Floristic Diversity and Biological Spectrum in Urban and Peri-urban Areas of Ganderbal, Kashmir

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Abstract: The study was conducted to investigate tree diversity, life forms and leaf spectra during 2022 and 2023.Vegetation analysis was conducted in nine wards of Municipal Committee of Ganderbal and peri-urban locations within a 1-2 km vicinity of the wards. Random sampling of trees, shrubs and herbs was carried out using 10 m x 10 m, 5 m x 5 m and 1 m x 1 m quadrants, respectively. The study identified 115 species across 50 families, comprising 101 dicots, 8 monocots and 6 gymnosperms. Dominant families included Asteraceae (11.30 %), Rosaceae (9.56 %), Leguminosae (6.08 %) and Amaranthaceae (5.21 %). *Prunus* and *Rosa* were the most diverse genera, each with three species. Moreover, two species were recognized as endemic, with an additional 12 species classified as native to the study area. There was greater biodiversity in urban regions than in peri-urban areas, highlighting urbanisation's impact on plant richness and composition. Of the surveyed species, trees, shrubs and herbs were 225.22 , 19.13 and 51.30 % respectively emphasizing the prevalence of herbaceous vegetation. According to Raunkiaer's life form system, therophytes (34.78 %) were predominant, followed by nanophanerophytes (17.39 %), indicating a thero-phanerophytic phytoclimate. Microphylls (34.78 %) and simple leaves (66.09 %) were prevalent in the leaf size spectrum and leaf lamina type. The dominance of therophytes suggests an adaptation to harsh climate conditions and anthropogenic pressures in urban and peri-urban areas.

Floristic diversity and biological spectrum have been extensively studied by researchers worldwide. Numerous studies have examined the floristic composition and biological spectrum of forests across various regions, significant knowledge gaps persist, particularly in the Kashmir Himalayas. Wani and Pant (2023) explored the floristic diversity and community characteristics of Gulmarg Wildlife Sanctuary in the Kashmir Himalaya, while Pulicherla et al. (2023) conducted a floristic exploration of the East Sikkim district in Sikkim. Haq et al. (2023) provided a comprehensive analysis of vegetation composition in the Shiwalik Mountain Range Forest. Similarly, Surmal et al. (2022) investigated species diversity in the coniferous forests of Bhallesa Hills in the Pir Panjal Mountain range of the Western Himalaya. Further, Rahman et al. (2021) examined the biological spectrum of vascular flora in Zaini Pass, District Chitral, Pakistan, whereas Sen and Bhakat (2020) conducted a quantitative analysis of floristic composition, biological spectrum, and leaf spectrum in a sacred grove in Jhargram District, West Bengal.. Despite these contributions, the lack of research in urban environments necessitates focused efforts to better understand the floristic diversity and biological spectrum within these evolving landscapes.

MATERIAL AND METHODS

Study area: The investigation was conducted in Ganderbal district, Jammu and Kashmir UT,during 2022-2023.Ganderbal is located between 34.23°N and 74.78°E at an elevation of 1650 to 3000 meters above sea level. The district, situated on the left bank of River Sindh, covers 39,304 hectares, comprising forest (27.86 %), non-agricultural use (14.65 %), barren and un-cultivable land (8.04 %), permanent pastures / other grazing land (4.55 %), cultivable waste land (2.48 %) and net area sown (42.42 %) (Anonymous 2011).

Data collection: The floristic diversity and phytosociological characteristics of vegetation in urban and peri-urban areas of Ganderbal were conducted through field surveys in nine wards of the Municipal Committee of Ganderbal and nine peri-urban areas within 1-2 km of the wards. Using multistage random sampling, 630 quadrants were laid, with 5 for trees, 10 for shrubs and 20 for herbs per location. Trees were sampled using species-area curve-determined quadrats, while shrubs and herbs were sampled with 5m x 5m and 1m x 1m quadrats, respectively. Standard ecological methods were followed for data collection (Curtis and McIntosh 1950, Greig-Smith 1957, Misra 1968, Mueller-Dombois and Ellenberg 1974). The similarity index was determined using the Sorenson index, while the diversity index was calculated according to the Shannon-Wiener diversity function (Shannon-Wiener 1963).

Biological spectrum: In-depth field observations on

aspects like habit (growing form, Raunkiaer's life form), leaf type (size, lamina) and other characteristics of each species were observed. Growth forms were divided into tree, shrub, sub-shrub, herb, palm and climberbased on growth direction, size and main shoot branching (Perez-Harguindeguy et al., 2013). Life forms were categorized by the location of the perennating bud during unfavourable seasons into geophytes, therophytes, hemicryptophytes, chamaephytes, nanophanerophytes, microphanerophytes, mesophanerophytes and megaphanerophytes (Muzafar et al., 2019). Leaf size, indicative of local edaphic and climatic conditions, was classified into leptophyll, nanophyll, microphyll, mesophyll, macrophyll and megaphyll (Ali et al., 2016). Leaf lamina shapes were as simple, dissected, compound and needle, reflecting adaptations for optimal light capture (Malhado et al., 2009).

RESULTS AND DISCUSSION

Floristic diversity: The investigation unveiled 115 plant species representing 102 genera across 29 plant orders belonging to 50 plant families (Table 1). This included 8 species as monocotyledons, 6 species as gymnosperms and 101 species as dicotyledonous. Asteraceae emerged as the most diverse family with 13 species, followed by Rosaceae with 11 species. Leguminosae and Amaranthaceae encompassing 7 and 6 species, respectively. Verma and Kapoor(2011) highlighted Asteraceae, Rosaceae and other families as dominant .The prevalence of Asteraceae can be attributed to their adaptive seed dispersal mechanisms, ecological tolerance and ability to thrive across various environmental conditions (Awas and Demissew, 2009). The diverse genera in terms of species richness were *Prunus* and *Rosa*, each comprising three species (Fig. 1). The two species were identified as endemic; while 12 species were categorized as native to the study area (Fig. 2). Khuroo et al. (2017) reported a higher proportion of alien species (52 %) compared to native species (48 %) in an urban biodiversity hotspot in the Indian Himalayas. The prevalence of non-native species along roadsides is likely due to frequent anthropogenic disturbances, such as fragmentation, pollution, and the heat island effect, which create favourable conditions for their establishment. Trombulak and Frissell (2000) and Lippe and Kowarik (2008) observed that T species from families Asteraceae and Poaceae often become dominant invaders in urban areas .In present study in urban area there were 27 tree species, 21 shrubs, 59 herbs, 2 sub-shrubs and 2 climbers, while peri-urban areas had 17 tree species, 16 shrubs, 43 herbs and 1 sub-shrub (Fig. 3).

Shannon-Wiener Index (H') of urban and peri-urban

Table 1. Plant species in the urban and peri-urban areas of ganderbal

Name	Family	Common name
Abelia × grandiflora Rehder	Caprifoliaceae	Glossy Abelia
Aesculus indica (Wall. ExComb.) Hk. f.	Sapindaceae	Indian horse Chestnut
Ailanthus altissima Swingle.	Simoaroubaceae	Tree of Heaven
Alcea rosea L.	Malvaceae	Hollyhock
Amaranthus caudatus L.	Amaranthaceae	Velvet flower
Amaranthus tricolor L.	Amaranthaceae	Edible amaranth
Anthemis cotula L.	Asteraceae	Sticking Chamomile
Antirrhinum majus L	Plantaginaceae	Dog Flower
Arctium lappa L.	Asteraceae	Greater Burdock
Avena sativa L.	Poaceae	Oat
Berberis lycium Royle	Berberidaceae	Indian Barberry
Bothriochloa ischaemum L.	Poaceae	Yellow bluestem
Brassica rapa L.	Brassicaceae	Field mustard
Buddleja davidii Franch.	Scrophulariaceae	Butterfly brush
Buxus sempervirens L.	Buxaceae	Boxwood
Callistephus chinensis (L.) Nees	Asteraceae	Annual Aster
Campsis grandiflora (Thunb.) K. Schum.	Bignonaceae	Trumpet
Canna indica L.	Cannaceae	Indian shot
Cannabis sativa L.	Cannabaceae	Marijuana
Carpesium abrotanoides L.	Asteraceae	Carpesium Fruit
Catalpa bignoniodes Walter	Bignoniaceae	Indian Bean Tree
Cedrus deodara (Roxb.)	Pinaceae	Deodar
Celosia argentea L.	Amaranthaceae	Plumed Cock's Comb
Celtis australis L.	Cannabaceae	European nettle tree
Cercis siliquastrum L.	Leguminosea	Judas Tree
Chenopodium album L.	Amaranthaceae	White goosefoot
Cirsium arvense Scop.	Amaranthaceae	Wool bearing Thistle
Clarkia pulchella Pursh	Onagraceae	Ragged Robin
Convolvulus arvense L.	Convolvaceae	Field Bindweed
Conyza canadensis L.	Asteraceae	Horseweed
Crataegus songarica K.Koch	Rosaceae	Hawthorn
Cryptomeria japonica D. Don	Cupressaceae	Japanese Cedar
Cupressus sempervirens L.	Cupressaceae	Meditteranean cypress
Dahlia pinnata Cav.	Asteraceae	Garden dahlia
Daucus carota L.	Apiaceae	Wild Carrot
Dianthus caryophyllus L.	Caryophyllaceae	Clove pink
Dianthus chinensis L.	Caryophyllaceae	Rainbow pink
Eschscholzia californica Cham.	Papaveraceae	California Poppy
Euonymus japonicus Thunb.	Celastraceae	Japanese spindle

Cont...

Table 1. Plant species in the urban and peri-urban areas of ganderbal

Name	Family	Common name
Euphorbia peplus L.	Euphorbiaceae	Milkweed
Ficus carica L.	Moraceae	Common Fig
Foeniculum vulgare Mill.	Apiaceae	Fennel
Forsythia viridissima Lind.	Oleaceae	Chinese golden bell tree
Fragaria nubicola (Hoof.f) Linn.	Rosaceae	Himalayan Strawberry
Galinsoga parviflora Cav.	Asteraceae	Quick weed
Gomphrena globosa L.	Amaranthaceae	Bachelor's Button
Halianthus annus L	Asteraceae	Common sunflower
Hedera helix L.	Araliaceae	Common ivy
Hibiscus syriacus L.	Malvaceae	Rose of Sharon
Hydrangea macrophylla (Thunb.) Seringe	Hydrangeacea	French hydrangea
Hypericum androsaemum L.	Hypericaceae	St John's Wort
Iberis amara L.	Brassicaceae	Rocket Candytuft
Indigofera heterantha Wall	Leguminosae	Himalayan indigo
Juglans regia L.	Juglandaceae	English Walnut
Juniperus communis L.	Cupressaceae	Common juniper
Lagerstroemia indica L.	Lythraceae	Crape Myrtle
Lavandula angustifolia Mill.	Lamiaceae	English lavender
Lepidium sativum L.	Brassicaceae	Garden cress
Ligustrum lucidum Ait.f.	Oleaceae	Chinese privet
Lupinus polyphyllus Lindl.	Leguminosae	Garden lupin
Magnolia kobus DC	Magnoliaceae	Mokryeon
Magnolia liliflora Desr.	Magnoliaceae	Japanese
Malva neglecta Wallr.	Malvaceae	Common Mallow
Marrubium vulgare L.	Lamiaceae	Horehound
Matricaria aurea (Loefl.) Sch.Bip.	Asteraceae	Golden Chamomille
Melia azedarach L.	Meliaceae	Chinaberry tree
Mentha arvensis L.	Lamiaceae	Field Mint
Morus alba L.	Moraceae	Mulberry
Myosotis arvensis (L.) Hill	Boraginaceae	Field forget-me-not
Nerium indicum Mill.	Apocynaceae	Nerium
Oxalis corniculata L.	Oxalidaceae	Sleeping beauty
Paparver dubium L.	Papaveraceae	Long headed Poppy
Phlox drummondii Hook.	Polemoniaceae	Annual phlox
Picea smithiana (Wall.) Boiss.	Pinaceae	Western Himalayan Spruce
Plantago major L.	Plantaginaceae	Broad leaf Plantain
Platanus orientalis L.	Platanaceae	Chinar
Polygonum hydropiper L.	Polygonaceae	Water pepper
Populus nigra L.	Salicaceae	Black poplar

Table 1. Plant species in the urban and peri-urban areas of ganderbal

Name	Family	Common name
Populus deltoides W.Bartram ex Marshall	Salicaceae	Eastern cottonwood
Prunus avium L.	Rosaceae	Wild cherry
Prunus cerasifera Ehrh.	Rosaceae	Cherry plum
Prunus persica Batsch	Rosaceae	Peach
Robinia psuedoacacia L.	Leguminosae	Black Locust
Rosa × damascena Mill	Rosaceae	Turkish rose
Rosa moschata Herrm.	Rosaceae	Musk rose
Rosa multiflora Thunb.	Rosaceae	Baby rose
Rubus niveus Thunb.	Rosaceae	Mysore Raspberry
Rubus ulmifolius Schott	Rosaceae	Elm leaf blackberry
Rumex dentatus L.	Polygonaceae	Aegean dock
Rumex hastatus D. Don	Polygonaceae	Arrowleaf Dock
Salix alba L.	Salicaceae	Willow
Salix babylonica L.	Salicaceae	Weeping Willow
Scilla siberica Andrews	Asparagaceae	Siberian squill
Setaria virdis (L.) P.Beauv.	Poaceae	Green foxtail
Sophora japonica L.	Leguminosae	Japanese pagoda tree
Spiraea japonica L.f.	Rosaceae	Japanese spiraea
Stellaria media L.	Caryophyllaceae	Chickweed
Tagetes minuta L.	Asteraceae	Mint marigold
Tagetes patula L.	Asteraceae	French marigold
Thuja orientalis L.	Cupressaceae	White cedar
Trachycarpus fortunei (Hook.) H.Wendl.	Arecaceae	Chinese windmill palm
Trifolium pratense L.	Leguminosea	Red Clover
Trifolium repens L	Leguminosea	White Clover
Tropaeolum majus L.	Tropaeolaceae	Garden nasturtium
Urtica dioica L.	Urticaceae	Stinging nettle
Verbascum thapsus L.	Plantaginaceae	Great mullein
Veronica persica Poir.	Plantaginaceae	Persian speedwell
Viburnum opulus L.	Adoxaceae	Guelder-rose
Vinca major L.	Apocynaceae	Large periwinkle
Viola tricolor L.	Violaceae	Wild pansy
Wigelia florida A. DC.	Caprifoliaceae	Rose Weigela
Xanthium spinosum L.	Asteraceae	Prickly burweed
Yucca aloiflora L.	Asparagaceae	Dagger plant
Zantedeschia aethiopica (L.) Spreng.	Araceae	Arum lily
Zinnia elegans L.	Asteraceae	Common zinnia

areas of Ganderbal: The Shannon-Wiener Index was calculated using IVI values to assess species richness (Fig. 4). The diversity index for various urban areas in Ganderbal, with Dud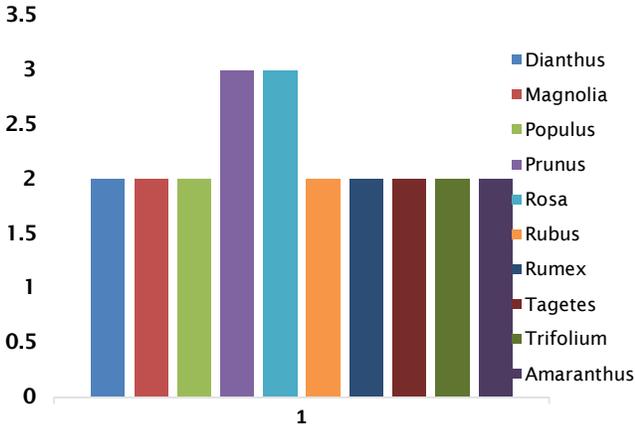erhama exhibited the highest index at 1.53, followed by Gangerhama, Ganderbal, Saloora, Bamloora, and Wanipora. Beehama had the lowest index at 1.23. The diversity index for peri-urban areas, showed highest index inTulmulla (1.49), followed by Arch, Rangil and Sarich Chodri Bagh . Harran had the lowest index (1.32).

These values suggest moderate species diversity, with higher diversity observed in Duderhama (urban) and Tulmulla (peri-urban). The diversity levels align with those reported by Dar and Sundarapandian (2016) and Sharma et al. (2010) but are lower than reported by Malik and Bhat (2015) and Bhat et al. (2020) in other parts of the Indian Himalayas. The lower diversity observed in this study may be due to factors such as uneven species distribution, environmental stress, habitat fragmentation, invasive species or the ecological succession stage. Comprehensive sampling across various habitats contributed to capturing this range of diversity.

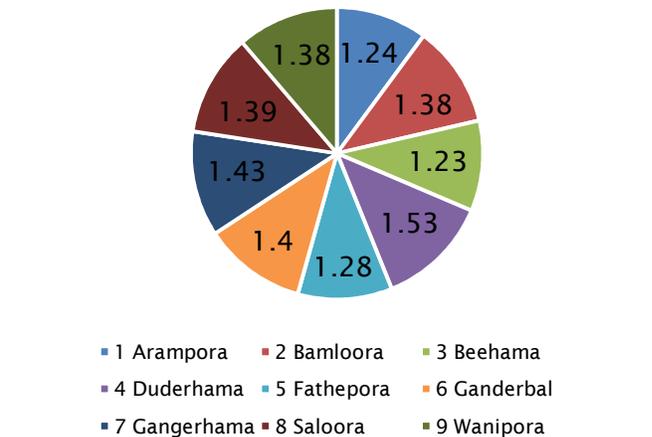**Biological spectrum of urban and peri-urban areas of Ganderbal**

Fig. 1. Genera from the study area with 2 or greater than 2 species
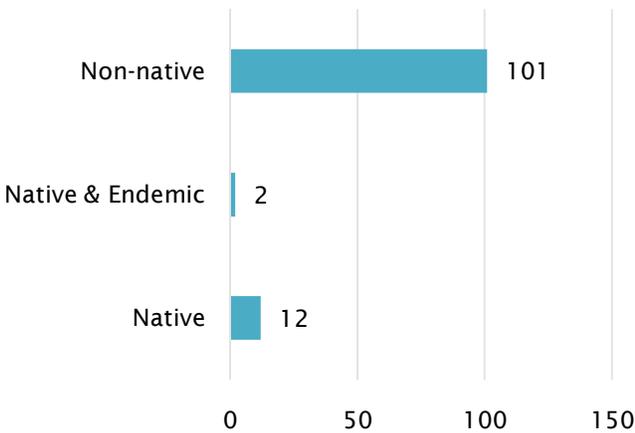
Fig. 2. Nativity and endemism of flora in the urban and peri-urban areas of Ganderbal
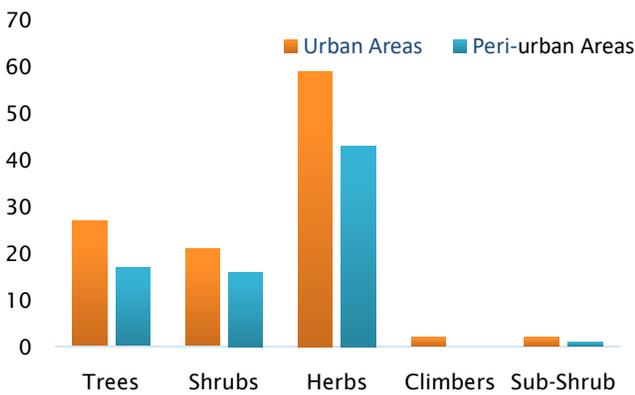
Fig. 3. Comparative analysis of different plant growth forms in the urban and peri-urban areas of Ganderbal

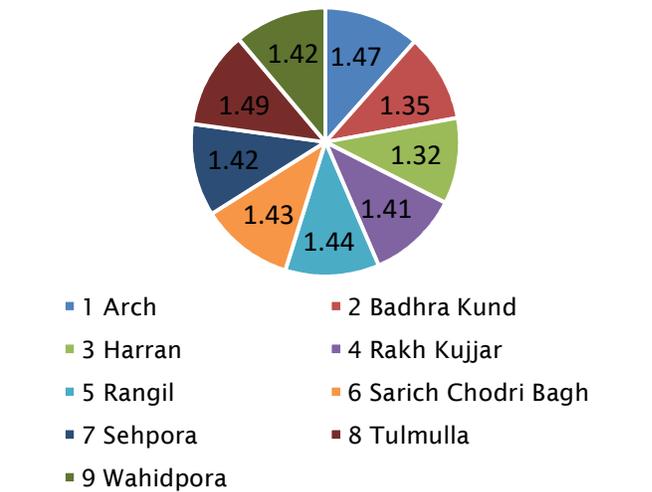**Fig. 4.** Shannon diversity index under Urban areas of Ganderbal

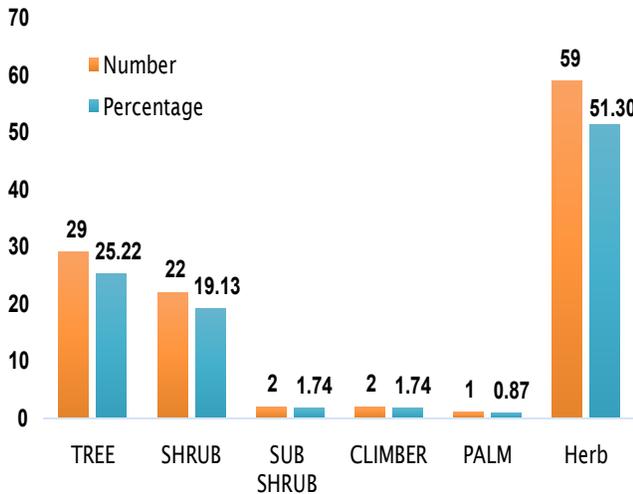**Fig. 5.** Shannon diversity index value of under Peri-urban areas of Ganderbal

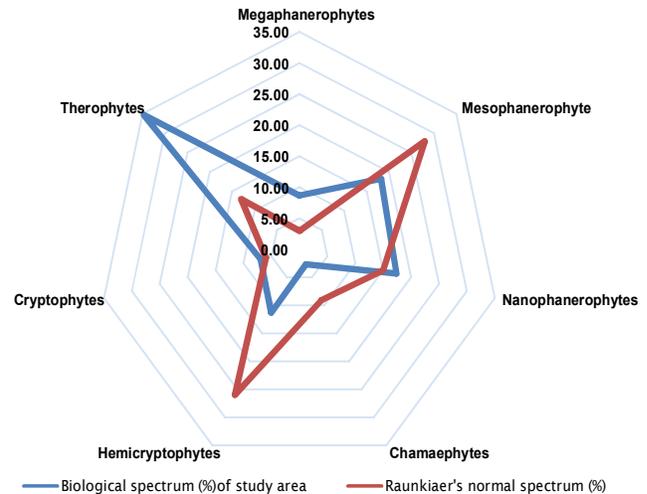**Fig. 7.** Growth form distribution in urban and Peri-urban areas of Ganderbal

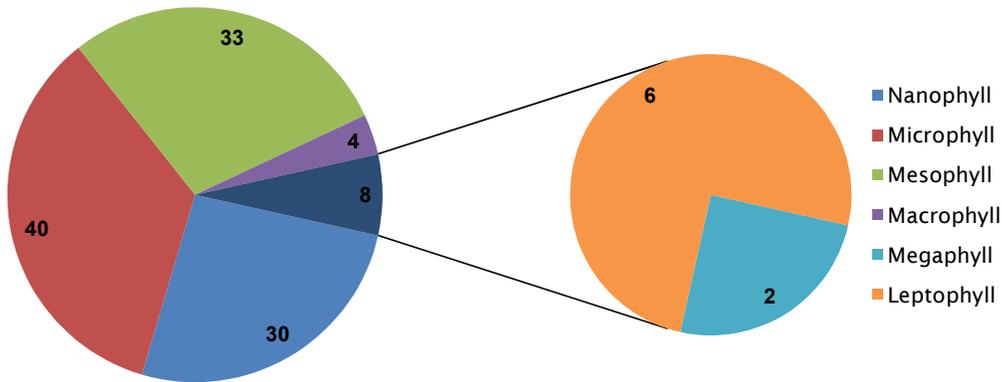**Fig. 8.** Comparison of Biological spectrum with Raunkiaer's normal spectra

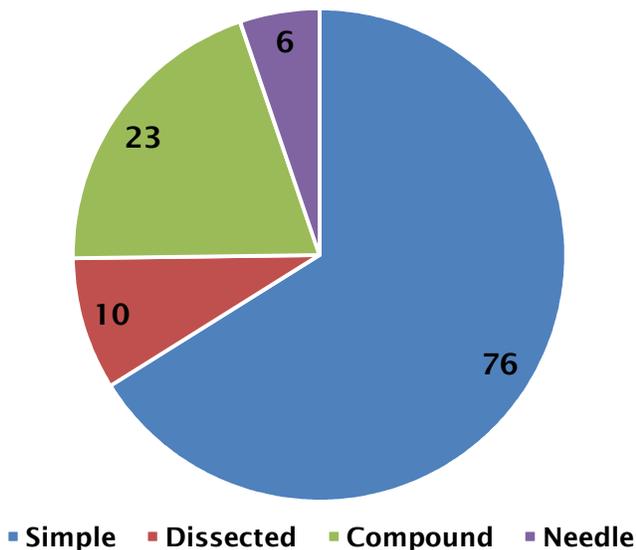**Fig. 9.** Representation of leaf size in the Urban and Peri-urban areas of Ganderbal

Fig. 10. Representation of leaf lamina types in the urban and Peri-urban areas of Ganderbal

The biological spectrum of urban and peri-urban areas of Ganderbal includes 25.22 % trees, 19.13 % shrubs, 1.74 % sub-shrubs, 1.74 % climbers, 0.87 % palms, and 51.30 % herbs (Fig. 7). Raunkiaer classification shows: maximum were therophytes (34.78 %) followed by nano-phanerophytes, hemicryptophytes, meso-phanerophytes, micro-phanerophytes and mega-phanerophytes, geophytes, and chamaephytes . The phytoclimate is thero-phanerophytic (Fig. 8). Leaf spectra revealed microphylls were maximum in number while megaphylls were least present (Fig. 9). Leaves with simple leaf lamina were maximum in number (Fig. 10).

The dominance of herbaceous plants aligns with previous research in the Indian Himalayan Region (IHR) by Rawat (2021) and Sharma et al. (2019).This prevalence of herbaceous species is likely due to the temperate climate of the Himalayan region, which favours herbs over woody plants (Mehraj et al., 2018). Herbs' short life cycle and adaptability to diverse and disturbed environments, such as urban areas, enable them to thrive, particularly in areas with high

disturbance like roadsides. Khuroo et al. (2017) also observed that herbs constituted a significant portion of the flora, likely due to their ability to rapidly colonize and exploit available resources in such environments.

The high prevalence of therophytes is likely due to the frequent disturbances caused by anthropogenic activities, consistent with findings by Knapp et al. (2008). Therophytes thrive in disturbed environments, which may be attributed to the introduction of annual weeds and biotic influences, indicating environmental disruption (Al-Yemeni and Sher 2010). The region's microclimate, characterized by warm and dry summers, further supports the dominance of therophytes, which are adapted to survive arid conditions by synchronizing their life cycles with suitable seasons. Comparing our results with Raunkiaer's normal spectrum, we observed a significant increase in therophytes, suggesting that the phytoclimate of the area is thero-phanerophytic. This trend has been noted in previous studies in Jammu and Kashmir by by Singh and Kachroo (1994). The dominance of therophytes in warm and dry climates, coupled with human disturbances like overgrazing, highlights their ability to occupy niches created by such disruptions.

The dominance of small-leaved species is likely due to the region's arid climate and harsh winters. This pattern aligns with findings from other studies in the Indian Himalayan Region (IHR) by Khan et al. (2013) and Malik et al. (2007) with high prevalence of microphylls in similar climates. Most species in the study had simple leaf lamina. The shape and size of leaves are crucial for optimizing light capture and water management, especially in resource-deficient environments, as suggested by Malhado et al. (2009) and Manzoni et al. (2013). Ihsan et al. (2016) also observed a predominance of simple leaves in their studies.

The floristic diversity in urban and peri-urban areas patterns became apparent. Urban areas showed greater species diversity across all categories, with 27 tree species, 21 shrubs, 59 herbaceous plants, 2 sub-shrubs, and 2 climbers, compared to 17 tree species, 16 shrubs, 43 herbaceous plants, 1 sub-shrub, and no climbers in peri-urban areas. Moreover, the utilization of the Shannon-Wiener Index underscored variations in plant species diversity between urban and peri-urban environments in Ganderbal. The Shannon-Wiener Index further highlighted this difference, with the highest diversity index of 1.53 in Duderhama (urban) and 1.49 in Tulmulla (peri-urban). However, the highest similarity index (93%) was observed between Gangerhama (urban) and Sarich Chodri Bagh (peri-urban) in the tree and shrub categories, indicating some overlap. These variations provide insights into the differing ecological dynamics of urban and peri-urban environments in Ganderbal.

CONCLUSION

This study offers the first comprehensive assessment of floristic diversity and biological spectra in the urban and peri-urban areas of Ganderbal, Kashmir, revealing significant variations in species composition and ecological dynamics. A total of 115 plant species were identified, with urban areas showing greater diversity across all plant categories. Asteraceae and Rosaceae emerged as the most diverse families, while therophytes and microphylls were the dominant growth forms and leaf types. The study highlights the ecological significance of park habitats, which hosted the highest concentration of species, and underscores the need for targeted conservation strategies. Regular monitoring and a well-defined conservation policy are essential to ensure the effective management and preservation of prioritized communities and habitats in the region.

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