Saudi Journal of Biological Sciences (2016) **xxx**, xxx–xxx

King Saud University

Saudi Journal of Biological Sciences

www.ksu.edu.sa
www.sciencedirect.com

الجمعية السعودية لعلوم الحياة
SAUDI BIOLOGICAL SOCIETY

ORIGINAL ARTICLE

Life forms, leaf size spectra, regeneration capacity and diversity of plant species grown in the Thandiani forests, district Abbottabad, Khyber Pakhtunkhwa, Pakistan

Waqas Khan [a], Shujaul Mulk Khan [b,*], Habib Ahmad [d], Abdulaziz A. Alqarawi [c], Ghulam Mujtaba Shah [a], Manzoor Hussain [a], E.F. Abd_Allah [c,e,*]

[a] *Department of Botany, Hazara University Mansehra, KPK, Pakistan*
[b] *Department of Plant Sciences, Quaid-i-Azam University, Islamabad, Pakistan*
[c] *Department of Plant Production, Collage of Food & Agricultural Sciences, P.O. Box 2460, Riyadh 11451, Saudi Arabia*
[d] *Islamia College University Peshawar, Pakistan*
[e] *Seed Pathology Department, Plant Pathology Research Institute, ARC, Giza 12511, Egypt*

Received 26 August 2016; revised 8 November 2016; accepted 9 November 2016

KEYWORDS

Life form;
Leaf spectra;
Diversity;
Forests;
Family importance values;
Plant species

Abstract The life form and leaf size spectra of plant species of the Thandiani forests, district Abbottabad, were studied during the summer of 2013. These forests host 252 plant species of 97 families. Biological spectra showed that Hemicryptophytes (80 spp., 31.74%) were dominant followed by Megaphanerophytes (51 spp., 20.24%), Therophytes (49 spp., 19.44%) and Nanophanerophytes (45 spp., 17.86). Hemicryptophytes are the indicators of cold temperate vegetation. At the lower elevations, Megaphanerophytes and Nanophanerophytes were dominant which confirm trees as dominant habit form due to high soil depth, moisture and temperature factors. Data on Leaf spectra in the area showed that Microphyllous (88 spp., 34.92%) species were dominant followed by Leptophyllous (74 spp., 29.36%) and Nanophyllous (60 spp., 23.80%). The Microphyllous plants again are the indicator of cold temperate zone as the area is situated at an elevation of 1191–2626 m. Similarly, Nanophylls were dominant at lower elevations. Data on family importance values and diversity among various communities were also recorded. Life

* Corresponding authors at: Department of Plant Sciences, Quaid-i-Azam University, Islamabad 45320, Pakistan (S.M. Khan). Department of Plant Production, Collage of Food & Agricultural Sciences, P.O. Box 2460, Riyadh 11451, Saudi Arabia (E.F. Abd_Allah).
E-mail addresses: smkhan@qau.edu.pk (S.M. Khan), eabdallah@ksu.edu.sa (E.F. Abd_Allah).
Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.sjbs.2016.11.009

form and Leaf spectra studies could be used to understand the micro climatic variation of the region.

1. Introduction

Thandiani (Thandiani 'very cold') is one of the important cool moist temperate forests in Pakistan with a diversity of valuable plant and animal species. It is situated at 35 km in the North-east of Abbottabad district between 34°-17 and 34°-10 North latitude and 73°-23 and 73°-17 East longitude. The flora and its ecological characteristics such as life form, leaf spectra, regeneration capacity, and family importance value and similarity index were studied. The leaf size knowledge may help in understanding of eco-physiological processes of plants and plants communities (Oosting, 1956). It indicates the climatic conditions, grazing pressure and human disturbance in the area (Cain and Castro, 1959). Some work has been done on the life form of alpine area of Rudranath (Ram and Arya, 1991). The available Refs. are those of Davies et al., 2009; Tareen and Qadir, 1991; Rasheed, 1999; Malik and Malik, 2004; Malik, 2005; Malik et al., 2000; Malik et al., 2007.

Such studies can be helpful in understanding climatic conditions of a region as well as indicator species (Khan et al., 2011; Ahmad et al., 2016a; Ahmad et al., 2016b). Such studies could also be helpful in future research in the field of invasive, and non native and weed species (Iqbal et al., 2015).

The aim of the study was to report leaf spectra, life form and other ecological features quantitatively so that the original picture of the vegetation could be determined. Studies like this are extremely useful for environmentalists, ecologists and those engage in range management and other field studies.

2. Materials and methods

The investigated area located in the range of western Himalayan mountains running southwards in the eastern proximity of Abbottabad at northwestern bank of River Kunhar. The elevation range of whole area is from 1191 m (3930 ft) to 2626 m (8615 ft). The highest peaks are Shikhar and Sattu peak. The natural flora and geomorphological characteristics of the area are preserved in their original state as natural heritage of the nation. The investigated area was divided into fifty localities with five plant associations on the basis of elevation and physiognomic differences. The life form reflects the adaptation of plants to climate of a region. The relative proportion of different life form for a given region is sometime called as its bio-spectrum as well. The plants were classified into different life form classes following Raunkiaer (1934) and Muller and Ellenberg (1974) life form classification. The plants were divided into the following: (a) Leptophyll (L), (b) Megaphyll (Me), (c) Microphyll (Mi) and (d) Nanophyll (N). However, for rapid estimation of the leaves in the field Raunkiaer (1934) diagram method was used.

The self-generation capacities of forests were determined by classifying woody plants into different tree diameter classes. The class interval was kept 30 cm (Table 1).

Table 1 Age classes of woody species as defined on the basis of available data.

Class	Range of diameter
1	01–30
2	31–60
3	61–90
4	91–120
5	121–150
6	151–180
7	181–210
8	211–240
9	241–270
10	271–300

The family importance values (FIV) for each family were quantified. Moreover Sorenson Index was used for the comparison of various communities within an area. It is defined as the number of species common to the two communities and is expressed as percentage of the total number of both the communities. This index was calculated following Sorenson measures:

$$I.S. = \frac{2C}{A + B} \times 100$$

where
C = Number of species common to two communities and have least Importance value
A = Total importance values of community A
B = Total importance values of community B
I = Index of similarity
S = Sorenson Index
Index of Dissimilarity = 100-IS

3. Results and discussion

3.1. Life form and leaf spectra

The life form spectra have been recorded for TsFD during summer 2013. There were 31.74% Hemicryptophytes (80-spp), 20.24% Megaphanerophytes (51-spp), 19.44 Therophytes (49-spp), 17.86% Nanophanerophytes (45-spp), 7.93% geophytes (20-spp), 1.98% lianas (5-spp) and 0.79% Chamaephytes (2-spp) (Table 2). There were five plant communities recorded from Thandiani forests, district Abbottabad (Khan et al., 2016). Various species were classified into major life forms, following the procedures of Raunkiaer (1934). In this field Von Humboldt was the first who wrote about the concept of life forms for which he used the term Vegetative form. The life form of the plants is the physiognomic form produced as a result of all life processes in interaction with the environment. The deliberations of life forms help in the ecological elucidation of the vegetation. Life form classification of Raunkiaer (1934) is the most compact and uniform which is based upon the principles of position and degree of protection to parenting bud during the adverse seasons (Khan et al., 2013c). Phyto-climates on the basis of life form on the earth, i.e.,

Table 2 Life Form and Leaf Spectra classes of plants of Thandiani Sub Forests Division Abbottabad.

S. no.	Life form	No. of species	%
1	Megaphanerophytes	51	20.24
2	Nanophanerophytes	45	17.86
3	Chamaephytes	02	00.79
4	Hemicryptophytes	80	31.74
5	Geophytes	20	07.93
6	Therophytes	49	19.44
7	Lianas	05	01.98
Total		252	100
S. no.	**Leaf spectra**	**No. of species**	**%**
1	Leptophylls	74	29.36
2	Nanophylls	60	23.80
3	Microphylls	88	34.92
4	Mesophylls	30	11.90
Total		252	100

phanerophytic, therophytic and hemicryptophytic in the tropics, deserts and cold temperate zone can be distinguished using these techniques, while according to Muller-Dumbois and Ellenberg it is the the simplest way to classify all the species on a list into five basic Raunkiaer form classes.

Life forms of all the species recorded from Thandiani Sub Forest Division were classified into major life form classes to obtain biological spectra. Biological spectrum is useful in comparing geographically separated plant habitats and is also regarded as an indicator of prevailing climate. The similar biological spectra in different regions show similar climatic conditions. In Thandiani Sub Forest Division, life form of various plant species was recorded. Raunkiaer (1934) prepared a normal spectrum based on sampling of world flora using one thousand structures. Climate of a region, is characterized by life form; however, biotic components are the potential causes for variation in the biological spectrum in a given floristic zone as well i.e. agricultural practices, grazing and deforestation. In the study area life-form spectra of different plant communities showed that hemicryptophytic, megaphanerophytic and therophytic elements were dominating the vegetation. Cain and Castro (1959) and Shimwell (1971) reported that hemicryptophytes indicate the temperate zone, whereas therophytes and geophytes are the indicator of the desert and Mediterranean sort of climates, respectively. The climate of the study area differs from subtropical to moist temperate at middle elevations and to sub-alpine meadows at higher elevations (Khan et al., 2015; Khan et al., 2016; Khan 2012; Khan et al., 2013b). Floristically, Thandiani Sub Forest Division comes under cool moist temperate zone. Close to our findings, Malik et al. (1994) and Malik et al. (2001) observed that in the moist temperate part of Dhirkot and Neelum valleys of Kashmir region, hemicryptophytes and therophytes were the dominant life form classes. Malik (2005) reported hemicryptophytic and therophytic species were dominating in Ganda Chotti and Bedori hills at an elevation of 1700–3700 m as well. Malik and Malik (2004) reported that qualitatively nanophanerophytes and hemicryptophytes were dominant in Kotli hills. Malik (2007) reported that hemicryptophytes and therophytes were dominant in Pir Chinasi hills. Due to severe pressure of deforestation and other human activities growth of trees and shrubs regeneration capacity is badly affected in these regions (Rahman et al., 2016). Tareen and Qadir (1993) reported that from Harnai to Duki moist and cold conditions, low temperature and winds characterize specific life form classes. Habitat destruction was also common in the region due to overgrazing, crushing, deforestation and over-exploitation. Therophytes thus dominated in such disturbed zones. Similar domination of therophytes was observed by Hussain et al. (1997) in Girbanr and Dabargai hills, due to destruction of natural habitat. In open physiognomies, hemicryptophytes prevail dominantly, whereas in dense ones megaphanerophytes are the best representatives (Hussain, 2009). Similarly degraded vegetation supports hemicryptophytic vegetation. Malik and Hussain (1990) reported similar results from Sarsawa hills and pointed out that vegetation degradation occurs due to severe biotic pressure. Barik and Misra (1998) reported that the biological spectrum of grassland ecosystem of the South Orissa consisted of therophytes, chamaephytes, hemicryptophytes and cryptophytes. The supremacy of therophytes is reflected similar to the present study. Chamaephytes become more prominent in sub-alpine zones due to soil and climatic conditions. In the study area high proportion of therophytes presence is the indication of enormous anthropogenic disturbances. Ram and Arya (1991) reported 36% short herbaceous flowering plants, and 27% cushion & spreading herbs. Studies of Thandiani Sub Forest Division are also in close harmony with them. The finding of Tareen and Qadir (1993) showed dominance of hemicryptophytes in temperate regions of Balochistan. Hence a Raunkiaerian life form spectra fail to fulfill the numerical status of plants in the field; therefore, quantitative characters such as density, frequency and canopy cover explain vegetation structure with dominating environmental conditions has been discussed by Khan et al. (2016) for this region. Even then the life spectra classification is preferable when researcher works at smaller scales and needs a quick description via physiognomy.

The Leaf size spectra of the plants and their communities show that microphyllous (34.92%) species followed by leptophyllous (29.36%) and nanophyllous (23.80%) were dominant in the studied area. Microphylls are representative of steppes, whereas nanophylls and leptophylls are representative of hot deserts (Cain and Castro, 1959; Tareen and Qadir, 1993). Species with large leaves occur in warmer moist climates while smaller leaves represent cold and dry climates. The Present study reveals that microphylls and nanophylls were present at high elevations while leptophylls present in the lower elevation. Malik & Hussain (1990) and Qadri (1986) reported that a high percentage of leptophylls and nanophylls occurred in dry subtropical semi evergreen forests of Kotli hills Azad Jammu and Kashmir. Malik (2005) also reported microphyllous and nanophyllous were dominant at Ganga Chotti and Bedori hills (Azad Jammu and Kashmir). His findings are in resemblance with our results. The leaf structure, usually determines habitat condition such as smaller leaves generally are characteristics of dry and adverse environmental condition. The observed relationship between small leaves and cold or hot desert climates is adaptive feature in retaining soil moisture. Moisture retaining is critical when the root is sensitive to low temperature resulting in a decrease of water absorption from the soil (Grelier, 1988). In our case, high percentage of microphylls represents the cool climate of temperate and sub-alpine meadow under cold conditions where the roots absorb low moisture and

Please cite this article in press as: Khan, W. et al., Life forms, leaf size spectra, regeneration capacity and diversity of plant species grown in the Thandiani forests, district Abbottabad, Khyber Pakhtunkhwa, Pakistan. Saudi Journal of Biological Sciences (2016), http://dx.doi.org/10.1016/j.sjbs.2016.11.009

nutrients. Our findings are comparable with those of Qadir and Tareen (1987) who reported high percentage of microphylls and nanophylls in a temperate sort of climate in the district Quetta of Baluchistan. Malik (2007) reported similar findings in Pir Chinasi hills. Saxina et al. (1985) observed that the percentage of microphylls was positively correlated with the increasing elevation. In the present case the percentage of leaf form classes also differ with increasing altitude. Some other findings are contradictory with ours due to climatic variations such as temperature and wet tropical sort of conditions observed in tropical sort of habitats. The sizes of the leaves alone could not explain the specific leaf zone or climate. Plant habit and its root system also play an important role. The leaf size knowledge though helps in understanding physiological processes of plants and plant communities and is hence useful while classifying plants into various associations (see Tables 3 and 4).

3.2. Regeneration capacity

The number of trees different girth classes is depicted in Table 5. It was observed that *Pinus wallichiana* and *Abies pindrow* had a maximum girth of 241 cm and 270 cm respectively. The difference among girth classes shows presence of plants of different age groups. The presence of young plants from seedling to mature or overmature stage shows a chance of regeneration. The *Diospyrus lotus*, *Juglens regia*, *Pinus roxburghii*, *Pyrus pashia* and *Quercus incana* were observed with full regeneration capacity, while *Acacia arabica*, *Aesculus indica*, *Ficus carica*, *Morus nigra* and *Pistacia antegrrimma* were not found in the regenerating capabilities as these were present in the form of sporadic individuals in few girth classes. These findings can be compared with Mehmood et al., 2015; Ullah et al., 2015; Khan et al., 2013a; Khan et al., 2011 in terms of species distribution.

Table 3 Percentage of life form recorded from Thandiani forests, district Abbottabad during the summer of 2013.

Ser. no.	Plant associations	Elevation (m)	T.S	Li		Ch		G		H		Mp		Np		Th	
				No	%	No	%	No	%	No	%	No	%	No	%	No	%
1	*Melia-Punica-Euphorbia*	1200–1500 masl	94	03	3.2	02	2.1	02	2.1	26	27.7	29	30.8	19	20.2	16	17
2	*Zizyphus-Zanthoxylum-Rumex*	1501–1800 masl	174	03	1.7	02	1.1	11	6.3	51	29.3	41	23.6	34	19.5	33	18.9
3	*Quercus-Cornus-Viola*	1801–2100 masl	170	04	2.4	01	0.6	16	9.4	53	31.2	34	20	33	19.4	29	17
4	*Cedrus-Viburnum-Achillea*	2101–2350 masl	142	02	1.4	01	0.7	15	10.6	47	33.1	22	15.5	32	22.5	23	16.2
5	*Abies-Daphne-Potentilla*	2351–2626 masl	81	00	00	01	01.2	07	8.6	26	32	20	24.7	18	22.2	09	11.1

T.S, Total species; Ch, Chamaephytes; G, Geophytes; H, Hemicryptophytes; Mp, Megaphanerophytes; Np, Nanophanerophytes; Th, Therophytes; Li, Lianas.

Table 4 Percentage of leaf spectra recorded from Thandiani forests, district Abbottabad during 2012–2014.

S. no.	Plant associations	Elevation (m)	T.S	Le		Me		Mi		N	
				No	%	No	%	No	%	No	%
1	*Melia-Punica-Euphorbia*	1200–1500 masl	94	24	25.5	13	13.8	40	42.5	17	18
2	*Zizyphus-Zanthoxylum-Rumex*	1501–1800 masl	174	46	26.4	24	13.8	68	39.1	36	20.7
3	*Quercus-Cornus-Viola*	1801–2100 masl	170	51	30	22	12.9	57	33.5	40	23.5
4	*Cedrus-Viburnum-Achillea*	2101–2350 masl	142	44	31	16	11.3	48	33.8	34	23.9
5	*Abies-Daphne-Potentilla*	2351–2626 masl	81	25	30.8	19	23.5	28	34.6	09	11

T.S, Total species; Le, Leptophylls; Me, Megaphylls; Mi, Microphylls; N, Nanophylls.

Table 5 Regeneration capacity of important tree species of Thandiani Sub Forests Division, Abbottabad.

S. no.	Age classes	0–30	31–60	61–90	91–120	121–150	151–180	181–210	211–240	241–270	Status
1	*Abies pindrow*	0	0	0	0	6	9	97	6	5	R
2	*Acacia Arabica*	0	0	0	2	8	1	0	0	0	D
3	*Aesculus indica*	0	0	2	4	4	8	3	0	0	D
4	*Diospyrus lotus*	0	0	1	12	9	11	5	2	0	R
5	*Ficus carica*	0	0	11	20	35	13	0	0	0	D
6	*Juglens regia*	0	0	0	1	6	8	11	3	0	R
7	*Morus nigra*	0	0	4	10	15	10	1	0	0	D
8	*Pinus roxburghii*	0	0	0	13	14	13	13	6	0	R
9	*Pinus wallichiana*	0	0	11	34	63	64	48	21	26	R
10	*Pistacia antegrrimma*	0	0	2	1	3	7	6	0	0	D
11	*Pyrus pashia*	0	0	5	15	19	9	3	0	0	R
12	*Quercus incana*	0	0	0	7	14	12	6	2	0	R

R, Regenerative; D = Dying.

Please cite this article in press as: Khan, W. et al., Life forms, leaf size spectra, regeneration capacity and diversity of plant species grown in the Thandiani forests, district Abbottabad, Khyber Pakhtunkhwa, Pakistan. Saudi Journal of Biological Sciences (2016), http://dx.doi.org/10.1016/j.sjbs.2016.11.009

An age class is the ratio of various age groups of a population at a given time. Age class has been used as a guide to timber execution. The diameter of the trunk at breast height or dbh has been used as an indicator of the age on the expectation that diameter increases with age. The greater the diameter the older would be the tree but it is valid for dominant trees canopy. Sometimes small trees also have the same age as larger individuals in the canopy. Age pyramids help to contemplate the age structure of a population. As the population changes with time, the numbers of young individuals, which expand the base of the pyramid, characterize a growing population. This large class of young's eventually move up into the older age classes characterizes a declining population with fewer individuals of the reproductive age classes and hence further distress the population. In this way age structure changes over time. In the present study it was observed that *Pinus wallichiana* and *Abies pindrow* were the tree species which shows relatively higher regenerating capacity. The girth of both these trees ranged up to 241 and 270 cm respectively. Chaghtai and Ghawas (1976) observed that *Pinus roxburghii* having 2–33 cm girth in various classes in Malakand showed higher regeneration capacity. In the present study cutting of the few mature individuals of *Pinus roxburghii* was present without showing any regeneration because *Pinus roxburghii* grows at lower elevations whereas there is maximum human interference. *Pinus roxburghii* have been removed from natural habitat for building houses and agricultural land expansion. In our case *Pinus wallichiana* varies from 5 to 210 cm. Majority of the individuals of *Abies pindrow* and *Pinus wallichiana* population in Thandiani Sub Forests Division had a medium size tree, which shows their considerable regenerating capacity in existing climate. However abiotic factors influence their regenerating capacity (Shaheen et al., 2015; Khan et al., 2012). Khan et al. (2014) reported that grazing activity has an important impact on community structure and regenerating capacity. Grazing livestock exerts high negative pressure on the regeneration of *Quercus ilex* and other palatable trees. Age and growth rate of plants greatly differ among different species, sites and even with two similar sized trees of the same species. The size of trees either increased or decreased with increase in elevation, depending upon the species altitudinal requirements. Pinus *wallichiana* forest at Thandiani Sub Forests Division is adversely affected by the fuel wood collection. The entire requirements for heating, fodder, and timber wood extraction are fulfilled by these forests. The over-exploitation of these resources leads to their consumption, which ultimately causes habitat destruction of plant and animals. The distribution of plants in different age classes indicates age and population status of plant species i.e., regeneration capacity, declining population or facing other environmental changes.

3.3. Similarity (SI) and Dissimilarity (DI) indices

In the study area there were 8 transects and 50 stations forming 5 plant communities, each having different SI and DI. Data show that the highest similarity (IS) (92.1348%) was reported between Kakl RFC and Mathrika in Transect 3-Kukule, while the majority of the stations shared 45–60% similarity among them. The remaining stations had less than 30% similarity among themselves (Tables 6). Mueller-Dumbois and Ellenberg (1974) reported that communities/habitats having less than 65% similarity are called as dissimilar (ID). A similarity index does not show the relative abundance of a species but these become more useful when major interest lies in the presence or absence of a species. Degree of similarity between two plant stations allows combining them into an association or vegetation type. It reduces the higher number of plant species into few similar vegetation types. The higher similarities between the communities might be due to the difference in altitude, similarity in nutrients, proximity of stands to each other, which almost had similar habitat conditions in terms of nutrients, etc. The least similarity among the communities/habitat types was due to change in altitude, climatic, edaphic and biotic conditions, such as erosion, soil differences such as silty loam to sandy loam, pH, EC, nitrates, overgrazing, trampling and deforestation as discussed in Khan et al. (2016). Such differences cause changes in nutrient status and low relationship of habitat and thus species. The indices of similarities between plant communities showed high differences among themselves owing to the variation in altitude and biotic factors (Malik et al., 1990; Malik, 2007; Malik, 2005). The communities in which dominant vegetation comprised of therophytes showed least similarities. Malik and Malik (2004) reported that plant communities differ from one another due to topography, exposure, erosion and biotic factors.

3.4. Family importance values

There were 97 families found in the study area in which largest family in terms of numbers of species was Rosaceae with 20 species, followed by Asteraceae with 14 species and Ranunculaceae with 12 species. On the other hand based on Family Importance Value Pinaceae was the largest family containing 1892.364 FIV followed by Rosaceae with 1478.24 FIV and Ranunculaceae with 762.0672 FIV (Table 7). Families with least FIVs were Acanthaceae, Asclepiadaceae and Dioscoreaceae having 0.12, 1.992138482, and 4.063641215 FIV respectively, and all these families are also represented by only 01 species each (Table 7). The present study agrees with Ahmad et al. (2012), Khan et al., 2011 and Bano et al. (2014) who

Table 6 Similarity Index and Dissimilarity Index of different plant communities of Thandiani Sub Forests Division, Abbottabad.

	Melia-Punica-Euphorbia	*Zizyphus-Zanthoxylum-Rumex*	*Quercus-Cornus-Viola*	*Cedrus-Viburnum-Achillea*	*Abies-Daphne-Potentilla*
Melia-Punicaa-Euphorbia	**X**	33.58	58.94	69.49	73.72
Zizyphus-Zanthoxylum-Rumex	66.42	**X**	26.53	45.57	58.43
Quercus-Cornus-Viola	41.06	73.47	**X**	31.83	54.4
Cedrus-Viburnum-Achillea	30.51	54.43	68.17	**X**	57.85
Abies-Daphne-Potentilla	26.28	41.57	45.6	42.15	**X**

Table 7 Family Importance Value of 10 highest & 10 least families of Thandiani Sub Forests Division, Abbottabad.

S. no.	Highest families	No. of species	%
1	Pinaceae	5	12.58
2	Rosaceae	20	9.83
3	Ranunculaceae	12	5.1
4	Papilionaceae	9	4.9
5	Polygonaceae	5	4.6
6	Poaceae	5	3.6
7	Asteraceae	14	3.3
8	Plantaginaceae	3	2.8
9	Euphorbiaceae	4	2.7
10	Caprifoliaceae	6	2.6
S. no.	Rarest families	No. of species	%
1	Acanthaceae	1	0.00085
2	Asclepiadaceae	1	0.013
3	Dioscoreaceae	1	0.031
4	Apocynaceae	1	0.032
5	Taxaceae	1	0.033
6	Hypericaceae	2	0.041
7	Myrsinaceae	1	0.042
8	Staphyliaceae	1	0.044
9	Scheuchzeriaceae	1	0.045
10	Hamamelidaceae	1	0.052

F.I.V., Family Importance Value.

reported that Rosaceae, Pinaceae and Polygonaceae were the best representative families of Himalayas Forests. FIVs show the overall dominance and biomass level of an area at taxonomic families' levels.

Acknowledgment

The authors would like to extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for funding this research group (NO. RG-1435-014).

References

Ahmad, K.S., Qureshi, R., Hameed, M., Ahmad, F., Nawaz, T., 2012. Conservation assessment and medicinal importance of some plants resources from Sharda, Neelum valley, Azad Jammu and Kashmir, Pakistan. Int. J. Agric. Biol. 14 (6), 997–1000.

Ahmad, Z., Khan, S.M., Abdallah, E.F., Alqarawi, A.A., Hashem, A., 2016a. Weed species composition and distribution pattern in the maize crop under the influence of edaphic factors and farming practices: a case study from Mardan, Pakistan. S. J. Biol. Sci. 23 (6), 741–748.

Ahmad, Z., Khan, S.M., Ali, S., Rahman, I.U., Ara, H., Noreen, I., Khan, A., 2016b. Indicator species analyses of weed communities of maize crop in district Mardan, Pakistan. Pak. J. Weed Sci. Res. 22, 227–238.

Bano, A., Ahmad, M., Hadda, T.B., Saboor, A., Sultana, S., Zafar, M., Khan, M.P.Z., Arshad, M., Ashraf, M.A., 2014. Quantitative ethnomedicinal study of plants used in the skardu valley at high altitude of Karakoram-Himalayan range, Pakistan. J. Ethnobiol. Ethnomed. 10 (1), 1.

Barik, K.L., Misra, B.N., 1998. Biological spectrum of grassland ecosystem of South Orissa. Ecoprint 5, 73–77.

Cain, S.A., Castro, G.M.D., 1959. Manual of Vegetation Analysis. harper hand Brothers, Publication Newyork, pp. 55.

Davies, K.W., Svejcar, T.J., Bates, J.D., 2009. Interaction of historical and nonhistorical disturbances maintains native plant communities. Ecol. Appl. 19 (6), 1536–1545.

Hussain, F., Ilyas, M., Takatsuki, S., 1997. Plant communities of Girbanr Hills, Swat District, North Western Pakistan. Ecol. Rev. 23 (4), 247–260.

Hussain, T., 2009. A floristic description of flora and ethnobotany of Samahni Valley (AK), Pakistan. Ethnobotanical Leaflets 7, 6.

Iqbal, M., Khan, S.M., Khan, M.A., Rahman, I.U., Abbas, Z., 2015. Exploration and inventorying of weeds in wheat crop of the district Malakand, Pakistan. Pak. J. Weed Sci. Res. 21, 435–452.

Khan, S.M., 2012. Plant communities and vegetation ecosystem services in the Naran Valley, Western Himalaya (Doctoral dissertation). University of Leicester.

Khan, S.M., Harper, D.M., Page, S., Ahmad, H., 2011. Species and community diversity of vascular flora along environmental gradient in Naran Valley: a multivariate approach through indicator species analysis. Pak. J. Bot. 43 (5), 2337–2346.

Khan, W., Khan, S.M., Ahmad, H., Ahmad, Z., Page, S., 2016. Vegetation mapping and multivariate approach to indicator species of a forest ecosystem; a case study from the Thandiani sub Forests Division (TsFD) in the Western Himalayas. Ecol. Indic. 71, 336–351.

Khan, W., Khan, S.M., Ahmad, H., 2015. Altitudinal variation in plant species richness and diversity at thandiani sub forests division, Abbottabad, Pakistan. J. Biod. Environ. Sci. 7 (1), 46–53.

Khan, S.M., Page, S., Ahmad, H., Harper, D.M., 2013a. Sustainable utilization and conservation of plant biodiversity in Montane Ecosystems; using the Western Himalayas as a Case Study. Ann. Bot. 112 (3), 479–501.

Khan, S.M., Page, S., Ahmad, H., Harper, D., 2013b. Identifying plant species and communities across environmental gradients in the Western Himalayas: method development and conservation use. Ecol. Inform. 14, 99–103.

Khan, S.M., Page, S., Ahmad, H.A.B.I.B., Shaheen, H., Harper, D. M., 2012. Vegetation dynamics in the Western Himalayas, diversity indices and climate change. Sci., Tech. and Dev. 31, 232–243.

Khan, S.M., Page, S., Ahmad, H., Ullah, Z., Shaheen, H., Ahmad, M., Harper, D.M., 2013c. Phyto-climatic gradient of vegetation and habitat specificity in the high elevation Western Himalayas. Pak. J. Bot. 45 (SI), 223–230.

Malik, N.Z., Malik, Z.H., 2004. Present status of subtropical chir pine vegetation of Kotli Hills, Azad Jammu and Kashmir. J. Res. Sci. 15 (1), 85–90.

Malik, S.A., Dasti, A.A., Mamoona, S., 2000. Phytosociological studies of waste land at B. Z. University, new campus Multan. Sci. Khy. 13 (2), 11–22.

Malik, Z.H., 2005. Comparative study of vegetation of Gunga Chotti and Bedori Hills, Distric Bagh, Azad Jammu and Kashmir with special reference to range conditions. PhD. Thesis. University of Peshawar, Pakistan.

Malik, Z.H., Ahmad, S., Hussain, F., 1994. Present status of subtropical chir pine vegetation of Samani Hills Azad Jammu and Kashmir. Sci. KPK. Pak. 7, 51–58.

Malik, Z.H., Hussain, F., 1990. Phytosociology of some parts of Kotli Hills, Azad Kashmir. J. Sci. Technol. 14, 117–123.

Malik, Z.H., Hussain, F., Malik, N.Z., 2007. Life form and leaf size spectra of plant communities are bring Ganga Chotti and Bedori Hills. Int. J. Agric. Biol. 9 (6), 833–838.

Malik, Z.H., Malik, N.Z., Bashir, S., Gorsi, M.S., 2001. Phytosociological studies on the vegetation of Dao Khun Hills. J. Sci. Technol. 25, 35–41.

Mehmood, A., Khan, S.M., Shah, A.H., Shah, A.H., Ahmad, H., 2015. First floristic exploration of District Torghar, Khyber Pakhtunkhwa, Pakistan. Pak. J. Bot. 47 (SI), 57–70.

Muller, D.B., Ellenberg, H., 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York, p. 547.

Oosting, H.J., 1956. The Study of Plant Communities, second ed. W H Freeman and Co, Sanfrancisco. ISSN 0-471-62290-7. pp. 69–78. <https://www.researchgate.net/publication/275652823>.

Qadri, M., 1986. Phytosociological Study on the Vegetation of Kotli Hill, Azad Kashmir, M. Phil Thesis, Bot. Peshawar University, 211 pp.

Rahman, A., Khan, S.M., Hussain, A., Rahman, I.U., Iqbal, Z., Ijaz, F., 2016. Ecological assessment of plant communities and associated edaphic and topographic variables of the Peochar Valley District Swat of the Hindu Kush Mountains. Mou. Res. Dev. 36 (3), 332–341.

Ram, J., Arya, P., 1991. Plant forms and vegetation analysis of an alpine meadow of Central Himalaya, India. Proc. Nat. Acad. Sci. India 57, 311–318.

Raunkiaer, C., 1934. The Life Form of Plants and Statistical Plant Geography. Clarendon Press, Oxford, pp. 623.

Rasheed, M.A., 1999. Recovery of experimentally created gaps within a tropical Zostera capricorni (Aschers.) seagrass meadow, Queensland Australia. J. Exp. Mar. Biol. Ecol. 235 (2), 183–200.

Saxina, A.K., Pandey, T.P., Singh, J.S., 1985. Altitudinal variation in the vegetation of Kaumaun Himalaya. In: Rao, D.N. (Ed.), Perspectives in Environmental Botany. Print House, Lucknow, pp. 43–66.

Shaheen, H., Sarwar, R., Firdous, S.S., Dar, M.E.I., Ullah, Z., Khan, S.M., 2015. Distribution and structure of conifers with special emphasis on Taxus Baccata in moist temperate forests of Kashmir Himalayas. Pak. J. Bot. 47 (SI), 71–76.

Shimwell, D.W., 1971. The Description and Classification of Vegetation. Sedgwick and Jackson, London, pp. 322.

Tareen, R.B., Qadir, S.A., 1991. Life form and leaf spectra of the plant communities of diverse areas ranging from Harnai, Sinjawi to Duki region of Pakistan. Pak. J. Bot. 25, 83–92.

Ullah, Z., Ahmad, M., Sher, H., Shaheen, H., Khan, S.M., 2015. Phytogeographic analysis and diversity of the grasses and sedges (Poales) of northern Pakistan. Pak. J. Bot. 47 (SI), 93–104.

Please cite this article in press as: Khan, W. et al., Life forms, leaf size spectra, regeneration capacity and diversity of plant species grown in the Thandiani forests, district Abbottabad, Khyber Pakhtunkhwa, Pakistan. Saudi Journal of Biological Sciences (2016), http://dx.doi.org/10.1016/j.sjbs.2016.11.009