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Diversity of Shrubs in Kibber Beat in Kibber Wildlife Sanctuary of Lahaul & Spiti District, Himachal Pradesh

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ABSTRACT: The protected area of the cold desert is mostly under explored for documentation and diversity of vegetation. The diversity and distribution of shrubs are important for watershed protection in the cold desert. At present, there is a need to access the composition and diversity of shrubs. The Kibber Wildlife Sanctuary (KWLS) is located in Lahaul & Spiti District of Himachal Pradesh. The study on the diversity of shrubs in the Sanctuary was conducted during 2017 to 2019. Total 9 species, 8 genera and 8 families were recorded. The total density/25m^2 ranged from 6.49 to 23.64. The diversity index (H) ranged from 0.73 to 1.18. *Ephedra gerardiana* was threatened plant. There is need of conservation and management of shrubs diversity in the Sanctuary. The results of the study can be used as a baseline for preparing management plan of biodiversity in the Sanctuary.

Keywords: Himalaya, Cold Desert, Documentation, Kibber, Shrubs and Diversity.

I. INTRODUCTION

Biodiversity comprises of all form of life in this world and is maintaining the ecological balance, which has importance in evolutionary processes. Whatever variation in all form of life observes today on this earth, it is the outcome of 35 billion years of evolution. The sustainable utilization of biodiversity and its conservation is very important for sustainable development [1]. India is one of the mega biodiversity country and having four global biodivetsity hotspots i.e. Western Ghats, Himalaya, Indo Burma and Sundaland which are facing disturbance due to climatic variability and anthropogenic pressure [3].

Arid and semi arid areas are located in 10 states, which occupy 30.80% of the country's total geographical area. The cold arid zone occupy 5.62% area of the country in the trans Himalayan zone. The cold desert has unique plant diversity comprising of 6% of total plant species as endemic. It is found many threatened plant of socio-economical importance in the cold desert [18].

The cold desert is located between 31°44′ 34″N to 32° 59' 57″N latitudes and 76° 46′ 29″E to 78°41′34″E longitude in Himachal Pradesh, covering Lahaul and Spiti district and some part of Pooh sub division in Kannur [12]. Lahaul and Spiti Valley is occupying 24.59% of the total area of the Himachal Pradesh [38].

Himalaya is the largest, youngest and highest mountain chain in the world, having lot of variation in vegetation, it is gifted with unique socio-economically important flora and fauna. Thus, the region is important from ecological and biodiversity conservation point of view [30, 8].

Indian Himalayan region has about 18,440 species of plants [8, 26, 34]. Indian Himalayan region is located between latitudes 27° to 38° N and 72°to 89° E from Jammu Kashmir to Arunachal Pradesh and also having altitudinal range greater than 8000 m amsl [20, 8].

Assessment of biodiversity is very important to study effect of current practices of conservation [19, 8]. Nevertheless, a very few study have been conducted in the protected areas of Himachal Pradesh. The research work on floristic diversity and composition of vegetation in Himalayas has been carried out by various research workers [2, 4, 7-10, 16, 21-25, 28, 29, 32, 33, 36-42, 47-49, 51].

However, focused study on community diversity and distribution pattern of species of Kibber Wildlife Sanctuary (KWLS) has not been conducted so far. The strong database with focused objective is required for conservation and management of biodiversity in Indian Himalayan region. Therefore, while explaining floristic diversity of KWLS an attempt has also been made to study diversity of community and distribution pattern of shrub species with conservation strategy.

II. MATERIAL AND METHODS

Study area: The study was conducted in Kibber beat in Kibber Wildlife Sanctuary (KWLS). The Sanctuary is located between 32° 8′ 49.082″ N to 32° 45′39.903″ N latitude and 77° 47′ 59.726″ to 78° 31′ 29.452″E longitudes. The area of the Sanctuary is 2220.12 km^2 which is located in north by Ladakh in east Tibet and in northern catchment of Spiti river. The largest beat of the Sanctuary by area wise is the Kibber beat. The area of the Kibber beat is 1120.54 km^2. The temperature in cold desrt ranged from -45°C in winter and 40°C in summer. The rain fall is below 60 mm. The pH ranged from 7.4 to 9.4 [43]. The soil has poor water retention capacity and is less fertile [13]. Total 7 sites has been selected for study in Kibber beat. The geo-coordinates and other details of the study sites are given Table 1.

Table 1: The details of location of different study sites of KWLS in Himachal Pradesh.

S.No.	Site Name (Nearest Prominent location)	Aspect	Slope	Altitude (m)	Latitude (N)	Longitude (E)
1.	Badang	NW	10°-30°	4508	32°21'01.8"	078°02'05.2"
2.	Dhinam	NW	10°-30°	4956	32°18'47.9"	078°03'15.4"
3.	Chhicham-1	NW	25°-40°	4327	32°22'17.0"	077°00'04.5"
4.	Chhicham-2	NW	20°-35°	4468	32°23'51.2"	077°58'61.2"
5.	Gete	NW	5°-25°	4488	32°18'29.6"	078°01'54.7"
6.	Ladarcha	NW	25°-35°	4467	32°23'54.1"	077°57'35.2"
7.	Racholakmo	NE	10°-35°	4597	32°37'43.5"	078°19'12.3"

Field sampling and data collection: The sites were finalized after carrying out through survey of the Kibber beat in the sanctuary. The study sites were selected randomly at an altitudinal range i.e. 4250 to 5000 m. The quadrates were laid out randomly in altitudinal ranges. The relevant details of the study sites are given in Table 1. The data was recorded randomly for shrubs by laying out 80 quadrates/site of 5 m × 5 m except the site- Racholakmo where only 40 quadrates were laid due to occurrence of vegetation in small patches and inaccessibility.

III. DATA ANALYSIS

The recorded data were analysied for density, frequency and abundance as per the formula given by Curtis & Macintosh (1950) [6]. Importance value index (IVI) was determined by sum of relative density, relative frequency and relative dominance. The distribution pattern was calculated by the abundance to frequency ratio indicates regular (<0.025), random (0.025-0.050) and contagious (>0.050) distribution [5]. The species diversity was calculated by Shannon Wiener Diversity Index (H) [27].

$H = -\Sigma (n_i/N)\ln (n_i/N)$

where,

n_i = Importance value for each species

N = Total of importance values

Concentration of dominance (C) was calculated by Simpson's Index [31].

$\mathbf{C} = \Sigma(ni/N)^2$

where ni = Importance value for each species

N = Total of importance values

Richness Index (R) was calculated as per Margalef (1958) *i.e.* R = S-1/ln N and Evenness Index (E) was determined as per Hill (1973) [11] *i.e.* E = H/ ln S, where S = total number of species, N = total number of individuals of all the species and H = Index of diversity.

IV. RESULTS AND DISCUSSION

Phytosociological analysis of the seven study sites i.e. Badang, Dhinam, Chhicham-1, Chhicham-2, Gete, Ladarcha and Racholakmo has been explained below:

(i) Badang Site: Phytosociological analysis of shrubs (Table 2) in Badang showed that 4 species of shrubs were recorded. *Caragana versicolor* showed highest value for density/25 m^2 (5.88) followed by *Lonicera spinosa* (0.45), *Ephedra gerardiana* (0.40) and lowest value (0.29) was observed for *Krascheninnikovia ceratoides* (Table 2). Maximum frequency % was observed for *Caragana versicolor* (43.75) followed by *Lonicera spinosa* (13.75), *Ephedra gerardiana* (7.50) and minimum (6.25) was observed for *Krascheninnikovia ceratoides* (Table 3). Maximum abundance was observed for *Caragana versicolor* (13.43) followed by *Ephedra gerardiana* (5.33), *Krascheninnikovia ceratoides* (4.60) and minimum (3.27) was observed for *Lonicera spinosa* (Table 4). *Caragana versicolor* (237.49) was dominant species on the basis of IVI followed by *Lonicera spinosa* (31.82), *Ephedra gerardiana* (17.46) and least dominant was *Krascheninnikovia ceratoides* (13.82) (Table 5).

(ii) Dhinam Site: Total 5 species of shrubs was recorded at Dhinam. *Caragana versicolor* showed

highest value (4.66) for density/25 m^2 followed by *Krascheninnikovia ceratoides* (0.89), *Ephedra gerardiana* (0.56), *Potentilla arbuscula* (0.53) and lowest value (0.35) was recorded for *Lonicera spinosa* (Table 2). Maximum frequency % was observed for *Caragana versicolor* (40.00) followed by *Krascheninnikovia ceratoides* (13.75), *Lonicera spinosa* (8.75) and *Potentilla arbuscula* (8.75) and minimum value (5.00) was observed for *Ephedra gerardiana* (Table 3). Maximum abundance was observed for *Caragana versicolor* (11.66) followed by *Ephedra gerardiana* (11.25), *Krascheninnikovia ceratoides* (6.45), *Potentilla arbuscula* (6.00) and minimum value (4.00) was observed for *Lonicera spinosa* (Table 4).

Caragana versicolor (216.27) was dominant species onthe basis of IVI followed by *Krascheninnikovia ceratoides* (31.24), *Potentilla arbuscula* (19.38), *Lonicera spinosa* (17.85) and least dominant was *Ephedra gerardiana* (15.27) (Table 5).

(iii) Chhicham-1 Site: Total 7 species of shrubs were recorded at Chhicham-1. *Caragana versicolor* showed highest value for density/25 m^2 (5.45) followed by *Ephedra gerardiana* (1.05), *Lonicera spinosa* (0.91), *Potentilla arbuscula* (0.75) and lowest value (0.04) was observed for *Lonicera semenovii* (Table 2). Maximum frequency % was observed for *Caragana versicolor* (47.50) followed by *Krascheninnikovia ceratoides* (18.75), *Lonicera spinosa* (12.50), *Potentilla arbuscula* (11.25) and minimum (1.25) was recorded for *Ribesorientale* (Table 3). Maximum abundance was observed for *Caragana versicolor* (11.47) followed by *Ephedra gerardiana* (10.50), *Lonicera spinosa* (7.30), *Potentilla arbuscula* (6.67) and minimum (2.27) was observed for *Krascheninnikovia ceratoides* (Table 4). *Caraganversicolor* (194.47) was dominant species on the basis of IVI followed by *Lonicera spinosa* (29.00), *Krascheninnikovia ceratoides* (26.53), *Ephedra gerardiana* (23.56) and least dominant was *Lonicera semenovii* (1.70) (Table 5).

(iv) Chhicham-2 Site: Total 5 species of shrubs were recorded at Chhicham-2. *Caragana versicolor* showed highest value for density/25 m^2 (15.88) followed by *Ephedra gerardiana* (3.86), *Krascheninnikovia ceratoides* (0.48), *Lonicera spinosa* (0.15) and lowest value (0.14) was observed for *Potentilla arbuscula* (Table 2). Maximum frequency % was observed for *Caragana versicolor* (50.00) followed by *Ephedra gerardiana* (11.25), *Krascheninnikovia ceratoides* (10.00), *Potentilla arbuscula* (2.50) and minimum (1.25) was observed for *Lonicera spinosa* (Table 3). Maximum abundance was observed (34.33) for *Ephedra gerardiana* followed by *Caragana versicolor* (31.75), *Lonicera spinosa* (12.00), *Potentilla arbuscula* (5.50) and minimum (4.75) for *Krascheninnikovia ceratoides* (Table 4). *Caragana versicolor* (242.72) was dominant species on the basis of IVI followed by *Ephedra gerardiana* (34.77), *Krascheninnikovia ceratoides* (15.69), *Potentilla arbuscula* (4.31) and least dominant was *Lonicera spinosa* (2.51) (Table 5).

(iv) Gete Site: Total 5 species was recorded at Gete. *Caragana versicolor* showed highest value for density/25 m^2 (4.03) followed by *Lonicera spinosa* (0.71), *Ephedra gerardiana* (0.63), *Kraschenikovinia ceratoides* (0.69) and lowest value (0.44) was recorded for *Potentilla arbuscula* (Table 2). Maximum frequency % was observed for *Caragana versicolor* (42.50) followed by *Kraschenikovinia ceratoides* (12.50), *Lonicera spinosa* (11.25), *Ephedra gerardiana* (10.00) and minimum value (8.75) for *Potentilla arbuscula* (Table 3). Maximum abundance was observed for *Caragana versicolor* (9.47) followed by *Lonicera spinosa* (6.33), *Ephedra gerardiana* (6.25), *Kraschenikovinia ceratoides* (5.50) and minimum value (5.00) was observed for *Potentilla arbuscula* (Table 4). *Caragana versicolor* (209.55) was dominant species on the basis of IVI followed by *Krascheninnikovi ceratoides* (27.15), *Lonicera spinosa* (24.48), *Ephedra gerardiana* (21.57) and least dominant was *Potentilla arbuscula* (17.25) (Table 5).

Table 2: Density (Ind./25m^2) of species within different study sites of KWLS in Himachal Pradesh.

S. No.	Name of species	Study Sites						
		I	II	III	IV	V	VI	VII
1.	*Caragana versicolor* Benth.	5.88	4.66	5.45	15.88	4.03	18.43	6.03
2.	*Ephedra gerardiana* Wall. ex Stapf	0.40	0.56	1.05	3.86	0.63	1.50	0.38
3.	*Krascheninnikovi aceratoides* (L.) Gueldenst.	0.29	0.89	0.43	0.48	0.69	0.48	0.48
4.	*Lonicera semenovii* Regel			0.04				
5.	*Lonicera spinosa* (Decne.) Jacq. Ex Walp.	0.45	0.35	0.91	0.15	0.71	3.20	0.95
6.	*Myricaria germanica* (L.) Desv.							0.15
7.	*Potentilla arbuscula* D. Don		0.53	0.75	0.14	0.44		
8.	*Rhamnus prostrata* Jacq.						0.04	
9.	*Ribes orientale* Desf.			0.06				
Total		7.01	6.99	8.69	20.50	6.49	23.64	7.98

Abbreviation used: I= Badang, II= Dhinam, III= Chhicham-1, IV= Chhicham-2, V= Gete, VI= Ladarcha and VII= Racholakmo.

(vi) Ladarcha Site: Total 5 species was recorded at Ladarcha. *Caragana versicolor* showed highest value for density/25 m^2 (18.43) followed by *Lonicera spinosa* (3.20), *Ephedra gerardiana*, (1.50), *Krascheninnikovia ceratoides* (0.48) and lowest value (0.04) was recorded for *Rhamnus prostrata* (Table 2).

Maximum frequency % was observed for *Caragana versicolor* (50.00) followed by *Lonicera spinosa* (12.50), *Ephedra gerardiana* (6.25), *Krascheninnikovia ceratoides* (3.75) and minimum value (2.50) was recorded for *Rhamnus prostrata* (Table 3). Maximum abundance was observed for *Caragana versicolor* (36.85) followed by *Lonicera spinosa* (25.60), *Ephedra gerardiana* (24.00), *Krascheninnikovia ceratoides* (12.67) and minimum value (1.50) was recorded for *Rhamnus prostrata* (Table 4). *Caragana versicolor* (237.65) was dominant species on the basis of IVI followed by *Lonicera spinosa* (36.84), *Ephedra gerardiana* (14.92), *Krascheninnikovia ceratoides* (7.09) and least dominant was *Rhamnus prostrata* (3.50) (Table 5).

(vii) Racholakmo Site: Total 5 species was recorded at Racholakmo. *Caragana versicolor* showed highest value for density/25 m^2 (6.03) followed by *Lonicera spinosa* (0.95), *Krascheninnikovia ceratoides* (0.48), *Ephedra gerardiana* (0.38) and lowest value (0.15) was recorded for *Myricaria germanica* (Table 2). Maximum frequency % was observed for *Caragana versicolor* (50.00) followed by *Krascheninnikovia ceratoides* (15.00), *Lonicera spinosa* (10.00) and minimum value (5.00) was recorded for *Myricaria germanica* and *Ephedra gerardiana* (Table 3). Maximum abundance was observed for *Caragana versicolor* (12.05) followed by *Lonicera spinosa* (9.50), *Ephedra gerardiana* (7.50), *Krascheninnikovia ceratoides* (3.17) and minimum value (3.00) was observed for *Myricaria germanica* (Table 4).

Table 3: Frequency percent of species within different study sites of KWLS in Himachal Pradesh.

S. No.	Name of species	Study Sites						
		I	II	III	IV	V	VI	VII
1.	*Caragana versicolor* Benth	43.75	40.00	47.50	50.00	42.50	50.00	50.00
2.	*Ephedra gerardiana* Wall. ex Stapf	7.50	5.00	10.00	11.25	10.00	6.25	5.00
3.	*Krascheninnikovia ceratoides* (L.) Gueldenst.	6.25	13.75	18.75	10.00	12.50	3.75	15.00
4.	*Lonicera semenovii* Regel			1.25				
5.	*Lonicera spinosa* (Decne.) Jacq. Ex Walp.	13.75	8.75	12.50	1.25	11.25	12.50	10.00
6.	*Myricaria germanica* (L.) Desv.							5.00
7.	*Potentilla arbuscula* D. Don		8.75	11.25	2.50	8.75		
8.	*Rhamnus prostrata* Jacq.						2.50	
9.	*Ribes orientale* Desf.			1.25				

Abbreviation used: I= Badang, II= Dhinam, III= Chhicham-1, IV= Chhicham-2, V= Gete, VI= Ladarcha and VII= Racholakmo.

Table 4: Abundance of species within different study sites of KWLS in Himachal Pradesh.

S. No.	Name of species	Study Sites						
		I	II	III	IV	V	VI	VII
1.	*Caragana versicolor* Benth.	13.43	11.66	11.47	31.75	9.47	36.85	12.05
2.	*Ephedra gerardiana* Wall. ex Stapf	5.33	11.25	10.50	34.33	6.25	24.00	7.50
3.	*Krascheninnikovia ceratoides* (L.) Gueldenst.	4.60	6.45	2.27	4.75	5.50	12.67	3.17
4.	*Lonicera semenovii* Regel			3.00				
5.	*Lonicera spinosa* (Decne.) Jacq. Ex Walp.	3.27	4.00	7.30	12.00	6.33	25.60	9.50
6.	*Myricaria germanica* (L.) Desv.							3.00
7.	*Potentilla arbuscula* D. Don		6.00	6.67	5.50	5.00		
8.	*Rhamnus prostrata* Jacq.						1.50	
9.	*Ribes orientale* Desf.			5.00				
Total		**26.63**	**39.36**	**46.21**	**88.33**	**32.55**	**100.62**	**35.22**

Abbreviation used: I= Badang, II= Dhinam, III= Chhicham-1, IV= Chhicham-2, V= Gete, VI= Ladarcha and VII= Racholakmo.

Table 5: Importance Value Index (IVI) of species within different study sites of KWLS in Himachal Pradesh.

S. No.	Name of species	Study Sites						
		I	II	III	IV	V	VI	VII
1.	*Caragana versicolor* Benth	237.49	216.27	194.47	242.72	209.55	237.65	231.61
2.	*Ephedra gerardiana* Wall. ex Stap f	17.46	15.27	23.56	34.77	21.57	14.92	11.01
3.	*Krascheninnikovia ceratoides* (L.) Gueldenst.	13.24	31.24	26.53	15.69	27.15	7.09	24.83
4.	*Lonicera semenovii* Regel			1.70				
5.	*Lonicera spinosa* (Decne.) Jacq. Ex Walp.	31.82	17.85	29.00	2.51	24.48	36.84	24.77
6.	*Myricaria germanica* (L.) Desv.							7.78
7.	*Potentilla arbuscula* D. Don		19.38	22.78	4.31	17.25		
8.	*Rhamnus prostrata* Jacq.						3.50	
9.	*Ribes orientale* Desf.			1.97				
Total		**26.63**	**39.36**	**46.21**	**88.33**	**32.55**	**100.62**	**35.22**

Abbreviation used: I= Badang, II= Dhinam, III= Chhicham-1, IV= Chhicham-2, V= Gete, VI= Ladarcha and VII= Racholakmo.

Caragana versicolor (231.61) was dominant species on the basis of IVI followed by *Krascheninnikovia ceratoides*(24.83), *Lonicera spinosa* (24.77), *Ephedra gerardiana*(11.01) and least dominant was *Myricaria germanica* (7.78) (Table 5).

Distribution pattern: Contiguous distribution pattern was observed for all the shrubs species in all the sites.

Concentration of dominance (C): Maximum value of concentration of dominance (C) was 0.67 at Chhicham-2 followed by Ladarcha (0.65), Badang (0.64), Racholakmo (0.61) and minimum value was 0.45 for Chhicham-1 (Fig. 1 and Table 6).

Diversity Index (H): The diversity index (H) was recorded maximum (1.18) at Chhicham-1 followed by Gete (1.03), Dhinam (0.97), Racholakmo (0.83) and minimum was 0.68 at Chhicham-2 (Fig. 1 and Table 6).

Species richness index (R): Highest value of richness index was 0.92 at Chhicham-1 followed by Racholakmo (0.69), Gete (0.64), Chhicham-2 (0.54) and lowest (0.47) was observed at Badang (Fig. 1 and Table 6).

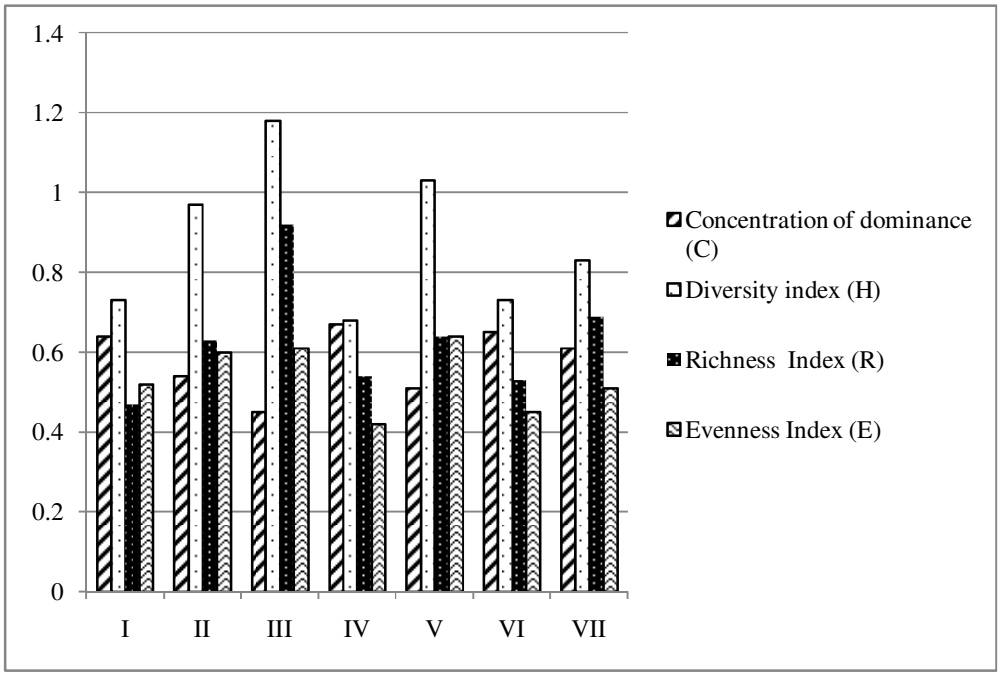

Fig. 1. Concentration of dominance (C), diversity index (H), richness index (R) and evenness index (E) of different study sites of KWLS in Himachal Pradesh.

Table 6: Concentration of dominance (C), diversity index (H), richness index (R) and evenness index (E) of different study sites of KWLS in Himachal Pradesh.

S. No.	Name of site	Concentration of dominance (C)	Diversity index (H)	Richness Index (R)	Evenness Index (E)
1.	Badang	0.64	0.73	0.47	0.52
2.	Dhinam	0.54	0.97	0.63	0.60
3.	Chhicham 1	0.45	1.18	0.92	0.61
4.	Chhicham 2	0.67	0.68	0.54	0.42
5.	Gete	0.51	1.03	0.64	0.64
6.	Ladarcha	0.65	0.73	0.53	0.45
7.	Racholakmo	0.61	0.83	0.69	0.51
	Mean	**0.58**	**0.88**	**0.63**	**0.54**

Evenness index (E): Maximum value of evenness index (E) was 0.64 at Gete followed by Chhicham-1 (0.61), Dhinam (0.60), Badang (0.52) and minimum value (0.42) was recorded at Chhicham-2 (Fig. 1 and Table 6).

Discussion: Total 9 shrubs species were recorded during sampling belonging to 8 genera and 8 families in Kibber beat. Total number of species in sampling sites ranged from 4 to 7. *Caragana versicolor* showed the highest density and dominance in all the study sites. Total density/25 m^2 ranged from 6.49 at Gete to 20.50 at Chhicham-2. *Rhamnus prostrata* was foundonly at Chhicham-1. The variation in density, frequency, abundance and dominance of vegetation depend upon microclimate, soils, aspects and topography in the cold deserts. *Ephedra gerardiana* is the threatened shrub so conservation of the species is very important. The contiguous pattern of distribution was observed for all the species which is also reported by the various worker [14, 46, 15, 35].

The concentration of dominance ranged from 0.45 to 0.65. The higher the value of dominance mean less dominance species [46]. The value of diversity index (H) ranged from 0.73 to 1.18 and the variation in the value of diversity index (H) has also been reported by Arya & Samant (2017); Verma *et al.,* (2003) [2, 45].

The value of richness index (R) ranged from 1.09 to 2.11. The value of eveness index (E) ranged from 0.97 to 1.47. The diversity of vegetation also depends upon heterogeneity of environment in cold arid region of Himachal Pradesh [44].

V. CONCLUSION

Total 9 shrubs species were recorded. *Caragana versicolor* was the dominant species in the Kibber beat. The diversity of shrubs was found highest at Chhicham-1 study site and lowest at Badang and Ladarcha.

Conservation and management strategies should be prepared for the species which have less density. The species should be observed at regular interval in Sanctuary. The shrubs of economic importance should be conserved and management strategies can be developed.

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REFERENCES

[1]. Arrawatia, M.L. and Tambe, S. (2011). Biodiversity of Sikkim: Exploring and conserving a global hotspot. Information and Public Relations Department, Government of Sikkim, Gangtok. Printed by Kwality Store, National Highway, Gangtok, Sikkim, India. Preface.

[2]. Arya, S.C., and Samant, S.S. (2017). Assessment of vegetation and prioritization of communities for conservation in Latakharak Alpine Meadows of Nanda Devi Biosphere Reserve, West Himalaya, India. *International journal of Advanced Research*, **5**(9): 1349-1366.

[3]. Chitale, V.S., Behera, M.D. and Roy, P.S. (2015). Global biodiversity hotspots in India: Significant yet under studied. *Current Science*, **108**(2), 149-50.

[4]. Chowdhery, H.J., & Wadhwa, B.M. (1984). Flora of Himachal Pradesh, Vol. 1-3: Botanical Survey of India.

[5]. Curtis, J.T. and Cottam, G. (1956). Plant ecology work book- laboratory field reference manual. Burgess Publishing Co., Minnesota.

[6]. Curtis, J.T. and Mclntosh, R.P. (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, **1**: 434-455.

[7]. Devi, L.N., Singha, D., & Tripathi, S. K. (2018). Tree species composition and diversity in tropical

moist forests of Mizoram, Northeast India. *Indian Journal of Ecology,* **45**(3): 454-461.
[8]. Devi, K., Samant, S.S., Puri, S. and Lal, M. (2019). Diversity, structure and regeneration pattern of tree communities in Kanawar Wildlife Sanctuary of Himachal Pradesh, North West Himalaya, India. *Indian Journal of Ecology*, **46**(1): 94-103.
[9]. Dhaliwal, D.S. and Sharma, M. (1999). Flora of Kullu District (Himachal Pradesh). Dehradun: Bishen Singh Mahendra Pal Singh.
[10]. Gautam, A.K., Bhatia, M.K. and Bhadauria R. (2011). Diversity and usage custom of plants of Western Himachal Pradesh, India - Part I. *Journal of Phytology*, **3**(3): 24-36.
[11]. Hill, M.O. (1973). Diversity and its evenness, a unifying notation and its consequences. *Ecology,* **54**: 427-432.
[12]. Jishtu, V. and Goraya, G.S. (2008). Cold deserts of Himachal Pradesh: Unique habitat and threatened plants. In: Rawat, G. S. (Ed.). Special habitats and threatened plants of India. *Envis Bulletin Wildlife and Protected Areas*, **11**(1). Wildlife Institute of India, Dehradun, India.
[13]. Kapoor, K.S. (2004). Biodiversity in cold deserts of Western Himalayas. Discussion forum. Time network, 17-21
[14]. Kershaw, K. A., & Looney, J. H. H. (1985). Quantitative and dynamic plant ecology. Edward Arnold. *Victoria*.
[15]. Kunhikannan, C., Ram K. Verma, K. Verma Raj, P.K. Khatri and N.G. Totey. (1998). Ground flora, soil micro flora and fauna diversity under plantation ecosystem on bhata land of Bilaspur, Madhya Pradesh. *Environment and Ecology,* **16**: 539-548.
[16]. Lal, M., and Samant, S. S. (2010). Floristic Diversity of the Kais Wildlife Sanctuary in Himachal Pradesh, North-Western Himalaya. Biodiversity Potentials of the Himalaya. *Gyanodaya Prakashan, Nainital, Uttrakhand, India,* 115-142.
[17]. Margalef, R. (1958). Temporal succession and spatial heterogeneity in phyto-plankton. In: A. A. Buzzati-Traverso. (Ed.). *Perspective in Marine Biology*. University of California Press, Berkeley, 323-347.
[18]. MoEFF & CC. (2009). India's 4th National report to the Convention on Biological Diversity. Ministry of Environment and Forest Government of India, Paryavaran Bhawan, CGO Complex, Lodhi Road, New Delhi. Edited by Mr AKGoyal and Dr. Sujata Arora.
[19]. Naidu, M.T., Premavani, D., Suthari, S. and Venkaiah, M. (2018). Assessment of tree diversity in tropical deciduous forests of North- Central Eastern, Ghats, India. *Geology, Ecology and Landscapes*, **2**: 216 -227.
[20]. Pant, S., Samant, S. S. and Arya, S.C. (2009). Diversity and indigenous household remedies of the inhabitants surrounding Mornaula reserve forest in West Himalaya. *Indian Journal of Traditional Knowledg*e, **8**(4): 606-610
[21]. Prasad, C. and Sharma, R.C. (2018). Wild edible plants of Kedarnath Valley, Garhwal Himalaya, India. *Indian Journal of Ecology,* **45**(3): 433-434.
[22]. Rana, M. S. and Samant, S. S. (2009). Prioritization of habitats and communities for conservation in the Indian Himalaya Region: A state-of-the-art approach from Manali Wildlife Sanctuary. *Current Science,* **97**(3): 326-335.
[23]. Rana, M.S., Samant, S.S. and Rawat, Y.S. (2011). Plant communities and factors responsible for vegetation pattern in an Alpine area of the Northwestern Himalaya. *Journal of Mountain Science*, **8**: 817-826.
[24]. Rawat, G. S. and Adhikari, B. S. (2005). Floristics and distribution of plant communities across moisture and topographic gradients in TsoKar basin, Changthang plateau, Eastern Ladakh. *Arctic Antarctic and Alpine Research*, **37**(4): 539-544.
[25]. Samant, S.S., Singh, A., Sharma, P. and Lal, M. (2010). Studies on diversity and conservation status of plant in a proposed Cold Desert biosphere Reserve of Trans and North West Himalaya. Final technical report submitted to Ministry of Environment and Forest, Government of India, New Delhi.
[26]. Samant, S.S. and Joshi, H.C. (2005). Plant diversity and conservation status of Nanda Devi National Park and comparison with Highland National Parks of the Indian Himalayan region. *International Journal of Biodiversity Science and Management*, **1**: 65-73.
[27]. Shannon, C.E. and Wiener, W. (1963). The Mathematical Theory of Communication. Univ. of Illinois Press. Urbana, U.S.A.
[28]. Sharma, Pankaj and Mishra, N.K. (2009). Diversity, utilization pattern and indigenous uses of plants in and around a cement factory in Bilaspur district of Himachal Pradesh, North-Western Himalaya. *Biological Forum—An International Journal,* **1**(2): 89-91.
[29]. Sharma, P., Rana, J.C., Devi, U., Randhawa, S.S. and Kumar, R. (2014). Floristic diversity and distribution pattern of plant communities along altitudinal gradient in Sangla Valley, Northwest Himalaya. *The Scientific World Journal* http://dx.doi.org/10.1155/2014/264878.
[30]. Sheng-Ji, P. (2001). Ethnobotanical approaches of traditional medicinal studies: Some experiences from Asia. *Pharmaceutical Biology,* **139**(1): 74-79.
[31]. Simpson, E. H. (1949). Measurement of diversity. *Nature*, *163*(4148), 688-688.
[32]. Singh, A. (2007a). Assessment of plant diversity and conservation status of forest vegetation in a proposed Cold Desert Biosphere Reserve of the Western Himalaya (Ph.D. thesis). Kumaun University, Nainital, India.
[33]. Singh, A. and Samant, S.S. (2010). Conservation prioritization of habitats and forest communities in the Lahaul Valley of proposed Cold Desert Biosphere Reserve, North Western Himlayan, India. *Applied Ecology and Environment Research*, **8**(2): 101-117.

[34]. Singh, D.K. and Hajra, P.K. 1996. Floristic diversity: In changing perspectives of biodiversity in Himalaya. Gujral, G.S. and Sharma, V. (Eds.). British Council New Delhi, 23-38.
[35]. Singh, J.S. and Yadava, P.S. (1974). Seasonal variation in composition, plant biomass and net primary productivity of a tropical grass land at Kurukshetra, India. *Ecological Monographs*, **44**: 357-375.
[36]. Singh, K.N. (2008). Ecological studies on landscape elements, species diversity and ethnobotany of higher plants in Lahaul-Spiti region of western Himalaya (Ph.D. thesis). HNB University, Garhwal, India. 230+VIII
[37]. Singh, M. (2007b). Assessment of floristic diversity and prioritization of communities for conservation in Manali Wildlife Sanctuary of Himachal Pradesh in North-Western Himalaya (Ph.D. thesis). Kumaun University, Nainital, India.
[38]. Singh, R. P. and Gupta, M. K. (1990). Soil and vegetation study of Lahual and Spiti cold desert of western Himalaya. *The Indian Forester*, **116**(10): 785-790.
[39]. Singh, R.P., Negi, D.V. and Chand, P. (1997). Ecological studies on *Rosa webbiana* wall. Ex Royle in cold desert areas of Spiti valley in Himachal Pradesh. The *Indian Forester*, **123**(9), 827-830.
[40]. Singh, S.K., & Rawat, G.S. (2000). *Flora of Great Himalayan National Park: Himachal Pradesh*.
[41]. Singh, S., Malik, Z.A., and Sharma, C.M. (2016). Tree species richness, diversity, and regeneration status in different Oak (*Quercus* spp.) dominated forests of Garhwal Himalaya, India. *Journal of Asia-Pacific Biodiversity*, **9**(3): 293-300.
[42]. Thakur, S.D., Kapoor, K.S. and Samant, S.S. (2015). Conservation prioritization of habitats and communities of Tirthan Wildlife Sanctuary, District Kullu, Himachal Pradesh, India: A floristic approach based on potential distribution of vascular plant species. *Ecology Environemnt and conservation,* 165-173.
[43]. Tewari, V.P. and Kapoor, K.S. (2013). Western Himalaya Cold Desert: Biodiversity, eco-restoration, ecological concerns and securities. *Annals of Arid Zone*, **52**(3&4): 223-230.
[44]. Verma, R.K., Jishtu, V. and Kapoor, K.S. (2008). Plant species diversity in Labrang valley of cold desert in District Kinnaur, Himachal Pradesh. *Environment & Ecology*, **26**(2): 505-516.
[45]. Verma, R.K., Jishtu, V., Kapoor, K.S. and Subramani, S.P. (2003). Analysis of plant diversity in Man Lunga Valley and Khamengar Valley of Pin Valley National Park in Himachal Pradesh. *Environmment & Ecology*, **21**(4): 941-946.
[46]. Verma, R.K., Kapoor, K. S., Subaramani, S.P. and Jishtu, V. (2003a). Assessment of Plant speices diversity in *Betula utilis* D. Don Forest in Cold Arid Region of Himachal Pradesh. *Environment & Ecology*, **21**(4), 922-927.
[47]. Verma, R.K. (2015). Assessment of Floristic Diversity in Khajjiar beat of Kalatop Khajjiar Wild Life Sanctuary of district Chamba, Himachal Pradesh. *Bio Bulletin*, **1**(1): 12-21.
[48]. Verma, R.K. and Kapoor, K.S. (2014). Status of Plant Diversity in Alpine Area of Rakchham- Chitkul Wild life Sanctuary of District Kinnaur, Himachal Pradesh. *Biological Forum–An International Journal,* **6**(1): 5-12.
[49]. Verma, R.K. and Kapoor, K.S. (2010). Assessment of floristic diversity in Pooh valley of cold deserts of District Kinnaur, Himachal Pradesh. *Biological Forum – An International Journal,* **2**(1): 35-44.
[50]. Verma, R.K. (2016). Status of Plant Diversity along an Altitudinal Gradient in Dankund Beat of Kalatop Khajjiar Wild Life Sanctuary of District Chamba, Himachal Pradesh. *Biological Forum – An International Journal,* **8**(1): 540-547.
[51]. Verma, R. K. (2017). Phyto-Diversity Studies in Kanasa Valley of Rakchham Chitkul Wild life Sanctuary of District Kinnaur, Himachal Pradesh. *Biological Forum – An International Journal,* **9**(1): 62-69.