

ECOLOGICAL EVALUATION OF
SOME RANGELAND PLANTS OF
HARBOI HILLS, KALAT,
BALOCHISTAN

By
Mufakhirah Jan Durrani



DEPARTMENT OF BOTANY,
UNIVERSITY OF PESHAWAR
PESHAWAR
(2000)

Dedication

**Sincerely dedicated to
my beloved parents.**

University of Peshawar

Peshawar

Ecological Evaluation of Some Rangeland Plants
of Harboi Hills, Kalat, Balochistan

A Dissertation submitted in partial satisfaction
of the requirement for the degree of

Doctor of Philosophy

in

Botany

by

Mufakhirah Jan Durrani

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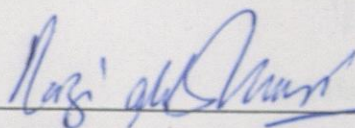
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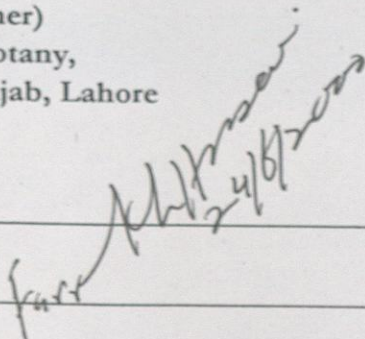
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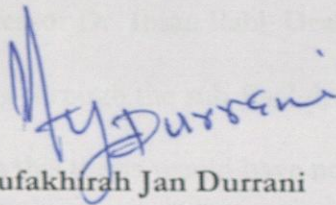
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Abstract

Ecological Evaluation of Some Rangeland Plants of Harboi hills, Kalat, Balochistan.

by
Mufakhirah Jan Durrani

The floristic, vegetation structure, productivity and chemical evaluation of plants of Harboi Hills rangelands of Kalat were determined from 1997 to 1999. There were 202 species of 45 plant families with scattered Juniper forest. Asteraceae, Papilionaceae, Poaceae, Brassicaceae and Lamiaceae were important families in the area. *Artemisia maritima*, *Sophora griffithii*, *Hertia intrmedia*, *Nepeta juncea*, *Astragalus Spp* and *Convolvulus leiocalycinus* were most common shrubs. Along the water courses, *Perovskia abrotanides* and *Verbascum erianthum* were common. *Pennisetum orientale*, *Bromus tectorum*, *Bromus sericeus*, *Shismus arabicus*, *Poa bulbosa*, *Piptatherum vicarium*, *Stipa pennata*, *Tetrapogon villosus*, *Cymbopogon jwarancusa*, *Melica persica*, *Aristida Spp* and *Phacelurus speciosus* were most common grasses. Biological spectrum showed that therophytic and hemicryptophytic life forms and nanophylls, microphylls and leptophylls leaf sizes were dominant in the area.

The growing season starts at the end of March and lasts upto November with two flowering seasons. Around, 63.6% plants flowered during April to June while 30.3% plants had flowering during July to September. Only a few species exhibited flowering throughout the season.

The area is rich in economic plants of various uses. They include fodder (129 Spp), medicinal (50 Spp), vegetable/fruits (12 Spp), fuelwood (7 Spp), roof thatching (3 Spp), herbal tea (3 Spp) and other varied uses.

Based on cluster analysis and principal coordinate ordination, the plant communities were classified into three major vegetation types i.e. *Bromus* type, *Artemisia* Steppe, and *Juniperus* types during spring, while *Artemisia* Steppe, *Astragalus* Steppe and *Juniperus* types during summer. Two plant communities were established in water courses i.e. *Perovskia* - *Artemisia* - *Bromus* and *Perovskia* - *Artemisia* - *Perovskia* during spring; while *Perovskia* - *Perovskia* - *Peganum* and *Sophora* - *Euphorbia* - *Perovskia* were established during summer.

The soil texture varied from sandy loam, sand clay loam to clay in different stands. Organic matter was rich in soils under Juniper cover compared to open or open vegetation cover. The soils were highly calcareous and non-saline with moderate to slightly alkaline nature. pH ranged from 8.4 to 8.6. Electrical conductivity was generally low. The differences in concentration of various minerals analyzed during the season was non-significant.

The available fodder species for livestock varied from April to October. There were 129 palatable species. Among them, 50.4% (65 Spp) were highly palatable, 41.1% (53 Spp) mostly palatable, 4.7% (6 Spp) less palatable and 3.9% (5 Spp) were rarely palatable.

Considering the grazeable parts, it was found that in 99 species (63%) shoots/whole plants were grazed, in 30 species (19%) foliage/leaves were used while in 29 species (18%) floral parts were consumed.

Climatic fluctuation strongly influenced plant productivity in both the years (1997, 1998). The total average biomass for both the years was 10772.55 Kg/ha. July and August were the most productive months (2120.69 and 2012.72 Kg/ha, respectively). The biomass gradually increased from April to July and then exhibited a progressive decreasing trend till the October.

Forage quality decreased with the advancement of phenological stages in all the plants analyzed. Forage quality was higher during spring than that of other season

Grasses were lower in crude protein concentration and higher in crude fiber, neutral detergent fiber, acid detergent fiber and hemicellulose contents than shrubs. The mineral constituents of plant species were statistically similar. The concentration of crude protein and phosphorus of grasses were below the optimal level and those of shrubs were upto the optimum level for goats and sheep.

Across all the grazing seasons, the diet of both animal species were deficient in crude protein, digestible and metabolized energy and manganese contents. Phosphorus contents were sufficient during spring and insufficient in other seasons. The rangelands need ecological management with the altruistic participation of local communities and Government to make a sustainable production.

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LIST OF ABBREVIATIONS

BCB	<i>Bromus - Caragana - Bromus</i>
BPS	<i>Bromus - Polygala - Shismus</i>
AAP	<i>Artemisia - Aristida - Phacelurus</i>
SIA	<i>Sophora - Iris - Artemisia</i>
ASC	<i>Artemisia - Sophora - Crepis</i>
JPL	<i>Juniperus - Pulicaria - Leptorhabdos</i>
PBA	<i>Perovskia - Bromus - Artemisia</i>
PAE	<i>Perovskia - Artemisia - Euphorbia</i>
PPA	<i>Pervoskia - Perovskia - Artemisia</i>
ABB	<i>Artemisia - Bromus - Bromus</i>
APH	<i>Artemisia - Perovskia - Hertia</i>
PEA	<i>Perovskia - Euphorbia - Artemisia</i>
PEA	<i>Perovskia - Euphorbia_m - Artemisia</i>
EEH	<i>Euphorbia - Eragrostris - Hertia</i>

INTRODUCTION

INTRODUCTION

Introduction

The name 'Harboi' is derived from "Har" meaning "all" and "Boi" means "Scents". The Harboi Hills, Kalat covering an area of 55230 acres, lie between 29° N and 66°, 45 to 67° E. The study area extends 30 Km from Kalat city, in the southwest direction, up to Harboi bungalow on Grishk hills (2723m). Harboi hills lie in Sarawan and Jhalawan divisions. It was declared as Protected Forest since January, 1967 (Fig. 1).

Geomorphology

The study area has rugged mountainous track with many low valleys alternating with high ridges. The highest peak located near Sirkokohi is 2896m, while the lowest point is 2273m near Mughal Kund. Other high peaks in the area are Kakku (2933m), Hamandu Kushta (2739m), Hinar (2453m) and Gishk (2727m).

The area is characterized by numerous dry ravines and water courses which flow from northeast to southwest directions. The Sarawan river originating in these hills drains toward north with dentritic drainage pattern. Some natural springs are also present which provide water to local inhabitants.

Stratigraphy

The exposed rocks are spintangi limestone. Marup conglomerates are recent to sub-recent. Spintangi limestone (Kirthar formation) consists of limestone of light grey, yellowish grey, brownish grey and creamy in color. It is mostly thick bedded and nodular. Calcite crystals are also found. Limestone is highly fossiliferous with *Nummulites spira* (Assilina) of middle eocene age.

The Marup conglomerates (Ghazij formation) consist of poorly sorted and well rounded pebbles and boulders of gray, white, pink limestone, green shale, marl and sandstones derived from the underlying structures. Yellow brown, black chart and dark maroon pebbles are of Par-limestone type. At some places Chiltan limestone of Jurassic age are also present.

There are many faults, folds and joints. The orientation of bed varies from N20E to N40E with dip angle upto 35° NW and SE. Folds are asymmetrical, NE to SW direction and faults are strike slip type, joints form two set system and third system cutting across each other (Fig. 2).

Climate

The study area has no meteorological station, therefore, the data for Kalat is taken as representative. However, temperature at Harboi hills are less than Kalat. The climate is of dry temperate type. The summers are warm and dry while winters are cold. Summer is comparatively short lasting from May to September with June and July as the hottest months. The mean temperature during these months rises to over 30°C with maximum hardly reaching up to 35 °C at Kalat. The winters are long and cold. They last for seven months from October to April. The coldest month, January, has a mean monthly temperature of - 4.34 °C (Table 1). The cold spell is quite severe with chilling winds. The temperature may drop as low as -16 °C (Khan, 1995).

Wind speed varies from 1.0 - 2.2 knots in the morning and evening while 3.64 - 4.58 knots at 12:00 (UTC). Wind direction is SW in the morning and NW in the evening (Table 1). The mean annual air pressure is 1511. It varies from low during May to September to high in winter season (Table 1). The mean annual relative humidity is 44.31 with lowest during July 32.48 and highest in January 60.00 (Table 1).

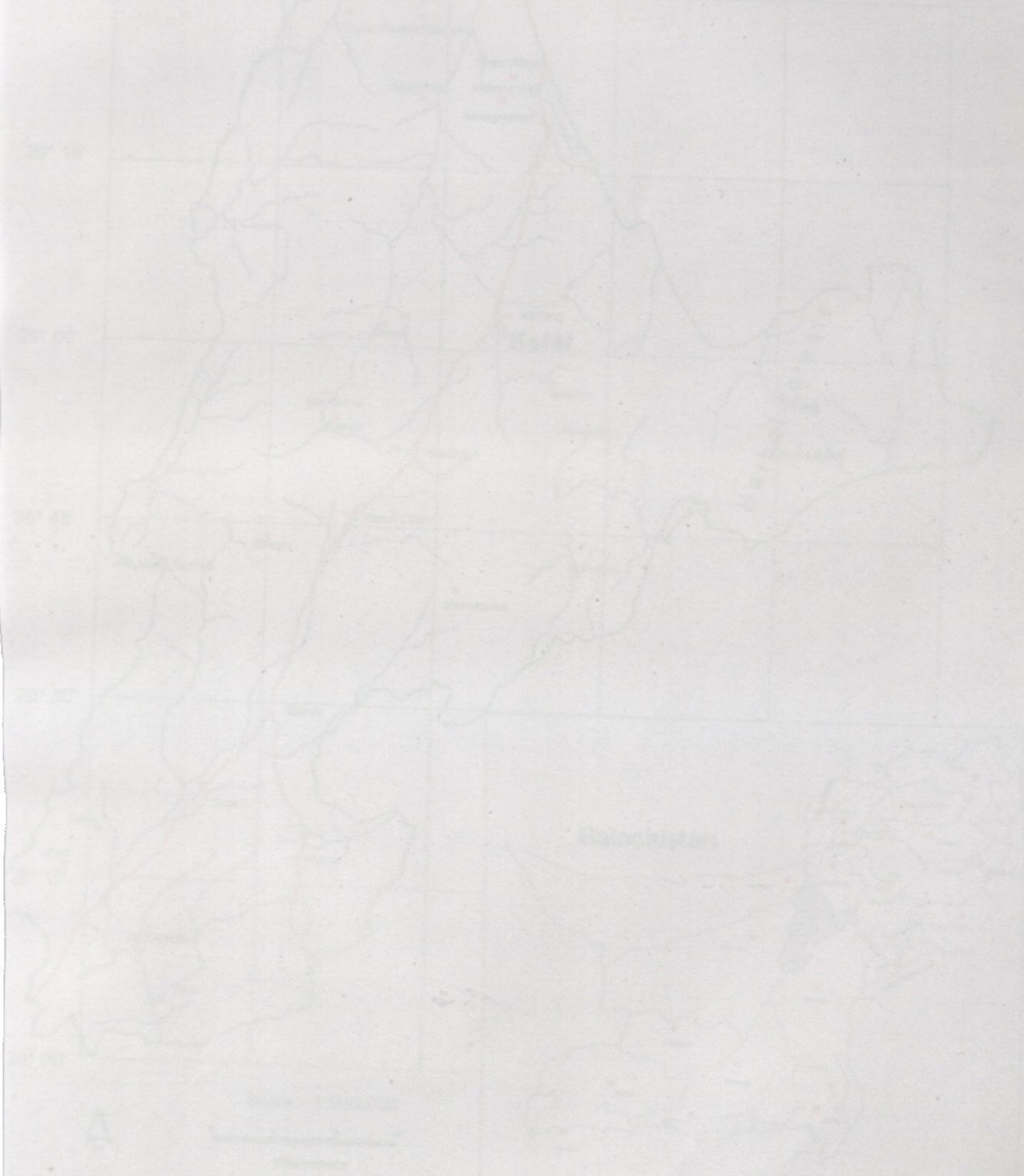
The mean value of clouds is 1.87 OKTS. The highest clouds 3.28 OKTS occur in March with least in September (0.62 OKTS). The mean dew point temperature varies from - 5.48 °C (January) to 9.69 °C (July) (Table 1). The area receives regular snowfall during winter. The mean annual rainfall is 341.98 mm. The rainfall is low which varies from 2.38 mm (September) to 124.77 mm (December). Evapo-transpiration is higher than rainfall which causes aridity. The precipitation is mostly received during winter from western depression (Table 1).

Vegetation

The study site is a part of the Juniper forest. It is characterized by *Juniperus excelsa* M. Bieb (*Juniperus macropoda*) which spreads approximately over 20235 hectares in Harboi hills. Major parts of Harboi hills are classified as temperate rangeland where different tribes graze their livestock. Some of the most common grasses are species of *Stipa*, *Cymbopogon*, *Piptatherum*, *Poa*, *Aristida*, *Tetrapogon*, *Melica*, *Bromus* and *Boissera* etc. while *Juncus Spp* are confined to aquatic habitats.

Biotic Factors

The area is under heavy biotic pressure. Plants are cut and uprooted for fuel and medicinal purposes. Overgrazing is also an ecological problem. They together have led to soil erosion and poor regeneration of the forest and rangeland species.



Map of Kailash showing research area

Fig. 1 Map of Kalat showing research area

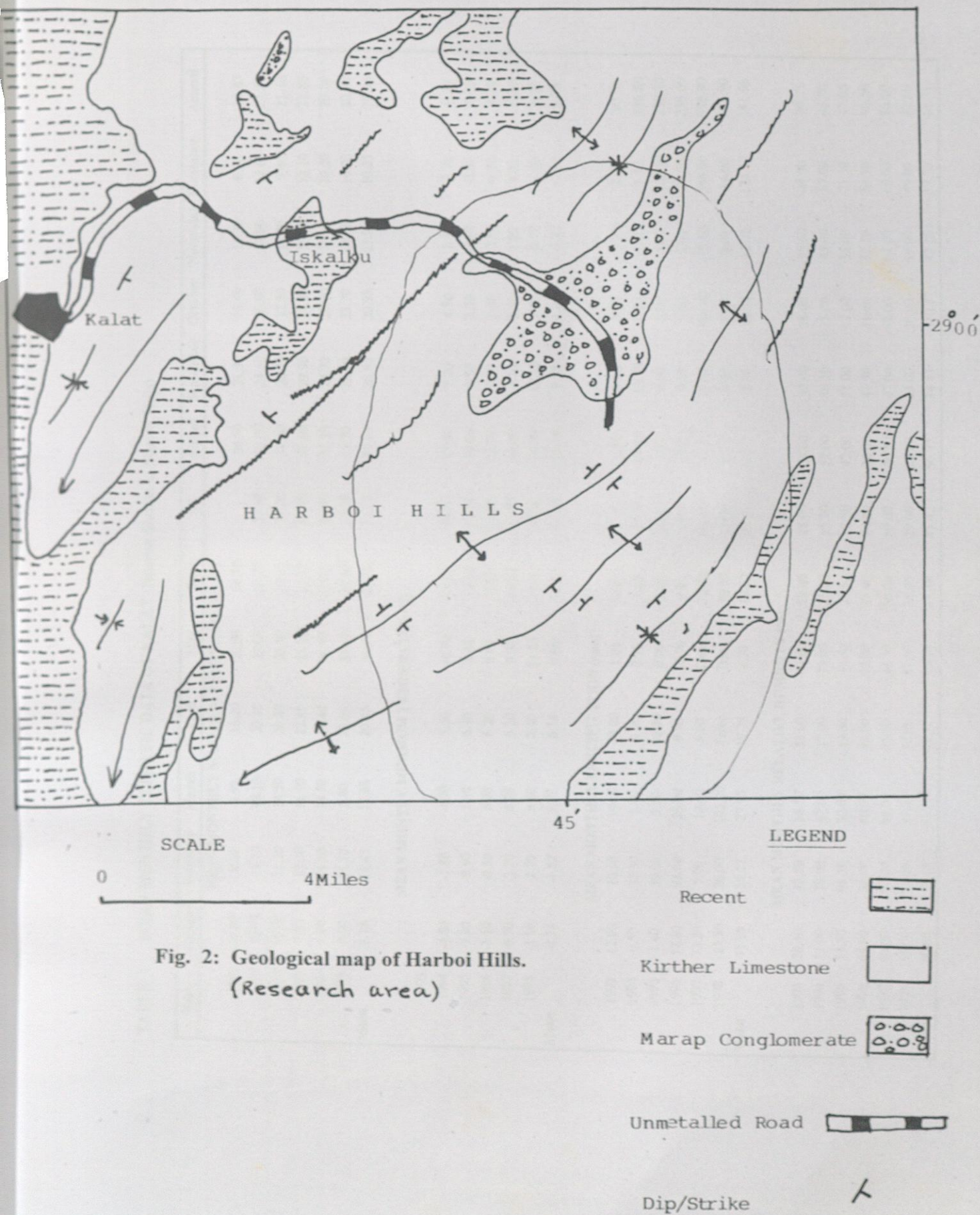


TABLE 1 MEAN MONTHLY CLIMATIC DATA OF KALAT (Nearest Station to Harobi Hills)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
MEAN MONTHLY MAXIMUM TEMPERATURE (°C)													
1993	4.20	8.10	8.90	16.20	22.90	26.30		24.50	21.30	13.40	11.30	6.00	14.83
1994	10.70	11.10	18.10	20.30	27.60	32.20	30.80	30.50	24.50	20.90	18.90	12.60	21.50
1995	10.70	11.30	13.50	20.80	25.50	29.70	31.20	32.00	28.20	22.50	17.90	9.40	21.10
1996	7.80	12.30	16.10	22.40	25.00	31.10	31.90	31.60	29.90	24.40	16.20	13.10	21.80
1997	9.80	14.70	14.50	19.40	24.40	29.80	32.40	31.10	28.70	20.70	13.60	10.20	20.80
1998	9.50	11.10	5.00	23.60	28.00	29.30	32.30	31.70	28.30	23.70	17.80	10.20	20.90
Mean	8.78	11.43	12.68	20.45	25.57	29.73	31.72	30.23	26.82	20.93	15.95	10.25	20.16
MEAN MONTHLY MINIMUM TEMPERATURE (°C)													
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-4.80	-1.80	4.50	5.50	10.70	13.60	18.20	17.50	7.20	4.50	2.90	-2.70	6.30
1995	-3.80	-0.90	1.30	6.40	8.80	13.30	17.00	16.00	8.90	5.30	-1.00	-0.80	5.90
1996	-3.10	-0.50	5.00	6.20	8.60	13.00	14.40	12.70	9.10	1.40	-3.80	-6.10	4.70
1997	-6.50	-3.20	4.30	6.20	9.00	14.30	17.30	14.80	9.10	5.50	1.00	3.00	5.70
1998	-3.50	-1.20	3.80	8.40	11.20	12.40	17.50	14.90	12.10	3.30	-0.70	-3.00	6.30
Mean	-4.34	-1.52	3.78	6.54	9.66	13.32	16.88	15.18	9.28	4.00	-0.32	-1.92	5.78
MEAN MONTHLY PRECIPITATION (mm)													
1993	12.00	10.00	19.00	48.00	1.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	90.50
1994	0.50	32.30	1.60	4.70	7.10	0.00	58.30	24.90	13.70	0.00	1.40	1.30	145.80
1995	1.40	39.00	3.50	30.30	0.00	0.00	26.80	3.70	0.00	0.00	3.00	122.50	230.20
1996	57.80	93.00	26.00	9.90	10.70	9.20	0.00	0.00	0.60	5.20	0.00	24.20	236.60
1997	72.20	5.00	12.60	6.00	Trace	72.00	74.60	11.50	0.00	104.90	72.10	546.00	976.90
1998	125.80	26.00	105.00	Trace	Trace	30.50	30.00	0.00	0.00	0.00	0.00	54.60	371.90
Mean	44.95	34.22	27.95	19.78	4.70	18.62	31.62	6.77	2.38	18.35	12.75	124.77	341.98
MEAN MONTHLY RELATIVE HUMIDITY (%)													
1993	70.50	48.50	58.50	45.00	33.00	28.00	28.00	28.00	30.00	28.00	35.00	44.00	39.75
1994	51.00	58.00	47.00	37.00	29.00	25.00	55.00	52.00	36.50	35.00	45.00	57.00	43.96
1995	53.50	68.50	52.00	49.00	37.50	29.50	52.50	42.00	31.00	42.00	35.00	71.50	47.05
1996	64.00	56.00	60.50	43.00	42.00	37.40	34.00	32.00	41.50	41.00	52.50	54.50	46.50
1997	66.00	57.00	66.00	55.00	44.50	50.00	50.00	46.50	47.00	57.00	67.00	69.00	56.00
1998	55.00	55.00	37.00	32.00	27.00	25.00	29.00	20.00	23.00	20.00	19.00	49.00	32.60
Mean	60.00	57.17	53.50	43.50	35.50	32.48	41.42	36.75	34.83	37.17	42.25	57.50	44.31

MEAN MONTHLY TOTAL CLOUDS (OKTAS)													
1993	3.60	2.60	2.70	3.00	1.30	0.40	4.00	0.50	0.80	0.20	0.80	1.40	1.80
1994	2.40	2.40	3.30	1.70	4.70	1.20	3.40	2.40	1.20	0.60	1.50	2.20	2.25
1995	2.70	3.10	2.90	1.60	0.75	2.00	2.40	0.80	0.50	0.40	2.90	2.10	1.85
1996	3.05	3.05	4.30	1.45	1.45	1.10	1.45	1.20	0.60	0.30	0.90	0.80	1.60
1997	1.90	0.75	3.75	1.55	0.60	2.20	2.25	1.60	0.30	2.20	2.80	2.65	1.90
1998	3.30	2.10	2.70	2.20	1.70	0.90	2.20	1.10	0.90	0.00	0.00	2.80	1.80
Mean	2.83	2.33	3.28	1.92	1.75	1.30	2.62	1.27	0.72	0.62	1.48	1.99	1.87

MEAN MONTHLY DEW POINT TEMPERATURE (C)													
1993	-2.00	-4.30	-0.50	2.80	4.30	4.80	4.8	3.00	1.40	-5.90	-5.10	-8.00	
1994	-8.50	-4.40	0.30	-0.90	2.10	4.10	13.6	12.70	0.10	-2.10	-1.10	-4.40	
1995	-6.00	-4.00	-2.20	-1.55	2.30	2.60	11.85	9.20	-0.95	-0.95	-7.55	-1.75	0.60
1996	-4.60	-3.45	2.30	2.35	2.40	5.35	5.85	4.45	3.65	1.75	-6.85	-8.05	0.40
1997	-6.30	-5.65	2.20	2.85	3.50	9.65	12.35	9.90	3.75	2.25	-0.70	-1.40	3.60
Mean	-5.48	-4.36	0.42	1.11	2.92	5.30	9.69	7.85	1.59	-0.99	-4.26	-4.72	1.53

MEAN MONTHLY DEW POINT TEMPERATURE AT 0000 UTC (C)													
1995	-6	-4	-2.2	1.5	1.8	1.7	10.8	8.9	-1.5	-1	-7	-1.9	0.1
1996	-4.7	-3.4	2.1	3.2	2	4.8	5.2	3.2	3.2	-0.5	-6.2	-8.4	0
1997	-7	-6.4	1.8	2.1	3	9	11.9	9.1	3.3	1.4	-0.9	-3.9	1.9
Mean	-5.9	-4.6	0.6	2.3	2.3	5.2	9.3	7.1	1.7	0.0	-4.7	-4.7	0.7

MEAN MONTHLY DEW POINT TEMPERATURE AT 0300 UTC (C)													
1995	-6	-4.3	-2.2	1.6	2.8	3.5	12.9	9.5	-0.4	-0.9	-8.1	-1.6	0.6
1996	-4.5	-3.5	2.5	1.5	2.8	5.9	6.5	5.7	4.1	4	-7.5	-7.7	0.8
1997	-5.6	-4.9	2.6	3.6	3.9	10.3	12.9	10.7	4.2	3.1	0.5	2.5	3.6
Mean	-5.4	-4.2	1.0	2.2	3.2	6.6	10.8	8.6	2.6	2.1	-5.0	-2.3	1.7

MEAN MONTHLY PRESSURE (MPA/GPM)													
1993	1539.30	1544.90	1525.80	1520.00	1493.10	1459.20	1460.30	1462.60	1491.40	1532.60	1560.60	1561.40	1512.60
1994	1544.20	1518.60	1535.30	1513.30	1505.40	1438.40	1426.30	1447.50	1510.00	1554.80	1568.70	1559.30	1510.15
Mean	1541.75	1531.75	1530.55	1516.65	1499.25	1448.80	1443.30	1455.05	1500.70	1543.70	1564.65	1560.35	1511.38

MEAN MONTHLY WIND SPEED AT 0000 UTC (knots)													
1994	1	0.5	0.9	0.9	0.3	0.2	0.5	0.8	0.7	1.9	1.7	0.8	0.9
1995	0.8	3.7	1	1	0.1	0.3	0.7	1	2	0.9	1.1	1.2	1.1
1996	1	1.8	1.2	0.9	0.7	0.8	0.4	0.3	0.6	0.1	0.5		
1997	1.2	2.6	1.3	1.3	0.1	0.5	1.2	1	0.2	0.6	0.1	0.8	0.9
Mean	1.0	2.2	1.1	1.0	0.3	0.5	0.7	0.8	0.9	0.9	0.9	0.9	1.0

MEAN MONTHLY WIND SPEED AT 1200 UTC (knots)													
1994	3.8	3.1	4.6	3.9	3.8	4.1	3.9	3.4	4.1	3.4	3.5	2.8	3.7
1995	3.7	3.7	4.2	4.3	4.3	4.1	3.4	3.3	4.3	3	2.9	3.8	3.8
1996	2.7	4.6	4.7	5.2	4.2	4.3	4.4	3.5	4.2	4.7	3.2		
1997	5	5.5	2.9	5.4	4.9	4.6	4.5	5	4.2	6.3	4	5.5	4.8
1998	6.3	5.3	5.9	5.2	4.8	3.5	6.5	4.2	4.2	5.5	4.6	4.7	5.1
Mean	4.3	4.44	4.46	4.8	4.4	4.12	4.54	3.88	4.2	4.58	3.64	4.2	4.4
MEAN MONTHLY WIND SPEED AT 0300 UTC (knots)													
1994	1.3	0.7	1.2	1.2	0.8	0.4	1.2	1.3	0.5	1.2	1.1	0.8	1
1995	0.9	1.3	1.3	1.3	0.3	0.8	0.6	1.1	1.3	1.1	0.7	1	1
1996	1	1.5	1.3	0.7	1.6	0.6	0.5	0.3	0.7	0.4	0.6		
1997	1.1	1.2	1.3	1.1	0.9	0.6	0.8	0.9	0.8	0.9	0.8	0.9	1.0
1998	3.2	1.0	1.0	1.1	1.2	0.2	0.1	0.3	0.9	0.2	3.3	1.5	1.2
Mean	1.5	1.1	1.2	1.1	1.0	0.5	0.6	0.8	0.8	0.8	1.3	1.1	1.1
MEAN MONTHLY WIND DIRECTION AT 0000 UTC													
1994	S11W	S31W	S87W	S03E	N67W	S13W	S45E	S	S37W	S	S03E	S27W	
1995	S06W	S30W	S	S34W	S	S	S	S09W	S05W	S03W	S	S18W	
1996	S34W	S17W	S45W	S05W	N08W	S	S	S	N	N	S72W	N45W	
1997	N11W	S48W	S51W	N07W	N45W	S45W	S56W	N72W	N45W	W	S19W	S63W	
MEAN MONTHLY WIND DIRECTION AT 1200 UTC													
1995	N43W	N50W	N54W	N60W	N28W	N21W	N80W	N44W	N30W	N23W	N24W	N73W	
1996	N45W	N63W	S81W	N57W	N28W	N40W	N42W	S51E	N07W	N02W	N37W	N49W	
1997	N77W	N65W	S65W	N36W	N49W	N60W	N56W	N41W	N36W	N60W	N80W	N40W	
1998	S11W	S90W	S90W	S25W	S40W	N07W	S09W	N53W	N04W	N11W	N40W	N40W	
MEAN MONTHLY WIND DIRECTION AT 0300 UTC													
1994	S17W	S36W	S34W	S11W	S56W	S14W	S37W	S	S45W	S09W	S02E	S23W	
1995	S06W	N63W	S04W	S25W	S45W	S39W	S14W	S26W	S08W	S04W	S04W	S27W	
1998	S	S56W	S34W	S18W	S27W	N	S	CALM	N	N	S	N56W	

Source: Data Processing Centre, Pakistan Meteorological Department,
University Road, Karachi - 75270

LITERATURE REVIEW

Literature Review

Floristics

William Griffith was the first to collect plants from Balochistan in 1839. Later on Stocks collected the plants during 1848 to 1850. Duke and Hamilton did a great deal of collection in 1877 to 1880. Duthie collected plants in 1888 for Harsukh. Burkill (1956) listed some 1000 flowering plants falling into 81 dicot families, 210 plants of monocot families and 7 species of 2 gymnosperm families from Balochistan. Stewart (1959) described 11 common families in the flora of Balochistan which included Asteraceae (138 species), Papilionaceae (136 species), Poaceae (128 species), Lamiaceae (56 species), Caryophyllaceae (56 species), Liliaceae (33 species), Apiaceae (33 species), Rosaceae (31 species), Boraginaceae and Chenopodiaceae.

Khan (1960) described the habitat, ecology and fodder value of 38 grasses and 12 shrubs from Quetta - Kalat region. Jafri (1962) listed 200 species from Bolan pass which belonged to 51 families. The common families included Poaceae (23 species), Papilionaceae (16 species), Asteraceae (14 species), Boraginaceae (12 species) and Apiaceae (10 species). Zaman and Khan (1972) listed some medicinal and flowering plants of Maslakh. No other reference on the flora of this area is available.

Phytosociology

Work on the phytosociology of various parts of Balochistan has been done, which is summarized below:

Khan and Hussain (1963) reported that plant cover increased up to 28% due to protection in Hazargangi forest. The increase of vegetation at the top of mountains was

33 - 37%, while at NW slopes 14 - 48%, at SE slopes 26 - 63%, on western side the increase was 22 - 52%.

Khan (1980) reported *Caragana* - *Thymus*, *Ephedra* - *Juniperus*, *Perovskia* - *Juniperus* and *Sophora* - *Hertia* communities in Khalifat (Ziarat) area. He also observed that Juniper seedlings were found in rock crevices due to protection against trampling by grazing animal. There were 3 - 4 Juniper seedlings in each community. In over-grazed areas palatable species were replaced by *Hertia* and *Sophora*.

Marwat and Haq (1982) reported *Hertia* - *Artemisia* - *Bromus*, *Haloxylon* - *Artemisia* - *Hertia*, *Erianthus* - *Artemisia* - *Centaurea*, *Boissiera* - *Peganum* - *Artemisia*, *Bromus* - *Sophora* - *Nepeta*, *Polygonum* - *Veronica* - *Euclidium* communities from Hanna - Urak, Quetta and suggested that over grazing is major ecological problem. Hussain (1983) gave an account of hydrosere in Quetta - Pishin valley.

Kayani *et al.* (1984) reported six plant communities i.e. *Peganum* - *Hordeum* - *Poa*, *Salsola* - *Alhaji*, *Kochia* - *Salsola*, *Peganum* - *Hordeum*, *Gaillonia* - *Suaeda* in wastelands of Quetta - Pishin District.

Tareen *et al.* (1987) described *Perovskia*, *Juniperus*, *Daphne*, *Ampheopsis*, *Spiraea*, *Tanacetum*, *Sophora*, *Salvia*, *Chrysopogon*, *Artemisia* and *Astragalus* communities around Chiltan in Quetta District. Ahmed *et al.* (1987) using multivariate analysis recognized *Artemisia*, *Chrysopogon*, *Salvia*, *Sophora* and *Juniperus* as the major groups of vegetation in Chiltan area.

Tareen *et al.* (1987) established nine plant communities in Spin Karez area. They were *Perovskia* - *Hertia* - *Artemisia*, *Artemisia* - *Sophora*, *Haloxylon*, *Artemisia* -

Astragalus - Prunus, Hertia - Artemisia - Saccharum, Chrysopogon - Artemisia - Gaillonia, Astragalus, Trigonella, Spirea - Tanacetum - Artemisia.

Tareen *et al.* (1987) established *Artemisia, Juniperus - Artemisia, Hertia - Artemisia, Sophora - Artemisia, Astragalus, Artemisia - Salvia, Artemisia - Prunus* communities in Zarghun area.

Tareen and Qadir (1987) grouped 16 plant communities into 4 Steppe types in Quetta District. They included *Artemisia maritima* steppe, *Haloxylon griffithii* steppe, *Alhagi maurorum* steppe and *Salsola baryosma* steppe. They reported that cover percentage of grasses were increased 32 - 61% in the protected areas.

Kayani *et al.* (1988) reported *Crotolaria - Capparis, Cyperus - Tamarix, Panicum, Prosopis - Capparis, Prosopis - Cynodon, Suaeda - Capparis, Tamarix - Desmostachya, Prosopis - Corchorus - Aerva, Rhazya - Haloxylon - Aerva* communities in Nasirabad and Sibi Districts.

Qadir and Ahmed (1989) recognized *Pistacia - Cymbopogon - Chrysopogon* and *Pistacia - Fraxinus - Cymbopogon* communities in Hazargangi National Park, Quetta. The total vegetation cover was about 32.42%, of them trees contributed 23.68%, shrubs contributed 0.5%, while herbs contributed 8.24%. The species diversity ranged 0.74 - 1.54 and maturity index was 21.42 - 47.96.

Ahmed *et al.* (1989) worked on the natural regeneration of Juniper in Ziarat, Chautair and Baba Khurwari area. They reported that the density of Juniper seedlings was low ($42 \pm 22/\text{ha}$) in Chautair, ($49 \pm 53/\text{ha}$) in Baba Khurwari, ($58 \pm 43/\text{ha}$) was in Ziarat and ($59 \pm 66/\text{ha}$) density was in Kuch area.

Marwat *et al.* (1989) recognized five plant communities in Masalakh range forest i.e. *Poa - Stocksia - Boissera*, *Boissera - Stocksia*, *Artemisia - Poa*, *Boissera - Poa - Artemisia* and *Artemisia - Boissera* communities. They suggested that dry temperate climate and aridity might be suitable for the growth of *Poa sinaica*.

Marwat *et al.* (1990) reported 63 species and recognized 5 plant communities in Zangilora area. They were *Elymus*, *Alhagi - Desmostachya*, *Aeluropus - Artemisia*, *Alhagi - Elymus* and *Malcolmia - Desmostachya* communities. They observed that vegetation improved due to protection.

Tareen and Qadir (1990) grouped 23 plant communities in 7 steppe types in Quetta District. They are *Peganum*, *Saccharum*, *Perovskia*, *Sophora*, *Hertia* and *Artemisia* steppe and wet steppe consisted of 3 communities. Species diversity was 0.79 - 2.23. The vegetation coverage was low as it ranged 10.71 - 49.28%. The highest cover percentage was in *Saccharum - Sophora* communities.

Ahmed *et al.* (1990 a) quantitatively analyzed *Juniperus macropoda* forests in four districts of Balochistan and reported 11 associated species. *Artemisia*, *Ephedra*, *Pennisetum*, *Cousinia*, *Acantholimon*, *Prunus*, *Nepeta*, *Caragana* and *Allium* were widely distributed while *Perovskia* and *Thymus* were restricted to 3 to 5 stands. The density of Juniper was 105 trees/ ha while basal area was 18.4 m²/ha. The density of female trees was higher than male trees. The growth rate of trees was 18 years/cm radial growth.

Ahmed *et al.* (1990 b) reported that the density of *Juniperus* tree was 5.6 - 332/ha in Ziarat area while seedlings were 5.1/ha. The tallest tree reported from Chautair was 26.28m high. The height of medium sized trees was 14.1 - 20m. They observed that Chautair and Ziarat forests had 25% old trees and low seedlings while Baba Khurwari and

Kuch area had higher percentage of healthy trees. Female trees were 74/ha and male trees and 6.7/ha while bisexual trees were 2.3% of total samples.

Ahmed *et al.* (1991a) reported that the density of *Pinus gerardiana* trees ranged from 24 to 930 trees/ha with average basal area 25.5m²/ha in Suleman range Balochistan. The seedlings density was high on east facing slopes while tree density was higher on west facing slopes. The average estimated growth rate was 0.08 cm/year radial growth. The trees on high elevation and cooler slopes grew faster. *Pinus gerardiana* was found in 42 stands followed by *Fraxinus xanthxyloides* in 25 stands in Suleman range of Balochistan. They reported that at 2880m to 3000m elevation *Pinus gerardiana* was associated with *Pinus wallichiana* in 3 stands. Above 3000m *Pinus gerardiana* was completely replaced by *Pinus wallichiana*. The associates were *Pistacia khinjuk*, *Pistacia munitia*, *Olea ferruginea*, *Prunus amagdalidis*, *Prunus eburnea*, *Populus euphratica*, *Ephedra*, *Astragalus*, *Berberis*, *Cotoneaster*, *Placanthus* and *Agropyron*, *Melica*, *Stipa* was prominent grasses.

Tareen and Qadir (1991) recognized 57 plant communities in the hills of Quetta district. Forty five communities were grouped into 8 steppe types. They were *Artemisia*, *Nepeta*, *Salvia*, *Cymbopogon*, *Chrysopogon*, *Sophora*, *Astragalus* and *Prunus*. Species diversity was 0.16 - 2.33. The cover percentage varied from 18.3 - 50.1% in Walitangi, 43.74% in Hazargangi, 42.12% in Spin Karez, 34.53% in Hanna Lake, 32.65% in Zarghun, 32.27% in Kach dam, 28.62% in Brewery, 26.57% in Kohi Murdar and lowest in Ghazaband area.

Marwat *et al.* (1992) recognized four plant communities in Chiltan National Park Quetta. They are *Artemisia - herba alba*, *Artemisia - Poa - Taenianthram*, *Bromus -*

Prunus and *Artemisia - Sophora*. They reported that vegetation of Hazargangi was remnant of original *Juniperus macropoda* forest in the past.

Sardar (1992) reported that enclosure had positive effects on range vegetation of Chiltan National Park, Hazargangi. The recovery was remarkably rapid, highly palatable species were reappearing. Trees and shrubs covered 30.2% while grasses had 13.6%.

Khan (1992) recognized three plant communities in Hazargangi, Chiltan and Takatu hills *Juniperus - Ephedra - Daphne* and *Sophora - Artemisia* were in Hazargangi and Chiltan area while *Artemisia - Cymbopogon - Ephedra* community in Takatu mountain *Pistacia* and *Fraxinus* were dominating in water courses of Hazargangi.

Durrani *et al.* (1996) established seven plant communities in Iskulku rangeland (Kalat). They are *Artemisia - Gailonia - Hertia*, *Artemisia - Sophora - Perovskia*, *Hertia - Convolvulus - Sophora*, *Artemisia - Perovskia - Perovskia*, *Hertia - Artemisia - Convolvulus* and *Artemisia - Convolvulus - Sophora*. Species diversity was 1.33 - 2.44.

Life form (Ecological Spectrum)

Life form refers to the form based on the location of the over wintering part. The life form of a species is caused primarily by its genetic constitution and secondarily by the environmental condition. Life form reflects the environmental and biotic influences prevailing at that locality.

No quantitative data is available regarding biological spectrum of the vegetation of present study area. However, some work has been reported by workers regarding the biological spectrum of vegetation in other regions.

Khan (1980) reported life form of vegetation of Khalifat Ziarat. At 2400 - 2700m nanophanerophytes were 31%, therophytes 28% and chamaephytes 21%, below 2400m

hemicryptophytes were 33%, therophytes 29% while nanophanerophytes 21%. In third community chamaephytes and therophytes were 26%, hemicryptophyte 22% and nanophanerophytes 17%. However, at dry exposed southern hotter aspect at medium altitude, chamaephytes were 36%, nanophanerophytes 27%, hemicryptophyte 18% while therophytes were 14%. Geophytes were 4 - 10% at high altitude.

Shaukat *et al.* (1981) reported the sequence of life form invasions and their progression along with the lithosere succession. In early stages hemicryptophytes, in intermediate stage phanerophytes and chamaephytes increased. While in climax stage chamaephytes followed by phanerophytes were important. In early stage leaf size spectra consisted high proportion of leptophylls while proportion of plants with bigger leaves increased as the vegetation proceeds from early to climax stage.

Hussain and Chaghtai (1984) reported that the vegetation of Zangilora comprised 50% each hemicryptophytes and therophytes in over grazed area while 39.9% hemicryptophytes, 55.5% therophytes and 5.55% geophytes in the protected area.

Hussain and Tajul - Malook (1984) worked on the biological spectrum of sub-tropical pine vegetation of Karamar hills (District Mardan). They reported that therophytes were in higher percentage (29.51%) followed by hemicryptophytes (21.31%), nanophanerophytes (19.67%) megaphanerophytes (14.75%) and chamaephytes (13.11%) while geophytes were (1.64%).

Qadir and Tareen (1987) described life form and leaf size spectra of the flora of Quetta District. They reported 42% hemicryptophytes, 36% therophytes, 10% cryptophytes, 7.5% phanerophytes, 3.75% chamaephytes and 7.5% geophytes, while 2.5%

were hydrophytes. Microphylls were 46.3%, nanophylls 31.7%, 9% mesophylls, 11% leptophylls, 0.63% macrophylls and 0.06% mesophylls.

Khan and Ahmed (1991) reported that life form spectra of flora of Makran Coast was composed of chamaephytes (35%), therophytes (28.23%) and phanerophytes (21.03%). The proportions of hemicryptophytes and cryptophytes were low. The leaf size spectrum was predominately occupied by nanophylls (37.77%), microphylls (35.62%), only 4 species belonged to aphyllous class and 16 species to mesophyllous class. On the basis of longevity, the flora was relatively dominated by short lived (31.2%) and short lived perennials (29%) species.

Shah *et al.* (1991) reported that nanophanerophytes, hemicryptophytes and chamaephytes were more than megaphanerophytes and therophytes at Docut hills, District Swat during winter season. Hussain and Ilahi (1991) reported that number of conifers and broad leaved species was less than shrubs and herbaceous components in vegetation of lesser Himalayas.

Tareen and Qadir (1993) reported life form and leaf size spectra of the plant communities of diverse area ranging from Harnai, Sinjawi to Duki regions. They reported that hemicryptophytes, therophytes and chamaephytes were significantly higher and geophytes were significantly lower. Phanerophytes decreased gradually from lower elevation to higher. They reported 37.74% phanerophytes, 12.7% chamaephytes, 31.7% hemicryptophytes, 4.76% geophytes and 19.04% therophytes at 2000 - 2400m and above 2400m, 30% phanerophytes, 13.7% chamaephytes, 30% hemicryptophytes, 1.25% geophytes and 25% therophytes. Leaf size spectra showed 14.28% leptophylls, 31.74% nanophylls, 44.44% microphylls and 9.53% mesophylls at 2000 - 2400m, while above

2400m 10% leptophylls, 31.25% nanophylls, 46.25% microphylls and 12.5% mesophylls.

While macrophylls were absent.

Badshah *et al.* (1996) reported that therophytes (27.84%), nanophanerophytes (20.62%) and hemicryptophytes (19.59%) were most abundant at Pirghar hills, South Waziristan. Leaf size spectra showed microphylls as dominating group (44.33%) followed by nanophylls (23.71%) and leptophylls (22.68%).

Sikarwar (1996) reported that flora of Morena district showed therophytic phytoclimate (45.68%). The phanerophytes (17.6%), nanophanerophytes (6.14%) and chamaephytes (3.48%) indicated the extensive biotic influence on the vegetation. Lianas (7.4%), hemicryptophytes (1.82%), geophytes (1.66%), hydrophytes and halophytes (14.78%), parasites (0.83%), succulents (0.33%) and epiphytes 0.16% were the major types.

Durrani *et al.* (1996) reported that nanophanerophytes were 47%, therophytes 30%, chamaephytes 7% and geophytes were 3% at Iskulku rangeland, Kalat.

Hussain *et al.* (1997a) reported biological spectra of plant communities of Girbanr hill (Swat). Therophytes were dominant life form in four communities while nanophanerophytes were dominant in two of the communities. The leaf size spectra showed the dominance of lepto-nanophyllous type in this area.

Hussain *et al.* (1997b) reported that the vegetation of Dabargai hill up to 2400m is dominated by therophytes, hemicryptophytes and nanophanerophytes and thereafter at higher elevation it shifted to chamaephytic and nanophanerophytic types. The communities in lower elevation were mostly micro-nanophyllous while at high altitude they were

lepto-microphyllous.

Das and Lahiri (1997) reported that therophytes (40%) were most successful life form on Tiger hills, Darjeeling district, West Bengal. Chamaephytes (24.7%) were well represented along with 14.12% cryptophytes, 12.94% hemicryptophytes and 2.23% phanerophytes.

Lokesha and Vasudeva (1997) reported 487 rare/endangered angiosperms of four life form (herbs, shrubs, trees and lianas) from south India. They observed that specific feature such as habit, life form, pollination and dispersal modes might be important in rendering plants to become threatened.

Uppendra *et al.* (1997) analyzed forest vegetation of a protected area in Uttar Pardesh. They reported that floristic representativeness in all growth forms (trees, shrubs, and herbs) increased significantly with altitude and high percentage of non-native species was observed.

Sauris *et al.* (1997) reported 60 species (herbs, shrubs) and 2 aquatic species in semi-arid regions of Sambalpur district Orissa (India).

Lunt (1997) compared growth form/life form composition of grazed grassy forest and ungrazed grassland in Gippland Victoria, using multivariate clustering analysis. He classified 33 forb species into 4 groups: 1- annual and forbs, 2- climbers and decumbent perennials, 3- rosette perennial and rhizomic ground cover forbs more in grassy forest, 4- tall erect geophytes were significantly more in grassland; and grassland contained significantly more tall forbs(>20cm) than forest.

Brooks *et al.* (1997) suggested that life form i.e. trees, shrubs, forbs, mosses, deciduous or evergreen plants can be used to group plants with similar physiological

characteristics. Eckstein and Karlsson (1997) stated that variation in plant nutrient turnover characteristics were related to habitat, life form and species. Dwarakan and Alagesaboopathi (1998) studied biological spectrum of vegetation of Kolli hills, Eastern Ghats Salem district in Tamil Nadu. They reported 1038 plant species of different life forms.

Knapp and Carter (1998) reported different growth forms annual/perennial/aquatic herbs, trees and grasses from open, intermediate and shady understory habitat in Mississippi and Kansas, USA. The dominant species were *Acer rubrum*, *Arundinaria gigantea*, *Diospyros virginian*, *Eichhornia crassipes*, *Ilex opaca*, *Pinus palustris* and *Magnolia grandiflora*.

Hussain and Badshah (1998) reported that the vegetation of Pirghar hills was dominated by therophytes and hemicryptophytes. The dominance of micro-nanophyllous species indicates the relatively dry condition in the area. Dastagir *et al.* (1999) reported that the vegetation of Mai Dhani hills was dominated by nanophanerophytes and hemicryptophytes. Nanophanerophytes and megaphanerophytes decreased as the altitude increased. Khan *et al.* (1999) reported that the life form spectra of grass dominated communities consisted of therophytes (43.3%) and chamaephytes (30%). While leaf size spectrum was dominated by nanophylls and microphylls. Hongling and Hungta (1999) reported that phanerophytes were dominant life form in *Erythropheum fordii* community in Dinghaushan. Leaf form was dominated by mesophylls.

Palatability and Animal Preference

Palatability is defined as a plant characteristic or condition that stimulate particular species or plant part as consumed by an animal (Range Term Glossary Committee, 1974).

While preference refers to selection of a plant species by the animal and is largely a behavioral response (Heady, 1964). Tribe (1952) described several factors influencing palatability. They are: i). Animal factor, ii). Grazing preference of different kind or species or animal, iii). Age, degree of maturity, stage of pregnancy, general physical condition of animal, iv). Hunger of animal, v). season and growth stage of plant, vi). Palatability and relative abundance of associated species, vii). Differences in location, sites and climate, viii). Physical characteristics of plants.

Wilson *et al.* (1975) regarded sheep as grass eater and the proportion of trees and shrub species consumed was quite small. While feral goat consumed 50% browse but it was 70 to 90% when goats grazed the area following sheep. Huston (1978) stated that goats are energetic, inquisitive and versatile in the art of food gathering.

Ahmed *et al.* (1981) stated that goat diet consisted of 70 to 80% shrubs and 20% grasses and forbs. Lope and Stuth (1984) observed significant seasonal shifts in the selection of grasses and browse by Spanish goats. They reported that degree of dietary overlap between sheep and goats is probably greatest in dry season because of limited forage availability.

Black and Kenney (1984a) reported that sheep preference for dried feed was less because of taste, odour or feel. Black and Kenney (1984b) stated that the rate of pasture intake were related to sward height only. Sheep preferred the one they could eat faster (i.e. 6 g mg dm/min) as the pasture height increased, the bite increased 12 fold from 14 to 173 mg. Sheep ignore bare ground and select dense plant material. Sheep can take 10 cm² in each bite. Kenney *et al.* (1984) reported that sheep prefer fresh *Pennisetum clandestinum* in its vegetative stage than dried. Intake rate decreased from 60 to

14 gm/min as dry matter contents increased. The 10 mm length pieces were eaten faster than 40 mm. Pfister and Malechek (1986) found that fruits and flowers were seasonally important in animal diets. Migongo - Bake and Hansen (1987) reported that in East Africa sheep diets usually consist of more than 50% grasses during all seasons. The shrub component of their diet tends to increase during dry seasons due to decrease in grass availability.

Wahid (1990) observed that *Convolvulus* was highly palatable browse species equally liked by both kind of livestock in Zarchi, Kalat. Sheep diet was composed of 53 to 80% shrubs, while goats preferred 56 to 81% shrubs. Goats disgust *Cymbopogon* in all seasons, and did not like *Chrysopogon* in spring. *Ebenus* was important for goats at blooming stage than *Caragana* and *Perovskia*. Sheep did not graze on rolling hills.

Vallentine (1990) reported that Spanish goats consumed 25% grasses, 5% forbs, and 70% browse, while Angora goats consumed 53% grasses, 6% forbs and 41% browse, during different seasons. In winter, Spanish goats consumed 28% browse in their diet, while Angora goats consumed 19%. Sheep selected 2 to 3 browse, 3 to 62% forbs, 36 to 70% grasses. Kababia *et al.* (1992) reported that goat grazed 6 hours daily on natural mediterranean rangeland of Judean Mountains. Goats consumed 87, 79 and 86% dry matter of bushes in winter, spring and summer respectively and corresponding value for grasses were 13, 21 and 14%.

Grunzoaltd *et al.* (1994) reported that goats preferred dicotyledonous herbs and shrubs in most periods. They concluded that goats were not primarily browsers and showed the ability to maintain the quality of their diet even though range conditions declined.

Nyamangara and Ndlovu (1995) observed that feed selection of animals varied with season. From January to March (wet season), 55 to 70% grasses were consumed while May to early November (dry period) browse, herbs and fruit formed 77 to 91% of diet. Hussain and Mustafa (1995) reported 119 palatable species in Nasirabad Valley (Hunza). Of them, 58.37% were used by goats and sheep. Classification on the basis of parts used indicated that in 12.09% species foliage, in 83.07% species shoots, while in 4.4% species floral parts were consumed.

Hunt (1996) studied that grazing of sheep together with poor seasonal condition results in expansion of the area surrounding water points in Southern Australia. He reported that about 20% standing foliage biomass removed/day. He suggested that there are need to minimize the death of mature plants by preventing heavy grazing during dry period.

Khan (1996) recorded the preferential food by different livestock in Thar desert, India. He reported that goats selected about 60% shrubs, 30% grasses and 10% forbs, whereas sheep preferred about 20% shrubs, 30% forbs and 50% grasses. He reported that animals never gone in far grown up trees. Goats in extreme condition go even for unpalatable bushes and forbs.

Gyamtsho *et al.* (1996) reported that alpine rangelands of Bhutan were overgrazed by both domestic livestock and wild ungulates. They reported that *Rhododendron*, *Juniperus* and *Berberis* were non palatable shrubs. They also stated that there was a considerable potential for improving the productivity of pasture through the introduction of white clover (yield 300 Kg/ha to 6000 Kg/ha). In improved rangeland, forbs covered 70%, *Agrostris*, *Elymus* and *Poa* had 10% cover, while *Carex* and *Juncus* had 5 to 10%

ground cover, bare ground and litter covered 2 to 10%. Holechek *et al.* (1998) reported that Angora goats prefer 48% grasses, 12% forbs, and 40% shrubs, while sheep prefer 69% grasses, 33% forb and 8% shrubs.

Rangeland Productivity

Mirzadinov and Yakovleva (1990) estimated dry matter yield of *Festuca ovina*, *Stipa pennata*, *Stipa sareptaroa*, *Artemisia austriaca* and *Trifolium lupinaster* communities in Chingiz Tarbagatai region (Kazakh) over a five years period. Dry matter ranged from 0.16 t/ha to 0.45t/ha.

Prince (1991) estimated the primary production in semi-arid grassland in Senegal, Mali and Niger. It ranged from 61 to 161 Kg/ha. He reported that there was a strong linear relationship between the normalized difference vegetation indices and seasonal primary production. Omar (1991) estimated herbage production of protected area in semi arid rangeland of Kuwait. The mean herbage production was 174 Kg/ha. Annual forbs were most common. During the drought year *Rhanterium epapposum* dominated. *Shismus bargatus* and *Cutandia memphitica* were annual grasses and *Plantago boissieri* was dominant annual forb.

Vaitkus and Eddleman (1991) studied the relation between the size/age of trees and biomass production of associated vegetation beneath and immediately adjacent to the canopy on upper and lower slopes of *Juniperus occidentalis* woodland in Central Oregon. They observed that most grasses and forbs had increased biomass production with increases tree size and also produced more biomass beneath the canopy than in the space between canopies.

Deshmukh (1992) estimated wood biomass in Jabba Valley, Southern Somalia and reported that bushland carried 1 to 30 Kg/ha and woodlands 2 to 75 Kg/ha dry weight of wood. Flood plains were dominated by *Acacia - Thespesia* and *Terminalia*. Outside the flood plains *Acacia/Commiphora* while bushlands were dominated by *Acacia Spp*.

Mwalyosi (1992) investigated primary productivity in grazed and ungrazed areas in semi arid region of Tanzania. He reported that *Cynodon plectostachys* and *Cenchrus ciliaris* were abundant in ungrazed plots whereas *Pennisetum mezianum*, *Perotis patens*, *Eragrostris superba*, *Sporobolus cordofanus* and *Panicum massaiense* common on both the plots. The standing herbage biomass and canopy height were positively correlated with rainfall.

Redak *et al.* (1992) reported that 50 to 75% removal of *Artemisia tridentata* resulted in 20% increase in summer understory biomass production but understory plant cover was not effected by the removal. Zhao (1992) reported that grazing restricted the development of shrubs and perennial grasses and favored the growth of annuals in rangeland of inner Mongolia, China.

Milchunas *et al.* (1992) studied the effects of large herbivores on growth and production of semi arid grasslands in North Central Colorado and reported that above ground production was much greater on long term protected sites.

Shanmughavel and Ramarathianm (1993) reported that the above ground biomass was 558 g/m² in September and 191 g/m² in January at Perungudi Village, Madurai District of Tamil Nadu, India. They reported that litter biomass varied from 20 to 45 g/m².

Momotove *et al.* (1993) estimated that average biomass yield of natural rangeland vegetation was 0.38 t/ha and 22% of this yield consisted of ephemeral plants. Grunzaldt

et al. (1994) reported that plant cover was reduced from 62.3% to 23.8% after four years of goat grazing. Thomas *et al.* (1994) reported that the net annual primary productivity in Xinjiang Province (China) ranged from 750 to 836 Kg/ha at foot hills, 380 to 400 Kg/ha at top and middle alluvial fans, 650 to 1200 Kg/ha on bottom of alluvial fans, 750 to 965 Kg/ha in saline alluvial plains and 250 Kg/ha in sand dunes.

Bodla *et al.* (1994) reported that in arid and semi arid environment herbage and biomass production inside the protected areas was about double compared to that in the grazed area. Snyman (1994) reported that *Chloris gayana* produced more above ground biomass than *Digitaria*, *Eragrostris*, *Panicum*, *Cenchrus* and *Antherphora* in both wet and drier conditions. Theunissen (1995) reported that no correlation was detected between production ability of grass species and long term average rainfall at semi arid grassland of Southern Africa. He suggested that the effect of both genetic and environmental factors on the production ability of a species determined the eventual biomass production of a species.

Perez *et al.* (1995) studied the production and nutritional quality in semi arid grassland in Central Western Spain. They reported that the above ground biomass ranged in between 126 and 304 g/m² on upper and lower slopes. Vegetation on the lower slopes was dominated by grasses and on the upper slopes by forbs.

Khan (1996) reported that biodiversity of Thar desert (India) was depleting faster. The major factor was livestock and human population beyond the carrying capacity. He reported that 6.4% plants are endemic. Yessef *et al.* (1996) monitored forage production within different types located along an altitudinal gradient ranging from 960 to 2070 m at Morocco. Phytomass, plant cover and forage values were measured from April to June

within protected and unprotected areas. They observed that herbaceous species were absent above 1400 m altitude. Phytomass was highest from 630 to 1272 Kg/ha in May and 423 to 539 Kg/ha in June. Degree of utilization was 50 to 70% for all sites. They reported that forage quality decreased with the development of plant species and their maturation from February to June.

Wolters *et al.* (1996) reported that plant biomass was significantly greater (1514 Kg/ha) on the desert grasslands than on either desert scrub (60 Kg/ha) or transition zone (943 Kg/ha). Black grama grass was dominant species occupying over 40% of the soil surface on haplocalcid soils. *Larrea tridentata* - *Bouteloua eriopoda* - *Gutierrezia sarothrae* community had 17% total cover in desert scrubs (Petronodic haplocaieics soil).

Lichacar *et al.* (1996) observed that the presence of shrubs did not mean degradation in Mediterranean type rangelands. Shrubs may provide green fodder, once annuals dry out, and shelter for livestock and wildlife. They suggested that shrub plantations were suitable for land rehabilitation, desertification control and fuel production. Thapa (1996) emphasized rotational grazing which helps decomposing the organic matter, promotes vegetative growth and eradicates parasites. He observed that in most parts of Nepal, the animals move toward the alpine rangeland in monsoon season and to the lower altitude rangelands during winter.

Liu *et al.* (1996) investigated grassland deterioration in arid and semi arid regions of China. They reported that palatable above ground biomass decreased from 40 to 60% and disappearance of good plant species and invasion of unpalatable plants. They suggested that: 1. Seasonal grazing system should be adopted, 2. Rapid increase of animal

population should be controlled to enhance the quality of animal product, 3. Artificial grassland established, fencing and reseeding should be adopted.

Hickman *et al.* (1996) studied the effects of grazing system and stocking rates on plant species diversity in Kansas. They reported that temporal stability in botanical composition and diversity was generally high but was reduced at high stocking rates. They suggested that stocking rates and grazing system influenced the composition and biodiversity of tall grass prairies. Species richness increased from 23 to 28/transect at highest stocking rates. Plant diversity was greater in ungrazed and moderately grazed areas (1.8 ha/Animal unit).

Kitchen and Hall (1996) observed that only shrubs of enclosed area had improved the frequency and abundance in 59 years controlled sheep grazing on Great Basin Salt Desert community, USA, while perennial grasses, perennial forbs and annual grasses had no significant differences.

Lubbinge *et al.* (1996) evaluated the ecological status of semi arid Kalahari plant species and range condition in South Africa. They reported that scattered shrubs and trees covered 95% of total area. The plant species reacted differentially to degradation in different plant communities. Batanouny (1996) reported that rangelands in Arab region were rapidly deteriorating. Change in floristic composition resulted changes in biodiversity. *Panicum turgidum* was palatable by sheep and camels and was a soil binder. It was replaced by *Haloxylon salicornicum* (less palatable). *Artemisia herba-alba* is favored by sheep, goats and camels. *Artemisia* community is replaced by *Salsola Spp.*

Li *et al.* (1996) investigated the effects of grazing on the biodiversity in arid and semi arid rangelands of China. They reported that grazing was a key factor influencing

biodiversity. Some 135 species were declared as rare species. They suggested that the highest biodiversity was from moderate grazing pressure. Makulbelova (1996) ecologically evaluated the present condition of rangeland vegetation of Kazakhstan deserts. He reported that 52% area occupied highly disturbed ecological system. The presence of *Artemisia* reduced the fodder availability in pastures. The vegetation consisted of *Calligonum ceratoides*, *Artemisia arenaria*, *Artemisia scoparia*, *Stipa pennata*, *Euphorbia* and *Peganum* (poisonous or less fodder value species).

Roberto and Roberto (1996) studied the vegetation dynamics of temperate semi arid rangelands of Argentina. They reported that there was non-equilibrium model of vegetation dynamics in natural system. They classified rangeland in 5-five states:

1. Mid preferred grasses, 2. Short preferred grasses, 3. Non preferred grasses, 4. Short preferred grasses and shrubs, and 5. Shrubs and non preferred grasses and annuals. All these are interchangeable with a change in the grazing pressure. State 1 changes to state 2 under moderate continuous grazing and state 3 under heavy grazing continuous grazing.

Wills *et al.* (1996) emphasized the use of chenopod shrubs (*Atriplex halimus*, *Kochia prostrata*) for dry land revegetation and forage in the South Island, New Zealand. They suggested that both these species provide green forage for the period of feed shortage.

Rangeland Productivity (Balochistan)

Of the total area of 34.7 million ha. of Balochistan, the rangelands cover some 30 million hectares. They have been broadly classified into area of poor, medium and high potential producing annually less than 50, 60 and 190 Kg DM/ha, respectively. The rangelands of poor productivity cover about 62% of the province and are generally

located in the south. The rangelands of medium productivity cover 25% of the area, and high potential productive rangelands covering 13% of the area are located mostly on highland Balochistan (FAO, 1995).

In Balochistan, livestock system vary. It depends on the lifestyle of livestock owner and rangeland property regime. About 30% of small ruminants are owned by nomadic powindahs, 60% by transhumants, and only 10% by sedentary livestock owners. Generally people own 30 sheep and 22 goats on average. 60% of small ruminants are found in flocks of up to 100 animals/herder. The remainder belonged to owner with larger flocks and farms. They get 40 to 70% income from transhumant and 100% depends in case of nomadic pastoralists (FAO, 1983). In Balochistan, about 20 million small ruminants are present. Sheep and goats are the major livestock species of Balochistan. These animals are best adapted physiologically to the rough topography and harsh environmental condition of the province. About 53.64% sheep and 46.36% goats are present in Balochistan (GOP, 1998).

Said and Hussain (1959) reported that the total palatable vegetation cover in Maslakh range increased up to 52.9% within four years of protection. The also observed that annuals decreased from 97 to 47%, while perennials accordingly increased due to protection. Later on, Irshad (1961) reported that protected area had 4981 plants/acre compared to 2508/acre in the non protected sites in Masalakh range. Repp and Khan (1960) stated that grazing and tramping eliminated Juniper seedlings in Ziarat Juniper forests as they could only be seen in protected places like beneath shrubs and trees.

Rafi (1965) reviewing the effects of 10 years protection on the vegetation of Masalakh forest, reported that annuals constituted the major and nutritional part of available forage in the area. *Artemisia* was preferred by livestock during spring and autumn.

Ali (1966) reported that rangelands in Quetta - Kalat region have been severely overgrazed. He estimated that 200 acres might support one sheep for one year due to low rainfall. But the region was overstocked by about 20 times. Irshad (1966) reported that about 126000 sq. miles arid rangelands are present in Quetta - Kalat region which produced relatively small amount of palatable forage. Khattak and Sheikh (1981) reported that natural regeneration of Juniper was poor and young seedlings are killed due to overgrazing. Hussain and Chaghtai (1984) reported that *Hordeum murinum* and *Peganum harmala* communities respectively existed in the protected and overgrazed area with 17 and 9 associated species. Heymell (1989) reported that average cover was 12.7% at Nichara rangeland. Of them, *Artemisia maritima* contributed 7.4% cover. Average biomass was 42.7 g/m². He reported that grazing reduced vegetation cover, biomass, density and number of species in the area.

Wahid (1990) reported that standing crop dynamics were correlated to the amount of rainfall received. At Zarchi (Kalat), the biomass was 73.10 to 107.71 Kg dry matter/ha. Shrub biomass was 91 to 94%. *Artemisia* contributed highest than *Haloxylon*. Annual forbs were 14.85% during spring. While standing crop peaked 473.67 to 509.69 Kg dry matter/ha during May at Tomagh (Loralai). Sardar (1992) reported that total production of Hazargangi National Park was 2468 Kg/ha. Out of which, shrubs were 52%, while grasses were 34%.

Afzal (1993) reported that rangelands of Balochistan could be classified into excellent (3.2%), very good (9.5%), good (8.1%), fair (17%), poor (33.7%) and non-grazable (28.5%) types. The annual feed requirement of range livestock was estimated to be 5379 millions Kg. Whereas ranges were producing upto maximum 3458 millions Kg per annum.

Akbar *et al.* (1994) studied the potential of exotic grass species for rehabilitation of arid land in Balochistan. They reported that weeping love grass had highest (2424 Kg/ha) production. The production was 1600 to 1890 Kg/ha in November and 172.4 to 816.7 Kg/ha in June at Mastung. While at Tomagh, it was 310 to 2424 Kg/ha and 265 to 1945 Kg/ha in November and June, respectively. Klapwijk (1996) conducted an experimental work on range management and fodder production in Kach Malazai, Sinjawi, Loralai, Kila Saifullah, Mastung, Sibi (Balochistan). *Atriplex canescens* was introduced along bunds and field margin with the cooperation of local community. He reported that the plants established very well.

Mori and Rehman (1997) reported that the effect of protection on biodiversity was dramatic in Kanak Valley (Balochistan). The number of species increased from 18 to 34. Total vegetation cover increased from 4 to 21% (average 58%/year). The biomass increased up to 443 Kg (DM)/year in protected area as compared to 65 Kg (DM)/year in unprotected area. Ahmed (1998) reported that *Chrysopogon aucheri* and *Cymbopogon jwarancusa* had 7 and 15% ground cover respectively after 34 years of protection from sheep and goat grazing at Chiltan National Park Quetta (Balochistan).

Nutritional Value and Chemical Evaluation of Forage Plants

Range animal productivity is based on common goal of optimum economic gains through proper utilization of range forage. Efficiency of livestock production is mainly associated with the amount and nutritive quality of available vegetation to meet the daily nutritional demands of grazing animals. The daily nutrient demand might fluctuate with the physiological functions of the grazing animal, such as maintenance, gestation, growth, fattening and lactation (Cook and Harris, 1977). The nutritive value of range plants can be influenced directly or indirectly by various environmental factors such as weather, soil, plant competition and grazing. Laycock and Price (1970) summarized the effects of environmental condition upon the quality of forage plants i.e. leaching of herbaceous plants as a result of exposure to rain cause large losses in protein, phosphorus, ash and carotene contents.

Plant material may be divided into two main constituents, the fibrous and non fibrous fractions. In ruminants, fiber fraction play a key role because cellulose and hemicellulose can easily be digested in animal system and are the major energy source of ruminants. The phenolic polymer like lignin is almost indigestible and may hinder carbohydrate digestion (Harkin, 1973). The nutrients consumed by animal are deposited in tissues. They are utilized for milk production and other products. Generally, the composition of feeding stuff varies between different regions due to variation in soil, plant, species composition, climatic conditions and agronomic practices. Cook and Harris (1977) found that phosphorus contents of both grasses and forbs decreased as the season advanced whereas browse gained slight increase in its phosphorus content. Grasses had low phosphorus than either forbs or browse during all period of summer.

Malik and Khan (1965) analyzed nutritive value of certain grasses at different phenological stages. Crude protein was 2.3 - 18.5%, crude fiber 4.2 - 37.2%, ash 4.5 - 20.8% and carbohydrates were 29.05 to 58.2%. Crude protein, ash and fat was highest in flowers, fiber and carbohydrate were higher in leaves while moisture was highest in leaf stalk. Malik and Khan (1966) investigated nutritive value of desert grasses of Cholistan. Ash was 6.4 - 24%, crude protein was 5.3 to 14.2%, crude fiber 15.2 to 50.71%, ether extract was 0.037 to 0.33, carbohydrates were 22.5 to 61.57%. They reported that protein contents was highest in grasses and is liked by animals. Malik and Khan (1967) reported that *Tetrapogon villosus* had a dry matter of 88.6%, ash 17.5%, crude protein 6.4%, crude fiber 27.8%, ether extract 47% and carbohydrates were 32.3%, while in *Cymbopogon jwarancusa* the same values were 90.2%, 7.4%, 8.6%, 22.9%, 33% and 47%, respectively.

Malik and Khan (1971) studied the correlation of chemical composition of grasses with various chemical components of soil. They reported that positive relationship was observed between exchangeable magnesium, phosphorus, calcium and crude protein and sodium content of soil and ash content of grasses, ether extract with potassium and magnesium. There was an upward trend in the carbohydrate contents with increasing level of phosphorus.

Lewis *et al.* (1975) reported grass crude protein of only 10% in April which then fell to less than 4% by October. Forbs declined from 16% to 6% and shrubs declined from 12% to 6% during the same period.

Dabo *et al.* (1980) reported that concentration of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were strongly affected by maturation.

Kalmbacher and Martin (1981) reported that defoliation had strong influence on the contents of phosphorus, potassium, calcium, magnesium, manganese, zinc and copper of creeping blue stem. Kalmbacher *et al.* (1981) reported that creeping blue stem had 80% NDF, 42.4% ADF and 5.8% ADL. Crude protein was 4.5 to 7.7%. Kalmbacher (1983) reported that creeping blue stem, Indian grass, Maidencan and Wire grass had 38 to 54% dry matter, 4 to 7.8% crude protein, 0.05 to 0.08% phosphorus, 0.46% potassium, 0.10 to 0.22% calcium, 0.06% magnesium, 34 ppm. iron, 35 ppm. manganese, 2 ppm copper, and 25 ppm. zinc contents.

Hart *et al.* (1983) stated that grasses generally undergo great reduction in their nutrients through various development stages. Murray (1984) determined the phosphorus content of Crested wheat grass as low as 0.08% in mid September. While in other seasons it was high.

Meyer and Brown (1985) reported that mean crude protein concentration of five grasses were significantly lower than crude protein contents of non grasses. Whereas phosphorus content did not differ among grasses, forbs and shrubs.

Briske (1986) reported that *Cymbopogon jwarancusa* is a nutritive grass but the presence of essential oil reduced the frequency and intensity of grazing.

Azim *et al.* (1989) analyzed chemical composition of maize at two different vegetative stages and reported crude protein was highest in leaves and young plant. Crude fiber ranged 19.12 to 35.6%. Mature plants contain more crude fiber. Neutral detergent fiber was more in bottom portion. Acid detergent fiber similar and ADL were lowest in top. Variation in mineral composition was non significant. The reduction of crude protein was 30 to 66% at the age of two to three months. Vallentine (1990) reported that

Artemisia had 9.4% crude protein, 0.67% phosphorus, 51% total digestible nutrients and 0.58 (Mcal/Kg) metabolized energy.

Rana *et al.* (1990) reported 64 - 75% moisture in leaves, 29.6 to 83% in stems, while 1.6 - 4.5% ash in stems and 2 to 4.6% in leaves. They determined proximate composition and mineral constituents of seeds and recommended as food supplement with tropical legumes to improve the animal production by increasing their protein availability. Pinchak *et al.* (1990) observed a decline in the protein contents for all classes of forage from the beginning of grazing season until grazing ceased. Fierro and Bryant (1990) reported that diet composition and nutrition of herded sheep in Andes of Southern Peru varied with season and herding. It was influenced by available forage which shifted from short grasses in the dry season to grass-like plants in the early rainy season and to tall grasses in the late rainy season. Forbs consisted of 10% of the diet. Crude protein decreased from 13.6 to 5.6% with maturity of vegetation. Feed intake was 82.8 g/Kg in dry season compared with 99.7 g/Kg body weight in other season. Stocking rate was 2 ewe equivalent/ha for this region.

Wahid (1990) reported that crude protein contents were 18.06% in May and reduced upto 3.95% in September. Phosphorus was 0.13 to 0.05%. While neutral detergent fiber increased 22.39 to 57.93% with the advancing season. Liu (1993) chemically compared forage samples of arid rangelands, typical rangelands, desert and pasture in inner Mongolia Steppe. He reported that crude protein was 9.22% and crude fiber was 30.01% in arid rangeland, (CP 8.55%, CF 30.71%) typical rangeland, (CP 8.06%, CF 30.71%) in desert and (CP 7.32%, CF 32.12%) in pasture. Nitrogen Free Extract (NFE) content was highest in pasture (44.41%) and in arid rangeland 38.1%, while

it was 35.36% in desert. Ash contents were higher, 24.41% in May, 8.88% in April, 11.69% in October and 11.26% in December.

Robles and Boza (1993) investigated nutritional value of vegetation in Alemeria South Eastern Spain. They reported that crude protein contents of shrub species were higher (11.1%) than that of perennial herbaceous species (9.8%) and annual grassland (9.4%). Although lignin contents were also higher (13.6%) in shrubs compared with 6.3% and 6.5% in perennial and annual herbaceous species, respectively. Andrighetto *et al.* (1993) reported that the botanical composition of pasture changed as the vegetative season advanced. They reported that with the progressive increase in grass species protein contents decreased from 16.3 to 7.9% from July to September, respectively. However, neutral detergent fibers increased from 62.1 to 79.4% in late season.

Kurganova and Olovyannikova (1993) estimated productivity in unimproved rangelands in semi-desert of Northern Russia (near Aral Sea). They considered *Tanacetum achilleifolium* and *Kochia prostrata* highest quality native forage as they had 12% and 10.6% crude protein respectively. While *Medicago romanica* and *Artemisia pauciflora* respectively had 13.3% and 13.1% crude protein. The productivity of re-sown rangelands was 2 to 3 fold than that of natural rangeland.

Saleem (1993) reported that the essential oil contents of *Cymbopogon jwarancusa* is regarded as an avoidance mechanism. However, biomass and crude protein was greater in *Chrysopogon aucheri* than *Cymbopogon*. Snyman (1994) reported that crude protein of *Panicum maximum* was higher (7.9%) during July to December; while *A. pubescens* had 5.02% during January to June.

Perez *et al.* (1995) studied the above ground biomass, protein, fiber contents and nutritional quality of forage in semi arid grassland in Central Western Spain. Crude protein, neutral detergent fiber and hemicellulose contents were higher on the low altitude area than upper slopes, while lignin content was lower. Theunissen (1995) reported that highly palatable grasses *Themeda triandra*, *Eragrostis racemosa* and *Digitaria eriantha* had higher level of total phenolics compared to less palatable ecotypes with low level of phenolics.

Ashraf *et al.* (1995a) studied proximate composition of different indigenous Rabi and Kharif fodders. They reported that dry matter and crude fibers (CF) were invariably high in Berseem at final cuttings. It ranged from 19.4 to 20.11%. Crude protein, ether extract and ash contents were higher at primary cutting and lower at later cuttings. Crude fiber was more at final cuttings. Ashraf *et al.* (1995b) analyzed different varieties of Rabi and Kharif fodder at different growth stages for cell wall constituents. They reported that Agati variety of Berseem showed higher neutral detergent fiber (NDF), hemicellulose and lignin. Cellulose and acid detergent fiber (ADF) were higher in Composite, while silica was higher in Khdravi variety of Berseem. In lucerne hemicellulose was 8 to 9 time higher than others.

Nyamangara and Ndlovu (1995) reported that crude protein level of animal diet ranged from 128 to 157 g/Kg body weight over the season. Neutral detergent fiber contents ranged from 590 to 790 g/Kg. It was highest in wet months and lowest in dry months. Feed intake ranged from 33 to 60 g/Kg body weight. Feeding duration of 5 hours/day was adequate for maintenance but insufficient for optimum production. Dutoit and Alard (1996) reported that there was no significant differences between chemical

composition of grazed and ungrazed plots. Grazed leaves and barks were rich in calcium and chlorine. However, there is a risk of mineral deficiency for those animals which stay a long time in unimproved grassland and eat species poor in minerals.

Rehman and Mackintosh (1996) reported that concentration of potassium was high in samples preferred by sheep than in less preferred samples. Sheep preferred optimum potassium level of 1.16% in *Atriplex cinerea*. While very high (3.64%) or very low (0.2%) potassium concentration adversely effected the preference of sheep for plants. Holecheck *et al.* (1998) reported that crude protein was 10 to 16% in actively growing forage, while it dropped to 6% during dormant stage.

Harboi Rangelands

Some work on the ecology and flora of this area has also been reported. Khattak (1951) worked on the ephedrine contents of *Ephedra nebrodensis*, *Ephedra vulgaris*, *Ephedra intermedia* and *Ephedra foliata* from Balochistan. Kazmi (1953) listed 17 medicinal plants and reported that about 20 tons of *Ephedra* was being collected from these hills. Burkill (1956) listed 40 plants of 18 dicot and 3 monocot families from here. Rafi (1965) reported that the coniferous forests here consisted of *Juniperus macropoda* and *Fraxinus xanthoxyloides* at an altitude of 2800 m. While shrub layer comprised of *Prunus eburnea*, *Berberis lycium*, *Daphne mucronata*, *Ephedra nebrodensis*, *Caragana ambigua*, *Caragana ullicina*, *Rosa lacerans*, *Sophora griffithii* and *Perovskia atriplicifolia*. Third layer consisted of *Artemisia maritima*, *Hertia itermedia*, *Stipa himalaica* and *Oryzopsis coerulescens*.

Zaman *et al.* (1968) working on the population of *Juniper* observed that there were 16 female trees per acre, 10 large size tree, 12 medium size tree and 6 small size tree

per acre in Harboi hills. The total yield of berries was 18000 mounds/annum. Zaman *et al.* (1971) estimated that about 4000 acres area in Harboi hills (Kalat) supported *Ephedra* with a total yield of 4000 mounds. There were 5 bushes per acre which provided 8 lbs. berries/acre. Durrani *et al.* (1996) reported seven plant communities from Iskalko. They observed high state of vegetation degradation due to deforestation, overgrazing and over collection of plants by locals. No other reference is available on the Harboi Rangeland, Kalat.

Aims and objectives

Due to lack of ecological knowledge and quantitative data on the floristics, vegetation and productivity of Harboi Rangeland, there is a dire need to collect the information on plant diversity, vegetation structure, palatability and nutritive value of plants of this area. No ecological effort can be made without a baseline data.

The present study therefore, has the following objectives:

1. To make an inventory showing the plant diversity and their classification on the basis of uses.
2. To analyze the vegetation structure and characteristics of some representative sites.
3. To workout the edaphology of the area.
4. To prepare life form and leaf size spectra of the vegetation and to establish their relationship with the habitat.
5. To classify fodder/forage plants into various palatability classes.
6. To determine the productivity of some representative sites within this rangeland.
7. To chemically evaluate some of the most common palatable plants.
8. To suggest ecological measures for the improvement of rangeland.

MATERIALS AND METHODS

Materials and Methods

I. Floristic Structure and Composition

A. Florisitic Composition

The research area was surveyed every month for 3 consecutive years i.e. 1996 to 1998. Plants were collected, dried and preserved. They were identified with the help of available literature (Burkil, 1956; Nasir and Ali, 1971-1994, Ali and Qaisar, 1995 - 1999) and confirmed at National Herbarium NARC, Islamabad, Pakistan Museum of Natural History, Islamabad and Herbarium Department of Botany, University of Karachi. A complete floristic list along with families was compiled. Observation on the life form and phenological behaviour were recorded.

Biological Spectra

Biological spectrum of the flora based on the life form was prepared by following Raunkiaer's (1934) life form classes as follows:

a. Therophytes (Th)

Annual seed bearing plants which complete their life cycle in one year and over winter the unfavorable season by means of seeds or spores.

b. Cryptophytes (Cr)

- i. Geophytes (G): Perennating buds located below the surface of soil including plants with deep rhizomes, bulbs, tubers and corm etc.
- ii. Hydrophytes (Hyd): Submerged hydrophytes and those rooted in the muddy substratum. The above ground or upper parts die at the end of growing season

c. Hemicryptophytes (H)

Herbaceous perennial in which aerial portion of plant dies at the end of growing season, leaving a perennating bud at or just beneath the ground surface.

d. Chamaephytes (Ch)

Perennating buds located close to the ground surface (below the height of 25 cm.) They include herbaceous, low woody trailing, low stem succulents and cushion plants.

e. Phanerophytes (P)

They are shrubby and tree species whose perennating buds are borne on aerial shoot reaching a height of at least 25 cm above the ground surface.

- i. Megaphanerophytes (Mp): 30 meters tall
- ii. Mesophanerophytes (Ms): 7.5 to 30 meters tall
- iii. Microphanerophytes (Mc): 2 to 7.5 meters tall
- iv. Nanophanerophytes (Np): 0.25 to 2 meters tall

After having assigned a life form to all the plants Raunkiarian spectra was calculated as follows:

$$\text{Biological Spectra} = \frac{\text{Number of species falling in a particular life form class}}{\text{Total number of all the species for that community/stand}} \times 100$$

Quantitative life form spectra were calculated on the basis of importance value of each species encountered in sampling by quadrat method by following Cain and Castro (1959) and Qadir and Shetvy (1986).

Leaf Size Classes

Plants were classified into Raunkiaerian leaf sizes (Raunkiaer, 1934) as follows:

- | | |
|------------------|-------------------------------------|
| i. Leptophyll: | Leaf area up to 25 sq. mm. |
| ii. Nanophyll: | Leaf area 25 to 225 sq. mm. |
| iii. Microphyll: | Leaf area 225 to 2025 sq. mm. |
| iv. Mesophyll: | Leaf area 2025 to 18225 sq. mm. |
| v. Macrophyll: | Leaf area 18225 to 164,025 sq. m.m. |
| vi. Megaphyll: | Leaf area larger than class v. |

For rapid classification in the field a leaf size diagram (Fig. 3) was used following Raunkiaer (1934).

- a. Raunkiaerian spectrum was calculated as follows

$$\text{Leaf size spectra} = \frac{\text{Number of species falling in a particular leaf size class}}{\text{Total number of all the species for that community/ stand}} \times 100$$

- b. Quantitative leaf size spectra was calculated using importance value indices of plant species following Cain and Castro (1959).

Phenological Behaviour

The phenological observations were recorded every month from 1996 to 1998

Following phenological stages were recognized:

- Pre-flowering stage (Vegetative or seedlings) (V_1)
- Reproductive stage (Flowering/fruiting)
- Post reproductive stage (V_2)
- The dormant stage (V_3).

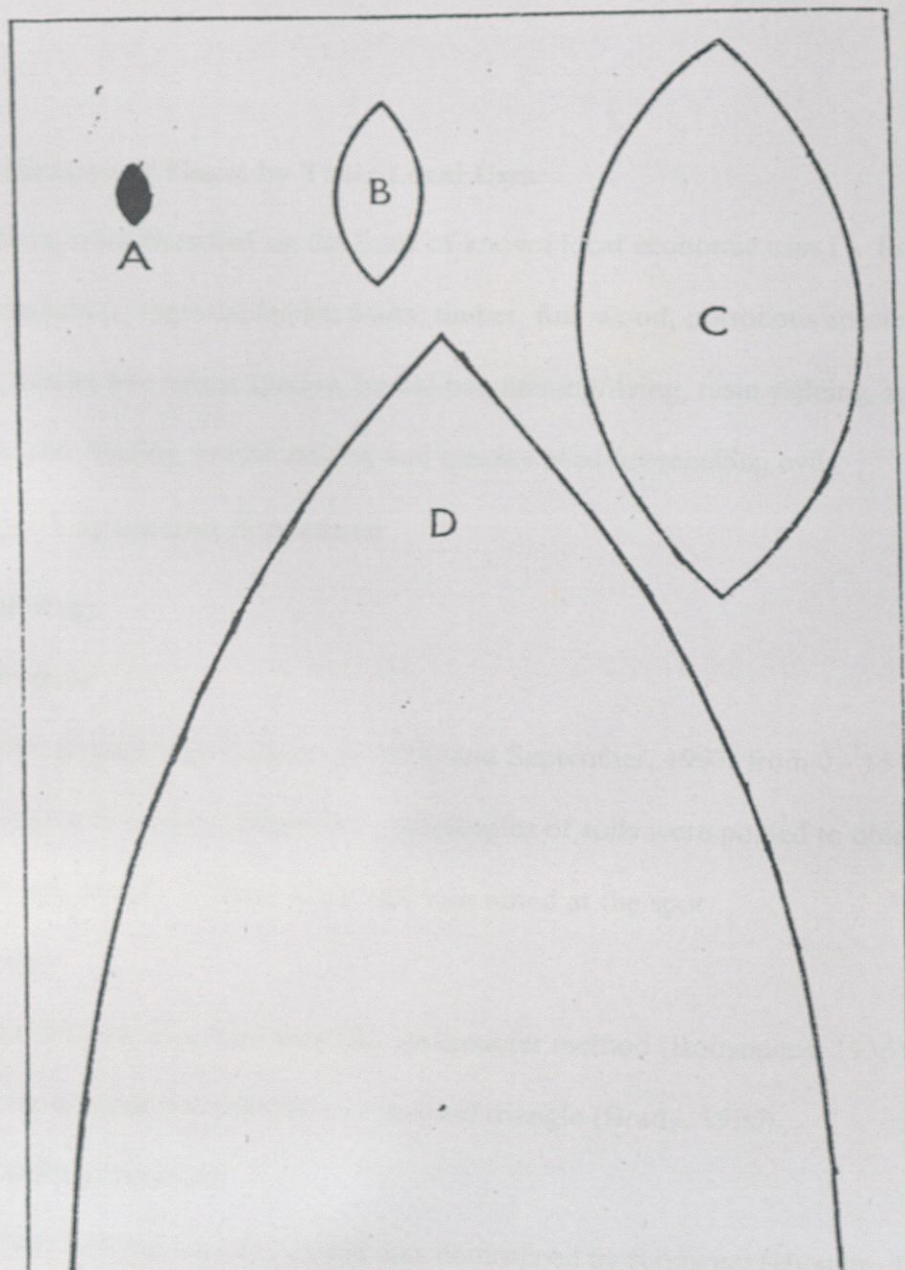


Fig. 3: Leaf size classes (After Raunkiaer) Diagram for use in rapid determination of the class size of a leaf. The figure shows the boundaries between the individual classes, thus:

- Less than A = Leptophyll
- Between A and B = Nanophyll
- Between B and C = Microphyll
- Between C and two times D = Mesophyll
- Between two time D and eight times the size of the diagram has bounded by the black lines = Macrophylls
- More than eight times the size of the diagram as bounded by the black lines = Megaphylls

B. Classification of Plants by Their Local Uses

Plants were classified on the basis of known local economic uses i.e. fodder/forage species, medicinal, vegetable/edible fruits, timber, fuel wood, poisonous species, roof thatching, honey bee nectar species, herbal tea, tanning/dying, resin yielding, washing utensils/cloths, fencing, pencil making and species used for repelling evils.

II. Range Vegetation Structure

A. Edaphology

Soil Collection

Soil samples were collected in May and September, 1997, from 0 - 15 cm depth at 5 different sites in a stand. These five sub-samples of soils were pooled to obtain a composite soil sample. Colour of the soil was noted at the spot.

Soil Texture

Soil texture was determined by hydrometer method (Bonyoucos, 1936). Textural class was determined with the help of textural triangle (Brady, 1990).

Water Holding Capacity

Water holding capacity of soil was determined by following (Hussain, 1989),

$$\text{Water Holding Capacity} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$$

pH

pH of soil samples were determined by pH meter using 1:5 soil saturation extract (Jackson, 1962).

Electrical Conductivity

Electrical conductivity was measured by Electrical Conductivity meter using soil saturation paste.

Litter, Organic Matter and Nitrogen

Litter was separated from each soil sample and expressed in percentage. Organic matter was determined by Walkley and Black's titration method.

$$\text{Organic Matter \%} = \frac{S - T}{S} \times 6.7$$

Where:

S = blank reading

T = volume used of FeSO_4

N % = Organic Matter X 0.05

Calcium Carbonate

The amount of Calcium Carbonates was determined by acid neutralization method, HCl was used for neutralization (Hussain, 1989).

$$\text{CaCO}_3\% = \frac{\text{Blank reading} - \text{Sample reading} \times 5}{2}$$

Determination of Dissolved Carbonates and Bicarbonates

Dissolved Carbonates and Bicarbonates were determined by titration method (Jackson, 1962):

$$\text{Carbonate (meq/liter)} = \frac{(\text{Volume of acid used in A for CO}_3) \times 2 \times N \times 1000}{\text{Volume of soil extract}}$$

$$\text{Bicarbonate (meq/liter)} = \frac{\text{Volume of acid used in B} - \text{Volume used in A for CO}_3 \times N \times 1000}{\text{Volume of soil extract}}$$

Chloride (Cl)

Soluble Chlorides were determined by titrating the soil saturation extract with silver nitrate, using potassium chromate as an indicator (Richard, 1954).

$$\text{Chloride (meq/liter)} = \frac{\text{ml of AgNO}_3 - \text{ml of AgNO}_3 \text{ used for blank} \times 0.005 \times 1000}{\text{Volume of soil extract}}$$

Calcium + Magnesium ($\text{Ca}^{++} + \text{Mg}^{++}$)

Calcium + Magnesium of soil saturated extract were determined by titration with ethylene diamine tetra-acetate (EDTA) and disodium salt (Versenate) (Richard, 1954).

Sodium (Na)

Sodium contents of soil saturated extract were determined by Flame photometer.

Sodium Adsorption Ratio (SAR)

SAR was determined by following formula (Richard, 1954).

$$\text{SAR} = \frac{\text{Na}^+}{\sqrt{\text{Ca}^{++} + \text{Mg}^{++}}} / 2 \text{ meq/liter}$$

Sulphate

Sulphate was determined by precipitation as barium sulphate (Richard, 1954).

$$\text{SO}_4 \text{ (meq/liter)} = \frac{\text{mg of BaSO}_4 \text{ precipitate} \times 8.568}{\text{Volume of soil extract}}$$

Potassium

Potassium was determined by atomic adsorption spectrophotometer in the flame emission mode after diluting the sample with 250 ml of 1% lithium sulphate solution.

Standard solutions were prepared to plot the standard curve. Then Potassium of each sample was calculated from respective curve.

Trace Elements

Atomic absorption spectrophotometer of Pye Unicam SP9 was used for the analysis of Manganese, Iron, Zinc and Copper. The following conditions were set for the determination of these metals. Wavelength (nm): Copper (324.8), Iron (248.3), Manganese (279.5) and Zinc (213.9). Maximum current used by hollow cathode lamp (mA): Copper (5), Iron (15), Manganese (12) and Zinc (10); Acetylene gas pressure 10 lbs., air pressure: 30 lbs. Computer programme Spa on the attached computer was operated and key run commenced the sample feeding for metal estimations. 20 gm soil was taken in 40 ml. of reagent [3.9335g Diethylenetriaminepenta Acetic acid (DTPA), 2.9404 gm Calcium Chloride and 26.64 gm triethanol amine (TEA) were taken and volume made up to 2 liter with double distilled water]. The contents were shaken for two hours followed by filtration with Whatmann 42. Filtrate, used for the determination of Copper, Iron, Manganese and Zinc (prepared by dissolving pure metals in Concentrated HCl or HNO_3), were diluted to 0 - 10 parts per million (ppm) as working strengths for the calibration curves. Each sample was analyzed in triplicate.

Statistical Analysis

For seasonal comparison the results were analyzed statistically by using paired t-test.

B. Vegetational Features

After a general preliminary survey of the area, 10 representative sites were selected on the basis of physiognomic contrast, altitude, habitat, species composition and stages of degradation (erosion and grazing).

Vegetation of Hills

The vegetation of hills was analyzed by using 10, 25 x 25 m quadrats for trees, 10, 4 x 4 m quadrats for shrubs and 20, 1 x 1 m quadrats for herbs/grasses in each site. The quadrats were laid randomly in a nested manner. Density, Density/ha., frequency and cover/basal area were calculated using standard techniques (Phillips, 1959; Hussain, 1989; Mueller - Dombios and Ellenberg, 1974). The canopy cover of herbs/grasses and shrubs was determined by using Daubenmire's cover scale (Daubenmire, 1959). Basal area of trees was determined by following Mueller - Dombios and Ellenberg's crown diameter method (Mueller - Dombios and Ellenberg, 1974). These values were changed to relative values (Hussain, 1989; Mueller - Dombois and Ellenberg, 1974). Importance value (IV) for each species were obtained by adding the relative values within a stand. The community was named after the three leading species having the highest importance values.

Vegetation of Water Courses/Dry beds

Line intercept method was used in dry water course (Cainfield, 1941; Mueller - Dombois and Ellenberg, 1974; Hussain, 1989). Five intercept lines, 30 m each, were laid randomly in each stand for measuring density, frequency and cover of each species. The data was changed to relative scale and treated as before.

Determination of Similarity Index

Similarity index was calculated by using modified Sorensen's index (Sorensen, 1948). Motyka *et al.* (1950) used quantitative value rather than simply computing presence or absence of species. The similarities among the stands and between spring and summer aspects were compared:

$$IS_{M0} = \frac{2W}{A + B} \times 100$$

Where

W = Sum of lowest quantitative value of the species pair common to both communities

A = Sum of quantitative value of all species in community A.

B = Sum of quantitative value of all species in community B.

Index of Dissimilarity was calculated as follows:

ID = 100 - Index of similarity.

The stands/communities having (above 55%) similarity were merged together.

Determination of tree height/age classes

The height of Juniper is related to its age (Ahmed *et al.*, 1989). Therefore, height was measured to assign the trees into different age/height classes to see its regeneration capacity. Forty trees of Juniper in each stand were randomly selected for the determination of height and basal area. The height was determined with the help of Clinometer by using following formula:

$$\tan \theta = \frac{P}{b}$$

Where

P = height of tree

b = distance of tree from observer.

The trees were segregated into male, female, undistinguished or young and dioecious plants (bisexual) following Ahmed *et al.* (1989). The trees were classified into nine height classes i.e. A = 0.5 to 2 m, B = 2 to 4 m., C = 4 to 6 m., D = 6 to 8 m.,

E = 8 to 10 m., F = 10 to 15 m., G = 15 to 20 m., H = 20 to 25m., I = 25 to 30 m.

Determination of Homogeneity

The uniformity or homogeneity of the community was calculated by using Raunkiaer's law of Frequency (Raunkiaer, 1934).

$$A > B > C \geq D < E$$

A	present in up to	1 - 20%
B	present in up to	21 - 40%
C	present in up to	41 - 60%
D	present in up to	61 - 80%
E	present in up to	81 - 100%

Determination of Constancy

Plants were classified into following constancy classes following Raunkiaer (1934).

A	present in up to	1 - 20%	of the stands
B	present in up to	21 - 40%	of the stands
C	present in up to	41 - 60%	of the stands
D	present in up to	61 - 80%	of the stands
E	present in up to	81 - 100%	of the stands.

Species Diversity

Species diversity was calculated by two methods:

a. Simpson's index of diversity (Simpson, 1949)

$$\lambda = \sum_{i=1}^s p_i^2$$

Where:

$$P_i = \frac{n_i}{N}, \quad i = 1, 2, 3, \dots, S.$$

N = total number of individuals for all species in the population

n = number of individuals of a species.

b. Shannon - Weaver (1949) index of diversity

$$H' = - \sum_{i=1}^s \left[\left(\frac{n_i}{n} \right) \ln \left(\frac{n_i}{n} \right) \right]$$

Where:

n = total number of individuals of all species

n_i = number of individuals of i th species.

Species Richness

Species richness was worked out by using following formula (Menhinick, 1964)

$$\text{Species Richness} = d = S/\sqrt{N}$$

Where:

S = total number of species in a stand

N = total number of individuals in a stand

Equitability

Equitability component is related to the evenness of allotment of individual among the species (Peet, 1974). It was determined as follows:

$$e = g/g_{\max}$$

Where:

e = equitability

g = observed general diversity

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$g_{\max}$ = maximum species diversity

$$g_{\max} = 3.3219 (\log_{10} s)$$

where s = total species.

Maturity Index

The community maturity index was obtained by Pichi - Sermollis (1948) method.

$$\text{Degree of maturity index} = \frac{\text{Frequency values of all species in a stand}}{\text{Total number of species in a stand}}$$

Cluster Analysis

Cluster analysis (CA) is a classification technique for placing similar entities or objects into groups or clusters. The arrangement in a hierarchical tree like structure is called a dendrogram. These clusters or groups of sampling units may represent different biotic communities.

The community classification was performed following programme Multi Variate Statistical Package (MVSP). The classification was based on compositional dissimilarity among stands and dendrograms were constructed for vegetational stands of spring and summer aspects of hills and water courses.

Principal Coordinate Ordination

Principal coordinate analysis is the most widely used ordination procedure in ecology and available in computer statistical packages (Multivariate Statistical Package (MVSP)). It is basically a multivariate statistical technique that deals with the internal structure of matrices.

Principal coordinate analysis is a method of breaking down or partitioning a resemblance matrix into a set of orthogonal (perpendicular) axes or components. This matrix consists of variances, covariance or correlation. Each axis corresponds to an eigen

value of the matrix. The eigen value is the variance accounted for by the axis. The ordination provide information about the ecological resemblance between communities. Principal coordinate analysis was applied to dissimilarity data of 10 stands (spring and summer aspect) of Harboi hills.

III. Degree of Palatability

The degree of palatability of different species was recorded by observing the grazing livestock in the field. Daily one animal of both animal species i.e. goat or sheep were observed twice a day. One hour in the morning at the on set of grazing and one hour in the afternoon 5:00 p.m. Each plant species was observed to determine the preference pattern by both sheep and goats. The information was also supplemented from knowledge gathered from local herders. Plants were classified into palatable and non-palatable species. Palatable plants were further classified by animal preferences, part grazed, freshness/dryness of plants and season of availability. Following palatability classes were used for classification:

1. Non Palatable (NP): Not grazed by animals.
2. Highly Palatable (HP): Species which were highly preferred by livestock
3. Mostly Palatable (MP): Species with average likeness by the livestock
4. Less Palatable (LP): Species with less preference
5. Rarely Palatable (RP): Species grazed rarely when no other option was available for feed.

IV. Measurement of Range Productivity

The productivity measurements were made every month from April to October for two consecutive years i.e. 1997 - 1998. Since the methods were different for herbaceous and shrubby species, therefore, following methods were used for each group.

A. Herbaceous Biomass

Above ground herbaceous foliage of grasses and herbs was harvested by species at ground level using 10, 0.5 m quadrats. The harvested material was immediately weighed fresh in the field using a field balance and oven dried at 65°C for 72 hours. The dry weight of all the species was then combined to get the total biomass estimates of an area (Bonham, 1989).

B. Shrub Biomass

Shrub biomass was estimated by Reference Unit Technique (Andrew *et al.* 1981; Kirmse and Norton, 1985). A small representative part of a plant like shoot was designated as Reference Unit. The size of the reference unit was 10 to 20% of the foliage weight of average plant. The number of reference units of a plants were counted and multiplied by average weight of clipped reference unit to estimate shrub biomass production.

V. Chemical Evaluation of Some Plants

Collection of Plant Samples

Plant samples of following six shrubs and four grasses (Table 2) were collected at three phenological stages (seedling/pre reproductive, flowering/reproductive and post reproductive). The plant selection was based on the animal preferences. Fresh weight of each sample was determined at the time of sampling. Samples were packed in paper bags

Table 2: Plant Species and Phenological Stage used for chemical analysis

S.No.	Species	Palatability		
		Seedling Stage	Flowering Stage	Post reproductive Stage
1	<i>Artemisia maritima</i>	HP	HP	HP
2	<i>Perovskia abrotanoides</i>	RP	HP	HP
3	<i>Perovskia atriplicifolia</i>	RP	HP	HP
4	<i>Convolvulus leiocalyimus</i>	HP	HP	HP
5	<i>Sophora griffithii</i>	NP	NP/MP (Pods)	HP
6	<i>Hertia intermedia</i>	NP	MP	NP
7	<i>Pennisetum orientale</i>	HP	HP	HP
8	<i>Stipa pennata</i>	HP	HP	HP
9	<i>Tetrapogon villosus</i>	HP	HP	HP
10	<i>Cymbopogon jwarancusa</i>	LP	LP	LP

HP = Highly palatable RP = Rarely palatable LP = Less palatable

MP = Mostly palatable NP = Non palatable

Preparation of Plant Samples

The dried plant samples were powdered by electric grinder and samples were stored in plastic bags for all further analysis (Reuter and Robinson, 1986).

1. Proximate Analysis

Dry Matter (DM%)

Dry matter was obtained by oven drying the plant sample at 65 °C for 72 hours (AOAC, 1984) and percent dry matter was calculated by following equation:

$$\text{Dry Matter \%} = \frac{\text{Weight of dried sample}}{\text{Weight of fresh sample}} \times 100$$

Ash Contents

One to 2 gm of plant sample were ignited in the Muffle furnace at 550 - 600 °C for at least 8 hours and ash contents of samples were determined (AOAC, 1984) as follows:

$$\text{Ash \%} = \frac{\text{Weight of Ash}}{\text{Weight of sample}} \times 100$$

Organic Matter

Organic matter is that portion of the sample which is not water or ash (i.e. Carbon, Hydrogen, Oxygen, Nitrogen bonding) (Galyean, 1985). It was calculated as follows:

$$\text{Organic Matter \% (dry matter basis)} = 100 - \text{ash}$$

Plant Digestion

All nutrients determination involved wet digestion of plant sample. One gm plant sample was digested in selenium sulphuric acid (concentrated) and hydrogen peroxide was added to each digestion tube. The sample was digested by placing digestion tubes on a heating block (pre heated at 250 °C). The digestion was continued (at 350 °C) until colour of the solution was clear. The prepared solution was diluted with doubled distilled water and stored in tubes. This solution was used for the analysis of Nitrogen/Crude protein, Potassium, Phosphorus, Copper, Zinc, Iron and Manganese.

Nitrogen/Crude Protein

Nitrogen in each sample was determined by micro Kjeldahl procedures (AOAC, 1984). Nitrogen in the digested sample was collected in 4% boric acid solution by distillation. Boric acid was titrated against 0.02 normal standardized H_2SO_4 by a semi automatic titrator. Crude protein in the sample was calculated by the following formula:

$$\text{Crude Protein \%} = \frac{(\text{ml H}_2\text{SO}_4 - \text{blank}) \times \text{N} \times 100 \times 6.25 \times 14.01}{\text{Sample weight} \times 1000}$$

Crude Fiber (CF)

Crude fiber was determined by following AOAC (1984) method, by digesting the sample with 1.25% H_2SO_4 for 30 minutes followed by 30 minutes with 1.25% sodium

hydroxide. The insoluble residues were dried, weighed and ashed and the insoluble organic matter was reported as crude fiber. Crude fiber was calculated by following formula:

$$\text{Crud Fiber \%} = \frac{\text{loss in weight on ignition}}{\text{Weight of sample}} \times 100$$

Ether Extract (EE) (Crude Fat)

Ether extract recovers lipid and fats which contain 2.25 time of energy or carbohydrates (Van Soest, 1994). Ether extract procedure involves a reflux apparatus which boils ether, condenses it and allows it to pass through the sample (Galyean, 1985).

Ether extract was calculated as follow:

$$\text{Ether Extract \%} = \frac{\text{Weight of extract}}{\text{Weight of sample}} \times 100$$

Nitrogen Free Extract (NFE)

Nitrogen free extract was calculated by the following formula (Galyean, 1985):

$$\text{NFE} = \text{Dry matter \%} - (\% \text{ Ash} + \% \text{ Crude Fiber} + \% \text{ Ether Extract} + \% \text{ Crude Protein})$$

The nitrogen free extract represents highly digestible carbohydrates.

Gross Energy (GE)

Gross energy of samples was calculated from the proximate composition of feed stuff by following method of Garrett and Johnson (1983). It was done by multiplying the percentage of each proximate component with its appropriate energy value, followed by summation of these products.

$$\text{GE (Kcal/g)} = 5.72 (\text{CP}) + 9.5 (\text{EE}) + 4.79 (\text{CF}) + 4.03 (\text{NFE}).$$

Total Digestible Nutrients (TDN)

Total digestible nutrients for sheep and goats were calculated by following equations (Harris *et al.*, 1967). Total digestible nutrients is a measure of the digestible energy content of sample on carbohydrate equivalent basis.

$$\begin{aligned} \%TDN = & 37.937 - 1.018 (CF) - 4.886 (EE) + 0.173 (NFE) + 1.042 (CP) \\ & + 15 (CF)^2 - 0.058 (EE)^2 + 0.008 (CF) NFE + 0.119 (EE) \\ & (NFE) + 0.038(EE) CP + 0.003 (EE)^2 (CP) \end{aligned}$$

OR from Digestible energy for sheep and goats (Anonymous, 1982)

$$\%TDN = \frac{DE \text{ (Mcal/kg)}}{0.04409}$$

Digestible Energy (DE)

Digestible energy was calculated from TDN% for sheep and goats (Anonymous, 1982).

$$DE \text{ (Mcal/Kg)} = TDN\% \times 0.04409$$

$$\begin{aligned} \text{OR } DE = & 0.0229 (CP) + 0.0349 (EE) + 0.0091 (CF) + 0.00017 (NFE)^2 + \\ & 0.5 NFE\% - 0.068 \end{aligned}$$

Metabolizable Energy (ME)

Metabolizable energy was calculated from digestible energy for sheep and goats (Moe and Tyrrell, 1976).

$$ME \text{ (Mcal/Kg)} = 0.45 + 1.01 (DE) \text{ (Mcal/Kg)}$$

2. Cell Wall Constituents

Neutral Detergent Fiber (NDF)

One gm of plant sample was placed in a beaker for refluxing. To it 100 ml of a cold neutral detergent solution and 2 ml of decalin were added. The solution was then boiled for 5 - 10 minutes and refluxed for 60 minutes. Afterwards, it was filtered through a previously - tarred, sintered glass crucible using low vacuum. The filtered mat was broken up and washed twice with hot water. It was further washed with acetone and crucible was dried at 100 °C for eight hours and weighted (Van Soest, 1964; Goering and Van Soest, 1970). NDF was calculated as follows:

$$\text{NDF \%} = \frac{\text{Weight of treatment}}{\text{Sample weight}} \times 100$$

Acid Detergent Fiber (ADF)

One gm sample was taken into a beaker suitable for refluxing. One hundred ml cold acid detergent solution and 2 ml decahydronaphthalene was added. The acid detergent solution was heated to boiling and refluxed for 60 minutes. The sample was then filtered on a previously tarred gooch crucible. The filtered mat was broken up with a rod and first washed with hot water twice followed by acetone until the affluent was clear. After that, the filtrate was dried at 100 °C for eight hours and weighed. ADF was calculated as follows (Van Soest, 1963; Van Soest and Wine, 1967):

$$\text{ADF \%} = \frac{(W_0 - W_t)}{S} \times 100$$

Where:

W_0 = weight of oven dry crucible including fiber

Wt = tarred weight of oven dried crucible

S = oven dried sample weight

Acid Detergent Lignin (ADL)

The ADF was used as a preparatory step for the determination of ADL. It was analyzed from ligno - cellulose (residue of ADF). These cellulose was dissolved by 72% H_2SO_4 . The remaining residue consisted of lignin and acid insoluble ash (Georing and Van Soest, 1970; Waldern, 1971). ADL was primarily lignin, but some cutin and bound nitrogen were also present.

Hemicellulose

The difference between neutral detergent fiber and acid detergent fiber is an estimate of hemicellulose (Van Soest and Robertson, 1985).

Hemicellulose = NDF - ADF

Total Carbohydrates

Total carbohydrates was calculated by using the following formula (Galyean, 1985).

Total Carbohydrates (%) = $100 - \text{moisture \%} - (\% \text{Ash} + \% \text{Crude Protein} + \text{Ether Extract \%})$.

3. Mineral Constituents

Phosphorus

Phosphorus contents in the sample were determined by spectrophotometric analysis using spectronic - 20 (AOAC, 1984). A standard phosphorus solution was prepared. This standard phosphorus sample with a reagent blank was run through a spectrophotometer and a standard curve was prepared by plotting phosphorus concentrations against percent

light transmission. Then the sample solution was run to determine the parts per million (ppm) of phosphorus in the solution from the respective standard curves.

Potassium

Potassium contents were determined by atomic absorption spectrophotometer (PYE UNICAM Spa) in the flame emission mode at 766.5 nm using a fuel lean air/acetylene flame. Computer programme Spa on the attached computer was operated and key run commenced the sample feeding for estimation of potassium. Standard potassium solutions were prepared and run through spectrophotometer and standard curve was plotted with different concentrations of potassium. The samples were diluted with 250 ml of lithium sulphate solution. Then the sample solutions were run to determine the potassium contents in samples from the respective standard curve and calculated for each sample.

Metallic contents (Zinc, Iron, Manganese and Copper)

The standard solutions were prepared for each metal. The atomic absorption spectrophotometer was optimized. Computer programme was started. The standard curve was prepared before running the samples for each metal (following: PYE UNICAM SP9 operation manual).

Copper

Copper was determined in the emission mode at analytic wavelength of 324.7 nm using a fuel lean nitrous oxide/acetylene flame. No dilution is required for plant digested solutions.

Manganese

Manganese was determined with a fuel lean condition but a stronger signal is obtained if the flame is optimized. Wavelength used was 279.5 nm. A 1 + 1 dilution with distilled water is required prior to analysis.

Zinc

Flame condition with a fuel lean and wavelength of 213.9 nm was used. A 1 + 1 dilution with distilled water was used prior to analysis.

Iron

The flame condition of fuel lean and wavelength of 248.3 nm was used. A 1 + 1 dilution with distilled water was required prior to analysis.

Statistical Analysis

For comparison of the chemical contents of grasses and shrubs t-test was applied. For comparison of the chemical contents among phenological stages, among grasses and shrubs a randomized block design was used.

RESULTS

Results

I. Floristic Structure and Composition

Floristic Composition

The floristic list comprised of 202 species (Table 3) that belonged to 45 families: 35 dicot, 8 monocot and 2 gymnosperm. Asteraceae (29 Spp) and Poaceae (24 Spp) were the most represented families. These were followed by Brassicaceae and Papilionaceae (each with 17 Spp), Lamiaceae (15 Spp), Boraginaceae (11 Spp), Chenopodiaceae (7 Spp), Euphorbiaceae, Ranunculaceae, Scrophulariaceae and Apiaceae (each with 6 Spp), Caryophyllaceae and Liliaceae (5 Spp each), Rosaceae (4 Spp) and Juncaceae (3 Spp). The remaining 30 families had one or two species. *Juniperus excelsa* was the only tree species. It was associated with 34 shrubs, 138 herbs and 30 grass/sedge species in the research area.

Biological Spectra

Raunkiaerian approach revealed that Therophytes (47.52%) were dominant in the area (Table 4). On hills, they constituted 50.3% and along water courses 46.1% of the total plant species. Hemicryptophytes were the next dominant class with an overall representation of 20.8%. Their representation on hills was 18.9% and along water course 24.4%. Chamaephytes had 9.9% share in the area being 11.8% on the hills and 7% along water courses. Nanophanerophytes as a whole had 7.9% occurrence. On hilly sites, they were 9.5% while along water courses only 6.1%. Geophytes had 8.3% share on hills and 6.1% along water courses. Hydrophytes were 9.6% in water courses. *Orobanche cernua* was the only root parasit (0.59%) in the area (Table 4). Climbers were (2%, overall)

Table 3: Floristic list, life form and leaf size spectra of plants of Harboi rangeland.

S.No	Name of Species	Life form	Leaf size Spectra	Hill	Water Course
1-Amaranthaceae					
1	<i>Aerua javanica</i> (Burm.f) Juss	CH	Mic	+	+
2-Alliaceae					
2	<i>Allium dolichostylum</i> Vved	G	Mic	+	-
3	<i>Asparagus capitatus</i> Baker (climber)	NP	Na	+	-
3-Apiaceae					
4	<i>Bupleurum exaltatum</i> Bieb.	H	Na	+	-
5	<i>Bupleurum linearifolium</i> DC.	H	Na	+	-
6	<i>Cuminum cyminum</i> L.	Th	L	+	-
7	<i>Ferula foetida</i> Regal	G	Mes	+	-
8	<i>Psammogeton</i> sp	Th	L	+	-
9	<i>Seseli libanotis</i> (L.) Koch	H	Mic	+	-
4-Asteraceae					
10	<i>Achillea santolina</i> L.	H	L	+	+
11	<i>Artemisia maritima</i> L.	CH	L	+	+
12	<i>Artemisia tournefortiana</i> Reich b.	CH	Na	+	-
13	<i>Asteriscus pygmaeus</i> (DC.) Coss & Dur	H	Na	+	+
14	<i>Conyza bonariensis</i> (L.) Cronquist	Th	Na	+	-
15	<i>Cousinia heterophylla</i> Boiss	Th	Mic	+	+
16	<i>Cousinia onopordioides</i> Ledeb	H	Mes	+	+
17	<i>Cousinia</i> sp.	Th	Mic	+	-
18	<i>Crepis sancta</i> (L.) Bab.	Th	Na	+	+
19	<i>Echinops echinatus</i> Rox b.	Th	Mic	+	+
20	<i>Gnaphalium luteoalbum</i> L.	H	Na	+	+
21	<i>Hertia intermedia</i> (Boiss.) O. Ktze	CH	Mic	+	+
22	<i>Heteroderis stocksiana</i> Boiss	Th	Mic	+	-
23	<i>Lactuca auriculata</i> Wall. ex DC.	Th	Na	+	-
24	<i>Lactuca orientalis</i> (Boiss.) Boiss	Th	Mic	+	+
25	<i>Lactuca persica</i> Boiss	Th	Mes	+	-
26	<i>Filago hurdwarica</i> (DC.) Wagenitz	Th	L	+	-
27	<i>Pulicaria gnaphalodes</i> (Vent.) Boiss	H	Na	+	+
28	<i>Sonchus maritimus</i> L.	Th	Mic	-	+
29	<i>Scorzonera laciniata</i> L.	G	Mic	+	-
30	<i>Scorzonera tortuosissima</i> Boiss	G	Mic	+	-
31	<i>Scorzonera</i> sp	Th	Na	-	+
32	<i>Scrozonera mollis</i> M. Bieb	G	Na	+	+
33	<i>Seneco</i> sp	Th	Na	+	+
34	<i>Taraxacum officinale</i> Weber	G	Mic	-	+
35	<i>Tragopogon gracilis</i> D. Don	G	Mic	+	+
5-Berberidaceae					
36	<i>Berberis balochistanica</i> Ahrendt	NP	Mic	+	+
37	<i>Berberis callibotrys</i> Aitchex Koenne	NP	Mic	+	-

6-Boraginaceae

38 <i>Heliotropium brahuicum</i> Stocks	Th	Na	+	-
39 <i>Lappula microcarpa</i> (Ledeb) Gurke	Th	Na	+	-
40 <i>Lappula sessiliflora</i> (Boiss). Gurke	Th	Na	+	+
41 <i>Lappula spinocarpus</i> (Forssk.) Ascherson	Th	Na	+	-
42 <i>Lithospermum arvense</i> L.	Th	Mic	+	-
43 <i>Onasma dichroanthum</i> Boiss	Th	Na	+	-
44 <i>Onasma limitaneum</i> LM. Johnston	Th	Na	+	-
45 <i>Mattiastrum asperum</i> (Stocks) Brand	Th	Mic	+	+
46 <i>Nonnea caspica</i> (Willd) G. Don	Th	Na	+	-
47 <i>Nonnea kandaharensis</i> H. Riedl	Th	L	+	-
48 <i>Trichodesma stocksii</i> Boiss	Th	Mic	+	-

7-Brassicaceae

49 <i>Alyssum linifolium</i> Staph ex Willd	Th	Na	+	-
50 <i>Alyssum marginatum</i> Stend ex Willd	Th	Na	+	+
51 <i>Alyssum szovitzianum</i> F & M.	Th	L	+	-
52 <i>Alyssum desertorum</i> Stafp	Th	Na	+	+
53 <i>Arabis saxicola</i> Edgew	Th	Na	+	+
54 <i>Conringia planisiliqua</i> Fisch & Mey	Th	Mic	+	+
55 <i>Coronopus didymus</i> (L.) Sm	Th	Na	+	+
56 <i>Descurainia sophia</i> (L.) Webb & Berth	Th	Na	+	+
57 <i>Drabopsis verna</i> C. Koch	Th	Na	+	+
58 <i>Farsetia heliophila</i> Bunge ex Coss	Th	Mic	+	-
59 <i>Isatis emarginata</i> Kar & Kir	Th	Mic	+	-
60 <i>Leptaleum filifolium</i> (Willd.) DC	Th	Na	+	+
61 <i>Malcolmia africana</i> (Linn.) R. Br.	Th	Mic	+	-
62 <i>Malcolmia</i> sp.	Th	Mic	-	+
63 <i>Malcolmia strigosa</i> Boiss	Th	Mic	+	-
64 <i>Neslia apiculata</i> Fisch & Mey & Avelal	Th	Mic	+	+
65 <i>Robeschia schimperii</i> (Boiss) O.E.S.	Th	Na	+	-

8-Capparifoliaceae

66 <i>Lonicera hypoleuca</i> Dene	NP	Na	+	-
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9-Caryophyllaceae

67 <i>Holosteum umbellatum</i> L.	Th	Na	+	+
68 <i>Gypsophila lignosa</i> Hemsl & Lace (cussion)	CH	L	+	-
69 <i>Minuartia meyeri</i> (Boiss.) Bornum	Th	L	+	+
70 <i>Silene brahuica</i> Boiss	Th	Na	+	-
71 <i>Stellaria alsinoides</i> Boiss & Buhse	Th	Na	+	+
72 97-83	Th	L	+	+

10-Chenopodiaceae

73 <i>Chenopodium album</i> L.	Th	Mic	+	-
74 <i>Chenopodium botrys</i> L.	Th	Na	-	+
75 <i>Chenopodium foliosum</i> (Moench) Ashers	Th	Mic	-	+
76 <i>Chenopodium hybridum</i> L.	Th	Mic	-	+
77 <i>Haloxylon griffithii</i> (Moq.) Bunge ex Boiss	CH	L	+	+
78 <i>Kochia stellaris</i> Moq.	CH	L	+	-
79 <i>Salsola kali</i> L.	H	L	-	+

11-Convolvulaceae					
80	<i>Convolvulus arvensis</i> L. (climber)	H	Mic	-	+
81	<i>Convolvulus leiocalycinus</i> Boiss (cussion)	CH	Na	+	+
12-Cupressaceae					
82	<i>Juniperus excelsa</i> M. Bieb	MP	L	+	+
13-Cyperaceae					
83	<i>Carex sp</i> (1)	Hydro	Na	-	+
84	<i>Carex sp</i> (2)	Hydro	Na	-	+
85	<i>Cyperus sp</i>	Hydro	Na	-	+
14-Dipsicaceae					
86	<i>Scabiosa oliveri</i> Coult	Th	Na	+	+
15-Ebenaceae					
87	<i>Ebenus stellata</i> Boiss	CH	Na	+	-
16-Ephedraceae					
88	<i>Ephedra intermedia</i> var <i>glauca</i> Schren K. Regel, Stap	NP	L	+	-
17-Euphorbiaceae					
89	<i>Euphorbia caeladenia</i> Boiss	H	Na	+	-
90	<i>Euphorbia falcata</i> L.	Th	Mic	+	-
91	<i>Euphorbia graulata</i> Forssk	Th	L	+	+
92	<i>Euphorbia maddenii</i> Boiss	H	Na	+	+
93	<i>Euphorbia multifurcata</i> Rech f. et al.	Th	Mic	+	+
94	<i>Euphorbia prostrata</i> Ait	Th	L	+	-
18-Fumariaceae					
95	<i>Fumaria indica</i> (Hausskn.) H.N.	Th	Na	+	+
19-Geraniaceae					
96	<i>Erodium cicutarium</i> (L.) L' Herit ex Ait.	Th	Mic	+	-
20-Iridaceae					
97	<i>Iris sp</i>	G	Mes	+	+
98	<i>Iris tenuifolia</i> Pall	G	Mes	+	+
21-Juncaceae					
99	<i>Juncus sp</i>	Hydro	Na	-	+
100	<i>Juncus articulatus</i> L.	Hydro	Na	-	+
101	<i>Juncus infexus</i> L.	Hydro	Na	-	+
22-Juncaginaceae					
102	<i>Triglochin palustris</i> L.	Hydro	Mic	-	+
23-Lamiaceae					
103	<i>Eremostachys vicarys</i> Benth	H	Mes	+	-
104	<i>Isodon rugosus</i>	NP	Mic	+	+
105	<i>Lallementia royleana</i> (Bth.) Bth	Th	L	+	-
106	<i>Marrubium vulgare</i> L.	H	Mic	+	-
107	<i>Mentha longifolia</i> (L.) Huds	Hydro	Mic	-	+
108	<i>Nepta sp</i>	H	Na	+	-
109	<i>Nepeta juncea</i> Bth	H	Na	+	+
110	<i>Perovskia abrotanoides</i> Karel	NP	Mic	+	+
111	<i>Perovskia atriplicifolia</i> Bth	NP	Mic	+	+
112	<i>Salvia cabulica</i> Bth	CH	Mic	+	-
113	<i>Scutellaria stocksii</i> Boiss	H	Na	+	-
114	<i>Scutellaria sp</i>	H	Na	-	+
115	<i>Teucrium stocksianum</i> Boiss	H	Na	+	-

116	<i>Zizyphora clinopodioides</i> Lam	H	Na	+	-
117	<i>Zizyphora tenuior</i> L.	Th	L	+	+
	24-Leonticaceae				
118	<i>Bongardia chrysogonum</i> (Linn) Spach	G	Mic	+	-
	25-Liliaceae				
119	<i>Eremerus persicus</i> (Jaub & Spach) Boiss	G	Mes	+	+
120	<i>Gagea pseudo-reticulata</i> Vved	G	Na	+	-
121	<i>Gagea</i> sp	G	L	+	-
122	<i>Rhinapetalum karelinii</i> Fisch	G	Na	+	-
123	<i>Tulipa polychroma</i> Stapf	G	Mic	+	+
	26-Malvaceae				
124	<i>Malva neglecta</i> Wallr.	H	Mic	+	+
	27-Onagraceae				
125	<i>Epilobium minutiflorum</i> Hausskn	Hydro	Mic	-	+
	28-Orobanchaceae				
126	<i>Orobanche cernua</i> Loeffl (Root paratiste)	P	Na	+	-
	29-Papaveraceae				
127	<i>Hypecoum pendulum</i> L.	Th	Na	+	+
128	<i>Papaver macrostomum</i> Boiss & Huet ex Boiss	Th	Mic	+	-
	30-Papilionaceae				
129	<i>Astragalus gompholobium</i> Bth.ex Bunge	CH	Mic	+	-
130	<i>Astragalus</i> 97 - 151	Th	L	+	-
131	<i>Astragalus</i> 97 - 53 (cussion)	CH	Na	+	-
132	<i>Astragalus</i> 97 - 8	NP	Na	+	-
133	<i>Astragalus afghanus</i> Boiss	Th	L	+	+
134	<i>Astragalus anisacanthus</i> Boiss	H	L	+	-
135	<i>Astragalus orthocarpus</i> Boiss	Th	Na	+	+
136	<i>Astragalus psilocentros</i> Fisch	H	Na	+	+
137	<i>Astragalus purpurascens</i> Bunge	CH	Na	+	-
138	<i>Astragalus sublifformis</i> DC.	Th	Na	+	-
139	<i>Caragana stocksii</i>	NP	Na	+	-
140	<i>Colutea armata</i> Hemsl. & Lace	CH	Na	+	-
141	<i>Medicago lupulina</i> L.	Th	Na	+	-
142	<i>Medicago polymorpha</i> L.	Th	L	+	+
143	<i>Onobrychis cornuta</i> (L.) Desv (cushion)	CH	L	+	+
144	<i>Onobrychis dealbata</i> stocks	H	Na	+	-
145	<i>Sophora griffithii</i> Stocks	CH	Na	+	+
	31-Plantaginaceae				
146	<i>Plantago lanceolata</i> L.	Hydro	Mic	-	+
147	<i>Plantago major</i> Aitch	Hydro	Mic	-	+
	32-Plumbaginaceae				
148	<i>Acantholimon munroanum</i> Aitch & Hemsl (cushion)	CH	Na	+	-
149	<i>Acantholimon polystachyum</i> Boiss (cushion)	CH	Na	+	+
	33-Poaceae				
150	<i>Aristida</i> sp	Th	Na	+	+
151	<i>Aristida adscensionis</i> L.	H	Mes	+	+
152	<i>Boissera squarrosa</i> (Soland) Nevski	Th	Na	+	-
153	<i>Bothriochloa ischaemum</i> (L.) Keng	H	Na	-	+
154	<i>Bromus sericeus</i> Drobov	Th	Na	+	+

155 <i>Bromus tectorum</i> L.	Th	Na	+	+
156 <i>Cymbopogon jwarancusa</i> (Jones) Schult	H	Na	+	+
157 <i>Phacelurus speciosus</i> (Stend.) C. E. Hubb	H	Mes	+	-
158 <i>Eragrostis minor</i> Host	Th	Na	+	+
159 <i>Festuca arundinacea</i> Schreb	Th	Na	+	-
160 <i>Hordeum bogdannii</i> Wilensky	Th	Na	-	+
161 <i>Melica persica</i> Kunth	H	Na	+	+
162 <i>Pennisetum orientale</i> L.	H	Mic	+	+
163 <i>Phalaris</i> sp	H	Mic	-	+
164 <i>Piptatherum vicarium</i>	Th	Na	+	-
165 <i>Poa bulbosa</i> L.	H	Mic	+	+
166 <i>Poa sinaica</i> Steud	H	Mic	+	+
167 <i>Polypogon fugas</i> Nees ex Steud	H	Na	-	+
168 <i>Shismus arabicus</i> Nees	Th	Na	+	+
169 <i>Stipa pennata</i> L.	H	Na	+	+
170 <i>Tetrapogon villosis</i> Desf	H	Na	+	+
171 <i>Vulpia ciliata</i> (Lam K. & DC) Link	Th	Na	-	+
172 97 - 108	Th	Mic	+	+
173 97 - 150	H	Mic	+	+
34-Polygalaceae				
174 <i>Polygala hohenackeriana</i> Fisch & Meiy	Th	L	+	-
175 <i>Polygala sibirica</i> Linn	Th	L	+	+
35-Polygonaceae				
176 <i>Polygonum aviculare</i> L.	Th	Na	-	+
177 <i>Polygonum paronychioides</i> C.A. Mey	H	Na	-	+
36-Primulaceae				
178 <i>Androsace</i> sp	Th	Na	+	-
37-Ranunculaceae				
179 <i>Adonis aestivalis</i> L.	Th	Na	+	-
180 <i>Anemone tschernfaewii</i> Regal	H	Na	+	-
181 <i>Ceratocephalla falcatus</i> (L.) Pers.	Th	L	+	-
182 <i>Ceratocephalla testiculata</i> (Crantz) Roth	Th	L	+	-
183 <i>Clematis graveolens</i> Lindl (climber)	NP	Mic	+	-
184 <i>Clematis orientalis</i> L. (climber)	NP	Mic	+	-
38-Rosaceae				
185 <i>Prunus</i> sp	NP	Na	+	+
186 <i>Prunus eburnea</i> Aitch	NP	Na	+	+
187 <i>Rosa lacerans</i> Boiss & Buhse	NP	Mic	+	-
188 <i>Spiraea boissieri</i> Schneider	CH	Na	+	-
39-Rubiaceae				
189 <i>Gaillonia eriantha</i> Jaub & Spach (cussion)	CH	Na	+	-
190 <i>Galium aparine</i> L.	Th	L	+	+
40-Scrophulariaceae				
191 <i>Leptorhabdos parviflora</i> (Bth) Bth	Th	Mic	+	+
192 <i>Scrophularia</i> sp	Th	Na	-	+
193 <i>Verbascum erianthum</i> Bth	H	Mes	-	+
194 <i>Vernonia didyma</i> Tenore	Th	L	+	+
195 <i>Veronica anagallis-aquatica</i> L.	H	Mic	-	+
196 <i>Veronica biloba</i> L.	Th	L	+	+

41-Solanaceae				
197	<i>Solanum nigrum</i> L.	Th	Na	- +
198	<i>Hyoscyamus pusillum</i> L.	Th	Na	+ +
42-Tamariaceae				
199	<i>Reaumaria</i> sp	Th	Na	+ -
43-Thylmeleaceae				
200	<i>Daphne mucronata</i> Royle	NP	Mic	+ +
44-Valerianaceae				
201	<i>Valerianella oxyrrhyncha</i> Fisch & Mey	Th	Na	+ +
45-Zygophyllaceae				
202	<i>Peganum harmala</i> L.	H	Mic	- +

+ Present

- Absent

Key: Life form

Th: Therophyte

H: Hemicryptophyte

CH: Chamaephyte

MP: Megaphanerophyte

NP: Nanophanerophyte

G: Geophyte

Hydro: Hydrophyte

P: Parasite

Key: Leaf size

L: Leptophyll

Mic: Microphyll

Na: Nanophyll

Mes: Mesophyll

Table 4: Lifeform and leaf size spectra of plants of hills and water course.
(the figures in parenthesis are the percentages)

S.No.	Lifeform	Overall	Hills	Water Course
A - Lifeform				
1.	Therophytes	96(47.5)	85(50.3)	53(46.1)
2.	Hemicryptophytes	42(20.8)	32(18.9)	28(24.4)
3.	Chamaephytes	20(9.9)	20(11.8)	8(7.0)
4.	Nanophanerophytes	16(7.9)	16(9.5)	7(6.1)
5.	Megaphanerophytes	1(0.5)	1(0.6)	1(0.9)
6.	Geophytes	15(7.4)	14(8.3)	7(6.1)
7.	Hydrophytes	11(5.4)	-	11(10.0)
8.	Root Parasite	1(0.5)	1(0.6)	-
Total		202	169	115
B - Leaf size Spectra				
1.	Leptophylls	32(15.9)	31(18.3)	16(13.9)
2.	Nanophylls	99(49.0)	82(48.5)	56(48.7)
3.	Microphylls	61(30.2)	47(27.8)	37(32.2)
4.	Mesophylls	10(5.0)	9(5.3)	6(5.2)
Total		202	169	115

1.77% on hills and 0.9% along water courses. Similarly, there were 4.1% cushion plants on hills and 2.6% along water courses (Table 3).

Leaf Size Spectra

Leaf size spectra showed that nanophylls (49.0%) dominated the investigated area. They were followed by microphylls (30.2%), leptophylls (15.8%), mesophylls (5%) (Table 4). Macrophylls and megaphylls were absent in the area (Tables 3 & 4).

Phenological Behaviour

There were two flowering seasons in the area. One from April to May/June followed by the second from July to October. In the first spell 63.6% species flowered which included 61% shrubs, 65.2% herbs and 63% grasses. In the second 30.3% species flowered. Of them, 30.5% were shrubs, 29.7% herbs and 31% grasses. However, some plants including 8.3% shrubs, 5.9% herbs and 3.7% grasses had relatively constant flowering pattern along the growing season (Fig. 4).

Month of May appeared to be the peak flowering season as 83.3% species were blooming. During April 59% species flowered, while during June, July, August and September respectively 60.4%, 58.2%, 61.8% and 61.9% species were in flowering stage. It declined to 33.9% in October (Fig. 4). The percentage of species in post flowering stage (V_2) remained almost constant from June to September. Majority of the species i.e. 54.8% became dormant during October whereas only 9.7% were dormant in September (Fig. 4).

The only tree species *Juniperus excelsa* flowered from April to May and its fruit matured during September. Usually the berries thereafter remain intact on parent trees for upto two years. Shrubby species had maximum flowering around May 72.4% (Fig. 5)

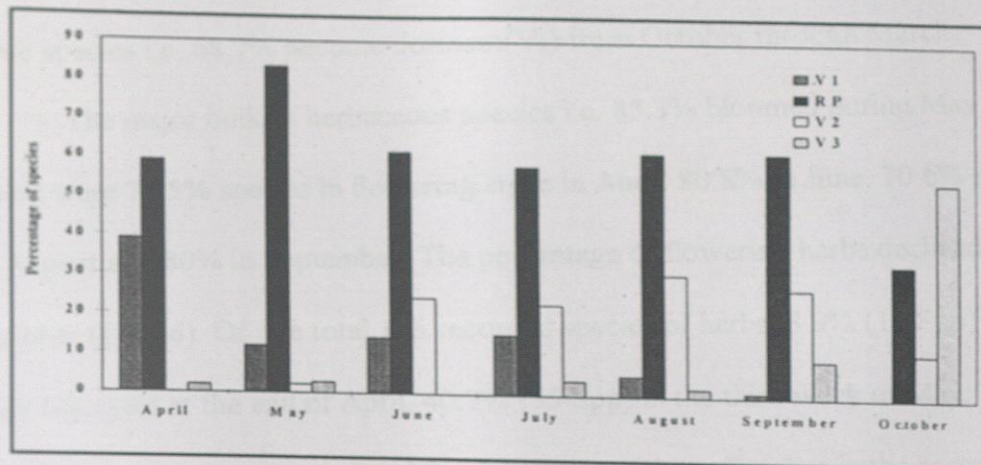


Fig. 4: Phenological pattern of vegetation of Harboi Hills.

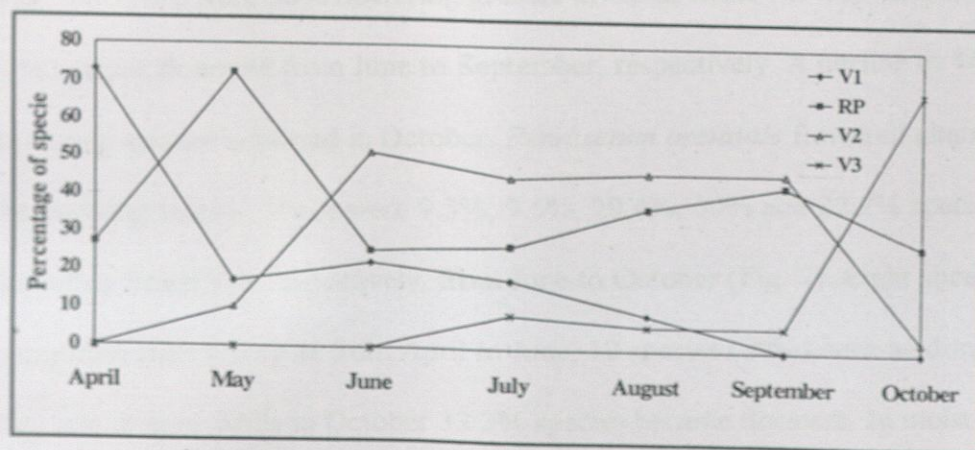


Fig. 5: Phenological behaviour of shrubs.

which decreased to 43.7% towards September. Some 47.7% of shrub species in post flowering stage (V_2) were relatively constant from June to September. The majority of the shrub species i.e. 68.7% become dormant (V_3) from October through March.

The major bulk of herbaceous species i.e. 85.3% bloomed during May (Fig. 6). There were 76.5% species in flowering stage in April, 80.8% in June, 70.6% in July, 75% in August and 80% in September. The percentage of flowering herbs declined to 38.1% in October (Fig. 6). Of the total 135 recorded species of herbs, 8.9% (12 Spp) completed their life cycle at the end of April, 40.7% (55 Spp) in the third week of May. However, 22.9% (31 Spp) completed their life cycle during July to October in the second flowering season (Fig. 6).

Maximum flowering of grass species (90%) was observed during first week of May (Fig. 7). There were 30% flowering grasses in April, while 71.4%, 76.2%, 70.6% and 50% species flowered from June to September, respectively. A decline to 44.4% in the flowering species occurred in October. *Pennisetum oreintale* flowered almost through out the growing season. There were 9.5%, 9.5%, 29.4%, 50% and 22.2% species in the post flowering stage (V_2), respectively, from June to October (Fig. 7). Eight species (26.7%) completed their life cycle from April to June, 10 species (30%) became dormant during July and August while in October 33.3% species became dormant. In moist habitats 16.6% (5 Spp) were in post flowering stage (V_2) in October.

During 1998, the precipitation was comparatively less than in 1997 and weather relatively dry and hot. This influenced the phenological activity and stimulated the flowering. Thus, majority of plants bloomed a month earlier than observed during 1997 and completed their life cycle in early September and become dormant in late September.

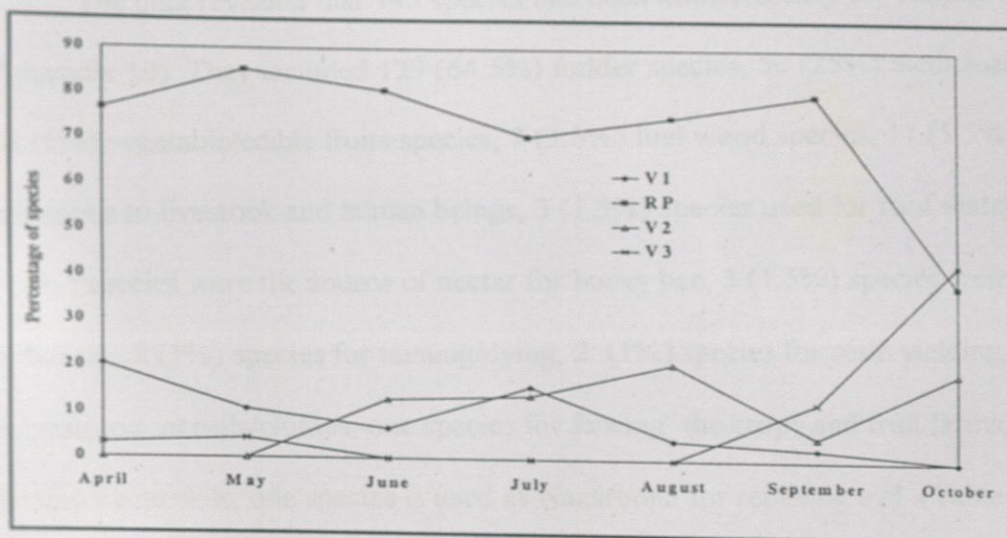


Fig. 6: Phenological behaviour of herbs.

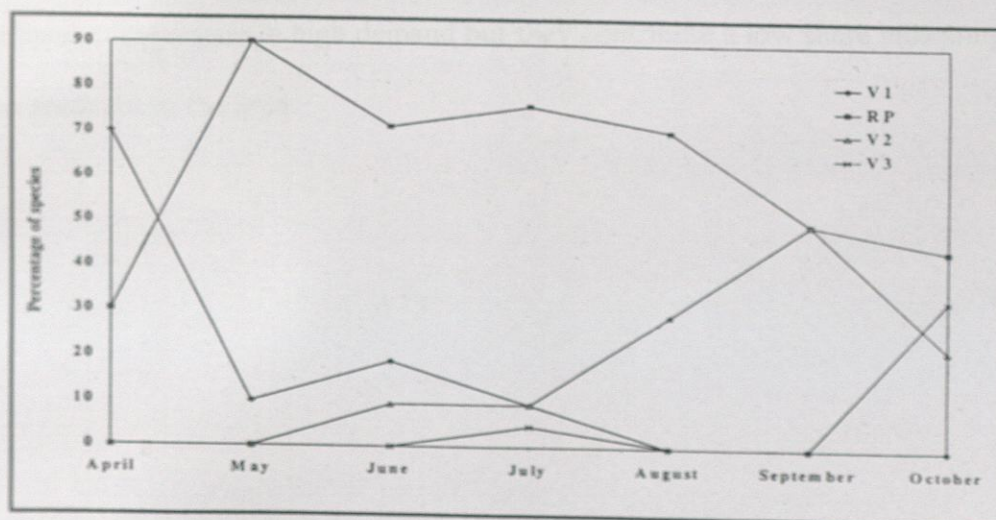


Fig. 7: Phenological behaviour of grasses.

Classification of Plants by Their Local Uses

The data revealed that 145 species had been known locally for various uses (Appendix 19). They included 129 (64.5%) fodder species, 50 (25%) medicinal species, 12 (6%) vegetable/edible fruits species, 7 (3.5%) fuel wood species, 11 (5.5%) species poisonous to livestock and human beings, 3 (1.5%) species used for roof thatching, 2 (1%) species were the source of nectar for honey bee, 3 (1.5%) species were used as herbal tea, 2 (1%) species for tanning/dying, 2 (1%) species for resin yielding, one species for washing utensils/clothes, one species for fencing the crops and fruit farms, one species for making pencils, one species is used as Nazarbund for repelling evil (Table 5). It is evident that most of the plants are used as fodder. It was obvious that the major resources were rangeland plants (64.5%) followed by medicinal plants (25%). Although, timber and fuelwood species are in high demand but they contribute a low share indicating shortage of this resource in the area.

Table 5: Summary of the classification of plants of Harboi Hills on the basis of economic uses

S.No	Economic Uses Classes	No of species	Percentage
1.	Medicinal species	50	25.0
2.	Fodder/forage species	129	64.5
3.	Fuelwood species	7	3.5
4.	Timber wood species	1	0.5
5.	Vegetable/edible fruit species	12	6
6.	Poisonous species	11	5.5
7.	Roof thatching species	3	1.5
8.	Honey bee species	2	1
9.	Tanning/dying species	2	1
10	Resin yielding species	2	1
11	Herbal tea species	3	1.5
12.	Utensil washing species	1	0.5
13.	Evil repellent species	1	0.5
14.	Pencil making species	1	0.5
15.	Fences of crops and orchards	1	0.5

II. Range Vegetation Structure

A. Edaphology

a. Hills

The colour of soils of different communities varied from brown (BPB, BZB, IAP, TJB) to reddish brown (IAT), grey reddish (ASI), yellowish grey (AAB). Soils were generally shallow with 1.2 to 17% weathered material and made up of lime stone or sand stone (Table 6). The texture of soil varied from sand loam, sandy clay loam to clay (in IAT community). Soils were highly calcareous, non saline with moderate to slightly alkaline reaction owing to the presence of bicarbonates in majority of the communities. It ranged from 2.84 to 6.59%. The litter contents varied from less than 1% to 9.3% (under juniper) which depended on the state of erosion and canopy layer. Beneath juniper, 4 - 7 cm thick litter was present. The soil were aggregated in the case of BZB, TJB and compact in the case of ASI and IAT communities.

The pH ranged in between 8.38 to 8.63 among the stands during spring and summer showing almost no change (Table 7). Likewise, E_c varied from as low as 0.52 to 1.27 during both the seasons. There were non-significant differences in both seasons (Table 7).

The water holding capacity was maximum (45 to 47.4%) under Juniper canopy owing to the presence of thick layer of organic matter. Whenever there was less organic matter, the water holding capacity decreased because as was related to organic matter contents. There were non-significant differences in organic matter contents in both the seasons (Table 7).

Nitrogen contents varied from 0.02 to 0.24 among the stands and between the seasons. It was less during summer in (stands 1,2, 3) while it increased slightly in other stands. The differences were non-significant. Calcium carbonate contents varied from as low as 15 to 39% during spring which generally increased during summer season. It ranged from 28 to 55% among the stands. Carbonates were absent in all the sampled stands.

Ca+Mg contents slightly increased during summer. They ranged from 3.09 to 10.37 among the stands and between the seasons (Table 8). Sulphate contents were low in all the stands. They ranged from 0.17 to 1.46 among the stands and between the seasons. SAR varied from 0.65 to 1.6 meq/l and there were non-significant differences among stands and between seasons. Sodium contents were in between 1.21 to 2.26 meq/l during spring while they were 1.02 to 1.3 meq/l during summer. There was slight decrease during summer. Potassium was very high in all the stands. It varied from 95 to 1168.5 during spring while it was 200 to 266.5 during summer. Copper was high in all the plant communities (> 0.5 high). Copper contents slightly decreased during summer. It varied between 1.11 to 2.2 ppm. among the stands and between the seasons. Manganese was also very high in all the plant communities (high > 1.0). It was 5.65 to 16.15 ppm. during spring while 5.1 to 25 ppm. during summer. Iron contents were also very high in all plant communities. It increased during summer and ranged from 6.5 to 17.55 ppm. among stands and between the seasons.

Zinc contents were generally low in soil samples as they were 0.92 to 4.53 ppm during spring and 0.78 to 2.1 ppm. during summer (Table 8).

Table 6: Physical characteristics of soils of different plant communities (Spring Aspect).

S.No.	Plant Communities	Weathered material %	Type	Sand (%)	Clay (%)	Silt (%)	Soil Textural Class	Soil Colour	Litter (%)	Erosion
A - Hills										
1.	BPB	17.00	Limestone	60	19	21	Sandy loam	Brown	1.30	Eroded
2.	BZB	12.30	Limestone	59	19	22	Sandy loam	Brown	9.30	Not eroded
3.	IAP	15.90	Sandstone	67	19	14	Sandy loam	Brown	1.27	Eroded
4.	AAB	1.27	Sandstone	51	33	16	Sandy clay loam	Yellowish grey, reddis	0.00	Highly eroded
5.	ASI	15.00	Sandstone	61	28	11	Sandy clay loam	Grey, reddish brown	1.50	Eroded
6.	IAT	4.90	Sandstone	42	44	14	Clay	Reddish brown	0.78	Highly eroded
7.	TJB	2.58	Limestone	68	22	10	Sandy clay loam	Brown	4 - 7 cm thick layer	Not eroded
B- Water Courses										
1.	APB	Boulder, pebble totally covered the surface	Par limestone	73	19	8	Sandy loam	Brown	1.2	Eroded
2.	PAP	Boulder, pebble partially covered the surface	Black chart	67	22	11	Sandy clay loam	Reddish brown	1.7	Eroded

Key for the communities as given in Tables: 11 & 14.

Table 7: Physical characteristics of soils of different plant communities

S.No. Parameters	Plant Communities											
	BPB	AAS	BZB	LPE	IAP	AIC	AAB	ASI	ASE	IAT	AEA	TJB
	SP	SM	SP	SM	SP	SM	SP	SM	SM	SP	SM	SP
1. pH	8.43	8.48	8.38	8.58	8.42	8.55	8.51	8.59	8.53	8.53	8.56	8.38
2. E.Ce (ds/cm)	0.58	0.59	0.73	0.74	0.60	0.70	0.52	0.70	0.69	0.60	0.65	1.27
3. MWHC (%)	39.25	35.50	43.40	44.00	43.00	38.00	36.30	37.00	43.50	43.20	43.00	45.97
4. O.M.(%)	1.15	0.57	0.45	0.40	1.20	1.03	0.73	0.75	3.25	0.74	1.93	2.69

SP - Spring
SM - Summer

Table 8: Chemical characteristics of soils of different plant communities

S.No Parameters	Plant Communities											
	BPB	AAS	BZB	LPE	IAP	AIC	AAB	ASI	ASE	IAT	AEA	TJB
	SP	SM	SP	SM	SP	SM	SP	SM	SM	SP	SM	SP
1. Nitrogen %	0.06	0.03	0.02	0.02	0.00	0.02	0.04	0.04	0.16	0.04	0.10	0.14
2. CaCO ₃ %	19.00	47.00	15.00	55.00	23.00	33.00	35.00	39.00	29.00	39.00	35.00	26.33
3. HCO ₃ %	3.38	3.57	4.71	3.86	3.21	4.71	3.14	4.40	3.92	3.45	3.14	6.59
4. Ca+Mg (Meq/l)	4.00	5.06	6.19	6.86	4.45	5.67	4.01	5.43	5.79	4.21	5.67	10.34
5. Chloride (Meq/l)	1.71	1.97	2.36	2.37	1.84	1.92	1.92	2.54	2.27	2.18	2.37	4.88
6. SO ₄ (Meq/l)	0.24	0.59	0.64	0.75	0.62	0.17	0.34	0.57	0.81	0.84	1.46	1.11
7. SAR (Meq/l)	0.65	0.65	0.90	0.80	0.80	0.70	1.00	1.30	0.70	1.60	0.80	0.93
8. Na (Meq/l)	1.22	1.02	1.52	1.30	1.42	1.30	1.39	2.10	1.15	2.26	1.20	2.24
9. K (ppm)	1168.50	200.00	211.00	222.00	212.00	244.00	235.00	230.00	250.00	95.00	217.00	167.33
10. Cu (ppm)	1.96	1.14	1.70	1.27	2.20	1.40	1.56	1.30	1.57	1.11	1.50	1.22
11. Mn (ppm)	8.10	9.35	15.30	9.50	5.90	16.20	5.90	11.60	15.10	5.40	5.10	16.15
12. Fe (ppm)	10.90	10.75	16.30	11.10	9.60	10.70	6.50	12.70	11.45	7.50	7.10	11.22
13. Zn (ppm)	1.12	0.90	1.12	1.17	2.48	2.10	1.23	1.62	1.42	0.92	0.78	4.53

SP - Spring
SM - Summer

Key for the communities as given in Tables: 11 & 13.

Water Courses

The colour of soils varied from brown (APB) to reddish brown (PAP community) (Table 18). Soils were generally shallow and loose. The soil surface was covered by boulders/ pebbles. The texture of soil varied from sand loam to sandy clay loam. Soils were highly calcareous, non saline with moderate to slightly alkaline reaction owing to presence of bicarbonates (2.88 to 3.79). There were non-significant differences in both the seasons (Table 9). The litter contents varied from 1.2 to 17%. There was tremendous soil erosion during rainy season.

The pH ranged in between 8.50 to 8.72 among the stands and between the seasons (Table 9). Likewise, E_c varied from as low as 0.5 to 1.4 ds/cm during both seasons. There was non-significant changes in both the seasons (Table 21). The water holding capacity was maximum (38.33%) during summer. It was slightly low during spring as a result of winter rains. It varied from 30.67% to 35.5% during spring season (Table 9). Organic matter contents ranged in between 0.49 to 0.86% among the stands and between the seasons. There were significant changes ($p = 0.05$) in organic matter between the seasons. Nitrogen contents varied from 0.03 to 0.04%. There were not much differences in both seasons (Table 9).

Calcium carbonate contents varied from 45.67% to 57% which slightly decreased during summer seasons. Ca+Mg contents were in between 3.55 to 4.03 with non-significant differences among stands and between seasons. Bicarbonate contents were slightly high during summer. It ranged from 2.88 to 3.95 among stands and between seasons. Sulphate contents decreased during summer. They ranged from 1.63 to 3.84 meq/l during spring and 1.21 to 1.81 meq/l during summer.

Table 9: Physical and chemical characteristics of some selected sites of Water Courses.

S.No.	Parameters	Plant Communities			
		PAB SP	PPP SM	PAP SP	SEP SM
A - Physical Characteristics					
1.	pH	8.50	8.55	8.51	8.72
2.	E.Ce	0.50	0.53	1.40	0.82
3.	MWHC (%)	30.67	38.33	35.50	36.00
4.	O.M.(%)	0.49	0.86	0.64	0.78
B - Chemical Characteristics					
5.	Nitrogen %	0.03	0.04	0.032	0.039
6.	CaCO ₃ %	57.00	45.67	56.000	51.500
7.	HCO ₃ %	2.88	3.05	3.790	3.950
8.	Ca+Mg (Meq/l)	1.63	1.21	3.845	1.810
9.	Chloride (Meq/l)	0.39	0.39	1.560	2.750
10.	SO ₄ (Meq/l)	3.55	3.87	3.620	4.035
11.	SAR (Meq/l)	1.10	0.73	4.055	2.950
12.	Na (Meq/l)	1.45	1.29	7.070	3.680
13.	K (ppm)	82.10	120.67	73.000	123.500
14.	Cu (ppm)	0.96	1.07	1.115	0.815
15.	Mn (ppm)	4.34	6.95	5.250	3.725
16.	Fe (ppm)	5.92	8.52	6.180	5.100
17.	Zn (ppm)	1.07	0.75	0.930	0.835

SP - Spring

SM - Summer

Key for the plant communities as given in Table: 14.

Chloride contents increased during summer. It ranged from 0.39 to 1.56 meq/l during spring while 0.93 to 2.75 during summer. Ca+Mg contents increased slightly during summer. It varied from 3.55 to 4.03 among the stands and between the seasons. SAR decreased during summer. It ranged from 0.73 to 2.95 during summer and 1.1 to 4.05 during spring. Sodium content decreased during summer. It ranged from 1.45 to 7.07 meq/l during spring and 1.29 to 3.68 meq/l during summer. Potassium varied from medium to slightly high range in the area. Potassium content increased during summer. It ranged from 73.0 to 82.10 ppm. during spring and 120.67 to 123.5 ppm. during summer. Copper content was high in wet places. It varied from 0.96 to 1.11 ppm. among the stands and between the seasons. Manganese content was also high as it ranged from 4.34 to 5.25 ppm. during spring and 3.72 to 6.95 ppm. during summer. Iron content was high in both communities. It ranged from 5.1 to 8.52 ppm. Zinc content was very low in both communities in both the seasons. It varied from 0.75 to 1.07 ppm. (Table 9).

B. Vegetational Features

The vegetation was analyzed during spring and summer, 1997, at the same locations. Each aspect is discussed separately. On the basis of cluster analysis seven plant communities were established during both the seasons.

Vegetation of Hills

a. Spring Aspect

There were seven plant communities representing the spring aspect. *Juniperus excelsa*

was the only tree species in all the seven communities. They are detailed as follows:

1. *Bromus - Polygala - Bromus* Community (BPB)

At an altitude of 2240m, *Bromus - Polygala - Bromus* community existed (Appendix 1). Of the 69 recorded species, there were 22 shrubs, 37 herbs and 9 grass species. The total importance value (TIV) contributed by 3 dominants was 46.1 while the remaining species shared a TIV of 253.9. The contribution by tree was 7.4, by shrubs 99.5, by herbs 123.2 and grasses 70.0 (Table 10).

The community had a total cover of 65.4%. The 3 dominant species collectively covered 6.4% while the remaining species exhibited a total cover of 59.1%. The shrub layer shared 32%, herbs 14.4%, grasses 16.6% and *Juniperus* 2.5% (Table 11). Nine shrubs, 38 herbs and one grass species individually had less than 1% cover (Appendix 1).

The dominating status of annual grasses/ herbs was due to their high density in the area. *Bromus sericens* had 62250 individuals/ha, *Polygala sibirica* 36250 and *Bromus tectorum* 34750 (Appendix 1). Frequency was 45% for *Aerua* followed by *Juniperus*, *Artemisia*, *Caragana*, *Daphne*, *Gaillonia* and *Nepeta* (40%). The frequency of herbs and grasses ranged between 5 - 27%.

Few seedlings of *Juniperus* were observed in the rock crevices only. *Ebenus stellata*, *Cymbopogon jawarancusa*, *Spiraea boissieri* and *Eremostachys vicarys* were confined to this community only and therefore exhibited a high fidelity in the area. In addition to these *Mattiastrum asperum*, *Onasma limitaneum* and *Sesili libanotis* were also found in the area.

Therophytic (50.7%) species dominated the community. They were followed by hemicryptophytes (18.8%) and nanophanerophytes (17.4%), while quantitatively therophytic species had 49.9% share, nanophanerophytes 19.3% and hemicryptophytes 17.2% (Fig. 8). The community consisted of nanophylls (59.4%); microphylls and leptophylls were 20.3% and 18.8%, respectively. Quantitatively, nanophylls were 62.5%, while leptophylls and microphylls contributed 19.5% and 17.5%, respectively. Mesophylls were poorly represented (Fig. 9).

2. *Bromus - Zizyphora - Bromus* Community (BZB)

At an altitude of 2300 m, *Bromus - Zizyphora - Bromus* community existed (Appendix 2). Of the 52 recorded species, there were 15 shrubs, 30 herbs and 6 grass species. The total importance value (TIV) contributed by 3 dominants was 50.5% while the remaining species shared a TIV of 249.5. The contribution by tree was 7.1, by shrubs 102.6, herbs 125.6 and by grasses 64.7 (Table 10).

The community had a total cover of 71.9%. The 3 dominant species collectively covered 7.3% while the remaining species exhibited a total cover of 64.6%. The shrub layer shared 36.8%, herb 18.0%, grasses 14.8%, and *Juniperus* 2.3% (Table 11). Seven shrubs and 27 herb species individually had less than 1% cover (Appendix 2).

The dominating status of annual grasses/herbs was due to their high density in the area. *Bromus sericus* had 43500 individuals/ha, *Zizyphora tenuior* 38500 and *Bromus tectorum* 33500 (Appendix 2).

The frequency was high (60%) in case of *Salvia cabulica*, followed by *Convolvulus leiocalycinus*, *Gaillonia eriantha* and *Nepeta juncea* which recorded 50% frequency. Herbs generally had low occurrence. The frequency of herbs and grasses ranged

between 10 - 25%. *Clematis graveolens*, *Erodium cicutarium*, *Hyoscyamus pusillus* and *Trichodesma stocksii* were confined to this community only and, therefore, exhibited a high fidelity in the area.

Therophytic species dominated (51.9%), while nanophanerophytes (15.4%) and hemicryptophytes were also abundant (Fig. 8). Quantitatively, therophytic species were 46.6%, nanophanerophytes were 19.3% and hemicryptophytes were 13.9%.

The community consisted of nanophylls (48.1%), microphylls (38.5%) and leptophylls 13.5%. Quantitatively nanophylls had 50.9%, microphylls 30.5% and leptophylls had 18.6% share (Fig. 9).

3. *Iris - Astragalus - Poa* Community (IAP)

At an altitude of 2400 m., *Iris - Astragalus - Poa* community was identified (Appendix 3). Of the 39 recorded species, there were 14 shrubs, 21 herbs and 3 grass species in this community. The total importance value (TIV) contributed by 3 dominants was 68.3 while the remaining species shared a TIV of 231.8. The contribution by tree was 10.7, by shrubs 107.8, herbs 145.6 and grasses 35.9 (Table 10).

The community had a total cover of 68.7%. The 3 dominant species covered 24.5% while the remaining species exhibited a total cover of 44.2%. The shrub layer shared 36.2%, herbs 20.3%, grasses 8.1% and *Juniperus* 4.1% (Table 11). Three shrubs, 20 herbs and one grass species individually had less than 1% cover (Appendix 3).

The dominating status of grass/herbs was due to their high density in the area. *Poa bulbosa* had 19000 individuals/ha while *Iris tenuifolia* 30500. The high density was also recorded for annual herb (97 - 83) which was 33000 individuals/ha, followed by *Veronica biloba* with 21500 individuals/ha, *Helitropium brahuica* 19500, *Holostem umbellatum*

14500 while *Bromus sericens* had 14000 (Appendix 3).

The frequency was high (60%) for *Astragalus* (97 - 83) which was followed by *Nepeta juncea* (50%). The frequency of herbs and grasses ranged from 10% to 25%. *Asparagus capitatus* was generally confined to shady places beneath the Juniper trees. Few seedlings of *Juniperus* were observed beneath the trees and in the rock crevices.

Therophytic (51.3%) species dominated the community. They were followed by nanophanerophytes (20.5%) and chamaephytes (12.8%). Quantitatively, therophytes had 33.7%, nanophanerophytes 21.5% and hemicryptophytes had 11.8% contribution (Fig. 8).

The community consisted of nanophylls (51.3%), leptophylls (23.1%) and microphylls (20.5%). Quantitative spectrum indicated the same sequence i.e. nanophylls (42.3%), leptophylls (24.1%), microphylls (20.7%), and mesophylls (12.9%) (Fig. 9).

4. *Astragalus - Artemisia - Berberis* Community (AAB)

At an altitude of 2450 m., *Astragalus - Artemisia - Berberis* community was established (Appendix 4). The community had 7 shrubs, 14 herbs and 5 grass species. The total importance value (TIV) contributed by the 3 dominants was 88.5% while the remaining species shared a TIV of 211.5. The contribution by tree was 11.4, by shrubs 118.3, herbs 113.5, and grasses 56.8 (Table 10).

The community had a total cover of 60.2%. The 3 dominant species covered 31.7%, while the remaining species exhibited a total cover of 28.5%. The shrub layer shared 37.1%, herbs 9.4%, grasses 10.5% and *Juniperus* 2.8% (Table 11). The 2 shrubs, 12 herbs and one grass species individually had less than 1% cover (Appendix 4).

Annual herbs exhibited highest density. *Veronica biloba* had 14500 individuals/ha, *Polygala hohenacheriana* had 13000 individuals/ha, *Ceratocephalla testiculata* had 12500 individuals/ha, while *Shismus arabicus* had 11000 individuals/ha (Appendix 4).

Astragalus had the higher (90%) frequency, followed by *Artemisia* (50%). Herbs and grasses had (10 - 20%) frequency. *Melia persica* gradually gained dominance in this site.

Therophytic species were dominant (29.6%), they were followed by geophytes (22.2%) and nanophanerophytes (18.5%). While quantitatively, therophytes had 29.1%, nanophanerophytes 20.0%, chamaephytes 14.3% and geophytes had 13.9% share (Fig. 8). The community consisted of nanophylls and microphylls (each with 33.3%), while leptophylls were 25.9%. Quantitatively, nanophylls had 37.4%, microphylls 28.8% and leptophylls 26.1% contribution. Mesophylls were poorly represented (Fig. 9).

5. *Artemisia - Sophora - Iris* Community (ASI)

At an altitude of 2500 m., *Artemisia - Sophora - Iris* community (Appendix 5) consisted of 13 shrubs, 20 herbs and 3 grass species. The total importance value (TIV) contributed by 3 dominants was 110.6, while the remaining species shared a TIV of 189.4. The contribution by tree was 15.0, shrubs 120.8, herbs 124.5 and grasses 39.8 (Table 10).

The community had a total cover of 53.9% including 32.6% by the 3 dominant species. The remaining species exhibited a total cover of 21.3%. The shrub layer shared 33.8%, herbs 12.9%, grasses 3.6% and *Juniperus* 3.7% (Table 11). Ten shrubs, 19 herbs and 3 grass species individually contributed less than 1% cover (Appendix 5).

Annual species exhibited high density. *Polygala hohenacheriana* had 19250 individuals/ha, *Bromus sericuens* 18725, *Iris tenuifolia* had 17750 and *Bromus tectorum* 13312 (Appendix 5).

Sophora griffithii had 70% frequency while *Juniperus* and *Astragalus* 60%, and *Artemisia* exhibited 50% frequency. The frequency of herbs and grasses ranged in between 5 - 30% (Appendix 5). *Asparagus capitatus* and *Orobancha cernua* were confined to beneath Juniper tree. *Fritilaria* and *Bongardia* were sporadically distributed.

Thero-nanophanerophytic species dominated (each with 24.3%), followed by hemicryptophytes (20.0%) and geophytes (16.2%). Quantitatively, therophytic species were 24.0%, chamaephytes 21.1%, nanophanerophytes 20.0%, geophytes 17.0% and parasitic species 2.7% (Fig. 8).

The community consisted of nanophylls (45.9%), microphylls (35.1%) and leptophylls (13.5%). On quantitative basis, nanophylls (43.2%), leptophylls (29.1%), microphylls (16.6%) and mesophylls (11.0%) were important (Fig. 9).

6. *Iris - Astragalus - Tulipa* Community (IAI)

At a height of 2600 m., *Iris - Astragalus - Tulipa* community was identified (Appendix 6). It composed of 12 shrubs, 9 herbs and one grass species. The total importance value (TIV) contributed by 3 dominants was 79.8, while the remaining species share a TIV of 220.3. The contribution by tree was 19.2, by shrubs 122.5, herbs 141.1 and grasses 17.3 (Table 10).

The community had a total cover of 82.8%. The 3 dominant species covered 20.9%, while the remaining species contributed a total cover of 61.9%. The shrub layer shared 47.2%, herbs 22.5%, grasses 6.4% and *Juniperus* 6.7% (Table 11). Four shrubs

and 2 herb species individually had less than 1% cover (Appendix 6).

The dominating status of herbs was due to their high density in the area. *Iris tenuifolia* had 26000 individuals/ha, *Tulipa polychroma* (seedlings) 21500, followed by *Psammogeton* and *Perovskia* (seedlings) which had 1300 individuals/ha. Few seedlings of *Juniperus* were also observed beneath the trees.

Juniperus had 60% frequency. It was followed by *Astragalus* (cussion), *Astragalus psilocentros* and *Psammogeton* each with 40% frequency. The remaining species had 10 - 30% frequency (Appendix 6). *Psammogeton* sp was confined to this community only and therefore exhibited a high fidelity in the area while *Tragopogon gracillis* was confined to comparatively wet places.

Geo-Chamaephytic species dominated (each with 26.1%), they were followed by nanophanerophytes (21.7%). Quantitatively, geophytes were 33.4%, chamaephytes 24.8% and nanophanerophytes 15.8% (Fig. 8).

The community consisted of nano-microphylls (34.8%), leptophylls (17.4%) and mesophylls (13.0%). On quantitative basis microphylls were 29.7%, nanophylls were 27.2% and leptophylls were 24.4%, while mesophylls were 18.2% (Fig. 9).

7. *Tulipa* - *Juniperus* - *Bromus* Community (TJB)

At a height of 2650 m., *Tulipa* - *Juniperus* - *Bromus* community was present (Appendix 7). There was one tree species, 18 shrubs, 36 herbs and 5 grass species at the site. The total importance value (TIV) contributed by 3 dominants was 57.0 while the remaining species shared a TIV of 243.0. The contribution by tree was 20.9, by shrubs 83.6, herbs 155.7 and grasses 39.9 (Table 10).

The community had a total cover of 84.9% including 19.9% by 3 dominant species. The remaining species exhibited a total cover of 64.2%. The shrub layer shared 34.4%, herbs 29.0%, grasses 9.2% and *Juniperus* 11.5% (Table 11). Seven shrubs, 27 herbs and one grass species individually had less than 1% cover (Appendix 7).

The dominance of *Tulipa polychroma* (seedlings) was due to their high density. It had 80250 individuals/ha, followed by *Bromus sericens* who had 44937 individuals/ha, *Neslia apiculata* 24250, while *Bromus tectorum* had 20000 (Appendix 7).

Juniperus exhibited 70% frequency which was followed by 50% occurrence in the case of *Astragalus* (cushion) and *Onobrychis cornuta*. *Artemisia maritima* and *Gypsophila lignosa* had 45% frequency. The remaining species had 5 - 35% frequency in the area.

Rosa lacerans, *Achillea santolina*, *Cuminum cyminum*, and *Astragalus gompholobium* were confined to this community only and, therefore, had high fidelity. In addition to these *Lonicera hypaleuca*, *Androsace* spp, *Isatis emarginata*, *Lithospermum arvensis* and *Anemone tschernfaowii* were found in this site.

Therophytic species dominated (43.3%). They were followed by hemicryptophytes (16.7%) and chamaephytes (15%). On basis of quantitative analysis, therophytes were 35.9%, chamaephytes 17.2%, and geophytes 15.6% (Fig. 8). The community consisted of nanophylls (50%), leptophylls (26.7%) and microphylls (16.7%). While quantitatively, nanophylls (45.1%), leptophylls (27.9%), mesophylls (14.5%) and microphylls (12.5%) were important (Fig. 9).

Table 10: Showing the number of component species and their share in Total Importance Value of spring communities.

	BPB	BZB	IAP	AAB	ASI	IAT	TJB
Total Species	69.0	52.0	39.0	27.0	37.0	23.0	60.0
I-Tree	1.0	1.0	1.0	1.0	1.0	1.0	1.0
II-Shrubs	22.0	15.0	14.0	7.0	13.0	12.0	18.0
III-Herbs	37.0	30.0	21.0	14.0	20.0	9.0	36.0
IV-Grasses	9.0	6.0	3.0	5.0	3.0	1.0	5.0
Total IV contributed by 3 dominant	46.1	50.5	68.3	88.5	110.6	79.8	57.0
II-By remaining species	253.9	249.5	231.8	211.5	189.4	220.3	243.0
III-By Tree	7.4	7.1	10.7	11.4	15.0	19.2	20.9
IV-By Shrubs	99.5	102.6	107.8	118.3	120.8	122.5	83.6
V-By Herbs	123.2	125.6	145.6	113.5	124.5	141.1	155.7
VI-By Grasses	69.9	64.7	35.9	56.8	39.8	17.3	39.9

Table 11: The Total cover (%) and share by various groups of species in the spring communities

	BPB	BZB	IAP	AAB	ASI	IAT	TJB
Total cover	65.4	71.9	68.7	60.2	53.9	82.8	84.1
By 3 dominants	6.4	7.3	24.5	31.7	32.6	20.9	19.9
By remaining species	59.1	64.6	44.2	28.5	21.3	61.9	64.2
By trees	2.5	2.3	4.1	2.8	3.7	6.7	11.5
By shrubs	32.0	36.8	36.2	37.1	33.8	47.2	34.4
By herbs	14.4	18.0	20.3	9.4	12.9	22.5	29.0
By grasses	16.6	14.8	8.1	10.8	3.6	6.4	9.2

Key:

BPB: *Bromus - Polygala - Bromus* community

BZB: *Bromus - Zizyphora - Bromus* community

IAP: *Iris - Astragalus - Poa* community

AAB: *Astragalus - Artemisia - Berberis* community

ASI: *Artemisia - Sophora - Iris* community

IAT: *Iris - Astragalus - Tulipa* community

TJB: *Tulipa - Juniperus - Bromus* community

Raunkiaarian

Quantitative

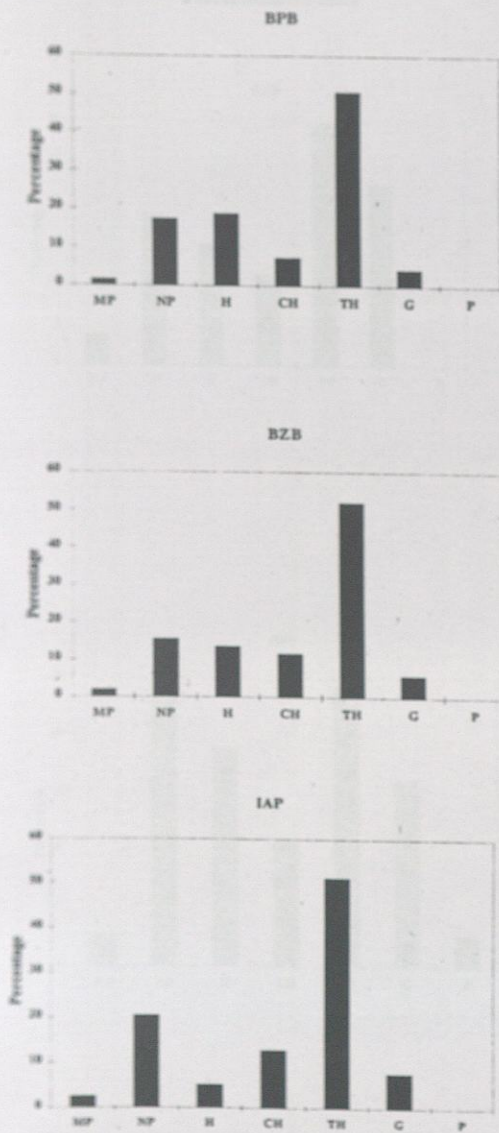
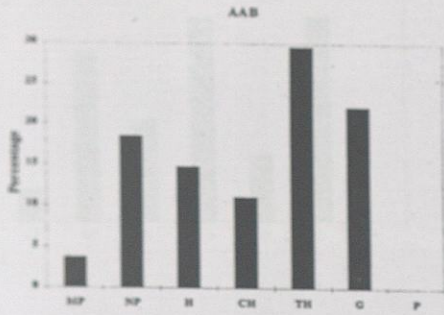


Fig. 8 Life form spectra of spring communities.

Raunkiaarian



Quantitative

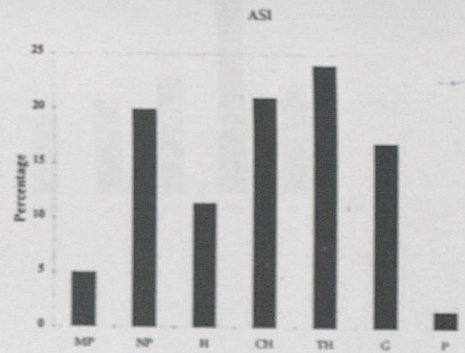
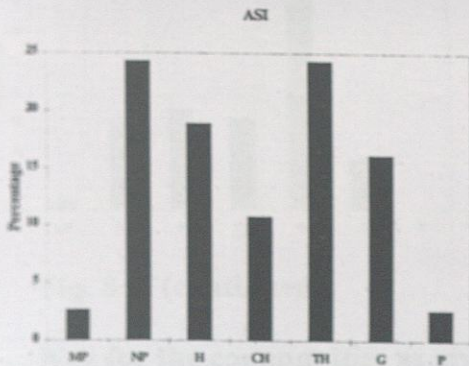
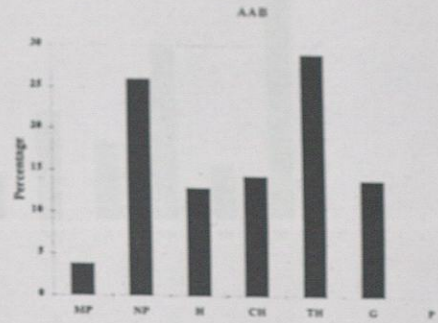


Fig. 8 (continued)

Raunkiaarian

Quantitative

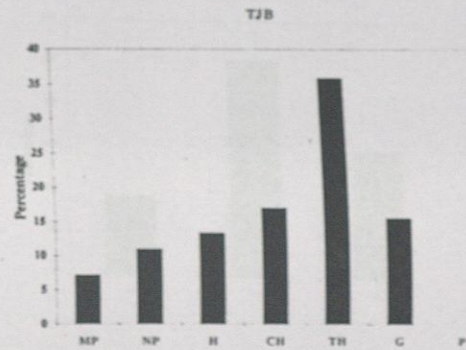
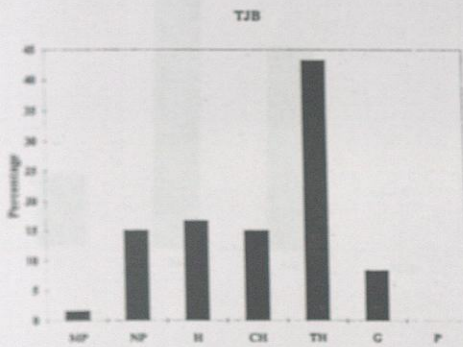
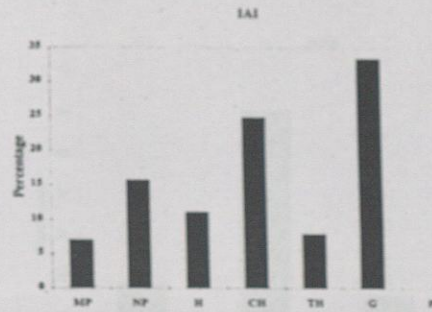
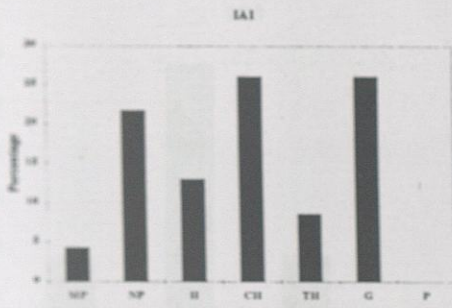


Fig. 8 (continued)

Key for the communities as given Table: 10.
Key for life form as given in Table: 3.

Raunkiaerian

Quantitative

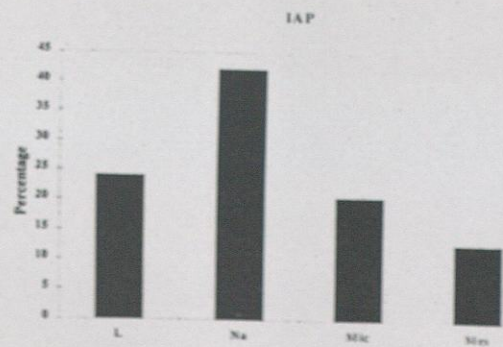
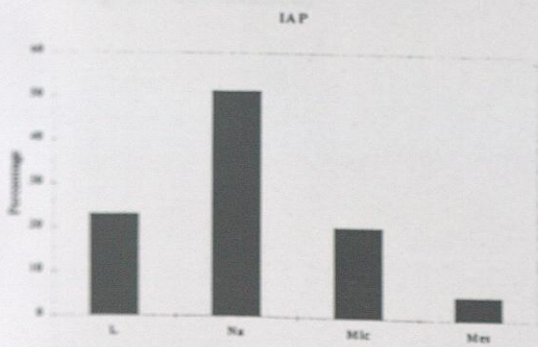
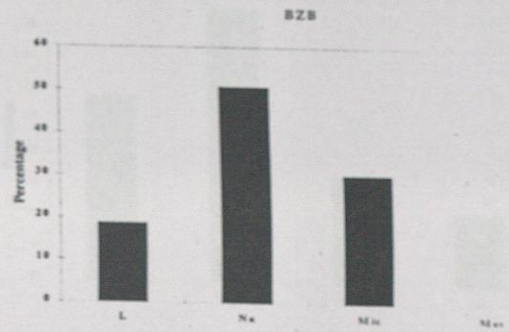
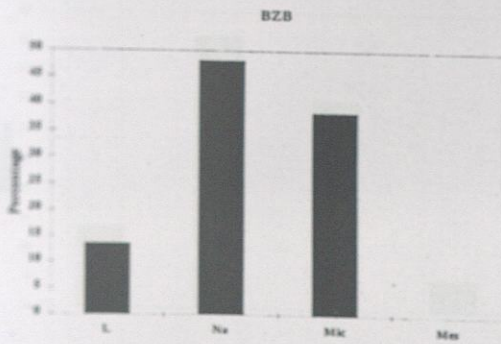
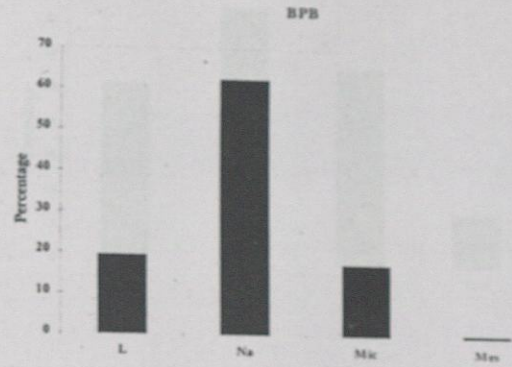
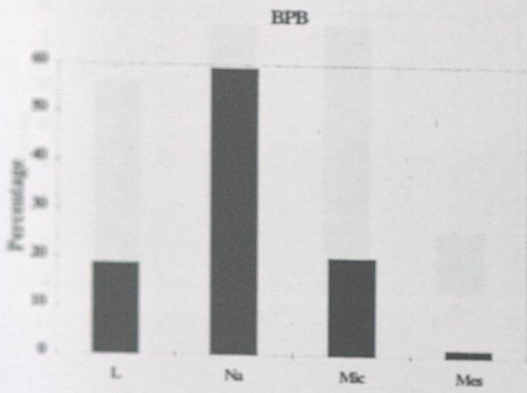
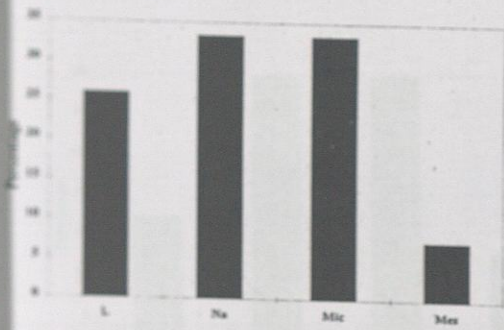


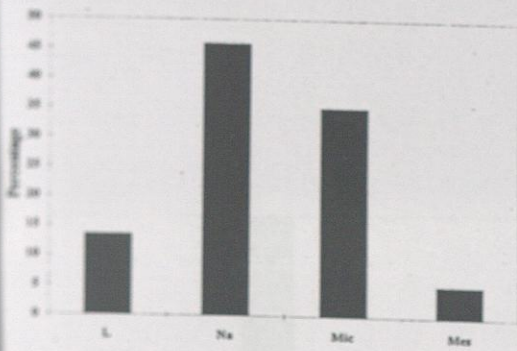
Fig. 9 Leaf size spectra of spring communities.

Raunkiaerian

AAB

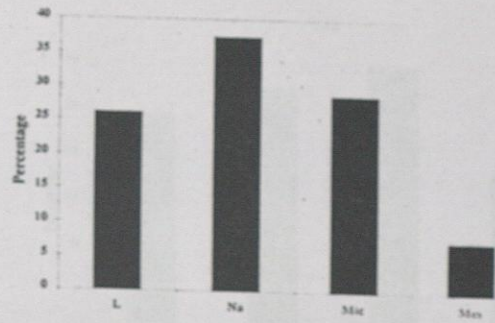


ASI



Quantitative

AAB



ASI

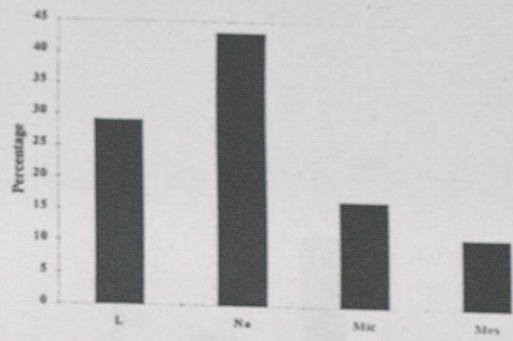


Fig. 9 (continued)

Raunkiaerian

Quantitative

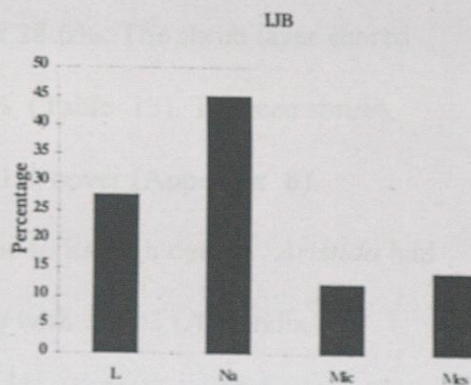
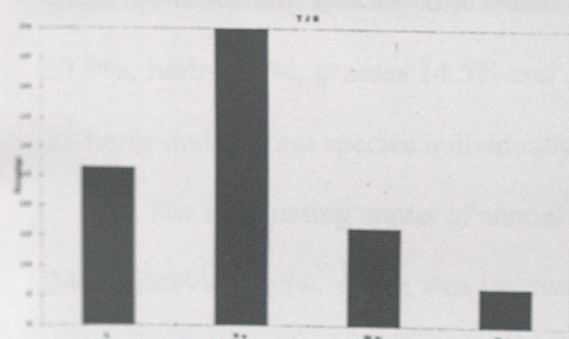
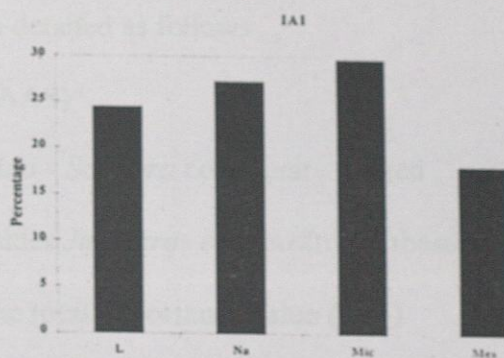
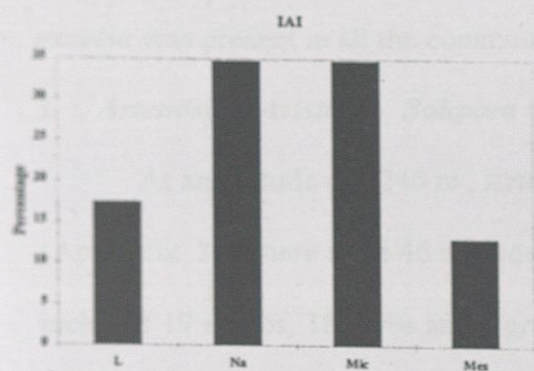


Fig. 9 (continued)

Key for the communities as given in Table: 10.

Key for leaf size spectra as given in Table: 3.

b. Summer Aspect

There were seven plant communities representing the summer aspect. *Juniperus excelsa* was present in all the communities. They are detailed as follows:

1 . *Artemisia - Aristida - Sophora* Community (AAS)

At an altitude of 2240 m., *Artemisia - Aristida - Sophora* community existed (Appendix 3). There were 46 recorded species. Besides *Juniperus excelsa* (tree), these included 19 shrubs, 18 herbs and 8 grass species. The total importance value (TIV) contributed by 3 dominants was 116.1. The remaining species shared a TIV of 183.9. The contribution by tree was 8.8, by shrubs 128.6, herbs 91.8 and grasses 70.7 (Table 12).

The community had total cover of 57.2%. The 3 dominant species shared 28.6%, while the remaining species contributed a total cover of 28.6%. The shrub layer shared 33.9%, herbs 6.3%, grasses 14.5% and *Juniperus* 2.5%. (Table 13). Thirteen shrubs, 21 herbs and 3 grass species individually had less than 1% cover (Appendix 8).

The dominating status of annual grasses was due to its high density. *Aristida* had 24688 individuals/ha. which was followed by *Artemisia* with 17593 (Appendix 8).

Artemisia had 80% frequency, followed by *Sophora* (65%) and *Haloxylon* (55%). The remaining species had 5 to 45% frequency. *Scutellaria stocksii* was restricted to rock crevices. *Teucrium stocksiamm* was confined to this community only and therefore exhibited a high fidelity in the area.

Therophytic species dominated (30.4%), followed by hemicryptophytes (28.3%) and nanophanerophytes (26.1%) of the area. Quantitatively, therophytes were 28.2%, chamaephytes 24.6%, hemicryptophytes 23.3% and nanophnerophytes 20.0% (Fig. 10). The community consisted of 47.8% nanophylls, 32.6% microphylls and 10.9% leptophylls.

While quantitatively there were 48.1% nanophylls, 27.2% leptophylls and 17.1% microphylls (Fig. 10).

2. *Leptorhabdos - Pulicaria - Euphorbia* Community (LPE)

Leptorhabdos - Pulicaria - Euphorbia community existed at an altitude of 2300 m. (Appendix 9). There were 28 recorded species, besides *Juniperus excelsa* (tree), these included 16 shrubs, 9 herbs and 2 grass species. The total importance value (TIV) contributed by 3 dominants was 81.0, while the remaining species shared a TIV of 219.1. The contribution by tree was 9.2, by shrubs 119.4, by herbs 142.8 and grasses 28.8 (Table 12).

The community had a total cover of 43.7%. The 3 dominant species covered 7.5%, while the remaining species exhibited a total cover of 36.2%. The shrub layer shared 23.4%, herbs 12.2%, grasses 5.8% and *Juniperus* 2.3% (Table 13). Eight shrubs, 5 herbs and one grass species individually covered less than 1% cover.

The dominating status of annuals/herbs was due to their high density in the area. *Leptorhabdos* had 19375 individuals/ha, *Euphorbia* 16375, *Pulicaria* 10000. *Artemisia* and *Nepeta* recorded 60% frequency. It was followed by *Sophora*, *Leptorhabdos* and *Pulicaria* with 50% occurrence (Appendix 9). The remaining species had (20 - 40%) frequency. *Clematis graveolens* was confined to this site only and therefore exhibited a high fidelity in the area. In addition to these *Kochia stellaris* was found in this area.

Nanophanerophytic species dominated (35.7%). They were followed by hemicryptophytic (32.1%) and chamaephyte (17.9%). Quantitatively, hemicryptophytes were 37.4%, nanophanerophytes 23.5%, and therophytes 21.6% (Fig. 10). The community consisted of nanophylls (50%), microphylls (35.71%), and leptophylls

(14.3%). Quantitatively, nanophylls (46.6%), microphylls (41.1%) and leptophylls 12.3% were important (Fig. 11).

3. *Astragalus - Iris - Crepis* Community (AIC)

Astragalus - Iris - Crepis community was identified at an altitude of 2400 m. (Appendix 10). Besides *Juniperus excelsa* (tree) there were 13 shrubs, 10 herbs and one grass species. The total importance value (TIV) contributed by the 3 dominants was 100.3. While the remaining species shared a TIV of 199.7. The contribution by tree was 13.6, by shrubs 116.4, by herbs 149.7 and by grasses 20.3 (Table 12).

The community had a total cover of 56.7% including 26.9% by the 3 dominants species. The remaining species exhibited a total cover of 29.8%. The shrub layer shared 32.0%, herbs 18.6%, grasses 2% and *Juniperus* 4.1% (Table 13). Nine shrubs, 4 herbs and one grass species individually had less than 1% cover (Appendix 10).

The dominance of *Iris* and *Crepis* was due to high density in the stand as they had 15312 and 14000 individuals/ha, respectively. They were followed by *Eremurus persicus*, (12000 individuals/ha) and *Asteriscus pygmaeus* (10687 individuals/ha). *Astragalus* had 70% frequency. It was followed by *Artemisia* with 50% frequency. The rest of species had a frequency from 10 to 40% in the site. *Clematis orientalis*, *Artemisia tournefortiana*, *Isodon rugosus* and *Salsola kali* were found in this area.

Nanophanerophytic species dominated (32%) the stand. They were followed by chamaephytes (24%), hemicryptophytes and therophytes (each with 16%). Quantitatively, nanophanerophytes were 30.9%, therophytes 18%, geophytes 17.4%, and chamaephytes 15.4% (Fig. 10). The community consisted of nanophylls (60%), microphylls (20%) and

mesophylls (12%). While quantitatively there were 54.1% nanophylls, 18.2% mesophylls and 14.9% microphylls (Fig. 11).

4. *Astragalus - Sophora - Iris* Community (ASI)

At an altitude of 2450 m., *Astragalus - Sophora - Iris* community had 15 species (Appendix 11). Besides *Juniperus excelsa* there were 7 shrubs, 6 herbs and one grass species. The total importance value (TIV) contributed by 3 dominants was 135.5. The remaining species shared a TIV of 164.5. The contribution by tree was 12.7, by shrubs 128.8, herbs 125.5 and grasses 33.0 (Table 12).

The community had a total cover of 55.6%. The 3 dominant species covered 33.3% while the remaining species exhibited a total cover of 22.3%. The shrub layer shared 32.3%, herbs 17.4%, grasses 3.2% and *Juniperus* 2.8% (Table 13). Three shrubs and 2 herbs individually had less than 1% cover (Appendix 11).

Iris dominated due to its high population as it had 20937 individuals/ha in the community. The high density was also recorded for *Melica persica* with 26000, *Sophora griffithii* 19812, while *Causinia heterophylla* and *Euphorbia porstrata* had 18687 individuals/ha (Appendix 11).

Astragalus had 90% frequency, which was followed by *Artemisia* and *Sophora* 70% frequency. The rest of the species had 10 - 40% frequency (Appendix 11).

Nanophanerophytic species were dominant (35.3%). They were followed by hemicryptophytes (20%), chamaephytes, therophytes and geophytes (each with 13.3%). Quantitatively, nanophanerophytes were (39.6%), geophytes (16.2%), therophytes (15.5%), hemicryptophytes (13.9%) (Fig. 10). The community consisted of nanophylls (46.7%), leptophylls and microphylls (each with 20%), and mesophylls (13.1%).

Quantitatively, nanophylls were (44.4%), leptophylls (21.4%), mesophylls (17.3%) and microphylls (16.9%) (Fig. 11).

5. *Artemisia - Sophora - Eragrostris* Community (ASE)

Artemisia - Sophora - Eragrostris community was established at 2500 m.

(Appendix 12). There were 12 shrubs, 12 herbs, and one grass species (Table 12). The total importance value (TIV) contributed by the 3 dominants was 122.6, while the remaining species shared a TIV of 177.4. The contribution by tree was 14.5, by shrubs 127.9, herbs 129.9 and grasses 27.8 (Table 12).

The community had a total cover of 54.4%. The 3 dominants had 30.7% cover, while the remaining species provided a total cover of 24.2%. The shrub layer shared 37.5%, herbs 12.4%, grasses 0.7% and *Juniperus* 3.7% (Table 13). Six shrubs, 8 herbs and one grass species individually had less than 1% cover (Appendix 12).

The dominating status of annual grass *Eragrostris minor* was due to their high density. It had 27000 individuals/ha. It was followed by *Crepis sancta* 20000 individuals/ha, *Sophora griffithii* 17875, *Iris* 15656, while *Asteriseus pygmacus* and *Perovskia abrotanoides* (seedlings) had 11656 individuals/ha.

Artemisia had 85% frequency. It was followed by *Juniperus* and *Eremerus* 50% frequency. The remaining species had 10 - 40% frequency. *Asparagus capitatus* was confined to shady place, beneath the Juniper tree.

Nanophanerophytic species dominated (34.6%), followed by therophytic (23.1%) and hemicryptophytes (19.2%). Quantitatively, nanophanerophytes were 30.7%, therophytes were 24.2% and chamaephtes were 19.2% (Fig. 10). The community

consisted of nanophylls 46.2%, microphylls 30.8%, leptophylls 15.4%. Quantitatively, nanophylls were 34%, microphylls 30.4%, while leptophylls were 27.6% (Fig. 11).

6. *Artemisia - Eragrostris - Asteriscus* Community (AEA)

Artemisia - Eragrostris - Asteriscus community was composed of 21 species at 2600 m. (Appendix 13). It included 13 shrubs, 6 herbs, one grass and tree species (Table 12). The total importance value contributed by 3 dominants and remaining species was 112.7 and 187.3, respectively. The contribution by tree was 177, by shrubs 130.0, by herbs 113.3 and by grasses 39.0 (Table 12).

A total cover of 67.2% is shared by the 3 dominants (22.9%) and other species (44.3%). The shrub layer shared 42.4%, herbs 16.9%, grasses 1.2% and *Juniperus* 6.7% (Table 13). Five shrubs, 3 herb species individually had less than 1% cover (Appendix 13).

Eragrostris dominated due to its high population of 44000 individuals/ha. It was followed by *Asteriscus* with 25312 and *Iris* 2068.

Asteriscus had 80% frequency. It was followed by *Artemisia* with 70% frequency. *Juniperus*, *Sophora* and *Eragrostris*, each had 60% and *Nepeta* had 50% frequency. The rest of species had 20 - 40% frequency (Appendix 13).

Nano-chamaephytic species dominated (each with 28.6%). They were followed by hemicryptophyte (19.1%). Quantitatively, therophytes were 23.2%, chamaephytes 22.5%, nanophanerophytes 17.9% and hemicryptophytes were 16.7% (Fig. 10). The community consisted of 52.4% nanophylls, 23.8% microphylls and 14.3% leptophylls. On the

quantitative basis, 53.3% nanophylls, 21.9% leptophylls, while 13.8% mesophylls (Fig. 11).

7. *Leptorhabdos* - *Juniperus* - *Zizyphora* Community (LJZ)

Leptorhabdos - *Juniperus* - *Zizyphora* community was present between altitudes of 2650 to 2750 m. (Appendix 14). It had 15 shrubs, 19 herbs and one grass species. The total importance value (TIV) was shared by 3 dominants (77.0) and the remaining species (223.0). The contribution by tree was 25.4, by shrubs 111.2, by herbs 160.3 and by grasses 3.2 (Table 12).

The 3 dominant species covered 19.9%, while the remaining species exhibited a total cover of 50.4%. The shrub layer shared 37.6%, herbs 20.7%, grasses 0.6% and *Juniperus* 11.5% (Table 13). Four shrubs, 13 herbs and one grass species individually had less than 1% cover (Appendix 14).

Leptorhabdos dominated due high population of 18000 individuals/ha. It was followed by *Zizyphora* with 9656 individuals/ha. and *Euphorbia prostrata* had 9000 (Appendix 14).

Juniperus had 70% frequency. It was followed by *Leptorhabdos* (50%), *Artemisia* and *Astragalus* (cushion) each with 45%. The remaining species had 5 - 40% frequency (Appendix 14). *Rosa lacerans*, *Neslia apiculata*, *Psammogeton* and *Ceniza bonartensis*, *Astragalus gompholobium* were confined to this community only and therefore exhibited a high fidelity in the area. In addition to these *Artemisia tournefortiana* and *Nepeta spp* were found in this area.

Therophytic species dominated (25%), they were followed by hemicryptophytes and chamaephytes (each with 22.2%), while nanophanerophytes were 19.4%.

Table 12: Showing the number of component species and their share in total Total Importance Value of various summer communities.

	AAS	LPE	AIC	ASI	ASE	AEA	LJZ
Total Species	46.0	28.0	25.0	15.0	26.0	21.0	36.0
I-Tree	1.0	1.0	1.0	1.0	1.0	1.0	1.0
II-Shrubs	19.0	16.0	13.0	7.0	12.0	13.0	15.0
III-Herbs	18.0	9.0	9.0	6.0	12.0	6.0	19.0
IV-Grasses	8.0	2.0	2.0	1.0	1.0	1.0	1.0
Total IV contributed by 3 dominant	116.1	81.0	100.3	135.5	122.6	112.7	77.0
II-By Remaining species	183.9	219.1	199.7	164.5	177.4	187.3	223.0
III-By Tree	8.8	9.2	13.6	12.7	14.5	17.7	25.4
IV-By Shrubs	128.6	119.4	116.4	128.8	127.9	130.0	111.2
V-By Herbs	91.8	142.8	149.7	125.5	129.9	113.3	160.3
VI-By Grasses	70.7	28.7	20.3	33.0	27.8	39.0	3.2

Table 13: Total cover (%) and share by the component species of summer communities.

	AAS	LPE	AIC	ASI	ASE	AEA	LJZ
Total cover	57.2	43.7	56.7	55.6	54.4	67.2	70.3
By 3 dominants	28.6	7.5	26.9	33.3	30.2	22.9	19.9
By remaining species	28.6	36.2	29.8	22.3	24.2	44.3	50.4
By trees	2.5	2.3	4.1	2.8	3.7	6.7	11.5
By shrubs	33.9	23.4	32.0	32.3	37.5	42.4	37.6
By herbs	6.3	12.2	18.6	17.4	12.4	16.9	20.7
By grasses	14.5	5.8	2.0	3.2	0.7	1.2	0.6

Key:

- AAS: *Artemisia - Aristida - Sophora* community
 LPE: *Leptorhabdos - Pulicaria - Euphorbia* community
 AIC: *Astragalus - Iris - Crepis* community
 ASI: *Astragalus - Sophora - Iris* community
 ASE: *Artemisia - Sophora - Astragalus* community
 AEA: *Artemisias - Eragrostris - Asteriscus* community
 LJZ: *Leptorhabdos - Juniperus - Zizyphora* community

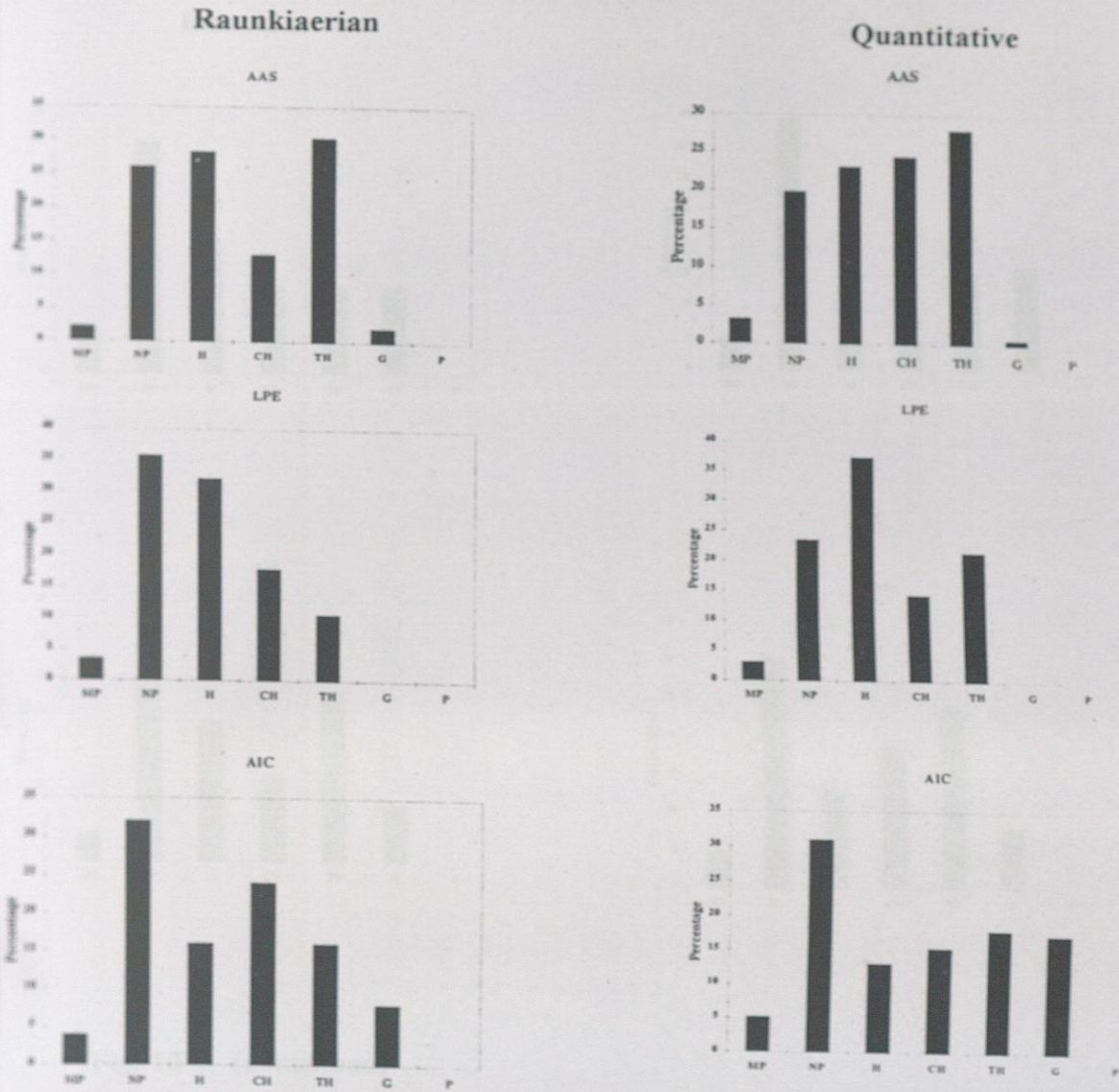
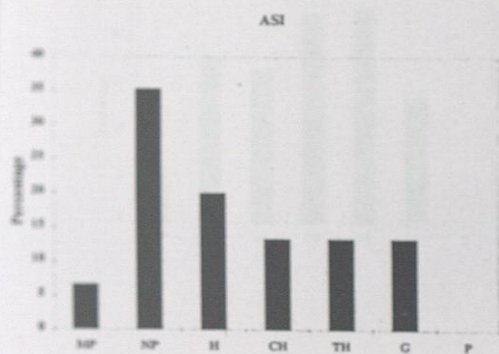


Fig. 10 Life form spectra of summer communities.

Raunkiaerian



Quantitative

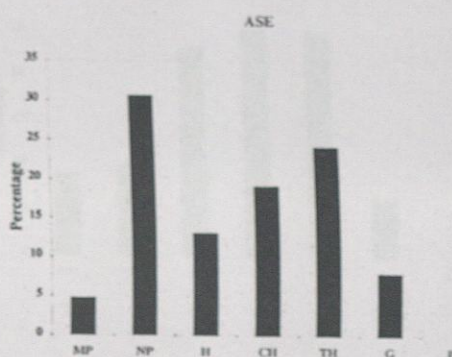
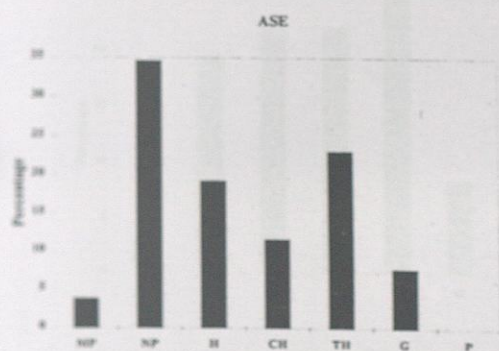
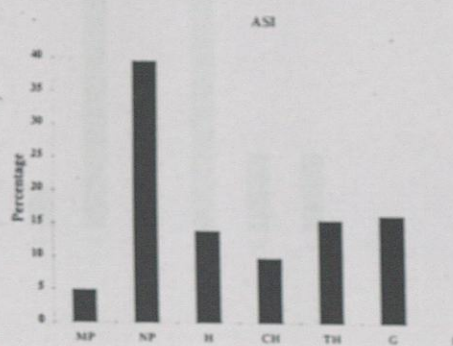


Fig. 10 (continued)

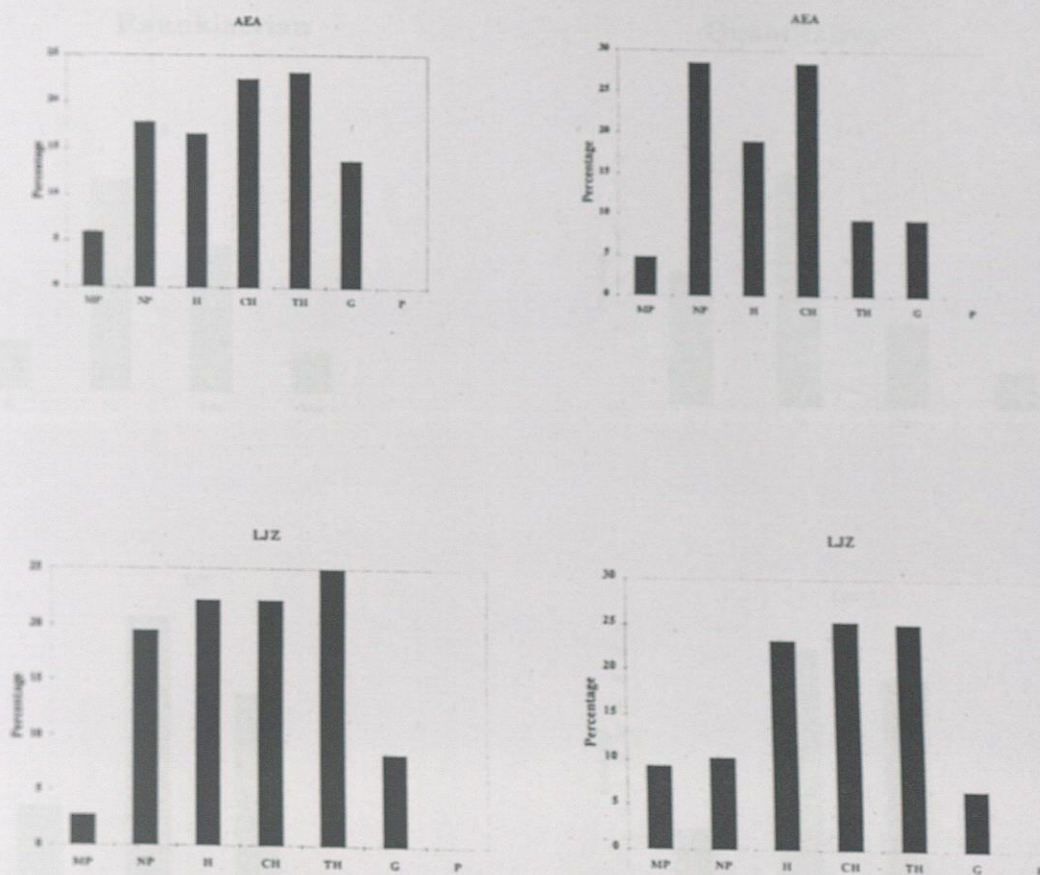


Fig. 10. (Continued).

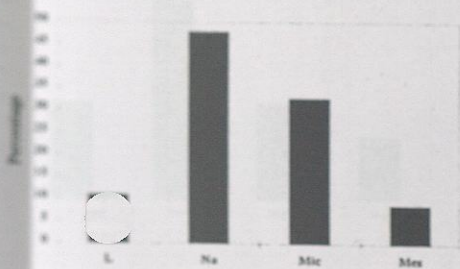
Key for communities as given in Table: 13.

Key for life form as given in Table: 3.

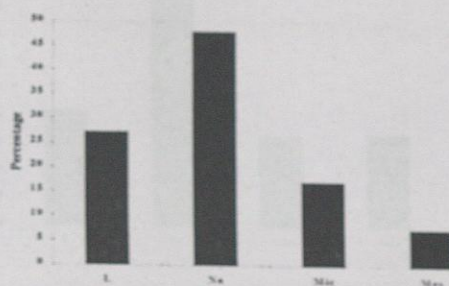
Raunkiaerian

Quantitative

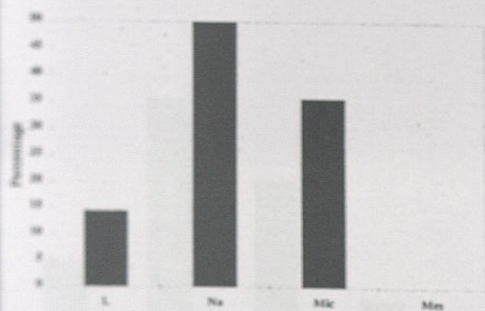
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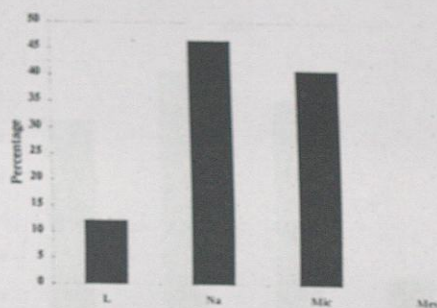
AAS



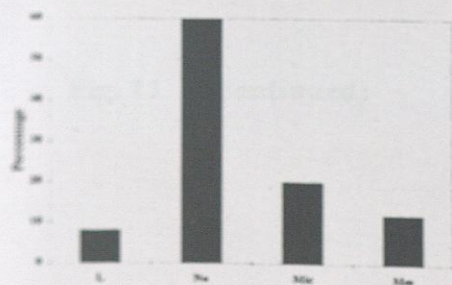
LPE



LPE



AIC



AIC

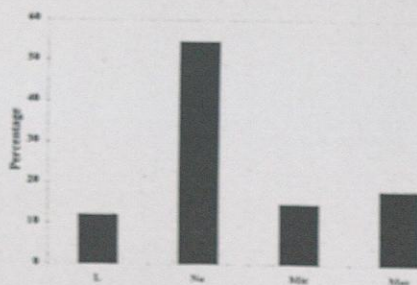
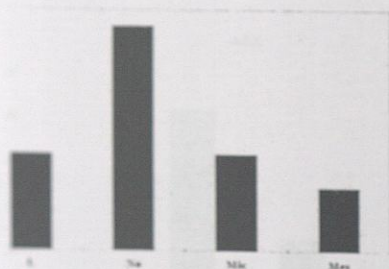


Fig. 11 Leaf size spectra of summer communities.

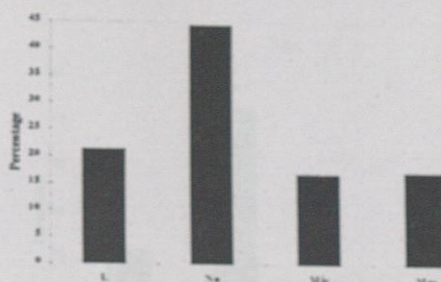
Raunkiaerian

ASI

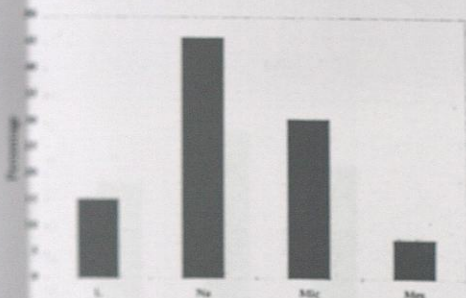


Quantitative

ASI



ASE



ASE

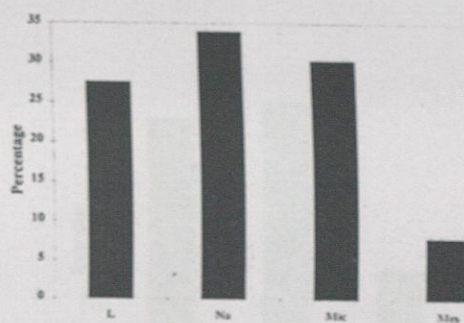


Fig. 11 (continued)

Raunkiaerian

Quantitative

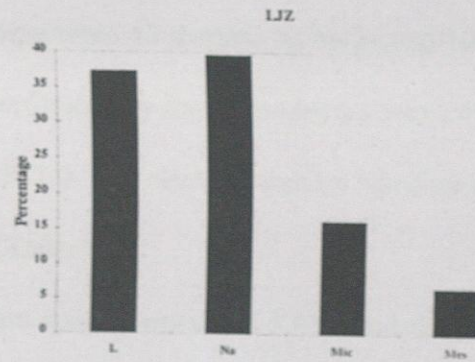
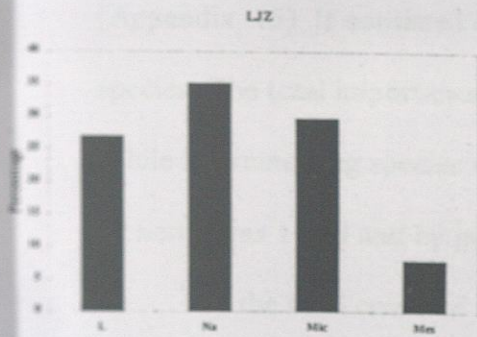
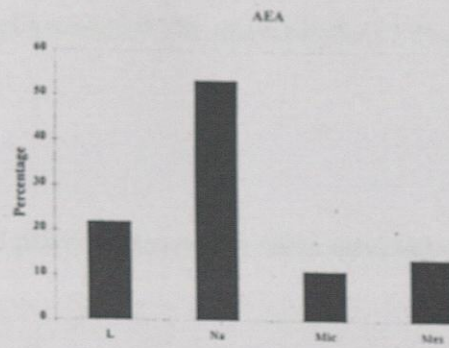
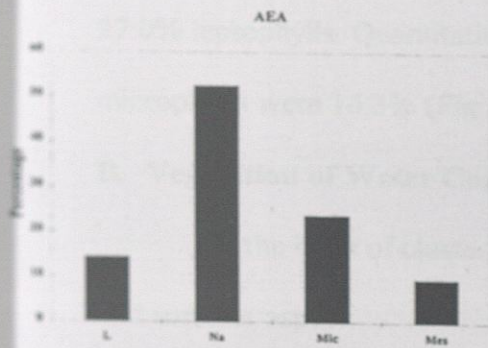


Fig. 11 (continued)

Key for the communities as given in Table: 12.

Key for the leaf size spectra as given in Table: 3.

Quantitatively, chamaephytes were 25.3%, therophytes 25.2% and hemicryptophytes were 23.3% (Fig. 10). The community consisted of 35.1% nanophylls, 29.7%, microphylls and 27.0% leptophylls. Quantitatively, nanophylls were 39.7%, leptophylls 37.3%, while microphylls were 16.3% (Fig. 11).

B. Vegetation of Water Courses

On the basis of cluster analysis two plant communities were established for spring and summer aspect.

a. Spring Aspect

1. *Perovskia - Artemisia - Bromus* Community (PAB)

Perovskia - Artemisia - Bromus community was found at 2240 - 2300 m. altitude (Appendix 15). It consisted of 55 species. There were 13 shrubs, 32 herbs and 10 grass species. The total importance value (TIV) contributed by the 3 dominants was 103.0. While the remaining species shared a TIV of 197.0. The contribution by shrubs was 108.9, by herbs was 118.8 and by grasses was 72.4 (Table 14).

Of the total cover of 15.7%, 3 dominant species provided 5.8%, and the remaining species 8.2%. The shrub layer shared 9.3%, herbs 4.5% and grasses 2.0% (Table 14). Eleven shrub, 31 herb and 10 grass species individually had less than 1% cover (Appendix 15). *Artemisia* had 80% frequency. It was followed by *Perovskia abrotanoides* 73.33%, *Sophora griffithii*, *Bromus sericens*, *Bromus tectorum* and *Euphorbia maddenii* with 60% occurrence. The rest of the species had a frequency from 6.7% to 40% (Appendix 15). *Cymbopogon jwarancusa* and *Verbascum erianthum* were confined to this community only. The lower percentage of plant cover in water courses was due to

instability of soil, erosion and continuous disturbance by transport. The plants were uprooted after rain.

Therophytic species were dominant (56.4%). They were followed by hemicryptophytes (21.8%), nanophanerophytes (14.5%) and geophytes. Quantitatively, therophytes were 44.0%, nanophanerophytes 22.6%, hemicryptophytes 18.0%, while chamaephytes were 14.8% (Fig. 12). The community consisted of nanophylls (49.1%), leptophylls and microphylls (each with 23.6%). Quantitatively, nanophylls were 41.0%, microphylls 29.6% and leptophylls were 25.5% (Fig. 13).

2. *Perovskia* - *Artemisia* - *Perovskia* Community (PAP)

Perovskia - *Artemisia* - *Perovskia* community was identified at an altitude of 2400 -2500 m. (Appendix 16). It consisted of 40 species. There were 14 shrubs, 19 herbs and 7 grass species. The total importance value (TIV) contributed by 3 dominants was 93.4, while the remaining species shared a TIV of 206.6. The contribution by shrubs was 157.9, by herbs was 87.5 and by grasses was 54.6 (Table 14).

The community had a total cover of 11.1%. The 3 dominant species covered 5.2%, and the remaining species 5.9%. The shrub layer shared 7.9%, herb 2.1% and grasses 1.1% (Table 14). Twelve shrub, 19 herb and 7 grass species individually had less than 1% cover (Appendix 16).

Artemisia and *Perovskia abrotanoides* had 100% frequency. It was followed by *Hertia* 70%, *Bromus sericens*, *Bromus*, *Pennisetum oreintale* and *Eremerus persicus* with 60% occurrence. The rest of the species had 10 to 50% frequency (Appendix 16).

Therophytic species were dominant (44.8%), they were followed by hemicryptophytes (31.0%) and nanophanerophytes (17.2%). Quantitatively,

nanophanerophytes were 35.3%, hemicryptophytes 29.6% and therophytes were 25.4% (Fig. 12). The community consisted of 51.7% nanophylls, 37.9% microphylls, while leptophylls and mesophylls had poor presentation. On quantitative basis, microphylls were 56.2%, nanophylls 27.9% and leptophylls were 12.0% (Fig. 13).

b. Summer Aspect

1. *Perovskia* - *Perovskia* - *Peganum* Community (PPP)

At a height of 2240 -2300 m, *Perovskia* - *Perovskia* - *Peganum* community was present (Appendix 17) that consisted of 29 species. There were 8 shrubs, 14 herbs and 7 grass species. The total importance value (TIV) contributed by 3 dominants was 98.5, while the remaining species shared a TIV of 201.5. The contribution by shrubs was 127.3, by herbs 117.3 and grasses 55.4 (Table 14).

The community had a total cover of 18.5%. The 3 dominant species covered 7.5%. While the remaining species exhibited a total cover of 10.6%. The shrub layer shared 11.4%, herbs 4.1% and grasses 3.0% (Table 14). Four shrub, 13 herb and 7 grass species individually had less than 1% cover (Appendix 17).

Perovskia atriplicifolia had 86.7% frequency. It was followed by *Perovskia abrotanoides* and *Euphorbia maddenii* with 80% frequency, *Artemisia* and *Sophora* each with 73.3%, *Hertia* 66.7%, *Pulicaria* and *Verbascum* with 60% occurrence. The rest of the species had 6.7 to 53.3% frequency. *Chenopodium hybridum*, *Chenopodium botrys* were confined to this community only.

Therophytic species were dominant (47.5%), they were followed by nanophanerophytes 20%, chamaephytes 12.5%, hemicryptophytes and geophytes 10.0%. Quantitatively, nanophanerophytes were 31.3%, therophytes 31.3% and chamaephytes

were 20.3% (Fig. 12). The community consisted of 47.5% nanophylls, 25% leptophylls and 22.5% microphylls. On the quantitative basis, nanophylls were 35.7%, microphylls 31.4%, while leptophylls were 28.0% (Fig. 13).

2. *Sophora - Euphorbia - Perovskia* Community (SEP)

Sophora - Euphorbia - Perovskia community was established between altitude of 2400 - 2500 m. (Appendix 18). It consisted of 26 species. There were 12 shrubs, 11 herbs, and 3 grass species. The total importance value (TIV) contributed by 3 dominant was 93.8. While the remaining species shared a TIV of 206.2. The contribution by shrubs was 156.7, by herbs was 119.9 and by grasses was 23.4 (Table 14).

The community had a total cover of 11.6%. The 3 dominant species covered 4.4%, while the remaining exhibited a total cover of 7.2%. The shrub layer shared 7.3%, herbs 3.8% and grasses 0.5% (Table 14). Eight shrub, 10 herb and 3 grass species individually had less than 1% cover (Appendix 18).

Sophora and *Asteriscus* had 90% frequency. They were followed by *Hertia*, *Nepeta*, *Perovskia abrotanoides* and *Euphorbia granulata* each with 80% frequency. *Artemisia* 70%. The remaining species had 10 - 60% frequency (Appendix 18).

Few seedlings of Juniper were recorded. *Bothriochloa ishaemum* was confined to this community only and preferred comparatively moist place.

Nanophanerophytic species were dominant (34.6%), they were followed by therophytes (30.8%), and hemicryptophytes (23.1%). Quantitatively, nanophanerophytes were 38.5%, therophytes 34.5% and hemicryptophytes were 18.6% (Fig. 12). The community consisted of 53.8% nanophylls, 23.1% microphylls and 19.2% leptophylls. On the quantitative basis, nanophylls were 47.9%, microphylls 28.9% while leptophylls were 19.3% quantitatively (Fig. 13).

Table 14: The number of component species and their share in Total Importance Value (TIV) and Cover of Plant communities in Water Courses

	PAB	PPP	PAP	SEP
	Spring	Summer	Spring	Summer
A - Total speceis and TIV				
Total Species	55.0	30.0	40.0	26.0
Shrubs	13.0	8.0	14.0	12.0
Herbs	32.0	15.0	19.0	11.0
Grasses	10.0	7.0	7.0	3.0
Total IV contributed by 3 dominants	103.0	98.5	93.4	93.8
By Remaining species	197.0	201.5	206.6	206.2
By Shrubs	108.9	127.3	157.9	156.7
By Herbs	118.8	117.3	87.5	119.8
By Grasses	72.4	55.4	54.6	23.4
B - Total cover and share by component groups				
Total cover	15.7	18.5	11.1	11.6
By 3 dominants	7.6	7.5	5.2	4.4
By remaining species	8.2	10.6	5.9	7.2
By Shrubs	9.3	11.4	7.9	7.3
By Herbs	4.5	4.1	2.1	3.8
By Grasses	2.0	3.0	1.1	0.5

Key:

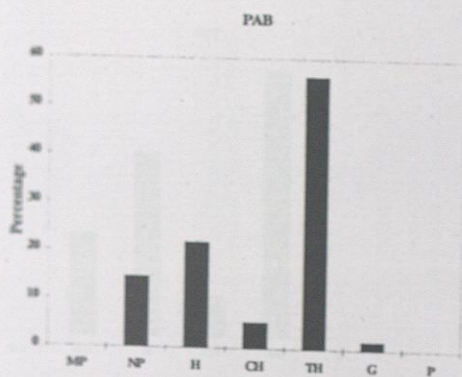
PAB: *Perovskia - Artemisa - Bromus* community

PAP: *Perovskia - Artemisia - Perovskia* community

PPP: *Perovskia - Perovskia - Peaganum* community

SEP: *Sophora - Euphorbia - Perovskia* community

Raunkiaerian



Quantitative

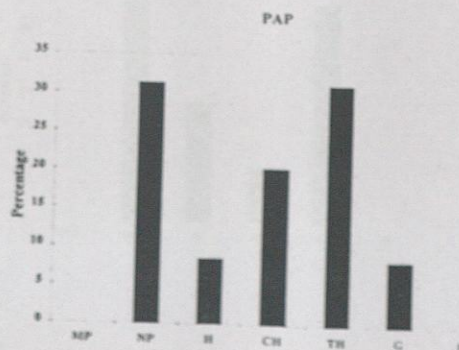
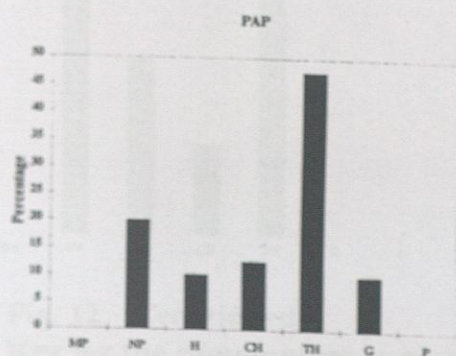
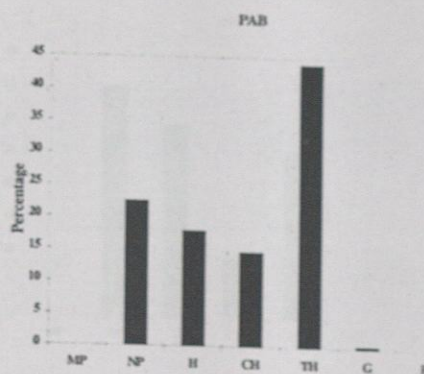


Fig. 12 Life form spectra of spring and summer communities of Water Courses

Raunkiaerian

Quantitative

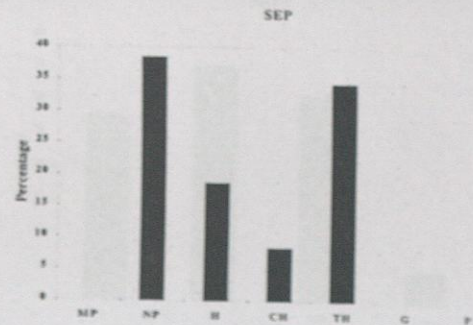
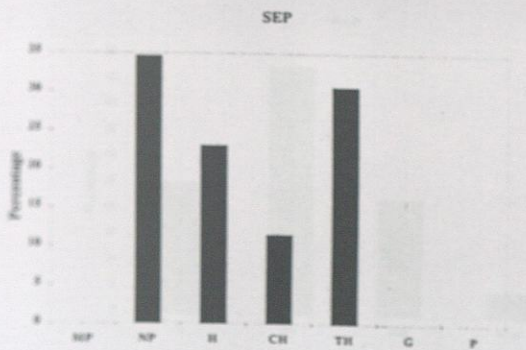
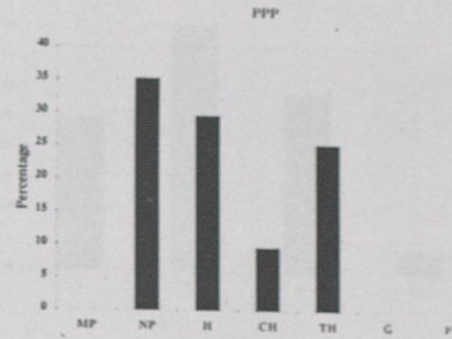
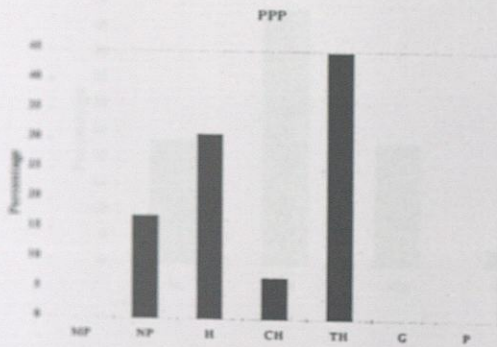


Fig. 12 (continued)

Key for the communities as given in Table: 14.

Key for the life form as given in Table: 3.

Raunkiaerian

Quantitative

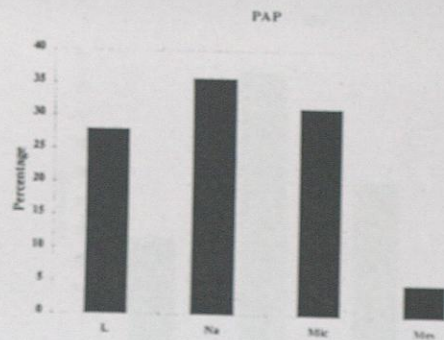
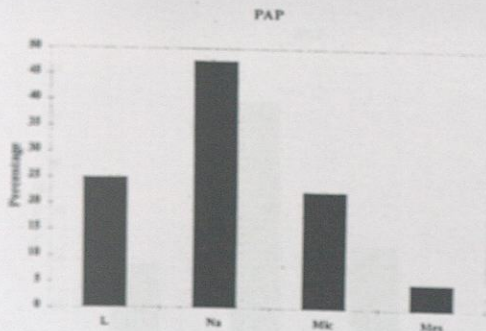
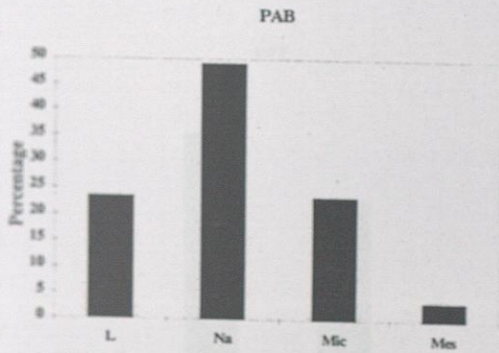


Fig. 13 Leaf size spectra of spring and summer communities of Water Course

Key for the communities as given in Table: 14.

Key for the leaf size spectra as given in Table: 3.

Raunkiaerian

Quantitative

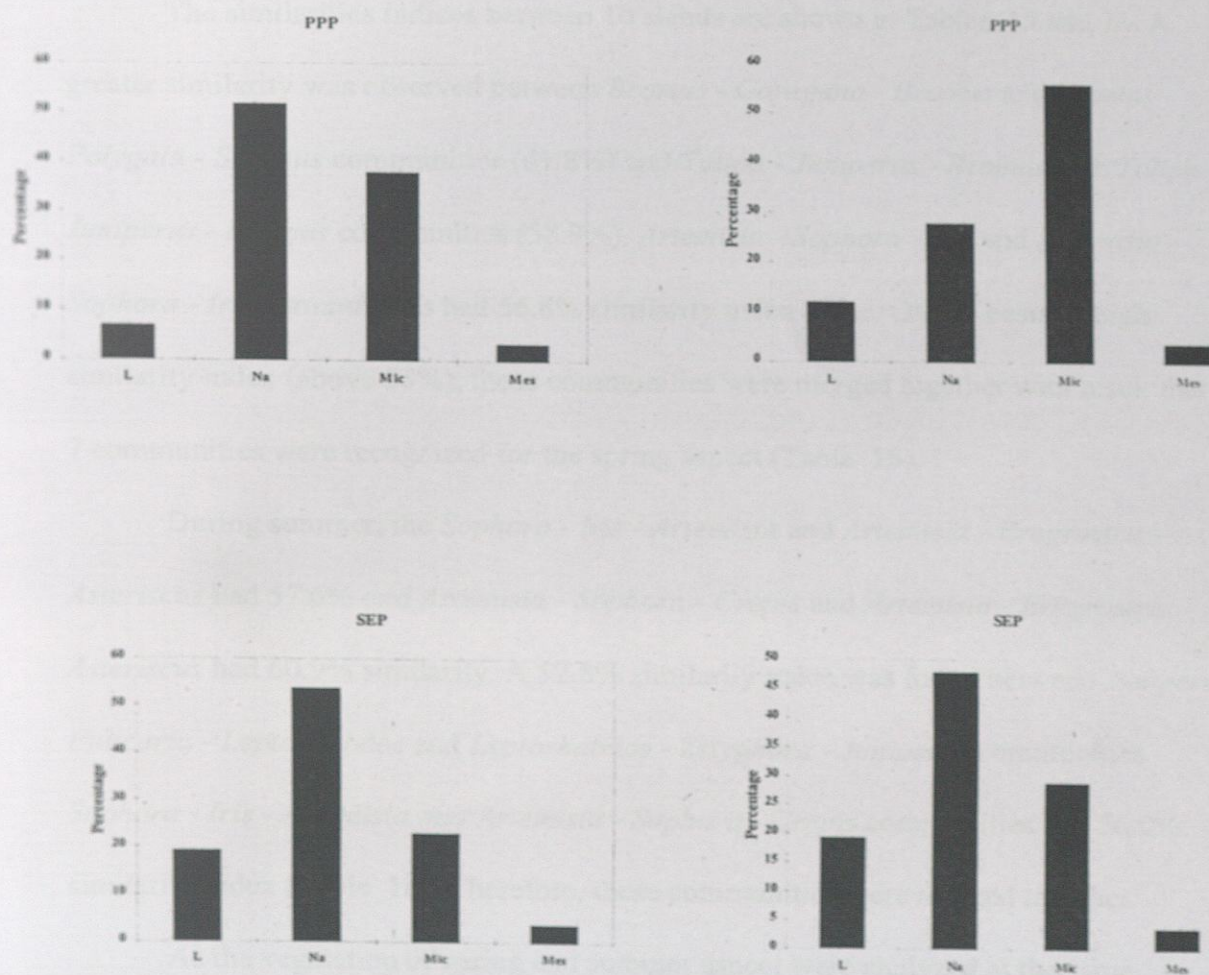


Fig. 13 (Continued)

Similarity Indices

A. Vegetation of hills

The similarities indices between 10 stands are shown in Tables 15 and 16. A greater similarity was observed between *Bromus - Caragana - Bromus* and *Bromus - Polygala - Shismus* communities (61.8%) and *Tulipa - Juniperus - Bromus* and, *Tulipa - Juniperus - Bromus* communities (58.9%). *Artemisia - Sophora - Iris* and *Artemisia - Sophora - Iris* communities had 56.8% similarity index value. On the basis of high similarity index (above 55%), these communities were merged together with result that 7 communities were recognized for the spring aspect (Table 15).

During summer, the *Sophora - Iris - Artemisia* and *Artemisia - Eragrostris - Asteriscus* had 57.6% and *Artemisia - Sophora - Crepis* and *Artemisia - Eragrostris - Asteriscus* had 60.9% similarity. A 52.8% similarity value was found between *Juniperus - Pulicaria - Leptorhabdos* and *Leptorhabdos - Zizyphora - Juniperus* communities. *Sophora - Iris - Artemisia* and *Artemisia - Sophora - Crepis* communities had 56.0% similarity index (Table 16). Therefore, these communities were merged together.

As the vegetation of spring and summer aspect were analyzed at the same locations, therefore, a uniformity in community *Artemisia - Aristida - Phacelurus* and *Artemisia - Aristida - Sophora* communities were also merged together and seven plant communities were recognized for summer season.

During summer, the *Sophora - Iris - Artemisia* and *Artemisia - Eragrostris - Asteriscus* had 57.6% and *Artemisia - Sophora - Crepis* and *Artemisia - Eragrostris - Asteriscus* had 60.9% similarity. A 52.8% similarity value was found between *Juniperus -*

Pulicaria - Leptorhabdos and *Leptorhabdos - Zizyphora - Juniperus* communities.

Sophora - Iris - Artemisia and *Artemisia - Sophora - Crepis* communities had 56.0% similarity index (Table 16). Therefore, these communities were merged together.

As the vegetation of spring and summer aspect were analyzed at the same locations, therefore, a uniformity in community *Artemisia - Aristida - Phacelurus* and *Artemisia - Aristida - Sophora* communities were also merged together and seven plant communities were recognized for summer season.

Comparison between Spring and Summer Communities

A comparative account of spring and summer aspects showed that *Artemisia - Sophora - Iris* and *Artemisia - Sophora - Crepis* communities had 50.2% similarity followed by *Tulipa - Juniperus - Bromus* and *Juniperus - Pulicaria - Leptorhabdos* communities (47.2%). Rest of the communities exhibited 23.4 - 44.6% similarities between the two seasons (Table 19).

The spring aspect had altogether 138 species compared to 77 species in the summer communities. Of them, tree and shrub components remained similar in both the seasons. However, there was a difference of herbs and grasses from spring to summer. There were 13 and 11 grasses in spring and summer communities, respectively. Similarly 94 and 38 herb species were recorded in spring and summer communities, respectively.

B. Vegetation of Water Courses

In water courses a 54.0% similarity was observed between *Perovskia - Bromus - Artemisia* and *Perovskia - Artemisia - Eurphorbia* and 51.5% between *Perovskia -*

Table 15: Similarity indices of spring plant communities
(Based on Importance Value, Spring Aspect)

Site No.	1	2	3	4	5	6	7	8	9	10
1.	0.0									
2.	49.9									
3.	61.8	55.2								
4.	34.8	33.3	37.5							
5.	19.9	20.7	24.2	43.4						
6.	29.2	31.9	32.6	47.8	41.3					
7.	20.8	26.6	29.8	39.1	34.5	56.8				
8.	18.5	21.2	21.2	33.6	19.8	34.8	25.9			
9.	35.2	36.1	32.8	32.3	24.7	34.1	26.3	36.1		
10.	27.5	33.4	26.3	33.8	22.2	37.0	27.7	37.1	58.9	0.0

Table 16: Similarity indices of summer plant communities
(Based on Importance Value, Summer Aspect)

Site No.	1	2	3	4	5	6	7	8	9	10
1.	0.0									
2.	30.4									
3.	47.2	37.4								
4.	25.8	25.1	30.5							
5.	27.3	15.3	29.3	49.6						
6.	33.8	23.1	40.4	45.5	52.5					
7.	28.5	21.4	48.7	34.3	35.5	56.0				
8.	27.8	24.6	39.4	48.0	38.5	57.6	60.9			
9.	21.3	39.9	30.8	29.6	25.1	24.9	28.5	30.8		
10.	21.6	41.3	33.4	33.4	26.7	31.7	28.7	40.9	52.8	0.0

Table 17: Similarity indices of spring plant communities of Water Courses (Based on Importance Value, Spring Aspect)

Site No.	1	2	3	4	5
1.	0.0				
2.	54.0				
3.	51.5	48.3			
4.	38.2	36.2	39.0		
5.	43.9	42.1	47.1	46.3	0.0

Table 18: Similarity indices of plant communities of Water Courses (Based on Importance Value, Summer Aspect)

Site No.	1	2	3	4	5
1.	0.0				
2.	63.9				
3.	59.8	46.9			
4.	50.5	45.8	45.0		
5.	46.8	39.9	38.2	56.1	0.0

Table 19: Similarity Indices of spring and summer communities (Based on Importance Value of species)

Hills		Hills		Water Course	
Site No.		Site No.		Site No.	
1.	23.4	6.	42.3	1.	44.8
2.	25.1	7.	50.2	2.	43.6
3.	32.0	8.	36.0	3.	29.2
4.	38.8	9.	47.2	4.	34.1
5.	44.6	10.	37.7	5.	54.2

Bromus - Artemisia and *Artemisia - Bromus - Bromus* communities (Table 17).

Therefore, they were merged together to form one community (PAB). Similarly, *Artemisia - Perovskia - Hertia* and *Perovskia - Artemisia - Polygala* communities were merged together as they maintained the uniformity with summer communities. Thus two plant communities were recognized for spring aspect (Table 17).

Similarly, 63.9% similarity was observed between *Perovskia - Perovskia - Artemisia* and *Perovskia - Euphorbia - Artemisia* communities and 59.8% between *Perovskia - Perovskia - Artemisia* and *Perovskia - Euphorbia - Artemisia* communities (Table 18). These three communities were merged together to form one community (PPP). Likewise 56.1% similarity was observed between *Sophora - Perovskia - Euphorbia* and *Euphorbia - Eragrostis - Hertia* communities, they were merged together. So two plant communities were recognized for summer aspect (Table 18).

Seasonal Comparison Between Communities

There were 85 species in water courses. Of them, shrub component remained similar (as 15:14), while 43 herb species were recorded in spring and 26 in summer. Similarly 13 and 9 grasses were recorded in spring and summer, respectively. As a whole 71 species were recorded in spring communities and 49 species in summer. The communities of spring and summer aspect had 31.5% to 39.9% similarities (Table 19). The total number of species in terrestrial habitat was greater (126 Spp) than in water courses (85 Spp).

Regeneration Capacity of Juniper

The regeneration capacity of *Juniperus excelsa* was determined by assigning the trees to different height classes as height is related to the age of the trees

(Ahmed *et al.* 1989). The maximum recorded height was 27.2 m for a male tree at 2600 m altitude. It was followed by 20.2 m tall female tree at 2300 m. The maximum height for a bisexual tree was 17.1 m at 2750 m altitude. All the measured trees were classified into different height classes (Fig. 14). It was observed that there were 6.25% young trees in class A, 9.5% in class B, 1.5% trees were in class C. Among male trees, 4.5% were in class A, 21.5% in class B, 11.5% in class C and 1.5% were in class D, while only 0.25 - 0.75% trees had attained the height above 8 m. to 30 m. (Class E - I). Similarly, among the female trees, 4.25% were in class A, 20.5% in class B, 11.75% were in class C and 1.75% were in class D. While 0.25% trees were present in each of higher class (E - H). Only 1.25% bisexual trees were recorded in class B, 1% were in class C and 0.25% were assigned class D and G.

It was interesting to see that the height of trees increased with increase in the altitude. The height of the trees ranged from 0.9 to 7 m. in between altitude 2240 to 2600 m (with only one exception of 20 m height at 2300 m). While the trees had a height from 1.5 to 27.2 m. in between 2650 to 2750 m. altitude (Table 20).

Sex Ratio of Juniper

The distribution of Juniper trees by various sex ratio is given in Table 20. The percentage of female trees ranged from 27.5 to 50% (average $39.3\% \pm 7.8$). The male trees were 27.5 to 50% (average $40.8\% \pm 8.1$), young/undistinguished trees were 10 to 32.5% (average $17.3\% \pm 7.1$), while bisexual trees were 2.5 to 7.5% (average $2.8\% \pm 2.4$) in the area. It was observed that the percentage of male trees were more than others. The percentage of male trees increased with increasing altitude. While the percentage of young and female trees decreased with increasing altitude. Juniper appeared to be

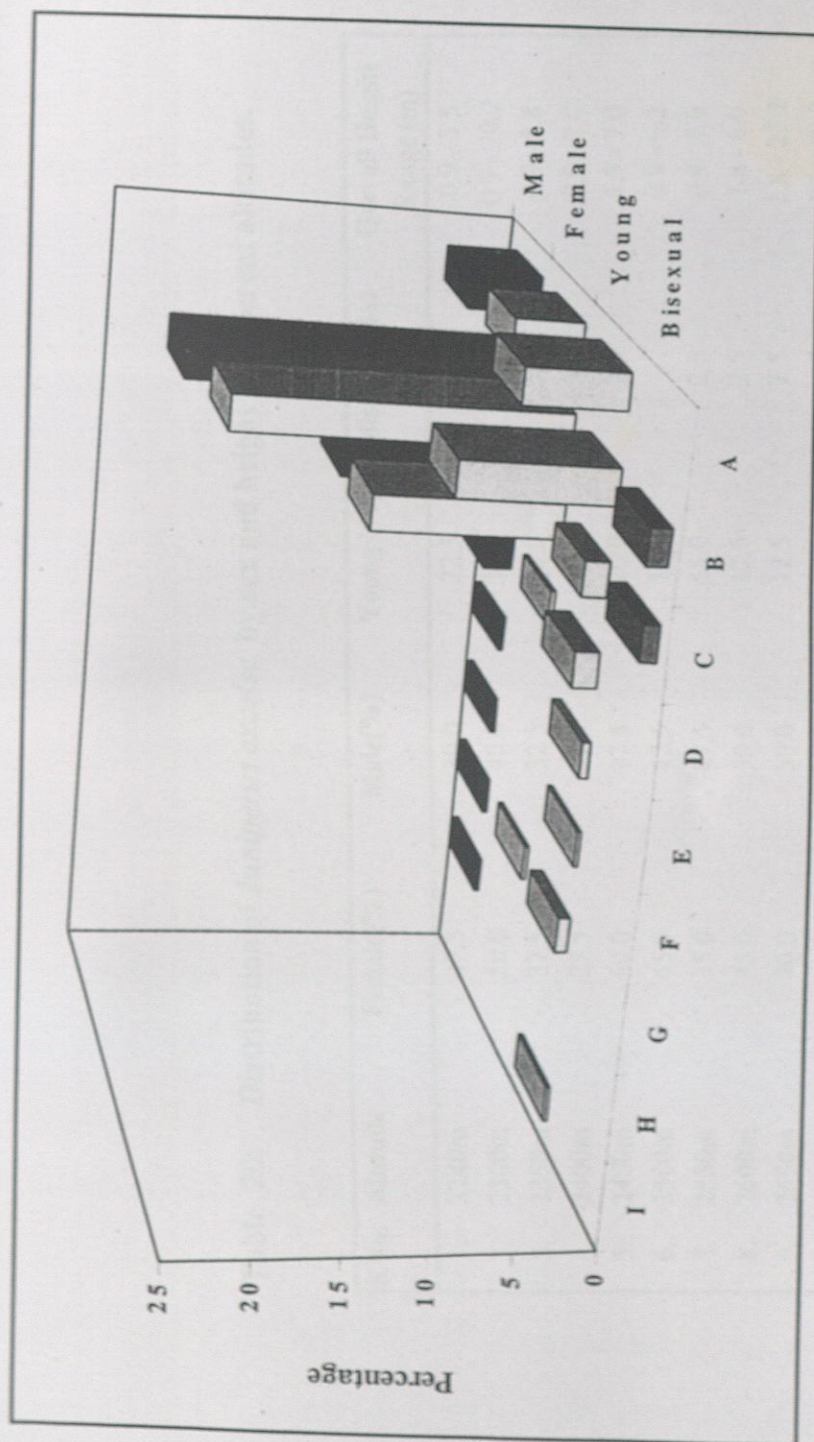


Fig. 14: Percentage Juniper in different height classes
Key:

A: 0.5 - 2 m, B: 2 - 4m, C: 4 - 6m, D: 6 - 8m,

E: 8 - 10m, F: 10 - 15m, G: 15 - 20m, H: 20 - 25m

Table 20: Distribution of *Juniperus excelsa* by sex and height at different altitudes.

S.No.	Altitude	Female(%)	Male(%)	Young (%)	Bisexual (%)	Overall Height Range (m)
1.	2240m	47.5	30.0	22.5	-	0.9 - 5.5
2.	2300m	50.0	40.0	10.0	-	0.9 - 20.2
3.	2350m	37.5	32.5	25.0	5.0	0.9 - 5.8
4.	2400m	27.5	37.5	32.5	2.5	0.9 - 7.0
5.	2450m	50.0	27.5	20.0	2.5	1.5 - 7.0
6.	2500m	45.0	42.5	12.5	-	0.9 - 6.2
7.	2550m	35.0	47.5	15.0	2.5	0.9 - 7.0
8.	2600m	35.0	50.0	12.5	2.5	1.8 - 6.0
9.	2650m	30.0	50.0	12.5	7.5	1.8 - 27.2
10.	2750m	35.0	50.0	10.0	5.0	1.5 - 19.7
Range		27.5 - 50%	27.5 - 50%	10 - 32.5%	2.5 - 7.5%	
Average		39.30%	40.70%	17.30%	2.70%	

regenerating in the area as 15% trees were less than 2m. in height, 52.8% trees were up to 4 m. height and 25.8% trees were up to 6 m. height. While only 3.5% trees were upto 8 m. height. The mature trees were 0.3% to 1.3% in the area (Fig. 14).

Homogeneity of the Communities

During spring aspect 63.4 to 80.6% species belonged to class A, 12.5 to 24% species belonged to class B, 1.4 to 7.4% for class C, class D had poor presentation (1.5 to 2.5%), while only one community had 3.7% species for class E. Except AAB, ASI and TJB, class D and E were blank in all other communities (Fig. 15). The data suggest that majority of communities were heterogeneous.

During summer aspect 27.6 to 71.4% species belonged to class A, 2.4 to 51.7% species to class B, 3.6% to 20.7% to class C, 2.6 to 14.7% to class D and 2.9 to 5.9% species to class E among different communities (Fig. 16). Two communities (AAS and ASE) had species for all 5-five classes, while AIC, AEA and LJZ communities had their species restricted to class A to D. There were no representation in class C in (ASI) community, and class D and E in LPE community. Class A and B were well represented in all the communities, while class E had poor representation (Fig. 16). The communities were, therefore, heterogeneous.

All communities of water courses had representation in all five classes during both the seasons. During spring, 48.8% to 71.9% species belonged to class A, 17.5 to 31.7% for class B, 7.0 to 12.2% for class C, 2.4 to 3.5% for class D and 4.9% species belonged to class E. Similarly, during summer, 38.5 to 63.6% species belonged to class A, 9.1 to 19.2% for class B, 12.1 to 15.4% for class C, 12.1 to 19.2% for class D and 3.0 to 7.7% species belonged to class E (Fig. 17).

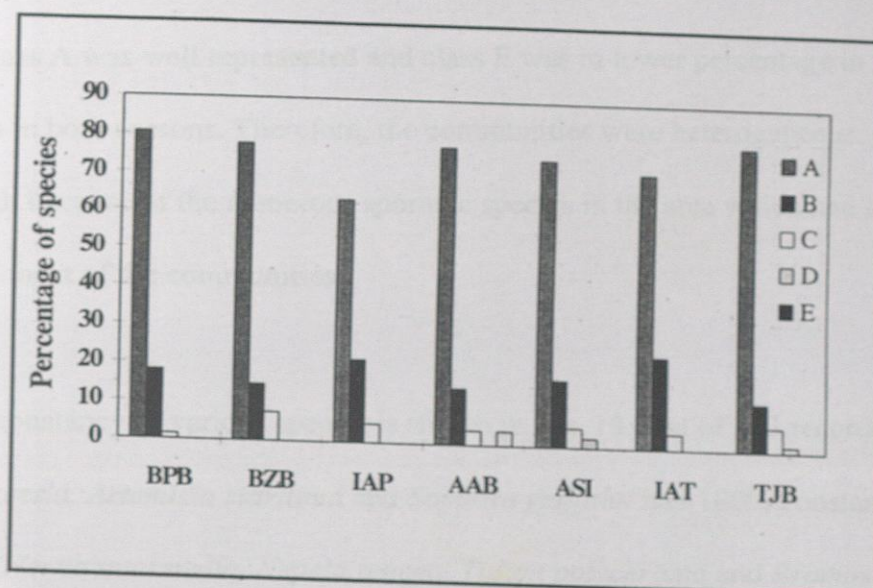


Fig. 15: Homogeneity of communities of spring aspect.
Key for the communities as given in Table: 10

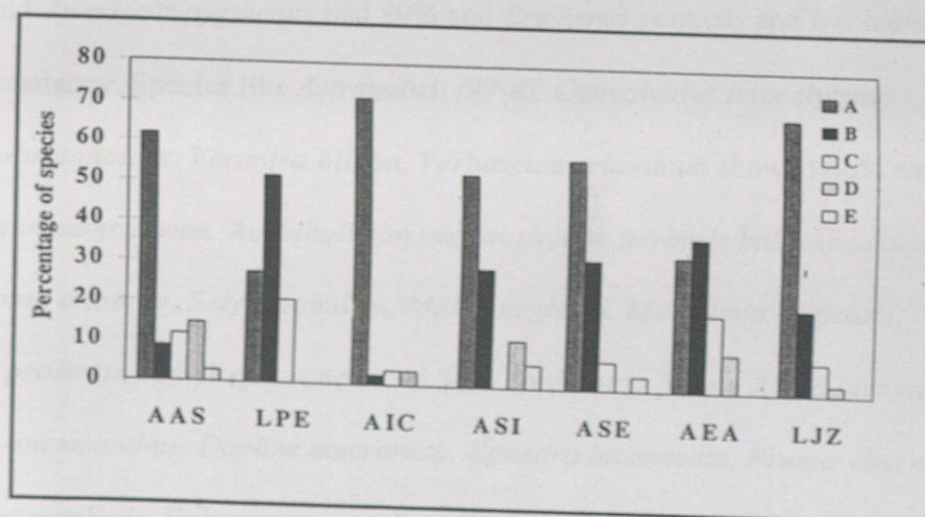


Fig. 16: Homogeneity of communities of summer aspect.
Key for the communities as given in Table: 12

As class A was well represented and class E was in lower percentage in all the communities in both seasons. Therefore, the communities were heterogeneous. Class A was very high because of the numerous sporadic species in the area which had low frequency in most of the communities.

Constancy

The constancy of various species is shown in Fig. 18. Out of 163 recorded species, *Juniperus excelsa*, *Artemisia maritima* and *Sophora griffithii* had 100% constancy, followed by *Hertia intermedia*, *Nepeta juncea*, *Tulipa polychroma* and *Bromus tectorum* (90%). They appeared to be constant species, while *Bromus sericeus*, *Pennisetum orientale* and *Asteriscus pygmaeus* had 80% and *Eremerus persicus* and *Iris tenuifolia* had 70% constancy. Species like *Astragalus* (97-8), *Convolvulus leiocalycinus*, *Perovskia abrotanoides*, *Veronica biloba*, *Verbascum erianthum* showed 60% constancy. *Acantholimon munroanum*, *Acantholimon polystachyum*, *Berberis balochistanica*, *Prunus Spp.*, *Gaillonia eriantha*, *Salvia cabulica*, *Malva neglecta*, *Malcolmia affricana*, *Euphorbia prostrata* and *Crepis sancta* had 50% constancy. While *Aerva javanica*, *Astragalus anisacanthus*, *Daphne mucronata*, *Ephedra intermedia*, *Prunus eburnea*, *Cousinia heterophylls*, *Polygonum aviculare*, *Zizyphora tenuior* and *Aristida Spp* gave 40% constancy. The remaining species had 30% or less than 30% constancy in the area.

The data showed that majority of the species were in constancy class I. It was followed by class II while few species were in constancy class IV (Fig. 18).

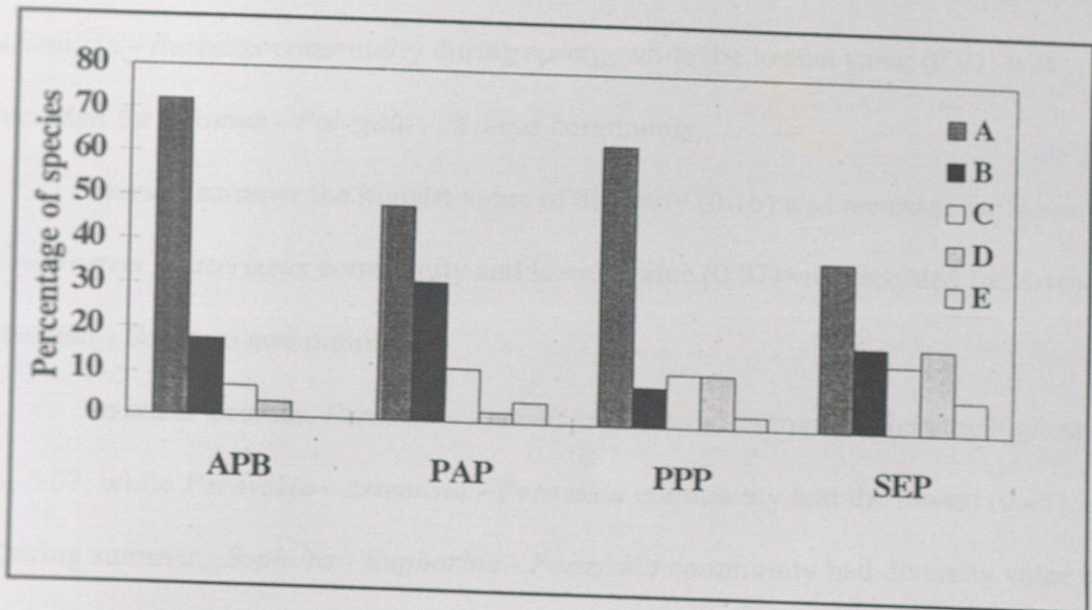


Fig. 17: Homogeneity of communities of water courses as determined by Raunkiaer's frequency classes.

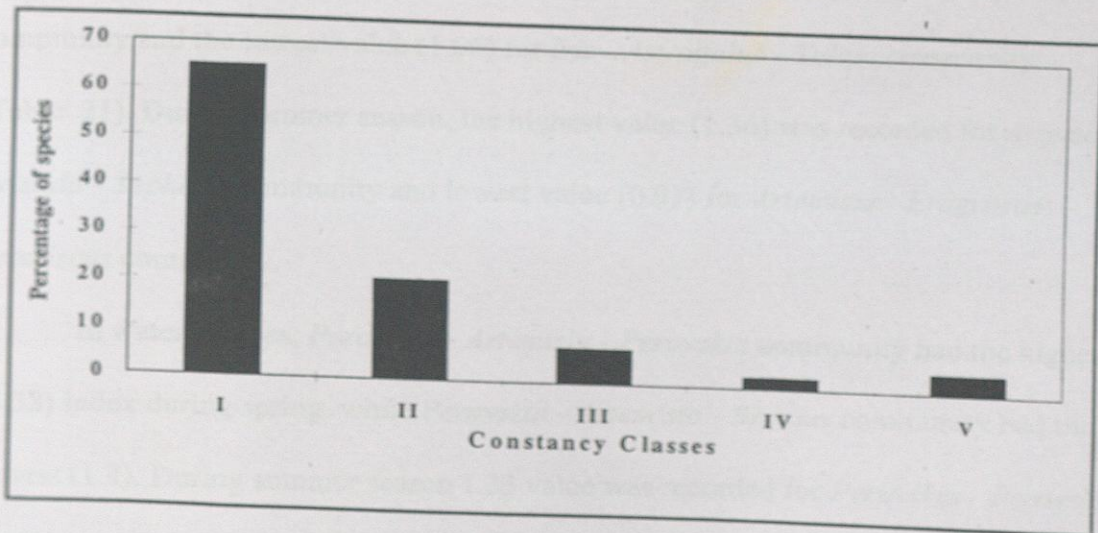


Fig. 18: Percentage of species in different constancy classes.

Simpson's Diversity Index

The highest value for index of diversity (0.12) was recorded for *Astragalus - Artemisia - Berberis* community during spring, while the lowest value (0.05) was recorded for *Bromus - Polygala - Bromus* community.

During summer the highest value of diversity (0.16) was recorded for *Artemisia - Eragrostris - Asteriscus* community and lowest value (0.07) was recorded for *Artemisia - Aristida - Sophora* community.

In water courses, *Perovskia - Artemisia - Bromus* community had the highest value of 0.07, while *Perovskia - Artemisia - Perovskia* community had the lowest (0.45). During summer, *Sophora - Euphorbia - Perovskia* community had diversity value of 0.07, while *Perovskia - Perovskia - Peganum* had 0.05 value (Table 21).

Shannon - Weaver Diversity Index

The highest value of 1.46 was recorded for *Bromus - Polygala - Bromus* community and the lowest value (1.06) for *Iris - Astragalus - Tulipa* community (Table 21). During summer season, the highest value (1.36) was recorded for *Artemisia - Aristida - Sophora* community and lowest value (0.91) for *Artemisia - Eragrostris - Asteriscus* community.

In water courses, *Perovskia - Artemisia - Perovskia* community had the highest (1.38) index during spring, while *Perovskia - Artemisia - Bromus* community had the lowest (1.3). During summer season 1.33 value was recorded for *Perovskia - Perovskia - Peganum* community and 1.17 diversity for *Sophora - Euphorbia - Perovskia* community (Table 21).

The equitability value was highest (0.28) for *Astragalus - Artemisia - Berberis* community during spring, while *Tulipa - Juniperus - Bromus* community had the lowest value (0.23) (Table 21). During summer, *Artemisia - Aristida - Sophora* community had highest (0.25) value, while *Artemisia - Eragrostis - Asteriscus* community had the lowest (0.21) value.

Equitability was more in *Perovskia - Artemisia - Perovskia* (0.27) than *Perovskia - Artemisia - Bromus* community (0.23). in water courses. During summer, *Perovskia - Perovskia - Peganum* community had more value (0.28) than *Sophora - Euphorbia - Perovskia* community (0.26) (Table 21).

Species Richness

Species richness was generally high in the area. It ranged in between 1.67 (*Iris - Astragalus - Tulipa*) to 2.70 (*Bromus - Polygala - Bromus*) in spring communities and 1.1 (*Astragalus - Sophora - Iris*) to 3.41 (*Artemisia - Aristida - Sophora*) in summer communities (Table 21). In water courses, it varied from 5.41 (*Artemisia - Perovskia - Bromus*) to 5.11 (*Perovskia - Artemisia - Perovskia*) in spring communities. While during summer, it was 3.19 for both the communities (Table 21). Species richness was generally high during the spring compared to summer aspect (with few exceptions) as more species were present in spring. Usually the annuals die during hot and dry summer. Similarly, the values were high near water courses due to high number of species in moist habitat. The value was almost doubled in water courses than in terrestrial situation.

Table 21: Index of diversity and its components of plant communities of Hills and Water Courses

S.No.	Communities	Elevation (m)	Total	Simpson's Diversity	Shannon's	Species Richness	Equitability	Maturity Index
I - Hills								
A - Spring Communities								
1.	BPB	2240	69	0.05	1.46	2.59	0.25	16.2
2.	BZB	2300	52	0.06	1.36	2.26	0.25	19.5
3.	IAP	2400	39	0.07	1.27	1.85	0.25	21.9
4.	AAB	2450	27	0.12	1.27	1.8	0.28	21.9
5.	ASI	2500	37	0.06	1.32	2.32	0.26	16.6
6.	IAT	2600	23	0.09	1.06	1.67	0.24	23.7
7.	TJB	2650 - 2750	60	0.06	1.34	2.55	0.23	16.1
B - Summer Communities								
1.	AAS	2240	46	0.07	1.36	3.41	0.25	19.8
2.	LPE	2300	28	0.10	1.12	2.31	0.24	36.1
3.	AIC	2400	24	0.09	1.12	1.99	0.25	25.2
4.	ASI	2450	15	0.14	0.92	1.1	0.24	34.7
5.	ASE	2500	26	0.10	1.1	1.72	0.24	25.1
6.	AEA	2600	21	0.16	0.91	1.36	0.21	37.1
7.	LJZ	2650 - 2700	36	0.07	1.11	2.86	0.22	21.5
II - Water Courses.								
A - Spring Communities								
1.	PAB	2240	55	0.07	1.3	5.41	0.23	21.6
2.	PAP	2400	40	0.05	1.38	5.11	0.27	32.3
B - Summer Communities								
1.	PPP	2240	29	0.05	1.33	3.19	0.28	36.3
2.	SEP	2400	26	0.07	1.17	3.19	0.26	41.9

Key for the communities as given in Tables: 11, 13 & 14.

During spring, the maturity index varied from 15.5 (*Bromus - Polygala - Bromus* community) to 23.7 (*Iris - Astragalus - Tulipa* community). While in summer the maturity index ranged from 19.8 (*Artemisia - Aristida - Sophora* community) to 37.1 (*Artemisia - Eragrostris - Aesteriscus* community) (Table 21).

The maturity index was in between 21.6 (*Artemisia - Perovskia - Bromus* community) to 32.3 (*Perovskia - Artemisia - Perovskia* community) in water courses during spring. It was 36.3 (*Perovskia - Perovskia - Peganum* community) to 41.9 (*Sophora - Euphorbia - Perovskia* community) in summer (Table 21). The maturity index value was generally higher in summer than in the spring communities. Similarly, moist habitats showed higher values than terrestrial. It was interesting to see that high maturity index was associated with lower species richness showing an inverse relationship.

Cluster Analysis

The cluster analysis of 10 stands of hills and 5 stands of water courses of both seasons are summarized in dendrogram (Figs. 19, 20, 21 and 22). Which show that sampling stands 1 and 3, 6 and 7, and 9 and 10 were closely related. Therefore, these three pairs of stands were merged together and seven plant communities were established for hills. The cluster analysis indicate similarities or correlation between plant communities of adjacent stands such as stand 1 and 3 were dominated by *Bromus sericeus*, stands 6 and 7 were dominated by *Artemisia maritima*, while stands 9 and 10 were dominated by *Juniperus excelsa* during spring. Likewise, in summer aspect *Artemisia - Aristida* were dominated in stand 1 and 3, *Sophora - Artemisia* in stand 6 and 7 while *Juniperus -*

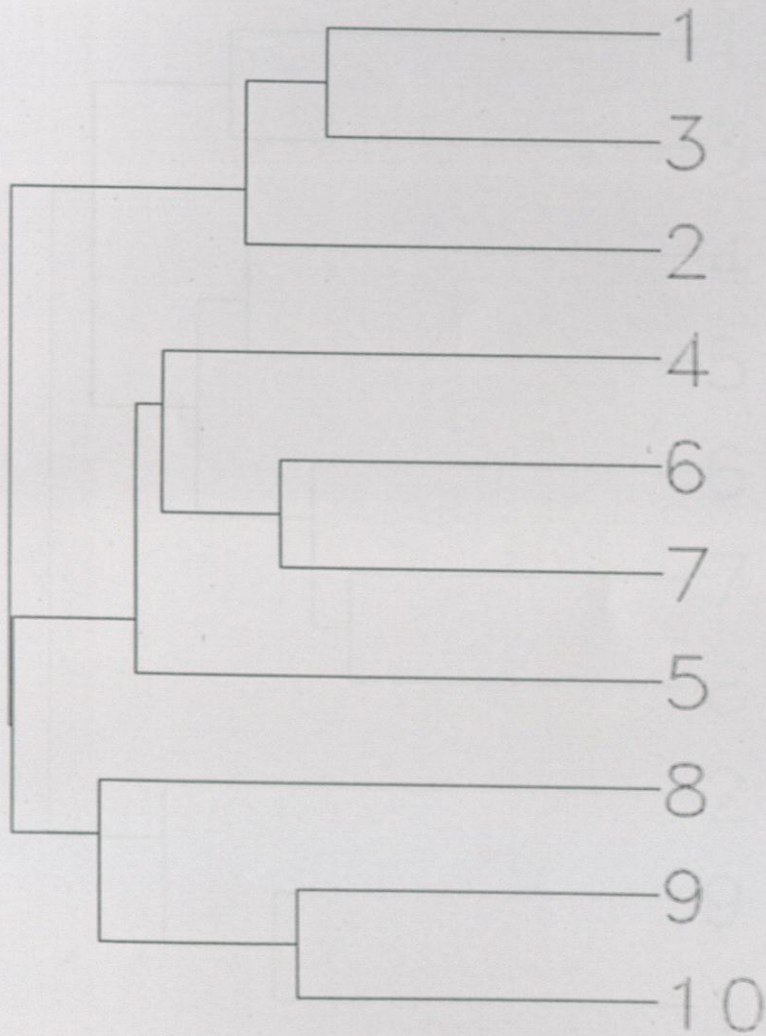


Fig. 19: Cluster analysis of 10 stands of hills (Spring Aspect).

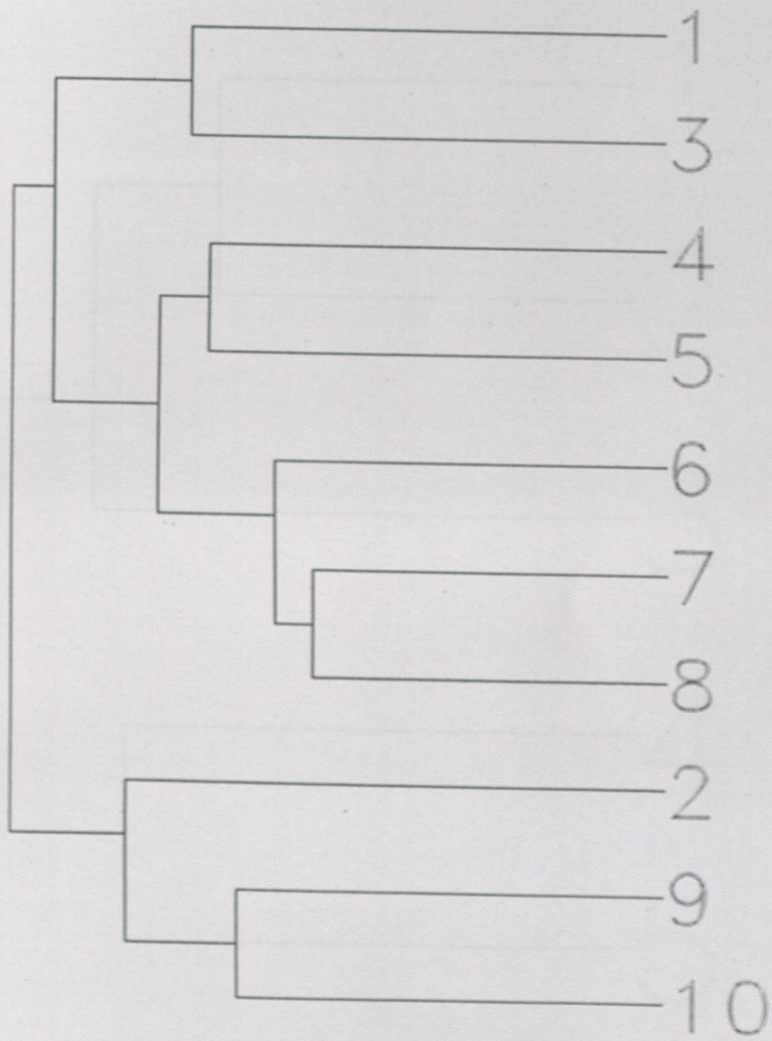


Fig. 20: Cluster analysis of 10 stands of hills (Summer Aspect).

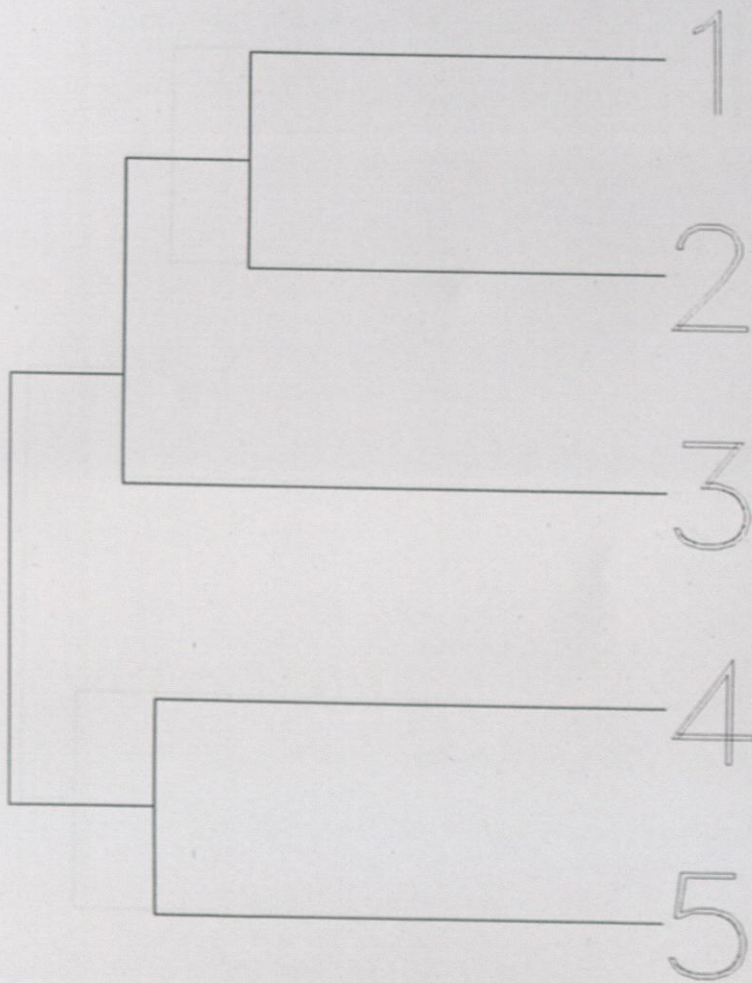


Fig. 21: Cluster analysis of 5 stands of water courses (Spring Aspect).

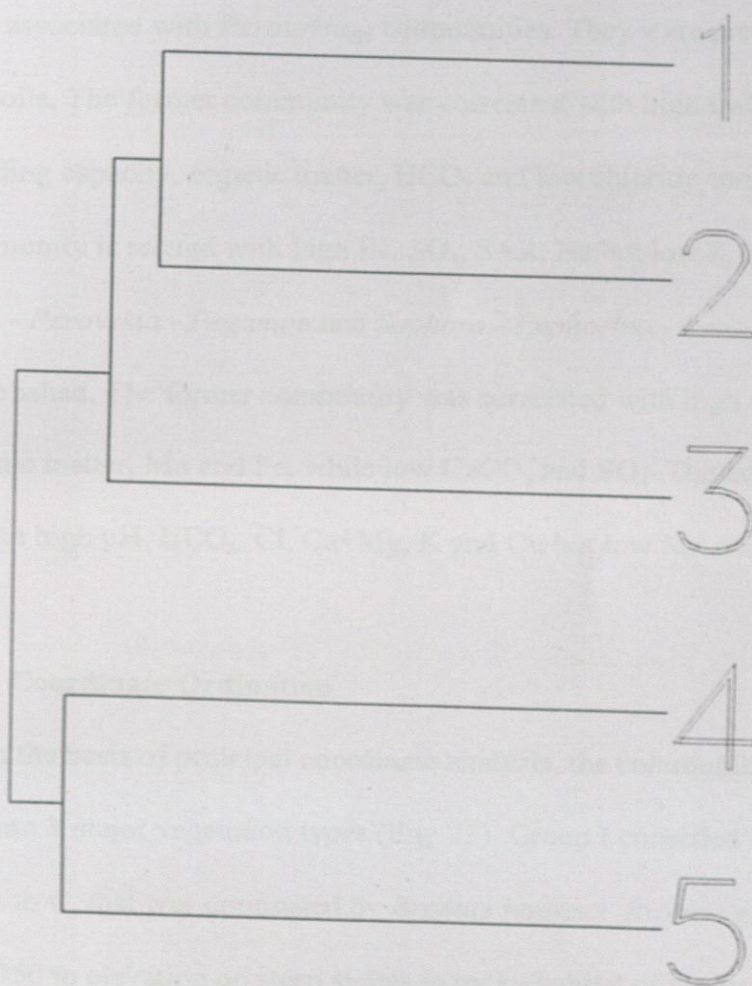


Fig. 22: Cluster analysis of 5 stands of water courses (Summer Aspect).

Leptorhabdos were dominated in stand 9 and 10.

In dry water courses, the sampling units (stands) 1, 2 & 3, and 4 & 5 were merged together (Fig. 21, 22) and two plant communities were established for each season. During spring *Perovskia_{ab}* - *Artemisia* associated with *Bromus* and *Perovskia_{ab}* - *Artemisia* associated with *Perovskia_{at}* communities. They were present on highly eroded unstable soils. The former community was correlated with high CaCO_3 and Zn while low water holding capacity, organic matter, HCO_3 and low chloride contents. However, the later community is related with high Ec, SO_4 , SAR, Na but low K content. In summer *Perovskia* - *Perovskia* - *Peganum* and *Sophora* - *Euphorbia* - *Perovskia* communities were established. The former community was correlated with high water holding capacity, high organic matter, Mn and Fe, while low CaCO_3 and SO_4 . The later community was related with high pH, HCO_3 , Cl, Ca+Mg, K and Cu but low Mn and Fe.

Principal Coordinate Ordination

On the basis of principal coordinate analysis, the communities of spring were grouped into 3 major vegetation types (Fig. 23). Group I consisted of sampling units (stands) A to C, that was dominated by *Bromus sericeus*. *Bromus* grassland were found at 2240 to 2350 m elevation on steep slopes in rocky habitat of limestone. It was characterized by grasses such as *Pennisetum orientale*, *Piptatherum vicarium*, *Poa bulbosa*, *Stipa pennata*, *Shismus arabicus*, *Cymbopogon jawarancusa*, *Vulpia ciliata* and *Bromus spp.* They were well distributed except *Vulpia ciliata* which was rare. Soil seemed to be suitable for grasses with an adequate moisture. Annual herbs are abundant in this type which is indicator of high turnover. *Bromus* grassland is correlated with high

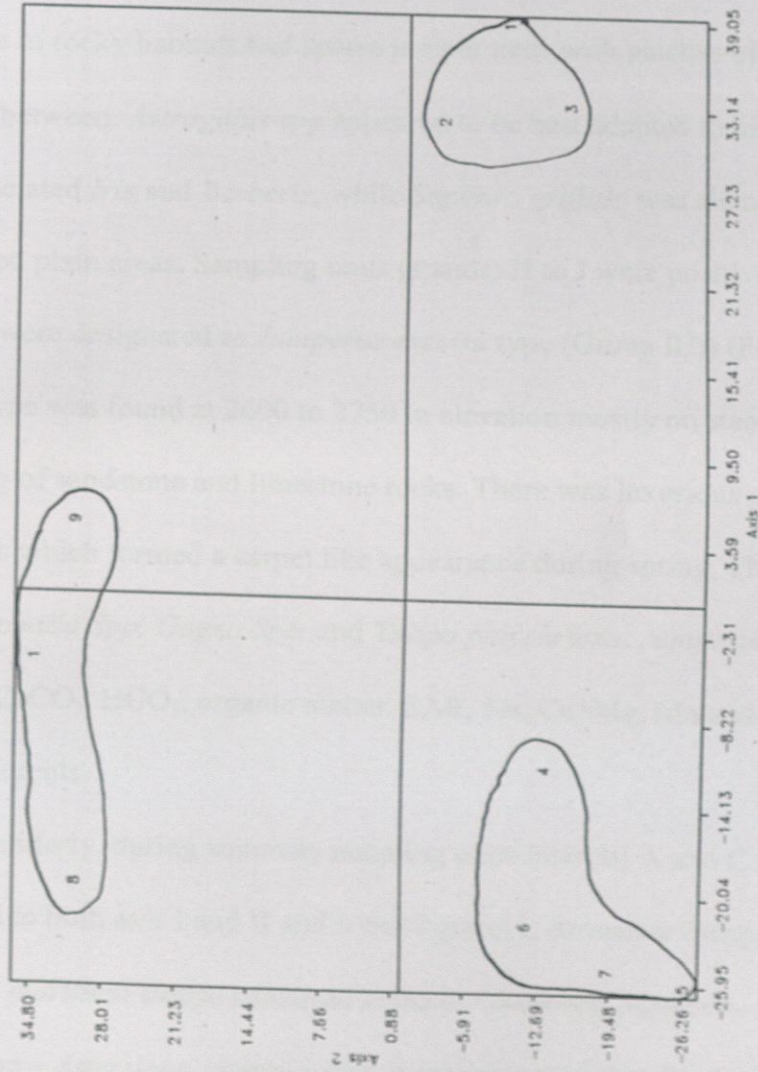


Fig. 23: Principal Coordinate Ordination showing grouping of stands (Spring Aspect).

CaCO₃ content, high pH and high potassium contents and low Na, SAR and Ca+Mg contents.

The sampling units (stands) D to G were negatively correlated to Group I. They were dominated by *Artemisia maritima* to form *Artemisia* steppe (Group II). *Artemisia maritima* steppe was found at 2400 to 2500 m. elevation. The eroded less steep sandstone in rocky habitats had sparse juniper trees with patches of herbaceous or shrubby plants in between. *Astragalus spp* appeared to be best adapted to highly eroded sandstone with associated *Iris* and *Berberis*, while *Sophora griffithi* was abundant at comparatively less eroded plain areas. Sampling units (stands) H to J were positively correlated to axis II and they were designated as *Juniperus excelsa* type (Group III)) (Fig. 23). *Juniperus excelsa* type was found at 2600 to 2750 m elevation mostly on steep eroded slopes consisting of sandstone and limestone rocks. There was luxurious growth of annuals and geophytes which formed a carpet like appearance during spring. These included *Ceratocephalla Spp*, *Gagea Spp*, and *Tulipa polychroma*. *Juniperus* type was related with high Ec, CaCO₃, HCO₃, organic matter, SAR, Na, Ca+Mg, Mn and Zn, while soil had low copper contents.

Similarly, during summer, sampling units (stands) A and C were positively correlated to both axis I and II and formed group I, *Artemisia* Steppe type (Fig. 24). *Artemisia maritima* steppe consisted *Aristida - Sophora*, *Sophora - Eragrostis* and *Eragrostis - Astersicus* communities. It was observed that *Sophora* and *Eragrostis* gained dominance with increase in altitude. *Aristida* was restricted to 2240 m elevation. These communities were correlated with high pH, high SO₄ while low water holding capacity, low K, Mn and Zn. Sampling units (stands) D to G were negatively correlated to

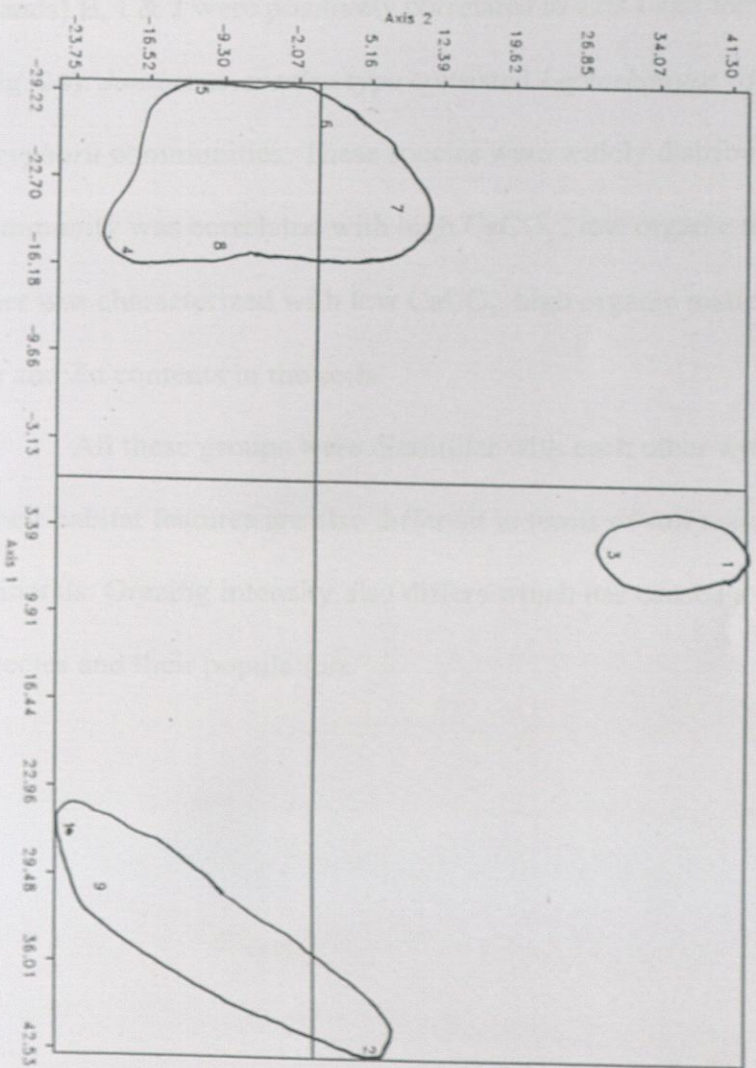


Fig. 24: Principal Coordinate Ordination showing grouping of stands (Summer Aspect).

axis I and formed a distinct Group II, *Astragalus* Steppe. *Astragalus* steppe was restricted to 2400 to 2500 m elevation in the area. These communities were related to low SO_4 on highly eroded sites with surface covered with weathered sandstone. The sampling units (stands) B, I & J were positively correlated to axis I and formed Group III, *Juniperus* type (Fig. 24). *Juniperus excelsa* type consisted *Leptorhabdos* - *Pulicaria* and *Leptorhabdos* - *Zizyphora* communities. These species were widely distributed in the area. The former community was correlated with high CaCO_3 , low organic matter and nitrogen while the later was characterized with low CaCO_3 , high organic matter, MWHC, nitrogen, K, Mn, Fe and Zn contents in the soils.

All these groups were dissimilar with each other with their species composition. Their habitat features are also different in terms of soil texture, water holding capacity and minerals. Grazing intensity also differs which has caused a change in the component species and their population.

IV. Degree of Palatability

Of the total 145 recorded species belonging to 37 families, 129 were palatable (Appendix 20). Among them, 50.4% (65 Spp.) were highly palatable, 41.1% (53 Spp.) mostly palatable, 4.7% (6 Spp.) less palatable and 3.9% (5 Spp.) species were rarely palatable. The ratio of palatable species to all the total listed species was 44.8% highly palatable, 36.6% most palatable, 4.1% less palatable and 3.4% rarely palatable.

Juniper leaves were highly preferred by both sheep and goats during early spring (April and May) (Fig. 25). Among the shrubs, 17 species (13.2%) were highly palatable while 14 species (10.9%) were mostly palatable. The livestock mostly preferred the shrub species. *Rosa lacerans* and *Hertia intermedia* were preferred mostly only at flowering stages. *Artemisia maritima* was highly preferred species during early spring and late summer, while it was not grazed during June to August. *Perovskia Spp*, *Sophora griffithii* and *Haloxylon griffithii* were preferred over other species from July to September and were less preferred in other months (i.e. at seedling and mature stage). Similarly, *Nepeta juncea* was preferred the most from July to October and less preferred from April to June.

There were 74 (57.4%) palatable herbs. Of them, 32 (24.8%) were highly palatable, 33 (25.6%) mostly palatable, 5 (3.9%) less palatable and 4 (3.1%) rarely palatable.

There were 23 species (17.8%) of palatable grasses. Of them, 15 species (11.6%) were highly palatable, 6 species (4.7%) mostly palatable, one species i.e. *Cymbopogon jwarancusa* was less and *Polypogon fagus* was rarely palatable grass species.

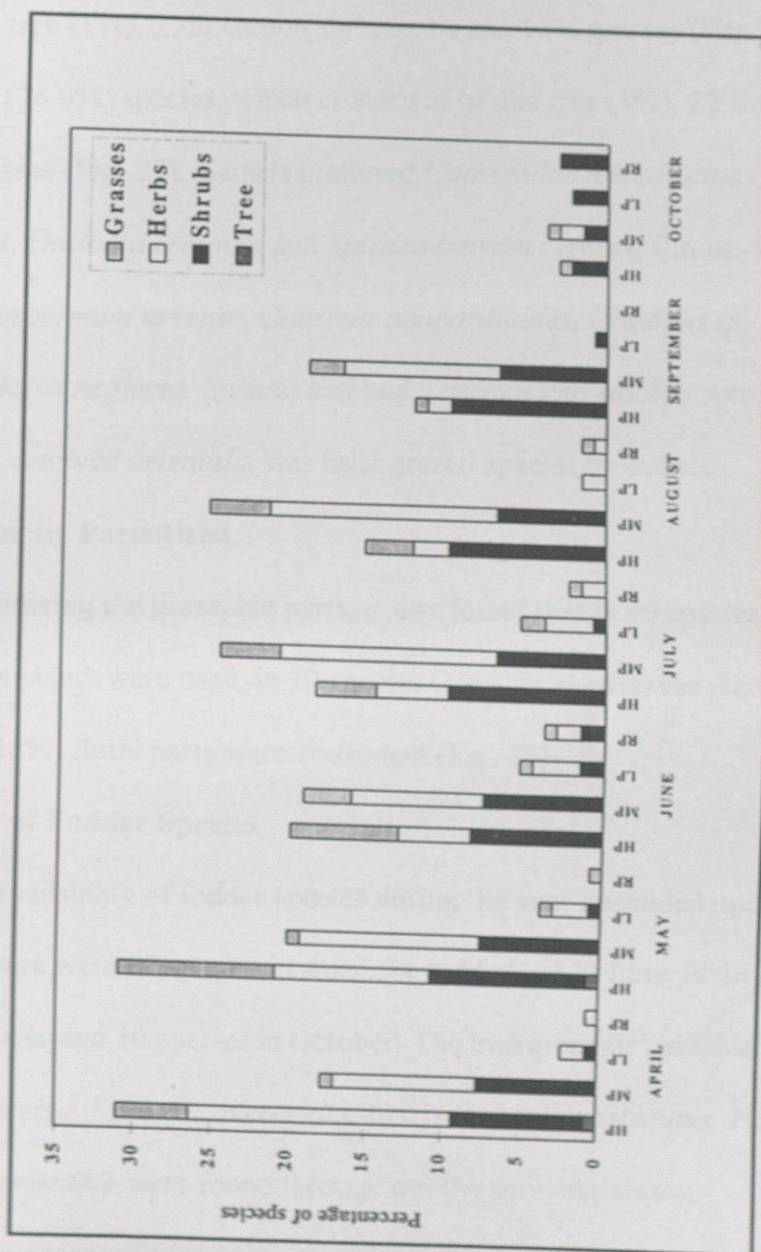


Fig. 25: Availability of palatable species during different months

Key:

- HP: Highly palatable
 MP: Mostly palatable
 LP: Less palatable
 RP: Rarely palatable

Preference by Animals

Among the palatable species, 104 (80.6%) species were used by goats. They included one tree (1%), 27% shrubs, 60% herbs and 12% grasses (Fig. 26). Sheep preferred 98 (76.0%) species, which comprised of one tree (1%), 22 shrubs, 54% herbs and 23% grasses (Fig. 27). Camels preferred *Convolvulus leiocalycinus*, *Perovskia abrotanoides*, *Gailonia eriantha* and *Spiraea boissieri* among shrubs. While *Descurinia sophia*, *Lithospermum arvense*, *Cousinia onopordioides*, *Cousinia sp*, *Echinops echinatus*, *Malva neglecta*, *Salsola kali* and *Trichodesma stocksii* were mostly preferred herb species. *Lactuca orientalis* was least grazed species by camels.

Classification by Parts Used

Considering the grazeable parts, it was found that in 99 species (63%) shoots/whole plants were used, in 30 species (19%) foliage/leaves were used, , while in 29 species (18%) floral parts were consumed (Fig. 28).

Availability of Fodder Species

The availability of fodder species during the year depended upon the seasons (Fig. 25). There were 67 species in April, 71 in May, 63 in June, 66 in July, 57 in August, 42 in September and 16 species in October. The evergreen or perennial species like *Juniperus excelsa*, *Ephedra intermedia*, *Convolvulus leiocalycinus*, *Prunus spp* and *Pennisetum orientale* were found through out the growing season.

It was observed that majority of the highly palatable species were available in higher percentage (31%) during April and May, that gradually declined during October (3.1%) through course of time (Fig. 25). Mostly palatable species gradually increased from April to August (17.9 to 32.6%) and thereafter they decreased.

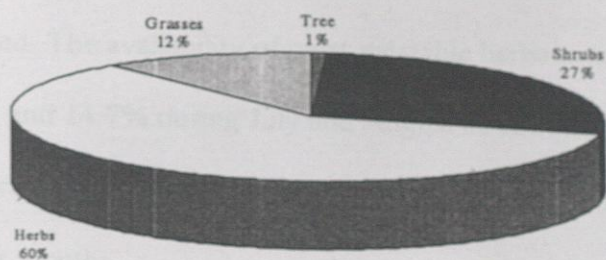


Fig. 26: Classification of palatable species as grazed by goats

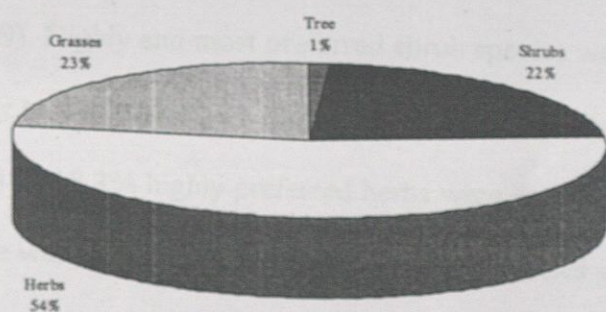


Fig. 27: Classification of palatable species as grazed by sheep.

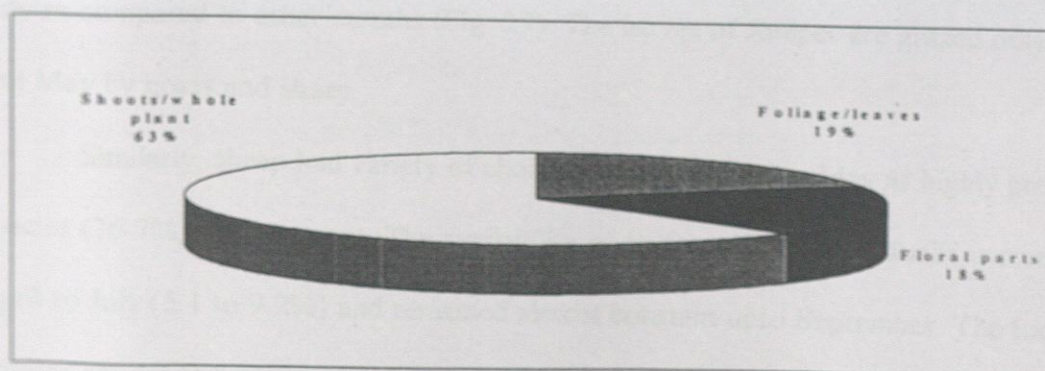


Fig. 28: Grazeable parts of species preferred by livestock.

The highly and mostly preferred shrub components were almost equal (8.5, 10.1 and 8.5%) from April to June and July to September (10.1%) (Fig. 25). Highly palatable herbaceous species were available abundantly (17.1%) during April and thereafter gradually decreased. The availability of most palatable herbaceous species was almost similar i.e. 13.4% and 14.7% during July and August as compared to other seasons. The highly palatable grasses were mostly available during May and June (10.1 and 7.0%) and decreased in other months.

The species highly preferred by goats were available (38.5%) during May and therefore, they had more choices for fodder. Similarly, 7.7% and 9.6% species of grasses were available during May and June, respectively, which declined gradually upto September (Fig. 29). Highly and most preferred shrub species were relatively constantly available from May to September (11.5%). They decreased in October (2.9%) and onwards. The 16.4 to 18.3% highly preferred herbs were available in April and May and thereafter a decline was recorded. While most preferred species gradually increased from April to July (6.7 to 15.4%). They remained almost constant upto September and decreased in October (1.9%). The species with low preferences by livestock were more in July as compared to other months (Fig. 29). The leaves of Juniper are grazed only in April and May by goats and sheep.

Similarly, sheep had variety of choices for fodder during May as highly preferred species (36.7%) were present. The availability of preferred shrubs gradually increased from April to July (5.1 to 9.2%) and remained almost constant upto September. The fodder choices are limited during October due to limited availability of species (2.0%) (Fig. 30). The number of highly preferred herbs was relatively greater (17.4%) in April and May as

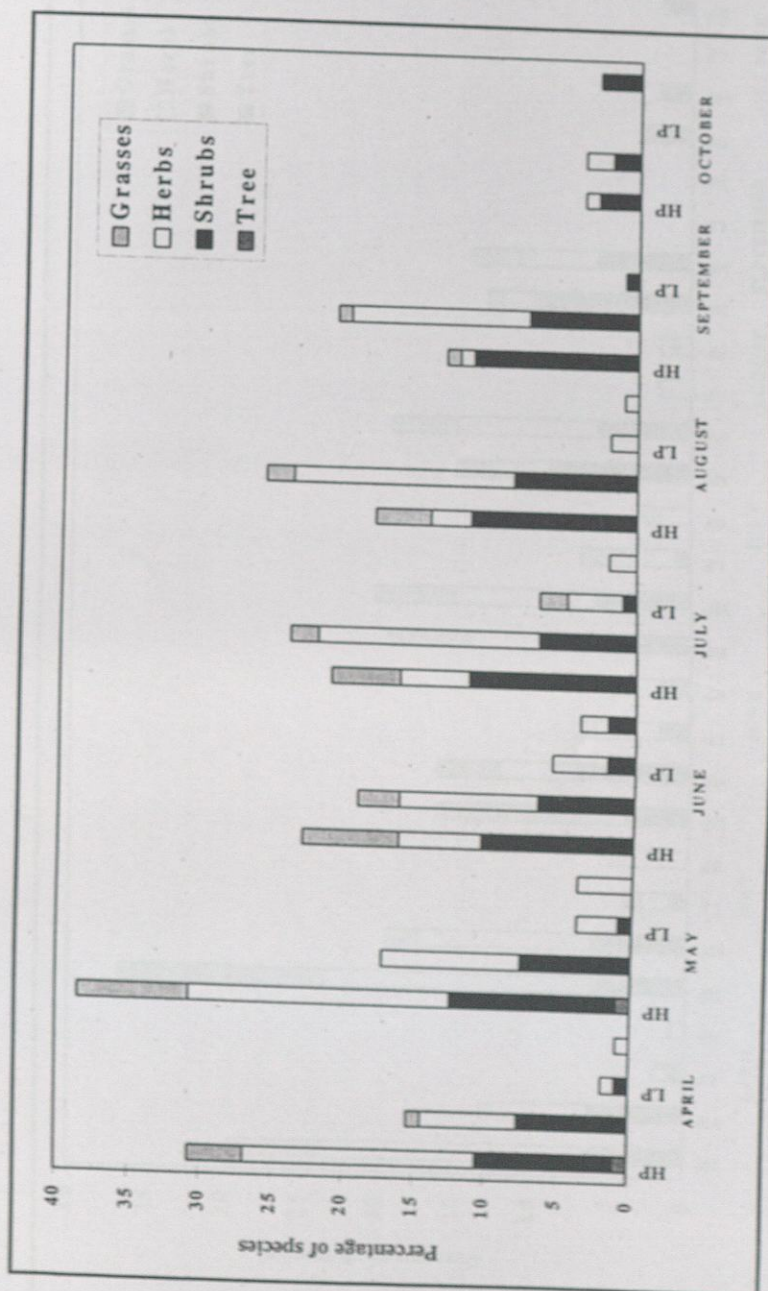


Fig. 29: Preferences of goats during different months.

Key as given in fig. 25.

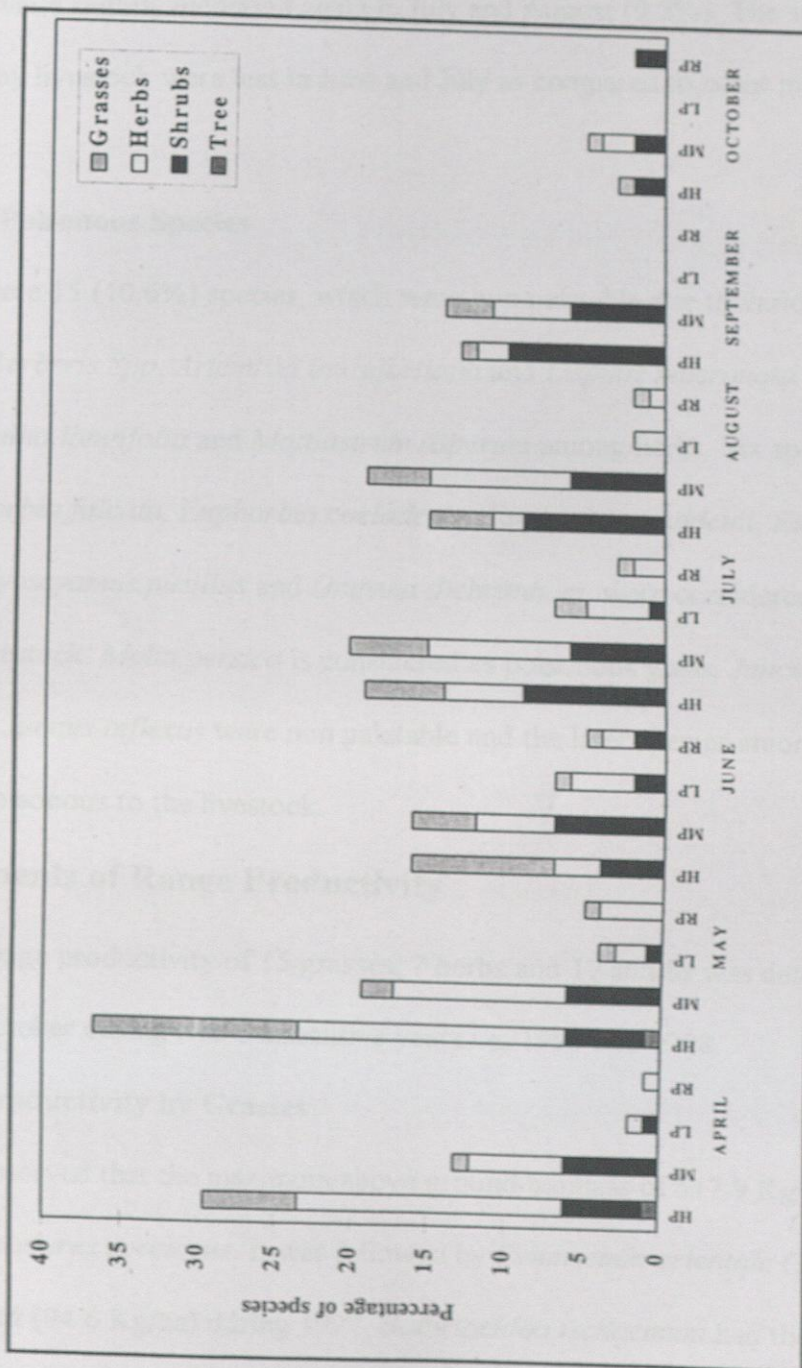


Fig. 30: Preferences of sheep during different months.
Key as given in Fig. 25

compared to other months. Most preferred herbs were 11.2% during May; they decreased in June (5.1%) while slightly increased again in July and August (9.2%). The species with low preference by livestock were less in June and July as compared to other months (Fig. 30).

Non Palatable/Poisonous Species

There were 15 (10.6%) species, which were non palatable due to various reasons. They included *Berberis Spp*, *Artemisia tourefortiana* and *Daphne mucronata* among shrubs; and *Mentha longifolia* and *Mattiastrum asperum* among herbs. Six species including *Euphorbia falcata*, *Euphorbia coeladenia*, *Euphorbia maddenii*, *Euphorbia multifurcata*, *Hyoscyamus pusillus* and *Onasma dichranhum* were considered as poisonous to livestock. *Melia persica* is considered as poisonous grass. *Juncus articulata*, *Juncus Spp* and *Juncus inflexus* were non palatable and the later species among sedges is considered as poisonous to the livestock.

V. Measurements of Range Productivity

The herbage productivity of 15 grasses, 7 herbs and 17 shrubs was determined from April to October during two consecutive years i.e. 1997 and 1998.

A. 1. Forage Productivity by Grasses

It was observed that the maximum above ground biomass of 517.9 Kg/ha was provided by *Phacelurus speciosus*. It was followed by *Pennisetum orientale* (343.5 Kg/ha) and *Stipa pennata* (94.6 Kg/ha) during 1997. *Bothriochloa ischaemum* had the least (1.4 Kg/ha) production in 1997. During 1998, *Phacelurus speciosus* once again exhibited the highest value of 523.2 Kg/ha. It was followed by *Pennisetum orientale* (375.5 Kg/ha).

Stipa pennata (87.9 Kg/ha) and *Bothriochloa ischaemum* yielded the least herbage (Table 22).

Generally speaking, the total productivity was slightly better during 1997 (1291.5 Kg/ha) than in 1998 (1246.8 Kg/ha). The herbage productivity gradually increased from April to July 1997 (83.6 to 247.9 Kg/ha) and thereafter declined up to October (151.5 Kg/ha) (Fig. 31).

A similar trend was observed for 1998. The herbage biomass enhanced from 87.7 to 300.1 Kg from April through July and showed declination in the subsequent months till October (51 Kg/ha) (Fig. 32).

The total productivity of grasses was 1269.2 Kg/ha. It increased from 85.7 to 171.2 Kg/ha during April to May with a slightly depression in June (167.5 Kg/ha). It reached to its peak production 274.0 Kg/ha in July (Table 22).

A. 2. Herbaceous Productivity

This included herbs other than grasses. It was observed that *Eremerus persicus* had the maximum biomass production of 1004.1 Kg/ha during 1997. It was followed by *Iris tenuifolia* (234.3 Kg/ha). *Alyssum Spp.*, an annual herb, had the minimum (2.3 Kg/ha) biomass. During 1998, *Eremerus persicus* and *Iris tenuifolia* once again were the highest producers and respectively gave a productivity of 100.4 Kg/ha and 76.2 Kg/ha. *Tulipa polychroma* gave the least value 3.1 Kg/ha.

The total herbage productivity was slightly greater during 1997 (1270.0 Kg/ha) than during 1998 (216.8 Kg/ha). Four of the species registered slight increase while *Eremerus* and *Iris* exhibited drastic decline in the production.

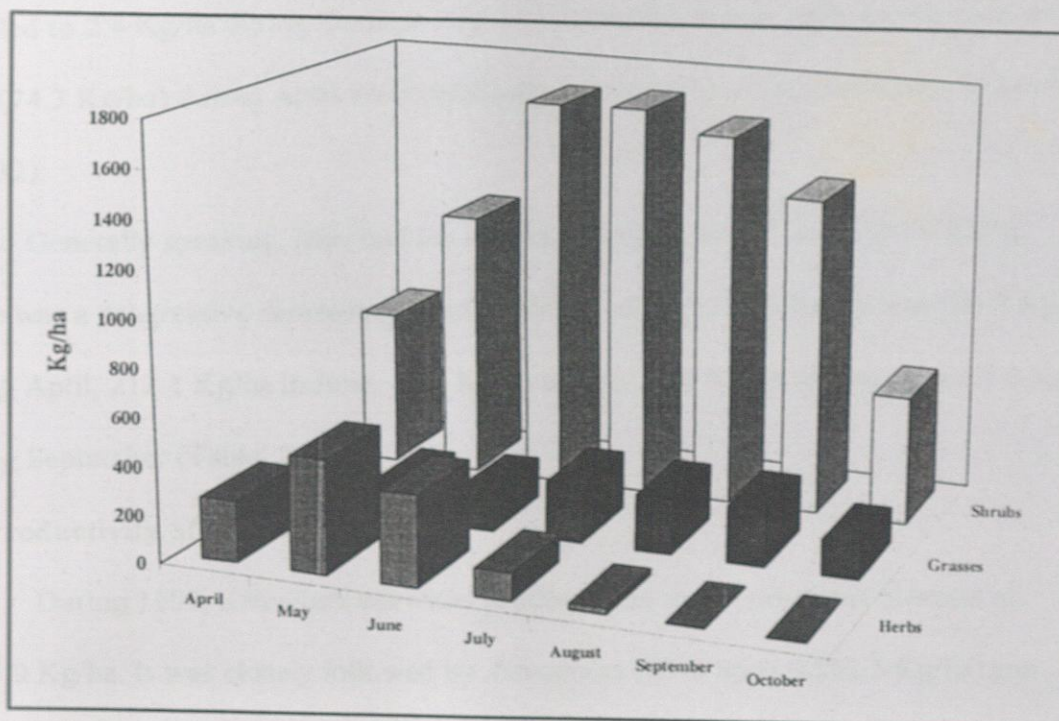


Fig. 31: Productivity of vegetation during different months of 1997.

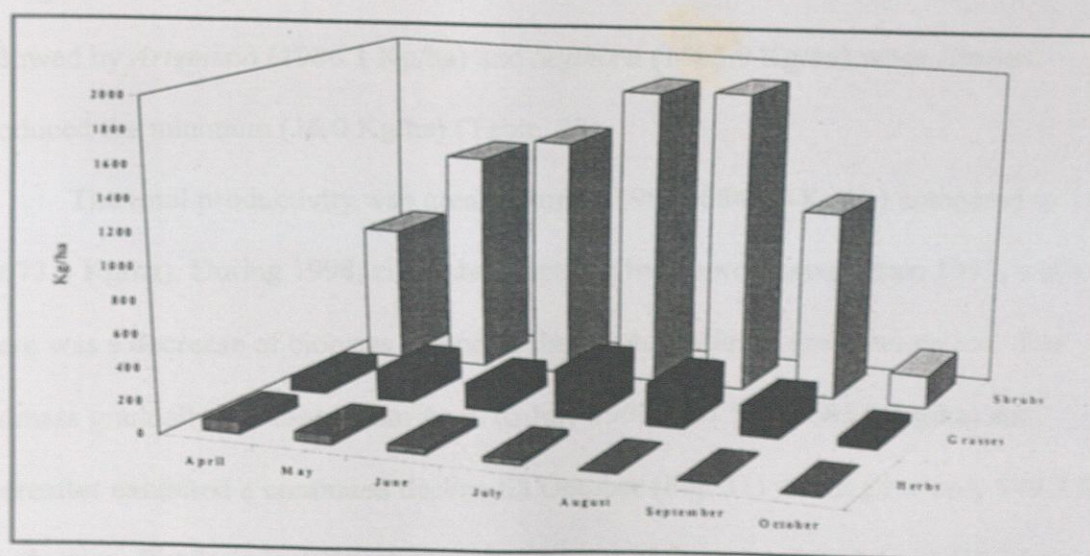


Fig. 32: Productivity of vegetation during different months of 1998.

The total productivity was highest (478.3 Kg/ha) during May 1997, which dwindled to 2.4 Kg/ha during October (Fig. 31). Similarly, during 1998, the biomass was more (74.3 Kg/ha) during April which gradually decreased to 6.9 Kg/ha during September (Fig. 32).

Generally speaking, May had the highest average production of 267.6 Kg/ha. There was a progressive decreasing trend till the October (1.2 Kg/ha). It was 166.7 Kg/ha during April, 212.1 Kg/ha in June, 74.4 Kg/ha in July, 16.1 Kg/ha in August and 5.3 Kg/ha during September (Table 22).

B. Productivity of Shrubs

During 1997, *Artemisia maritima* produced the maximum shoot biomass of 1955.9 Kg/ha. It was closely followed by *Astragalus* (97-8 Spp) (1862.5 Kg/ha) and *Sohpora griffithii* (1786.9 Kg/ha). *Ebenus stellata* gave the least (15.3 Kg/ha) production. During 1998, *Astragalus* (97-8 Spp) yielded the maximum (2116.4 Kg/ha) biomass. It was followed by *Artemisia* (1986.1 Kg/ha) and *Sophora* (1585.9 Kg/ha) while *Ebenus* produced the minimum (16.0 Kg/ha) (Table 22).

The total productivity was greater during 1998 (8846.5 Kg/ha) compared to 1997 (8673.5 Kg/ha). During 1998, eight shrub species had more biomass than 1997, while there was a decrease of biomass in nine of the shrub species in the same period. The biomass gradually increased from April to July 1997 (667.5 to 1685.1 Kg/ha) and thereafter exhibited a continued decline till October (Fig. 31) which gave only 549.7 Kg/ha production. Similarly in 1998, the biomass increased from April to August (837.5 to 1888.8 Kg/ha) and in the subsequent months it declined 206.5 Kg/ha especially in

October (Fig. 32).

The period from April to August was more productive during both the years. However, due to dry spell in 1998, the biomass decreased in September and October as compared to the productivity of 1997. As a whole, shrub biomass was 8760.0 Kg/ha which continuously increased from April to July (752.5, 1253.6, 1591.3 and 1772.4 Kg/ha, respectively) and then declined from August to October (1743.5, 1268.7 and 378.1 Kg/ha, respectively).

The Overall Productivity of Forage

The total average biomass for both the years was 10772.6 Kg/ha. The months of July and August were the most productive (2120.7 and 2012.7 Kg/ha, respectively). The biomass gradually increased from April to July followed by progressive decreasing trend till the October (480.5 Kg/ha).

Table 22: The herbage productivity (Biomass Kg/ha) of Shrubs, Herbs and Grasses in different months during 1997 and 1998.

S.No	Name of Species	Year	April	May	June	July	August	September	October	Total
A - Grasses										
1.	<i>Aristida adscensionis</i>	1997				19.0	22.2	28.1	22.9	92.2
		1998				15.1	14.5	4.2	1.2	35.0
	Mean					17.0	18.4	16.2	12.0	63.6
2.	<i>Aristida spp</i>	1997				2.6	4.1	0.4		7.1
		1998				3.7	3.9	0.3		8.0
	Mean					3.2	4.0	0.4		7.5
3.	<i>Bothriochloa ischaemum</i>	1997				0.7	0.5	0.2		1.4
		1998				0.6	0.3	0.1		1.1
	Mean					0.7	0.4	0.2		1.2
4.	<i>Bromus sericens</i>	1997	1.9	19.6						21.5
		1998	2.5	20.3						22.8
	Mean		2.2	20.0						22.2
5.	<i>Bromus tectorum</i>	1997	4.2	4.2						8.4
		1998	4.5	9.6						14.1
	Mean		4.4	6.9						11.3
6.	<i>Cymbopogon jwarancusa</i>	1997		16.5	3.5	1.3				21.3
		1998		19.7	7.4	0.4				27.5
	Mean			18.1	5.4	0.9				24.4
7.	<i>Eragrostis minor</i>	1997			2.0	3.4	3.9	2.3	0.6	12.1
		1998			2.8	4.3	4.3	3.2	0.0	14.6
	Mean				2.4	3.8	4.1	2.8	0.3	13.4
8.	<i>Melica persica</i>	1997			15.3	28.3	16.5			60.1
		1998			18.6	16.8	0.0			35.4
	Mean				16.9	22.5	8.3			47.7
9.	<i>Pennisetum orientale</i>	1997	34.2	45.5	92.1	30.4	38.2	52.2	50.9	343.5
		1998	38.8	47.8	90.1	92.4	81.7	20.1	4.7	375.5
	Mean		36.5	46.7	91.1	61.4	60.0	36.2	27.8	359.5
10.	<i>Phaeoleurus speciosus</i>	1997				132.1	151.1	157.5	77.2	517.9
		1998				155.4	160.2	162.5	45.1	523.2
	Mean					143.7	155.7	160.0	61.2	520.5
11.	<i>Piptatherum vicarium</i>	1997	18.8	24.5	21.0	4.8	1.6			70.6
		1998	15.0	22.1	19.3	0.6	0.0			57.0
	Mean		16.9	23.3	20.1	2.7	0.8			63.8

12. <i>Poa bulbosa</i>	1997	4.4	5.2									9.6
	1998	4.6	4.8									9.4
	Mean	4.5	5.0									9.5
13. <i>Shismus arabicus</i>	1997	0.7	2.6									3.2
	1998	1.2	3.4									4.6
	Mean	0.9	3.0									3.9
14. <i>Stipa pennata</i>	1997	19.5	32.9	28.8	12.9	0.5						94.6
	1998	21.2	43.5	13.1	10.2	0.0						87.9
	Mean	20.3	38.2	20.9	11.6	0.2						91.3
15. <i>Tetrapogon villosus</i>	1997		0.4	10.7	12.5	2.7	1.8					28.2
	1998		19.7	10.4	0.6	0.0	0.0					30.8
	Mean		10.1	10.6	6.6	1.3	0.9					29.5
GRAND TOTAL:1997		83.6	151.4	173.2	247.9	241.3	242.6	151.5				1291.5
GRAND TOTAL:1998		87.7	190.9	161.7	300.1	265.0	190.4	51.0				1246.8
AVERAGE		85.7	171.2	167.5	274.0	253.1	216.5	101.3				1269.2
B - Herbs												
1. <i>Alyssum Spp</i>	1997	0.8	1.5									2.3
	1998	1.8	1.6									3.5
	Mean	1.3	1.6									2.9
2. <i>Bupleurum exaltatum</i>	1997		4.0	3.8	1.7	0.2						9.7
	1998		4.1	3.4	2.5	0.5						10.4
	Mean		4.0	3.6	2.1	0.4						10.0
3. <i>Eremerus persicus</i>	1997	172.3	385.2	331.3	96.7	18.5						1004.1
	1998	50.1	22.2	16.3	11.8	0.0						100.4
	Mean	111.2	203.7	173.8	54.2	9.3						552.2
4. <i>Iris tenuifolia</i>	1997	83.1	85.7	45.2	16.8	3.5						234.3
	1998	19.3	26.2	18.5	12.2	0.0						76.2
	Mean	51.2	56.0	31.9	14.5	1.8						155.2
5. <i>Pulicaria gnaphalodes</i>	1997		1.9	2.5	2.8	3.5	3.7	2.4				16.8
	1998		2.9	3.2	4.3	6.0	6.9	0.0				23.2
	Mean		2.4	2.8	3.5	4.8	5.3	1.2				20.0
6. <i>Tulipa polychroma</i>	1997	2.8										2.8
	1998	3.1										3.1
	Mean	3.0										3.0
GRAND TOTAL:1997		259.0	478.3	382.9	117.9	25.7	3.7	2.4				1270.0
GRAND TOTAL:1998		74.3	57.0	41.3	30.8	6.6	6.9	0.0				216.8
AVERAGE		166.7	267.6	212.1	74.3	16.1	5.3	1.2				743.4

C - Shrubs											
1. <i>Aerva javanica</i>	1997	19.2	25.2	23.3							67.6
	1998	20.3	21.2	11.5							53.0
	Mean	19.7	23.2	17.4							60.3
2. <i>Artemisia maritima</i>	1997		47.1					407.3	486.9	245.0	
	1998		32.4					652.1	472.5	67.0	
	Mean		39.8					529.7	479.7	156.0	
3. <i>Astragalus 97 - 8</i>	1997		245.2					251.4	93.5	78.2	
	1998		403.6					275.2	75.9	27.2	
	Mean		324.4					263.3	84.7	52.7	
4. <i>Berberis balochistanica</i>	1997		11.3					9.3	6.8	4.2	
	1998		12.1					13.0	11.7	1.7	
	Mean		11.7					11.2	9.2	3.0	
5. <i>Caragana stocksi</i>	1997		27.3								
	1998		21.3								
	Mean		24.3								
6. <i>Convolvulus leiocalycinus</i>	1997		165.2					51.1	19.9	3.2	
	1998		124.1					97.1	95.2	12.6	
	Mean		144.7					74.1	57.6	7.9	
7. <i>Daphnne mucronata</i>	1997		5.1					11.2	7.5	6.7	
	1998		6.8					16.2	9.4	7.2	
	Mean		5.9					13.7	8.4	7.0	
8. <i>Ebenus stellata</i>	1997		7.5								
	1998		7.8								
	Mean		7.6								
9. <i>Ephedra intermedia</i>	1997		31.5					30.2	8.8	4.9	
	1998		42.2					52.7	45.3	15.1	
	Mean		36.8					41.4	27.0	10.0	
10. <i>Haloxylon griffithii</i>	1997							13.1	18.5	4.3	
	1998							17.4	20.1	5.7	
	Mean							15.3	19.3	5.0	
11. <i>Hertia intermedia</i>	1997		31.8					32.4	30.8	22.2	
	1998		36.6					12.3	5.2	0.0	
	Mean		34.2					22.3	18.0	11.1	
12. <i>Nepeta juncea</i>	1997		15.7					19.1	29.9	17.6	
	1998		25.6					12.2	7.9	4.3	
	Mean		20.7					15.6	18.9	10.9	

VI. Chemical Evaluation of Some Range Plants

I. Proximation Composition

The proximate composition including dry matter, ash contents, crude protein, crude fibre, ether extract, nitrogen, nitrogen free extract, gross energy and carbohydrate contents are given in Table 23a.

Dry Matter (DM%)

Generally, grasses had more dry matter than shrubs. It ranged from 63.41% (*Pennisetum orientale*) to 80.9% (*Tetrapogon villosus*) while *Cymbopogon jwarancusa* had 73.8% and *Stipa pennata* had 69.0% dry matter. In shrubs, the DM level ranged from 52.2%, in *Perovskia abrotanoides*, to 71.7% in *Artemisia maritima*. The DM was least in *Artemisia maritima* at pre-reproductive stage, which gradually increased with the advancing age of plants. There were highly significant differences in DM of grasses and shrubs at reproductive and post-reproductive stages (Table 23b).

Ash Contents (Total Minerals)

Ash contents (total minerals) of shrubs were greater than those of grasses (Table 23a). It varied from 6.5% (*Sophora griffithii*) to 11.2% (*Hertia intermedia*). *Hertia* had high ash contents at pre-reproductive stage while it become lowest in *Sophora griffithii* and *Convolvulus leiocalycinus* at similar stages. At post-reproductive stage ash contents were highest in *Perovskia atriplicifolia* and lowest in *Sophora griffithii*. The average ash contents of grasses were as high as 10.4% in *Tetrapogon villosus* which declined to 8.0% in *Cymbopogon jwarancusa*. At pre-reproductive stage *Stipa pinnata* had the lowest ash contents while at reproductive and post-reproductive stages the value enhanced. *Pennisetum* had highest ash contents at reproductive stage and lowest at post-

reproductive stage (Table 23a).

The differences between ash contents of grasses and shrubs were non-significant at all phenological stages (Table 23b). Generally saying, the ash contents were high at pre-reproductive stage and gradually decreased in post-reproductive phase. However, in some cases (*Stipa* and *Sophora* at reproductive stage while *Perovskia atriplicifolia* at post-reproductive stage) slightly increase was observed at later stage.

Crude Protein (CP)

The crude protein contents of grasses were as high as 10.0% (*Pennisetum orientale*) which declined to 6.8% (*Cymbopogon jwarancusa*) (Table 23a). *Pennisetum* had highest value at pre-reproductive stage and reproductive stages while *Tetrapogon* exhibited highest contents at post-reproductive stage.

Shrubs exhibited slightly higher crude protein contents than grasses. But the differences were non-significant. It ranged from 8.2% (*Hertia intermedia*) to 11.5% (*Artemisia maritima*). *Artemisia* had highest value at pre-reproductive and post-reproductive stages whereas *Hertia* contained the lowest crude protein at similar stages. *Sophora* had highest crude protein contents at reproductive stage only, while *Convolvulus* had the lowest crude protein at this stage.

Generally speaking crude protein concentration averaged high at pre-reproductive stage than other growth stages. However, in *Artemisia maritima*, *Perovskia atriplicifolia* and *Hertia intermedia* a slight increase in crude protein contents was observed in later growth stages (post-reproductive stage) due to re-growth of plants after summer season.

Crude Fibre (CF)

Shrubs generally had greater crude fibre contents than grasses (Table 23a). It ranged from 23.9% in (*Pennisetum Spp*) to 26.9% in (*Tetrapogon Spp*). It was high at reproductive and post-reproductive stages in *Tetrapogon Spp*, while *Cymbopogon Spp* had highest crude fibre at pre-reproductive stage. *Convolvulus* exhibited 29.3% crude fibre contents while *Hertia* had 19.4% crude fibre, *Convolvulus* maintained the highest crude fibre contents at all the three stages (Table 23a). Crude fibre contents differed significantly ($P = 0.01$) between grasses and shrubs at pre-reproductive stages and post-reproductive stages (Table 23b).

Ether Extract (EE) and Crude Fat

Shrubs had higher ether extract than grasses. The differences were significant at pre-reproductive and post-reproductive stages (Table 23b). It was maximum in *Pennisetum* (5.9%) and least in *Tetrapogon* (2.0%). *Stipa*, *Pennisetum* and *Cymbopogon* had higher ether extract at pre-reproductive, reproductive and post-reproductive stages, respectively.

Maximum ether extract value of 8.5% was achieved for *Hertia*, which narrowed down to 3.0% in *Convolvulus*, *Hertia* had highest ether extract contents at pre-reproductive and post-reproductive stage. Both the species of *Perovskia* had highest ether extract at reproductive stage (Table 23a).

Nitrogen Contents

Nitrogen contents were slightly higher in shrubs than grasses (Table 23a). Nitrogen contents were highest in *Artemisia* (1.8%) and the lowest in *Hertia* (1.3%). Similarly, among the grasses it was the highest in *Pennisetum* (1.6%) and the

Table 23a: Proximate Composition % of some Grasses and Shrubs of Harbol Hills

S.No	Species	Phenological Stages	Moisture %	Organic Matter %	Nitrogen %	Crude Protein %	Crude Fiber %	Ether Extract	Ash %	NFE* %	Carbohydrates %
A - Grasses											
1.	<i>Stipa pinnata</i>										
		Pre-Rep. Stage	59.3	91.5	1.9	11.9	23.2	2.6	8.5	53.8	17.7
		Reproductive Stage	27.7	90.2	1.5	9.6	24.5	3.0	9.8	53.2	50.0
		Post Rep. Stage	5.9	92.2	1.0	6.4	30.0	2.7	7.8	53.2	77.2
		Mean	31.0	91.3	1.5	9.3	25.9	2.8	8.7	53.4	48.3
2.	<i>Pennisetum orientale</i>										
		Pre-Rep. Stage	48.6	89.7	2.3	14.3	22.1	2.5	10.3	50.8	24.3
		Reproductive Stage	41.5	90.2	1.6	10.0	19.9	13.4	9.8	46.9	25.4
		Post Rep. Stage	19.7	93.3	0.9	5.6	29.8	1.9	6.7	56.0	66.1
		Mean	36.6	91.1	1.6	10.0	23.9	5.9	8.9	51.2	38.6
3.	<i>Tetrapogon villosus</i>										
		Pre-Rep. Stage	41.8	83.8	1.5	9.1	20.4	2.3	16.2	52.0	30.6
		Reproductive Stage	6.2	92.8	1.1	7.2	30.2	1.5	7.2	54.0	78.0
		Post Rep. Stage	9.3	92.2	1.3	8.3	30.0	2.1	7.8	51.8	72.5
		Mean	19.1	89.6	1.3	8.2	26.9	2.0	10.4	52.6	60.4
4.	<i>Cymbopogon jawarancusa</i>										
		Pre-Rep. Stage	41.3	90.8	1.2	7.2	25.2	2.3	9.2	56.1	40.0
		Reproductive Stage	28.3	91.9	1.1	6.9	26.9	1.9	8.1	56.2	54.9
		Post Rep. Stage	9.1	93.2	1.0	6.4	26.6	3.0	6.8	57.3	74.8
		Mean	26.2	92.0	1.1	6.8	26.2	2.4	8.0	56.5	56.5

1. *Artemisia maritima*

Pre-Rep. Stage	41.3	90.3	2.5	15.8	14.1	9.2	9.7	51.2	24.0
Reproductive Stage	25.2	93.1	1.1	7.1	27.8	6.9	9.5	48.7	51.3
Post Rep. Stage	18.4	91.7	1.9	11.6	22.9	8.3	9.6	47.6	52.1

Mean	28.3	91.7	1.8	11.5	21.6	8.1	9.6	49.2	42.5
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2. *Perovskia abrotanoides*

Pre-Rep. Stage	56.3	90.8	2.2	13.9	13.5	8.3	9.2	55.1	12.3
Reproductive Stage	44.4	91.2	1.5	9.4	24.8	7.2	8.8	49.8	29.3
Post Rep. Stage	42.6	92.6	1.0	6.0	23.3	8.2	7.4	55.1	35.8

Mean	47.8	91.5	1.6	9.8	20.5	7.9	8.5	53.3	25.8
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3. *Perovskia atriplicifolia*

Pre-Rep. Stage	52.4	89.5	1.5	9.6	14.6	7.5	10.5	57.8	20.0
Reproductive Stage	37.6	92.1	1.2	7.7	26.0	7.2	7.9	51.2	39.6
Post Rep. Stage	27.8	88.2	1.4	8.7	19.3	7.9	11.8	52.3	43.8

Mean	39.3	89.9	1.4	8.7	20.0	7.5	10.1	53.8	34.5
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4. *Convolvulus leiocalycinus*

Pre-Rep. Stage	33.7	88.3	2.5	15.4	26.7	1.5	11.7	44.7	37.7
Reproductive Stage	46.0	95.2	0.7	4.4	28.6	4.6	4.8	57.6	40.3
Post Rep. Stage	15.6	91.8	1.3	8.3	32.7	3.0	8.2	47.8	64.9

Mean	31.8	91.8	1.5	9.3	29.3	3.0	8.2	50.1	47.6
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5. *Sophora griffithii*

Pre-Rep. Stage	51.8	95.3	1.9	12.0	22.5	2.0	4.8	58.8	29.4
Reproductive Stage	47.6	91.1	1.9	11.9	24.0	5.4	8.9	49.8	26.3
Post Rep. Stage	36.2	94.3	1.6	10.2	21.4	7.9	5.7	54.8	40.0

Mean	45.2	93.5	1.8	11.4	22.6	5.1	6.5	54.5	31.9
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6. *Hertia intermedia*

Pre-Rep. Stage	62.7	87.2	1.4	8.7	14.3	12.7	12.8	51.5	3.1
Reproductive Stage	64.4	88.4	1.3	7.9	27.5	4.5	11.6	48.5	11.6
Post Rep. Stage	25.0	90.9	1.3	8.1	16.3	8.4	9.1	58.1	49.4
Mean	50.7	88.8	1.3	8.2	19.4	8.5	11.2	52.7	21.4

Table 23b: Statistical comparison of proximate composition of grasses and shrubs at three phenologica stages.

	Pre-Rep.		Reproductive		Post Rep.		Reproductive		Post Rep.	
	Grass	Shrubs	Grass	Shrubs	Grass	Shrubs	Grass	Shrubs	Grass	Shrubs
Ash										
	8.5	9.7	9.8	9.5	7.8	9.6	11.9	15.8	9.55	7.12
	10.33	9.2	9.8	8.8	6.7	7.4	14.26	13.9	9.98	9.4
	16.2	10.5	7.2	7.9	7.8	11.8	9.1	9.6	7.15	7.7
	9.2	11.69	8.1	4.84	6.8	8.2	7.2	15.37	6.9	4.37
		4.75	8.89	8.89		5.72		11.97		11.89
		12.8	11.6			9.1		8.7		7.9
Sum	11.0575	9.773333	8.725	8.588333	7.275	8.636667	10.615	12.5567	8.395	8.063333
Variance	12.32189	7.786067	1.675833	4.912177	0.369167	4.275267	9.631567	8.83971	2.543767	6.223867
t-Test	0.53643	0.563994	0.915049	0.905276	0.243762	0.178242	0.348809	0.36031	0.821267	0.804112
	NS		NS		S		NS		NS	NS
Crude Protein										
Sum	11.0575	9.773333	8.725	8.588333	7.275	8.636667	10.615	12.5567	8.395	8.063333
Variance	12.32189	7.786067	1.675833	4.912177	0.369167	4.275267	9.631567	8.83971	2.543767	6.223867
t-Test	0.53643	0.563994	0.915049	0.905276	0.243762	0.178242	0.348809	0.36031	0.821267	0.804112
	NS		NS		S		NS		NS	NS
Ether extract										
Sum	23.2	14.1	24.46	27.8	29.96	22.9	2.6	9.2	2.99	6.9
Variance	22.1	13.5	19.9	24.8	29.8	23.3	2.5	8.3	13.4	7.2
t-Test	20.4	14.6	30.16	26	30	19.3	2.31	7.5	1.45	7.2
	25.2	26.7	26.9	28.6	26.6	32.7	2.3	1.53	1.9	4.57
		22.5	24	24	21.4	16.3		2.01	5.4	5.4
		14.3	27.5	27.5				12.7	4.5	4.5
Sum	22.725	17.61667	25.355	26.45	29.09	22.65	2.4275	6.87333	4.935	5.961667
Variance	4.049167	31.15367	18.6777	3.295	2.763067	30.919	0.021692	18.7989	32.26523	1.667217
t-Test	0.12237	0.081148	0.588555	0.658532	0.057987	0.03593	0.079446	0.0537	0.672453	0.744375
	S		NS		S		S		NS	S
Carbohydrate										
Sum	53.8	51.2	53.2	48.7	53.18	47.6	17.7	24	49.96	51.28
Variance	50.81	55.1	46.92	49.8	55.99	55.1	24.29	12.33	25.37	29.3
t-Test	51.99	57.8	54.04	51.2	51.76	52.3	30.59	20.02	78	39.6
	56.1	44.71	56.2	57.62	57.25	47.82	39.97	37.69	54.85	40.27
		58.77	49.82	49.82		54.78		29.44		26.27
		51.5	48.5	48.5		58.1		3.1		11.64
Sum	53.175	53.18	52.59	50.94	54.545	52.61667	28.1375	21.0967	52.045	33.06
Variance	5.314567	26.95252	15.8852	11.64304	6.3415	17.83783	89.92249	151.055	465.811	189.1564
t-Test	0.99862	0.998402	0.502197	0.523454	0.440145	0.392889	0.363458	0.33877	0.124023	0.183821
	NS		NS		NS		NS		NS	S
NFE*										
Sum	53.175	53.18	52.59	50.94	54.545	52.61667	28.1375	21.0967	52.045	33.06
Variance	5.314567	26.95252	15.8852	11.64304	6.3415	17.83783	89.92249	151.055	465.811	189.1564
t-Test	0.99862	0.998402	0.502197	0.523454	0.440145	0.392889	0.363458	0.33877	0.124023	0.183821
	NS		NS		NS		NS		NS	S

S - Significant

NFE: Nitrogen Free Extract

NS - Non-significant

lowest (1.1%) in *Cymbopogon*. The nitrogen contents were generally better at pre-reproductive stage than at other phenological stages in all the tested species. There were non-significant differences of nitrogen content between grasses and shrubs at all phenological stages (Table 23b).

Carbohydrate Contents

There was an increasing trend of carbohydrates from pre-reproductive stage to post-reproductive stage in all the tested species. They were usually higher in grasses than in the shrubs (Table 23a). *Tetrapogon* had the maximum (60.4%) while *Pennisetum* the least value (38.6%). In shrubs, it was maximum (47.7%) in *Convolvulus* and least in *Hertia* (21.4%). The differences in the carbohydrates contents were highly significant ($p = 0.05$) between grasses and shrubs at post-reproductive stages and non-significant at other stages (Table 23b).

Nitrogen Free Extract (NFE)

No significant differences could be seen between grasses and shrubs at all the three phenological stages (Table 23b). However, NFE were the highest in *Cymbopogon* (56.5%) and lowest in *Pennisetum* (51.2%). Similarly, among shrubs, nitrogen free extract was maximum in *Sophora* (54.5%) while least in *Convolvulus* (50.1%) (Table 23a).

Gross Energy (GE)

Gross energy ranged from 406.1 in *Tetrapogon* to 434.4 in *Pennisetum* among the grasses. While it was 424.4 in *Convolvulus* to 444.7 in *Artemisia* among the shrubs (Table 24).

Table 24: Different Types of Energies Available to Livestock in different plants

S.No.	Species	Phenological Stages	Energy (GE)(Kcal/g)	TDN%	DE Mcal/Kg	ME Mcal/Kg
A - Grasses						
1.	<i>Stipa pinnata</i>	Pre-Rep. Stage	420.7	63.3	2.8	4.3
		Reproductive Stage	414.6	72.2	3.2	3.7
		Post Rep. Stage	419.9	59.8	2.6	3.1
		Mean	418.4	65.1	2.9	3.7
2.	<i>Pennisetum orientale</i>	Pre-Rep. Stage	415.9	62.0	2.7	3.2
		Reproductive Stage	468.8	70.9	3.1	3.6
		Post Rep. Stage	418.5	62.4	2.8	3.3
		Mean	434.4	65.1	2.9	3.4
3.	<i>Tetrapogon villosus</i>	Pre-Rep. Stage	381.2	56.2	2.5	3.0
		Reproductive Stage	416.9	59.3	2.6	3.1
		Post Rep. Stage	420.1	59.1	2.6	3.1
		Mean	406.1	58.2	2.6	3.0
4.	<i>Cymbopogon jawarancusa</i>	Pre-Rep. Stage	409.8	61.0	2.7	3.2
		Reproductive Stage	412.9	60.8	2.7	3.2
		Post Rep. Stage	422.8	61.7	2.7	3.2
		Mean	415.2	61.2	2.7	3.2
B - Shrubs						
1.	<i>Artemisia maritima</i>	Pre-Rep. Stage	451.7	64.9	2.9	3.3
		Reproductive Stage	435.7	61.7	2.7	3.2
		Post Rep. Stage	446.7	65.9	2.9	3.4
		Mean	444.7	64.2	2.8	3.3
2.	<i>Perovskia abrotanoides</i>	Pre-Rep. Stage	445.1	72.7	3.2	3.7
		Reproductive Stage	441.7	82.4	3.6	4.1
		Post Rep. Stage	445.9	67.9	3.0	3.5
		Mean	444.2	74.4	3.3	3.8

3. <i>Perovskia atriplicifolia</i>					
	Pre-Rep. Stage	429.0	70.2	3.1	3.6
	Reproductive Stage	443.3	64.8	2.9	3.3
	Post Rep. Stage	428.0	65.4	2.9	3.4
	Mean	433.5	66.8	2.9	3.4
4. <i>Convolvulus leiocalycinus</i>					
	Pre-Rep. Stage	410.5	57.1	2.5	3.0
	Reproductive Stage	437.6	65.1	2.9	3.4
	Post Rep. Stage	425.1	57.4	2.5	3.0
	Mean	424.4	59.9	2.6	3.1
5. <i>Sophora griffithii</i>					
	Pre-Rep. Stage	432.2	68.0	3.0	2.5
	Reproductive Stage	435.1	67.1	2.8	3.3
	Post Rep. Stage	456.7	71.0	3.1	3.6
	Mean	441.3	68.7	3.0	3.1
6. <i>Hertia intermedia</i>					
	Pre-Rep. Stage	446.5	70.7	3.1	3.6
	Reproductive Stage	415.1	58.0	2.6	3.0
	Post Rep. Stage	438.4	71.2	3.1	3.6
	Mean	433.3	66.6	2.9	3.4

The differences between grasses and shrubs were non significant in all phenological stages.

TDN - Total Digestible Nutrients

DE - Digestible Energy

ME - Metabolized Energy

Total Digestible Nutrients (TDN%)

Total digestible nutrients were in between 58.2% (*Tetrapogon*) to 65.1%, (*Stipa*) among grasses while it was 74.4% (*Perovskia abrotanoides*) to 59.9% in *Convolvulus leiocalycinus* among shrubs. There were non-significant differences between grasses and shrubs and between different phenological stages (Table 24).

Digestible Energy (DE Mcal/kg)

Digestible energy was highest in *Stipa* (2.9) followed by slight reduction in *Pennisetum* and *Cymbopogon* (2.7 Mcal/kg) and a further reduction in *Tetrapogon* 2.6 Mcal/kg. Among the shrubs, the digestible energy ranged in between 3.3 (*Perovskia abrotanoides*) to 2.6 (*Convolvulus leiocalycinus*). The differences between grasses and shrubs and between phenological stages were non-significant (Table 24).

Metabolized Energy (ME Mcal/kg)

Metabolized energy ranged from 3.7 (*Stipa*) to 3.0 (*Tetrapogon villosus*). While amongst shrubs it varied from 3.8 (*Perovskia abrotanoides*) to 3.1 (*Convolvulus leiocalycinus*). The differences were non-significant between grasses and shrubs and between phenological stages (Table 24).

II. Cell Wall Constituents

The cell wall constituents including Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL) and hemicelluloses are given in (Table 25a) as per following explanation.

Neutral Detergent Fibre (NDF)

Shrubs had lower NDF values than the grasses. The differences were highly significant ($p = 0.05$) at pre-reproductive and post-reproductive stages (Table 25b). The

data revealed that average NDF value was highest (70.4%) in *Tetrapogon* and lowest (49.6%) in *Pennisetum*. *Tetrapogon* gained highest value at pre-reproductive and reproductive stages while *Pennisetum* had the highest NDF contents at post-reproductive stage.

Among the shrubs, the highest value of 47.8% was recorded for *Perovskia atriplicifolia* and the lowest (33.3%) for *Hertia*. The later species registered the lowest value at all three stages. *Convolvulus* had the highest NDF value at pre-reproductive and reproductive stages. There was an increasing trend of NDF from pre-reproductive to reproductive stage and thereafter it declined. However, for *Perovskia atriplicifolia* the trend was reversed.

Acid Detergent Fibre (ADF)

ADF of grasses were significantly ($p = 0.05$) higher than shrubs at pre-reproductive and post-reproductive stages (Table 25b). It was 42.3% in *Pennisetum* and 35.4% in *Tetrapogon* (Table 25a). The trend of ADF value was almost similar to that of NDF value at pre-reproductive and post-reproductive stages. At reproductive stage, ADF value was the highest in *Cymbopogon* and the lowest in *Pennisetum*. *Convolvulus* showed the highest (37.6%) ADF and *Hertia* had the lowest (24.5%). *Hertia* showed the lowest value at all the three stages. In *Convolvulus*, it was the highest at reproductive and post-reproductive stages. *Sophora* gave highest value at pre-reproductive stage (Table 25a).

Hemicelluloses

The differences were significant ($p = 0.05$) between grasses and shrubs at all the phenological stages (Table 25b). Hemicelluloses had greater value in grasses than shrubs (Table 25a). Among the grasses, it ranged from 28.0% (*Tetrapogon*) to 14.2%

Table 25a: Cell Wall constituents of some Grasses and shrubs of Harboi hills at three Phenological Stages.

S.No	Species	Phenological Stages	NDF %	ADF %	Hemi-Cellulose %	ADL %
A - Grasses						
1.	<i>Stipa pinnata</i>	Pre-Rep. Stage	63.1	36.6	25.5	4.6
		Reproductive Stage	66.2	37.9	28.3	6.7
		Post Rep. Stage	70.0	42.9	27.1	6.8
		Mean	66.4	39.1	27.0	6.0
2.	<i>Pennisetum orientale</i>	Pre-Rep. Stage	38.0	32.8	5.2	8.9
		Reproductive Stage	36.7	28.9	7.8	11.6
		Post Rep. Stage	74.1	44.5	29.6	8.8
		Mean	49.6	35.4	14.2	9.8
3.	<i>Tetrapogon villosus</i>	Pre-Rep. Stage	68.2	43.0	25.2	11.6
		Reproductive Stage	73.6	43.1	30.5	11.5
		Post Rep. Stage	69.3	40.9	28.4	6.6
		Mean	70.4	42.3	28.0	9.9
4.	<i>Cymbopogon jawarancusa</i>	Pre-Rep. Stage	55.5	38.0	17.5	6.8
		Reproductive Stage	73.1	43.4	29.7	4.7
		Post Rep. Stage	68.4	36.0	32.4	6.3
		Mean	65.7	39.1	26.5	5.9
B- Shrubs						
1.	<i>Artemisia maritima</i>	Pre-Rep. Stage	31.1	22.7	8.4	5.8
		Reproductive Stage	52.7	36.7	16.0	7.9
		Post Rep. Stage	48.8	33.2	9.6	15.4
		Mean	44.2	30.9	11.3	9.7
2.	<i>Perovskia abrotanoides</i>	Pre-Rep. Stage	36.6	26.8	9.8	9.0
		Reproductive Stage	48.3	40.0	8.3	11.8
		Post Rep. Stage	44.8	35.6	9.2	15.4
		Mean	43.2	34.1	9.1	12.1

3.	<i>Perovskia atriplicifolia</i>	Pre-Rep. Stage	38.3	29.9	8.4	11.8
		Reproductive Stage	49.0	37.4	10.6	11.8
		Post Rep. Stage	56.0	33.1	22.9	16.5
		Mean	47.8	33.5	14.0	13.4
4.	<i>Convolvulus leiocalycinus</i>	Pre-Rep. Stage	47.1	32.0	15.1	10.4
		Reproductive Stage	55.5	42.5	13.0	7.1
		Post Rep. Stage	39.1	38.2	0.9	13.2
		Mean	47.2	37.6	9.7	10.2
5.	<i>Sophora griffithii</i>	Pre-Rep. Stage	39.5	36.8	2.7	7.3
		Reproductive Stage	49.6	38.0	11.6	9.4
		Post Rep. Stage	48.1	34.8	13.3	11.0
		Mean	45.7	36.5	9.2	9.2
6.	<i>Hertia intermedia</i>	Pre-Rep. Stage	24.7	17.8	6.9	6.3
		Reproductive Stage	43.8	30.8	13.0	8.7
		Post Rep. Stage	31.5	24.9	6.6	9.0
		Mean	33.3	24.5	8.8	8.0

Table 25b: Statistical comparison of cell wall constituents of grasses and shrubs at three phenological stages

	Pre-reproductive		Reproductive		Post reproductive	
	Grass	Shrubs	Grass	Shrubs	Grass	Shrubs
NDF						
	63.1	31.1	66.2	52.7	70	48.8
	38	36.6	36.7	48.3	74.1	44.8
	68.2	38.3	73.6	49	69.3	56
	55.5	47.1	73.1	55.5	68.4	39.1
		39.5		49.6		48.1
		24.7		43.8		31.5
Sum	56.200	36.2166667	62.4	49.816667	70.45	44.7166667
Variance	174.44667	58.5056667	304.95333	15.965667	6.35	72.3336667
t-Test	0.0154519	0.04747224	0.1185485	0.2459008	0.000415	0.00037006
	S		NS		S	
ADF						
	36.6	22.7	37.9	36.7	42.9	33.2
	32.8	26.8	28.9	40	44.5	35.6
	43	29.9	43.1	37.4	40.9	33.1
	38	32	43.4	42.5	36	38.2
		36.8		38		34.8
		17.8		30.8		24.9
Sum	37.6	27.6666667	38.325	37.566667	41.075	33.3
Variance	17.786667	45.9906667	45.855833	15.402667	13.615833	20.432
t-Test	0.0323183	0.02134515	0.8262389	0.8486613	0.0215166	0.02151664
	S		NS		S	

ADL						
	4.6	5.8	6.7	7.9	6.8	15.4
	8.9	9	11.6	11.8	8.8	15.4
	11.6	11.8	11.5	11.8	6.6	16.5
	6.8	10.4	4.7	7.1	6.3	13.2
		7.3		9.4		11
		6.3		8.7		9
Sum	7.975	8.43333333	8.625	9.45	7.125	13.4166667
Variance	8.9225	5.65866667	12.075833	3.907	1.2891667	8.55366667
t-Test	0.7935107	0.80634375	0.6412903	0.6873852	0.0037515	0.00212255
	NS		NS		S	
HEMICELLULOSES						
	25.5	8.4	28.3	16	27.1	9.6
	5.2	9.8	7.8	8.3	29.6	9.2
	25.2	8.4	30.5	10.6	28.4	22.9
	17.5	15.1	29.7	13	32.4	0.9
		2.7		11.6		13.3
		6.9		13		6.6
Sum	18.35	8.58	24.075	12.083333	29.375	10.4166667
Variance	90.563333	20.357	118.54917	6.7536667	5.1091667	54.2856667
t-Test	0.0516606	0.1303489	0.0286848	0.1129362	0.0011853	0.00088221
	S		S		S	

S - Significant

NS - Non-significant

Key as in Table: 25

(*Pennisetum*). They were high in *Stipa*, *Tetrapogon* and *Cymbopogon* at pre-reproductive, reproductive and post-reproductive stages, respectively.

Among the shrubs, hemicellulose contents were the highest (14.0%) in *Perovskia atriplicifolia* and the lowest (8.8%) in *Hertia*. It was high in *Convolvulus* at pre-reproductive stage, *Artemisia* at reproductive stage and *Perovskia atriplicifolia* at post-reproductive stage.

Acid Detergent Lignin (ADL)

ADL value was significantly ($p = 0.05$) greater in shrubs than grasses at post-reproductive stage (Table 25b). The range for ADL value was in between 10.0% (*Tetrapogon*) to 5.9% (*Cymbopogon*). *Pennisetum* gave the highest value at reproductive and post-reproductive stages, while *Tetrapogon* manifested the highest ADL value at pre-reproductive stage. Likewise among shrubs, a maximum of 13.4% was recorded in *Perovskia atriplicifolia* and the least value (8%) in *Hertia*. *Perovskia atriplicifolia* exhibited high value at all the three stages. There was a tendency of increase ADL from pre-reproductive to post-reproductive stage in the case of shrubs. While in grasses *Tetrapogon* and *Cymbopogon* had the highest value at pre-reproductive stage, *Pennisetum* at reproductive stage while *Stipa* had the highest value at post-reproductive stage (Table 25a).

III. Mineral Constituents

The mineral composition of grasses and shrubs at three phenological stages is

explained below:

Potassium

No significant differences in Potassium contents were observed among the various phenological stages and among different plants except *Pennisetum orientale* in which post-reproductive stage had high value of Potassium (15.6). Average Potassium contents among grasses ranged in between 1.05 - 6.75 while in shrubs it varied in between 0.74 to 2.59 (Table 26a). The differences in grasses and shrubs were also non-significant.

Phosphorus

No significant differences in Phosphorus contents between the phenological stages and among the different plants except at post-reproductive stage (at $P < 0.01$) were observed. The average Phosphorus contents among grasses ranged in between 0.09 to 0.21 and among shrubs from 0.13 to 0.2 (Table 26a). The differences in Phosphorus contents between grasses and shrubs were non-significant.

Copper

The shrubs had higher copper contents than the grasses (Table 26a). The copper contents among grasses ranged from 4.74 to 11.41 ppm., while it was 7.19 to 14.13 ppm for shrubs. The copper contents of shrubs were significantly higher at post-reproductive stage while the differences were non-significant at other stages. *Stipa* and *Pennisetum* had greater copper contents at pre-reproductive and reproductive stages, respectively. While *Tetrapogon* and *Cymbopogon* exhibited high contents at post-reproductive stage. Similarly, the highest amount of copper was recorded at reproductive stage for *Convolvulus*, *Sophora* and *Hertia* while *Artemisia* exhibited high content at post-reproductive stage and *Perovskia abrotanoides* and *Perovskia atriplicifolia* at pre-reproductive stage (Table 26a).

Manganese

Grasses had greater manganese content than shrubs. The manganese contents significantly ($p = 0.05$) differed between grasses and shrubs at pre-reproductive stage while it was non-significant at other stages. Among the grasses, it ranges from 57.32 to 80.4 ppm., while in shrubs they varied from 20.17 to 55.9 ppm. Generally, the manganese contents were lower at flowering stage (reproductive) in all the plants except in *Cymbopogon* and *Tetrapogon*, where post-reproductive stage exhibited lower value (Table 26a).

Iron

There were highly significant ($p = 0.05$) differences in iron contents between the three phenological stages of shrubs and grasses but no significant differences were found between grasses and shrubs. The highest iron contents occurred in *Tetrapogon* (1411 ppm) and *Pennisetum* (1020 ppm) at post-reproductive stage while *Convolvulus* exhibited highest value (1518 ppm) at pre-reproductive stage and *Sophora* (1006 ppm) at post-reproductive stage. The mean maximum value of Iron was in *Tetrapogon* (5672) and (889.67) in *Convolvulus* (Table 26a).

Zinc

The differences in zinc contents were in-significant between grasses and shrubs. Likewise non-significant differences occurred at pre and post-reproductive stage in grasses. However, highly significant differences occurred at reproductive stage (Table 26b). Among the grasses, it varied from 12.61 to 24.92 ppm. While in shrubs it ranged from 9.32 (*Sophora*) to 55.0 ppm in (*Perovskia atriplicifolia*). The Zinc content became lower at reproductive stage in grasses except in *Tetrapogon*. Likewise, it was greater in all the shrubs at reproductive stage except *Hertia* and *Perovskia atriplicifolia*, which had greater value at pre-reproductive stage (Table 26a).

Table 26a: Mineral constituents of some grasses and shrubs of Harboi hills at three Phenological Stage.

S.No	Species	Phenological Stages	K (ppm)	P (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
A - Grasses								
1.	<i>Stipa pinnata</i>	Pre-Rep. Stage	1.05	0.16	9.4	72.1	74	27.78
		Reproductive Stage	1.26	0.1	8.6	22.9	793	6.75
		Post Rep. Stage	1.31	0.1	4.4	59	160	8.6
		Mean	1.21	0.12	7.47	51.33	342.33	14.38
2.	<i>Pennisetum orientale</i>	Pre-Rep. Stage	2.27	0.22	9.96	43.4	327	18.7
		Reproductive Stage	2.32	0.24	16.9	26.8	85.3	15.9
		Post Rep. Stage	15.6	0.16	7.38	116.6	1020	40.16
		Mean	6.73	0.21	11.41	62.27	477.43	24.92
3.	<i>Tetrapogon villosus</i>	Pre-Rep. Stage	1.46	0.131	5.35	132.5	111	18.29
		Reproductive Stage	2.1	0.15	7.2	59	164	17.3
		Post Rep. Stage	1.3	0.13	8.6	28.8	1411	11.4
		Mean	1.62	0.14	7.05	73.43	562.00	15.66
4.	<i>Cymbopogon jwarancusa</i>	Pre-Rep. Stage	0.95	0.1	3.33	97.5	102	16.61
		Reproductive Stage	1.28	0.16	5.1	90.5	661	7.72
		Post Rep. Stage	0.92	0.01	5.8	53.2	668	13.5
		Mean	1.05	0.09	4.74	80.40	477.00	12.61
B- Shrubs								
1.	<i>Artemisia maritima</i>	Pre-Rep. Stage	0.001	0.16	5.8	11.7	426	30.12
		Reproductive Stage	2.22	0.24	12.7	17.5	138	46.6
		Post Rep. Stage	1.02	0.21	18.3	31.3	336	43.4
		Mean	1.08	0.20	12.27	20.17	300.00	40.04
2.	<i>Perovskia abrotanoides</i>	Pre-Rep. Stage	1.14	0.15	15.5	35	145	19.6
		Reproductive Stage	2.13	0.28	11.4	9.7	976	37.4
		Post Rep. Stage	1.02	0.13	8.6	35	694	34.7
		Mean	1.43	0.19	11.83	26.57	605.00	30.57
3.	<i>Perovskia atriplicifolia</i>	Pre-Rep. Stage	2.03	0.26	12.7	25	391	65.8
		Reproductive Stage	1.83	0.13	11.4	19.5	960	39.3
		Post Rep. Stage	1.14	0.15	11.4	21.5	870	59.9
		Mean	1.67	0.18	11.83	22.00	740.33	55.00

4.	<i>Convolvulus leiocalycinus</i>	Pre-Rep. Stage	1.05	0.084	5.35	84.8	1518	13.26
		Reproductive Stage	1.86	0.11	11.4	33.92	589	16.05
		Post Rep. Stage	1.38	0.21	7.2	49	562	3.1
		Mean	1.43	0.13	7.98	55.91	889.67	10.80
5.	<i>Sophora griffithii</i>	Pre-Rep. Stage	0.75	0.15	1.31	33.92	167	9.36
		Reproductive Stage	0.85	0.33	10.3	32.9	194	9.91
		Post Rep. Stage	0.63	0.11	9.96	58.2	1006	8.7
		Mean	0.74	0.20	7.19	41.67	455.67	9.32
6.	<i>Hertia intermedia</i>	Pre-Rep. Stage	1.81	0.22	11.4	28.7	246	37.5
		Reproductive Stage	3.43	0.13	16.9	58.2	543	26.1
		Post Rep. Stage	2.53	0.15	14.1	61.1	57	17.3
		Mean	2.59	0.17	14.13	49.33	282.00	26.97

Table 26b: Statistical comparison of mineral constituents of grasses and shrubs at three phenological stages.

	Pre-reproductive		Reproductive		Post reproductive	
	Grass	Shrubs	Grass	Shrubs	Grass	Shrubs
Potassium						
	1.05	0.001	1.26	2.22	1.31	1.02
	2.27	1.14	2.32	2.13	15.6	1.02
	1.46	2.03	2.1	1.83	1.3	1.14
	0.95	1.05	1.28	1.86	0.92	1.38
		0.75		0.85		0.63
		1.81		3.43		2.53
Sum	1.4325	1.13016667	1.74	2.0533333	4.7825	1.286667
Variance	0.360425	0.53958817	0.3026667	0.6928267	52.04109	0.429907
t-Test	0.514823783	0.49770917	0.5298595	0.4939891	0.258075	0.40437
	NS		NS		NS	
Phosphorous						
	0.16	0.16	0.1	0.24	0.1	0.21
	0.22	0.15	0.24	0.28	0.16	0.13
	0.131	0.26	0.15	0.13	0.13	0.15
	0.1	0.084	0.16	0.11	0.01	0.21
		0.15		0.33		0.11
		0.22		0.13		0.15
Sum	0.15275	0.17066667	0.1625	0.2033333	0.1	0.16
Variance	0.00261025	0.00377867	0.0033583	0.0085467	0.0042	0.00172
t-Test	0.643914727	0.63131879	0.4586237	0.415769	0.108611	0.166029
	NS		NS		S (0.1%)	
Manganese						
	72.1	11.7	22.9	17.5	59	31.3
	43.4	35	26.8	9.7	116.6	35
	132.5	25	59	19.5	28.8	21.5
	97.5	84.8	90.5	33.92	53.2	49
		33.92		32.9		58.2
		28.7		58.2		61.1
Sum	86.375	36.52	49.8	28.62	64.4	42.68333
Variance	1433.969167	629.9848	997.91333	297.236	1382.267	251.4377
t-Test	0.035221134	0.07093982	0.2029873	0.2847153	0.23162	0.335818
	S		NS		NS	

Copper						
	9.4	5.8	8.6	12.7	4.4	18.3
	9.96	15.5	16.9	11.4	7.38	8.6
	5.35	12.7	7.2	11.4	8.6	11.4
	3.33	5.35	5.1	11.4	5.8	7.2
		1.31		10.3		9.96
		11.4		16.9		14.1
Sum	7.01	8.67666667	9.45	12.35	6.545	11.59333
Variance	10.23753333	28.7542667	26.736667	5.547	3.358767	16.44587
t-Test	0.595460206	0.55588877	0.2561105	0.3546614	0.050281	0.030588
	NS		NS		S	
Iron						
	74	426	793	138	160	336
	327	145	85.3	976	1020	694
	111	391	164	960	1411	870
	102	1518	661	589	668	562
		167		194		1006
		246		543		57
Sum	153.5	482.166667	425.825	566.66667	814.75	587.5
Variance	13627	270640.567	124878.12	129191.87	282624.9	122324.7
t-Test	0.257305084	0.188537	0.5582324	0.5600718	0.433689	0.48703
	NS		NS		S	
Zinc						
	27.78	30.12	6.75	46.6	8.6	43.4
	18.7	19.6	15.9	37.4	40.16	34.7
	18.29	65.8	17.3	39.3	11.4	59.9
	16.61	13.26	7.72	16.05	13.5	3.1
		9.36		9.91		8.7
		37.5		26.1		17.3
Sum	20.345	29.2733333	11.9175	29.226667	18.415	27.85
Variance	25.38616667	429.826667	29.717892	205.32847	214.1822	481.303
t-Test	0.430965824	0.35198191	0.0528436	0.0320155	0.475471	0.4383
	NS		S		NS	

S - Significant

NS - Non-significant

Discussion

1. Floristic Structure and Composition

Florida list of higher plants comprised of 242 species. Benth (1900) recorded only 12 species. Furthermore, half of them could not be collected during the present study. This variation might possibly be due to the fact that Benth might have collected others from other parts of Florida like in the range of state all over the State and not just one region. The present study was confined to the lower portion (Tampa) and other parts of the State. It is also the species reported by Benth that have not been collected during the present study might have been previously collected or have been collected from the past but were not recorded.

DISCUSSION

Florida, the present floristic list, under Benth, has recorded only 12 species of higher plants. Benth and J. G. Smith collected the first list of higher plants in 1900. There was a 20% floristic similarity with the plants of Florida District of Kentucky (Lynch and others, 1961, 1962, 1963). The low floristic similarity with the plants of Florida might be due to the fact that in Florida, further, expanding the lower higher plants were found. These factors might have caused differences in the flora. There was 10% similarity in species from plants of Florida (Lynch and others, 1961). The higher similarity in the flora of the state of Florida and the state of Kentucky is due to the fact that the flora of the state of Florida is more diverse than the flora of the state of Kentucky. The higher similarity in the flora of the state of Florida and the state of Kentucky is due to the fact that the flora of the state of Florida is more diverse than the flora of the state of Kentucky.

The present study of higher plants in the state of Florida is more diverse than the flora of the state of Kentucky. The higher similarity in the flora of the state of Florida and the state of Kentucky is due to the fact that the flora of the state of Florida is more diverse than the flora of the state of Kentucky.

Discussion

I. Floristic, Structure and Composition

Foristic list of Harboi Hills comprised of 242 species. Burkill (1956) reported only 42 species. Furthermore, half of them could not be collected during the present study. This variation might possibly be due to the reason that Burkill might have collected plants from other parts of Harboi hills as this range extends all over the Sarawan and Jalawan region. The present study was confined to the Kalat portion (Sarawan). Another possibility might be that the species reported by Burkill that remained uncollected during the present study might have been previously misidentified or have been eliminated from the area owing to over collection as medicinal, fuel or fodder species or overgrazing during the past years. Similarly, the present floristic list from Harboi hills showed only 27 species (6 shrubs, 16 herbs and 5 grasses) common to the floristic list of Bolan pass by Jafri (1962). There was 25% floristic similarity with the plants of Quetta District as reported by Tareen and Qadir (1987, 1990 & 1991). The low floristic similarity with the plants of Quetta might be due to more rainfall in Quetta. Further, altitudinally, the latter is higher in elevation. Both these factors might have caused differences in the flora. There was 12% similarity in species from plants of Iskulku rangeland (Durrani *et al.*, 1996). This might be explainable on the basis of low altitude of Iskulku and biotic disturbance as settlements are located in this area. The rangeland is effected by agriculture, irrigation and intensive grazing due to the proximity to human settlement.

The biggest chunk of pure Juniper forest in the world spreads over Ziarat, Kalat and Loralai districts of Balochistan (Khattak, 1963). Harboi hills (Kalat), included in dry temperate Juniper forest (Champions *et al.*, 1965), are the representative of the western

range. At present, there is a pure *Juniperus excelsa* forest. However, Rafi (1965) reported mixed *Juniperus macropoda* - *Fraxinus xanthoxyloides* forest in the past. It was interesting to see that *Fraxinus xanthoxyloides* was not even recorded in the present study area. It appeared to have been completely eliminated from the area due to deforestation by the local inhabitants. Ahmed *et al.* (1990) also observed a similar pure Juniper forest at Rodth Malazai in the nearby area. Our view regarding elimination of *Fraxinus xanthoxyloides* agrees with them as they also stated that deforestation has eliminated many species including *Fraxinus xanthoxyloides* from the area. In protected areas of Ziarat, mixed forest of *Juniperus polycarpus* - *Fraxinus xanthoxyloides* are present (Ciesla *et al.*, 1998), while *Pinus gerardiana* was associated with *Juniperus polycarpus* in the Babusar Valley, Diamer (Khan, 1996). *Juniperus polycarpus (excelsa)* is associated with scattered individuals of *Pinus roxburghii* at lower altitude in similar climatic regions of Astore (Ahmed, 1988). *Fraxinus xanthoxyloides* or *Pinus gerardiana* is an associated tree of Juniper forests. Its absence/presence has been governed by climatic conditions and deforestation. In the past Harboi rangeland was owned by Khan of Kalat who controlled all the affairs of forest and rangeland. Therefore, it remained less disturbed. However, with the merger of princely states during 1974 into settled districts of Pakistan, the area became open to inhabitants that resulted in ruthless cutting of trees and shrubs including *Fraxinus* for burning and other varied uses. Thus, it ultimately led to the elimination of *Fraxinus* and creation of pure Juniper forests in the area.

The shrubby species were almost common through out the Juniper and *Artemisia* range. *Artemisia maritima*, *Sophora griffithii*, *Hertia intermedia*, *Nepeta juncea*, *Astragalus* (97-8) and *Convolvulus leiocalycinus* were the most common shrubs. In dry

water courses *Perovkia abrotanoides* and *Verbascum erianthum* were widely distributed.

All these species had wide ecological amplitude and were commonly found in other regions of Balochistan and other parts of this range with similar climatic conditions.

Asteraceae was the dominating family in the area. Stewart (1959) also observed this family to be well represented in Balochistan. Papilionaceae, Poaceae and Brassicaceae were next important families in the area. Many other studies such as those of Stewart (1972) and Badshah *et al.*, (1996) also reported these families to be well represented in other parts of Pakistan. Asteraceae, Poaceae, Brassicaceae, Lamiaceae, Boraginaceae are the major families in the flora of Pakistan (Jafri, 1962, Stewart, 1972, Nasir and Ali, 1971 - 94, Ali and Qaisar, 1995 - 1999).

Pennisetum oreintale, *Bromus tectorum* and *Bromus sericeus* were well represented in the study area, while *Poa bulbosa*, *Pipatherum vicarium*, *Stipa pennata*, *Tetrapogon villus*, *Cymbopogon jwarancusa*, *Melica persica*, *Aristida Spp* and *Phacelurus speciosus* had limited distribution. *Shimus arabicus* was abundant in relatively moist habitats such as beneath canopy of trees and within the thickets of shrubby plants. While, *Eragrostris minor* was common over open dry places especially during summer. Most of the grasses recorded in present study have been commonly reported from other areas of Balochistan with similar climatic nature (Tareen and Qadir, 1987). Koochehi and Baker (1993) reported that *Festuca oveina*, *Poa bulbosa*, *Bromus tectorum*, *Stipa pennata* and *Phalaris minor* were the main grass species in dry temperate area of Zagros and Eburz (Iran) under the canopy of *Juniperus excelsa*. It appears that floristic composition of study area resembles with the flora of adjoining area of Iran. Both have similar climate. The

study area is an extension of flora and vegetation of Iran as many plants were common to Flora Iranica.

Cushion plants are characteristic of high altitude area with dry climatic conditions. For the same reasons *Acantholimon mnuroanum*, *Acantholimon polystachyum* and *Gaillonia eriatntha* were common in the area. *Astragalus* (97-53) and *Onobrychus cornuta* were recorded between altitudes of 2500 to 2800 m. The spiny cushion plants seem to have had some biological advantage that allow them to adopt to harsh conditions of the habitat, cold winters with high evaporation, strong winds and intense grazing pressure. *Acantholimon* species are components of the cushion plant formation of all over the Middle East vegetation (Danin, 1999).

Although, the rangeland was dry but there were three perennial and few seasonal small water springs. They had their own micro-climate and flora. The most common species were *Mentha longifolia*, *Juncus articulata*, *Juncus influxus*, *Carex Spp*, *Taraxicum officinale* and *Veronica anagalis - aquatica* in the moist habitats. The margins had *Convolvulus arvensis*, *Plantago lanceolata*, *Plantago major*, *Scutelaria Spp*, *Gnaphalium luteoalbum*, *Trichlochin palustris*, *Epilobium minutiflorum*, *Cyperus Spp*, *Pharis Spp*, *Hordeum bogdanii*, *Polypogon fugux* and *Juncus Spp*. All such species survive for longer period due to continuous supply of moisture. Their life cycle was comparatively longer than those growing in dry soil.

Although floristically many species were found at Harboi rangeland, they had limited distribution, restricted life cycle (as most were annuals) with xeromorphic characters. This is reflected by small leaf size, spiny habit, bushy life form, stunted growth, cushioned habit, sparse distribution, isolated individuals and dwarf height, all are

characteristic of xerophytic flora. Many species of Asteraceae, Lamiaceae and Apiaceae are aromatic. In dry arid temperate flora there is always predominance of aromatic plants and the same was true for the present study. A rich flora would definitely mean high species diversity and species richness in the area. However, floristic composition is a qualitative character, therefore it alone cannot be a good indicator of range productivity. This feature must be supplemented with some quantitative measurements to properly assess the health and productivity of this rangeland. Yet floristic composition is a good source of plant life, gene pool and diversity of plant of any area and the present list serves this purpose. These features are further explained by the leaf size and life form spectra of the flora.

Biological and Leaf size Spectra

Life form and leaf size spectra are indicators of biotic interaction, climate and habitat deterioration. They help in understanding the flora and structure of vegetation in relation to prevailing ecological conditions.

In the present study, therophytes and hemicryptophytes were the dominants. They indicated an unfavourable habitat. In dry climatic conditions, overgrazing and animal trampling increases therophytic species (Cain, 1950). This might be true in this case as the area was subjected to heavy grazing. Therophytes emerge as dominants in the degraded and disturbed vegetation. The findings of Sikarwar (1996) support our results as he also observed that extensive biotic influence increased short lived annuals. Annuals appear only in moist period i.e. during spring in this area. There is a prolonged dry spell from March to November. During this period perennials remained inactive. Plants suffer from aridity, strong winds, poor soil development and short growing season in desert like Kalat and

other high altitude regions. They, therefore, adapt to the prevailing conditions by reducing their size, height, foliage and duration of growth. In the present study nanophylls, microphylls and leptophylls dominated the flora. This was well correlated with the adverse and dry climatic conditions of the area. The rainfall was poor with long dry season. The dominance of small leaf size plants has also been reported by Qadir and Tareen (1987) in Quetta District. Tareen and Qadir (1993) reported similar life form in Harnai, Duki and Sinjawi regions. Badshah *et al.* (1996) also stated that the dominance of micro-nanophyllous species in dry temperate parts of Waziristan was due to dry conditions. Leaf size is related to the dryness of climate. With increase in moisture large leaf sizes are prominent. Macrophylls were absent in the area due to the same reasons. Therophytic and hemicryptophytic life forms coupled with small leaf sizes is a good strategy of plants to cope with dry environmental and deteriorated habitat conditions. Overgrazing in such a climate further intensifies the adverse effects of environment.

Most plants have assumed a bushy habit which otherwise might have grown erect. Reduction in body size and leaf area reduces the chances of being grazed and transpirational loss of water. Dwarf plants are also characteristic of windy habitat that is true in the present case also.

Phenological Behaviour

Phenological study envisages a relationship between climate and growing periods of plants of an area. Such studies are important for planning regeneration, afforestation and conservation programmes in rangeland and forestry. In temperate regions the vegetation had a different physiognomic contrast in various seasons due to replacement of different species including annuals and bulbous geophytes and flowering, fruiting and

dormancy of the perennial species. In the present study it was observed that the growing season usually commenced at the end of March whereby only few herbaceous and shrubby plants initiated vegetative growth and bloomed during early April. They included *Astragalus Spp*, *Caragana stocksii*, *Prunus ebernea* and some geophytes like *Anemone techernfaewii*, *Bongardia chrysogonum*, *Gagea pseudo-reticulata*, *Gagea Spp*, *Rhinopetalum karelinii* and *Tulipa polychroma* and some herbs like *Ceratocephalla flacatus*, *Certocephalla testiculata* and *Leptaleum filifolium*. It was observed that there were two flowering periods in Harboi hills. One characterized by early spring flush during late April to May/June and the other by post summer aspect during July to October. The present findings agree with those of Shrestha and Shrestha (1998) who reported that majority of flowering occurred during April/May in Riyale, Nepal. Similarly, Zhanghe *et al.* (1999) also reported that peak of flowering occurred during May in various parts of China. Shranghetti and Ranga (1997) reported that in Brazil shrubs had continuous flowering from March to May. In the present study few species like *Acantholimon Spp*, *Salvia cabulica* and *Gypsophylla lignosa* exhibited flowering throughout the growing season. While species of *Clematis*, *Nepeta*, *Daphnea* and *Perovskia* flowered during July to September (second flowering period). Our findings are in the line with those of Kim (1996) and Shranghetti and Ranga (1997) who also observed two flowering periods for their study area.

During 1998, the climate was relatively drier than in 1997, as there was little rain during summer (only 60 mm from April to September, Table 1). Phenological activities of plants were almost similar in both the years from April to June. Species of summer aspect completed their life cycle one month earlier during 1998 than 1997. The vegetation almost

completely went dormant from late September onwards. Morellato and Leitao - Filho (1992) suggested that lack of nutrients during transition from dry season to wet might be an important factor determining the fruitification period of many species and that low precipitation rate and fall of the leaves of many species during dry season offers good opportunities for seed dispersal. Phenological cycles of plants of Harboi hills were in accordance with the climatic cycle of the area. The growing season commenced at March and it fully bloomed during April - May and again in the August when conditions with or without rains were suitable for some of the plants. Generally plants dispersed seeds/fruits before the cold weather. During winter the plants and their seeds received cold treatment and were ready for germination and sprouting from below ground parts or shoots during early spring. Plants of dry temperate regions such as those of Kalat are adapted to cold treatment for germination and flowering and this is how they get it. The grazing period could be regulated with the phenological cycle. Grazing might be allowed only in periods when there is no flowering and fruiting. Once the shrubs shed the seeds, they may be grazed. Likewise, grazing of annual herbaceous plants before flowering will slowly eliminate them as seeds are the only source of survival and regeneration.

Seed collection can be done during two seasons i.e. before summer and then before winter for storage or as a gene bank. The critical grazing period that coordinates with flowering or seeding might be avoided to ensure a good seed bank for future regeneration. The annuals usually flush flowering during the wet season. It is to be noted that rainfall was uncertain in the area, therefore the amount of seeds produced and emergence of seedlings might be variable during different years.

livelihood. Moreover, most of medicinal plants were grazed by the local livestock.

Overgrazing has caused the destruction of medicinal plants as green parts are being removed and damaged due to trampling. It, therefore, becomes important to manage the grazing system and encourage the regeneration of medicinal plants. This aspect must be correlated with phenological cycle. Plants or shoots that are grazed and collected for medicinal purpose are a threat to their regeneration. Similarly, a grazeable plant that is collected for roots, rhizome or bulb is threatened. The plants fail to develop flowers and seeds while below ground parts are destructively collected. This definitely reduces the chances of their regeneration.

People living around the rangelands are mostly poor and lack the basic facilities. They depend on fuelwood for domestic and livelihood earning. Juniper wood is collected for commercial and domestic purposes. *Artemisia*, *Prunus*, *Astragalus* and other shrubby species are being uprooted for domestic fuels only. In either case there is a tremendous pressure on rangeland. Grazing and collection of medicinal plants coupled with their use as fuelwood has drastically reduced all those species that are simultaneously subjected to these three biotic factors. Fuelwood collectors irrespective of any other value of plant gather, rather uproot, any plant with some woody bases, roots or stems. Thus the vegetation has become open, heavily grazed and subjected to dry dessicating summer. Uprooting of plants has further intensified the process of elimination of such preferred plants. One can see camel load everywhere carrying fuelwood species.

Leaves of *Eremerus persicus* are used as vegetable. It was observed that there was a decrease in the population of *Eremerus* during the past few years as a result of collection and its sale in local market along with overgrazing. Species used locally had almost similar

uses in other regions of Balochistan such as twelve medicinal species reported in the present study were also commonly used in Southern Balochistan (Goodman and Ghafoor, 1992). Likewise, 12 fodder species and 5 medicinal plants found in this rangeland were also commonly used in Kharan District (Shinwari and Shah, 1996). There were 14 medicinal plants commonly used in Kanak Valley, Mastung District (FAO, 1997). This similarity was due to the common traditions of the locals and similarity in the climate and wide range of species which were present in other parts of Balochistan.

It was obvious that the major bulk of species i.e. 129, were classified as fodder species with different degree of palatability. This also gave an idea that this area is suitable for range purposes only. Poor vegetation cover, aridity and dry soil cannot support any other thing except range species. Most of these plants have been reported as fodder species by many workers in and outside Balochistan (Burkil, 1956; Khan, 1960, Jafri, 1962, Rafi, 1965, Hussain & Mustafa, 1995 and Shinwari & Shah, 1996). The present findings regarding the range plants agree with them. The major utility of this ecosystem could be as a pasture, therefore all efforts be directed to improve it as a rangeland and wildlife conservation unit. The medicinal plants will automatically be conserved with ecological management.

There is a need to conserve these resources for future as they are refuge for endangered animal and birds. The rangeland as a whole is faced with problems like deforestation, overgrazing and collection of medicinal and fuelwood species. Many plants are subjected to multiple pressures such as grazing, medicinal utility and as a fuelwood. Therefore, there is an immense biotic pressure on such plants which is further intensified by the dry weather conditions of the area. The area is primarily a dry temperate rangeland

and this aspect should be highlighted and managed in participation with the local communities. The poor vegetation cover has promoted soil erosion that caused further deterioration of habitat.

II. Range Vegetation Structure

A. Edaphology

a. Texture and Structure

Rangelands are characterized by a great diversity of soils due to wide differences in natural factors leading to the soil formation such as parent material, relief, time, climate and living matter. Human activities significantly modify the soil factor by inducing deforestation, erosion, overgrazing and compaction due to trampling by livestock.

The soil colour varied in the Harboi hills. Dark coloured soils which were frequently present under juniper trees had high organic matter than the light coloured soils of bare areas or with poor vegetation cover. Repp and Khan (1960) supported our findings as they observed that humus contents increased from 3 to 8% in enclosure of Bastargi (Ziarat) especially beneath and around juniper trees. Junipers play an important role in soil and water conservation on steep mountain slopes at high altitude (2200 - 2600 m) (Azhibekov, 1982). Tongway and Ludwig (1996) reported that piles of tree branches served as an effective trap for top soil, litter and water that improved the infiltration of water and soil aeration. This is what happened beneath and around juniper trees whereby branches and litter accumulated in the surface layers of soil to impart a rich litter layer. The accumulation of litter was obvious under coniferous forests including junipers (Daubenmire, 1974; Hussain and Ilahi, 1991).

The litter from juniper also accumulated due to resinous material, which is resistant to decay. Furthermore, poor soil moisture and lack of sufficient microorganisms might be other constraints in the decay of litter. Resultantly, a thick layer of litter was always present beneath juniper in Harboi hills imparting a black colour to the soil.

Texture affects soil characteristics by altering water and nutrient relations and workability. The soil texture varied from sandy loam, sand clay loam to clay in different investigated sites. Similar variation in soil texture was reported for Maslakh and Hazargangi rangelands (Marwat *et al.*, 1989 - 1992). At places the soils were of brown, gray reddish, reddish brown and yellowish grey colour due to the presence of iron oxides. Townsend (1982) reported that natural soil colour varied due to occurrence of oxides in rocks and soils. Hematite (Fe_2O_3) is red, maghemite (Fe_2O_3) is dark brown and limonite is yellow in colour. The reddish grey colour of soil might have been due to restricted drainage because hard bed rock was present beneath the thin layer of soil. Miller and Donahue (1990) reported that reddish brown and grayish coloured indicated a soil that had inadequate aeration and restricted drainage. The soils of investigated range were highly calcareous and non-saline with moderate to slightly alkaline reaction. Similar soil features have been reported for Hazargangi rangeland (Qadir and Ahmed, 1989). Generally, due to low moisture holding capacity of the barren limestone, soil surface is heated up due to high temperature and therefore the soils are rendered unfavourable for germination and plant growth. In dry mountainous regions such as Harboi hills, where severe cold snowy winters and a short summers prevail, plants suffer injuries due to dry summer with high temperature dessicating winds and low winter temperature. The frost churning and frost heaving of soil was common from November to March in this area. Such activity has

brought stones to the surface in the form of frost boils each year. Plants have been pushed out of the soil and seedlings were killed with this process. Frost heaving and churning promotes soil erosion during both windy and rainy weather. Such soils are injurious to plants as they are unstable due to alternate freezing and thawing. It was commonly observed that bulbous geophytes were more affected through such processes. Bulbs of *Scilla*, *Eremerus* and *Tulipa* were seen exposed on the surface of the soil. Although, some annual plants might be benefited due to loosening of soil surface as they might easily germinate and their shallow roots might utilize such habitats. Durrani *et al.* (1996) reported a similar soil heaving and frost boils in the nearby Iskulku range.

Soil erosion was common in most parts of Harboi hills. Similarly, Sandoval *et al.* (1996) observed that grassland vegetation suffered high soil losses by erosion than shrublands. In Harboi hills, there were few grasses and the major vegetational cover was that of shrubs. Grasses and shrubs had sparse distribution with poor and stunted growth. Such a vegetation cover is susceptible to soil erosion.

b. Nutrients

The soil composition is affected by many external factors like moisture, erosion, weathering and plant litter. These factors also cause variation in soil nutrients that is further modified by heterogeneity of the soil itself.

Soil pH is an important factor controlling germination, growth and other soil-plant relationships. In arid and semi-arid areas where soil pH is high, imbalance of nutrients occurs (Brady, 1990). It affects the availability and solubility of other minerals such as copper, manganese, iron and zinc. The soils of Harboi hills exhibited a high pH ranging from 8.38 to 8.63 in different stands. This might be one of the factors for the non-

brought stones to the surface in the form of frost boils each year. Plants have been pushed out of the soil and seedlings were killed with this process. Frost heaving and churning promotes soil erosion during both windy and rainy weather. Such soils are injurious to plants as they are unstable due to alternate freezing and thawing. It was commonly observed that bulbous geophytes were more affected through such processes. Bulbs of *Iris*, *Eremerus* and *Tulipa* were seen exposed on the surface of the soil. Although, some annual plants might be benefited due to loosening of soil surface as they might easily germinate and their shallow roots might utilize such habitats. Durrani *et al.* (1996) reported a similar soil heaving and frost boils in the nearby Iskulku range.

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availability of other minerals to plants. Electrical conductivity is primarily based on the total salt contents of soil which is affected by temperature and rate of evaporation of air and soil. The Electrical conductivity of this range was low in the early spring which is correlated to low temperature and low evaporation in early spring. When temperature and evaporation increased in summer, the electrical conductivity also increased. In arid areas like Harboi rangelands high temperature and evaporation brought the dissolved salts to top soil layers resulting an increased in salt contents during this dry period. The differences in concentration of various minerals analyzed during various seasons were non-significant. Yet electrical conductivity was high during summer than in the spring. Sodium and potassium contents had inverse correlation in soil. With the increasing sodium contents, the availability of potassium decreased in the soil and this feature caused potassium deficiency and nutritional disorders for the plants. Although, soil analysis indicated very high potassium value in all the analyzed soils whereas sodium and sulphates were low at the same time.

The amount of micro-nutrients of various sites of Harboi hills, when compared to the standard ranges as recommended by Soltanpour (1985), showed that iron, manganese and copper contents were significantly high while zinc contents were low in all the investigated sites. Availability of copper decreases under high calcium carbonate contents. A similar copper non-availability might occur in the present case as almost all the tested habitats had high calcium carbonate contents. The distribution of copper and manganese was largely controlled by bedrock geology whereas the geochemical dispersion of Fe, K, Na and Zn was modified by soil and hydromorphic process (Bowell and Anshah, 1994). It was interesting to see that there were non-significant differences among the sodium,

potassium, copper, manganese, iron and zinc contents between both seasons. Thus, no seasonal variations were evident in the area.

B. Vegetational Features

The vegetation structure is defined as the organization in space of the individuals that form a stand (and by extension of a vegetation type or a plant association). The primary elements of the structure are growth forms, stratification and coverage (Dansereau, 1957). The five levels of vegetation structure are vegetation physiognomy, floristic structure, stand structure, life form structure and biomass structure. The vegetation physiognomy is the external appearance of vegetation.

The floristic composition, the structure and appearance of vegetation type depends to some extent on the local flora, i.e. the number and characters of the species that occur in the neighbourhood and so are available to compete for survival on any given site. A natural community is an admixture of unequal successful species. The dominance not only influences the structure and functions of the subordinates species but also determines the structure and diversity of the community.

Based on principal coordinate ordination analysis, the plant communities harboring Harboi rangeland have been classified into three major vegetational types.

A vegetation type was composed of species coming from diverse taxonomic and genetic groups.

In all, 163 species were encountered during sampling of stands whereas the overall floristic list of the area was composed of 202 species. On the basis of importance value, only 24 species attained the status as first, second or third dominants in various stands or

communities. *Artemisia maritima*, *Sophora griffithii* and *Juniperus excelsa* were the most wide spread species in the area that occurred almost in all the stands. They dominated in 6, 4 and 2 of the communities, respectively. *Hertia intermedia*, *Nepeta juncea*, *Tulipa polychroma* and *Bromus tectorum* were present in 9 of the stands. There were 127 species which were recorded in 3 or less than 3 stands. The species with high constancy were widely distributed in the area due to either their wide ecological amplitude or proximity or similarity of various stands in the investigated area. The species with high fidelity were restricted to localized micro-habitats. Their adaptation might be due to overgrazing or over exploitation of medicinal plants as such factors were common in the area. It was generally observed that most of the annuals preferred protected places in the rock crevices and under the thicket of shrubby or spiny non-palatable species than exposed spaces. The reason might be that, either the soils were comparatively rich in humus or they were protected under canopy than exposed surface. Danin (1999) stated that rocks and eroded sites do not absorb much water through run off, therefore annuals prefer rock crevices than the exposed rocks or soils. In the present case soils have been exposed due to erosion and practically they did not hold sufficient moisture. The eroded habitats had poor water holding capacity. The annuals or other herbaceous perennials therefore appeared beneath the thicket of shrubs where some soil had been retained. Vaitkus and Eddleman (1991) also supported our findings as they reported more biomass of grasses and forbs beneath the canopy of *Juniperus occidentalis* compared to spaces between canopies. In the present case soils beneath *Juniperus excelsa* had thick layers of organic matter. The density of species varied considerably. Most of the species had low density but few species like *Bromus sericeus*, *Broums tectorum* and *Tulipa polychroma* (seedlings) exhibited high

density in the area during spring whereas *Eragrostis minor*, *Iris tenuifolia*, and *Asteriscus pygmeus* exhibited high density during summer. All these species were short lived annuals or perennials. The annuals produced ample quantity of seeds and were mostly surface feeders. Seeds were present in the surface layer of soil. The availability of adequate moisture either during spring or after summer rains stimulated the germination to flush the seedlings. *Tulipa polychroma* and *Iris tenuifolia* - the bulb bearing geophytes, sprouted as soon as they received moisture and quickly completed their life cycle by producing seeds within 3 to 4 weeks. *Iris* may remain vegetative up to July/ August and then became dormant.

The soil pH significantly affects the availability of other elements of importance to plants and microbes (Brady, 1990). The presence of annual grasses in abundance indicated the developmental stage of soil. The dominance of grasses like *Cymbopogon commulatus*, *Chrysopogon aucheri*, *Stipa arabica* and *Pipatatherum balochistanicum* had also been reported by Tareen and Qadir (1987) in protected areas (Hazargangi, Karkhasa, Walitangi) of Quetta District. The area was eroded at places and resulted in dispersion of litter. Litter was also accumulated at some places. However, due to lack of adequate moisture in hard bed rocks, it remained undecayed and dispersed by animal trampling from steep slopes. The area is under intense grazing and fuel wood collection pressure because it is near to settlements and nomads.

Astragalus steppe were correlated with high copper contents in the soil. The appearance of reddish brown and reddish grey colour was due to reduced oxides of copper in the soils. The other characteristic features were low electric conductivity, iron,

manganese and bicarbonate contents in the soil. Thus, deficiency of these minerals was due to high soil erosion.

Artemisia maritima steppe is wide spread in Quetta and Kalat districts (Tareen and Qadir, 1991) and correlated with low Ec, bicarbonates and Ca+Mg. This study also arrived at similar conclusions. *Artemisia maritima*, *Sophora griffithi*, *Berberis balochistanica*, *Astragalus spp* and *Iris tenuifolia* are adapted to extreme dry climatic conditions under grazing pressure. It was observed that *Astragalus* and *Artemisia* gained the dominance in the area as the steepness decreased.

The amount of litter and organic matter was tremendously high under this type than others where there was less erosion. The area is under severe biotic pressure. The presence of perennial water spring made it a bedding and resting place for livestock. Due to overgrazing, spiny cushion plants like *Astragalus*, *Onasma*, *Gypsophylla*, *Acantholimon* and *Onobrychus* have increased characteristically in this area. Similarly, comparatively moist places (near water springs) were dominated by *Mentha longifolia*, *Taraxicum*, *Juncus* and *Carex Spp* to form a separate micro-habitat. These less palatable species dominated as a result of overgrazing.

Artemisia maritima is generally adapted to summer drought throughout Balochistan. Association of *Artemisia* with *Sophora* is commonly found in Quetta District and other parts of Balochistan (Tareen and Qadir, 1987, 1990, 19991). *Aristida* and *Eragrostris* (annual grasses) formed the summer aspect. *Eragrostris* was distributed in open dry habitats. Due to lack of adequate moisture and hard surface with thin soils layers, it was restricted to a very small size i.e. 2 to 6 cm height.

Floristics in *Astragalus* steppe were poor due to erosion. It was observed that non-palatable grass, *Melica persica* increased in the area. Grazing pressure was severe due to low percentage of palatable species.

The dry water courses were covered with small to medium sized gravel or rubbles of various origins that supported scattered xeromorphic species. Scattered few individuals of Juniper were found in water courses. However, they were not included in our sampling.

Tareen and Qadir (1990) reported similarity in the edaphic factors with the *Perovskia* steppe, which was found on the soils having low MWHC, organic matter and low Cl contents. This relationship was observed in the present case for spring communities. Similarly, low HCO_3 was diagnostic character of *Bromus sericeus* in both the areas. The water course are being heavily grazed and used as passage, resting and bedding places for nomads and livestock.

Life form and Leaf size Spectra of Plant Communities

Life form and leaf size spectra are reflect habitat and environmental conditions. Each climate has its own characteristic life form and leaf size spectra. Climatic life form may be sometimes modified by overgrazing and other biotic factors.

The life form spectra of various plant communities indicated that therophytes and nanophanerophytes were dominant during spring while geophytes were found to be lesser than the normal spectrum of Ranukiaer. Cain and Castro (1959) and Shimwell (1971) reported that therophyte are characteristics of desert climate. The study area has a dry temperate arid climate and the life form clearly indicated this important feature. Harboi range is dry with scattered stunted plants. Badshah *et al.* (1996) also reported that the dry temperate parts of Waziristan had therophytes and nanophanerophytes as the major life

form class. Nanophanerophytes gradually decreased from low elevation to high elevation, while chamaephytes accordingly increased from lower altitude to high altitude in the area. Geophytes had better representation between 2400 to 2600m. Therophytes showed no consistency with regards to change in the altitude. They were generally more abundant during early spring and after rains. According to Cain (1950) and Cain and Castro (1959) chamaephytes are indicators of high altitudes and high latitudes. In both these situation aridity and strong winds were characteristics. Similar trend was observed by Tareen and Qadir (1993) and Hussain *et al.* (1997, a, b) for other vegetation types. Qadir and Shetvy (1986) considered chamaephytes and therophytes indicators of unfavourable environment in desert regions. Cain (1950) had stated that therophytes developed especially in an area where the native vegetation had been disturbed. In the nearby area in Iskulku rangeland, Kalat (Durrani *et al.*, 1996) both therophytes and nanophanerophytes dominated the overgrazed area. The present findings are in agreement with the findings of above workers.

The life form of a plant species is usually an inherited feature. But the same species may assume a different life form when growing under very different environmental conditions. The development of low bushes of *Artemisia* and *Prunus* are examples in the area. Plants of the same life form growing together are likely to compete severely and directly for the same space or niche. Their similarity in life form indicates common adaptation to the utilization of environmental resources offered in a given space. During summer nanophanerophytes and hemicryptophytes were found to be higher in the area when most of the annuals and geophytes had disappeared from the scene. They were prominent in the early spring aspect. With their disappearance hemi-cryptophytes and nanophanerophytes gained the dominance. Such perennial plants were present even during

spring but the presence/absence of therophytes and geophytes shifted the dominance of life form. Hemicryptophytes and nanophanerophytes are characteristics of harsh unfavourable climatic conditions similar to those prevailing in this rangeland.

According to Cain and Castro (1959) and Shimwell (1971) hemicryptophytes are characteristics of temperate regions. The findings of Qadir and Tareen (1987) and Tareen and Qadir (1993) supported the present results as they also reported the dominance of hemicryptophytes in other dry temperate regions of Balochistan. Khan *et al.* (1999) reported that hemicryptophytes and geophytes had massive subterranean perennating bodies that form a better means of propagation enabling them to recover after adverse dry period. Under stressful conditions there is a natural selection for those species which have more efficient means of recovery and propagation after stress.

The weightage of life form when expressed quantitatively using importance values varied substantially from the Raunkiaerian spectra. The dominant life form changed from one class to another depending upon the approach adapted in many vegetation types i.e. nanophanerophytes and therophytic species were dominant during summer communities. Similarly, nanophanerophytes were found to be higher in water courses. In Raunkiaerian approach, the number of species were considered and all species had equal weightage while in quantitative approach some quantitative data such as importance value in this case, reflected the actual conditions prevailing in the field. Buell and Wilbur (1948) and Qadir and Shetvy (1986) used quantitative life form data. Similarly, Khan *et al.* (1999) noted a shift towards increased percentage of hemi-cryptophytes as well as geophytes in their quantitative spectra. The field conditions are better represented by using quantitative life form spectra. The density, frequency and coverage which contribute to importance

value are important features. It is, therefore suggested that quantitative life form spectra are better indicators of the existing plant habitat relationship than the Raunkiaerian spectra.

Like life form, the characters of leaf is related to environmental responses experienced by plants. The size of leaf is related to dryness/wetness of the habitat. Leaf is responsible for transpiration, therefore, plants reduce the surface area to decrease water losses. Higher the aridity lesser will be the leaf area. A similar trend was observed here. The climate of Harboi hills is characteristically arid with long dry season. The plants, therefore, developed adaptations towards this aridity by reducing leaf size. This was reflected by the complete absence of mega- and macrophyllous plants in area. There was a good set of combination of life form and leaf size spectra in the area.

The present findings indicated that nanophyllous and leptophyllous plants dominated the area. Raunkiaerian spectra revealed that nanophylls, microphylls and leptophylls were dominant in most of the communities during all the seasons. Small leaf size reflect aridity and severe climate of the area. Qadir and Tareen (1987) and Tareen and Qadir (1993) also reported high percentage of microphylls and nanophylls for the flora of Quetta, Duki and Sinjawi regions. In a similar climatic conditions found elsewhere, microphylls were dominant (Qadir and Shetvy, 1986). Cain and Castro (1959) also stated that nanophylls and leptophylls are characteristics of hot deserts while microphylls are usually characteristics of steppes. The study area represents a dry *Artemisia* and *Bromus* steppe type of vegetation. At higher altitude and in desert regions plants mostly have small leaves to reduce water loss and damages due to strong winds.

Leaf size classes magnitude also varied significantly when expressed quantitatively using importance value. The dominance among the leaf size classes shifted from

microphylls to leptophylls during spring season and from microphylls to mesophylls during summer seasons. It was obvious that the overall appearance of vegetation was leptophyllous as indicated by the quantitative spectra. Similarly, after summer rains mesophylls emerged as the important group. During spring there were more ephemeral annuals. They generally had small leaves and that was the reason they become prominent. In the summer annuals mostly disappeared and the vegetation was left mostly with shrubby plants that by comparison to annuals had larger leaves which was reflected by the quantitative spectra. Small leaf size classes resulted due to severe climatic conditions in arid and semi arid regions. The findings of Khan *et al.* (1999) support our findings as they reported the dominance of nanophylls and microphylls due to dry climatic conditions in arid regions of Karachi. It is concluded that dwarf habit with small leaves are ecological adaptation of these plants to the prevalent environmental conditions.

Homogeneity of Communities

The findings showed that the present communities were mostly heterogeneous. Similar heterogeneous communities were also observed in water courses during both the seasons. The heterogeneity of communities was due to the presence of short lived annuals/grasses and forbs, which was a natural response of vegetation to dry climate, eroded soil and overgrazing in the area. The annuals grew better in shaded and protected locations than in the exposed sites. The shaded and protected places had more moisture and were less hot. For this reason, they had limited disturbance. Severe grazing and trampling also created unfavourable conditions for growth.

The shrub components were more uniformly distributed than annual species. They showed homogeneity in the area. *Artemisia maritima*, *Sophora griffithi*, *Hertia intermedia*

and *Nepeta juncea* were common species at hills while *Perovskia abrotanoides* and *Perovskia atriplicifolia* were common in dry water courses. The homogenous nature of communities was attributed to few species that had uniform distribution in the area. Spacing and interplant distances were kept uniform due to intense competition for soil moisture and nutrients. There was always soil moisture deficiency in the area. Variation of habitat conditions were less as most of the sites were eroded and had poor organic matter. This caused lack of fertility, moisture deficiency and hostile habitats which allowed growth facilities to some of the perennial plants and that is why the communities turned homogenous.

Similarity Indices

Degree of similarity between two communities allowed combining them into one association or vegetation type. The data showed that three communities had (above 55%) similarities during spring i.e. ¹BCB & BPS, TJB & TJB, and ASI & ASI while the communities with less similarities were BCP & IAT, BCB & AAB, and AAB & IAT. The higher similarity between community might have been due to the proximity of stands that almost had similar habitat conditions in terms of nutrients and soil texture. While least similarity was due to change in micro-climatic condition, erosion, edaphic differences and biotic factors like deforestation and overgrazing that resulted in differences in nutrient status to cause differences among the various communities.

Similarly, during summer four pairs of communities had greater similarities (above 50%) i.e. SIA & AEA, ASC & AES, TPL & LZJ, and SIA & ASC between them. The

¹ The communities portrayed by these symbol have been given on page No: xviii

communities with lower similarities were LPE & ASI, LPE & ASC, BCB & TJB, and BCB & TJB.

In water courses, greater similarity (above 50%) was observed between PBA & PAE & ABB during spring while lowest between PAE & APH communities. Similarly, the communities of summer aspect had higher similarities (above 55%) in PPA & PtEAg & PbEm A and SEP & EEH.

The communities were similar due to uniformity in habitat features. These dry water courses were eroded due to rain water every year. These unstable soils supported mostly annuals and few shrubs that had adapted and resisted the severe eroded soil in this area.

The present study envisaged that the communities ASE & ASC had greater similarity (above 50%) while BCB & AAP had lowest similarity between two seasons. The greater similarity in these communities might have been due to the dominance of shrubs with few annuals. Thus, there were little differences among the two seasons. While communities with least similarity were composed of a large number of spring annuals that disappeared in the next season. This created the differences among seasonal aspect and similarity.

In dry water courses all the communities had less than 40% similarity in both the seasons. Hussain and Malook (1984) and Shah *et al.* (1991) reported that differences among the plant communities were due to topography, exposure, erosion and biotic factors. Similarly, Hussain *et al.* (1997) reported that high similarity values were recorded between plant communities found on slopes with similar aspect and habitat conditions

while low similarity values were recorded between plant communities having differences in habitat features. Our findings agree with them in this regard.

Regeneration capacity of Juniper

Juniperus excelsa is a slow growing tree in the area. It attains a large size under favourable conditions. The maximum height recorded in the present study was in between 17 to 27 m. The presence of mature and over mature trees indicated climax stage of Juniper forests. Ahmed *et al.* (1990) noticed in Chautair Juniper forests that the tallest trees were 26 to 28 m. high and medium height trees were 14.1 to 20 m.

A young tree of 1 m. height might be 50 to 60 years of age (Ahmed *et al.*, 1989). Annual growth in height was 25 mm. and 1 mm/year in diameter (Ciesla *et al.*, 1998). According to our estimates, the average age of trees at Harboi hills might be 140 - 150 years. The present study showed Juniper density in between 12.5 to 50.0 ha⁻¹. While basal area of Juniper ranged from 14.87 m²/ha to 29.3 m²/ha. The basal area and density of Juniper was highly variable within and between sites. Junipers at Harboi hills were scattered and their density very low when compared to Ziarat (56 to 332/ha) and Rodth Malazai (54 to 152/ha) (Ahmed *et al.*, 1990, a, b). The reason of low density might be due to major differences in rainfall, snow fall and topography. This rangeland is more dry than Ziarat and Rodth Malazai. Moreover, the altitude of Ziarat is more than Harboi rangeland. The area has the potential for the regeneration of Junipers as there were 6 to 10 cm high seedlings in different sites. Contrary to our findings, lack of regeneration of Juniper was recorded by Ahmed *et al.* (1990b) in Rodth Malazai forest. Majority of Juniper populations in Harboi rangeland had medium sized trees which indicated that Juniper was

regenerating under the existing climate and habitat conditions. However, deforestation and degraded edaphic features might be hindrance in its regeneration.

Age and growth rate greatly vary from species to species, site to site and even with two similar sized trees of same species. In Harboi range, the tallest trees were found between 2300 to 2750 m elevation. The size of trees generally increased with increasing altitude. However, Ahmed *et al.* (1990 a) found significantly negative correlation between altitude and growth of trees at Ziarat forests.

The percentage of male trees was slightly more than the female trees in Harboi hills. On the contrary, the percentage of female trees was higher in Ziarat and Rodth Malazai forests (Ahmed *et al.*, 1990 a & b). Bisexual trees were rarely found (2.5 to 5%) in this area. A similar situation was reported for Juniper forests of Ziarat and Rodth Malazai by Ahmed *et al.*, (1990 a, b) and our findings agree with them in the respect.

Juniper forests at Harboi hills are being severely affected by fuelwood collection. It was observed that about 1500 kg of Juniper wood was collected and transported on every alternate day from this area (personal communication with collectors). The wood was transported by camels to the neighbouring villages. This situation might be severe in winter because of lack of fuel resources and more need for fire wood. The fuelwood is not only collected for daily use but also stored for winters. Winters are snowbound and every house needs more heating. The requirement is met from the local forests and rangeland.

Similarly, fodder for winter feeding is collected. This enhances pressure on the rangeland.

Species Diversity

Species diversity is an important feature of any rangeland. It not only reflects the health of vegetation but also its productivity. Index of diversity is the measure of

complexity of form and function within a community or area. Its precise measurement leads to understanding of processes involved in the developmental change and organization of communities (Shaukat *et al.*, 1978). Community diversity deals with the number of taxa and relative abundance within a stand (West, 1993). The data showed that the summer communities had higher Simpson's diversity index than the spring communities. It was observed that Simpson's diversity index had inverse correlation with species richness. Species diversity is composed of two factors i.e. species richness and species equitability. Species richness is the total number of different species and species equitability is the evenness of balance of species distribution (Peet, 1974).

The Shannon - Weaver function is the most appropriate index of diversity because it weighs the number of species rather than the equitability in importance value. It was observed that species diversity decreased during summer in all the plant communities. This is because, in summer many annuals and geophytes disappeared leaving behind less number of species in the area. Species diversity was significantly positively correlated with maturity index and species richness in both the seasons (at $p = 0.05$ level).

Species diversity of an area is the reflection of different factors such as overgrazing, environmental stress and susceptibility of species, which lowers the species diversity of rangelands (Willoughby, 1996). This area is being severely overgrazed and subjected to reduction in vegetation cover and species. The observed low species diversity in Harboi range might be due to overgrazing and quick disappearance of annual/geophytic species. Opposed to our findings, high species diversity was reported by Dasti and Malik (1998) for moist mountain communities of Indus Valley Scarp slope as result of high precipitation. Danin (1999) also reported that species diversity of desert vegetation

increased along the humidity gradient. In the present case, overgrazing, deforestation, low precipitation, high temperature, aridity and erosion might be some of the factors responsible for the observed low species diversity.

Many workers who employed Shannon's diversity index on vegetation (Xyeying and Meeling, 1998; Houcheng, 1998) observed high diversity due to plantations in the forest. However, Khan *et al.* (1999) observed low species diversity due to few species and stressful environmental stresses. Sharing of some limited resources by the associating species is proportionally related to the dominance of the species which become more distinct with low diversity (Yodizis, 1978). Reid *et al.* (1996) pointed out another aspect that cultivation had strong negative effect on species diversity in Nairobi, Kenya and Ethiopia. It was observed that the trend of shifting of rangeland into cultivated areas was gradually increasing in the peripheral parts. This situation might be threatening to species diversity of the area. Kichenken and Hall (1996) reported that species diversity was a poor indicator of community stability. They reported that grazing effect on species diversity was non significant. In our case grazing appeared to be one of the major causes for low species diversity.

Continuous moderate grazing shifts the competitive advantage to the productive group of grass species at the expense of the drought resistant grasses and as a result it slowly reduces species diversity (Folke *et al.*, 1996). The effect of grazing on plant diversity depends on grazing intensity, evolutionary history of the sites and climatic regimes (West, 1993). Moderate livestock grazing might enhance community and landscape level diversity by decreasing the ability of community dominants to compete one

and exclude other species. Species diversity and complicated structure in the community reflects climatic conditions of the area.

Richness refers to variety or species density. The rate at which species richness increases/decreases within an area is related to the combined effect of niche relations, habitat diversity, mass effects and ecological equivalency (Shimida and Wilson, 1985). A slightly higher species richness was observed in the area as compared to Hazargangi National Park (Qadir and Ahmed, 1989). Similarly, a low species richness/diversity was reported by Tareen and Qadir, (1987, 1990 & 1991) for the vegetation of Quetta. The reason might be that, the present study area is far from settlement and less disturbed than Hazargangi National Park and parts of Quetta.

The species richness decreased from spring to summer. As the species richness depends on number of species and there was an abundance of annuals during spring season compared to summer that resulted in the high value of species richness. During summer most of the annuals and geophytes disappeared and resultantly the species richness decreased.

The higher value of species richness was recorded for communities of moist habitats than dry habitats. Moist habitats were comparatively humid due to continuous supply of water from temporary or permanent water springs while dry habitats entirely depended on rainfall only. Species richness treats all taxa equally. It is affected by evenness, patchiness, natural distribution and human influences (West, 1993). The vegetation of moist habitats and that of dry water courses was patchy and aggregated in distribution. Therefore, a high value for species richness in such habitat was a natural phenomenon.

Equitability or evenness is the relative abundance of component taxa. It is more important to land resource analysis than richness in rangelands (West, 1993). The present study showed that spring communities had more equitability value than those of summer communities. The reason might be that annuals were in abundance during spring season. A high equitability may result in highly stable environment over a prolonged period of time (Shaukat and Khan, 1979). It appeared that high equitability value had significant positive correlation with maturity index. Maturity index refers to those populations, which are relatively constant over time and not subjected to rapid replacement and are resistant to invasion of other species. The present data suggested that summer communities had high value for maturity index than spring communities. Similarly, the moist habitat communities exhibited high maturity index than terrestrial communities. It appeared that, species richness was inversely related to maturity index.

Shaukat *et al.* (1981) observed that density was correlated with equitability and species richness while maturity index had a significant inverse relationship with general diversity. Similarly, Khan *et al.* (1987) reported that equitability and species richness were not equally important in determining the overall diversity of a community. They reported that equitability appeared more influential than species richness in controlling the diversity variations. Similarly, Khan *et al.* (1999) reported that variation of diversity depended more on equitability component than on the species richness and this is what this study also achieved.

The community with low diversity value and high maturity index is more stable because in stable communities, the major fraction of species present is long lived (shrubs

or trees). In the present case high maturity index during summer was for the same reason as the major representatives were shrubs and perennial herbs.

III. Degree of Palatability

Growth of plants in Harboi rangeland is frequently limited by low and erratic rainfall, short growing season, shallow or rocky eroded soils and steep topography. Under such a climatic and habitat condition, the forage plants are more susceptible to grazing and trampling than those growing under a more favourable environment.

Harboi range is freely grazed primarily by sheep and goats in mixed herds form and by camels. The grazing season lasts from the first week of April to end of October. There is no management of the grazing as traditional grazing system is practiced. The vegetation is being consumed by grazing livestock as and when produced. Annuals like *Bromus sericeus*, *Bromus tectorum*, *Shimus arabicus*, *Ceratocephala falcata* and *C. testiculata* emerge frequently during early spring but are quickly grazed by livestock within a short duration even before they can attain maturity. Similarly, a large number of tulips and other geophytes shoot out in the early April but hardly a few can reach to the flowering stage except those found hedged by spiny plants or thickets such as *Artemisia*, *Convolvulus* and other non palatable plants.

Juniperus excelsa is highly preferred by livestock only during late winter and early spring as no other food is available at this time. It has tender shoots in early spring which are preferred by goats and sheep. Our results are in contrast with those of Hussain and Mustafa (1995) and Gyamtosho *et al.* (1996) who reported *Juniperus* species to be non palatable for animals. Juniper is reported to cause dermatitis in animals (Muenscher, 1960). The possible reason for its palatability in Harboi hills might be that no other food is available to the livestock and thus they have adapted to such a diet. Furthermore, they

might have an adaptation for utilization and digestion of the compounds of these commonly ungrazed plants.

The livestock preferred most of the shrubs in the Harboi range which makes 33.3 to 39.7% in their diet selection during April to August. While during September and October the availability of palatable species decreased and animals were forced to consume low quality food (i.e. at mature stage).

Development and growth of shrubs was impaired due to grazing at an early stage of life. *Artemisia maritima*, *Caragana stocksii*, *Astragalus Spp*, *Ephedra intermedia*, *Ebenus stellata*, *Haloxylon griffithii*, *Convolvulus leiocalycinus*, *Prunus Spp*, *Perovskia Spp* and *Sophora griffithii* were the most preferred shrubs in the area. These had become stunted with deformed or cushion like canopy. These findings are in line with those of Wahid (1990) who reported that these shrubs were equally preferred by livestock in other rangelands in Balochistan.

Range vegetation varies greatly in palatability, nutritive value and productive ability. Grazing animals select the most palatable plant first. A poor management, therefore, results in the complete replacement of good quality forage plants by low quality or non-palatable plants. The findings agree with those of Hussain and Chughtai (1984) who reported that overgrazing has promoted the dominance and growth of non-palatable species in Quetta. The removal of plant cover has accelerated soil erosion in the area. One can see severely eroded sites all over Harboi hills under heavy grazing.

In general, selectivity of forage is directly proportional to the amount of herbage available. It is important to recognize that many annual grasses and forbs grow in periods when perennials are dormant. Annual forbs/grasses provide an important nutritional

contribution to the livestock and reduced pressure on palatable perennial grasses during the growing seasons. In Harboi hills, annuals and geophytes appear when most of the shrubby component is still dormant. Thus, it provided a chance for shrubs to produce vegetative growth. By the time annuals mature, shrubby forage was available.

The palatability of plants depends on nutritional needs of animals. It declines as needs are met (Provenza, 1996). In the present study, 93% of preferred species were short lived annuals. Of them, 55.4% were available during early spring and the remaining 37.8% during summer. The plant preferences and feed selection of livestock shifted with the progress of season from spring to autumn through summer. The preference for herbaceous species was highest during April (56.1%) and May (43.7%) that slightly declined in June (36.5%). While it was in between 45.5% to 35.7% from July to September and ultimately lowered to 12.5% during October. This was well correlated with the availability of grasses which increased from April to June and thereafter gradually decreased during July through September. *Poa Spp*, *Piptatherum sp*, *Bromus Spp* and *Schimus sp* were preferred the most by livestock from April to June. While *Stipa Spp*, *Tetrapogon Spp* and *Festuca Spp* were desired the most during June and July. *Aristida Spp* and *Eragrostris Spp* were preferred species form July to October. *Pennisetum orientale* was available and also preferred through out the season by livestock. These highly palatable grasses decreased in the area. Such palatable species were performing well in inaccessible parts of the hills, where livestock could not approach. Less palatable grasses such as *Melica persica* and *Cymbopogon jwarancusa* increased in the range. Saleem (1993) and Wahid (1990) stated that *Cymbopogon jwarancusa* had spread over a majority of the grazing lands in Balochistan owing to its low palatability. Their findings also agree with our results as these

grasses had more distribution and cover in the Harboi hills for the same possible reasons.

Its dominance on the rangelands was an indicator of the severity and intensity of past livestock grazing in various parts of Balochistan including Harboi hills. It, therefore, becomes necessary on the part of the herders that bedding and feeding grounds must be changed frequently to maintain a healthy palatable cover.

Unpleasant feelings of physical discomfort are caused by excess of certain nutrients and toxins by nutrient deficiency and animal acquire aversion to food. This is manifested when animal no longer eats the food or when it shows less preference for food when offered alternatives (Provenza, 1995). There is not always a sharp distinction between poisonous and nonpoisonous plants. Most plants are poisonous only when eaten in large amounts and may provide nutritive forage when consumed in smaller amounts or mixed with other forages (Vallentine, 1990). The toxic components include all species poisonous or injurious to grazing animals. Some species are harmful at a particular stage of growth (Huston and Pinchak, 1993).

Various species of *Solanum* cause poisoning, *Senecio* damages liver, *Chenopodium* harms kidneys, *Taraxacum* creates intestinal disorders in animals and some species of *Festuca* cause gangrene of extremities (Mundy and Morris, 1978). Gardner *et al.* (1996) reported that the presence of pyrrolizadin alkaloids in range plants such as species of *Vertrum*, *Lupinus*, *Conium*, *Nicotiana*, *Astragalus*, *Solanum*, *Senecio*, *Cynoglossum* and *Crotalaria* cause significant livestock loses from hepatotoxicity. Reyna *et al.* (1996) reported that alkaloids, glycosides, nitrogenous compounds, oxalates and other organic acids were toxins present in many range plants including *Chenopodium album*, *Clematis drummondii*, *Conyza coultari*, *Descurainia pinnata*, *Euphorbia prostrata*,

Kochia serriola, *Malva parviflora*, *Melilotus albus*, *Peganum mexicanum*, *Salsola iberica*, *Salvia reflexa* and *Solanum nigrum* etc. Similarly, Malulbekova (1996) reported that *Artemisia scoparia*, *Euphorbia spp* and *Peganum harmala* are poisonous to livestock.

Some of the preferred species recorded in the present study might have been harmful to livestock owing to their unfavourable chemical composition or texture such as *Artemisia*, *Solanum*, *Senecio*, *Peganum*, *Chenopodium*, *Taraxacum*, *Euphorbia*, *Astragalus*, *Clematis*, *Conyza*, *Descurania*, *Kochia*, *Malva*, *Salsola* and *Salvia*. It might be possible that poor health and performance of livestock in this range are partly due to such toxic species. Since there is always shortage of forage in the area, therefore, these less palatable or toxic species are grazed as no other choice was available to the livestock. *Peganum harmala* and *Euphorbia prostrata* are generally not palatable in other parts of the country but in Harboi range these plants were grazed under compulsion. Similarly, Hussain and Mustafa (1995) reported *Sophora* and *Perovskia atriplicifolia* as non palatable species in dry temperate pasture of Nasirabad. While the same were highly preferred species by livestock in the present case. This contrast might be due to non-availability of fodder and special adaptations of the animals to such plants. Wahid (1990) reported that livestock in Balochistan rangelands (Loralai, Kalat) had an ability to digest highly lignified feed like *Artemisia*, not preferred in other regions. This justification might also be true in the present case.

Over grazing sometimes forces livestock to eat a harmful amount of poisonous plants. On a good grazing land, poisonous and less palatable plants are subjected to intense competition from vigorous high producing forage plants as many of plant species are available as forage (Vallentine, 1990). In the present case non-palatable do not face much

competition as the vegetation was poor and sparse which further decreased by the constant removal of palatable species by livestock. This has facilitated the spread and growth of undesirable vegetation cover.

Fruits and flowers are seasonally important in animals diet (Pfister and Malecheck, 1986). In the present study, flowers/fruits of 22.5% species were preferred by livestock. *Hertia* and *Rosa* were preferred only at flowering stage. The reason might be that fruits and flowers of forbs and shrubs generally might have had a much higher level of cell soluble and proteins than leaves. Similarly, vegetative buds of shrubs are particularly high in cell soluble and crude protein (Holechek *et al.*, 1998). Similar trend for preference of flowers and fruits was reported by Hussain and Mustafa (1995) for other plants in the pastures of Nasirabad valley.

The leaves of 19% species were preferred by livestock in this area. While shoots/whole plants were consumed in majority of the species (especially annuals). Leaves of nearly all forage species had high crude protein and phosphorus and low fiber and lignin than stems. Stems of woody species were low in quality because of high level of lignification (Holechek *et al.*, 1998). Similarly, green herbaceous component were easily digestible than dried or mature plants.

Sheep prefer fresh foliage than dried forage. There is a deliberate preference of feed which could be eaten faster. The preference for dried feed decreases because of taste, odour and feel. Leaves from forbs and shrubs are more digestible than grasses. Many grasses accumulate silica that reduces digestibility (Holechek *et al.*, 1998). For this reason many grasses with high silica contents and woody culms were non-palatable in the area.

However, grass leaves and stems were higher in cellulose and lower in lignin concentration than forbs and shrubs. This also made a change in the palatability of species.

Limited green foliage resulted in difficulty in grazing sufficient forage and animals spend more time for feeding. Animals prefer highly succulent, new fleshy tender growth and small twigs than older growth or dormant parts. The livestock face severe forage deficiency in Harboi hills from September onward owing to decline in vegetational cover and growth including the palatable species. At this phase, most of the plants enter into dormant phase. Leaves and tender shoots were insufficiently available. Only the woody or spiny and over mature leaves might be available that made the plants less palatable with poor forage availability.

The chemical composition of forage is an other major factor determining palatability. Although, the effective constituents associated with palatability are situation specific rather than universal. Fresh forage with high crude protein, fats, sugar, cellulose contents are highly digestible and generally preferred. While plants with high fiber, lignin, silica, low magnesium and phosphorus, high secondary plant metabolites and low digestibility are less preferred by livestock. During late season the plants have a chemistry which is not acceptable by the gazing livestock.

Animal Preference

The relative availability of plant composition in rangeland appears to have an effect on relative palatability. Sheep gain higher digestible energy by selecting better quality diet than goats. Sheep are able to utilize high cellulose forage such as graminoids. Dutoit and Alard (1996) reported that sheep grazing is good for plant diversity and subsequent mineral diversity in rangeland.

Sheep graze on young and tender grasses. In the absence of grasses they browse on bushes and shrubs. In the present study, the preference of grasses by sheep increased from 15.9% to 34.1% from April to June, followed by gradual decline towards September. The availability of preferred herbaceous species declined from 56.8 to 54.0% from April to May in this area. It showed a further decline to 31.8% in June but increased again to 40.8% during July due to emergence of summer annuals after summer rains. During September/October again a decline was observed. Similarly, the preference of shrubs by sheep increased from 27.3 to 34.9% during April to June. It declined in July to 22.7% due to availability of other herbaceous species and again enhanced to 39.5% in August when non shrub species became deficient. The livestock had less choice for forage during September to October. Sheep preferred *Haloxylon griffithii*, *Artemisia maritima* and *Sophora griffithii* during September to October.

The mechanism of feeding was very interesting. Sheep either bite the forage off the plants or break it off as they grip and jerk their heads backward or less commonly forward (Arnold and Dudzinaski, 1978). Sheep may walk upto 10 Km to reach preferred plant communities to acquire energy rich feed (Landsberg and Gillieson, 1996). In Harboi hills, sheep travel more frequently longer distances to select the preferred species that were sparsely distributed with poor herbage cover.

Forage selection changes tremendously within and between the years. Goats can distinguish between bitter, salty, sweet or sour species which enable them to choose from a wider range plant species than sheep (Mohammad, 1989). Goats can cope with a variety of dietary alternatives. When shrubs are highly unpalatable, the goats often readily shift to

herbaceous species. *Convolvulus leiocalycinus* and *Prunus Spp* were most preferred shrubs throughout the grazing season. The availability of preferred shrub species was 38.4 to 40.7% from April to June which gradually increased with the disappearance of herbaceous component. The availability of preferred herbaceous species for them was 52 to 55.4% during April to May and thereafter it decreased. Grasses were available to them within of 10 to 18.5% from April to June that reduced to 5.4% during September. The results of Nyamanagava and Ndlova (1995) agree with our findings as they reported seasonal variation of animal preferences. They observed that grasses were preferred from January to March while herbs and shrubs were preferred from May to November. Likewise, Grunzoaltd *et al.* (1994) also reported that goats preferred dicot herbs and shrubs in most periods. Their findings also agree with us regarding the selection by goat diet.

Goats are highly versatile and adapted to a wide variety of terrain and vegetation types. So additional energy expenditure is associated with travel distance, slopes and difficulty of terrain to be traversed. Walking up a steep gradient might require upto 10 times more energy as walking on the plain. Goats travel long distances and reach/climb to inaccessible places where other livestock would not go.

Goat preference depend upon forage availability and stage of growth. The ability of goats to consume browse is due to its mouth's mobile upper lip and a very prehensible tongue permit the goat to eat short grass and browse, individual leaves or tiny leave even from armed plants or from thorny species that are not normally eaten by other livestock. Goats prefer leaves and tender twigs and do not consume tough woody growth. This is the reason that all these perennial plants which are preferred by goats have bushy or cushioned

habit as their young and tender shoots are consumed before they could grow into branches. This also is a reason for the destruction of floral shoots of species preferred by goat. Although plants have the capability to regrow but they can not cope with the repeated heavy grazing.

At the community level of organization, differences in animal forage preference often results in differential frequency and intensity of defoliation frequency and intensity of defoliation of plant on a site and cause a shift in competitive interactions. Plant grazed less frequently gain an advantage over plants that are utilized at greater frequency or intensity. Thus, grazing induces a shift in competitive interactions, contribute to change in soils, phytomass, plant composition over time (Vladychenskiy *et al.*, 1995).

There is a tremendous potential to improve carrying capacity of this rangeland. This will ultimately help in raising living standards of herders of the area. Managed grazing system will avoid localized degradation of the area. Therefore, it needs ecological attention with the participation of local communities.

IV. Measurements of Range Productivity

Optimum use of natural resources like rangelands depends on the accurate understanding of the amount and dynamics of seasonal phytomass production. It is generally accepted that climatic fluctuations influence above ground phytomass production. Gou *et al.* (1997) recommended that use of biomass or productivity data as the most appropriate variable because it can best be represented per capita resource use and resource partitioning among organisms in competitive situation.

Biomass is a measure of community's resources tied up in different species. Vegetation composition based on dry weight is one of the best indicator of species importance within a plant community (Bonham, 1989). In Harboi hills, the above ground biomass production on dry matter basis for 1997 was 43% greater than the production measured during 1998. The recorded biomass was quite high in amount when compared to annual production of other places such as Hazarganji (Sardar, 1992), Zarchi (Kalat) (Wahid, 1990), Mastung and Tomagh (Loralai) (Akbar *et al.*, 1994), Kanak valley (Mori and Rehman, 1997) and for Asghara (Sinjavi) and Kuch Mulazai and Karez Kadi areas (Saleem, 1997) in different parts of Balochistan.

In the present study, productivity during June, 1997 was higher while July had the maximum production during 1998. The shrubs contribution of the total yield was 72.7% and 85.8%, respectively for 1997 and 1998. This was due to the response of vegetation to late winter and early spring rains during 1997 (the total annual rainfall for 1997 was 976.9 mm which was the highest recorded during the past six years, see Table 1). The total rainfall during June and July for the 1997 was 146.6 mm and this allowed a better growth of the vegetation to increase the productivity owing to favourable soil moisture. The life

cycle and herbage productivity besides other factors are linearly related to the annual precipitation (Socholes and Baker, 1993). Similarly, Shanmughavel and Ramarathinum (1993) reported that primary productivity in wet season was higher than dry and winter season in rangelands. Same was true in our case as there was a decline in the herbage production during dry and winter months. On the basis of average productivity, July and August were more productive months. The productivity was greater during 1998 in May (by 19.1%), July (by 4.9%) and August (by 0.3%) when compared to 1997 in the same months. However, differences were greater in dry matter yield among both the years during October. As a whole it was 45.4% higher in 1997 than that observed in 1998. The decrease of dry matter during 1998 was probably due to long dry spell with high temperature which resulted in poor growth of vegetation and early completion of life cycle during late September. Similar results were reported by Akbar *et al.* (1994) who observed that high dry matter production occurs due to rains received in spring and summer in Mastung and Tomagh rangelands.

Herbaceous productivity shared about 11.3% of the total per hectare dry matter yield during 1997. It was 2.1% of the total yield during 1998. There was 9.2% decrease during 1998. Standing crop of herbaceous components peaked during May. Yossef *et al.* (1996) reported maximum production of herbaceous phytomass during May due to moderate temperature and moisture. A similar situation prevailed in this case. The annual herbs primarily contributed towards the total productivity only during April and May due to their short life cycle. Similarly, flush of tulips and other geophytes appeared during early spring only. They contributed 1.1 to 4.2 kg/ha during April; thereafter they remained dormant for rest of the year. The findings of Danin (1999) supported our findings as he

reported that phytomass produced by annuals in the plant communities that develop on unfavourable soils is always less compared with those growing on good and deep soils.

A drastic decrease in phytomass was observed for the year 1998. The main difference was by 81.8% in *Eremerus persicus* and by 50.9% in *Iris tenuifolia*. It was observed from the last few years that collection of plants for medicinal/vegetable purpose on commercial scale had greatly reduced both these species as well as others in the area. Plants were dug out including the bulbs which caused permanent loss of these plants. This led to decreased grasslands resources and increased desertification as reported by Liu *et al.* (1996) for similar grasslands in China. In Harboi rangelands, a similar situation prevailed. Locals dig out plants for medicinal and fuel wood purpose. A 40 to 60% decrease in biomass was observed for grassland of China (Liu *et al.*, 1996) due to over exploitation. Similarly, Hussain *et al.* (1997) reported that grazing had decreased desirable plant species in the pastures. Herbivory by other organisms also effect the productivity, species composition and stability of communities (West, 1993).

In the present case, grasses constituted about 11 to 12% of total dry matter yield as observed during 1997-98. The phytomass of grasses was 1.8% greater during 1997 than in 1998. There was 2.4 to 11.5% increase during April to August while 49.63% decrease was recorded in October, 1998.

Although annual grasses, such as *Bromus spp* and *Shimus arabicus*, were abundant during early spring, their biomass contribution was low due to their small size (about 4 to 10 cm height). Likewise, *Eragrostris minor* had little contribution during June to October due to their small size ranging from 2 to 6 cm. Thin layer of eroded soil in mountainous regions reduces the size and vigor of plants due to low water holding capacity, low organic

matter and low nutrients and this is also true in the present case. Range productivity is primarily based on the density and production of native, palatable perennial grasses and diversity of palatable forage species.

Stocking Rate/Carrying Capacity of Rangelands

Forage intake of grazing animals varies with body weight and forage quantity and availability. Generally, five to seven hours/day are required for animal feeding which splits into intensive early morning and late evening feeding period (Nyamangara and Ndlova, 1995).

Grazing time depends on accessibility of plant parts, availability of total forage and quality of consumed diet. Grazing time is reduced when good quality forage is abundant. It was observed that about 1000 to 1500 animals in mixed herds graze in Harboi hills every day during growing season. According to an estimate (FAO, 1983), the requirement of livestock and camels are as follow:

Species	Average body weight	Daily DM. Kg required	Annual DM Kg required	Available amount of number of animals
Sheep	29.50	0.885	823.00	14
Goats	26.00	0.780	284.7	15
Camels	-	7.5	2737.5	1.6

According to the USA recommendation range utilization level is 30 to 40% of key species with 130 to 300 mm annual precipitation for shrub steppe vegetation in semi arid regions (Holechek, 1988). It may reach up to 50% utilization of range during high productive years and declined during dry period.

It was estimated that Harboi rangeland produced an average of 4309.02 Kg of forage. However, animal grazing in this area required 832.5 to 1248.75 Kg per day. The data showed that the available forage was insufficient for the present stocking rate. It can

be concluded that the available amount of forage in Harboi rangeland was sufficient only for 24 sheep/ha or 25 goats/ha (= 5 AUM's/ha) and for three camels only during growing season (April to October). Wahid (1990) reported that 5 sheep or goats were equal to 1 AUM's. The stocking rate in present study was better when compared to finding of Wahid (1990) who reported 0.89 AUM's capacity in Zarchi and Tomagh rangelands. Based on these observation it is suggested that the range is suffering from overgrazing which adversely affected the productivity at primary and secondary level. Overgrazing not only caused compaction of soil, but also removed palatable plant cover to open the way for destructive erosion which was seen every where in the rangeland. The rangeland health is the degree to which the integrity of soil and ecological processes of rangeland ecosystem are sustained.

Major factors influencing range-animal nutritional status include stocking rate, grazing system, type of forage species, types of animals and season of use (Holechek *et al.*, 1998). Hussain and Badshah (1998) reported that grazing and over exploitation by local inhabitant has caused degradation of palatable resources. Ahmed *et al.* (1998) reported that protected units show dominance trend of grass - shrub land and woodland, respectively. Contrarily unprotected areas were degraded in terms of woodland dominance. In an overgrazed rangeland non-palatable species increase at the cost of preferred species (Hussain and Chaghtai, 1984). A similar situation was met here also.

The rural population of adjoining areas are dependent upon this rangeland for their fuel wood required for room heating during winter and other domestics use as there was no other facility. They uproot almost every plant for their household needs irrespective of its forage or medicinal value. Protection from grazing has increased biodiversity and

biomass in Kanak valley, Balochistan (Mori and Rehman, 1997). Likewise, Saleem (1997) reported that protection enhanced the biomass from 81 to 151% in Asghara (Sinjavi), Kuch Mulzai and Karez Kadi area. Afzal *et al.* (1993) reported that in the nearby area like Musa Khail, Zhob and Loralai districts and Olive Zone in Ziarat, a traditional method of land protection is being practiced. This system is locally called "Pargore" (Pushto). A part of the grazing area is set aside during a growing season and grazing disallowed. A better vegetation was observed in the protected area compared to an area open to grazing. There is a potential for improving ranges by adopting traditional and scientific measures. This system must be introduced in other rangelands as well and if adopted will improve Harboi rangelands.

Although, Harboi hills is a protected forest. Yet grazing of livestock and collection of forest resources by locals is a common practice in the absence of stringent laws. The area has a great potential for increased biomass production, improved forage quality and productivity with properly managed grazing system. Thus, it becomes imperative to conserve the resources.

AZRI (unpublished data, 1999) recorded 285 kg/ha dry matter during early summer and 239 kg/ha dry matter during fall season in Kovak valley (Kalat District).

It is recommended that low stocking rate during the growing season and moderate during summer by judicious proper livestock management techniques might improve range biomass, species diversity and range carrying capacity.

There is need to replace the existing low yielding livestock with better breed of high quality livestock. It will not only improve the range resources but also provide more livelihood to the locals. Diseased and unhealthy animals be removed from the range.

V. Chemical Evaluation of Some Range Plants

Range vegetation is highly heterogeneous and dynamic across space and time. The chemical composition of the species available to the grazing animals and information on the nutritional status of grazing animals indicates the condition of rangelands.

Late winter or early spring lambing/kidding is a common practice on rangelands of Balochistan. This is when rapid spring growth commences with warming climate. The forage in this period is considered nutritionally adequate and enough for all physiological and reproductive requirements of sheep and goats. The maintenance period of animal is from June to September and this is the time when these rangelands generally fail to provide the needed requirement. It results in poor weighed animals which means poor productivity at secondary level.

Grazing of herbaceous plants and grasses in early growing stage is nutritionally advantageous to livestock because actively growing forages contain highest level of cell solubles, crude protein and phosphorus and show substantial decline as plants become dormant (Holechek *et al.*, 1998).

In the present study dry matter percentage of grasses and shrubs increased with maturity. These results agree with those of Vallentine (1990) who observed increased dry matter at maturity in some range plants. Similarly, Ashraf *et al.* (1995) observed that dry matter increased significantly with crop maturity.

Ash contents play an important role in promoting balanced growth of animals. Ash contents of shrubs were greater than those of grasses in the present case. Ash contents of forage progressively declined with advancing maturity (Kilcher, 1981). In the present study also, most of the tested grasses and shrubs exhibited similar tendency of decreasing

ash contents with advanced stage of growth and season. Similarly, Azim *et al.* (1989) observed a high value of ash contents with increasing degree of maturity of plants. However, some plants like *Artemisia maritima* and *Perovskia atriplicifolia* had higher ash contents at later stages of growth. This disagrees with results of Kilcher (1981) who reported decline of ash contents with advanced age but agree with the findings of Bedel (1971), Wahid (1990) and Liu (1993) who also did not observe decline in the ash contents of some forage plants with aging of plants and season.

Crude protein refers to all the nitrogenous compounds present in a forage feed. Sheep and goats need protein for maintenance, growth, reproduction and finishing. The deficiency of protein is characterized by reduced appetite, lower feed intake and poor food efficiency that results in poor growth and development of livestock (NRC, 1985). In the present study, it was observed that shrubs generally had slightly high crude protein than grasses. These results are similar to those of Vallentine (1990) and Holechek *et al.* (1998) who reported high crude protein contents in shrubs. Similarly, Robles and Boza (1993) also observed high crude protein contents in shrub species than annual and perennial herbaceous species. Since protein cannot be stored by the animal's body therefore a continuous supply is required (Holechek *et al.*, 1998). The time when plants are rich in protein, livestock are more healthy and their health might decline with decreased protein availability.

Crude protein contents were generally high at pre-reproductive stage (vegetative) than other stages with few exceptions such as *Artemisia maritima*, *Perovskia abrotanoides* and *Hertia intermedia*, where crude protein increased at post reproductive stage. This might be due to the reason that more storage of crude protein occurs in early

stages of growth which is then consumed during flowering and fruiting. Thereafter, the plants move toward dormant phase whereby their nutritional requirement decreases. More nitrogenous food is needed by plants for vegetative growth.

Among grasses, 8.7% and 5.6% decrease of crude protein was observed for *Pennisetum orientale* and *Stipa pennata* toward maturity. While among shrubs, 8.7% to 11% decrease of crude protein was observed for *Artemisia maritima* and *Convolvulus leiocalycinus*.

NRC (1985) suggested that sheep require 13.4% crude protein during March to May and 9.4% from June to December, while goats need 12.8% crude protein during March to May and 11% .6% during June to December. This need was related to the requirement of growth period of goats and sheep. When compared to NRC (1985) recommendations, the crude protein contents in the present study was lower in all the tested grasses at all the growth stages for both the livestock. However, *Pennisetum orientale* at pre-reproductive stage had 14.3% crude protein. While shrubs like *Artemisia maritima*, *Perovskia abrotanoides* and *Convolvulus leiocalycinus* had sufficient crude protein contents at pre-reproductive stage. At the later stages of growth and season, *Artemisia* had satisfactory level of crude protein in October. The average crude protein contents of *Artemisia maritima* was lower than *Artemisia pauciflora* (13.1%) (Kurganova and Olovyannikova, 1993) found in Northern Russia. Therefore, livestock face a severe protein deficiency during all the seasons in the Harboi rangeland. A similar decreasing trend for crude protein for various forage plants from the beginning of grazing season toward autumn was observed by other workers (Pinchak *et al.*, 1990).

Fierro and Bryant (1990) observed a decrease in the crude protein contents of forage plants with maturity. Our findings also agree with those of Andrighetto *et al.*, (1993) who observed that crude protein of grasses decreased from July to September with the advancement of vegetative season. Ashraf *et al.* (1995a) observed that crude protein of forage plants was higher at primary cutting i.e. spring and lower at later cutting (i.e. maturity).

Semi arid and arid rangelands are generally dominated by characteristics vegetation that is relatively high in quality during early vegetative growth but declines quickly in quality as the forage matures (Huston and Pinchak, 1993). This was true in our case as most of the plants were protein rich during early vegetative phase that declined at the end of season. In the present study, the growing season started from March and terminated during November. During this period, dry spell from May to October was characteristic for the area. This was the time when forage plants were low in quality and poor in crude protein. Thus, mostly crude protein deficient feed was available in insufficient quantity that led to the poor growth of livestock in the area.

Young plant tissues are biochemically active capturing and storing more energy, synthesizing higher protein and fats contents than older tissue which have comparatively low biochemical activity. Forage contains fixed energy largely in the form of complex carbohydrates, waxes, terpenes and essential oils which have inverse relationship to nutritional value of grazing animal because of low digestibility.

Holechek *et al.* (1998) stated that forage nutritive quality varied tremendously between different seasons. The level of cell solubles, crude proteins and phosphorus were higher in actively growing forages and show substantial decline as plants become dormant.

Green forage contains high protein contents and high phosphorus which are good source of digestible energy. Some plant species, although, are highly nutritive but they are available in limited quantity. On the other hand, more readily available species might have less nutrition. A similar trend was noticed in the plants of Harboi hills. *Euphorbia*, *Hertia* and some other species were frequently found with more foliage but they were less palatable and poor in nutrition. On the contrary highly preferred species like *Ebenus stellata*, *Caragana stocksii*, *Stipa pennata* and *Poa bulbosa* had low population and less foliage cover. This is natural as non-palatable species have vigorous growth and better distribution compared to preferred palatable species. Hussain and Chaghtai (1984) reported a similar situation where preferred species decreased in the overgrazed areas of Quetta.

Mature plants usually contain more crude fiber as compared to the younger plants. Seasonal variation also affects the crude fiber contents (Azim *et al.*, 1989). In the present study, plants at reproductive and post-reproductive stages had more crude fiber contents than pre-reproductive stage. Our results in this respect agree with the findings of Azim *et al.* (1989) and other workers.

The crude fiber contents were higher in grasses than in the shrubs except *Convolvulus leiocalycinus*. This was in agreement with the results of Holechek *et al.* (1998) who reported that grasses generally had more crude fiber than forbs and shrubs and therefore they were less digestible. Fiber is digested very slowly than cell contents and it is the reason that it is less nutritional.

Among the grasses, annuals show much greater decline in nutritive quality than do the perennial grasses (Holechek *et al.*, 1998). This was true in our case as *Tetrapogon*

villosus contained more crude fiber at mature stages than perennial grasses such as *Pennisetum* and *Cymbopogon*. Annuals complete their life cycle within one season while perennials live longer. This might be the reason that annuals end up with high crude fiber.

The range of crude fibers in the present study was greater when compared to other forage species (Ashraf *et al.*, 1995a). This difference might be due to differences in the climate, moisture availability and other related factors. Forage plants of dry habitats generally have more crude fiber contents (Holechek, *et al.*, 1998). This could be true in this case as the area is dry temperate arid land.

The higher contents of carbohydrates in fodder plants is considered better than higher lignin contents. Carbohydrates are energy producing and their requirement cannot be met by protein in ordinary way because carbohydrates are easily digestible and readily available source of energy (Holechek *et al.*, 1998). In the present case, it was observed that the total carbohydrates contents were higher in grasses than in shrubs. There was a progressive increase in the carbohydrate contents from pre-reproductive stage to post-reproductive stages in all the tested samples. However, high carbohydrates contents at late phenological stage were less beneficial to livestock because of less digestibility in the form of cellulose and hemi-cellulose.

Nitrogen free extracts were non-significantly higher in grasses than those in shrubs. The nitrogen free extract values ranged greater in our plants when compared to those reported by Liu (1993) for plants in other pasture, desert and in arid rangeland species. Cook and Stubbendieck (1986) reported that nitrogen free extract may be nearly equal in many forages and this is what we also noticed. We observed non-significant differences among grasses, shrubs and between various phenological stages of the same species.

Gross energy represents the total combustible energy in a feed stuff. Gross energy determinations are necessary to calculate metabolized energy (ME). Metabolized energy is the most suitable index for energy furnishing qualities for range forages. Total digestible nutrients can be used as an index of energy for range forage. Cook and Harris (1977) observed that grasses had higher gross energy than shrubs while our study showed that shrubs contain slightly higher gross energy than the grasses.

The nutritional requirement of sheep and goats are considered necessary for maintenance, optimum production and prevention of all signs of nutritional deficiency. Goats are more active and travel greater distances than sheep which increase energy requirements. The energy requirements are also affected by environmental factors like temperature, humidity, sunshine and wind velocity. Goat and sheep on average require 50 to 66% total digestible nutrients, 0.7 to 6.9 Mcal/kg/day digestible energy and 0.5 to 5.6 Mcal/kg/day metabolized energy for the maintenance of animals. While 4.4 Mcal/kg/day digestible energy and 3.6 Mcal/kg/day metabolized energy is additionally required as the body weight of the animal increases (NRC, 1985).

In the present study, the investigated species partially fulfilled the requirement of livestock as all the species had low digestible energy and metabolized energy throughout the season. In contrast to our findings Liu (1993) reported 70.3 to 79.0% total digestible nutrients in plants of rangeland and desert. The nutritional energy limitation for livestock at Harboi range might result from inadequate feed intake or from a low quality diet. It was observed that, there were non-significant differences between total digestible nutrients, metabolized energy and digestible energy or between shrubs and grasses at all phenological stages. Findings of Robles and Boza (1993) support our findings as non-significant

differences in metabolized energy contents of shrubs, perennial herbaceous species and annual rangeland species were observed.

Detergent fiber of plant species and its phenological stages have strong positive linear relationship (Wahid, 1990). Concentration of neutral detergent fiber (NDF) and acid detergent fiber (ADF) are strongly affected by maturation of plants (Dabo *et al.*, 1988).

The analyzed forage species had tendency for increasing NDF value towards maturity. NDF concentration of grasses were higher than shrub during all the seasons. The lower NDF (>50%) in shrubs throughout the season indicated severe energy deficiency problem for sheep and goats. So supplementation with energy rich feeds or reduced stocking density may increase animal production. Findings of Wahid (1990) support our results as a similar trend of NDF for forage plants of Zarchi range was observed. Angrighetta *et al.* (1993) also noticed increase in NDF contents in late phenological stages of plants and so supports our findings.

The tested species had lower ADF value at pre-reproductive stage, reached a maximum at blooming and then exhibited a minor decline at post-reproductive stages. Wahid (1990) also reported a similar trend at Zarchi rangeland for different plants. Similarly Ashraf *et al.* (1995b) observed increase in NDF and ADF in fodder at different growth stages and our results agree with them.

Lignin is the portion of the plant cell wall that cannot be utilized even by microorganisms. Lignin is higher in stems than in leaves and it increases as the plant matures (Holecheck *et al.*, 1998). In our case, acid detergent lignin was higher in shrubs than in the grasses. The present findings are in line with those of Robles and Boza (1993) who found higher lignin contents in shrubs than grasses. This study also suggested that

ADL increases from pre-reproductive to post-reproductive stage. Similarly Azim *et al.* (1989) also reported that lignin contents increased with age and caused a corresponding decrease in the nutritive value.

Lignin digestibility of plant type were quite variable and unpredictable by both animal species. Wahid (1990) reported that in *Artemisia maritima*, lignin was highly digestible at flowering stage and less digestible at vegetative stage for livestock. However, it was observed that *Artemisia maritima* was highly preferred by livestock in early spring at vegetative stage. The reason might be that these animals are compelled to digest such feed as they have less choice in the presence of few palatable species.

The present study suggests that there were highly significant differences in hemi-cellulose contents between grasses and shrubs at all the phenological stages. Grasses generally had more hemi-cellulose than shrubs at various phenological stages. Variation in the amount of structural carbohydrates occurs with seasonal changes and growth stages of plant (Singh, 1976). Livestock preferred grasses and they can efficiently use cellulose and hemi-cellulose because the microorganisms in their digestive system are capable of digesting these carbohydrates (Holecheck *et al.*, 1998).

It was observed that a great diversity existed between the patterns revealed by different elements in different plant species at various phenological stages. At least 0.5 ppm potassium is required by livestock (NRC, 1985) in feed for enzymes, muscles and nerve functions. Potassium contents were quite high in all the tested plants at all the phenological stages. They, in general, can fulfill the requirement of grazing animals except *Artemisia maritima* in which potassium contents were lower at pre-reproductive stage. Since it is most preferred species available during early spring and is grazed, therefore,

there is possibility that livestock in Harboi range might face some potassium deficiency. However, other plants might compensate this deficiency.

Azim *et al.* (1989) reported high potassium contents at late season (i.e. August to October). This trend was also observed in a few species in the present case. However, other species did not follow this trend as a slight decline was observed at post-reproductive stage. Rehman and Mackintosh (1996) reported that livestock preferred higher level (1.2%) of potassium in fodder species as compared to low potassium feed. The present investigation showed that, almost all plants had sufficient amount of potassium as reported by Rehman and Mackintosh (1996).

Phosphorus is essential for skeleton and teeth, blood plasma, for assimilation of carbohydrates and fats. It is also a vital ingredient of the protein and necessary for enzyme activation. The deficiency causes poor growth and development of knocking knees in animals. Sheep and goats require a minimum of 0.16 to 0.37% phosphorus (NRC, 1985).

Phosphorus content of grasses were lower than the NRC (1985) suggested level during all the phenological stages. Phosphorus is the most limiting mineral to grazing animal productivity throughout the world (Holechek *et al.*, 1998). Phosphorus is available in very small amount for the plants because phosphorus is tightly bound in the clay particles which are removed from the terrestrial environment through erosion (Billing, 1966). Soils are greatly deficient in phosphorus and plants growing on such soil have further reduced phosphorus contents (Vallentine, 1990).

Goats need 0.23% phosphorus during March to April and 0.21% in October, while sheep require 0.2% to 0.06% during spring and 0.23% in winter (NRC, 1985). The phosphorus contents of shrubs of Harboi range might fulfill the phosphorus requirement of

animals i.e. *Artemisia* at reproductive and post-reproductive stage, *Sophora* and *Perovskia* *abrotanoides* at reproductive stage and *Perovskia atriplicifolia* at pre-reproductive stage, while *Convolvulus leiocalyeimus* at post-reproductive stage had sufficient amount of phosphorus. All these species had low phosphorus at other phenological stages of growth.

Phosphorus concentration of the plant declined significantly with maturity. The plants had maximum concentration of phosphorus during spring season i.e. at vegetative stage. Thus, livestock grazing in Harboi range might not face phosphorus deficiency during spring. While they might experience phosphorus deficiency for the remaining grazing period. Since the phosphorus contents of the various species differed at various growth stages and at a similar stage of growth. This will be an advantage to grazing animals as phosphorus would be available in some of the plants to utilize throughout the grazing period. Wahid (1990) support our findings, as he reported decline in phosphorus contents with maturity of plants at Zarchi and Tomagh rangelands. Similarly, Azim *et al.* (1989) also observed decrease in phosphorus contents with increasing maturity of plants.

Copper affects the dietary intake of elements. Anemia in animals is associated with copper deficiency. Livestock need 4.5 to 5 ppm. Copper. While 8 to 25 ppm. copper is toxic level (NRC, 1985). It was seen that copper contents were within the toxic limits in tested plants at most of growth stages, except *Stipa*, *Pennisetum* and *Convolvulus* at post-reproductive stage, *Artemisia* and *Convolvulus* at pre-reproductive and *Cymbopogon* at all three stages. Copper contents of recorded species were higher in comparison to some other range plants (Kalmbacher and Martin, 1981). While on the other hand they ran lower than those determined for forage plants by Reuter *et al.* (1986). They reported that, there are great differences in mineral contents if the samples were used unwashed or washed.

The differences in the present case might be due to analysis techniques used in different laboratories.

Balance concentration and nature of minerals in grasses vary with plant species, stage of growth and availability of minerals in the soil (Minson, 1982). It was true in our case as it varied within species at different growing seasons.

Although there existed a variation in the manganese contents of different plants and growth stages, yet the results were non-significant. Manganese contents were non-significantly higher in grasses than in the shrubs in the present study. The contents of manganese in tested species were well below 18 to 36 ppm., a range recommended by the NRC (1985). However, manganese contents were substantially less in *Artemisia* at pre-reproductive and *Perovskia abrotanoides* at reproductive stage than the 18 ppm. suggested minimum level by NRC (1985) for livestock. Manganese deficiency results in impaired growth, skeletal abnormalities and abnormalities of new born. Manganese contents of recorded species were almost within a similar range as determined for creeping blue stem by Kalmbacher and Martin (1981) and for forage plants by Reuter *et al.* (1986). Thus our findings are supported by their results regarding manganese contents.

Iron is an essential component of haemoglobin, myoglobin, the cytochrome and enzyme system involved in transport of O₂ to cells. All the analyzed plants in the present study gave very high Fe contents at all the phenological stages. The dietary requirement of goats and sheep lies within 30 to 50 ppm. (NRC, 1985). There were non-significant differences between iron contents of grasses and shrubs. However, grasses among

themselves had significant variation at different growth stages. Iron contents in the recorded species were very high as compared to the creeping blue stem (27.5 to 69.4 ppm.) (Kalmbacher and Matin, 1981). However, Reuter *et al.* (1986) reported as high as 524 mg/Kg iron contents in mixed herbage feeds and supports our findings.

Zinc is an activator of more than 30 enzymes in nucleic acid, protein synthesis and carbohydrates metabolism. The zinc deficiency results in impaired growth of testicles and cessation of spermatogenesis and stripped wool. The Zinc contents were higher in shrubs than grasses while seasonal variation of Zinc contents were non-significant.

The suggested level set by the NRC (1985) for Zinc intake is 35 to 50 ppm. An amount of 900 to 1000 ppm. is toxic for livestock. In our case this level was met by all the tested plants at all the phenological stages. Zinc contents of grasses of Harboi range lower than creeping blue stem (Kalmbacher and Martin, 1981) and for forage species (Reuter *et al.*, 1986) as determined elsewhere. The findings suggested that although the vegetation cover is poor yet when grazed it will provide the required level of zinc to the grazing animals.

General Conclusions and Recommendations

1. The study was conducted from 1997 to 1999 to understand the vegetation - habitat relationships, structure, productivity, palatability and chemical nature of some representative palatable plants.
2. The study showed that the flora was composed of 202 species that belong to 35 dicot, 8 monocot and 2 gymnospermic families. The number of species recorded in the present study is far higher than any previous work on this rangeland.
3. Asteraceae, Poaceae, Brassicaceae, Papilionaceae, Lamiaceae, Boraginaceae and Chenopodiaceae were important families.
4. The flora was dominated by therophytic, hemicryptophytic, nanophyllous and microphyllous species. This is well in accordance with the climate of the area.
5. There were two flowering periods: first, from April to May/June and second, from July to October with the peak flowering period in May. The flowering was related to wetness of season.
6. The major utility of the area was as rangeland, 64.5% of the species were used as fodder/forage. They were followed by medicinal plants (25%). It was obvious that the area is basically a rangeland with some potential for medicinal plants.
7. There is a severe shortage of fuel and timber wood species that has enhanced deforestation pressure on the existing shrubby and woody species.
8. Various phytosociological parameters and statistical treatments reveal that the vegetation had 3 main types: *Artemisia* steppe, Juniper type, *Bromus/Astragalus* steppe. All these types characterized arid rangelands.

9. The physical and chemical analysis of habitat features reveal that the flora, vegetation structure and its productivity was governed by temperature, soil moisture and altitude. Soil nutrients appeared to be playing secondary role in shaping the vegetation.
10. The area is basically a juniper rangeland. Juniper is being removed for fuel wood. The area has potential to regenerate as there were seedling, young to mature plants. There is an urgent need for complete ban on the cutting and collection of young juniper plants.
11. Of the 129 palatable species, 50% were highly and 41% were mostly palatable species. Thus, 91% of palatable plants were preferred species. This indicates non-availability of sufficient forage and high grazing pressure in the area. The grazing must be ecologically regulated to reduce the grazing pressure on vegetation. The herd size must be kept in accordance with the carrying capacity of this rangeland.
12. The preference of livestock varies by species, by parts, by phenological stage of plants and the most important by availability of forage. There is need to allow mixture of livestock so that grazing pressure on few preferred species might be relaxed. Rotational grazing specially during non-flowering periods might provide a chance for the vegetation to produce foliage and seeds.
13. The productivity of the range depended upon the season, phenological stage of vegetation and amount of rainfall. The later factor appeared to be more decisive than any other factor of the environment.
14. The chemical analysis of some representative plants indicated that the quality of forage declined as the phenological stages advanced from spring to dry season.

Generally, the tested plants had high potassium, zinc, copper, iron and phosphorous and low crude protein, digestible and metabolized energies, manganese, crude fibre. The overall nutritive value of tested forage plants were generally low while zinc, copper, and iron contents were very high reaching to the toxic level.

Based on the above conclusions, it is recommended that:

1. Moderate and rotational grazing management be enforced to enhance the rangeland primary productivity.
2. There is severe deforestation pressure for fuel and timber wood. Alternate source of fuel/timber could be provided and the area should be closed for a period 15 years to promote shrub and tree cover.
3. Retrogression of climax community to disclimax is widespread. This can be managed by regulating grazing and deforestation with participation of local communities.
4. There is an urgent need to promote ethics that conservation and improvement of natural vegetation is critical for soil and land management. Soil is being eroded very rapidly due to lack of vegetation cover.
5. There are more avenues like exploration of research activity for knowing the germination, seed production and growth pattern for successful propagation and reintroduction of fodder, fuelwood and medicinal plants in the area.
6. Marketing policies for livestock and medicinal plants should be regulated and upgraded as at present there is no such facility.

7. Cooperation and participation of local people is essential to enforce effective management plan this might be possible with the help of influentials of the area.
8. A balance between the food and feed supply, nutrient input, livestock population and human influences will be critical for long term sustainability of rangeland.
9. Strong linkages among international programmes, regional and sub-regional research and developmental programmes are required to devise an integrated management plan so that the ecological and socio-economic problems could be addressed properly.
10. To improve and ensure overall sustainable biological productivity from this ecosystem, long term plans are needed. It might include rehabilitation of degraded habitats by introducing fast growing fodder species, replacement of low yielding livestock with high yielding breeds, rotational and mix grazing, provision of water points, provision of alternate source of fuelwood and livelihood. Such long term efforts might reduce pressure and allow the flora and fauna to revert to its natural original status.
11. The rangeland can be used as a game reserve for income regeneration that can be used for its development.
12. There is strong positive hope to promote ecotourism in the area. This will be an additional source of income.

References Cited

1. A. C. 1954. *Official Methods of Analysis* (14th ed.). Association of Official Agricultural Chemists, Washington, D. C.
2. L. J. S. Allen and S. M. Steel. 1963. *Statistical Analysis of Experimental Data*. Chapman & Hall, London, U. K.
3. H. B. G. Brown and R. E. Brown. 1957. *Statistical Analysis of Experimental Data*. Chapman & Hall, London, U. K.
4. H. B. G. Brown and R. E. Brown. 1957. *Statistical Analysis of Experimental Data*. Chapman & Hall, London, U. K.
5. H. B. G. Brown and R. E. Brown. 1957. *Statistical Analysis of Experimental Data*. Chapman & Hall, London, U. K.

REFERENCES CITED

References Cited

- A.O. A. C. 1984. Official Methods of Analysis (14th ed). Association of Official Analytical Chemists, Washington, D. C.
- Afzal, J., A.S. Alvi and S.N. Mirza. 1993. Potential for rehabilitation of degraded rangelands of Balochistan. *Pak. J. For.*, 43:99 - 106.
- Ahmed, M., R. B. Tareen and K. R. Tareen. 1987. Vegetation ordination of Chiltan in Balochistan. In Ilahi, I & F. Hussain (eds). Modern Trends Pl. Sci. Res. Pakistan. Botany Department University of Peshawar. Pp. 39 - 43.
- Ahmed, M. 1988. Plant communities of some northern temperate forests of Pakistan. *Pak. J. For.*, 38:32- 40.
- Ahmed, M., I. Ahmed and P.I. Anjum. 1989. A study of natural regeneration of *Juniperus excelsa* M. Bieb in Balochistan, Pakistan. *Pak. J. Bot.*, 21:118 - 127.
- Ahmed, M., S. S. Shahid and A. H. Buzdar. 1990a. Population structure and dynamics of *Juniperus excelsa* in Balochistan, Pakistan. *J. Veg. Sci.*, 1:27 - 276.
- Ahmed, M., E. E. Nagi and E. L. Wang. 1990b. Present state of Juniper in Rodhmallazai forests of Balochistan. *Pak. J. For.*, 40: 227 - 236.
- Ahmed, M., A. Mohammad, A. Mohammad and S. Mohammad. 1991. Vegetation Structure and Dynamics of *Pinus gerardiana* forests in Balochistan. *Pak. J. Veg. Sci.*, 2:119 - 124.
- Ahmad, M., F.A. Raza, G. Akbar and M. Arshad. 1998. Ecological assessment of rangeland vegetation in southern Attock. Part I. Phytosociology. *Pak. J. Sci. Ind. Res.*, 41:251 - 255.
- Ahmed, S. E., J. G. Morris and S. R. Radosevich. 1981. Summer diet of Spanish goats grazing Chaparral. *J. Range Manage.*, 34:33 - 35.
- Ahmed, S. 1998. Regeneration ecology of *Chrysopogon aucheri* and *Cymbopogon jwarancusa* grasslands of upper Balochistan, Pakistan. Ph.D. Thesis, Utah State University.
- Akbar, G., S. Rafique and M. Asghar. 1994. Evaluation of different exotic grass species in upland Balochistan. *Pak. J. For.*, 1:1 - 8.
- Ali, S. I. and M. Qaisar. 1995 - 1999. Flora of Pakistan. Pakistan Agricultural Research Council, Islamabad.

- Ali, Z. 1966. Review of range management in Quetta - Kalat Region. Proc. 1st West Pakistan Range Manage. Conf. Pakistan Forest Institute, Peshawar. Pp 144 -155.
- Andrew, M. H., I. R. Noble, R. T. Lange and A. W. Johnson. 1981. The measurement of shrub forage weight by three methods compared. *Aust. Range J.*, 3:74 - 82.
- Andrighetto, I., G. Cozzi, P. Berzaghi and M. Zancan. 1993. Avoidance of degradation of alpine pasture through grazing management investigation of change in vegetation nutrition characteristics as a consequence of sheep grazing at different period of growing season. *Land Degradation and Rehabilitation.*, 4:37 - 43.
- Anonymous. 1982. Manual for Feed Analytical Laboratory. PARC, Islamabad.
- Arnold, G. W. and M. L. Dudzinski. 1978. Ethology of free ranging domestic animals. Elsevier, New York. Pp.198.
- Ashraf, Y., A. H. Gillani and S. A. Nagra. 1995a. Effect of harvesting interval and varieties on the chemical composition of indigenous fodder. I: Proximate Composition. *J. Agric. Res.*, 33:31 - 43.
- Ashraf, Y., A. H. Gillani and S. A. Nagra. 1995b. Chemical composition of indigenous fodder as affected by varieties and harvesting intervals II. Cell Wall Constituents. *J. Agric. Res.*, 33:45 - 56.
- Azhibekov, K. A. 1982. Forestry in the Juniper forest zone of Krigizia, *Lesnoe. Khozyaistvo*, 7:64 - 66.
- Azim, A., Z. Naseer and A. Ali. 1989. Nutritional evaluation of maize fodder at two different vegetative stages. *Aust. J. Agric. Res.*, 2:27 - 34.
- AZRI. 1999. Range vegetation analysis of Kovak and Asghara Valleys. Project Report (Unpublished).
- Badshah, L., F. Hussain and Z. Mohammad. 1996. Floristic and ethnoecological studies on some plants of Pirghar Hills, South Waziristan, Pakistan. *Pak. J. Pl. Sci.*, 2:167 - 176.
- Batanouny, K. H. 1996. Biodiversity in the rangelands of the Arab countries. In West, N. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp. 39 - 40.

- Bedel, T. E. 1971. Nutritive value of forage and diets of sheep and cattle from Oregon sub clover grass mixtures. *J. Range Manage.*, 24:125 - 133.
- Billing, W. D. 1966. Plant and the Ecosystem. Wordsworth Publishing Company, California.
- Black, J. L. and P. A. Kenny. 1984a. Factors affecting diet selection by sheep. I. *Aust. J. Agric. Res.*, 35:551 - 563.
- Black, J. L. and P. A. Kenney. 1984b. Factors affecting diet selection by sheep. II Height and density of pasture. *Aus. J. Agric. Res.*, 35:565 - 578.
- Bodla, M. A., M. S. Baig, S. R. A. Shamsi, V. R. Squires and A. T. Ayoub. 1994. Forage production from salt affected and water logged area in Punjab Pakistan. Proc. International Workshop on Halophytes for reclamation of Saline Wasteland and as a resource for livestock problems and prospects, Nairobi. Pp 231 - 234.
- Bonham, C.D. 1989. Measurement for Terrestrial Vegetation. John Wiley & Sons. New York.
- Bouyoucos, G. J. 1936. Direction for making mechanical analysis of soils by the hydrometer method. *Soil Sci.*, 42:225 - 229.
- Bowell, R. J. and R. K. Anshah. 1994. Mineral status of soils and forage in the Mole National Park, Ghana and implications for wildlife nutrition. *Environmental Geochemistry and Health*, 16:41 - 58.
- Brady, N. C. 1990. The Nature and Properties of Soils. 3rd Ed. MacMillan Publishing Company, New York.
- Briske, D. D. 1986. Plant responses to defoliation and morphological considerations and allocation priorities. P. 425 - 427. In P. J. Joss, P. W. Lynch and O. B. William (ed.), Rangelands: A resource under seige. Proc. 2nd International Rangeland Congress. Australian Academy of Science, Canberra, Australia.
- Brooks, J. R., L. B. Flanagan., N. Buchamann., J. R. Ehleringer. 1997. Carbon Isotope Composition of boreal plants: Functional grouping of life forms. *Oecologia*, 110:301 - 311.
- Buell, M. F. and R. L. Wilbur. 1948. Life form spectra of the hardwood forests of the Itasca Park region, Minnesota. *Ecology*, 29:352 - 359.

- Burkill, I. E. 1956. A working list of the flowering plants of Balochistan. Pakistan Printing Press, Quetta.
- Cain, S. A. 1950. Life form and phytoclimates. *Bot. Rev.*, 16:1 - 32.
- Cain, S. A. and G.M. O. Castro. 1959. Manual of Vegetation Analysis. Harper & Brothers, New York. Pp. 325.
- Canfield, R. 1941. Application of the line intercept method in sampling range vegetation. *J. Forestry*, 39:388 - 394.
- Champion, H. G., S. K. Seth and G. M. Khattak. 1965. Forest Types of Pakistan. Pakistan Forest Institute, Peshawar.
- Ciesla, M. W., G. Mohammad and A. H. Buzdar. 1998. Balochistan's Ancient Junipers: Bringing sustainable management. *Journal of Forestry*, 96:34 - 37.
- Cook, C. W. And L. Harris. 1977. Nutritive value of seasonal ranges. Utah Agric. Exp. Sta. Utah State University Bull. 472: 55 p.
- Cook, C. W. and J. Stubbendieck (ed.). 1986. Range Research, Basic Problems and Techniques. Society for Range Management, Colorado.
- Dabo, S. M., C. M. Taliaferro, S. W. Coleman, F. P. Horn and P. L. Claypool. 1980. Chemical composition of old world blue stem grasses as affected by cultivar and maturity. *J. Range Manage.*, 41:40 - 48.
- Danin, A. 1999. Desert rocks as plant refugia in the near east. *The Botanical Review*, 65:93 - 170.
- Dansereau, P. 1957. Biogeography, an Ecological Perspective. The Ronald Press, New York.
- Das, A. P. and A. K. Lahiri. 1997. Phytosociological studies of the ground flora in different type of vegetation on Tiger hill Dargeeting District, West Bengal. *Indian Forester*, 123:1176 - 1187.
- Dastagir, G., I. Haq and Z. H. Malik. 1999. Biological spectrum and comparison of coefficient of communities between plant communities harboring Mai Dhani hills, Muzaffarabad (AJK). *Pak. J. Biological Science*, 2:352 - 356.
- Dasti, A. A. and S. A. Malik. 1998. A transect of vegetation and soils on the Indus Valley Slope, Pakistan. *Pak. J. Pl. Sci.*, 4:73 - 84.

- Daubenmire, R. F. 1959. Canopy coverage method of vegetation analysis. *Northwest Sci.*, 33:301 - 330.
- Daubenmire, R. F. 1974. *Plants and Environment*. John Willey & Sons, New York.
- Deshmukh, I. 1992. Estimation of wood biomass in the Jubba Valley Southern Somalia and its application to East Africa rangelands. *African J. Ecology*, 30:127 - 136.
- Durrani, M. J., S. A. Shahwani and F. Hussain. 1996. Phytosociological studies of Iskalku rangelands, District Kalat. *J. Sci and Technol.*, 20:29 - 33.
- Dutiot, T. and D. Alard. 1996. Mineral contents and plant diversity in Chalk grassland under different management. In West, N. E. (ed). *Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah*. Pp. 122 - 123.
- Dwarakan, P. and C. Alagesaboopathi. 1998. Biological spectrum of the vegetation of Kolli hills - Eastern Ghats Salem District in Tamil Nadu. *Journal of Living World*, 5:24 - 27.
- Eckstein, R. L. and P. S. Karlsson. 1997. Above ground growth and nutrient use by plants in a subarctic environment: Effects of habitat lifeform and species. *Oikos*, 79:311 - 324.
- FAO. 1983. Report of assistance to rangeland and livestock development survey in Balochistan. FAO. TCP/PAK/0107. Food and Agricultural Organization of the United Nations, Islamabad.
- FAO. 1995. Land and Range Resource Management issues and Food Security in Balochistan. Arid Zone Research Institute, Quetta (Report).
- FAO. 1997. Brahui women's indigenous knowledge of medicinal plants. Project Report, FO-GCP/INT/542/ITA - 5.
- Fierro, L. C. and F. C. Bryant. 1990. Nutrition of herded sheep in the Andes of Southern Peru. *Small Ruminant Research*, 3:117 - 134.
- Folke, C., C. S. Holling and C. Perrings. 1996. Biological diversity, ecosystems, and the human scale. *Ecological Applications*, 6:1018 -1024.
- Gadner, D., B. Stegelmeter, K. Panter and L. James. 1996. Teratogenic and hepatotoxic range plants. In West, N. E. (ed). *Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah*. Pp. 171 - 172.

- Galyean, M. 1985. Techniques and procedures in animal nutrition research, New Mexico State University, Deptt. Animal & Range Conditions.
- Goering, H. K. and P. J. Van Soest. 1970. Forage fiber analysis (Apparatus, reagents, procedures and some applications) ARS, U.S, goat printing office, Washington, DC. 20402.
- Goodman, S. M. and A. Ghafoor. 1992. The ethnobotany of Southern Balochistan, Pakistan, with particular reference to medicinal plants. Fieldiana, Field Museum of Natural History, USA.
- GOP. 1998. Livestock Census 1996. Balochistan Vol. II. Part - 4. Agricultural Census Organization Statistics Division, Govt. of Lahore.
- Gorrett, W. N. and D. E. Johnson. 1983. Nutritional energetics of ruminants. *J. Anim. Sci.*, 57: 478.
- Griffith, W. 1847. Journals of travels in Assam, Burma, Bhutan, Afghanistan and the neighbouring countries. Pp. 435.
- Grunzoaltd, E. G., A. R. Pedrani and A. I. Vich. 1994. Goat grazing in arid piedmount of Argentina. *Small Ruminant Research*, 13:211 - 216.
- Guo, Q. F., F. W. Rundel, Q. F. Guo. 1997. Measuring dominance and diversity in ecological communities: choosing the right variables. *J. Veg. Sci.*, 8:405 - 408.
- Gyamtscho, P., J. Noeberger and M. Menzi. 1996. Existing status and potential for sustainable improvement of high altitude rangelands of Bhutan. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp. 195 - 196.
- Hongling, Yi, W. C. and W. B. Z. Hungta. 1999. Species composition and structural feature in *Erythrophleum fordii* community in Dinghushan. *J. Tropical and Sub Tropical Bot.*, 7:7 - 14.
- Harris, L. E., G. P. Lofgreen, C. J. Kercher, R. J. Raleigh and V. R. Bohman. 1967. Techniques of research in range livestock nutrition. Utah Agri. Ex. Sta. Bulletin No.471.
- Harkin, J. M. 1973. Lignin. In G. W. Butler and R. W. Bailey (eds.) Chemistry and Biochemistry of herbage. Academic Press, New York.
- Holechek, J. L. 1988. An approach for setting the stocking rate. *Rangeland*, 10:10 -14.

- Hart, R. H., O. M. Abdullah, D. H. Clark, M. B. Marshal, M. H. Hamid, J. A. Hager and J. Waggoner, Jr. 1983. Quality of forage and cattle diets on the Wyoming high plains. *J. Range Manage.*, 36:46 - 51.
- Heady, H. G. 1964. Palatability of herbage and animal preference. *J. Range Manage.*, 17:76 - 82.
- Heymell, V. 1989. Evaluation of pasture conditions in Nichara Union Council in relation to construction of water storage tanks. Project Report, Pak-German Self-Help Project for Rural Development Balochistan.
- Hickman, K., D. Hartnett and R. Cochran. 1996. Effects of grazing systems and stocking rates on plant diversity in Kansas tall grass prairie. In West, N. E. (ed). *Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah*. Pp. 228 - 229.
- Holechek, J.L., R.D. Pieper and C.H. Herba. 1998. *Range Management. Principles and Practices*. 3rd Edition. Prentice Hall, Upper Saddle River, New Jersey, 07458.
- Houcheng, Z. 1998. The structure of *Pinus massoniana* on Nan'ao Island Guangdong *J. Tropical and Subtropical Bot.*, 6:203 - 208.
- Hunt, L. P. 1996. Spatial variation in the dynamics of an arid zone perennial shrubs under sheep grazing. In West, N. E. (ed). *Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah*. Pp. 255 - 256.
- Hussain, F. 1983. A reconstruction of hydrosere in Quetta - Pishin Valley, Balochistan, Pakistan., 7:37 - 46.
- Hussain, F. 1989. *Field and Laboratory Manual of Plant Ecology*. University Grants Commission, Islamabad.
- Hussain, F. and S. R. Chaghtai. 1984. The effect of overgrazing on the development of herbaceous vegetation in Zangilora, Quetta, Balochistan, Pakistan. *Pakistan Area Study Journal*, 91:29 - 38.
- Hussain, F., and S. Tajul - Malook. 1984. Biological spectrum and comparison of coefficient of communities between the plant communities of Karamar hills, District Mardan. *Jour. Sci and Technol.*, 8:53 - 60.
- Hussain, F. and I. Ilahi. 1991. *Ecology and Vegetation of Lesser Himalayas, Pakistan*. Jadoon Printing Press, Peshawar.

- Hussain, F. and G. Mustafa. 1995. Ecological studies on some pasture plants in relation to animal use found in Nasirabad Valley, Hunza, Pakistan. *Pak. J. Pl. Sci.*, 1:255 - 262.
- Hussain, F., M. Ilyas and S. Takatsuki. 1997a. Plant communities of Girbanr hills, Swat District, Northwestern Pakistan. *Ecological Review*, 23:247 - 260.
- Hussain, F., A. Khaliq and I. Ilahi. 1997b. Effect of altitude, aspect and biotic factors on the plant diversity of Dabargai hills Swat, Pakistan. In Mufti, S. A., C. A. Wood and S. Hasan (eds). Biodiversity of Pakistan. Pakistan Museum of Natural History, Islamabad. Pp. 169 - 179.
- Hussain, F. and L. Badshah. 1998. Vegetation structure of Pirghar Hills South Waziristan, Pakistan. *J. Tropical and Subtropical Bot.*, 6:187 - 195.
- Huston, J. E. 1978. Symposium. Dairy goats., Forage utilization and nutrient requirements of the goats. *J. Dairy. Sci.*, 61:988 - 993.
- Huston, J. E. and W. E. Pinchak. 1993. Range animal nutrition. Grazing management: An ecological perspective. Timber Press, Portland, Oregon.
- Irshad, S.M. 1961. *Haloxylon* on Masalakh Range. *Pak. J. For.*, 11:302 -304.
- Irshad, S. M. 1966. Possibilities of economic development of Quetta - Kalat division through proper range management. Proc. 1st West Pakistan Range Management Conf. Pakistan Forest Institute, Peshawar. Pp. 74 - 79.
- Jackson, M. A. 1962. Soil Chemical Analysis. Constable & Co. Ltd., London.
- Jafri, S. M. H. 1962. Botanising the Bolan Pass. *Pak. J. For.*, 12: 52 - 70.
- Kababia, D., S. Landan, A. Perevolostsky., Y. Vecht, L. Eliasof and S. Zeltzer. 1992. The feeding behaviour of milking goats in woody rangeland in the Judean Mountains. *Hassadch*. 72:1536 - 1540.
- Kalmbacher, R. S. 1983. Distribution of dry matter and chemical constituents in plant parts of four Florida native grasses. *J. Range Manage.*, 36:298 - 301.
- Kalmbacher, R. S. and F. G. Martin. 1981. Mineral content in creeping blue stem as affected by time of cutting. *J. Range Manage.*, 34:406 - 408.
- Kalmbacher, R. S., F. G. Martin, and J. M. S. Andrade. 1981. Yield and quality of creeping blue stem affected by time of cutting. *J. Range Manage.*, 34:471 - 474.

- Kayani, S. A., A. K. Achakzai and S. A. Qadir. 1984. Phytosociological studies in wastelands of Quetta - Pishin District, Balochistan, Pakistan. *Pak. J. Bot.*, 16:255 - 265.
- Kayani, S. A., A.K. Achakzai, I. Ahmed and S.A. Qadir. 1988. Relationship between plant communities and soil conditions in Nasirabad and Sibi Districts, Balochistan, Pakistan. *Pak. J. Bot.*, 20:55 - 60.
- Kazmi, M. A. 1953. On the drug plants of Kalat State (Balochistan). *Pak. J. For.*, 3: 217 - 223.
- Kenny, P. A., J. L. Black and W. F. Colebrook. 1984. Factor affecting diet selection by sheep. III. Dry matter content and particle length of forage. *Aust. J. Agric. Res.*, 35: 565 - 578.
- Khan, A. H. and S. M. Hussain. 1963. Ecological assessment of the effect of closure in Quetta Division Forests (Hazargangi area). *Pak. J. For.*, 13:167 - 198.
- Khan, D. and R. Ahmed. 1991. Life form, leaf size and halo-physiotypic spectra of coastal flora of Pakistan. Proc. National Conference on Problems and Resources of Mekran Coast and Plan of action for its development. Pak. Council Sci. Tech. Islamabad.
- Khan, D., S. S. Shaukat and S. Ismail. 1987. Structure, composition and pattern in *Achyranthes aspera* dominated ruderal vegetation in the suburbs of Karachi. *Pak. J. Bot.*, 19:157 - 174.
- Khan, D., M. M. Alam and M. Faheemuddin. 1999. Structure, composition and above ground standing phytomass of some grass dominated communities of Karachi: Summer Aspect. *Hamdard Medicus.*, XLII:19 - 52.
- Khan, F. K. 1995. A Geography of Pakistan, Environment, People and Economy. Oxford Univ. Press, Karachi. Pp.31- 51.
- Khan, H. M. 1960. Range Plant Hand Book for Quetta - Kalat region. West Pakistan Forest Deptt. Record No: 1. Government Printing Press, Lahore.
- Khan, I. I. 1996. Biodiversity depletion with respect to Human and livestock population in Indian Desert. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp. 286 - 287.
- Khan, M.H. 1980. Plant communities of the Juniper forests in Khalifat, Ziarat (Balochistan). *Pak. J. For.*, 30:167 - 175.
- Khan, M. H. 1992. Vegetation types in the habitat of Markhor in Hazargangi - Chiltan and Takatu hills, Balochistan. *Pak. J. For.*, 42: 94 - 101.

- Khan, M. H. 1996. Vegetation studies in Babusar Valley, Diamir District, Pakistan. *Pak. J. Pl. Sci.*, 2:79 - 89.
- Knapp, A. K. and G. A. Carter. 1998. Variability in leaf optical properties among 26 species from a broad range of habitats. *American Journal Botany.*, 85:940 - 946.
- Khattak, G. M. 1951. *Ephedra* in Balochistan. *Pak. J. For.*, 1:37 - 40.
- Khattak, G. M. 1963. Working plan for the Juniper forests of Quetta Civil Division. Government Printing Press W. Pakistan.
- Khattak, G. M. and M. I. Sheikh. 1981. Dry zone afforestation in Juniper forests of Balochistan. *Pak. J. For.*, 31:89 - 94.
- Kim, A. C. 1996. Lianas da Mata Atlantica do estado de Sao Paulo. Campinas, UNICAMP. Dissertacao (Mestradoem Biologia).
- Kilcher, M. R. 1981. Plant development, stage of maturity and nutrient composition. *J. Range Manage.*, 34:363 - 364.
- Kirmse, R. D. and B. E. Norton. 1985. Comparison of the reference unit method and dimension analysis methods for two large shrubby species in the Caatinga Woodlands. *J. Range Manage.*, 38:425 - 428.
- Kitchan, S. G. and D. B. Hall. 1996. Diversity and sheep grazing - induced compositional shifts in salt desert communities, USA. In West, N. E. (ed). *Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah.* Pp. 292 - 293.
- Klapwijk, M. 1996. Integrated Range and Livestock Development in Balochistan. Project Report: Pak/88/071 (APO's Final Report).
- Koocheki, A. and M.J. Baker. 1993. Improvement strategies in winter cold temperate rangeland ecosystem with particular reference to extensive grazing land of Iran. *Grasslands for Our World, New Zealand.* Pp. 598 - 602.
- Kurganova, I. N. and I. N. Olovyannikova. 1993. Productivity and nutritional value of native and sown herbs in a semi-desert of the northern near Aral Sea. *Problems of Desert Development*, 1: 41 - 47.
- Laycock, W. A. and D. A. Price. 1970. Factors influencing forage quality: Environmental influence on nutritional value of forage plants. Miscellaneous Publication No: 1147. US Department of Agriculture.

- Lewis, C. E., R. S. Lowery., S. G. Manson and F. E. Knox. 1975. Seasonal trends in nutrients and cattle digestibility of forage on pine - wire grass range. *J. Animal Sci.*, 41:208 - 212.
- Li, Bo., J. Niu., Ci. Yoeng and Y. Zhao. 1996. Study on rangeland biodiversity in China. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp.314 - 315.
- Lichacar, S., R. M. Love, D. W. Rains and H. M. Laude. 1996. The effect of some California soil on the early growth of *Atriplex polycarpa* (Terr.)Wats. and *Atriplex repanda* Phil. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere, 5th International Congress 1995, Salt Lake City Utah. Pp.300 - 301.
- Liu, D., J. Yun, X. Hao and S. Meng. 1996. Grassland deterioration and control measures in arid and semi - arid region in China. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp. 320 - 321.
- Liu, Y. Z. 1993. Study on the dynamic features of nutritive substances in inner Mongolia Steppe. *Grassland of China*, 4:16 - 20.
- Lokesha, R. and R. Vasudeva. 1997. Pattern of life history traits among rare/endangered flora of South India Special section: Biodiversity of Western Ghats. *Current Science*, 73:171 - 172.
- Lopes, E. A. and J.W. Stuth. 1984. Dietary selection and nutrition of Spanish goats as influenced by brush management. *J. Range Manage.*, 37:554 - 560.
- Lubbinge, J. E., N. V. Rooyen and J. Du P. Bothma. 1996. Ecological status of semi-arid Kalahari plant species and range condition assessment. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere, 5th International Congress 1995, Salt Lake City Utah. Pp. 325 - 326.
- Lundsberg, J. and D. G. Ilesen. 1996. Looking beyond the biosphere to locate biodiversity reference areas in Australia's Rangelands. Pp. 304 - 305.
- Lunt, I. D. 1997. A multivariate growth form analysis of grassland and forest forbs in South Eastern Australia. *Australian J. Bot.*, 45:691 - 705.
- Makulbekova, G. B. 1996. The ecological evaluation of the present condition of rangeland vegetation of Kazakhstan deserts. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp. 338 - 339.

- Malik, M. N. and A. A. Khan. 1965. Nutritive value of grasses, Part I. Basic chemical composition of certain grasses. *Pak. J. For.*, 15:310 - 318.
- Malik, M. N. and A. A. Khan. 1966. Development of rangelands in West Pakistan. Physio - chemical characteristics of soil and nutritive value of forage grasses of Cholistan. *Pak. J. For.*, 16:261 - 273.
- Malik, M. N. and A. A. Khan. 1967. Nutritive value of grasses of Kala Chitta Forests. *Pak. J. For.*, 17:529 - 538.
- Malik, M. N. and A. A. Khan. 1971. The chemical composition of grasses related to some edaphic factors of reserved rangelands of Thal. *Pak. J. For.*, 21:287 - 294.
- Marwat, Q. D. and I. Haq. 1982. Phyto-ecological studies in Hanna - Urak, Quetta, Balochistan, Pakistan. *J. Sci. and Technol.*, 8: 79 - 81.
- Marwat, Q. D., F. Hussain and N. A. Khan. 1989. Vegetation studies in Masalakh Range Forest, District Pishin, Balochistan, Pakistan. *Pak. J. Agri. Res.*, 10:367 - 375.
- Marwat, Q. D., F. Hussain and I. Mohammad Khilji. 1990. Phyto-ecology of the vegetation of Zangilora area Quetta, Balochistan. *Pak. J. Agri. Res.*, 4:275 - 283.
- Marwat, Q. D., N. Mohammad and F. Hussain. 1992. Vegetation studies on Chiltan National Park Hazargangi. *Pak. J. Agri. Res.*, 13:71 - 79.
- Menhinick, E. F. 1964. A comparison of some species - individuals diversity indices applied to samples of field insects. *Ecology*, 45:859 - 861.
- Meyer, M. W. and R.D. Brown. 1985. Seasonal trends in the chemical composition of ten range plants in South Texas. *J. Range Manage.*, 38:154 - 157.
- Migongo - Bake, W. and R. M. Hensen. 1987. Seasonal diets of camels, cattle, sheep and goats in a common range in Eastern Africa. *J. Range Manage.*, 40:76 - 79.
- Milchunas, D. G., W. K. Lauenorth and P. L. Chapman. 1992. Plant communities abiotic and long and short term effects on large herbivores on demography of opportunistic species in semi arid grassland. *Oecologia*, 520 - 531.
- Miller, R.W. and R.L. Donahue. 1990. Soils, An introduction to Soils and Plant Growth. 6th edition. Prentice Hall, Englewood Cliffs, New Jersey, 07632.
- Minson, D.J. 1982. The chemical composition and nutritive value of tropical grasses. In P.J. Skerman (eds). Tropical Grasses, Rome, F.A.O.

- Mirzadinov, R. V. and G. P. Yakovelva. 1990. Productivity of vegetation of semi arid territories of the Kazakh hilly region. *Problems of Desert Development*, 1: 25 - 32.
- Moe, P. W. and H. F. Tyrrel. 1976. Estimating metabolized and net energy for feed. In Fonnesbeck, P. V., L. E. Harris and L. C. Kcard (eds) Proc. 1st International Smp. On feed composition. Animal nutrient requirement and computerization of diet. Logon, Utah State Univ. Pp. 232 - 237.
- Mohammad, N. 1989. Rangeland Management in Pakistan. ICIMOD, Kathmandu, Nepal.
- Momotov, I. F., A. G. Alimzhanov and B. V. Berkovick. 1993. The role of herbaceous vegetation in farmig the yield of natural and artificial phytocoenoses in the Kyzyl Kum Gypseous desert. *Problem of Desert Development*, 3: 42 - 45.
- Morellato, L. P. C. & H. F. Leitaio Filho. 1992. Padroes de frutificacao e dispersao na serra doo Japi. 112 - 139. In: L. P. C. Merellato (org.) Historia natural da Serra do Japi: Ecologia e preservacao de uma area florestal no sudeste do Brasil. Editora da UNICAMP - FAPESP. Campinas.
- Mori, P. and S. Rehman. 1997. Rangeland Rehabilitation in Balochistan (The experience of Kanak Valley). FAO Project (F. O. - GCP/INT/542/ITA).
- Motyka, J., B. Dobrazanki and S. Zawadski. 1950. Preliminary studies on meadow in the south east of the province Lublin (English summary) Ann. Univ. M. Curie - Sklodowska, see ES, 13:367 - 447.
- Mueller - Dumbois, and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. Willey Int. Edi. New York. Pp. 57.
- Muenschner, W. C. 1960. Poisonous Plants. MacMillan Co., New York.
- Munday, B. L. and D. I. Morris. 1978. Tasmanian Plants Toxic for Animals. Pub. Tasmanian Deptt. Agric. 101 Pp.
- Murray, R. B. 1984. Yields, nutrient quality and palatability to sheep of fourteen grass assession for potential use on Sagebrush - Grass range in South eastern, Idaho. *J. Range Manage.*, 37: 343 - 348.
- Mwalyosi, R. B. B. 1992. Influence of livestock grazing on range condition in South West Masai-land, Northern Tanzania. *J. Appl. Ecol.*, 29:581 - 588.

- Nasir, E. and S. I. Ali. 1971 - 1994. Flora of Pakistan. Pakistan Agriculture Research Council, Islamabad.
- NRC. 1985. Nutrient requirements of domestic animals. Number 5. Nutrient requirements of sheep. 6th ed. Natl. Acad. Sci., Washington, D. C. Pp.112.
- Nyamangara, M. E. and L. R. Ndlovu. 1995. Feeding behaviour, feed intake, chemicals and botanical composition of the diet of indigenous goats raised on natural vegetation in a semi - arid region of Zimbabwe. *J. Agri. Sci.*, 124: 455 - 461.
- Omar, S. A. S. 1991. Dynamics of range plant following ten years of protection in arid rangelands of Kuwait. *J. Arid. Envir.*, 21:91 - 111.
- Peet, R. K. 1974. Species diversity. *Ann. Rev. Ecol. and System*, 5:245 - 289.
- Perez, C. M.E., C. A. Garcia., C. B. Garcia and A. B. R. Vazquez-de. 1995. Pattern of above ground herbage production and nutritional quality structure on semi arid grasslands. *Communications in Soil Sci. and Plant Analysis*, 26:1323 - 1341.
- Pfister, J. A. and J. C. Malechek. 1986. Dietary selection by goats and sheep in a deciduous woodland of North Eastern Brazil. *J. Range Manage.*, 39:24 - 28.
- Phillips, E. A. 1959. Methods of Vegetation Study. A Holt Dryden Books Henery Hold & Co. Inc. New York. 107 pp.
- Pichi - Sermolli, R. 1948. An index for establishing the degree of maturity in plant communities. *J. Ecol.*, 36:85 - 90.
- Pinchak, W. E., S. K. Canon., R. K. Hertschmidt and S. L. Dowber. 1990. Effect of long term, yearlong grazing at moderate and heavy rates of stocking on diet selection and forage intake dynamics. *J. Range Manage.*, 43:304 - 309.
- Prince, S. D. 1991. Satellite remote sensing of primary production, composition of results of Sahelian grassland. *Intern. J. Remote Sensing*, 12:1301 - 1311.
- Provenza, F. D. 1995. Postingestive feed back as an elemental determinant of food reference and intake in ruminants. *J. Range Manage.*, 48:2 - 17.
- Provenza, F. D. 1996. A functional explanation for palatability. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp. 123 - 125.
- Qadir, S. A. and O. A. Shetvy. 1986. Life form and leaf size spectra and phytosociology of some Libyan plant communities. *Pak. J. Bot.*, 18:271 - 286.

- Qadir, S.A. and R.B. Tareen. 1987. Life form and leaf size spectra of the flora of Quetta District. In Ilahi, I & F. Hussain (eds). Modern Trends. Pl. Sci. Res. Pakistan. Botany Department University of Peshawar. Pp. 59 - 62.
- Qadir, S.A. and S. Ahmed. 1989. Phytosociology of woodland communities of Hazarganji National Park Quetta. *Pak. J. Bot.*, 21:128 - 139.
- Rafi, M. 1965a. Vegetation types of Balochistan Province (Pakistan). A preliminary survey. Government of Punjab, Lahore.
- Rafi, M. 1965b. Masalakh range project Quetta, West Pakistan (A review of its first ten years). *Pak. J. For.*, 15:319 - 338.
- Rana, G., Q. Iftikhar and M. Arshad. 1990. Chemical composition and nutritive value of *Panicum antidotale*. *Sarhad J. Agric.*, 6:25 - 28.
- Raunkiaer, C. 1934. The Life form and Plants and Statistical Plant Geography. Oxford, Clarendon Press.
- Redak, R. A., J. L. Capinera., C. D. Bonham. 1992. Effects of sagebrush removal and herbivory by Mormon Crickets on understory plant biomass and cover. *Environmental Entomology*, 21:94 - 102.
- Rehman, A. and J. B. Mackintosh. 1996. Factors affecting preference of sheep for Saltbush (*Atriplex Spp*). In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp. 466 - 467.
- Reid, R. S., J. W. Cathleen, R. L. Kruska. 1996. The influence of human use of rangeland biodiversity in Ghibe Valley, Ethiopia, as affected by natural resource use changes and livestock disease control. Pp. 648 - 469.
- Repp. G. and Khan, A.H. 1960. Studies on vegetation and ecological pathology in Ziarat *Juniperus* forests. UNESCO, Tech. Rep. 9.
- Reuter, D. J. and J. B. Robinson (eds). 1986. Plant Analysis (An Interpretation Manual) Inkata Press, Melbourne Sydney. Pp. 27 - 30.
- Reyna, V. J. and L. A. Gonzalez. 1996. Poisonous noxious weeds from Coahuila, Mexico. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. Pp. 580 - 581.
- Richards, L. A. (ed). 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA Agric. Handbook No: 60. Washington, D. C.

- Roberto, D. A. and M. B. Roberto. 1996. Vegetation status and transition in temperate semi arid rangelands of Argentina. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah. PP. 117 - 118.
- Robles, C. A. B. and L. J. Boza. 1993. Native forage flora of southeastern Spain. II. Nutritive value. *Pastos*, 29:47 - 60.
- Said, M. and I. Hussain. 1959. Range and pasture improvement project, Masalakh (Quetta - Kalat Circle). Results of four year protection and other range improvement practices. *Pak. J. For.*, 9:160 - 162.
- Saleem, M. 1993. Ecology of *Chrysopogon aucheri* and *Cymbopogon jwarancusa* III. Morphology and defoliation response. *Pak. J. For.*, 43:106 - 118.
- Saleem, M. 1997. Range management activities in the Integrated Range Livestock Development Project. Project Report: Pak/88/071.
- Sandoval, L. J. J., A. G. Aguirre, R. D. G. Guevara and L. M. R. Martinez. 1996. Determining the erosion effect in 5 vegetation types in mountainous areas. In West, E. (ed). Proc. Rangelands. In a sustainable biosphere, 5th International Congress 1995, Salt Lake City Utah. Pp. 491 - 492.
- Sardar, M.R. 1992. Carrying capacity and range condition of Hazarganji - Chiltan National Park. *Pak. J. For.*, 42:36 - 44.
- Sauris, P., A. D. Das., A. K. Lahiri and S. Panda. 1997. Wasteland reclamation by some pailionaceous taxa possibilities and prospects. *Indian Forester*, 123:21 25.
- Scholes, R. J., M. J. Baker. 1993. Nutrient cycling in semi-arid grasslands and savannas: its influence on pattern, productivity and stability. *Grasslands of Our World*, 21:484 - 487.
- Shah, A., S. Ayaz and F. Hussain. 1991. Similarity indices, biological spectrum and phenology of plant communities of Docut Hills, District Swat, during winter. *J. Sci & Technol.*, 15:15 - 21.
- Shanmugavel, P. and D. R. Ramarathinam. 1993. Biomass and primary productivity of *Tephrosia* in semi - arid vegetation at Perungudi District Madurai. *Indian Forester*, 119:326 - 333.
- Shannon, C. E. and W. Weaver. 1949. The Mathematical Theory of Communication. Univ. Illinois Press, Urbana, IL.

- Shaukat, S. S., A. Khairi and M. A. Khan. 1978. Relationships amongst dominance, diversity and community maturity in a desert vegetation. *Pak. J. Bot.*, 10:183 - 196.
- Shaukat, S. S. and D. Khan. 1979. A comparative study of the statistical behaviour of diversity and equitability indices with reference to desert vegetation. *Pak. J. Bot.*, 11:155 - 165.
- Shaukat, S. S., D. Khan and S. A. Qadir. 1981. On the vegetational dynamics of calcareous hills around Karachi. *Pak. J. Bot.*, 13:17 - 37.
- Shimwell, D. W. 1971. Description and Classification of Vegetation. Sidgwick and Jackson, London.
- Shinwari, Z. K. and M. Shah. 1996. The ethnobotany of Kharan District, Balochistan. In Shinwari, Z. K., B. A. Khan and A. A. Khan (ed.) Proceedings Ethnobotany and its Application to Conservation Sep. 1996. Pp. 124 - 132.
- Shmida, A. and M.V. Wilson. 1985. Biological determinants of species diversity. *J. Biogeogr.*, 12:1 - 20.
- Shrestha, S., P.K. Jha and K. K. Shrestha. 1998. Vegetation of degraded, regenerating and natural forests in Riayle, Kavrepalanchok, Nepal. *Pak. J. Pl. Sci.*, 4:13 - 28.
- Simpson, E. H. 1949. Measurement of diversity. *Nature*, 163: 688.
- Singh, R. 1976. Voluntary intake, digestibility and efficiency of utilizing as influenced by compositional factors. In Proceedings: Forage quality evaluation and processing techniques for increased animal productivity. Pradah, K. and S.S. Khirwar (eds). Pp.153 - 155.
- Sikarwar, R.L. S. 1996. Life forms and biological spectrum of the flora of Morena District, Madhya Pradesh. *J. Indian Bot. Soc.*, 75:275 - 277.
- Snyman, H. A. 1994. Evapotranspiration, water use efficiency and quality of six dryland planted pasture species and natural vegetation in a semi arid rangeland. *African. J. Range & Forage Sci.*, 11:82 - 88.
- Soltanpour, P.N. 1985. Communication in Social Science. *Plant Analysis*, 16:328 - 338.
- Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Det. Cong. Dansk, Videnk, Selsk. *Biol. Skr.*, 5:1 - 34.

- Stewart, R. R. 1959. The flora of Balochistan. *Pak. J. For.*, 291 - 293.
- Stewart, R. R. 1972. An Annotated Catalogue to the Vascular Plants of West Pakistan and Kashmir. Fakhri Printing Press, Karachi.
- Stocks. 1850. Graphic sketch of the Balochi flora. *In Kew Jour. Bot.*, 2:303 - 308.
- Stranghetti, V. and N. T. Ranga. 1997. Phenological aspects of flowering and fruiting at the Ecological Station of Paulo de Faria - SP- Brazil. *Tropical Ecology*, 38:323 - 327.
- Tareen, R. B. and S. A. Qadir. 1987. Phytosociology of the Plains of Quetta District. *Pak. J. Bot.*, 19: 139 - 156.
- Tareen, R.B., A. Mohammad and S. A. Qadir. 1987a. Phytosociological studies of Spin Karez area. *Biologia*, 33:311 - 321.
- Tareen, R.B., E. Ahmed and S. A. Qadir. 1987b. Phytosociological studies of Zarghun areas Quetta, *Pakistan. J. Univ. Balochistan*, 1:101 - 116.
- Tareen, R.B., M. Ahmed and K.R. Tareen. 1987. Plant communities around Chiltan in Quetta District of Balochistan. In Ilahi, I. & F. Hussain (eds). Modern Trends Pl. Sci. Res. Pakistan. Botany Department, University of Peshawar. Pp. 5 - 10.
- Tareen, R.B. and S. A. Qadir. 1990. Phytosociology of the water courses of Quetta district. *Pak. J. Bot.*, 22:52 - 65.
- Tareen, R.B. and S. A. Qadir. 1991. Phytosociology of hills of Quetta district. *Pak. J. Bot.*, 23:90 - 114.
- Tareen, R.B. and S. A. Qadir. 1993. Life form and leaf size spectra of the plant communities of diverse areas ranging from Harnai, Sinjawi to Duki regions of Pakistan. *Pak. J. Bot.*, 25:83 - 92.
- Thapa, M. B. 1996. Indigenous rangeland management system in high altitude Nepal. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere, 5th International Congress 1995, Salt Lake City Utah. Pp. 554 - 555.
- Theunissen, J. D. 1995. Phenolic compound in the leaves of ecotypes of three graminoides in the semi arid grassland of South Africa. *J. Arid Environ.*, 29:439 - 445.

- Thomas, D. A., X. M. Sun, J. P. Zhang, J. Z. Zhu, M. Lewis and P. Xu. 1994. Land capability of Fukang County, Zinjiang Province, People's Republic of China. *Arid Soil Research and Rehabilitation*, 8:373 - 387.
- Tirbe, D. E. 1952. The relation of palatability to nutritive value and its importance in the utilization of herbage by grazing animals. Proc. 6th International Grassland Congress., 11:1265 - 1270.
- Tongway, D. J. and J. A. Ludwig. 1996. Restoration of landscape patchiness in semi-arid rangeland, Australia. In West, N. E. (ed). Proc. Rangelands. In a sustainable biosphere, 5th International Congress 1995, Salt Lake City Utah. Pp. 563 - 564.
- Townsend, W.N. 1982. An Introduction to the Scientific Study of the Soil. Edward Arnold Ltd. 41 Bedford Square, London.
- Uppeandra, D., R. S. Rawal., S. S. Samant and U. Dhar. 1997. Structural diversity and representativesness of forest vegetation protected area of Kumaun Himalaya India: Implication for Conservation. *Biodiversity and Conservation*, 6:1045 - 1062.
- Vaitkus, M. R. and L. E. Eddleman. 1991. Tree size and understory phytomass production in a Western Juniper Woodland, Great Basin. *Naturalist*, 51:236- 243.
- Vallentine, J.F. 1990. Grazing Management. Academic Press, USA.
- Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II a rapid method for the determination of fiber and lignin. *J. Assoc. Official Agri. Chem.*, 46:829.
- Van Soest, P. J. 1964. A method for the determination of cell wall constituents in forages using detergent and relationship between this fraction and voluntary intake and digestibility. Proc. American Dairy Sci. Assoc. Tucson Arizona, June, 1964.
- Van Soest, P. J. and R. H. Wine. 1967. Use of detergents in the analysis of fibrous feeds IV. The determination of plant cell wall constituents. *J. Assoc. Official. Anal. Chem.*, 50:50.
- Van Soest, P. J. and J. B. Robertson. 1985. Analysis of Forages and Fibrous Foods. A laboratory Manual for Animal Science. 613 Cornell Univ. USA.
- Van Soest, P. J. 1994. Nutritional Ecology of Ruminants. 2nd ed, Cornell University Press: Ithaca, New York.

- Vladychenskiy, A. S., T. Yu, U. I. Yanova, S. A. Balandin and I. N. Kozlov. 1995. Effect of grazing on Juniper forest soils of the southwestern Tyan-Shan region. *Eurasian Soil Science.*, 27:1 - 9.
- Wahid, A. 1990. Dietary composition and nutritional status of sheep and goats grazing two rangeland types in Balochistan, Pakistan. Ph. D. Thesis, Oregon State University.
- Waldern, D. E. 1971. A rapid micro-digestion procedure for neutral and acid detergent fibre. *Can. J. Anim. Sci.*, 51:67.
- West, N. E. 1993. Biodiversity of Rangelands. *J. Range Manage.*, 46:2 - 13.
- Willoughby, M. G. 1996. Species diversity and how it is affected by livestock grazing on Alberta's Eastern Slopes. In West, N. E. (ed). *Proc. Rangelands. In a sustainable biosphere, 5th International Congress 1995, Salt Lake City Utah.* Pp. 610 - 611.
- Wills, B. J., J. H. Sheppards and K. T. Trainor. 1996. A review of the use of chenopod shrubs for dryland revegetation and forage in the South Island, New Zealand. In West, N. E. (ed). *Proc. Rangelands. In a sustainable biosphere, 5th International Congress 1995, Salt Lake City Utah.* Pp. 612 - 613.
- Wilson, A. D., J. H. Leigh, N. L. Hindley and W. E. Molhan. 1975. Comparison of the diets of goats and sheep on a *Easuarina cristata* - *Heterodendran oleifolium* woodland community in Western New South Wales. *Aust. J. Exp. Agri. Anim. Husb.*, 15:45 - 53.
- Wolters, G. L., S. R. Loftin and R. Agnilar. 1996. Changes in species composition along a Chihuahuan desert scrub/desert grassland transition zone in Central New Mexico. In West, N. E. (ed). *Proc. Rangelands. In a sustainable biosphere, 5th International Congress 1995, Salt Lake City Utah.* Pp. 614 - 615.
- Xueying, Z. and Y. Meeling. 1998. An investigation of floristic diverstiy of three types of plantations in Hong Kong. *J. Tropical and Subtropical Bot.*, 6:196 - 202.
- Yossef, M., M. A. Bellarbi and O. Berkat. 1996. Rangeland production and degree of utilization along an altitudinal gradient witin the middle Atlas Morocco. In West, N. (ed). *Proc. Rangelands. In a sustainable biosphere. 5th International Congress 1995, Salt Lake City Utah.* Pp. 620 - 621.
- Yodzis, P. 1978. Competition for space and the structure of ecological communities, *Lect. Notes in Biomathematics.* Springer - Verlag, Berlin.

- Zaman, M. B., A. A. Khan, A. Ahmed and M. S. Khan. 1971. Quantitative survey of *Ephedra* in reserved and Guzara forests of Balochistan. *Pak. J. For.*, 21:351 - 358.
- Zaman, M. B., A. A. Khan, A. Ahmed and M. S. Khan. 1968. Survey of Juniper berries in Balochistan forests and prospects for their exploitation. *Pak. J. For.*, 18:503 - 509.
- Zaman, M. B. and M. A. Khan. 1972. List of medicinal and other flowering plants of Dir. Biological Science Research Div. Pakistan. For. Inst. Peshawar. Bulletin No:6. Pp. 28.
- Zhanghe, C., C. Jieyuan and Z. Yunlong. 1999. Flowering and fruiting phenologies of the woody plants in three floras in China. *J. Tropical and Subtropical Bot.*, 7:102 - 108.
- Zoa, A. F. 1992. Root growth of vegetation in degraded rangeland in Inner Mongolia, China. Report Institutionen-for- Ekology-och-Miljovard,-Sveriges-Lantbruksuniversitet, 54:37.

Appendix - 1

WINDING AND UNWINDING OF THE WINDING
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APPENDICES

Appendix - 1

SPRING ASPECTS (HILLS) (April to June, 1997)
 PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - I
Bromus - Polygala - Bromus (BPB)
 Altitude 2240 m.

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	19	0.03	40	2.505	0.0042	3.58	3.83	7.42
	Sub total:		0.03	40	2.51	0.0042	3.58	3.83	7.42
	Shrubs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	31	0.05	5.00	0.06	0.01	0.45	0.09	0.55
2	<i>Acantholimon polystachyum</i> Boiss	94	0.15	10.00	0.19	0.02	0.90	0.28	1.20
3	<i>Aerua javanica</i> (Burm.f) Juss	1094	1.75	45.00	2.09	0.25	4.03	3.19	7.47
4	<i>Artemisia maritima</i> L.	1344	2.15	40.00	3.05	0.30	3.58	4.65	8.54
5	<i>Astragalus</i> 97 - 8	313	0.50	15.00	2.29	0.07	1.34	3.49	4.91
6	<i>Astragalus anisacanthus</i> Boiss	156	0.25	10.00	0.12	0.04	0.90	0.18	1.11
7	<i>Berberis balochistanica</i> Ahrendt	63	0.10	10.00	0.63	0.01	0.90	0.96	1.87
8	<i>Caragana stocksii</i>	1063	1.70	40.00	3.38	0.24	3.58	5.16	8.98
9	<i>Convolvulus leiocalycinus</i> Boiss	531	0.85	35.00	1.36	0.12	3.14	2.08	5.33
10	<i>Daphne mucronata</i> Royle	344	0.55	40.00	2.44	0.08	3.58	3.73	7.39
11	<i>Ebenus stellata</i> Boiss	125	0.20	10.00	0.21	0.03	0.90	0.32	1.25
12	<i>Ephedra intermedia</i> var glauca Schren K. Regel, Stapf.	125	0.20	15.00	0.25	0.03	1.34	0.37	1.75
13	<i>Gaillonia eriantha</i> Jaub & Spach	844	1.35	40.00	2.55	0.19	3.58	3.90	7.67
14	<i>Haloxylon griffithii</i> (Moq.) Bunge ex Boiss	438	0.70	35.00	1.12	0.10	3.14	1.71	4.95
15	<i>Hertia intermedia</i> (Boiss) O. Ktze	188	0.30	10.00	0.22	0.04	0.90	0.33	1.27
16	<i>Juniperus excelsa</i> M. Bieb *	63	0.10	10.00	0.19	0.01	0.90	0.28	1.19
17	<i>Nepeta juncea</i> Bth	969	1.55	40.00	1.80	0.22	3.58	2.74	6.55
18	<i>Perovskia abrotanoides</i> Karel	156	0.25	10.00	1.25	0.04	0.90	1.91	2.84
19	<i>Prunus eburnea</i> Aitch	94	0.15	15.00	0.63	0.02	1.34	0.96	2.32
20	<i>Prunus</i> sp.	250	0.40	20.00	1.49	0.06	1.79	2.27	4.12
21	<i>Salvia cabulica</i> Bth	750	1.20	35.00	4.98	0.17	3.14	7.60	10.91
22	<i>Sophora griffithii</i> Stocks	906	1.45	35.00	1.14	0.20	3.14	1.74	5.08
23	<i>Spirea boissieri</i> Schneider	94	0.15	15.00	0.59	0.02	1.34	0.90	2.27
	Sub total:		16.05	540.00	31.97	2.26	48.39	48.85	99.51
	Herbs								
1	<i>Allium dolichostylum</i> Vved	1500	2.40	3.33	0.50	0.34	0.30	0.76	1.40
2	<i>Alyxum linifolium</i> Staph ex Willd	23000	36.80	17.50	0.39	5.19	1.57	0.60	7.36
3	<i>Alyxum marginatum</i> Stend ex Willd	18375	29.40	20.00	0.52	4.15	1.79	0.79	6.73
4	<i>Alyxum szovitzianum</i> F & M	3813	6.10	5.00	0.13	0.86	0.45	0.19	1.50
5	<i>Arabis saxicola</i> Edgew	3750	6.00	7.50	0.19	0.85	0.67	0.29	1.81
6	<i>Artemisia maritima</i> L. *	1000	1.60	5.00	0.13	0.23	0.45	0.19	0.86
7	<i>Astragalus afghanus</i> Boiss	1000	1.60	5.00	0.13	0.23	0.45	0.19	0.86
8	<i>Astragalus subuliformis</i> DC.	1250	2.00	5.00	0.14	0.28	0.45	0.21	0.94
9	<i>Bromus sericeus</i> Drobov	62250	99.60	27.50	3.38	14.05	2.46	5.16	21.68
10	<i>Bromus tectorum</i> L.	34750	55.60	20.00	1.53	7.85	1.79	2.34	11.98

Appendix - 2

SPRING ASPECTS (HILLS) (April to June, 1997)

PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - II

Bromus - Zizyphora - Bromus (BZB)

Altitude 2300 m.

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	19	0.03	40	2.26	0.01	3.94	3.14	7.09
	Sub total:		0.03	40	2.26	0.01	3.94	3.14	7.09
	Shrubs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	563	0.9	20	0.87	0.17	1.97	1.21	3.35
2	<i>Acantholimon polystachyum</i> Boiss	250	0.4	20	0.87	0.08	1.97	1.21	3.26
3	<i>Artemisia maritima</i> L.	1000	1.6	30	2.5	0.30	2.96	3.48	6.74
4	<i>Astragalus psilocentros</i> Fisch	250	0.4	20	0.5	0.08	1.97	0.70	2.74
5	<i>Berberis callibotrys</i> Aitchex Koenne	250	0.4	30	2.5	0.08	2.96	3.48	6.51
6	<i>Clematis graveolens</i> Lindl	563	0.9	30	5.5	0.17	2.96	7.65	10.78
7	<i>Convolvulus leiocalycinus</i> Boiss	1250	2	50	5.76	0.38	4.93	8.01	13.32
8	<i>Daphne mucronata</i> Royle	375	0.6	30	3.75	0.11	2.96	5.22	8.29
9	<i>Ephedra intermedia</i> var <i>glauca</i> Schrenk. Regel, Sta	125	0.2	20	0.5	0.04	1.97	0.70	2.70
10	<i>Gaillonia eriantha</i> Jaub & Spach	1500	2.4	50	4.1	0.45	4.93	5.70	11.08
11	<i>Hertia intermedia</i> (Boiss.) O. Ktze	438	0.7	30	0.49	0.13	2.96	0.68	3.77
12	<i>Nepeta juncea</i> Bth	2438	3.9	50	5.82	0.74	4.93	8.10	13.76
13	<i>Perovskia abrotanoides</i> Karel	313	0.5	30	0.75	0.09	2.96	1.04	4.09
14	<i>Salvia cabulica</i> Bth	688	1.1	60	2.41	0.21	5.91	3.35	9.47
15	<i>Sophora griffithii</i> Stocks	375	0.6	20	0.5	0.11	1.97	0.70	2.78
	Sub total:		16.6	490	36.82	3.14	48.28	51.22	102.63
	Herbs								
1	97 - 183	6000	9.6	10	0.25	1.82	0.99	0.35	3.15
2	<i>Allium dolichostylum</i> Vved	2625	4.2	10	0.25	0.79	0.99	0.35	2.13
3	<i>Arabis saxicola</i> Edgew	6500	10.4	10	0.25	1.97	0.99	0.35	3.30
4	<i>Artemisia maritima</i> L.	1500	2.4	10	0.25	0.45	0.99	0.35	1.79
5	<i>Astragalus purpurascens</i> Bunge	3000	4.8	15	0.75	0.91	1.48	1.04	3.43
6	<i>Bromus sericeus</i> Drobov	43500	69.6	20	3.65	13.17	1.97	5.08	20.21
7	<i>Bromus tectorum</i> L.	33500	53.6	10	2.19	10.14	0.99	3.05	14.17
8	<i>Chenopodium album</i> L.	3000	4.8	10	0.25	0.91	0.99	0.35	2.24
9	<i>Cousinia</i> sp.	12500	20	20	1.1	3.78	1.97	1.53	7.28
10	<i>Descurainia sophia</i> (L.) Webb & Berth	4000	6.4	10	0.25	1.21	0.99	0.35	2.54
11	<i>Echinops echinatus</i> Roxb.	1000	1.6	10	0.25	0.30	0.99	0.35	1.64
12	<i>Erodium cicutarium</i> (L.) L' Herit ex Ait.	2500	4	10	0.75	0.76	0.99	1.04	2.79
13	<i>Euphorbia multifurcata</i> Rech f. et al.	1000	1.6	10	0.12	0.30	0.99	0.17	1.45
14	<i>Fursetia heliophila</i> Bunge ex Cass	3500	5.6	10	0.63	1.06	0.99	0.88	2.92
15	<i>Fumaria indica</i> (Hassk.) H.N.	7000	11.2	20	0.63	2.12	1.97	0.88	4.97
16	<i>Galium asparine</i> L.	7000	11.2	20	0.05	2.12	1.97	0.07	4.16
17	<i>Hetderoderis stockiana</i> Boiss	3500	5.6	10	0.25	1.06	0.99	0.35	2.39
18	<i>Hyoscyamus pusillus</i> L.	3000	4.8	10	0.12	0.91	0.99	0.17	2.06
19	<i>Lappula sessiliflora</i> (Boiss.) Oakes	7000	11.2	10	0.38	2.12	0.99	0.53	3.63
20	<i>Malcolmia africana</i> (Linn.) R. Br.	9000	14.4	15	0.56	2.72	1.48	0.78	4.98
21	<i>Malva neglecta</i> Wallr.	3000	4.8	15	0.31	0.91	1.48	0.43	2.82
22	<i>Papaver macrostomum</i> Boiss & Huet ex Boiss	1000	1.6	10	0.75	0.30	0.99	1.04	2.33
23	<i>Peganum harmala</i> L.	2000	3.2	10	1.1	0.61	0.99	1.53	3.12

24 <i>Pennisetum orientale</i> L.	4000	6.4	15	1.37	1.21	1.48	1.91	4.59
25 <i>Polygala sibirica</i> Linn	20500	32.8	15	0.56	6.20	1.48	0.78	8.46
26 <i>Polygonum aviculare</i> L.	2000	3.2	10	0.28	0.61	0.99	0.39	1.98
27 <i>Robeschia schimper</i> (Boiss) O.E.S.	2500	4	10	0.25	0.76	0.99	0.35	2.09
28 <i>Scorzonera</i> sp	1000	1.6	10	0.25	0.30	0.99	0.35	1.64
29 <i>Scorzonera mollis</i> M. Bieb	1500	2.4	10	0.25	0.45	0.99	0.35	1.79
30 <i>Shismus arabicus</i> Nees	20500	32.8	15	2.31	6.20	1.48	3.21	10.90
31 <i>Silene brahuica</i> Boiss	2500	4	10	0.44	0.76	0.99	0.61	2.35
32 <i>Stipa pennata</i> L.	9500	15.2	20	4.13	2.88	1.97	5.74	10.59
33 <i>Tetrapogon villosis</i> Desf	3500	5.6	15	1.19	1.06	1.48	1.66	4.19
34 <i>Trichodesma stocksii</i> Boiss	500	0.8	10	0.12	0.15	0.99	0.17	1.30
35 <i>Tulipa polychroma</i> Stapf *	31875	51	10	1.5	9.65	0.99	2.09	12.72
36 <i>Tulipa polychroma</i> Stapf	4000	6.4	15	0.38	1.21	1.48	0.53	3.22
37 <i>Veronica biloba</i> L.	11000	17.6	10	3.25	3.33	0.99	4.52	8.84
38 <i>Zizyphora tenuior</i> L.	38500	61.6	25	1.44	11.65	2.46	2.00	16.12
Sub total:		512	485	32.81	96.85	47.78	45.64	190.28
Grand total:		528.63	1015	71.89	100	100	100	300

* Seedlings

Appendix - 3

SPRING ASPECTS (HILLS) (April to June, 1997)

PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - III

Iris - Astragalus - Poa (IAP)

Altitude 2400 m.

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	25	0.04	40	4.1	0.01	4.68	5.97	10.66
	Sub total:		0.04	40	4.1	0.01	4.68	5.97	10.66
	Shrubs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	313	0.5	20	0.32	0.11	2.34	0.47	2.92
2	<i>Acantholimon polystachyum</i> Boiss	438	0.7	20	0.56	0.16	2.34	0.82	3.31
3	<i>Artemisia maritima</i> L.	750	1.2	30	5.65	0.27	3.51	8.23	12.00
4	<i>Astragalus</i> 97 - 8	3875	6.2	60	10.5	1.39	7.02	15.29	23.69
5	<i>Astragalus anisacanthus</i> Boiss	688	1.1	40	1.13	0.25	4.68	1.65	6.57
6	<i>Berberis balochistanica</i> Ahrendt	250	0.4	30	2.2	0.09	3.51	3.20	6.80
7	<i>Convolvulus leiocalycinus</i> Boiss	1000	1.6	40	2.98	0.36	4.68	4.34	9.38
8	<i>Gaillonia eriantha</i> Jaub & Spach	500	0.8	10	1.2	0.18	1.17	1.75	3.10
9	<i>Hertia intermedia</i> (Boiss.) O. Ktze	1250	2	40	1.75	0.45	4.68	2.55	7.67
10	<i>Nepeta juncea</i> Bth	1688	2.7	50	2.51	0.60	5.85	3.65	10.11
11	<i>Perovskia abrotanoides</i> Karel	125	0.2	10	0.63	0.04	1.17	0.92	2.13
12	<i>Prunus eburnea</i> Aitch	250	0.4	30	1.25	0.09	3.51	1.82	5.42
13	<i>Prunus</i> sp.	250	0.4	10	1.25	0.09	1.17	1.82	3.08
14	<i>Sophora griffithii</i> Stocks	2188	3.5	40	4.25	0.78	4.68	6.19	11.65
	Sub total:		21.7	430	36.18	4.86	50.29	52.68	107.83
	Herbs								
1	97 - 83	33000	52.8	25	0.66	11.83	2.92	0.96	15.71
2	<i>Asparagus capitatus</i> Baker	500	0.8	10	0.75	0.18	1.17	1.09	2.44
3	<i>Astragalus orthocarpus</i> Boiss	3000	4.8	10	0.3	1.08	1.17	0.44	2.68
4	<i>Bromus sericeus</i> Deobov	14000	22.4	25	1.16	5.02	2.92	1.69	9.63
5	<i>Bromus tectorum</i> L.	11375	18.2	20	0.8	4.08	2.34	1.16	7.58
6	<i>Ceratocephalla falcatus</i> (L.) Pers.	7500	12	10	0.28	2.69	1.17	0.41	4.27
7	<i>Ceratocephalla testiculata</i> (Cranitz) Roth	15000	24	20	0.5	5.38	2.34	0.73	8.44
8	<i>Cousinia heterophylla</i> Boiss	1000	1.6	10	0.25	0.36	1.17	0.36	1.89
9	<i>Drabopsis verna</i> C. Koch	1500	2.4	10	0.12	0.54	1.17	0.17	1.88
10	<i>Echinops echinatus</i> Rox b.	1000	1.6	10	0.25	0.36	1.17	0.36	1.89
11	<i>Eremurus persicus</i> (Jaub & Spach) Boiss	6500	10.4	25	5.25	2.33	2.92	7.64	12.90
12	<i>Heliotropium brahmicum</i> Stocks	19500	31.2	15	0.41	6.99	1.75	0.60	9.34
13	<i>Holosteum umbellatum</i> L.	14500	23.2	15	0.41	5.20	1.75	0.60	7.55
14	<i>Hypocoum pendulum</i> L.	3500	5.6	10	0.28	1.25	1.17	0.41	2.83
15	<i>Iris tenuifolia</i> Pall	30500	48.8	30	7.87	10.93	3.51	11.46	25.90
16	<i>Juniperus excelsa</i> M. Bieb *	1500	2.4	10	0.19	0.54	1.17	0.28	1.98
17	<i>Lactuca orientalis</i> (Boiss.) Boiss	3000	4.8	10	0.19	1.08	1.17	0.28	2.52
18	<i>Malcolmia africana</i> (Linn.) R. Br.	4000	6.4	15	0.38	1.43	1.75	0.55	3.74
19	<i>Medicago polymorpha</i> L.	3500	5.6	10	0.19	1.25	1.17	0.28	2.70
20	<i>Poa sinica</i> Steud	19000	30.4	25	6.13	6.81	2.92	8.93	18.66
21	<i>Polygonum aviculare</i> L.	4000	6.4	10	0.28	1.43	1.17	0.41	3.01

22 <i>Senecio Spp</i>	1000	1.6	10	0.25	0.36	1.17	0.36	1.89
23 <i>Stellaria alsinoides</i> Boiss & Buhse	5000	8	10	0.28	1.79	1.17	0.41	3.37
24 <i>Tulipa polychroma</i> Stapf *	37500	60	15	0.56	13.44	1.75	0.82	16.01
25 <i>Tulipa polychroma</i> Stapf	3000	4.8	10	0.25	1.08	1.17	0.36	2.61
26 <i>Veronica biloba</i> L.	21500	34.4	15	0.41	7.71	1.75	0.60	10.06
Sub total:		424.6	385	28.4	95.13	45.03	41.35	181.51
Grand total:		446.34	855	68.68	100	100	100	300

* Seedlings

Appendix - 4

SPRING ASPECTS (HILLS) (April to June, 1997)

PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - IV

Astragalus - Artemisia - Berberis (AAB)

Altitude 2450 m.

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	13	0.02	40	2.8	0.01	6.78	4.66	11.44
	Sub total:		0.02	40	2.8	0.01	6.78	4.66	11.44
	Shrubs								
1	<i>Artemisia maritima</i> L.	3188	5.1	50	8.47	2.29	8.47	14.08	24.85
2	<i>Astragalus</i> 97 - 8	3875	6.2	90	16.7	2.79	15.25	27.76	45.81
3	<i>Astragalus anisacanthus</i> Boiss	688	1.1	40	1.1	0.49	6.78	1.83	9.10
4	<i>Berberis balochistanica</i> Ahrendt	313	0.5	40	6.5	0.22	6.78	10.81	17.81
5	<i>Hertia intermedia</i> (Boiss.) O. Ktze	2125	3.4	40	3.31	1.53	6.78	5.50	13.81
6	<i>Prunus eburnea</i> Aitch	63	0.1	10	0.63	0.04	1.69	1.05	2.79
7	<i>Sophora griffithii</i> Stocks	188	0.3	20	0.37	0.13	3.39	0.62	4.14
	Sub total:		16.7	290	37.08	7.51	49.15	61.65	118.31
	Herbs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	3000	4.8	10	0.25	2.16	1.69	0.42	4.27
2	<i>Bromus tectorum</i> L.	10000	16	20	0.44	7.20	3.39	0.73	11.32
3	<i>Bongardia chrysogonum</i> (Linn) Spach	3000	4.8	10	0.44	2.16	1.69	0.73	4.59
4	<i>Ceratocephalla falcatus</i> (L.) Pers.	7000	11.2	10	0.25	5.04	1.69	0.42	7.15
5	<i>Ceratocephalla testiculata</i> (Crantz) Roth	12500	20	10	0.28	9.00	1.69	0.47	11.16
6	<i>Eragrostis minor</i> Host	2000	3.2	15	2.63	1.44	2.54	4.37	8.35
7	<i>Eremerus persicus</i> (Jaub & Spach) Boiss	3000	4.8	15	1.88	2.16	2.54	3.13	7.83
8	<i>Iris tenuifolia</i> Pall	9500	15.2	20	2.88	6.84	3.39	4.79	15.01
9	<i>Malva neglecta</i> Wallr.	3500	5.6	10	0.25	2.52	1.69	0.42	4.63
10	<i>Melica persica</i> Kunth	10000	16	20	4.13	7.20	3.39	6.87	17.45
11	<i>Minuartia meyeri</i> (Boiss.) Bornm	8000	12.8	20	0.44	5.76	3.39	0.73	9.88
12	<i>Pennisetum orientale</i> L.	2000	3.2	10	2.64	1.44	1.69	4.39	7.52
13	<i>Perovskia atriplicifolia</i> Bth *	6000	9.6	10	0.88	4.32	1.69	1.46	7.48
14	<i>Polygala hohenackeriana</i> Fisch & Meiy	13000	20.8	15	0.38	9.36	2.54	0.63	12.53
15	<i>Rhinopetalum karelinii</i> Fisch	5000	8	10	0.47	3.60	1.69	0.78	6.07
16	<i>Scorzonera tortuosissima</i> Boiss	3000	4.8	10	0.28	2.16	1.69	0.47	4.32
17	<i>Shismus arabicus</i> Nees	11000	17.6	15	1	7.92	2.54	1.66	12.12
18	<i>Tulipa polychroma</i> Stapf	2500	4	10	0.25	1.80	1.69	0.42	3.91
19	<i>Veronica biloba</i> L.	14500	23.2	20	0.5	10.44	3.39	0.83	14.66
	Sub total:		205.6	260	20.27	92.48	44.07	33.70	170.25
	Grand total:		222.32	590	60.15	100	100	100	300

* Seedlings

Appendix - 5

SPRING ASPECTS (HILLS) (April to June, 1997)
 PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - V
Artemisia - Sophora - Iris (ASI)
 Altitude 2500 m.

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	22	0.04	50.00	3.69	0.01	8.13	6.85	14.99
	Sub total:		0.04	50.00	3.69	0.01	8.13	6.85	14.99
	Shrubs								
1	<i>Artemisia maritima</i> L.	8250	13.20	65.00	14.88	5.20	10.57	27.59	43.36
2	<i>Astragalus</i> 97 - 56	125	0.20	15.00	0.45	0.08	2.44	0.83	3.34
3	<i>Astragalus</i> 97 - 8	781	1.25	35.00	2.59	0.49	5.69	4.80	10.98
4	<i>Astragalus psilocentros</i> Fisch	531	0.85	25.00	0.59	0.33	4.07	1.09	5.49
5	<i>Berberis balochistanica</i> Ahrendt	31	0.05	5.00	0.24	0.02	0.81	0.44	1.27
6	<i>Berberis callibotrys</i> Aitchex Koenne	31	0.05	5.00	0.24	0.02	0.81	0.44	1.27
7	<i>Convolvulus leiocalycinus</i> Boiss	219	0.35	20.00	0.60	0.14	3.25	1.10	4.49
8	<i>Hertia intermedia</i> (Boiss.) O. Ktze	844	1.35	25.00	0.72	0.53	4.07	1.33	5.92
9	<i>Nepeta juncea</i> Bth	344	0.55	20.00	0.50	0.22	3.25	0.93	4.40
10	<i>Perovskia abrotanoides</i> Karel	125	0.20	5.00	0.13	0.08	0.81	0.23	1.12
11	<i>Prunus eburnea</i> Aitch	31	0.05	5.00	0.24	0.02	0.81	0.44	1.27
12	<i>Salvia cabulica</i> Bth	63	0.10	5.00	0.43	0.04	0.81	0.79	1.64
13	<i>Sophora griffithii</i> Stocks	6063	9.70	60.00	12.19	3.82	9.76	22.61	36.19
	Sub total:		27.90	290.00	33.75	10.98	47.15	62.61	120.75
	Herbs								
1	<i>Alyssum desertorum</i> Stapf	3750	6.00	5.00	0.13	2.36	0.81	0.23	3.41
2	<i>Artemisia maritima</i> L. *	6250	10.00	5.00	0.75	3.94	0.81	1.39	6.14
3	<i>Asparagus capitatus</i> Baker	250	0.40	5.00	0.38	0.16	0.81	0.70	1.67
4	<i>Bongardia chrysogonum</i> (Linn) Spach	2250	3.60	7.50	0.17	1.42	1.22	0.32	2.95
5	<i>Bromus sericeus</i> Drobav	18725	29.96	30.00	0.92	11.80	4.88	1.70	18.37
6	<i>Bromus tectorum</i> L.	13313	21.30	30.00	0.60	8.39	4.88	1.11	14.38
7	<i>Cousinia heterophylla</i> Boiss	2750	4.40	10.00	0.49	1.73	1.63	0.90	4.26
8	<i>Cousinia onopordioides</i> Ledeb	4000	6.40	7.50	0.19	2.52	1.22	0.35	4.09
9	<i>Eremurus persicus</i> (Jaub & Spach) Boiss	3250	5.20	15.00	2.04	2.05	2.44	3.78	8.26
10	<i>Heliotropium brahmicum</i> Stocks	4500	7.20	7.50	0.19	2.83	1.22	0.35	4.41
11	<i>Iris tenuifolia</i> Pall	17750	28.40	30.00	4.75	11.18	4.88	8.81	24.87
12	<i>Lappula sessiliflora</i> (Boiss.) Gurke	4750	7.60	7.50	0.19	2.99	1.22	0.35	4.56
13	<i>Leptaleum filifolium</i> (Willd.) DC	2250	3.60	5.00	0.13	1.42	0.81	0.23	2.46
14	<i>Malcolmia africana</i> (Linn.) R. Br.	5000	8.00	10.00	0.25	3.15	1.63	0.46	5.24
15	<i>Malva neglecta</i> Wallr.	1250	2.00	5.00	0.13	0.79	0.81	0.23	1.83
16	<i>Medicago lupulina</i> L.	2000	3.20	5.00	0.07	1.26	0.81	0.12	2.19
17	<i>Nepeta juncea</i> Bth	4250	6.80	5.00	0.75	2.68	0.81	1.39	4.88
18	<i>Orobancha cernua</i> Loeffl	3500	5.60	12.50	0.32	2.20	2.03	0.58	4.82
19	<i>Peganum harmala</i> L.	1750	2.80	5.00	0.32	1.10	0.81	0.58	2.50
20	<i>Pennisetum orientale</i> L.	2500	4.00	10.00	2.07	1.57	1.63	3.83	7.03
21	<i>Polygala hohenackeriana</i> Fisch & Meiy	19250	30.80	25.00	0.54	12.13	4.07	0.99	17.18
22	<i>Polygonum paronychioides</i> C.A. Mey	3750	6.00	7.50	0.19	2.36	1.22	0.35	3.93

23 <i>Rhinopetalum karelinii</i> Fisch	1500	2.40	7.50	0.16	0.94	1.22	0.29	2.45
24 <i>Tulipa polychroma</i> Stapf *	10000	16.00	7.50	0.55	6.30	1.22	1.02	8.54
25 <i>Tulipa polychroma</i> Stapf	1250	2.00	5.00	0.13	0.79	0.81	0.23	1.83
26 <i>Scrozonera mollis</i> M. Bieb	1500	2.40	5.00	0.13	0.94	0.81	0.23	1.99
Sub total:		226.06	275.00	16.47	89.00	44.72	30.54	164.26
Grand total:		254.00	615.00	53.91	100	100	100	300

* Seedlings

Appendix - 6

SPRING ASPECTS (HILLS) (April to June, 1997)
 PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - VI
Iris - Astragalus - Tulipa (IAI)
 Altitude 2600 m.

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	38	0.06	60	6.71	0.03	11.01	8.11	19.15
	Sub total:		0.06	60	6.71	0.03	11.01	8.11	19.15
	Shrubs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	625	1	20	1.1	0.53	3.67	1.33	5.52
2	<i>Acantholimon polystachyum</i> Boiss	438	0.7	30	1.1	0.37	5.50	1.33	7.20
3	<i>Artemisia maritima</i> L.	1563	2.5	20	4.6	1.31	3.67	5.56	10.54
4	<i>Astragalus</i> 97 - 53	2063	3.3	40	14	1.73	7.34	16.91	25.99
5	<i>Astragalus psilocentros</i> Fisch	1313	2.1	40	2.38	1.10	7.34	2.88	11.32
6	<i>Berberis callibotrys</i> Aitchex Koenne	125	0.2	20	1.25	0.11	3.67	1.51	5.28
7	<i>Daphne mucronata</i> Royle	63	0.1	10	0.47	0.05	1.83	0.57	2.46
8	<i>Gaillonia eriantha</i> Jaub & Spach	250	0.4	20	0.56	0.21	3.67	0.68	4.56
9	<i>Juniperus excelsa</i> M. Bieb *	63	0.1	10	0.12	0.05	1.83	0.14	2.03
10	<i>Nepeta juncea</i> Bth	438	0.7	20	0.56	0.37	3.67	0.68	4.71
11	<i>Onobrychis cornuta</i> (L.) Desv	1750	2.8	30	11.25	1.47	5.50	13.59	20.57
12	<i>Prunus</i> sp.	3188	5.1	30	9	2.68	5.50	10.87	19.06
13	<i>Sophora griffithii</i> Stocks	500	0.8	10	0.85	0.42	1.83	1.03	3.28
	Sub total:		19.8	300	47.24	10.41	55.05	57.07	122.52
	Herbs								
1	<i>Cousinia heterophylla</i> Boiss	1000	1.6	10	0.13	0.84	1.83	0.16	2.83
2	<i>Eremerus persicus</i> (Jaub & Spach) Boiss	5000	8	20	5.25	4.20	3.67	6.34	14.22
3	<i>Iris</i> sp	8000	12.8	10	1.1	6.73	1.83	1.33	9.89
4	<i>Iris tenuifolia</i> Pall	26000	41.6	20	5.38	21.86	3.67	6.50	32.03
5	<i>Pennisetum orientale</i> L.	7000	11.2	20	6.38	5.89	3.67	7.71	17.26
6	<i>Psammogeton</i>	13000	20.8	40	2.1	10.93	7.34	2.54	20.81
7	<i>Perovskia abrotanoides</i> Karel *	13000	20.8	10	3.74	10.93	1.83	4.52	17.29
8	<i>Scorzonera laciniata</i> L.	1500	2.4	10	0.5	1.26	1.83	0.60	3.70
9	<i>Tragopogon gracilis</i> D. Don	5500	8.8	20	1.75	4.63	3.67	2.11	10.41
10	<i>Tulipa polychroma</i> Stapf *	21500	34.4	10	1.5	18.08	1.83	1.81	21.73
11	<i>Tulipa polychroma</i> Stapf	5000	8	15	1	4.20	2.75	1.21	8.17
	Sub total:		170.4	185	28.83	89.56	33.94	34.83	158.33
	Grand total:		190.26	545	82.78	100	100	100	300

* Seedlings

Appendix - 7

SPRING ASPECTS (HILLS) (April to June, 1997)
 PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - VII
Tulipa - Juniperus - Bromus (TJB)
 Altitude 2700 m.

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	41	0.07	70.00	11.46	0.01	7.12	13.47	20.61
	Sub total:		0.07	70.00	11.46	0.01	7.12	13.47	20.61
	Shrubs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	531	0.85	25.00	1.12	0.16	2.54	1.31	4.01
2	<i>Acantholimon polystachyum</i> Boiss	281	0.45	10.00	1.05	0.08	1.02	1.23	2.34
3	<i>Aerua javanica</i> (Burm.f) Juss	563	0.90	20.00	1.69	0.17	2.04	1.99	4.19
4	<i>Artemisia maritima</i> L.	1688	2.70	45.00	3.65	0.51	4.58	4.29	9.38
5	<i>Astragalus</i> 97 - 53	1156	1.85	50.00	9.48	0.35	5.09	11.14	16.57
6	<i>Astragalus anisacanthus</i> Boiss	63	0.10	5.00	0.13	0.02	0.51	0.15	0.67
7	<i>Astragalus psilocentros</i> Fisch	563	0.90	35.00	0.99	0.17	3.56	1.16	4.89
8	<i>Berberis balochistanica</i> Ahrendt	63	0.10	5.00	1.50	0.02	0.51	1.76	2.29
9	<i>Ephedra intermedia</i> var <i>glauca</i> Schrenk. Regel, Sta	344	0.55	20.00	0.73	0.10	2.04	0.86	3.00
10	<i>Hertia intermedia</i> (Boiss.) O. Ktze	875	1.40	30.00	1.42	0.26	3.05	1.66	4.98
11	<i>Juniperus excelsa</i> M. Bieb *	31	0.05	5.00	0.13	0.01	0.51	0.15	0.67
12	<i>Nepeta juncea</i> Bth	375	0.60	15.00	0.74	0.11	1.53	0.86	2.50
13	<i>Onobrychis cornuta</i> (L.) Desv	2594	4.15	50.00	5.00	0.78	5.09	5.88	11.74
14	<i>Perovskia abrotanoides</i> Karel	344	0.55	15.00	1.24	0.10	1.53	1.45	3.08
15	<i>Perovskia atriplicifolia</i> Bth	188	0.30	5.00	0.28	0.06	0.51	0.33	0.89
16	<i>Prunus</i> sp.	31	0.05	5.00	0.13	0.01	0.51	0.15	0.67
17	<i>Rosa lacerans</i> Boiss & Buhse	188	0.30	10.00	3.38	0.06	1.02	3.97	5.04
18	<i>Salvia cabulica</i> Bth	31	0.05	5.00	0.15	0.01	0.51	0.18	0.69
19	<i>Sophora griffithii</i> Stocks	875	1.40	27.50	1.65	0.26	2.80	1.94	5.60
	Sub total:		17.25	382.50	34.41	3.23	38.93	40.44	82.60
	Herbs								
1	97 - 150	5750	9.20	15.00	1.57	1.72	1.53	1.84	5.09
2	<i>Achillea santolina</i> L.	11750	18.80	5.00	0.55	3.52	0.51	0.65	4.68
3	<i>Adonis aestivalis</i> L.	2500	4.00	7.50	0.19	0.75	0.76	0.22	1.74
4	<i>Alyssum marginatum</i> Steud ex Willd	5000	8.00	5.00	0.25	1.50	0.51	0.29	2.30
5	<i>Arabis saxicola</i> Edgew	1750	2.80	5.00	0.13	0.52	0.51	0.15	1.18
6	<i>Artemisia maritima</i> L. *	4000	6.40	5.00	0.22	1.20	0.51	0.26	1.97
7	<i>Astragalus</i> 97 - 144	1000	1.60	5.00	0.38	0.30	0.51	0.44	1.25
8	<i>Bromus sericeus</i> Drobov	44938	71.90	17.50	3.82	13.46	1.78	4.48	19.73
9	<i>Bromus tectorum</i> L.	20250	32.40	15.00	1.32	6.07	1.53	1.55	9.14
10	<i>Ceratocephalla falcatus</i> (L.) Pers.	7250	11.60	7.50	0.28	2.17	0.76	0.33	3.26
11	<i>Ceratocephalla testiculata</i> (Craetz) Roth	11250	18.00	7.50	0.50	3.37	0.76	0.59	4.72
12	<i>Chenopodium album</i> L.	3750	6.00	7.50	0.19	1.12	0.76	0.22	2.11
13	Composite (unidentified)	9500	15.20	7.50	0.82	2.85	0.76	0.96	4.57
14	<i>Cuminum cyminum</i> L.	1750	2.80	5.00	0.13	0.52	0.51	0.15	1.18
15	<i>Descurainia sophia</i> (L.) Webb & Berth	2000	3.20	10.00	0.25	0.60	1.02	0.29	1.91
16	<i>Eremurus persicus</i> (Jaub & Spach) Boiss	2500	4.00	10.00	1.19	0.75	1.02	1.40	3.17
17	<i>Eremostachys vicarys</i> Berth	1000	1.60	5.00	0.44	0.30	0.51	0.52	1.33
18	<i>Fursetia heliophila</i> Bunge ex Coss	1750	2.80	5.00	0.25	0.52	0.51	0.29	1.33
19	<i>Fumaria indica</i> (Hauksn.) H.N.	4000	6.40	10.00	0.35	1.20	1.02	0.41	2.63
20	<i>Gagea pseudo-raticulata</i>	3813	6.10	10.00	0.19	1.14	1.02	0.22	2.38

21 <i>Gagea</i> sp	2500	4.00	10.00	0.23	0.75	1.02	0.26	2.03
22 <i>Gypsophila lignosa</i> Hemsl & Lace	1188	1.90	45.00	2.29	0.36	4.58	2.69	7.62
23 <i>Heliotropium brahuicum</i> Stocks	7500	12.00	10.00	0.25	2.25	1.02	0.29	3.56
24 <i>Iris tenuifolia</i> Pall	5250	8.40	12.50	0.94	1.57	1.27	1.10	3.95
25 <i>Lappula spinocarpus</i> (Forssk.) Ascherson	9000	14.40	12.50	0.44	2.70	1.27	0.52	4.49
26 <i>Malcolmia strigosa</i> Boiss	7750	12.40	15.00	0.50	2.32	1.53	0.59	4.44
27 <i>Malva neglecta</i> Wallr.	1925	3.08	10.00	0.69	0.58	1.02	0.81	2.41
28 <i>Nepeta juncea</i> Bth	750	1.20	5.00	0.13	0.22	0.51	0.15	0.88
29 <i>Neslia apiculata</i> Fisch & Mey & Avelal	24250	38.80	25.00	1.10	7.27	2.54	1.29	11.10
30 <i>Nonnea caspica</i> (Willd) G. Don	3000	4.80	7.50	0.19	0.90	0.76	0.22	1.89
31 <i>Onasma dichroanthum</i> Boiss	750	1.20	30.00	3.97	0.22	3.05	4.67	7.94
32 <i>Peganum harmala</i> L.	656	1.05	25.00	1.75	0.20	2.54	2.06	4.80
33 <i>Pennisetum orientale</i> L.	4000	6.40	12.50	1.73	1.20	1.27	2.03	4.50
34 <i>Polygonum aviculare</i> L.	1500	2.40	7.50	0.19	0.45	0.76	0.22	1.44
35 <i>Psammogeton</i>	250	0.40	5.00	0.07	0.07	0.51	0.08	0.66
36 <i>Pulicaria gnaphalodes</i> (Vent.) Boiss	2250	3.60	5.00	0.44	0.67	0.51	0.52	1.70
37 <i>Robeschia schimperi</i> (Boiss) O.E.S.	3188	5.10	7.50	0.15	0.95	0.76	0.18	1.89
38 <i>Seseli libanotis</i> (L.) Koch	2500	4.00	20.00	1.75	0.75	2.04	2.06	4.84
39 <i>Stipa pennata</i> L.	1750	2.80	5.00	0.75	0.52	0.51	0.88	1.91
40 <i>Tulipa polychroma</i> Stapf *	80250	128.40	35.00	4.63	24.04	3.56	5.44	33.04
41 <i>Tulipa polychroma</i> Stapf	3000	4.80	15.00	0.29	0.90	1.53	0.34	2.77
42 <i>Veronica biloba</i> L.	7500	12.00	5.00	0.45	2.25	0.51	0.52	3.28
43 <i>Zizyphora clinopodioides</i> Lam	5000	8.00	35.00	3.22	1.50	3.56	3.78	8.84
44 <i>Zizyphora tenuior</i> L.	1750	2.80	5.00	0.13	0.52	0.51	0.15	1.18
Sub total:		516.73	530.00	39.22	96.76	53.94	46.09	196.79
Grand total:		534.05	982.50	85.09	100	100	100	300

* Seedlings

Appendix - 8

SUMMER ASPECTS (HILLS) (July to October, 1997)
 PHYTO SOCIOLOGICAL ATTRIBUTES OF COMMUNITIES - I
Artemisia - Aristida - Sophora (AAS)
 (Altitude - 2240 meters)

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	19	0.03	40	2.51	0.02	4.40	4.38	8.79
	Sub total:		0.03	40	2.51	0.02	4.40	4.38	8.79
	Shrubs								
1	<i>Acantholimon polystachyum</i> Boiss	63	0.1	10	0.16	0.05	1.10	0.28	1.43
2	<i>Aerua javanica</i> (Burm.f) Juss	563	0.9	10	0.75	0.49	1.10	1.31	2.90
3	<i>Artemisia maritima</i> L.	9938	15.9	90	16.75	8.72	9.89	29.28	47.89
4	<i>Astragalus</i> 97 - 8	156	0.25	15	0.50	0.14	1.65	0.87	2.66
5	<i>Astragalus anisacanthus</i> Boiss	281	0.45	10	0.37	0.25	1.10	0.65	1.99
6	<i>Berberis balochistanica</i> Ahrendt	31	0.05	5	0.24	0.03	0.55	0.41	0.99
7	<i>Caragana stockii</i>	656	1.05	25	1.30	0.58	2.75	2.27	5.60
8	<i>Convolvulus leiocalycinus</i> Boiss	563	0.9	40	1.41	0.49	4.40	2.46	7.35
9	<i>Daphne mucronata</i> Royle	219	0.35	25	1.33	0.19	2.75	2.32	5.26
10	<i>Ephedra intermedia</i> var <i>glauca</i> Schrenk. Regel, Sta	344	0.55	10	0.81	0.30	1.10	1.42	2.82
11	<i>Haloxylon griffithii</i> (Moq.) Bunge ex Boiss	1125	1.8	55	0.79	0.99	6.04	1.38	8.41
12	<i>Hertia intermedia</i> (Boiss.) O. Ktze	188	0.3	20	0.24	0.16	2.20	0.42	2.78
13	<i>Nepeta juncea</i> Bth	1563	2.5	45	2.05	1.37	4.95	3.57	9.89
14	<i>Perovskia atriplicifolia</i> Bth	31	0.05	5	0.13	0.03	0.55	0.22	0.80
15	<i>Prunus eburnea</i> Aitch	31	0.05	5	0.16	0.03	0.55	0.27	0.85
16	<i>Prunus</i> sp	188	0.3	20	0.87	0.16	2.20	1.51	3.87
17	<i>Salvia cabulica</i> Bth	125	0.2	10	0.60	0.11	1.10	1.05	2.26
18	<i>Sophora griffithii</i> Stocks	4188	6.7	65	5.31	3.67	7.14	9.28	20.10
19	<i>Spiraea boissieri</i> Schneider	31	0.05	5	0.13	0.03	0.55	0.22	0.80
	Sub total:		32.45	470	33.87	17.79	51.65	59.20	128.64
	Herbs								
1	<i>Aristida</i>	24688	39.5	35	5.52	21.65	3.85	9.65	35.15
2	<i>Aristida adscensionis</i>	656	1.05	5	1.25	0.58	0.55	2.19	3.31
3	<i>Artemisia maritima</i> L. *	7656	12.25	20	0.42	6.71	2.20	0.73	9.64
4	<i>Asteriscus pygmaeus</i> (DC.) Cass & Dur	4688	7.5	25	0.52	4.11	2.75	0.90	7.76
5	<i>Bupleurum exaltatum</i> Bieb	1000	1.6	10	0.25	0.88	1.10	0.44	2.41
6	<i>Cousinia heterophylla</i> Boiss	1656	2.65	20	0.30	1.45	2.20	0.52	4.17
7	<i>Cousinia onopordioides</i> Ledeb	1688	2.7	15	0.35	1.48	1.65	0.61	3.74
8	<i>Cousinia</i> sp.	1000	1.6	10	0.15	0.88	1.10	0.26	2.24
9	<i>Crepis sancta</i> (L.) Bab.	3344	5.35	10	0.15	2.93	1.10	0.26	4.29
10	<i>Cymbopogon jwarancusa</i> (Jones) Schult	1656	2.65	10	1.00	1.45	1.10	1.75	4.30
11	<i>Phacelurus</i> Spp	1344	2.15	10	4.60	1.18	1.10	8.04	10.32
12	<i>Ephedra intermedia</i> var <i>glauca</i> Schrenk. Regel, Sta	344	0.55	10	0.10	0.30	1.10	0.17	1.58
13	<i>Eremostachys vicaryi</i> Benth	344	0.55	5	0.10	0.30	0.55	0.17	1.03
14	<i>Euphorbia maddenii</i> Boiss	4344	6.95	20	0.42	3.81	2.20	0.73	6.73
15	<i>Euphorbia prostrata</i> Ait	2656	4.25	10	0.15	2.33	1.10	0.26	3.69
16	<i>Forsetia heliophila</i> Bunge ex Cass	7656	12.25	5	0.50	6.71	0.55	0.87	8.14
17	<i>Ferula foetida</i> Regel	688	1.1	10	0.20	0.60	1.10	0.35	2.05
18	<i>Hertia intermedia</i> (Boiss.) O. Ktze *	1000	1.6	10	0.25	0.88	1.10	0.44	2.41
19	<i>Juniperus excelsa</i> M. Bieb *	344	0.55	5	0.10	0.30	0.55	0.17	1.03
20	<i>Mattiastrium asperum</i> (Stocks) Brand	344	0.55	5	0.10	0.30	0.55	0.17	1.03

21 <i>Melica persica</i> Kunth	1344	2.15	10	0.15	1.18	1.10	0.26	2.54
22 <i>Nepeta juncea</i> Bth *	3656	5.85	10	0.60	3.21	1.10	1.05	5.35
23 <i>Perovskia abrotanoides</i> Karel *	1000	1.6	10	0.25	0.88	1.10	0.44	2.41
24 <i>Piptatherum vicarium</i>	4344	6.95	10	0.65	3.81	1.10	1.14	6.04
25 <i>Pulicaria gnaphalodes</i> (Vent.) Boiss	2656	4.25	30	0.50	2.33	3.30	0.87	6.50
26 <i>Scutellaria stocksii</i> Boiss	2656	4.25	10	0.21	2.33	1.10	0.36	3.79
27 <i>Silene brahuica</i> Boiss	1000	1.6	10	0.15	0.88	1.10	0.26	2.24
28 <i>Sophora griffithii</i> Stocks *	1344	2.15	10	0.60	1.18	1.10	1.05	3.33
29 <i>Stipa pennata</i> L.	2656	4.25	10	0.17	2.33	1.10	0.29	3.72
30 <i>Tetrapogon villosus</i> Desf	3656	5.85	10	0.60	3.21	1.10	1.05	5.35
31 <i>Teucrium stocksianum</i> Boiss	1000	1.6	10	0.25	0.88	1.10	0.44	2.41
32 <i>Zizyphora clinopodioides</i> Lam	1313	2.1	20	0.30	1.15	2.20	0.52	3.87
Sub total:	149.95		400	20.84	82.20	43.96	36.42	162.57
Grand total:	182.43		910	57.21	100	100	100	300

* Seedlings

Appendix - 9

SUMMER ASPECTS (HILLS) (July to October, 1997)
 PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY -II
Leptorhabdos - Pulicaria - Euphorbia (LPE)
 Altitude 2300 meters

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	19	0.03	40	2.26	0.02	3.96	5.17	9.15
	Sub total:		0.03	40	2.26	0.02	3.96	5.17	9.15
	Shrubs								
1	<i>Acantholimon polystachyum</i> Boiss	875	1.4	40	1.75	0.96	3.96	4.01	8.92
2	<i>Aerua javanica</i> (Burm.f) Juss	250	0.4	30	0.75	0.27	2.97	1.72	4.96
3	<i>Artemisia maritima</i> L.	1313	2.1	60	2.75	1.43	5.94	6.29	13.67
4	<i>Berberis callibotrys</i> Aitchex Koenne	250	0.4	30	0.75	0.27	2.97	1.72	4.96
5	<i>Caragana stockii</i>	375	0.6	20	0.5	0.41	1.98	1.14	3.53
6	<i>Clematis graveolens</i> Lindl	750	1.2	30	4.5	0.82	2.97	10.30	14.09
7	<i>Convolvulus leiocalycinus</i> Boiss	125	0.2	20	0.25	0.14	1.98	0.57	2.69
8	<i>Daphne mucronata</i> Royle	375	0.6	40	1	0.41	3.96	2.29	6.66
9	<i>Ephedra intermedia</i> var <i>glauca</i> Schren K. Regel, Stapf.	125	0.2	20	0.5	0.14	1.98	1.14	3.26
10	<i>Haloxylon griffithii</i> (Moq.) Bunge ex Boiss	500	0.8	30	0.75	0.55	2.97	1.72	5.23
11	<i>Hertia intermedia</i> (Boiss.) O. Ktze	1313	2.1	40	2.25	1.43	3.96	5.15	10.54
12	<i>Nepeta juncea</i> Bth	1563	2.5	60	1.5	1.71	5.94	3.43	11.08
13	<i>Prunus eburnea</i> Aitch	375	0.6	30	1	0.41	2.97	2.29	5.67
14	<i>Prunus</i> sp	250	0.4	30	0.75	0.27	2.97	1.72	4.96
15	<i>Salvia cabulica</i> Bth	125	0.2	20	0.62	0.14	1.98	1.42	3.54
16	<i>Sophora griffithii</i> Stocks	1938	3.1	50	3.75	2.12	4.95	8.58	15.65
	Sub total:		16.8	550	23.37	11.47	54.46	53.49	119.42
	Herb								
1	<i>Aristida</i> spp	2688	4.3	20	3	2.94	1.98	6.87	11.78
2	<i>Euphorbia exaltatum</i> Bieb	4000	6.4	40	0.83	4.37	3.96	1.90	10.23
3	<i>Ephedra intermedia</i> var <i>glauca</i> Schren K. Regel, Stapf.	2688	4.3	20	0.3	2.94	1.98	0.69	5.60
4	<i>Euphorbia falcata</i> L.	16375	26.2	40	0.67	17.89	3.96	1.53	23.39
5	<i>Euphorbia corollata</i> Boiss	6250	10	40	0.33	6.83	3.96	0.76	11.54
6	<i>Leptorhabdos parviflora</i> (Bth) Bth	19375	31	50	1.5	21.17	4.95	3.43	29.55
7	<i>Malva neglecta</i> Wall.	3313	5.3	30	0.67	3.62	2.97	1.53	8.12
8	<i>Marrubium vulgare</i> L.	1313	2.1	20	0.3	1.43	1.98	0.69	4.10
9	<i>Pennisetum orientale</i> L.	5000	8	50	2.83	5.46	4.95	6.48	16.89
10	<i>Polygonum paronychioides</i> C.A. Mey	3313	5.3	20	0.5	3.62	1.98	1.14	6.74
11	<i>Pulicaria grapholodes</i> (Vent.) Boiss	10000	16	50	5.3	10.93	4.95	12.13	28.01
12	<i>Zizyphora clinopodioides</i> Lam	6688	10.7	40	1.83	7.31	3.96	4.19	15.46
	Sub total:		129.6	420	18.06	88.51	41.58	41.34	171.43
	Grand total:		146.43	1010	43.69	100	100	100	300

Appendix - 10

SUMMER ASPECTS (HILLS) (July to October, 1997)
PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - III*Astragalus - Iris - Crepis* (AIC)

Altitude 2400 meters

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	25	0.04	40	4.1	0.03	6.35	7.23	13.61
	Sub total:		0.04	40	4.1	0.03	6.35	7.23	13.61
	Shrubs								
1	<i>Acantholimon musroarum</i> Aitch & Hemsl	125	0.2	10	0.3	0.13	1.59	0.53	2.24
2	<i>Acantholimon polystachyum</i> Boiss	125	0.2	20	0.3	0.13	3.17	0.53	3.83
3	<i>Aerua javanica</i> (Burm.f) Juss	125	0.2	20	0.37	0.13	3.17	0.65	3.95
4	<i>Artemisia maritima</i> L.	2750	4.4	50	3.75	2.79	7.94	6.61	17.34
5	<i>Astragalus</i> 97-8	4000	6.4	70	18.7	4.06	11.11	32.99	48.16
6	<i>Berberis balochistanica</i> Ahrendt	125	0.2	20	1.23	0.13	3.17	2.17	5.47
7	<i>Convolvulus leiocalycinus</i> Boiss	63	0.1	10	0.25	0.06	1.59	0.44	2.09
8	<i>Daphne mucronata</i> Royle	63	0.1	10	0.47	0.06	1.59	0.83	2.48
9	<i>Juniperus excelsa</i> M. Bieb	63	0.1	10	0.12	0.06	1.59	0.21	1.86
10	<i>Nepeta juncea</i> Bth	125	0.2	20	0.25	0.13	3.17	0.44	3.74
11	<i>Perovskia abrotanoides</i> Karel	1188	1.9	30	5.5	1.21	4.76	9.70	15.67
12	<i>Prunus eburnea</i> Aitch	125	0.2	20	0.25	0.13	3.17	0.44	3.74
13	<i>Prunus</i> sp	63	0.1	10	0.25	0.06	1.59	0.44	2.09
14	<i>Sophora griffithii</i> Stocks	125	0.2	20	0.25	0.13	3.17	0.44	3.74
	Sub total:		14.5	320	31.99	9.20	50.79	56.43	116.43
	Herb								
1	<i>Aristida</i> Sp	4688	7.5	30	0.7	4.76	4.76	1.23	10.76
2	<i>Artemisia maritima</i> L. *	1313	2.1	10	0.2	1.33	1.59	0.35	3.27
3	<i>Asteriscus pygmaeus</i> (DC.) Cass & Dur	10688	17.1	30	0.7	10.85	4.76	1.23	16.85
4	<i>Astragalus orthocarpus</i> Boiss	6688	10.7	20	2	6.79	3.17	3.53	13.49
5	<i>Astragalus purpurascens</i> Bunge	4000	6.4	20	0.3	4.06	3.17	0.53	7.77
6	<i>Cousinia emepardioides</i> Ledeb	688	1.1	10	0.2	0.70	1.59	0.35	2.64
7	<i>Crepis sancta</i> (L.) Babo.	14000	22.4	30	0.7	14.22	4.76	1.23	20.22
8	<i>Eremurus persicus</i> (Jaub & Spach) Boiss	12000	19.2	20	2.7	12.19	3.17	4.76	20.12
9	<i>Festuca arundinacea</i> Schreb	4000	6.4	20	1.3	4.06	3.17	2.29	9.53
10	<i>Hertia intermedia</i> (Boiss.) O. Ktze *	4000	6.4	20	0.3	4.06	3.17	0.53	7.77
11	<i>Iris tenuifolia</i> Pall	15313	24.5	20	7.5	15.55	3.17	13.23	31.96
12	<i>Pulicaria grapholodes</i> (Vent.) Boiss	6000	9.6	30	3	6.09	4.76	5.29	16.15
13	<i>Sophora griffithii</i> Stocks *	6000	9.6	10	1	6.09	1.59	1.76	9.44
	Sub total:		143	270	20.6	90.77	42.86	36.34	169.97
	Grand total:		157.54	630	56.69	100	100	100	300

* Seedlings

Appendix - 11

SUMMER ASPECTS (HILLS) (July to October, 1997)
 PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - IV
Artemisia - Sophora - Iris (ASI)
 Altitude 2450 meters

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	13	0.02	40	2.8	0.01	7.69	5.04	12.74
	Sub total:		0.02	40	2.8	0.01	7.69	5.04	12.74
	Shrubs								
1	<i>Artemisia maritima</i> L.	3563	5.7	70	5.88	2.94	13.46	10.57	26.97
2	<i>Astragalus</i> 97 - 8	4188	6.7	90	20.8	3.46	17.31	37.40	58.17
3	<i>Berberis balochistanica</i> Ahrendt	63	0.1	10	0.25	0.05	1.92	0.45	2.42
4	<i>Convolvulus leiocalycinus</i> Boiss	938	1.5	40	2.63	0.77	7.69	4.73	13.20
5	<i>Hertia intermedia</i> (Boiss.) O. Ktze	188	0.3	10	0.12	0.15	1.92	0.22	2.29
6	<i>Juniperus excelsa</i> M. Bieb *	63	0.1	10	0.12	0.05	1.92	0.22	2.19
7	<i>Prunus eburnea</i> Aitch	63	0.1	10	0.25	0.05	1.92	0.45	2.42
8	<i>Sophora griffithii</i> Stocks	4500	7.2	70	2.2	3.71	13.46	3.96	21.13
	Sub total:		21.7	310	32.25	11.19	59.62	57.99	128.80
	Herb								
1	<i>Cousinia heterophylla</i> Boiss	18688	29.9	30	1.75	15.42	5.77	3.15	24.33
2	<i>Cousinia onopordioides</i> Ledeb	1313	2.1	10	0.2	1.08	1.92	0.36	3.37
3	<i>Eremerus persicus</i> (Jaub & Spach) Boiss	4688	7.5	20	3.5	3.87	3.85	6.29	14.01
4	<i>Euphorbia maddenii</i> Boiss	2000	3.2	10	1	1.65	1.92	1.80	5.37
5	<i>Euphorbia prostrata</i> Ait	18688	29.9	30	0.58	15.42	5.77	1.04	22.23
6	<i>Iris tenuifolia</i> Pall	20938	33.5	20	7.5	17.28	3.85	13.49	34.61
7	<i>Melica persica</i> Kunth	26000	41.6	30	3.2	21.45	5.77	5.75	32.98
8	<i>Sophora griffithii</i> Stocks *	15313	24.5	20	2.83	12.63	3.85	5.09	21.57
	Sub total:		172.2	170	20.56	88.80	32.69	36.97	158.46
	Grand total:		193.92	520	55.61	100	100	100	300

* Seedlings

Appendix - 12

SUMMER ASPECTS (HILLS) (July to October, 1997)
 PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - V
Artemisia - Sophora - Eragrostis (ASE)

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	22	0.035	50	3.69	0.02	7.75	6.96	14.73
	Sub total:		0.035	50	3.69	0.02	7.75	6.96	14.73
	Shrubs								
1	<i>Aerua javanica</i> (Burm.f) Juss	94	0.15	10.00	0.25	0.07	1.55	0.47	2.09
2	<i>Artemisia maritima</i> L.	10719	17.15	85	17.685	7.47	13.18	33.36	54.00
3	<i>Astragalus</i> 97 - 8	750	1.20	40.00	3.45	0.52	6.20	6.51	13.23
4	<i>Berberis balochistanica</i> Ahrendt	125	0.2	15	1.31	0.09	2.33	2.47	4.88
5	<i>Colutea armata</i>	94	0.15	10	0.485	0.07	1.55	0.91	2.53
6	<i>Convolvulus leiocalycinus</i> Boiss	281	0.45	25.00	1.25	0.20	3.88	2.36	6.43
7	<i>Hertia intermedia</i> (Boiss.) O. Ktze	375	0.6	25	0.475	0.26	3.88	0.90	5.03
8	<i>Nepeta juncea</i> Bth	500	0.80	20.00	0.54	0.35	3.10	1.02	4.47
9	<i>Prunus eburnea</i> Aitch	31	0.05	5.00	0.32	0.02	0.78	0.59	1.39
10	<i>Salvia cabulica</i> Bth	63	0.1	5	0.155	0.04	0.78	0.29	1.11
11	<i>Sophora griffithii</i> Stocks	8219	13.15	40	10.25	5.72	6.20	19.33	31.26
	Sub total:		34.00	280.00	36.17	14.80	43.41	68.21	126.42
	Herbs								
1	<i>Asparagus capitatus</i> Baker	1344	2.15	15	1.5	0.94	2.33	2.83	6.09
2	<i>Asteriscus pygmaeus</i> (DC.) Cass & Dur	11656	18.65	35.00	0.63	8.12	5.43	1.18	14.72
3	<i>Astragalus subuliformis</i> DC.	1000	1.6	10	0.15	0.70	1.55	0.28	2.53
4	<i>Cousinia heterophylla</i> Boiss	2656	4.25	25	0.475	1.85	3.88	0.90	6.62
5	<i>Crepis sancta</i> (L.) Babo.	20000	32.00	35.00	0.65	13.93	5.43	1.23	20.58
6	<i>Eragrostis minor</i> Host	27000	43.20	50.00	0.74	18.80	7.75	1.40	27.95
7	<i>Eremurus persicus</i> (Jaub & Spach) Boiss	1656	2.65	10.00	0.42	1.15	1.55	0.78	3.49
8	<i>Euphorbia graulata</i> Forsk	8750	14	20	0.26	6.09	3.10	0.49	9.69
9	<i>Euphorbia prostrata</i> Ait	3250	5.2	20	0.165	2.26	3.10	0.31	5.68
10	<i>Hertia intermedia</i> (Boiss.) O. Ktze *	1344	2.15	10	0.165	0.94	1.55	0.31	2.80
11	<i>Iris tenuifolia</i> Pall	15656	25.05	25	3.25	10.90	3.88	6.13	20.91
12	<i>Perovskia abrotanoides</i> Karel *	11656	18.65	15	2	8.12	2.33	3.77	14.22
13	<i>Polygonum paronychioides</i> C.A. Mey	5344	8.55	25.00	0.27	3.72	3.88	0.51	8.11
14	<i>Pulicaria gnaphalodes</i> (Vent.) Boiss	1344	2.15	10	1	0.94	1.55	1.89	4.37
15	<i>Sophora griffithii</i> Stocks *	9656	15.45	10	1.5	6.73	1.55	2.83	11.10
	Sub total:		195.7	315	13.165	85.19	48.84	24.83	158.85
	Grand total:		229.74	645.00	53.02	100	100	100	300

* Seedlings

Appendix - 13

SUMMER ASPECTS (HILLS) (July to October, 1997)

PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - VI

Artemisia - Eragrostris - Asteriscus (AEA)

Altitude 2600 meters

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	38	0.06	60	6.71	0.03	7.69	9.99	17.70
	Sub total:		0.06	60	6.71	0.03	7.69	9.99	17.70
	Shrubs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	500	0.8	20	0.5	0.34	2.56	0.74	3.64
2	<i>Acantholimon polystachyum</i> Boiss	125	0.2	20	0.25	0.08	2.56	0.37	3.02
3	<i>Artemisia maritima</i> L.	7625	12.2	70	18.5	5.12	8.97	27.53	41.63
4	<i>Astragalus</i> 97 - 53	563	0.9	30	2	0.38	3.85	2.98	7.20
5	<i>Berberis balochistanica</i> Ahrendt	125	0.2	20	0.5	0.08	2.56	0.74	3.39
6	<i>Daphne mucronata</i> Royle	63	0.1	10	0.32	0.04	1.28	0.48	1.80
7	<i>Hertia intermedia</i> (Boiss.) O. Ktze	1063	1.7	30	0.75	0.71	3.85	1.12	5.68
8	<i>Nepeta juncea</i> Bth	1188	1.9	50	1.1	0.80	6.41	1.64	8.85
9	<i>Onobrychis cornuta</i> (L.) Desv	375	0.6	30	1.5	0.25	3.85	2.23	6.33
10	<i>Perovskia abrotanoides</i> Karel	1375	2.2	40	3.5	0.92	5.13	5.21	11.26
11	<i>Prunus eburnea</i> Aitch	125	0.2	20	1.1	0.08	2.56	1.64	4.29
12	<i>Prunus</i> sp	1000	1.6	30	5.3	0.67	3.85	7.89	12.41
13	<i>Sophora griffithii</i> Stocks	3313	5.3	60	7.1	2.23	7.69	10.57	20.48
	Sub total:		27.9	430	42.42	11.71	55.13	63.13	129.98
	Herb								
1	<i>Asteriscus pygmaeus</i> (DC.) Coss & Dur	25313	40.5	80	3.2	17.01	10.26	4.76	32.02
2	<i>Cousinia heterophylla</i> Boiss	6688	10.7	40	0.83	4.49	5.13	1.24	10.86
3	<i>Crepis sancia</i> (L.) Babc.	20000	32	40	0.83	13.44	5.13	1.24	19.80
4	<i>Eragrostris minor</i> Host	44000	70.4	60	1.2	29.56	7.69	1.79	39.04
5	<i>Eremurus persicus</i> (Jaub & Spach) Boiss	6000	9.6	30	7	4.03	3.85	10.42	18.30
6	<i>Iris tenuifolia</i> Pall	20688	33.1	20	4.5	13.90	2.56	6.70	23.16
7	<i>Polygonum paronychioides</i> C.A. Mey	8688	13.9	20	0.5	5.84	2.56	0.74	9.14
	Sub total:		218.2	290	18.06	88.26	37.18	26.88	152.32
	Grand total:		238.16	780	67.19	100	100	100	300

Appendix - 14

SUMMER ASPECTS (HILLS) (July to October, 1997)

PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - VII

Leptorhabdos - *Juniperus* - *Zizyphora* (LJZ)

S.No.	Trees	Density/ ha	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Juniperus excelsa</i>	41	0.065	70	11.46	0.04	9.03	16.29	25.37
	Sub total:		0.065	70	11.46	0.04	9.03	16.29	25.37
	Shrubs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	969	1.55	30	2.63	0.98	3.87	3.73	8.58
2	<i>Acantholimon polystachyum</i> Boiss	250	0.4	15	0.38	0.25	1.94	0.53	2.72
3	<i>Aerua javanica</i> (Burm.f) Juss	594	0.95	30	2.63	0.60	3.87	3.73	8.20
4	<i>Artemisia maritima</i> L.	2906	4.65	45	9.08	2.94	5.81	12.90	21.65
5	<i>Astragalus</i> 97 - 53	1281	2.05	45	6.63	1.30	5.81	9.42	16.52
6	<i>Berberis balochistanica</i> Ahrendt	63	0.1	10	1.50	0.06	1.29	2.13	3.49
7	<i>Ephedra intermedia</i> var <i>glauca</i> Schrenk, Regel, Sta	188	0.3	20	0.5	0.19	2.58	0.71	3.48
8	<i>Hertia intermedia</i> (Boiss.) O. Ktze	813	1.3	40	1.56	0.82	5.16	2.22	8.20
9	<i>Juniperus excelsa</i> M. Bieb *	125	0.2	15	0.25	0.13	1.94	0.36	2.42
10	<i>Nepeta juncea</i> Bth	969	1.55	35	2.50	0.98	4.52	3.55	9.05
11	<i>Onobrychis cornuta</i> (L.) Desv	781	1.25	20	2.25	0.79	2.58	3.20	6.57
12	<i>Perovskia abrotanoides</i> Karel	63	0.1	5	1.88	0.06	0.65	2.67	3.37
13	<i>Prunus</i> sp	125	0.2	10	0.25	0.13	1.29	0.36	1.77
14	<i>Rosa lacerans</i> Boiss & Buhse	188	0.3	15	2.94	0.19	1.94	4.18	6.31
15	<i>Salvia cabulica</i> Bth	63	0.1	10	0.25	0.06	1.29	0.36	1.71
16	<i>Sophora griffithii</i> Stocks	1156	1.85	20	2.38	1.17	2.58	3.38	7.13
	Sub total:		16.85	365	37.58	10.67	47.10	53.42	111.19
	Herbs								
1	<i>Asteriscus pygmaeus</i> (DC.) Coss & Dur	5000	8	20	0.78	5.06	2.58	1.10	8.75
2	<i>Astragalus</i> 97 - 144	2219	3.55	5	0.50	2.25	0.65	0.71	3.60
3	<i>Conyza bomariensis</i> (L.) Cronquist	344	0.55	5	0.04	0.35	0.65	0.06	1.05
4	<i>Eremurus persicus</i> (Jaub & Spach) Boiss	3000	4.8	20	1.35	3.04	2.58	1.92	7.54
5	<i>Euphorbia granulata</i> Forsk	1938	3.1	10	0.13	1.96	1.29	0.18	3.43
6	<i>Euphorbia prostrata</i> Ait	9000	14.4	25	0.33	9.12	3.23	0.47	12.81
7	<i>Forsetia heliophila</i> Bunge ex Coss	2344	3.75	10	0.13	2.37	1.29	0.18	3.84
8	<i>Ferula foetida</i> Regel	344	0.55	5	0.10	0.35	0.65	0.14	1.14
9	<i>Gypsophila lignosa</i> Hemsl & Lace	375	0.6	30	0.56	0.38	3.87	0.79	5.04
10	<i>Iris tenuifolia</i> Pall	7000	11.2	20	1.25	7.09	2.58	1.78	11.45
11	<i>Leptorhabdos parviflora</i> (Bth) Bth	18000	28.8	50	2.94	18.23	6.45	4.17	28.86
12	<i>Malva neglecta</i> Wallr.	1344	2.15	10	0.10	1.36	1.29	0.14	2.79
13	<i>Neslia apiculata</i> Fisch & Mey & Avelal	2656	4.25	5	0.50	2.69	0.65	0.71	4.05
14	<i>Peganum harmala</i> L.	281	0.45	10	0.25	0.28	1.29	0.36	1.93
15	<i>Pennisetum orientale</i> L.	1000	1.6	10	0.60	1.01	1.29	0.85	3.16
16	<i>Perovskia abrotanoides</i> Karel *	2000	3.2	5	0.50	2.03	0.65	0.71	3.38
17	<i>Polygala sibirica</i> Linn	10000	16	5	0.10	10.13	0.65	0.14	10.92

18 <i>Psammogeton</i>	3344	5.35	10	0.60	3.39	1.29	0.85	5.53
19 <i>Pulicaria gnaphalodes</i> (Vent.) Boiss	6656	10.65	35	3.55	6.74	4.52	5.05	16.31
20 <i>Seseli libanotis</i> (L.) Koch	1656	2.65	10	1.50	1.68	1.29	2.13	5.10
21 <i>Zizyphora clinopodioides</i> Lam	9656	15.45	40	5.52	9.78	5.16	7.84	22.78
Sub total:		141.05	340	21.30	89.29	43.87	30.28	163.45
Grand total:		157.965	775	70.34	100	100	100	300

* Seedlings

SPRING ASPECT (WATER COURSE) (April to June, 1997)
 PHYTO SOCIOLOGICAL ATTRIBUTES OF COMMUNITIES - I
Perovskia - Artemisia - Bromus (PAB)

S.No.	Shrubs	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Aerua javanica</i> (Burm.f) Juss	1.00	40.00	0.33	0.97	3.37	2.12	6.46
2	<i>Artemisia maritima</i> L.	10.47	80.00	3.12	10.13	6.74	19.86	36.73
3	<i>Astragalus psilocentros</i> Fisch	0.07	6.67	0.01	0.06	0.56	0.07	0.69
4	<i>Berberis balochistanica</i> Ahrendt	0.07	6.67	0.14	0.06	0.56	0.89	1.52
5	<i>Convolvulus leiocalycinus</i> Boiss	0.13	13.33	0.06	0.13	1.12	0.38	1.63
6	<i>Daphne mucronata</i> Royle	0.20	13.33	0.22	0.19	1.12	1.38	2.69
7	<i>Haloxylon griffithii</i> (Moq.) Bunge ex Boiss	0.27	6.67	0.08	0.26	0.56	0.51	1.33
8	<i>Hertia intermedia</i> (Boiss.) O. Ktze	0.60	20.00	0.19	0.58	1.69	1.19	3.45
9	<i>Nepeta juncea</i> Bth	0.13	13.33	0.03	0.13	1.12	0.19	1.44
10	<i>Perovskia abrotanoides</i> Karel	3.00	73.33	3.95	2.90	6.18	25.14	34.22
11	<i>Perovskia atriplicifolia</i> Bth	0.87	33.33	0.50	0.84	2.81	3.18	6.83
12	<i>Prunus eburnea</i> Aitch	0.07	6.67	0.13	0.06	0.56	0.83	1.45
13	<i>Sophora griffithii</i> Stocks	2.00	60.00	0.54	1.94	5.06	3.41	10.40
Sub total:		18.87	373.33	9.30	18.26	31.46	59.14	108.86
Herbs								
1	97 - 83	1.07	13.33	0.02	1.03	1.12	0.13	2.28
2	97 - 150	0.40	6.67	0.01	0.39	0.56	0.06	1.01
3	<i>Alyssum desertorum</i> Stapf	6.27	33.33	0.24	6.07	2.81	1.53	10.40
4	<i>Alyssum marginatum</i> Stend ex Willd	4.53	26.67	0.19	4.39	2.25	1.23	7.86
5	<i>Astragalus afghanus</i> Boiss	0.07	6.67	0.01	0.06	0.56	0.08	0.71
6	<i>Astragalus orthocarpus</i> Boiss	0.07	6.67	0.01	0.06	0.56	0.07	0.69
7	<i>Bromus sericeus</i> Drobov	19.53	60.00	0.50	18.91	5.06	3.15	27.11
8	<i>Bromus tectorum</i> L.	14.23	60.00	0.38	13.78	5.06	2.44	21.27
9	<i>Chenopodium botrys</i> L.	1.47	6.67	0.04	1.42	0.56	0.23	2.21
10	<i>Cousinia heterophylla</i> Boiss	0.07	6.67	0.01	0.06	0.56	0.07	0.70
11	<i>Cousinia onopordioides</i> Ledeb	0.07	6.67	0.04	0.06	0.56	0.23	0.86
12	<i>Cymbopogon fwarancusa</i> (Jones) Schult	1.07	20.00	0.32	1.03	1.69	2.03	4.75
13	<i>Descurainaea sophia</i> (L.) Webb & Berth	0.20	13.33	0.06	0.19	1.12	0.40	1.72
14	<i>Drabopsis verna</i> C. Koch	0.60	6.67	0.02	0.58	0.56	0.11	1.25
15	<i>Echinops echinatus</i> Rax b.	0.13	13.33	0.05	0.13	1.12	0.30	1.55
16	<i>Euphorbia falcata</i> L.	0.20	6.67	0.02	0.19	0.56	0.11	0.86
17	<i>Euphorbia maddenii</i> Boiss	5.93	60.00	1.45	5.74	5.06	9.22	20.02
18	<i>Galium asparine</i> L.	0.33	6.67	0.01	0.32	0.56	0.06	0.95
19	<i>Hetderoderis stocksiiana</i> Boiss	0.27	13.33	0.02	0.26	1.12	0.13	1.51
20	<i>Holosteum umbellatum</i> L.	2.53	33.33	0.15	2.45	2.81	0.95	6.22
21	<i>Hypecoum pendulum</i> L.	0.20	6.67	0.03	0.19	0.56	0.16	0.92
22	<i>Lappula sessiliflora</i> (Boiss.) Gurke	1.20	20.00	0.05	1.16	1.69	0.32	3.16
23	<i>Leptaleum filifolium</i> (Willd.) DC	0.33	6.67	0.02	0.32	0.56	0.11	0.99
24	<i>Mattiastrium asperum</i> (Stocks) Brand	0.07	6.67	0.01	0.06	0.56	0.08	0.71
25	<i>Minuartia meyeri</i> (Boiss.) Bornm	1.40	26.67	0.10	1.36	2.25	0.66	4.26
26	<i>Peganum harmala</i> L.	0.33	13.33	0.11	0.32	1.12	0.72	2.17
27	<i>Pennisetum orientale</i> L.	0.33	13.33	0.11	0.32	1.12	0.72	2.17

SPRING ASPECT (WATER COURSE) (April to June, 1997)
 PHYTO SOCIOLOGICAL ATTRIBUTES OF COMMUNITIES - I
Perovskia - Artemisia - Bromus (PAB)

S.No.	Shrubs	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Aerua javanica</i> (Burm.f) Juss	1.00	40.00	0.33	0.97	3.37	2.12	6.46
2	<i>Artemisia maritima</i> L.	10.47	80.00	3.12	10.13	6.74	19.86	36.73
3	<i>Astragalus psilocentros</i> Fisch	0.07	6.67	0.01	0.06	0.56	0.07	0.69
4	<i>Berberis balochistanica</i> Ahrendt	0.07	6.67	0.14	0.06	0.56	0.89	1.52
5	<i>Convolvulus leiocalycinus</i> Boiss	0.13	13.33	0.06	0.13	1.12	0.38	1.63
6	<i>Daphne mucronata</i> Royle	0.20	13.33	0.22	0.19	1.12	1.38	2.69
7	<i>Haloxylon griffithii</i> (Moq.) Bunge ex Boiss	0.27	6.67	0.08	0.26	0.56	0.51	1.33
8	<i>Hertia intermedia</i> (Boiss.) O. Ktze	0.60	20.00	0.19	0.58	1.69	1.19	3.45
9	<i>Nepeta juncea</i> Bth	0.13	13.33	0.03	0.13	1.12	0.19	1.44
10	<i>Perovskia abrotanoides</i> Karel	3.00	73.33	3.95	2.90	6.18	25.14	34.22
11	<i>Perovskia atriplicifolia</i> Bth	0.87	33.33	0.50	0.84	2.81	3.18	6.83
12	<i>Prunus eburnea</i> Aitch	0.07	6.67	0.13	0.06	0.56	0.83	1.45
13	<i>Sophora griffithii</i> Stocks	2.00	60.00	0.54	1.94	5.06	3.41	10.40
Sub total:		18.87	373.33	9.30	18.26	31.46	59.14	108.86
Herbs								
1	97 - 83	1.07	13.33	0.02	1.03	1.12	0.13	2.28
2	97 - 150	0.40	6.67	0.01	0.39	0.56	0.06	1.01
3	<i>Alyssum desertorum</i> Stapf	6.27	33.33	0.24	6.07	2.81	1.53	10.40
4	<i>Alyssum marginatum</i> Stend ex Willd	4.53	26.67	0.19	4.39	2.25	1.23	7.86
5	<i>Astragalus afghanus</i> Boiss	0.07	6.67	0.01	0.06	0.56	0.08	0.71
6	<i>Astragalus orthocarpus</i> Boiss	0.07	6.67	0.01	0.06	0.56	0.07	0.69
7	<i>Bromus sericeus</i> Drobv	19.53	60.00	0.50	18.91	5.06	3.15	27.11
8	<i>Bromus tectorum</i> L.	14.23	60.00	0.38	13.78	5.06	2.44	21.27
9	<i>Chenopodium botrys</i> L.	1.47	6.67	0.04	1.42	0.56	0.23	2.21
10	<i>Cousinia heterophylla</i> Boiss	0.07	6.67	0.01	0.06	0.56	0.07	0.70
11	<i>Cousinia onopordioides</i> Ledeb	0.07	6.67	0.04	0.06	0.56	0.23	0.86
12	<i>Cymbopogon fwarancusa</i> (Jones) Schult	1.07	20.00	0.32	1.03	1.69	2.03	4.75
13	<i>Descurainaea sophia</i> (L.) Webb & Berth	0.20	13.33	0.06	0.19	1.12	0.40	1.72
14	<i>Drabopis verna</i> C. Koch	0.60	6.67	0.02	0.58	0.56	0.11	1.25
15	<i>Echinops echinatus</i> Rax b.	0.13	13.33	0.05	0.13	1.12	0.30	1.55
16	<i>Euphorbia falcata</i> L.	0.20	6.67	0.02	0.19	0.56	0.11	0.86
17	<i>Euphorbia maddenii</i> Boiss	5.93	60.00	1.45	5.74	5.06	9.22	20.02
18	<i>Galium asparine</i> L.	0.33	6.67	0.01	0.32	0.56	0.06	0.95
19	<i>Hetderoderis stockiana</i> Boiss	0.27	13.33	0.02	0.26	1.12	0.13	1.51
20	<i>Holosteum umbellatum</i> L.	2.53	33.33	0.15	2.45	2.81	0.95	6.22
21	<i>Hypecoum pendulum</i> L.	0.20	6.67	0.03	0.19	0.56	0.16	0.92
22	<i>Lappula sessiliflora</i> (Boiss.) Gurke	1.20	20.00	0.05	1.16	1.69	0.32	3.16
23	<i>Leptaleum filifolium</i> (Willd.) DC	0.33	6.67	0.02	0.32	0.56	0.11	0.99
24	<i>Matthiastrium asperum</i> (Stocks) Brand	0.07	6.67	0.01	0.06	0.56	0.08	0.71
25	<i>Minuartia meyeri</i> (Boiss.) Bornm	1.40	26.67	0.10	1.36	2.25	0.66	4.26
26	<i>Peganum harmala</i> L.	0.33	13.33	0.11	0.32	1.12	0.72	2.17
27	<i>Pennisetum orientale</i> L.	0.33	13.33	0.11	0.32	1.12	0.72	2.17

28 <i>Perovskia abrotanoides</i> Karel *	0.60	20.00	0.42	0.58	1.69	2.69	4.96
29 <i>Perovskia atriplicifolia</i> Bth *	0.07	6.67	0.01	0.06	0.56	0.08	0.71
30 <i>Piptatherum vicarium</i>	0.60	20.00	0.08	0.58	1.69	0.53	2.80
31 <i>Poa sinaica</i> Stend	0.87	13.33	0.02	0.84	1.12	0.15	2.11
32 <i>Polygala sibirica</i> Linn	5.27	33.33	0.12	5.10	2.81	0.74	8.65
33 <i>Polygonum aviculare</i> L.	0.33	20.00	0.04	0.32	1.69	0.28	2.28
34 <i>Pulicaria gnaphalodes</i> (Vent.) Boiss	0.07	6.67	0.01	0.06	0.56	0.04	0.67
35 <i>Scabiosa oliveri</i> Coult	0.13	6.67	0.02	0.13	0.56	0.11	0.80
36 <i>Shismus arabicus</i> Nees	2.67	6.67	0.07	2.58	0.56	0.47	3.61
37 <i>Stellaria alsinoides</i> Boiss & Buhse	0.93	20.00	0.06	0.90	1.69	0.38	2.97
38 <i>Stipa pennata</i> L.	1.33	20.00	0.42	1.29	1.69	2.67	5.65
39 <i>Tetrapogon villosus</i> Desf	0.40	13.33	0.06	0.39	1.12	0.39	1.90
40 <i>Tulipa polychroma</i> Stapf	0.20	13.33	0.01	0.19	1.12	0.05	1.37
41 <i>Valerianella oxyrrhyncha</i> Fisch & Mey	1.73	26.67	0.13	1.68	2.25	0.81	4.73
42 <i>Verbascum erianthum</i> Bth	2.60	40.00	0.77	2.52	3.37	4.92	10.80
43 <i>Vernoica didyma</i> Tenore	2.13	20.00	0.08	2.07	1.69	0.51	4.26
44 <i>Zizyphora tenuior</i> L.	1.60	26.67	0.12	1.55	2.25	0.74	4.54
Sub total:	84.43	813.33	6.43	81.74	68.54	40.86	191.14
Grand total:	103.30	1186.67	15.73	100	100	100	300

* Seedlings

Appendix - 16

SPRING ASPECT (WATER COURSE) (April to June, 1997)
 PHYTOSOCIOLOGICAL ATTRIBUTES OF COMMUNITY - II
Perovskia - Artemisia - Perovskia (PAP)

S.No.	Shrubs	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Artemisia maritima</i> L.	8.70	100.00	1.84	14.19	7.75	16.57	38.51
2	<i>Astragalus</i> 97 - 53	0.60	30.00	0.16	0.98	2.33	1.40	4.70
3	<i>Astragalus psilocentros</i> Fisch	0.80	40.00	0.12	1.31	3.10	1.08	5.49
4	<i>Acantholimon munroanum</i> Aitch & Hemsl	0.60	30.00	0.10	0.98	2.33	0.90	4.20
5	<i>Berberis balochistanica</i> Alrendt	0.50	40.00	0.23	0.82	3.10	2.03	5.94
6	<i>Convolvulus leiocalycinus</i> Boiss	0.50	20.00	0.20	0.82	1.55	1.80	4.17
7	<i>Hertia intermedia</i> (Boiss.) O. Ktze	1.10	70.00	0.66	1.79	5.43	5.94	13.16
8	<i>Nepeta juncea</i> Bth	0.60	10.00	0.13	0.98	0.78	1.13	2.88
9	<i>Onobrychis cornuta</i> (L.) Desv	1.50	30.00	0.37	2.45	2.33	3.33	8.10
10	<i>Perovskia abrotanoides</i> Karel	6.30	100.00	2.50	10.28	7.75	22.51	40.54
11	<i>Perovskia atriplicifolia</i> Bth	1.70	50.00	0.87	2.77	3.88	7.83	14.48
12	<i>Prunus eburnea</i> Aitch	0.30	20.00	0.18	0.49	1.55	1.58	3.62
13	<i>Prunus</i> sp	0.20	20.00	0.14	0.33	1.55	1.22	3.09
14	<i>Sophora griffithii</i> Stocks	1.30	40.00	0.42	2.12	3.10	3.78	9.00
Sub total:		24.70	600.00	7.90	40.29	46.51	71.09	157.90
Herbs								
1	97 - 128	0.30	10.00	0.03	0.49	0.78	0.23	1.49
2	<i>Alyssum marginatum</i> Steud ex Willd	3.80	40.00	0.17	6.20	3.10	1.53	10.83
3	<i>Bothriochloa ischaemum</i> (L.) Keng	0.20	10.00	0.03	0.33	0.78	0.28	1.38
4	<i>Bromus sericeus</i> Drobov	4.30	60.00	0.24	7.01	4.65	2.16	13.83
5	<i>Bromus tectorum</i> L.	2.90	60.00	0.18	4.73	4.65	1.58	10.96
6	<i>Chenopodium foliosum</i> (Moench) Ashers	0.40	10.00	0.04	0.65	0.78	0.37	1.80
7	<i>Conringia planisiliqua</i> Fisch & Mey	0.30	20.00	0.03	0.49	1.55	0.23	2.26
8	<i>Cousinia heterophylla</i> Boiss	0.60	20.00	0.03	0.98	1.55	0.23	2.75
9	<i>Drabopais verna</i> C. Koch	0.70	10.00	0.03	1.14	0.78	0.23	2.14
10	<i>Eremerus persicus</i> (Jaub & Spach) Boiss	2.20	60.00	0.58	3.59	4.65	5.18	13.42
11	<i>Holosteum umbellatum</i> L.	1.10	20.00	0.04	1.79	1.55	0.33	3.68
12	<i>Iris tenuifolia</i> Pall	0.10	10.00	0.04	0.16	0.78	0.38	1.32
13	<i>Lactuca orientalis</i> (Boiss.) Boiss	0.40	30.00	0.05	0.65	2.33	0.45	3.43
14	<i>Leptaleum filifolium</i> (Willd.) DC	0.60	20.00	0.02	0.98	1.55	0.18	2.71
15	<i>Malva neglecta</i> Wallr.	0.70	30.00	0.07	1.14	2.33	0.64	4.11
16	<i>Medicago polymorpha</i> L.	0.20	10.00	0.02	0.33	0.78	0.14	1.24
17	<i>Melica persica</i> Kunth	0.80	30.00	0.22	1.31	2.33	1.94	5.57
18	<i>Pennisetum orientale</i> L.	2.10	60.00	0.55	3.43	4.65	4.95	13.03
19	<i>Poa pratensis</i> L.	0.20	20.00	0.04	0.33	1.55	0.32	2.20
20	<i>Polygala sibirica</i> Linn	5.10	30.00	0.27	8.32	2.33	2.39	13.03
21	<i>Polygonum aviculare</i> L.	0.50	20.00	0.07	0.82	1.55	0.59	2.95

22 <i>Scrozonera mollis</i> M. Bieb	0.80	30.00	0.04	1.31	2.33	0.36	3.99
23 <i>Shizmus arabicus</i> Nees	2.90	20.00	0.15	4.73	1.55	1.35	7.63
24 <i>Stellaria alsinoides</i> Boiss & Buhse	2.00	10.00	0.16	3.26	0.78	1.40	5.43
25 <i>Tulipa polychroma</i> Stapf *	2.30	10.00	0.04	3.75	0.78	0.32	4.84
26 <i>Tulipa polychroma</i> Stapf	0.40	10.00	0.06	0.65	0.78	0.54	1.97
27 <i>Veronica anagalis aquatica</i> L.	0.70	30.00	0.07	1.14	2.33	0.64	4.11
Sub total:	36.60	690.00	3.21	59.71	53.49	28.91	142.10
Grand total:	61.30	1290.00	11.11	100.00	100.00	100.00	300.00

* Seedlings

Appendix - 17

SUMMER ASPECT (WATER COURSE) (July to October, 1997)
 PHYTO SOCIOLOGICAL ATTRIBUTES OF COMMUNITIES - I
Perovskia - Perovskia - Peganum (PPP)

S.No.	Shrubs	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Aerua javanica</i> (Burm.f) Juss	0.20	13.33	0.06	0.30	1.16	0.30	1.76
2	<i>Artemisia maritima</i> L.	5.67	73.33	2.10	8.48	6.40	10.98	25.86
3	<i>Daphne mucronata</i> Royle	0.27	26.67	0.27	0.40	2.33	1.41	4.14
4	<i>Hertia intermedia</i> (Boiss.) O. Ktze	2.60	66.67	0.58	3.89	5.81	3.03	12.74
5	<i>Nepeta juncea</i> Bth	0.87	26.67	0.24	1.30	2.33	1.24	4.86
6	<i>Perovskia abrotanoides</i> Karel	4.40	80.00	3.33	6.59	6.98	17.43	31.00
7	<i>Perovskia atriplicifolia</i> Bth	3.87	86.67	3.99	5.79	7.56	20.89	34.23
8	<i>Sophora griffithii</i> Stocks	4.27	73.33	1.06	6.39	6.40	5.54	18.33
Sub total:		22.13	446.67	11.63	33.13	38.95	60.83	132.91
Herbs								
1	<i>Aristida</i>	5.80	53.33	0.99	8.68	4.65	5.18	18.51
2	<i>Artemisia maritima</i> L.	0.67	6.67	0.10	1.00	0.58	0.54	2.12
3	<i>Asteriscus pygmaeus</i> (DC.) Coss & Dur	0.93	13.33	0.12	1.40	1.16	0.63	3.19
4	<i>Chenopodium botrys</i> L.	0.93	13.33	0.09	1.40	1.16	0.49	3.05
5	<i>Chenopodium hybridum</i> L.	0.60	20.00	0.07	0.90	1.74	0.37	3.01
6	<i>Cymbopogon jawarancusa</i> (Jones) Schult	0.80	26.67	0.23	1.20	2.33	1.22	4.74
7	<i>Echinops echinatus</i> Rox b.	1.27	40.00	0.21	1.90	3.49	1.12	6.50
8	<i>Euphorbia graulata</i> Forssk	8.40	53.33	0.85	12.57	4.65	4.46	21.69
9	<i>Euphorbia maddentii</i> Boiss	5.20	80.00	1.26	7.78	6.98	6.57	21.33
10	<i>Euphorbia multifurcata</i> Rech f. et al.	0.27	6.67	0.08	0.40	0.58	0.44	1.42
11	<i>Festuca arundinacea</i> Schreb	1.87	26.67	0.21	2.79	2.33	1.12	6.24
12	<i>Hertia intermedia</i> (Boiss.) O. Ktze	0.60	13.33	0.09	0.90	1.16	0.47	2.53
13	<i>Malcolmia</i> sp.	0.93	13.33	0.08	1.40	1.16	0.44	3.00
14	<i>Malva neglecta</i> Wallr.	0.20	13.33	0.03	0.30	1.16	0.17	1.64
15	<i>Peganum harmala</i> L.	0.60	20.00	0.11	0.90	1.74	0.59	3.24
16	<i>Pennisetum orientale</i> L.	0.33	20.00	0.08	0.50	1.74	0.40	2.64
17	<i>Perovskia abrotanoides</i> Karel	0.87	20.00	0.13	1.30	1.74	0.66	3.70
18	<i>Perovskia atriplicifolia</i> Bth	3.73	40.00	0.61	5.59	3.49	3.21	12.29
19	<i>Poa pratensis</i> L.	1.73	20.00	0.27	2.59	1.74	1.41	5.75
20	<i>Polygonum aviculare</i> L.	1.07	13.33	0.11	1.60	1.16	0.58	3.33
21	<i>Palicourea gnaphalodes</i> (Vest.) Boiss	2.33	60.00	0.57	3.49	5.23	2.98	11.71
22	<i>Scrophularia</i> sp	0.07	6.67	0.01	0.10	0.58	0.05	0.73
23	<i>Solanum nigrum</i> L.	0.33	26.67	0.05	0.50	2.33	0.26	3.09
24	<i>Tetrapogon villosus</i> Desf	0.27	13.33	0.06	0.40	1.16	0.31	1.88
25	<i>Verbascum erianthum</i> Bth	2.13	60.00	0.63	3.19	5.23	3.31	11.74
26	<i>Vulpia ciliata</i> (Lam K. & DC) Link	2.73	20.00	0.42	4.09	1.74	2.20	8.03
Sub total:		44.67	700.00	7.49	66.87	61.85	39.17	167.09
Grand total:		66.80	1146.67	19.12	100	100	100	300

Appendix - 18

SUMMER ASPECT (WATER COURSE) (July to October, 1997)
 PHYTO SOCIOLOGICAL ATTRIBUTES OF COMMUNITIES - II
Sophora - Euphorbia - Perovskia (PEP)

S.No.	Shrubs	Density	Frequency	Cover	Relative Density	Relative Frequency	Relative Cover	Importance Value
1	<i>Acantholimon munroanum</i> Aitch & Hemsl	0.20	10.00	0.04	0.30	0.92	0.31	1.53
2	<i>Artemisia maritima</i> L.	3.70	70.00	0.98	5.57	6.42	8.38	20.37
3	<i>Astragalus psilocentros</i> Fisch	0.50	20.00	0.09	0.75	1.83	0.73	3.32
4	<i>Berberis balochistanica</i> Ahrendt	0.20	10.00	0.07	0.30	0.92	0.56	1.78
5	<i>Convolvulus leiocalycinus</i> Boiss	0.30	20.00	0.10	0.45	1.83	0.86	3.15
6	<i>Hertia intermedia</i> (Boiss.) O. Ktze	5.20	80.00	1.07	7.83	7.34	9.15	24.32
7	<i>Nepeta juncea</i> Bth	3.20	80.00	0.61	4.82	7.34	5.20	17.36
8	<i>Perovskia abrotanoides</i> Karel	3.40	80.00	1.94	5.12	7.34	16.67	29.13
9	<i>Perovskia atriplicifolia</i> Bth	3.60	60.00	1.02	5.42	5.50	8.76	19.69
10	<i>Prunus eburnea</i> Aitch	0.10	10.00	0.04	0.15	0.92	0.34	1.41
11	<i>Prunus</i> sp	0.10	10.00	0.05	0.15	0.92	0.44	1.51
12	<i>Sophora griffithii</i> Stocks	8.80	90.00	1.36	13.25	8.26	11.68	33.19
Sub total:		29.30	540.00	7.34	44.13	49.54	63.07	156.74
Herbs								
1	<i>Asteriscus pygmaeus</i> (DC.) Cass & Dur	6.40	90.00	0.85	9.64	8.26	7.26	25.15
2	<i>Bothriochloa ischaemum</i> (L.) Keng	0.90	30.00	0.15	1.36	2.75	1.25	5.35
3	<i>Cousinia heterophylla</i> Boiss	0.40	30.00	0.08	0.60	2.75	0.66	4.02
4	<i>Cousinia onopordioides</i> Ledeb	2.40	60.00	0.27	3.61	5.50	2.32	11.44
5	<i>Crepis sancta</i> (L.) Babc.	3.30	50.00	0.24	4.97	4.59	2.02	11.58
6	<i>Eragrostis minor</i> Host	6.10	50.00	0.35	9.19	4.59	2.96	16.74
7	<i>Euphorbia graulata</i> Forssk	9.70	80.00	1.11	14.61	7.34	9.54	31.48
8	<i>Euphorbia maddenii</i> Boiss	1.30	30.00	0.37	1.96	2.75	3.18	7.89
9	<i>Juniperus excelsa</i> M. Bieb *	0.10	10.00	0.02	0.15	0.92	0.18	1.25
10	<i>Leptorhodos parviflora</i> (Bth) Bth	4.00	40.00	0.56	6.02	3.67	4.77	14.46
11	<i>Pennisetum orientale</i> L.	0.10	10.00	0.03	0.15	0.92	0.27	1.33
12	<i>Polygonum aviculare</i> L.	1.50	30.00	0.20	2.26	2.75	1.68	6.69
13	<i>Polygonum paronychioides</i> C.A. Mey	0.60	20.00	0.07	0.90	1.83	0.56	3.30
14	<i>Solanum nigrum</i> L.	0.30	20.00	0.04	0.45	1.83	0.30	2.59
Sub total:		37.1	550	4.30	55.87	50.46	36.93	143.26
Grand total:		66.4	1090	11.64	100	100	100	300

* Seedling

Appendix - 20

Comprehensive list of palatable tree, shrubs, herbs and grasses/sedges

S.No.	Name of Species	April	May	June	July	August	September	October
Tree								
1	<i>Juniperus excelsa</i> M. Bieb.	HP	HP	NP	NP	NP	NP	
Shrubs								
1	<i>Acantholimon munroanum</i> Aitch & Hemsl.	HP	HP	HP	HP	HP	HP	
2	<i>Acantholimon polystachyum</i> Boiss	HP	HP	HP	HP	HP	HP	
3	<i>Aerua javanica</i> (Burm.f) Juss	MP	MP	MP	MP			
4	<i>Artemisia maritima</i> L.	HP	HP	NP	NP	NP	HP	
5	<i>Astragalus</i> 97 - 53	HP	HP	HP	HP	HP	HP	
6	<i>Astragalus</i> 97 - 8	HP	HP	HP	HP	HP	HP	
7	<i>Astragalus anisacanthus</i> Boiss		HP	HP				
8	<i>Astragalus psilocentrus</i> Fisch		HP	HP				
9	<i>Caragana stocksii</i>	HP	HP	HP				
10	<i>Clematis graveolens</i> Lindl				MP	MP	MP	MP
11	<i>Clematis orientalis</i> L.			MP	MP	MP	MP	
12	<i>Colutea armata</i> Hemsl. & Lace.	MP	MP	MP	MP	MP	MP	
13	<i>Convolvulus leiocalycinus</i> Boiss.	HP	HP	HP	HP	HP	HP	HP
14	<i>Ebenus stellata</i> Boiss	MP	MP	MP				
15	<i>Ephedra intermedia</i> var <i>glauca</i> Schren K. Regel, Stap	HP	HP	HP	HP	HP	HP	HP
16	<i>Gaillonia eriantha</i> Jaub & Spach	MP	MP	MP				
17	<i>Haloxylon griffithii</i> (Moq.) Bunge ex Boiss			LP	HP	HP	HP	RP
18	<i>Hertia intermedia</i> (Boiss.) O. Ktze	MP	MP	NP	NP	NP	NP	
19	<i>Isodon rugosus</i>				HP	HP	HP	
20	<i>Lonicera hypoleuca</i> Dene	MP	MP	MP	MP	MP	MP	
21	<i>Nepeta juncea</i> Bth	LP	LP	LP	MP	MP	MP	MP
22	<i>Nepeta</i> sp				LP	MP	MP	
23	<i>Onobrychis cornuta</i> (L.) Desv	MP	MP	MP	MP	MP	MP	
24	<i>Perovskia abrotanoides</i> Karel		NP	RP	HP	HP	HP	RP
25	<i>Perovskia atriplicifolia</i> Bth	NP	NP	RP	HP	HP	HP	RP
26	<i>Prunus eburnea</i> Aitch	HP	HP	HP	HP	HP	LP	
27	<i>Prunus</i> sp	HP	HP	HP	HP	HP	HP	HP
28	<i>Rosa lacerans</i> Boiss & Buhse	MP	MP	NP	NP	NP	NP	
29	<i>Salvia cabulica</i> Bth	MP	MP	MP	MP	MP	MP	
30	<i>Sophora griffithii</i> Stocks	NP	NP	MP	HP	HP	HP	
31	<i>Spiraea boissieri</i> Schneider	MP	MP	MP	MP	MP	MP	
Herbs								
1	<i>Achillea santolina</i> L.			MP	MP	MP		
2	<i>Adonis aestivalis</i> L.	HP	HP					
3	<i>Allium dolichostylum</i> Vved		MP					
4	<i>Alyssum desertorum</i> Stapf	HP	HP					
5	<i>Alyssum linifolium</i> Stapf ex Willd	HP	HP					
6	<i>Alyssum marginatum</i> Steud ex Willd	HP	HP					
7	<i>Alyssum szovitzianum</i> F & M.	HP	HP					
8	<i>Asparagus capitatus</i> Baker		MP	MP	MP	MP		
9	<i>Astragalus gomphobobium</i> Bth ex Bunge			MP	MP			
10	<i>Astragalus</i> 97 - 151			HP	HP			
11	<i>Bupleurum exaltatum</i> Bieb			LP	LP	LP		
12	<i>Bupleurum linearifolium</i> D.C.		LP	LP	LP			
13	<i>Ceratocephalla falcatus</i> (L.) Pers.	HP						
14	<i>Ceratocephalla testiculata</i> (Crantz) Roth	HP						
15	<i>Chenopodium album</i> L.	HP	HP		HP	HP	HP	
16	<i>Chenopodium botrys</i> L.		MP		MP	MP		

17	<i>Chenopodium foliosum</i> (Moench) Ashers		MP				
18	<i>Chenopodium hybridum</i> L.				MP	MP	MP
19	<i>Convolvulus arvensis</i> L.			HP	HP	HP	
20	<i>Conyza bonariensis</i> (L.) Cronquist					HP	HP
21	<i>Cousinia onopordioides</i> Ledeb	NP	NP	MP	MP	MP	
22	<i>Cousinia</i> sp.	NP	MP				
23	<i>Descurainia sophia</i> (L.) Webb & Berth		HP				
24	<i>Echinops echinatus</i> Rox b.		MP	MP			
25	<i>Epilobium</i> sp.					MP	MP
26	<i>Eremerus persicus</i> (Jaub & Spach) Boiss	MP	MP	MP	MP		
27	<i>Eremostachys vicarys</i> Benth.			MP	MP	MP	MP
28	<i>Euphorbia granulata</i> Forssk.				MP	MP	MP
29	<i>Euphorbia prostrata</i> Ait			MP	MP	MP	MP
30	<i>Farsetia heliophila</i> Bunge ex Coss		HP	HP	HP		
31	<i>Filago hurdwarica</i> (DC.) Wagenitz		HP				
32	<i>Fumaria indica</i> (Hausskn.) H.N.	MP	MP				
33	<i>Gagea pseudo-reticulata</i> Vved.	MP					
34	<i>Gagea</i> sp.	MP					
35	<i>Galium asparine</i> L.		HP				
36	<i>Gnaphalium luteoalbum</i> L.		MP				
37	<i>Gypsophila lignosa</i> Hemsl & Lace		MP	MP	MP	MP	MP
38	<i>Heliotropium brahmicum</i> Stocks	MP	MP				
39	<i>Holosteum umbellatum</i> L.	HP	HP				
40	<i>Hypecoum pendulum</i> L.	HP	HP				
41	<i>Kochia stellaris</i> Moq.				MP	MP	MP
42	<i>Lactuca auriculata</i> Wall. ex DC.		RP	RP	RP	RP	
43	<i>Lactuca orientalis</i> (Boiss.) Boiss		RP				
44	<i>Lactuca persica</i> Boiss	RP	RP				
45	<i>Lithospermum arvense</i> L.	HP	HP				
46	<i>Malcolmia africana</i> (Linn.) R. Br.	HP	HP	HP			
47	<i>Malcolmia</i> sp.				MP	MP	MP
48	<i>Malcolmia strigosa</i> Boiss		HP				
49	<i>Malva neglecta</i> Wallr.	MP	MP	MP	MP	MP	
50	<i>Marrubium vulgare</i> L.				MP	MP	MP
51	<i>Medicago lupulina</i> L.		HP	HP			
52	<i>Medicago polymorpha</i> L.				HP		
53	<i>Minuartia meyeri</i> (Boiss.) Bornm	HP	HP				
54	<i>Neslia apiculata</i> Fisch & Mey & Avelal	HP	HP	HP	HP	MP	MP
55	<i>Nonnea caspica</i> (Willd) G. Don	MP					
56	<i>Orobancha cernua</i> Loeffl	LP	LP	LP	LP		
57	<i>Peganum harmala</i> L.		RP	RP	RP		
58	<i>Polygala hohenackeriana</i> Fisch & Mey	HP	HP				
59	<i>Polygala sibirica</i> Linn	HP	HP				
60	<i>Polygonum paronychioides</i> C.A. Mey				LP	LP	LP
61	<i>Salisola kali</i> L.				MP	MP	
62	<i>Senecio</i> sp.		MP				
63	<i>Silene brahucica</i> Boiss		LP	LP			
64	<i>Solanum nigrum</i> L.						
65	<i>Sonchus maritimus</i> L.				MP	MP	MP
66	<i>Stellaria alsinoides</i> Boiss & Buhac	HP	HP				
67	<i>Taraxacum officinale</i> Weber.		MP	MP	MP	MP	MP
68	<i>Trichodesma stockii</i> Boiss		MP	MP			
69	<i>Tulipa polychroma</i> Stapf.	HP					
70	<i>Valerianella oxyrrhyncha</i> Fisch & Mey	HP	HP				
71	<i>Vernonia didyma</i> Tenore	HP	HP				
72	<i>Veronica biloba</i> L.	HP	HP				
73	<i>Zizyphora clinopodioides</i> Lam				MP	MP	
74	<i>Zizyphora tenuior</i> L.	HP	HP				

Grasses									
1	<i>Aristida sp</i>			MP	MP	MP	MP		
2	<i>Aristida adscensionis</i> L.				MP	MP	MP		MP
3	<i>Boissiera squarrosa</i> (Soland) Nevski		HP	HP					
4	<i>Bothriochloa ischaemum</i> (L.) Keng				MP	MP			
5	<i>Bromus sericeus</i> Drob.	HP	HP						
6	<i>Bromus tectorum</i> L.	HP	HP						
7	<i>Carex sp</i> (i)			HP	HP				
8	<i>Carex sp</i> (ii)			HP	HP				
9	<i>Cymbopogon jwarancusa</i> (Jones) Schult		LP	LP	LP				
10	<i>Eragrostis minor</i> Host		HP	HP	HP	HP			
11	<i>Festuca arundinacea</i> Schreb				HP	HP			
12	<i>Hordeum bogdanni</i> Wilensky		HP	HP	LP				
13	<i>Pennisetum orientale</i> L.	HP	HP	HP	HP	HP	HP		HP
14	<i>Phalaris sp</i>			MP	MP	MP			
15	<i>Piptatherum vicarium</i>	MP	MP	MP					
16	<i>Poa sinaica</i> Steud			HP	HP	HP			
17	<i>Poa bulbosa</i> L.	HP	HP						
18	<i>Polypogon fagax</i> Nees ex Steud		RP	RP	RP	RP			
19	<i>Shismus arabicus</i> Nees	HP	HP						
20	<i>Stipa pennata</i> L.	HP	HP	HP	HP				
21	<i>Tetrapogon villosus</i> Desf		HP	HP					
22	Unidentified (97-108)		HP						
23	Unidentified (97-150)			MP	MP	MP	MP		

Key:

HP = Highly Palatable

MP = Mostly Palatable

LP = Less Palatable

RP = Rarely Palatable

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