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Research Article

Ecological Assessment of the Native Flora of Matta Kharari Village, Swat, Khyber Pakhtunkhwa, Pakistan

Shima Habib[1], Lal Badshah[1], Ishtiaq Ahmad[2], Waqar Ahmad[3], Abdullah[4]*, and Shujaul Mulk Khan[4,5]*

[1]Department of Botany, University of Peshawar, Pakistan
[2]Department of Botany, Islamia College University Peshawar, Pakistan
[3]Fujian Agriculture and Forestry University, Cangshan District, Fuzhou, Fujian Province, China
[4]Department of Plant Sciences, Quaid-i-Azam University Islamabad-45320, Pakistan
[5]Pakistan Academy of Sciences, Islamabad, Pakistan

Abstract: Plant species composition, diversity and distribution is a hierarchical expression of vegetation determined by different environmental factors. A study was conducted to document the floristic composition and biological spectrum of plant species of the Matta-Kharari region, Swat. The region has not been ecologically explored yet. We used quantitative ecological techniques for sampling plant species. Sixty-seven quadrats of 1x1 m^2 for herbs, 5x5 m^2 for shrubs and 10x10 m^2 size for trees were established. Plant species data were analyzed using multivariate statistical techniques. We evaluated 76 plant species belonging to 42 families. Asteraceae and Rosaceae were the leading families with 8 species each, followed by Ranunculaceae, Lamiaceae and Moraceae with 4 species each. Among life form classes i.e., geophytes were dominant (13 species, 17.10 %), followed by therophytes (12 species, 15.87 %), nanophanerophytes (11 species, 14.47 %), and chamaephytes (10 species, 13.58 %). Moreover, Mesophylls (36.84 %) were the dominant leaf spectra class followed by nanophyll (30.26 %), microphyll (27.63 %), and megaphyll (2.63 %). The two-way cluster analysis classified the vegetation into three clusters. The detrended correspondence analysis shows the distribution of plants in a mixed array because the locations explored are characterized by similar climatic factors and vegetation. We elucidate that the variation in climatic factors and topography brings variation in vegetation. Understanding these responses at the life form and leaf spectra level will provide a better understanding and knowledge that how plant species and their communities or associations respond to changes in climate in the future. The current study could be utilized as a baseline for large-scale studies in the future.

Keywords: Floristic Composition, Biological Spectrum, Multivariate Analysis, Detrended Correspondence Analysis

1. INTRODUCTION

Ecological assessment of a floristically rich and diverse region is crucial for determining the key elements responsible for hosting such a diverse and rich Phyto-diversity [1]. Floristic classification of a region depends on different characteristics such as habitat, species diversity, composition, and geographical features. The floristic inventory of a region is a complete set of wild, native, horticultural and agricultural plant species [2]. Precise floristic inventories can assist in a better understanding of topography, climate, soil, hydrology and many other features influencing forest diversity and composition [3]. The collective growth of the plant in a particular area characterized by a component of species or combination of species is known as vegetation. They are a key component of the ecosystem which describes different ecological patterns and facts across the landscape [4]. Classification of vegetation of a region into various associations or communities is crucial for resource management [5]. Quantitative ecological techniques are used to determine vegetation, pattern distribution and composition in a meaningful way [6]. Various qualitative and quantitative features

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*Corresponding Authors: Abdullh <Abdullhakhan@bs.qau.edu.pk>;
Shujaul Mulk Khan <shuja60@gmail.com; shujaqau@gmail.com>

of vegetation such as density, cover, frequency, abundance, richness, and phenology are focused on in the field of plant ecology [7].

Plant life forms and leaf spectral traits reflect the existing environmental conditions of a region [8]. A number of authors have disentangled the complex relationship of plant life form and leaf spectral traits with the surrounding environment i.e., Harboi rangeland Kalat [9], Mastuj valley Chitral [10], Havelian Abbottabad [11], Manoor Valley Kaghan [8], Balakot Mansehra [2] Biha valley Swat [12] and many others. It is crucial to understand the state of the floristic diversity of the unexplored areas [13]. Plant life forms and spectra are an important expression of the current climate. In some species, leaf size increases when moving from dry to most sorts of climatic regions. Multivariate statistical analyses are used to understand the complex species distribution pattern [14]. Cluster and two-way clusters are used for the classification and understanding of the distribution pattern of species [15]. On the other hand, detrended correspondence analysis (DCA) is used to identify various vegetation groups, communities and associations [16].

The current study region Matta-Kharari lies in the floristically rich region of Swat. However, a study presenting floristic composition by using multivariate ecological techniques is missing. Therefore, the current study is the first-ever attempt to analyze life and leaf spectral data as well as plant species data through different multivariate ecological tools and it will serve as a baseline for large-scale studies in the future. The current study aimed to elaborate on floristic composition with a special focus on life form and leaf spectra traits.

2. MATERIALS AND METHODS

2.1 Study Area

The beautiful valley of Swat is geographically situated at 34^0 34' to 35^0 55' North latitude and 72^0 08' to 72^0 50' East longitude. It lies in the Norwest parts of the Khyber-Pakhtunkhwa province of Pakistan. The region has beautiful sites with an altitudinal range from 700-6000 meters [17]. Swat Valley is best known for its waterfalls, lakes, and lush green hills. Physically it forms parts of the Himalayan, Hindukush and Karakorum mountains and is considered among the most beautiful places of the subcontinent, also known as the "Switzerland of the East" [18]. Swat contains innumerable monuments of ancient civilizations, spanning 5,000 years of history. The annual rainfall in Swat ranges from 1000-1200 mm. On the other hand, the average temperature is mostly in the range of -2 ^{0}C to 37 ^{0}C [17]. Swat Valley has diverse flora distributed across its moist and temperate zones. The region is considered a hub for different fruits and vegetables. Apple, peach, plum, apricot and persimmon are among the popular fruits of the region. It has an area of 5,337 square kilometers and a population of 2,309 [19]. The region is divided into seven tehsils: (1) Barikot (2) Babuzai (3) Bahrain (4) Charbagh (5) Kabal (6) Khwazakhela (7) and Matta [19].

Matta is the leading administrative subdivision of Swat [17], [20]. Tehsil Matta has a population of about 465,996 individuals and 52,625 households [21]. It is situated at 34° 36' 59" to 35° 44' 51' N and from 72° 29' 52" to 72˚ 09' 52" E and at an altitude of 1136 meters at sea level [20]. It has a total area of 683 Km^2. Word Matta is a traditional word that means clay. Matta lies 20 Km from the main city of Mingora. Most of its population is rural [20]. Apple and peach (more than 95 %) of Swat are produced in the Matta sub-division rightly termed as the "Apple region". Matta Kharari is located near the north junction of the Swat and Haronai rivers. Matta Swat has a lot of biodiversity resources. A review of the available information shows that the livelihood and primary healthcare in traditional communities are mostly dependent upon the vegetation of the area.

2.2 Collection and Preservation

We collected various plant species from different sites in the Matta Khararai region. We used quadrat quantitative ecological techniques across the area. Quadrats of 10x10 m^2 for trees, 5x5 m^2 for shrubs and 1x1 m^2 for herbaceous plants were used. Plant samples were properly tagged and dried with their respective codes of each quadrat. We identified our samples using various updated volumes of the flora of Pakistan. All samples were cross-checked with previously collected samples by different researchers from various regions of the country. Plant samples were poisoned for preservation using mercuric chloride and ethanol solution. Preserved

samples were mounted on standard herbarium sheets. Then the collected plants were preserved and mounted on standard herbarium sheets. A complete alphabetical floristic list of species along with families and ecological descriptions was prepared. The plants with voucher numbers were submitted to the Herbarium, Department of the Botany University of Peshawar, Pakistan.

2.3 Life Form and Leaf Spectra Classes

We arranged plants into different Raunkiaer (1934) life form classes [22]. The Raunkiaer (1934) life form classes include Phanerophytes (Megaphanerophytes > 30 m, Mesophanerophytes 7.5-30 m, Microphanrerophytes 2-7.5 m, Nanophanerophytes 0.25-2 m, Chaemiphytes, Hemicryptophytes, Geophytes, Therophytes, Climber and Lianna. Moreover, we further classified these plant species into different classes based on leaf size following Raunkiaer's (1934) leaf spectra classification. The Raunkiaer (1934) leaf spectra classes are Leptophyll up to 25 mm, Nanophyll with leaf size 25-225 mm^2, Microphyll 225-2025 mm^2, Mesophyll 2025-18225 mm^2, Macrophyll 18225-164025 mm^2 and Megaphyll larger than 164025 mm^2 [23].

2.3 Data Analysis

Data analyses were carried out to know the distribution and classification patterns of vegetation. The data were put and sorted in MS Excel for hierarchical cluster and Two-Way Cluster Analysis as per the requirement of the software. Cluster and Two-Way Cluster dendrograms were constructed using PCORD software. We used presence and absence data (1,0) for Two-Way Cluster analysis to understand the distribution pattern in the study region. In Two-Way Cluster the black dots show the presence while the white empty dots show the absence of a particular species. Species are grouped in Two-Way Cluster based on similarities and dissimilarities in presence and absence frequency (Figure 3). For ordinations, we used detrended correspondence analyses. It is a type of indirect gradient analysis used to know species ordination in a particular region. The Canodraw function of CANOCO software was used for data visualization and graph creation. Vegetation ecologists mostly use detrended correspondence analyses when they are interested in understanding the relationship among species or sampling plots.

3. RESULTS AND DISCUSSION

3.1 Floristic Composition and Ecological Features

We collected 76 plant species belonging to 42 families (Table 1). Among these 42 families, only one family belongs to Gymnosperms while the remaining are Angiosperms. Angiosperms have 35 dicots and 6 monocot families. Asteraceae and Rosaceae are the top dominant families each with 8 species followed by Ranunculaceae, Lamiaceae and Moraceae each contributing 4 species. Brassicaceae and Fabaceae have 3 species each. Buxaceae, Polygonaceae, Adoxaceae, Salicaceae and Caprifoliaceae have 2 species each. Plantaginaceae, Papaveraceae, Violaceae, Diosccoreaceae, Poaceae, Juglandaceae, Berberidaceae, Hyperiacaceae, Scrophulariaceae, Cannabaceae, Ebenaceae, Rubiaceae, Onagraceae, Asparagaceae, Utricaaceae, Primulaceae, Paeoniaceae, Araliaceae, Aquifoliaceae, Geraniaceae, Saxifragaceae, Boraginaceae, Colchicaceae, Crassulaceae, Balasaminaceae, Elaegnaceae, Phyllanthaceae and Celastraceae are having 1 species each.

Shaheen *et al.* [26] documented 248 plant species in 166 genera and 38 families from the desert of Thal Punjab Pakistan. Based on their findings the most dominant families were Poaceae, Fabaceae, Amaranthaceae and Asteraceae which are in complementarity to our results. On the other hand, Nasir and Sultan [24] explored the floristic composition of the district Chakwal and revealed that the dominant families are Asteraceae and Poaceae which support our findings. The vegetation of Hayatabad Peshawar is explored by Shah and Hussain [25], they documented that Asteraceae, Brassicaceae, Poaceae and Solanaceae are the top leading families of the region. Their results strongly support our findings. Khan *et al.* [27], classified the vegetation of the dry and Coal rich Dara Adam Khel mountains into different biological spectrums. They reported 54 species belonging to 30 different families. Asteraceae was the topmost leading family followed by Lamiaceae and Solanaceae which support our findings.

3.2 Life Form

Plants are classified into different life form classes to know about the general appearance of the vegetation of a region because it reflects the impact of the environment on the existing vegetation. It assists vegetation scientists in the recognition and description of the flora of a region. Raunkiaers life form classification system is more accurate and reliable. It is based on the protection of perennating buds during adverse and unfavorable conditions [22]. Following Raunkiaer's classification, we classified all plant species into different life form classes i.e., geophytes (13 species, 17.10 %), therophytes (12 species, 15.87 %), nanophanerophytes (11 species, 14.47 %), chamaephytes (10 species, 13.58 %), Mesophnarophytes (9 species11.84 %), mega-phanerophytes (9 species, 11.84 %), hemicryptophytes (8 species, 10.52 %), and Microphanerophytes (2 species, 2.63 %) as shown in (Figure 1).

3.3 Leaf Size Spectra

In the current study, the Mesophylls (36.84 %) were the dominant leaf spectra class followed by nanophyll (30.26 %), microphyll (27.63 %), megaphyll (2.63 %) and leptophyll (1.31 %) as shown in (Figure 2). Malik *et al.* [29], explored the moist temperate vegetation of Pir Chinnasi hills in Azad Jammu Kashmir by classifying their plant species into leaf spectra classes. Their results revealed that in the spring season microphylls were the dominant class followed by nanophylls. Their results are in accordance with our findings because the Azad Jammu Kashmir has great similarity to the climatic conditions of Swat.

Moreover, the Dheri Baba hills explored by Shah and Rozina [30], documented that the microphylls and mesophylls were the top leading leaf spectra classes in the region. Leaf spectral classes reveal that the microphylls increase with a gradual increase in altitude from the lower foothills to the top peaks. According to them, Nanophylls density was higher at lower altitudes. Plant species with minute leaf sizes are the general indicators of dry and xerophytic ecosystems because small leaf size is an adaptation to dry and arid types of habitats [24]. According to Batalah and Martin [31, 33] that leaf size is significantly correlated to drought and soil conditions.

3.4 Distribution of Plant Species in the Study Area

Based on the presence and absence of the plant species in the specific quadrat using 1-0 data a two-way cluster dendrogram was constructed. Where black blocks show the presence of plant species while white blocks indicate the absence of the species in a particular quadrat. It tells us about the distribution pattern of plant species in the studied region [1,15, 32]. Species with maximum black dots show dominancy while rare species are shown by very few dots in the dendrogram (Figure 3). *Lonicera quinquelocularis, Rubus niveus, Fragaria vesca, Thalictrum hamatum, Cannabis sativa,*

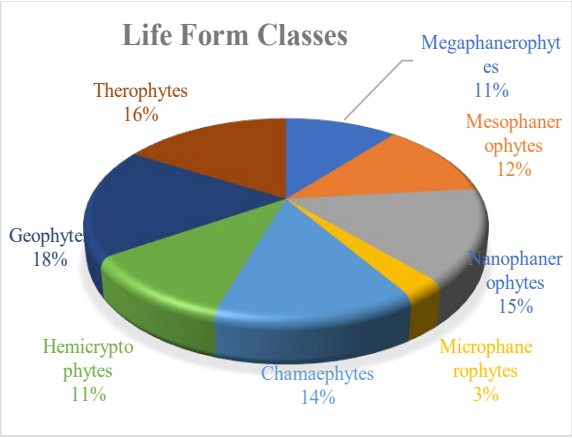

Fig. 1. Percentage of Raunkaier life form classes

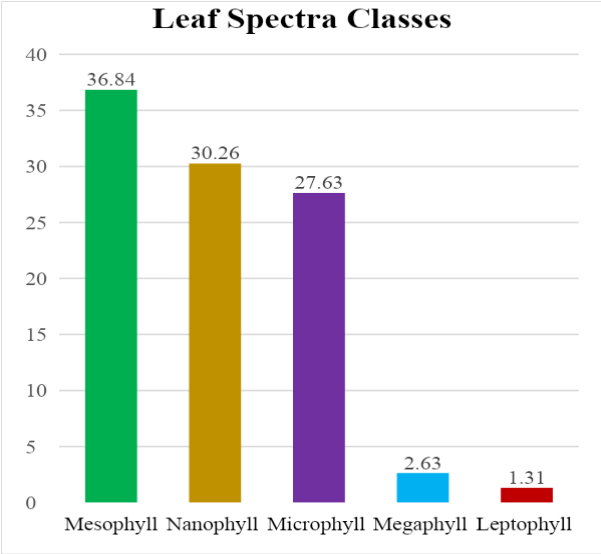

Fig. 2. Percentage of Raunkaier leaf spectra classes

Table 1. Floristic composition, life form and leaf size spectra

Family	No. of Species	Botanical name	Collection No	Local name	Life form	Leaf spectra
Pinaceae	2	*Picea smithiana* (Wall.) Boiss.	23	Mangazai	MegP	N
		Pinus wallichiana A.B. Jacks	2	Peuch	MegP	N
Asteraceae	8	*Aster flaccidus* Bunge	90	--	Th	Mic
		Onopordum acanthium L	72	Candeyary	G	Mes
		Conyza bonariensis (L.) Cronquist	66	--	Th	N
		Prenanthes brunoniana Wall. ex DC	42	--	Th	Mes
		Artemisia vulgaris L.	40	Tarkha	Ch	Mic
		Launaea secunda (C.B. Clarke) Hook. F	20	Karazay	H	L
		Leontopodium himalayanum DC.	14	Sargary	H	N
		Tussilago farfara L.	7	Nakipanra	G	Mes
Rosaceae	8	*Rubus niveus* Wall. ex G. Don	97	Boganra	MP	N
		Spirea Pall.	80	--	MP	Mic
		Prunus cornuta (Wall. ex Royle) Steud.	49	Barid	Mic	Mes
		Fragaria vesca L.	36	Zmakeen Toot	Th	Mic
		Rosa moschata Herrm	34	Qurach	MP	N
		Sorbaria tomentosa (Lindl.) Rehder	28	Jajrai	NP	Mic
		Spiraea canescens D. Don	80	Chaghge-botay	NP	Mic
		Cotoneaster himalaiensis hort. ex Zabel	73	Kharawa	MP	N
Ranunculaceae	4	*Delphinium denudatum* Wall.ex Hook. f. & Thomson	70	Leghonay	H	N
		*Thalictrum hamatu*m Maxim	21	Kekerbotay	TH	N
		Ranunculus laetus Wall. ex Royle	19	Zergolay	G	N
		Aquilegia fragrans Benth.	11	Zergolay	Ch	N
Lamiaceae	4	Origanum vulgare L.	82	Desipodina	Ch	Mic
		Isodon rugosus (Wall. ex Benth.) Codd	69	Sperkay	NP	Mes
		Mentha longifolia (L.) Huds.	58	Welanay	G	N
		Ajuga bracteosa Wall.exBenth.	13	Boti	H	Mic
Moraceae	4	*Morus nigra* - L.	81	Tor toot	MegP	Mes
		Ficus palmata Forssk.	77	Enzar	MegP	Mes
		Ficus foveolata (Wall. ex Miq.) Miq.	63	Patenzar	MegP	Mes
		Morus serrata Roxburgh	55	Toot	MegP	Mes
Brassicaceae	3	*Nasturtium officinale* R. Br	57	Tarmera	G	Mic
		Cardamine hirsuta L.	43	--	Ch	Mic
		Arabidopsis thaliana (L.) Heynh	6	--	Th	N
Plantaginaceae	1	*Plantago lancelata* L.	45	Gabai	Th	Mes
Fabaceae	3	*Robinia pseudoacacia* L.	95	Kikar	MicP	N
		Indigofera heterantha Wall.ex Brandis	60	Gowareaga	Ch	N
		Trifoliun repenes L.	46	Shawtal	Ch	N
Buxaceae	2	*Buxus wallichiana* Baill.	4	Shamshad	NP	MIc
		Sarcococca saligna (D. Don) Müll. Arg.	3	Akhtar	NP	Mic
Polygonaceae	1	*Bistorta amplexicaulis* (D.Don) Greene	51	Tarwapanra	H	Mes

Family	No. of Species	Botanical name	Collection No	Local name	Life form	Leaf spectra
Liliaceae	2	Gagea elegansWall. ex D. Don.	9	Spinsakay	G	N
		Tulipa clusiana Redouté	41	Gantol	G	Mes
Adoxaceae	2	*Viburnum grandiflorum* Wall. ex DC	1	Gultan	MP	Mes
		Viburnum cotinifolium D. Don	54	Inzargul	MP	Mes
Salicaceae	2	*Salix tetrasperma* Roxb.,Pl. Corom	55	Wela	Mp	Mes
		Populus nigra L.	96	Toorsperdar	Mp	Mes
Papaveraceae	1	*Corydalis diphylla* Wall.	17	Shamdana	Mp	Mg
Violaceae	1	*Viola canescens* Wall	16	Banafsha	Th	Mic
Diosccoreaceae	1	*Dioscorea deltoidea*Wall.ex Griseb.	62	Kanrhiz	G	Mes
Poaceae	1	Dactylis glomerata L.	61	Wakha	G	N
Juglandaceae	1	*Juglans regia* L.	65	Guz	MesP	Mic
Berberidaceae	1	*Berberis pseudoumbellata* subsp. gilgitica Jafri	59	Kwaray	NP	N
Hypericaceae	1	*Hypericum perforatum* L.	84	Desi shin chay	Ch	N
Scrophulariaceae	1	*Verbascum thapsus* L.	86	Warmagu	Th	Mg
Cannabaceae	1	*Cannabis sativa* Linn	91	Bang	Th	Mic
Ebenaceae	1	*Diospyros kaki* L.	98	Soramlook	MegP	Mes
Rubiaceae	1	*Galium aparine* L.	94	--	Th	N
Onagraceae	1	*Oenothera speciosa* Nutt	39	--	H	Mic
Asparagaceae	1	*Polygonatum verticillatum* (L.)	50	Noryalam	G	Mic
Caprifoliaceae	1	*Lonicera quinquelocularis* Hardwicke in Hook	48	--	NP	N
Urticaceae	1	*Urtica dioica* Linn.	38	Galbang	Th	Mic
Primulaceae	1	*Androsace rotundifolia* Hardwicke	37	Kanrkan	H	Mes
Paeoniaceae	1	*Paeonia emodi* Wallich ex Royle	35	Mameakh	Ch	Mes
Caprifoliaceae	1	*Lonicera myrtillus* Hook. f. & Thoms.	33	Aday	Np	Mes
Araliaceae	1	*Hedera nepalensis* K. Koch, Hort. Dendrol.	30	Palul	NP	Mes
Aquifoliaceae	1	*Ilex dipyrena* Wall.	29	Banj	MegP	Mes
Geraniaceae	1	*Geranium nepalense* Sweet.	27	--	Ch	Mic
Saxifragaceae	1	*Bergenia ciliata* Haw.	26	Gut panra	G	Mes
Boraginaceae	1	*Myosotis alpestris* F. W. Schmidt, Fl. Boem	22	--	H	Mic
Cochicaceae	1	*Colchicum luteum* Linn.	5	Zargulay	G	N
Crassulaceae	1	*Sedum ewersii* Ledeb.	88	Warkharay	G	Mes
Balsaminaceae	1	*Impatiens bicolor* Royle.	67	Pratai	Th	Mes
Elaeagnaceae	1	*Elaeagnus umbellata*	76	Ganamranga	NP	Mic
Phyllanthaceae	1	*Andrachne cordifolia* (Wall. ex Decne.) Muell.	83	Shrub	Th	Mes
Celastraceae	1	*Maytenus wallichiana* Spreng.	53	Bampora	NP	Mic
Polygonaceae	1	*Rumex dentatus* Linnaeus	24	Shalkhy	Ch	Mes

and Verbascum thapsus are the species clumped together and shown by many presence values than the other species. They mostly prefer similar sort of climatic conditions and grow in associations.

3.5 Detrended Correspondence Analysis (DCA)

Plant species are classified in various quadrants via

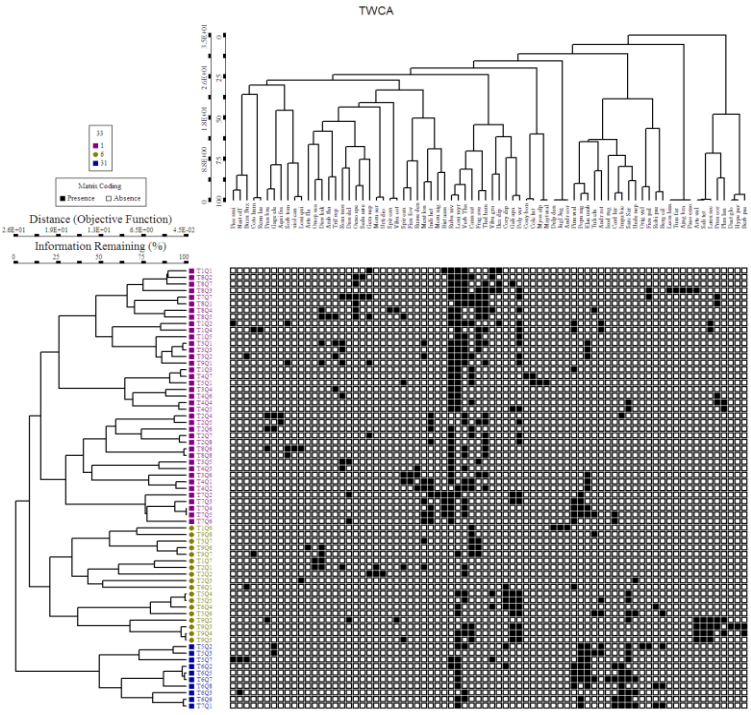

Fig. 3. Two-way cluster dendrogram presenting species distribution

Detrended correspondence analysis (DCA) using CANOCO software. Detrended correspondence analysis was carried out for all plant species in the studied region (Figure 4). The DCA diagram shows the distribution of species in the studied region. In DCA ordination the maximum length recorded for axes 1 was 5.203 with an eigenvalue of 0.913, the length of the gradient for axis 2 was 4.2 with an eigenvalue of 0.734, the length of the gradient for axis 3 was 5.572 with an eigenvalue 0.512, length of the gradient for axis 4 was 3.282 with eigenvalue 0.399. The total inertia recorded for this DCA was

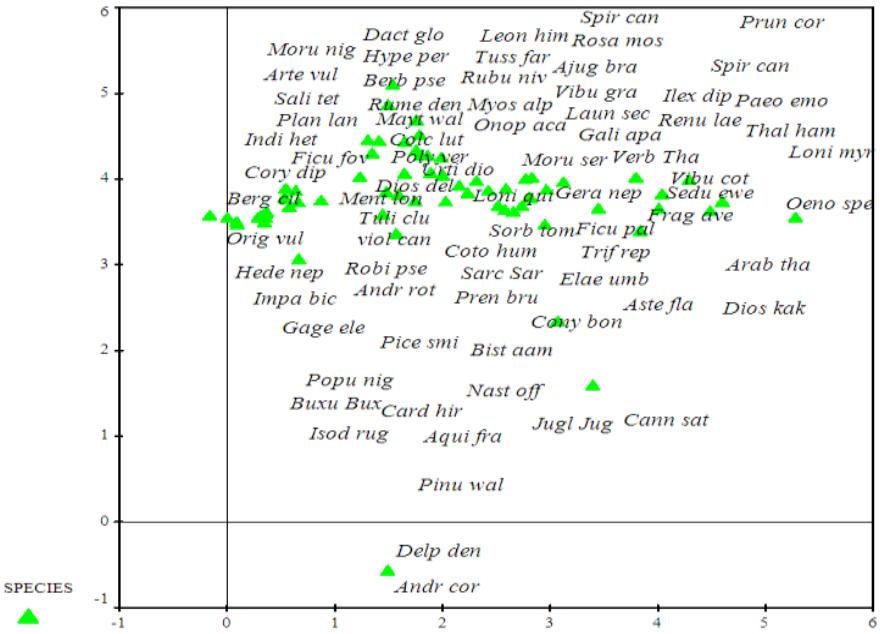

Fig. 4. Detrended correspondence analysis showing plant species distribution and ordination

Table 2 Summary of Detrended Correspondence Analysis

Axes	1	2	3	4	Total inertia
Eigenvalues	0.913	0.734	0.512	0.399	11.308
Lengths of gradient	5.203	4.2	5.572	3.282	
Cumulative percentage variance of species data	8.1	14.6	19.1	22.6	
Sum of all eigenvalues					11.308

11.308. The cumulative percentage variance of species data was 8.1 for axis 1, 14.6 for axis 2, 19.1 for axis 3 and 22.6 for axis 4 (Table 2).

4. CONCLUSION

We conclude that multivariate ecological techniques such as Two-Way Cluster analysis and detrended correspondence analysis are the most important methods for vegetation classification and ordination. Leaf spectral classes reveal that the microphylls increase with a gradual increase in altitude from the lower foothills to the top peaks. Moreover, nanophyll's density was higher at lower altitudes. Plant species with minute leaf sizes are the general indicators of dry and xerophytic ecosystems because small leaf size is an adaptation to dry types of habitats, that leaf size is significantly correlated to drought and soil conditions. Understanding these responses at the life form and leaf spectra level will provide a better understanding and knowledge that how plant species and their communities or associations respond to changes in climate in the future, which is already predicted with a decrease in water and snow and an increase in temperature. The current study could be utilized as a baseline for large-scale studies in the future.

5. ACKNOWLEDGEMENTS

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6. CONFLICT OF INTEREST

The authors declared no conflict of interest.

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