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PHYTOCLIMATE ANALYSIS AND SEASONAL VARIATION IN LIFE FORM AND LEAF SIZE SPECTRA OF FLORA OF DISTRICT SWABI, PAKISTAN

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Abstract

This study was carried out in eight different stands in District Swabi during the four consecutive seasons of spring, summer, autumn, and winter in 2019-2020. These stands were selected on basis of physiognomic contrast, floristic composition and edaphic factors for the study of ecological characteristics of flora. The objective of this study was to explore seasonal variation in phytoclimate and leaf size spectrum in the research area. A total of 145 species were identified in spring (March-May) followed by 131 species in summer (June-August), 126 species in autumn (September-November) and 77 species in winter (December-February). The life forms and leaf size spectra of flora in research area were studied with the help of the Raunkiaer's classification. Therophytes were the dominant life form in all four seasons: spring (66.3%), summer (48.8%), autumn (50.8%), and winter (46.7%), followed by hemicryptophytes and megaphanerophytes. Similarly, microphylls were the most common leaf size spectra in all four seasons: spring (40.0%), summer (45.8%), autumn (44.5%), and winter (35.0%), followed by nanophylls, leptophylls, and mesophylls. Therophytes and microphylls were found to be the most common life forms and leaf size spectra in all four seasons of the study. The dominance of therophytes and microphylls indicated that the area is under biotic pressure due to deforestation and overgrazing and has extreme climatic conditions. Further study is needed to enumerate the data and suggest plans for the biodiversity and conservation of the area. These findings underscore the need for integrated conservation strategies to manage grazing pressure and deforestation.

Key words: Flora**,** Life form, Leaf size, Phytoclimate spectrum, Seasonal variation, Swabi

INTRODUCTION

On July 1, 1988, District Swabi was upgraded and declared to the status of District. It is located between 72°-13' and 72°-49' East longitude and 33°-55' and 34°-23' North latitude. It is bounded in the east by District Haripur, in west by District Mardan and Nowshera, in north by District Buner and in south by District Attock of Punjab Province (Fig 1). The district has a total area of 1,543 km^2, which may be divided into two geographical regions; hilly areas and plains. The hilly areas mostly lie in the north while plain areas lie in south. Swabi, Lahore, Topi and Razar are four tehsils of District Swabi (Anwar *et al*., 2020). Swabi has extreme and harsh climate, experiences a cold winter and a scorching summer. Temperature rose steeply from May onward and gradually decreased from October onward. June, July and August are hottest months while January is the coldest month (Table 1). The monsoon months (July and August) received maximum rainfall during which humidity increases, and weather becomes hot (Anwar *et al*., 2015). Traditionally, there are four seasons of three months; spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). Each has its own light, temperature, and weather patterns which affect the physiognomy, floristic, phytoclimatic characteristics and eco-physiological processes of the vegetation of an area.

Table 1: Climatic data of District Swabi Khyber Pakhtunkhwa, Pakistan.

Months	Temperature (°C)			Average Precipitation (mm)	Average humidity (%)
	Maximum	Minimum	Average		
January	17.7	2.8	10.2	55	27
February	19.4	6	12.7	58	41
March	24.4	10.6	17.5	69	38
April	30.1	15.3	22.7	47	34
May	36.1	20	28	23	25
June	41	24.9	32.9	25	24
July	38	25.7	31.8	110	44
August	36	24.8	30.4	137	51
September	35	21.9	28.4	58	43
October	31.7	15.1	23.4	14	29
November	25.5	8.3	16.9	12	29
December	19.7	3.8	11.7	31	24
Annual	**29.5**	**14.9**	**22.2**	**53.2**	**34.0**

Source: Climate data. org., 2018

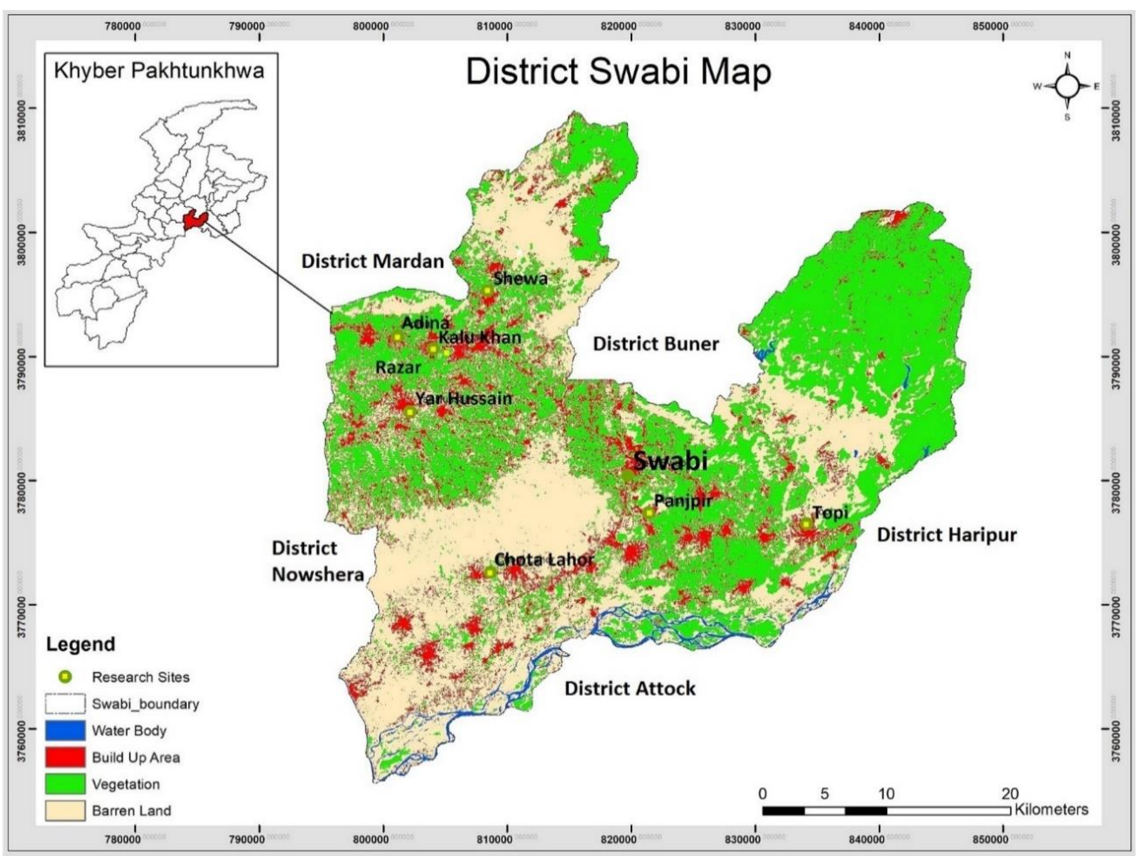

Fig. 1: Map of District Swabi showing research sites

Seasonal variation is the regular change in the environment that occurs over time. It can be caused by number of factors, including; climate, temperature and precipitation. Seasonal variation has many effects on plants such as; effects on growth and development, phytochemistry, chemical composition, physiological activity and hardening. Flora refers to all plant life occurring in any geographic region at a specific geological period and includes the number of species (Badshah *et al*., 2013). In simple words, flora represents particularly to species composition. The floral diversity and climate interactions in a region are seen as signs and indicators of the natural community's general vitality (Jahangeer *et al.,* 2020). The flora of any region in the natural habitat depends on environmental factors such as time, altitude, and precipitation patterns (Ilyas and Moncrieff, 2012).

The general appearance of the plant body is referred to in its life form. Raunkiaer (1934) proposed the term "biological spectrum" to describe the distribution of life forms in flora and their phytoclimatic characteristics. Phytoclimate refers to the climate or atmospheric conditions that prevail within a plant community or vegetation, influencing the growth, development, and distribution of plants. The phytoclimatic spectrum can be used to identify and explore the requirements for long-term conservation approaches to the natural habitat of species in a region (Khan *et al.,* 2013). Plant ecologists have been researching the plant species composition relying on interaction and habitat phytoclimatic variability (Shaheen *et al.* 2012). It is not enough to only assess the vegetation in natural habitats; but it is also important to identify the phytoclimatic spectrum of a region. The plant species and life forms show the external appearance of how they adapt to the climatic conditions.

Plant species can be grouped into five main classes under Raunkiaer's system; phanerophytes, chamaephytes, hemicryptophytes, cryptophytes, and therophytes. The percentage of these various life form classes together is called the biological spectrum. Both microclimate and macroclimate can be predicted by life form spectra (Shimwell, 1971). The plant relationship with a specific area is indicated by leaf size spectra. Leaf size can help in the accounting of physiological activities in a plant community (Oosting, 1956). The physiognomic aspects of life form and leaf size spectra are both essential indicators of climate in a specific area. Life form and leaf spectra are important because they show the ecological amplitude and tolerance of the species (Cain and Castro, 1959). Life form and leaf size spectra indicate climatic and human disturbance of a particular area (Sher and Khan, 2007; Durrani *et al.* 2010).

The present study aimed to explore seasonal variation in life form and leaf size spectra of flora of District Swabi, Pakistan. This research will provide baseline knowledge about plant resources and biodiversity, and it will be helpful for the assessment of phytoclimatic spectrum in the study area.

MATERIALS AND METHODS

Site selection, Field survey and Plant identification

This study was carried out in eight different stands in District Swabi during the four consecutive seasons of spring, summer, autumn, and winter in 2019-2020. These stands were selected on basis of physiognomic contrast, floristic composition and edaphic factors for the study of ecological characteristics of flora. Vegetation was analyzed by using square shaped, 10 quadrats (10x10 meters) for trees, 10 quadrats (4x4 meters) for shrubs and 10 quadrats (1x1 meters) for herbs in each stand (Hussain, 1989). All quadrats were located and distributed systematically. In each season, a total of 80 square-shaped quadrats were studied in the study area. Plant species were thoroughly collected from each quadrat and were completely dried in papers and then mounted on herbarium sheets. The "Flora of Pakistan" (Nasir and Ali, 1970-1989; Ali and Nasir, 1989-1991) was used to identify each of these plants.

Life form spectra/Biological spectra

Plant species were classified into numerous life form classes after Raunkiaer (1934) and Hussain (1989) as;

I. Phanerophytes

Plants with perennating buds are located on upper part more than 25 cm above the ground surface. They include tree and shrubby plants. They are further divided into following four sub-classes;

i. Megaphanerophytes

Tall trees with perennating buds above 30 meters in height.

ii. Mesophanerophytes

Small trees with perennating buds that range in height from 7.5 to 30 meters.

iii. Microphanerophytes

Small trees and shrubby plants with perennating buds located above the height of 2 meters to 7.5 meters.

iv. Nanophanerophytes

Perennial shrubs with perennating buds above 0.25 meters (25 cm) to 2 meters in height.

II. Chamaephytes

In this case perennating buds are definitely above the ground surface but less than 25 cm high. They includes woody and semi-woody plants, under shrubs, low stem succulent, herbaceous perennials, trailers and cushion plants.

III. Hemicryptophytes

Herbaceous perennials in which perennating buds are half buried in the soil. Aerial parts die toward the ending of the growing season, leaving perennating buds at or close the surface of the soil.

IV. Geophytes

The perennating bud in this case is found below the soil surface. Plants having a deep rhizome, bulbs, tubers and corms, are included.

V. Therophytes

These are annual seed-bearing plants which complete their life cycle from seed to seed in very short period. Their perennating bud rests in the seed, in the form of embryo.

Raunkiaer's life form spectra were calculated as;

Life form spectra (%) = (Number of species in a class ÷ Total species) × 100

Leaf size spectra

According to Raunkiaer (1934), plant species were classified into several leaf size classes as follows;

Class I. Leptophylls: Leaf area smaller than 25 mm^2

Class II. Nanophylls: Leaf area ranging from 25 to 225 mm^2

Class III. Microphylls: Leaf area ranging from 225 to 2025 mm^2

Class IV. Mesophylls: Leaf area ranging from 2025 to 18225 mm^2

Class V. Macrophylls: Leaf area ranging from 18225 to 164025 mm^2

Class VI. Megaphylls: Leaf area greater than Macrophylls.

I. Leaf size/area was calculated according to method of Cain and Castro (1959).
Leaf size/area = Leaf length (mm) × Leaf breadth (mm) × 2/3

II. Raunkiaer's leaf size spectra was calculated as;
Leaf size spectra (%) = (Number of species in a class ÷ Total species) × 100

RESULTS

Seasonal variation in life form spectra

A total of 145 species were identified in spring (Fig 2). Seasonal variation in life form spectra showed that in spring the dominant life form was therophytes 96 species (66.3%). Hemicryptophytes shared 17 species (11.7%) followed by megaphanerophytes 10 species (6.9%), geophytes, nanophanerophytes and microphanerophytes each with 6 species (4.1%), mesophanerophytes 3 species (2.1%) and parasite 1 species (0.7%) as presented in Table 2 and Figure 3.

A total of 131 species were identified in summer (Fig 2). During summer there were 64 species (48.8%) therophytes, 25 species (19.1%) hemicryptophytes, nanophanerophytes and megaphanerophytes each 10 species (7.7%), geophytes 9 species (6.8%), microphanerophytes 6 species (4.6%), mesophanerophytes 4 species (3.1%), chamaephytes 2 species (1.5%) and parasite 1 species (0.7%) are shown in Table 2 and Figure 3.

A total of 126 species were identified in autumn (Fig 2). According to Table 2 and Figure 3, in autumn season, there were 64 (50.8%) species were therophytes followed by hemicryptophytes 20 (15.9%) species, nanophanerophytes 11 (8.7%) species, megaphanerophytes 10 (7.9%) species, geophytes 8 (6.3%) species, microphanerophytes 6 (4.8%) species, mesophanerophytes 4 (3.2%) species and chamaephytes 3 (2.4%) species.

A total of 77 species were listed in winter (Fig 2). During winter the dominant life form was therophytes with 36 (46.7%) species. Hemicryptophytes 12 (15.6%) species followed by megaphanerophytes 10 (13.0%) species, nanophanerophytes 7 (9.1%) species, microphanerophytes 6 (7.8%) species, mesophanerophytes 3 (3.9%) species and each geophytes, chamaephytes and parasite with 1 (1.3%) species are shown in Table 2 and Figure 3.

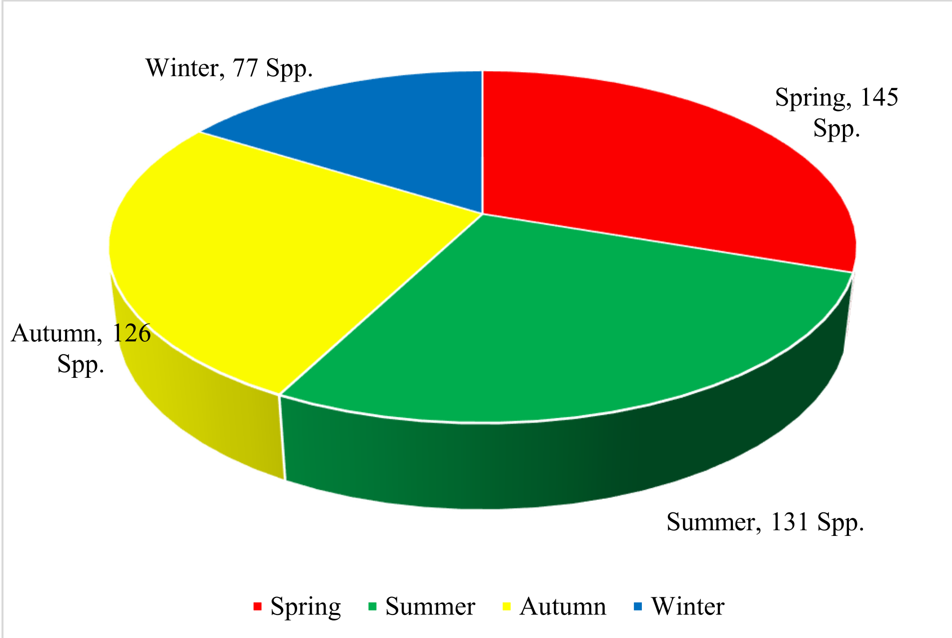

Fig. 2: Seasonal variation in the flora of District Swabi.

Table 2: Seasonal variation in life form spectra of flora of District Swabi, Pakistan

S.No.	Ecological attributes	Spring		Summer		Autumn		Winter	
		No.	% age	No.	% age	No.	% age	No.	% age
1.	Therophytes	96	66.3	64	48.8	64	50.8	36	46.7
2.	Hemicryptophytes	17	11.7	25	19.1	20	15.9	12	15.6
3.	Geophytes	6	4.1	9	6.8	8	6.3	1	1.3
4.	Nanophanerophytes	6	4.1	10	7.7	11	8.7	7	9.1
5.	Megaphanerophytes	10	6.9	10	7.7	10	7.9	10	13.0
6.	Microphanerophytes	6	4.1	6	4.6	6	4.8	6	7.8
7.	Mesophanerophyte	3	2.1	4	3.1	4	3.2	3	3.9
8.	Chamaephytes	0	0.0	2	1.5	3	2.4	1	1.3
9.	Parasite	1	0.7	1	0.7	0	0	1	1.3
Total		**145**	**100**	**131**	**100**	**126**	**100**	**77**	**100**

Seasonal variation in leaf size spectra

Seasonal variation in leaf size spectra showed that in spring microphylls 58 (40.0%) species were dominant followed by nanophylls 48 (33.1%) species, leptophylls 21 (14.5%) species, mesophylls 16 (11.0%) species and aphyllous 2 (1.4%) species are depicted in Table 3 and Figure 4.

Table 3 presents that in summer season, microphylls 60 (45.8%) species were dominant followed by nanophylls 38 (29.0%) species, leptophylls 17 (13.0%) species, mesophylls 14 (10.7%) species and aphyllous 2 (1.5%) species as shown in Figure 4.

During autumn season, there were 56 (44.5%) species microphylls, 41 (32.5%) species nanophylls, leptophylls and mesophylls each with 14 (11.1%) species and aphyllous 1 (0.8%) species as presented in Table 3 and Figure 4.

During winter season, microphylls were 27 (35.0%) species followed by nanophylls 26 (33.8%) species, mesophylls 13 (16.9%) species, leptophylls 9 (11.7%) species and aphyllous 2 (2.6%) species as shown in Table 3 and Figure 4.

DISCUSSION

Seasonal variation is the regular change in the environment that occurs over time. It can be caused by number of factors, including; climate, temperature and precipitation. Seasonal variation has many effects on plants such as; effects on chemical composition, growth and development, physiological activity and hardening. The physiognomy of the flora and vegetation, which is the outcome of all living activities in combination with the environment, is reflected in the life form. The relationship between life form and leaf size spectra, with climate dynamics, provides valuable insights into the ecological characteristics of an area, representing its biodiversity and prevailing climatic conditions.

Raunkiaer's life form classification is more accurate, as it is based on the location and degree of protection provided to perennating buds during unfavorable conditions. In the study area, therophytes dominate in all seasons, but particularly in the spring. There is always a bloom of annual plants in the spring and early summer. Therophytes are seed-bearing annual plants that complete their life cycle from seed to seed in a very short period. This agrees with the findings of Badshah *et al*. (2013). The domination of therophytes in all seasons indicated that the area investigated was under heavy biotic pressure. This agrees with the findings of Khan et al. (2012), Badshah *et al*. (2013) and Sher *et al.* (2014). The dominance of therophytes in the research area are mainly because of extreme climate, experiences a cold winter and a scorching summer. Our results are agreed with the findings of Barik and Misra (1998) who stated that therophytes could stand adverse conditions such as cold and dry climate in many parts of the world.

The proportion of various life form groups changes seasonally due to the existence of annuals, rhizomatous, or bulbous geophytes, according to the findings of this study. Perennials and some evergreens, on the other hand, practically maintained their status throughout the seasons.

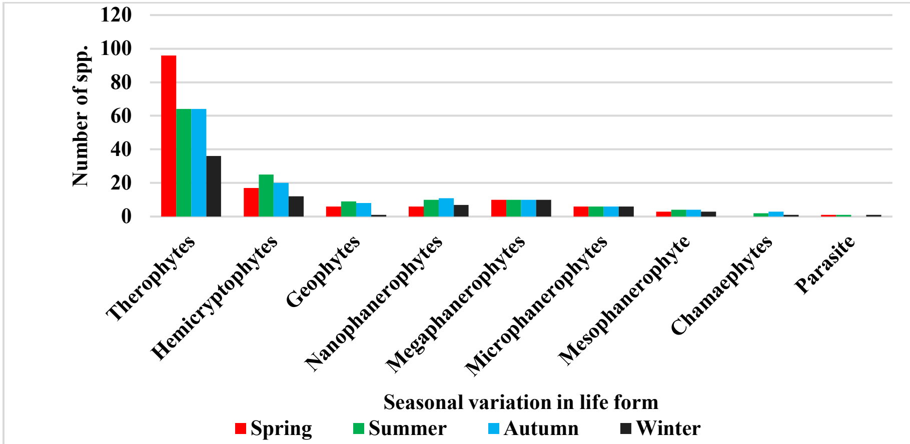

Fig. 3: Seasonal variation in life form spectra of flora of District Swabi.

Table 3: Seasonal variation in leaf size spectra of flora of District Swabi, Pakistan.

S.No.	Ecological attributes	Spring		Summer		Autumn		Winter	
		No.	% age	No.	% age	No.	% age	No.	% age
1.	Microphylls	58	40.0	60	45.8	56	44.5	27	35.0
2.	Nanophylls	48	33.1	38	29.0	41	32.5	26	33.8
3.	Leptophylls	21	14.5	17	13.0	14	11.1	9	11.7
4.	Mesophylls	16	11.0	14	10.7	14	11.1	13	16.9
5.	Aphyllous	2	1.4	2	1.5	1	0.8	2	2.6
Total		**145**	**100**	**131**	**100**	**126**	**100**	**77**	**100**

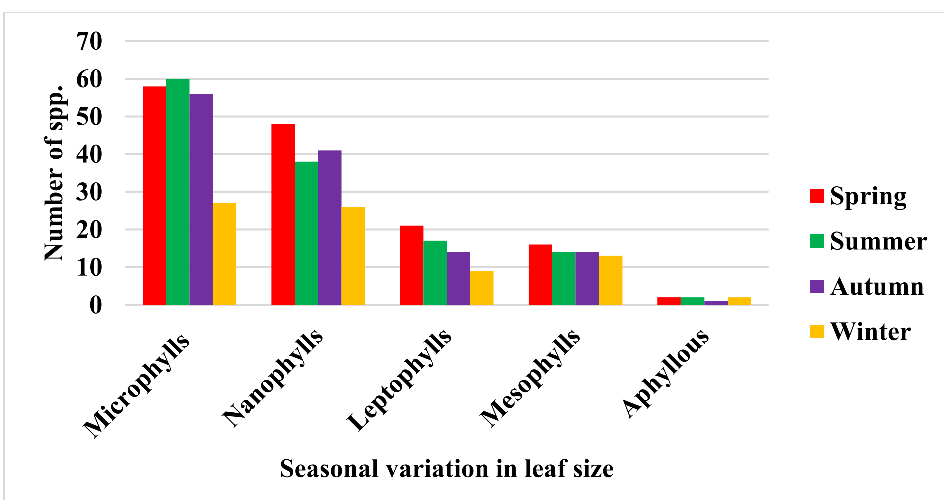

Fig. 4: Seasonal variation in leaf size spectra of flora of District Swabi

Leaf size spectra are a method of classifying plant species within an area based on the size of their leaves to understand how these leaf sizes interact with the environment. This classification assists ecologists in determining the distribution of various leaf sizes and their relationship to factors like climate, rainfall, and solar radiation. According to Oosting (1956), understanding the physiological processes of plants requires an understanding of leaf size.

In the study area, microphylls were dominant in all seasons, especially in summer, this might be due to the regional climate, which favors plants with smaller leaves that can tolerate dry conditions. The prevalence of microphylls in summer season in the research area is a result of adaptation to factors like high summer temperatures, extreme climate and high level of biotic pressure. According to Hussain *et al*. (2015), regional climate plays a significant role in determining the dominance of specific leaf size spectra that supports our findings. Sher *et al.* (2014) stated that the dominance of microphylls in area is the indication of heavy biotic pressure.

Our findings are agreed with them. Shaheen *et al*. (2016) stated that vegetation in any area exhibits different physiognomic conditions depending on altitude and growing seasons. The proportion of various leaf size classes changed seasonally in the current study due to the presence of some rhizomatous or bulbous geophytes and annual plants. Similar trends were observed by Badshah *et al*. (2013) while studying seasonal variation in leaf size spectra of plants of District Tank, Pakistan.

The size of the leaves could not be used to determine a specific leaf zone or climate. Other characteristics of plants, such as their habit and root system, may also be important.

The physiognomic aspects of life form and the leaf size spectra are both important indicators of climate in each area. Life form and leaf size spectra reveal climatic and human disturbance in a specific area. Both are significant because they demonstrate the ecological amplitude and tolerance of the species. The phytoclimatic spectrum based on life form can be used to identify and investigate the needs for long-term conservation strategies for species' natural habitats in a region.

CONCLUSION

It was concluded that therophytes and microphylls were dominant life form and leaf size spectra in all four seasons. The dominance of therophytes and microphylls indicated that the area is under biotic pressure due to deforestation and overgrazing and has extreme climatic conditions. Most of the plants were uprooted for burning purposes and grazed by the livestock. Further study is needed to enumerate the data and suggest plans for the biodiversity and conservation of the area. These findings underscore the need for integrated conservation strategies to manage grazing pressure and deforestation.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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