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Research Article

FLORISTIC COMPOSITION AND PHENOLOGY OF VEGETATION IN DISTRICT DIR LOWER, KHYBER PAKHTUNKHWA, PAKISTAN

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ABSTRACT

The present study explores the floristic composition and phenology of vegetation in district Dir Lower, Khyber Pakhtunkhwa, Pakistan. This district features diverse biological and climatic conditions, creating a unique environment for ecological studies. The research was conducted from May to November in 2018 and 2019, documenting 206 plant species across 182 genera and 82 families. The dominant families were Lamiaceae, Asteraceae, and Poaceae. Using Raunkaier's life form classification, the study found a dominance of therophytes (41%) and nanophanerophytes (13%), indicating the local ecosystem's adaptation to annual climatic changes. In terms of leaf size spectrum, microphylls were the most abundant (39%), followed by mesophylls (27%) and Nanophylls (22%). The distribution of plant species in the research area reflects the adaptation of the local flora to specific environmental conditions. Phenological observations revealed two distinct flowering seasons: the primary season from May to August and the secondary season from September to November. During the first season, the majority of plants (85%), predominantly herbs, were in bloom. In contrast, the second season showed a smaller diversity of blooming plants, including six fern species. Fruiting patterns mirrored the flowering trends, with a higher fruiting rate observed from May to August (106 species) compared to September to November (100 species). This research provides a comprehensive overview of the floristic diversity, biological spectrum, and phenological patterns in district Dir Lower, contributing valuable information to plant ecology and conservation in the region.

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INTRODUCTION

District Lower Dir is situated in the northwestern part of the Khyber Pakhtunkhwa province, between 34° 37′ to 35° 07′ N latitudes, and 71° 31′ to 72° 14′ E longitudes (Nasir et al., 2023). The district was formed in 1996 when Dir was divided into Upper Dir and Lower Dir. Timergara city is the district headquarters and the largest city. The district is mainly comprised of terrain drained by the Panjkura River and its tributaries. Dir derives its name from a village that served as the capital during the Nawab era (Ullah et al., 2024). It borders district Swat to the east, Afghanistan to the west, Upper Dir to the northwest, and Malakand to the south. The primary spoken language is Pashto, followed by Kohistani and Gujri (Hamayun, 2005).

According to statistics, July is the warmest month, while January is the coldest. In some hilly areas, the temperature can fall below zero at times (Ullah et al., 2023a). The winter season starts in December and lasts until the end of March, while summer begins in May and ends in August. The most humid months are January, August, and December (Abbas and Mayo, 2021). The highest rainfall occurs in spring, reaching up to 240 mm, while October sees the lowest rainfall. Snowfall usually starts in December and continues until March, sometimes remaining on mountain tops until April, providing recreational sites for locals (Ullah et al., 2017, 2023b).

The adaptation of plants to specific ecological conditions determines their life forms, making this an important physiognomic characteristic widely used in vegetation analysis. This indicates the macro and microclimate of a particular area as well as human disturbances (Sajid et al., 2023). Raunkiaer (1934) proposed the term "biological spectrum" to describe the distribution of life forms in flora and their phytoclimatic characteristics (Ullah et al., 2019c). Plant species can be grouped into five main classes under Raunkiaer's system: phanerophytes, chamaephytes, hemicryptophytes, cryptophytes, and therophytes (Rahman et al., 2021). The percentage of these various life form classes together is called the biological spectrum. Raunkiaer's normal spectrum serves as a model against which spectra in different life forms can be compared. The normal spectrum indicates a phanerophyte community, and deviations from it determine a habitat's phytoclimate (Shah et al., 2020). The occurrence of similar biological spectra in different regions suggests similar climatic conditions. Thus, differences between the normal spectrum and life forms of the biological spectrum may indicate which life form characterizes the phytoclimate or vegetation of an area (Rashid et al., 2011).

The present study aims to investigate the floristic composition and phenology of vegetation in the district of Lower Dir, Khyber Pakhtunkhwa, Pakistan.

MATERIALS AND METHODS

Collection of plant samples

Plant samples were gathered during field research, labeled, pressed, and dried using blotting papers in a field press. Newspapers were replaced within 24 hours to accommodate plant and environmental conditions (Lalrinkima, 2013).

Preservation of dried specimens

For the preservation of the dried specimens, a mixture of three percent ethyl alcohol, mercuric chloride, and copper sulfate was used (Khatri et al., 1995).

Arrangement of specimens

Specimens of various plant species were arranged on standard herbarium sheets measuring 17.5″ × 11.5″, following the guidelines set by the Herbarium of Hazara University, Pakistan (Batalha and Martins, 2004).

Identification of plant specimens

The identification of plants was assisted by references such as "Flora of Pakistan" and works by previous authors (Shinwari et al., 2018; Hussain et al., 2010; Hassan et al., 2020; Shah and Khan, 2006; Irfan et al. 2022).

Voucher specimens

The voucher specimens were then deposited in the Herbarium of Hazara University, Pakistan.

Biological spectrum

Life form classification

Plants were classified into different groups using Raunkiaer's classification based on the location oftheir perennating buds:

1. Phanerophytes

Buds located more than 0.25 meters above the soil surface.

2. Chamaephytes

Buds situated above 25 cm from the ground.

3. Hemicryptophytes

Buds are found at the level of the soil surface.

4. Geophytes

Buds buried within the soil.

5. Therophytes

Plants that complete their entire lifecycle from seed in a single season.

Leaf size classification

The Raunkiaer classification system was also used for the leaf size spectrum, defining the following categories:

1. Leptophyll (L)

Less than 25 square mm.

2. Nanophyll (N)

Ranging from 25 square mm to 25 × 91 square mm.

3. Microphyll (Mi)

From 25 × 9 square mm to 25 × 92 square mm.

4. Mesophyll (Mes)

Between 25 × 92 square mm and 25 × 93 square mm.

5. Macrophyll (Mac)

From 25 × 93 square mm to 25 × 94 square mm.

6. Megaphyll (Mg)

Greater than 25 × 94 square mm.

Phenological observations

The phenological patterns of various plant species were observed through bimonthly visits to the research area throughout 2018 and 2019. Key phenological phases, such as the flowering and fruiting stages of each plant species, were documented during the study period (Ullah et al., 2019a).

RESULTS

Floristic composition

The study area comprises 206 different specimens related to 182 genera and 82 families. The dominant family is Lamiaceae, with 19 plant species, followed by Asteraceae (ca. 18 species) and Poaceae (ca. 11 species). Other significant families include Amaranthaceae (ca. 9 species), Rosaceae (ca. 8 species), Euphorbiaceae (ca. 7 species), and both Composite and Solanaceae, each with 6 plant species. Boraginaceae and Rubiaceae each have around 5 species. Families such as Apocynaceae, Fabaceae, Leguminosae, Malvaceae, Moraceae, Polygonaceae, and Pteridaceae each contain around 4 species. Families like Acanthaceae, Cyperaceae, Ranunculaceae, and Scrophulariaceae each have around 3 species, while Asparagaceae, Aspleniaceae, Brassicaceae, Caryophyllaceae, Convolvulaceae, Nyctaginaceae, Onagraceae, Plantaginaceae, Primulaceae, Salicaceae, and Verbenaceae each contain approximately 2 species.

Similarly, Violaceae have around 2 species each. Families such as Apiaceae, Anacardiaceae, Araceae, Araliaceae, Asclepiadaceae, Asphodelaceae, Betulaceae, Berberidaceae, Campanulaceae, Buxaceae, Cannabaceae, Celastraceae, Chenopodiaceae, Cleomaceae, Commelinaceae, Cornaceae, Dennstaedtiaceae, Dioscoreaceae, Ebenaceae, Equisetaceae, Fagaceae, Geraniaceae, Hypericaceae, Juglandaceae, Lythraceae, Meliaceae, Myrtaceae, Oleaceae, Orobanchaceae, Oxalidaceae, Phyllanthaceae, Pinaceae, Platanaceae, Plumbaginaceae, Polygalaceae, Punicaceae, Rhamnaceae, Rutaceae, Santalaceae, Sapindaceae, Sapotaceae, Saxifragaceae, Simaroubaceae, Smilacaceae, Thymelaeaceae, Urticaceae, Valerianaceae, and Zygophyllaceae each have only one species.

The investigation also revealed that the area has no endemic species. The floristic analysis highlighted a rich diversity within the mentioned families, underscoring the ecological significance of these taxonomic groups. The absence of endemic species suggests a low level of unique evolutionary processes occurring in this region. However, the presence of numerous families with limited species raises questions about the factors influencing their distribution and survival. Notably, certain families, such as Brassicaceae and Caryophyllaceae, contribute to the overall species richness despite varying degrees of dominance in different habitats. This observation indicates potential niche specialization among the species, which may be crucial for understanding community dynamics.

Further research could explore the ecological interactions among these species, particularly their roles as pollinators or seed dispersers, and their interactions with surrounding flora and fauna. Such investigations are critical for informing conservation strategies, especially in light of environmental pressures that may threaten these plant communities. The data are shown in Tables 1, 2, 3, 4, and 5.

Table 1. List of plants' family names, life forms, leaf spectra, flowering periods, voucher numbers, and fruiting of trees.

Sr. No.	Voucher No	Plant name	Family name	Life form	Leaf spectra	Flowering	Fruiting
1	7259	*Acacia modesta Wall*	Leguminosae	Mesophanerophyte	Microphyll	July- August	July
2	7173	*Ailanthus altissima (Mill.) Swingle*	Simaroubaceae	Mesophanerophyte	Macrophyll	July- August	September
3	7203	*Alnus nitida (Spach) Endl*	Betulaceae	Mesophanerophyte	Mesophyll	August-October	December
4	7084	*Broussonetia papyrifera. (L.)*	Moraceae	Megaphanerophyte	Microphyll	April-May	June
5	7202	*Celtis australis L.*	Cannabaceae`1	Mesophanerophyte	Microphyll	May-August	September
6	7199	*Cornus macrophylla Wall.*	Cornaceae	Mesophanerophyte	Mesophyll	May-June	August
7	7088	*Debregeasia salicifolia (D.Don) R*	Urticaceae	Megaphanerophyte	Mesophyll	April-May	June
8	7142	*Diospyros lotus L.*	Ebenaceae	Mesophanerophyte	Mesophyll	August-September	December
9	7145	*Ehretia serrata Roxb.*	Boraginaceae	Mesophanerophyte	Mesophyll	March-May	June
10	7220	*Ficus carica L*	Moraceae	Mesophanerophyte	Mesophyll	June-September	December
11	7050	*Ficus palmata* Forssk.	Moraceae	Mesophanerophyte	Mesophyll	June-September	December
12	7121	*Grewia optiva J.R.Drumm. ex Burret*	Malvaceae	Mesophanerophyte	Mesophyll	May-August	September
13	7035	*Juglans regia L.*	Juglandaceae	Mesophanerophyte	Mesophyll	February-April	July
14	7165	*Mallotus philippensis (Lam.) Müll.Arg.*	Euphorbiaceae	Megaphanerophyte	Mesophyll	February-November	December
15	7175	*Melia azedarach L.*	Meliaceae	Megaphanerophyte	Mesophyll	March-May	June
16	7221	*Monotheca buxifolia (Falc.) A. DC.*	Sapotaceae	Megaphanerophyte	Microphyll	April-May	August
17	7098	*Morus nigra L*	Moraceae	Megaphanerophyte	Mesophyll	March-July	August
18	7123	*Myrtus communis L.*	Myrtaceae	Megaphanerophyte	Microphyll	April-May	June
19	7168	*Olea ferruginea* Royle	Oleaceae	Mesophanerophyte	Nanophyll	April-June	August
20	7222	*Pinus roxburghii Sarg.*	Pinaceae	Megaphanerophyte	Nanophyll	February-April	August
21	7195	*Platanus orientalis*	Platanaceae	Megaphanerophyte	Mesophyll	April-May	June
22	7223	*Populus nigra L.*	Salicaceae	Therophyte	Mesophyll	April	May
23	7090	*Punica granatum L.*	Punicaceae	Megaphanerophyte	Nanophyll	April-May	July
24	7178	*Pyrus pashia Buch.-Ham. ex D.Don*	Rosaceae	Megaphanerophyte	Microphyll	March-April	June
25	7070	*Quercus incana Bartram*	Fagaceae	Megaphanerophyte	Mesophyll	April-May	June
26	7086	*Rhus punjabensis J. L. Stewart*	Anacardiaceae	Mesophanerophyte	Microphyll	October	December
27	7095	*Ricinus communis L.*	Euphorbiaceae	Nanophanerophyte	Macrophyll	January–March	June

28	7143	*Robinia pseudoacacia L.*	Fabaceae	Megaphanerophyte	Mesophyll	March-May	July
29		*Salix babylonica* L	Salicaceae	Megaphanerophyte	Mesophyll	March-April	May
30	7051	*Zanthoxylum armatum DC.*	Rutaceae	Megaphanerophyte	Mesophyll	April-May	June

Table 2. List of plants' family names, life forms, leaf spectra, flowering periods, voucher numbers, and fruiting of shrubs.

Sr. No.	Voucher No	Plant name	Family name	Life form	Leaf spectra	Flowering	Fruiting
1	7052/ 7113	*Aerva javanica (Burm.f.) Juss. ex Schult.*	Amaranthaceae	Chamaephyte	Nanophyll	August-September	October
2	7224	*Aloe vera* L (Brum)	Asphodelaceae	Therophyte	Microphyll	May-June	July
3	7176	*Andrachne cordifolia (Decne.) Müll.Arg*	Phyllanthaceae	Nanophanerophyte	Mesophyll	August-September	November
4	7089	*Berberis lycium Royle*	Berberidaceae	Nanophanerophyte	Nanophyll	April	July
5	7225	*Buddleja crispa Benth*	Scrophulariaceae	Nanophanerophyte	Microphyll	April-May	June
6	7072	*Calotropis procera* (*Aiton*) *Dryand*	Apocynaceae	Megaphanerophyte	Mesophyll	May-June	July
7	7226	*Colebrookea oppositifolia Sm*.	Lamiaceae	Nanophanerophyte	Mesophyll	May-June	July
8	7227	*Cotoneaster microphyllus Diels*	Rosaceae	Nanophanerophyte	Nanophyll	March-April	May
9	7228	*Daphne mucronata* Royle	Thymelaeaceae	Nanophanerophyte	Nanophyll	August	September
10	7194	*Dodonaea viscosa (L.) Jacq.*	Sapindaceae	Nanophanerophyte	Microphyll	March-April	May
11	7122	*Gymnosporia royleana Wall. ex M.A.Lawson*	Celastraceae	Nanophanerophyte	Microphyll	July-August	October
12	7229	*Indigofera heterantha Brandis*	Fabaceae	Nanophanerophyte	Microphyll	June-July	August
13	7093	*Lespedeza juncea* (*L.f.*) *Pers*	Leguminosae	Therophyte	Nanophyll	June	July
14	7230	*Limonium cabulicum* (*Boiss*.) *Kuntze*	Plumbaginaceae	Hemicryptophytes	Microphyll	May	June
15	7174	*Myrsine africana L.*	Primulaceae	Nanophanerophyte	Nanophyll	June-July	August
16	7120	*Nerium oleander L.*	Apocynaceae	Nanophanerophyte	Microphyll	June-July	August
17	7231	*Otostegia limbata* (*Benth*.) Boiss	Lamiaceae	Nanophanerophyte	Nanophyll	May-June	August
18	7067	*Periploca aphylla Decne*	Asclepiadaceae	Chamaephyte	Aphyllous	April-May	July
19	7232	*Rosa canina L.*	Rosaceae	Mesophanerophyte	Mesophyll	June-July	September
20	7166	*Rubus caesius L.*	Rosaceae	Nanophanerophyte	Microphyll	May-June	July
21	7179	*Rubus ulmifolius Schott*	Rosaceae	Nanophanerophyte	Mesophyll	June-July	September
22	7177	*Sarcococca saligna var. chinensis Franch*	Buxaceae	Nanophanerophyte	Microphyll	August-September	November
23	7069	*Sophora mollis* (Royle) Graham ex *Baker*.	Fabaceae	Nanophanerophyte	Nanophyll	June-July	September

24	7073	*Vincetoxicum arnottianum (wight).*	Apocynaceae	Mesophanerophyte	Mesophyll	July-August	October
25	7060	*Vitex negundo L.*	Lamiaceae	Nanophanerophyte	Nanophyll	August-September	November
26	7077	*Woodfordia fruticosa* (*L.*) *Kurz*	Lythraceae	Nanophanerophyte	Mesophyll	April-May	June
27	7169	*Ziziphus nummularia (Burm.f.) Wight & Arn.*	Rhamnaceae	Nanophanerophyte	Mesophyll	April-May	June

Table 3. List of plants' family names, life forms, leaf spectra, flowering periods, voucher numbers, and fruiting of herbs.

Sr. No.	Voucher No	Plant name	Family name	Life form	Leaf spectra	Flowering	Fruiting
1	7118	*Abutilon indicum (L.) Sweet herbs*	Malvaceae	Therophyte	Mesophyll	July-August	September
2	7233	*Achyranthes aspera L.*	Amaranthaceae	Therophyte	Microphyll	June-July	September
3	7140	*Actaea spicata L.*	Ranunculaceae	Chamaephyte	Mesophyll	July-August	September
4	7037	*Adenostemma lavenia* var.	Asteraceae	Hemicryptophytes	Nanophyll	April-May	June
5	7087	*Ajuga bracteosa Wall. Ex Benth*	Lamiaceae	Therophyte	Mesophyll	March-April	May
6	7059	*Ajuga parviflora Benth*	Lamiaceae	Therophyte	Nanophyll	March-April	May
7	7114	*Alternanthera pungens Kunth*	Amaranthaceae	Nanophanerophyte	Macrophyll	July-August	October
8	7117	*Amaranthus blitoides S.Watson*	Amaranthaceae	Therophyte	Nanophyll	June-July	August
9	7234	*Androsace rotundifolia Hardw.*	Primulaceae	Therophyte	Microphyll	June-July	August
10	7076	*Arabis saxicola Edgew.*	Brassicaceae	Chamaephyte	Nanophyll	June-July	August
11	7196	*Arisaema flavum* (*Forssk.*) *Schott*	Araceae	Geophyte	Macrophyll	April	May
12	7097	*Artemisia scoparia Waldst. & Kitam.*	Asteraceae	Chamaephyte	Microphyll	July	August
13	7038	*Artemisia vulgaris Burm.f.*	Asteraceae	Geophyte	Mesophyll	May-June	September
14	7235	*Asclepias curassavica L.*	Apocynaceae	Hemicryptophytes	Microphyll	May-June	July
15	7149	*Asparagus gracilis Salisb*	Asparagaceae	Chamaephyte	Leptophyll	June-July	September
16	7236	*Aster altaicus* Willd	Compositae	hemicryptophytes	Mesophyll	May-June	August
17	7146	*Aster alpinus L.*	Asteraceae	Therophyte	Mesophyll	July-August	September
18	7092	*Barleria cristata L.*	Acanthaceae	Chamaephyte	Microphyll	August-September	October
19	7161	*Bergenia ciliata (Haw.) Sternb.*	Saxifragaceae	Geophyte	Mesophyll	March-May	June
20	7127	*Bidens cernua L.*	Asteraceae	Therophyte	Nanophyll	May-June	August
21	7130/ 7136	*Calamintha umbrosa (M.Bieb.) Rchb.*	Lamiaceae	hemicryptophytes	Microphyll	July-August	October

22	7053	*Bidens pilosa L.*	Asteraceae	Therophyte	Nanophyll	March-April	May
23	7171	*Campanula pallida* Wall	Campanulaceae	Therophyte	Nanophyll	April	May
24	7055	*Cannabis sativa L.*	Cannabinaceae	Therophyte	Megaphanerophyte	May-June	August
25	7062	*Chenopodiastrum murale*	Amaranthaceae	Therophyte	Leptophyll	May-June	July
26	7061	*Chenopodium botrys* L	Chenopodiaceae	Therophyte	Microphyll	May	June
27	7237	*Chenopodium album L.*	Amaranthaceae	Therophyte	Microphyll	July-August	October
28	7075/ 7187	*Chenopodium ambrosioides L.*	Amaranthaceae	Therophyte	Mesophyll	April-May	July
29	7189	*Chrozophora tinctoria (L.) A.Juss.*	Euphorbiaceae	Therophyte	Microphyll	July-August	October
30	7238	*Clematis grata* Wall	Ranunculaceae	Megaphanerophyte	Mesophyll	August	September
31	7085	*Cleome aculeata L.*	Cleomaceae	Therophyte	Mesophyll	July-August	October
32	7162	*Commelina agraria Kunth*	Commelinaceae	Therophyte	Mesophyll	July-August	October
33	7186	*Convolvulus arvensis L.*	Convolvulaceae	Therophyte	Nanophyll	July-August	September
34	7180	*Conyza bonariensis* (L.)	Asteraceae	Therophyte	Microphyll	July	September
35	7158	*Cyperus imbricatus Retz.*	Cyperaceae	Chamaephyte	Microphyll	July-August	October
36	7157	*Dicliptera roxburghiana Nees*	Acanthaceae	Therophyte	Microphyll	August-September	October
37	7182	*Digera muricata* (L.) Mart.	Amaranthaceae	Therophyte	Microphyll	August-September	November
38	7054	*Digitaria ciliaris (Retz.) Koeler*	Amaranthaceae	Therophyte	Leptophyll	April-May	July
39	7044	*Duchesnea indica (Jacks.) Focke*	Rosaceae	Chamaephyte	Mesophyll	April-May	June
40	7047	*Epilobium hirsutum L.*	Onagraceae	Megaphanerophyte	Microphyll	July-August	September
41	7048	*Equisetum arvense L.*	Equisetaceae	Geophyte	Microphyll	June-July	September
42	7131	*Eryngium billardierei F.Delaroche*	Apiaceae	Nanophanerophyte	Macrophyll	May-June	August
43	7160	*Euphorbia heterophylla L.*	Euphorbiaceae	Megaphanerophyte	Microphyll	July	August
44	7057	*Euphorbia hirta L.*	Euphorbiaceae	Therophyte	Microphyll	August-September	November
45	7147	*Euphorbia pilulifera L.*	Euphorbiaceae	Therophyte	Nanophyll	June-July	September
46	7239	*Euphorbia serpens Kunth*	Euphorbiaceae	hemicryptophytes	Nanophanerophyte	August	September
47	7240	*Euphrasia multiflora*	Orobanchaceae	Therophyte	Leptophyll	August	October
48	7116	*Fragaria vesca L.*	Rosaceae	Therophyte	Leptophyll	April-May	June
49	7115	*Galium elegans* Wall	Rubiaceae	Therophyte	Nanophyll	May-June	July

50	7079	*Galium asperuloides Edgew.*	Rubiaceae	Therophyte	Nanophyll	April-May	July
51	7105	*Geranium rotundifolium L.*	Geraniaceae	Geophyte	Mesophyll	April-May	June
52	7108	*Gypsophila alsinoides Bunge*	Caryophyllaceae	Hemicryptophytes	Leptophyll	July-August	September
53	7107	*Heliotropium strigosum Willd.*	Boraginaceae	Geophyte	Nanophyll	July-August	September
54	7144	*Hibiscus lobatus (Murray) Kuntze*	Malvaceae	Therophyte	Microphyll	August	September
55	7216	*Hypericum perforatum L.*	Hypericaceae	Therophyte	Nanophyll	August	September
56	7124	*Isodon rugosus (Wall. ex Benth.) Codd*	Lamiaceae	Nanophanerophyte	Microphyll	June-July	September
57	7133	*Lactuca orientalis (Boiss.) Boiss.*	Asteraceae	Chamaephyte	Microphyll	June-July	August
58	7241	*Lactuca serriola L.*	Asteraceae	Therophyte	Microphyll	May-June	July
59	7163	*Launaea secunda (C.B.Clarke) Hook.f.*	Compositae	Therophyte	Mesophyll	July-August	October
60	7111	*Lepidium ruderale L.*	Brassicaceae	Therophyte	Nanophyll	July-August	September
61	7091	*Lotus corniculatus L.*	Fabaceae	Therophyte	Nanophyll	July-August	September
62	7096	*Malva parviflora*	Malvaceae	Therophyte	Microphyll	March-April	May
63	7049	*Marrubium vulgare*	Lamiaceae	Therophyte	Microphyll	May-June	July
64	7119	*Mentha longifolia (L.) L.*	Lamiaceae	Geophyte	Mesophyll	July-August	September
65	7066	*Micromeria biflora (Buch. -Ham.)*	Lamiaceae	Therophyte	Leptophyll	April-May	July
66	7112	*Mirabilis jalapa L.*	Nyctaginaceae	Therophyte	Mesophyll	August-September	November
67	7125	*Myosotis caespitosa Schultz*	Boraginaceae	Chamaephyte	Leptophyll	August	September
68	7148	*Myriactis nepalensis Less*	Compositae	Therophyte	Nanophyll	July-August	September
69	7242	*Nanorrhinum incanum (Wall.) Betsche*	Plantaginaceae	Therophyte	Microphyll	August-September	October
70	7132	*Nepeta linearis Royle ex Benth.*	Lamiaceae	hemicryptophytes	Nanophyll	August	September
71	7064	*Nepeta praetervisa Rech.f.*	Lamiaceae	Therophyte	Microphyll	August	September
72	7243	*Oenothera speciosa Nutt.*	Onagraceae	Therophyte	Nanophyll	July-August	September
73	7244	*Onopordum acanthium L.*	Asteraceae	Therophyte	Microphyll	July-August	September
74	7193	*Onosma hispidum Wall. ex G. Don*	Boraginaceae	Therophyte	Microphyll	April-May	June
75	7128	*Onychium japonicum (Thunb.) Kunze*	Pteridaceae	Geophyte	Nanophyll	June-July	August
76	7159	*Ophiopogon intermedius D.Don*	Asparagaceae	Chamaephyte	Microphyll	July-August	October
77	7102	*Oxalis corniculata L.*	Oxalidaceae	Therophyte	Nanophyll	April-May	June
78	7081	*Oxytropis humifusa Kar. & Kir.*	Leguminosae	hemicryptophytes	Leptophyll	June-July	August
79	7063	*Oxytropis mollis A.Gray*	Leguminosae	hemicryptophytes	Leptophyll	August-September	November

80	7043	*Parthenium hysterophorus L.*	Asteraceae	Therophyte	Mesophyll	June-July	August
81	7212	*Persicaria barbata (L.) H.Hara*	Polygonaceae	hemicryptophytes	Microphyll	June-July	August
82	7188	*Phagnalon niveum* Edgew.	Compositae	Therophyte	Nanophyll	April-May	July
83	7197	*Phlomis spectabilis* Falc. ex Benth.	Lamiaceae	Nanophanerophyte	Microphyll	June-July	August
84	7134	*Phyla nodiflora (L.) Greene*	Verbenaceae	Therophyte	Microphyll	August-September	November
85	7214	*Physalis divaricata D. Don*	Solanaceae	Therophyte	Microphyll	July-August	September
86	7172	*Plantago lanceolata L.*	Plantaginaceae	Therophyte	Microphyll	April-May	July
87	7104	*Polygala abyssinica R.Br. ex Fresen.*	Polygalaceae	Therophyte	Leptophyll	July-August	September
88	7129	*Polygonum polycnemoides Jaub. & Spach*	Polygonaceae	Hemicryptophytes	Leptophyll	April-May	August
89	7110	*Potentilla supina* L	Rosaceae	Chamaephyte	Leptophyll	April	June
90	7036	*Pseudoconyza viscosa* (Mill.)	Asteraceae	Chamaephyte	Macrophyll	March-May	June
91	7099	*Pseudogaillonia hymenostephana (Jaub. & Spach) Linchevskii*	Rubiaceae	Therophyte	Nanophyll	May-July	September
92	7245	*Ranunculus laetus Wall. ex* D.*Don*	Ranunculaceae	Therophyte	Microphyll	April	June
93	7156	*Rubia cordifolia L.*	Rubiaceae	Therophyte	Nanophyll	August	October
94	7083	*Rumex hastatus D. Don*	Polygonaceae	Nanophanerophyte	Microphyll	April-May	June
95	7135	*Salvia moorcroftiana Wall. ex Benth*	Lamiaceae	hemicryptophytes	Mesophyll	July-August	September
96	7040	*Salvia nubicola Wall. ex Sweet*	Lamiaceae	Therophyte	Mesophyll	July-August	October
97	7246	*Scrophularia polyantha Royle ex Benth*	Scrophulariaceae	Therophyte	Nanophyll	July-August	October
98	7247	*Serratula pallida DC*	Compositae	Therophyte	Microphyll	April-May	June
99	7151	*Solanum villosum* Miller	Solanaceae	Therophyte	Microphyll	May	July
100	7248	*Solanum nigrum L.*	Solanaceae	Therophyte	Microphyll	April-May	August
101	7249	*Solanum surattense Burm. f*	Solanaceae	Chamaephyte	Microphyll	September-October	December
102	7126	*Sonchus oleraceus* (L.) L	Compositae	Chamaephyte	Mesophyll	May-June	July
103	7103	*Sonchus asper (L.) Hill*	Asteraceae	Chamaephyte	Microphyll	June-July	September
104	7106	*Spergularia diandra (Guss.)*	Caryophyllaceae	Therophyte	Leptophyll	September-October	November
105	7250	*Stachys emodi* Hedge	Lamiaceae	Hemicryptophytes	Microphyll	June-July	September
106	7206	*Strobilanthes urticifolia* Wall. ex Kuntze	Acanthaceae	Therophyte	Nanophyll	June	July
107	7251	*Tagetes minuta L*	Asteraceae	Therophyte	Mesophanerophyte	March-April	May

108	7170	*Symphyotrichum grandiflorum*	Asteraceae	Hemicryptophytes	Microphyll	June-July	August
109	7046	*Taraxacum officinale (L.) Weber ex F.H.Wigg.*	Asteraceae	Therophyte	Mesophyll	June-July	August
110	7208	*Teucrium royleanum* Wall. ex Benth	Lamiaceae	Therophyte	Microphyll	August-September	October
111	7094	*Teucrium stocksianum* Boiss., Diagn	Lamiaceae	Therophyte	Microphyll	August	October
112	7153	*Tiaridium indicum (L.) Lehm.*	Boraginaceae	Hemicryptophytes	Nanophyll	August-September	October
113	7154	*Tribulus terrestris L.*	Zygophyllaceae	Therophyte	Nanophyll	April-May	August
114	7252	*Valeriana wallichii DC.*	Valerianaceae	Therophyte	Mesophyll	August	September
115	7211	*Verbascum thapsus L.*	Scrophulariaceae	Therophyte	Mesophyll	April-May	July
116	7065	*Verbena officinalis*	Verbenaceae	Therophyte	Macrophyll	May-June	July
117	7253	*Verbesina encelioides (Cav.) Benth. & Hook.f. ex A.Gray*	Asteraceae	Therophyte	Microphyll	August-September	November
118	7254	*Viola canescens* Wall. ex Roxb	Violaceae	Therophyte	Mesophyll	March-April	June
119	7141	*Viola aberrans Greene*	Violaceae	Therophyte	Microphyll	June-July	September
120	7071	*Viscum cruciatum Sieber ex Boiss*	Santalaceae	Hemicryptophytes	Microphyll	September-October	December
121	7138	*Withania coagulans (Stocks) Dunal*	Solanaceae	Chamaephyte	Microphyll	July-September	October
122	7202	*Withania somnifera (L.) Dunal*	Solanaceae	Nanophanerophyte	Mesophyll	August	September
123	7046	*Xanthium strumarium L.*	Asteraceae	Therophyte	Mesophyll	September-October	December

Table 4. List of plants' family names, life forms, leaf spectra, flowering periods, voucher numbers, and fruiting of grasses.

Sr. No.	Voucher No	Plant name	Family name	Life form	Leaf spectra	Flowering	Fruiting
1	7184	*Teucrium royleanum* Wall. ex Benth	Lamiaceae	Therophyte	Microphyll	August-September	October
2	7255	*Teucrium stocksianum* Boiss., Diagn	Lamiaceae	Therophyte	Microphyll	August	October
3	7256	*Tiaridium indicum (L.) Lehm.*	Boraginaceae	Hemicryptophytes	Nanophyll	August-September	October
4	7181	*Tribulus terrestris L.*	Zygophyllaceae	Therophyte	Nanophyll	April-May	August
5	7041	*Valeriana wallichii DC.*	Valerianaceae	Therophyte	Mesophyll	August	September
6	7042	*Verbascum thapsus L.*	Scrophulariaceae	Therophyte	Mesophyll	April-May	July
7	7074	*Verbesina encelioides (Cav.) Benth. & Hook.f. ex A.Gray*	Asteraceae	Therophyte	Microphyll	August-September	November

8	7183	*Verbena officinalis*	Verbenaceae	Therophyte	Macrophyll	May-June	July
9	7152	*Viola canescens* Wall. ex Roxb	Violaceae	Therophyte	Mesophyll	March-April	June
10	7039	*Viola aberrans Greene*	Violaceae	Therophyte	Microphyll	June-July	September
11	7082	*Viscum cruciatum Sieber ex Boiss*	Santalaceae	Hemicryptophytes	Microphyll	September-October	December

Table 5. List of plants'family names, life forms, leaf spectra, flowering periods, voucher numbers, and fruiting of ferns.

Sr. No.	Voucher No	Plant name	Family name	Life form	Leaf spectra	Flowering	Fruiting
1	7155	*Adiantum capillus-veneris f. rimicola (Sloss.) Fernald fern*	Pteridaceae	Geophyte	Microphyll	June-July	August
2	7139	*Asplenium dalhousiae Hook.*	Aspleniaceae	hemicryptophytes	Microphyll	Jun-July	September
3	7150	*Asplenium fontanum (L.) Bernh.*	Aspleniaceae	hemicryptophytes	Microphyll	August	September
4	7205	*Cheilanthes bicolor Fraser-Jenk*	Pteridaceae	hemicryptophytes	Nanophyll	July-August	September
5	7190	*Pteridium aquilinum (L.) Kuhn*	Dennstaedtiaceae	Geophyte	Macrophyll	May-June	July
6	7068	*Pteris cretica. L.*	Pteridaceae	Geophyte	Mesophyll	May-June	August

Table 6. List of plants' family names, life forms, leaf spectra, flowering periods, voucher numbers, and fruiting of climber.

Sr. No.	Voucher No	Plant name	Family name	Life form	Leaf spectra	Flowering	Fruiting
1	7056	*Boerhavia procumbens Banks ex Roxb*	Nyctaginaceae	Megaphanerophyte	Microphyll	June-July	September
2	7100	*Dioscorea deltoidea Wall. ex Griseb.*	Dioscoreaceae	Liana	Microphyll	May-June	July
3	7215	*Hedera* nepalensis - *K.Koch*	Araliaceae	Mesophanerophyte	Microphyll	August-September	October
4	7109	*Ipomoea eriocarpa R. Br*	Convolvulaceae	Therophyte	Microphyll	April	June
5	7164	*Origanum vulgare L.*	Lamiaceae	Therophyte	Nanophyll	June-July	October
6	7058	*Pupalia lappacea (L.) Juss.*	Amaranthaceae	Therophyte	Nanophyll	July-August	September
7	7258	*Rubia manjith Roxb. ex Fleming*	Rubiaceae	Megaphanerophyte	Microphyll	June-July	September

Table 7. List of plants' family names, life forms, leaf spectra, flowering periods, voucher numbers, and fruiting of Liana.

Sr. No.	Voucher No	Plant name	Family name	Life form	Leaf spectra	Flowering	Fruiting
1	7078	*Smilax glaucophylla* Klotzsch	Smilacaceae	Nanophanerophyte	Microphyll	November-December	February

Biological spectrum

The biological spectrum of the vegetation in the Biha Valley is detailed below.

Life form analysis

The analysis of plant species revealed a diverse array of life forms. The most prevalent were therophytes (annual plants that complete their life cycle within a single growing season) constituting 41% of the total with 84 species. Nanophanerophytes, woody plants ranging from 2 to 8 meters in height, followed at 13%, comprising 27 species. Hemicryptophytes, perennial plants with survival structures (like buds) located at or just below the soil surface, represented 12% with 24 species. Both megaphanerophytes (plants characterized by their tall stature, typically exceeding 30 meters about 98 feet in height) and chamaephytes, which have perennial stems growing close to the ground (typically under 25 cm in height), each accounted for 10% with 21 and 20 species, respectively.

Macrophanerophytes, which are woody plants typically exceeding 5 meters in height, including trees and large shrubs, made up 8% of the total, with 16 species. Geophytes, perennial plants that bear their perennating buds below the soil surface, comprised 6% with 13 species. Lianas, long-stemmed woody vines that root in the ground and use trees or other vertical structures to climb, were the least represented, with just 1 species, making up 1% of the total.

This distribution highlights the rich botanical diversity of the area, particularly the significant presence of annual plants, as shown in Tables, 6, 8, and Figure 1. The varied distribution of plant species underscores the ecological dynamics within the habitat. The dominance of Therophytes suggests an adaptation to seasonal climates, where these annual plants thrive during favorable conditions, rapidly completing their life cycles. Their prevalence indicates a strategy to capitalize on transient resources, such as water and light, which may be scarce during other times of the year (Khan, 2012).

In contrast, the presence of Nanophanerophytes and Hemicryptophytes highlights the significance of perennial forms, which are better suited to endure longer, less favorable periods. These life forms provide stability to the ecosystem, contributing to soil structure and serving as crucial resources for various fauna (Khan et al., 2011). Megaphanerophytes and Chamaephytes, while slightly less abundant, contribute significantly to vertical stratification within the plant community, providing habitat for numerous species and enhancing biodiversity (Shah et al., 2020). The Macrophanerophytes and Geophytes further enrich the landscape, with their distinctive adaptations allowing them to survive in various microhabitats (Siraj et al., 2018).

The minimal representation of Lianas, with just a single species present, is particularly intriguing (Nasrullah et al., 2015). This could indicate specific ecological constraints, such as limitations in host trees or competition with more dominant climbers. Their marginal presence suggests a niche that remains underexplored, highlighting opportunities for further research into the interactions between different plant species and their environment (Hazrat et al., 2020).

The data from this analysis not only underscores the rich botanical tapestry present in the area but also invites deeper investigation into the ecological roles these plants play, their interrelations, and their responses to environmental changes. The implications of such findings are crucial for conservation efforts and understanding the resilience of these ecosystems in the face of ongoing climatic shifts, as illustrated in Table, 7, 8, and Figure

Table 8: Life form classes of plant species recorded from Tehsil Timergara.

Sr. No.	Classes of life form	Numbers of spp.	% age
1	Megaphanerophyte	21	10%
2	Mesophanerophyte	16	8%
3	Nanophanerophyte	27	13%
4	Chamaephyte	20	10%
5	Hemicryptophyte	24	12%
6	Geophyte	13	6%
7	Therophyte	84	41%
8	Liana	1	1%

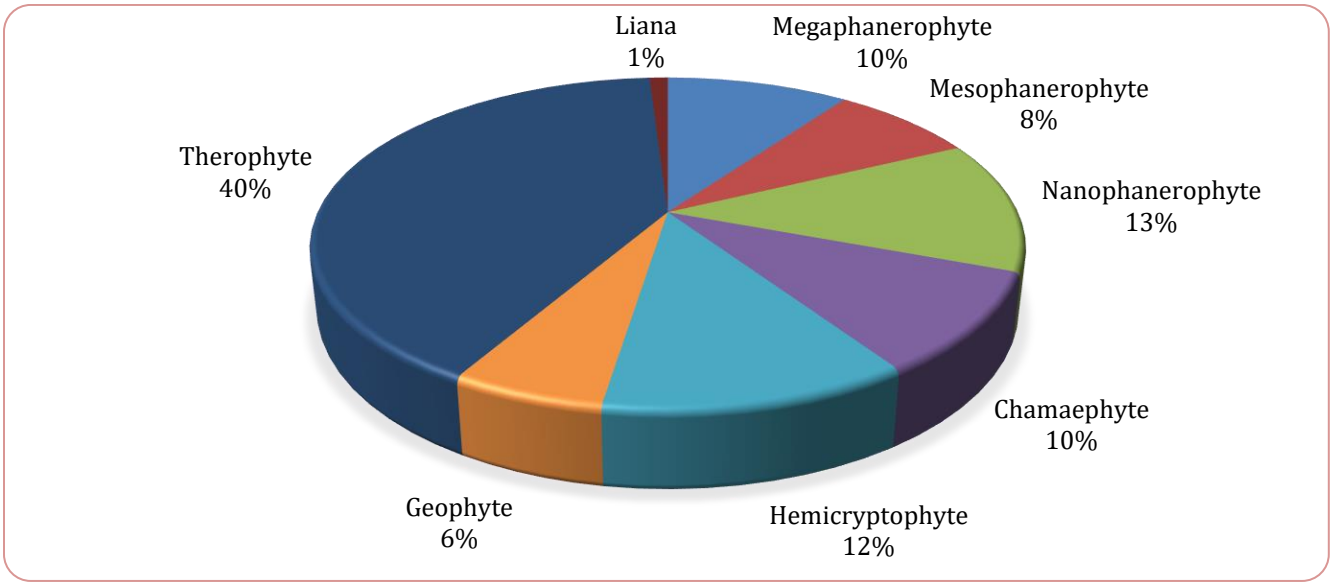

Figure 1. Graphical representation of life forms of Raunkiaer's classification based on the location of their perennating buds (Megaphanerophyte, Mesophanerophyte, Nanophanerophyte, Chamaephyte, Hemicryptophyte, Geophyte, Therophytes, and Liana) recorded from Tehsil Timergara.

Leaf spectra

The analysis of leaf size in the study area revealed a diverse range of foliage types among plant species. The dominant category was Microphylls (small, simple leaves with a single vascular trace), comprising about 39% of the total with 82 species, followed by Mesophyll (between Macrophyll and Microphyll) at 27% with 56 species. Nanophylls (leaf structures that are typically small and narrow), also had notable representation, accounting for 22% with 45 species. Smaller categories like Leptophylls (very thin slender leaves that are typically narrow, and elongated) comprised 7% of 14 species, while Macrophylls (large compared to other leaf types and have a broad, flat morphology) were less common at 4% of 8 species. The least prevalent category was Aphyllous (leafless plants), representing only 1% with one identified species. These plants have adapted to certain environments by lacking leaves to reduce water loss, often found in arid regions. This distribution underscores the predominance of smaller leaf sizes, specifically Microphylls, and Mesophylls, suggesting adaptations of the local flora to the environmental conditions of the research area (Table 9 and Figure 2).

Phenology

The phenology of the plant species was recorded through frequent monthly field trips (Tables 1, 2, 3, 4, 5 and Figure 2). During field observations in the research area, two distinct flowering seasons were noted. The first season spans from May to August, while the second extends from September to November, as shown in Figure 3. The duration of each flowering season varied among the plant species, with some exhibiting prolonged blooming periods and others displaying shorter timelines.

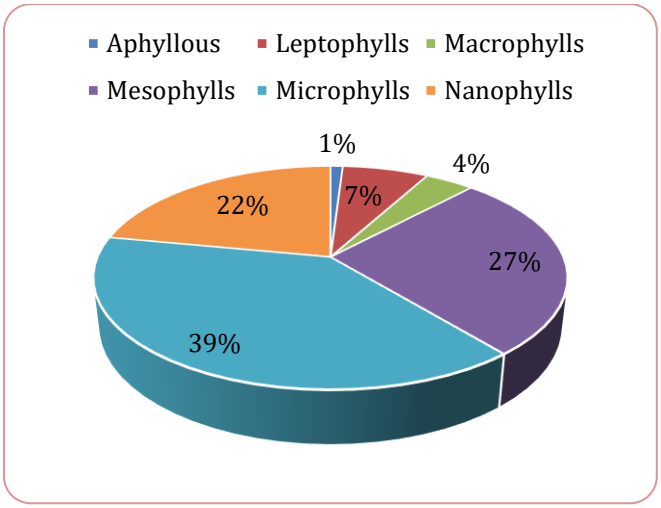

Figure 2. Graphical representation of leaf spectra of Raunkiaer's classification based on the size of the leaf (Aphyllous, Leptophyll, Macrophyll, Mesophyll, Microphyll, and Nanophyll) recorded in Tehsil Timergara.

For instance, Species A and Species B produced a higher number of flowers during the first season, peaking in July, as indicated by the data in Table 3. Conversely, Species C showed a remarkable resurgence in the latter flowering season, particularly in October, as depicted in Table 4 and further illustrated in Figure 2.

Table 9. Leaf spectra of plant species recognized from Tehsil Timergara.

Sr. No.	Classes of leaf spectra	Numbers of spp.	% age
1	Aphyllous	1	1%
2	Leptophylls	14	7%
3	Macrophylls	8	4%
4	Mesophylls	56	27%
5	Microphylls	82	39%
6	Nanophylls	45	22%

Additional observations indicated that environmental factors, including temperature and precipitation, played a crucial role in influencing the timing and intensity of flowering. For instance, unusually high rainfall in June appeared to hinder the flowering of several species, causing a delayed onset for some individuals. This trend is supported by the climatic data presented in Table 5, highlighting the correlation between weather patterns and phenological responses.

Furthermore, the potential impact of pollinators on flowering success was inferred throughout the study. Field notes suggested that insect activity varied significantly between the two seasons, with a notable increase in bee populations during the latter months, coinciding with the flowering of Species C. Figure 3 illustrates the relationship between flowering times and pollinator visits, underscoring the interconnectedness of these ecological factors.

The extensive field data collected provide valuable insights into the phenology of the targeted plant species. Ongoing monitoring and further research are essential to fully understand the implications of climate variability on their reproductive strategies and overall ecological health. Future studies could also explore the adaptive mechanisms these species may employ in response to changing environmental conditions (Shuaib et al., 2018).

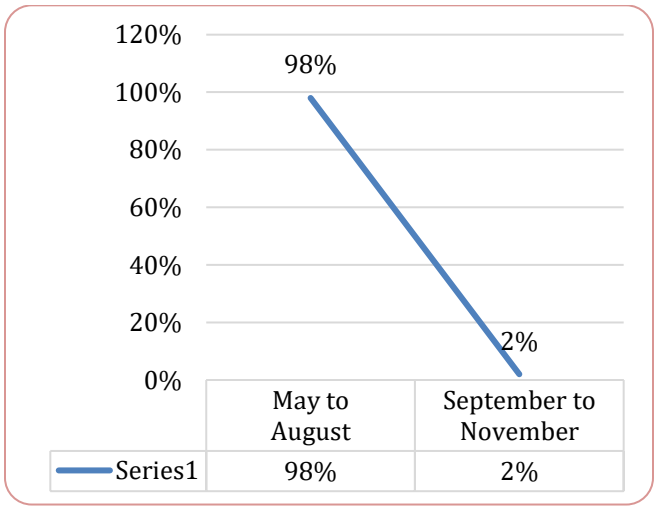

Figure 3. Flowering period of plant species in tehsil Timergara: observations from May to August and September to November.

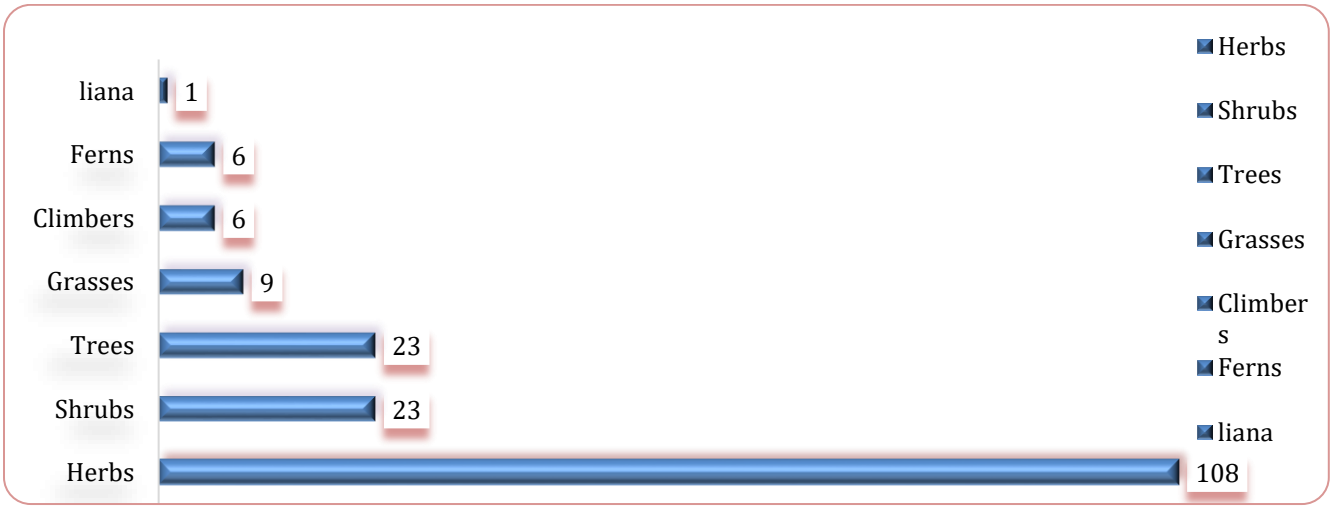

Figure 4. Flowering phases of herbs, shrubs, trees, and grasses in different seasons recognized from tehsil Timergara.

Flowering

The results showed that different species flowered at various times throughout the year. The main flowering period lasted from May to August, followed by a secondary phase from September to November, as illustrated in Tables 2 and 3, and Figures 1 and 2. During the primary season from May to August, 175 species (85%) were in bloom, including 108 herbaceous species (62%), 23 shrubs (13%), 23 trees (13%), 6 ferns (3%), 6 climbers (3%), and 9 grasses (6%). The secondary flowering season, from September to December, saw 29 species (15%) flowering, comprising 16 herbs, 7 trees, 4 shrubs, 2 grasses, and 1 each of climbers and lianas, with no ferns recorded. This information is presented in Figure 4.

Fruiting

Between May and August, 106 plant specimens were observed in their fruiting phase. Herbaceous plants were the majority, with 59 specimens (55%). Trees accounted for 21 specimens (20%), followed by shrubs with 17 (16%), grasses with 4 species (4%), climbers with 2 species (2%), ferns with 2 species (2%), and lianas with 1 species (1%). These data are shown in Tables 2 and 3 and Figures 1 and 2.

From September to November, 100 plant species (49% of the total) were in their fruiting stage, predominantly herbs with 65 specimens (65%). Shrubs included 10 species (10%), trees had 9 species (9%), climbers had 5 species (5%), grasses had 7 species (7%), and ferns had 4 species (4%). No liana species were recorded during this period, as illustrated in Figures 5 and 6.

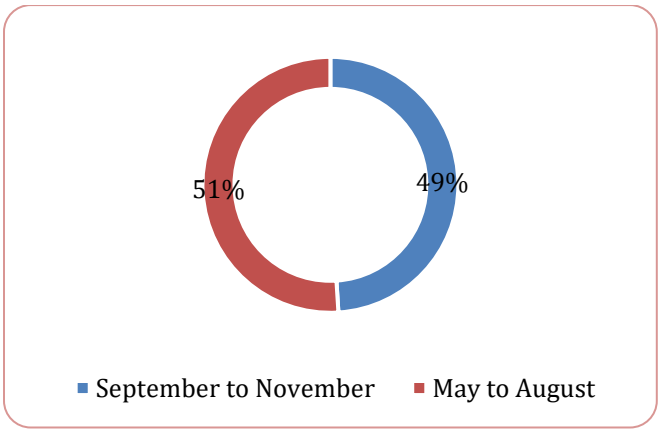

Figure 5. Fruiting of plant species recorded from tehsil Timergara.

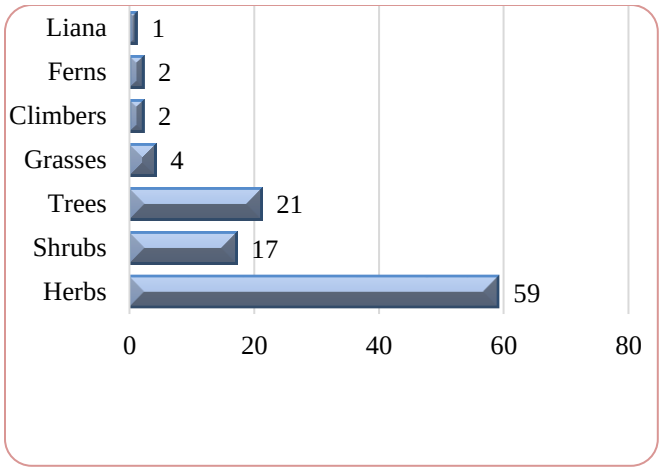

Figure 6. Fruiting of herbs, shrubs, trees, and grasses recognized in tehsil Timergara.

DISCUSSION

The floristic composition of district Dir Lower, as detailed in our results, aligns with findings from other studies conducted in similar climatic and geographical regions. The dominance of families such as Lamiaceae, Asteraceae, and Poaceae is a common occurrence in areas with temperate climates, as observed in studies by (Asim et al. 2016) and (Ullah et al. 2019b).

Our study identified 206 different specimens related to 182 genera and 82 families. The dominant family was Lamiaceae, which consists of 19 plant species, followed by Asteraceae (ca. 18 species) and Poaceae (ca. 11 species). Other significant families include Amaranthaceae (ca. 9 species), Rosaceae (ca. 8 species), Euphorbiaceae (ca. 7 species), and both Composite and Solanaceae, each comprising 6 plant species. Boraginaceae and Rubiaceae each have approximately 5 species. Families such as Apocynaceae, Fabaceae, Leguminosae, Malvaceae, Moraceae, Polygonaceae, and Pteridaceae each contain approximately 4 species. Acanthaceae, Cyperaceae, Ranunculaceae, and Scrophulariaceae each have approximately 3 species. Additionally, families including Asparagaceae, Aspleniaceae, Brassicaceae, Caryophyllaceae, Convolvulaceae, Nyctaginaceae, Onagraceae, Plantaginaceae, Primulaceae, Salicaceae, Verbenaceae, and Violaceae each have approximately 2 species (Ullah et al., 2021a).

The diversity of families and genera found in our study reflects the rich biodiversity of the region, a phenomenon also noted by Asim et al. (2016) in their study of the flora of Khyber Pakhtunkhwa. The biological

spectrum of the study area, particularly the prevalence of therophytes, indicates the region's Phyto climate. Therophytes, often abundant in areas with seasonal drought (Al-Yemeni et al., 2010; Ullah et al., 2021a), suggest a similar climatic influence in district Dir Lower. This finding corroborates the work of Fang et al. (2009), who reported a high percentage of therophytes in arid and semi-arid regions of Pakistan.

In terms of leaf spectra, the predominance of microphylls and mesophylls in the study area can be attributed to the region's specific environmental conditions, particularly light and moisture availability. The adaptation of smaller leaf sizes in plants has been associated with water conservation in arid conditions, as described by Mantovani et al. (2019). The presence of nanophanerophytes and hemicryptophytes highlights the significance of perennial forms, which are better suited to endure longer, less favorable periods (Ullah et al., 2021b). These life forms provide stability to the ecosystem, contributing to soil structure and serving as crucial resources for various fauna (Irfan et al., 2022).

Megaphanerophytes and chamaephytes, while slightly less abundant, contribute significantly to vertical stratification within the plant community, providing habitat for numerous species and enhancing biodiversity. The macrophanerophytes and geophytes further enrich the landscape, with their distinctive adaptations allowing them to survive in various microhabitats. The minimal representation of lianas, with just a single species present, is particularly intriguing. This could indicate specific ecological constraints, such as limitations in host trees or competition with more dominant climbers (Ullah et al., 2021a).

The phenological patterns observed, with two distinct flowering seasons, are consistent with the region's temperate climate. The primary flowering period from May to August coincides with the warmer and wetter months, facilitating pollination and growth, a pattern similar to findings in other temperate regions (Cortés-Flores et al., 2015). The secondary flowering season in the cooler months from September to November is less common but not unheard of, as also noted by (Rafferty, 2011) and (Ullah et al. 2021b). The fruiting patterns observed, with a higher fruiting rate from May to August, align with the flowering patterns and are crucial for seed dispersal and species survival. The decrease in fruiting species during the September to November period may be attributed to the onset of cooler temperatures, limiting plant growth and reproductive activity, as suggested by (Büntgen et al., 2022).

The floristic composition, biological spectrum, and phenological patterns observed in district Dir Lower provide valuable insights into the region's plant diversity and ecological dynamics. The results highlight the significance of seasonal variations and climatic factors in shaping the region's flora, aligning with patterns observed in other temperate regions worldwide.

CONCLUSION

The study area comprises 206 different specimens related to 182 genera and 82 families. The dominant family was Lamiaceae, followed by Asteraceae, Poaceae, Amaranthaceae (ca. 9 species), Rosaceae (ca. 8 species), Euphorbiaceae, Composite, Solanaceae, Boraginaceae, and Rubiaceae. The observed phenological patterns, with two distinct flowering seasons, align with the region's temperate climate. The floristic composition, biological spectrum, and phenological patterns in district Dir Lower provide valuable insights into the region's plant diversity and ecological dynamics. These results highlight the significance of seasonal variations and climatic factors in shaping the region's flora, consistent with patterns observed in other temperate regions worldwide.

FUTURE RECOMMENDATIONS

Future studies could further explore the implications of these patterns for the conservation and sustainable management of these diverse ecosystems.

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AUTHORS' CONTRIBUTIONS

SU and LS conceptualized the study design and research objectives; GS and MS analyzed and interpreted the botanical data; RZ and IK were responsible for planning and logistics of the fieldwork; MA and WHT contributed to the literature review and background research; SA.IZ wrote the manuscript, and HK proofread it.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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