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Plant Species Composition and Diversity at the Aravalli Mountain Range in Haryana, India

Pawan Kumar Gaury[1] and Rani Devi[2]

[1]Department of Environmental Sciences, Central University of Himachal Pradesh, Dharamshala 176 215, Himachal Pradesh, India
E-mail: pawan.evs@gmail.com
[2]Department of Energy and Environmental Sciences, Chaudhary Devi Lal University, Sirsa 125 055, Haryana, India

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ABSTRACT The assessment of plant biodiversity specifies adaptability of species and other sets of environmental conditions, which are essential for the growth of an ecosystem. During this study, a total of 92 plant species including 15 trees, 9 shrubs and 68 herbs belonging to 34 families and 84 genera were noticed. The quadrates of 10m×10m, 05m×05m and 01m×01m sized were fixed for trees, shrubs and herbs, respectively, inside 15 plots of 50m×50m sized to get density, abundance, relative density, relative frequency and basal area etc. The density and frequency represented the species composition, whereas the importance value index indicated the dominancy of one species over another and besides, Shannon and Simpson's index revealed the species diversity and concentration of dominance, respectively. The *Acacia arabica* amongst trees, *Prosopis juliflora* in shrubs and *Cynodon dactylon* in herbs were found to be the dominant species. Although, the herbs were found dominated over shrubs, followed by trees. The Febaceae amongst trees, Febaceae and Malvaceae among shrubs and Poaceae amid herbs was observed to be the dominant family. This study provides exact information about composition of every plant species at the site, which is essential to make conservational strategies for the preservation and development of plant biodiversity.

Abbreviations Used
• Species density: D • Species richness: SR • Abundance: A •Frequency (%): F •Total Basal Area: TBA • Relative density (%): RD •Relative frequency (%): RF •Relative Basal Area (%): RBA •Importance Value Index: IVI •Species diversity: SD •Concentration of dominance: CD

INTRODUCTION

The biodiversity is treated in terms of gene, species and ecosystem (Krishnamurthy 2003). It plays an important role in providing ecosystem services to the people (Cardinale et al. 2012; Liu et al. 2017), maintaining ecological balance and environmental monitoring (Patel and Patel 2010). The plant biodiversity in nature is very complex and differs from one site to another in term of structure, composition and occurrence (Raturi 2012). The distribution of species in terms of growth, reproduction and survival are controlled by abiotic and biotic factors of environment (Aiba et al. 2012). The biodiversity is essential for the survival of the whole sphere of life on earth and facing threat of loss due to increasing pressure of land use for habitation, agricultural, transportation, river valley projects and mining etc. Human interventions suppress the plant species to flourish and inhibit biodiversity to be fully fledged. The efforts to save biodiversity are increasing throughout the world, but neither the species nor the habitat loss seem to be reduced (Butchart 2010; Goncalves et al. 2016). The increasing population and change in land use pattern are the accelerating factors of future biodiversity change (Gupta and Narayan 2006).

The Aravalli mountain range consists of diverse and unique topography, which provides different type of habitats for plants and animals to survive and flourish. At this range, the variations in terms of slopes, altitudes, water percolation, wind velocity and angle of sunshine influence the vegetation of a particular type to grow and inhibit the other. The Aravalli mountain consists of xeric and sparse vegetation having seasonal fluctuations in survival, growth and development. The present study site has been a regular supplier of stones as a raw material from thousands of its mines to more than

500 crushing mills situated in the surrounding region. The plant species at the study site are under threat of loss and exploitation from mining and other mismanaged activities of people for getting fuel wood, timber and fodder, etc. The Aravalli mountain range is controversial between government to ban on mining for preservation of biodiversity and people to continue it for their livelihood.

The biodiversity assessment is essential to know the existing scenario and make proper preservation strategies for the future. Several studies regarding assessment of plant biodiversity have been carried out in past by several researchers (Katewa 1996; Sharma et al. 2001; Sharma and Upadhay 2002; Aggarwal et al. 2006; Kumar 2013a; Kumar et al. 2013b; Chaturvedi and Raghubanshi 2014; Dular 2015). The inventory study of plant biodiversity expresses only types of species in any area and do not provide any information regarding the spatial pattern, composition and inter and intra-specific relationship existing between them. This mountain range is also a home to various types of birds, reptiles, bats and other types of living creatures, which helps in maintain the ecological balance. The objective of present study has been to observe the plant biodiversity and its species composition with one another in terms of abundance, richness, dispersal rate etc. and beside the dominant and rare species, The present study will also be helpful to find a gap for futuristic study and in preservation and further development of plant biodiversity, which is facing threat of loss and reached the verge of extinction.

MATERIAL AND METHODS

The Study Site

The present study has been carried out at the Aravalli mountain range in Khanak of District Bhiwani (Haryana), India (Fig. 1), located at $28^0$54'13.61"N latitude and $75^0$51'33.22"E longitude at the elevation of 771 feet above mean sea level. It is the oldest mountain range of the world, covering 692 km from south-west and north-east direction across various states like Haryana, Rajasthan, Gujarat and union territory Delhi, India (Rathore 2009). In Haryana, it is distributed across various districts Gurgaon, Faridabad, Mewat, Mahendragarh, Charkhi Dadri and Bhiwani. The climate of Haryana is hot in summer and cold in winter season. The temperature there in May and June generally rises up to 46^0C or even 48^0C (Chauhan 2011). The concerned region has unreliable rainfall and cool winters (Gupta and Pandey 2008) and the months of May and June are associated with dust, storms and thundershowers (Murthy 2009).

Methodology

A total of 15 plots of 50m×50m sized (Sharma et al. 2001) were randomly fixed at different locations of the present study site, and inside of each plot; 10 quadrates (10m×10m) for trees, 10 (05m×05m) for shrubs and 20 (01m×01m) for herbs were fixed. The total numbers of species in each quadrate were counted and then identified with the help of expert and literature available (Jain et al. 2005; Shrivastava and Singh 2009; Singh 2011). The total numbers of herbs, shrubs and trees species were counted, which represent the SR as well as the ecological community (Colwell 2009). The SD was calculated by dividing the total number of individuals of a single species in all the quadrates, with total number of quadrates studied (Curtis and Intosh 1950). The species abundance was observed by dividing the total number of individuals of a single species in all the quadrates, by total number of quadrates in which that particular species occurred (Vinothkumar et al. 2011). The 'F' was calculated by dividing the number of quadrates in which individual species occurred, by the total number of quadrates studied and then multiplied by 100. The TBA was measured from ground level to 1.3 m height for trees and calculated by multiplying mean basal area by 'D'. The RF, RD and RBA were calculated by using formula:

$$\text{(i) } RF = \frac{\text{The Frequency of individual species}}{\text{Total frequency of all the species}} \times 100$$

$$\text{(ii) } RD = \frac{\text{The total number of individual of species}}{\text{The total number of individual of all of the species}} \times 100$$

$$\text{(iii) } RBA = \frac{\text{Total basal area of a species}}{\text{Total basal area of all of the species}} \times 100$$

The IVI was known by adding RF, RD and RBA (Sagaran et al. 2011) for trees and by adding RF and RD for shrubs and herbs, respectively. The value of CD was observed by using Simpson's index, which is represented by D (Simpson 1949). The value of this index comes up to 01 and was calculated using the following formula:

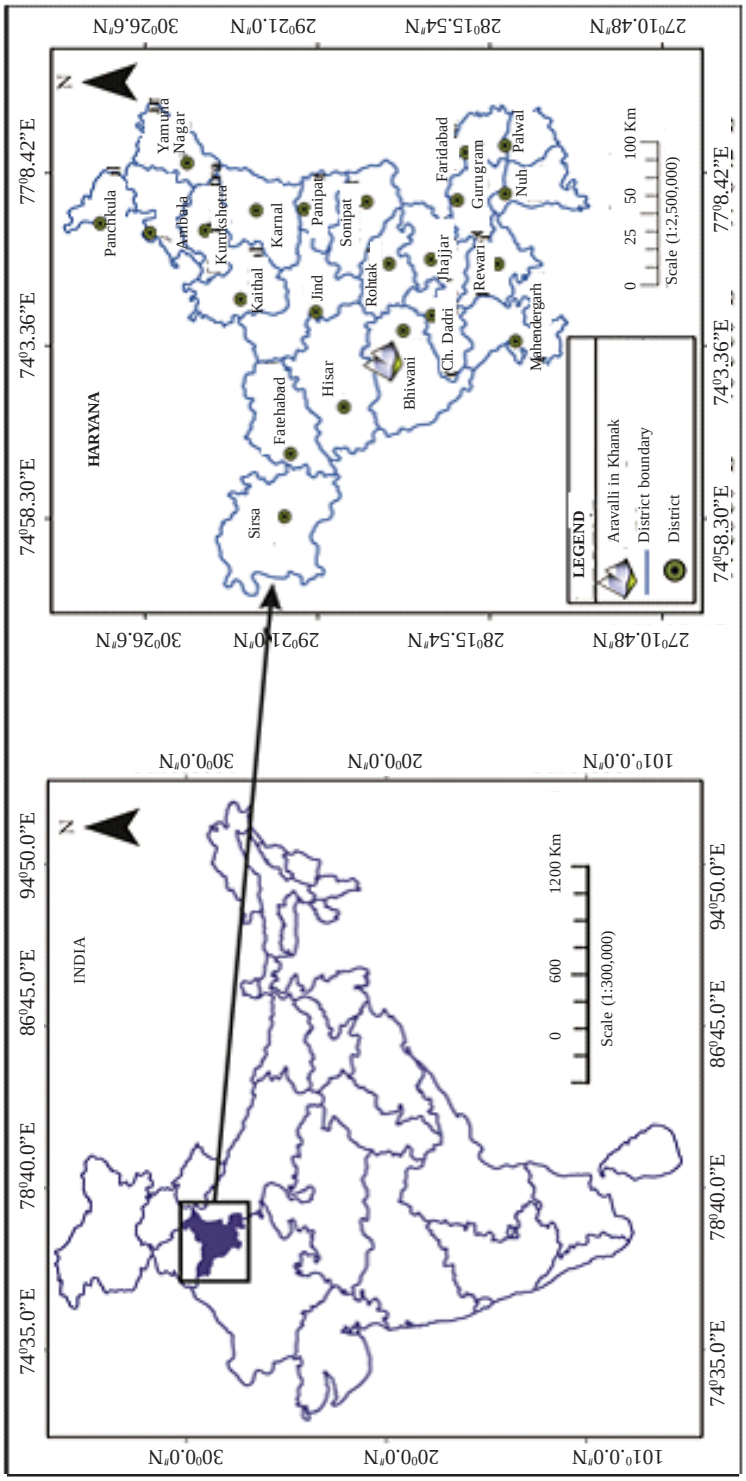

Fig. 1. Location of Aravalli mountain range in Khanak of District Bhiwani (Haryana), India

$$D=1-\left(\frac{\Sigma n(n-1)}{N(N-1)}\right)$$

Where, 'N' is the total number of individuals of all the species and 'n' is the number of individuals of single species. The Shannon Index (Shannon and Wiener 1963) was used to determine SD (Sharma et al. 2009; Bijalwan 2010). The Shannon Index was calculated as:

$$H=-\Sigma p_i \ln p_i$$

Where, 'H' is the Shannon Index of the diversity, 'p_i' is equal to *ni*/N, that is, proportion of importance value of ith species, 'N' is the total number of all species and '*ni*' is the total number of ith (particular) species.

RESULTS AND DISCUSSION

A total of 92 plants species including 15 trees, 9 shrubs and 68 herbs belonging to 34 families and 84 genera were noticed from the study site by fixing quadrates at randomly selected different sites. The total numbers of plant species in the present study are equal to noticed by Singh (2003) from Sariska national park of the Aravalli mountain range of eastern Rajasthan, India; but more than observed by Sharma et al. (2001) from Sanganer, Rajasthan, India. However, the total plant species noticed during present study are less than observed by Kukshal et al. (2009) and Vinothkumar et al. (2011) from north-west Himalaya and sacred grooves in Pudukotti district of Tamil Nadu, India, respectively.

The Tree Species

At the present study site, *Acacia arabica* revealed highest 'D', 'F', IVI and 'A', (Table 1) and is found to be dominant tree species with highest dispersal rate and per unit area covered as compared to other species. The total value of 'D', 'F' and 'A' is case of trees is found to be less than observed by Sharma and Sharma (2011) from sand dune of sandy plain of Ajmer, Rajasthan, India. The *Ziziphus mauritian* exhibited lowest 'D', 'F', IVI, SD and CD with less dispersal rate and ground covered. The species *Albizia lebbeck* revealed the lowest value of 'A' and having per unit area very less. Many species were found to be contained equal values of different parameters with similar dispersal rate. The 'D' of entire trees at this site was observed in the range of 0.01-0.093 and that of 'A' 01-2.25, 'F' 0.66- 41.3 and IVI 1.39-120.5. The values of SD and CD observed at present study site are less than noticed by Devlal and Sharma (2008) from temperate forest of Garhwal, Himalaya, India, due to more intervention of human being and xeric types of environmental condition. The highest TBA was noticed in *Acacia Arabica*, which indicates this species is better adapted to the climatic condition from the long time. The lowest value of TBA in *Ziziphus mauritian* followed by *Balenite aegyptiaca, Capparis deciduas, Carateva religiosa* and *Prosopis cineraria* indicate reduced growth and less basal area covered by these species. The total value (2.11) of Shannon and Weiner index in case of trees at the present study site is less than noticed by

Table 1: The values of different parameters of tree species at Aravalli mountain range in Khanak, Haryana, India

S. No.	*Tree species*	*Family*	*D*	*A*	*F*	*IVI*	*SD*	*CD*
1	*Acacia arabica*	Fabaceae	0.66	1.596	41.333	120.575	0.36658	0.15838
2	*Acacia nilotica*	Fabaceae	0.246	1.370	18	32.1612	0.28383	0.02174
3	*Acacia senegal*	Fabaceae	0.113	1.133	10	16.3595	0.18371	0.00444
4	*Ailanthus excelsa*	Simaroubaceae	0.06	1.285	4.666	12.1108	0.12034	0.00117
5	*Albizia lebbeck*	Febaceae	0.026	1	2.666	6.0971	0.06653	0.00019
6	*Balenite aegyptiaca*	Zygophyllaceae	0.046	1.166	4	6.3828	0.10068	0.00068
7	*Boswellia serrate*	Burseraceae	0.093	1.272	7.333	31.6089	0.16225	0.00297
8	*Capparis decidua*	Capparaceae	0.06	1.125	5.333	8.3068	0.12034	0.00117
9	*Crateva religiosa*	Capparidaceae	0.026	1.333	2	3.4156	0.06653	0.00019
10	*Dalbergia sissoo*	Fabaceae	0.066	1.25	5.333	9.3712	0.12946	0.00146
11	*Ficus religiosa*	Moraceae	0.04	1.2	3.333	9.0411	0.09003	0.00048
12	*Melia azadirachta*	Meliaceae	0.046	1.166	4	9.7595	0.10068	0.00068
13	*Prosopis cineraria*	Fabaceae	0.06	2.25	2.666	6.1066	0.12034	0.00117
14	*Salvadora oleoides*	Salvadoraceae	0.093	1.166	8	27.294	0.16225	0.00297
15	*Ziziphus mauritian*	Rhamnaceae	0.013	2	0.666	1.3988	0.03885	0.00003
		Total value	1.648	20.31	119.33	300	2.112405	0.19778

Sinha and Sinha (2013) from Baikunthpur, Chhattisgarh, India.

The Shrub Species

The shrubs species at study site were more densely distributed than trees. The shrub species *Prosopis juliflora* was found to have maximum 'D', IVI, SD and CD, and is considered as the dominant species (Table 2). *Phragmites australis* revealed the maximum 'A' with very high per unit area of distribution. The shrubs were found to be dispersed all around at the study site, which seem to tolerate all types of environmental conditions. The lowest value of 'D' and IVI was reflected by *Chamaecrista nomane*, which means that per unit area and the dominancy of this species is very less. The values of 'D' of entire shrubs lie between 0.06-0.63 and that of 'A' 1.3-23.5, 'F' 02.66- 27.33, IVI 7.09-58.81, SD 0.09-0.35 and CD 0.0006- 0.085. The values of Simpson's and Shannon-Weiner index in case of shrubs are less than noticed by Devi and Yadava (2006) from the tropical semi-evergreen forest of Manipur, north-east India. The main reason behind higher value of this index in semi-evergreen forest is the best environmental condition for the growth of plants as compared to the present study site.

The Herb Species

The dominant species amongst herbs was found to be *Cynodon dactylon* on the basis of highest value of 'D', 'F' and IVI, etc. (Table 3). The same species was also noticed dominant by Aggarwal et al. (2012) and Sharma et al. (2001) from dry tropical peri-urban region of Uttarakhand and Sanganer Jaipur, India, respectively. The lowest values of IVI for *Ipomoea pestigridis* and *Momordica balsamica* express these species fewer in number and with less dispersal rate. The value of 'A' at the present site (that is, per unit area) for all trees and shrubs is found to be somehow similar, except *Phragmites australis*. However, the herbs revealed much difference of occurrence from one another and also from trees and shrubs, which means that the distributional composition of herbs is more. The herbs species were found to be superior in position than trees and shrubs at the present study site. The values of 'D' among herbs are observed between 0.06-4.18 and that of 'A' 01-09, 'F' 0.33-66-75, RD 0.030-19.22, RF 0.03-8.63, IVI 0.06-27.8 and CD 4E-09 to 0.03. The observed value of Shannon and Weiner index was found to be less than noticed by Sinha and Sinha (2013), due to environmental conditions and human interventions.

The values of different parameters in case of trees and shrubs are observed to be increased from 'D' to IVI and then decreased onward, but in herbs it increased from 'D' to 'F' and then decreased onward (Fig. 2). The values of shrubs and trees are somehow closer for all the parameters, but different than herbs. However, the values of some parameters are found to be inversely proportional to each other, which is also noticed by Devlal and Sharma (2008) in their own study at another site. Total value of 'D' among different species (Herbs, shrubs and trees) reveal the strength and distributional composition of one species relative to another and was found highest in case of herbs, followed by shrubs and lowest by trees. The per unit area on the basis of total 'A' value came out highest in herbs, followed by shrubs and trees. On the ba-

Table 2: The values of different parameters of shrub species at Aravalli mountain range in Khanak, Haryana, India

S. No.	*The shrub species*	*Family*	*D*	*A*	*F*	*IVI*	*SD*	*CD*
1	*Abutilon indicum*	Malvaceae	0.086	1.3	6.666	11.205	0.1289	0.0014
2	*Aerva tomentasa*	Amaranthaceae	0.18	1.5	12	21.283	0.207	0.0067
3	*Chamaecrista nomane*	Fabaceae	0.06	1.5	04	7.093	0.0993	0.0006
4	*Clerodendrum multiflorum*	Lamiaceae	0.093	1.4	6.666	11.513	0.1357	0.0017
5	*Commiphora wightii*	Burseraceae	0.12	1.5	08	14.188	0.1606	0.0029
6	*Grewia tenax*	Malvaceae	0.226	1.416	16	27.759	0.2365	0.0107
7	*Phragmites australis*	Poaceae	0.626	23.5	2.666	31.889	0.3589	0.0809
8	*Prosopis juliflora*	Fabaceae	0.633	2.317	27.333	58.816	0.3597	0.0853
9	*Ziziphus numularia*	Rhamnaceae	0.133	1.428	9.333	16.243	0.1718	0.00363
		Total value	2.157	35.86	92.664	200	1.8584	0.19383

Table 3: The values of different parameters of herb species at Aravalli mountain range in Khanak, Haryana, India

S. No.	*The herb species*	*Family*	*D*	*A*	*F*	*IVI*	*SD*	*CD*
1	*Achyranthes aspera*	Amaranthaceae	0.25	1.46	17.3	3.15	0.051	0.00013
2	*Adiantum incisum*	Pteridaceae	0.023	3.5	0.66	0.18	0.007	9.8E-08
3	*Alloteropsis cimicina*	Poaceae	0.816	2.09	39	8.24	0.123	0.0014
4	*Amaranthus spinosus*	Amranthaceae	0.04	1.71	2.33	0.45	0.011	3E-06
5	*Aristida adscensionis*	Poaceae	2.83	4.44	63.6	20.3	0.265	0.016
6	*Artemisia caudate*	Asteraceae	0.01	1.5	0.66	0.12	0.003	1.4E-08
7	*Boerhaavia diffusa*	Nyctaginaceae	0.94	1.95	48	9.84	0.135	0.0018
8	*Bothriochloa ischaemum*	Poaceae	0.396	2.12	18.6	3.97	0.072	0.00032
9	*Brachiaria distachya*	Poaceae	0.09	1.92	4.66	0.95	0.022	1.6E-05
10	*Brachiaris ramose*	Poaceae	0.536	1.64	32.6	6.22	0.091	0.0006
11	*Calamagrostis stricta*	Poaceae	0.773	2.12	36.3	7.73	0.118	0.0012
12	*Cardiospermum halicacabum*	Sapindaceae	0.043	1.44	03	0.54	0.012	3.6E-06
13	*Cenchrus ciliaris*	Poaceae	0.446	1.67	26.6	5.12	0.079	0.00041
14	*Cenchrus echinatus*	Poaceae	0.313	2.54	12.3	2.85	0.061	0.0002
15	*Cenchrus longispinus*	Poaceae	0.656	2.26	29	6.35	0.105	0.0009
16	*Chenopodeum album*	Amaranthaceae	0.043	3.25	1.33	0.35	0.012	3.6E-06
17	*Citrullus colocynthis*	Cucurbitaceae	0.013	1.33	1	0.17	0.004	2.8E-08
18	*Cleome gynandra*	Capparaceae	0.016	1.66	0.66	0.15	0.005	4.7E-08
19	*Cocculus pendulus*	Menispermaceae	0.06	1.28	4.66	0.81	0.016	7.2E-06
20	*Colotropis procera*	Asclepiadaceae	0.093	1.16	08	1.34	0.023	1.7E-05
21	*Commelina benghalensis*	Commelinaceae	0.316	1.86	17	3.41	0.061	0.00021
22	*Convolvulus arvensis*	Convolvulaceae	0.023	1.4	1.66	0.29	0.007	9.8E-08
23	*Conyza anadensis*	Asteraceae	0.08	1.41	5.66	1.01	0.020	1.3E-05
24	*Cucumis callosus*	Cucurbitaceae	0.046	1.4	3.33	0.59	0.013	4.2E-06
25	*Cympogon jwarancusa*	Poaceae	0.873	1.74	50	9.76	0.129	0.0016
26	*Cynodon dactylon*	Poaceae	4.183	5.57	75	27.8	0.317	0.0369
27	*Cyprus rotundus*	Cyperaceae	0.716	2.82	25.3	6.20	0.112	0.00107
28	*Dactyloctenium aegyptium*	Poaceae	0.486	5.03	9.66	3.34	0.084	0.00049
29	*Datura metel*	Solanaceae	0.036	2.2	1.66	0.36	0.010	2.5E-06
30	*Desmodium gengeticum*	Febaceae	0.056	1.7	3.33	0.64	0.015	6.3E-06
31	*Desmostachya bipinnata*	Poaceae	0.036	1.37	2.66	0.47	0.010	2.5E-06
32	*Dichanthium annulatum*	Poaceae	0.413	1.90	21.6	4.39	0.075	0.00036
33	*Dicoma tomentosa*	Asteraceae	0.07	1.61	4.33	0.82	0.018	9.8E-06
34	*Echinochloa colona*	Poaceae	0.243	2.92	8.33	2.07	0.050	0.00012
35	*Echinops echinatus*	Asteraceae	0.05	1.25	4	0.69	0.013	4.9E-06
36	*Eleusine indica*	Poaceae	0.36	3.27	11	2.92	0.067	0.00027
37	*Eragrostis minor*	Poaceae	0.073	1.57	4.66	0.87	0.019	1.1E-05
38	*Erogrostis tenella*	Poaceae	0.976	3.25	30	7.94	0.139	0.00201
39	*Euphorbia hirta*	Euphorbiaceae	0.18	1.92	9.33	1.90	0.039	6.7E-05
40	*Evolvulus numularius*	Convolvulaceae	0.043	1.3	3.33	0.58	0.012	3.6E-06
41	*Fagonia indica*	Zygophyllaceae	0.046	1.27	3.66	0.63	0.013	4.2E-06
42	*Galega officinalis*	Fabaceae	0.036	1.22	3	0.51	0.010	2.5E-06
43	*Helitropium strigosum*	Boraginaceae	0.066	1.25	5.33	0.92	0.017	8.9E-06
44	*Heteropogon contortus*	Poaceae	0.273	1.82	15	2.98	0.054	0.00016
45	*Indigofera linnaei*	Leguminoseae	0.073	1.37	5.33	0.95	0.019	1.1E-05
46	*Ipomoea pestigridis*	Convolvulaceae	0.006	2	0.33	0.06	0.002	4E-09
47	*Leptadenia pyrotechnica*	Apocynaceae	0.033	1.11	3	0.49	0.009	2.1E-06

Table 3: Contd...

S. No.	The herb species	Family	D	A	F	IVI	SD	CD
48	*Leunaea nudicaulis*	Compositeae	0.103	1.55	6.66	1.24	0.025	2.1E-05
49	*Momordica balsamica*	Cucurbitaceae	0.006	1	0.66	0.10	0.002	4E-09
50	*Ocimum basilicum*	Lamiaceae	0.02	1.6	1.66	0.31	0.008	1.3E-06
51	*Ocimum canum Sims*	Lamiaceae	0.01	1.33	1	0.17	0.004	2.8E-08
52	*Opuntia ficus indica*	Cactaceae	0.02	03	0.66	0.16	0.006	7E-08
53	*Parthenium hysterophorus*	Asteraceae	0.02	1.33	2	0.35	0.008	1.3E-06
54	*Physalis minima*	Solanaceae	0.01	1.5	0.66	0.12	0.003	1.4E-08
55	*Portulaca quadr ifida*	Portulacaceae	0.06	1.58	04	0.75	0.016	8E-06
56	*Pupalia lappacea*	Amaranthaceae	0.97	1.97	49	10.0	0.138	0.00198
57	*Ruellia patula*	Acanthaceae	0.90	2.25	40	8.75	0.132	0.0017
58	*Rynchosia minima*	Febaceae	0.06	02	3.33	0.68	0.017	8.9E-06
59	*Saccharum spontaneum*	Poaceae)	0.08	1.2	6.66	1.13	0.020	1.3E-05
60	*Solanum surratense*	Solanaceae	0.08	1.25	6	1.07	0.021	1.4E-05
61	*Tephrosia purpurea*	Febaceae	0.08	1.56	5.33	0.99	0.021	1.4E-05
62	*Tribulus terrestris*	Zygophyllaceae	0.58	1.45	40	7.26	0.096	0.0007
63	*Tridax procambens*	Asteraceae	0.26	2.16	12.3	2.64	0.053	0.00015
64	*Typha angustifolia*	Typhaceae	0.12	9	1.33	0.70	0.028	2.9E-05
65	*Verbesina encelioides*	Asteraceae	0.01	1.66	1	0.19	0.005	4E-08
66	*Vernonia cinerea*	Asteraceae	0.04	1.2	3.33	0.56	0.011	3.1E-06
67	*Withania somnifera*	Solanaceae	0.01	2.5	0.66	0.15	0.005	4.6E-08
68	*Xanthium strumarium*	Asteraceae	0.06	1.46	4.33	0.78	0.016	8E-06
		Total value	21.67	139.1	868.3	200	3.184	0.071

sis of higher value of Shannon and Weiner index (SD), the herbs expressed large number of species with small number of individuals, followed by trees and shrubs. The value of this index is found closer to that noticed from mangroves of Kerala, India by Vinothkumar et al. (2011) and from the Sagar district of Madhya Pradesh, India by Thakur and Khare (2008). The value of this index is found to be less then observed from grassland of Rajasthan by Krishna et al. (2014) and mangroves of Kannur, Kerala by Vidyasagaran et al. (2011), but more than observed by Galav et al. (2005) from southern Aravalli hill of Rajasthan, India. The closer val-

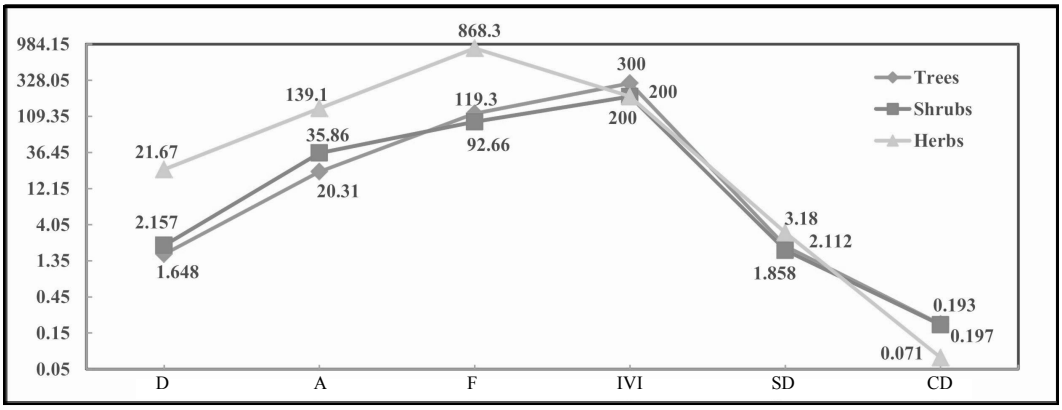

Fig. 2. The values of different parameters of entire habits at Aravalli mountain range in Khanak, Haryana, India

ues indicate similar environmental conditions like moisture condition, temperature and nutrients availability, while less and more values are due to difference in climatic conditions and anthropogenic activities. The Simpson's index noticed for entire habits indicates that the species diversity is highest amongst herbs; followed by shrubs and trees. The value of Simpson's index is found to be in the range noticed by Kumar et al., (2002) from the grassland of Rajasthan. The trees and shrubs are having closer pattern of distribution at the present study site, but little different than herbs. The dominancy among all the habits at the site is revealed by herbs, followed by shrubs and trees.

The dominant plant family at present study site is found to be Poaceae, followed by Febaceae, Astraceae, Amranthaceae, Solanaceae, Cucurbitaceae, Convolvulaceae, Zygophylaceae, Lamiaceae, Burgeraceae, Capparaceae, Malvaceae, Rhamnaceae and Acaranthaceae, etc. (Table 4). A study carried out by Kukshal et al. (2009) in north-west Himalaya, India, also revealed Asteraceae, Poaceae, Febaceae and Lamiaceae, the dominant families. The greatest numbers of species (21) and genus (18) at study site were noticed in the family Poaceae, which is more than (17 species) noticed by Devi and Yadava (2006) in an earlier study at another site. The dominancy of this family indicates well adaptation of its species to the existing environmental conditions at the study site as compared to species of other families. The dominant family in case of trees came out Febaceae, in shrubs Febaceae and Malvaceae and in herbs Poaceae. The remaining others families with lowest and equal numbers of species (01) and genus (01) were Acaranthaceae, Apocynaceae, Asclepidaceae, Boraginaceae, Cactaceae, Commelinaceae, Compositа, Capparidaceae, Cyperaceae, Euphorbiaceae, Leguminoseae, Meliaceae, Menispermaceae, Moraceae, Nyctaginaceae, Portulaceae, Pteridoceae, Salvadoraceae, Sapindaceae, Simaroubanceae and Typhaceae (Table 4).

Table 4: Different families with species and genus at Aravalli Mountain Range in Khanak, Haryana, India

Family	*Species*	*Genus*
Poaceae	21	18
Febaceae	12	09
Astraceae	09	09
Amranthaceae	05	05
Solanaceae	04	04
Cucurbitaceae	03	03
Convolvulaceae	03	03
Zygophylaceae	03	03
Lamiaceae	03	02
Burgeraceae	02	02
Capparaceae	02	02
Malvaceae	02	02
Rhamnaceae	02	01
Remaining families	01	01

The regular dispersal pattern amongst trees was indicated by *Acacia arabica* and *Acacia nilotica* etc. with high 'F' values, while irregular pattern by *Ziziphus mauritian, Albizia lebbeck* and *Prosopis cineraria* etc. with low 'F' values. This regular pattern among shrubs was shown by *Prosopis juliflora*, followed by *Grewia tenax* and *Aerva tomentasa*, while irregular pattern by *Phragmitis australis*, *Abutilon indicum* and *Clerodendrum multiflorum* etc. The herbs represented this scenario of regular dispersion in case of *Cynodon dactylon*, followed by *Cympogon jwarancusa*, *Pupalia lappacea* and *Boerhaavia diffusa*, whereas irregular pattern by *Citrullus colocynthis*, *Ocimum canum* and *Verbesina encelioides*. The dispersal rate of entire habits at the site was found highest in herbs, followed by trees and lowest in shrubs. The dominant species at study site amongst trees was found to be *Acacia arabica*, followed by *Acacia nilotica*, *Acacia senegal, Boswellia serrata* and *Salvadora oleoides*, and among shrubs the dominant species was *Prosopis juliflora*, followed by *Phragmites australis, Grewia tenax* and *Aerva tomentasa*. The *Cynodon dactylon* was noticed the dominant species among entire herbs, which was followed by *Aristida adscensionis, Pupalia lappacea, Erogrostis tenella* and *Boerhaavia diffusa*. Certain species like *Albizia lebbeck, Boswellia serrate, Crateva religiosa* and *Ziziphus mauritiana* among trees, *Chamaecrista nomane, Abutilon indicum* in shrubs and *Adiantum incisum, Artemisia caudate, Citrullus colocynthis, Ipomoea pestigridis, Momordica balsamica, Verbesina encelioides* and *Withania somnifera* etc. among herbs were found to be scarcely scattered. These species can be categorized as rare species and need higher attention to be paid by mankind for their conservation. The species richness at the site was observed highest in herbs (68), followed by trees (15) and lowest in shrubs (9). The Poaceae family was found to be dominant with highest numbers of species (21) and genus (18).

CONCLUSION

It is concluded that on being dry climatic condition and hot weather, the present study site is rich from plant diversity points of views, but much less than noticed elsewhere due to impact of mining and other anthropogenic activities. If the entire flora at the present study site allow growing under natural as well as controlled condition and without any kind of external interferences of human being, then this mountain range will be full of more floristic wealth in near times to come. The plant biodiversity throughout the world should be monitored and assessed with detail description of every plant species, which can play a vital role in making proper strategies for the preservation and further development of plant diversity.

RECOMMENDATIONS

The present study site, that is, Aravalli mountain range is having rich plant biodiversity, which is under threat of lose due to mining and other mismanaged anthropogenic activities. There is no specific criterion still so far to save plant biodiversity from mining and related activities. The mining should not be allowed at all and stopped with no time effect to preserve the floristic wealth. The government should also framework and implement proper strategies for conservation of plant biodiversity with public participation.

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