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FLORISTIC, FREQUENCY AND VEGETATIO-BIOLOGICAL SPECTRA OF MURREE-KOTLI SATTIAN-KAHUTA NATIONAL PARK, PAKISTAN

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Abstract

Present study was aimed at documenting floristic, frequency and vegetatio-biological spectra of the vascular plants distributed in 246 sampling sites of the Murree-Kotli Sattian-Kahuta National Park, Punjab, Pakistan. The study area is situated at the latitude value of 33º21′ to 34º01′ N and longitude value of 73º11′ to 73°38′ E in the Rawalpindi, and comprised of total land area of 934 Km^2. In all, 352 plant species distributed across 150 genera and 82 families were recorded from the 246 sampling stations. The flora included 330 natives (93.75%), followed by weeds (14 spp., 3.98%), cultivated & naturalized (3 spp., 0.85% each) as well as endemic and introduced (1 sp., 0.28% each). According to floristic life form spectra, therophytes were dominated in the area (31.25%), followed by hemicryptophytes (28.13) and nanophanerophytes (11.36), while the frequency spectra revealed the domination of hemicryptophytes (32.07%), followed by nanophanerophytes (21.62%) and therophytes (20.77%). Hemicryptophytes were the leading class in the vegetation spectra (32.07%), followed by nanophanerophytes (21.25%), therophytes (20.77%) and macrophanerophytes (13.48%). Homogeneity analysis exhibited a significant difference between floristic and vegetation life form (X^2 = 17.26, p<0.05). The proportion of hemicryptophyte increased from floristic to vegetation spectrum; whereas therophytes decreased from floristic to vegetation spectra. This study concludes that floristic life-form spectra showed clearer picture than that of Raunkiaer's classification and correctly explained the existing climatic conditions of the studied area. Besides, it is suggested that the vegetation spectrum requires the meticulous physiognomy coupled with ecological factors if worked in smaller areas to be deliberated.

Key words: Biological spectra, Raunkiare's floristics, Frequency spectrum, Vegetation spectrum, Homogeneity analysis, Murree-Kotli Sattian-Kahuta National Park.

Introduction

The floristic aspect of plant communities has long been appreciated but the concept of growth forms came after Humboldt by classifying vegetation on physiognomic basis. This functional plant classification system incorporates the role of climatic outlook of the vegetation of an ecosystem (Mack, 2003). This depicts an expression of the harmony between plants and their environment (Ewald, 2003). Similar life form under a certain ecological condition shows the adaptive ability of plant species (with a distinct set of genes) to ensure the continuation of ancestral adoptive legacy. This physiognomic attribute is given due attention in the vegetation science (Phillips, 1929; Braun-Blanquet, 1932; Khan *et al*., 2016). Life forms and physiognomy not only show the competitive ability and social capacity (Cain, 1950) but also the morphological adjustment that has evolutionary basis and adaptation to the environmental constrains and the survival of species (Khan *et al*., 2016). Life form distribution pattern cannot only be assessed by studying micro and macroclimate (Shimwell, 1971) but by extent and degree of anthropogenic disturbance as well.

The study of life forms is the 2nd most important aspect of the vegetation description after the floristic composition studies (Cain, 1950). Many scientists proposed different systems of grouping of the plant species on the morphological and physiognomic basis irrespective of their systematic position. Out of various systems, the Raunkiaer's system (1934) got much popularity, sometime strongly criticized (Sarmiento & Monasterio, 1983; Batalha & Martins, 2004) but still most widely used classification system of plants life form. This system emphasizes on the relative position of the perenating buds as function of unfavorable. Thus, by hiding the renewing buds mechanism, the plant species get more protection (Batalha & Martins, 2004). The Raunkaier's biological spectra not only express the life form distribution but also the prevailing phytoclimate. Raunkaier (1934) explained the normal spectrum as a null model against which life form of a particular flora can be compared. Life-forms as single-character-based functional group, shows the ecological convergence of plant species of the different phyletic lineages under the influence of evolutionary forces (Bocher, 1977) to occupy the resources at the same temporal and spatial scale, which is indeed the success of plant life against the ever changing environment (Solbrig, 1993). The study of life forms can be used in understanding of the floristic, vegetation and frequency spectrum of any region (Batalha & Martins, 2004).

Earlier, some of the studies highlighting life forms have been reported from various ecological regions of the country using Raunkaiers's system (Tareen & Qadir, 1993; Nasir & Sultan, 2002; Malik & Malik 2004; Nazir & Malik, 2006; Malik *et al*., 2007; Sher & Khan, 2007; Qureshi, 2008; Qureshi & Bhatti, 2010; Qureshi & Ahmad, 2010; Qureshi *et al.*, 2011, 2014; Badshah *et al*., 2013, 2016; Khan *et al*., 2016); however, no such study has been conducted from this project area. The aim of the current study was to answer the questions such as what is the dominant life form in the study area. Does the floristic biological spectrum different from Raunkaier's normal spectrum? Does the vegetation spectrum differ from floristic spectrum?

Materials and Methods

Study area: Murree-Kotli Sattian-Kahuta National Park (MKSKNP) is located in the sub-Himalayan mountain range between 33º21′ to 34º01′ N latitudes and 73º11′ to 73°38′ E longitude in District Rawalpindi, Punjab, Pakistan (Fig. 1). The total area of the park is 934 Km^2 with elevation ranges from 500 to 2270 meters. The area is bounded by the river Jhelum in the east, Islamabad in the west, Khyber Pakhtunkhwain in the north and Gujar Khan in the south. The topography at the higher altitude is mainly composed of rugged terrain with narrow valleys; whereas, at the lower elevation, it is relatively flat. The soil of the study area is residual as well as of transported (Qureshi & Shaheen, 2013).

Data collection

The study area was surveyed from August, 2013 to September, 2015 for the collection of floristic and vegetation data by using stratified random sampling design. A total of 246 sites were sampled. At each sampling site, seven quadrats were studied i.e. one quadrat (10×10m) for trees, two (4×4m) for shrubs and four (1×1m) for herbs (Hussain, 1989). Plant specimens were also collected and identified with help of various floristic literatures (Stewart, 1972; Ali & Qaiser, 1995-2017; Anon., 2012a, 2012b, 2014; Anon., 2012).

The vascular plant species were classified into different life form classes by Raunkaier's system modified by Mueller-Dombios & Ellenberg (1974). In the biological spectrum, every species has the same weightage for floristic biological spectrum; whereas in vegetation biological spectrum, instead of species each life form is counted and weighted by its abundance (Batalha & Martins, 2004). But counting each life form, individual becomes nearly impossible because it is not always possible to distinguish one individual from another. To avoid this problem, Raunkaier proposed frequency spectrum in which the number of sampling units in which species found was used to weight the species (Raunkaier, 1934).

For the construction of life form and frequency spectrum, each species was assigned to a single life form class only. The data regarding life form was used to construct floristic, frequency, and vegetation life form spectra (Raunkaier, 1934; Batalha & Martins, 2004). For vegetation life form spectrum, each life form was weighted by the number of individuals of that particular life form, for frequency life form spectrum, each species was weighted by the number of quadrats in which species appeared (Batalha & Martins, 2004).

Data analysis

To find if there was a significant difference between life form spectrum and expected Raunkaier's normal spectrum, chi-square test was applied (Zar, 1999). For significant difference, we calculated the percent contribution to the chi-squere value (Batalha & Martins, 2004). We compared floristic, vegetation and frequency spectrum pair-wise with homogeneity test to find spectral significant difference (Zar, 1999) using R software version 3.3.2.

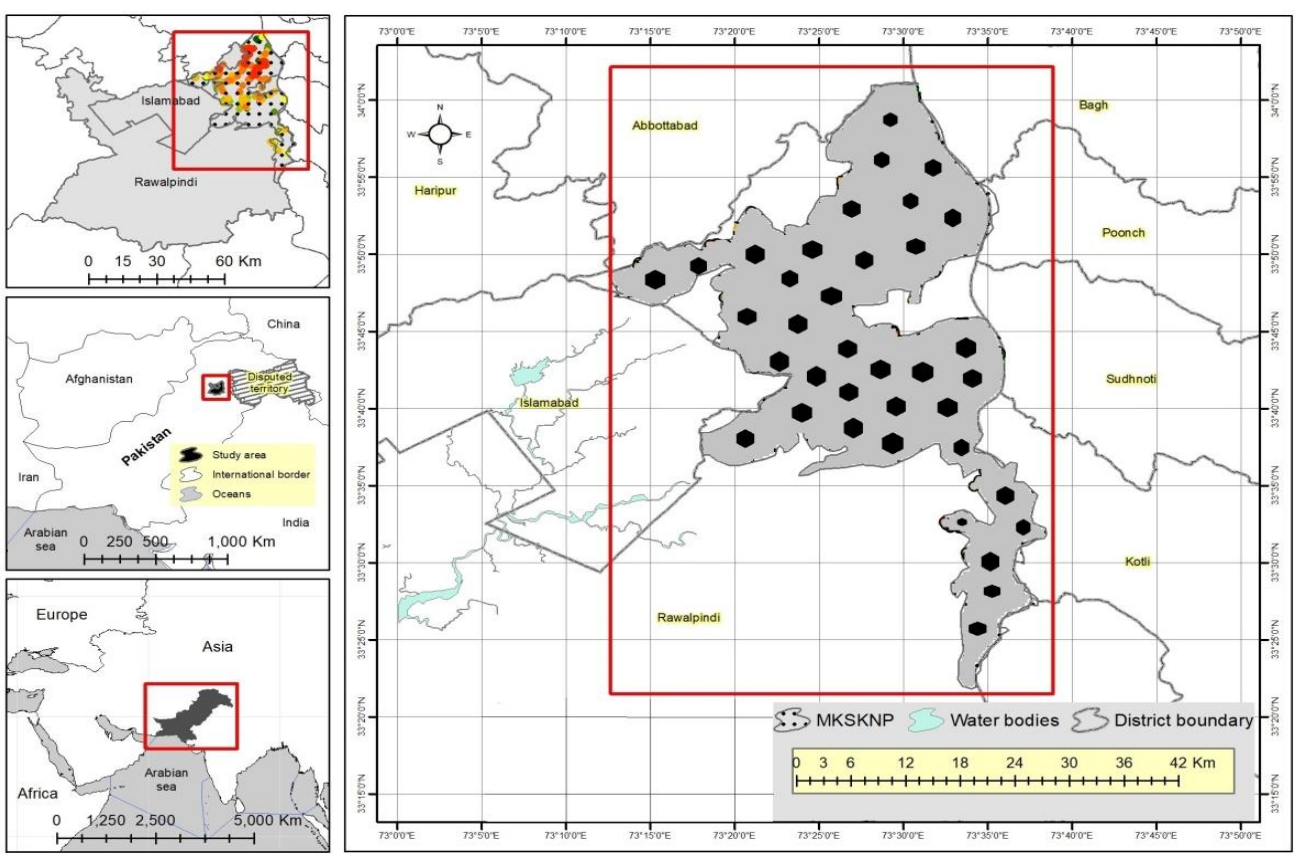

Fig. 1. Location map showing collection of data of the study area.

Results

Floristic inventory: In all, 352 plant species distributed across 150 genera and 82 families were recorded from the 246 sampling stations (Table 1). The status of flora is shown in Fig. 2 that revealed that there was highest proportion of natives with 330 species (93.75%), followed by weeds (14 spp., 3.98%), cultivated/naturalized (3 spp., 0.85% each), endemic and introduced (1 sp., 0.28% each). Out of 15 weeds, 13 species viz., *Brachiaria reptans, Carpesium cernuum, Euphorbia prostrata, Justicia japonica, Lolium temulentum, Medicago polymorpha, Plantago lanceolata, Poa annua, Polypogon fugax, Ranunculus muricatus, Setaria pumila, Setaria viridis, Verbena officinalis*, while three species such as *Cyperus iria, Lantana camara* and *Trifolium dubium* were naturalized to the area.

Life form spectra: The collected data of vascular plants were placed in 6 life form classes according to Raunkiaer system of classification. The summary of results is provided in Fig. 3. It revealed that therophytes were dominating in the area with 110 species (31.25%), followed by hemicryptophytes (99 spp., 28.13%) nanophanerophytes (50 spp., 14.20%), macrophanerophytes (40 spp., 11.36%), chamaephytes (21 spp., 5.97%) and geophytes (20 spp., 5.68%), while lianas was the least recorded life form (12 spp., 3.41%). The most striking feature in floristic life form spectrum of study was the highest percentage of therophyte (Fig. 3).

The floristic, frequency and vegetation life form classification were pair-wise compared. It has been observed that there was dominancy of therophytes in floristic life form spectra (31.25%), followed by hemicryptophytes (28.13) and nanophanerophytes (11.36), while the frequency spectra revealed the domination of hemicryptophytes (32.07%), followed by nanophanerophytes (21.62%) and therophytes (20.77%). Hemicryptophytes were the leading class in the vegetation spectra (32.07%), followed by nanophanerophytes (21.25%), therophytes (20.77%) and macrophanerophytes (13.48%). Homogeneity analysis exhibited a significant difference between floristic and vegetation life form (X^2 = 17.26, p<0.05).

The frequency spectrum depicted 4116 occurences in 246 samples; while, in the vegetation spectrum, 22479 individuals were recorded. Therophytes, the most representative class in floristic spectrum was less represented in vegetation and frequency sptrectrum. The proportion of hemicryptophyte increased from floristic to vegetation spectrum; whereas therophytes decreased from floristic to vegetation spectra (Table 2). The comparison between floristic life form spectrum and Raunkiaer's normal spectrum is showed in Table 3 that reveals a statistically significant difference (X^2-squared = 13.737, p-value = 0.008184).

Leaf spectra: The leaf spectra of the study area is summarized in Fig. 4 that revealed that microphyll was the most dominant class with 113 species (32.10%) followed by nanophyll (106 spp., 30.11%), leptophyll (87 spp., 24.72%), and mesophyll (46 spp., 13.07%).

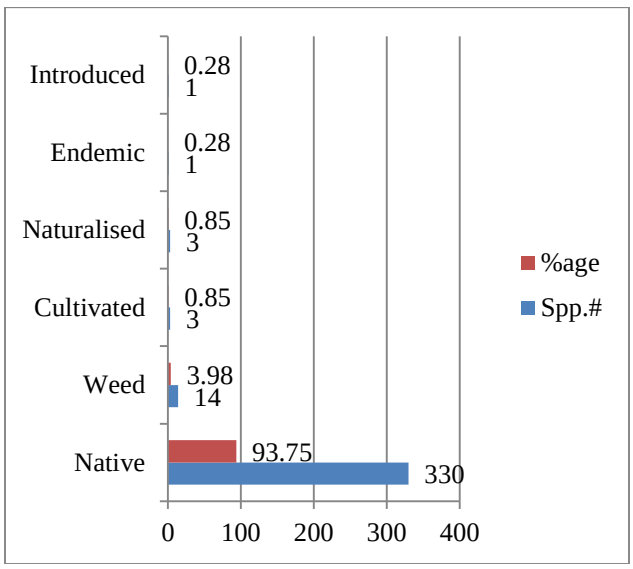

Fig. 2. Status of the flora of National Park.

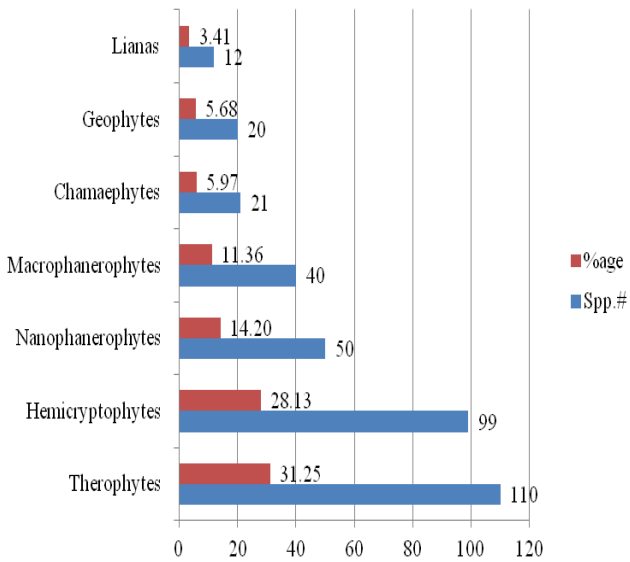

Fig. 3. Raunkaier Life form classes of MKSKNP, Pakistan.

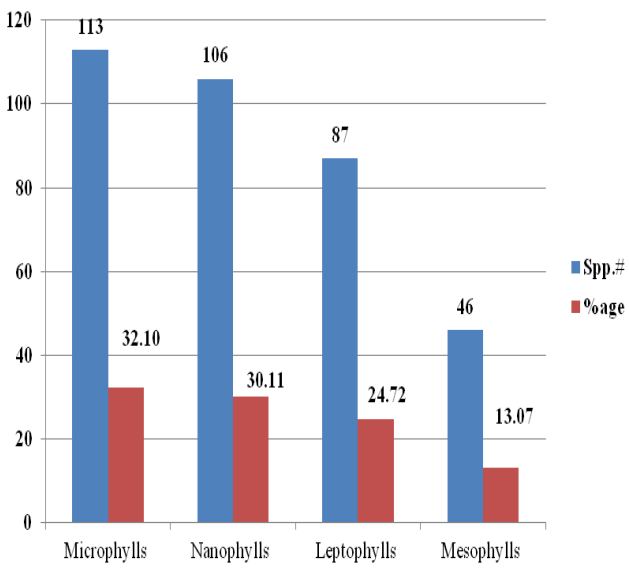

Fig. 4. Leaf spectral classes of MKSKNP, Pakistan.

Table 1. Inventory of plants of the project area along with life form and leaf spectra.

Group/Family	Sr #	Plant species/Voucher#	Life form	Leaf spectra	Status
		Pteridophytes			
1. Adiantaceae	1	*Adiantum capillus-veneris* L./WA-251	HC	N	NV
	2	*Adiantum caudatum* L./WA-95	HC	N	NV
	3	*Adiantum incisum* Forssk./WA-252	HC	N	NV
	4	*Adiantum venustum* D. Don/WA-253	HC	N	NV
	5	*Onychium contiguum* Wall. ex C. Hope/WA-96	HC	LP	NV
2. Aspleniaceae	6	*Asplenium adiantum-nigrum* L./WA-254	HC	N	NV
	7	*Asplenium trichomanes* L./WA-256	HC	N	NV
	8	*Asplenium dalhousiae* Hook./WA-255	HC	LP	NV
4. Dryopteridaceae	9	*Dryopteris filix-mas* (L.) Schott/WA-382	HC	ME	NV
	10	*Dryopteris ramosa* (C. Hope) C. Chr./WA-241	HC	ME	NV
	11	*Dryopteris stewartii* Fraser-Jenk./WA-190	HC	ME	NV
	12	*Polystichum aculeatum* (L.) Roth ex Mert./WA-383	HC	N	NV
5. Equisetaceae	13	*Equisetum ramosissimum* Desf./WA-384	HC	LP	NV
	14	*Hippochaete debilis* (Roxb. ex Vaucher) Ching/WA-385	G	LP	NV
6. Pteridaceae	15	*Cheilanthes argentea* (S.G. Gmel.) Kunze/WA-387	HC	MI	NV
	16	*Coniogramme rosthornii* Hieron. /WA-386	HC	MI	NV
	17	*Pteris cretica* L./WA-189	HC	MI	NV
	18	*Pteris vittata* L./WA-257	HC	MI	NV
7. Hypodematiaceae	19	*Hypodematium crenatum* (Forssk.) Kuhn/WA-591	HC	LP	NV
		Gymnosperms			
8. Pinaceae	20	*Abies pindrow* (Royle ex D.Don) Royle/WA-258	MP	LP	NV
	21	*Cedrus deodara* (Roxb. ex D. Don) G. Don/WA-172	MP	LP	NV
	22	*Pinus roxburghii* Sarg./WA-203	MP	LP	NV
	23	*Pinus wallichiana* A.B. Jacks./WA-99	MP	LP	NV
		Monocotyledons			
11. Araceae	24	*Arisaema flavum* (Forssk.) Schott/WA-259	G	ME	NV
	25	*Arisaema jacquemontii* Blume/WA-97	G	ME	NV
	26	*Sauromatum venosum* (Dryand. ex Aiton) Kunth/WA-226	G	ME	NV
12. Asparagaceae	27	*Asparagus racemosus* Willd./WA-98	NP	LP	NV
	28	*Ophiopogon intermedius* D. Don/WA-377	HC	N	NV
13. Commelinaceae	29	*Commelina paludosa* Blume/WA-103	T	MI	NV
14. Convallariaceae	30	*Polygonatum multiflorum* (L.) All./WA-261	G	MI	NV
15. Cyperaceae	31	*Carex cardiolepis* Nees/WA-262	HC	LP	NV
	32	*Carex fedia* Nees/WA-183	HC	LP	NV
	33	*Carex filicina* Nees/WA-104	HC	LP	NV
	34	*Carex schlagintweitiana* Boeck./WA-180	HC	LP	NV
	35	*Carex foliosa* D. Don/WA-263	HC	LP	NV
	36	*Cyperus alopecuroides* Rottb./WA-391	HC	N	NV
	37	*Cyperus iria* L./WA-265	T	N	WE
	38	*Cyperus niveus* Retz./WA-389	G	N	NV
	39	*Eriophorum comosum* (Wall.) Nees/WA-392	HC	LP	NV
	40	*Fimbristylis dichotoma* (L.) Vahl/WA-266	HC	LP	NV
	41	*Fimbristylis squarrosa* Vahl/WA-607	T	LP	NV
	42	*Kobresia laxa* Nees/WA-599	HC	LP	NV
	43	*Kyllinga squamulata* Vahl/WA-371	T	N	NV
	44	*Pycreus pumilus* (L.) Nees/WA-374	T	N	NV
	45	*Pycreus flavidus* (Retz.) T.Koyama/WA-373	T	N	NV
16. Hypoxidaceae	46	*Curculigo orchioides* Gaertn./WA-229	G	N	NV
18. Juncaceae	47	*Juncus articulatus* L./WA-394	HC	LP	NV
20. Orchidaceae	48	*Cephalanthera longifolia* (L.) Fritsch/WA-395	HC	N	NV
	49	*Epipactis helleborine* (L.) Crantz/WA-270	G	MI	NV
	50	*Epipactis persica* (Soó) Hausskn. ex Nannf./WA-272	G	MI	NV
	51	*Habenaria furcifera* Lindl./WA-587	T	MI	NV
	52	*Spiranthes sinensis* (Pers.) Ames/WA-271	HC	N	NV
21. Poaceae	53	*Agrostis gigantea* Roth/WA-396	HC	LP	NV
	54	*Agrostis stolonifera* L./WA-398	HC	LP	NV
	55	*Apluda mutica* L./WA-397	HC	LP	NV
	56	*Aristida cyanantha* Steud./WA-231	HC	LP	NV

Table 1. (Cont'd.).

Group/Family	Sr #	Plant species/Voucher#	Life form	Leaf spectra	Status
	57	*Arthraxon lancifolius* (Trin.) Hochst./WA-369	HC	LP	NV
	58	*Arthraxon prionodes* (Steud.) Dandy/WA-367	HC	LP	NV
	59	*Bothriochloa bladhii* (Retz.) S.T.Blake /WA-365	HC	N	NV
	60	*Brachiaria eruciformis* (Sm.) Griseb./WA-366	T	N	NV
	61	*Brachiaria ramosa* (L.) Stapf/WA-597	T	N	NV
	62	*Brachiaria reptans* (L.) C.A. Gardner & C.E. Hubb./WA-200	T	N	WE
	63	*Bromus hordeaceus* L./WA-399	T	N	NV
	64	*Bromus oxyodon* Schrenk/WA-628	T	N	NV
	65	*Bromus pectinatus* Thunb./WA-361	T	N	NV
	66	*Bromus ramosus* Huds./WA-363	HC	N	NV
	67	*Capillipedium parviflorum* (R.Br.) Stapf/WA-400	HC	N	NV
	68	*Chrysopogon aucheri* (Boiss.) Stapf./WA-354	HC	LP	NV
	69	*Chrysopogon serrulatus* Trin./WA-355	HC	LP	NV
	70	*Chrysopogon gryllus* (L.) Trin./WA-401	HC	LP	NV
	71	*Cymbopogon martini* (Roxb.) Will. Watson/WA-433	HC	LP	NV
	72	*Cynodon dactylon* (Linn.) Pers./WA-353	HC	LP	NV
	73	*Dactylis glomerata* L./WA-434	HC	N	NV
	74	*Dichanthium annulatum* (Forssk.) Stapf./WA-232	HC	LP	NV
	75	*Dichanthium foveolatum* (Delile) Roberty/WA-107	HC	LP	NV
	76	*Eragrostis amabilis* (L.) Wight & Arn./WA-350	T	LP	NV
	77	*Eulaliopsis binata* (Retz.) C.E. Hubb./WA-404	HC	N	NV
	78	*Festuca gigantea* (L.) Vill./WA-600	HC	N	NV
	79	*Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult./WA-454	HC	LP	NV
	80	*Imperata cylindrica* (L.) Raeuschel/WA-405	HC	N	NV
	81	*Lolium perenne* L./WA-187	T	N	NV
	82	*Lolium persicum* Boiss. & Hohen./WA-108	T	N	NV
	83	*Lolium temulentum* L./WA-188	T	N	WE
	84	*Oplismenus compositus* (L.) P. Beauv./WA-191	HC	N	NV
	85	*Paspalum distichum* L./WA-544	HC	N	NV
	86	*Pennisetum orientale* Rich./WA-503	HC	LP	NV
	87	*Poa alpina* L/WA-273	HC	LP	NV
	88	*Poa annua* L./WA-274	T	LP	WE
	89	*Poa nemoralis* L./WA-603	T	LP	NV
	90	*Poa polycolea* Stapf/WA-533	T	N	NV
	91	*Poa pratensis* L/WA-407	T	LP	NV
	92	*Polypogon fugax* Nees ex Steud./WA-436	T	LP	WE
	93	*Polypogon viridis* (Gouan) Breistr./WA-601	T	LP	NV
	94	*Saccharum ravennae* (L.) L./WA-411	HC	MI	NV
	95	*Saccharum spontaneum* L. /WA-527	HC	MI	NV
	96	*Setaria pumila* (Poir.) Roem. & Schult./WA-276	T	N	WE
	97	*Setaria viridis* (L.) P. Beauv./WA-234	T	MI	WE
	98	*Themeda anathera* (Nees ex Steud.) Hack./WA-201	HC	LP	NV
23. Smilacaceae	99	*Smilax aspera* L./WA-111	L	MI	NV
	100	*Smilax glaucophylla* Klotzsch/WA-112	L	MI	NV
		Dicotyledons			NV
25. Acanthaceae	101	*Barleria cristata* L./WA-236	CH	MI	NV
	102	*Dicliptera bupleuroides* Nees/WA-415	HC	N	NV
	103	*Justicia adhatoda* L./WA-237	NP	MI	NV
	104	*Justicia japonica* Thunb./WA-349	NP	ME	WE
	105	*Strobilanthes urticifolia* Wall. ex Kuntze/WA-110	CH	ME	NV
26. Adoxaceae	106	*Viburnum cotinifolium* D. Don/WA-205	T	ME	NV
	107	*Viburnum grandiflorum* Wall. ex DC./WA-278	T	ME	NV
28. Amaranthaceae	108	*Achyranthes aspera* L./WA-114	CH	MI	NV
	109	*Chenopodium album* L. /WA-314	T	N	NV
	110	*Dysphania ambrosioides* (L.) Mosyakin & Clemants/WA-546	T	N	NV
	111	*Pupalia lappacea* (L.) Juss./WA-542	CH	N	NV
29. Anacardiaceae	112	*Cotinus coggygria* Scop./WA-279	NP	MI	NV
	113	*Pistacia integerrima* J. L. Stewart ex Brandis/WA-240	MP	MI	NV

Table 1. (Cont'd.).

Group/Family	Sr #	Plant species/Voucher#	Life form	Leaf spectra	Status
30. Apiaceae	114	*Bupleurum marginatum* Wall. ex DC./WA-418	HC	N	NV
	115	*Carissa opaca* Stapf ex Haines/WA-199	NP	MI	NV
	116	*Eryngium caeruleum* M.Bieb./WA-299	T	MI	NV
	117	*Heracleum candicans* Wall. ex DC./WA-280	CH	MI	NV
31. Apocynaceae	118	*Dregea volubilis* (L.f.) Benth. ex Hook.f./WA-119	L	MI	NV
	119	*Nerium oleander* L./WA-335	NP	MI	NV
33. Araliaceae	120	*Hedera nepallensis* K. Koch/WA-116	L	MI	NV
34. Aristolochiaceae	121	*Aristolochia punjabensis* Lace/WA-532	L	MI	EN
36. Asteraceae	122	*Achillea millefolium* L. /WA-523	T	LP	NV
	123	*Ageratum conyzoides* (L.) L./WA-550	T	MI	NV
	124	*Ainsliaea latifolia* (D.Don) Sch.Bip./WA-548	HC	MI	NV
	125	*Anaphalis adnata* DC./WA-120	G	N	NV
	126	*Anaphalis busua (*Buch.-Ham.) DC./WA-570	G	N	NV
	127	*Anaphalis margaritacea* (L.) Benth. & Hook. f./WA-281	G	N	NV
	128	*Artemisia dubia* Wall. ex Besser/WA-529	CH	LP	NV
	129	*Aster flaccidus* Bunge/WA-124	T	N	NV
	130	*Bidens biternata* (Lour.) Merr. & Sherff/WA-298	T	N	NV
	131	*Carpesium abrotanoides* L./WA-530	T	MI	NV
	132	*Carpesium cernuum* L./WA-572	T	MI	WE
	133	*Conyza canadensis* (L.) Cronq. /WA-122	T	N	NV
	134	*Cousinia thomsonii* C.B.Clarke /WA-283	T	MI	NV
	135	*Erigeron multiradiatus* (Lindl. ex DC.) Benth. ex C.B. Clarke/WA-536	T	MI	NV
	136	*Erigeron bonariensis* L./WA-440	T	MI	NV
	137	*Erigeron trilobus* (Decne.) Boiss./WA-125	T	N	NV
	138	*Himalaiella heteromalla* (D.Don) Raab-Straube	T	N	NV
	139	*Gerbera gossypina* (Royle) Beauverd/WA-284	HC	MI	NV
	140	*Inula cappa* (Buch.-Ham. ex D. Don) DC./WA-575	NP	MI	NV
	141	*Inula conyza* (Griess.) DC./WA-626	T	MI	NV
	142	*Lactuca brunoniana* (DC.) Wall. ex C.B.Clarke/WA-178	T	LP	NV
	143	*Lactuca dissecta* D.Don/WA-285	T	N	NV
	144	*Launaea secunda* (C.B.Clarke) Hook.f./WA-426	T	ME	NV
	145	*Launaea procumbens* (Roxb.) Ram. & Rajgo./WA-574	T	MI	NV
	146	*Leucanthemum vulgare* (Vaill.) Lam/WA-580	HC	MI	NV
	147	*Myriactis nepalensis* Less./WA-287	T	MI	NV
	148	*Myriactis wightii* DC./WA-286	T	MI	NV
	149	*Senecio nudicaulis* Buch.-Ham. ex D.Don/WA-578	G	MI	NV
	150	*Siegesbeckia orientalis* L./WA-442	T	ME	NV
	151	*Sonchus arvensis* L. /WA-526	T	ME	NV
	152	*Sonchus asper* (L.) Hill/WA-571	T	ME	NV
	153	*Taraxacum campylodes* G.E.Haglund/WA-624	HC	MI	NV
	154	*Xanthium strumarium* L. /WA-581	T	ME	NV
	155	*Youngia japonica* (L.) DC./WA-583	T	N	NV
37. Balsaminaceae	156	*Impatiens brachycentra* Kar. & Kir/WA-288	T	MI	NV
	157	*Impatiens edgeworthii* Hook. f./WA-289	T	MI	NV
	158	*Sinopodophyllum hexandrum* (Royle) T.S.Ying/WA-144	G	ME	NV
38. Berberidaceae	159	*Berberis lycium* Royle./WA-174	NP	N	NV
	160	*Berberis parkeriana* C.K.Schneid./WA-291	NP	N	NV
39. Boraginaceae	161	*Cynoglossum glochidiatum* Wall. ex Benth./WA-444	T	MI	NV
	162	*Cynoglossum lanceolatum* Forssk./WA-445	T	MI	NV
	163	*Trichodesma indicum* (L.) Lehm./WA-446	T	MI	NV
40. Brassicaceae	164	*Arabis nova* Vill./WA-616	T	N	NV
41. Buxaceae	165	*Sarcococca saligna* (D.Don) Muell.-Arg./WA-292	NP	MI	NV
	166	*Buxus papillosa* C.K. Schneid. (WA-564)	NP	MI	EN
43. Campanulaceae	167	*Campanula pallida* Wall/WA-438	T	N	NV
44. Cannabaceae	168	*Cannabis sativa* L./WA-331	T	ME	NV
45. Caprifoliaceae	169	*Lonicera hispida* Pall. ex Schult./WA-612	NP	MI	NV
	170	*Lonicera myrtillus* Hook. f. & Thomson/WA-560	NP	MI	NV
47. Celastraceae	171	*Cassine glauca* (Rottb.) Kuntze/WA-519	MP	MI	NV
	172	*Maytenus royleanus* (Wall. ex Lawson) Cufodontis/WA-329	NP	N	NV

Table 1. (Cont'd.).

Group/Family	Sr #	Plant species/Voucher#	Life form	Leaf spectra	Status
48. Convolvulaceae	173	*Cuscuta reflexa* Roxb. /WA-94	T	LP	NV
	174	*Cuscuta gigantea* Griff./WA-328	T	LP	NV
49. Cornaceae	175	*Cornus macrophulla* Wall./WA-295	MP	ME	NV
	176	*Cornus oblonga* Wall/WA-265	NP	ME	NV
50. Cucurbitaceae	177	*Solena amplexicaulis* (Lam.) Gandhi/WA-296	L	ME	NV
51. Dioscoreaceae	178	*Dioscorea deltoidea* Wall. ex Griseb./WA-495	L	MI	NV
52. Ebenaceae	179	*Diospyros lotus* L. /WA-493	MP	ME	CU
53. Elaeagnaceae	180	*Elaeagnus angustifolia* L./WA-489	MP	N	NV
55. Euphorbiaceae	181	*Euphorbia hirta* L./WA-515	T	LP	NV
	182	*Euphorbia prolifera* Buch.-Ham. ex D.Don/WA-621	T	N	NV
	183	*Euphorbia prostrata* Aiton/WA-516	T	LP	WE
	184	*Mallotus philippensis* (Lam.) Müll. Arg. /WA-210	MP	ME	NV
56. Fabaceae	185	*Acacia modesta* Wall./WA-197	MP	LP	NV
	186	*Acacia nilotica* (L.) Delile/WA-196	MP	LP	NV
	187	*Alysicarpus bupleurifolius* (L.) DC./WA-535	HC	LP	NV
	188	*Alysicarpus monilifer* (L.) DC./WA-218	HC	LP	NV
	189	*Alysicarpus ovalifolius* (Schum.) Leonard/WA-511	HC	LP	NV
	190	*Argyrolobium roseum* (Cambess.) Jaub. & Spach/WA-512	T	LP	NV
	191	*Astragalus leucocephalus* Bunge/WA-92	T	LP	NV
	192	*Atylosia scarabaeoides* (L.) Benth./WA-217	CH	N	NV
	193	*Bauhinia variegata* L./WA-243	MP	MI	NV
	194	*Cassia fistula* L./WA-216	MP	ME	NV
	195	*Crotalaria calycina* Schrank/WA-214	T	LP	NV
	196	*Crotalaria medicaginea* Lam./WA-215	T	LP	NV
	197	*Dalbergia sissoo* DC./WA-209	MP	ME	CU
	198	*Desmodium elegans* DC./WA-89	NP	MI	NV
	199	*Hylodesmum podocarpum* (DC.) H.Ohashi & R.R.Mill/WA-57	NP	N	NV
	200	*Indigofera cordifolia* Roth/WA-219	T	LP	NV
	201	*Indigofera heterantha* Brandis/WA-506	NP	LP	NV
	202	*Indigofera linifolia* (L. f.) Retz./WA-538	T	LP	NV
	203	*Lespedeza juncea* (L.f.) Pers./WA-87	CH	LP	NV
	204	*Lotus corniculatus* L./WA-504	HC	LP	NV
	205	*Medicago edgeworthii* Sirj./WA-221	T	LP	NV
	206	*Medicago lupulina* L./WA-2	T	LP	NV
	207	*Medicago laciniata* (L.) Mill/WA-483	T	LP	NV
	208	*Medicago orbicularis* (L.) Bartal. /WA-220	T	LP	NV
	209	*Medicago polymorpha* L./WA-481	T	LP	WE
	210	*Mimosa himalayana* Gamble/WA-488	MP	LP	NV
	211	*Pueraria tuberosa* (Willd.) DC./WA-479	G	ME	NV
	212	*Trifolium dubium* Sibth./WA-301	T	N	IN
	213	*Trifolium repens* L./WA-300	HC	N	NV
	214	*Trifolium pratense* L./WA-478	HC	N	NV
	215	*Trigonella emodi* Benth./WA-171	T	N	NV
	216	*Trigonella gracilis* Benth./WA-170	T	N	NV
	217	*Uraria picta* (Jacq.) DC./WA-611	HC	MI	NV
	218	*Vicia hirsuta* (L.) Gray/WA-628	T	LP	NV
57. Fagaceae	219	*Quercus dilatata* Royle/WA-126	MP	ME	NV
	220	*Quercus glauca* Thunb./WA-173	MP	ME	NV
	221	*Quercus incana* Bartram/WA-86	MP	ME	NV
58. Gentianaceae	222	*Gentiana argentea* (Royle ex D.Don) Royle ex D.Don/WA-83	T	LP	NV
	223	*Gentiana olivieri* Griseb./WA-302	HC	N	NV
	224	*Swertia cordata* (Wall. ex G. Don) C.B. Clarke/WA-132	T	N	NV
	225	*Swertia paniculata* Wall./WA-84	T	N	NV
	226	*Swertia tetragona* R.H. Miao/WA-130	T	N	NV
59. Geraniaceae	228	*Geranium lucidum* L./WA-1	T	MI	NV
	229	*Geranium nepalense* Sweet/WA-303	HC	MI	NV
	227	*Geranium rotundifolium* L./WA-137	HC	MI	NV
	230	*Geranium wallichianum* D. Don ex Sweet/WA-138	HC	MI	NV

Table 1. (Cont'd.).

Group/Family	Sr #	Plant species/Voucher#	Life form	Leaf spectra	Status
62. Hypericaceae	231	*Hypericum dyeri* Rehder/WA-347	NP	MI	NV
	232	*Hypericum oblongifolium* Choisy/WA-135	NP	MI	NV
	233	*Hypericum perforatum* L./WA-134	CH	N	NV
64. Lamiaceae	234	*Ajuga bracteosa* Wall. ex Benth./WA-165	HC	MI	NV
	235	*Ajuga parviflora* Benth./WA-166	HC	N	NV
	236	*Callicarpa macrophylla* Vahl/WA-32	NP	N	NV
	237	*Clinopodium umbrosum* (M.Bieb.) Kuntze/WA-474	HC	N	NV
	238	*Colebrookea oppositifolia* Sm. /WA-49	NP	ME	NV
	239	*Isodon coetsa* (Buch.-Ham. ex D. Don) Kudô/WA-473	CH	MI	NV
	240	*Isodon rugosus* (Wall. ex Benth.) Codd/WA-304	CH	MI	NV
	241	*Lamium album* L./WA-168	T	MI	NV
	242	*Leucas decemdentata* (Willd.) Sm/WA-245	T	MI	NV
	243	*Leucas nutans* (Roth) Spreng. /WA-50	HC	N	NV
	244	*Mentha longifolia* (L.) L./WA-44	HC	N	NV
	245	*Micromeria biflora* (Buch.-Ham. ex D.Don) Benth./WA-244	HC	LP	NV
	246	*Origanum vulgare* L./WA-305	HC	N	NV
	247	*Phlomoides spectabilis* (Falc. ex Benth.) Kamelin & Makhm./WA-627	CH	MI	NV
	248	*Prunella vulgaris* L/WA-6	HC	MI	NV
	249	*Pseudocaryopteris foetida* (D.Don) P.D.Cantino/WA-582	NP	MI	NV
	250	*Rydingia limbata* (Benth.) Scheen & V.A.Albert /WA-31	NP	N	NV
	251	*Teucrium quadrifarium* Buch.-Ham./WA-622	CH	LP	NV
	252	*Teucrium royleanum* Wall. ex Benth./WA-40	CH	N	NV
	253	*Vitex negundo* L./WA-472	NP	N	NV
65. Lauraceae	254	*Neolitsea pallens* (D. Don) Momiy. & H. Hara/WA-139	MP	MI	NV
	255	*Machilus duthiei* King/WA-140	MP	ME	NV
66.Linaceae	256	*Reinwardtia indica* Dumort./WA-29	CH	N	NV
68. Lythraceae	257	*Woodfordia fruticosa* (L.) Kurz/WA-7	NP	MI	NV
69. Malvaceae	258	*Grewia asiatica* L./WA-69	MP	ME	NV
	259	*Grewia eriocarpa* Juss./WA-613	MP	ME	NV
	260	*Malvastrum aboriginum* B.L. Rob./WA-202	T	MI	NV
	261	*Sida cordifolia* L./WA-207	CH	N	NV
	262	*Sida cordata* (Burm.f.) Borss.Waalk./WA-51	CH	N	NV
72. Menispermaceae	263	*Cissampelos pareira* L./WA-247	L	MI	NV
74. Moraceae	264	*Broussonetia papyrifera* (L.) L'Hér. ex Vent./WA-429	MP	ME	NT
	265	*Ficus auriculata* Lour./WA-428	MP	ME	NV
	266	*Ficus carica* L./WA-8	MP	ME	CU
	267	*Ficus sarmentosa* Buch.-Ham. ex Sm./WA-33	L	MI	NV
77. Nyctaginaceae	268	*Boerhavia procumbens* Banks ex Roxb./WA-9	HC	N	NV
78. Oleaceae	269	*Jasminum humile* L./WA-307	NP	N	NV
	270	*Jasminum officinale* L./WA-470	NP	N	NV
	271	*Olea ferruginea* Royle/WA-195	MP	MI	NV
79. Onagraceae	272	*Oenothera rosea* L'Hér. ex Aiton/WA-34	T	N	NV
80. Oxalidaceae	273	*Oxalis corniculata* L. /WA-192	T	N	NV
	274	*Oxalis pes-caprae* L. /WA-208	HC	N	NV
82. Phyllanthaceae	275	*Andrachne cordifolia* (Decne.) Müll.Arg./WA-176	NP	MI	NV
	276	*Bridelia verrucosa* Haines/WA-52	NP	MI	NV
	277	*Glochidion heyneanum* (Wight & Arn.) Wight/WA-25	MP	N	NV
	278	*Phyllanthus emblica* L./WA-38	MP	LP	NV
	279	*Phyllanthus niruri* L./WA-451	T	LP	NV
	280	*Phyllanthus virgatus* G.Forst./WA-24	T	LP	NV
83. Plantaginaceae	281	*Plantago lanceolata* L. /WA-452	HC	MI	WE
	282	*Plantago major* L./WA-185	HC	ME	NV
	283	*Plantago ovata* Forssk./WA-184	HC	MI	NV
84. Polygalaceae	284	*Polygala abyssinica* R.Br. ex Fresen/WA-81	CH	LP	NV
	285	*Polygala arvensis* Willd./WA-459	T	LP	NV
	286	*Polygala erioptera* DC./WA-55	T	LP	NV
85. Polygonaceae	287	*Persicaria amplexicaulis* (D. Don) Ronse Decr./WA-80	T	MI	NV
	288	*Persicaria hydropiper* (L.) Delarbre/WA-79	T	MI	NV
	289	*Persicaria nepalensis* (Meisn.) Miyabe/WA-56	HC	MI	NV
	290	*Rumex hastatus* D. Don/WA-82	CH	N	NV
	291	*Rumex nepalensis* Spreng./WA-36	G	ME	NV

Table 1. (Cont'd.).

Group/Family	Sr #	Plant species/Voucher#	Life form	Leaf spectra	Status
86. Primulaceae	292	*Androsace rotundifolia* Hardw./WA-75	HC	N	NV
	293	*Embelia robusta* Roxb./WA-23	NP	MI	NV
	294	*Myrsine africana* L/WA-194	NP	N	NV
	295	*Myrsine semiserrata* Wall./WA-12	NP	N	NV
87. Punicaceae	296	*Punica granatum* L./WA-64	NP	MI	NV
88. Ranunculaceae	297	*Anemone vitifolia* Buch.-Ham. ex DC./WA-76	CH	ME	NV
	298	*Aquilegia pubiflora* Wall. ex Royle/WA-63	G	MI	NV
	299	*Clematis barbellata* Edgew./WA-311	L	MI	NV
	300	*Clematis grata* Wall./WA-147	L	MI	NV
	301	*Clematis montana* Buch.-Ham. ex DC./WA-58	L	MI	NV
	302	*Ranunculus laetus* Wall. ex Hook. f. & J.W. Thomson/WA-157	G	MI	NV
	303	*Ranunculus muricatus* L./WA-148	T	MI	WE
89. Rhamnaceae	304	*Rhamnus virgata* Roxb./WA-13	NP	MI	NV
	305	*Sageretia thea* (Osbeck) M.C. Johnston /WA-461	NP	N	NV
	306	*Ziziphus mauritiana* Lam./WA-155	MP	MI	NV
90. Rosaceae	307	*Cotoneaster affinis* Lindl./WA-464	NP	N	NV
	308	*Duchesnea indica* (Jacks.) Focke/WA-186	HC	N	NV
	309	*Fragaria nubicola* (Hook. f.) Lindl. ex Lacaita/WA-465	HC	N	NV
	310	*Potentilla reptans* L./WA-320	HC	N	NV
	311	*Pyrus pashia* Buch.-Ham. ex D. Don/WA-204	MP	ME	NV
	312	*Rosa moschata* Herrm./WA-316	NP	MI	NV
	313	*Rosa* multiflora Thunb./WA-513	NP	MI	NV
	314	*Rubus ellipticus* Sm./WA-469	NP	MI	NV
	315	*Rubus fruticosus* L./WA-14	NP	MI	NV
	316	*Rubus niveus* Thunb./WA-179	NP	MI	NV
	317	*Rubus sanctus* Schreb./WA-317	NP	MI	NV
	318	*Rubus ulmifolius* Schott/WA-410	NP	MI	NV
	319	*Spiraea canescens* D. Don/WA-21	NP	N	NV
91. Rubiaceae	320	*Galium acutum* Edgew./WA-159	T	LP	NV
	321	*Galium aparine* L./WA-424	T	LP	NV
	322	*Galium asperifolium* Wall./WA-161	T	LP	NV
	323	Galium elegans Wall. ex Roxb./WA-160	T	LP	NV
	324	*Galium rotundifolium* L./WA-193	T	LP	NV
	325	*Himalrandia tetrasperma* (Wall. ex Roxb.) T.Yamaz./WA-423	NP	N	NV
	326	*Rubia cordifolia* L./WA-162	CH	N	NV
	327	*Wendlandia heynei* (Schult.) Santapau & Merchant/WA-20	MP	MI	NV
92. Rutaceae	328	*Zanthoxylum armatum* DC./WA-422	NP	N	NV
93. Salicaceae	329	*Flacourtia indica* (Burm. f.) Merr./WA-152	MP	N	NV
	330	*Salix acmophylla* Boiss./WA-15	MP	N	NV
	331	*Xylosma longifolia* Clos/WA-150	MP	MI	NV
94. Sapindaceae	332	*Aesculus indica* (Wall. ex Cambess.) Hook./WA-468	MP	ME	NV
	333	*Dodonaea viscosa* (L.) Jacq./WA-198	NP	MI	NV
95. Saxifragaceae	334	*Bergenia ciliata (*Haw.) Sternb./WA-19	HC	ME	NV
97. Simaroubaceae	335	*Ailanthus altissima* (Mill.) Swingle/WA-16	MP	MI	NT
98. Solanaceae	336	*Datura stramonium* L./WA-68	T	ME	NV
	337	*Physalis divaricata* D. Don/WA-326	T	MI	NV
	338	*Solanum americanum* Mill./WA-163	T	MI	NV
	339	*Solanum erianthum* D. Don/WA-325	MP	ME	NV
	340	*Solanum surattense* Burm. f/WA-67	HC	ME	NV
99. Thymelaeaceae	341	*Daphne papyracea* Wall. ex G. Don/WA-175	NP	MI	NV
100. Ulmaceae	342	*Celtis australis* subsp. *caucasica* (Willd.) C.C.Towns./WA-154	MP	N	NV
101. Urticaceae	343	*Debregeasia saeneb* (Forssk.) Hepper & J.R.I.Wood/WA-72	NP	ME	NV
102. Valerianaceae	344	*Valeriana hardwickii* Wall./WA-420	G	MI	NV
	345	*Valeriana jatamansi* Jones/WA-348	G	MI	NV
103. Verbenaceae	346	*Lantana camara* L./WA-323	NP	MI	NT
	347	*Phyla nodiflora* (L.) Greene/WA-419	HC	LP	NV
	348	*Verbena officinalis* L./WA-321	T	MI	WE
104. Violaceae	349	*Viola cancescens* Wall. /WA-467	HC	MI	NV
	350	*Viola pilosa* Blume/WA-66	HC	MI	NV
	351	*Viola stocksii* Boiss./WA-212	HC	MI	NV
105. Zygophyllaceae	352	*Tribulus terrestris* L./WA-65	T	LP	NV

Legend: Leaf spectra= ME= Mesophylls, MI= Microphylls, LP= Leptophylls, N=Nanophylls; **Life form spectra=** CH= Chamaephytes, G= Geophytes, HC= Hemicryptophytes, MP= Macrophanerophytes, NP= Nanophanerophytes, T = Therophytes; **Status=** CU= cultivated, EN= endemic, IN= introduced, NT= naturalized, NV= native, IV=Invesive, WE= weed.

Table 2. Percentage of floristic, frequency and vegetation spectra of MKSKNP, Pakistan.

Life Forms	Life-form spectra		
	Floristic (%)	Frequency (%)	Vegetation (%)
Therophytes	31.25	20.77	15.60
Hemicryptophytes	28.13	32.07	43.71
Nanophanerophytes	14.20	21.62	21.25
Macrophanerophytes	11.36	15.26	13.48
Chamaephytes	5.97	5.81	4.63
Geophytes	5.68	2.19	0.67
Lianas	3.41	2.28	0.66

Table 3. Spectral comparision in terms of statistical values of MKSKNP, Pakistan.

Pair-wise spectra	Chi-aquere	P-value
Floristic vs. Frequency	7.8273	> 0.05
Frequency vs. Vegetation	4.518	> 0.05
Floristic vs. vegetation	16.17	< 0.05**

**= significant value

Discussion

Life form and leaf spectra of a particular geographical region are the critical physiognomic attributes which not only indicate the plant environment interaction (Khan *et al*., 2013) but also help understand the micro and macroclimate under which plant species thrive (Malik *et. al*., 2007). The vegetation in our study area is dominated by therophytes, followed by hemicryptophytes which are characteristic features of temperate climate with cold temperature and humid conditions (Ilyas *et al*., 2015). Domination of therophytes in floristic spectrum may be attributed to high anthropogenic disturbance (Qureshi, 2008; Qureshi & Bhatti, 2010; Qureshi & Ahmad, 2010; Qureshi *et al.*, 2011, 2014). Similar domination of therophytes was observed by Hussain *et al*., (1997) in Girbanr and Dabargai hills, due to destruction of natural habitat.

Vegetation and frequency life form spectra showed the dominancy of hemicryptophytes by 43.71% and 32.07%, respectively because of high disturbance rate in the area (Table 2). This trend was also pointed out from Thandiani forest in western Himalaya (Khan *et al*., 2016), and Sarsawa hills district Kotli, Azad Kashmir (Nazir *et al*., 2014). Khan *et al*., (2013) attributed over grazing and deforestation for domination of such life forms in Naran Valley of western Himalaya Pakistan. The higher elevations of the park show temperate climate with distinct winter and summer is particularly dominated by hemicryptophytes; a trend also reported from temperate regions of Balochistan as well Tareen & Qadir (1993). The climate though supports phanerophytes, but the domination of therophytes in particular is the indicator of harsh climate (Qureshi *et al.*, 2011; Badshah *et al*., 2016; Khan *et al*., 2016) which in the area is because of the biotic stress in the form of over grazing and wood extraction (Ullah *et al*., 2015; Badshah *et al*., 2016).

This study reported domination of hemicryptophyteas as well as cryptophytes at higher elevation of MKSKNP (Table 3). This trend is also reported from Naran valley (Khan *et al*., 2013). The increasing proportion of hemicryptophyte and chamaephytes from floristic to vegetation spectrum may be associated with frequent forest fire particularly at middle elevation with the domination of *Pinus roxburghii*. As the national park through Siwalik Chir Pine forest at middle elevation, it intermingles with the Himalaya moist temperate forest at upper elevation (Champion *et al*., 1965). Besides, there was domination of phenarophytes showing condensed physiognomic feature as those of Batalha & Martins (2004).

In our study, frequency spectrum showed quite difference from the vegetation spectrum (Table 3), however, Batalha and Martins (2004) disagree to use frequency spectrum because of non significant difference from floristic spectrum. The low winter temperature being the limiting factor in MKSKNP justifies the application of Raunkaier's life form classification which is criticized in tropical communities by Sarmiento and Monasterio (1983).

This study depicted the predominance of therophytes in floristic spactrum (Fig. 3), a characteristic feature of sub-tropics, may be credited due to some other factors like over grazing and intentional removal of shrubs and trees by the local inhabitants to promote the growth of grasses and other herbs which they collect as winter fodder. Similar causes were advocated by other workers (Sher & Khan, 2007; Khan *et al.,* 2012) to explain the predominance of therophytes in other Himalayan regions as well.

With reference to leaf spectra, the project area is dominated by microphylls and nanophylls (Fig. 4), which are characteristics of the temperate zone (Cain & Castro, 1959). Like the study area, various studies carried out in Himalayan regions reported the same results as those of Shehzad *et al*., (1999), Ilyas *et al*., (2013) and Khan *et al*., (2016).

This study explained in detail about the vegetation spectrum of Murree-Kotli Sattian-Kahuta National Park that was significantly different from Raunkiare's normal spectrum revealing the domination of phanerophytes. Comparing with Raunkiaer's life form classification, floristic life-form spectra proved in correctly explaining the existing climatic conditions of the vegetation of the study area. Our results were in agreement of those of Batalha & Martins (2004), who reported that the frequency spectrum was not considerably diverse and not a good estimator of the abundance.

Conclusion

This study was carried to compare Raunkiare's floristics, frequency and vegetatio-biological spectra of vascular plants from Murree-Kotli Sattian-Kahuta National Park, Punjab, Pakistan. The project area is mostly inhabited with native species along with one endemic species (i.e. *Buxus papillosa*). Comparing with Raunkiaer's life form classification, floristic life-form spectra proved in correctly explaining the existing physiognomic feature of the vegetation of the study area. Besides, the frequency spectrum did not give clear picture considerably and not found a good estimator of the abundance. The vegetation spectrum was significantly different from Raunkiare's normal spectrum that revealed domination of hemicryptophytes and phanerophytes. It is therefore suggested that while studying the vegetation, there is need to have meticulous physiognomy along with ecological factors for getting a clear picture of the vegetation spectrum of any area.

Aknowledgement

This article is extracted from the PhD thesis of the first author.

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