowering and fruiting: June-August.

***Capillipedium assimile* (Steud.) A.Camus**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Chaurangi Khal; 30.6448°N, 78.4887°E; alt. 2200-2300 m; 06.09.2015 Jaswant Singh 33935 leg.; PUN 60494.

Identification: Suffrutescent; spikelets in short racemes with 2-6 sessile spikelets.

Distribution: Uncommon, sub-tropical to temperate regions (Chaurangi Khal, Rarhi) (1500-2400 m), Uttarkashi.

Flowering and fruiting: July-October.

***Chrysopogon gryllus* (L.) Trin.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Rarhi; 30.7705°N, 78.2250°E; alt. 2200 m; 11.08.2014; Jaswant Singh 33915 leg.; PUN 60474.

Distribution: Common, temperate to sub-alpine regions (Bhaironghati, Gangotri, Kankhu, Lanka, Naitwar, Nelong, Rarhi, Seema) (900-3350 m), Uttarkashi.

Flowering and fruiting: July-October.

***Chrysopogon serrulatus* Trin.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Sakurna; 30.8141°N, 78.2002°E; alt. 1200–1400 m; 10.09.2013 Jaswant Singh 36608 leg.; PUN 63103.

Identification: Perennial, tall, leaves not distichous, inflorescence panicle lax, joints of rhachis and pedicel narrow, seldom thickened upward, pedicel shorter than half the length of the sessile spikelet, racemes reduced to triad, spikelets laterally compressed, sessile spikelets awned, upper glume rounded on the back in lower $\frac{3}{4}$, keeled and ciliate in the upper $\frac{1}{4}$, sessile and pedicelled spikelets 6-7 mm long.

Distribution: Common, sub-tropical to temperate regions (Barkot, Hanuman Chatti, Ponti, Rarhi, Sakurna) (900-2000 m), Uttarkashi.

Flowering and fruiting: July-October.

***Cymbopogon distans* (Nees ex Steud.) W.Watson**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Chaurangi Khal; 30.6448°N, 78.4887°E; alt. 2300 m; 06.09.2015 Jaswant Singh 33933 leg.; PUN 60492.

Identification: Perennial, aromatic grass, leaves filiform and flexuous, panicles simple, racemes in pairs supported by spathes, joints of rachis and the pedicel are narrow and not toothed at the apex, spikelets 6-8 mm long, surface of lower glumes of sessile spikelet flat and margins sharply infolded, spikelets in each pair dissimilar, upper lemma of sessile spikelet 2-lobed, awned in the sinus.

Distribution: Common, sub-tropical to temperate regions (Chaurangi Khal, Dharkot, Rarhi, Sakurna) (1600-2400 m), Uttarkashi.

Flowering and fruiting: July-October.

***Cymbopogon martini* (Roxb.) W.Watson**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Saadda; 30.7014°N, 78.4729°E; alt. 1250 m; 10.09.2013; Jaswant Singh 36552 leg.; PUN 62973.

Distribution: Common, sub-tropical to temperate regions (Purola, Rajgarhi, Saadda, Sonaldi) (1000-2000 m), Uttarkashi.

Flowering and fruiting: July-October.

***Cynodon dactylon* (L.) Pers.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Manpur; 30.6978°N, 78.4868°E; alt. 1700 m; 28.05.2014; Jaswant Singh 33942 leg.; PUN 60501.

Distribution: Common, sub-tropical to temperate regions (Chaurangi Khal, Manpur, Sankri) (Up to 2300 m), Uttarkashi.

Flowering and fruiting: May-September.

***Dactylis glomerata* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Kalkati Dhar; 31.1332°N, 78.3930°E; alt. 3200 m; 07.09.2014; Jaswant Singh 36604 leg.; PUN 63099.

Distribution: Common in Har Ki Dun (Har Ki Dun, Kalkati Dhar, Osla, Renugaad) Valley but rather uncommon in Assi Ganga (Dharkot), Bhagirathi (Gangotri, Harsil), Kedar Ganga and Yamuna (Kharsali, Phoolchatti) Valleys (2200-3700 m), Uttarkashi

Flowering and fruiting: May-October.

***Dactyloctenium aegyptium* (L.) Willd.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Damta; 30.6396°N, 78.0239°E; alt. 900 m; 15.08.2017 Jaswant Singh 35263 leg.; PUN 62436.

Identification: Perennial sub-erect herb, inflorescence digitate racemes, axis of spike ending into a sharp point (2 mm).



Figure 4: Field/herbarium photographs of grass species. **A.** *Dactyloctenium aegyptium*. **B.** *Deschampsia cespitosa*. **C.** *Echinochloa crus-galli*. **D.**

Echinochloa frumentacea. **E.** *Eleusine indica*. **F.** *Elymus himalayanus*. **G.** *Elymus jacquemontii*. **H.** *Elymus nutans*. **I.** *Elymus schrenkianus*. **J.** *Eragrostis nigra*. **K.** *Festuca alata*. **L.** *Festuca gigantea*. **M.** *Festuca rubra*. **N.** *Festuca valesiaca*. **O.** *Glyceria tonglensis*. **P.** *Helictotrichon uniyalii*. **Q.** *Helictotrichon virescens*. **R.** *Heteropogon contortus*. **S.** *Microstegium nudum*. **T.** *Mnesithea laevis*. **U.** *Oplismenus composites*. **V.** *Panicum psilopodium*. **W.** *Paspalidium flavidum*. **X.** *Paspalum dilatatum*.

Distribution: Common, sub-tropical regions (Damta) (Up to 1100 m), Uttarkashi.

Flowering and fruiting: July-October.

***Deschampsia cespitosa* (L.) P.Beauv.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Darwa; 30.9139°N, 78.5122°E; alt. 3700 m; 31.07.2015; Jaswant Singh 36694 leg.; PUN 63030.

Distribution: Common, alpine regions of Assi Ganga (Darwa), Har Ki Dun (Morinda Lake, Ratadoi) and Nila Valleys (3300-3900 m), Uttarkashi.

Flowering and fruiting: May-August.

***Echinochloa crus-galli* (L.) P.Beauv.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Taluka; 31.0787°N, 78.2464°E; alt. 2100 m; 04.09.2014 Jaswant Singh 36599 leg.; PUN 62945.

Identification: Annual, culms erect, leaves scabrid, spikes thickened, spikelets 5 mm, elliptic, hairy and densely crowded.

Distribution: Common, sub-tropical to temperate regions (Taluka) (Up to 2300 m), Uttarkashi.

Flowering and fruiting: August-October.

***Echinochloa frumentacea* Link**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Sangamchatti; 30.8343°N, 78.4505°E; alt. 1650 m; 02.08.2015; Jaswant Singh 36537 leg.; PUN 62958.

Distribution: Common, sub-tropical to temperate regions (Sangam Chatti, Shandra) (Up to 2400 m), Uttarkashi.

Flowering and fruiting: August-October.

***Eleusine indica* (L.) Gaertn.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Taluka; 31.0787°N, 78.2464°E; alt. 2100 m; 18.IX.2014 Jaswant Singh 33946 leg.; PUN 60505.

Identification: Annual, leaf blades flat; inflorescence digitate; racemes 2-7, linear, 3-5 mm broad; one raceme often set below the rest.

Distribution: Common, sub-tropical to temperate regions (Dhatmeer, Manpur, Taluka) (Up to 2500 m), Uttarkashi.

Flowering and fruiting: August-October.

***Elymus gangotrianus* Pusalkar, D.K.Singh & S.K.Srivast.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Chirwasa; 30.9798°N, 79.0242°E; alt. 3600 m; 31.06.2015; Jaswant Singh 35230 leg.; PUN 62233.

Distribution: Less common, found in sub-alpine and alpine regions of Bhagirathi (Chirwasa, Devgaad, Kankhu) and Kedar Ganga Valleys (3100-3800 m), Uttarkashi.

Flowering and fruiting: June-September.

***Elymus himalayanus* (Nevski) Tzvelev**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Bhojwasa; 30.9497°N, 79.0530°E; alt. 3800 m; 24.06.2016; Jaswant Singh 33975 leg.; PUN 61021.

Distribution: Common, alpine regions of Bhagirathi (Bhojwasa, Gaumukh) and Kedar Ganga Valleys (Above 3500 m), Uttarkashi.

Flowering and fruiting: May-September.

***Elymus jacquemontii* (Hook.f.) Tzvelev**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Chirwasa (on slopes); 30.9798°N, 79.0242°E; alt. 3600–3750 m; 11.07.2014; Jaswant Singh 35213 leg.; PUN 61965.

Distribution: Uncommon, alpine regions of Bhagirathi (Bhojwasa, Chirwasa) and Jadh Ganga Valleys (Above 3500 m), Uttarkashi.

Flowering and fruiting: June-September.

***Elymus longearistatus* (Boiss.) Tzvelev**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Bhojwasa; 30.9497°N, 79.0530°E; alt. 3800 m; 24.06.2016; Jaswant Singh 35209 leg.; PUN 61961.

Distribution: Common, alpine regions of Bhagirathi (Bhojwasa, Chirwasa, Gaumukh) and Kedar Ganga Valleys (3400-3900 m), Uttarkashi.

Flowering and fruiting: June-September.

***Elymus nufans* Griseb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Bhojwasa; 30.9497°N, 79.0530°E; alt. 3700 m; 24.06.2016; Jaswant Singh 33976 leg.; PUN 61022.

Distribution: Common, temperate to alpine regions of Bhagirathi (Bhojwasa, Gaumukh) and Jadh Ganga (Nelong) Valleys (2700-4000 m), Uttarkashi.

Flowering and fruiting: May-September.

***Elymus schrenkianus* (Fisch. & C.A.Mey. ex Schrenk) Tzvelev**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gaumukh; 30.9373°N, 79.0703°E; alt. 3900 m; 24.06.2016; Jaswant Singh 35233 leg.; PUN 62236.

Distribution: Quite common, alpine regions of Bhagirathi (Bhojwasa, Chirwasa, Gaumukh) and Kedar Ganga Valleys (3600-4500 m), Uttarkashi.

Flowering and fruiting: June-September.

***Elymus semicostatus* (Nees ex. Steud.) Meld.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangotri; 30.9947°N, 78.9396°E; alt. 3100 m; 08.07.2014; Jaswant Singh 33987 leg.; PUN 61940.

Distribution: Common, sub-tropical to alpine regions of Uttarkashi (Agora, Barnala Lake, Barsu, Bebra, Devgaad, Dharkot, Gangotri, Har Ki Dun, Kalkati Dhar, Kankhu, Osla, Renugaad, Seema) (1600-4000 m), Uttarkashi.

Flowering and fruiting: June-September.

***Eragrostis nigra* Nees ex Steud.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Rarhi; 30.7705°N, 78.2250°E; alt. 2250 m; 09.07.2014; Jaswant Singh 35299 leg.; PUN 63060.

Distribution: Common, sub-tropical to sub-alpine regions (Naitwar, Rarhi) (1400-3500 m), Uttarkashi.

Flowering and fruiting: July-October.

***Eulaliopsis binata* (Retz.) C.E.Hubb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Kansol; 30.7966°N, 78.1388°E; alt. 1100 m; 24.03.2014; Jaswant Singh 36559 leg.; PUN 62980.

Distribution: Common, sub-tropical regions of Purola range (Kansol) (Up to 1600 m), Uttarkashi.

Flowering and fruiting: March-June.

***Festuca alatavica* (St.-Yves) Roshev.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Morinda Lake; 31.1668°N, 78.4283°E; alt. 3800 m; 01.06.2016 Jaswant Singh 36651 leg.; PUN 63071.

Identification: perennial, tufted herb 70 cm tall, leaves linear, rigid, convolute, inflorescence ovate panicle 7-15 cm long, lower branches 2-nate, spikelets 8-15 mm long, lemma hyaline and rounded on back, lemma shortly awned, palea linear oblong, keel scabreulous.

Distribution: Uncommon, alpine regions of Har Ki Dun Valley (Morinda Lake, Ratadoi) (3500-4000 m), Uttarkashi.

Flowering and fruiting: August-September.

***Festuca gigantea* (L.) Vill.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Taluka; 31.0787°N, 78.2464°E; alt. 2100 m; 04.09.2014; Jaswant Singh 33916 leg.; PUN 60475.

Distribution: Very common in Assi Ganga Valley but uncommon in Barkot, Bhagirathi, Har Ki Dun, Kedar Ganga, Rarhi and Rudra Ganga Valleys (Chaurangi Khal, Dhatmeer, Dodital, Gangarh, Nachiketa Tal, Orcha Band, Taluka) (1600-3900 m), Uttarkashi.

Flowering and fruiting: May-October.

***Festuca rubra* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Kalkati Dhar; 31.1332°N, 78.3930°E; alt. 3300 m; 14.08.2016 Jaswant Singh 36673 leg.; PUN 63009.

Distribution: Uncommon, sub-alpine to alpine regions of Har Ki Dun Valley (Kalkati Dhar) (3000-3600 m), Uttarkashi.

Flowering and fruiting: July-September.

***Festuca valesiaca* Schleich. ex Gaudin**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Morinda Lake; 31.1668°N, 78.4283°E; alt. 3750 m; 01.06.2016; Jaswant Singh 36663 leg.; PUN 62999.

Distribution: Common, temperate to alpine plains and mountainous regions of Bhagirathi (Bhaironghati, Bhojwasa, Chirwasa, Gangotri), Har Ki Dun (Kalkati Dhar, Morinda Lake), Jadh Ganga (Nelong) and Kedar Ganga Valleys (2800-5200 m), Uttarkashi.

Flowering and fruiting: May-August.

***Glyceria tonglensis* C.B.Clarke**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Seema; 31.1168°N, 78.3496°E; alt. 2700 m; 14.08.2016 Jaswant Singh 36679 leg.; PUN 63015.

Identification: Perennial, aquatic herb, ligule membranous and less than 2 mm, margins of leaf sheaths fused, leaf blades narrow and linear, inflorescence a panicle, spikelets several flowered, lemma 3-3.5 mm long and 7-nerved, and without keel and awn.

Distribution: Common, water-fed regions on the way to Har Ki Dun Valley (Gangarh, Har Ki Dun, Kalkati Dhar, Seema) (2000-3400 m), Uttarkashi.

Flowering and fruiting: July-September.

***Helictotrichon asperum* (Munro ex Thwaites) Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dharkot; 30.8599°N, 78.5112°E; alt. 2500-2700 m; 29.07.2017 Jaswant Singh 35253 leg.; PUN 62426.

Identification: Perennial herb, inflorescence a nodding panicle and widely spreading, spikelets with 3-4 florets, lemma tip bifid (2-fid), lemma awn epimedial, lemma scabrid and dull.

Distribution: Uncommon, over slopes in Assi Ganga Valley (Dharkot) (2200-2800 m), Uttarkashi.

Flowering and fruiting: May-September.

***Helictotrichon uniyalii* Kandwal & B.K.Gupta**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Rarhi; 30.7705°N, 78.2250°E; alt. 2200 m; 09.08.2014 Jaswant Singh 35234 leg.; PUN 62407.

Identification Note: Perennial oat grass, spikelets with geniculate awn, lemma tip entire, anthers 2 mm long.

Distribution: Uncommon, sub-tropical to temperate regions of Rarhi Valley (Rarhi) (1100-2300 m), Uttarkashi.

Flowering and fruiting: July-September.

***Helictotrichon virescens* (Nees ex Steud.) Henrard**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Bhojwasa; 30.9497°N, 79.0530°E; alt. 3600-3700 m; 24.06.2016; Jaswant Singh 35257 leg.; PUN 62430.

Distribution: Occasional, Assi Ganga (Kacheru) and Bhagirathi (Bhojwasa, Chirwasa, Devgaad) Valleys (2200-3700 m), Uttarkashi.

Flowering and fruiting: May-September.

***Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Sonaldi; 30.8221°N, 78.2060°E; alt. 1150 m; 11.09.2014; Jaswant Singh 33918 leg.; PUN 60477.

Distribution: Common, sub-tropical to temperate regions (Barkot, Sonaldi) (Up to 2300 m), Uttarkashi.

Flowering and fruiting: July-November.

***Koeleria macrantha* (Ledeb.) Schult.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dunda; 30.6962°N, 78.3486°E; alt. 1100 m; 22.03.2014; Jaswant Singh 35251 leg.; PUN 62424.

Distribution: Occasional, sub-tropical to alpine regions (Chirwasa, Dunda, Kuteti Devi) (Up to 4000 m), Uttarkashi.

Flowering and fruiting: March-October.

***Melica scaberrima* (Nees ex Steud.) Hook.f.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dodital; 30.8975°N, 78.5265°E; alt. 3000 m; 28.07.2017; Jaswant Singh 36506 leg.; PUN 62902.

Distribution: Common, sub-tropical to sub-alpine regions of Assi Ganga (Dodital-Darwa) and Har Ki Dun (Osla, Renugaad, Taluka) Valleys (1800-3500 m), Uttarkashi.

Flowering and fruiting: July-August.

***Microstegium nudum* (Trin.) A.Camus**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangarh; 31.1007°N, 78.3141°E; alt. 2400 m; 16.08.2016 Jaswant Singh 36684 leg.; PUN 63020.

Identification: Annual, culms rambling; racemes 2-7 very slender, 4-8cm; spikelets of a pair, one sessile, one pedicelled; raceme rachis fragile.

Distribution: Common, temperate montane regions of the district (Chaurangi Khal, Gangarh, Nachiketa Tal, Rarhi) (1500-2500 m), Uttarkashi.

Flowering and fruiting: July-October.

***Milium effusum* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dodital-Darwa; 30.9025°N 78.5183°E; alt. 3400 m; 28.07.2017; Jaswant Singh 35259 leg.; PUN 62432.

Distribution: Uncommon, sub-alpine to alpine zones of Assi Ganga Valley (Dodital-Darwa) (3000-3700 m), Uttarkashi.

Flowering and fruiting: June-August.

***Mnesithea laevis* (Retz.) Kunth**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Rajgarhi; 30.8385°N, 78.2393°E; alt. 1300-1400 m; 16.08.2017 Jaswant Singh 35260 leg.; PUN 62433.

Identification: Perennial and setaceous herb, inflorescence a spike, axis of spike fragile, spikelets paired, keel not winged and pedicels not fused.

Distribution: Uncommon, sub-tropical regions (Palar, Rajgarhi) (1100-1450 m), Uttarkashi.

Flowering and fruiting: May-October.

***Oplismenus compositus* (L.) P.Beauv.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Sonaldi; 30.8221°N, 78.2060°E; alt. 1150 m; 11.09.2014 Jaswant Singh 36921 leg.; PUN 60480.

Identification: Perennial stoloniferous grass; spikelets distant, adjacent pairs on the lowest raceme 4-12 mm apart; lowest raceme 2.5-10 mm long.

Distribution: Common, sub-tropical to temperate regions (Sonaldi, Nachiketa Tal) (1400-2500 m), Uttarkashi.

Flowering and fruiting: July-October

***Oplismenus undulatifolius* (Ard.) P.Beauv.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Nachiketa Tal; 30.6446°N, 78.4708°E; alt. 2500 m; 10.09.2016; Jaswant Singh 36697 leg.; PUN 63033.

Distribution: Common, sub-tropical to temperate regions (Gangarh, Nachiketa Tal, Rarhi, Seema, Taluka) (1300-2600 m), Uttarkashi.

Flowering and fruiting: July-October

***Panicum psilopodium* Trin.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Rajgarhi; 30.8385°N, 78.2393°E; alt. 1350 m; 16.08.2017 Jaswant Singh 36637 leg.; PUN 63092.

Identification: Annual, nodes and leaf sheaths glabrous, panicles pyramidal and effuse, spikelets oblong-ovoid and greenish-purple, glumes membranous and palea hyaline.

Distribution: Common, sub-tropical regions (Purola, Rajgarhi) (Up to 1600 m), Uttarkashi.

Flowering and fruiting: July-October.

***Paspalidium flavidum* (Retz.) A.Camus**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On Way to Damta; 30.6396°N, 78.0239°E; alt. 950 m; 15.08.2017 Jaswant Singh 35297 leg.; PUN 63058.

Identification: Perennial, culms tufted, slightly compressed, inflorescence composed of racemes, racemes 4-18, borne along a central axis, distant, unilateral, spikelets spreading, or deflexed; solitary, fertile spikelets sessile, or pedicelled, pedicels reduced to a stump, glumes similar; shorter than spikelet, thinner than fertile lemma.

Distribution: Uncommon, sub-tropical regions (Damta) (Up to 1300 m), Uttarkashi.

Flowering and fruiting: July-October.

***Paspalum dilatatum* Poir.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Barkot; 31.8077°N, 78.2213°E; alt. 1300 m; 07.09.2013 Jaswant Singh 35298 leg.; PUN 63059.

Identification: Perennial, caespitose, inflorescence composed of racemes, racemes 3-5 borne along a central axis, spikelets comprising 1 basal sterile floret, 1 fertile floret, without rhachilla extension, spikelets ovate, dorsally compressed, plano-convex, lemma surface striate, lemma margins involute, lemma apex obtuse, palea involute, indurate.

Distribution: Common, sub-tropical regions (Barkot) (Up to 1400 m), Uttarkashi.

Flowering and fruiting: July-September.

***Paspalum distichum* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Sonaldi; 30.8221°N, 78.2060°E; alt. 1150 m; 11.09.2014 Jaswant Singh 33920 leg.; PUN 60479.

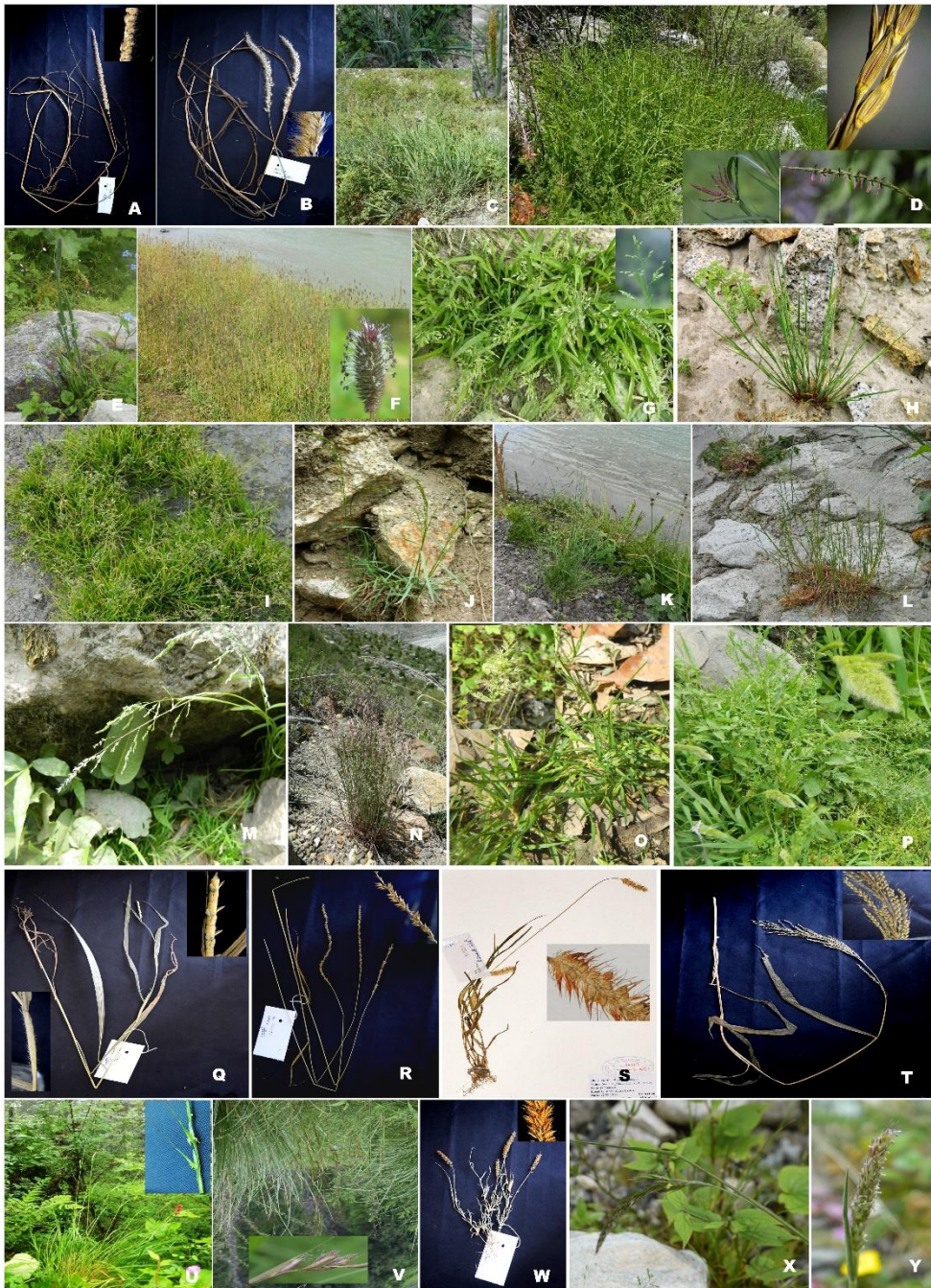


Figure 5: Field/herbarium photographs of grass species. **A.** *Pennisetum alopecuroides*. **B.** *Pennisetum lanatum*. **C.** *Pennisetum purpureum*. **D.** *Phacelurus speciosus*. **E.** *Phleum alpinum*. **F.** *Phleum pretense*. **G.** *Poa annua*.

H. *Poa poophagorum*. **I.** *Poa setulosa*. **J.** *Poa stapfiana*. **K.** *Poa stewartiana*. **L.** *Poa supina*. **M.** *Poa trivialis*. **N.** *Poa versicolor*. **O.** *Polypogon fugax*. **P.** *Polypogon monspeliensis*. **Q.** *Rottboellia cochinchinensis*. **R.** *Sacciolepis indica*. **S.** *Setaria glauca*. **T.** *Setaria homonyma*. **U.** *Stipa roylei*. **V.** *Themeda triandra*. **W.** *Tragus roxburghii*. **X.** *Trisetum clarkei*. **Y.** *Trisetum spicatum*.

Identification: Perennial with rhizomes and stolons; inflorescence of 2-3 racemes arising together or separated by a short axis; racemes 3-7 cm.

Distribution: Common, sub-tropical regions (Sonaldi) (Up to 1450 m), Uttarkashi.

Flowering and fruiting: July-October.

***Pennisetum alopecuroides* (L.) Spreng.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On Way to Gangarh; 31.1007°N, 78.3141°E; alt. 2400 m; 11.09.2014 Jaswant Singh 36674 leg.; PUN 63010.

Identification: Perennial, culms much-branched, inflorescence linear, rachis of spikes woolly, spikelets pedicellate, solitary and up to 6 mm long, involucre bristles purple and 20-30 mm long.

Distribution: Common, temperate regions (Dharkot, Gangarh) (2000-2800 m), Uttarkashi.

Flowering and fruiting: July-October.

***Pennisetum lanatum* Klotzsch**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Chirwasa; 30.9798°N, 79.0242°E; alt. 3500 m; 22.06.2016 Jaswant Singh 33961 leg.; PUN 61007.

Identification: Caespitosed, rhizomatous and perennial grass; plant body ciliate; inflorescence contracted spike cylinder-like panicle; rachis villous.

Distribution: Common, temperate to alpine regions of Bhagirathi (Chirwasa) and Kedar Ganga and Rudra Ganga (Rudragaira) Valleys (2750-3600 m), Uttarkashi.

Flowering and fruiting: May-September.

***Pennisetum orientale* Rich.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Manpur; 30.6978°N, 78.4868°E; alt. 1700 m; 24.03.2014; Jaswant Singh 36555 leg.; PUN 62976.

Distribution: Common, sub-tropical to temperate regions (Naitwar, Manpur) (Up to 2200 m), Uttarkashi.

Flowering and fruiting: July-October.

***Pennisetum purpureum* Schumach.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Mori; 31.0182°N, 78.0458°E; alt. 1200 m; 10.09.2013 Jaswant Singh 36688 leg.; PUN 63024.

Identification: Perennial, culms robust, inflorescence linear, rachis of spikes woolly, spikelets pedicellate, solitary and up to 6 mm long, involucre bristles golden and 10-18 mm long.

Distribution: Common, sub-tropical to temperate regions (Barkot, Mori) (Up to 2200 m), Uttarkashi.

Flowering and fruiting: July-October.

***Phacelurus speciosus* (Steud.) C.E.Hubb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangotri; 30.9947°N, 78.9396°E; alt. 3100 m; 09.07.2014; Jaswant Singh 33903 leg.; PUN 60462. • *ibid.*, Kankhu; 30.9960°N, 78.9553°E; alt. 3160 m; 09.07.2014; Jaswant Singh 33957 leg.; PUN 61003. • *ibid.*, On way to Nachiketa Tal; 30.6446°N, 78.4708°E; alt. 2400 m; 10.09.2016; Jaswant Singh 36696 leg.; PUN 63032.

Distribution: Common, temperate montane and sub-alpine regions of the district (Agora, Bebra, Chaurangi Khal, Dhatmeer, Gangarh, Gangotri, Kacheru, Kankhu, Nachiketa Tal, Orcha Band, Rarhi, Taluka) (2000-3300 m), Uttarkashi.

Flowering and fruiting: June-November.

***Phleum alpinum* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Morinda Lake - Ratadoi; 31.1668°N, 78.4283°E; alt. 3900 m; 01.06.2016; Jaswant Singh 35236 leg.; PUN 62410.

Distribution: Common, sub-alpine to alpine regions, Har Ki Dun (Har Ki Dun, Kalkati Dhar, Morinda Lake, Ratadoi), Nila and Rudra Ganga Valleys (3000-4850 m), Uttarkashi.

Flowering and fruiting: June-September.

***Phleum pratense* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Darwa; 30.9139°N, 78.5122°E; alt. 3700 m; 31.07.2015 Jaswant Singh 35242 leg.; PUN 62415.

Identification: Perennial herb, inflorescence compact spikulate panicle that is more than four times as long as broad, awn one-third as long as the glumes.

Distribution: Common, sub-alpine to alpine regions of Assi Ganga Valley (Dodital-Darwa) (3200-4000 m), Uttarkashi.

Flowering and fruiting: May-September.

***Piptatherum aequiglume* (Duthie ex Hook.f.) Roshev.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dhatmeer Bridge; 31.0860°N, 78.2681°E; alt. 2100 m; 04.09.2014; Jaswant Singh 36603 leg.; PUN 63098.

Distribution: Uncommon, Assi Ganga (Dodital-Darwa), Bhagirathi (Gangotri) and Har Ki Dun (Dhatmeer Bridge, Taluka) Valleys (2000-3800 m), Uttarkashi.

Flowering and fruiting: July-October.

***Piptatherum gracile* Mez**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Devgaad; 30.9955°N, 78.9810°E; alt. 3350 m; 21.06.2014; Jaswant Singh 36584 leg.; PUN 62930.

Distribution: Common, Bhagirathi (Bhojwasa, Chirwasa, Devgaad, Kankhu), Kedar Ganga, Jadh Ganga and Rudra Ganga Valleys (2700-4250 m), Uttarkashi.

Flowering and fruiting: June-September.

***Piptatherum laterale* (Regel) Nevski**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Kankhu; 30.9960°N, 78.9553°E; alt. 3150 m; 08.07.2014; Jaswant Singh 33962 leg.; PUN 61008.

Distribution: Common, Bhagirathi (Devgaad, Gangotri, Kankhu) and Rudra Ganga (Rudragaira) Valleys (2800-3900 m), Uttarkashi.

Flowering and fruiting: May-September.

***Piptatherum munroi* (Stapf ex Hook.f.) Mez**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Gangotri; 30.9947°N, 78.9396°E; alt. 3000 m; 09.07.2014; Jaswant Singh 36580 leg.; PUN 62926.

Distribution: Common, Bhagirathi (Bhojwasa, Gangotri, Kankhu) and Rudra Ganga (Rudragaira) Valleys (2700-3600 m), Uttarkashi.

Flowering and fruiting: May-September.

***Poa annua* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Kotiyal Gaon; 30.8017°N, 78.1428°E; alt. 1100 m; 25.03.2014; Jaswant Singh 36561 leg.; PUN 62982.

Distribution: Common, sub-tropical to sub-alpine regions of the district (Chaurangi Khal, Dharali, Kotiyal Gaon, Majhi, Naitwar, Naugaon, Purola, Rarhi, Sakurna, Saat Tal) (Up to 3500 m), Uttarkashi.

Flowering and fruiting: March-October.

***Poa burmanica* Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Darwa Top; 30.9139°N, 78.5122°E; alt. 3800 m; 29.07.2017; Jaswant Singh 36525 leg.; PUN 66291.

Identification: Perennial herb, tufted, ligule 1.1-1.2 mm, oblong panicle 6-10 cm, spikelets elliptic 3.6-5.3 mm long, lemma firmly keeled on back and awnless, lemma surface scabrid and keel ciliate in lower 2/3, palea keels semipilose, anther 0.6-0.9 mm.

Distribution: Occasional, Assi Ganga Valley (Darwa) (3000-4200 m), Uttarkashi.

Flowering and fruiting: July-September.

***Poa falconeri* Hook.f.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Darwa; 30.9139°N, 78.5122°E; alt. 3500 m; 29.07.2017; Jaswant Singh 36526 leg.; PUN 62947.

Distribution: Common, sub-alpine to alpine regions, Assi Ganga (Dodital-Darwa), Bhagirathi, Kedar Ganga and Yamuna Valleys (3100-3800 m), Uttarkashi.

Flowering and fruiting: June-August.

***Poa harae* Rajbh.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Devgaad; 30.9955°N, 78.9810°E; alt. 3500 m; 11.07.2014 Jaswant Singh 36591 leg.; PUN 62937.

Distribution: Uncommon, sub-alpine to alpine regions of Bhagirathi (Devgaad) and Kedar Ganga Valleys (3400-3750 m), Uttarkashi.

Flowering and fruiting: July-September.

***Poa nepalensis* (Wall. ex Griseb.) Duthie**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Kalkati Dhar; 31.1332°N, 78.3930°E; alt. 3300 m; 18.06.2014; Jaswant Singh 35289 leg.; PUN 63050.

Distribution: Uncommon, sub-alpine to alpine regions of Har Ki Dun (Har Ki Dun, Kalkati Dhar) and Yamuna (Yamunotri) Valleys (Up to 3500 m), Uttarkashi.

Flowering and fruiting: June-October.

***Poa nephelophila* Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dharali; 31.0406°N, 78.7982°E; alt. 2500-2700 m; 23.05.2014; Jaswant Singh 36564 leg.; PUN 62985.

Distribution: Uncommon, temperate montane forests to alpine regions of Bhagirathi (Dharali, Gaumukh) and Yamuna Valleys (2200-3500 m), Uttarkashi.

Flowering and fruiting: May-September.

***Poa pagophila* Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Har Ki Dun; 31.1524°N, 78.4308°E; alt. 3500 m; 01.06.2016; Jaswant Singh 36656 leg.; PUN 63076.

Distribution: Common, sub-alpine to alpine regions of Bhagirathi (Gaumukh), Har Ki Dun (Har Ki Dun, Morinda Lake) and Kedar Ganga (Kedar Kharak) Valleys (3150-4300 m), Uttarkashi.

Flowering and fruiting: June-September.

***Poa polycolea* Stapf**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Morinda Lake; 31.1668°N, 78.4283°E; alt. 3800 m; 01.06.2016; Jaswant Singh 36654 leg.; PUN 63074.

Distribution: Uncommon, sub-alpine to alpine regions of Har Ki Dun (Morinda Lake) and Nila Valleys (3400-4300 m), Uttarkashi.

Flowering and fruiting: June-September.

***Poa poophagorum* Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Nelong; 31.1064°N, 79.0082°E; alt. 3500 m; 20.06.2015; Jaswant Singh 35295 leg.; PUN 63056.

Distribution: Uncommon in temperate to alpine regions of the Bhagirathi and Jadh Ganga (Nelong) Valleys (3000-4300 m), Uttarkashi.

Flowering and fruiting: May-August.

***Poa pratensis* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangotri; 30.9947°N, 78.9396°E; alt. 3100 m; 08.07.2014; Jaswant Singh 36576 leg.; PUN 62922.

Distribution: Common, temperate to alpine regions of Bhagirathi (Gangotri), Kedar Ganga and Har Ki Dun (Morinda Lake) Valleys (3000-4400 m), Uttarkashi.

Flowering and fruiting: May-August.

***Poa rhadina* Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangotri; 30.9947°N, 78.9396°E; alt. 3100 m; 08.07.2014; Jaswant Singh 36575 leg.; PUN 62996.

Distribution: Uncommon in temperate to alpine regions of the Bhagirathi (Gangotri, Kankhu) and Yamuna Valleys (2600-3250 m), Uttarkashi.

Flowering and fruiting: June-August.

***Poa setulosa* Bor**

Material examined. INDIA - Western Himalaya • Uttarakhand, Uttarkashi, On Way to Morinda Lake; 31.1668°N, 78.4283°E; alt. 3700 m; 01.06.2016; Jaswant Singh 36660 leg.; PUN 63080.

Distribution: Common, sub-alpine to alpine regions of Bhagirathi (Deodar forest floor at Bhojwasa and Chirwasa) and Har Ki Dun (Morinda Lake) Valleys (3000-3900 m), Uttarkashi.

Flowering and fruiting: May-September.

***Poa stapfiana* Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Bhojwasa; 30.9497°N, 79.0530°E; alt. 3800 m; 01.09.2015; Jaswant Singh 36670 leg.; PUN 63006.

Distribution: Common, temperate to alpine regions of Assi Ganga (Darwa), Bhagirathi (Bhojwasa), Har Ki Dun (Morinda Lake, Ratadoi) and Yamuna Valleys (2650-4300 m), Uttarkashi.

Flowering and fruiting: May-October.

***Poa sterilis* M.Bieb.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Devgaad; 30.9955°N, 78.9810°E; alt. 3350 m; 11.07.2014; Jaswant Singh 36585 leg.; PUN 62931.

Distribution: Uncommon, temperate to alpine regions of Bhagirathi (Devgaad, Gangotri), Kedar Ganga (Kedar Kharak) and Nila Valleys (2600-4300 m), Uttarkashi.

Flowering and fruiting: May-September.

***Poa stewartiana* Bor**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Morinda Lake; 31.1668°N, 78.4283°E; alt. 3650 m; 01.06.2016; Jaswant Singh 36664 leg.; PUN 63000.

Distribution: Occasional, temperate to alpine regions of Assi Ganga (Darwa), Har Ki Dun (Morinda Lake) Valleys and to the Jaunsar area (near Tons River) (2400-3800 m), Uttarkashi.

Flowering and fruiting: May-September.

***Poa supina* Schrad.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Morinda Lake; 31.1668°N, 78.4283°E; alt. 3800 m; 01.09.2015; Jaswant Singh 36648 leg.; PUN 63095.

Distribution: Common, Assi Ganga (Dodital), Har Ki Dun (Kalkati Dhar, Morinda Lake, Ratadoi) and Kedar Ganga Valleys (3000-3800 m), Uttarkashi.

Flowering and fruiting: April-October.

***Poa trivialis* L.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dhatmeer Bridge; 31.0860°N, 78.2681°E; alt. 2100 m; 16.06.2014; Jaswant Singh 36573 leg.; PUN 62994.

Distribution: Occasional, Har Ki Dun (Dhatmeer, Gangarh) and Nila Valleys (2000-4300 m), Uttarkashi.

Flowering and fruiting: May-September.

***Poa versicolor* Besser**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Bhojwasa; 30.9497°N, 79.0530°E; alt. 3800 m; 22.06.2016; Jaswant Singh 35294 leg.; PUN 63055.

Distribution: Uncommon, Bhagirathi (Bhojwasa) and Har Ki Dun (Morinda Lake) Valleys (3400-4300 m), Uttarkashi.

Flowering and fruiting: May-August.

***Polypogon fugax* Nees ex Steud.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Chaurangi Khal; 30.6448°N, 78.4887°E; alt. 2300 m; 26.03.2014 Jaswant Singh 36566 leg.; PUN 62987.

Distribution: Common, temperate to sub-alpine regions of the district (Chaurangi Khal, Rarhi, Sakurna) (Up to 3200 m), Uttarkashi.

Flowering and fruiting: March-June.

***Polypogon monspeliensis* (L.) Desf.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Manpur; 30.6978°N, 78.4868°E; alt. 1650 m; 23.03.2014 Jaswant Singh 36557 leg.; PUN 62978.

Distribution: Uncommon, temperate montane regions of Uttarkashi (Manpur) (Up to 2200 m), Uttarkashi.

Flowering and fruiting: March-June.

***Rottboellia cochinchinensis* (Lour.) Clayton**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Barkot; 31.8077°N, 78.2213°E; alt. 1300 m; 11.09.2014 Jaswant Singh 36607 leg.; PUN 63102.

Identification: Annual, rhizomatous, culms tall and erect, inflorescence of axillary and terminal racemes, racemes cylindrical and 8-15cm long, spikelets in pairs, one sessile other pedicelled, joints of rachis and pediceles fused, lower glume of sessile spikelet entire at the tip, spikelets 2-flowered.

Distribution: Common, sub-tropical regions (Barkot, Kanseru, Purola) (Up to 1450 m), Uttarkashi.

Flowering and fruiting: May-November.

***Sacciolepis indica* (L.) Chase**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Kharadi; 30.8461°N, 78.2768°E; alt. 1300 m; 16.08.2017 Jaswant Singh 35262 leg.; PUN 62435.

Identification: Annual, slender, tufted grass. Panicle crowded with ovoid, acute spikelets (spike-like panicle).

Distribution: Uncommon, sub-tropical regions along riverbeds (Kharadi) (Up to 1500 m), Uttarkashi.

Flowering and fruiting: June-November.

***Setaria glauca* (L.) P.Beauv.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Seema; 31.1168°N, 78.3496°E; alt. 2650 m; 04.09.2014 Jaswant Singh 33974 leg.; PUN 61020.

Identification: Perennial herb, panicle open/ contracted, ovate in outline, callus pillose, spikelets in pairs or triplets.

Distribution: Common, temperate regions (Rarhi, Seema) (Up to 2800 m), Uttarkashi.

Flowering and fruiting: June-October.

***Setaria homonyma* (Steud.) Chiov.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Sonaldi; 30.8221°N, 78.2060°E; alt. 1200 m; 07.09.2015 Jaswant Singh 36623 leg.; PUN 63118.

Identification: Annual, leaves with fan-fashion, spikelets solitary and subtended by 1 to many persisting bristles, inflorescence a loose, narrow panicle, branches mostly simple from base, upper glume almost as long as the upper lemma.

Distribution: Common, sub-tropical regions (Barkot, Sankri, Sonaldi) (Up to 1400 m), Uttarkashi.

Flowering and fruiting: June-October.

***Setaria pumila* (Poir.) Roem. & Schult.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Rarhi; 30.7705°N, 78.2250°E; alt. 2250 m; 05.09.2013; Jaswant Singh 36542 leg.; PUN 62963.

Distribution: Common, temperate regions (Rarhi) (Up to 2400 m), Uttarkashi.

Flowering and fruiting: June-October.

***Stipa roylei* (Nees) Duthie**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dodital; 30.8975°N, 78.5265°E; alt. 3100 m; 28.07.2017 Jaswant Singh 36508 leg.; PUN 62904.

Identification: Perennial, loosely tufted, panicles narrow, spikelets greenish, spikelets with 1-fertile floret, floret laterally compressed, lemma linear, lemma tip entire with downwardly directed spines just below insertion of awn, column of awn not twisted.

Distribution: Common, temperate to sub-alpine regions (Chaurangi Khal, Dodital-Darwa, Nachiketa Tal, Rarhi) (1800-3200 m), Uttarkashi.

Flowering and fruiting: July-October.

***Themeda anathera* (Nees ex Steud.) Hack.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Janki Chatti; 30.9808°N, 78.4427°E; alt. 2550 m; 16.06.2015; Jaswant Singh 36615 leg.; PUN 63110.

Distribution: Common, sub-tropical to temperate regions (Jakhol, Janki Chatti, Sankri, Taluka) (1200-2800 m), Uttarkashi.

Flowering and fruiting: May-October.

***Themeda triandra* Forssk.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Dharkot; 30.8599°N, 78.5112°E; alt. 2450 m; 09.08.2015 Jaswant Singh 36629 leg.; PUN 63084.

Identification: Perennial from a knotty rootstock, yellowish, ligule 2 mm, compound panicle lax, often nodding, spathate fascicles, racemes composed of triads, 1 sessile and 2 pedicelled above the involucre of 2 homogamous pairs, sessile spikelets awned and the raceme is less than 1.5cm.

Distribution: Common, sub-tropical to temperate regions (Dharkot) (1300-2800 m), Uttarkashi.

Flowering and fruiting: June-November.

***Tragus roxburghii* Panigrahi**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Damta; 30.6396°N, 78.0239°E; alt. 900 m; 15.08.2017 Jaswant Singh 35261 leg.; PUN 62434.

Identification: Annual, culms terete, rooting at lower nodes, inflorescence a solitary and terminal raceme, 1.5-4cm long, spikelets sub-sessile, 2-spikelets facing each other appearing like a single spikelet with two echinulate glumes, lower glume very minute, hyaline, upper glume coriaceous.

Distribution: Common, sub-tropical forest regions (Damta) (Up to 1200 m), Uttarkashi.

Flowering and fruiting: July-October.

***Trisetum aeneum* (Hook.f.) R.R. Stewart**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, On way to Darwa; 30.9139°N, 78.5122°E; alt. 3700 m; 28.07.2017; Jaswant Singh 35245 leg.; PUN 62418.

Distribution: Uncommon, temperate to alpine regions of Assi Ganga (Darwa), Kedar Ganga and Rudra Ganga Valleys (2600-3800 m), Uttarkashi.

Flowering and fruiting: June-September.

***Trisetum clarkei* (Hook.f.) R.R. Stewart**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Dodital-Darwa; 30.9025°N, 78.5183°E; alt. 3400 m; 28.07.2017; Jaswant Singh 35246 leg.; PUN 62419.

Distribution: Uncommon in temperate to alpine regions of the Assi Ganga (Dodital-Darwa) and Bhagirathi (Bhojwasa) Valleys (2750-4000 m), Uttarkashi.

Flowering and fruiting: June-September.

***Trisetum spicatum* (L.) K. Richt.**

Material examined. INDIA - **Western Himalaya** • Uttarakhand, Uttarkashi, Gangotri; 30.9947°N, 78.9396°E; alt. 3100 m; 15.06.2015; Jaswant Singh 35249 leg.; PUN 62422.

Distribution: Common, temperate to alpine regions of Assi Ganga (Dodital), Bhagirathi (Bhojwasa, Gangotri, Kankhu), Har Ki Dun (Morinda Lake), Kedar Ganga and Rudra Ganga Valleys (2800-4200 m), Uttarkashi.

Flowering and fruiting: May-September

Discussion

Uttarkashi district's phytogeographic position in the Himalaya biodiversity hotspot gave it a variety of habitats and floristic elements. Many of the species that grow there are endemic to the Western Himalaya, including *Elymus gangotrianus*, *Festuca lucida*, *Helictotrichon uniyalii*, *Poa jaunsarensis*, *Poa rhadina*, *Poa royleana* and *Trisetum micans*. The Indian Himalaya and nearby areas are home to many other plant species, such as *Agropyron thomsonii*, *Calamagrostis stolizkae*, *Microstegium falconeri*, *Piptatherum hilariae*, *Phacelurus speciosus*, *Poa falconeri*, *Poa gammieana*, *Poa setulosa*, *Poa stapfiana*, *Poa stewartiana*, *Spodiopogon dubius*, *Trisetum aeneum* and many more (POWO, 2024).

While studying the grass cover in India, Dabadghao and Shankarnarayan, (1973) recorded 32 species in the grassland spread around Sandra-Naitwar and Osla-Har Ki Dun. Negi et al., (1985) noted 10 grass species around Dodital, and the authors added 20 more species found in the grasslands of the study area. Rana et al., (2003) reported 18 species from Tons Valley (Mori, Naitwar, Sankri, and Sandra) and found that plants of some species were also present in other surveyed areas of Barkot, Chaurangi Khal, Damta, Rarhi, Sangamchatti, Uttarkashi, up to an altitude of 2000 m.

Pusalkar et al., (2008) and Pusalkar and Singh, (2012) reported 95 species and 33 genera in the preserved area under Gangotri National Park (Table 1), embodying the plant collections of previous expeditions undertaken by J.F. Duthie (*Alopecurus arundinaceus*, *Briza media*, *Deschampsia cespitosa*, *Poa lahulensis*, *Poa polycolia*, *Poa stapfiana*, *Poa trivialis*), B.D. Naithani (*Elymus schrenkianus*), D.C. Nautiyal (*Calamagrostis emodensis*, *Elymus nutans*, *Poa alpigena*, *Poa bactriana*, *Poa hirtiglumis*, *Poa jaunsarensis*, *Poa kanaii*, *Poa khasiana*, *Poa mustangensis*), M. Kandwal (*Bromus hordeaceus*, *Bromus inermis*, *Poa arnoldii*, *Poa sikkimensis*, *Poa supina*), S. Uniyal (*Stipa orientalis*) and U.C. Bhattacharyya (*Danthonia schneideri*) (Pusalkar and Singh, 2012).

Previous expeditions from the Govind Pashu Vihar Wildlife Sanctuary and National Park recorded 57 species (Manikandan and Srivastava, 2015; Manikandan et al., 2020), to which the authors added 28 species. Sekar et al., (2023) identified 18 species in the Nelong Valley, out of which *Agropyron thomsonii* and *Poa poophagorum* were in the Nelong and 12 more species outside the Nelong Valley.

The grass species diversity of the district was estimated to be 188 species and 72 genera (Table 1). The species richness shares 32.30 % (188/582) of the grass species recorded in Western Himalaya, 12.28 %

(188/1531) in India and 1.74 % (188/11506) of the world grass flora. The genus *Poa* L., with 40 species, is the most diverse, followed by *Bromus* L. and *Festuca* L., each with 8 species. *Calamagrostis* Adans and *Elymus* L., each presented seven species; *Agrostis* L., with six species; *Pennisetum* Rich. and *Piptatherum* P.Beauv., each with five species; *Helictotrichon* Besser, *Setaria* P.Beauv., *Stipa* L. and *Trisetum* Pers., each with four species; *Chrysopogon* Trin., *Digitaria* Haller, *Echinochloa* P.Beauv. and *Phleum* L., each with 3 species; *Alopecurus* L., *Arthraxon* P.Beauv., *Arundinella* Raddi, *Avena* L., *Brachypodium* P.Beauv., *Cymbopogon* Spreng., *Danthonia* DC., *Eleusine* Gaertn., *Eragrostis* Wolf, *Melica* L., *Microstegium* Nees, *Muhlenbergia* Schreb., *Oplismenus* P.Beauv., *Paspalum* L., *Polypogon* Desf., *Saccharum* L., *Themeda* Forssk. and *Tripogon* Roem., each with 2 species, and the remaining 38 genera were represented with a single species (Table 1).

Conclusion

Exploring and enlisting the diversity of floral resources in natural habitats is in prime demand due to the ongoing threat to plants and species richness, which is necessary to understand distribution patterns. This checklist will assist in identifying the germplasm of western Himalayan grasses that reside in the grasslands of Uttarkashi district.

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Chapter 2

Bioactive composition and nutrient profile of leaves of *Cymbopogon citratus*: implications for therapeutic use

Rajesh Kumar Verma¹, Subhalakshmi Rout² and Sugimani Marndi^{2*}

¹Department of Dravyaguna, Naiminath Ayurvedic Medical College and Research Centre, Agra, Uttar Pradesh, India

²Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

*Email-Id: sugimani2marndi@gmail.com

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Abstract: *Cymbopogon citratus* (lemongrass) is a widely used medicinal and culinary herb valued for its aromatic essential oils and diverse bioactive compounds. Its strong fragrance is attributed to major constituents such as citral, geraniol, citronellal and limonene. Present study aimed to evaluate primary metabolites through proximate analysis and assess major secondary metabolites using qualitative and quantitative phytochemical screening. Secondary metabolites, including alkaloids, flavonoids, tannins, saponins, phenolics and terpenoids, were analysed using standard procedures. The results indicated that *C. citratus* contains a substantial amount of carbohydrates, fibre and essential phytoconstituents, particularly phenolics and flavonoids, which contribute to its antioxidant and therapeutic potential. This integrated biochemical profiling provides scientific support for the nutritional, medicinal and industrial applications of *C. citratus*, further validating its importance in both traditional and modern healthcare systems.

Keywords: Lemongrass, nutritional evaluation, proximate analysis

Introduction

Medicinal plants play a vital role in traditional and modern healthcare systems due to their diverse phytochemical constituents and nutritional properties (Radha et al., 2021). The genus *Cymbopogon*, derived from the Greek words kymbe (boat) and pogon (beard), comprises aromatic perennial grasses belonging to the family Poaceae (Shah et al., 2011). These grasses are widely distributed across tropical and subtropical regions of Asia, Africa, America and Australia (Avoseh et al., 2015). They are known for their essential oil content, strong lemon-like aroma and extensive medicinal, culinary and industrial applications (Maybodi et al., 2025). More than 140 species of *Cymbopogon* have been identified globally, with *C. citratus*, *C. flexuosus*, *C. nardus* and *C. winterianus* being the most economically

significant (Latha et al., 2021). Among these species, *Cymbopogon citratus* (DC.) Stapf is particularly valued for its high aromatic content and multifunctional benefits (Telangi et al., 2022). Commonly known as lemongrass, it is rich in citral cyclic monoterpene responsible for its characteristic lemon scent (Oladeji et al., 2019). The grass contains various phytochemicals including flavonoids, essential oils, phenolic compounds and other metabolites associated with pharmacological activities such as anti-obesity, antibacterial, antifungal, antinociceptive and antidiarrheal effects (Hassan et al., 2024). Traditionally, lemongrass has been used in Ayurveda, folk medicine and culinary practices for its antimicrobial, antioxidant, anti-inflammatory and digestive properties (Ishaya et al., 2025). Scientific evaluation of medicinal plants typically includes the study of both primary metabolites, such as carbohydrates, proteins, lipids and fiber and secondary metabolites, such as alkaloids, flavonoids, phenolics, tannins, terpenoids and saponins, which are responsible for therapeutic activities (Rithu et al., 2020). Although *C. citratus* is widely used, systematic biochemical profiling that integrates proximate analysis and secondary metabolite evaluation is essential for validating its therapeutic potential. Therefore, present study was undertaken to analyze the nutritional composition and phytochemical constituents of *C. citratus*.

Methodology

Collection of plant sample

The leaves of *Cymbopogon citratus* were collected from the nearby Mahanadi River areas of Cuttack district of Odisha. The plant species was identified by the authors (Figures 1 & 2; Nayak and Kumar, 2023). Soxhlet extraction method was adopted using four solvents for phytochemical analysis (Kumar et al., 2013; Marndi et al., 2025). Detection of eight secondary metabolites was conducted using standard methods (Devi et al., 2022; Jena et al., 2024; Marndi et al., 2024).

Qualitative phytochemical analysis

Primary metabolites

Test for protein: One ml of the filtrate of leaf extract was mixed with 2-5 drops of Millon's reagent and kept in the water bath for 30 minutes. The pink coloration indicates the presence of protein.

Test for carbohydrate: One ml of the filtrate of leaf extract was mixed with 2-5 drops of Fehling's solution A and B and kept in the water bath for 30 minutes. A reducing sugar reacts with Fehling's reagent in an alkaline



Figure 1: Plant sample (*C. citratus*) for quantitative and qualitative analysis

medium to form orange-to-red precipitate. The appearance of an orange or red precipitate indicates the presence of carbohydrates.

Test for starch: To 1 ml of the filtrate of leaf extract, 2-3 drops of concentrated HCL were added and heated for 1-2 minutes. NaOH, following Benedict's reagent, was added to this solution and kept in the water bath. The change in coloration from bluish-green to red-orange indicates the presence of starch.

Test for sucrose: About 1 ml of the filtrate of the leaf extract was mixed with 2-3 drops of iodine. The appearance of a blue-black color indicates the presence of sucrose.

Test for lipid: About 1 ml of the filtrate of leaf extract was mixed with 2-5 drops of Sudan-III. The appearance of pink droplets indicates the presence of lipids.

Test for amino acid: One ml of the filtrate of leaf extract was mixed with 5 drops of Ninhydrin reagent and kept in the water bath for 30 minutes. Ninhydrin is a powerful oxidizing agent that gives a purple-colored product termed Rhuemann's purple.



Figure 2: Habit and habitat of *Cymbopogon citratus*

Secondary metabolites

Test for tannin: About 1 ml of the leaf extract was taken. Three to five drops of 10 % lead acetate solution were added. The gelatinous precipitate formation confirms the presence of tannin.

Test for saponin: About 1 ml of the leaf extract was taken and 1 ml of distilled water was added and shaken well. The formation of persistent froth confirms the presence of saponin.

Test for flavonoids: About 1 ml of the leaf extract was taken. Two ml of 2 % NaOH solution and 3 to 4 drops of diluted HCl were added. The color initially turns to an intense yellow color with NaOH solution and later becomes colorless. This color change in appearance confirms the presence of flavonoids.

Test for terpenoids: About 1 ml of the leaf extract was added with 5-6 drops of chloroform and placed in the water bath for a few minutes. Then 5-6 drops of concentrated sulphuric acid were added. The reddish-brown interface confirms the presence of terpenoids.

Test for phenolic groups: About 1 ml of the leaf extract was taken. A few drops of 5 % ferric chloride solution were added. The dark bluish-black appearance confirms the presence of phenolic compounds.

Test for reducing sugars: About 1 ml of the leaf extract was taken and 2 drops of Fehling's solution A followed by Fehling's solution B were added and kept in the water bath for some time. The presence of red-orange precipitate confirms the presence of reducing sugar.

Test for steroids: About 1 ml of the leaf extract was taken. 1 ml of chloroform and 1 ml of concentrated sulphuric acid were added to it. The appearance of upper red and lower yellow colors with green fluorescence indicated the presence of steroids.

Test for alkaloids: About 1 ml of the leaf extract was taken and 3 to 4 drops of Dragendorff's reagent were added. The formation of a reddish-brown precipitate confirms the presence of alkaloids.

Quantitative estimation of secondary metabolites

Estimation of tannin: 200 mg of tannic acid was mixed with 20 ml of distilled water. From this solution, 5, 15, 25, 35 and 50 μ l were taken in different test tubes. The volume was made up to 1 ml. Then 0.5 ml of Folin reagent and 2.5 ml of 20 % sodium carbonate were added to each test tube. The mixed solutions were shaken for 5 minutes in the dark. The solutions in each test tube

were left for 40 minutes. After 40 minutes, readings were taken at 720 nm to make a standard graph.

Extraction of tannins: 200 mg of the sample was transferred into a 100 ml conical flask to which 75 ml of distilled water was added and boiled for 30 minutes. The whole solution was centrifuged at 2000 rpm for 20 minutes. Supernatant was then taken in a 100 ml volumetric flask and made up to the volume. 1 ml of the sample was taken from a 100 ml volumetric flask and 75 ml of distilled water, 5 ml of Folin reagent and 10 ml of 20 % sodium carbonate were added. The volume was made up to 100 ml. After shaking for 5 minutes, the readings were taken at 720 nm. The amount of tannin was calculated from the standard graph ([Sadasivam and Manickam, 2019](#)).

Estimation of saponin: The determination of total saponin was done by the method of Obadoni and Ochuko, (2001) with minor modifications. 2 g of sample was added to 30 ml of 20 % aqueous-ethanol and kept in a flask on a stirrer for half an hour. It is heated for 4 hours at 45 °C. The mixture was filtered by using Whatman filter paper-1 and the residue was again extracted with another 20 ml of 25 % aqueous ethanol. The combined extracts were concentrated. The concentrate was transferred into a separator funnel and extracted twice with 10 ml diethyl ether. The ether layer was discarded while the aqueous layer was kept and re-extracted with 15 ml n-butanol. The n-butanol extract was washed twice with 5 ml of 5 % aqueous sodium chloride. The remaining solution was evaporated. After evaporation, the sample was dried in the hot air oven at 40 °C to a constant weight. The saponin content was calculated.

$\% \text{ of saponins} = (\text{Final weight of sample} / \text{Initial weight of extracts}) \times 100$

Extraction of phenol: Three replicas of 0.5 g of the sample were taken and crushed with 60 % methanol in a mortar and pestle. Samples were centrifuged 5 times at 5000 rpm for 20 minutes.

Estimation of phenols: Seven test tubes were taken, including a blank and 2 test tubes for each replica. 0.1 and 0.2 ml of the sample were taken in each test tube except the blank. 60 % methanol was added to each test tube to bring the volume up to 1 ml. 1 ml of 0.1 N HCl was added and allowed to stand for a few minutes. 1 ml of sodium nitrite molybdate mixture was added, shaken well and allowed to stand for a few minutes, diluted with 5 ml of distilled water. After dilution, 2 ml of 1N NaOH was added and allowed to stand for 20 minutes. Readings were taken at 515 nm. The amount of phenol present in the sample was calculated from the standard graph ([Swain and Hillis, 1959](#)).

Estimation of flavonoids: A sample of 100 µl of the extract was mixed with 100 µl of 5 % sodium nitrite and allowed to stand for 5 minutes. Next, 100 µl of aluminium trichloride was added and incubated for 6 minutes, followed by the addition of 1 ml of 1 M sodium hydroxide. The total volume of the mixture was made up to 5 ml with distilled water and incubated for 15 minutes at room temperature in the dark for taking absorbance at 510 nm. The amount of flavonoid present in the sample was calculated from the standard graph. The standard graph was prepared for quercetin ([Chang et al., 2002](#); [Raina and Misra, 2023](#)).

Results

The qualitative screening of primary metabolites in different leaf extracts of *Cymbopogon citratus* revealed considerable variation depending on solvent polarity ([Table 1](#)). Non-polar extracts such as n-hexane showed no detectable primary metabolites. In contrast, polar solvents exhibited the presence of key nutritional components. Both ethanol and methanol extracts tested positive for carbohydrates, indicating their good solubility in medium to high-polarity solvents. The aqueous extract showed the presence of carbohydrates as well as proteins, suggesting that water is an effective solvent for extracting hydrophilic primary metabolites from *C. citratus*.

Table 1: Qualitative phytochemical analysis for the detection of primary metabolites

Polarity	Extract	Detected primary metabolites
Non-Polar  Polar	n-Hexane	No tested metabolites were detected
	Ethanol	Carbohydrates only
	Methanol	
	Aqueous	Protein and carbohydrates

The evaluation of secondary metabolites demonstrated that metabolite detection depended strongly on solvent polarity ([Table 2](#)). The non-polar n-hexane extract did not exhibit the presence of any of the tested secondary metabolites, confirming the limited solubility of phytochemicals such as tannins and phenolics in non-polar solvents. Among the polar extracts, ethanol showed the presence of tannins and reducing sugars. Methanol and aqueous extracts demonstrated a broader phytochemical profile, showing tannins, phenols and reducing sugars. Methanol and water, due to their high

polarity, were the most efficient solvents for extracting phenolic constituents from *C. citratus*.

Table 2: Qualitative phytochemical analysis for the detection of secondary metabolites

Polarity	Extract	Detected secondary metabolites
Non-Polar  Polar	n-Hexane	No tested metabolites were detected
	Ethanol	Tannin and reducing sugars
	Methanol	Tannin, phenol and reducing sugars
	Aqueous	

The phytochemical patterns observed in this study highlighted the significant influence of solvent polarity on the extraction efficiency of both primary and secondary metabolites of *Cymbopogon citratus* leaves. Non-polar extraction using n-hexane yielded no detectable metabolites, which is consistent with the previous findings that primary metabolites (such as carbohydrates and proteins) and most secondary metabolites (such as phenolics and tannins) are predominantly polar in nature. Polar solvents, particularly ethanol, methanol and water, successfully extracted key nutritional and bioactive compounds. The detection of carbohydrates in ethanol and methanol extracts indicated the moderate solubility of these primary metabolites in organic solvents (Table 3).

Table 3: Quantitative estimation of total Phenol, Tannin, Flavonoid contents and Saponin percentage

<i>Cymbopogon citratus</i> (Leaves)	Bioactive compound	Content
	Total Phenol (mg/100g)	0.14
	Tannin (mg/100g)	1.1
	Flavonoid (mg/100g)	0.14
	Saponin (%)	1.1

The presence of carbohydrates and proteins in the aqueous extract aligns with the hydrophilic properties of these compounds. The detection of

tannins, phenols and reducing sugars in methanol and aqueous extracts is noteworthy, as these secondary metabolites are associated with significant pharmacological activities, including antioxidant, antimicrobial and anti-inflammatory properties (Hossen et al., 2025). Methanol, being a highly polar solvent, often demonstrate superior extraction ability for phenolic compounds (Shi et al., 2022), and this was evident in the present results. Similarly, the aqueous extract's richness in phenolics further supports the traditional use of water-based lemongrass preparations (such as infusions and decoctions) in medicinal applications. It contains various uses such as culinary, aroma therapy, medicinal and insect repellent properties (Ishaya et al., 2025). The results indicated that *C. citratus* contain a diverse range of bioactive and nutritional components, particularly in polar extracts. These findings support the plant's established therapeutic effects and justify its widespread use in traditional medicine systems (Figure 3). The presence of phenolics and tannins, especially in methanol and aqueous extracts emphasizes the therapeutic potential of lemongrass as a natural source of antioxidants and health-promoting compounds.

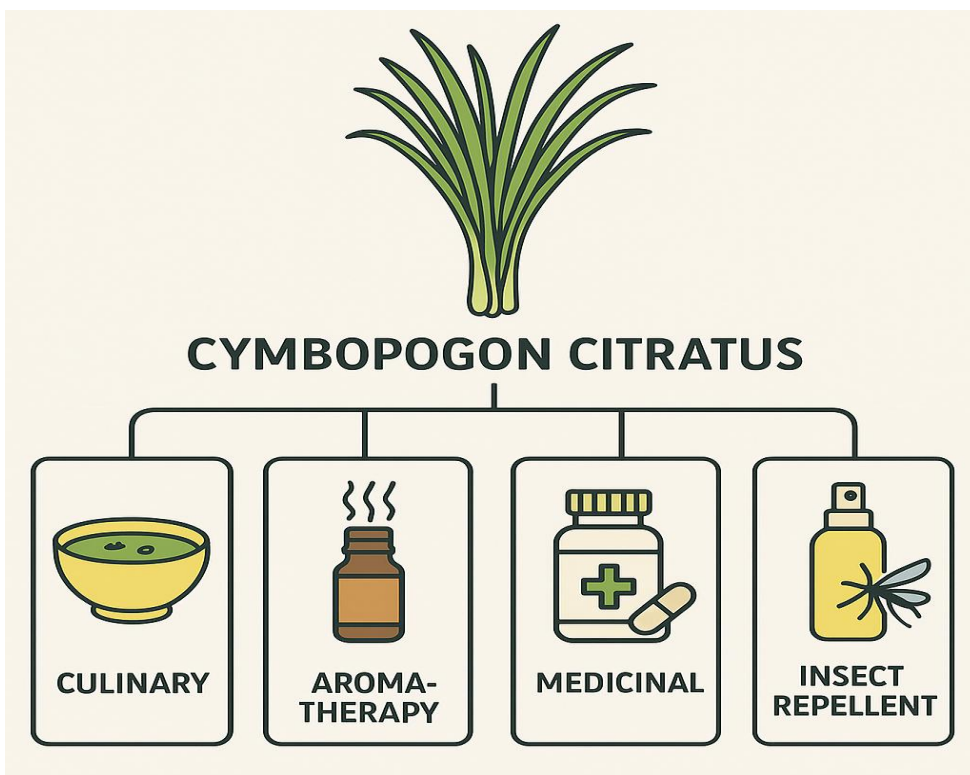


Figure 3: Illustration of various uses of *Cymbopogon citratus*

Conclusion

Present study provides a comprehensive assessment of the nutritional and phytochemical composition of *C. citratus* leaves using qualitative and quantitative methods. Solvent polarity played a significant role in metabolite extraction, with polar solvents, particularly water and methanol, proving most efficient. The aqueous extract contained essential primary metabolites such as carbohydrates and proteins, while methanol and water extracts were rich in tannins, phenols and reducing sugars. Quantitative analysis further confirmed the presence of phenolics, tannins, flavonoids and saponins, which contribute to the antioxidant, antimicrobial and anti-inflammatory properties of lemongrass. These findings reinforce the therapeutic potential of *C. citratus* and validate its longstanding use in traditional medicine. Further advanced studies, including bioactivity assays and compound isolation, are recommended to fully elucidate its pharmacological applications.

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Chapter 3

Grasses and sedges of green urban space: a floristic survey

Sumitra Jethy, Sugimani Marndi and Rajkumari Supriya Devi*

Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

*Email-Id: supriyark91@gmail.com

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Abstract: Urban parks serve as important ecological and social refuges within rapidly expanding cities, yet their ground-layer plant diversity often remains understudied. Present study documented the diversity and composition of grasses (Poaceae) and sedges (Cyperaceae) in Biju Pattanaik Park of Cuttack, Odisha, India. A total of 31 species were recorded, comprising 15 grass species across 12 genera and 16 sedge species across 3 genera. The grass flora exhibited high generic diversity, with *Digitaria* and *Eragrostis* being the most species-rich genera, while the sedges were dominated by the genus *Cyperus*. Species showed clear microhabitat preferences, with grasses largely occupying open lawns as well as disturbed grounds and sedges occurring in moist depressions, drainage channels and seasonally waterlogged areas. Several disturbance-tolerant species, including *Cynodon dactylon* and *Cyperus rotundus*, were widespread across the park, reflecting adaptation to urban management regimes. The present study highlights the ecological significance of urban parks as reservoirs of low-stature plant diversity and the importance of recognizing grasses and sedges as functional components of urban biodiversity and ecosystem service provision.

Keywords: Cyperaceae, Poaceae, urban parks

Introduction

Urban parks have functioned as vital interfaces between nature and the built environment, offering much-needed respite from the fast-forwarding pace of urban life (Zhang et al., 2025). Rapid urbanization, expanding infrastructure, deforestation, pollution and increasingly demanding work cultures have distanced urbanites from direct interactions with nature (Sen and Guchhait, 2021). In this context, urban green spaces emerge as carefully constructed yet essential substitutes for lost natural landscapes, providing moments of quiet, reflection and reconnection within the dense and hectic urban settings (Sen and Guchhait, 2021). Historically, parks have been shaped not merely as recreational grounds but as deliberate interventions

to improve urban health and quality of life. From ancient gardens to colonial botanical gardens to contemporary urban parks, these spaces reflect changing societal attitudes toward nature, well-being and public life (Sharma et al., 2021). While designed and managed, urban parks retain ecological relevance by hosting diverse plant communities that persist amidst anthropogenic pressures. They function as compact biodiversity reservoirs within concrete-dominated landscapes, often supporting taxa that would otherwise be excluded from urban matrices (Nagendra and Gopal, 2011). Ecologically, urban parks deliver a suite of critical ecosystem services (Singkran, 2023). Vegetation within these spaces contributes to air purification, pollutant absorption, microclimate regulation, carbon sequestration and mitigation of surface runoff and water-logging. Grasses and sedges, in particular, play a foundational role in these processes by stabilizing soil, supporting trophic interactions and maintaining habitat continuity at the ground layer (Tobias, 2013). Beyond ecological functions, urban green spaces foster social cohesion and cultural engagement, serving as sites for leisure, community interaction and cultural expression. Increasing evidence also highlights the role of everyday contact with urban nature in enhancing mental well-being and strengthening nature connectedness among urban populations (Jabbar et al., 2022). Thus, urban parks represent not only ecological assets but also socio-cultural and psychological lifelines within modern cities. Therefore, a survey was conducted in the Biju Pattnaik Park situated at CDA Sector 11, located in the Cuttack district of Odisha, India. It is one of the well-maintained urban green spaces of Cuttack, named after the aviator and former chief minister of Odisha, Shri Biju Patnaik. The survey aimed to document the species diversity of grasses and sedges found in the park, thereby highlighting the importance of urban parks in city life.

Methodology

Field surveys were conducted during November and December 2025 at the Biju Pattnaik Park situated in the Cuttack district of Odisha, India. The park represents a typical urban green space within a densely populated city, surrounded by the Mahanadi River, influenced by seasonal changes and anthropogenic activities. The species identification was done using standard regional flora (Saxena and Brahmam, 1996). Common names were searched from different online databases (Kumar, 2025). The field data were compiled into a checklist with botanical names and common names.

Results

The floristic survey of the Biju Pattnaik Park situated in the Cuttack district of Odisha, India recorded a diverse assemblage of grasses and sedges,

comprising 15 grass species (Table 2) across 12 genera and 16 sedge species (Table 1) across 3 genera.

Table 1: Diversity of sedges in the urban park

Sedge name	Common name
<i>Abildgaardia ovata</i>	Flatspike sedge
<i>Cyperus brevifolius</i>	Greenhead sedge
<i>Cyperus compressus</i>	Poorland flat sedge, Summer sedge
<i>Cyperus cuspidatus</i>	Coastal plain flatsedge
<i>Cyperus cyperoides</i> (Figure 5)	Pacific island flat sedge, Common flat sedge
<i>Cyperus distans</i>	Slender sedge, Piedmont flatsedge
<i>Cyperus dubius</i> var. <i>dubius</i>	Soft sedge, Dubious flatsedge
<i>Cyperus flavescens</i> (Figure 6)	Yellow flatsedge
<i>Cyperus haspan</i>	Dwarf sedge, Dwarf paper reed
<i>Cyperus iria</i>	Ricefield flatsedge, Umbrella sedge
<i>Cyperus neochinensis</i> (Figure 7)	Chinese flatsedge
<i>Cyperus polystachyos</i>	Bunchy flat sedge, Many-spiked flatsedge
<i>Cyperus rotundus</i>	Nutgrass, Purple nutsedge
<i>Cyperus squarrosus</i> (Figure 9)	Bearded flatsedge
<i>Fimbristylis dichotoma</i> (Figure 10)	Annual fringe rush
<i>Fimbristylis schoenoides</i> (Figure 8)	Ditch fimbry

Table 2: Diversity of grasses in the urban park

Grass name	Common name
<i>Bothriochloa pertusa</i> (Figure 2)	Indian bluegrass, Hurricane grass
<i>Chloris barbata</i> (Figure 4)	Swollen fingergrass
<i>Chrysopogon aciculatus</i>	Golden beardgrass, Love grass
<i>Cynodon dactylon</i>	Bermuda grass
<i>Dactyloctenium aegyptium</i>	Crowfoot grass
<i>Digitaria bicornis</i>	Asian crabgrass
<i>Digitaria ciliaris</i> (Figure 1)	Southern crabgrass
<i>Digitaria longiflora</i> (Figure 3)	Indian crabgrass
<i>Echinochloa colona</i>	Jungle rice

<i>Eragrostis ciliaris</i>	Gophertail lovegrass
<i>Eragrostis tenella</i>	Japanese lovegrass
<i>Eragrostis unioloides</i>	Chinese lovegrass
<i>Setaria pumila</i>	Yellow foxtail
<i>Sporobolus diandrus</i>	Indian dropseed
<i>Zoysia matrella</i>	Manila grass, Japanese carpetgrass



Figure 1: Inflorescence of *Digitaria ciliaris*



Figure 2: Inflorescence of *Bothriochloa pertusa*



Figure 3: Inflorescence of *Digitaria longiflora*



Figure 4: Inflorescence of *Chloris barbata*



Figure 5: Inflorescence of *Cyperus cyperoides*



Figure 6: Habitat of *Cyperus flavescentis*



Figure 7: *Cyperus neochinensis* in its habitat

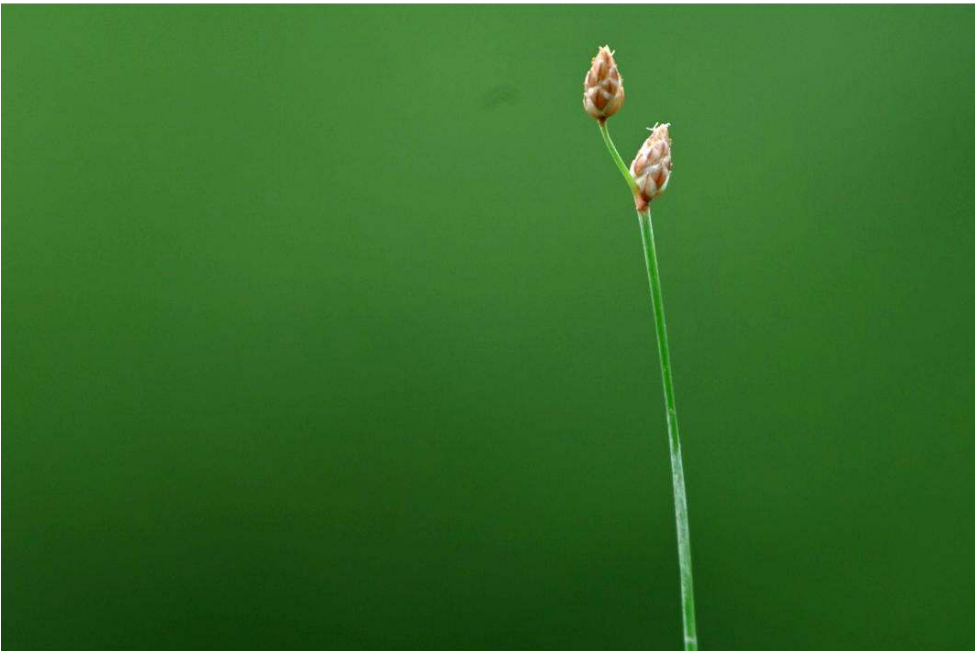


Figure 8: Inflorescence of *Fimbristylis schoenoides*



Figure 9: Inflorescences of *Cyperus squarrosus*

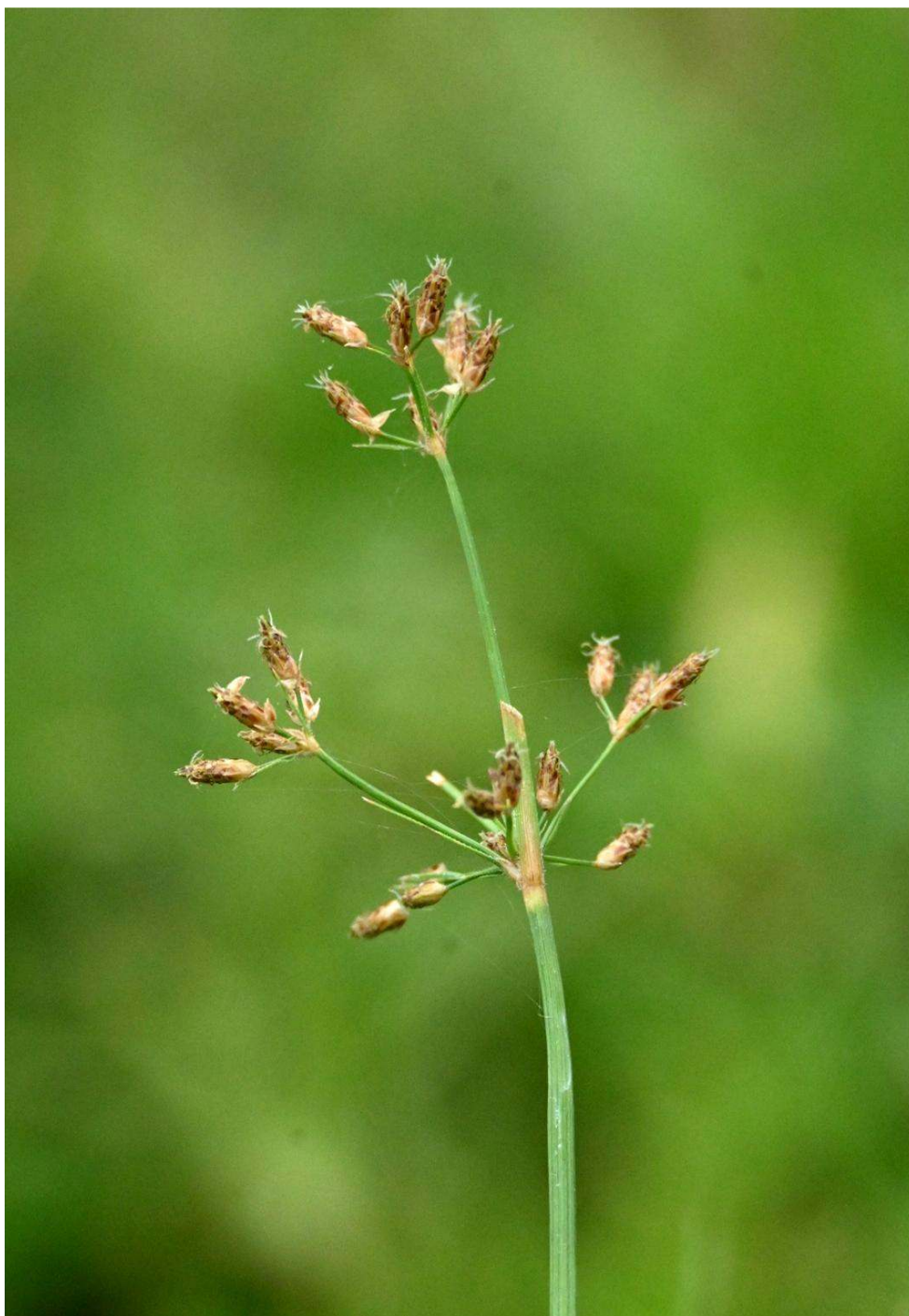


Figure 10: Aerial parts of *Fimbristylis dichotoma*

Grasses exhibited high generic diversity, with *Digitaria* and *Eragrostis* being the most species-rich genera, while sedges had a predominance of genus *Cyperus*, which contained the majority of the recorded Cyperaceae species. Both groups showed clear habitat partitioning within the park landscape; grasses primarily dominated open lawns, trampled grounds and managed recreational areas, whereas sedges were more frequent in moist depressions, drainage lines and seasonally waterlogged patches. Disturbance-tolerant and fast-growing species such as *Cynodon dactylon* and *Cyperus rotundus* were widely distributed and abundant. It shows their high adaptability to urban management regimes. Collectively, grasses and sedges contributed substantially to ground-layer vegetation, which enhances soil stabilization, moisture regulation and microhabitat diversity (Roy and Devi, 2025), reinforcing the role of urban parks as compact yet functionally significant biodiversity hotspots within the densely built concrete environments.

Conclusion

The floristic survey demonstrated that urban parks, despite intensive management and anthropogenic pressures, support a considerable diversity of grasses and sedges. The coexistence of multiple genera and species with varied ecological preferences indicates strong habitat heterogeneity within the urban landscape. Grasses contribute predominantly to lawn structure, soil stabilization and recreational functionality, while sedges occupy ecologically sensitive niches associated with moisture retention and drainage, enhancing ecosystem resilience. The dominance of adaptable and disturbance-tolerant species like *C. rotundus*, *C. compressus* and *D. aegyptium* reflects the selective pressures imposed by urban environments, yet the persistence of habitat-specific taxa suggests conservation potential within managed green spaces. Recognizing and documenting such ground-layer diversity in Biju Pattnaik Park was essential for informed urban biodiversity planning and sustainable park management of the city. Future studies integrating seasonal variation, functional traits and ecosystem service assessments would further strengthen understanding of the role of grasses and sedges in urban ecological networks.

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Chapter 4

Diversity of some aquatic grasses: fodder and medicinal values

Parminder Singh Dehar¹, Smitaa Basole², Bhagwati Prashad Sharma³, Sweta Mishra⁴ and Sugimani Marndi^{4*}

¹Department of School Education, GHS Kamalpur, Sangrur, Punjab, India

²Department of Botany, Balbhim College, Beed, Maharashtra, India

³Department of Botany, Sidharth Government College, Nadaun, Himachal Pradesh, India

⁴Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

*Email-Id: sugimani2marndi@gmail.com

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Abstract: Aquatic grasses constitute an important component of wetland and freshwater ecosystems, contributing significantly to ecological stability, biodiversity conservation and sustainable resource utilization. Belonging mainly to the family Poaceae, these grasses thrive in aquatic and semi-aquatic habitats, such as marshes, ponds, riverbanks, floodplains and paddy fields, across India. Present study provides a comprehensive overview of the diversity of aquatic grasses, highlighting their nutritional and medicinal values. Many aquatic grass species serve as nutritious forage for livestock due to their high biomass production, palatability and mineral content, particularly during dry seasons when terrestrial fodder becomes scarce. In addition to their fodder importance, several species possess notable medicinal properties and are traditionally used in indigenous healthcare benefits for treating ailments such as fever, inflammation, digestive disorders, wounds and urinary problems. Despite their ecological and economic significance, aquatic grasses remain underexplored compared to terrestrial grasses. The current research emphasizes the need for systematic documentation, conservation and sustainable utilization of aquatic grasses to enhance fodder security and preserve traditional medicinal knowledge in India.

Keywords: Aquatic grasses, bioindicators, climate change, fodder

Introduction

Aquatic ecosystems, including wetlands, marshes, lakes, rivers and floodplains, represent one of the most productive yet vulnerable ecosystems in the world. In India, these ecosystems support a rich diversity of plant species, among which aquatic and semi-aquatic grasses play a vital role (Dash et al., 2022). Aquatic grasses, predominantly belonging to the family Poaceae, are specially adapted to survive in waterlogged or periodically

inundated environments through morphological and physiological modifications such as hollow stems, extensive rhizome systems and parenchymatous tissues (Hodkinson, 2018). These adaptations enable them to stabilize sediments, regulate nutrient cycling and maintain ecological balance within aquatic habitats (Priyadarshini et al., 2021). India harbours a wide variety of aquatic grasses distributed across diverse climatic and physiographic regions (Mande et al., 2025). Genera such as *Echinochloa*, *Leersia*, *Paspalum*, *Oryza*, *Hygroryza*, *Ischaemum* and *Eragrostis* are commonly found in wetlands and shallow water bodies (Chorghe and Prasanna, 2021). These grasses contribute substantially to primary productivity and serve as an important food source for livestock, wild herbivores and aquatic fauna (Siddabathula and Prasanna, 2023). Their rapid growth, high regenerative capacity and tolerance to fluctuating water levels make them valuable fodder resources, especially in rural and flood-prone regions where conventional fodder availability is limited. Beyond their fodder value, aquatic grasses possess considerable medicinal significance rooted in traditional knowledge such as Ayurveda, folk medicine and ethnoveterinary practices. Various plant parts, including leaves, stems, roots and rhizomes, are used in the treatment of ailments such as diarrhoea, dysentery, skin diseases, fever, ulcers and inflammatory conditions (Sinha et al., 2023; Das et al., 2024). Some species are also known for their antimicrobial, antioxidant and anti-inflammatory properties, highlighting their potential for pharmacological research and development in future works. Despite their multifunctional importance, aquatic grasses are often overlooked in floristic surveys and conservation programs. Increasing anthropogenic pressures such as wetland degradation, agricultural intensification, pollution and climate change pose serious threats to their diversity and distribution. Therefore, documenting the diversity of aquatic grasses along with their fodder and medicinal values is essential for promoting sustainable wetland management, conserving plant genetic resources and supporting rural livelihoods. The present study aims to present a detailed account of aquatic grass diversity in India and to emphasize their role as valuable fodder and medicinal resources, thereby highlighting the need for their conservation and sustainable utilization.

Methodology

Both literature and field surveys were conducted to document the aquatic grasses. The field surveys revealed a varied species diversity in different study areas of India, such as submerged, marshy, waterlogged and near the water bodies, which have potent fodder and medicinal value. Through a tentative literature and field survey, a wide array of ethnomedicinal uses was revealed and through the literature survey, their pharmacological values were

documented. Literature data were gathered from Scopus, Web of Science, Springer, PubMed, Google Scholar, MDPI, Science Direct, SciFinder, Scirus and Scientific Electronic Library Online (SciELO) using search terms "aquatic grasses", "medicinal", "fodder" and "ecological values" from 2020-2025 (Jena et al., 2025).

Results and discussion

The present study documented a total of 47 grass species belonging to the family Poaceae, representing diverse ecological habitats such as wetlands, marshes, coastal zones, grasslands, agricultural fields and forest margins (Table 1, Figure 1). The recorded species exhibited wide variation in flowering and fruiting periods, with most taxa flowering between July and January, indicating peak reproductive activity during monsoon and post-monsoon seasons. A few species, such as *Aeluropus lagopoides* and *Dactyloctenium aegyptium* were observed flowering throughout the year, reflecting their high ecological adaptability. Analysis of ethnobotanical utility revealed that all documented species possess either medicinal, fodder or dual importance. Among them, fodder use predominated, with species such as *Diplachne fusca*, *Eriochloa procera*, *Hygroryza aristata*, *Isachne globosa*, *Leersia hexandra*, *Paspalum distichum*, *Sacciolepis indica*, *Urochloa mutica* and *Thysanolaena latifolia* being widely used as livestock feed. Several grasses, such as *Echinochloa crus-galli*, *Hymenachne amplexicaulis*, *Oryza rufipogon* and *Urochloa distachyos*, showed dual utility as fodder and medicinal plants. Medicinally important species accounted for a significant proportion of the flora, with therapeutic uses including antidiabetic, antioxidant, antibacterial, anti-inflammatory, wound healing, hepatoprotective, antitumor, antiulcer and gynaecological applications. Notable examples include *Imperata cylindrica* (anti-inflammatory), *Saccharum spontaneum* (treatment of piles), *Phragmites australis* (fever and vomiting), *Setaria palmifolia* (hypertensive disorders in pregnancy) and *Coix lacryma-jobi* (immunity enhancement). The results clearly demonstrate that grasses, traditionally perceived as ecologically dominant but economically underappreciated plants, possess substantial ethnomedicinal and fodder value. The dominance of species flowering during the monsoon and post-monsoon period aligns with favourable moisture and temperature conditions that support vegetative growth and reproductive success. Species with extended or year-round phenology, such as *Aeluropus lagopoides*, exhibit stress tolerance traits that enable survival in saline and coastal ecosystems. The widespread use of whole plants in medicinal preparations suggests the presence of bioactive compounds distributed throughout plant tissues, corroborating earlier phytochemical studies reporting flavonoids, phenolics, alkaloids and terpenoids in grasses. The high frequency of antioxidant and

antidiabetic activities observed in species such as *Eragrostis* species, *Setaria* species and *Echinochloa* species highlights their potential role in managing lifestyle-related disorders. Fodder grasses recorded in the study play a crucial role in sustaining livestock-based rural livelihoods, particularly during lean seasons when conventional fodder resources are scarce. Wetland grasses like *Hygroryza aristata* and *Hymenachne amplexicaulis* are especially important in flood-prone regions, contributing to both forage availability and ecosystem stability. Additionally, the presence of medicinal properties in commonly occurring and often neglected grasses highlights the need for conservation and sustainable utilization of grassland and wetland ecosystems. Traditional knowledge associated with these species provides valuable leads for pharmacological validation and future drug discovery. The current research emphasize that grasses are not merely ecological dominants but also multifunctional resources with significant medicinal, nutritional and economic importance. Integrating ethnobotanical knowledge with modern scientific research can enhance their utilization while promoting biodiversity conservation and sustainable development.

Table 1: Aquatic grasses with their fodder and medicinal values in India

Botanical name	Flowering/ fruiting	Common name	Uses, if any (Medicinal or fodder)	Sources
<i>Aeluropus lagopoides</i> (L.) Thwaites	Throughout the year	Mangrove grass	It is used to treat wound healing.	Khair et al., (2023)
<i>Bothriochloa bladhii</i> (Retz.) S.T.Blake (Figure 2)	Aug-Jan	Australian bluestem	Whole plant is used for mosquito repellent/ fodder.	Verma et al., (2008); Behera et al., (2025)
<i>Centotheca lappacea</i> (L.) Desv.	Nov-Jan	Lappaceious Sandbur	Whole plant is used for anti-aging.	Kamoltham et al., (2018)
<i>Chrysopogon zizanioides</i> (L.) Roberty	Aug-Dec	Vetiver & Khus	Root is used to relieve tiredness/fodder.	Pandey and Tiwari, (2023); Behera et al., (2025)

<i>Coix lacryma-jobi</i> L.	Aug-Mar	Job's tears	Root possesses antibacterial activity/ Seed is used as an immunity booster/ fodder.	Feng et al., (2020)
<i>Cyrtococcum trigonum</i> (Retz.) A. Camus	Aug-Dec	Zigzag grass	Fodder	Behera et al., (2025)
<i>Dactyloctenium aegyptium</i> (L.) Willd.	Throughout the year	Common crowfoot	Whole plant possesses antidiabetic activity/ fodder.	Al-Snafi, (2017b); Raveendran et al., (2024)
<i>Diplachne fusca</i> (L.) P.Beauv. ex Roem. & Schult.	Sep-Jan	Bearded sprangletop	Fodder	Rahat et al., (2019)
<i>Echinochloa colona</i> (L.) Link	July- Feb	Jungle rice	Whole plant is used to treat ulcers/ fodder.	Borkar et al., (2016)
<i>Echinochloa crus-galli</i> (L.) P.Beauv.	Aug-Feb	Barnyard grass	Whole plant possesses antidiabetic activity/ fodder.	Al-Snafi, (2017a)
<i>Eragrostis cilianensis</i> (All.) Vignolo ex Janch.	Sep-Jan	Stink grass	Whole plant is used to treat kidney diseases.	Muhammad et al., (2025)
<i>Eragrostis japonica</i> (Thunb.) Trin.	Oct-Jan	Pond lovegrass	Whole plant possesses antioxidant activity.	Na et al., (2018)
<i>Eragrostis pilosa</i> (L.) P.Beauv.	Aug-Dec	Indian lovegrass	Whole plant possesses antioxidant activity.	Badwaik et al., (2021)

<i>Eriochloa procera</i> (Retz.) C.E.Hubb.	Sep-Dec	Tall cupgrass	Fodder	Behera et al., (2025)
<i>Hackelochloa granularis</i> (L.) Kuntze	Aug-Dec	Pitscale grass	Fodder	Behera et al., (2025)
<i>Hygroryza aristata</i> (Retz.) Nees ex Wight & Arn. (Figure 3)	Oct-Mar	Floating rice	Fodder	Hossain et al., (2021)
<i>Hymenachne amplexicaulis</i> (Rudge) Nees (Figure 4)	Sep-Feb	West Indian marsh grass	Whole plant possesses antitumor activity/ fodder.	Rostini et al., (2014); Assad et al., (2021);
<i>Imperata cylindrica</i> (L.) Raeusch.	Sep-Dec	Cogon grass	Whole plant is used to treat inflammation/ fodder.	Nayim et al., (2023); Behera et al., (2025)
<i>Isachne globosa</i> (Thunb.) Kuntze	Sep-Nov	Swamp millet	Fodder	Behera et al., (2025)
<i>Ischaemum polystachyum</i> J.Presl	Oct-Dec	Muraina grass	Fodder	Rostini et al., (2014)
<i>Leersia hexandra</i> Sw. (Figure 5)	Oct-Jan	Southern cutgrass	Fodder	Orocio-Carrillo et al., (2025)
<i>Moorochloa eruciformis</i> (Sm.) Veldkamp	July-Dec	Eruciformis grass	Whole plant possesses antioxidant activity.	Ragheb et al., (2025)

<i>Oplismenus compositus</i> (L.) P.Beauv.	Sep-Dec	Running mountain grass	Whole plant paste is used to treat wound healing/ fodder.	Sahu et al., (2024)
<i>Oryza meyeriana</i> (Zoll. & Moritz) Baill.	Jun-Mar	Meyer's rice	Fodder/ consumed as rice to boost immunity.	Gong et al., (2000)
<i>Oryza rufipogon</i> Griff. (Figure 6)	Aug- Jan	Brown beard rice	It possesses antioxidant activity/ fodder.	Fasahat et al., (2012)
<i>Ottochloa nodosa</i> (Kunth) Dandy	Jul-Mar	Pullenna	It possesses antibacterial activity.	Latib et al., (2022)
<i>Panicum brevifolium</i> L.	Oct-Dec	Brevifolium foxtail	Whole plant is used to cure infections.	Satapathy et al., (2019)
<i>Panicum sumatrense</i> Roth	Sep-Jan	Little millet	Whole plant is used to treat antiulcer activity/ fodder.	Taher et al., (2025); Behera et al., (2025)
<i>Paspalum distichum</i> L.	Aug-Dec	Knot grass	Fodder	Behera et al., (2025)
<i>Paspalum scrobiculatum</i> L.	Aug-Dec	Kodo millet	It is used to cure gynaecological diseases/ fodder.	Pal and Sen, (2025)
<i>Paspalum vaginatum</i> Sw.	Sep-Jan	Seashore paspalum	It possesses antibacterial activity.	Anuforo et al., (2025)
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	Oct-Dec	Elephant grass	The dried rhizome has long been used to relieve fever and vomiting.	Unuofin et al., (2024)

<i>Phragmites karka</i> (Retz.) Trin. ex Steud.	Sep-Mar	Tall reed	Whole plant is used to treat wound healing.	Khan et al., (2025)
<i>Pogonatherum paniceum</i> (Lam.) Hack.	Apr-Jun	Baby panda plant	Whole plant possesses anti-inflammatory activity.	Thongboont ho et al., (2023)
<i>Pogonatherum crinitum</i> (Thunb.) Kunth	May-Mar	Bamboo grass	Whole plant is used to treat skin diseases.	Gupta et al., (2016)
<i>Polypogon monspeliensis</i> (L.) Desf.	Mar-April	Annual beard grass	It possesses hepatoprotective activity.	Abbass et al., (2024)
<i>Saccharum spontaneum</i> L.	Aug-Feb	Wild sugarcane	Whole plant is used to treat piles/ fodder.	Hassan et al., (2024)
<i>Sacciolepis indica</i> (L.) Chase	Aug-Jan	Indian cudweed	Fodder	Behera et al., (2025)
<i>Sacciolepis interrupta</i> (Willd.) Stapf	Aug-Mar	Interrupted cupscale grass	Fodder	Behera et al., (2025)
<i>Setaria intermedia</i> Roem. & Schult.	Aug-Jan	Intermediate foxtail	It possesses antioxidant activity.	Verma et al., (2020)
<i>Setaria palmifolia</i> (J.Koenig) Stapf	Aug-Dec	Palm grass	Leaves and stems are used to treat hypertensive disease in pregnancy.	Lainata et al., (2017)
<i>Setaria punctata</i>	Aug-Jan	Bristly foxtail	Seed extract is consumed as a	Sireesha et al., (2023)

(Burm.f.) Veldkamp			savoury to cure diabetes.	
<i>Sporobolus virginicus</i> (L.) Kunth	May-Dec	Seashore dropseed	Fodder	Tisarum et al., (2022)
<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	Apr-Dec	Asian broom grass	Fodder	Wongleang et al., (2024)
<i>Urochloa distachyos</i> (L.) T.Q. Nguyen	Sep-Dec	Two-awned Urochloa	Fodder/ whole plant possesses antimicrobial activity.	Kumar, (2025)
<i>Urochloa mutica</i> (Forssk.) T.Q.Nguyen (Figure 7)	Sep-Dec	Para grass	Fodder	Tadesse et al., (2024)
<i>Urochloa ramosa</i> (L.) T.Q.Nguyen	Jul-Dec	Browntop millet	Whole plant is used to treat anti-inflammatory activity.	Singh et al., (2022)

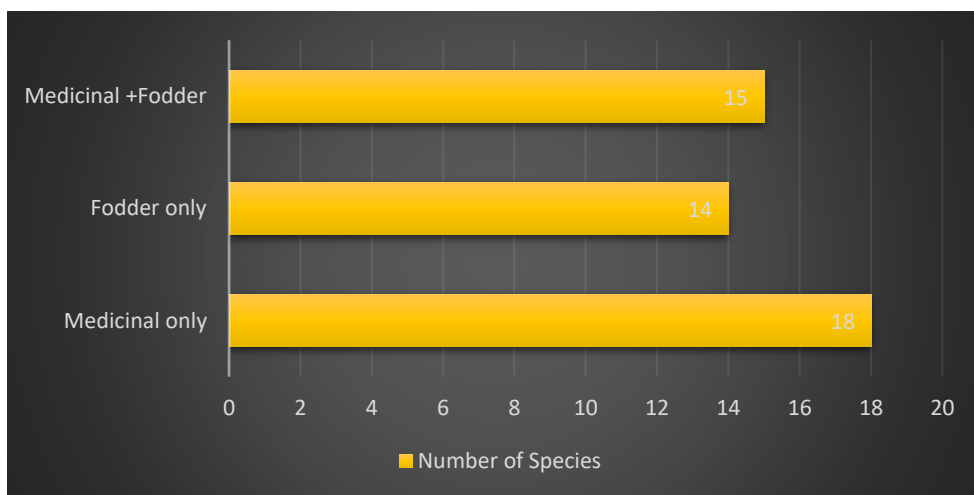


Figure 1: Distribution of aquatic grass species based on uses



Figure 2: Inflorescence of *Bothriochloa bladhii* in the wild



Figure 3: Habit and habitat of *Hygroryza aristata* in the wild



Figure 4: Inflorescence of *Hymenachne amplexicaulis* in the wild



Figure 5: Inflorescence of *Leersia hexandra* in the wild



Figure 6: Habit and habitat of *Oryza rufipogon*



Figure 7: Habit and habitat of *Urochloa mutica*

According to [Table 1](#), it was revealed that aquatic grasses possess fodder and medicinal value. Less work has been carried out on many aquatic grasses in terms of medicinal aspects, as compared to their fodder value. The graph illustrates the relative proportion of grass species used exclusively for medicinal purposes, solely as fodder and those having dual medicinal and fodder value ([Figure 1](#)). Medicinally important grasses constitute the dominant group, highlighting the therapeutic significance of Poaceae members. The bar graph illustrates the distribution of grass species based on their ethnobotanical uses, categorized into medicinal only, fodder only and medicinal + fodder. Among the documented species, medicinal-only grasses constitute the highest number (18 species), indicating their prominent role in traditional healthcare practices. This is followed by species used for both medicinal and fodder purposes (15 species), highlighting the multifunctional nature of several grass species that support both human health and livestock nutrition. Fodder-only species account for 14 species, reflecting their importance in sustaining grazing systems and rural livelihoods. The graph demonstrates that a substantial proportion of grass species possess medicinal significance, either exclusively or in combination with fodder value. This distribution emphasizes the underrecognized therapeutic potential of grasses and showcasing their dual contribution to traditional medicine and agro-pastoral systems.

Gap analysis

Thoroughly going through the literature and field survey, it was revealed that due to severe threats, some of the aquatic grasses are diminishing. Due to such activity, as a consequence, little or no exploration work has been carried out to document their medicinal and fodder uses. Despite their wide distribution and ecological dominance, grasses remain largely underexplored for their medicinal and therapeutic potential. Existing studies have primarily focused on their ecological roles, agronomic importance and fodder value, while systematic documentation of ethnomedicinal knowledge is limited and often fragmented. Scientific validation of traditional uses through phytochemical, pharmacological and clinical investigations is insufficient, particularly for commonly occurring wild and wetland grasses that are frequently regarded as weeds. Moreover, comparative studies linking phenological patterns with bioactive compound production are scarce and fodder grasses possessing dual medicinal benefits have received minimal research attention. The lack of region-specific inventories integrating traditional knowledge with modern scientific approaches further constrains effective conservation and sustainable utilization strategies. Consequently, there is a pressing need for

comprehensive, interdisciplinary studies to bridge these gaps and unlock the untapped medicinal and economic potential of grasses and sedges.

Conclusion

The present study highlights the rich diversity of grass species and their significant ethnobotanical importance, with many species serving as a valuable source of traditional medicine and fodder. A majority of 47 grasses exhibit medicinal properties such as antidiabetic, antioxidant, anti-inflammatory, antibacterial and wound-healing activities, while several others play a crucial role in sustaining livestock through their fodder value. The occurrence of dual-purpose species underscores the multifunctional role of grasses in supporting both human healthcare and rural livelihoods. The recent study emphasizes the need for systematic scientific validation, conservation and sustainable utilization of grass resources to harness their full ecological and therapeutic potential.

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Chapter 5

Bioactive compounds of Lemon grass (stems) and its flavonoid estimation

Nibedita Jena, Sugimani Marndi and Sweta Mishra*

Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

*Email-Id: swetamishra.aprf@gmail.com

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Abstract: Grasses play a vital role in our biodiversity conservation with respect to food, medicinal, ecological and economic value. *Cymbopogon citratus* (lemon grass) is one of the famous aromatic medicinal grasses widely valued for its therapeutic properties and bioactive constituents. However, its stems remain comparatively underexplored. Present study aimed to investigate the qualitative phytochemical profile and quantitative flavonoid content of *C. citratus* stem using solvent extraction of varying polarity. Soxhlet extraction was carried out using n-hexane, ethanol, methanol and distilled water. Qualitative phytochemical analysis revealed the presence of carbohydrates as the primary metabolite in polar extracts, while secondary metabolites such as tannins, reducing sugars, saponins and flavonoids were predominantly detected in aqueous extract. The total flavonoid content was estimated to be 0.05 mg/100 g. The results highlight the significance of utilizing lesser-studied plant parts and support the sustainable use of *C. citratus* as a source of natural bioactive compounds for pharmaceutical and nutraceutical applications.

Keywords: Bioactive compounds, flavonoids, lemon grass

Introduction

The increasing demand for natural antioxidants and plant-based therapeutic agents has intensified scientific interest in underutilized plant parts rich in bioactive compounds (Hrelia et al., 2025). *Cymbopogon citratus* (lemon grass), a perennial aromatic grass of the family Poaceae, is widely recognized for its essential oil-bearing leaves with extensive medicinal applications (Parveen et al., 2025). However, during commercial processing and household use, lemon grass stems are often discarded or used minimally, despite their biochemical richness. Exploring the phytochemical composition of lemon grass stems offers an opportunity to transform agricultural by-products into valuable sources of health-promoting compounds (Zeppa et al., 2025). Bioactive compounds such as phenolics, flavonoids, tannins and terpenoids play a pivotal role in plant defence

mechanisms and contribute significantly to their pharmacological activities (Sharma et al., 2025). In lemon grass stems, these secondary metabolites are known to exhibit antioxidant, antimicrobial and anti-inflammatory properties, which are essential in mitigating oxidative stress-related disorders (Kiani et al., 2022). Among these compounds, flavonoids are particularly important due to their ability to neutralize free radicals, inhibit lipid peroxidation and modulate cellular signaling pathways involved in disease prevention (Zahra et al., 2024). Assessment of flavonoid content in lemon grass stems not only provides insight into their therapeutic potential but also supports the sustainable utilization of the whole plant. From scientific validation of the bioactive profile of stems, the present study contributes to the development of natural antioxidant sources for pharmaceutical, nutraceutical and functional food applications. Such an approach aligns with current trends in sustainable agriculture, waste reduction and the discovery of eco-friendly alternatives to synthetic antioxidants.

Methodology

Collection of plant sample

The stems of *Cymbopogon citratus* were collected from the vicinity of the Mahanadi River in the Cuttack district of Odisha, India. The plant material was taxonomically identified by the authors (Figures 1 & 2; Nayak and Kumar, 2023). Phytochemical extraction was carried out using the Soxhlet extraction method with four different solvents of varying polarity, following standard procedures (Kumar et al., 2013; Marndi et al., 2024). Qualitative detection of selected secondary metabolites was performed using established phytochemical screening methods as described by Devi et al., (2022), Jena et al., (2024) and Marndi et al., (2024).

Qualitative phytochemical analysis

Primary metabolites

Test for protein: One ml of the filtrate of the stem extract was mixed with 2-5 drops of Millon's reagent and kept in the water bath for 30 minutes. The pink coloration indicates the presence of protein.

Test for carbohydrates: One ml of the filtrate of the stem extract was mixed with 2-5 drops of Fehling's solution A and B and kept in the water bath for 30 minutes. A reducing sugar reacts with Fehling's reagent in an alkaline medium to form an orange-to-red precipitate. The appearance of an orange or red precipitate indicates the presence of carbohydrates.



Figure 1: Plant sample for experimental work

Test for starch: To 1 ml of the filtrate of the stem extract, 2-3 drops of concentrated HCl were added and heated for 1-2 minutes. NaOH, following Benedict's reagent, was added to this solution and kept in the water bath. The change in coloration from bluish-green to red-orange indicates the presence of starch.

Test for sucrose: About 1 ml of the filtrate of the stem extract was mixed with 2-3 drops of iodine. The appearance of a blue-black color indicates the presence of sucrose.

Test for lipid: About 1 ml of the filtrate of the stem extract was mixed with 2-5 drops of Sudan-III. The appearance of pink droplets indicates the presence of lipids.

Test for amino acid: One ml of the filtrate of the stem extract was mixed with 5 drops of Ninhydrin reagent and kept in the water bath for 30 minutes. Ninhydrin is a powerful oxidizing agent that gives a purple-colored product termed Rhuemann's purple.



Figure 2: Morphology of *C. citratus* in the wild areas

Secondary metabolites

Test for tannin: About 1 ml of the stem extract was taken. Three to five drops of 10 % lead acetate solution were added. The gelatinous precipitate formation confirms the presence of tannin.

Test for saponin: About 1 ml of the stem extract was taken and 1 ml of distilled water was added and shaken well. The formation of persistent froth confirms the presence of saponin.

Test for flavonoids: About 1 ml of the stem extract was taken. Two ml of 2 % NaOH solution and 3 to 4 drops of diluted HCl were added. The color initially turns to an intense yellow color with NaOH solution and later became colorless. This color change in appearance confirms the presence of flavonoids.

Test for terpenoids: About 1 ml of the stem extract was added with 5-6 drops of chloroform and placed in the water bath for a few minutes. Then 5-6 drops of concentrated sulphuric acid were added. The reddish-brown interface confirms the presence of terpenoids.

Test for phenolic groups: About 1 ml of the stem extract was taken. A few drops of 5 % ferric chloride solution were added. The dark bluish-black appearance confirms the presence of phenolic compounds.

Test for reducing sugars: About 1 ml of the stem extract was taken and 2 drops of Fehling's solution A followed by Fehling's solution B were added and kept in the water bath for some time. The presence of red-orange precipitate confirms the presence of reducing sugar.

Test for steroids: About 1 ml of the stem extract was taken. 1 ml of chloroform and 1 ml of concentrated sulphuric acid was added to it. The appearance of upper red and lower yellow colors with green fluorescence provides the presence of steroids.

Test for alkaloids: About 1 ml of the stem extract was taken and 3 to 4 drops of Dragendroff's reagent were added. The formation of a reddish-brown precipitate confirms the presence of alkaloids.

Quantitative estimation of secondary metabolites

Estimation of flavonoids: A sample of 100 µl of the extract was mixed with 100 µl of 5 % sodium nitrite and allowed to stand for 5 minutes. Next, 100 µl of aluminium trichloride was added and incubated for 6 minutes, followed by addition of 1 ml of 1 M sodium hydroxide. The total volume of the mixture was made up to 5 ml with distilled water and incubated for 15 minutes at room temperature in the dark for taking absorbance at 510 nm. The amount of flavonoid present in the sample was calculated from the standard graph. The standard graph was prepared for quercetin ([Chang et al., 2002](#); [Raina and Misra, 2023](#)).

Results and discussion

The qualitative phytochemical screening of *C. citratus* stem extracts for primary metabolites in Table 1 indicated that carbohydrate was the only primary metabolite detected. Ethanol, methanol and aqueous extracts showed positive results for carbohydrates, whereas the non-polar n-hexane extract showed no detectable primary metabolites. This observation suggested that carbohydrates present in the stems are predominantly polar in nature and were efficiently extracted using polar solvents. The absence of primary metabolites in the non-polar extract highlighted the solvent-dependent extraction efficiency and supports the use of polar solvents for nutritional and biochemical studies.

Table 1: Qualitative phytochemical analysis for the detection of primary metabolites in *C. citratus* stem extracts

Polarity	Extract	Detected primary metabolites
Non-Polar  Polar	n-Hexane	No tested metabolites were detected
	Ethanol	Carbohydrates only
	Methanol	
	Aqueous	

Table 2: Qualitative phytochemical analysis for the detection of secondary metabolites in *C. citratus* stem extracts

Polarity	Extract	Detected secondary metabolites
Non-Polar  Polar	n-Hexane	No tested metabolites were detected
	Ethanol	Tannin and reducing sugars
	Methanol	
	Aqueous	Tannin, saponin, flavonoid and reducing sugars

The qualitative screening for secondary metabolites (Table 2) revealed notable variations among different solvent extracts. Ethanol and methanol extracts showed the presence of tannins and reducing sugars, indicating moderate polarity of these compounds. The aqueous extract exhibited a richer phytochemical profile, revealing the presence of tannins, saponins, flavonoids and reducing sugars. In contrast, the n-hexane extract did not show any of the tested secondary metabolites, confirming that these bioactive constituents are largely polar in nature. The higher diversity of secondary metabolites in the aqueous extract suggested that water is an effective solvent for extracting bioactive compounds from *C. citratus* stems, particularly those associated with antioxidant and therapeutic activities.

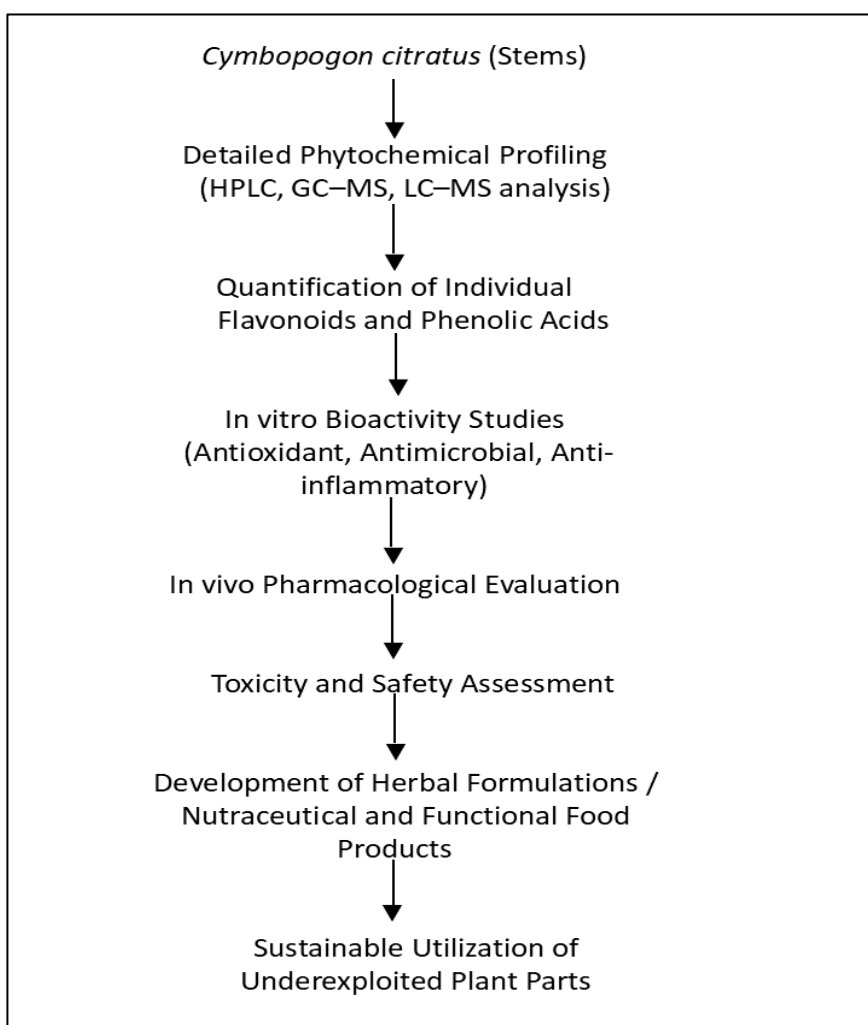


Figure 3: Illustration of *C. citratus* (stems) for future research scope

Table 3: Quantification of total Flavonoid content

<i>Cymbopogon citratus</i> (stems)	Bioactive compound	Content (mg/100g)
	Flavonoid	0.05

The quantitative estimation of total flavonoid content in *C. citratus* stem is presented in Table 3. The flavonoid content was recorded as 0.05 mg/100 g of sample. Although the detected level is relatively low, the presence of flavonoids confirms the antioxidant potential of the stems. Flavonoids are known for their ability to scavenge free radicals, reduce oxidative stress and contribute to anti-inflammatory and antimicrobial activities (Zahra et al., 2024). The detected flavonoid content, along with the qualitative presence observed in the aqueous extract, supports the therapeutic relevance of lemon grass stems. Present study emphasizes that even lesser-studied plant parts, such as stems, possess bioactive compounds that can contribute to pharmaceutical and nutraceutical applications in future aspects (Figure 3).

Conclusion

The present scenario demonstrates that the stems of *Cymbopogon citratus* possess a range of bioactive compounds, with solvent polarity playing a crucial role in extraction efficiency. Qualitative phytochemical screening confirmed the presence of carbohydrates as primary metabolites in polar extracts and revealed important secondary metabolites such as tannins, saponins, flavonoids and reducing sugars, particularly in aqueous extracts. Quantitative estimation indicated a measurable flavonoid content, supporting the antioxidant potential of the stems despite their relatively low concentration. These results emphasize that plant parts often considered underutilized or discarded, such as stems, can serve as a valuable source of bioactive compounds. The study contributes to the growing body of knowledge on *C. citratus* and promotes the sustainable utilization of the whole plant. Further exploration of these bioactive constituents may enhance their application in pharmaceutical, nutraceutical and functional food industries.

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Chapter 6

Fodder grasses of spotted deer of Chandaka-Dampara Wildlife Sanctuary, Odisha, India

Sanjeet Kumar¹, Nibedita Jena¹, Arun Kumar Mishra² and Sugimani Marndi^{1*}

¹Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

²HN-3002, DN Oxy Park, Dumuduma, Bhubaneswar- 751019, Odisha, India

*Email-id: sugimani2marndi@gmail.com

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Abstract: The Chandaka-Dampara Wildlife Sanctuary, located in Khordha district of Odisha, supports a rich diversity of flora and fauna, including the spotted deer (*Axis axis*). Present study aimed to document the diversity and seasonal use of fodder grasses by spotted deer from January to November 2025. Field surveys across grasslands, forest edges and scrublands recorded 40 grass species from the family Poaceae, categorized by palatability as high, medium and low. Highly palatable species, including *Cynodon dactylon*, *Chloris barbata*, *Digitaria ciliaris* and *Urochloa mutica*, formed the primary diet. Seasonal changes influenced grazing patterns, with open grasslands favoured during the monsoon and shaded, moist patches used in summer. Present findings highlighted the importance of maintaining diverse grassland and forest-edge habitats for supporting spotted deer populations and illuminated the need for effective habitat management to ensure forage availability and ecosystem stability.

Keywords: Ecosystem stability, forest-edge habitat, palatability, scrublands

Introduction

The Chandaka-Dampara Wildlife Sanctuary is a prominent protected forest area located about 20 kilometres northwest of Bhubaneswar, the capital city of Odisha (Satapathy et al., 2025a). The sanctuary is known for its rich biodiversity and scenic natural landscapes. Six major forest types are represented in the sanctuary, which include moist bamboo brakes, lateritic semi-evergreen forests, peninsular Sal forests, secondary moist mixed deciduous forest and tropical dry evergreen forests (Behera et al., 2025). It serves as an important green buffer for the rapidly growing urban areas around it and plays a vital role in ecological balance and wildlife conservation (Satapathy et al., 2025b). The sanctuary is home to a variety of flora and fauna, including elephants, deer and numerous species of birds and reptiles. With its dense forests, rolling hills and tranquil environment,

Chandaka-Dampara Wildlife Sanctuary is not only a haven for wildlife but also a popular destination for nature lovers, researchers and eco-tourists (Behera et al., 2025). Chandaka-Dampara Wildlife Sanctuary provides an ecologically significant habitat for the spotted deer, supporting its feeding, shelter and breeding requirements through a diverse range of vegetation (Behera et al., 2025). The sanctuary's mosaic of dry deciduous forest, scrub and grassland patches creates favourable conditions for the sustenance of spotted deer populations, particularly through the availability of seasonal fodder grasses (Pattnayak et al., 2018). Spotted deer utilize open grasslands for grazing and forested areas for cover, reflecting a close association between habitat structure and species behaviour (Rastogi et al., 2021). The presence of perennial and seasonal grasses within the sanctuary plays a vital role in maintaining herd stability and spatial distribution of spotted deer throughout the year (Rastogi et al., 2021). As one of the primary herbivores of Chandaka-Dampara, spotted deer also contribute to ecosystem processes such as nutrient cycling and vegetation dynamics, emphasizing their ecological importance and the need for focused habitat management within the sanctuary (Behera et al., 2025). The present study aims to document the diversity of fodder grasses utilized by spotted deer in Chandaka-Dampara Wildlife Sanctuary, examine seasonal feeding patterns and highlight key conservation concerns. The findings are intended to support informed habitat management and contribute to the long-term conservation of spotted deer and grassland ecosystems within the sanctuary.

Methodology

The field surveys were conducted in Chandaka-Dampara Wildlife Sanctuary from January 2025 to November 2025 to document fodder grasses consumed by spotted deer (*Axis axis*). Surveys covered major habitat types, including grasslands, scrub and dry deciduous forests, using line transects and direct field observations (Figure 1). Seasonal visits were undertaken during the winter, summer and monsoon periods to record variations in grass availability and use. Grass species were identified using standard floras and palatability was assessed based on direct grazing observations, feeding signs and field evidence such as cropped shoots. The collected data were analyzed to determine the diversity and seasonal importance of fodder grasses (Sinha et al., 2023; Das et al., 2024; Behera et al., 2025).

Results and discussion

The field investigations conducted between January 2025 to November 2025 recorded a total of 40 species of fodder grasses belonging to the family Poaceae that were utilized by spotted deer in Chandaka-Dampara Wildlife

Sanctuary (Table 1; Figure 2). These species occurred across grasslands, forest clearings, scrub patches, wetland margins and bamboo-dominated areas, reflecting the habitat heterogeneity of the sanctuary. Based on field observations and feeding signs, the recorded grasses were categorized into high (H), medium (M) and low (L) palatability classes (Figure 3). A majority of the species exhibited high palatability, indicating their significant contribution to the diet of spotted deer. Highly preferred grasses such as *Cynodon dactylon*, *Chloris barbata*, *Digitaria ciliaris*, *Urochloa mutica*, *Imperata cylindrica*, *Oryza rufipogon* and *Panicum repens* were frequently observed in grazing sites and showed clear signs of repeated utilization. These grasses were particularly abundant during the monsoon and post-monsoon seasons, supporting increased grazing activity and herd aggregation in open grassland areas. Bamboo species such as *Bambusa bambos* and *Dendrocalamus strictus* were also consumed, especially during lean periods, highlighting their supplementary role in the diet. Seasonal variation in fodder availability influenced grazing patterns and habitat use by spotted deer. During the monsoon season, the abundance of fresh and succulent grasses resulted in extensive use of open grasslands and forest edges. During summer months, deer were more frequently observed near moist areas, wetlands and shaded forest patches where perennial grasses such as *Hymenachne amplexicaulis*, *Leersia hexandra* and *Isachne globosa* persisted. Low-palatability species such as *Saccharum spontaneum*, *Aristida setacea* and *Setaria* spp. were rarely grazed and were mostly utilized only under conditions of limited forage availability. The dominance of highly palatable grasses suggests that Chandaka-Dampara Wildlife Sanctuary currently supports a suitable forage base for sustaining spotted deer populations. However, signs of grazing pressure were evident in certain grassland patches, particularly near water sources and frequently used trails. As a key herbivore, spotted deer play an important role in shaping grassland structure, influencing plant regeneration and contributing to nutrient cycling. Their selective grazing behaviour helps maintain grass diversity but may also lead to localized overuse if habitat management is inadequate. The current study emphasized the ecological importance of grassland and grass-forest ecotone habitats within the sanctuary. Conservation efforts should be focused on maintaining grassland diversity, preventing habitat degradation and ensuring seasonal availability of key fodder species. Sustainable grassland management will not only support spotted deer populations but also benefit other herbivores and enhance overall ecosystem stability in Chandaka-Dampara Wildlife Sanctuary (Table 1).

Table 1: List of fodder grasses of Chandaka-Dampara Wildlife Sanctuary

Botanical name	Common name	Local name	Palatability
<i>Allotheropsis cimicina</i> (L.) Stapf	Summer grass	Bada borati ghasa	L
<i>Apluda mutica</i> L.	Mauritian grass	Mugar ghasa	H
<i>Aristida setacea</i> Retz.	Broom grass	Jhadu ghasa	L
<i>Axonopus compressus</i> (Sw.) Beauv. (Plate 1a) P.	Tropical carpet grass	Kachuri ghasa	M
<i>Bambusa bambos</i> (L.) Voss	Giant thorny bamboo	Kanta baunsa	H
<i>Bothriochloa bladhii</i> (Retz.) S.T. Blake	Australian Bluegrass	Gandhabena	H
<i>Bothriochloa pertusa</i> (L.) A. Camus	Pitted beard grass	Basana	H
<i>Chloris barbata</i> Sw.	Swollen finger grass	Gajalakha	H
<i>Chrysopogon aciculatus</i> (Retz.) Trin.	Love grass	Guguchia	H
<i>Coix lacryma-jobi</i> L. (Plate 1b)	Job's tears	Gargada	H
<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	Duba ghasa	H
<i>Cyrtococcum trigonum</i> (Retz.) A. Camus	Zigzag grass	Chhunchunia ghasa	M
<i>Dactyloctenium aegyptium</i> (L.) Willd. (Plate 1c)	Crowfoot	Kukudia	H
<i>Dendrocalamus strictus</i> (Roxb.) Nees	Solid bamboo	Salia baunsa	H
<i>Digitaria ciliaris</i> (Retz.) Koeler	Southern crabgrass	Chiri-chiri ghasa	H
<i>Dinebra chinensis</i> (L.) P.M. Peterson & N. Snow	Chinese sprangletop	Bhuru	M

<i>Eleusine indica</i> (L.) Gaertn. (Plate 1h)	Indian goosegrass	Nandia	H
<i>Eragrostis ciliaris</i> (L.) R.Br.	Gophertail lovegrass	Gajalakha	M
<i>Eragrostis unioides</i> (Retz.) Nees ex Steud. (Plate 1f)	Chinese lovegrass	Phurphuri ghasa	H
<i>Hackelochloa granularis</i> (L.) Kuntze (Plate 1d)	Pitscale grass	Tinpali	H
<i>Heteropogon contortus</i> (L.) P. Beauv. ex Roem. & Schult. (Plate 1i)	Black speargrass	Sinkula	H
<i>Hymenachne amplexicaulis</i> (Rudge) Nees	Dal grass	Jala ghasa	M
<i>Imperata cylindrica</i> (L.) Raeusch. (Plate 1e)	Cogon grass	Chhana ghasa	H
<i>Isachne globosa</i> (Thunb.) Kuntze	Swamp millet	Dhana ghasa	M
<i>Leersia hexandra</i> Sw.	Swamp rice grass	Jala dhana	M
<i>Oplismenus burmanni</i> (Retz.) P. Beauv.	Burmann's basket grass	Kaugodia ghasa	H
<i>Oryza rufipogon</i> Griff.	Wild rice	Balunga	H
<i>Panicum repens</i> L.	Creeping panic grass	Panidal	H
<i>Panicum sumatrense</i> Roth	Little millet	Suan	M
<i>Paspalum scrobiculatum</i> L. (Plate 1g)	Kodo millet	Kodua	M
<i>Polytrias indica</i> (Houtt.) Veldkamp	Java grass	Kachranga ghasa	M
<i>Saccharum spontaneum</i> L.	Kans grass	Kasatandi	L
<i>Sacciolepis indica</i> (L.) Chase	Indian cupscale grass	Nilendri ghasa	L
<i>Setaria flavida</i> (Retz.) Veldkamp	Yellow watercrown grass	Bileilanji ghasa	L
<i>Setaria pumila</i> (Poir.) Roem. & Schult.	Yellow foxtail	Siala languda	L
<i>Setaria verticillata</i> (L.) P. Beauv.	Bristly foxtail	Baunsa ghasa	L
<i>Sporobolus diandrus</i> (Retz.) P. Beauv.	Smut grass	Kakarchada	H
<i>Urochloa distachyos</i> (L.) T.Q. Nguyen	Tropical signal grass	Dhanri ghasa	M

<i>Urochloa mutica</i> (Forssk.) T.Q. Nguyen	Para grass	Para ghasa	H
<i>Urochloa panicoides</i> P.Beauv.	Liverseed grass	Jalganti	H

(L: Low; M: Moderate and H: High)

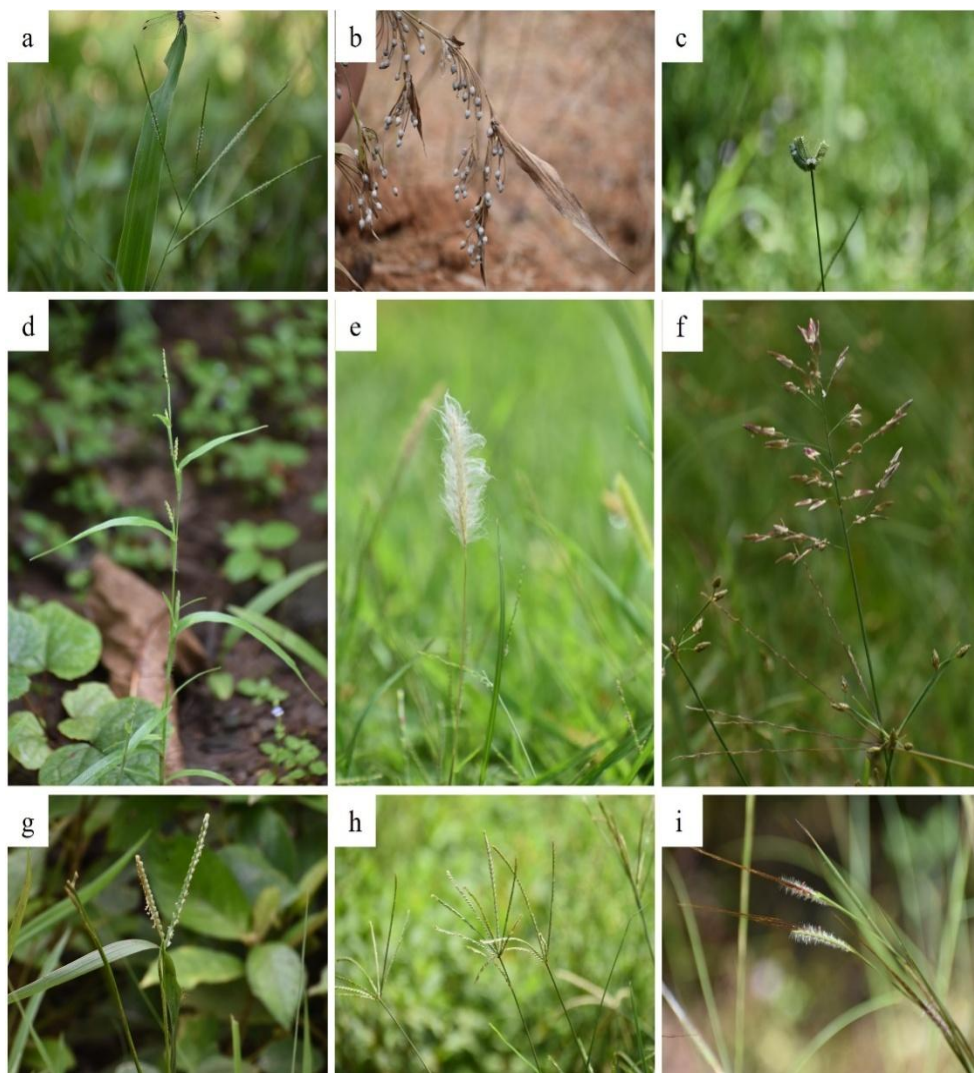


Plate 1: Palatable fodder grasses: (a) *Axonopus compressus*, (b) *Coix lacryma-jobi*, (c) *Dactyloctenium aegyptium*, (d) *Hackelochloa granularis*, (e) *Imperata cylindrica*, (f) *Eragrostis unioides*, (g) *Paspalum scrobiculatum*, (h) *Eleusine indica* and (i) *Heteropogon contortus*



Figure 1: Observation of fodder grasses in the grazing area of spotted deer



Figure 2: Spotted deer in the study area during grazing

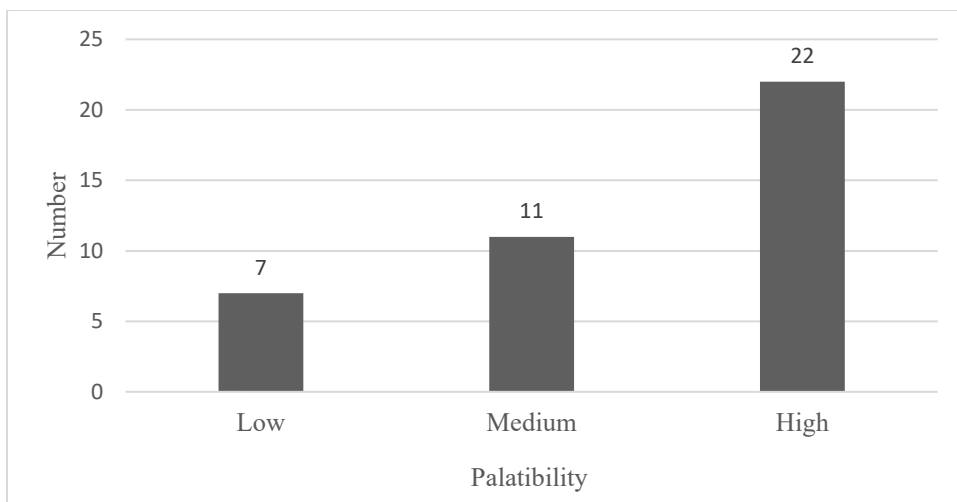


Figure 3: Palatability range of fodder grasses in the study area

Conclusion

The present study documented 40 fodder grass species consumed by spotted deer in Chandaka-Dampara Wildlife Sanctuary, with several highly palatable species forming the core of their diet. Seasonal variations influenced grazing patterns, highlighting the importance of diverse grassland and forest-edge habitats. Effective management of these habitats is essential to sustain deer populations and maintain ecosystem balance within the sanctuary.

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Chapter 7

***Schoenoplectiella juncooides* (Roxb.) Lye: morphological and ecological account of a wetland sedge**

Rajkumari Supriya Devi*

Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

*Email-Id: supriyark91@gmail.com

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Abstract: Wetlands are highly productive ecosystems in which sedges (Cyperaceae) play a key role in maintaining ecological structure and function. *Schoenoplectiella juncooides* (rock bulrush) is a widely distributed wetland sedge adapted to flooded and waterlogged conditions through its slender culms, reduced leaves, fibrous root system and prolific seed production. It commonly inhabits marshes, shallow water bodies, riverbanks and flooded agricultural fields, where it stabilizes soils, reduces erosion, regulates hydrology and contributes to primary productivity and nutrient cycling. As an early successional species, it facilitates wetland development and provides habitat and food resources for wetland fauna. Although often considered a weed in rice agroecosystems, *S. juncooides* has significant ecological value in natural wetlands. The study emphasizes the need for greater research attention to wetland sedges to better understand their ecological roles and support effective wetland conservation and management.

Keywords: Cyperaceae, hydrological regulation, soil stabilization, wetland conservation

Introduction

Wetlands are among the most productive and ecologically valuable ecosystems on Earth, providing a wide range of ecosystem services that support biodiversity, water regulation and human livelihoods (Moreno-Mateos et al., 2012). Within these systems, members of the family Cyperaceae (sedges) play a pivotal role in maintaining wetland structure, stability and ecological functioning (Wong, 2004; Barrett, 2013). Sedges commonly dominate marshes, swamps, floodplains, shallow lakes, rice fields and other seasonally or permanently inundated landscapes, where few plant groups can survive under prolonged waterlogged conditions (Prasad et al., 2019). Their well-developed, fibrous and rhizomatous root systems form dense underground networks that firmly anchor plants in saturated soils,

effectively stabilizing substrates, reducing shoreline and surface erosion and minimizing sediment loss during flooding events (Gautam and Gautam, 2021). In addition to their structural role, Cyperaceae strongly influence wetland hydrology by slowing water movement, enhancing water retention and regulating surface runoff. Their erect culms and dense stands reduce flow velocity, allowing suspended sediments to settle and preventing downstream siltation (Gaberščik and Zelnik, 2021). The substantial above-ground biomass produced by sedges contributes significantly to primary productivity and organic matter accumulation, forming the base of wetland food webs. Through litter deposition and decomposition, sedges enrich soils with organic carbon and nutrients, thereby supporting microbial activity and sustaining nutrient cycling processes (Hossain et al., 2025). *Schoenoplectiella juncoides*, commonly known as rock bulrush, is a characteristic wetland sedge widely distributed in tropical and subtropical regions, particularly in lowland wetland ecosystems. Morphologically, it is a grass-like herb with erect, slender, triangular culms arising from fibrous roots. Leaves are usually reduced, with bladeless sheaths at the base, giving the plant a rush-like appearance. The inflorescence consists of compact clusters of small spikelets borne near the culm apex and the fruit is a small, dry achene (Saxena and Brahmam, 1996). These structural features enable the species to tolerate prolonged flooding and anaerobic soil conditions. The species produces a large number of viable seeds, ensuring rapid colonization and persistence in disturbed or seasonally inundated habitats. Although perennial in natural wetlands, it may behave as an annual in cultivated fields such as rice paddies, completing its life cycle within a single growing season (Umkhulzum et al., 2018). The present study discusses the morphological, ecological distributional and other aspects of *S. juncoides*.

Morphology

Schoenoplectiella juncoides (Figure 1) is a slender, erect and tufted sedge, attaining up to 45 cm in height. Stems are terete to subterete or slightly angular, ribbed and smooth. Leaves reduced to membranous sheaths, obliquely truncate at the apex and often bearing a very small, rudimentary blade. Inflorescence pseudolateral, capitate, comprising 1-7 spikelets. Involucral bract erect, 1.4-15 cm long, shorter than the stem, with a groove on the inner surface. Spikelets sessile, many-flowered, oblong-ovoid, stramineous to brownish at maturity. Glumes tightly appressed, slightly keeled near the apex, 2.5-4 mm long, obtuse, shortly mucronulate, with a prominent midrib and faintly many-nerved sides; margins minutely ciliate near the apex. Bristles 5-6, unequal in length. Stamens 2-3; style 2-3-fid. Nut unequally biconvex, broadly obovoid, black and shortly apiculate (Saxena and Brahmam, 1996).

Ecology

It typically inhabits marshes, shallow ponds, riverbanks, ditches and flooded agricultural fields, where it thrives in permanently or seasonally waterlogged, puddled and nutrient-rich soils. The species exhibits a high degree of tolerance to fluctuating water levels and periodic inundation, enabling it to persist in dynamic wetland environments. It plays a vital role in binding and stabilizing saturated soils through its dense root and rhizome systems, effectively reducing erosion along wetland margins and channel banks (Umkhulzum and Ameen, 2019). As an early successional colonizer, the species facilitates wetland development by modifying microhabitat conditions such as improving substrate stability, retaining moisture and moderating temperature, thereby creating favourable niches for the establishment of other hydrophytic and semi-aquatic plant species. Its dense above-ground growth further helps maintain local moisture regimes and hydrological balance, supporting wetland structure, productivity and ecological functioning (Das et al., 2018). It plays an important supportive role in wetland conservation and grassland development. Although it is not considered a major economic species, it contributes indirectly to ecosystem services by improving soil structure, enhancing sediment retention and aiding in the regulation of water quality through nutrient uptake and filtration (Roy and Devi, 2025). It is grazed opportunistically by livestock at certain growth stages and in seasonally inundated grasslands. It can function as a supplementary fodder resource when preferred forage species are scarce. It also provides shelter, breeding sites and refuge for a wide range of wetland organisms, including aquatic insects, amphibians and small vertebrates. Its seeds and vegetative parts form part of the diet of waterfowl and other wetland-dependent fauna, thereby contributing to local food webs and supporting biodiversity (Mitra, 2021).

Distribution

It is widely distributed across tropical and subtropical regions of Asia and the Indo-Pacific, extending to parts of Africa and Central Asia. The species occurs in South, East and Southeast Asia, including the Himalaya, China, Japan, Korea, India, Pakistan, Sri Lanka, Southeast Asia and the Pacific Islands. In India, it is distributed in Odisha, Punjab, Assam, Tamil Nadu, Karnataka, Kerala, West Bengal, Manipur, Punjab and Himachal Pradesh (POWO, 2025; Saxena and Brahmam, 1996; Rawat and Adhikari, 2015).

Threats

Despite its ecological significance, *S. juncoides* is perceived differently across habitats. In natural wetlands, it represents a valuable structural and



Figure 1: *Schoenoplectiella juncooides* in its habitat

functional component of the ecosystem, contributing to stability, succession and biological diversity. In contrast, within rice agroecosystems, it is often regarded as a problematic weed due to its strong competitive ability, rapid growth under flooded conditions and prolific seed production, which can reduce crop yields (Umkhulzum et al., 2019).

Conclusion

Wetland sedges, including *S. juncooides*, are often overlooked despite their considerable ecological significance and functional importance within wetland ecosystems. These species contribute to soil stabilization, nutrient cycling, hydrological regulation and habitat provision for a wide range of aquatic and semi-aquatic organisms. However, their roles remain inadequately documented. Comprehensive research is therefore needed to better understand the ecology, functional traits and ecosystem services of such sedges across natural and managed wetlands. Focused studies on their role in wetland succession, resilience to hydrological fluctuations, interactions with other plant species and responses to anthropogenic pressures would help to improve ecological knowledge and inform wetland conservation, restoration and sustainable management strategies.

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Chapter 8

Phytochemical screening and flavonoid quantification of *Cymbopogon citratus* (inflorescence)

Subhalakshmi Rout¹, Sumitra Jethy¹, Sugimani Marndi¹ and Anjali Jaiswal^{2*}

¹Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

²Science Educationist, JCPRO Academy, Bangalore, Karnataka, India

*Email-id: 94anjali@gmail.com

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Abstract: *Cymbopogon citratus* (lemon grass) is an economically and medicinally important aromatic grass widely used in traditional medicine and nutraceutical formulations. Present study aimed to evaluate the qualitative and quantitative phytochemical composition of *C. citratus* inflorescence using different solvent extracts. Primary and secondary metabolites were screened through standard phytochemical assays, while total flavonoid content was quantified using the aluminium chloride colorimetric method with quercetin as the standard. The qualitative analysis revealed that non-polar extracts showed no detectable metabolites, whereas polar extracts exhibited a broad spectrum of bioactive compounds. Aqueous extracts showed the richest profile, containing proteins, carbohydrates, starch, tannins, flavonoids and reducing sugars, indicating that most metabolites in *C. citratus* are water-soluble. Quantitative estimation revealed a total flavonoid content of 31.31 mg/100 g, suggesting moderate antioxidant potential of the inflorescence. The current work highlights the phytochemical richness and potential therapeutic value of *C. citratus*, especially in its polar extracts.

Keywords: Antioxidant activity, *Cymbopogon citratus*, ethnopharmacology, flavonoid content, phytochemical screening

Introduction

Medicinal plants play a significant role in both traditional and modern healthcare schemes because of their diverse phytochemical constituents and associated therapeutic properties. Over a period of centuries, medicinal plants have made a promising over modern medicine nowadays. Within this group, the genus *Cymbopogon* (family Poaceae) comprises more than 140 aromatic grass species distributed across the tropical and subtropical regions of Asia, Africa and Australia (Tibenda et al., 2022). Species of this genus are well-known for their essential oils, rich secondary metabolites and extensive applications in culinary, cosmetic and

pharmaceutical industries (Das and Tiwari, 2025). *Cymbopogon citratus*, commonly known as lemon grass, is one of the most extensively cultivated species in the genus. It is highly valued for its characteristic lemon-like fragrance, primarily attributed to its citral-rich essential oil. Traditionally, the plant has been used as an herbal tea and as a natural remedy with antibacterial, antimicrobial, anti-inflammatory, digestive and antioxidant properties (Oladeji et al., 2019; Hussain et al., 2023). Although several studies have focused on its essential oil composition, comparatively fewer investigations have explored the phytochemical constituents present in its inflorescence extracts. Phytochemical screening is an essential preliminary procedure for identifying primary metabolites (such as carbohydrates, proteins, starch and lipids) and secondary metabolites (including tannins, flavonoids, phenolics, saponins and alkaloids), which collectively contribute to the nutritional and medicinal significance of plants (Maheshwaran et al., 2024). The efficiency of metabolite extraction is strongly influenced by the polarity of the solvent used, as it determines the solubility and extraction capacity for different classes of compounds. This study aims to assess the qualitative and quantitative phytochemical profile of *C. citratus* inflorescence using both non-polar and polar solvent extracts. Standard biochemical assays were performed to detect various metabolites and the total flavonoid content was quantified through the aluminium chloride colorimetric method. The findings provide a comprehensive understanding of the distribution of bioactive constituents in *C. citratus*, highlighting its potential as a valuable natural source of nutritionally and therapeutically important phytochemicals.

Methodology

Collection of plant sample

The inflorescence of *Cymbopogon citratus* was collected from the nearby Mahanadi River areas of Cuttack district of Odisha. The plant species was identified by the authors (Figure 1; Nayak and Kumar, 2023). Soxhlet extraction method was adopted using four solvents for phytochemical analysis (Kumar et al., 2013; Marndi et al., 2024). Detection of the secondary metabolites was conducted using standard methods (Figure 2; Devi et al., 2022; Jena et al., 2024; Marndi et al., 2024)

Qualitative phytochemical analysis

Primary metabolites

Test for protein: One ml of the filtrate of the inflorescence extract was mixed with 2-5 drops of Millon's reagent and kept in the water bath for 30 minutes. The pink coloration indicates the presence of protein.



Figure 1: Inflorescence of *C. citratus* in wild habitat

Test for carbohydrate: One ml of the filtrate of the inflorescence extract was mixed with 2-5 drops of Fehling's solution A and B and kept in the water bath for 30 minutes. A reducing sugar reacts with Fehling's reagent in an alkaline medium to form orange-to-red precipitate. The appearance of an orange or red precipitate indicates the presence of carbohydrates.

Test for starch: To 1 ml of the filtrate of the inflorescence extract, 2-3 drops of concentrated HCl were added and heated for 1-2 minutes. NaOH, following Benedict's reagent, was added to this solution and kept in the water bath. The change in coloration from bluish-green to red-orange indicates the presence of starch.

Test for sucrose: About 1 ml of the filtrate of the inflorescence extract was mixed with 2-3 drops of iodine. The appearance of a blue-black color indicates the presence of sucrose.

Test for lipid: About 1 ml of the filtrate of the inflorescence extract was mixed with 2-5 drops of Sudan-III. The appearance of pink droplets indicates the presence of lipids.

Test for amino acid: One ml of the filtrate of the inflorescence extract was mixed with 5 drops of Ninhydrin reagent and kept in the water bath for 30 minutes. Ninhydrin is a powerful oxidizing agent that gives a purple-colored product termed as Rhuemann's purple.



Figure 2: Plant sample for experimental work

Secondary metabolites

Test for tannin: About 1 ml of the inflorescence extract was taken. Three to five drops of 10 % lead acetate solution were added. The gelatinous precipitate formation confirms the presence of tannin.

Test for saponin: About 1 ml of the inflorescence extract was taken and 1 ml of distilled water was added and shaken well. The formation of persistent froth confirms the presence of saponin.

Test for flavonoids: About 1 ml of the inflorescence extract was taken. Two ml of 2 % NaOH solution and 3 to 4 drops of diluted HCl were added. The color initially turned to an intense yellow color with NaOH solution and later

became colorless. This color change in appearance confirms the presence of flavonoids.

Test for terpenoids: About 1 ml of the inflorescence extract was added with 5-6 drops of chloroform and placed in the water bath for a few minutes. Then 5-6 drops of concentrated sulphuric acid were added. The reddish-brown interface confirms the presence of terpenoids.

Test for phenolic groups: About 1 ml of the inflorescence extract was taken. A few drops of 5 % ferric chloride solution were added. The dark bluish-black appearance confirms the presence of phenolic compounds.

Test for reducing sugars: About 1 ml of the inflorescence extract was taken and 2 drops of Fehling's solution A followed by Fehling's solution B were added and kept in the water bath for some time. The presence of red-orange precipitate confirms the presence of reducing sugar.

Test for steroids: About 1 ml of the inflorescence extract was taken. 1 ml of chloroform and 1 ml of concentrated sulphuric acid were added to it. The appearance of upper red and lower yellow colors with green fluorescence provides the presence of steroids.

Test for alkaloids: About 1 ml of the inflorescence extract was taken and 3 to 4 drops of Dragendorff's reagent were added. The formation of a reddish-brown precipitate confirmed the presence of alkaloids.

Quantitative estimation of secondary metabolites

Estimation of flavonoids: A sample of 100 µl of the extract was mixed with 100 µl of 5 % sodium nitrite and allowed to stand for 5 minutes. Next, 100 µl of aluminium trichloride was added and incubated for 6 minutes, followed by the addition of 1 ml of 1 M sodium hydroxide. The total volume of the mixture was made up to 5 ml with distilled water and incubated for 15 minutes at room temperature in the dark for taking absorbance at 510 nm. The amount of flavonoid present in the sample was calculated from the standard graph. The standard graph was prepared for quercetin ([Chang et al., 2002](#); [Raina and Misra, 2023](#)).

Results and discussion

The qualitative screening of primary metabolites in different solvent extracts of *Cymbopogon citratus* revealed notable variations depending on solvent polarity ([Table 1](#); [Figure 3](#)). Non-polar (n-hexane) extract did not show the presence of any of the tested primary metabolites, indicating that major nutritional compounds of the plant are polar and require medium to high polarity solvents for extraction. Polar solvents such as ethanol, methanol and

aqueous extracts tested positive for carbohydrates, while the aqueous extract also showed the presence of proteins and starch. The detection of these essential metabolites suggested that *C. citratus* inflorescence possesses important nutritional components. The aqueous extract showed the broadest profile of primary metabolites, which may be attributed to the ability of water to dissolve a wide range of hydrophilic nutrients.

Table 1: Qualitative phytochemical analysis for detection of primary metabolites in *C. citratus* (inflorescence)

Polarity	Extract	Detected primary metabolites
Non-Polar  Polar	n-Hexane	No tested metabolites were detected
	Ethanol	Carbohydrates only
	Methanol	
	Aqueous	Protein, carbohydrates and starch

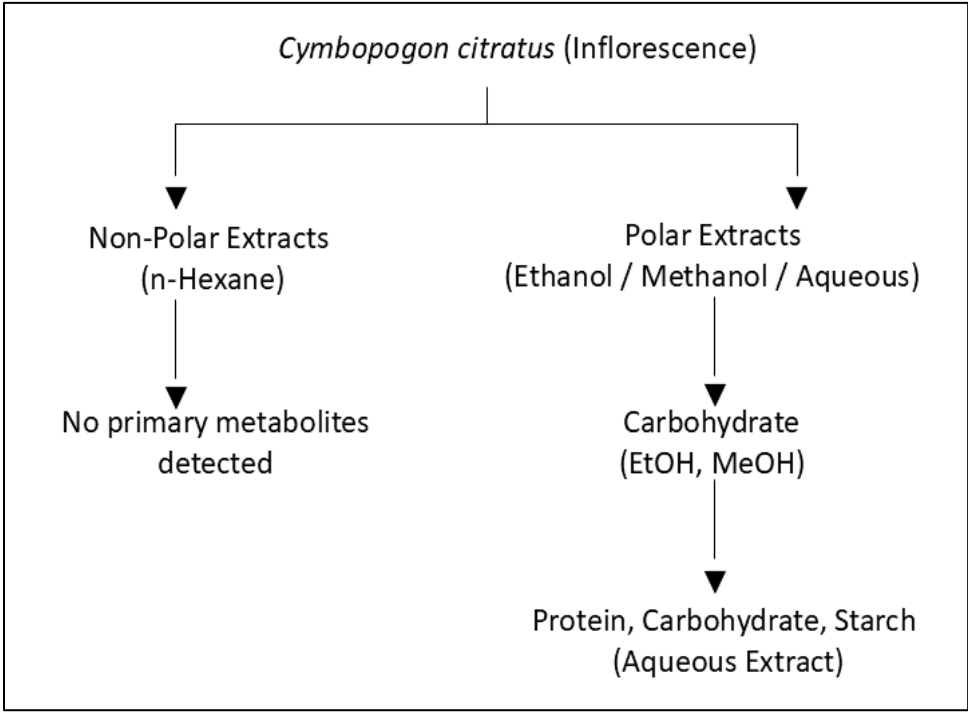


Figure 3: Extraction of primary metabolites from *C. citratus*

The non-polar n-hexane extract again showed no detectable secondary metabolites, confirming that key phytoconstituents in *C. citratus* are polar (Table 2; Figure 4). Among polar extracts, ethanol demonstrated the presence of tannins and reducing sugars. Methanol extracts showed a broader spectrum including tannins, phenols and reducing sugars. Aqueous extracts revealed tannins, flavonoids and reducing sugars. Flavonoids were not detected in alcohol extracts but were prominent in the aqueous fraction, suggesting that flavonoid compounds in *C. citratus* are predominantly water-soluble.

Table 2: Qualitative phytochemical analysis for detection of secondary metabolites in *C. citratus* (inflorescence)

Polarity	Extract	Detected secondary metabolites
Non-Polar  Polar	n-Hexane	No tested metabolites were detected
	Ethanol	Tannin and reducing sugars
	Methanol	Tannin, phenolic compounds and reducing sugars
	Aqueous	Tannin, flavonoid and reducing sugars

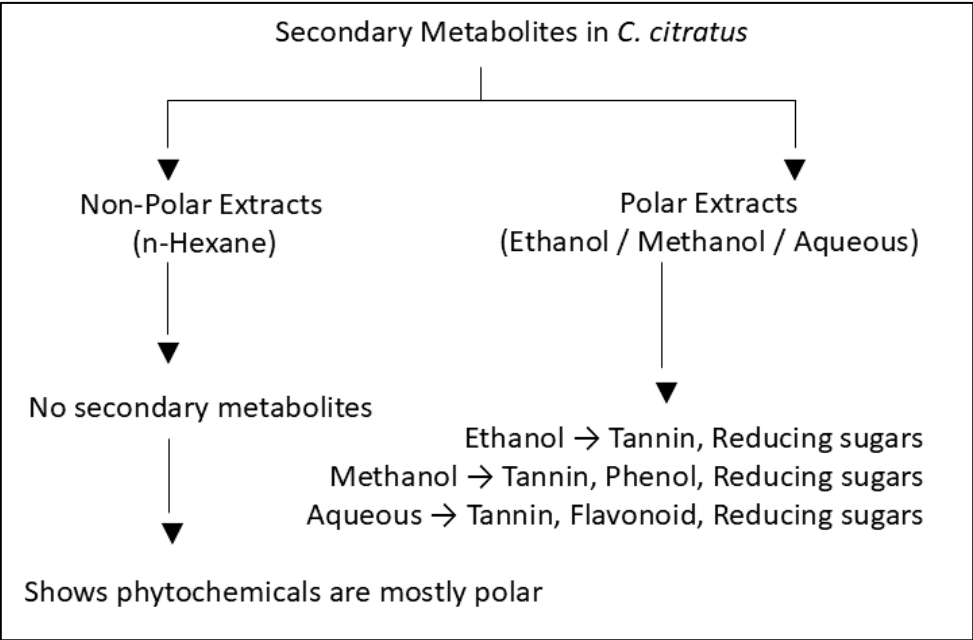


Figure 4: Distribution of secondary metabolites in *C. citratus*

Quantitative analysis revealed that the *Cymbopogon citratus* inflorescence contains 31.31 mg/100 g of flavonoids (Table 3; Figure 5). This indicates a moderate level of flavonoid bioactivity compared to typical medicinal plant standards. Flavonoids are known for antioxidant, anti-inflammatory and antimicrobial properties, suggesting that the inflorescence may serve as a potent source for nutraceutical and therapeutic applications.

Table 3: Quantification of total flavonoid content

<i>Cymbopogon citratus</i> (Inflorescence)	Bioactive compound	Content (mg/100g)
	Flavonoid	31.31

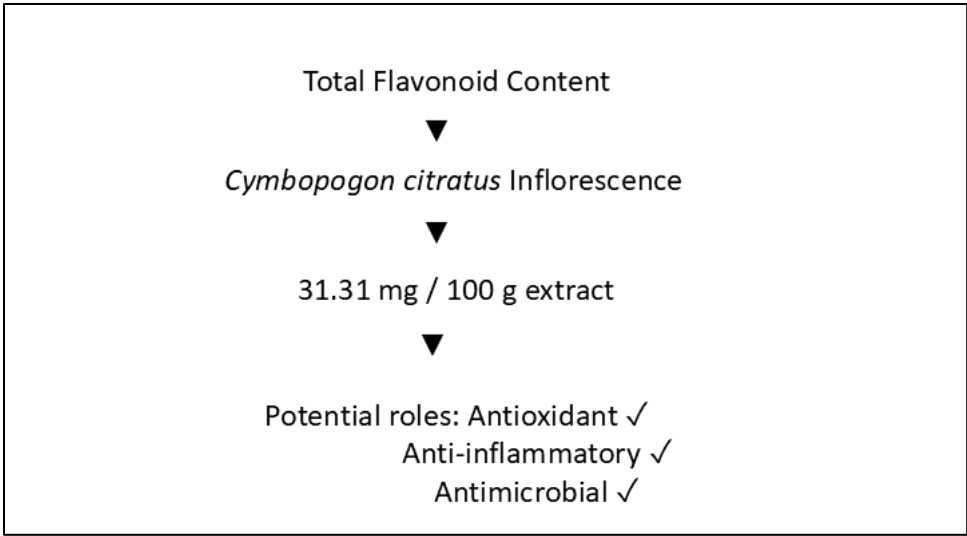


Figure 5: Illustration of flavonoid quantification in *C. citratus*

Conclusion

The current study showed that *Cymbopogon citratus* inflorescence contain several important primary and secondary metabolites, especially in polar solvent extracts. Aqueous extracts exhibited the highest phytochemical richness. The total flavonoid content (31.31 mg/100 g) indicates notable antioxidant potential. Therefore, *C. citratus* is a valuable natural source of bioactive compounds with nutritional and therapeutic significance.

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Chapter 9

Grass diversity of Deomali hills, Koraput, Odisha, India

Sanjeet Kumar¹*, K. V. Bhaskar Rao² and Arun Kumar Mishra³

¹Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

²Office of the Divisional Forest Officer cum Wildlife Warden, Koraput Forest Division, Koraput, Odisha, India

³HN-3002, DN Oxy Park, Dumuduma, Bhubaneswar- 751019, Odisha, India

*Email-Id: sanjeetaprf@gmail.com

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Abstract: The Deomali hills of Koraput district, Odisha, represent one of the biologically rich regions of the Eastern Ghats, supporting a wide diversity of grass species that play a crucial role in ecological functioning and local livelihoods. The present study documented the diversity and phenological patterns of grasses occurring in the Deomali hills. A total of 49 grass species belonging to 36 genera of the family Poaceae were recorded. The documented grasses include ecologically significant wild species as well as economically important millets, fodder and medicinal grasses. The presence of perennial grasses such as *Cynodon dactylon*, *Alloteropsis cimicina* and *Sporobolus diandrus* indicates stable grassland ecosystems, whereas the occurrence of seasonal species reflects climatic influences on vegetation dynamics. The present study highlights the ecological importance of grass diversity in the Deomali hills and emphasizes the need for conservation and sustainable management of these grassland resources.

Keywords: Deomali hills, Eastern Ghats, grass diversity, Odisha, phenology, Poaceae

Introduction

Grasses, belonging to the family Poaceae, constitute one of the most widespread and ecologically important groups of flowering plants on Earth. With more than 12,000 species distributed across diverse habitats, grasses dominate terrestrial ecosystems such as grasslands, savannas, wetlands, agricultural fields and forest understoreys (Hooker, 1897; Mande et al., 2025). They play a crucial role in maintaining ecosystem stability by contributing to soil conservation, nutrient cycling, carbon sequestration and providing food and shelter for a wide range of organisms. In addition to their ecological significance, grasses are of immense economic importance, as they include major cereal crops, millets, fodder species, medicinal plants and aromatic grasses (Priyadarshini et al., 2021). The Eastern Ghats of India represent a

unique biogeographical region characterized by complex topography, varied climatic conditions and rich plant diversity (Shukla and Ramakrishnan, 1982). Within this region, the Deomali hills, located in the Koraput district of Odisha, form the highest peak of Odisha and are recognized for their ecological and floristic significance. The hills involve a tropical monsoon climate with distinct wet and dry seasons, creating favourable conditions for the growth and diversification of grass species (Pujari, 2025). The variation in altitude, coupled with diverse soil types and moisture regimes, supports a wide range of grassland and forest-edge habitats. Grasslands of the Deomali hills serve as an important component of the local ecosystem, supporting grazing resources for livestock, preventing soil erosion on steep slopes and sustaining traditional agricultural practices. Many indigenous and local communities depend on grasses for fodder, food grains, medicinal uses, thatching, broom making and other livelihood needs. Despite their importance, grasses are often under-represented in floristic studies compared to trees and shrubs, leading to gaps in knowledge regarding their diversity, distribution and phenology. The present study aims to document the diversity and phenological patterns of grasses occurring in the Deomali hills, Koraput district, Odisha. Through documentation of grass species along with their common names and phenological characteristics, the present study seeks to enhance understanding of the grass flora in the Deomali hills and generate baseline data for future ecological monitoring, conservation planning and sustainable utilization of grassland resources.

Methodology

The present study was conducted in the Deomali Hills, located in the Koraput district of Odisha, India. Deomali represents the highest peak of Odisha and is characterized by undulating terrain, rocky slopes, open grasslands, forest margins and cultivated landscapes (Figure 1). Extensive field surveys were carried out across diverse habitats of the Deomali hills, including open grasslands, hill slopes, wetlands, roadside areas and agricultural fields in the year 2025 (Behera et al., 2025).

Results and discussion

The present study revealed a total of 49 grass species of 36 genera from the Deomali hills, Koraput district, Odisha. The documented species exhibited considerable diversity in terms of growth habit, ecological adaptation and phenological behaviour, reflecting the heterogeneous environmental conditions of the region. The study revealed that the grass species diversity of Deomali hills is represented by a wide range of genera such as *Digitaria*, *Setaria*, *Eragrostis*, *Panicum*, *Sorghum*, *Cymbopogon*, *Bothriochloa* and *Bambusa* (Table 1). Among these, genera like *Digitaria*, *Setaria* and *Eragrostis*



Figure 1: Field survey carried out in Deomali hills, Koraput, Odisha

showed higher species richness, indicating their adaptability to varying moisture and soil conditions prevalent in the region (Bor, 1960; Clayton and Renvoize, 1986). Higher representation of genera like *Digitaria*, *Setaria* and *Eragrostis* suggested their wide ecological amplitude and adaptability to the varied edaphic and climatic conditions of the Eastern Ghats (Hooker, 1897; Karthikeyan et al., 1989). The occurrence of wild grasses (*Heteropogon contortus*, *Themeda quadrivalvis*, *Saccharum spontaneum*) and cultivated or semi-cultivated millets (*Eleusine coracana*, *Panicum sumatrense*, *Paspalum scrobiculatum*) highlighted the agro-ecological importance of

the study areas. As per phenological patterns, it revealed that the majority of grass species blooms during the monsoon to post-monsoon period (August-January). This seasonal trend corresponds with higher rainfall and favourable climatic conditions, which promote vegetative growth and reproductive success. Species such as *Apluda mutica*, *Aristida setacea*, *Bothriochloa bladhii* and *Setaria* species showed restricted seasonal phenology, whereas grasses like *Cynodon dactylon*, *Digitaria ciliaris*, *Echinochloa colona* and *Sporobolus diandrus* were present throughout the year, indicating their perennial nature and resilience to environmental fluctuations. As per ecological and economic values documented by many researchers, several recorded species play a significant role in soil stabilization, fodder supply and traditional agriculture. Perennial grasses such as *Saccharum spontaneum* and *Heteropogon contortus* contribute to erosion control on hill slopes, while fodder grasses like *Cenchrus pedicellatus* and *Bothriochloa pertusa* support livestock-based livelihoods. The presence of economically important species such as *Cymbopogon citratus* (medicinal and aromatic grass) and millets (*Eleusine coracana* and *Sorghum bicolor*) highlights the ethnobotanical and agricultural value of the region's grass diversity (Kirtikar and Basu, 1935; Jain, 1991). The rich grass diversity of Deomali hills reflects a healthy grassland ecology (Whyte et al., 1959; Nayar and Sastry, 1987); however, increasing anthropogenic pressure, grazing and land-use changes may threaten these natural resources. Documentation of grass species and their phenology provides baseline data essential for future ecological monitoring and conservation planning.

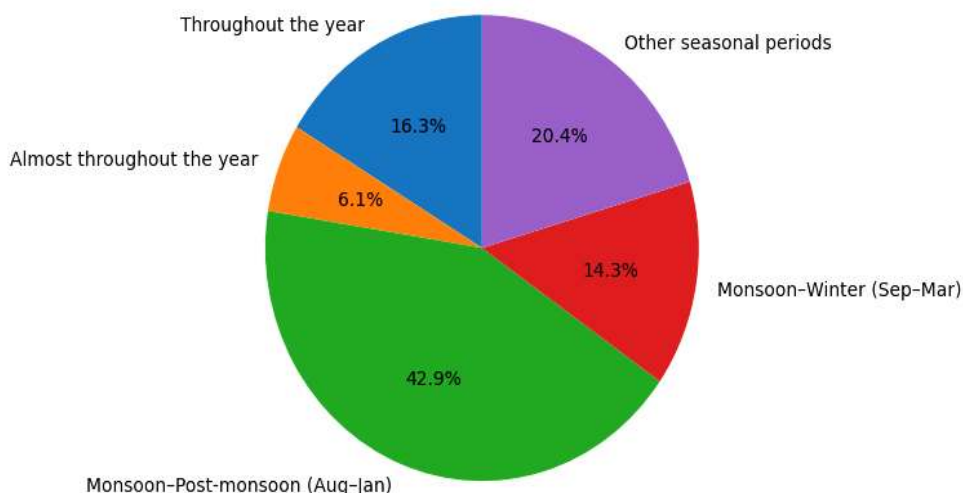


Figure 2: Phenological distribution of grass species recorded from the Deomali hills, Koraput district, Odisha

A majority of species (~43%) exhibit flowering and fruiting during the monsoon to post-monsoon period (August-January), followed by species occurring in other seasonal phases. Perennial grasses present throughout the year indicate ecological stability of the grassland ecosystem (Figure 2).

Table 1: Grasses of Deomali hills, Koraput, Odisha

Botanical name	Common name	Phenology
<i>Alloteropsis cimicina</i> (L.) Stapf (Figure 3)	Summer grass	Throughout the year
<i>Apluda mutica</i> L. (Figure 4)	Mauritian grass	Aug-Feb
<i>Aristida setacea</i> Retz (Figure 5)	Wire grass	Aug-Jan
<i>Arthraxon lancifolius</i> (Trin.) Hochst. (Figure 6)	Lanceolate-leaved Arthraxon	Aug-Dec
<i>Arundinella pumila</i> (Hochst. ex A.Rich.) Steud. (Figure 7)	Dwarf arundinella	Aug-Dec
<i>Arundo donax</i> L. (Figure 8)	Giant reed	Nov-Dec
<i>Bambusa bambos</i> (L.) Voss	Indian thorny bamboo	Jan-Mar
<i>Bambusa tulda</i> Roxb.	East India brown cane	July -Aug
<i>Bothriochloa bladhii</i> (Retz.) S. T. Blake (Figure 10)	Australian bluestem	Aug-Jan
<i>Bothriochloa pertusa</i> (L.) A. Camus (Figure 9)	Hurricane grass	Aug-Jan
<i>Capillipedium parviflorum</i> (R.Br.) Stapf (Figure 11)	Small-flowered Capillipedium	Aug-Dec
<i>Cenchrus pedicellatus</i> (Trin.) Morrone	Deenanath grass	Aug-Dec
<i>Chrysopogon aciculatus</i> (Retz.) Trin. (Figure 12)	Lesser spear grass	Apr-Nov
<i>Cymbopogon citratus</i> (DC.) Stapf (Figure 13)	Lemon grass	Sep-Jan
<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	Throughout the year
<i>Cyrtococcum oxyphyllum</i> (Hochst. ex Steud.) Stapf (Figure 14)	Oxyphyllous cyrtococcum	Aug-Dec
<i>Diectomis fastigiata</i> (Sw.) P.Beauv. (Figure 15)	Annual tufted grass	Sep-Dec
<i>Digitaria bicornis</i> (Lam.) Roem. & Schult. (Figure 16)	Asian crab grass	Aug-Dec

<i>Digitaria ciliaris</i> (Retz.) Koeler (Figure 17)	Southern crabgrass	Throughout the year
<i>Digitaria longiflora</i> (Retz.) Pers. (Figure 18)	Long-flowered finger grass	July-Nov
<i>Dimeria ornithopoda</i> Trin. (Figure 19)	Feather grass	Sep-Jan
<i>Echinochloa colona</i> (L.) Link (Figure 20)	Jungle rice	Throughout the year
<i>Eleusine coracana</i> (L.) Gaertn. (Figure 21)	Finger millet	Sep-Mar
<i>Eleusine indica</i> (L.) Gaertn. (Figure 22)	Indian goosegrass	Throughout the year
<i>Eragrostis ciliaris</i> (L.) R.Br. (Figure 23)	Gophertail lovegrass	Almost throughout the year
<i>Eragrostis pilosa</i> (L.) P.Beauv.	Indian lovegrass	Almost throughout the year
<i>Eragrostis unioides</i> (Retz.) Nees ex Steud. (Figure 24)	Love grass	Almost throughout the year
<i>Heteropogon contortus</i> (L.) P.Beauv. ex Roem. & Schult. (Figure 25)	Black spear grass	Jul-Nov
<i>Isachne globosa</i> (Thunb.) Kuntze (Figure 26)	Swamp millet	Sep-Nov
<i>Ischaemum rugosum</i> Salisb. (Figure 29)	Saramollagrass	Oct-Jan
<i>Iseilema anthephoroides</i> Hack. (Figure 27)	Anthephoroides grass	July-Dec
<i>Melinis repens</i> (Willd.) Zizka (Figure 30)	Fairy grass	Sep-Dec
<i>Oplismenus compositus</i> (L.) P. Beauv.	Basket grass	Sep-Dec
<i>Panicum repens</i> L.	Torpedo grass	Sep-Jan
<i>Panicum sumatrense</i> Roth	Little millet	Aug-Jan
<i>Paspalum scrobiculatum</i> L. (Figure 31)	Kodo millet	Throughout the year
<i>Pogonatherum crinitum</i> (Thunb.) Kunth (Figure 32)	Bamboo grass	May-Mar
<i>Polytrias indica</i> (Houtt.) Veldkamp (Figure 28)	Yellow bluestem	Oct-Feb
<i>Saccharum spontaneum</i> L. (Figure 33)	Wild sugarcane	Sep-Mar
<i>Sacciolepis indica</i> (L.) Chase (Figure 34)	Indian cudweed	Aug-Jan
<i>Setaria flavida</i> (Retz.) Veldkamp (Figure 35)	Yellow foxtail	Aug-Feb
<i>Setaria intermedia</i> Roem. & Schult. (Figure 36)	Intermediate foxtail	Aug-Jan

<i>Setaria italica</i> (L.) P. Beauv. (Figure 37)	Indian millet	Sep-Mar
<i>Setaria pumila</i> (Poir.) Roem. & Schult. (Figure 38)	Yellow foxtail	Jun-Jan
<i>Setaria viridis</i> (L.) P.Beauv.	Green foxtail	July-Sep
<i>Sorghum bicolor</i> (L.) Moench (Figure 39)	Indian millet	Aug-Dec
<i>Sorghum halepense</i> (L.) Pers. (Figure 40)	Johnglass	Oct-Jan
<i>Themeda quadrivalvis</i> (L.) Kuntze (Figure 41)	Grader grass	Aug-Dec
<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda (Figure 42)	Asian broom grass	Apr-Dec



Figure 3: Habit and habitat of *Alloteropsis cimicina*



Figure 4: Inflorescence of *Apluda mutica*



Figure 5: Inflorescence of *Aristida setacea*



Figure 6: Morphology of *Arthraxon lancifolius*



Figure 7: Inflorescence of *Arundinella pumila*



Figure 8: Habit and habitat of *Arundo donax*



Figure 9: Inflorescence of *Bothriochloa pertusa*



Figure 10: Inflorescence of *Bothriochloa bladhii*



Figure 11: Morphology of *Capillipedium parviflorum*



Figure 12: Inflorescence of *Chrysopogon aciculatus*



Figure 13: Habit and habitat of *Cymbopogon citratus*



Figure 14: Inflorescence of *Cyrtococcum oxyphyllum*

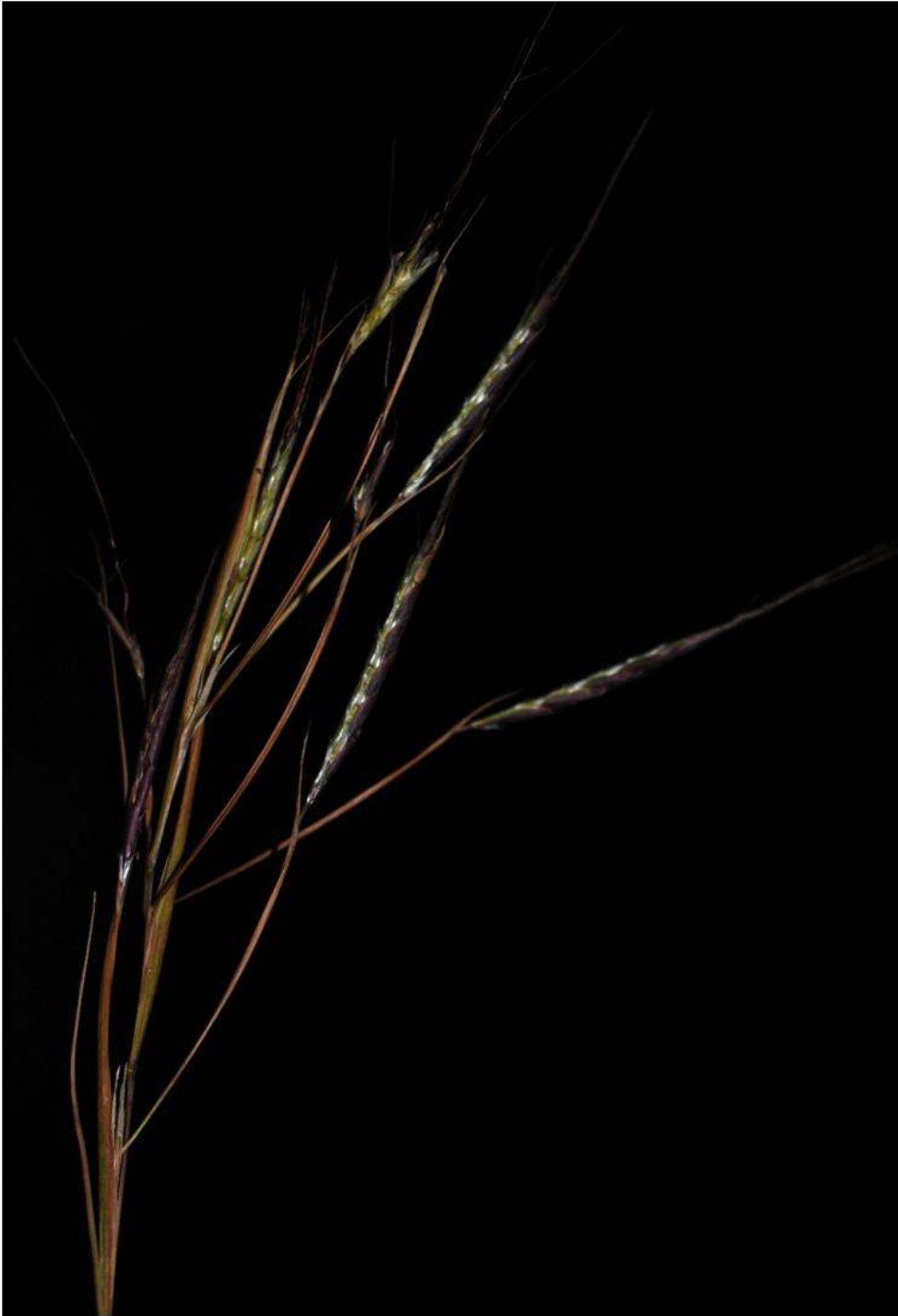


Figure 15: Inflorescence of *Diectomis fastigiata*



Figure 16: Habit and habitat of *Digitaria bicornis*



Figure 17: Inflorescence of *Digitaria ciliaris*



Figure 18: Inflorescence of *Digitaria longiflora*



Figure 19: Habit and habitat of *Dimeria ornithopoda*



Figure 20: Inflorescence of *Eleusine indica*



Figure 21: Inflorescence of *Echinochloa colona*



Figure 22: Fruit of *Eleusine coracana*



Figure 23: Inflorescence of *Eragrostis ciliaris*



Figure 24: Habit and habitat of *Eragrostis unioides*



Figure 25: Habit of *Heteropogon contortus*



Figure 26: Morphology of *Isachne globosa*



Figure 27: Habit of *Iseilema anthephoroides*



Figure 28: Inflorescence of *Polytrias indica*



Figure 29: Inflorescence of *Ischaemum rugosum*



Figure 30: Inflorescence of *Melinis repens*



Figure 31: Habit of *Paspalum scrobiculatum*



Figure 32: Habit and habitat of *Pogonatherum crinitum*



Figure 33: Inflorescence of *Saccharum spontaneum*



Figure 34: Inflorescence of *Sacciolepis indica*

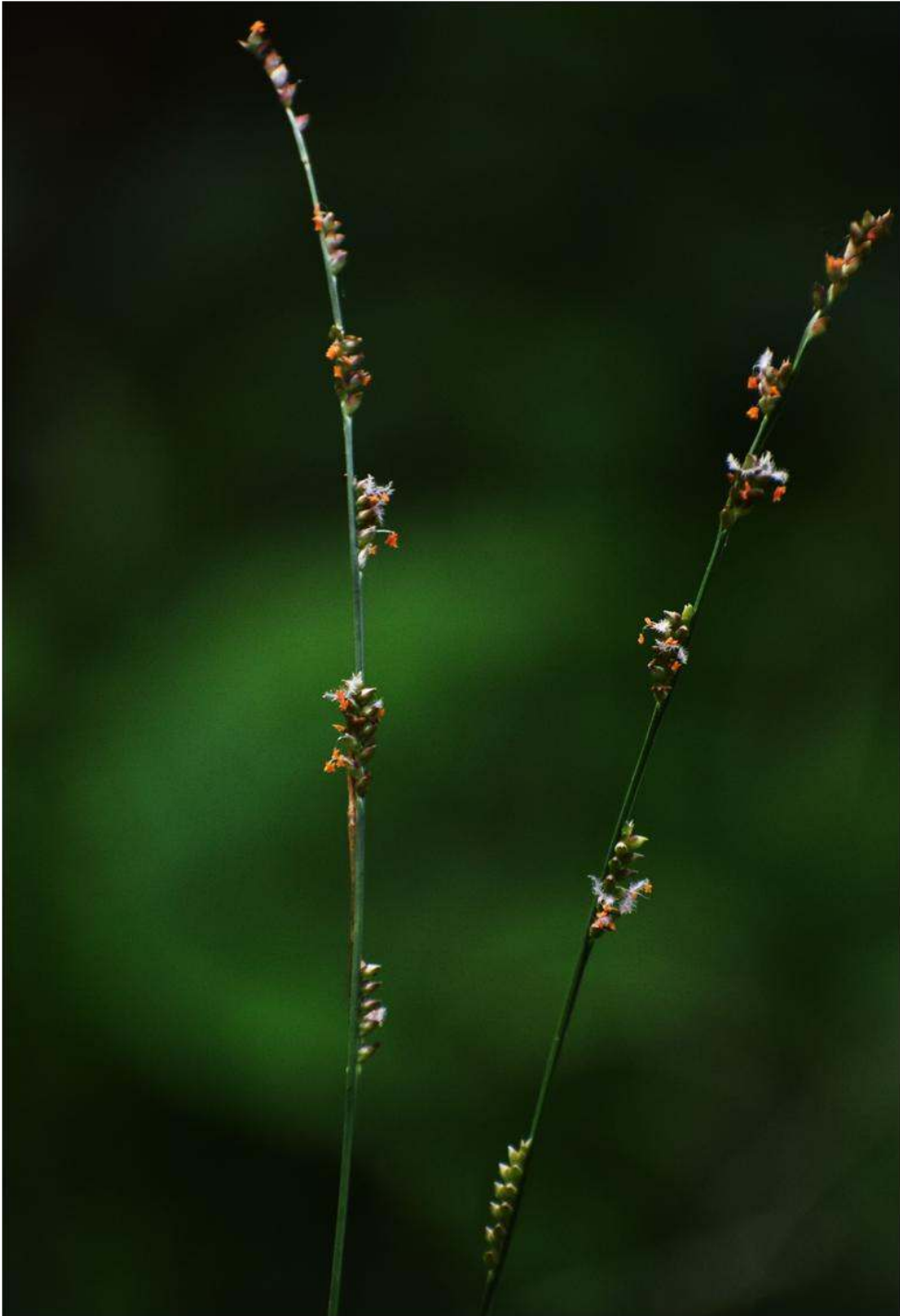


Figure 35: Inflorescence of *Setaria flavida*



Figure 36: Morphology of *Setaria intermedia*



Figure 37: Morphology of *Setaria italica*



Figure 38: Inflorescence of *Setaria pumila*



Figure 39: Grains of *Sorghum bicolor*



Figure 40: Inflorescence of *Sorghum halepense*



Figure 41: Habit of *Themeda quadrivalvis*



Figure 42: Habit and habitat of *Thysolaena latifolia*

Conclusion

The present study provides a comprehensive account of the grass diversity of Deomali hills, Koraput district, Odisha, documenting 49 species of 36 genera belonging to the family Poaceae along with photos of common species. The high species richness and representation of diverse genera such as *Digitaria*, *Setaria*, *Eragrostis*, *Panicum*, *Cymbopogon* and *Bothriochloa* reflect the heterogeneous edaphic and climatic conditions of the region and feature the ecological significance of the Eastern Ghats grasslands. The dominance of adaptable genera like *Digitaria*, *Setaria* and *Eragrostis* indicates their wide ecological amplitude and resilience to environmental variability. Phenological observations reveal that most species flower and fruit during the monsoon to post-monsoon period (August-January), coinciding with favourable moisture and temperature conditions. Moreover, the coexistence of wild grasses and cultivated or semi-cultivated millets highlights the close linkage between natural grasslands and traditional agricultural practices in the region. Before study of ecological, economical and ethnomedicinal uses, it is very crucial to document the present status of the diversity of grass species in a specific region. Therefore, an attempt has been made to document the grass diversity in Deomali hills. The rich grass diversity of Deomali hills signifies a healthy grassland ecosystem; however, increasing anthropogenic pressures and land-use changes pose potential threats. The baseline data generated through this study will be valuable for future ecological monitoring, sustainable management and conservation planning of grassland resources in the Deomali hills.

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Chapter 10

Mythologically important grasses of the Indian subcontinent

Sumitra Jethy, Sugimani Marndi and Sanjeet Kumar*

Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

*Email-Id: sanjeetaprf@gmail.com

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Abstract: Across centuries, grasses have emerged as enduring symbols of socio-cultural, religious and ecological resilience. Often overlooked in ecological narratives, they nonetheless provide essential ecosystem services, including carbon sequestration, soil stabilization and water regulation. Closely associated with human civilization over long temporal scales, grasses have transitioned from peculiar ground-layer vegetation to important sources of traditional medicine and integral elements of ritual practice. In India, species such as *Desmostachya bipinnata* (Kūśa) are revered as sacrificial grasses, while *Saccharum spontaneum* (Kāśa) and *Arundo donax* (Nāīa) are prominently used in funerary rites. *Cynodon dactylon* (Dhūrvā) holds a significant place in traditional medicine and *Oryza sativa* remains central to livelihood sustenance and ritual offerings across cultures. The present study highlights grass not only as an ecologically significant taxon but also as a living repository of mythological, medicinal and cultural meaning.

Keywords: Indian mythology, Kusa, *Oryza sativa*, Poaceae

Introduction

Grasses have been an integral part of culture and religion since the day of civilization (Doust, 2007). They have existed, grew and evolved alongside human beings. Humans have utilized them for medicine, thatching, as fodder and food, in sacred rituals and even for entertainment, thus establishing a strong association with grasses (Sharma et al., 2025). Today, India homes a diverse range of grasses estimated to be more than 1500 species, which is about 10 % of the global grass species richness (Mande et al., 2025). In Vedic culture, grasses have an important place as symbols of abundance, continuity, wealth, grains and even death (Table 1). They were used in culinary practices as food grains, plates and sitting mats (Boddupalli, 2024). In religious practices, they were seen as sacred and used as offerings, amulets or charms, sacrificial elements and for worshipping (Sheshadri, 2013). They've also been recorded and reviewed to be used in cloth making,

crystal making, for thatching roofs, weaving baskets and even for preparing acid to be used in electric instruments (Sheshadri, 2013). When it comes to traditional medicine, grasses can be seen from a pharmacological point of view (Roy and Devi, 2025), serving as key ingredients for the preparation of herbal remedies with healing properties.

Table 1: Some Vedic grasses of India (Sheshadri, 2013; Boddupalli, 2024)

Vedic Name	Botanical Identification
Balvaja	<i>Eleusine indica</i>
Darbha	<i>Imperata cylindrica</i> (general)
Durva (Dūrvā)	<i>Cynodon dactylon</i>
Gavedhuka	<i>Coix barbata</i> / <i>Coix lacryma-jobi</i>
Kasha (Kāśa)/ Ashvavala	<i>Saccharum spontaneum</i>
Kusha / Kushara/ Khara darbha	<i>Desmostachya bipinnata</i>
Mridudarbha	<i>Eragrostis ciliaris</i>
Muñja, Munjanaka, Munjata	<i>Saccharum benghalense</i>
Naḷa	<i>Arundo donax</i>
Sara	<i>Saccharum sara</i>
Shashpa	Young sprouting grass (non-specific)
Shumbala	Straw (generic grass residue)
Sugandhitejana	Fragrant grass (unidentified)
Veerana	<i>Andropogon muricatus</i> syn. <i>Chrysopogon zizanioides</i>
Vēṇu	<i>Bambusa arundinacea</i>
Vṛīhi; Shāli	<i>Oryza sativa</i>

Their widespread distribution across diverse habitats, from arid plains and sandy deserts to riverbanks and cultivated hedges, shows both ecological adaptability and human sustainability across centuries. In that context, five grass species (*Desmostachya bipinnata*, *Cynodon dactylon*, *Saccharum spontaneum*, *Oryza sativa* and *Arundo donax*) with mythological importance have been reviewed in the study through a literature survey to illustrate how grasses are not merely structural components of landscapes but active participants in spiritual, traditional medicine and ecological strata of life.

Methodology

A systematic literature survey was conducted to compile information on the grasses with mythological importance. Relevant literature was collected from scientific databases such as Google Scholar, PubMed, Science Direct,

Scopus and Springer Link using keywords including "Vedic grasses", "medicinal uses", "*Arundo donax*", "*Cynodon dactylon*", "Kusha grass", "*Saccharum spontaneum*", "Vrihi" and "religious significance". Data were extracted, categorized and critically analyzed under thematic headings such as botany, medicinal and pharmacological values and ritualistic significance. The collected information was synthesized in a narrative format to provide a comprehensive overview of grasses having mythological significance (Kumar, 2025).

Results and discussion

Among the diverse population of grasses with mythological and folkloric significance, five resilient species were selected for review, symbolizing prosperity and spiritual growth. The present study explores the cultural and spiritual importance of *Arundo donax*, *Cynodon dactylon*, *Desmostachya bipinnata*, *Oryza sativa* and *Saccharum spontaneum*, exploring their symbolic meanings, ritualistic uses in Vedic traditions, geographical distribution and medicinal properties (Table 2).

Arundo donax

Otherwise known as the giant reed, presents a more specialized ritual narrative, restricted primarily to funerary rites such as Pitṛmēdha (Boddupalli, 2024). Native to the Mediterranean but naturalized in parts of India, this species is invoked symbolically as a vessel for crossing from the mortal world to that of the ancestors. Medicinally, its rhizome is said to contain alkaloids with uterine stimulant, hypotensive and neuroactive properties. The grass thus occupies a paradoxical position, a conduit for spiritual passage and a source of powerful physiological action.

Cynodon dactylon

Locally and traditionally known as Dhūrvā grass is a species that blankets much of India up to high altitudes and persists resiliently in both rural and urban environments. In Vedic rituals such as Mahāgnicayana, Dhūrvā is placed between altar bricks, symbolizing regeneration and continuity, which shows in its botanical form, where each of its joints gives rise to new shoots and roots. This regenerative symbolism aligns closely with its medicinal reputation as a powerful stytic, diuretic and wound-healing agent (Boddupalli, 2024). Rich in phenolic compounds and flavonoids, *C. dactylon* bridges ritual metaphor and biochemical efficacy (Tripathi et al., 2025).



Figure 1: Leaves and inflorescence of *Arundo donax*



Figure 2: Flowers of *Cynodon dactylon*



Figure 3: Inflorescence of *Desmostachya bipinnata*

Desmostachya bipinnata

It is commonly known as Kusha or sacrificial grass, thrives in dry, hot regions and desert margins, yet holds one of the most respectable positions in Vedic ritual practices (Sheshadri, 2013). It is integral to the physical construction of sacred spaces, as seating mats, altar-cleaning bundles and has ritualistic implementations in yajñas (Boddupalli, 2024). Meticulous care is given during its harvesting and use, which is accompanied by mantra chanting at every stage, showing how Indian rituals treat ecological elements as sacred. Medicinally, Kusha roots are valued for their cooling, diuretic and astringent properties, addressing disorders of the urinary and reproductive systems, thereby reinforcing the continuity between ritual purity and bodily healing.

Table 2: Ecological distribution, ritual significance and medicinal uses of selected grasses (Boddupalli, 2024; POWO, 2025)

Species	Other names	Distribution/habitat	Ritualistic significance	Medicinal properties
<i>Arundo donax</i> L. (Figure 1)	Giant reed; Nala	Native to west and central Asia to Temperate East Asia; thrives in subtropical biomes	Symbolically used as a vessel to cross into the world of ancestors.	Rhizome: diuretic, emollient, uterine stimulant, hypotensive; contains alkaloids (bufotenidine) with neuroactive and smooth-muscle effects.
<i>Cynodon dactylon</i> (L.) Pers. (Figure 2)	Bermuda grass; Dhūrvā	Native to the temperate and subtropical Old World to Australia; grows in subtropical biomes	Used in Mahāgnicayana as Dūrveṣṭakā, placed between altar bricks symbolizing regeneration and continuity.	Astringent, diuretic, styptic, antiseptic; used for wounds, bleeding piles, cystitis, nephritis, skin diseases; roots recommended for menorrhagia and burning micturition; rich in phenolics and flavonoids.
<i>Desmostachya bipinnata</i> (L.) Stapf	Sacrificial grass; Darbha; Kuśa	Native to the Sahara to Tanzania	Used in yajñas, altar cleaning	Roots: cooling, diuretic, galactagogue,

(Figure 3)		and Indo-China; grows in seasonally dry tropical biomes.	(kūrcā), seating mats for priests and deities, integral to Mahāgnicayana rituals with strict procedural sanctity.	astrigent; used for urinary calculi, bladder disorders, dysuria, vaginal discharge, erysipelas; Culms used in menorrhagia, dysentery, diarrhoea.
<i>Oryza sativa</i> L. (Figure 4)	Rice; Vṛīhi; Shāli	Native to Asia; Habitat: temperate biome; Cultivated as a food crop	Central to Vedic rituals as Caru, Purōḍāśa and Anna; offerings made to Agni, Indra, Savitr, Āditya in major yajñas (Rājasūya, Pavamānēṣṭi, Kāmyēṣṭi).	Rice water demulcent, refrigerant, diuretic; used in febrile, inflammatory, gynaecological disorders; straw ash for wounds; coloured rice rich in anthocyanins.
<i>Saccharum spontaneum</i> L. (Figure 5)	Kans grass; Kāśa	Native to Sicilia, Africa, Asia, to North and North-east Australia; Habitat: dry tropical biome	Used in funerary rites (Pitṛmēdha); offered to the deceased as spiritual protection during the transition to the ancestral realm.	Whole plant used for dysuria, kidney and bladder stones, dysentery, haemorrhagic conditions; Roots included in Ayurvedic Tripanchmūla formulation.

Oryza sativa

Among the grasses associated with Indian landscapes, *Oryza sativa* occupies a uniquely intimate position, bridging sustenance, ritual and healing. Cultivated across the subcontinent, rice is both a food crop and a ritual substance of profound symbolic weight. In Vedic traditions, Vṛīhi is

offered in multiple forms like Caru, Purōḍāśa and Anna across major yajñas, where different varieties of rice are dedicated to deities such as Agni, Indra, Savitr and Āditya to invoke prosperity, spiritual merit and cosmic order (Boddupalli, 2024). This ritual centrality mirrors its medicinal significance; rice water is valued as a cooling, demulcent remedy for inflammatory and urinary disorders, while rice straw and ash are employed in wound healing and digestive ailments.



Figure 4: Panicles of *Oryza sativa*

Saccharum spontaneum

This riverine grass, called as Kāśa or Kans grass, occupies a small space between life and death in the context of rituals. It is found along streams and floodplains across the subcontinent, plays a significant role in funerary rites, where it is offered to the deceased as symbolic protection during their journey to the ancestral realm (Boddupalli, 2024). This association with transition is mirrored in its medicinal applications, as the entire plant is used to alleviate burning sensations, dysuria, haemorrhagic conditions and kidney stones. It is also included in the Ayurvedic formulation Tripanchmūla because of its potential as a purifier and regulator of body fluids, emphasizing its ecological and symbolic alignment with water (Das et al., 2024).



Figure 5: *Saccharum spontaneum* near wetlands

Conclusion

Mythological narratives foster social cohesion by bringing people together through shared stories and rituals and continue to inspire contemporary Indian art, literature and culture. The dynamic presence of mythology in

Indian society showcases its existing relevance and importance. Especially, in Vedic traditions, many grasses are associated with deities, highlighting their divine connection, but the lesser-known facts lie in their uses in purifying rituals and traditional medicine. The selected grasses *Arundo donax*, *Cynodon dactylon*, *Desmostachya bipinnata*, *Oryza sativa* and *Saccharum spontaneum* in the present study highlighted that botanical presence in landscapes is inseparable from cultural memory and embodied knowledge. Their persistence in contemporary urban and semi-urban environments is not merely ecological survival but cultural continuity. Recognizing such species within modern green spaces invites a rethinking of urban biodiversity, not as neutral greenery, but as living archives of ritual practice, traditional medicine and human-nature relationships.

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Chapter 11

Grass diversity of Siddheswar temple: ethnobotanical significance of a sacred grove

Sumalatha BS¹, Sweta Mishra² and Sumitra Jethy^{2*}

¹Department of Botany, Dr. Manmohan Singh Bengaluru City University, Bengaluru, Karnataka, India

²Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India

*Email-Id: sumitrajethy19@gmail.com

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Abstract: Sacred groves represent unique landscapes where cultural faith and ecological conservation coexist. The present case study explores the diversity and traditional uses of grasses within the Siddheswar sacred grove of Cuttack, Odisha. A total of 23 grass species belonging to 18 genera were recorded, reflecting notable floristic richness within this culturally protected site. Many of the documented grasses possess ethnobotanical value and are traditionally used by local communities across the world for healthcare, animal husbandry and nutrition. Species such as *Alloteropsis cimicina* are used in the management of diabetes and indigestion, while *Chrysopogon aciculatus*, *Saccharum spontaneum* and *Cymbopogon citratus* are associated with treatments for digestive and nervous ailments. Religiously important grasses like *Cynodon dactylon* contribute to primary healthcare practices, whereas *Chloris barbata*, *Aristida setacea* and *Eragrostis pilosa* are mainly employed in veterinary care. Several species also serve as valuable fodder and food resources, though a few lacked recorded traditional uses. The present study highlights the role of sacred groves as living repositories of grass diversity and indigenous knowledge, emphasizing their ecological, cultural and conservation significance.

Keywords: Ethnomedicine, grass diversity, sacred grove

Introduction

Sacred groves act as traditional conservation units where religious beliefs ensure long-term protection of native flora and associated biodiversity (Onyekwelu et al., 2024). Siddheswar is a sacred grove centred around the ancient Siddheswar temple at Naraj (Figure 1), situated on the hilltop overlooking the Kathajodi branch of the Mahanadi River, which preserves diverse indigenous plant species, highlighting the role of cultural heritage in safeguarding ecologically valuable habitats. Sacred groves like Siddheswar play a crucial role in in situ biodiversity conservation (Sharma, 2018) by protecting native and often rare plant species through traditional beliefs and

cultural taboos that restrict exploitation (Kandari et al., 2014). They also function as ecological refugia, maintaining ecosystem services such as soil stability, microclimate regulation and preservation of traditional knowledge linked to sustainable resource use (Khan et al., 2008). Among the existing flora, grasses form an important component of sacred grove flora by contributing to ecosystem stability and resilience through soil binding, prevention of erosion and regulation of local microclimate (Behera et al., 2025).



Figure 1: Siddheswar temple on Naraj hill-top, Cuttack, Odisha

Their presence also supports trophic interactions and nutrient cycling, providing habitat and forage for insects, birds and small herbivores, thereby enhancing overall biodiversity and ecological functioning of sacred groves (Singh et al., 2022). But the lesser-known fact is that grasses are not only an important component of the ecological system, but they are an integral part of the folk medicinal system and significantly contribute towards the healing and livelihood of the people and fauna associated with them (Sharma et al., 2025). The present study was taken as an initiative to study the diversity of grass species in Siddheswar and document their ethnobotanical uses.

Methodology

The floristic survey of grasses (family Poaceae) was conducted within the sacred grove of Siddheswar, Cuttack, Odisha, India, to document species diversity. Field surveys were carried out during the peak growing season between July and September 2025 to ensure accurate identification following published literature (Behera et al., 2025).

Results and discussion

The field survey of Siddheswar, Cuttack, Odisha, recorded a total of 23 grass species belonging to 18 different genera. Several of the documented grasses were found to have ethnobotanical importance, being traditionally used for medicinal, veterinary or dietary purposes by local communities (Table 1).

Table 1: Grass list of Siddheswar temple and their ethnobotanical uses

Grass species	Common name	Plant part(s)	Use(s)
<i>Alloteropsis cimicina</i> (L.) Stapf	Bugseed grass, Summer grass	Whole plant	In diabetes and indigestion (Sharma et al., 2025)
<i>Aristida setacea</i> Retz.	Broom grass, Bristly needle grass	Whole plant, roots	To treat foot and mouth diseases in animals (Rajakaruna et al., 2002)
<i>Axonopus compressus</i> (Sw.) P.Beauv.	Carpet grass	Whole plant	As an herbal bath (He et al., 2021)
<i>Bambusa bambos</i> (L.) Voss (Figure 2)	Spiny bamboo, Bamboo	Shoots, leaves, roots,	Leaf decoction is useful in relieving

		stems and seeds	cough (Adnan et al., 2014)
<i>Chloris barbata</i> Sw.	Swollen finger grass	Whole plant	Used as a disinfectant in animal health care (Majeed et al., 2020)
<i>Chrysopogon aciculatus</i> (Retz.) Trin. (Figure 4)	Love grass, Golden beard grass	Root, flowers, whole plant and leaves	In the treatment of gastric disorders and fever (Satapathy et al., 2019)
<i>Chrysopogon zizanioides</i> (L.) Roberty	Vetiber grass	Whole plant	In skin ailments (Gunasekar et al., 2025)
<i>Cymbopogon citratus</i> (DC.) Stapf (Figure 5)	Lemon grass	Whole plant and leaves	Tea prepared from leaves used as a sedative for the central nervous system (Shah et al., 2011)
<i>Cynodon dactylon</i> (L.) Pers. (Figure 7)	Bermuda grass	Roots, leaves and whole plant	Decoction or juice is taken orally for menstrual problems (Mazzei et al., 2014)
<i>Dactyloctenium aegyptium</i> (L.) Willd. (Figure 10)	Crowfoot grass	Grain/seeds, whole plant, leaves and stems	Whole plant decoction is administered for treating smallpox (Malavika et al., 2024)
<i>Dendrocalamus strictus</i> (Roxb.) Nees (Figure 6)	Solid bamboo	Leaves	In cold and fever (Goyal et al., 2011)
<i>Digitaria abludens</i> (Roem. & Schult.) Veldkamp	Stalked crabgrass	-	-

<i>Digitaria bicornis</i> (Lam.) Roem. & Schult. (Figure 3)	Asian crabgrass	-	-
<i>Eleusine indica</i> (L.) Gaertn.	Indian goosegrass, Silver crabgrass	Whole plant, aerial parts, roots and seeds	Whole plant is used in the treatment of influenza and hypertension (Al-Zubairi et al., 2011)
<i>Eragrostis pilosa</i> (L.) P.Beauv.	Jersey love grass	Whole plant	Paste or decoction is used for dysentery in animals (Majeed et al., 2020)
<i>Eragrostis tenella</i> (L.) P.Beauv. ex Roem. & Schult.	Cane grass, Japanese lovegrass	-	-
<i>Eragrostis unioides</i> (Retz.) Nees ex Steud.	Chinese lovegrass	-	Used as animal fodder (Dangol, 2008)
<i>Panicum repens</i> L.	Torpedo grass, Bullet grass	-	Palatable fodder for animals (Sharma et al., 2025)
<i>Paspalum floridanum</i> Michx.	Florida paspalum	-	-
<i>Saccharum spontaneum</i> L. (Figure 8)	Kans grass	Aerial parts, roots	In Dyspepsia, a burning sensation (Das et al., 2024)
<i>Sporobolus diandrus</i> (Retz.) P.Beauv.	Smut grass	Whole plant	Palatable fodder for animals (Sharma et al., 2025)
<i>Urochloa distachyos</i> (L.) T.Q.Nguyen (Figure 9)	Signal grass	-	-
<i>Urochloa ramosa</i> (L.) T.Q.Nguyen	Browntop millet, Dixie signal-grass	Seeds	As grains for culinary uses (Bano et al., 2025)



Figure 2: Habit and habitat of *Bambusa bambos*



Figure 3: Inflorescence of *Digitaria bicornis*



Figure 4: Inflorescence of *Chrysopogon aciculatus*



Figure 5: Habitat of *Cymbopogon citratus*



Figure 6: Flowers of *Dendrocalamus strictus*



Figure 7: Inflorescence of *Cynodon dactylon*



Figure 8: *Saccharum spontaneum* in its habitat



Figure 9: Healthy population of *Urochloa distachyos*



Figure 10: Spikelets of *Dactyloctenium aegyptium*

Among the recorded species, *Alloteropsis cimicina* is used in the treatment of diabetes and indigestion, while *Chrysopogon aciculatus* (Figure 4), *Saccharum spontaneum* (Figure 8) and *Cymbopogon citratus* (Figure 5) are commonly employed for managing gastric disorders, fever, dyspepsia and nervous conditions. *Cynodon dactylon* (Figure 7) and *Eleusine indica* are used for menstrual disorders, influenza and hypertension, highlighting their role in primary healthcare. Several grasses such as *Chloris barbata*, *Aristida setacea* and *Eragrostis pilosa* are mainly used in animal healthcare, particularly for infections, dysentery and foot-and-mouth disease. In addition to medicinal uses, some grasses, including *Eragrostis unioides*, *Panicum repens* and *Sporobolus diandrus*, serve as palatable fodder for livestock, while *Urochloa ramosa* is consumed as a grain. However, a few species such as *Digitaria abludens*, *Digitaria bicornis* (Figure 3), *Eragrostis tenella*, *Paspalum floridanum* and *Urochloa distachyos* (Figure 9) were recorded without specific ethnobotanical uses. The results indicated that the Siddheswar sacred grove conserves and preserves grass diversity with medicinal, veterinary and nutritional uses, emphasizing the ecological and cultural significance of sacred groves in biodiversity conservation.

Conclusion

Siddheswar sacred grove serves as an important cultural, religious and ecological refuge for flora, fauna and humans associated with it. The grass diversity of the grove supports 23 species across 18 genera with varied ecological and ethnobotanical significance. Many of the recorded grasses contribute globally to traditional human healthcare, veterinary practices and livestock nutrition, reflecting the close relationship between local communities and their natural surroundings. The documentation provides baseline data for its conservation and future research can be added to the rich cultural and ecological heritage of Odisha.

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EDITORS' PROFILE



Dr. Bhagwati Prashad Sharma

He is working in the department of Higher Education, Government of Himachal Pradesh, India and presently posted as Associate Professor and Head, Department of Botany, Sidharth Government College Nadaun, Himachal Pradesh, India. He has 24 years of academic experience. His field of specialization is Orchid Tissue Culture and Ethnobotany. His current research is focused on ethnobotany, biodiversity conservation, threatened plants and pollination biology. He has published more than 45 research articles in reputed national and international journals. He has published 17 books, 93 book chapters in edited books including Taylor and Francis, Apple Academic Press and many popular articles. He has presented his research work in more than 64 International and national conferences, symposia and seminars. He has delivered invited lectures on several occasions. He is life member of several academic associations, including The Indian Science Congress Association and The Orchid Society of India.





Dr. Rajkumari Supriya Devi

She is currently serving as Project Director, Ambika Prasad Research Foundation, Odisha, with nearly 10 years of research experience in the field of botany, medicinal plants, ethnobotany, microbiology, wetland and riverine ecosystems, forest fire studies and taxonomy. She has authored over 135 publications, including 75 research papers, 55 book chapters and 7 books in reputed national and international platforms. She played a key role in formulating the Management Plan for the State Botanical Garden, Nandankanan Zoological Park, Odisha, India and has delivered numerous presentations on wetlands, ethnobotany, riverine ecology and biodiversity conservation at national and international seminars and workshops. Her current research interest focuses on the wetland flora, wildlife fodder plants from Cyperaceae, with an emphasis on wetland conservation.





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