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Grasses of Castlerock Wildlife Range in Kali Tiger Reserve, India

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Abstract: This study aimed to provide a baseline understanding of the grass diversity and its associated habitats in the Kali Tiger Reserve of Karnataka, India. A comprehensive investigation revealed a rich assemblage of 75 species, under 46 genera. Notably, the *Arundinella* genus exhibited the highest species richness (5 species), followed by the *Pennisetum* genus. The study highlighted the palatability values of different grass species and also revealed that open areas, grasslands, agriculture lands, and rock crevices are the most suitable habitats. Based on the outcomes, management strategies such as habitat conservation, grazing management and restoration of degraded grasslands are proposed to maintain the ecosystem services of grasslands. These management strategies can assist forest managers and policymakers in developing targeted conservation efforts that focus on preserving and managing these habitats to conserve grass diversity.

Keywords: *Castlerock, Checklist, Grass, India, Kali Tiger Reserve, Karnataka, Poaceae.*

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I. INTRODUCTION

The Western Ghats in India are one of the biodiversity hotspots and the second-most diverse centre for endemism and is home to 1,500 species of endemic plants (Abhijit & Krishnamurthy, 2020). This extensive mountain range runs parallel to India's west coast. It is composed of thick evergreen forests, grasslands, streams, and varying sorts of wetlands. The area comprises a diversified plant life due to the considerable rainfall brought on by the southwest monsoon and favourable edaphic conditions (Gadgil, 1996). Among these plant species, grass is one of the principal herbs that will significantly help to keep the ecological balance. According to paleobotanical, paleofaunal and stable carbon isotope data, grass-dominated habitats first appeared through five key stages of evolution in the late Miocene. All continents, with the exception of Antarctica, have known grasses between the early Paleocene and middle Eocene (Jacobs & al., 1999). One-fifth of the earth's land area is covered by grasses, which are angiosperms with a varied range of morphological traits. The grasses are members of the Poaceae family, and they make up 24% of all vegetation on earth, including savannas and natural grasslands (Abhijit & Krishnamurthy, 2020). Grasses play a key role in supporting both human and animal life such as they act as major source of food, including major grains like rice, wheat, and maize (Raja & al., 2021). The food chain is a key component of the grassland ecosystem's structure and operation. Grass species are numerous, coexist alongside angiosperms in practically all environments and are not only dominating in many ecosystems but also have significant effects on the survival of animal species and the flammability of landscapes. The volume of grass-dominated vegetation has an impact on the regional hydrology, nitrogen cycling, and many ecosystem processes.

Grasses are a major source of calories for humans, directly through grain consumption or indirectly through animal feed. Grass cell walls also provide dietary fibre that has several health benefits (Vogel, 2008). Grasslands are also essential for the survival and habitat of various animals, including insects, birds, lizards, and snakes. But the habitat disturbance is known to alter grassland species composition (Abhijit & Krishnamurthy, 2020). The significance of grasslands has often been overshadowed by forests and forestry issues (Shantz, 1954). There are approximately 10,550 grass species across the globe, organized into 715 genera, with around 1,200 species from 268 genera identified in India alone (Abhijit & Krishnamurthy, 2020; Pathak, 2013). The Indian state of Karnataka boasts a diverse range of grassland ecosystems that extend from the northern plains to the dense forests of the Western Ghats. There have been

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only a limited number of studies that have examined the grass diversity of Karnataka. For instance, the grass diversity of Bhadra Wildlife Sanctuary (central Karnataka), Shimogga District (central Karnataka) and Savandurga forest (southern Karnataka) have been documented, which have identified 67, 45 and 140 species, respectively (Abhijit & al., 2016; Dhatchanamoorthy & al., 2021; Vasanthakumari & al., 2010). Only a study has (Rao & al., 2012) documented 32 species of Poaceae in the Kali Tiger Reserve (northern Karnataka) in 2012. Within the Kali Tiger Reserve, extensive areas of grassland are observed in regions such as Castlerock, Kumbarwada, and Joida (New Indian Express, 2019). These grasslands are home to a diverse array of plant and animal species and play a crucial role in the maintenance of ecosystem health and functioning. However, these grasslands are under threat due to a variety of human activities, including agricultural intensification, urbanization, and infrastructure development (New Indian Express, 2019). Moreover, invasive species such as *Eupatorium* and Lantana are dominating the grasslands, preventing grass regeneration (*MEE Report- Kali Tiger Reserve*, 2022).

The objective of this study is to establish baseline and understand the diversity of grass species for grassland ecosystem management and maintenance in the study region. This study aims to contribute to the scientific literature and assist forest managers in developing effective management practices to conserve the grassland ecosystems in Kali Tiger Reserve, which is key landscape in Karnataka for diverse range of flora and fauna.

II. MATERIALS AND METHODS

The study was conducted in the Castlerock Wildlife Range of Kali Tiger Reserve, located in the south-west region of India. Encompassing a vast area of approximately 260 square kilometres, the study area spans from 15.252˚N to 15.525 ˚N latitude and from 74.251˚E to 74.510 ˚E longitude. Situated on the state's border with Karnataka and Goa, the region is perched at an elevation of around 620 m in the ecologically sensitive Western Ghats. The Castlerock Wildlife Range is a well-known protected area, comprising 16 Forest Beats (the smallest administrative unit of the forest, and is supervised by a Beat Forester) (MEE Report- Kali Tiger Reserve, 2022).The Castlerock Wildlife Range is renowned for its thickly wooded wet tropical deciduous vegetation and is a crucial catchment for tributaries like Dusagi, Pandri, Katle and Varlewadi. The region experiences the monsoons from June to September, followed by winter from November to February, and summer from March to May. With an average annual rainfall of nearly 6000mm and an average annual temperature of 28˚C, Castlerock Wildlife Range is a unique landscape that supports a good network of protected areas (Castlerock Railway Station, 2023; Range Forest Officer, 2023).

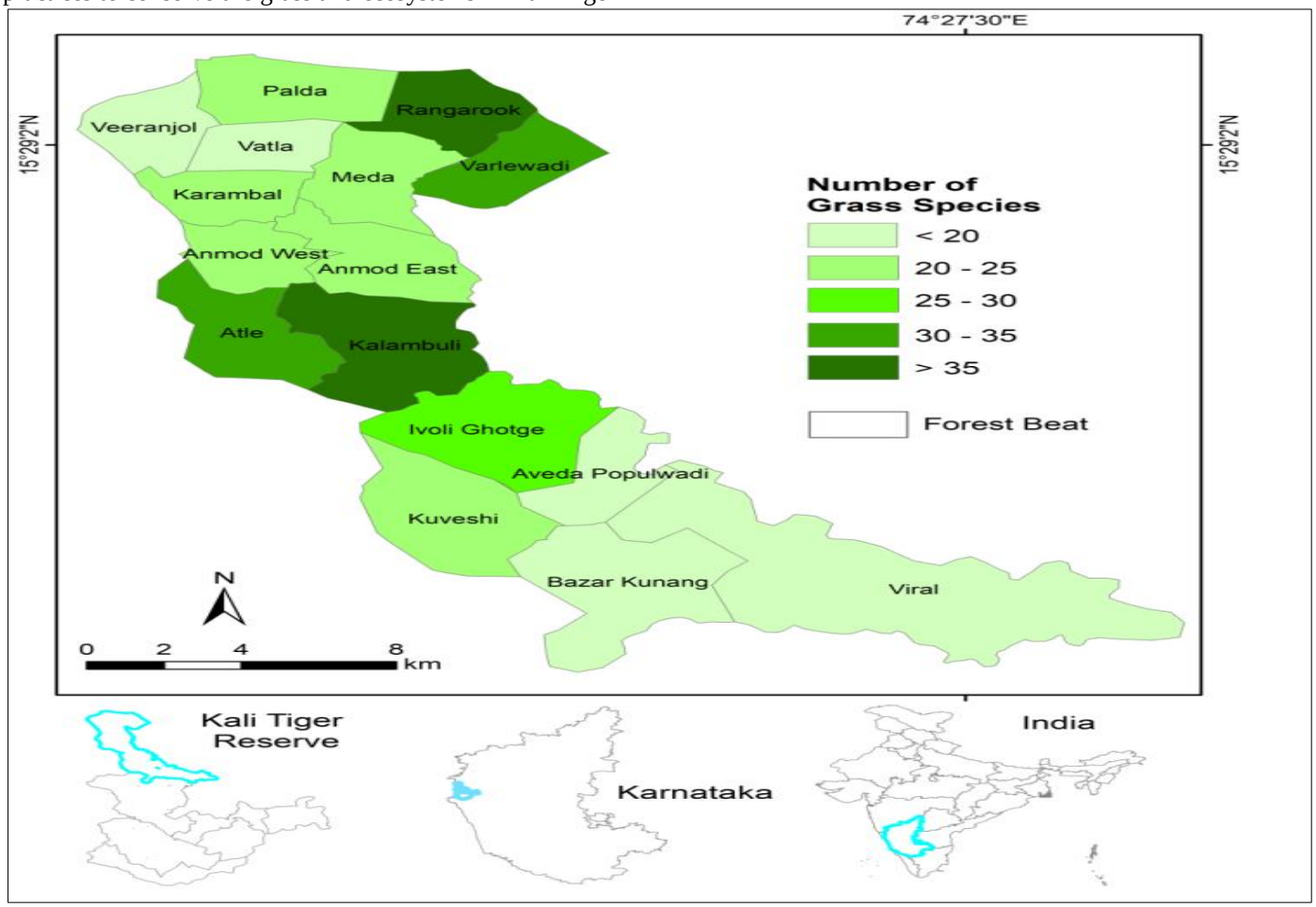

Fig 1 Map Showing the Casterock Wildlife Range with its Grass Species Richness (Denoted by Gradient Green Colours) Present in Each Forest Beats.

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➢ *Sampling Period, Sampling Techniques and Floristic Study*

This study extensively sampled the grass species of the study area from September 2021 to February 2023, encompassing a diverse range of habitats including agriculture lands, human habitation, roadside lands, hilly grasslands, open grasslands, wetlands and abandoned constructions. To ensure a representative sample, a random sampling approach was applied to collect grasses from each Forest Beat. To accurately identify the collected specimens, a variety of taxonomic references including floras, research papers, taxonomic revisions and literatures (Bor, 1961; Gamble, 1915; Hooker, 1875; Karthikeyan, 2005; Sachin A & Lakshminarasimhan, 2011) were consulted. The grass species were classified based on the Bor classification system (1961). The photographs of voucher specimen were taken and deposited at the Wildlife Research and Training Centre, Karnataka, India, to provide a reference for future research.

This comprehensive and methodical approach enabled the identification of 75 grass species, belonging to 46 genera and 12 tribes of the Poaceae family. Among these species, the *Arundinella* genus had the highest number of species (5), followed by the *Pennisetum* genus. The study provides a vital contribution to understanding the biodiversity of the Kali Tiger Reserve and the grass flora of the region, which will inform future conservation efforts.

III. RESULTS

This study presents the findings of a qualitative floristic assessment of the Poaceae family across different regions of the study area, revealing a total of 75 grass species belonging to 46 genera, 12 tribes, and 4 subfamilies. The subfamily Panicoideae was found to be the most abundant, with 48 species of 28 genera and 2 tribes, followed by the subfamily Pooideae with 22 species of 15 genera and 7 tribes. Among the 46 genera, the *Arundinella* genus had the highest number of species. Aristideae and Centotheceae tribes have the fewest number of species found, while Andropogoneae tribe has the greatest number of species (Fig. 2).

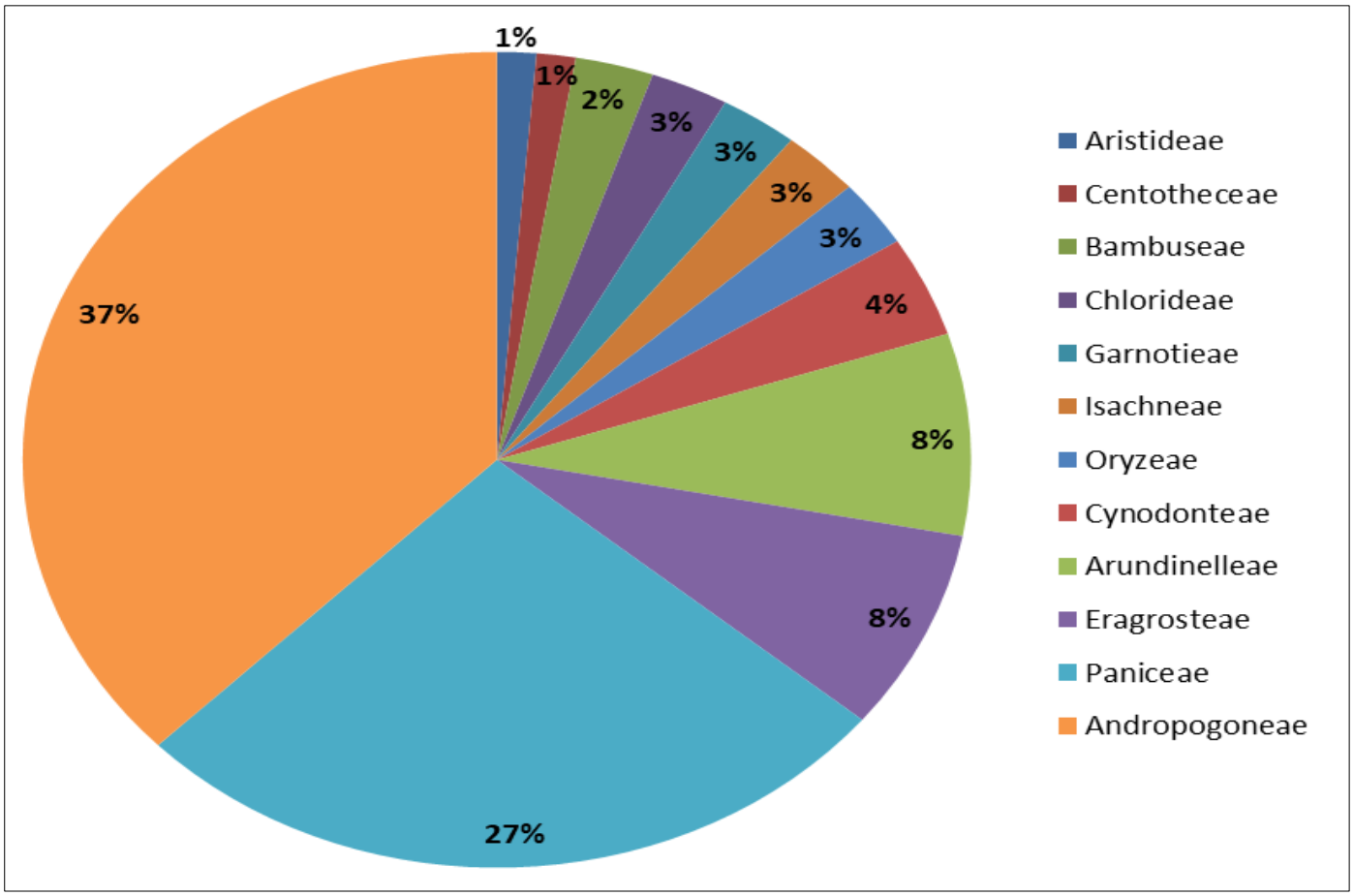

Fig 2 Pie Chart Displaying the Proportion of Grass Species Belonging to 12 Tribes Present in Castlerock. Andropogoneae Tribe has the Highest Number of Species Followed by Paniceae, While Aristideae and Centotheceae have the Lowest Number of Species.

The study found that November was the most suitable month for blooming in almost all grass species, followed by October and December. Conversely, flowering of grass species was not observed in the wild during the months of April and May, with the exception of some garden areas and agricultural regions where water is usually applied. Based on the observation on field, almost 41 of the species were found to be palatable, while 11 were not palatable. Of the 75 species documented, 16 were annuals and 59 were perennials.

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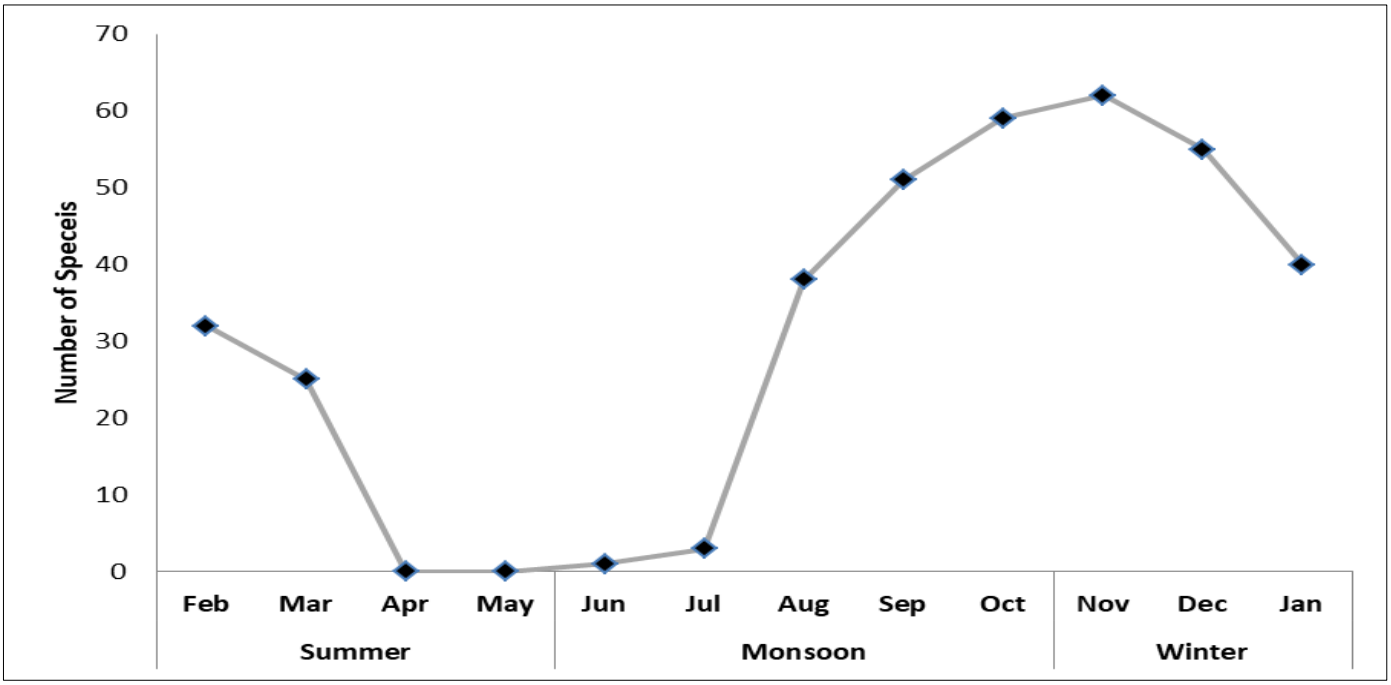

Fig 3 Graph depicting the number of species blooming in each month. November was the most suitable month for blooming while, flowering of grass species was not observed during the months of April and May.

The checklist of grass species provided in Table 1 includes their vernacular names, tribe, flowering season, palatability, IUCN conservation status, and habitat of each species. The selected species are also illustrated in Figures 4-14, providing a visual reference of the identified species for future study. The grass species inventory revealed 32 species from open grasslands, 20 from agriculture lands, 14 from human habitation and roadside lands, 6 from wetlands, 2 from abandoned constructions, and 1 from hilly grasslands. Among the documented species, 9 are least concerned and one is endangered, while the rest are classified as not evaluated by IUCN. However, in terms of regional occurrence, 39 species are common, 21 are occasional, 13 are rare and 2 are very rare.

Table 1 Showing The Detailed Checklist of Grass Species of Castlerock, Karnataka. [Y-Palatable; N-Non Palatable; NE- Not Evaluated; LC- Least Concerned; EN- Endangered]

Sl. No	Scientific name	Vernacular name	Tribe	Flowering month	Palatability	IUCN Status	Habitat type
1	*Acroceras munroanum* (Balansa) Henrard		Paniceae	Nov-Dec	N	NE	Wetlands
2	*Apluda mutica* L.	ಕಾಡು ಹಂಚಿ ಹುಲ್ಲು	Andropogoneae	Aug-Mar	Y	NE	Open grassland
3	*Aristida setacea* Trin.	Broom Grass	Aristideae	Aug-Mar	N	NE	Open grassland
4	*Arthraxon hispidus* (Thunb.) Makino	Small carpet Grass	Andropogoneae	Aug-Jan	N	NE	Agriculture land
5	*Arthraxon lancifolius*		Andropogoneae	Sep-Mar	N	NE	Wetlands
6	*Arundinella leptochloa* (Nees ex Steud.) Hook.		Arundinelleae	Nov-Jan	Y	LC	Open grassland
7	*Arundinella metzii* Hochst.		Arundinelleae	Nov-Jan	Y	NE	Open grassland
8	*Arundinella nepalensis* Trin.	Reed Grass	Arundinelleae	Aug-Mar	N	LC	Wetlands
9	*Arundinella pumila* (Hochst. ex A.Rich.) Steud.	Dwarf Reed Grass / ಗುಬ್ಬಿ ಪುಚ್ಚದ ಹುಲ್ಲು	Arundinelleae	Oct-Dec	Y	NE	Open grassland
10	*Arundinella setosa* Trin.		Arundinelleae	Jun-Sep	Y	NE	Open grassland

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11	*Axonopus compressus* (Sw.) P.Beauv.	Broad-leaved carpetgrass/ Buffalo Grass	Paniceae	Aug-Mar	N	NE	Human Habitation and Roadside land
12	*Brachiaria distachya* (L.) Stapf	Armgrass Millet	Paniceae	Oct-Jan	Y	NE	Agriculture land
13	*Brachiaria ramosa* (L.) Stapf		Paniceae	Oct-Feb	Y		Wetlands
14	*Capillipedium huegelii* (Hack.) A.Camus		Andropogoneae	Oct-Dec	Y		Open grassland
15	*Centotheca lappacea* (L.) Desv.	Johnson Grass	Centotheceae	Aug-Mar	N	NE	Agriculture land
16	*Chloris barbata* Sw.	Swollen Finger Grass / ಮಂಚದಕಾಲು ಹುಲ್ಲು	Chlorideae	Oct-Dec	Y	NE	Human Habitation and Roadside land
17	*Chrysopogon gryllus* (L.) Trin.		Andropogoneae	Aug-Oct	Y	NE	Hilly grassland
18	*Chrysopogon zizanioids* (L.) Roberty		Andropogoneae	Sep-Dec	Y		Human Habitation and Roadside land
19	*Coelachne simpliciuscula* (Wight & Arn. ex Steud.)		Isachneae	Aug-Dec	N	NE	Agriculture land
20	*Cynodon dactylon* (L.) Pers. (Panicum dactylon L.)	Bermuda Grass / ಗರಿಕೆ	Chlorideae	Sep-Dec	Y	NE	Open grassland
21	*Cyrtococcum accrescens* (Trin.) Stapf		Paniceae	Oct-Jan	N	NE	Agriculture land
22	*Cyrtococcum oxyphyllum* (Hochst. ex Steud.) Stapf		Paniceae	Aug-Mar	N	NE	Agriculture land
23	*Dactylonium azypticum*		Cynodonteae	Sep-Dec	Y		Open grassland
24	*Dichanthium concanensis* (Hook.f.) S.K.Jain & Deshp.		Andropogoneae	Aug-Dec	Y		Open grassland
25	*Digitaria ciliaris* (Retz.) Koeler		Paniceae	No data	No data		Agriculture land
26	*Digitaria stricta* Roth		Paniceae	No data	No data	NE	Agriculture land
27	*Dimeria gracilis* Nees ex Steud.		Andropogoneae	Sep-Dec	Y	NE	Agriculture land
28	*Dimeria hohenackeri* Hochst. ex Miq.		Andropogoneae	Aug-Feb	Y	EN	Agriculture land
29	*Dimeria stapfiana* C.E.Hubb. ex Pilg.		Andropogoneae	Aug-Feb	No data	NE	Open grassland
30	*Eleusine indica* (L.) Gaertn.	Crab Grass	Eragrosteae	Jul-Jan	Y	NE	Agriculture land
31	*Elytrophorus spicatus* (Willd.) A.Camus		Eragrosteae	Oct-Mar	No Data	NE	Agriculture land
32	*Enteropogon dolichostachyus* (Lag.) Keng		Cynodonteae	Oct-Jan	No data		Agriculture land
33	*Eragrostis minor* Host	Little Love Grass	Eragrosteae	Aug-Mar	Y	NE	Human Habitation and Roadside land
34	*Eragrostis unioloides* (Retz.) Nees ex Steud.	Chinese Love Grass	Eragrosteae	Aug-Mar	Y	NE	Human Habitation and Roadside land

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35	*Eragrostis viscosa* Scribn.		Eragrosteae	Aug-Mar	Y	NE	Human Habitation and Roadside land
36	*Eulalia trispicata* (Schult.) Henrard	Silver Grass	Andropogoneae	Nov-Dec	Y	NE	Open grassland
37	*Garnotia arborum* Stapf ex Woodrow		Garnotieae	No data	No data	NE	Abandoned Construction
38	*Garnotia tenella* (Arn. ex Miq.) Janowski		Garnotieae	Aug-Nov	No data		Abandoned Construction
39	*Glyphochloa acuminata* (Hack.) Clayton		Andropogoneae	Oct-Feb	Y	NE	Open grassland
40	*Glyphochloa mysorensis* (S.K.Jain & Hemadri) Clayton		Andropogoneae	Oct-Nov	Y	NE	Open grassland
41	*Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult.	Spear Grass	Andropogoneae	Aug-Mar	Y	NE	Open grassland
42	*Heteropogon triticeus* (R.Br.) Stapf ex Craib		Andropogoneae	Nov-Dec	Y	NE	Open grassland
43	*Imperata cylindrica* (L.) P.Beauv.		Andropogoneae	Aug-Mar	No data	NE	Open grassland
44	*Indopoa paupercula* (Stapf) Bor	Poor Indian Grass	Eragrosteae	Sep-Nov	No data	NE	Open grassland
45	*Isachne globosa* (Thunb.) Kuntze	Swamp Millet /	Isachneae	Aug-Nov	Y	LC	Agriculture land
46	*Ischaemum indicum* (Houtt.) Merr.		Andropogoneae	No data	Y		Open grassland
47	*Ischaemum rugosum* Salisb.	ಜೌಗು ರಾಗಿ	Andropogoneae	Sep-Jan	No data	LC	Open grassland
48	*Ischaemum semisagittatum* Roxb.	Saramolla Grass	Andropogoneae	Aug-Dec	N	NE	Agriculture land
49	*Ischaemum timorense* Kunth	Arrowleaf Muraina Grass	Andropogoneae	Sep-Feb	Y		Agriculture land
50	*Jansenella griffithiana* (C.Muell.) Bor	Murrain Grass	Arundinelleae	Nov-Dec	Y	NE	Open grassland
51	*Leersia hexandra* Sw.	Rice Grass	Oryzeae	Aug-Feb	No data	NE	Open grassland
52	*Oplismenus burmannii* (Retz.) P. Beauv.	Burmann's basket Grass	Paniceae	Sep-Nov	No data	NE	Agriculture land
53	*Oplismenus compositus* (L.) P.Beauv.		Paniceae	Aug-Nov	No data	NE	Agriculture land
54	*Panicum capillare* L.	Witch Grass	Paniceae	Aug-Mar	Y	NE	Wetlands
55	*Panicum notatum* Retz.		Paniceae	Aug-Mar	No data		Open grassland
56	*Paspalum canarae* (Steud.) Veldkamp		Paniceae	Aug-Sep	No data	LC	Wetlands
57	*Paspalum scrobiculatum* L.	Koda millet	Paniceae	Aug-Mar	No data	NE	Agriculture land
58	*Pennisetum glaucum* (L.) R.Br.		Paniceae	No data	No data		Human Habitation and Roadside land
59	*Pennisetum hohenackeri* Hochst. Ex Steud.	Fountain Grass	Paniceae	Aug-Mar	Y	LC	Human Habitation and Roadside land
60	*Pennisetum pedicellatum* Trin.	Kyasuwa Grass	Paniceae	Sep-Oct	Y	LC	Open grassland
61	*Pennisetum polystachion* (L.) Schult.	Thin Napier Grass / Mission Grass	Paniceae	Aug-Mar	Y	LC	Open grassland
62	*Perotis indica* (L.) Kuntze		Cynodonteae	No data	No data	NE	Human Habitation and Roadside land

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63	*Porteresia coarctata* (Roxb.) Tateoka		Oryzeae	No data	Y		Open grassland
64	*Pseudanthistiria heteroclita* (Roxb.) Hook.f.	Gondia Grass/Kangaroo Grass	Andropogoneae	Aug-Mar	Y	NE	Open grassland
65	*Pseudanthistiria hispida* Hook.f.		Andropogoneae	Aug-Mar	No data		Human Habitation and Roadside land
66	*Pseudoxytenanthera ritcheyi* (Munro) H.B.Naithani		Bambuseae	Aug-Mar	No data		Human Habitation and Roadside land
67	*Pseudoxytenanthera stocksii* (Munro) T.Q.Nguyen		Bambuseae	Aug-Mar	No data		Human Habitation and Roadside land
68	*Saccharum spontaneum* L.	Wild Sugarcane / ಕಾಡು ಕಬ್ಬು	Andropogoneae	Aug-Mar	Y	LC	Open grassland
69	*Sacciolepis indica* (L.) Chase	Glenwood Grass	Paniceae	Aug-Mar	No data		Human Habitation and Roadside land
70	*Setaria pumila* (Poir.) Roem. & Schult.	Yellow bristle Grass	Paniceae	Jul-Oct	No data	NE	Agriculture land
71	*Sorghum halepense* (L.) Pers	Johnson Grass/ ಹುಬ್ಬು ಜೋಳ	Andropogoneae	Aug-Sep	Y	NE	Open grassland
72	*Spodiopogon rhizophorus* (Steud.) Pilg.		Andropogoneae	Jan-Feb	Y	NE	Human Habitation and Roadside land
73	*Themeda quadrivalvis* (L.) Kuntze	Gondia	Andropogoneae	Sep-Dec	Y		Open grassland
74	*Themeda tremula* (Nees ex Steud.) Hack.		Andropogoneae	Sep-Dec	Y	NE	Open grassland
75	*Themeda triandra* Forssk.	Root Gras/ Red Grass	Andropogoneae	Oct-Mar	Y	NE	Open grassland

IV. DISCUSSION

The main objective of this study was to document and understand the diversity of grass species in the Kali Tiger Reserve, and to fill in the gaps in our knowledge about the grass diversity of the region. Our findings demonstrate the presence of 75 species from 46 genera belonging to 12 tribes and four subfamilies, providing valuable information for future research. The identification of ten of the twelve grass subfamilies in India, four of which are found in the Castlerock region, highlights the grass diversity of the area. Additionally, our study provides insights into the phenology and palatability of grass species, which can assist in the establishment of appropriate grassland management and targeted conservation efforts.

The present study has provided significant insights into the phenology and palatability of grass species in the Kali Tiger Reserve. The results revealed that the blooming of grass species mostly occurs in November, October, and December, while the months of April and May showed no flowering in the wild. The palatability of grass species was found to be high, as evidenced by the significant consumption of *Arundinella pumila*, *Chloris barbata*, *Dichanthium concanensis*, *Eleusine indica*, *Eragrostis unioloides*, *Heteropogon contortus* and *Arundinella leptochloa* by many herbivores in the area. *Chloris barbata* is a rare but excellent fodder for most herbivores. These species are rich in sulphur, calcium, and sodium (Ramírez-Lozano, 2015), which are essential nutrients for herbivores in the forest system. Cynodon dactylon was found to be the most preferred grass by lower herbivores such as hares, mouse-deers, and rodents. The loss of grasslands can lead to the loss of herbivores, affecting grazing and soil carbon loss, making grasslands a promising nature-based solution for climate mitigation and adaptation (Naidu et al., 2022).

Moreover, this study identified open areas, grasslands, agriculture lands, and rock crevices as the most suitable habitats for grass species in the study area. The findings of this study could be useful for forest managers to develop targeted conservation efforts aimed at preserving and managing these habitats to conserve grass diversity. The study contributes to bridging the information gap about grass diversity in the Kali Tiger Reserve, providing valuable information for future research. The four subfamilies of grasses found in the study area, including Panicoideae, Bambusoideae, Pooideae, and Chloridoideae, highlight the diverse grass species present in the region.

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In Castlerock, various forms of disturbance such as livestock grazing, ecotourism, urbanisation, encroachment, agricultural intensification, and construction operations like upgrading a single-track railway track to a double-track over plant-rich and sensitive areas have all been observed to have a significant impact on vegetation density. The present study fills an important knowledge gap by providing a comprehensive account of the grass flora of Kali Tiger Reserve. Hence, the results of this study provide valuable information on grass distribution, phenology, palatability and habitat preferences that can serve as a valuable resource for forest managers in establishing appropriate grassland management and targeted conservation efforts.

V. CONCLUSION

The grasslands of the Kali Tiger Reserve in Karnataka are of great ecological and conservation value, providing habitat for a variety of wildlife species. However, the grasslands in Castlerock are facing a multitude of threats from various anthropogenic activities, such as livestock grazing, ecotourism, encroachment and agricultural intensification, as well as invasive species growth. To ensure the protection and preservation of these grasslands, it is imperative to regulate these activities and implement measures to control the invasive species. Further research can be conducted to investigate the impact of specific anthropogenic activities, such as ecotourism or agricultural intensification, on the grassland ecosystem. In addition, more detailed studies can be conducted to understand the relationship between the grassland vegetation and wildlife populations, including the impact of invasive species on herbivores.

The grasslands are at a heightened risk of wildfires during the summer months, necessitating regular monitoring and prompt responses to satellite-based fire alarms. The construction of artificial water holes can help sustain the grasslands during dry periods. Additionally, identifying the most preferred grass species by herbivores, including *Arundinella pumila, Chloris barbata, Dichanthium concanensis, Eleusine indica, Eragrostis unioloides,* and *Heteropogon contortus,* and collecting their seeds can facilitate the restoration of grasslands in even the most barren areas. It would also be beneficial to explore the potential of using traditional ecological knowledge and management practices in grassland conservation efforts. Finally, ongoing monitoring and assessment of the grasslands can provide insights into the effectiveness of the implemented management strategies and identify areas for improvement.

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