**FIRST INSIGHT INTO THE FLORISTIC COMPOSITION, BIOLOGICAL SPECTRA, AND ECOLOGICAL FEATURES**

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**Abstract**

The present study was conducted to explore the floristic composition, biological spectrum, and ecological characteristics of the vegetation of Sultan Khail valley, Dir Upper, Pakistan. Regular trips were arranged during 2017–2019 to collect plant specimens and prepare a checklist of the flora of the area. The life form and leaf size spectra of vegetation were determined. The area is home to 332 species belonging to 234 genera and 96 families. Asteraceae (32 species, 9.7%) was the dominant family in the area, followed by Rosaceae (28 species, 8.5%) and Lamiaceae (21 species, 6.4%). Herbaceous flora (220 species) was found to be dominant in the region, followed by shrubs (54 species) and trees (48 species). Seasonal variation indicated that maximum numbers of species were found in the summer season. Therophytes were found to be dominant (126 species, 38%) in the area, followed by phanerophytes, while microphylls (107 species, 32.2%) were dominant in leaf size classes, followed by nanophylls (99 species, 29.8%). Seasonal variation in life forms showed that the spring, autumn, and winter season’s flora was dominated by phanerophytes (104 species, 41.8%), while therophytes were found dominant in the summer season. Seasonal variation in leaf size spectra showed that microphylls were dominant in the spring and summer seasons, while in the autumn and winter seasons, nanophylls were dominant. The highest numbers of species were found in dry places, followed by forests. The flora of the area is subjected to severe anthropogenic stress and needs proper conservation.

**Keywords** Floristic composition, life form, leaf size, habitat, Sultan Khail valley, Dir Upper, Pakistan

**Introduction**

Flora is an assembled checklist of all plant species growing in a particular geographical region (Amjad *et al.,* 2016). The floristic composition of a region represents the type, number, composition, population size, and distribution of plant species. For the study of biodiversity and understanding the prevailing climate, the knowledge of the flora of any area is important (Thakur *et al.,* 2012) and offers an effective starting point for more systematic studies (Khan *et al.,* 2017). A Floristic inventory is a taxonomic analysis of a major division of flora in a given area (Panda *et al.,* 2014). Floristic diversity describes physiognomy and ecological relations in a variety of environments (Catarino *et al.,* 2002). The life form of the plant is defined as the form that the vegetative body of the plant takes as a result of all life processes affected by the climate, whereas the biological spectrum is the proportion of various life form classes combined (Sharma & Sharma, 2018). The life form reflects the adaptation of plant species to particular ecological conditions. Species that have identical morphological characteristics are grouped under the same life form in response to environmental factors (Khalid, 2017). Life form and leaf size spectra are the key physiognomic features that indicate the micro and macroclimatic state and association of plants, as well as the anthropogenic disturbance in a specific region (Cain & Castro, 1959). Comprehensive life form research gives an idea of the physiological processes of plant communities (Oosting, 1956). The leaf size spectrum also provides an understanding of the floristic version, which is useful for exploring plant relationships about dominant climatic features and for studying flora at the local level (Rashid et al., 2011). The physiognomic properties of plants, such as life form and leaf size spectra, have been frequently used in vegetation research (Khalid, 2017). The life form represents climate adaptability and, therefore, the entire vegetation will be an indication of the dominant climate in particular (Al-Shaye *et al.,* 2020). However, biotic impacts such as overgrazing, agricultural operations, trampling, and deforestation may alter the percentage of different life forms (Badshah *et al.,* 2017).

Various researchers have investigated the floristic and biological spectrum in Pakistan and abroad (Sharma & Sharma,2018; Al-Shaye *et al.,* 2020; Al-Yemeni & Sher*,* 2010; Khalik *et al.,* 2013; Zhu *et al.,* 2019, Rahman *et al.,* 2018; Ullah & Badshah*,* 2017; Ibrahim *et al.,* 2019;Anjum *et al.,* 2020;Zaman & Badshah*,* 2021 andNafeesa *et al*., 2021). However, no such work has been conducted in the Sultan Khail valley, Dir Upper, Pakistan. Therefore, the present study aimed to explore the floristic inventory, ecological characteristics, and biological spectrum of vegetation of the Sultan Khail valley, Dir Upper Pakistan. Such information is scanty and so no such study is conducted in the target area. In the present study, the following questions were answered: (1) what is the current floristic composition, life form spectrum, and leaf size spectrum of the study area? (2) What is the habitat condition of the area? (3) What is the phytoclimate of the study area? (4) Is there any similarity in the floristic structure and biological spectrum of the area with other areas in Pakistan and abroad? This study will be helpful for further research on the flora of the valley.

**Materials and Methods**

*Study area*

The beautiful Sultan Khail valley is situated in Dir Upper, Khyber Pakhtunkhwa, Pakistan. It lies in Pakistan's subtropical dry temperate zone (Champion *et al.,* 1965). The area can be counted phytogeographically in the Sino-Japanese region (Ali & Qaiser, 1986) It lies between 34°59’339", 35°59’870" North latitude and 71°00’176", 72°00’036"East longitude. The area is mostly dominated by hills and mountains that are a part of the Hindu Kush range of Pakistan. The altitude of the area varies from 1015 meters to 3230 meters. The highest peak in the valley is Shekly Top. The valley is bordered by the rivers Panjkoro and Nehag Dara in the East, Dir Lower (Maidan) in the West, Jelar Valley in the South, and Kair Dara in the North (Figure 1). The climate of the study area is influenced by various topographic and ecological variables. Spring, summer, autumn, and winter are the four distinct seasons of the year in the area. The winter season is very cold and severe and starts in the middle of November when the temperature falls abruptly. The summer season in the valley is typically moderate, with June and July being the hottest months of the year. The average maximum temperature reaches 35.5 C to 35.9 C in June and July, while in January the mean minimum temperature falls below zero (-1.3) degrees centigrade. The relative humidity is moderately high throughout the year. The area receives maximum rainfall in February (6.7mm), March (8.2mm), and August (8.6mm). Snow usually begins to fall in the upper parts of the valley in December and gradually descends as the temperature decreases in January and February. Depending on elevation, snowmelt starts in the valley in March and continues into April *(*Meteorological station data Dir Upper, 2017-2019).



**Figure 1** **Location map of Sultan Khail valley, Dir Upper, Pakistan.**

*Data collection and analysis*

From 2017 to 2019, regular trips were arranged in different seasons of the year to conduct data for the preparation of a floristic checklist of the Sultan Khail valley, Dir Upper, Pakistan. The collected specimens of plant species were preserved and identified with the help of the flora of Pakistan, compiled in alphabetical order, and deposited at the Herbarium, Department of Botany, Islamia College, Peshawar. The collected plant species were divided into different life form classes (Raunkiaer, 1934; Husain, 1989)using the formulas:

$$Life form spectra=\frac{ (Number of species in each life form class) }{Total number of species }x100$$

$$ Leaf size spectra=\frac{ Number of species found in a specific leaf size class }{Total number of species}x100$$

 Plant species were also classified based on their habitat (Ullah & Badshah, 2017).

**Results and discussion**

***Floristic composition***

The flora of the Sultan Khail valley is found to be diverse and home to 332 species belonging to 235 genera and 96 families (Table 1). Angiosperms were represented by 302 species (Dicots, 275 species; Monocots, 27 species), while Gymnosperms (8 species) and pteridophytes (22 species) were less predominant. Asteraceae was the dominant family in the area (32 species, 9.7%), followed by Rosaceae (28 species, 8.5%), Lamiaceae (21 species, 6.4%), Fabaceae (13 species, 3.9%), and Poaceae (12 species, 3.6%) (Figure 2). Among the others, two families contributed 8 species (2.4%) and four families contributed 7 species for each while the remaining families were represented by a lower number of species. A similar study was conducted by (Al-Shaye *et al.* (2020) in the Riyadh region of Saudi Arabia and reported 172 plant species (37 families) in which Asteraceae (17.4%) was reported as dominant, followed by Poaceae (11%), Brassicaceae and Fabaceae, while Anjum *et al.* (2020) reported 154 plant species in 39 families from Karkhasa (Baluchistan) and found Asteraceae the dominant family, followed by Poaceae. Ibrahim *et al*. (2019) explored the flora of Takht Bhai and listed 140 species in 63 families. They also found the family Asteraceae dominant, followed by Poaceae and Solanaceae. Ullah & Badshah (2017) reported 250 species in 77 families in the Jelar Valley Dir upper, in which Asteraceae and Lamiaceae were dominant, followed by Rosaceae and Fabaceae. Our findings strongly coincide with(Singh *et al.,* 2019), who found Asteraceae as the dominant family followed by Rosaceae, Lamiaceae, and Poaceae in Jammu and Kashmir. Similarly, Haq *et al.* (2019) also found Rosaceae, the largest family followed by Asteraceae and Lamiaceae in the Keran valley, north-western Himalaya. The dominance of Asteraceae in the target area as well as in the world represents its wide range of ecological amplitude (Al-Shaye *et al.,* 2020; Jeffrey *et al.,* 1978). In gymnosperms, Pinaceae was the leading dominant family while Dryopteridaceae was the richest family of Pteridophytes (Table 1). The present findings are in line with (Khan *et al.,* 2017; Sher *et al.,* 2010*;* Hadi *et al.,* 2019*)* reported similar findings from Swat (Ranizai and Miandam valleys) and Chitral (Kalash valley).

**Figure 2 Top twelve plant families and their contribution to species in the study area.**

**Table 1. Floristic composition, biological spectrum, and ecological characteristics of flora of Sultan Khail valley, Dir Upper, Pakistan**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. no.** | **Taxon** | **Habit** | **Life form** | **Leaf form** | **Habitat** | **Seasonality** |
| **Spring** | **Summer** | **Autumn** | **Winter** |
|  | **Pteriddophytes** |
| **1** | **Adiantaceae** |
| 1 | *Adiantum capillus-veneris* L. | H | Hem | Nan | Mp-Rc | + | + | + | + |
| 2 | *Adiantum incisum* Forssk. | H | Hem | Lep | Mp-Rc | + | + | + | + |
| 3 | *Adiantum venustum* D.Don. | H | Hem | Nan | Mp-F | + | + | + | + |
| **2** | **Aspleniaceae** |
| 4 | *Asplenium adiantum-nigrum* L. | H | Hem | Nan | Mp-Rc | + | + | + | + |
| 5 | *Asplenium septentrionale* (L.) Hoffmann. | H | Hem | Lep | Wp | + | + | + | - |
| 6 | *Asplenium trichomanes* L. | H | Hem | Lep | Mp-Rc | + | + | + | + |
| 7 | *Ceterach dalhousiae* (Hk.) C. Chr. | H | Hem | Nan | Mp-F | + | + | + | + |
| **3** | **Cystopteridaceae** |
| 8 | *Cystopteris fragilis* (L.) Bernh. | H | Geo | Mic | Wp | + | + | + | + |
| **4** | **Dryopteridaceae** |
| 9 | *Dryopteris odontoloma* (Moore.). | H | Hem | Lep | Mp-F | + | + | + | + |
| 10 | *Dryopteris serrato-dentata* (Bedd.) Hayata. | H | Hem | Lep | Mp-Rc | + | + | + | - |
| 11 | *Dryopteris sieboldii* L. | H | Hem | Lep | Wp | + | + | + | - |
| 12 | *Hypodematium crenatum* (Forssk.) Kuhn. | H | Hem | Lep | Mp | + | + | + | - |
| 13 | *Polystichum discretum* (D. Don) J. Sm. | H | Hem | Nan | Mp-Rc | + | + | + | + |
| 14 | *Polystichum lonchitis* (L.) Roth. | H | Hem | Nan | Mp-Rc | + | + | + | + |
| 15 | *Polystichum wilsonii* Christ. | H | Hem | Nan | Wp-Rc | + | + | + | + |
| **5** | **Equisetaceae** |
| 16 | *Equisetum arvense* L. | H | Hem | Lep | Wp | + | + | + | - |
| 17 | *Equisetum ramossimum* Desf. | H | Geo | Aph | Mp | + | + | + | - |
| **6** | **Pteridaceae** |
| 18 | *Pteridium aquilinum* (L.) Kuhn. | H | Geo | Mic | Wp-F | + | + | + | + |
| 19 | *Pteris cretica* L. | H | Hem | Mic | Mp | + | + | + | + |
| 20 | *Pteris vitata* L. | H | Hem | Mic | Mp-Rc | + | + | + | + |
| 21 | *Onychium Contiguum* Wall ex. Hope | H | Geo | Mic | Wp | + | + | + | - |
| 22 | *Cheilanthes pteridioides* (Reichard.) C. Chr. | H | Hem | Nan | Wp | + | + | + | + |
|  | **Gymnosperm** |
| **1** | **Cupressaceae** |
| 23 | *Cupressus sempervirens* L. | T | Phen | Lep | CU | + | + | + | + |
| 24 | *Juniperus communis* L. | S  | Phen  | Lep | F | + | + | + | + |
| **2** | **Pinaceae** |
| 25 | *Picea smithiana* (Wall.) Boiss. | T  | Phen | Nan | F | + | + | + | + |
| 26 | *Pinus roxburghii* Sargent | T  | Phen | Nan | Drp-Rp | + | + | + | + |
| 27 | *Pinus wallichiana* A.B. Jackson. | T  | Phen | Nan | F | + | + | + | + |
| 28 | *Abies pindrow* Royle. | T | Phen | Nan | F  | + | + | + | + |
| 29 | *Cedrus deodara* (Roxb. Ex. D. Don) G. Don | T | Phen | Nan | F | + | + | + | + |
| **3** | **Taxaceae** |
| 30 | *Taxus wallichiana* Zucc. | T | Phen | Nan | F | + | + | + | + |
|  | **Angiosperm** |
|  | **Monocotyledonae** |
| **1** | **Alliaceae** |
| 31 | *Allium cepa* L. | H | Geo | Mes | CU | + | + | - | + |
| 32 | *Allium sativum* L. | H | Geo | Mes | CU | + | + | - | + |
| **2** | **Amaryllidaceae** |
| 33 | *Narcissus tazetta* L. | H | Geo | Mic | G | + | - |  - | + |
| **3** | **Araceae** |
| 34 | *Arisaema flavum* (Forssk.) Schott | H | Geo | Mes | Mp-Sp | + | + | - | - |
| 35 | *Arisaema jacquemontii* Blume. | H | Geo | Mes | F | + | + | + | - |
| 36 | *Sauromatum venosum* (Dryand. ex Aiton) Kunth | H | Geo | Mes | Drp | + | + | - | - |
| **4** | **Asparagaceae** |
| 37 | *Asparagus gracilis* Royle | S | Ther | Lep | Drp | + | + | + | + |
| **5** | **Colchicaceae** |
| 38 | *Colchicum luteum* Baker. | H | Geo | Nan | Drp | + | - | - | + |
| **6** | **Commelinaceae** |
| 39 | *Commelina benghalensis* L. | H | Ther | Mic | Mp-Sp | - | + | - | - |
| **7** | **Cyperaceae** |
| 40 | *Cyperus rotundus* L. | H | Ther  | Nan |  Mp | + | + | - | - |
| **8** | **Liliaceae** |
| 41 | *Gagea elegans* Wall. ex Royle | H | Geo | Nan | Af-Drp | + | - | - | - |
| 42 | *Polygonatum verticillatum* All. | H | Geo | Mic | Mp  | + | + | - | - |
| 43 | *Tulipa stellata* HK. | H | Geo | Lep | Af | + | - | - | - |
| **9** | **Orchidaceae** |
| 44 | *Aristida cyanantha* Nees ex steud.  | H | Hem | Mic | Drp | + | + | - | - |
| **10** | **Poaceae** |
| 45 | *Apluda mutica* L. | H | H | Nan | Af-Drp | - | + | - | - |
| 46 | *Avena fatua* L. | H | Ther  | Mic | Af | + | + |  - | - |
| 47 | *Cynodon dactylon* (L.) Pers. | H | H | Lep | Drp-Af | - | + | + | - |
| 48 | *Dicanthium annulatum* (Forssk.) Stapf. | H | Hem | Nan | Af | + | - | - | + |
| 49 | *Hordeum vulgare* L. | H | Hem | Mic | Af | + |  - | - | + |
| 50 | *Oryza sativa* L. | H | Ther | Mic | CU | - | + | + | - |
| 51 | *Setaria viridis* (L.) P. Beauv. | H | Ther | Nan | Drp | - | + | + | - |
| 52 | *Sorgham helipense* (L.) Persoon | H | Hem | Mic | Af | + | + | - | - |
| 53 | *Themeda anathera* ( Nees) Hack. | H | Hem | Nan | Drp | - | + | + |  - |
| 54 | *Triticum aestivum* L. | H | Ther | Mic | CU | + |  - | - | + |
| 55 | *Zea mays* L. | H | Ther | Mes | CU | - | + | - | - |
| 56 | *Cenchrus ciliaris* L.  | H | Ther  | Nan | Drp | + | + | + | + |
| **11** | **Smilacaceae** |
| 57 | *Smilax glaucophylla* Klotzsch. | C  | Phen | Mes | Epi | + | + | + | + |
|  | **ii. Dicotyledonae** |
| **1** | **Acanthaceae** |
| 58 | *Dicliptera bupleuroides* Nees | H | Hem | Mes | Wap | + | + | + | - |
| **2** | **Aceraceae** |
| 59 | *Acer Caesium* Wall ex Brandis | T | Phen | Mac | G | + | + | + | + |
| **3** | **Amaranthaceae** |
| 60 | *Achyranthes bidentata* Blume. | H | Ther | Mic | Wap | + | - | - | + |
| 61 | *Alternanthera pungens* Kunth. | H | Ther | Mic | Wap | + | + | - | - |
| 62 | *Amaranthus caudatus* L. | H | Cham | Mic | Wap | - | + | + | - |
| 63 | *Amaranthus spinosus* L. | H | Therer | Mic | Wap | + | + | - | - |
| 64 | *Amaranthus viridis* L. | H | Therer | Mic | Drp | + | + | - | - |
| **4** | **Anacardiaceae** |
| 65 | *Pistacia chinensis* Bunge. | T | Phen | Mic | F-G | + | + | + | + |
| 66 | *Rhus punjabensis* J. L.  | T | Phen | Mes | F | + | + | + | + |
| **5** | **Apiaceae** |
| 67 | *Aegopodium burttii* Nasir. | H | Hem | Mic | F | - | + | + | - |
| 68 | *Bupleurum atroviolaceum* (O.E.Schulz) Nasir | H | Ther | Mic | F | - | + | + | - |
| 69 | *Bupleurum falcatum* L. | H | Ther  | Mic | F | - | + | + | - |
| 70 | *Bupleurum longicaule* Wall. ex DC. var. ramosum Nasir | H | Ther  | Mic | Drp | - | + | + | - |
| 71 | *Chaerophyllum Reflexum* Aitch. | H | Hem | Mic | Rc | + | + | - | + |
| 72 | *Coriandrum sativum* L. | H | Ther | Lep | CU | - | + | + | - |
| 73 | *Foeniculum vulgare* Mill. | H | Ther | Nan | CU | - | + | + | - |
| 74 | *Scaligeria indica* Wolff  | H | Cham | Nan | F | + | + | - | - |
| **6** | **Apocynaceae** |
| 75 | *Nerium oleander* L. | S | Phen | Mes | Mp | + | + | + | + |
| **7** | **Araliaceae** |
| 76 | *Hedera nepalensis* K. Koch. | C  | Phen | Mes | F | + | + | + | + |
| **8** | **Asclepiadaceae** |
| 77 | *Oxystelma esculentum* R. Br. | H  | Cham | Lep | Drp | - | + | + | + |
| 78 | *Calotropis procera* (Willd.) R. Brown | S | Cham | Mes | Drp | + | + | + | + |
| 79 | *Periploca aphylla* Dcne. | S | Phen | Aph | Rp | + | + | + | + |
| **9** | **Asteraceae** |
| 80 | *Anaphalis boissieri* E. Georg. | H | Ther | Nan | Drp | - | + | + | - |
| 81 | *Anaphalis margaritacea* (L.) Benth. | H | Hem | Nan | Af-Drp | + | + | + | - |
| 82 | *Anaphalis nepalensis* (spring). Hangs.-Mazz | H | Ther | Nan | Drp | + | + | + | - |
| 83 | *Anaphalis triplinervis* (Sims.) C.B. Clarke. | H | Geo | Mes | Af-Drp | - | + | + | - |
| 84 | *Artemisia absintnium* L. | H | Cham | Nan | Drp | - | + | + | - |
| 85 | *Artemisia biennis* Wild. | H | He  | Mic | Drp | + | + | + | - |
| 86 | *Artemisia dubia* Wall.ex Besser | H | Cham | Lep | Drp | + | + | + | - |
| 87 | *Artemisia santolinifolia* Turez ex Krasch | H | Cham | Nan | Rp-G | - | + | + | - |
| 88 | *Artemisia scoparia* Waldst. & Kit. | H | Ther | Nan | Drp | + | + | - | + |
| 89 | *Aster flaccidus* Bunge | H | Ther | Nan | Drp | + | + | + | - |
| 90 | *Aster mulliuscus* Wall. | H | Ther | Mic | Drp | + | - | - | - |
| 91 | *Bidens biternata* (Lour.) Merrill & Scheriff | H | Ther  | Mic | Mp | + | + | + | - |
| 92 | *Calendula arvensis* L. | H | Ther | Mic | Drp | + | - | - | - |
| 93 | *Cirsium falconeri* (Hook. F.) Petrak | H | Ther | Mes | Drp | + | + | - | + |
| 94 | *Cirsium vulgare* (Savi) Ten. | H | Ther | Mes | Drp | + | + | - | + |
| 95 | *Conyza canadensis* (L.) Corgn. | H | Ther | Nan | Mp-Wap | + | + | + | - |
| 96 | *Erigeron multiradiatus* (Lindl.) Benth | H | Ther | Lep | Drp | - | + | + | - |
| 97 | *Filago hardwarica* (Wall ex DC.) Wagenitz | H | Ther | Lep | Drp | + | + | + | - |
| 98 | *Galinosoga parviflora* Cav. | H | Ther | Mic | Af | - | + | + | - |
| 99 | *Helianthus anus* L. | H | Ther | Mes | CU | - | + | - | - |
| 100 | *Helianthus tuberosus* L. | H | Ther | Mes | Drp | + | + | + | + |
| 101 | *Lentopodium himalayanum* DC. | H | Hem | Lep | F | - | + | + | - |
| 102 | *Onopordum acanthium* L. | H | Ther | Mes | Af-Drp | + | + |  - | - |
| 103 | *Prenanthes stewartii* Roohi Bano & Qaiser | H | Ther | Nan | F | + | + | + | - |
| 104 | *Senecio chrysanthemoides* DC. | H | Ther | Mes | Rp | + | + | - | - |
| 105 | *Solidago virgaurea* L. | H | Hem | Mic | Wap | - | + | - | - |
| 106 | *Sonchus arvensis* L. | H | Ther | Mes | Af  | - | + | - | - |
| 107 | *Sonchus asper* (L.) Hill. | H | Ther | Mes | Mp-Wap | + | + | - | - |
| 108 | *Sonchus oleraceus* L. | H | Ther | Mic | Wp-Mp | + | + | - | - |
| 109 | *Tagetes minuta* L. | H | Ther | Mic | Drp and F | + | + | - | - |
| 110 | *Taraxacum officinale* Weber. | H | Ther | Mic | Wap | + | + | - | - |
| 111 | *Xanthium strumarium* L. | H | Ther | Mes | Wap | + | + | - | - |
| **10** | **Balsaminaceae** |
| 112 | *Impatiens bicolor* Royle. | H | Ther | Mes | Mp-Rp | - | + | + | - |
| 113 | *Impatiens brachycentra* Kar. & Kir. | H | Ther | Mic | Mp-Rp | - | + | - | - |
| 114 | *Impatiens egeworthii* Hook. f. | H | Ther  | Mes | Wp | + | + | - | - |
| 115 | *Impatiens fliemingii* Hook. F. | H | Ther | Mes | Mp | - | + | + | - |
| **11** | **Berberidaceae** |
| 116 | *Berberis lycium* Royle | S | Phen | Nan | Rp-F | + | + | + | + |
| 117 | *Berberis pseudumbellata* Parker ssp pseudumbellata | S | Phen | Nan | Rp-F | + | + | + | + |
| **12** | **Betulaceae** |
| 118 | *Alnus nitida* (Spach). Endl. | Tree | Phen | Mes | Wp | + | + | + | + |
| 119 | *Betula utilis* D. Don. | T | Phen | Mes | F-Rp | + | + | + | + |
| **13** | **Boraginaceae** |
| 120 | *Cynoglossum glochidiatum* Wall. Ex Benth. | H | Ther | Mic | Drp | + | + |  - | - |
| 121 | *Cynoglossum lanceolatum* Forssk. | H | Ther | Mic | Drp | + | + | - | - |
| 122 | *Heliotropium undulatum var. suberosa* Clarke. · | H | Geo | Lep | Drp | - | + | + | - |
| 123 | *Myosotis alpestris* F. W. Schmidt var. albicans (H.Riedl) Y.Nasir. | H | Hem | Mic | F | + | + | - | - |
| 124 | *Onosma dichronata* Boiss. | H | Ther  | Mic | Drp | + | - | - | + |
| 125 | *Onosma hispida* Wall e G. Don, Gen. | H | Ther  | Mic | Drp | + | - |  - | + |
| 126 | *Pseudomertensia nemorosa* (A. DC.) Stewart & Kazmi | H | Ther | Nan | F | + | + | + | - |
| **14** | **Brassicaceae** |
| 127 | *Coronopus didymus* (L.) Sm. | H | Ther  | Nan | Wap-Af  | + | + | + | + |
| 128 | *Farsetia jaquemontii* Hook.f. & Thomson. | H | Cham | Nan | F | + | + | - | + |
| 129 | *Nasturtium officinale* R. Br. | H | Geo | Mic | Wp | + | + | + | + |
| 130 | *Raphanus sativus* L. | H | Ther | Mac | CU | + | - | - | + |
| 131 | *Thlaspi arvense* L. | H | Ther | Nan | Wap | + | + | - | + |
| 132 | *Thlaspi griffithianum* Boiss | H | Ther | Nan | Wap | + | + | - | + |
| 133 | *Verbascum thapsus* L. | H | Ther | Meg | Drp | + | - | - | + |
| **15** | **Buxaceae** |
| 134 | *Sarcococca saligna* (Don) Muell. | S | Phen | Mic | Mp-Sp | + | + | + | + |
| **16** | **Caesalpinaceae** |
| 135 | *Cleome viscosa* L. | H | Ther | Mic | Mp | + | + | + | - |
| **17** | **Campanulaceae** |
| 136 | *Campanula aristata* Wallich | H | Hem | Nan | Af-Drp | + | + | - | - |
| **18** | **Cannabaceae** |
| 137 | *Cannabis sativa* L. | H | Ther | Mic | Wap | + | + | + | - |
| **19** | **Caprifoliaceae** |
| 138 | *Viburnum grandiflorum* Wall. ex DC. | S | Phen | Mes | F | + | + | + | + |
| 139 | *Viburnum cotinifolium* D.Don. | S | Phen | Mic | F | + | + | + | + |
| 140 | *Viburnum mullaha* Buch. Ham . ex D.Don. | S | Phen | Mes | F | + | + | + | + |
| **20** | **Caryophyllaceae** |
| 141 | *Arenaria serpyllifolia* L. | H | Ther | Lep | Mp | - | + | + | - |
| 142 | *Gypsophila cerastioides* D.Don | H | Ther | Nan | Mp | + | + | + | - |
| 143 | *Silene vulgaris* (Moench) Garcke | H | Ther  | Nan | Drp | + | + | - | - |
| **21** | **Celastraceae** |
| 144 | *Maytenus royleanus* (Wall. ex Lawson.) Cufedintis. | S | Phen | Mic | Drp | + | + | + | + |
| 145 | *Maytenus Wallichiana* (Springe) Raju & Bull. | S | Phen | Mic | Drp | + | + | + | + |
| **22** | **Chenopodiaceae** |
| 146 | *Chenopodium foliosum* Aschers. | H | Ther | Nan | Drp | + | + | - | - |
| 147 | *Chenopodium album* L. | H | Ther  | Mes | Wap | + | + | - | - |
| 148 | *Chenopodium ambrosioides* L | H | Ther | Mes | Wap | + | + | - | - |
| 149 | *Chenopodium botrys* L. | H | Ther | Mic | Wap | + | + | - | - |
| **23** | **Crassulaceae** |
| 150 | *Sedum hispanicum* L. | H | Hem | Nan | Mp | - | + | - | - |
| **24** | **Cucurbitaceae** |
| 151 | *Luffa cylindrica* (L) Roem | C  | Ther | Mes | CU | - | + | + | - |
| 152 | *Cucumis melo var. agrestis* Naudn, Ann. | C | Ther  | Mic | Drp | - | + | + | - |
| 153 | *Cucumis sativus* L. | C | Ther | Mac | CU | - | + | - | - |
| 154 | *Cucurbita maxima* Duch. Ex Lam. | C | Ther | Meg | CU | - | + | - | - |
| 155 | *Cucurbita pepo* L. | C | Ther | Meg | CU | - | + | - | - |
| **25** | **Ebenaceae** |
| 156 | *Diospyros kaki* L. | T | Phen | Mes | Mp | + | + | + | + |
| 157 | *Diospyros lotus* L. | T | Phen | Mes | Mp | + | + | + | + |
| **26** | **Ericaceae** |
| 158 | *Gaultheria trichophylla* Royle | S | Cham  | Lep | F | + | + | + | + |
| 159 | *Rhododendron hypenanthum* Balf. f. | S | Phen | Mic | F | + | + | + | + |
| **27** | **Euphorbiaceae** |
| 160 | *Chrozophora tinctoria* (L.) Raf. | H | Ther | Mic | Drp | + | + | - | + |
| 161 | *Euphorbia helioscopia* L. | H | Ther | Nan | Af-Drp | - | - | + | + |
| 162 | *Euphorbia peplus* L.  | H | Ther | Lep | Af-Drp | - | - | + |  - |
| 163 | *Andrachne cordifolia* (Wall.ex Dcne.) Muell. Avg. | S | Phen | Mic | Mp-Sp | + | + | + | + |
| 164 | *Ricinus communis* L. | S | Phen | Mic | Drp | + | + | + | + |
| **28** | **Fagaceae** |
| 165 | *Quercus baloot* Griffth. | T | Phen | Mic | F-Drp | + | + | + | + |
| 166 | *Quercus dilatata* Royle. | T | Phen | Mic | Drp-Rp | + | + | + | + |
| 167 | *Quercus incana* Roxb. | T | Phen | Mic | F-Drp | + | + | + | + |
| **29** | **Fumaraceae** |
| 168 | *Fumaria indica* (Hausskn.) H.N. | H | Ther | Lep | Drp | + | - | - | + |
| **30** | **Gentianaceae** |
| 169 | *Swertia cordata* (G.Don) Clarke | H | Ther | Lep | Drp-F | - | + | + | - |
| **31** | **Geraniaceae** |
| 170 | *Erodium cicutarium* L. | H | Ther  | Mes | Wp | + | + | - | + |
| 171 | *Geranium colinum* Sweet. | H | Hem | Mic | F | - | + | + | - |
| 172 | *Geranium ocellatum* Camb. | H | Ther | Mic | F | + | + | - | - |
| 173 | *Geranium pussillum* Burm. | H | Ther | Mic | F | + | + |  - | - |
| 174 | *Geranium wallichianum* D. Don. Ex Sweet | H | Ther | Mic | F | + | + | + | - |
| **32** | **Grossulariaceae** |
| 175 | *Ribes alpestre* Dcne. | S | Phen | Nan | F | + | + | + | + |
| **33** | **Hamamelidaceae** |
| 176 | *Parrotiopsis jacquemontiana* (Dcne.) Rehder. | S | Phen | Mes | F | + | + | + | + |
| **34** | **Hippocastinaceae** |
| 177 | *Aesculus indica* (Wall Ex. Camb.)Hk. F.) | T | Phen | Mes | Mp  | + | + | + | + |
| **35** | **Hypericaceae** |
| 178 | *Hypericum oblongifolium* Choisy | S | Phen | Nan | F | + | + | + | + |
| 179 | *Hypericum perforatum* L. | H | Cham | Nan | F | - | + | + | - |
| **36** | **Juglandaceae** |
| 180 | *Juglans regia* L. | T | Phen | Mic | Drp | + | + | + | + |
| **37** | **Lamiaceae** |
| 181 | *Ajuga bracteosa* Wall. ex Benth. | H | Hem | Mic | Drp | + | + | + | - |
| 182 | *Calamintha umbrosa* (M.Bieb.) Fisch. & Mey. | H | Ther | Nan | Mp-F | + | + | + | - |
| 183 | *Mentha arvensis* L. | H | Ther  | Mic | Drp-Wap | - | + | + | - |
| 184 | *Clinopodium umbrosum* (M. Bieb.) C. Koch. | H | Hem | Nan | Mp | + | + | - | - |
| 185 | *Clinopodium vulgare* L. | H | Hem | Mic | Drp | + | + | - | - |
| 186 | *Leucas cephalotes* (Roth.) Spreng. | H | Ther  | Mic | Drp | + | + | - | - |
| 187 | *Lycopis europis* L. | H | Cham  | Mes | Drp | + | + | - | - |
| 188 | *Marrubium vulgare* L. | H | Ther  | Mic | F | + | + | - | - |
| 189 | *Mentha longifolia* (L.) Huds. | H | H | Nan | Mp  | + | + | + | - |
| 190 | *Micromeria biflora* Benth. | H | Cham | Lep | M-Sp | + | + | + | - |
| 191 | *Nepeta discolor* Royle ex Benth. | H | Cham | Mic | Mp-F | - | + | + | - |
| 192 | *Ocimum basilicum* L. | H | Cham | Nan | Drp | + | + | + | + |
| 193 | *Origanum vulgare* L. | H | Hem | Nan | Rp | - | + | + | - |
| 194 | *Phlomis spectabilis* Falc. ex Benth. | H | Phen | Mic | Drp | + | + | + | + |
| 195 | *Salvia moorcroftiana* Wall. ex Bth. | H | Ther | Mac | Drp | + | - | - | + |
| 196 | *Salvia nubicola* Wall. Ex Sweet. | H | Ther | Mes | Drp | - | + | + | + |
| 197 | *Teucrium royleanum* Wall. ex Bth. | H | Ther | Mic | Drp | + | + | - | - |
| 198 | *Teucrium stocksianum* Boiss. | H | Ther | Mic | Drp | + | + | - | - |
| 199 | *Thymus linearis* Bth. Ssp. linearis Jalas | H | Hem | Nan | Mp | - | + | + | - |
| 200 | *Isodon rugosus* (Wall. ex Bth.) Codd. | S | Phen | Mes | Drp | + | + | + | + |
| 201 | *Rabdosia rugosa* Benth. | S | Phen | Mes | Drp-F | + | + | + | + |
| **38** | **Malvaceae** |
| 202 | *Abelmoschus esculentus* (L.) Moench. | H | Ther | Mes | CU | - | + | + | - |
| 203 | *Malva neglecta* Wallr. | H | Ther | Mic | Wap-Af | + | + | - | - |
| **39** | **Meliaceae** |
| 204 | *Cedrela serrata* Royle | T | Phen | Mic | Mp | + | + | + | + |
| 205 | *Melia azedarach* L. | T | Phen | Nan | Drp | + | + | + | + |
| **40** | **Moraceae** |
| 206 | *Ficus johanis* Boiss. | T | Phen | Mes | Drp | + | + | + | + |
| 207 | *Ficus palmata* Forssk. | T | Phen | Mes | Drp | + | + | + | + |
| 208 | *Morus alba* L. | T | Phen | Mes | Mp | + | + | + | + |
| 209 | *Morus macroura* Miq. | T | Phen | Mes | Mp | + | + | + | + |
| 210 | *Morus nigra* L. | T | Phen | Mes | Mp | + | + | + | + |
| **41** | **Myrsinaceae** |
| 211 | *Myrsine africana* L. | S | Phen | Nan | Drp-F | + | + | + | + |
| **42** | **Myrtaceae** |
| 212 | *Myractis wallichii* Less. | H | Ther | Nan |  F | - | + | + | - |
| 213 | Myrtus communis L. | S | Phen | Mic | Mp | + | + | + | + |
| **43** | **Nyctaginaceae** |
| 214 | *Boerhavia procumbens* Banks ex Roxb. | H | Hem | Nan | Mp | - | + | + | - |
| 215 | *Mirabilis jalapa* L | H | Ther | Mes | Drp | + | + | - | - |
| **44** | **Oleaceae** |
| 216 | *Fraxinus hookeri* Wenzig | T | Phen | Mes | F | + | + | + | + |
| 217 | *Jasminum humile* L. | S | Phen | Mic | Mp  | + | + | + | + |
| 218 | *Jasminum officinale* L. | S | Phen | Nan | Drp-F | + | + | + | + |
| 219 | *Olea ferruginea* Royle. | T | Phen | Mic | Drp-G | + | + | + | + |
| **45** | **Onagraceae** |
| 220 | *Epilobium hirsutum* L. | H | H | Nan | M-Sp | + | + | + | - |
| 221 | *Oenothera rosea* L.her.ex.Ait. | H | Hem | Mic | Wp |  - | + | + | - |
| **46** | **Oxalidaceae** |
| 222 | *Oxalis corniculata* L. | H | Ther | Nan | M-Sp | + | + | + |  - |
| **47** | **Fabaceae** |
| 223 | *Desmodium elegans* DC. | S | Phen | Mes | Drp | + | + | + | + |
| 224 | *Vicia sativa* L.  | C | Ther | Nan | Af | + | - | - | + |
| 225 | *Lespedeza juncea* (L.F.) Persoon. | H | Ther | Lep | Drp | + | + | + | + |
| 226 | *Medicago minima* (L.) Grufb. | H | Ther | Nan | Af | + | - | - | + |
| 227 | *Medicago sativa* L. | H | Hem | Nan | Mp-F | + | + | - | + |
| 228 | *Melilotus officinalis* (Linn.) Desr. | H | Ther | Nan | Mp-F | - | + | + | - |
| 229 | *Phaseolus vulgare* L. | H | Cham | Mes | CU | - | + | - | - |
| 230 | *Pisum sativum* L. | H | Ther | Mic | CU | + |  - | - |  - |
| 231 | *Trifolium repens* L. | H | Ther | Nan | F | + | + | - | + |
| 232 | *Trigonella gracilis* Benth. | H | Ther | Nan | Mp-Af | + | + | - | - |
| 233 | *Indigofera gerardiana* (Wall. ex Baker) Ali  | S | Phen | Lep | Drp | + | + | + | + |
| 234 | *Indigofera heterantha* Wall. ex Brand. | S | Phen | Lep | Drp  | + | + | + | + |
| 235 | *Robinia pseudo-acacia* L. | T | Phen | Mic | CU  | + | + | + | + |
| **48** | **Philadelphaceae** |
| 236 | *Deutzia staminea* R. Br .ex Wall. | S | Phen | Mic | Drp | + | + | + | + |
| **49** | **Plantaginaceae** |
| 237 | *Plantago himalaica* pilger. | H | Ther  | Mic | Drp | - | - | + | - |
| 238 | *Plantago lanceolata* L. | H | Ther | Mic | Mp  | - | + | - | - |
| 239 | *Plantago major* L. | H | Ther | Mes | Mp  |  - | + | + | - |
| **50** | **Platanaceae** |
| 240 | *Platanus orientalis* L. | T | Phen | Mes | F | + | + | + | + |
| **51** | **Plumbaginaceae** |
| 241 | *Limonium cabulicum* (Boiss.) O. Kuntze.Rev.gen. | H | Phen | Mes | Drp | + | + | + | + |
| **52** | **Polygalaceae** |
| 242 | *Polygala abyssinica* R. Br. ex Fresen. | H | Cham  | Nan | F | + | + | + | - |
| 243 | *Polygala sibirica* L. | H | Ther | Nan | F | + | + | + | - |
| **53** | **Polygonaceae** |
| 244 | *Rumex dentatus* L. | H | Hem | Mes | Mp | - | + | + | + |
| 245 | *Rumex hastatus* D.Don | H | Cham | Nan | Drp | + | + | - | + |
| 246 | *Bistorta amplexicaulis* (D. Don) Green | H | H | Mes | Mp-F | - | + | + | - |
| 247 | *Polygonum aviculare* L. | H | Ther | Nan | Wp | - | + | + | - |
| 248 | *Polygonum barbatum* L. | H | Ther | Nan | Mp | - | + | + | - |
| 249 | *Polygonum capitatum* Buch.-Ham. Ex D. Don. | H | Ther | Nan | Wap | - | + | + | - |
| 250 | *Polygonum maculosa* S. F. Gay. | H | Ther | Mic | Wap |  - | + | + | - |
| 251 | *Polygonum paronchioides* C. A. Mey. Ex Hohen. | H | Hem | Nan | Mp | - | + | + | - |
| **54** | **Primulaceae** |
| 252 | *Androsace rotundifolia* Hardwicke | H | Hem | Mes | Drp-F | + | + | - | - |
| 253 | *Primula denticulata* Wight. | H | Hem | Mes | Mp-F | + | - | - | + |
| 254 | *Primula floribunda* Wall. | H | Hem | Mes | Wp-Mp | - | + | + | - |
| 255 | *Primula vulgaris* Huds | H | There  | Mic | F-Mp | + | + | + | - |
| **55** | **Punicaceae** |
| 256 | *Punica grantaum* L. | T | Phen | Mic | Drp | + | + | + | + |
| **56** | **Ranunculaceae** |
| 257 | *Clematis graveolens* Roxb. ex. D.C. | C | Ther | Mic | Drp | + | + | + | - |
| 258 | *Aconitum heterophyllum* Wall. Ex Royle | H | Cham  | Mes | F | - | + | + | - |
| 259 | *Actaea spicata* L. | H | Hem | Mac | F | + | + | + | - |
| 260 | *Anemone obtusiloba* D.Don | H | Hem | Lep | F | - | + | + | - |
| 261 | *Ranunculus hirtellus* Royle. | H | Ther | Nan | Wp | - | + | - | - |
| 262 | *Ranunculus laetus* Wall. Ex Hk. F. & Thoms. | H | Geo | Nan | Wp | - | + |  - | - |
| 263 | *Ranunculus muricatus* L. | H | Geo | Mic | Wp | + | + | - | - |
| **57** | **Rhamnaceae** |
| 264 | *Rhodiola himalensis* (D. Don) S. H. Fu | H | Ther | Nan | F | - | + | + | - |
| 265 | *Rhamnus pentapomica* Fisch. & C.A.Mey. | S | Phen | Nan | Drp-F | + | + | + | + |
| 266 | *Sageretia thea* (L.) Brongn. | S | Phen | Nan | Drp | + | + | + | + |
| 267 | *Ziziphus nummularia* (Burm. f.) Wight & Arn. | S | Phen | Nan | Drp | + | + | + | + |
| 268 | *Ziziphus mauritiana* Lam. | T | Phen | Nan | Drp | + | + | + | + |
| **58** | **Rosaceae** |
| 269 | *Duchesnea indica* (Andr.) Focke | H | Ther | Mic | M-Sp | + | + | + | + |
| 270 | *Filipendula vestita* (Wall. ex G. Don.) Maxim. | H | Ther | Mes | F | - | + | + | - |
| 271 | *Fragaria nubicola* Lindl. | H | Hem | Nan | M-Sp | - | + | + | - |
| 272 | *Potentilla nepalensis* Hook. | H | Hem | Mic | F | - | + | - | - |
| 273 | *Poterium sanguisorba* Waldst.& Kit. | H | Ther | Nan | Wp | + | + | - | - |
| 274 | *Sibbaldia cuneata* Edgew. | H | Cham | Nan | Mp-F | - | + | - | - |
| 275 | *Cotoneaster bacillaris* Wall.ex Lindl. | S | Phen | Mic | F | + | + | + | + |
| 276 | *Cotoneaster microphyllus* Wall. Ex Lindl. | S | Phen | Nan | F | + | + | + | + |
| 277 | *Cotoneaster affinis* (Lindl.) Schn. | S | Phen | Nan | Drp | + | + | + | + |
| 278 | *Cotoneaster nummularia* Fish and Mey. | S | Phen | Nan | F | + | + | + | + |
| 279 | *Prunus jacquemontii* Hk. f. | S | Phen | Nan | F | + | + | + | + |
| 280 | *Rosa alba* L. | S | Phen | Nan | CU | + | + | + | + |
| 281 | *Rosa brunonii* Lindl. | S | Phen | Nan | Wp | + | + | + | + |
| 282 | *Rosa canina* L. | S | Phen | Nan | Mp-F | + | + | + | + |
| 283 | *Rosa webbiana* Wall. ex Royle | S | Phen | Nan | F | + | + | + | + |
| 284 | *Rubus ellipticus* Smith | S | Phen | Nan | F | + | + | + | + |
| 285 | *Rubus fruticosus* L. | S | Phen | Mes | Mp | + | + | + | + |
| 286 | *Rubus sanctus* Schreber | S | Phen | Mic | Mp | + | + | + | + |
| 287 | *Rubus ulmifolius* Schott | S | Phen | Mic | Mp | + | + | + | + |
| 288 | *Sorbaria tomentosa* (Lindl.) Rehdr | S | Phen | Mic | Wp | + | + | + | + |
| 289 | *Spiraea vaccinifolia* D.Don.  | S | Phen | Mic | F | + | + | + | + |
| 290 | *Malus pumila* Mill. | T | Phen | Mes | CU | + | + | + | + |
| 291 | *Prunus armeniaca* L. | T | Phen | Mes | CU | + | + | + | + |
| 292 | *Prunus cornuta* (Wall. Ex. Royle.) Steud. | T | Phen | Mes | F | + | + | + | + |
| 293 | *Prunus domestica* L. | T | Phen | Mes | CU | + | + | + | + |
| 294 | *Prunus persica* L. Batsch. | T | Phen | Mes | CU | + | + | + | + |
| 295 | *Pyrus communis* L. | T | Phen | Mic | CU | + | + | + | + |
| 296 | *Pyrus pashia* Ham. Ex. D.Don. | T | Phen | Mic | CU | + | + | + | + |
| **59** | **Rubiaceae** |
| 297 | *Galium aparine* L. | H  | Ther  | Nan | Wap-Af | + | + | + | - |
| **60** | **Rutaceae** |
| 298 | *Skimmia laureola* (DC.) Sieb. & Zucc. ex Walp | S | Phen | Mes | F | + | + | + | + |
| 299 | *Citrus sinensis* (L.) Osbeck. | T | Phen | Mes | CU | + | + | + | + |
| 300 | *Zanthoxylum armatum* DC. | T | Phen | Mes | Drp | + | + | + | + |
| **61** | **Salicaceae** |
| 301 | *Salix denticulata var. hazarica* (R. Parker) Ali | S | Phen | Mes | Mp-F | + | + | + | + |
| 302 | *Populus alba* Wall. | T | Phen | Mes | CU | + | + | + | + |
| 303 | *Populus nigra* L. | T | Phen | Mac | CU | + | + | + | + |
| 304 | *Salix babylonica* L. | T | Phen | Mic | Wp | + | + | + | + |
| 305 | *Salix tetrasperma* Roxb. | T | Phen | Mes | Wp | + | + | + | + |
| **62** | **Sambucaceae** |
| 306 | *Sambucus wightiana* Wall Ex Wight and Arn | H | Ther  | Mes | F | - | + | - | - |
| **63** | **Sapindaceae** |
| 307 | *Dodonaea viscosa* (L.) Jacq. | S | Phen | Mic | Drp | + | + | + | + |
| **64** | **Saxifragaceae** |
| 308 | *Bergenia ciliata* (Haw.) Sternb. | H | Geo | Mes | Mp-F | + | + | - | - |
| 309 | *Bergenia stracheyi* (H. & T.) Engl. | H | Geo | Mes | Mp-F | + | + | - | - |
| **65** | **Scrophulariaceae** |
| 310 | *Scrophularia umbrosa* Dumort. | H | Cham | Nan | Drp | - | + | + | - |
| 311 | *Veronica polita* Fries. | H | Ther  | Nan | Mp | + | + | + | - |
| **66** | **Simaroubaceae** |
| 312 | *Ailanthus altissima* (Mill.) Swingle | T | Phen | Mes | Wap | + | + | + | + |
| **67** | **Solanaceae** |
| 313 | *Datura innoxia* Mill. | H | Ther  | Mes | Wap | - | + | + | - |
| 314 | *Datura stramonium* L. | H | Ther  | Mes | Wap | - | + | + |  - |
| 315 | *Lycopersicon esculentum* Miller | H | Ther  | Mes | CU | + | + | + | - |
| 316 | *Solanum nigrum* L. | H | Ther | Mic | Drp-Wap | + | + | + | - |
| 317 | *Solanum pseudo-capsicum* L. | H | Ther | Mic | G | - | + | + | - |
| 318 | *Solanum surattense* Burm. f. | H | Ther | Mic | Wap | + | + | - | - |
| 319 | *Solanum tuberosum* L. | H | Geo | Mes | CU | - | + | - | - |
| **68** | **Thymeleaeceae** |
| 320 | *Wikstroemia canescens* Meisn. | S | Phen | Nan | F | + | + | + | + |
| 321 | *Daphne mucronata* Royle | S | Phen | Nan | Rp | + | + | + | + |
| **69** | **Trilliaceae** |
| 322 | *Trillium govanianum* Wall. ex Royle. | H | Cham  | Mes | F | - | + | - | - |
| **70** | **Ulmaceae** |
| 323 | *Celtis australis* L. | T | Phen | Mic | Drp | + | + | + | + |
| 324 | *Celtis caucasica* Willd. | T | Phen | Mic | Drp | + | + | + | + |
| **71** | **Urticaceae** |
| 325 | *Gerardinia palmata* Blume. | H | Ther | Meg | M-Sp | + | + | + | - |
| 326 | *Urtica dioica* L. | H | Ther | Mic | Mp | + | + | + | - |
| 327 | *Debregessia salcifolia* (D. Don) Rendle. | S | Phen | Mic | Mp-Wp | + | + | + | + |
| **72** | **Valerianaceae** |
| 328 | *Valeriana jatamansi* Jones. | H | Geo | Mic | Mp-F | + | + | - | - |
| **73** | **Verbenaceae** |
| 329 | *Verbena officinalis* L. | H | Ther | Mic | Mp-Rp | + | + | + | + |
| **74** | **Violaceae** |
| 330 | *Viola canescens* Wall. Ex Roxber | H | Hem | Mic | M-Sp | + | + | + | - |
| **75** | **Vitaceae** |
| 331 | *Vitis vinifera* L. | C | Phen | Mes | CU | + | + | + | + |
| **76** | **Zygophyllaceae** |
| 332 | *Tribulus terrestris* L. | H | Hem | Lep | Wap | - | + | - | - |

Key: Habit: T= Tree, S= Shrub, H= Herb, C= Cliber. Life form: Ther= Therophyte, Phen= Phanerophyte, Hem= Hemicryptophyte, Geo= Geophytes, Cham= Chamaephyte. Leaf form: Lep= Leptophyll, Mes= Mesophyll, Mic= Microphyll, Meg= Megaphyll, Nan= Nanophyll, Mac= Macrophyll, Aph= Aphyllous. Habitat type: Wap= Waste places, CU= Cultivated, Mp- Moist places Sp= shady places, Rp= rocky places, F= Forest, Drp= Dry places, G= Graveyards, Af= Agricultural fields, Rc= Rock Crevices, EPI= Epiphyte, WP= Wet places

***Morphological diversity***

Morphological diversity of plant species revealed that herbaceous flora was dominant (220 species, 66.3%) followed by shrubs (54 species, 16.3%) and trees (48 species, 14.5%) (Table 2), indicating over-exploitation of trees and shrubs species in the valley due to which their population is decreasing day by day. Similar findings were also reported by *Khan et al. (2017)* from Swat Ranizai, Ali *et al*. (2019) from district Nowshera, Hussain *et al.* (2005) from Ghalegay Hills Swat, Khan *et al.* (2011) from Darra Adam Khel and Akhtar (2014) from Miandam, Swat.

***Seasonal variation in vegetation***

Results of seasonal variation in vegetation revealed that maximum numbers of species were found in the summer season (32.4%) followed by the spring season (26.4%) (Table 2), indicating that the summer season is pleasant in the area while winter is very cold and harsh due to which declining occurs in the number of species in the winter season. The present findings are strongly supported by (Ullah & Badshah (2017) and Durrani *et al*. (2010). They also reported a maximum number of species in summer due to various distribution patterns of herbaceous flora.

**Table 2 Summary of ecological characteristics of vegetation of Sultan Khail valley Dir, Upper, Pakistan**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Characteristics** | **Number** | **Percentage** |
| **1** | **Vegetation** |
|  | Families | 96 | - |
|  | Genera | 234 | - |
|  | Species | 332 | - |
| **2** | **Habit** |
|  | Herbs | 220 | 66.3 |
|  | Shrubs | 54 | 16.3 |
|  | Trees | 48 | 14.5 |
|  | Climbers | 10 | 3.0 |
| **3** | **Seasonality** |
|  | Spring | 252 | 26.4 |
|  | Summer | 309 | 32.4 |
|  | Autumn | 230 | 24.3 |
|  | Winter | 161 | 17.0 |
| **4** | **Life form spectra** |
|  | Therophytes | 126 | 38.0 |
|  | Phanerophytes | 104 | 31.3 |
|  | Hemicryptophytes | 58 | 17.5 |
|  | Chamaephytes | 21 | 6.3 |
|  | Geophytes | 23 | 6.9 |
| **5** | **Leaf size spectra** |
|  | Microphylls | 107 | 32.2 |
|  | Nanophylls | 99 | 29.8 |
|  | Mesophylls | 83 | 25.0 |
|  | Leptophylls | 31 | 9.3 |
|  | Macrophylls | 6 | 1.8 |
|  | Megaphylls | 4 | 1.2 |
|  | Aphyllous | 2 | 0.6 |
| **6** | **Habitat type** |
|  | Wet places | 25 | 6.4 |
|  | Rock crevices | 10 | 2.5 |
|  | Forests | 83 | 21.1 |
|  | Moist places | 79 | 20.1 |
|  | waste places | 27 | 6.9 |
|  | Agriculture fields | 23 | 5.9 |
|  | Graveyards | 6 | 1.5 |
|  | Rocky places | 16 | 4.1 |
|  | Dry places | 92 | 23.4 |
|  | Epiphytes | 1 | 0.3 |
|  | Cultivated | 31 | 7.9 |

***Life form spectrum***

The physiognomy of flora and vegetation in relation to the prevailing climatic conditions of a specific region is indicated by the life form spectrum (Badshah *et al.,* 2013). In the present study area, therophytes (126 species, 38.0%) were found dominant, followed by phanerophytes (104 species, 31.3%) and hemicryptophytes (58 species, 17.5%) (Table 2), indicating that the phytoclimate of the area is thero-phanerophytic type. Therophytes are the indicators of arid phytoclimates, hemicryptophytes are the indicators of temperate regions, high altitudinal zones, and arctic (Singh *et al.,* 2019) while, Phanerophytes are the indicators of humid regions (Meher-Homji, 1964). Because of variations in microclimatic conditions (altitude, precipitation, and temperature), the Sultan Khail valley can be classified as subtropical, temperate, and, to a lesser degree, subalpine (Khan *et al.,* 2011).However, the dominance of therophytes in the area reflects that the flora is under heavy biological pressure such as deforestation, overgrazing, and over-exploitation of the plant species for fuel, timber wood, medicinal purposes, and agricultural practice (Malik *et al.,* 2007). A similar study was conducted by Al-Shaye *et al.* (2020) in Riyadh (Saudi Arabia), and therophytes and chamaephytes were reported to be dominant. Kambhar & Kotresha (2012) conducted similar research and found therophytes dominant, followed by phanerophytes, and stated that the environmental condition of the area is dry and hot. Similar results were also reported by Qureshi *et al.* (2011) and Sher *et al.* (2014).The present findings are strongly supported by Ullah & Badshah(2017), Haq *et al*. (2019), and Ullah *et al.* (2020) who reported the dominance of therophytes in the area and stated that the flora is under heavy biotic pressure such as deforestation, overgrazing, and over-exploitation of the plant species for fuel, timber, wood, and medicinal purposes.

*Seasonal variation in life form*

Seasonal variation in life form reveals that Phanerophytes (104 species, 41.4%) dominated the spring flora, followed by therophytes (80 species, 31.9%) and hemicryptophytes (38 species, 15.1%). In summer, therophytes (109 species, 35.4%) were the most abundant life form class, while in autumn and winter, phanerophytes were dominant. The seasonal variation in life form (Figure 3) is due to the presence of short-lived species as reported by *Badshah et al.* (2016), Ullah & Badshah (2017), Badshah *et al.* (2013), Ullah *et al.* (2020), and Musharaf *et al*. (2011).

**Figure 3 Seasonal variations in life form spectra**

***Leaf size spectrum of vegetation***

The knowledge of the leaf size of plant species may assist in understanding the physiological processes of plants and plant communities (Oosting, 1956). The results revealed that the vegetation of Sultan Khail valley is dominated by microphylls (107 species, 32.2%), while megaphylls and aphyllous were the least contributed leaf size classes (Table 2), indicating the dry climate and degraded habitat condition of the target area. The dominance of microphyllous and nanophyllous leaves indicates ecological adaptation to the arid conditions of the target area. The present findings agree with Qadir & Tareen, (1987) who reported a high percentage of microphylls and nanophylls in the dry temperate climate (wind, snowfall, and aridity) of the Quetta district. The percentage of microphylls also increases with increasing altitude. The same findings were also reported by Saxina *et al.* (1987), supporting the present study. The present findings are in line with Ahmed *et al.* (2021), who also reported microphylls as a dominant leaf size class in the Agror valley, district of Mansehra. The reason may be the similarity in climatic conditions. Ullah & Badshah(2017), reported microphylls dominating in the dry subtropical temperate area of Jelar valley Dir strongly supports our findings.

***Seasonal variation in leaf size spectra***

Seasonal variation in leaf size spectra shows that microphylls were dominant in the spring (34.3%) and summer (31.2%) seasons, while in autumn and winter, nanophylls were found dominant (Figure 4). The presence of geophytes and short-lived therophyte species causes differences in seasonal variation of leaf size classes Ullah *et al.* (2020), but altitude also plays an important role in the distribution of leaf size classes ( Ullah & Badshah,2017).

**Figure 4 Seasonal variations in leaf size spectra**

***Habitat types***

Based on their habitat, the maximum number of species (92 species, 23.4%) was found in dry places, followed by forests (83 species, 21.1%) and moist places (78 species, 19.9%) (Table 2). The results indicate that the habitat condition is mostly dry and is greatly disturbed by anthropogenic factors. However, the area still has the potential for the plantation of tree species. The distribution of species in different habitats is affected by various factors such as altitude, aspect, soil physical and chemical properties, soil water holding capacity, and habitat destruction (Ullah & Badshah,2017). Various researchers, such as Ali *et al*. (2016) and Samreen *et al.* (2016), classified plant species based on habitat type. So, our findings are correlated with them.

**Conclusions**

From the present study, it is concluded that the flora of the Sultan Khail valley is diverse and comprised of 332 species (22 pteridophytes, 8 gymnosperms, 302 angiosperms) belonging to 234 genera and 96 families. The phytoclimate of the area is of the thero-phanerophytic type. The vegetation of the investigated area is under heavy biotic pressure in the form of grazing, fuel wood, medicinal plant collection, timber wood smuggling to other areas, and some natural phenomena such as soil erosion and land sliding, due to which the vegetation of the area is decreasing day by day and needs proper conservation. The habitat condition of the area is mostly dry as the maximum number of species were found in dry habitats. This study provides baseline information on the flora of the Sultan Khail valley, and further studies will be needed to conduct on the conservation status of wild flora and quantitative information on vegetation.

**Author Contributions**

Conceptualization, K.R. and N.A.; methodology, N.A.; software, A.D. and A.U.J.; validation, A.D., A.U.J., A.A., F.M.A., and A.M.E.O.; formal analysis, K.R., N.A., A.D., and A.U.J.; investigation, K.R.; resources, A.D., and A.U.J.; data curation, K.R.; writing—original draft preparation, K.R.; writing—review and editing, K.R., N.A., A.D., A.U.J., A.A., F.M.A., and A.M.E.O.; visualization, K.R., N.A., A.D., A.U.J., A.A., F.M.A., and A.M.E.O.; supervision, N.A.; project administration, N.A., A.D., and A.U.J.; funding acquisition, A.A., F.M.A., and A.M.E.O.. All authors have read and agreed to the published version of the manuscript.

**Funding**

“This research received no external funding”

**Data Availability Statement:**

“Not applicable”

**Acknowledgments**

This article is a part of the Ph.D. research project of Mr. Khaista Rahman (Ph.D. scholar). The authors are thankful to the local inhabitants of Sultan Khail valley for their cooperation during data collection. Special thanks are also due to the Prime Minister of Pakistan for the initiation of laptop and fee reimbursement schemes for M.Phil/Ph.D. scholars from rural areas.

**Conflicts of Interest**

“The authors declare no conflict of interest.”

**References**

Ahmed, J., Z. Iqbal, I.U. Rahman, A. Azeem, N.U.A. Fatima, N. Taimur, G. Nawaz, S. Bibi, S. Kamal, R. Ahmad and S. Nawaz. 2021. Floral diversity and phytosociological studies on vegetation of Agror valley, district Mansehra. *Ukr. J. Ecol.,* 11(10): 84-93.

Akhtar, N. 2014. Exploring patterns of phytodiversity, ethnobotany, plant geography and vegetation in the mountains of Miandam, Swat, Northern Pakistan. M. Phil. dissertation submitted to the Georg-August-University school of science (GAUSS), Gottingen.

Ali, A., L. Badshah, F. Hussain and Z.K. Shinwari. 2016. Floristic composition and ecological characteristics of plants of Chail valley, district Swat, Pakistan. *Pak. J. Bot*. 48(3): 1013-1026.

Ali, S., S.Z. Shah, M.S. Khan, W.M. Khan, Z. Khan, N. Hassan and U. Zeb. 2019. Floristic list, ecological features and biological spectrum of district Nowshera, Khyber Pakhtunkhwa, Pakistan. *Acta Ecol. Sin.* 39(2): 133-141

Ali, S.I and M. Qaiser. 1986. A phytogeographical analysis of the phanerogams of Pakistan and Kashmir. *Proc. R. Soc. B: Biol. Sci.,* *89*: 89-101.

Al-Shaye, N.A., Y.S. Masrahi and J. Thomas. 2020. Ecological significance of floristic composition and life forms of Riyadh region, Central Saudi Arabia. *Saudi J. Biol. Sci.* 27(1): 35-40.

Al-Yemeni, M and H. Sher. 2010. Biological spectrum with some other ecological attributes of the flora and vegetation of the Asir Mountain of South West, Saudi Arabia. *Afr. J. Biotechnol.* *9*(34).

Amjad. M.S., M. Arshad, H.M. Sadaf, F, Akrim and A. Arshad. 2016. Floristic composition, biological spectrum and conservation status of the vegetation in Nikyal valley, Azad Jammu and Kashmir. *Asian Pac. J. Trop. Dis.* 6(1): 63-69.

Anjum, S., F. Hussain, M.J. Durrani, A. Masood, A. Mushtaq, S. Rizwan, U. Jabeen, E. Bashir and F. Behlil. 2020. Floristic Composition, Ecological characteristics and Ethnobotanical profile of protected and open grazing land of Karkhasa, Baluchistan, Pakistan. *Pak. J. Animal Plant Sci.* 30(2): 420-430.

Badshah, L., F. Hussain and Z. Sher. 2013. Floristic inventory, ecological characteristics and biological spectrum of rangeland, District Tank, Pakistan. *Pak. J. Bot*. 45(4): 1159-1168.

Badshah, L., F. Hussain and Z. Sher. 2016. Floristic inventory, ecological characteristics and biological spectrum of plants of Parachinar, Kurram agency, Pakistan. *Pak. J. Bot*. 48(4): 1547-1558.

Cain, S.A and G.M. Castro. 1959. Manual of vegetation analysis Harper & Brother Publ. New York, 325.

Catarino, L., E.S. Martins and M.A. Diniz. 2002. Vegetation structure and ecology of the Cufada Lagoon (Guinea‐Bissau). *Afr. J. Ecol.* 40(3): 252-259.

Champion, S.H., S.K. Seth, G.M. Khattak. 1965. Forest types of Pakistan. Forest types of Pakistan. Durrani, M.J., A. Razaq, S.G. Muhammad and F. Hussain. 2010. Floristic diversity, ecological, characteristics and ethnobotanical profile of plants of Aghberg rangelands, Balochistan, Pakistan. *Pak. J. Plant Sci.* 16(1).

Hadi, F., M. Ibrar and Ö. Kiliç. 2019. Floristic Diversity and Ecological Characteristics of Historical Kalash Valley (Pakistan). *Central European Journal of Botany* (5): 3-21

Haq, S.M., A.H. Malik, A.A. Khuroo and I. Rashid. 2019. Floristic composition and biological spectrum of Keran-a remote valley of northwestern Himalaya. *Acta Ecol. Sin.* 39(5): 372-379

Hussain. F. 1989. Field and Laboratory Manual of Plant Ecology. UGC. Islamabad.

Hussain. F., I. Iqbal and P. Akhtar. 2005. Floristic and vegetation studies of Ghalegay hills, district Swat, Pakistan. *Int. J. Biol. Biotechnol.* 2(4): 847-852.

Ibrahim, M., M.N. Khan, S. Ali, A. Razzaq, A. Zaman, M. Iqbal and F. Jan. 2019. Floristic composition and species diversity of plant resources of rural area “Takht Bhai” district Mardan, Khyber Pakhtunkhwa, Pakistan. *Med. Arom. Plants* 8(338): 2167-0412

Jeffrey, C. 1978. Asterales, compositae. In: Dod, B. (Ed.), Flowering plants of the world. Oxford University Press, Oxford 263–268.

Kambhar, S.V and K. Kotresha. 2012. Life-forms and biological spectrum of a dry deciduous forest in Gadag District, Karnataka, India. *Res. Rev. J. Bot.* 1(1): 1-28.

Khalid, S. 2017. Phytosociological and ethnobotanical studies of Mohmand agency (doctoral dissertation, Islamia College Peshawar, Pakistan).

Khalik, K.A., M. El-Sheikh and A. El-Aidarous. 2013. Floristic diversity and vegetation analysis of wadi Al-Noman, Mecca, Saudi Arabia. *Turk. J. Bot.,* *37*(5): 894-907

Khan, A., N. Khan, K. Ali and I.U. Rahman. 2017. An assessment of the floristic diversity, lifeforms and biological spectrum of vegetation in Swat Ranizai, District Malakand, Khyber Pakhtunkhwa, Pakistan. *Sci. Technol. Dev.* 36(2): 61-78

Khan, M., F. Hussain, S. Musharaf and Imdadullah. 2011. Floristic composition, life form, and leaf size spectra of the coal mine area vegetation of Dara Adam Khel, Khyber Pakhtunkhwa, Pakistan. *J. Biodiver. Environ. Sci.* 1(3): 1-6.

Khan, M.S. 2011. Diversity of vascular plants, ethnobotany and their conservation status in Ushairy valley, distt. DIR (Upper) NWFP; northern Pakistan (Doctoral dissertation, Quaid-i-Azam University Islamabad) 1-496.

Malik, Z.H., F. Hussain and N.Z. Malik. 2007. Life form and leaf size spectra of plant communities Harbouring Ganga Chotti and Bedori Hills during 1999-2000. *Int. J. Agri. Biol.* *9*(6): 833-838.

Meher-Homji, V.M. 1964, Life-forms and biological spectra as epharmonic criteria of aridity and humidity in the tropics. *J. Ind. Bot. Soc* 43(3): 424–430.

Meteorological station data Dir Upper, 2017-2019.

Musharaf, K., H. Farrukh and M. Shahana. 2011. Floristic composition, life form and leaf size spectra of the Coal Mine area vegetation of Darra Adam Khel, Khyber Pakhtunkhwa, Pakistan. *J. Biodiver. Environ. Sci.* 1(3): 1-6.

Nafeesa, Z., S.M. Haq, F. Bashir, G. Gaus, M. Mazher, M. Anjum, A. Rasool and N. Rashid. 2021. Observations on the floristic, life-form, leaf-size spectra and habitat diversity of vegetation in the Bhimber hills of Kashmir Himalayas. *Acta Ecol. Sin.* 41(3): 228-234

Oosting, H.J. 1956. The study of plant communities. An introduction to plant ecology. The study of plant communities. An introduction to plant ecology (2ndEdn).

Panda. S.S., N.K. Dhal, A. Dash and S.C. Panda. 2014. Floristic Diversity of Khandapara Forest Ranges of Nayagarh District Odisha, India. *J. Plant Sci.* 3(1): 2319-3824.

Qadir, S.A and R.B. Tareen. 1987. Life form and leaf size spectra of the flora of Quetta District. *Mod. Trends Plant Sci. Res. Pak.* 59-62.

Qureshi, R., G.R. Bhatti and G. Shabbir. 2011. Floristic inventory of PirMehr Ali Shah Arid Agriculture University research farm at Koont and its surrounding areas. *Pak. J. Bot*. 43(3): 1679-1684.

Rahman, I.U., A. Aftab, I. Zafar, F. Ijaz, N. Ali, M. Asif, J. Alam, A. Majid, R. Hart and R.W. Bussmann. 2018. First insights into the floristic diversity, biological spectra and phenology of Manoor Valley, Pakistan. *Pak. J. Bot*. 50(3): 1113-1124.

Rashid, A., M.F. Swati, H. Sher and M.N. Al-Yemeni. 2011. Phytoecological evaluation with detail floristic appraisal of the vegetation around Malam Jabba, Swat, Pakistan. *Asian Pac. J. Trop. Biomed.* 1(6): 461-467.

Raunkiaer, C. 1934. The life-forms of plants and statistical plant geography. Clarendon Press Oxford.

Samreen, U., M. Ibrar and L. Badshah 2016. Floristic composition, ecological characters and biological characters of Darazinda, F. R. D. I. Khan, Pakistan. *Int. Inv. J. Agric. Soil Sci.* 4(1): 9-21.

Saxina, A.K., T.P. Pandey and J.S. Singh. 1987. Altitudinal variation in the vegetation of Kaumaun Himalaya. *Persp. Environ. Bot.* 44–66.

Sharma, V and N.P. Sharma. 2018. The phytodiversity and comparative account of biological spectrum of Dehradun and Mussoorie region. *Res. J. Life Sci. Bioinfor. Pharm. Chem. Sci.* 4(5):250-259.

Sher, H., A. Ahmad, M. Eleyemeni, S.F. Hadi and H. Sher. 2010. Impact of nomadic grazing on medicinal plants diversity in Miandam, Swat, Pakistan (Preliminary results). *Int. J. Biodiver. Conser.*, 2(6): 146-154.

Sher, Z., F. Hossain and L. Badshah. 2014. Biodiversity and ecological characterization of the flora of Gadoon rangeland, district Swabi, Khyber Pakhtunkhwa, Pakistan. *Iran. J. Bot.* *20*(1): 96-108.

Singh, D., A. Sharma and N. Sharma. 2019. Composition, richness and floristic diversity along an elevational gradient in a semi-disturbed treeline ecotone, Bhaderwah, Jammu and Kashmir. *J. appl. Natur. Sci.,* 11(1): 23-34.

Thakur, M., V.K. Santvan and A. Nigam. 2012. Floristic composition and biological spectrum of Darlaghat wildlife sanctuary Solan Himachal Pradesh, India. *New York Sci. J.* *5*(12): 1-14.

Ullah, S. and L. Badshah. 2017. Floristic structure and ecological attributes of Jelar valley flora, district Upper Dir, Pakistan. *J. Biodivers. Environ. Sci.* 10(5): 89-105.

Ullah, S., A. Rahman, I. Ullah, M. Ahmad and M. Idrees. 2020. First floristic inventory and biological spectrum of the flora of Lajbouk, Dir Lower, Khyber Pakhtunkhwa, Pakistan. *Biosci. Res.,* 17(3): 1633-1642.

Zaman, A. and L. Badshah. 2021. Floristic diversity and chorotype analysis of Terich valley Chitral: A contribution to the flora of Hindu Kush range, northern Pakistan. *Pak. J. Animal Plant Sci.,* 31(6): 1739-1754.

Zhu, Y., D. Shan, B. Wang, Z. Shi, X. Yang and Y. Liu. 2019. Floristic features and vegetation classification of the HulunBuir steppe in North China: geography and climate-driven steppe diversification. *Glob. Ecol. Conserv.,* 20: e00741