DETERMINATION OF RELATIVE SPECIES COMPOSITION AND SEASONAL PLANT COMMUNITIES OF NURPUR RESERVED FOREST IN SCRUB RANGELANDS OF DISTRICT CHAKWAL

Ahmad Hussain[1], Sarwat N. Mirza[2], Irshad A. Khan[2*] and Muhammad A. Naeem[3]
[1]Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi
[2]Department of Forestry and Range Management, PMAS Arid Agriculture University, Rawalpindi
[3]Department of Soil Science and SWC, PMAS Arid Agriculture University, Rawalpindi
*Corresponding author's e-mail: irshaduaar@yahoo.com

A detailed research study was conducted during 2004-05 in subtropical subhumid Nurpur rangelands of district Chakwal with main objectives to assess the relative species composition and seasonal plant (major forage species) communities. Sixty nine plant species that were distributed among 29 families, were recorded on the vegetation transects in 4 sites of the rangelands. These included 20 species of grasses, 12 of trees, 31 of shrubs and 6 of undershrubs and herbs. Plant species composition was studied in three consecutive seasons (fall/winter 2004, spring and summer 2005) on the rangelands. Plant density, frequency and cover varied among grasses, trees and shrubs across the three growth seasons. There was highly significant difference in grasses, trees and shrubs in all four range sites. During winter 2004 season, flat areas had highest plant density (44010 plants ha^{-1}) as compared to sloping areas (42690 plants ha^{-1}) and nullah beds/channels (21750 plants ha^{-1}) respectively. In spring and summer season of 2005, same trend was observed in flat areas that exhibited highest plant density as compared to other range sites owing to its topographical features. Lowest plant density was recorded at exposed sandstone areas across the three seasons. Grass composition increased as the season advanced from fall to spring and summer. From species point of view, each plant species exhibited significant values. Twelve communities were identified at various range sites in Nurpur rangelands during winter 2004, spring 2005 and summer 2005.

Keywords: Plant density, average frequency, vegetative cover, species importance

INTRODUCTION

Chakwal is a barani district situated at 33:01:21 latitude (N) and 72:45:49 longitude (E) and is located almost in the middle of Sind Sagar Doab ranging between the heights of 450 meters to 1050 meters above mean sea level. The area is conveniently divided into mountainous and unleveled area with either rocks exposed to surface or highly eroded lands with big gullies and cuts. Here alluvial deposits exist at a few sites. Sand deposits are extensive and very thick. The formation is inter-bedded with thin layers of sand and gravels. Drilling for good supply of ground water is very expensive in whole tract. The ground waters of the district almost contain very high sodium or carbonate and hence are dominantly saline but not sodic. The higher salt concentration in ground waters of Chakwal may be attributed to nearness to the famous Salt Range (Khan *et al*., 2002).

The district is characterized by a number of serious constraints related to physical factors such as frequent climatic extremes (frost, drought, hot winds) and shallow and steep sloppy soils. Most of the soils in the district range from silt loam to loam with pH ranging from 7-9. Air temperature fluctuates throughout the year; winter temperatures normally range between 4° C and 25° C and summer temperatures average between 15° C and 40° C. June is the hottest month and December is the coldest month of the year. The average annual rainfall is 558 to 635 mm occurring in bimodal pattern and more than 70% of annual precipitation falls in the summer months. The sparse vegetation of scrub rangelands of the district Chakwal supports mainly grazing sheep and goats, which are raised for milk, wool and meat production. These three products are important to the national economy and the livelihood of the rural population as nearly 30-35 million rural population is involved in livestock raising in Pakistan (GoP, 2007).

Nurpur Reserved Forest lies 36 km southeast of Chakwal at an elevation zone of 560 meter to 700 meter. Total area of the Nurpur Reserved Forest under the administrative control of the Divisional Forest Officer, Pothwar Range Management Division, Chakwal is 1125.86 hectare and is divided into 9 compartments of varying areas. The forests in Chakwal including Nurpur RF were reserved vide Punjab Government notification No. 351, dated 21st August 1882 (Said, 1952). Vegetation of the area is dry deciduous scrub type. Phulai (*Acacia modesta*) and

Kahu (*Olea ferruginea*) are the dominant tree species while Sanatha (*Dodonea viscosa*), Gurgura *(Reptonia buxifolia)* and Pataki (*Gymnosporia royleana)* were the major species. The stocking on the whole is poor and the forest is open. There is no real forest canopy and the topsoil has been practically washed away. Grasses are abundant throughout the area. Good forages like Pharion (*Digitaria bicornis*) and Palwan (*Bothriochloa pertusa*) are found in places where the incidence of grazing is less. In areas subjected to heavy grazing, less desirable grasses like lamb (*Aristida depressa*) and khawi (*Cymbopogon jwarancusa*) take place of good quality grasses. More than 23567 livestock head of 18 surrounding villages and hamlets are dependent on the forest for their yearlong food and forage requirements in Nurpur rangelands of district Chakwal. The residents of villages and hamlets in the salt range have the right of taking dry and dead firewood for their private use but not for sale from the forest and such portion of other forest as may be duly closed from time to time but axes are not allowed to be taken into the forest in exercise of this right. The settlement provided that a sufficient number of trees for plough and other agricultural implements should be marked and sold to local zamindars at reasonable low price. In all the forest, whether closed or open to grazing, grass cutting is allowed on payment but there is no grass available for cutting in open areas. According to the settlement the term grazing includes browsing. The forests which are open to grazing are open to browsing too, unless otherwise specified.

For the effective planning for conservation of precious plant species and scientific inventory of rangelands in Chakwal, it is very essential to get the set of full information about eco-geographical attributes and threatening factors. An understanding of seasonal changes in rangeland biomass and offtake of different range types is fundamentally important for the efficient management of livestock grazing. These studies aimed at quantifying the seasonal changes in various parameters of vegetation and characteristics in Chakwal rangelands as the area has been often critical for the livelihoods of the poor people.

MATERIALS AND METHODS

The research studies outlined below were conducted at Nurpur RF of district Chakwal during 2004 and 2005 which was categorized in four range sites i.e., flat areas, sloping areas, nullah beds/channels and exposed sandstone areas depending on its topographic and geophysical characteristics.

Inventory of the plant species occurring in the study area was carried out by Line Intercept method (Hussain, 1989) at the beginning of winter season (December) of 2004. Seven transects of 100 m length each, with an interval of 15 m between each other, were laid across the slope and all the herbaceous plant species intercepted by measuring tape were identified and recorded. Aboveground vegetation cover was measured by using quadrat method where quadrats of size 1 m^2 each were studied along 100 m length transect line, with an interval of 10 m between each other, two transect lines being 15 m apart. In all, seven transects were laid in each compartment. For shrubs and trees above 2 m height, 10 m × 10 m quadrats were studied and different species occurring within each quadrat were identified, counted and recorded. Percent composition, density and frequency of each species was also determined by examining 1×1 m^2 quadrats at an interval of 10 m along the permanent transect 100 m long depending upon the site characteristics. The same procedure was twice repeated during spring season (March to April) and summer season (June- July) of 2005 under the grazing conditions in the field.

Various vegetational attributes were calculated according to the following formulae and communities were established as in quadrat method (Hussain, 1989).

$$\text{Density} = \frac{\text{Number of quadrats in which a species occurs}}{\text{Area samples (Total number of quadrats}} \times 100$$

$$\text{Frequency} = \frac{\text{Number of quadrats in which a species occurs}}{\text{Total number of quadrats sampled}} \times 100$$

$$\text{Coverage \%} = \frac{\text{Area covered by a species in a quadrat}}{\text{Total area covered by all the species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of a particular species}}{\text{Total density for all the species in a stand}} \div 100$$

$$\text{Relative Coverage} = \frac{\text{Coverage (Dominance of a particular species}}{\text{Total Coverage (Dominance) for all the species in a stand}} \times 100$$

The importance value (IV) of each species was calculated following the method of Curtis and McIntosh (1951) and Stephenson (1986).

Importance value = Relative density + Relative Frequency + Relative Coverage

The species within a stand were arranged on the basis of importance values and named after the leading species with the highest importance values. The closely approaching species were considered as co or sub-dominants of the community. Total importance value (TIV) was calculated by adding the value of three dominant plant species in a community, while the remaining total plants were added separately.

RESULTS AND DISCUSSION

Plant species composition and relative density

Sixty nine plant species that were distributed among 29 families were recorded on the vegetation transects in four sites of Nurpur rangelands of district Chakwal, all of which were native to the region. These included 20 species of grasses (28.9%), 12 of trees (17.4%), 31 of shrubs (44.9%) and 6 of undershrubs and herbs (8.7%). Mimosaceae, Capparidaceae, Asclepiadaceae and Rhamnaceae were the dominant families in winter season while Poaceae, Acanthacea, Sapindaceae and Chenopodiacae were the dominant families both in spring and summer seasons in the study area. Stewart (1972) reported that these families were well represented in Pakistan.

Herbaceous species that were observed in the study area but not recorded in the quadrats were also collected to provide the most complete possible record of the flora. Plants were identified using relevant literature and herbarium reference collection and where there was uncertainty; specimens were lodged at the National Herbarium at National Agriculture Research Centre (NARC), Islamabad. During the study period, the grass composition increased as the season advanced from fall to the spring and summer.

Plant density varied across the three growth seasons (fall/winter 2004, spring and summer 2005) in Nurpur RF (Table 1). There was highly significant difference in grasses, trees and shrubs. Collectively evaluated at all the seasons, shrubs (20309 plants ha^{-1}) were highly significant as compared to grasses and trees. Grasses (12208 plants ha^{-1}) were highly significant as compared to trees (648 plants ha^{-1}). Flat areas (17971 plants ha^{-1}) and sloping areas (15763 plants ha^{-1}) were non significant to each other but highly significant as compared to nullah beds/channels (7858 plants ha^{-1}) and exposed sandstone areas (2675 plants ha^{-1}). Nullah beds/channels were highly significant as compared to exposed sandstone areas. The interaction of vegetation and range sites showed similar density of shrubs in flat areas and sloping areas followed by similar density of grasses in flat areas and sloping areas across the three growth seasons.

In the study on vegetation dynamics in winter 2004 season, flat areas had highest plant density as compared to sloping areas and nullah beds/channels in Nurpur RF. It might be due to the fact that flat areas had more water retention capacity than the other range sites that nourished more vegetation. The lowest plant density was recorded at exposed sandstone areas. It might be due to its shallow soil layer that usually washed away with precipitation occurring in the form of heavy downpours and a little soil is left to support plant growth. In spring and summer season of 2005, same trend was observed in flat areas that exhibited highest plant density as compared to other range sites in Nurpur RF. An increase of 23.35 percent was recorded in plant density in flat areas from winter 2004 to spring 2005 while the increase in plant density from spring to summer season of 2005 was less pronounced in flat areas; being 9.18. The research findings are in agreement with Coppock (1994) who concluded that the vegetation compositions of rangelands varied depending on topography, climate and soil fertility.

Table 1. Average density of plants (#ha^{-1}) across three growth seasons in Nurpur Reserved Forest

Vegetation	Flat areas	Sloping areas	Nullah beds/channels	Exposed Sandstone	Mean
Grasses	19190 b	15350 bc	12920 c	1370 e	12208 B
Trees	1492 e	288.3 e	90.67 e	867.7 e	648 C
Shrubs	33230 a	31660 a	10560 cd	5790 de	20309 A
Mean	17971 A	15763 A	7858 B	2675 C	

Analysis of variance

Sources	P-values	LSD	S.E
Seasons	0.12		
Vegetation (V)	< 0.01	2574.00	877.50
Range sites (RS)	< 0.01	2972.00	1013.00
Interaction			
V x RS	< 0.01	5147.00	1755.00
CV (+ %)	27.47		

** Means in a column/row followed by same letter (s) are statistically non-significant at $P \leq 0.01$
NS = Non-significant difference among means at $P \leq 0.05$

Vegetation cover (%)

In Nurpur Reserved Forest, 7 grasses, 9 trees and 27 shrub species in fall/winter 2004, 14 grasses, 10 trees and 28 shrub species in spring 2005 and in summer 2005, total 20 grasses, 11 trees and 31 shrub species were encountered. Plant species cover studied in three consecutive seasons on four range sites along with its summary statistics has been given in Table 2.

Table 2. Vegetation cover (%) in Nurpur Reserved Forest and its summary statistics

Winter 2004

Items	Flat areas	Sloping areas	Nullah beds/ channels	Exposed sandstone	Mean	Standard error	Range
Grasses	0.68	0.23	0.35	0.32	0.39	0.09	0.45
Trees	1.09	1.03	0.88	0.30	0.82	0.18	0.79
Shrubs	1.34	2.70	1.92	0.57	1.63	0.45	2.13
Litter	0.13	0.10	0.03	0.22	12	0.03	0.19
Rocks	7.83	11.18	4.65	12.45	9.02	1.75	7.80
Bare Soil	88.93	84.76	92.17	86.14	88.00	1.63	7.41
Total	100.00	100.00	100.00	100.00			

Spring 2005

Items	Flat areas	Sloping areas	Nullah beds/ Channels	Exposed sandstone	Mean	Standard error	Range
Grasses	6.04	0.94	0.96	0.51	2.11	1.31	5.53
Trees	1.12	1.86	1.02	0.72	1.18	0.24	1.14
Shrubs	1.6	2.98	2.24	0.64	1.86	0.49	2.34
Litter	0.16	0.11	0.09	0.29	0.16	0.04	0.2
Rocks	7.86	11.09	4.28	13.01	9.06	1.91	8.73
Bare Soil	83.22	83.02	91.41	84.83	85.62	1.97	8.39
Total	100.00	100.00	100.00	100.00			

Summer 2005

Items	Flat areas	Sloping areas	Nullah beds/ Channels	Exposed sandstone	Mean	Standard error	Range
Grasses	58.20	21.37	36.49	2.04	29.52	11.87	56.16
Trees	1.87	1.43	1.02	0.36	1.17	0.32	1.51
Shrubs	1.44	2.76	2.38	0.93	1.87	0.42	1.83
Litter	0.60	0.29	1.72	0.77	0.84	0.30	1.43
Rocks	4.22	6.63	3.21	14	7.01	2.43	10.79
Bare Soil	33.67	67.52	55.18	81.9	59.56	10.21	48.23
Total	100.00	100.00	100.00	100.00			

Community structure

Each plant species possessed significance values for species importance. Twelve dfferent plant communities were identified at various range sites in Nurpur rangelands during winter 2004, spring 2005 and summer 2005 and the summary of vegetation analysis has been given in Table 3. The contribution towards total importance value (IV) by grasses, shrubs and trees changes across the three growth seasons.

CONCLUSIONS

Biodiversity is a key feature of properly functioning grazed ecosystem. Grasses, trees and shrubs (legumes as well as non legumes) are keystone plant species in productive grasslands (Sanderson *et al*., 2002). Communities are recognized with differing floristic and environmental characteristics; plots from each of these communities are viewed in winter as well as in spring and summer to gain insight into the vegetation (Smitheman and Perry, 1990). Fossil records indicated that the angiosperms date back to the tertiary period while pre tertiary fossils have no angiosperm affinities in Pothwar tract (Hussain, 2003).

Table 3. Summary of vegetation analysis in Nurpur Reserved Forest across three growth seasons

Growth season	Range Sites	Scientific name	Relative density	Relative frequency	Relative cover	Importance value	Total IV (3 Dominants)	Total IV (Other Sp.)
Winter 2004	**Flat areas**	*Adhatoda vasica*	12.974	5.55	6.90	25.429	**72.691**	**227.309**
		Desmostachya bipinnata	9.725	6.35	9.00	25.075		
		Dodonaea viscosa	9.725	4.76	7.70	22.187		
	Sloping areas	*Gymnosporia royleana*	15.039	5.79	11.60	32.424	**79.418**	**220.582**
		Adhatoda vasica	11.712	5.79	7.30	24.798		
		Rhazya stricta	8.363	4.13	9.70	22.196		
	Nullah beds/ channels	*Saccharum spontaneum*	19.678	4.39	4.90	28.973	**68.900**	**231.01**
		Sageretia brandrethiana	6.529	5.50	9.80	21.825		
		Saccharum ciliare	13.103	2.20	2.80	18.103		
	Exposed sandstone	*Prosopis cineraria*	35.726	7.15	1.60	44.472	**94.525**	**205.475**
		Suaeda fruticosa	23.706	5.71	1.01	30.430		
		Aristida depressa	1.336	4.29	14.00	19.622		
Spring 2005	**Flat areas**	*Desmostachya bipinnata*	7.884	3.96	18.70	30.540	**76.870**	**223.13**
		Heteropogon contortus	6.576	4.52	12.40	23.498		
		Lasiurus sindicus	6.576	3.96	12.30	22.832		
	Sloping areas	*Prosopis cineraria*	12.285	4.91	8.60	25.790	**58.597**	**241.403**
		Adhatoda vasica	9.208	3.07	4.60	16.874		
		Dodonaea viscosa	7.681	2.45	5.80	15.932		
	Nullah beds/ channels	*Heteropogon contortus*	12.056	5.45	5.70	23.206	**67.045**	**232.955**
		Prosopis cineraria	6.007	4.54	12.00	22.550		
		Lasiurus sindicus	12.056	3.63	5.60	21.289		
	Exposed sandstone	*Kochia indica*	26.407	3.90	0.20	30.504	**71.861**	**228.139**
		Calotropis procera	17.522	1.30	4.30	23.120		
		Desmostachya bipinnata	8.638	2.60	7.00	18.237		
Summer 2005	**Flat areas**	*Desmostachya bipinnata*	7.221	3.07	22.30	32.588	**66.637**	**233.363**
		Cenchrus ciliaris	3.610	3.07	11.20	17.878		
		Heteropogon contortus	1.181	4.09	10.90	16.171		
	Sloping areas	*Prosopis cineraria*	10.963	4.72	4.10	19.783	**55.800**	**244.2**
		Desmostachya bipinnata	4.109	3.54	10.60	18.248		
		Eulaliopsis binata	4.109	2.36	11.30	17.768		
	Nullah beds/ channels	*Thysanolaena anostis*	5.630	2.72	15.60	23.950	**81.067**	**218.933**
		Eulaliopsis binata	5.630	2.72	15.40	23.750		
		Desmostachya bipinnata	8.485	4.08	20.80	33.366		
	Exposed sandstone	*Kochia indica*	28.591	6.87	4.30	39.763	**83.694**	**216.306**
		Calotropis procera	18.971	3.44	1.21	23.618		
		Prosopis cineraria	4.676	3.44	12.20	20.312		

Due to heterogeneity in the macro and microenvironment of this tract, large plant and animal diversity is expected to be endemic to it (Hussain, 2003).

An understanding of seasonal changes in rangeland biomass, production and offtake of different range types is fundamentally important for the efficient management of livestock grazing. These studies aimed at quantifying the seasonal changes in various parameters of vegetation and characteristics in Chakwal rangelands as the area has been often critical for the livelihoods of the poor people. Results obtained on the various parameter for species importance studied in this part of Pothwar tract; frequency, density, coverage, relative frequency, relative density, relative coverage and importance values respectively from four range sites (ecologically diverse sites) of Nurpur rangelands corroborated with the work on some earlier researchers like Austin and Heyligers, (1989) and Kirk-Patrick (1990), Smitheman and Perry (1990) who supported the above criteria and described plant communities of different areas of the world. The criterion of the classification fixed in the present research was strongly supported by the findings of Hussain, (2002).

The species variation in plants from site to site may be due to the soil type, composition of soil, elevation of selected sites, moisture content of soil, nature of disturbance like grazing pressure, human interference, distance of study site from population area etc. All the factors determine the category of species in which the species fall (Ahmad *et al*., 2007). A rich flora indicated high species diversity and species richness in the investigated area, however, floristic composition is a qualitative character and it alone cannot indicate the true picture of range productivity. Thus a need of quantitative assessment of the vegetation resources is further substantiated.

REFERENCES

Ahmad, K., M. Hussain, M. Ashraf, M. Luqman, M.Y. Ashraf and Z.I. Khan. 2007. Indigenous vegetation of Soone Valley at the risk of extinction. Pak. J. Bot. 39(3): 679-690.

Austin, M.P. and P.C. Heyligers. 1989. Vegetation survey design for conservation: gradsect sampling of forest in north-eastern New South Wales. In: C.R.J. Margules (Ed.). Australian developments in conservation evaluation. Biological Conservation 50(1-4): 13-32.

Coppock, D.L. 1994. The Borona Plateau of Southern Ethiopia: Synthesis of pastoral research, development and change. International livestock Center for Africa, Addis Ababa, Ethiopia 19: 80-91.

Curtis, J.T. and R.R. McIntosh. 1951. The interrelations of certain analytic and synthetic phytosociological characters. Ecology 31: 434-455.

GoP. 2007. Economic Survey of Pakistan 2006-2007. Government of Pakistan, Islamabad.

Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology. University Grants Commission, Islamabad. pp. 18-112.

Hussain. M. 2002. Exploration of legume diversity endemic to salt range in the Punjab. Annual technical report submitted to the University of Agriculture, Faisalabad. pp. 22-26.

Hussain, M. 2003. Exploitation of forage legume diversity endemic to Soone vally in the Salt Range of the Punjab. Annual technical report submitted to PARC, Islamabad, Pakistan. pp. 18-21.

Khan, A., R. Hussain and R. Ahmad. 2002. Quality of Ground water in district Chakwal. Proc. Second South Asia Water Forum. 14-16 Dec., 2002. Islamabad, Pakistan. Vol. 1: 315-320.

Kirk-Patrick. A.H. 1990. A vegetation survey of heath and moorland in northern Ireland and co. congeal. Dissertation and abstracts international-B, Sciences and Engineering 51(2): 544b.

Said, R.M. 1952. Working plan for the forests of the Jhelum, Miawali and Shahpur Forest Divisions. Govt. of the Punjab. Vol. 1 & 2. Jhelum and Shahpur Districts. 1952-53 to 1981-82. Govt. of the Punjab. pp. 9-126.

Sanderson, M.A., F. Taupe, B. Tracy and M. Wachendorf. 2002. Plant species diversity relationship in grassland of the north eastern USA and northern Germany. Multi-function grasslands: quality forages, animal products and landscapes. In: Proceeding of the 17th General meeting of the European grassland Federation, La Rochelle, France, 17-30 May, 2002: 842-843.

Smitheman, J. and P. Perry. 1990. A vegetation survey of the karoo national botanic garden resrve, Worcester. South African J. Bot. 56: 525-541.

Stephenson, S.L. 1986. An ecological study of Balsam fir communities in West Virginia. Bull. Torry Bot. Club 133: 373-81.

Stewart, R.R. 1972. An Annotated Catalogue to the vascular plants of West Pakistan and Kashmir. Fakhir Printing Press, Karachi. pp.145-182.