ECOLOGICAL EVALUATION FOR SUSTAINABLE UTILIZATION OF PLANT RESOURCES OF GADOON HILLS DISTRICT SWABI, PAKISTAN



BY

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Dedication

Sincerely dedicated to my Parents

University of Peshawar

Peshawar

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by

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ABSTRACT

Ecological Evaluation for Sustainable Utilization of Plant Resources of Gadoon Hills, District Swabi, Pakistan.

by

ZAMAN SHER

This dissertation is multi-dimensional including floristic composition, ecological characterization, ethnobotany, vegetation structure, biomass productivity, palatability and animal preferences, mineral and nutritional analysis of some forage plants of Gadoon Hills, District Swabi, Pakistan during 2009 and 2010. There were 260 plant species belonging to 211 genera and 90 families. Asteraceae, Poaceae, Lamiaceae, Rosaceae, Papilionaceae, Brasicaceae, Euphorbiaceae, Moraceae, Polygonaceae and Caryophyllaceae were important families in the studied area. *Acacia modesta, Acacia catechu, Butea frondosa* and *Mallotus philippensis* were the well represented tree species in tropical deciduous and subtropical zones, while *Pinus roxburghii, Quercus dilatata, Q. incana, Parratiopsis jacquemontiana, Lonicera quinquilocularis, Cotoneaster bacillaris, Vibernum cotinifolium* and *Prunus cornuta* were common at high altitude. *Viscum album* and *Korthalsella opuntia* were the mistletoe and *Cuscuta reflexa* was the only parasite in Gadoon Hills. Shrubs like *Carissa spinarum, Dodonaea viscosa, Gymnosporia royleana, Justicia adhatoda, Otostegia limbata, Sageretia theezans* and *Zizyphus nummularia* were encountered at low altitude while *Berberis lycium, Indigofera heterantha* and *Sarcococa saligna* at the temperate zone. *Apluda mutica, Aristida adscensionis, Heteropogon contortus, Chrysopogon aucheri* and *Themeda anathera* were more or less evenly distributed in the investigated area. Some pteridophytes along with other temperate herbs like *Berginia ciliate, Bistorta amplexicaulis, Valeriana jatamansii* and *Viola serpens* were also recorded in the temperate forests. The biological spectrum showed that therophytes and megaphanerophytes were the most abundant life forms. Microphylls and leptophylls were dominant in the area. Gadoon Hills have rich plant diversity in relation to local uses. These included medicinal (149 spp.), fodder (82 spp.), fuel wood (59 spp.), vegetable (26 spp.), thatching/ roofing and sheltering (25 spp.), fruit yielding (22 spp.), fencing (17 spp.), ornamental (16 spp.), timber wood and poisonous (14 spp. each), agricultural tools making (10 spp.) and honeybee (8 spp.).

Based on cluster analysis the summer and winter vegetation of Gadoon Hills have been classified into three distinct vegetation types i.e. tropical , sub-tropical and temperate zone, occupying different altitudinal confines. Thirteen communities were recognized in each of the summer and winter seasons. The colour of the soil varied from brown to yellowish brown, grey brown. Soils were generally shallow and made up of sandstone and limestone. The texture of the soil varied from sandy to sandy loam. The pH of the soil ranged from 5.2 to 7.64 among the summer and winter showing almost no change. Organic matter contents differed insignificantly among the two seasons. Significant differences were observed in mineral contents among the communities while the differences among the seasons were insignificant. The plant communities inhabiting Gadoon Hills during summer and winter were mostly heterogeneous. Heterogeneity might be due to the presence of large number of annuals and habitat degradation, climate, soil conditions, deforestation, overgrazing, trampling and soil erosion in the study area.

Seasonal availability of palatable fodder species depended on climate and phenological stage. It was recorded that there were 57 species available in April, 56 in May, 60 in June, 59 in July, 55 in August, 42 in September and 30 species in October. The evergreen perennial species were found throughout the year. Of the total 260 recorded species in the study area, 82 plants were palatable. Among them, 26.83% (22 Spp.) were trees, 14.63% (12 Spp.) shrubs and 58.54% (48 Spp.) species were herbs. The overall ratio of palatable species to the total recorded species was 31.54%. The total fresh biomass produced in Gadoon hills was 470303 Kg/ha shared by shrubs (344542 Kg/ha) and herbs (125761 Kg/ha). The total fresh biomass of different shrubs and herbs varied with altitudinal variations in Gadoon hills. The highest total biomass (shrubs and herbs) was observed at 500 m (63366 Kg/ha) and 600 m (61270 Kg/ha) because the tree layer has been completely destroyed and the biomass of these communities was mostly contributed by *Dodonea viscosa* and *Zizyphus nummularia*, respectively.

Macro-mineral (Ca, K, Mg, Na, and N) contents recorded in the leaves of selected trees, shrubs and grasses at three phenological stages were sufficient enough that might execute the necessities of the dependent animals. Macro-mineral contents differed significantly among the forage species and among the phenological stages with some exceptions. Micro-minerals (Cd, Cr, Cu, Fe, Ni, Pb, Zn and Mn)

concentrations available in these forage plants to the grazing livestock were very low, hence this may be, one of the causes responsible for the pitiable health and productivity of the grazing animals in Gadoon hills. ANOVA (P = 0.05) revealed significant difference in micro-mineral contents among the various phenological stages while insignificant difference was observed for these micro-minerals among the different plant species.

The proximate composition and cell wall analysis of some fodder trees showed that dry matter of trees increased with advancing maturity. Ash level, CF was high in all tree species. EE had inconsistent trend in all tree species. In the present study protein contents decreased with advancing growth stages. Carbohydrate had inconsistent trend with advancing age. NDF contents increased with advancing growth stages only in *Celtis*. ADF concentrations increased with advancing maturity in some of the species while in other cases it decreased. The vegetative stages of *Acacia, Celtis* and *Grewia* had low ADL levels. *Q. dilatata* and *Vibernum* showed increase in ADL values with advancing maturity. Variations in the amount of celluloses and hemicelluloses might be due to with seasonal changes as well as with phenology.

Insignificant differences occurred in DM and Ash contents among the different shrubs but differences were significant among the phenological stages. Inconsistent trend was observed in DM and ash contents among the shrubs. Significant differences in crude proteins contents were found among the different phenological stages of the analyzed shrub leaves. There were variations in TDN among species and phenological stages showing inconsistent trend. ADF concentrations decreased in *Debregeasia* and *Rosa* with maturity and this deviates from the general trend already reported. ADL showed inconsistent trend.

In grasses, DM improved in *Heteropogon* and *Themeda* at advanced growth stages. The remaining species showed inconsistent trend. The present study recorded high crude fat contents in grasses species %. Maturity cause an increase in crude proteins levels in may forage plant species. The TDN increased with advancing maturity in some of the grasses while it decreased in other cases. NDF and ADL showed inconsistent trend with advancing maturity. Hemicelluloses ranged from 16.69% to 34.81% in the analyzed grasses. Cellulose contents decreased in *Aristida* and *Themeda* with advancing growth stages. Based on the present findings recommendations for sustainable utilization have also been given.

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INTRODUCTION

INTRODUCTION

Name and Location

District Swabi occupies the south and south-west part of Peshawar Valley, Khyber Pukhtunkhwa, with an average elevation varying from 360 to 2250 meters. It lies between latitude 34-0' and 34-25' N and longitude 72-9' and 72-40' E. The north and north-eastern boundary is natural following for the most part the interfluves of Ambela (Buner) and Gadoon mountains. The Indus river borders the south and south east while the west is separated by Mardan and Nowshera districts. Gadoon tract is hilly lying in the north-eastern part of Swabi District. Of the total 27441 ha area, 13921 ha and 8021 ha is occupied by forests and agriculture, respectively while the remaining 5499 ha are rangelands. It is bounded by District Buner on the North-West and Utman merged area on east and Panjmand-Pabenai-Topi area of the District Swabi. Gadoon tract derives its name from Gadoon or Jadoon tribe inhabiting it. This tribe came here during the sixteenth century with the intention to cross the Indus river and settle in Hazara. Two boats crossed but the third party was persuaded by Utmanzai and prevented them from crossing over. They also trace their descent to Ghurghusht and are named after their great-grand-father Muhammad Ashraf Alia Gadoon. The tribe is further divided in two sections, who own land (dautar), of Salars and Mansoors. Apart from these two sections, there is a third "Hamsaya" tribe of Hassazai who do not own land (dautar) and are given the rights to use wasteland and forest only for guzara and are called "Seri Khor". They have small population with few families. The altitude of the area varies from 410m on the eastern boundary of *mauza* Gandaf to 2250m at Shah Kot Sar (Mahaban forest). The hilly nature of topography of the tract has resulted in enormous increase in its surface area. Gadoon tract was tribal area till 1953 when it was merged into district Mardan. Regular settlement was carried out during 1961 and the wastelands were declared as Guzara forests. The area was once famous for poppy cultivation (Said, 1978).

History

The cultural heritage of Swabi is a glorious chapter of the ancient history of the Indo-Pakistan subcontinent. Its splendor is reflected in its ancient sites which are Lahor, Hund and Rani Ghat. So for the history of Gadoon is concerned very little is known.



Fig. 1. Map of Gadoon Hills showing the research area.

Population

The population of Gadoon tract was 27185 according to the 1961 census, and is entirely rural. It forms 8.2% of the total population of District Swabi (the then Tehsil of District Mardan) having population of 332,553 at the time. In 1981 the population of the tract increased to 52183 against the total population of 625035 of District Swabi. In 1996, the population of Gadoon tract was estimated to be 76,424 (Table 1). Since no population census has been carried out.

Table 1. Statement showing estimated changes in population of Gadoon tract during the period 1961-1996.

Year	Male	Female	Total
1961	13,781	13,404	27,185
1972	19,745	19,205	38,950
1981	26,364	25,819	52,183
1996	38540	37,884	76,424

Source: Bureau of Statistics of Khyber Pukhtunkhwa.

Agriculture

Out of a total of 8021 ha agricultural land a net area of 5650 ha is sown annually, including very limited area sown more than once. Except for Malik Abad and Gandaf villages where land is more or less flat, the arable land elsewhere is situated on steep slopes in the form of small terraces. Fertility is low and differs from place to place. The major crops are maize, Sorghum and wheat. The fruit and vegetables production is meager because of scarcity of irrigation water.

Livestock and Fodder

Livestock population is high. The number of animals per household is about 12. Goats, sheep, cows, buffaloes, donkeys and camels are the animals commonly reared by the tribal in the area. Fodder is obtained from grass cutting at the end of monsoon which is made into hay and stored for stall feeding during winter (Aurakzai, 1997).

Geology

Gadoon tract varies in age from Ordovician to Devonian and is part of lesser Himalayas. The hills are composed of crystalline and metamorphic rocks with non-fossiliferous sedimentary deposits and gabbroic intrusions. The major rock types

occurring in Gadoon tract consist predominantly of quartzite, lime stone, phyllite, carbonaceous and graphitic schist, chloritic schist and basic igneous rocks. The resultant soils obtained from these rocks vary in texture and contents from sandy loam to clayey loam mostly in mixture with gravel with fair depth in valley and shallow elsewhere. Profile development is generally weak with good drainage (Said, 1978).

Climate

The climate of the tract is sub-tropical and semi-arid. The climatic data is provided in Table 2. The area lies between monsoon and western disturbances, resulting in increase rainfall and humidity. The tract shows wide diurnal and annual ranges in temperature due to its inland position and is therefore, classified as continental type. Hot summers are the characteristics of the research area. June and July are the hottest months with mean maximum temperature of 40-42 ^{0}C. There is a slight drop in temperature with altitudinal rise. Winters are cold. The mean monthly winter temperatures are 4 to 10 ^{0}C. January is the coldest month. The annual rainfall varies from 24" to 57" increasing as one goes upward north and rises in height. Bulk of the rain is received during the monsoon. Snow fall in the winters is characteristic feature at high altitude.

Hydrology

The catchment area of the tract is entirely hilly and rises from 410m in the east to 2250m in the north, forming about 3 to 12% gradient along the general slope of the tract. Through the ages the hydrological forces along the precipitous slope have caused formation of numerous deeply cut nullahs along north-southern direction. Steep hilly topography of the tract has enormously increased the surface area with increased surface run-off. Numerous small nullahs combine to form Bada Khawar which drains itself into Indus river. The torrents cause maximum damage in nullahs beds where from boulders to gravel are carried and deposited in nullahs beds lower down with fanning effect. This action has resulted in increase in nullahs beds width and consequent damage to fields in the plains. Water obtained from snow fall and several springs in the upper reaches provides not only drinking water but in some places it is used for agricultural purposes. In the lower reaches of the tract, even drinking water is difficult to get.

Flora

The flora of Gadoon tract is rich. The common tree vegetation is composed of *Pinus roxburgii, Quercus sp. Acacia nilotica, A. catechue, A. modesta* and *Tamarix aphylla*. The

dominant shrubby flora consisted of *Zizyphus nummelaria, Justacia adhatoda, Dodonaea viscosa* and *Gymnosporia royleana,* while the *Saccharrum spontanum, Cenchrus ciliarus* and *Cymbopogon jawarancusa* etc are common grasses.

Fauna

Wild cat, fox, Jackal, wild rabbit, porcupine, Hedgehog, Squirrel, mice, snakes, lizards Quail, Owl, wild pigeon, black and grey partridges, crow, Dove and nightingale etc. are common fauna of the area.

TABLE 2. MEAN MONTHLY CLIMATIC DATA OF KAKUL (Nearest Station to Gadoon Hills).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NO OF CLOUDS AT 0800 AM (OCTAS) [-100 Means data not available]												
2001	0.3	0.9	0.8	1.4	0.5	2.2	2.9	2.1	1.1	0.3	0.6	0.9
2002	0.7	1	1.1	1.5	0.4	0.8	1.1	3.8	1.2	0.3	0.3	1.8
2003	0.5	2.4	2.4	1.4	1.4	0.7	3.9	3	2.5	0.3	1	1.5
2004	2.8	1.2	0.5	1.8	1.2	1.9	2.3	2.4	0.8	1.4	0.6	1.6
2005	1.8	3.2	2.7	1.4	0.9	1	3.3	1.7	1.6	0.7	1	0.2
2006	2.1	2	2	1.2	0.3	1.9	3.2	3	1.5	0.6	1.5	2.3
2007	0.5	2.6	2.5	0.4	0.5	1.6	2.3	1.4	1.8	0	0.1	0.8
2008	1.9	1.6	0.8	2	0.6	2.5	2.3	1.8	0.7	0.5	0.6	1.3
2009	1.9	1.8	1.4	1.3	0.6	1.2	1.5	2.4	0.5	0.4	0.6	0.7
2010	0.8	2.6	0.9	1.6	1.5	1	2.5	2.9	1	0.6	0.5	0.5
WIND DIRECTION AT 0800 AM [-100 Means data not available]												
2001	C	N45E	N18W	N52E	W	C	N18W	N45W	N45W	C	N45E	C
2002	S	CALM	N24E	N45W	S81E	S22E	S45E	S64E	CALM	N45E	S45E	E
2003	N45E	W	N23E	N60W	N62W	S67W	S45E	N45W	N30E	CALM	N	N
2004	CALM	S45W	N45W	S45E	N40W	CALM	N	S80W	CALM	S22E	CALM	CALM
2005	C	C	C	S45E	N45W	S45E	C	C	C	S	S45E	C
2006	N45E	C	C	C	N	N18W	C	C	C	C	C	C
2007	N16E	C	N22E	S45E	N18E	N45W	S23W	N18W	S45E	C	N45W	N45E
2008	N	S45W	N	N10E	W	C	C	N45W	C	S45E	N	N
2009	S45E	S82W	S74E	S67W	C	N09E	N45W	C	W	C	C	C
2010	N	S72E	C	N	N63W	N34W	N45W	C	N45W	S45E	C	C
ATM PRESSURE ON SEA LEVEL AT 0800AM (MBS) [-100 Means data not available]												
2001	1474.8	1474.7	1479.1	1474.4	1434.7	1409.9	1412.8	1431.7	1463.5	1489.7	1510	1513.5

2002	1488	1499.2	1481.3	1463.9	1435.6	1424.8	1406.8	1428.1	1469	1495.4	1503.6	1495.5
2003	1499.1	1475.2	1475	1470.1	1445.4	1406.8	1424.5	1431.5	1455.9	1496.2	1501.4	1504.1
2004	1483	1486.4	1483.8	1455.6	1436.4	1423.2	1413.2	1427.2	1469.5	1507.2	1511.5	1502.3
2005	1479.9	1471.7	1480.1	1474.4	1452.2	1412.7	1411.1	1417.2	1463.6	1495.1	1504	1492.7
2006	1487.4	1493.6	1478.3	1462.1	1442.8	1432.3	1406.4	1430.2	1463.8	1501.6	1503.2	1501.4
2007	1503.2	1472.9	1475.7	1471	1451.8	1421.5	1405.3	1422	1446.4	1487.2	1500.6	1496
2008	1474.4	1475.1	1474.6	1467	1434.7	1410.2	1408.1	1422	1469.1	1495.2	1501.3	1500.1
2009	1498.6	1477.8	1476.9	1466.7	1441.6	1425.9	1410.4	1433.3	1458.7	1491.3	1498.8	1494.7
2010	1504.7	1483.3	1479.6	1473.3	1440.7	1431.5	1423.2	1435.2	1455.7	1479.6	1494.1	1470.8
MONTHLY TOTAL RAIN (MM)[-1=TRACE] [-100 Means data not available]												
2001	0.5	8.8	100.1	95.6	46.7	242.9	201.6	161.1	33	10.1	36.1	3.5
2002	63.1	9.7	76.1	47.6	29.9	83.1	166.3	301.4	27.2	28.9	1	22.3
2003	30.9	282	198.6	119.2	90.3	121.4	285.5	158.9	105.5	7.5	27.2	86.4
2004	108.3	45.9	13.4	134	65.4	89.6	209.7	221.5	71.7	124.1	40.5	47.2
2005	117	196.1	186.5	64.7	68.4	45.3	198.1	146.3	41.4	79.3	21.5	0
2006	125.5	78.5	61.5	74.7	61.7	68.1	329.7	191.5	62	37	84.6	171.9
2007	2.1	85.8	179.2	41.1	65.6	135.1	294.6	180.4	155.2	0	19.3	35.7
2008	200	67.8	20.3	131	45.1	248.7	269.1	161.6	39.5	36.1	77	111.5
2009	74.2	99.5	85.6	207.8	34.5	78.9	152.5	177.8	48.8	23.8	34.7	8.2
2010	20.2	214.4	53.5	49.6	85.6	69.1	389.2	140.5	120	15.9	2	24.4
DEW POINT TEMP. AT 0800 AM (°C) [-100 Means data not available]												
2001	-5.4	-2.8	0.4	9.6	13.4	18.6	20.6	20	13.7	8.2	1.4	-1.3
2002	-3.4	0	4.4	8.7	11.6	14.7	17.2	19.4	13.6	9.1	2	-1.2
2003	-3.8	1.5	4.4	9.5	10.1	14.9	19.8	19.3	16.7	7.3	0.8	-0.3
2004	0.8	0.4	5.4	10	11.1	15.3	18.4	18.8	15.4	8.5	3.3	0.5
2005	-0.2	1.5	6.4	6.3	10.3	14.4	19.6	19	16.9	7.4	0.7	-5.5
2006	-0.4	3	5	7.6	12.8	14.3	20.1	19.7	15.1	10.1	5.8	0.5

2007	-3.6	2.7	4.6	10	12.4	16.6	19.4	19.6	16.3	5.5	0.5	-0.4
2008	-1.8	-1.3	4.3	9	12.3	19.2	19.9	19.1	14.4	9.7	1.6	1.1
2009	0.8	1.6	3.9	8.5	9.9	11.5	17.5	20.1	15.3	6.4	1.6	-1.7
2010	-2.7	1.6	5.6	9.8	11.4	13.4	18.2	19.6	15.2	9.3	2.6	-3
MONTHLY MEAN MINIMUM TEMPERATURE (oC) [-100 Means data not available]												
2001	-0.1	2.4	6.1	10.9	16.5	18.4	18.9	18.3	14.1	10.6	4.5	1.7
2002	-0.1	2.5	7.5	11.8	16.2	19	19.7	19.8	14.7	11.9	7.2	3.5
2003	2	2.8	6.4	11.3	13	18.7	19.8	19.2	17	10.5	5.5	3
2004	2.2	3.2	9.2	12.6	15.1	18.1	19.5	18.8	16.8	9.6	6.4	3.4
2005	0.1	1.7	7.1	9.6	12.5	18.6	20	18.9	17.2	10.3	5	1.2
2006	0.7	6.1	6.6	10.2	17.5	17.7	20.3	19.2	15.5	11.6	6.4	2.1
2007	0.1	3.5	5.5	11.9	16.2	18.9	18.9	19.4	16.1	9.5	6	1.3
2008	-1	0.9	8.5	10.1	14.9	19.3	19.4	18.7	14.7	11.4	5.7	3.4
2009	2.2	3	6	9.4	13.8	15.9	18.6	19.7	15.6	9.3	4.9	1.9
2010	1.7	1.9	8.3	11.9	14	16.2	18.1	19.2	15.1	10.4	5	1.2
MONTHLY MEAN MAX TEMP. (°C) [-100 Means data not available]												
2001	15.9	17.3	21.3	24.3	32.4	30.4	29.1	29.4	28.9	27.4	21.7	17.8
2002	15.1	14.3	21	25.7	31.8	33.2	32.5	28.5	27	26.1	22.3	15.8
2003	16.2	13.7	17.6	24.1	27.2	33.3	30	29.1	27.6	26.3	19.9	15.4
2004	12.3	16.8	24.7	26.6	30.3	31.4	31.6	29.1	29.1	22.7	21.4	16
2005	11.2	10.3	17.9	23.9	26.6	33.4	29.3	29.6	29.2	25.9	20	16.9
2006	12	18.6	18.4	25.1	32.7	31.9	30	27.9	28.5	26.2	18.5	13.1
2007	14.5	14.3	17.3	28.6	29.7	32.4	29.3	30.1	27.8	26.8	23.5	14.5
2008	9.9	13.9	23.4	23	30.3	30.8	29.5	28.8	28.6	27	21.5	16.6
2009	14.2	14.9	19.5	22.8	30.2	32.1	32.9	30.4	29.5	25.8	20.8	16.4
2010	17.6	13.9	23.7	27	29	31.9	30.9	28.3	28.1	26.4	22.8	17.8

REVIEW OF LITERATURE

LITERATURE REVIEW

Floristic composition

Floristic composition is a reflection of physiognomy, floristic diversity, environmental and biotic influences. Regional flora always save time and provide precise information. Thus, there is a dire need to prepare a comprehensive floristic list from ecological, taxonomic and wildlife point to establish baseline data. Jones & Hayes (1999) expressed their concern over recent losses of floristic diversity in British grasslands that have led to a new impetus to recreate species-rich pastures. Gutkowski *et al.* (2002) reported 69 species from Dynow Foothills, including 7 non native species to the area.

Kwiatkowski (2002) presented the list of vascular plants from Kaczawskie Mts and Plateau, Poland. Approximately 600 of the selected species, 160 rare, interesting and endangered taxa of vascular flora were found, most of them new. Exemplary rare and endangered species are: *Alchemilla subcrenata, Allium angulosum, Cardamine flexuosa, Elatine hydropiper, Epipactis purpurata, Linaria arvensis, Omphalodes scorpioides, Pyrola media, Sagina ciliata, Thlaspi perfoliatum.* While *Carex umbrosa, Epipactis albensis, Eryngium planum, Euphorbia virgultosa, Fumaria officinalis subsp. wirtgenii, Galium rivale, Gnaphalium norvegicum, Ononis repens, Poa subcaerulea* and *Symphytum bohemicum* were the new record for the area. Catarino *et al.* (2002) recorded 46 vascular plant species including 32 emergent macrophytes, mostly Poaceae and Cyperaceae, five floating-leaved, three submerged, one surface-floating and also five shrubs. Cluster analysis of the floristic data showed two main groups of inventories in both seasons.

Changwe & Balkwill (2003) enlisted 254 taxa in 172 genera and 63 families from Dunbar Valley in Barberton Greenstone Belt (BGB). The genus *Senecio* was the most specious genus. The level of species endemism was 2.0%. Lehnebach (2003) compiled checklist of the orchids of Chile by using databases. The list comprised of seven genera (*Aa, Bipinnula, Brachystele, Chloraea, Codonorchis, Gavilea* and *Habenaria*) and 50 taxa (49 species and one variety), 25 of which are believed to be endemic to Chile. El-Ghani & Amer (2003) reported 203 vascular species of 39

families. Asteraceae, Fabaceae, Chenopodiaceae and Poaceae were the largest families. Grasses constituted only 9% of the recorded species; woody perennials (shrubs and sub-shrubs) were 46%. There were 46% uniregional: Saharo-Arabian species. Some 50% species were biregional and pluriregional, extending their distribution all over the Saharo-Arabian, Sudano-Zambezian, Irano-Turanian and Mediterranean regions.

Waldhardt *et al.* (2003) observed decline in floristic diversity at the habitat level. They stressed the preservation of floristic diversity as one of the important goal of modern, multifunctional agricultural land use. Key indicator species allow an easy assessment and evaluation of diversity. Potentially, indicators of biodiversity measures at the habitat scale can be developed from a large number of parameters. Hussain *et al.*, (2004) reported 256 species belonging to 90 families from the various parts of District Swat. It included two bryophytes, 5 pteridophytes, 4 gymnosperms, 22 monocots and 215 dicots. These species were classified into 173 herbs, 48 shrubs, 35 trees, one parasite and one fungus. Muoghalu & Okeesan (2005) reported 49 climber species consisting of 35 (34%) liana and 14 (13.7%) vine species distributed over 41 genera and 28 families in the forest of Ile-Ife, Nigeria. The number of species, genera and families and basal area increased with altitude. Forty-two per cent (42%) of the trees in the forest carried climbers. There was significant positive correlation ($P \leq 0.05$) between girth sizes of host trees of 31–50 cm with the girths of climbers on them indicating that trees of these girth sizes are highly susceptible to climber infestation. Durrani *et al.* (2005) reported 202 species of 45 plant families from Harboi rangeland (Kalat, Pakistan). Asteraceae, Papilionaceae, Poaceae, Brassicaceae and Lamiaceae were the leading families. *Juniperus macropoda* was the only tree species while *Artemesia maritima, Sophora griffithii, Hertia intermedia, Nepeta juncea, Perovskia abrotanoides, Convolvulus leiocalycinus* and *Astragalus spp.* were the most common shrubs.

While observing changes in tree, liana, and under story plant diversity and community composition in five tropical rain forest fragments in the Valparai plateau, Western Ghats, Muthuramkumar *et al.* (2006) reported 144 tree species, 60 lianas, and 108 understory plants distributed among 103 families. Understory species density was highest in the highly disturbed fragment, due to weedy invasive species occurring

with rain forest plants. Segawa & Nkuutu (2006) reported 179 species belonging to 70 families and 146 genera from Lake Victoria Central Uganda. Rubiaceae was the dominant family with fourteen species followed by Euphorbiaceae (13 spp.), Apocynaceae (10 spp.) and Moraceae (9 spp.). The remaining 35 families were represented by one species each. Species diversity was higher in trees (72 sp.) followed by herbs (58 sp.), lianas (39 sp.) and shrubs (10 sp.).

Yadav & Gupta (2007) quantified the diversity of herbaceous species in relation to various micro-environmental conditions and human disturbance in the Sariska Tiger Project in Rajasthan, India. They concluded that disturbance adversely affected the species richness of the herbaceous vegetation. Several species were observed to be very sensitive to human disturbance and have disappeared from the disturbed areas. Hussain *et al.* (2007) recorded 111 species belonging to 46 families including 39 Dicot (98 spp), 5 monocot (11 spp) and 2 gymnosperms (2 spp.) from Mastuj, District Chitral. The monocot families were Alliaceae, Iridaceae, Juncaceae, Poaceae and Typhaceae. The two gymnosperms were Cupressaceae and Ephedraceae. Asteraceae (11 spp.); Papilionaceae (10 spp.); Rosaceae (9 spp.); Brassicaceae and Polygonaceae (5 spp. each); Chenopodiaceae, Lamiaceae, Salicaceae and Solanaceae (each with 4 spp.), Alliaceae, Apiaceae and Poaceae (each with 3 spp.) were the leading families in terms of number of species. The remaining families had less than 3 species.

Perveen & Hussain (2007) recorded 74 plant species representing 62 genera and 34 families from Gorakh Hill District Dadu. Out of these 3 families belonged to monocot; Poaceae, Palmae and Liliaceae and 31 to Dicots. Sher & Khan (2007) reported 222 plant species belonging to 88 families from Chagharzai Valley, District Buner. Of them 78 families were Dicots; 7 Monocots and 3 Pteridophytes. Pinaceae was the only Gymnosperm family. Asteraceae had 21 species, which was followed by Papilionaceae (12 spp.), Lamiaceae (10 spp.), Poaceae and Rosaceae (each with 9 spp.), Ranunculaceae (7 spp.), Moraceae (6 spp.). Each of the Amaranthaceae, Brassicaceae, Solanaceae, Apiaceae, Euphorbiaceae and Polygonaceae had 5 species. Chenopodiaceae, Mimosaceae and Papaveraceae had 4 species, while the remaining families had 3 or less than 3 species. Mohandass & Vijayan (2007) reported 83 species, 68 genera and 40 families from Montane evergreen forests, India. Of these,

16 species from 12 genera and 12 families were lianas. The remaining were trees. About 30% of the species were endemic. Faridah-hanum *et al.* (2008) reported that a 5-ha plot contained a total of 6621 trees (for trees greater than 5cm dbh) in Ayer Hitam Forest, Puchong Malaysia. These belonged to 319 species in 148 genera and 51 families and that is 11% species, 28% genera and 51% families of the total tree taxa found in Peninsular Malaysia. Endemism and new records were high, 33 species and 30 species respectively.

Mood (2008) reported a total of 37 families, 128 genera and 160 species from Birjand, eastern part Iran located along Afghanistan border. The big families were: Asteraceae (22 species), Chenopodiaceae (16 species), Brassicaceae (11 species), Lamiaceae (10 species), Caryophyllaceae (9 species), Poaceae (8 species), Fabaceae (8 species) and Boraginaceae (8 species). Asteraceae with 16 genera and 22 species is the largest family and the largest genera are *Salsola* and *Acanthophyllum* with 4 species. Perveen *et al.* (2008) recorded 79 plants species, 66 genera under 32 families from Dureji game reserve. The largest family was Poaceae (12 sp.), followed by Papilionaceae (7 sp.) and Asteraceae (6 sp.). No endemic species was found. *Cometes surattensis*, *Desmostachya bipinnata* and *Solanum surattense* were reported as rare species.

Qureshi (2008) identified 136 plant species including one fern, one gymnosperm, 6 sedges from Sawan Wari of Nara Desert. These species were distributed to 73 genera and 44 families. The leading plant families were Poaceae (18.38%), Fabaceae (8.82%), Amaranthaceae (5.15%), Convolvulaceae and Cyperaceae (4.14% each). Santos *et al.* (2008) listed 43 families, 130 genera, and 225 species along with species richness and distribution from northeastern Brazil. Precipitation and altitude were considered as possible predictors of species richness. Euphorbiaceae had the highest richness (34 sp.), with the genus *Croton* (11 sp.). Four species were found to be widely distributed, 33 demonstrated intermediate distribution, and 188 had restricted distribution. Francisco *et al.* (2009) stated that Commelinaceae of Equatorial Guinea, had 46 taxa in 12 genera. The best represented genus was *Palisota*, (11 sp.). Eleven species were first record in the country.

Böcük *et al.*, (2009) reported the survival of 589 species belonging to 314 genera classified within 67 families under natural and anthropogenic effects in Phrygia Region (Central Anatolia, Turkey). The largest family was Asteraceae (72 sp.) and the richest genus was *Centaurea* (13 sp.). Primary vegetation was destroyed in low and high parts around steppe plains and replaced by secondary vegetation with antropogenic characteristics in the area. Yemeni & Sher (2010) prepared a floristic list of 189 species belonging to 74 families from Asir Mountain of the Kingdom of Saudi Arabia. There were 65 dicots and 4 monocots, while gymnosperms and pteridophytes were represented by one family each. Asteraceae was the dominating family in the study area. Durrani *et al.* (2010) concluded that in Aghberg rangelands of Quetta Pakistan, the protected sites had 123 species of 36 families, while unprotected sites had only 28 species. The study showed that Asteraceae, Fabaceae, Poaceae, Brassicaceae, Lamiaceae and Boraginaceae were important families in the protected area. *Seriphedium qutensis, Sophora mollis, Hertia intrmedia, Nepeta juncea, Astragalus Spp.* and *Convolvulus leiocalycinus* were most common shrubs. *Pennisetum orientale, Bromus tectorum, Bromus sericeus, Schismus arabicus, Poa pratensis, Cymbopogon jwarancusa, Lolium temulentum, Eremopyrum benouepartes, Tanantherum crinatum* and *Saccharum bengalense* were most common grasses.The review of literature shows that no information exists on the flora of Gadoon Hills, therefore, there is a dire need to record the floristic diversity of this area.

Biological spectrum

Deteriorating environmental conditions such as aridity, soil salinity, soil erosion and acid rain are potential threats to biodiversity. The life form and leaf size spectra are important physiognomic attributes characterizing vegetation. The life form is indicator of micro and macroclimate condition. Mark *et al.* (2001) examined the alpine vegetation in southern Tierra del Fuego and stated that chamaephytes and hemicryptophytes dominated the vegetation.

Based on Raunkiaer's life-form spectra Batalha & Martins (2002) recognized hemicryptophytes and the phanerophytes as major groups from cerrado sites. The former prevailing in sites with open physiognomies and the later in closed physiognomies. The cerrado sites distinguished themselves from the savanna sites by

their under-representation of therophytes. El-Ghani & Amer (2003) reported that therophytes and chamaephytes are the most frequent classes denoting a typical desert life form spectrum of El-Qaa plain along the Gulf of Suez (south Sinai, Egypt). Batalha & Martins (2004) recorded 75 phanerophytes (52.21%), 13 chaemophytes (11.50%), 21 hemicryptophytes (18.58%), 1 geophyte (0.88%), 2 therophytes, (1.77%), 14 lianas (12.39%), 2 epiphytes (1.77%) and 1 saprophyte (0.88%) from cerrado site of Brazil.

Giménez *et al.* (2004) working on the flora and biodiversity of Iberian Peninsula reported 516 vascular endemic species or subspecies. The endemicity rate was 13%. The biological spectrum did not follow the usual patterns observed either in local flora in the south of the Iberian Peninsula or in other regions of the Mediterranean Basin. Chamaephytes (46.08%) and hemicryptophytes (31.37%) were very abundant, whereas therophytes (11.96%) and phanerophytes (0.98%) were comparatively rare. Chamaephytes had their highest density rates within 1400–2000 m a.s.l., but these records decrease with increasing rainfall. Abundance of hemicryptophytes is directly dependent on rainfall and inversely dependent on temperature. The altitudinal distribution pattern of therophytes is opposite to that of hemicryptophytes, but without any clear correlation with rainfall gradient.

Costa *et al.* (2007) stated that life-form spectrum consisted of therophytes (42.9%), phanerophytes (26.3%), camaephytes (15.8%), hemicryptophytes (12.8%), and cryptophytes (2.3%) in Caatinga vegetation. The herbaceous/woody ratio was 1.4. Sher & Khan (2007) stated that the biological spectrum of the vegetation of Chagharzai valley, District Buner consisted of therophytes (86 spp., 38.56%) and nanophanerophytes (41 spp., 18.38%) were the most abundant, followed by megaphanerophytes (38 spp., 17.04%). Geophytes (18 spp., 8.07%), hemicryptophytes (17 spp., 7.62%), chamaephytes (14 spp., 6.27%) and lianas (9 spp., 4.03%) had low occurrence in the investigated area. Leaf spectra of plants consisted of microphylls (54.70%), mesophylls (19.28%), nanophylls (13.00%), leptophylls (8.96%) and megaphylls (4.03%). Mood (2008) while determining the life form of plant species recorded that phanerophytes comprised 11.45%, chamaephytes 20%, hemicryptophytes 27%, chryptophytes 5.7% and therophytes 33% in the flora of Birjand (Iran). Perveen *et al.*, (2008) reported high percentage of chaemophytes from

Dureji game reserve followed by phanerophytes, therophytes, hemicryptophytes and climbers. Böcük *et al.*, (2009) stated that the dominant biological types in Phrygia Region consisted of hemicryptophytes (37%) and therophytes (29.9%).

Hussain & Perveen (2009) while determining the life form of plants from Tiko Baran, Khirthar range stated that chaemophytes were the most dominant class followed by therophytes, phanerophytes, hemicryptophytes and climbers. Manhas *et al.* (2010) reported that of the total of 206 species from Pathankot, Hoshiarpur and Garhshanker, India, therophytes (52%) were the most dominant life form followed by phanerophytes (27%) in the study area. Yemeni & Sher (2010) showed that therophytes (36.5%) followed by hemicryptophytes (15%) and geophytes (12.5%) were dominant in Asir Mountain of the Kingdom of Saudi Arabia. Chaemophytes 6.5%, mesophanerophytes 3%, megaphanerophytes 2%, nanophaneorophytes 13% and climbers 1.5% contributed towards the establishment of vegetation structure. The leaf size spectra revealed that microphylls (38.5%) followed by nanophylls (24%), leptophylls (13.5%), mesophylls (12%), macrophylls (3%) and megaphylls (1%) were important. The biological spectrum of the high altitude was characterized by phanerophytes mainly representing nanophanerophytic followed by hemicryptophytic and geophytic species. These were increasing with the rise in elevation while the megaphanerophytic species were decreasing.

Ethnobotany

Plants are fundamental to almost all life on the earth, providing protection and sustenance for organism ranging from bacteria to large mammals. With their unique capacity for photosynthesis, they form the basis of biological food web, meanwhile producing oxygen and mopping up excess levels of greenhouse gas carbon dioxide. Plants perform a number of important environmental services, recycling essential nutrients, stabilizing soils, protecting water catchment areas, and helping to control rainfall via the process of transpiration. Today ethnobotany is widely accepted as a science of human interaction with plants and its ecosystem. Due to changes in life style and knowledge, its material base is endangered and rapidly disappearing. The major benefits of ethnobotany are preservation and improvement in traditional

knowledge, community development, conservation and development of wild crop species and the endangered useful plants (Cotton, 1996).

Dar (2003) ethnobotanically explored in Lawat and its allied areas District Muzzaffarabad. Of the 52 recorded plant species, many were used medicinally and for other purposes. The investigation indicated that medicinal plants were used singly or used with mixtures by local inhabitants. The area under investigation due to unplanned exploitation had resulted in loss of medicinally important plant species. Olsen & Larsen (2003) reported the importance of commercial alpine medicinal plants from the wild by local rural house- holds throughout the Himalayas that are sold to increase household incomes. These include thousands of tones of roots, rhizomes, tubers, leaves, etc., worth millions of US dollars. The study by Ogunkunle & Oladele (2004) showed that 76% of households depend on fuel wood for cooking in five Local Government Areas (LGA) of Oyo State in Nigeria. The total annual wood consumption for fuelling by bread bakers, food sellers and in domestic cooking was 5984 metric tons for the region. The sawmills in the study area also convert 79889 metric tons of wood yearly into boards of different grades. Total wood consumption outstrips the quantity of wood extracted from the forests. Wazir *et al.* (2004) enlisted 41 species, belonging to 29 families of wild herbs, shrubs and trees, in Chapursan Valley, Pakistan. These plant species were found to be used as medicinal by the inhabitants in the valley. Ahmad (2007) reported 81 medicinal plants belonging 44 families along Lahore-Islamabad motorway used for curing fever, skin diseases, snakebite, jaundice, dysentery etc. He stressed for revitalization of traditional herbal medicines as the practice of herbal medicine is diminishing.

Hazrat *et al.* (2007) reported 51 local uses for various ailments for 39 species of the family Ranunculaceae in Dir Valley. The local medicinal uses include anticancer, painkiller, diuretic, febrifuges, carminative, anthelmintic, anti-inflammatory, aphrodisiac, cardio tonic, tonic, stomachache, dyspepsia, jaundice, leprosy, cough, asthma, ulcers, vomiting etc. Hussain *et al.* (2007) evaluated 111 species of 46 families as plant resources used traditionally in Mastuj, District Chitral, Pakistan. It was seen that there were 90 fodder, 52 medicinal, 40 firewood, 19 vegetable, 15 thatching/fencing, 13 timber and 9 fruit species. Two species including *Haloxylon griffithii* and *Vaccaria pyramidata* are used for making soap. Ibrar *et al.*

(2007) reported 37 fuel species, 37 forage/fodder species, 31 medicinal species, 18 edible species, 12 species used for making shelter, 10 vegetables species, 9 poisonous species, 7 ornamental species, 6 timber wood species, 4 furniture wood species, 4 species used for fencing, 4 honey bee plants, 3 species for agricultural tools, 2 species used as flavoring agents, 2 species for making mats and baskets from Ranyal Hills District Shangla, Pakistan. Khan & Khatoon (2007) reported 48 species of trees and shrubs used in everyday life such as for medicine, shelter, agricultural tools and fuel from Haramosh and Bugrote valleys in Gilgit of the Northern Areas of Pakistan. The population of the region primarily depends upon plant resources for their domestic needs.

Qureshi *et al.* (2007a) reported the medicinal value of 33 plant species from Sudhan Gali and Ganga Chotti Hills, District Bagh, Azad Kashmire. Phenological studies are helpful to identify the medicinal plants. Husain *et al.* (2008) reported 40 species belonging to 39 genera and 32 families which were used medically by inhabitants of Morgah Biodiversity Park, Rawalpindi. The inhabitants of the area use the medicinal plants for various purposes and have for a long time been dependent on surrounding plant sources for their food, shelter, fodders, health care and other cultural purposes. Ahmad & Husain (2008) reported the medicinal uses of 29 species belonging to 18 families on salt range (Kallar Kahar) Pakistan. Local communities of the area have rich tradition of using natural plant resources for their common day ailments such as fever, cold, cough and diarrhea could be treated by simple herbal teas and powders. The local people were using the medicinal plants because they cannot afford expensive synthetic drugs.

Ilahi (2008) reported the ethnobotanical importance and problems associated with regeneration of herbals in Kohat Region. As an alternate and to save the environment from further degradation, selected herbals were grown in the Medicinal Plants Farm of the university at Kohat University of Science and Technology. This experience has been successful with increased biomass and medicinal ingredients production. Khan & Khatoon (2008) reported 98 herbaceous plant species of medicinal importance from Haramosh and Bugrote valleys. These herbs are used for curing rheumatism, asthma, diabetes, blood pressure, stomach problems, abdominal

problems etc. The most common medicinal herbs found in the region belong to the families Labiatae, Compositae, Ranunculaceae, Umbelliferae and Gentianaceae.

Of the reported 160 species belonging to128 genera and 37 families from Birjand, located near the Afghanistan border in eastern Iran, 40% are used as medicinal plants, 47.8% pastoral, 8.3% poisonous and 4% with industrial uses (Mood, 2008). Ozturk *et al.* (2008) described ethnoecological aspects of 474 taxa belonging to 64 families of highly poisonous plants in Turkey and Northern Cyprus, which can prove fatal. The families contained the highest number of poisonous species are Fabaceae (50), Ranunculaceae (48), Asteraceae (44) and Liliaceae (28). One has to be very cautious before using these plants as the plants used for the purpose of treatment of diseases as a whole or parts thereof or consumed by the public directly could prove dangerous for the health.

Ahmad *et al.* (2009) recorded the ethnomedicinal uses of indigenous plants to control diabetes mellitus in District Attock. The most dominant antidiabetic plant bearing family was Fabaceae (5 spp.) followed by Poaceae (4 spp.) and Liliaceae (3 spp.). About 29 phytotherapies were investigated from the rural inhabitants of the area. These traditional recipes include extracts, leaves, powders, flour, seeds, vegetables, fruits and herbal mixtures. Ali & Qaiser (2009) reported 83 taxa are being used locally in Chitral valley for various purposes. Root is the major plant part used in most of the recipes. Majority of the recipes are prepared in the form of decoction from freshly collected plant parts. Mostly a single species is used and are mainly taken orally. All of these plants are collected from the wild.

Barkatullah *et al.* (2009) documented the indigenous knowledge of Charkotli Hills, Batkhela District, Malakand, Pakistan. They stated that most plants have more than one local uses. Sixty-six plants were found to be medicinal species, 21 fruit species, 11 furniture species, 18 fodder species, 12 vegetable species, 12 fuel species, 11 thatching and building species, 5 fencing species, 5 timber species, 5 poisonous plants, 2 miswak species, 1 species giving gum used as chewing gum, and 1 species used as insect repellent. Qureshi *et al.* (2009a) reported 29 species belonging to 25 genera and 18 families from Tehsil Chakwal. These plants are used by the local people for curing various human diseases.

Qureshi *et al.* (2009b) reported 28 species of 25 families that the locals especially women in southern Himalayan Mountains, Pakistan have been using for medicinal purposes. Sardar & Khan (2009) reported 102 species distributed among 93 genera and 62 families that were being used by local inhabitants for various purposes such as fuel, furniture, fodder, making baskets and mats, brushing teeth, medicinal, vegetables and edible fruits in the remote villages of tehsil Shakargarh, District Narowal, Pakistan. Sher & Hussain (2009) reported 50 species of plants belonging to 33 families as ethnobotanically important from Malam Jabba valley, District Swat. They examined the current status of the medicinal plants trade and investigating the linkages in the market chain starting from collectors to consumers.

Ajaib *et al.* (2010) reported 38 species of 36 genera belonging to 25 families of District Kotli, Azad Jammu & Kashmir, Pakistan. These plants were found useful as medicinal, fuel, shelter, fodder/forage and in making agricultural tools. Most of the shrubs were noticed having more than one ethnobotanical uses. Hazrat *et al.*, (2010) enlisted 50 species, belonging to 32 families with medicinal uses in Usherai Valley, District Dir. Qasim *et al.* (2010) reported 48 wild coastal plant species belonging 26 families from Hub, Lasbela District, Balochistan. The uses included fodder (56%), medicine (22%), food (5%), house hold utensils (5%), for increasing milk production in cattle (3%) and other uses (8%). Most frequently used species were from Poaceae (29%) followed by Amaranthaceae (Chenopodiaceae) (10%), Mimosaceae and Convolvulaceae (6%). About 56% of the collected plants were halophytes and rest of them was xerophytes (44%).

Qureshi *et al.* (2010) reported 63 plant species belonging to 50 genera and 29 families from Nara Desert, Sindh, Pakistan. These plants are used for curing fever, flue, cough, asthma, digestive troubles, piles, diabetes, urinary diseases, male sexual diseases, gynecological diseases, joints pain/rheumatic pains and inflammation, ear diseases, tooth problems, cuts and wounds, skin diseases, cooling agents and miscellaneous uses. Tareen *et al.* (2010) reported 61 species of medicinal plants belonging to 56 genera of 34 families from Kalat and Khuzdar (Balochistan), which are commonly used in digestive complaints, stomach problems, fevers, liver complaints, diabetes, children diseases and birth related problems. Sher *et al.*, (2011) recorded 216 ethnobotanically important plant species from Chagharzai Valley,

District Buner, Pakistan. Of them, 138 were medicinal species, 72 multi-purpose species, 66 fodder and forage species, 51 fuel wood species, 36 vegetable /pot-herb species, fruit yielding and thatching/ roofing 25 species each, 21 timber species, 19 ornamental species, 15 poisonous plants, 14 fencing/ hedges plants, 12 agricultural tools making species, 9 honeybee species and one species used to repel evils.

Vegetation

Vegetation is an ecological expression of an area showing complex inter-relationships among the various components including plant-plant, plant-animal and plant-physical environment interactions. It is the general effect produced by the growth of some or all species in various combinations forming associations or communities.

Hussain & Shah (1989) recognized three plant communities on eastern slopes, one on western slope, three on northern side, three on southern slope and one on the top of the hill during winter in Docut Hills, District Swat. The species diversity was low due to dormant winter season. Hussain *et al.* (1993) recognized three associations in the graveyards of District Swabi. These associations included *Dalbergia sissoo-Melia azedarch, Ziziphus mauritiana* with two subtypes and *Acacia modesta* with five subtypes. The vegetation of all the stands was stratified in to tree, shrub and herb layers. The variation in the dominant species was due to edaphic and biotic disturbance. The same vegetation when subjected to ordination by Hussain *et al.* (1994) revealed that soil pH, $CaCO_3$ and P_2O_5 were the controlling factors in the distribution of vegetation. Hussain *et al.* (1997) reported *Aristida-Artemisia-Cynodon, Aristida-Plectranthes-Cyperus, Apluda-Plectranthes-Chrysopogon, Chrysopogon-Apluda-Brachiaria, Chrysopogon-Brachiaria-Artemisia* communities were found on sandy loam and the only *Cynodon-Desmostchaya-Mentha* community on silt loam soils from subtropical chirpine forests of Girbanr Hills District Swat, Pakistan. The original Chir pine forests have been replaced with open scrub and grassland through over deforestation, terrace cultivation and grazing.

Hussain *et al.* (2000) recognized subtropical semi-evergreen forest, Subtropical Chirpine forest and blue pine temperate forests in Ghalegay Hills District Swat. They concluded that that there is a dire need of ecological management of the

plant resources for sustainable use. Tabanez & Viana (2000) recognized 4 physiognomic units such as (1) low forest, (2) bamboo forest, (3) high forest, and (4) mature forest in four Atlantic seasonal forests in southeastern Brazil. Tree density, basal area, and species diversity (Shannon-Wiener index) increased from low forest to bamboo forest to high forest to mature forest. Mark *et al.* (2001) recognized six alpine plant communities in lower and upper floristic zones of Tierra del Fuego. The richness (and range) of 80 local vascular taxa (18.6% of the regional flora), decreased with increasing altitude (6.6 per 100 m); however, richness differed significantly with aspect (north: 5.6, south: 7.5). Upper altitudinal limits (approximately 1250 m a.s.l.), were associated with a midsummer isotherm of approximately 1.7°C.

Mosugelo *et al.* (2002) assessed the changes in vegetation cover in northern Chobe National Park (Botswana) using aerial photographs. Coverage of woodland vegetation decreased from 60% to 30% between 1962 and 1998, while shrub land vegetation increased from 5% to 33% during the same period. During the study period, woodland has gradually retreated away from the river front. While riparian forest covered a continuous area along the riverfront in 1962, only fragments were left in 1998. Claros (2003) recorded 250 species in the Bolivian Amazon secondary forests, of which ca 50 percent made up 87 percent of the sampled individuals. The correspondence analysis indicated that species composition varies with stand age, forest layer, and site. The species composition of mature forests recovered at different rates in the different forest layers, being the slowest in the canopy layer. Species showed different patterns of abundance in relation to stand age, supporting the current model of succession. Changwe & Balkwill (2003) observed low similarity in species through Sorenson's index between serpentinite and non-serpentinite sites (β-diversity) at Dunbar Valley in the Barberton Greenstone Belt (BGB). Shannon-Wiener index indicated that α-diversity for the serpentinite was 2.631±0.901 and for the non-serpentinite, 2.886±0.130. However, t-test showed no significant difference in α-diversity between the two habitats.

El-Ghani & Amer (2003) while using TWINSPAN techniques classified the vegetation into five groups. Each of the definite vegetation and soil characters could be linked to a specific geomorphological unit. *Capparis spinosa var. spinosa* occupied the terraces, *Cornulaca monacantha, Convolvulus lanatus* and *Deverra*

tortuosa inhabited the alluvial plains, *Launaea nudicaulis* and *Artemisia judaica* characterized the wadi channels, *Acacia tortilis subsp. raddiana* and *Leptadenia pyrotechnica* characterized the alluvial fans and *Tamarix nilotica, Zygophyllum album* and *Nitraria retusa* on the playas and the coastal shore. Ordination techniques as detrended correspondence analysis (DCA) and canonical correspondence analysis (CCA) are used to examine the relationship between the vegetation and studied soil parameters. Kennedy *et al.* (2003) recorded 135 to 489 individual grasses from 189 sites in the Kruger National Park. After the drought had passed species richness, standing crop and percentage abundance recovered to 92.1%, 113.8% and 92.8% of their pre-perturbation values, respectively. The findings suggest that ecosystem stability may be negatively related to grass species richness in South African savanna grasslands. Salvatori *et al.* (2003) while studying the vegetation maps from 1979 and 1998 suggested that vegetation in 46% of the Reserve area was converted from shrub land to grassland, possibly as a result of fire and grazing pressure. A low density of rodents was recorded in all habitats except in areas of human activity.

Malik & Malik (2004) recognized *Adiantum-Olea, Acacia modesta, Dodonaea-Acacia- Themeda, Pinus-Themeda, Imperata-Pinus, Pinus roxburghii and Pinus-Carissa-Themeda* communities in Kotli Hills in Chir pine forest which shows heavy deforestation and overgrazing. Brown & Bredenkamp (2004) developed a structural classification of the woody component using species size (SPIZE) classes. They indicated that structural SPIZE classes could be used to explain the spatial distribution of woody species within and between various plant communities. Based on frequency, density, percentage crown cover and importance value for each woody species a classification of the woody component was done using a TWINSPAN classification algorithm. DeWalt & Chave (2004) determined the effect of soil fertility by measuring the density and basal area of trees, lianas, and palms on two soil types differing in fertility at each site. Cocha Cashu and KM41 had higher tree basal area and above ground biomass than La Selva or Barro Colorado Island. Although total stem density, basal area, and some biomass components differed significantly among forests, they seemed less variable than, species richness.

Patrick *et al.* (2004) conducted a phytosocological study in Degeya, Lufuka and Mpanga forests in central Uganda to find out the regeneration, density and size

class distribution of trees used for making drums. Diameter at breast height (DBH) of trees and number and species of seedlings, saplings and poles of six tree species were determined. Hussain, *et al.* (2005) recognized i. subtropical semi-evergreen forest (*Adhatoda-Cynodon- Olea, Olea-Cynodon- Adhatoda, Plectranthus-Indigofera-Dodoneae* communities); ii. subtropical pine forest (*Pinus-Indigofera-Themeda, Pinus-Plectranthus-Indigofera communities*) and iii. blue pine temperate forests (*Quercus-Stachiopsis-Fragaria, Pinus-Fragaria-Dryopteris* communities) in the Ghalegay Hills, District Swat. Malik & Husain (2006) reported four plant communities from Lohibehr reserve forest, Rawalpindi using Agglomerative clustering, TWINSPAN, and Detrended Correspondence Analysis (DCA). Remotely sensed data was used as an alternative in identifying and locating field sites from where floristic composition, environmental and spatial data were collected. Classification and ordination techniques provided very similar results based on the floristic composition. The results formed the basis for the mapping spatial distribution of vegetation communities using image analysis techniques.

Ahmed *et al.* (2007) determined the frequency, density and coverage / dominance of vegetation in Soone valley to examine the status as well as diversity of leguminous plants. They reported that the relationship between vegetation types, elevation, soil composition and soil mineral contents is an informative criterion to describe the plant diversity. While using TWINSPAN and CCA, Peer *et al.* (2007) recognized eleven communities in Hindu Kush mountains. The vegetation types were 1) the desert steppe comprising *Artemisea fragrans-Haloxylon thomsonii* community, *Stipa orientalis-Kraschenninkovia pungens* community, *Eremurus stenophyllus-Seutellaria multicaulis* community and *Koelpinia linearis-Mathiola chorassanica* community. 2) the *Artemisea brevifolia* steppe comprising *Brumus danthonae-Artemisea brevifolia* community, *Acantholimon kokandense- Artemisea brevifolia* community and *Cerastium cerestioides-Aconitum rotundifolium* community. 3) the alpine scree vegetation comprising *Acantholimon kokandense-Psychrogeton andryaloides* community and *Androsace baltistanica-Elymus schugnanicus* community. 4) the alpine mates comprising *Oxytropis hunifusa-Crepis multicaulis* community and *Leontopodium ochroleocum-Festuca alaica* community. Ecological

factors such as altitude, geographical position, grazing intensity and organic matter contents influencing the above vegetation types and plant communities.

Perveen & Hussain (2007) determined the plant biodiversity and phytosociological attributes of vegetation of the Gorakh hill, District Dadu. Quantitative analyses on species diversity in addition to phytosociological attributes analysis were work out. Some ecological parameters such as, life forms, species density, species cover, species relative density and frequency were calculated. Mohandass & Vijayan (2007) reported that species abundance distribution did not differ significantly from log normal indicative of a diverse tropical community. Species diversity as measured by Fisher's alpha index was 13.15 for trees and 4.54 for lianas, and basal area was 62 m^2 ha^{-1} for trees and 0.58 m^2 ha^{-1} for lianas. Montane evergreen forests, which are unique to the higher elevations of the Western Ghats, should be conserved on a priority basis.

Price & Morgan (2007) demonstrated that nutrient limitation was more important for species coexistence in herb-rich woodland than was water availability. Addition of fertilizer significantly reduced species richness relative to unmanipulated control and water addition plots after 3 years. This change coincided with significant increases in biomass, which were largely due to increased growth of exotic annual grasses. The reductions in richness observed in the fertilized plots were a consequence of both lower rates of local colonization and enhanced rates of local extinction of the resident species. Ahmad *et al.* (2008a) worked on the vegetation of Kufri site in the Soone Valley, Punjab, Pakistan. On the basis of some ecological attributes *i.e.*, topography, soil type and the nature of prevailing disturbances *Acacia modesta* and *Propsopis juliflora* communities were recognized at low altitude while *Olea- Acacia* association at high altitude. *Dodonaea viscosa* and *Justicia adhatoda* occurred very abundantly throughout the site because both species had resistance for grazing.

Arshad *et al.* (2008) recorded density, frequency, cover and importance value index to correlate the factors responsible for plant distribution in Cholistan desert. Vegetation types were analyzed for. The association of certain plant species to certain soil types was common indicating the influence of chemical composition of the soils. *Suaeda fruticosa* and *Haloxylon recurvum* the high salinity levels and low organic

matter. *Calligonum polygonoides, Aerva javanica, Dipterygium glaucum, Capparis deciduas* and *Haloxylon salicornicum* indicated better organic matter and low salinities. Malik & Hussain (2008) conducted a study to work out the relationship between remote sensing data and vegetation communities of ecological importance using multivariate techniques such as TWINSPAN, Principal Component Analysis (PCA) and Correspondence Canonical Analysis (CCA) in the Lohibehr scrub forest in the Foothills of Himalaya, northeast of Pakistan. Ordination analyses indicated positive correlation between floristic species composition and DN values along the first ordination axis, with the NIR. The ordination methods proved effective in summarizing basic, general structure of the plant community types and to some extent indicated correspondence with their spectral signatures.

Perveen *et al.* (2008) documented the floristic and phytosociological data in the threatened habitats of Dureji Game Reserve. They stated that vegetation cover varied from place to place depending upon the texture and structure of the soil while vegetation structure and density is greatly influenced by the rainfall. Qureshi (2008) recognized *Phragmites-Typha-Saccharum* in wetland, *Calligonum-Dipterygium-Salvadora* in desert, *Saccharum-Pluchea-Typha* in marshland, *Desmostachya-Brachiaria-Cynodon* in agriculture habitat and *Salvadora-Desmostachya-Posopis* in protected forest in Sawan Wari of Nara Desert. The most frequent species, *Euphorbia prostrate,* was present in all habitats, followed *Alhagi maurorum, Desmostachya, Saccharum spontaneum* found in 4 habitats.

Qureshi & Bhatti (2008) concluded that species composition in the different habitat of Nara Desert, Pakistan showed differences in species richness with highest species richness of 77.24% in flat habitats. The vegetation over major area was characterized by xerophytic adaptation. Wahab *et al.* (2008) carried out phytosociological sampling, structure, age and growth rates studies in 5 places of District Dangam, Afghanistan. On the basis of floristic composition and importance value index of tree species, two monospecific and one bispecific communities were recognized in the study area. It is shown that in *Picea smithiana* (Wall.) Boiss., Dbh, age and growth rates are not significantly correlated. Lack of tree seedlings indicates poor regeneration status of the forests. Wazir *et al.* (2008) identified 5 vegetation types viz: crassulescent steppes, chamaephytic steppes, erme, moist sub-alpine

pastures and riverine pseudo-steppes through cluster analysis in Chapursan Valley, Gilgit.

Abbas *et al.* (2009) reported that *Pinus roxburghii* was indicator species in north Himalayan mountains and Azad Kashmire. TWINSPAN and Sorenson's coefficient of similarity suggested high species diversity (99; trees 22, shrubs 24, herbs 31, grasses 52) in different stands (22–77). The canopy was fairly open and trees (3.80-44.42%), shrubs (6.20-68.73%) and herbs/grasses (9.89–59.54%) contributed different covers in different stands. Trees and shrubs constituted perennial layers, while herbs and grasses dry up during autumn and winter. Ahmed *et al.* (2009a) recognized 10 plant communities in forests dominated by *Olea ferruginea* using phytosociological attributes. Most of these communities showed similar floristic composition with different quantitative values. Though no significant relation between density/basal area, elevation/density and elevation/basal area was obtained.

Ahmed *et al.* (2009b) analyzed the floristics of vegetation of Abbottabad roadsides and based on soil, using multivariate analysis techniques DCA and CCA recognized 5 major communities on 5 major roadsides. Hussain & Perveen (2009) conducted quantitative analysis on species diversity in addition to phytosociological attributes analysis in Tiko Baran, Khirthar range. The cutting of trees and shrubs by people and the digging of valuable medicinal herbs are increasingly altering the composition and distribution of plants in the study area and its surrounding valleys. Qureshi *et al.* (2009) recognized ten plant communities on the basis of Summed Dominance Ratio (SDR) from District Sanghar, Sindh, Pakistan. These communities were 1) *Fagonia-Senna-Calotropis;* 2) *Pluchea-Dactyloctenium-Ochthochloa;* 3) *Dactyloctenium-Desmostachya-Pluchea*; 4) *Calotropis- Acacia-Alhagi;* 5) *Dactyloctenium*; 6) *Indigofera*; 7) *Desmostachya-Gynandropsis*; 8) *Desmostachya-Dactyloctenium-Indigofera*; 9) *Dactyloctenium* and 10) *Indigofera-Dactyloctenium-Indigofera*. There were 16 species which contributed in the formation of plant communities of the area.

Siddiqui *et al.* (2009) conducted a phytosociological study of *Pinus roxburghii* in Lesser Himalayan and Hindu Kush range of Pakistan by determining relative density, relative frequency and relative basal area and absolute values. Pine seedlings

were recorded in nine stands showing regeneration. The common angiospermic species were found in association with Chir pine like *Dodonaea viscosa, Punica granatum, Erodium cicutarium, Medicago denticulata* and *Vicia sativa.* Using DECORANA and DCA, Ahmad (2010) identified four communities which differ mainly on the basis of their ecological amplitudes along the road verges of motorway (M-2). Out of the four major communities, community number 1 occurred mostly in highly disturbed areas. The community number 2, which was the major and largest community, showed its appearance in areas seemed to be highly favorable for the flora as indicated by the occurrence of maximum number of species. The community number 3 occurred in habitat with relatively high temperature and low rainfall. Community 4 indicated quite hot and dry habitat loving species.

Based on the ordination technique TWINSPAN, Ahmad *et al.* (2010) identified two major communities (*Cynodon-Calotropis-Cenchrus* and *Heteropogon-Rhynchosia-Calotropis*) along the road verges of motorway (M-2). These communities were further divided into sub-communities on the basis of their ecological amplitudes. Despite the large number of species recorded on the road verges, the number of frequent species is not very large. It indicated wide ecological amplitude of the dominant species of road verges. Ali & Malik (2010a) reported four major community types of the open urban spaces viz., green belts, gardens and parks of Islamabad city. Using TWINSPAN analysis it was seen that vegetation was homogenous in overlapping manner. *Pinus roxburghii* and *Grewia asiatica* were more prevalent in green belts while native vegetation dominated by *Dalbergia sissoo* and *Acacia nilotica* were present in undisturbed green spaces. *Broussonetia papyrifera* and *Populus euphratica* were distributed along the drains/nullahs in the city. Later on Ali & Malik (2010b) identified *Broussonetia-Populus* and *Panicum-Conyzanthes* community types in Islamabad. The distribution pattern of vegetation was influenced by soil physico-chemical properties, invasive species and human disturbance.

Kabir *et al.* (2010) recognized fifteen plant communities in the industrial areas of Karachi. The herbaceous and shrubs vegetation was predominant. the variation in vegetation composition was due to edaphic factors owing to industrial activities and

pollutants. Khan *et al.* (2010) stated that *Quercus baloot* formed pure vegetation while *Quercus dilatata* was co-dominant in high altitude with high soil moisture and maximum water holding capacity. Naz *et al.* (2010) stated that community structure and distributional pattern of the species was mainly dependent on the salinity gradient in the Cholistan desert. salt tolerant species like *Sporobolus ioclados, Aeluropus lagopoides, Haloxylon recurvum* and *Suaeda fruticosa* were the dominants in highly saline sites, whereas, moderately saline habitats supported less tolerant species *Fagonia indica, Cymbopogon jwarancusa* and *Ochthochloa compressa.* Noroozi *et al.* (2010) working on the phytosociology and ecology of the high alpine zone of Tuchal Mts. (Central Alborz) recognized two provisional orders, four alliances and 13 associations of vegetation. Besides duration of snow-cover, edaphic, and hydrological quality of micro-sites was more important for the species composition and vegetation mosaic than the regional climatic gradient. About 90% of the species of the study area are Irano-Turanian elements.

Grazing

Grazing is very beneficial to the ecosystem. It is advantageous towards the soil and grasses, promoting nutrient dense soil and stimulating the growth of plant varieties. Grazing may also promote biodiversity. Eccard *et al.* (2000) investigated vegetation changes superimposed by grazing and their effect on small mammals in the Karoo (South Africa) on grazed farmland and an adjacent, 10-year livestock enclosure. Plains and drainage line habitats were compared by monitoring vegetation height and cover, and small mammal species composition and abundance along transects. Vegetation cover was low on the grazed compared to the ungrazed study site, but vegetation height did not differ. The number of small mammal individuals and the number of species captured was higher at the ungrazed study site.

Karki *et al.* (2000) compared the community structure, nutritive quality, and aboveground biomass of grazing lawns (patches of short grass communities) with neighboring grasslands in Nepal. Grazing lawns differed from the adjacent grasslands in species composition and community structure. Species diversity and species richness were higher on grazing lawns ($H = 1.60$, $S = 20.93$) than the grasslands ($H = 0.97$, $S = 8.97$). Fencing that excluded grazers for 150 days made areas of grazing

lawns indistinguishable from neighboring grasslands in terms of plant height and biomass. Grazing lawns appear to be maintained by continuous grazing and are enriched by deposition of urine, dung, and by certain plant species not found in the adjacent grasslands.

McIntyr & Lavorel (2001) observed that when grazing pressure increased, perennial grasses declined, while the relative proportion of forbs and annual grasses increased. Detailed functional group analyses were conducted for the perennial grass and forb life-forms. Eight grass and eight forb functional types were identified. Of the taxa that had an observed response to grazing, 54% of the grass taxa and 57% of the forb taxa corresponded to one of these functional types in terms of meeting both grazing response and trait criteria. Wassenaar & Aarde (2001) investigated that grazing had some apparent but insignificant effects on plant species composition, significantly affected plant species richness over time, and significantly increased the range of species richness and vegetation cover values as well as the relative abundance and numbers of plant species with erect growth forms. Vegetation cover changed significantly over time, independently of grazing.

Brits *et al.* (2002) reported the complete lack of woody individuals in the immediate vicinity of the watering points in the Kruger National Park. Shrub density increased with distance from the watering point, with the impact of large herbivores on shrub density extending up to 2.8 km. The woody vegetation existed far beyond the water point even after providing artificial water points in trough.Mapfumo *et al.* (2002) stated that litter C and N pools generally decreased with increased grazing intensity in smooth bromegrass (*Bromus inermis*) and meadow bromegrass (*Bromus riparius*) than annual grass, winter triticale. Root mass was greater for the perennial grasses than for triticale at all grazing intensities. Root C and N pools for triticale were 31 and 27%, respectively, of that for the perennial grasses. Estimated total C contribution (roots and litter) to the resistant soil organic C pool was 1.5 times greater for light compared to heavy grazing. Perennial grasses provided a larger litter base and root system that promote greater storage of C in the soil compared with triticale.

Lucas *et al.* (2004) compared effects of different seasons of use (cool season, warm season, and dormant season) and grazing intensities (light, moderate, and none)

of cattle on young narrow leaf cottonwood (*Populus angustifolia*) populations, and herbaceous vegetation in riparian areas of Black Range of western New Mexico. They concluded that increased grazing pressure did not have significant impact on cottonwood populations while the effects of season of use were significant on both herbaceous species richness and diversity. Mapinduzi *et al.* (2004) reported greater plant species diversity and less erosion risks in the pastoral landscapes than in the agro-pastoral landscapes while assessing the effects of grazing and cropping on rangeland biodiversity at macro and micro-landscape scales in northern Tanzania. They also found that the calf-grazing pastures had greater herbaceous species richness while non-calf pastures had more woody species.

Wang (2004) stated that components of biomass, and shoot and tiller densities of *Leymus chinensis* decreased significantly ($P < 0{\cdot}05$) with increased grazing intensity in the Songnen plain, north-eastern China. Conversely, the total biomass proportion increased considerably with grazing intensity because of rhizome biomass. Soil organic matter and moisture contents negatively correlated with soil pH and soil bulk density along the grazing gradient, indicating that the responses of *L. chinensis* to the canopy removal by long-term grazing are likely to have influenced changes in the soil. Chocarro *et al.* (2005) studied the effects of one severe winter-grazing of Lucerne over 3 years in an experiment in the Ebro Valley, Spain. In this region the crop is harvested six to seven times per season and winter grazing is a traditional practice. On average, winter-grazing reduced the yield at the first harvest in spring by 200 Kg dry matter (DM) h^{-1}.

Hirata *et al.* (2005) assessed the grazing impact by calculating the differences between the total available forage at the end of growing season and the end of dry season. They concluded that higher cover of herbaceous vegetation showed higher grazing impacts which reduced the total available forage at the end of the growing season by 0·817 (0·199) at the end of the dry season. Although these dense herbaceous vegetation types could possibly produce more available forage, they would incur more intensive grazing impact. On the contrary, lighter grazing impact would occur with a higher cover of shrub vegetation types.

Miller &Thompson (2005) while investigating forage preferences reported that the dominant pasture species, *Cortaderia pilosa* was the dominant species and consumed during the cooler periods of the year while in summer the proportion of fine grass species, including *Poa spp., Festuca magellanica* and *Agrostis capillaris,* and herbs and sedges in the diet was highest. The digestibility was also at its peak during this period. Milewsk & Madden (2006) reported that *A. seyal* lost shoot tips, produced long thorns, and had relatively few flowers and fruits exposed to intensive browsing. Increased lateral branching in *A. drepanolobium* and with an increased occurrence of short, thickened spines in *B. glabra* were recorded due to intensive browsing. Thorns, spines and flowers were measurable indicators of relative browsing.

Pavlu *et al.* (2006) reported an increase in the number of forb plants, particularly in the number of *Taraxacum spp.*, most probably due to an enabling of its seed production and decrease in grasses while evaluating monthly changes in plant density in semi-natural grassland in the Czech Republic. *Trifolium repens* was able to colonize and increase the number of its stolon growing-points in all the intensively grazed patches. Smit *et al.* (2006) stated that unpalatable plants can enhance tree regeneration in wooded pastures under grazing intensity. Sapling survival was significantly high near unpalatable plants, and significantly higher in plots with *Gentiana* than with *Cirsium*. These results have important management implications for the endangered and disappearing wooded pastures in Western Europe. Transplanting tree saplings near unpalatable plants could be an alternative reforestation technique in intensively grazed wooded pastures.

Loeser *et al.* (2007) determined that grazing declined the perennial forb cover and increased annual plants, particularly the exotic cheatgrass (*Bromus tectorum*) in semiarid grassland near Flagstaff, Arizona. The results suggested that some intermediate level of cattle grazing may maintain greater levels of native plant diversity than the alternatives of cattle removal or high-density, short-duration. Campanella & Bisigato (2010) reported decreased plant cover, changes in species composition and losses in soil nutrient due to grazing. Grazing caused reduction in leaf litter fall and in the inputs of nitrogen, soluble phenolics and lignin to the soil. This reduction was not only a result of the decrease in plant cover but also due to

changes in species composition. Ekblom & Gillson (2010) reported that variability in vegetation cover, and other factors such as grazing, herbivory and nitrogen availability was important as controlling mechanisms for woody cover in Limpopo National Park, Mozambique. They used palaeoecological data (i.e. pollen assemblages, charcoal abundance, C/N ratio, stable isotopes and herbivore-associated spore abundance) in order to test the relationship between vegetation cover and hydrology, nutrient availability and disturbance from grazing and fire over the last 1,200 years.

Rangeland Productivity

All plants and plant derived materials including animal manure, has great potential to provide renewable energy to the growing population and to uplift their economic conditions. Biomass could also be used for production of fibers or chemicals. Biomass may also include biodegradable wastes that can be burnt as fuel.

Norris *et al.*, (2001) reported an increase in woody plant abundance including the development of dense stands of eastern redcedar (*Juniperus virginiana*) in regions historically dominated by grasses is a recent land cover change in grasslands worldwide. Aboveground plant biomass for these redcedar-dominated sites ranged from 114 100 kg/ha for the youngest stand to 210 700 kg/ha for the oldest. Annual aboveground net primary productivity (ANPP) ranged from 7250 to 10 440 kg ha^{-1} $year^{-1}$ for the oldest and younger redcedar stands, respectively. Estimates of ANPP in comparable tallgrass prairie sites in this region average 3690 kg ha^{-1} $year^{-1}$ indicating a large increase in C uptake and aboveground storage as a result of the change from prairie to redcedar forests.

Evaluating production, use, and species richness of herbage Beck & Peek (2004) analyzed the effects of grazing by cattle (*Bos taurus*) and elk (*Cervus elaphus*) on mountain meadows in northeastern Nevada. The yield of the forb and grasses had no significant differences in clipped quadrats in early summer and mid-summer. Angassa (2005) studied the ecological impact of woody encroachment and the responses of herbage yield to encroachment at three locations in Borana rangeland at the end of the growing season. The grasses *Cenchrus ciliaris, Chrysopogon aucheri* and *Panicum coloratum* were dominant in both encroached and non-encroached sites.

The relative yield increased with non-encroached sites and varied at different altitude ranges. Differences based on altitude range were also significant for *Eragrostis papposa* and *Pennisetum stramineum*, while the three areas showed a significant difference for the mean yield of *Aristida adscensionis*, *Cenchrus ciliaris* and *Eragrostis papposa*.

Pande, (2005) reported that herbs and shrubs produced minimum biomass than trees while estimating biomass and productivity in some tropical dry deciduous disturbed teak (*Tectona grandis*) forests of Satpura plateau in three communities identified as *Tectona grandis– Lagerstroemia parviflora–Sterculia urens* (site I); *T. grandis–Lannea coromandalica–Diospyros melanoxylon–Butea monosperma* (site II); *T. grandis–Chloroxylon swietenia–L. parviflora–D. melanoxylon* (site III) and a young plantation of *T. grandis* (site IV). They related the minimum total biomass of site I with disturbance on the forests, lower soil depth and poor soil quality. They suggested that plantation of target species in the blanks inside the forest created by disturbances improves the productivity, and balances the structure of forest ecosystem due to invasion of local species in due course of time. Maestre *et al.* (2006) conducted a microcosm experiment to evaluate individual plant and whole community responses to species richness, species composition and soil nutrient heterogeneity. Communities containing *Plantago* and *Lolium* responded to nutrient heterogeneity by increasing above and below-ground biomass. Nutrient heterogeneity also increased size inequalities among individuals of these species. Their results suggested that nutrient heterogeneity may interact with plant species composition to determine community biomass, and that small-scale vertical differences in the location of nutrient patches affect individual and community responses to this heterogeneity.

Zheng *et al.* (2006) reported that forest biomass ranged from 362.1 to 692.6 Mg/ha and its allocation patterns in tropical seasonal rain forests of Xishuangbanna. Biomass of trees with diameter at 1.3 m breast height (DBH) $\geq$ 5 cm accounted for 98.2 percent of the rain forest biomass, followed by shrubs (0.9%), woody lianas (0.8%), and herbs (0.2%). Biomass allocation to different tree components was 68.4–70.0 percent to stems, 19.8–21.8 percent to roots, 7.4–10.6 percent to branches, and 0.7–1.3 percent to leaves. Biomass allocation to the tree sublayers was 55.3–62.2 percent to the A layer (upper layer), 30.6–37.1 percent to the B layer (middle), and

2.7–7.6 percent to the C layer (lower). Biomass of *Pometia tomentosa*, a dominant species, accounted for 19.7–21.1 percent of the total tree biomass. Hussain & Durrani (2007) reported that the total average dry biomass production was 10772.5 Kg/ha/year in Herboi range lands. They stated that in Harboi range lands the growing season lasts from April to October with seasonal and annual variation in rainfall and temperature. The months of July and August were the most productive months (2120.7 and 2012.7 Kg/ha, respectively). The total dry biomass, biomass contributed by grasses, herbs and shrubs generally increased from April through August and thereafter it progressively decreased till October. It was observed that the range is suffering with overgrazing, over exploitation and soil erosion, which must be cared for.

Pande & Patra (2010) while estimating the biomass and productivity of Sal (SF) and miscellaneous forests (MF) of Satpura plateau (Madhya Pradesh) India reported that the higher above ground tree biomass was produced by MF than of SF. These forests were further divided into closed canopy and open canopy forests. Closed canopy forests produced higher above ground tree biomass than of the open forests. OMF produced 9.5% less biomass than of the CMF whereas; OSF has 39.91% less bio-mass than of the CSF. The shrub biomass showed the same trend. Total net primary productivity was highest for closed forest stands than of the open ones. Disturbances in open forests not only reduced stand biomass of tree species but also declined the tree productivity. So, gap filling plantation inside the forest is suggested to improve the productivity of open forests. Gairola *et al.* (2011) reported statistically significant positive correlation between the average values of total biomass of living trees with altitude, which could be attributed to dominance of large conifers and hardwoods at higher altitudes compared to lower altitudes. The total biomass density also showed positive correlation with species richness. However diversity had no correlation with total biomass density.

Kumar *et al.* (2011) estimated the biomass and net primary productivity of *Butea monosperma* forests of different ages in western India, Rajasthan. They concluded that tree biomass and net primary productivity increased with increasing age of the forest stand, whereas the herb biomass and net primary productivity decreased significantly ($P < 0.01$) with increase in the forest age. While using generalized linear and additive models Namgail *et al.* (2011) examined the phytomass

and diversity of vascular plants along altitudinal gradients on the dry alpine rangelands of Ladakh, western Himalaya. They observed a hump shaped relationship between aboveground phytomass and altitude and suspected that this is engendered by low rainfall and trampling/excessive grazing at lower slopes by domestic livestock, and low temperature and low nutrient levels at higher slopes.

Mineral Composition

Minerals are essential for the normal growth and development of plants that ultimately affect the growth, maintenance and productivity of range animals at secondary level. Various environmental factors including edaphic, climatic, geographic and biotic stresses influence the mineral composition of forage species. Islam & Adams (2000) worked on the seasonal variations in nitrogen, sodium and phosphorus contents of *Atriplex amnicola* and *Atriplex nummularia*. Both species contained high level of nitrogen (N) in winter than summer. Both species had high level of sodium. Phosphorus was more uniformly distributed among pools of inorganic- P, phytate-P, nucleic acid-P and other (residual) fractions.

Yusuf *et al.* (2003) determined the levels of cadmium, copper and nickel in *Talinum triangulare, Celosia trigyna, Corchorus olitorus, Venomia amygydalina* and *Telfaria accidentalis,* and the soils in which they were grown. The levels of three heavy metals from the industrial areas were higher than those of the residential areas as a result of pollution. Khan *et al.* (2005) described the micro-mineral status of pasture having high population of small ruminants in Punjab, Pakistan. All soil mineral levels, except Co^{2+} and Se^{2+} , were above the critical levels and likely to be sufficient for normal growth of plants growing there; whereas soil Co^{2+} and Se^{2+} were severely deficient during both seasons for the normal plant growth. Forages contained marginal deficient level of Co^{2+} during winter, those of Cu^{2+} and Se^{2+} during the summer. Moderate deficient levels of Fe^{2+} and severe deficient level of Zn^{2+}, Mn^{2+} and Co^{2+} were found during the summer. Consequently, grazing animals at this location need continued mineral supplementation of these elements to prevent diseases caused by nutrient deficiency, and to support optimum animal productivity. Demirezen & Aksoy (2006) determined copper, cadmium, nickel, lead and zinc levels of various vegetables (cucumber, tomato, green pepper, lettuce, parsley, onion, bean, eggplant, peppermint, pumpkin and okra) produced in Kayseri, Turkey. These micro-

mineral were higher in urban area compared with rural area. The order of the elements in various vegetables and their concentration ranges in μg/g were Cu (22.19–76.5), Cd (0.24–0.97), Ni (0.44–13.45), Pb (3–10.7) and Zn (3.56–259.2).

Bukhsh *et al.* (2007) studied major trace elements include Cu, Fe, Mg, Mn, Cr, Zn, Mo, P, K, Na and Ca in some medicinal plants like *Carthamus oxyacantha*, *Eruca sativa* and *Plantago ovata*. The values for Ca, Mg, Zn, Fe, K, and Na are significantly higher as compared to the *E. purpurea* a medicinal plant of the Asteraceae. Hashmi *et al.* (2007) determined the concentrations of trace metals (Fe, Cu, Mn, Zn, and Cr) in common vegetables of Karachi. Maximum concentration of Fe was 32.3 μg/g in spinach, Zn 8.6 μg/g in ladyfinger, Mn 5.6 μg/g in mint, Cu 3.3 μg/g in mustard and chromium 1.2 μg/g in coriander. The overall contents of trace metals appeared to be within the limit laid down for safe human consumption.

Khan *et al.* (2007a) analyzed *Cynodon dactylon*, *Paspalum notatum*, *Hypoxis hirsute*, and *Panicum maximum* for iron, copper, zinc, manganese and selenium. No differences were seen between winter and summer for forage in Fe, Cu, Zn, Mn, and Se. Forage Cu concentrations increased in summer for *Paspalum* from 20.3 to 23.1 μg/g. This species had the highest zinc concentrations 90.8 μg/g in winter and had the highest level of Fe and Cu of 130.0 and 23.1 μg/g, respectively in summer. *Hypoxis* had the highest Mn concentrations (250.8 μg/g) in winter while its Se concentrations increased in summer from 0.033 to 0.042 μg/g. Se was showed greatest increase in *Panicum* from 0.028 to 0.049 μg/g in summer. Later on Khan *et al.* (2007b) analyzed the mineral composition (Ca, Na, Cu, and Zn) of different forages and soils in five agricultural local pastures in the Punjab, Pakistan. Some low levels in soil Zn were found in two pastures during summer and winter seasons. Winter season soil Ca and Cu concentrations were significantly higher than summer season. Most forage samples had very marginal mineral concentrations, below the critical levels known to be adequate for normal ruminant requirements. Forage levels of Ca, Na, Cu, and Zn were found to be significantly increased, generally, with plant maturity from summer to winter. Supplementation is the urgent need for grazing livestock to prevent deficiency diseases due to mineral imbalances.

Ahmad *et al.* (2008b) assessed the concentrations of Cu, Mn, Fe and Zn of some legume forage plants in the Soone valley, Punjab, Pakistan. Mn ranged between 3.92-5.09 and 5.90-6.83; Zn; 0.027-0.076 and 0.028- 0.064, Fe; 20.72-25.43 and 25.35-32.94, Cu; 0.38-0.54 and 0.34-0.51 mg g-1 in the leaves and pods, respectively. The forage species had varying mineral composition in both leaves and pods. The plants showed significant differences for Zn and Mn contents of leaves and non-significant differences for pods, while Fe exhibited non-significant difference for the plant parts. Thereafter, Ahmad *et al.* (2008c) analyzed some forage grasses and legumes for Na, P, K, Ca and Mg composition in the Soone Valley, Punjab, Pakistan. it was concluded that most of the forage samples had sufficient Na, P, K, Ca and Mg to meet the requirement of ruminants grazing therein. Comparatively, the macro-mineral concentrations in pods were higher than those found in the leaves and leaflets showing no need of mineral supplementation.

Farooq *et al.* (2008) determined the contents of lead, copper, chromium, zinc and cadmium in various leafy vegetables grown in an effluent irrigated fields in the vicinity of an industrial area of Faisalabad, Pakistan. The concentrations of Pb, Cu, Cr, Zn and Cd in the leaves, stems and roots of spinach, coriander, lettuce, radish, cabbage and cauliflower were found to be 1.1331−2.652, 1.313-2.161, 1.121-2.254; 0.252-0.923, 0.161-0.855, 0.221-0.931; 0.217- 0.546, 0.376-0.495, 0.338-0.511; 0.461-1.893, 0.361-0.874, 0.442-1.637; 0.033-0.073, 0.017-0.061, 0.011-0.052 mg kg-1 on dry matter basis, respectively. The leaves of spinach, cabbage, cauliflower, radish and coriander contained higher levels of Cu (0.923 mg kg-1), Cd (0.073 mg kg-1), Cr (0.546 mg kg-1), Zn (1.893 mg kg-1) and Pb (2.652 mg kg-1) as compared to other parts of each vegetable.

Hameed *et al.* (2008) determined the concentration of C, O, Na, Mg, Al, Si, S, P, Cl, K, Ca, Ti, Fe and Br in *Rumex hastatus, Rumex dentatus, Rumex nepalensis, Rheum australe, Persicaria maculosa* and *Polygonum plebejum* of the family Polygonaceae. The mineral composition including K, P, Cu, Mn, Fe and Zn of some forage grasses and shrubs at three phenological stages from Harboi rangeland, Kalat, Balochistan was analyzed by Hussain & Durrani (2008). The differences were insignificant between grasses and shrubs in K, P, Fe and Zn contents. The concentration of Cu was higher in shrubs than grasses while Mn was higher in grasses

than shrubs. The differences in the K, P, Mn, Fe and Zn were insignificant among the various phenological stages. Generally K and Fe were sufficient while P and Zn were deficient in most of the analyzed forage plants. The mineral concentration of forage plants generally increased/ decreased inconsistently with the advancing phenological growth stages in most plants.

Rahim *et al.* (2008) investigated macro-minerals (Ca, P, K and Mg) and micro-minerals (Cu, Zn, Mn and Co) in *Cynodon dactylon*, *Apluda mutica*, *Setaria pumila*, *Panicum turgidum*, *Pennisetum orientale*, *Digitaria sanguinalis*, *Saccharum spontaneum*, *Rottboellia exaltata*, *Arthraxon prionodes*, *Cenchrus ciliaris*, *Desmostachya bipinnata* and *Andropogon squarrosus*. The Ca, P, K and Mg at early bloom stage were 0.31±0.044, 0.024±0.003, 0.63±0.047 and 0.005±0.001%, respectively. The Cu, Zn, Mn and Co at early bloom stage was 17.25±1.42, 10.30±1.961, 7.35±0.489 and 0.020±0.005 ppm, respectively. The Ca, P, K and Mg at maturity were 0.32±0.044, 0.041±0.002, 0.53±0.044 and 0.007±0.003 %, respectively. The Cu, Zn, Mn and Co at maturity was 18.48±2.383, 4.30±0.853, 4.675±0.716 and 0.007±0.003 ppm, respectively.

Rehman & Iqbal (2008) reported the accumulation of Fe, Pb, Cu, Cr and Zn in the foliage of naturally growing plants of *Prosopis juliflora*, *Abutilon indicum* and *Senna holosericea* in the vicinity of Korangi and Landhi industrial areas of Karachi. High concentration of these metals were observed in the foliage of above naturally growing plants collected from the industrial areas when compared with the control. Sultan *et al.* (2008a) determined macro-minerals (Ca, P, K and Mg) and micro-minerals (Cu, Zn, Mn and Co) in some rangeland grasses from Chagharzai, District Bunair. The mean percentage values for Ca, P, K and Mg at early bloom stage were 0.26±0.022, 0.025±0.004, 0.69±0.113 and 0.044±0.006, respectively. The mean ppm values for Cu, Zn, Mn and Co at early bloom stage were 22.75±2.671, 14.70±2.065, 10.12±1.770 and 0.023±0.003, respectively. The mean percentage values for Ca, P, K and Mg at maturity were 0.30±0.049, 0.031±0.006, 0.68±0.108 and 0.028±0.004, respectively. The mean ppm values for Cu, Zn, Mn and Co at maturity were 29.8±2.962, 8.96±2.0701, 6.14±1.034 and 0.029±0.005, respectively.

Ahmad *et al.*, (2009) concluded that the concentration of Pb, Ni and Cr was significantly higher than their critical levels in some leguminous plant species (*Acacia farnesiana, Acacia modesta, Acacia nilotica, Medicago denticulata, Melilotus indica, Sophora mollis, Lathyrus aphaca* and *Vicia sativa*) and grasses (*Cynodon dactylon, Saccharum munja, Saccharum spontaneum* and *Cyperus rotundus*) of Salt Range. The Pb concentration in the leaves ranged from 0.034 to 0.069 mg g^{-1} in different pastures, while in pods it ranged from 0.040 to 0.065 mg g^{-1}. The leaf Cr varied from 0.156 to 0.285 mg g^{-1} and in pods it was from 0.166 to 0.223 mg g^{-1} .The leaf Ni concentration ranged from 0.030 to 0.068 and that in pods from 0.037 to 0.084 mg g^{-1}. Thus, these forages may cause some toxic effects in grazing animals of the area.

Khan *et al.* (2009a) analyzed forage samples for macro-minerals (Na, K, Ca and Mg) and micro-minerals (Mn, Fe, Zn and Cu). These results showed that pasture grasses/ forages had sufficient levels of K, Ca, Mg, Mn, Fe and Zn to meet the requirements of ruminants being reared there but the occurrence of marginal to deficient supplies of Na and Cu appears very likely in this area of investigation. Later on Khan *et al.* (2009b) reported the seasonal effect on Ca, Mg, Na and K status in both plants and goats at a particular Livestock Experimental Station in the Punjab, Pakistan. It was concluded that the mean concentration of these metals in the forage was high in summer than winter. Furthermore, Khan *et al.* (2009c) studied the effects of sampling frequencies on mineral status of *Trifollium* pastures in Sargodha. Forages were analysed for copper, iron, manganese, and znic, and cobalt. Forage Co and Cu concentrations were low and deficient in relation to cattle requirements grazing therein for most of the sampling periods. In relation to cattle requirement, the majority of forages were deficient in Co, Cu and Zn.

Milosevic *et al.* (2009) analyzed N, P, K, Ca and Mg concentrations. Highest seasonal changes were observed in the contents of Mg (CV=18.19%) and N (CV=12.95%) and the lowest ones in P content (CV=4.00%). Highest leaf contents of N (1.83±0.07%), P (0.43±0.09%) and K (1.77±0.04%) during the season were produced by cv. Nochione and those of Ca (1.27±0.07%) and Mg (0.44±0.42%) by cvs. Tonda Gentile Romana and Istarski Duguljasti, respectively. Naser *et al.* (2009) reported the levels of lead, cadmium, and nickel in some vegetables and in the rizosphere soils of the industrially polluted areas of Dhaka. Lead, Cd, and Ni

concentrations in the studied vegetables were higher compared with their non-polluted counterparts. Concentrations of metals in vegetable samples were related to their concentration in the corresponding soils.

Malik *et al.* (2010) assessed total contents of Pb, Cu, Zn, Co, Ni, and Cr in the soil and 16 plant samples collected from industrial zone of Islamabad, Pakistan. Total metal concentrations of Pb, Zn, Cu, Co, Ni, and Cr in soils varied between 2.0-29.0, 61.9-172.6, 8.9 to 357.4, 7.3-24.7, 41.4-59.3, and 40.2-927.2 mg/kg. Total metal concentrations pattern in roots were: Cu>Cr>Zn>Ni>Pb>Co. Grasses showed relatively higher total Zn concentration. Accumulation of Cu was highest in shoots followed by Zn, Cr, Pb, Co and Ni. Sobukola *et al.* (2010) determined the heavy metal levels in sixteen different fruits and leafy vegetables from selected markets in Lagos, Nigeria. The results showed that the levels of lead, cadmium, copper, zinc, cobalt and nickel ranged from 0.072±0.06 to 0.128±0.03; 0.003±0.01 to 0.005±0.01; 0.002±0.00 to 0.015±0.02; 0.039±0.01 to 0.082±0.01; 0.014±0.01 to 0.026±0.01 and 0.070±0.07 to 0.137±0.05 mg/kg, respectively, for the fruits. The levels of lead, cadmium, copper, zinc, cobalt and nickel for the leafy vegetables respectively ranged from 0.09±0.01 to 0.21±0.06; 0.03±0.01 to 0.09±0.00; 0.02±0.00 to 0.07±0.00; 0.01±0.00 to 0.10±0.00; 0.02±0.00 to 0.36±0.00 and 0.05±0.04 to 0.24±0.01 mg/kg. Sultan *et al.* (2010) determined the mineral composition of *Indigoferra gerardiana, Myrisine africana, Impatians bicolor* and *Adhatoda vasica* shrubs for ruminants. The Ca, 1.01-2.7 %; P, 0.016-0.064 %; K, 0.47-1.29 %; Mg 0.012-0.032 %; Cu, 14-25 ppm; Zn, 12.4-41.3 ppm; Mn, 9-12 ppm and Co, 0.012-0.061 ppm were observed among shrub species.

Nutritional Composition

The nutritional demands of livestock vary with age and physiological functions of the grazing animal such as growth maintenance, gestation, fattening and lactation etc. Range animal productivity depends upon the amount and nutritive quality of vegetation available to grazing animals. Plant material is divisible into fibrous and non-fibrous fractions. In ruminants, fiber fractions that provide energy are important as celluloses and hemicelluloses are easily digestible. Karki *et al.* (2000) after analysis the growing shoots of forage from grazing lawns concluded that forage had higher digestibility, crude protein, and sodium than forage from the grasslands.

Starks *et al.* (2006) determined the nutritive value of pastures including neutral-detergent fibre (NDF), acid-detergent fibre (ADF) and crude protein (CP) concentrations of herbage bermudagrass (*Cynodon dactylon*), and the relationships between these descriptors of nutritive value of herbage and canopy reflectance in broad spectral wavebands. Ratios of canopy reflectance in blue to red (R(blue)/R(red)) and in near infrared to red (R(NIR)/R(red)) wave bands were highly correlated with concentrations of CP in herbage and herbage mass of CP but the relationships between reflectance ratios and NDF and ADF concentrations of herbage were relatively low. Bukhsh *et al.* (2007) worked on the nutritional value of some medicinal plants of families Asteraceae, Cruciferrae and Plantaginaceae. Results showed that crude proteins, total proteins in seeds and total carbohydrates were significantly higher in leaves of *Eruca sativa* as compared to *Carthamus oxyacantha* and *Plantago ovata*. The amount of total fats was significantly higher in seeds of *C. oxyacantha* as compared to *E. sativa* and *P. ovata*. While the concentration of crude fiber was significantly higher in seeds of *P. ovata* than seeds and leaves of both *E. sativa* and *C. oxyacantha*.

Sultan *et al.* (2007) investigated the nutritive value of locally available 12 marginal land grasses from Chagharzai, District Bunair. Dry matter (DM), organic matter (OM), ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemi-cellulose, and lignin contents were determined. The mean percentage values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin at early bloom stage were 30.1±1.08, 27.6±0.92, 8.1±0.33, 8.7±0.39, 52.3±0.25, 25.8±1.36, 26.6±1.75 and 3.7±0.17, respectively. The mean percentage values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin at mature stage were 39.4±0.75, 36.1±0.67, 8.2±0.28, 5.7±0.25, 60.9±2.04, 31.1±1.22, 29.8±2.27 and 4.5±0.19, respectively. Later on Sultan *et al.* (2008b) determined the DM, OM, ash, CP, NDF, ADF, hemi-cellulose, and lignin of the ten grasses; *Heteropogon contortus, Chrysopogon aucheri, Panicum antidotale, Dichanthium annulatum, Chrysopogon gryllus, Cymbopogon jwarancusa, Chrysopogon montanus, Themeda anathera, Aristida adscensionis* and *Cymbopogon schoenanthus* in Chagharzai valley, District Bunair. The mean percentage values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin at early bloom stage were 33.1±0.69, 30.6±0.55, 7.4±0.42,

7.8±0.33, 54.7±2.08, 24.7±0.89, 30.0±2.11 and 3.9±0.22, respectively. The mean percentage values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin at mature stage were 43.6±1.03, 41.4±0.86, 7.1±0.42, 5.5±0.25, 61.9±1.44, 29.4±1.16, 31.5±2.14 and 4.7±0.17, respectively. Sultan *et al.* (2008c) analyzed 12 fodder tree species for dry matter (DM), organic matter (OM), ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemi-cellulose and lignin contents in Chagharzai valley. The mean percentage values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin were 27.65±1.64, 26.87±1.37, 5.72±0.43, 14.29±1.00, 55.50±1.82, 28.83±1.63, 26.67±1.09 and 6.02±0.54, respectively. The mean *In vitro* dry matter digestibility (IVDMD) and metabolizable energy (ME) of fodder tree leaves were 54.16±2.06% and 7.24±0.30 MJ/kg DM, respectively.

Hameed *et al.* (2008) determined the proximate composition of proteins, crude fibers, fats & oils, moistures, ash contents and carbohydrates in *Rumex hastatus, Rumex dentatus, Rumex nepalensis, Rheum australe, Persicaria maculosa* and *Polygonum plebejum.* They reported the highest ash contents, proteins, crude fibers, fats & oils, moistures and carbohydrates in various parts of these plants. Bano *et al.* (2009) determined protein, proline, sugar and abscisic acid (ABA) contents in the leaves of four herbaceous alpine plants. *Galium aparine* showed the maximum endogenous ABA; *Onobrychis dealbata* showed the highest sugar and protein content, whereas *Polygonum alpinum* All., exhibited maximum proline. All the plant species showed a general trend for increased accumulation of protein, sugar, proline and free endogenous ABA in leaves at high altitude.

Hussain & Durrani (2009b) after determining the proximate composition and cell wall contents of some fodder species from Harboi rangeland, Kalat, Balochistan at three phenological stages concluded that grasses generally had more DM, CF, carbohydrates, NFE, NDF, ADF and hemicelluloses than shrubs while shrubs were generally high in ash, CP, EE, N, GE, ADL contents than grasses. There were insignificant differences in TDN, DE and ME between grasses and shrubs. Generally DM, CF, NDF, ADF, ADL, carbohydrate and hemicellulose contents increased with the maturity of plants; while ash, CP, EE, N and ME declined with maturity of plants. Some parameters like NFE, GE, DE and TDN did not differ among various phenological stages. Sultan *et al.* (2009) investigated *Oenothera rosea, Athyrium*

acrotiochoides, Chenopodium album, Polygonum amplexicaule, Atrimisia maritima, Oriosma lispidum, Cynoglossum lanceolatum, Plantago ovata, Hackalia macrophyla, Lespedeza spp. and *Urtica dioka* for dry matter (DM), organic matter (OM), ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemi-cellulose, and lignin contents. The average values for DM, OM, ash, CP, NDF, ADF, hemi-cellulose and lignin were 27.5±1.66, 24.2±1.33, 11.6±0.96, 12.3±1.42, 56.7±1.87, 30.9±1.24, 25.8±1.42 and 4.4±0.42, respectively.

Hussain *et al.* (2010) analyzed *Solanum melongena, Trianthema portulacastrum, Abelmoschus esculentus, Spinacia oleracea, Praecitrullus fistulosus, Luffa acutangula, Cucurbita oschata* and *Cucumis sativus* for their nutritional values. Highest carbohydrate contents were found in *Cucurbita moschata* followed by *Luffa acutangula, Cucumis sativus,* and *Solanum melongena* compared with other species. *Spinacia oleracea* and *Trianthema portulacastrum* had higher protein content than *Abelmoschus esculentus, Praecitrullus fistulosus, Solanum melongena, Luffa acutangula, Cucurbita moschata* and *Cucumis sativus.* Similarly *Trianthema portulacastrum* had highest percentage of fat contents followed by *Spinacia oleracea* and *Solanum melongena* while in *Abelmoschus esculentus, Praecitrullus fistulosus, Luffa acutangula, Cucurbita moschata* and *Cucumis sativus* lower amounts of fats were found. Sultan *et al.* (2010) determined the nutritive value of *Indigofera gerardiana, Myrsine africana, Impatiens bicolor* and *Adhatoda vesica* shrubs for ruminants. Chemical analysis revealed that dry matter (DM) content varied from 24.3% (*Adhatoda vesica*) to 38.1% (*Indigofera gerardiana, Impatiens bicolor*). Maximum crude protein (14.7%) was observed for *Myrsine africana* while, minimum (15.6%) was noted for *Impatiens bicolor* and *Adhatoda vesica.* Higher ash content (14.7%) and lower neutral detergent fiber contents (49%) were observed for *Myrsine africana.* Higher hemicellulose (42%) and lignin (7.9%) contents, and lower acid detergent fiber (22%) were observed for *Impatiens bicolor.*

AIMS AND OBJECTIVES

Due to lack of ecological knowledge and quantitative data on the floristic, vegetation and productivity of Gadoon Hills, there is a dire need to collect the information on floristic diversity and its ecological characterization, ethnobotany, vegetation structure, biomass productivity, palatability and animal preferences, proximate composition and mineral analysis of some forage plants. This is important because no ecological effort for improving the socio-economic aspect and biodiversity can be made without the base line data. The present study therefore, has the following aims and objectives:

i. To record the Floristic Diversity and its ecological characteristics.
ii. To prepare ethno ecological profile of plants.
iii. To work out the Edaphology of the area.
iv. To analyze the vegetation structure, its diversity and ecological characteristics.
v. To classify the fodder/forage plants into various palatability classes.
vi. To assess the productivity of rangeland.
vii. To determine the mineral composition of some key palatable species.
viii. To evaluate the proximate composition of some key palatable plants.
ix. To suggest ecological measures for the improvement of biodiversity of the area.

MATERIALS AND METHODS

MATERIALS AND METHODS

1. Floristic Structure and Composition

A. Floristic composition

This study was conducted in winter and summer for two consecutive years (2009 and 2010). Plant specimens, collected from the area, were dried and preserved. They were identified through available literature Nasir & Ali (1971-1995) and Ali & Qaisar (1971-2010). These plant specimens were submitted to the Herbarium, department of Botany, University of Peshawar, Pakistan. Leaf size and life forms were determined after Raunkaiar (1934) and Hussain (1989).

B. Biological spectra

Biological spectrum of the flora based on life form was prepared after Raunkaiar (1934) as follow.

a. Therophytes (Th)

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

b. Cryptophytes (Cr)

i. Geophytes (G): Perennating bud is located below the surface of soil including plants with deep rhizome, 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 (Hc)

Herbaceous perennials in which aerial portion dies at the end of the 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, woody trailing, low stem succulent 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):** These are tall tree species whose perennating buds are located above the height of 30 m.

ii. **Mesophanerophytes (Ms):** These are small trees with their perennating buds are located from 7.5 m to 30 m (25 ft to 100 ft) height.

iii. **Microphanerophytes (Mc):** These are shrubby plant species with perennating buds located above 2 m to 7.5 m (6 ft to 25 ft) height.

iv. **Nanophanerophytes (Np):** Their perennating buds are borne on aerial shoots from 0.25 m (25 cm) up to 2 m (0.8 ft to 6 ft) above the ground surface.

a. Raunkiarean and quantitative spectra were calculated as fallows.

$$\text{Raunkiarean Life form spectrum} = \frac{\text{No. of sp. falling into a particular life form class}}{\text{Total number of all the species}} \times 100$$

b.Quantitative life form spectra were calculated on the basis of importance value of each species encountered in sampling by quadrat by following Cain &Castro (1956) and Qadir and Shetvy (1986).

C. Leaf Size classes

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

i. **Leptophyll (Lp):** Leaf area upto 25 mm^2

ii. **Nanophyll (Na):** Leaf area from 25 to 225 mm^2

iii. **Microphyll (Mic):** Leaf area from 225 to 2025 mm^2

iv. **Mesophyll (Mes):** Leaf area from 2025 to 18225 mm^2

v. **Macrophyll (Mac):** Leaf area from 18225 to 164025 mm^2

vi. **Megaphyll (Meg):** Leaf area larger than class v.

For rapid classification in the field a leaf size diagram (Fig. 2) was used following Raunkiaerian (1934).

a. Raunkiaerian spectrum was calculated as follows:

$$\text{Raunkiarean Leaf size spectrum} = \frac{\text{No.of sp.falling in a particular leaf size class}}{\text{Total number of all the species}} \times 100$$

b. Quantitative leaf size spectra were calculated using importance value indices of plant species following Cain & Castro (1956).

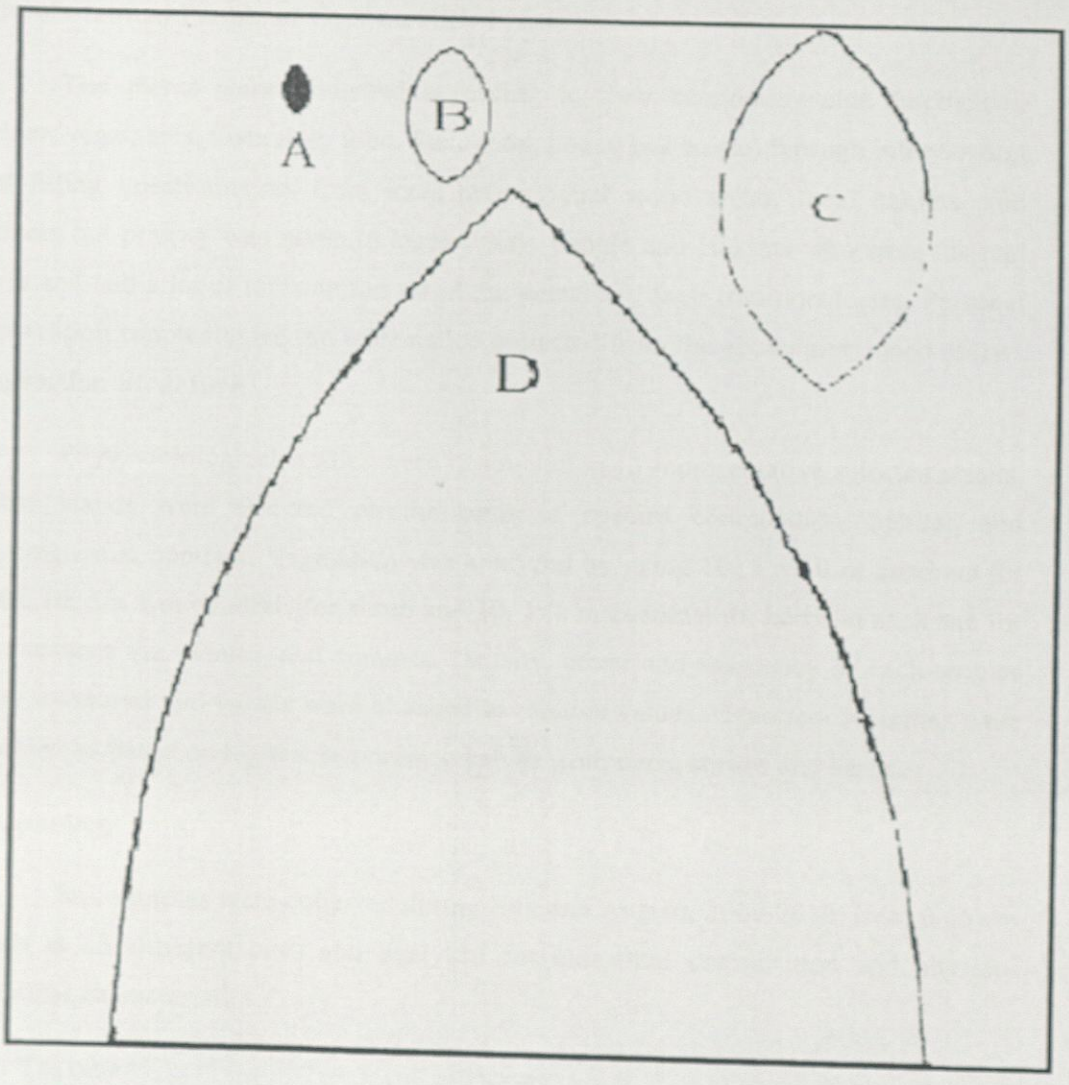


Fig. 2. Leaf size classes (After Raunkiaer) Diagram for use in rapid determination of the class size of a leaf. The figure shows the boundaries between the individual classes, thus

Less than A = Leptophyll

Between A and B = Nanophyll

Between B and C = Microphyll

Between C and two times D = Mesophyll

Between two times D and eight times the size of the diagram has bounded by the black lines= Macrophyll

More than eight times the size of the diagram as bounded by the black lines= Megaphyll

2. **Ethnobotanical Profile of Gadoon Hills Plants**

The plants were classified according to their economic value (medicinal, fodder, vegetables, thatching, food, fuel wood, honey bee sp.etc) through interviewing and filling questionnaires from local people, fuel wood seller, local hakims, and farmers but priority was given to local elderly people and Hakims who were the real users and had a lot of information about the plants and their traditional uses. Personal observation supplemented the information collected from the above mentioned users.

3. **Vegetation Structure**

Phytosociological studies were conducted in 13 representative selected stands. These stands were selected on the basis of species composition, habitat, and physiognomic contrast. Vegetation was analyzed by using 10, 5 x 10 m quadrats for trees, 10, 5 x 5 m quadrats for shrub and 10, 1x1 m quadrats for herbs in each site for two seasons viz. winter, and summer. Density, cover and frequency of each species were measured and values were changed to relative values. Plant communities were established based on highest importance values from trees, shrubs and herbs.

A. **Edaphology**

Soil samples were collected during July and August, 2009-2010, from 0-15 cm depth at 13 different sites and analyzed for elemental composition and physico-chemical characteristics.

Soil Texture

Soil textures was determined by Hydrometer method (Bouyoucos, 1936) and textural classes were determined with the help of textural triangle (Brady, 1990).

Water Holding Capacity

Water holding capacity of soils was determined by following Hussain (1989).

$$\text{Water holding capacity} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 10$$

Organic matter

Soil organic matter was determined by oxidation with potassium dichromate in sulphuric acid medium under standard wet combustion method of Walkley & Black (Ryan *et al.*, 1996).

Calcium carbonate

Calcium carbonate was determined by acid neutralization method (Ryan *et al.*, 1996).

Nitrogen

Total nitrogen was determined by the Kjeldahl method of Bremner & Mulvaney (1982).

Phosphorus

Phosphorus was determined after Olsen & Sommers (1982).

Potassium

Potassium was determined by flame emission spectroscopy (Jackson, 1962).

pH

Soil pH was measured in 1:5 soil water suspensions with a pH meter (Jackson, 1962).

Electrical Conductivity

Electrical conductivity of the soil was determined in 1:5 soil water suspension with EC meter.

Total Soluble Salts

TSS was determined by the recommended method of AOAC (1984).

Carbonates and Bicarbonates

Dissolved carbonates ($CO3^{--}$) and bicarbonates (HCO_3^{-}) were determined by titration method (Jackson, 1962) as follows:

$$\text{Carbonates } \left(\frac{\text{Meq}}{\text{lit}}\right) = \frac{\text{Volume of acid used in solution A for CO3} - - \times 2 \times \text{N} \times 1000}{\text{Volume of Soil extract}}$$

$$\text{Bicarbonates (Meq/lit)} = \frac{\text{Vol. of acid used in sol. B} - \text{Vol. used in sol. A} \times \text{N} \times 1000}{\text{Volume of Soil extract}}$$

Chloride

Dissolved chlorides (Cl) were determined by titrating the soil solution extract with Silver nitrate using Potassium chromate as an indicator (Richard, 1954).

$$\text{Chlorides (Meq/liter)} = \frac{\text{ml. of AgNO3 for sample} - \text{AgNO3 for blank x 0.005 x 1000}}{\text{5(i. e. ml of water)}}$$

Calcium + Magnesium

Calcium + Magnesium (Ca^{++}+ Mg^{++}) of soil saturated extract were determined by titration with Ethylenediamine tetra acetate (EDTA) and disodium salt (Versenate) after Richard (1954).

Sodium

Sodium (Na) content of soil saturated extract was determined by flame photometer.

Sodium Adsorption Ratio (SAR)

Sodium adsorption ratio (SAR) was determined after Richard (1954) as follows:

$$SAR = Na^{+} / \sqrt{Ca^{++} + Mg^{++}/2}$$

Sulphates

Sulphate (SO_4) was determined by precipitation as Barium sulphate (Richard, 1954).

$$\text{SO4 (Meq/liter)} = \frac{\text{mg of BaSO4 precipitate x 8.568}}{\text{Volume of Soil extract}}$$

B. Vegetational Features

Density

Density is the average number of individuals of a species in unit area

$$\text{Density} = \frac{\text{No. of individuals of a species in a Quadrat}}{\text{Total No. of Quadrats}}$$

$$\text{RD} = \frac{\text{Density of a species}}{\text{Total densities of all species}} \times 100$$

Herbage Cover

Cover is the vertical projection of foliage shoots crown of a species to the ground surface expressed as fraction or percent of a surface area.

$$\text{Cover} = \frac{\text{Cover of a species within quadrat}}{\text{Total Cover of all species}}$$

$$\text{RC} = \frac{\text{Cover of a species}}{\text{Total Cover of all species}} \times 100$$

Following six cover classes were established for estimating cover of a species. Mid points were used for calculation.

Class	Range %	Midpoints
1	0-5	2.5
2	5-25	15
3	25-50	37.5
4	50-75	62.5
5	75-95	85
6	95-100	97.5

Frequency

Frequency is the percentage occurrence of species in an area. It is the % occurrence of a species.

Frequency was determined as follows.

$$\text{Frequency} = \frac{\text{No. of quadrats in which a species was present}}{\text{Total number of quadrats applied}} \times 100$$

$$RF = \frac{\text{Frequency of a species}}{\text{Total frequencies of all species}} \times 100$$

Importance Value

The relative values of each species were added to get the importance values. Species importance values were summed to obtain family importance values (FIV) for each family. The community was named after the three leading species one each from trees, shrubs and herbs, having the highest importance values as follows.

$$IV = RD+RC+RF$$

Determination of Similarity Index

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

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

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, ID = 100 - Index of Similarity

Determination of Homogeneity

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

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

A = Present in up to 1-20%,

B = Present in up to 21-40%,

9963

C = Present in up to 41-60%,

D = Present in up to 61-80% and

E = Present in up to 81-100%.

Species Diversity

Species diversity was calculated by Simpson's index of diversity (Simpson, 1949).

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

Where: D = Diversity index,

N = Total number of individuals of all species,

n = Number of individuals of a species.

Species Richness

Species richness was calculated by using following formula (Menhinick, 1964).

$$d = S/\sqrt{N}$$

Where: S = Total number of species in a stand

N = Total number of individuals in a stand and

d = species richness

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 objects into group or clusters. The arrangement is 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 Multivariate Statistical Package (MVSP). The classification was based on compositional dissimilarity among stands and dendrograms were constructed for vegetational stands of the area.

Principal Coordinate Ordination

Principal coordinate analysis is the most widely used ordination procedure in ecology and available in computer statistical packages (MVSP). It is basically a multivariate statistical technique that deals with the internal structure of matrices. Principal coordinate ordination 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 provides information about the ecological resemblance between communities. Principal coordination analysis was applied to dissimilarity data of 13 analyzed stands.

4. Degree of Palatability of Plants

The degree of palatability of different plant species was recorded by observing the grazing livestock in the field. Cattle, goats and sheep were visually observed to determine their preferences. The palatability of these species was recorded from the shepherds and after following the animals while grazing in the rangeland during this study. Plants were classified into palatable and non-palatable species following Hussain & Durani (2009a). Palatable plant species were further classified by animal preference; part used and season of availability. Palatable plant species were classified as follows following Hussain & Durani (2009a).

i. Non Palatable (NP): Not grazed by livestock.
ii. Highly Palatable (HP): Plant species that were highly preferred by the livestock.

iii. Mostly Palatable (MP): Plant species with average likeness by the livestock.

iv. Less Palatable (LP): Plant species with less preference by livestock.

v. Rarely Palatable (RP): Plant species rarely grazed under compulsion when no other choice was available.

5. Measurement of Range Productivity

The productivity measurements were made at different altitude for two consecutive years. Shrub biomass was estimated by reference unit technique following Andrew *et al.* (1981) and Kirmse & Norton (1985). For herbs, above ground foliage of grasses and forbs was harvested by species at ground level using 1x1 m quadrats following Hussain (1989).

6. Mineral Evaluation of some selected Rangeland Plants

Plant samples of ten trees, eight shrubs and eight grasses were collected at three phenological stages (vegetative, reproductive and post reproductive) from Gadoon Hills. They were oven dried at 65°C for 72 h. The dried powdered samples were stored in plastic bags for chemical analysis. In macro-minerals calcium contents were measured at 422.7 nm, potassium at 766.5 nm, magnesium at 285.2 nm and sodium at 589.0 nm using computerized atomic adsorption spectrophotometer following standard procedures (Anon., 1982, 1985; Galyean, 1985). Nitrogen was determined by micro Kjeldahl procedures (AOAC, 1990). 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 titration apparatus. Micro-minerals like Cd contents were measured at 228.8 nm, Cr at 357.9 nm, Cu at 324.8 nm, Fe at 248.3 nm, Ni at 232.0 nm, Pb at 283.3 nm, Zn at 213.9 nm and Mn at 279.5 nm using computerized atomic adsorption spectrophotometer following standard procedures (Anon., 1982, 1985; Galyean, 1985).

7. Nutritional Analysis

A. Proximate Analysis

i. Dry Matter

Dry matter (DM) was obtained by oven drying the plant sample at 65 °C for 72 hours by AOAC (1984) method and percent dry matter was calculated as follows:

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

ii. Ash Contents

One to two grams of plant sample was ignited in the muffle furnace at 550 °C-600°C for 8 hrs and ash contents of samples were determined by AOAC (1984) method. Percent ash content was calculated as follows:

$$\text{Percent Ash Content \%} = \frac{\text{Weight of ash}}{\text{Weight of fresh Sample}} \times 100$$

iii. Organic Matter

Organic matter (OM) was calculated as follows:

$$\text{Percent Organic Matter \%} = 100 - \text{Ash}$$

iv. Plant Digestion

All nutrient determinations involved wet digestion of plant samples. One gm plant material was digested in concentrated selenium sulphuric acid and hydrogen peroxide was added to each digestion tube. The sample was digested by placing digestion tubes on heating blocks. The digestion was continued at 350°C until colour of the solution was clear. The prepared solution was diluted with double distilled water and stored in tubes. This solution was used for the analysis of nitrogen /crude protein, potassium, phosphorus, copper, zinc, and manganese using following methods.

v. Nitrogen / Crude Protein

Nitrogen 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 as follows:

$$\text{Percent Crude Protein} = \frac{(\text{ml H2SO4} - \text{blank}) \times \text{N} \times 6.25 \times 14.01}{\text{Sample weight} \times 1000}$$

vi. Crude Fiber

Crude fiber (CF) was determined by following AOAC (1984). The sample was digested with 1.25% H_2SO_4 for 30 minutes followed by 30 minutes with 1.25% NaOH. The insoluble residues were dried, weighed, ashed and the insoluble organic matter was reported as crude fiber as follows:

$$\text{Percent Crude Fiber} = \frac{\text{Loss in weight in ignition}}{\text{Weight of Sample}} \times 100$$

vii. Ether Extract (Crude Fat)

Ether extract (EE) procedure involves a reflux apparatus which boils ether, condenses it and allows it to pass through the sample. Ether extract was calculated as follows (Galyean, 1985):

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

viii. Nitrogen Free Extract

Nitrogen free extract (NFE) was calculated after Galyean (1985).

NFE = Dry matter (% Ash + % Crude fiber + % Ether extract + % Crude protein).

Nitrogen free extract represent highly digestible carbohydrates.

ix. Gross Energy

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

GE (Kcal/g) = 5.72(CP) + 9.5(EE) + 4.79(CF) + 4.03(NFE).

x. Total Digestible Nutrients

Total digestible nutrients (TDN) for livestock were calculated after Harris *et al* (1967). Total digestible nutrients are a measure of the digestible energy content of sample on carbohydrate equivalent basis.

Percent 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. OR

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

xi. Digestible Energy

Digestible energy (DE) was calculated from TDN% for sheep and goats following (Anonymous, 1982) as follows:

DE (Mcal/Kg) = TDN% x 0.04409.

OR DE = 0.0229 (CP) + 0.0349 (EE) + 0.0091 (CF) + 0.00017 $(NFE)^2$ + 0.5 NFE% - 0.068.

xii. Metabolizable Energy

Metabolizable energy (ME) was calculated from digestible energy for livestock Moe & Tyrrel (1976) as follows:

ME (Mcal/Kg) = 0.45 + 1.01 (DE).

xiii. Total Carbohydrates

Total carbohydrates were calculated after Galyean (1985) as follows:

Total Carbohydrates = 100 - % Moisture – (% Ash + % Crude Protein + % Ether Extract

B. Cell Wall Constituents

i. Neutral Detergent Fiber

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 was added. The solution was then boiled for 5-10 minutes and refluxed for 60 minutes. Then 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 weighed (Van Soest, 1963., Goering

& Van Soest, 1970). NDF was calculated as follows:

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

ii. Acid Detergent Fiber

One gm sample was taken into a beaker for refluxing. 100 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 and washed with hot water twice followed by acetone until it was clear. Then the filtered was dried at 100°C for eight hours and weighed. ADF was calculated as follows (Van Soest, 1963., Van Soest & Wine, 1967):

$$\text{ADF\%} = \frac{Wo - Wt}{S} \times 100$$

Where: WO = Weight of oven dry crucible including fiber

Wt = Tarred weight of oven dried crucible

S = Oven dried sample weight.

iii. Acid Detergent Lignin

Acid detergent lignin (ADL) was analyzed from lingo-cellulose (residue of ADF) following Georing & Van Soest, (1970) and Waldern (1971). The cellulose was dissolved by 72% H_2SO_4. The remaining residue consisted of lignin and acid insoluble ash.

iv. Hemi cellulose

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

Hemi cellulose = NDF – ADF.

RESULTS

RESULTS

1. Floristic Composition and its characteristics

Floristic composition

The flora of Gadoon Hills, District Swabi consisted of 260 plant species belonging to 211 genera and 90 families (Table 3). Of them, 77 families were Dicots, 7 Monocots, 4 Pteridophytes and 2 Gymnosperms (Table 3). Only twenty eight species were spiny. Asteraceae had 23 species which was followed by Poaceae (18 spp.), Lamiaceae (13 spp.), Rosaceae & Papilionaceae (each with 11 spp.) and Brasicaceae (10 spp.). Euphorbiaceae, Moraceae and Polygonaceae had 7 spp. each. Caryophyllaceae had 6 spp. Each of the Amaranthaceae, Apiaceae, Mimosaceae, Ranunculaceae and Scrophulariaceae had 5 species. Alliaceae, Cyperaceae, Malvaceae and Solanaceae were represented by 4 species each, while the remaining 71 families had 3 or less than 3 species. Forty five tree species associated with 30 taxa of shrubs and 185 herb species. Two species of mistletoe (*Viscum album, Korthalsella opuntia*) and one parasite (*Cuscuta reflexa*) were recorded in the study area (Table 3). Most of the species were growing wild (235 species). Sixteen species were cultivated. Nine species were growing wild as well as cultivated. Of the 75 trees and shrubs, 28 were evergreen and 48 were deciduous species. Annuals shared 129 species while 49 species were perennials.

The biological spectrum showed that therophytes (129 spp., 49.62%) and megaphanerophytes (45 spp., 17.31%). were the most abundant. They were followed by nanophanerophytes (30 spp., 11.54%), geophytes (25 spp., 9.62%), hemicryptophytes (19 spp., 7.31%), and chamaephytes (5 spp., 1.92%). Lianas and mistletoe were represented by 4 (1.54%) and 2 (0.77%) species, respectively (Fig. 2). While one species of parasite shared 0.38% contribution (Table 4). Leaf spectra (Table 4) consisted of microphylls (47.69%), leptophylls (19.23%) mesophylls (15%), nanophylls (13.85%), macrophylls (1.92%), megaphylls (0.77%) and leafless (1.54%) (Fig. 3).

Table 3. Floristic list, Life form and Leaf size classification of some plants of Gadoon Hills, District Swabi, Pakistan.

S.No.	Families and Species	W /C	Flower Period	LF	LS	Smr.	Wnt.
A.	**Pteridophytes**						
1.	**Adiantaceae**						
	1. Adiantum incisum Forsk.	W	Summer	G	Na	+	+
	2. Adiantum venustum D.Done	W	Summer	G	Na	+	+
2.	**Aspleniaceae**						
	3. Asplenium adiantum nigrum L.	W	Summer	G	Mic	+	+
	4. Ceterach dalhousiae (Hk.) C. Chr.	W	Summer	G	Mic	+	+
3.	**Equisetaceae**						
	5. Equisetum arvense L.	W	Summer	G	Lp	+	+
4.	**Pteridaceae**						
	6. Cheilanthes marantae (L.) Domin.	W	Summer	G	Mic	+	+
B.	**Gymnosperms**						
5.	**Pinaceae**						
	7. Pinus roxburghii Sergent	W	Spring	Mp	Lp	+	+
	8. Pinus wallichiana A.B.Jackson.	W	Spring	Mp	Lp	+	+
6.	**Taxaceae**						
	9. Taxus wallichiana Zucc.	W	Spring	Mp	Lp	+	+
C.	**Monocotyledons**						
7.	**Alliaceae**						
	10. Allium cepa L.	C	Summer	G	Mic	+	-
	11. Allium griffithianum Boiss.	W	Spring	G	Lp	+	-
	12. Allium jacquemontii Kunth	W	Spring	G	Lp	+	-
	13. Allium sativum L.	C	Summer	G	Mic	+	-
8.	**Amaryllidaceae**						
	14. Narcissus tazzeta L.	W	Summer	G	Mic	-	+
9.	**Asparagaceae**						
	15. Asparagus adscendens Roxb.	W	Winter	Ch	Lp	+	+
10.	**Araceae**						
	16. Acorus calamus Linn.	W	Summer	G	Mic	+	-
11.	**Cyperaceae**						
	17. Cyperus niveus Retz.	W	Spring	G	Lp	+	+
	18. Cyperus rotundus Linn.	W	Summer	G	Lp	+	+
	19. Fimbristylis dichotoma (L.) Vahl.	W	Summer	G	Mic	+	+
	20.Schoenoplectus litoralis Schrad.	W	Summer	G	Mic	+	+
12.	**Liliaceae**						
	21. Tulipa stellata Hk.f.	W	Spring	G	Lp	+	-
13.	**Poaceae**						
	22. Apluda mutica L.	W	Winter	Hc	Lp	+	+
	23. Aristida adscensionis L.	W	Spring	Hc	Lp	+	+
	24. Arthraxon prionodes (Steud.) Dandy.	W	Summer	Hc	Lp	+	+

	25. Avena sativa L.	W	Winter	Th	Lp	+	+
	26. Chrysopogon aucheri (Boiss.) Stapf	W	Winter	Hc	Lp	+	+
	27. Cynodon dactylon (L.) Pers.	W	Through out year	Hc	Lp	+	+
	28. Dichanthium annulatum (Forssk.) Stapf.	W	Summer	Hc	Mic	+	-
	29. Digitaria sanguinalis (L.) Scop.	W	Summer	Hc	Lp	+	+
	30. Heteropogon contortus (L.) P. Beauv.	W	Summer	Hc	Lp	+	+
	31. Imperata cylindrica (L.) P. Beauv.	W	Summer	Hc	Lp	+	-
	32. Miscanthus nepalensis (Trin.) Hack.	W	Summer	Hc	Lp	+	+
	33. Pennisetum orientale L. C. Rich.	W	Summer	Hc	Mic	+	-
	34. Phalaris minor Retz.	W	Spring	Th	Mic	-	+
	35. Poa annua L.	W	Through out year	Th	Lp	-	+
	36. Saccharum bengalense Ritz.	W	Autumn	Hc	Mic	+	-
	37. Saccharum spontaneum L.	W	Summer	Hc	Mic	+	-
	38. Sorghum helepense (L.) Bern.	W	Summer	Hc	Mic	+	-
	39.Themeda anathera (Nees) Hack.	W	Summer	Hc	Lp	+	-
D.	**Dicotyledons**						
14.	**Acanthaceae**						
	40. Dicliptera roxburghiana Nees	W	Summer	Th	Na	+	-
	41. Justicia adhatoda L.	W	Summer	Np	Mic	+	+
15.	**Amaranthaceae**						
	42. Achyranthes aspera L.	W	Spring	Th	Mes	+	-
	43. Aerva javanica (Burm. f.) Juss.	W	Summer	Th	Mic	+	-
	44. Amaranthus spinosus L.	W	Spring	Th	Mic	+	-
	45. Amaranthus viridis L.	W	Spring	Th	Mic	+	-
	46. Celosia cristata L.	W	Spring	Th	Na	+	-
16.	**Anacardiaceae**						
	47. Pistacia integrima J.L.Stewart ex Brandis	W	Spring	Mp	Mic	+	+
	48. Rhus cotinus L.	W	Summer	Mp	Mic	+	+
17.	**Apiaceae**						
	49. Ammi visnaga (L.) Lamk.	C		Th	Lp	+	-
	50. Bupleurum subuniflorum Boiss. & Heldr.	W	Summer	Th	Mic	+	-
	51. Coriandrum sativum L.	C	Early spring	Th	Lp	+	-
	52. Eryngium biebersteinianum Nevski ex Bobrov.	W	Summer	Th	Mes	+	+
	53. Foeoniculum vulgare Miller.	C	Summer	Th	Lp	+	-
18.	**Apocynaceae**						
	54. Carissa spinarum auct. non L.	W	Summer	Np	Mic	+	+
	55. Nerium indicum Mill.	C	Summer	Np	Mic	+	+

	56. Rhazya stricta Dcne.	W	Winter	Np	Mic	+	+
19.	**Araliaceae**						
	57. Hedera helix L.	W	Autumn	L	Mic	+	+
20.	**Asclepiadaceae**						
	58.Calotropis procera (Wild) R.Br.	W	Through out year	Np	Mes	+	+
	59. Pergularia daemia (Forssk.) Chiov.	W	Autumn	L	Mic	+	-
	60. Periploca aphylla Dcne.	W	Spring	Np	LL	+	+
21.	**Asteraceae**						
	61. Achillea millefolium L.	W	Summer	Th	Na	+	-
	62. Artemisia vulgaris L.	W	Summer	Ch	Mic	+	+
	63. Bidens cernua L.	W	Summer	Th	Mic	+	-
	64. Calendula arvensis L.	W	Spring	Th	Na	-	+
	65. Calendula officinalis L.	W	Spring	Th	Na	-	+
	66. Carthamus oxycantha M.B.	W	Spring	Th	Na	-	+
	67. Cichorium intybus L.	W	Spring	Th	Mes	+	-
	68. Cirsium arvense (L.) Scop.	W	Spring	Th	Mic	+	-
	69. Conyza canadensis (L.) Cronquist	W	Winter	Th	Lp	+	-
	70. Conyza crispus Pourr.	W	Winter	Th	Lp	+	-
	71. Echinops echinatus Roxb.	W	Spring	Th	Mic	+	-
	72. Filago spathulata C. Presl.	W	Spring	Th	Mic	+	-
	73. Inula cappa (Ham.) DC.	W	Winter	Th	Mic	+	-
	74. Inula racemosa Hk. f.	W	Winter	Th	Mic	+	-
	75. Lactuca serriola L.	W	Spring	Th	Mic	+	-
	76. Myriactus wallichii Less.	W	Spring	Th	Mic	+	-
	77. Saussurea heteromalla (D.Don.) Hand-Mazz	W	Spring	Th	Mic	-	+
	78. Sonchus arvensis L.	W	Spring	Th	Mes	-	+
	79. Sonchus asper L.	W	Spring	Th	Mes	-	+
	80. Sonchus auriculata L.	W	Spring	Th	Mes	+	-
	81.Tagetus minuta L.	W	Through out year	Th	Mic	-	+
	82. Taraxacum officinale Weber.	W	Spring	Th	Mic	-	+
	83. Xanthium strumarium L.	W	Summer	Th	Mes	+	-
22.	**Berberidaceae**						
	84. Berberis lycium Royle.	W	Summer	Np	Mic	+	+
23.	**Bombacaceae**						
	85. Bombax ceiba Linn.	W /C	Winter	Mp	Mes	+	+
24.	**Boraginaceae**						
	86. Lithospermum officinale L.	W	Summer	Th	Mic	+	-
	87. Trichodesma indica (L.) R.Br.	W	Summer	Th	Na	+	-
25.	**Brasicaceae**						
	88. Arabidopsis wallichii (H.&T.) N. Busch.	W	Summer	Th	Mic	-	+
	89. Brassica compestris L.	C	Winter	Th	Mes	-	+
	90. Capsella bursa-pestoris Medic.	W	Summer	Th	Mic	-	+

	91. Coronopus didymus (L.) Sm.	W	Summer	Th	Lp	-	+
	92. Eruca sativa L.	W	Spring	Th	Mic	+	-
	93. Lepidium apetalum Willd.	W	Summer	Th	Na	+	-
	94. Nasturtium officinale R.Br.	W	Summer	Th	Mes	-	+
	95. Neslia apiculata Fisch., Mey. & Ave Lall.	W	Spring	Th	Mic	+	-
	96. Sisymbrium orientale L.	W	Summer	Th	Mic	+	-
	97. Thlaspi perfoliantum L.	W	Summer	Th	Mic	+	-
26.	**Buddlejaceae**						
	98. Buddleja asiatica Lour.	W	Spring	Np	Mic	+	+
27.	**Buxaceae**						
	99. Buxus wallichiana Baill.	W	Spring	Mp	Mic	+	+
	100.Sarcococa saligna (Dcne) Duel	W	Autumn	Np	Mic	+	+
28.	**Cactaceae**						
	101. Opuntia dilleni Haw.	W	Spring	Np	LL	+	+
29.	**Caesalpinaceae**						
	102. Bauhinia variegata L.	W /C	Spring	Mp	Mes	+	+
	103. Cassia fistula Linn.	W	Summer	Mp	Mes	+	+
30.	**Canabanaceae**						
	104. Cannabis sativa L.	W	Summer	Th	Mic	+	-
31.	**Caprifoliaceae**						
	105. Lonicera hypoleuca Dcne.	W	Summer	Np	Mic	+	+
	106. Lonicera quinquilacularis Hardw.	W	Summer	Mp	Mic	+	+
	107.Vibernum cotinifolium D. Don.	W	Spring	Mp	Mic	+	+
32.	**Caryophyllaceae**						
	108. Arenaria serpyllifolia L.	W	Summer	Th	Lp	-	+
	109. Cerastium dichotomum L.	W	Spring	Th	Mic	-	+
	110. Cerastium fontanum Baumg.	W	Summer	Th	Mic	-	+
	111. Silene conoidea L.	W	Spring	Th	Na	-	+
	112. Silene vulgaris (Moench) Carcke	W	Summer	Th	Na	-	+
	113. Stellaria media (L.) Cyr.	W	Summer	Th	Lp	-	+
33.	**Celastraceae**						
	114. Gymnosporia royleana Wall ex Lawson	W	Through out year	Np	Mic	+	+
34.	**Chenopodiaceae**						
	115. Chenopodium album L.	W	Spring	Th	Mic	-	+
	116. Chenopodium ambrosioides L.	W	Summer	Th	Mic	-	+
	117. Chenopodium murale L.	W	Summer	Th	Mic	-	+
35.	**Convolvulaceae**						
	118. Convolvulus arvensis L.	W	Through out year	L	Mic	-	+
	119. Convolvulus pluricaulis Choisy	W	Spring	Th	Mic	-	+
36.	**Crassulaceae**						
	120. Sedum ewersii Ledeb.	W	Summer	Th	Lp	-	+
37.	**Cucurbitaceae**						

	121. Cucumis prophetarum L.	W	Summer	Th	Mic	+	-
	122. Luffa cylindrica (L.) Roem.	W	Summer	Th	Mac	+	-
	123. Melothria heterophylla Cogn.	W	Spring	Th	Mic	+	-
38.	**Cuscutaceae**						
	124. Cuscuta reflexa Roxb.	W	Summer	P	LL	+	+
39.	**Ebenaceae**						
	125. Diospyrus kaki L.	C	Summer	Mp	Mes	+	-
	126. Diospyrus lotus L.	W	Summer	Mp	Mic	+	-
40.	**Ericaceae**						
	127. Rhododendron arborium Smith.	W	Spring	Np	Mes	+	+
41.	**Euphorbiaceae**						
	128. Euphorbia cornigera Boiss.	W	Summer	Th	Na	+	+
	129. Euphorbia helioscopia L.	W	Summer	Th	Na	-	+
	130. Euphorbia hirta L.	W	Summer	Th	Na	-	+
	131. Euphorbia prostrata Ait.	W	Through out year	Th	Lp	+	+
	132. Mallotus philippensis Muell.	W	Spring	Mp	Mic	+	+
	133. Phyllanthus maderaspatensis L.	W	Summer	Th	Na	+	-
	134. Riccinis communis L.	W	Through out year	Np	Meg	+	+
42.	**Fagaceae**						
	135. Quercus dilatata Lindley	W	Spring	Mp	Mic	+	+
	136. Quercus incana Roxb.	W	Spring	Mp	Mic	+	+
43.	**Flacourtiaceae**						
	137. Flacourtia indica (Burm. f.) Merrill	W	Spring	Mp	Mic	+	+
44.	**Fumariaceae**						
	138. Fumaria indica (Hsskn) H.N.	W	Summer	Th	Lp	-	+
45.	**Gentianaceae**						
	139. Gentiana kurru Royle	W	Through out year	Th	Lp	+	+
46.	**Geraniaceae**						
	140. Geranium nepalensis Sweet	W	Summer	Th	Mic	+	+
	141. Geranium wallichianum D. Don. ex Sweet	W	Summer	Th	Mic	+	+
47.	**Hamamelidaceae**						
	142. Parrotiopsis jacquemontiana Dcne.	W	Spring	Mp	Mic	+	-
48.	**Hypericaceae/Guttiferae**						
	143. Hypericum perforatum L.	W	Summer	Th	Lp	+	-
49.	**Lamiaceae**						
	144. Ajuga bracteosa Wall. Benth.	W	Summer	Th	Mic	+	+
	145. Ajuga parviflora Benth.	W	Summer	Th	Mic	+	+
	146. Colebrookea oppositifolia Sm.	W	Spring	Np	Mic	+	+
	147. Leucas urticifolia (Vahl) R.Br.	W	Summer	Th	Mic	+	-
	148. Mentha longifolia (L.) Huds	W	Summer	G	Mic	+	-
	149. Mentha spicata L.	W	Summer	G	Mic	+	-

	150. Micromeria biflora (Ham.) Bth.	W	Through out year	Th	Mic	+	+
	151. Origanum vulgare L.	W	Summer	Ch	Mic	+	+
	152. Otostegia limbata Bth.	W	Spring	Np	Mic	+	+
	153. Plectranthus rugosus Wall.ex. Bth.	W	Spring	Th	Mic	+	+
	154. Salvia lanata Roxb.	W	Spring	Th	Mic	+	+
	155. Salvia moocruftiana Wall.	W	Summer	Th	Mes	+	-
	156. Thymus serphyllum L.	W	Spring	Th	Mic	+	-
50.	**Lauraceae**						
	157. Litsea deccanensis Gamble	W	Summer	Mp	Mes	+	+
51.	**Linaceae**						
	158. Linum strictum L.	W	Summer	Th	Lp	-	+
52.	**Loranthaceae**						
	159. Viscum album L.	W	Spring	M	Lp	+	+
	160. Korthalsella opuntia (Thunb.) Merrill	W	Summer	M	LL	+	+
53.	**Lythraceae**						
	161.Woodfordia fruticosa (L.) Kurz	W	Spring	Np	Mes	+	+
54.	**Malvaceae**						
	162. Malva neglecta Waller.	W	Summer	Th	Mic	+	-
	163. Malva parviflora L.	W	Summer	Th	Mic	+	-
	164. Malvastrum coromandelianum L.	W	Through out year	Hc	Mic	+	+
	165. Sida cordata (Burm.f) Borss-Waalkes	W	Spring	Th	Mic	+	-
55.	**Meliacea**						
	166. Cedrela serrata Royle.	W	Summer	Mp	Mes	+	+
	167. Melia azedarach L.	C	Spring	Mp	Mic	+	+
56.	**Menispernaceae**						
	168. Tinospora cordifolia (DC.) Meirs	C	Summer	L	Mac	+	+
57.	**Mimosaceae**						
	169. Acacia catechu (L.f.) Willd.	W	Summer	Mp	Lp	+	+
	170. Acacia modesta Wall.	W	Spring	Mp	Lp	+	+
	171. Acacia nilotica (L.) Delile.	W	Summer	Mp	Lp	+	+
	172. Albizia lebbeck (L.) Bth.	W /C	Spring	Mp	Lp	+	+
	173. Mimosa himalayana Gamble	W	Summer	Np	Lp	+	+
58.	**Moraceae**						
	174. Broussonetia papyrifera (L.) L'Herit. ex Vent.	W	Summer	Mp	Mes	+	+
	175. Ficus carica L.	W /C	Spring	Mp	Mes	+	+
	176. Ficus palmata Forssk.	W	Summer	Mp	Mes	+	+
	177. Ficus racemosa L.	W	Spring	Mp	Mac	+	+
	178. Ficus religiosa L.	C	Spring	Mp	Mes	+	+
	179. Morus alba L.	W /C	Spring	Mp	Mes	+	+

	180. Morus indica L.	W /C	Spring	Mp	Mes	+	+
59.	**Musaceae**						
	181. Musa sapientum L.	C	Through out year	G	Meg	+	+
60.	**Myrsinaceae**						
	182. Myrsine africana L.	W	Spring	Np	Na	+	+
61.	**Nyctaginaceae**						
	183. Boerhaavia diffusa L.	W	Winter	Th	Na	+	+
	184. Boerhavia procumbens Banks ex Roxb.	W	Winter	Th	Na	+	+
	185. Mirabilis jalapa L.	W	Autumn	Th	Mes	+	-
62.	**Onagraceae**						
	186. Epilobium brevifolium Don.	W	Summer	Th	Na	+	-
	187. Oenothera rosea Soland.	W	Summer	Th	Mic	+	-
63.	**Oxalidaceae**						
	188. Oxalis corniculata L.	W	Winter	Th	Mic		+
64.	**Papaveraceae**						
	189. Papaver rhoeas L.	W	Summer	Th	Mic	+	+
65.	**Papilionaceae**						
	190. Butea frondosa Roxb.	W	Spring	Mp	Mes	+	+
	191. Crotalaria medicaginea Lam.	W	Summer	TH	Na	-	+
	192. Dalbergia sissoo Roxb.	C	Spring	Mp	Mic	+	+
	193. Indigofera heterantha L.	W	Summer	Np	Lp	+	+
	194. Lathyrus aphaca L.	W	Spring	Th	Na	-	+
	195. Lespedeza juncea (L.f) Persoon	W	Summer	Th	Mic		-
	196. Medicago minima (Linn.) Grufb	W	Summer	Th	Na	-	+
	197. Medicago polymorpha L.	W	Spring	Th	Na	-	+
	198. Pueraria tuberosa (Roxb. ex Willd.) DC.	W	Spring	Th	Mic	+	-
	199. Trifolium repens L.	W	Winter	Th	Na	-	+
	200. Vicia saiva L.	W	Winter	Th	Na	-	+
66.	**Plantaginaceae**						
	201. Plantago lanceolata L.	W	Summer	Hc	Mic	+	+
	202. Plantago major L.	W	Summer	G	Mes	+	+
67.	**Platanaceae**						
	203. Platanus orientalis L.	W	Spring	Mp	Mac	+	+
68.	**Polygalaceae**						
	204. Polygala abyssinica R. Br.ex Fresen.	W	Summer	Th	Na	+	-
69.	**Polygonaceae**						
	205. Bistorta amplexicaulis (D.Don) Green	W	Winter	Th	Mes	-	+
	206. Polygonum barbatum L.	W	Summer	G	Mic	+	+
	207. Polygonum paronychioides C. A. Mey.ex Hohen	W	Winter	Th	Lp	-	+
	208. Polygonum plebejum R. Br.	W	Summer	Th	Mic	+	+

	209. Rumex dentatus L.	W	Spring	Th	Mes	+	-
	210. Rumex hastatus L.	W	Summer	Ch	Na	+	-
	211. Rumex vesicarius L.	W	Spring	Th	Na	+	-
70.	**Portulacaceae**						
	212. Portulaca olearaceae L.	W	Through out year	Th	Lp	+	-
71.	**Primulaceae**						
	213. Anagallis arvensis L.	W	Spring	Th	Lp	-	+
	214. Androsace rotundifolia Hardw.	W	Spring	Th	Mic	+	-
	215. Primula denticulata Sm.	W	Spring	Th	Mic	+	-
72.	**Punicaceae**						
	216. Punica granatum L.	C	Summer	Mp	Na	+	+
73.	**Ranunculaceae**						
	217. Caltha alba Jacq ex Comb.	W	Summer	G	Mes	+	-
	218. Consolida ambigua(L.) Ball & Heywood	W	Spring	Th	Na	+	-
	219. Delphinium denudatum Wall. ex H, & T.	W /C	Spring	Th	Mic	+	-
	220. Ranunculus muricatus L.	W	Spring	Th	Mic	-	+
	221. Thalictrum foliolosum DC.	W	Spring	Th	Na	+	-
74.	**Rhamnaceae**						
	222. Sageretia theezans (L.) Brongn.	W	Summer	Np	Lp	+	+
	223. Zizyphus jujuba Mill.	W /C	Summer	Mp	Mic	+	+
	224. Zizyphus nummularia Buem.f. Weight	W	Summer	Np	Lp	+	+
75.	**Rosaceae**						
	225. Cotoneaster bacillaris Wall. ex Lindle.	W	Spring	Mp	Mes	+	+
	226. Duchesnea indica (Andr.) Focke	W	Summer	Th	Mic	+	-
	227. Fragaria indica Andrew	W	Summer	Hc	Mic	+	-
	228. Fragaria vesca Lindle.ex Hk. f.	W	Summer	Hc	Mic	+	-
	229. Potentilla anserina L.	W	Summer	Th	Mic	+	-
	230. Potentilla supina L.	W	Summer	Th	Mic	+	-
	231. Prunus cornuta (Wall ex Royle) Steud.	W	Spring	Mp	Mes	+	+
	232. Pyrus pashia Ham ex. D. Done	W	Spring	Mp	Mes	+	+
	233. Rosa moschata non J. Herrm.	W	Spring	Np	Mic	+	+
	234. Rubus ellipticus Smith	W	Spring	Np	Mic	+	+
	235. Rubus ulmifolius Schott.	W	Spring	Np	Mic	+	+
76.	**Rubiaceae**						
	236. Gallium aparine L.	W	Summer	Th	Lp	+	+
77.	**Rutaceae**						
	237. Zanthoxylum aromatum D.C.	W	Spring	Np	Mes	+	+

78.	**Salicaceae**						
	238. Populus euphratica Olivier	C	Spring	Mp	Mac	+	+
	239. Salix tetrasperma Roxb.	C	Summer	Mp	Mic	+	+
79.	**Sapindaceae**						
	240. Dodonaea viscosa (L.) Jacq.	W	Spring	Np	Mic	+	+
80.	**Saxifragaceae**						
	241. Bergenia ciliata (Haw) Sternb.	W	Spring	G	Mes	+	-
81.	**Scrophulariaceae**						
	242. Antirrhinum orontium L.	W	Spring	Th	Lp	+	-
	243. Kickxia ramosissima (Wall) Janchen.	W	Spring	Th	Na	+	-
	244. Scrophularia scabiosifolia Bth.	W	Spring	Th	Na	+	-
	245. Verbascum thapsus L.	W	Spring	Th	Mes	+	+
	246. Veronica didyma Tenore	W	Spring	Th	Na	+	-
82.	**Simarubaceae**						
	247. Ailanthus altissima (Mill) Swingle	W	Summer	Mp	Mic	+	+
83.	**Solanaceae**						
	248. Datura innoxia Mill.	W	Summer	Np	Mes	+	+
	249. Solanum nigrum L.	W	Through out year	Th	Mic	+	+
	250. Solanum surratense Burm.f.	W	Through out year	Th	Mic	+	-
	251. Withania somnifera (L.) Dunal.	W	Through out year	Ch	Mes	+	+
84.	**Tiliaceae**						
	252. Grewia optiva Drum. ex. Burret.	W	Summer	Mp	Mic	+	+
85.	**Ulmaceae**						
	253. Celtis australis L.	W	Spring	Mp	Mic	+	+
86.	**Urticaceae**						
	254. Debregeasia salicifolia (D. Don) Rendle	W	Summer	Np	Mic	+	+
	255. Urtica dioca L.	W	Summer	Th	Mic	+	-
87.	**Valerianaceae**						
	256. Valeriana jatamansii Jones.	W	Spring	G	Mic	+	-
88.	**Verbenaceae**						
	257. Vitex negundo L.	W	Through out year	Np	Mic	+	+
89.	**Violaceae**						
	258. Viola serpens Wall.	W	Summer	Th	Mic	+	-
	259. Viola stocksii Boiss.	W	Spring	Th	Mic	+	-
90.	**Zygophyllaceae**						
	260. Tribulus terrestris L.	W	Through out year	Th	Na	+	-

Key: **W**: Wild, **C**: Cultivated, **LF**: Life form, **LS**: Leaf Size, **Th**: Therophytes, **Mp**: Megaphanerophytes, **Np**: Nanophanerophytes, **Hc**: Hemicryptophytes, **G**: Geophytes, **Ch**: Chamaephytes, **L**: Lianas, **M**: Mistletoe, **P**: Parasite, **Mic**: Microphylls, **Lp**: Leptophylls, **Mes**: Mesophylls, **Na**: Nanophylls, **Mac**: Macrophylls, **Meg**: Megaphylls, **LL**: Leafless, +: Grows, -: Dormant.

Table 4. Life form and Leaf spectra (%age) of the flora of Gadoon Hills District Swabi.

S.No.	Life form	%age	Leaf size	%age
1	Therophytes	49.62	Microphylls	47.69
2	Megaphanerophytes	17.31	Leptophylls	19.23
3	Nanophanerophytes	11.54	Mesophylls	15.00
4	Hemicryptophytes	7.31	Nanophylls	13.85
5	Geophytes	9.62	Macrophylls	1.92
6	Chamaephytes	1.92	Megaphylls	0.77
7	Lianas	1.54	Leafless	1.54
8	Mistletoe	0.77	-----	-----
9	Parasite	0.38	-----	-----

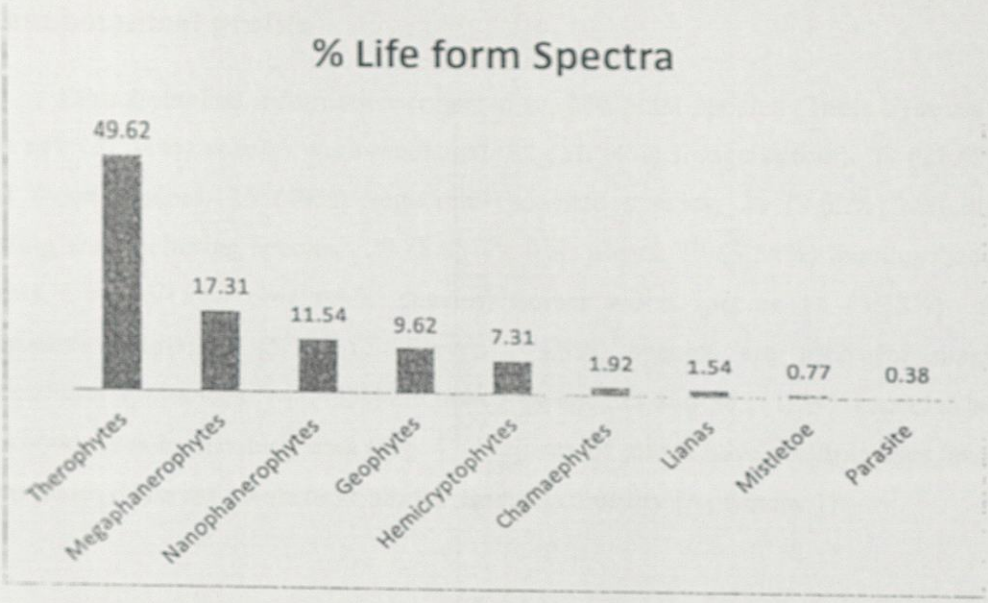


Fig. 3. Life form (%) of the flora of Gadoon Hills.

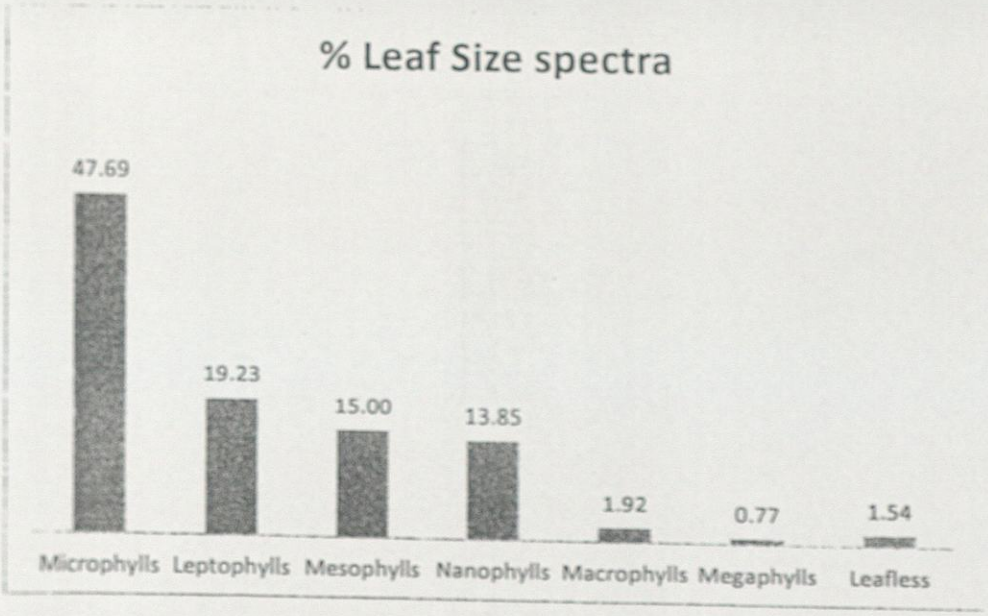


Fig. 4. Leaf size (%) of the flora of Gadoon Hills.

2. Ethnobotanical profile

Ethnobotanical information collected on 260 plant species (Table 5) revealed that 149 (57.31%) species were medicinal, 82 (31.54%) forage species, 59 (22.69%) fuel wood species, 26 (10%) vegetable /pot-herb species, 25 (9.62%) thatching/ roofing and sheltering species, 23 (8.85%) fruit plants, 17 (6.54%) fencing/ hedges Plants, 16 (6.15%) ornamental species, timber wood species 14 (5.38%) and poisonous plants 15 (5.77%). Eleven (4.23%) species are used for making agricultural appliances, 9 (3.46%) are honeybee species and 30 (11.54%) species have no known uses in the study area (Fig. 4). Majority of plants have multiple uses, and in some cases different plants have similar traditional utility (Appendix 1).

Table 5. Summary of the classification of plants of Gadoon Hills on the basis of economic uses.

S. No.	Economic uses classes	No. of Species	Percentage
1.	Medicinal species	149	57.31
2.	Forage species	82	31.54
3.	Fuel wood species	59	22.69
4.	Vegetables/pot herb species	26	10.00
5.	Thatching Sheltering & Roofing species	25	9.62
6.	Fruit species	23	8.85
7.	Fencing species	17	6.54
8.	Ornamental species	16	6.15
9.	Timber wood species	14	5.38
10.	Poisounus species	15	5.77
11.	Agricultural tools species	11	4.23
12.	Honey bee species	9	3.46
13.	Species with no known utility	30	11.54

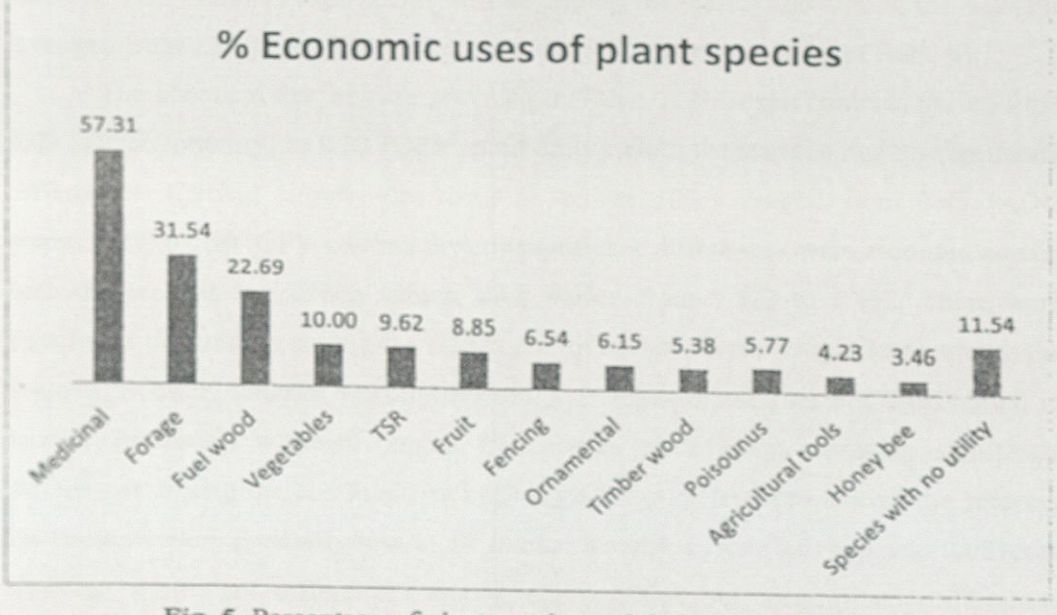


Fig. 5. Percentage of plant species and their economic uses.

3. Vegetation Structure

A. Edaphology

The physical features are provided in Table 6. The colour of the soil varied from brown (BZT, ADT, DH, ZC, ADC sites/communities) to yellowish brown (AGA, PBI, PIC, PBP sites/communities) and grey brown (ADH, QPV, QBF, PIP sites/communities). Soils were generally shallow and made up of sandstone and limestone. The texture of the soil varied from sandy to sandy loam. The soil of only ADH community was clay loam. The litter contents were usually negligible in most of the communities except ADH, QPV and QBF communities where 3-5 cm thick litter was present. The pH of the soil ranged from 5.2 (PIP) to 7.64 (ADC) among the summer and winter showing almost no change. Organic matter contents varied from 0.69 (BZP, PBP) to 2.59 (AGA). There were insignificant differences among the two seasons. TDS contents significantly varied among the stands and among the seasons. It ranged from 131.84 to 1728 mg/l among the different communities (Table 6).

The chemical features are provided in Table 7. Nitrogen contents varied from 0.03 (ZC community) to 0.33 (QBF community). Both the seasons had no significant differences. Ca+Mg slightly decreased in winter. They ranged from 0.45 (ADH community) to 1.0 (QPV community). Insignificant differences were recorded among both the seasons in Ca+Mg values. SAR varied from 0.523 to 1.432. There were significant differences among the stands but differences were insignificant among the seasons. Sodium contents were inbetween 3 to 9ppm in summer but it decreased in winter. Potassium contents ranged from 6ppm to 245ppm, showing significant differences among the communities but insignificant differences among the seasons. Zn contents were generally low in all stands. It ranged from 0.018ppm to 0.089ppm showing significant differences among communities but insignificant differences among the seasons. Ni concentrations were present in traces in most of the stands (BZT, ADT, ZC, ADC, ADH, PBI, PBP and QPV stands) while it was detectable in some communities (Table 7).

B. Vegetational Features

a. Summer Aspect

During summer there were 106 plant species belong to 97 genera and 54 families. The important families in terms of species composition were Poaceae (12

sp.), Asteraceae (10 sp.), Rosaceae (7 sp.), Lamiaceae (6 sp.), and Mimosaceae (5 sp.). Caprifoliaceae, Euphorbiaceae, Papilionaceae and Rhamnaceae (3 sp. each) were also important. The remaining families had low number of species (Table 8). Poaceae (FIV= 589.34) was the leading family possessing the highest Family importance value, followed by Mimosaceae (FIV= 408.24), Pinaceae (FIV= 360.21), Fagaceae (FIV= 352.02), Papilionaceae (FIV= 225.86), Lamiaceae (FIV= 209.71), Sapindaceae (FIV= 192.45), Rhamnaceae (FIV= 191.91) and Cyperaceae (FIV= 134.21). The family importance value of the remaining families was less than 100 (Table 8). The following 13 communities were recognized for summer vegetation.

1. Butea-Zizyphus-Themeda **community (BZT)**

This community was recognized in the plains of the study area. The plant community was dominated by *Butea frondosa* (IV=115.90), *Zizyphus nummularia* (IV=20.39) and *Themeda anathera* (IV=18.93) at 400 meters (Appendix 2). *Justicia adhatoda* (IV=12.63), *Dodonaea viscosa* (IV=13.51), *Heteropogon contortus* (IV=14.32), *Digitaria sanguinalis* (IV=12.88) and *Dichanthium annulatum* (IV=10.76) were sub-dominants. They were followed by six other species including *Carissa spinarum, Myrsine africana, Euphorbia hirta* and *Oxalis corniculata*. Low importance values were observed in the remaining 10 species. The total importance value (TIV) contributed by 3 dominants was 155.22, while the remaining species shared a TIV of 144.78. TIV contributed by trees was 115.90, while shrubs and herbs shared 72.44 and 111.66, respectively (Table 9). Intensive grazing was the primary ecological characteristic of the community.

Therophytic (40.91%) species dominated the community (Table 10). They were followed by nanophanerophytes (36.36%) and hemicryptophytes (18.18%). Megaphanerophytes (4.55%) were poorly represented. While quantitatively therophytes had 18.26% share, nanophanerophytes 24.15% and hemicryptophytes 18.96%. Megaphanerophytes had 38.63% share (Table 10). The community consisted of microphylls (50%) followed by leptophylls and nanophylls (18.18% each). Mesophylls were 13.64%. Quantitatively, microphylls contributed 27.88%, while leptophylls and nanophylls 22.17% and 7.78%, respectively (Table 11). Mesophylls (42.17%) were well represented.

2. *Acacia - Dodonaea - Themeda* community (ADT)

This community located on east facing slope showed the dominance of *Acacia modesta*, *Dodonaea viscosa* and *Themeda anathera* having the importance value 45.02, 34.47 and 17.17, respectively at 450 meters (Appendix 3). Co-dominant species of this stand were *Acacia catechu*, *Ficus palmata* and *Zizyphus nummularia* exhibiting the importance values 24.36, 17.28 and 14.78, respectively. *Mallotus philippensis* (IV=14.70), *Dichanthium annulatum* (IV=12.43), *Gymnosporia royleana* (IV=11.13), *Butea frondosa* (IV=11.01) and *Heteropogon contortus* (IV=9.99) were the associated species. The remaining species had low importance values. Young seedlings of *Dodonaea viscosa* were also observed, showing the regeneration. The total importance value (TIV) contributed by 3 dominants was 96.66, while the remaining species shared a TIV of 203.34. TIV contributed by trees was 118.56, while shrubs and herbs shared 97.03 and 84.41, respectively (Table 9). Grazing pressure was comparatively low.

Nanophanerophytic (34.62%) species dominated the community. They were followed by megaphanerophytes (23.08%), therophytes (19.23%) and hemicryptophytes (11.54%). Geophytes and chamaephytes were poorly represented. While quantitatively nanophanerophytes had 32.34% share, megaphanerophytes 39.52%, therophytes 9.14% and hemicryptophytes 13.19%. Geophytes and chamaephytes had 5.34% and 0.47% share, respectively (Table 10). The community consisted of microphylls (46.15%) and leptophylls (38.46%); nanophylls and mesophylls were 7.69% each. Quantitatively, leptophylls contributed 48.51%, while microphylls and mesophylls 37.66% and 9.43%, respectively. Nanophylls were poorly represented (Table 11).

3. *Dodonaea-Heteropogon* community (DH)

This community, at an altitude of 500 meters, was dominated by *Dodonaea viscosa* and *Heteropogon contortus* with importance values of 78.81 and 25.76 respectively (Appendix 4). These were followed by *Zizyphus nummularia* (IV=30.10), *Justicia adhatoda* (IV=24.64), *Euphorbia hirta* (IV=20.83), *Dichanthium annulatum* (IV=18.56), *Otostegia limbata* (IV=14.80), *Chrysopogon aucheri* (IV=12.68) and *Cynodon dactylon* (IV=11.46) as the co-dominants. *Apluda mutica*, *Aristida adscensionis* and *Micromeria biflora* appeared as associated species. The remaining 4

species possessed low importance values. This community consisted of 16 species; there were 4 shrubs and 12 herbs. No tree was found in this community. The total importance value (TIV) contributed by dominant species was 104.57, while the remaining species shared a TIV of 195.43. TIV contributed by shrubs was 148.35 and by herbs 151.65 (Table 9). Herbaceous vegetation was mostly represented by grasses. Intensive grazing, trampling, browsing and soil erosion, were primary ecological problems in this community.

Hemicryptophytic (37.5%) species dominated the community. They were followed by therophytes (31.25%), nanophanerophytes (25%) and geophytes (6.25%). While quantitatively hemicryptophytes had 30.93% share, therophytes 16.91%, nanophanerophytes 49.45% and geophytes 2.71% (Table 10). The community consisted of leptophylls (43.75%) and microphylls (37.5%); nanophylls and mesophylls were 12.5% and 6.25%, respectively. Quantitatively, leptophylls contributed 37.49%, while microphylls and nanophylls 51.56% and 9.43%, respectively. Mesophylls were poorly represented (Table 11).

4. ***Zizyphus - Chrysopogon* community (ZC)**

This community, recognized at an altitude of 600 meters, was dominated by *Zizyphus nummularia* and *Chrysopogon aucheri* with importance values of 53.72 and 23.33, respectively (Appendix 5). These were followed by *Otostegia limbata* (IV=53.57), *Sageretia theezans* (IV=26.65), *Carissa spinarum* (IV=23.47), *Heteropogon contortus* (IV=12.61), *Rhazya stricta* (IV=11.69) and *Themeda anathera* (IV=11.46) as the co-dominants. *Cynodon dactylon*, *Dodonaea viscosa* and *Aristida adscensionis* appeared as associated species. The remaining 12 species possessed low importance values. This community consisted of 23 species; there were 7 shrubs and 16 herbs. No tree was found in this community. The total importance value (TIV) contributed by dominant species was 77.05, while the remaining species shared a TIV of 222.95. TIV contributed by shrubs was 180.78 and by herbs 119.22 (Table 9). Herbaceous vegetation was mostly represented by stem stocks. Intensive grazing, trampling, browsing and soil erosion, were primary ecological problems in this community.

Therophytic (34.78%) species dominated the community. They were followed by nanophanerophytes (30.43%), hemicryptophytes (21.74%) and geophytes

(13.04%). While quantitatively therophytes had 14.08% share, nanophanerophytes 60.26%, hemicryptophytes 20.45% and geophytes 5.20% (Table 10). The community consisted of leptophylls and microphylls (39.13% each); mesophylls and nanophylls were 13.04% and 8.69%, respectively. Quantitatively, leptophylls contributed 50.66%, while microphylls and mesophylls 43.47% and 4.77%, respectively. Nanophylls were poorly represented (Table 11).

5. *Acacia - Dodonaea - Chrysopogon* community (ADC)

The plant community was dominated by *Acacia modesta, Dodonaea viscosa* and *Chrysopogon aucheri* having the importance values of 116.71, 25.36 and 20.93 (Appendix 6) respectively at 650 meters. *Zizyphus nummularia* (IV=14.95) *Themeda anathera* (IV=12.11), *Z. jujuba* (IV=11.98) and *Heteropogon contortus* (IV=11.61) were the co-dominants. *Sageretia theezans* (IV=8.83), *Cynodon dactylon* (IV=8.22) and *Calotropis procera* (IV=8.06) were associated species. Six species, including *Fimbristylis dichotoma, Otostegia limbata, Aristida adscensionis* and *Micromeria biflora* were considered to be the next important species. The remaining species had low importance values. The total importance value (TIV) contributed by 3 dominants was 163, while the remaining species shared a TIV of 137. TIV contributed by trees was 128.69, while shrubs and herbs shared 180.78 and 119.22, respectively (Table 9). This community was well protected with stone walls and hedges. Grazing and browsing were allowed only after grass cutting for winter stock. The community was utilized sustainably by the locals.

Therophytes and nanophanerophytes (29.17% each) dominated the community. They were followed by hemicryptophytes (20.83%), geophytes and megaphanerophytes (8.33% each). chamaephytes were poorly represented. While quantitatively therophytes had 8.69% share, nanophanerophytes 24.37%, hemicryptophytes 19.55%, geophytes 3.06% and megaphanerophytes 42.90% (Table 10). The community consisted of leptophylls (41.67%) and microphylls (37.5%); nanophylls and mesophylls were 12.5% and 8.33%, respectively. Quantitatively, leptophylls contributed 69.35%, while microphylls and mesophylls 24.59% and 3.65%, respectively. Nanophylls were poorly represented (Table 11).

Table 6. Physical characteristics of soil of different plant communities of Gadoon Hills, District Swabi.

	Stands/ communities												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Exposure	Plains	East	East	South	South	North-East	East	East	East	South-east	South-east	East	Top
Altitude	400	450	500	600	650	800	1350	1750	1850	1950	2050	2100	2250
Texture	sandy loam	sandy loam	sandy	Sandy	Sandy	sandy loam	sandy loam	sandy	sandy	sandy	sandy loam	sandy loam	sandy loam
OM %	0.69	2.07	2.346	0.517	0.862	1.104	2.587	0.517	2.346	0.69	0.759	6.554	1.587
pH	5.6	6.78	6.92	7.64	7.36	5.89	7.1	6.41	5.96	5.91	5.65	6.79	5.52
Ec (dsm^{-1})	0.936	0.646	0.297	0.708	0.408	0.936	0.482	0.415	1.2	0.272	0.206	1.924	2.7
TDS (mg/l)	599.04	413.44	190.08	453.12	261.12	599.04	308.48	265.6	768	174.08	131.84	1231.36	1728

OM= Organic matter, EC= Electrical conductivity, TDS= Total dissolved substances

Table 7. Chemical characteristics of soils of different plant communities of Gadoon Hills, District Swabi.

Stands/ communities	1	2	3	4	5	6	7	8	9	10	11	12	13
N%	0.034	0.103	0.117	0.026	0.043	0.055	0.129	0.026	0.117	0.034	0.038	0.328	0.079
SAR (mg/l)	1.099	0.787	0.869	1.028	0.973	0.523	1.432	0.989	0.89	0.67	2.163	0.796	0.835
P_2O_5 (ppm)	30	26	30	30	28	29	28	29	30	26	28	28	32
Ca+Mg	0.95	0.50	0.55	0.7	0.55	0.45	0.75	0.60	0.95	0.65	1.0	0.95	0.86
Na	8	5	4	7	5	5	8	5	7	3	8	7	9
Ca	89.112	66.984	30.72	82.056	49.308	165.996	46.008	40.582	109.956	30.768	19.632	136.296	213.936
Mg	16.848	13.716	11.7	10.62	3.48	16.92	16.452	10.56	16.8896	9.36	7.716	18.206	18.336
K	24	15	38	17	6	21	31	35	245	16	6	138	77
Zn	0.071	0.032	0.035	0.021	0.018	0.042	0.037	0.022	0.022	0.019	0.012	0.145	0.089
Cu	0.043	0.033	0.05	0.056	0.03	0.034	0.052	0.042	0.042	0.036	0.034	0.054	0.048
Fe	0.102	0.039	0.209	0.056	0.07	0.063	0.166	0.202	0.127	0.325	0.344	0.476	0.199
Mn	0.068	0.042	1.379	0.029	0.023	0.05	0.562	0.344	0.126	0.057	0.3	0.123	0.168
Pb	0.047	0.014	0.029	0.045	0.036	0.011	0.029	0.02	0.006	0.018	0.007	0.088	0.042
Cd	0.013	0.007	0.016	0.007	0.008	0.003	0.011	0.005	0.003	0.012	0.004	0.012	0.02
Cr	0.051	0.021	0.066	0.003	0.007	0.032	0.075	0.059	0.072	0.052	0.04	0.059	0.63
Ni	T	T	0.025	T	T	T	0.002	T	0.006	T	T	0.017	0.032

Key: T: Traces

6. *Acacia - Dodonaea - Heteropogon* community (ADH)

Acacia catechu, Dodonaea viscosa and *Heteropogon contortus* dominated at 800 m having importance values 63.62, 16.88 and 14.57, respectively (Appendix 7). This community was found on north- east facing slope. *Grewia optiva* (IV=31.58), *Butea frondosa* (IV=13.03), *Themeda anathera* (IV=14.06), *Chrysopogon aucheri* (IV=11.94), *Myrsine Africana* (IV=9.14) and *Mallotus philippensis* (IV=8.19) appeared as associated species. Six other species including *Asplenium adiantum nigrum, Carissa spinarum, Gymnosporia royleana* and *Geranium wallichianum* were also important species. The remaining species had low importance values. The total importance value (TIV) contributed by 3 dominants was 95.07, while the remaining species shared a TIV of 204.93. TIV contributed by trees was 151.34, while shrubs and herbs shared 54.49 and 94.16, respectively (Table 9). Grazing pressure was comparatively low.

Megaphanerophytic (33.33%) species dominated the community. They were followed by Therophytes (26.67%) and nanophanerophytes (20%). Geophytes and hemicryptophytes (10% each) were also well represented. While quantitatively megaphanerophytes had 50.45% share, Therophytes 10.85% and nanophanerophytes 18.16%. Geophytes and hemicryptophytes had 7.02% and 13.52% share respectively (Table 10). The community consisted of microphylls (53.33%) and leptophylls (30%); nanophylls and mesophylls were 10% and 6.67% respectively. Quantitatively, microphylls contributed 43.35%, while leptophylls and nanophylls 45.03% and 6.01%, respectively. Mesophylls were poorly represented (Table 11).

7. *Acacia-Gymnosporia-Apluda* community (AGA)

This community located on east facing slope, showed the dominance of *Acacia catechu, Gymnosporia royleana* and *Apluda mutica* having the importance values 119.02, 20.86 and 22.73, respectively at a height of 1350 meters (Appendix 8). Co-dominant species of this stand were *Dodonaea viscosa, Oxalis corniculata, Themeda anathera* and *Indigofera heterantha* exhibiting the importance values 16.87, 16.11, 15.62 and 10.78, respectively. *Chrysopogon aucheri* (IV=10.20), *Cyperus niveus* (IV=9.71), *Celtis australis* (IV=9.01), *Boerhaavia diffusa* (IV=9.01) and *Rumex dentatus* (IV=7.60) were the associated species. The remaining species had low importance values. The total importance value (TIV) contributed by 3 dominants

was 162.61, while the remaining species shared a TIV of 137.39. TIV contributed by trees was 133.71, while shrubs and herbs shared 48.52 and 117.77, respectively (Table 9). Grazing was the common problem.

Therophytic (38.89%) species dominated the plant community, followed by hemicryptophytes (22.22%). Megaphanerophytes and nanophanerophytes (16.67% each) had similar share. Geophytes were poorly represented. While quantitatively Therophytes had 17.47% share, hemicryptophytes 18.55%, megaphanerophytes 44.57% and nanophanerophytes 16.17%. Geophytes had 3.24% share (Table 10). The community consisted of microphylls (44.44%) and leptophylls (38.89%); nanophylls and mesophylls were 11.11% and 5.56% respectively. Quantitatively, microphylls contributed 28.14%, while leptophylls and nanophylls 65.05% and 4.27%, respectively. Mesophylls were poorly represented (Table 11).

8. ***Pinus-Berberis-Imperata*** **community (PBI)**

This community recognized at an altitude of 1750 meters, was dominated by *Pinus roxburghii, Berberis lycium* and *Imperata cylindrica* with importance values of 121.08, 28.21 and 31.15 respectively (Appendix 9). These were followed by *Chrysopogon aucheri* (IV=15.63), *Quercus dilatata* (IV=14.23), *Duchesnea indica* (IV=12.61), *Plantago lanceolata* (IV=11.09), *Micromeria biflora* (IV=10.56) and *Geranium wallichianum* (IV=9.05) as the co-dominants. *Ajuga bracteosa, Gallium aparine, Stellaria media* and *Trichodesma indica* appeared as associated species. This community consisted of 16 species; there were 2 trees, 3 shrubs and 11 herbs. The total importance value (TIV) contributed by dominant species was 180.44, while the remaining species shared a TIV of 119.56. TIV contributed by trees was 135.32, while shrubs and herbs shared 37.95 and 126.74, respectively (Table 9).

Therophytic (50%) species dominated the community. They were followed by hemicryptophytes and nanophanerophytes (18.75% each). Megaphanerophytes shared 12.5%. While quantitatively therophytes had 22.96% share, hemicryptophytes 19.29%, nanophanerophytes 12.65% and megaphanerophytes 45.11% (Table 10). The community consisted of microphylls (50%) followed by leptophylls (37.5%). Mesophylls and nanophylls were 6.25% each. Quantitatively, microphylls contributed 34.55%, while leptophylls and nanophylls 62.36% and 2.03%, respectively. Mesophylls were poorly represented (Table 11).

9. *Pinus-Indigofera-Chrysopogon* community (PIC)

Pinus roxburghii (IV=122.79), *Indigofera heterantha* (IV=29.41) and *Chrysopogon aucheri* (IV=32.58) were dominant at 1850 m (Appendix 10). *Heteropogon contortus* (IV=15.80), *Quercus dilatata* (IV=10.69) and *Berberis lycium* (IV=10.59) were sub-dominants; followed by six other species including *Imperata cylindrica, Phalaris minor, Duchesnea indica* and *Plantago lanceolata*. The remaining species had low importance values. The total importance value (TIV) contributed by 3 dominants was 184.78, while the remaining species shared a TIV of 115.22. TIV contributed by trees was 133.48, while shrubs and herbs shared 46.13 and 120.38, respectively (Table 9). The community was found to be highly disturbed by intensive grazing and browsing.

Therophytic (38.89%) species dominated the community. They were followed by hemicryptophytes (27.78%) and nanophanerophytes (22.22%). Megaphanerophytes shared 11.11%. While quantitatively therophytes had 16.30% share, hemicryptophytes 23.82% and nanophanerophytes 15.38%. Megaphanerophytes had 44.49% share (Table 10). The community consisted of microphylls (50%) followed by leptophylls (38.89%). Mesophylls were 11.11%. Quantitatively, microphylls contributed 23.19%, while leptophylls and mesophylls 74.27% and 2.54%, respectively (Table 11).

10. *Pinus-Berberis-Plantago* community (PBP)

Pinus roxburghii, Berberis lycium and *Plantago lanceolata* dominated at 1950 m having importance values 86.11, 23.92 and 30.88, respectively (Appendix 11). This community was found on south- east facing slope. *Quercus dilatata* (IV=44.39), *Myrsine africana* (IV=22.20), *Gentiana kurru* (IV=13.17), *Fimbristylis dichotoma* (IV=12.52), *Valeriana jatamansii* (IV=10.57) and *Quercus incana* (IV=10.33) appeared as associated species. The remaining species including *Ajuga parviflora, Gallium aparine, Micromeria biflora* and *Rhododenron arborium* were also important. The total importance value (TIV) contributed by 3 dominants was 140.91, while the remaining species shared a TIV of 159.09. TIV contributed by trees was 140.83, while shrubs and herbs shared 56.83 and 102.34, respectively (Table 9). Grazing pressure was comparatively low.

Therophytic (31.25%) species dominated the community. They were followed by nanophanerophytes (25%) and megaphanerophytes (18.75%). Geophytes (12.5%) were also well represented. Hemicryptophytes and lianas (6.25% each) shared similar

values. While quantitatively therophytes had 14.81% share, nanophanerophytes 18.94% and megaphanerophytes 46.94%. Geophytes and hemicryptophytes had 7.7% and 10.29% share respectively. Lianas were poorly represented (Table 10). The community consisted of microphylls (62.5%) and leptophylls (25%); nanophylls and mesophylls were 6.25% each. Quantitatively, microphylls contributed 52.65%, while leptophylls and nanophylls 38.17% and 7.40%, respectively. Mesophylls were poorly represented (Table 11).

11. Quercus-Parrotiopsis-Viola **community (QPV)**

The plant community was dominated by *Quercus dilatata, Parrotiopsis jacquemontiana* and *Viola serpens* having the importance values of 68.46, 16.64 and 18.79 (Appendix 12) respectively at 2050 meters. *Quercus incana* (IV=26.03) *Adiantum venustum* (IV=17.69), *Vibernum cotinifolium* (IV=14.39) and *Ceterach dalhousiae* (IV=11.69) were the co-dominants. *Bergenia ciliata* (IV=11.30), *Fimbristylis dichotoma* (IV=10.58) and *Valeriana jatamansii* (IV=10.53) were associated species.The remaining species, including *Asplenium adiantum nigrum, Cheilanthes marantae, Bistorta amplexicaulis* and *Hedera helix* were also considered to be important. The total importance value (TIV) contributed by 3 dominants was 103.88, while the remaining species shared a TIV of 196.12. TIV contributed by trees was 153.75, while shrubs and herbs shared 32.92 and 113.34, respectively (Table 9).

Geophytic (38.89%) species dominated the community. They were followed by megaphanerophytes (27.78%) and nanophanerophytes (16.67%). Therophytes shared 11.11%. Lianas were poorly represented. While quantitatively Geophytes had 26.87% share, megaphanerophytes 51.25%, nanophanerophytes 10.97%, therophytes 8.77% and Lianas 2.14% (Table 10). The community consisted of microphylls (77.78%) and mesophylls (11.11%); leptophylls and nanophylls were 5.56% each. Quantitatively, microphylls contributed 86.13%, while mesophylls and leptophylls 6.28% and 1.70%, respectively. Nanophylls shared 5.90% (Table 11).

12. Quercus-Berberis-Fimbristylis community **(QBF)**

This community recognized at an altitude of 2100 meters, was dominated by *Quercus dilatata, Berberis lyceum* and *Fimbristylis dichotoma* with importance values of 97.44, 12.26 and 62.30 respectively (Appendix 13). These were followed by *Pinus roxburghii* (IV=19.06), *Quercus incana* (IV=12.61), *Plantago lanceolata* (IV=11.77), *Indigofera heterantha* (IV=11.64), *Phalaris minor* (IV=9.29) and *Gentiana kurru* (IV=9.02) as the co-dominants. *Myrsine africana, Stellaria media* and *Avena sativa*

appeared as associated species. The remaining species possessed low importance values. This community consisted of 19 species; there were 3 trees, 6 shrubs and 10 herbs. The total importance value (TIV) contributed by dominant species was 171.99, while the remaining species shared a TIV of 128.01. TIV contributed by trees was 129.10, while shrubs and herbs shared 49.55 and 121.35, respectively (Table 9).

Therophytic (42.11%) species dominated the community. They were followed by nanophanerophytes (31.58%) and megaphanerophytes (15.79%). Hemicryptophytes and geophytes shared 5.26% each. While quantitatively therophytes had 16.24% share, nanophanerophytes 15.52%, megaphanerophytes 43.32%, hemicryptophytes 4.01% and geophytes 20.91% (Table 10). The community consisted of microphylls (57.89%) followed by leptophylls (31.58%). Mesophylls and nanophylls were 5.26% each. Quantitatively, microphylls contributed 76.66%, while leptophylls and nanophylls 20.49% and 2.43%, respectively. Mesophylls were poorly represented (Table 11).

13. Prunus - Indigofera - Poa **community (PIP):**

Prunus cornuta (IV=43.31), *Indigofera heterantha* (IV=12.77) and *Poa annua* (IV=37.07) were dominant at 2250 m (Appendix 14). *Lonicera quinquilacularis* (IV=39.66), *Lonicera hypoleuca* (IV=7.62) and *Plantago major* (IV=16.85) were sub-dominants; followed by eight other species including *Medicago polymorpha, Berberis lycium, Geranium wallichianum* and *Sarcococa saligna*. The remaining species had low importance values. The total importance value (TIV) contributed by 3 dominants was 93.16, while the remaining species shared a TIV of 206.84. TIV contributed by trees was 125.76, while shrubs and herbs shared 54.21 and 120.03, respectively (Table 9). The community was found to be highly disturbed by intensive grazing and browsing.

Therophytic (37.04%) species dominated the community. They were followed by nanophanerophytes (25.93%) and megaphanerophytes (18.52%). Geophytes shared 14.82%. Hemicryptophytes (3.70%) were poorly represented. While quantitatively Therophytes had 29.99% share, nanophanerophytes 18.07% and megaphanerophytes 41.92%. Geophytes and hemicryptophytes had 10.02% and 0.40% share, respectively (Table 10). The community consisted of microphylls (70.37%) followed by mesophylls and leptophylls (11.11% each). Nanophylls were 7.41%. Quantitatively, microphylls contributed 48.61%, while mesophylls and leptophylls 26.33% and 19.62%, respectively. Nanophylls (5.45%) were poorly represented (Table 11).

Table 8. Families, No. of genera, No, of species and FIV of the summer and winter plant communities of Gadoon Hills, District Swabi.

S.No.	Families	Summer Aspect			Winter Aspect		
		Genera	Species	FIV	Genera	Species	FIV
1.	Acanthaceae	1	1	42.4	1	1	43.22
2.	Adiantaceae	1	2	33.28	1	2	40.15
3.	Amaranthaceae	1	1	3.27	1	1	8.08
4.	Apocynaceae	2	2	54.43	2	2	58.43
5.	Araliaceae	1	1	10.37	1	1	8.82
6.	Asclepiadaceae	1	1	8.06	1	1	7.84
7.	Aspleniaceae	2	2	34.27	2	2	35.49
8.	Asteraceae	10	10	47.43	5	6	87.35
9.	Berberidaceae	1	1	87.64	1	1	96.08
10.	Boraginaceae	1	1	13.83	0	0	0
11.	Brasicaceae	0	0	0	1	1	10.63
12.	Buxaceae	1	1	13.72	1	1	17.43
13.	Caprifoliaceae	2	3	61.67	2	3	66
14.	Caryophyllaceae	2	2	25.09	1	1	4.41
15.	Celastraceae	1	1	44.3	1	1	55.37
16.	Crassulaceae	1	1	5.19	1	1	2.87
17.	Cucurbitaceae	1	1	1.41	0	0	0
18.	Cyperaceae	2	2	134.21	2	2	93.01
19.	Ericaceae	1	1	5.34	1	1	5.86
20.	Euphorbiaceae	2	3	73.67	2	4	53.93
21.	Fagaceae	1	2	352.02	1	2	374.1
22.	Flacourtiaceae	1	1	10.84	1	1	11.1
23.	Fumariaceae	0	0	0	1	1	9.7
24.	Gentianaceae	1	1	31.29	1	1	41.81
25.	Geraniaceae	1	1	26.86	1	1	21.62
26.	Hamamelidaceae	1	1	56.41	1	1	61.92
27.	Lamiaceae	5	6	209.71	3	4	193.63
28.	Liliaceae	1	1	14.93	0	0	0
29.	Linaceae	0	0	0	1	1	4.21
30.	Malvaceae	1	1	8.32	0	0	0
31.	Mimosaceae	3	5	408.24	3	5	291.28
32.	Moraceae	1	1	21.1	1	1	21.38
33.	Myrsinaceae	1	1	44.31	1	1	49.05
34.	Nyctaginaceae	1	1	22.24	1	1	24.36
35.	Onagraceae	2	2	2.52	1	1	5.72
36.	Oxalidaceae	1	1	60.24	1	1	51.79
37.	Papaveraceae	0	0	0	1	1	2.74
38.	Papilionaceae	3	3	225.86	2	2	223.29
39.	Pinaceae	1	1	360.21	1	1	364.33

40.	Plantaginaceae	1	2	79.09	1	2	46
41.	Poaceae	12	12	589.34	13	13	634.72
42.	Polygonaceae	2	2	21.2	2	2	16.57
43.	Primulaceae	1	1	1.23	2	2	11.23
44.	Pteridaceae	1	1	9.79	1	1	8.85
45.	Ranunculaceae	1	1	5.76	0	0	0
46.	Rhamnaceae	2	3	191.91	2	3	199.58
47.	Rosaceae	7	7	94.64	7	7	132.58
48.	Rubiaceae	1	1	22.82	1	1	26.99
49.	Sapindaceae	1	1	192.45	1	1	205.89
50.	Saxifracaceae	1	1	11.3	1	1	15.62
51.	Scrophulariaceae	1	1	17.58	0	0	0
52.	Simarubaceae	1	1	13.76	1	1	8.31
53.	Solanaceae	0	0	0	1	1	7.09
54.	Taxaceae	1	1	5.09	1	1	5.39
55.	Tiliaceae	1	1	31.58	1	1	32.09
56.	Ulmaceae	1	1	15.11	1	1	71.27
57.	Urticaceae	1	1	2.73	1	1	8.59
58.	Valerianaceae	1	1	21.1	1	1	11.76
59.	Violaceae	1	1	18.79	1	1	10.32
	Total	97	106	----	88	99	----

Table 9. The number of component species and their share in Total Importance Value (TIV) in summer aspect.

Communities	BZT	ADT	DH	ZC	ADC	ADH	AGA	PBI	PIC	PBP	QPV	QBF	PIP
Total species	21	25	16	23	23	30	18	15	17	15	15	17	25
Trees	1	6	0	0	2	10	3	2	2	3	5	3	5
Shrubs	8	9	4	7	7	6	3	3	4	4	3	6	7
Herbs	13	11	12	16	15	14	12	11	12	9	10	10	15
TIV By Dominants	155.22	96.66	104.57	77.05	163.00	95.07	162.61	180.44	184.78	140.91	103.88	171.99	93.16
TIV by remaining species	144.78	203.34	195.43	222.95	137.00	204.93	137.39	119.56	115.22	159.09	196.12	128.01	206.84
TIV by trees	115.90	118.56	0.00	0.00	128.69	151.34	133.71	135.32	133.48	140.83	153.75	129.10	125.76
TIV by shrubs	72.44	97.03	148.35	180.78	180.78	54.49	48.52	37.95	46.13	56.83	32.92	49.55	54.21
TIV by herbs	111.66	84.41	151.65	119.22	119.22	94.16	117.77	126.74	120.38	102.34	113.34	121.35	120.03

Key for summer communities

BZT=*Butea-Zizyphus-Themeda* community, ADT=*Acacia - Dodonaea - Themeda* community,
DH=*Dodonaea-Heteropogon* community, ZC=*Zizyphus - Chrysopogon* community,
ADC=*Acacia - Dodonaea - Chrysopogon* community, ADH=*Acacia - Dodonaea - Heteropogon* community
AGA=*Acacia-Gymnosporia-Apluda* community, PBI=*Pinus-Berberis-Imperata* community,
PIC=*Pinus-Indigofera-Chrysopogon* community, PBP=*Pinus-Berberis-Plantago* community,
QPV=*Quercus-Parrotiopsis-Viola* community, QBF=*Quercus-Berberis-Fimbristylis* community,
PIP=*Prunus - Indigofera - Poa* community.

Table 10. Raunkierian and quantitative Life form spectra of summer communities of Gadoon Hills, District Swabi.

Life form	R/Q	Communities												
		BZT	ADT	DH	ZC	ADC	ADH	AGA	PBI	PIC	PBP	QPV	QBF	PIP
Chamaephytes	R	----	3.85	----	----	4.17	----	----	----	----	----	----	----	----
	Q	----	0.47	----	----	1.44	----	----	----	----	----	----	----	----
Geophytes	R	----	7.69	6.25	13.04	8.33	10.00	5.56	----	----	12.50	38.89	5.26	14.81
	Q	----	5.34	2.71	5.20	3.06	7.02	3.24	----	----	7.70	26.87	20.91	10.02
Hemicryptophytes	R	18.18	11.54	37.50	21.74	20.83	10.00	22.22	18.75	27.78	6.25	----	5.26	3.70
	Q	18.96	13.19	30.93	20.45	19.55	13.52	18.55	19.29	23.82	10.29	----	4.01	0.40
Lianas	R	----	----	----	----	----	----	----	----	----	6.25	5.56	----	----
	Q	----	----	----	----	----	----	----	----	----	1.32	2.14	----	----
Megaphanerophytes	R	4.55	23.08	----	----	8.33	33.33	16.67	12.50	11.11	18.75	27.78	15.79	18.52
	Q	38.63	39.52	----	----	42.90	50.45	44.57	45.11	44.49	46.94	51.25	43.32	41.92
Nanophanerophytes	R	36.36	34.62	25.00	30.43	24.37	20.00	16.67	18.75	22.22	25.00	16.67	31.58	25.93
	Q	24.15	32.34	49.45	60.26	0.00	18.16	16.17	12.65	15.38	18.94	10.97	15.52	18.07
Therophytes	R	40.91	19.23	31.25	34.78	29.17	26.67	38.89	50.00	38.89	31.25	11.11	42.11	37.04
	Q	18.26	9.14	16.91	14.08	8.69	10.85	17.47	22.96	16.30	14.81	8.77	16.24	29.99

R: Raunkierian Life form

Q: Quantitative Life form

Table 11. Raunkierian and quantitative Leaf size spectra of summer communities of Gadoon Hills, District Swabi.

Leaf spectra	R/Q	Communities												
		BZT	ADT	DH	ZC	ADC	ADH	AGA	PBI	PIC	PBP	QPV	QBF	PIP
Leptophylls	R	18.18	38.46	43.75	39.13	41.67	30	38.89	37.5	38.89	25	5.56	31.58	11.11
	Q	22.17	48.51	37.49	50.66	69.35	45.03	65.05	62.36	74.27	38.17	1.70	20.49	19.62
Mesphylls	R	13.64	7.69	6.25	13.04	8.33	6.67	5.56	6.25	11.11	6.25	11.11	5.26	11.11
	Q	45.17	9.43	1.51	4.77	3.65	5.62	2.53	1.06	2.54	1.78	6.28	0.43	26.33
Microphylls	R	50	46.15	37.5	39.13	37.5	53.33	44.44	50	50	62.5	77.78	57.89	70.37
	Q	27.88	37.66	51.56	43.47	24.59	43.35	28.14	34.55	23.19	52.65	86.13	76.66	48.61
Nanophylls	R	18.18	7.69	12.5	8.69	12.5	10	11.11	6.25	----	6.25	5.56	5.26	7.41
	Q	7.78	4.40	9.43	1.09	2.41	6.01	4.27	2.03	----	7.40	5.90	2.43	5.45

R: Raunkierian Life form

Q: Quantitative Life form

Winter Aspect

For winter aspect only the herbaceous data was collected on the same location and same altitude. During winter there were 99 plant species belong to 88 genera and 53 families (Table 8). The important families in terms of species composition were Poaceae (13 sp.), Rosaceae (7 sp.), Asteraceae (6 sp.) and Mimosaceae (5 sp.). Lamiaceae, Euphorbiaceae (4 sp.) and Caprifoliaceae (3 sp.) were next important families. The remaining families had low number of species (Table 8). Poaceae (FIV= 634.72) was the leading family possessing the highest Family importance value, followed by Fagaceae (FIV= 374.10), Pinaceae (FIV= 364.33), Mimosaceae (FIV= 291.28), Papilionaceae (FIV= 223.29), Sapindaceae (FIV= 205.89), Rhamnaceae (FIV= 199.58), Lamiaceae (FIV= 193.63) and Rosaceae (FIV= 132.58). The family importance value of the remaining families was less than 100 (Table 8).

The following 13 communities were recognized for winter aspect.

1. Butea-Zizyphus-Themeda **community (BZT)**

The plant community dominated by *Butea frondosa* (IV=115.86), *Zizyphus nummularia* (IV=20.74) and *Themeda anathera* (IV=16.74) at 400 meters (Appendix 15). *Heteropogon contortus* (IV=16.61), *Digitaria sanguinalis* (IV=16.32), *Dichanthium annulatum* (IV=15.00), *Dodonaea viscosa* (IV=13.67) and *Justicia adhatoda* (IV=12.84) and were sub-dominants. They were followed by six other species including *Micromeria biflora, Boerhaavia diffusa, Euphorbia hirta, Carissa spinarum* and *Myrsine africana*. The remaining species had low importance values. The total importance value (TIV) contributed by 3 dominants was 153.34. The remaining species shared a TIV of 146.66. TIV contributed by trees was 115.86, while shrubs and herbs shared 73.37 and 110.76, respectively (Table 12). Intensive grazing was the primary ecological characteristic of the community.

Nanophanerophytic (36.36%) species dominated the community (Table 14). They were followed by therophytes (31.82%) and hemicryptophytes (22.73%). Megaphanerophytes and geophytes (4.55% each) were poorly represented. While quantitatively nanophanerophytes had 24.46% share, therophytes 12.46% and hemicryptophytes 23.01%. Megaphanerophytes and geophytes had 38.62% and 1.45% share, respectively (Table 13). The community consisted of microphylls (50%) followed by leptophylls and nanophylls (18.18% each). Mesophylls were 13.64%.

Quantitatively, microphylls contributed 26.12%, while leptophylls and nanophylls 23.47% and 8.28%, respectively. Mesophylls (42.14%) were well represented (Table 14).

2. *Acacia - Dodonaea - Themeda* community (ADT)

This community located on east facing slope, showed the dominance of *Acacia modesta, Dodonaea viscosa* and *Themeda anathera* having the importance value 45.50, 35.82 and 15.37 respectively at a height of 450 meters (Appendix 16). Co-dominant species of this stand were *Acacia catechu, Ficus palmata* and *Zizyphus nummularia* exhibiting the importance values 24.62, 17.51 and 15.32 respectively. *Mallotus philippensis* (IV=14.90), *Heteropogon contortus* (IV=11.90), *Gymnosporia royleana* (IV=11.57), *Dichanthium annulatum* (IV=11.50), *Butea frondosa* (IV=11.15) and *Sageretia theezans* (IV=10.92%) were the associated species. The remaining species had low importance values. The TIV contributed by 3 dominants was 96.69. The remaining species had a TIV of 203.31. TIV contributed by trees was 120.01; while shrubs and herbs shared 100.86 and 79.13, respectively (Table 12). Grazing pressure was comparatively low.

Nanophanerophytic (36%) species dominated the community. They were followed by megaphanerophytes and therophytes (24% each). Hemicryptophytes had 12% share. Geophytes were poorly represented. Quantitatively, there were 33.62% nanophanerophytes, megaphanerophytes 40%, therophytes 10.83% and hemicryptophytes 12.92%. Geophytes had 2.63% share (Table 13). The community consisted of microphylls (44%) and leptophylls (40%); nanophylls and mesophylls were 8% each. Quantitatively, microphylls contributed 39.52%, while leptophylls and mesophylls 47.32% and 9.55%, respectively. Nanophylls were poorly represented (Table 14).

3. *Dodonaea-Heteropogon* community (DH)

This community at 500 meters was dominated by *Dodonaea viscosa* and *Heteropogon contortus* with importance values of 79.51 and 28.29 respectively (Appendix 17). These were followed by *Zizyphus nummularia* (IV=30.11), *Justicia adhatoda* (IV=24.69), *Taraxacum officinale* (IV=17.68), *Otostegia limbata* (IV=14.81), *Aristida adscensionis* (IV=14.32), *Dichanthium annulatum* (IV=13.45) and *Boerhaavia diffusa* (IV=12.57) as the co-dominants. *Micromeria biflora, Cynodon dactylon* and *Apluda mutica* appeared as associated species. The remaining

species possessed low importance values. This community consisted of 18 species; there were 4 shrubs and 14 herbs. No tree was found in this community. The dominants had TIV of 107.44 and the remaining species shared a TIV of 192.56. TIV contributed by shrubs was 148.75 and by herbs 151.25 (Table 12). Herbaceous vegetation was mostly represented by grasses. Intensive grazing, trampling, browsing and soil erosion, were primary ecological problems in this community.

Therophytic (38.89%) species dominated the community. They were followed by hemicryptophytes (33.33%), nanophanerophytes (22.22%) and geophytes (5.55%). While quantitatively therophytes had 20.21% share, hemicryptophytes 28.46%, nanophanerophytes 49.58% and geophytes 1.75% (Table 13). The community consisted of microphylls (50%) and leptophylls (38.89%). Nanophylls had 11.11% share. Quantitatively, microphylls contributed 57.49%, while leptophylls and nanophylls 35.76% and 9.43%, respectively (Table 14).

4. *Otostegia - Chrysopogon* community (OC)

This community recognized at an altitude of 600 meters, was dominated by *Otostegia limbata* and *Chrysopogon aucheri* with importance values of 58.49 and 22.94 respectively (Appendix 18). These were followed by *Zizyphus nummularia* (IV=58.21), *Sageretia theezans* (IV=29.20), *Carissa spinarum* (IV=25.80), *Heteropogon contortus* (IV=14.53), *Rhazya stricta* (IV=12.87), *Cynodon dactylon* (IV=10.72) and *Aristida adscensionis* (IV=10.72) as the co-dominants. *Taraxacum officinale*, *Themeda anathera* and *Dodonaea viscosa* appeared as associated species. The remaining species possessed low importance values. This community consisted of 19 species. There were 7 shrubs and 12 herbs. Tree species were absent. The TIV of dominant species was 81.42 and the remaining species had a TIV of 218.58. TIV contributed by shrubs was 197.71 and by herbs 102.29 (Table 12). Intensive grazing, trampling, browsing and soil erosion, were primary ecological problems in this community.

Therophytic and nanophanerophytic (36.84% each) species dominated the community. They were followed by hemicryptophytes (26.32%). While quantitatively therophytes had 11.96% share, nanophanerophytes 65.90% and hemicryptophytes 22.14% (Table 13). The community consisted of leptophylls (47.37%) and microphylls (42.11%); mesophylls were 10.53%. Quantitatively, leptophylls contributed 54.38%, while microphylls shared 43.14%. Mesophylls were poorly represented (Table 14).

5. *Acacia - Dodonaea - Chrysopogon* community (ADC)

Acacia modesta, Dodonaea viscosa and *Chrysopogon aucheri* with importance values of 116.08, 24.91 and 17.08 (Appendix 19) respectively dominated the community at 650 meters. *Zizyphus nummularia* (IV=14.59), *Heteropogon contortus* (IV=13.20), *Themeda anathera* (IV=13.20) and *Z. jujuba* (IV=11.88) were the co-dominants. *Fimbristylis dichotoma* (IV=9.40), *Sageretia theezans* (IV=8.61), *Aristida adscensionis* (IV=8.00) and *Calotropis procera* (IV=7.84) were associated species. The remaining species had low importance values. The 3 dominants had TIV of 158.07. The remaining species contributed a TIV of 141.93. Trees had TIV of 127.95, shrubs 71.41 and herbs 100.64 (Table 12). This community was well protected with stone walls and hedges. Grazing and browsing were allowed only after grass cutting for winter stock. The site was utilized sustainably by the locals.

Therophytic (37.5%) species dominated the community. They were followed by nanophanerophytes (29.17%), hemicryptophytes (16.67%), geophytes and megaphanerophytes (8.33% each). While quantitatively therophytes had 14.35% share, nanophanerophytes 23.80%, hemicryptophytes 13.69%, geophytes 5.5% and megaphanerophytes 42.65% (Table 13). The community consisted of leptophylls and microphylls (41.67%); nanophylls and mesophylls were 8.33% each. Quantitatively, leptophylls contributed 65.33%, while microphylls and mesophylls 26.88% and 3.55%, respectively. Nanophylls shared 4.23% (Table 14).

6. *Acacia - Dodonaea - Heteropogon* community (ADH)

Acacia catechu (IV=64.87), *Dodonaea viscosa* (IV=17.92) and *Heteropogon contortus* (IV=15.73) dominated at 800 m (Appendix 20). This community was found on north- east facing slope. *Grewia optiva* (IV=32.09), *Butea frondosa* (IV=13.32), *Themeda anathera* (IV=11.86), *Myrsine Africana* (IV=9.60) and *Acacia nilotica* (IV=9.23) appeared as associated species. Six other species including *Asplenium adiantum nigrum, Carissa spinarum, Gymnosporia royleana* and *Ailanthus altissima* were also important species. The remaining species had low importance values. The 3 dominants had TIV of 98.52. The remaining species provided TIV of 201.48. TIV contributed by trees was 154.43, shrubs 57.24 and herbs 88.33 (Table 12). Grazing pressure was comparatively low.

Therophytic (34.38%) species dominated the community. They were followed by megaphanerophytes (31.25%) and nanophanerophytes (18.75%). Geophytes (6.25%) and hemicryptophytes (9.38%) were also well represented. While

quantitatively therophytes had 13.63% share, megaphanerophytes 51.48% and nanophanerophytes 19.08%. Geophytes and hemicryptophytes had 3.96% and 11.86% share respectively (Table 13). The community consisted of microphylls (56.25%) and leptophylls (31.25%); nanophylls and mesophylls had 6.25% share each. Quantitatively, microphylls contributed 45.11%, while leptophylls 45.04%. Mesophylls (5.73%) and nanophylls (4.11%) were poorly represented (Table 14).

7. *Celtis -Gymnosporia- Poa community* (CGP)

On east facing slope *Celtis australis, Gymnosporia royleana* and *Poa annua* having the importance value 65.06, 31.11 and 29.72 respectively dominated at a height of 1350 meters (Appendix 21). Co-dominants were *Dodonaea viscosa, Themeda anathera, Oxalis corniculata* and *Indigofera heterantha* exhibiting the importance values 26.97, 18.12, 18.12 and 15.92, respectively. *Cyperus niveus* (IV=13.77), *Chrysopogon aucheri* (IV=12.32), *Cynodon dactylon* (IV=10.15) and *Taraxacum officinale* (IV=8.70) were the associated species. The remaining species had low importance values. The same location in summer was occupied by *Acacia catechu* but the whole patch was lopped by timber mafia leaving the shrub and herb layer exposed. The TIV of 3 dominants was 125.89 and remaining species had TIV of 174.11. Trees had TIV of 65.06, shrubs 73.99 and herbs 160.94 (Table 12). Grazing was the common problem.

Therophytic (41.18%) species dominated the plant community, followed by hemicryptophytes (29.41%) and nanophanerophytes (17.65%). Geophytes and megaphanerophytes (5.88%) were poorly represented. Quantitatively there were 25.37% therophytes, hemicryptophytes 23.68% and nanophanerophytes 24.66%. There were 4.59% geophytes and 21.69% megaphanerophytes (Table 13). The community consisted of microphylls (52.94%) and leptophylls (41.18%); nanophylls were 5.88%. Quantitatively, microphylls contributed 56.51%, while leptophylls 42.03%. Nanophylls were less represented (Table 14).

8. *Pinus-Berberis-Imperata* community (PBI)

At 1750 meters *Pinus roxburghii, Berberis lycium* and *Imperata cylindrica* dominated the stand with importance values of 120.69, 27.60 and 31.36, respectively (Appendix 22). These were followed by *Chrysopogon aucheri* (IV=17.23), *Quercus dilatata* (IV=14.13), *Plantago lanceolata* (IV=11.36), *Geranium wallichianum* (IV=11.27) and *Potentilla supine* (IV=10.82) as the co-dominants. *Duchesnea indica, Gallium aparine, Micromeria biflora* and *Oxalis corniculata* appeared as associated

species. This community consisted of 17 species; there were 2 trees, 3 shrubs and 13 herbs. The dominants had TIV of 179.65. The remaining species had TIV of 120.35. the TIV of trees was 134.82, shrubs 37.13 and herbs 128.05 (Table 12).

Therophytic (55.56%) species dominated the community. They were followed by hemicryptophytes and nanophanerophytes (16.67% each). Megaphanerophytes shared 11.11%. While quantitatively therophytes had 22.7% share, hemicryptophytes 19.98%, nanophanerophytes 12.38% and megaphanerophytes 44.94% (Table 13). The community consisted of microphylls (61.11%) followed by leptophylls (27.78%) and Mesophylls 11.11%. On quantitative basis, microphylls contributed 36.61%, while leptophylls and mesophylls 61.36% and 2.03%, respectively (Table 14).

9. ***Pinus-Indigofera-Chrysopogon* community (PIC)**

Pinus roxburghii (IV=124.08), *Indigofera heterantha* (IV=30.74) and *Chrysopogon aucheri* (IV=33.90) were dominant at 1850 m (Appendix 23). *Heteropogon contortus* (IV=16.06), *Quercus dilatata* (IV=10.99) and *Berberis lycium* (IV=11.07) were sub-dominants; followed by *Plantago lanceolata, Oxalis corniculata, Imperata cylindrica* and *Duchesnea indica*. The remaining species had low importance values. The 3 dominants had TIV of 188.71 and remaining species had a TIV of 111.29. Trees had TIV of 135.07, shrubs 48.21 and herbs 116.72 (Table 12). The community was highly disturbed by intensive grazing and browsing.

Therophytes (38.89%) dominated the community, followed by hemicryptophytes (27.78%) and nanophanerophytes (22.22%). Megaphanerophytes shared 11.11%. Quantitatively, therophytes had 14.57% share, hemicryptophytes 24.34% and nanophanerophytes 16.07%. Megaphanerophytes had 45.02% share (Table 13). The community consisted of microphylls (50%) followed by leptophylls (38.89%). Mesophylls were 11.11%. Quantitatively, microphylls contributed 23.09%, while leptophylls and mesophylls 74.79% and 2.12%, respectively (Table 14).

10. ***Pinus-Berberis- Gentiana* community (PBG)**

Pinus roxburghii, Berberis lycium and *Gentiana kurru* dominated at 1950 m with importance values of 88.03, 26.66 and 27.53, respectively (Appendix 24). This community was found on south- east facing slope. *Quercus dilatata* (46.51), *Myrsine africana* (24.81), *Gallium aparine* (13.77), *Quercus incana* (11.11) and *Plantago lanceolata* (7.66) appeared as associated species. The remaining species were low in importance values. The 3 dominants had TIV of 142.22 and the remaining species had

a TIV of 157.78. TIV contributed by trees was 145.65, while shrubs and herbs shared 63.22 and 91.13, respectively (Table 12). Grazing pressure was comparatively low.

the community was dominated therophytes (33.33%), followed by nanophanerophytes (22.22%). Geophytes and megaphanerophytes (16.67% each) contributed similar share. Hemicryptophytes and lianas (6.25% each) also shared similar values. Quantitatively, therophytes had 17.94% share, nanophanerophytes 21.07% and megaphanerophytes 48.55%. Geophytes and hemicryptophytes had 8.44% and 2.55% share respectively. Lianas were poorly represented (Table 13). The community consisted of microphylls (61.11%), leptophylls and mesophylls (16.67% each). Nanophylls had 5.56% share. Quantitatively, microphylls contributed 45.67%, while leptophylls and nanophylls 40.73% and 8.27%, respectively. Mesophylls were poorly represented (Table 14).

11. Quercus-Parrotiopsis- Adiantum **community (QPA)**

The community dominated by *Quercus dilatata, Parrotiopsis jacquemontiana* and *Adiantum venustum* with importance values of 71.44, 18.09 and 15.61, respectively at 2050 meters (Appendix 25). *Quercus incana* (IV=27.38), *Vibernum cotinifolium* (IV=15.37), *Ceterach dalhousiae* (IV=10.84) and *Bergenia ciliata* (IV=9.84) were the co-dominants. *Cheilanthes marantae* (IV=8.85), *Duchesnea indica* (IV=7.48), *Viola serpens* (IV=7.48) and *Fimbristylis dichotoma* (IV=7.16) were associated species. The remaining species had low importance values. The TIV contributed by 3 dominants was 105.14, while the remaining species shared a TIV of 194.86. TIV contributed by trees was 163.41, while shrubs and herbs shared 35.57 and 101.02, respectively (Table 12).

Geophytic (38.1%) species dominated the community. They were followed by megaphanerophytes (23.81%). Nanophanerophytes and therophytes (14.29% each) shared similar values. Hemicryptophytes and lianas (4.76%) were poorly represented. While quantitatively Geophytes had 23.71% share, megaphanerophytes 48.55%, nanophanerophytes 11.86%, therophytes 6.48%, hemicryptophytes 1.99% and Lianas 1.5% (Table 13). The community consisted of microphylls (76.19%) followed by mesophylls and nanophylls (9.52% each). Leptophylls (4.76%) were poorly represented. Quantitatively, microphylls contributed 86.13%, while mesophylls and nanophylls 4.78% and 7.29%, respectively. Leptophylls shared 1.8% (Table 14).

12. Quercus-Berberis-Fimbristylis community (QBF)

This community recognized at an altitude of 2100 meters, was dominated by *Quercus dilatata, Berberis lyceum* and *Fimbristylis dichotoma* with importance values of 103.60, 15.51 and 33.85 respectively (Appendix 26). These were followed by *Pinus roxburghii* (IV=20.30), *Indigofera heterantha* (IV=14.49), *Quercus incana* (IV=13.86), *Avena sativa* (IV=11.45), *Plantago lanceolata* (IV=10.51), and *Gentiana kurru* (IV=10.02) as the co-dominants. *Myrsine africana, Poa annua* and *Phalaris minor* appeared as associated species. The remaining species possessed low importance values. This community consisted of 18 species; there were 3 trees, 6 shrubs and 11 herbs. The total importance value (TIV) contributed by dominant species was 152.96, while the remaining species shared a TIV of 147.04. TIV contributed by trees was 137.76, while shrubs and herbs shared 60.99 and 101.25, respectively (Table 12).

Therophytic (40%) species dominated the community. They were followed by nanophanerophytes (30%) and megaphanerophytes (15%). Hemicryptophytes and geophytes shared 10% and 5%, respectively. While quantitatively therophytes had 17.52% share, nanophanerophytes 20.33%, megaphanerophytes 45.92%, hemicryptophytes 4.94% and geophytes 11.28% (Table 13). The community consisted of microphylls (65%) followed by leptophylls (30%) and nanophylls (5%). Quantitatively, microphylls contributed 75%, while leptophylls and nanophylls 22.1% and 2.9%, respectively (Table 14).

13. Prunus - Berberis - Poa community (PBP):

Prunus cornuta (44.96), *Berberis lycium* (15.24) and *Poa annua* (46.78) were dominant at 2250 m (Appendix 27). *Lonicera quinquilacularis* (41.79), *Cotoneaster bacillaris* (20.39) and *Indigofera heterantha* (15.61) were sub-dominants; followed by eight other species including *Sarcococa saligna, Quercus incana, Lonicera hypoleuca, Fimbristylis dichotoma* and *Plantago major*. The remaining species had low importance values. The total importance value (TIV) contributed by 3 dominants was 107.34, while the remaining species shared a TIV of 192.66. TIV contributed by trees was 132.60, while shrubs and herbs shared 65.50 and 101.90, respectively (Table 12). The community was found to be highly disturbed by intensive grazing and browsing.

Nanophanerohytic (30.43%) species dominated the community. They were followed by therophytes (26.08%) and megaphanerophytes (21.74%). Geophytes

shared 17.39%. Hemicryptophytes (4.34%) were poorly represented. While quantitatively nanophanerophytes had 21.83% share, therophytes 23.45% and megaphanerophytes 44.2%. Geophytes and hemicryptophytes had 8.62% and 1.89% share, respectively (Table 13). The community consisted of microphylls (73.91%) followed by mesophylls and leptophylls (13.04% each). Quantitatively, microphylls contributed 53.64%, while mesophylls and leptophylls 24.15% and 22.21%, respectively (Table 14).

Degree of homogeneity

Of the 13 plant communities in summer and winter, only one community was homogenous and the remaining 12 plant communities were heterogeneous in each of the seasons (Table 15). The majority of the community showing heterogeneity might be due to the presence of large number of annuals particularly grasses and habitat degradation, climate, soil conditions, deforestation, overgrazing, trampling and soil erosion in the study area. All the sites lie within the same general climate and similar climatic and soil condition. The area is disturbed which result in more species in class A to C. Deforestation, overgrazing and other anthropogenic activities were the main culprits responsible for the degradation of phytodiversity of the investigated area.

Similarity Indices

The similarity indices between the summer plant communities are shown in Table 16. A greater similarity was observed between *Pinus-Indigofera-Chrysopogon* and *Pinus-Berberis-Imperata (*69.56%) communities and *Pinus-Berberis-Plantago* and *Pinus-Berberis-Imperata* (51.79%) communities. *Pinus-Berberis-Plantago* and *Quercus-Berberis-Fimbristylis* communities had 45.50% similarity value. Similarly 41.28% similarity value was found between *Zizyphus – Chrysopogon* and *Acacia - Dodonaea – Chrysopogon* communities. *Quercus-Parrotiopsis-Viola* and *Butea-Zizyphus-Themeda, Quercus-Parrotiopsis-Viola* and *Acacia - Dodonaea – Themeda, Quercus-Parrotiopsis-Viola* and *Dodonaea-Heteropogon, Quercus-Berberis-Fimbristylis* and *Acacia - Dodonaea – Themeda, Quercus-Berberis-Fimbristylis* and *Dodonaea-Heteropogon, Prunus - Indigofera - Poa* and *Butea-Zizyphus-Themeda, Prunus - Indigofera - Poa* and *Acacia - Dodonaea – Themeda, Prunus - Indigofera - Poa* and *Dodonaea-Heteropogon* and *Quercus-Berberis-Fimbristylis* and *Acacia-Gymnosporia-Apluda* communities had no similarity.

During winter the similarity was greater between *Pinus-Berberis-Imperata* and *Pinus-Indigofera-Chrysopogon* (36.82%) communities and *Pinus-Berberis-Imperata*

and *Pinus-Berberis- Gentiana* (24.68%) communities (Table 17). *Acacia - Dodonaea – Themeda* and *Acacia - Dodonaea - Chrysopogon* communities had 23.11% similarity value. Similarly, 22.47% similarity value was recorded between *Pinus-Berberis- Gentiana* and *Quercus-Berberis-Fimbristylis* communities. *Butea-Zizyphus-Themeda* and *Prunus - Berberis – Poa, Acacia - Dodonaea - Themeda* and *Pinus-Berberis- Gentiana, Acacia - Dodonaea - Themeda* and *Quercus-Berberis-Fimbristylis, Acacia - Dodonaea - Themeda* and *Prunus - Berberis – Poa, Dodonaea-Heteropogon* and *Pinus-Berberis- Gentiana, Dodonaea-Heteropogon* and *Quercus-Parrotiopsis- Adiantum, Dodonaea-Heteropogon* and *Quercus-Berberis-Fimbristylis, Dodonaea-Heteropogon* and *Prunus - Berberis – Poa, Otostegia - Chrysopogon* and *Pinus-Berberis- Gentiana, Otostegia - Chrysopogon* and *Quercus-Parrotiopsis-Adiantum, Otostegia - Chrysopogon* and *Quercus-Berberis-Fimbristylis, Otostegia - Chrysopogon* and *Prunus - Berberis – Poa, Celtis -Gymnosporia- Poa* and *Pinus-Berberis- Gentiana, Celtis -Gymnosporia- Poa* and *Quercus-Parrotiopsis- Adiantum* communities had no similarity.

Species Diversity

The highest diversity (0.29) was observed for *Quercus-Berberis-Fimbristylis* community during summer while the lowest value (0.05) was recorded for *Acacia-Dodonaea-Heteropogon* community. During winter highest diversity (0.16) was observed for *Prunus-Berberis-Poa* community while the lowest value (0.05) was observed for *Acacia-Dodonaea-Heteropogon* community (Table 18).

Species richness

Species richness was generally high in the area for both the summer and winter communities (Table 18). It ranged from 0.89 (*Quercus-Berberis-Fimbristylis* community) to 2.14 (*Acacia-Dodonaea-Heteropogon* community) in summer communities while during winter it varied from 1.12 (*Pinus-Berberis- Gentiana* community) to 2.41 (*Acacia - Dodonaea- Heteropogon* community).

Maturity index

During summer the maturity index varied from 42 (*Acacia - Dodonaea - Heteropogon* community) to 76.67 (*Quercus-Parrotiopsis-Viola* community) while in winter the maturity index ranged from 39.38 (*Acacia - Dodonaea - Heteropogon* community) to 62.78 (*Quercus-Parrotiopsis- Adiantum* community) (Table 18).

Table 12. The number of component species and their share in Total Importance Value (TIV) in winter aspect.

Communities	BZT	ADT	DH	OC	ADC	ADH	CGP	PBI	PIC	PBG	QPA	QBF	PBP
Total species	21	24	18	19	23	32	17	17	17	17	18	18	21
Trees	1	6	0	0	2	10	1	2	2	3	5	3	5
Shrubs	8	9	4	7	7	6	3	3	4	4	3	6	7
Herbs	13	10	14	12	15	16	13	13	12	11	13	11	11
TIV by Dominants	153.34	96.69	107.44	81.42	158.07	98.52	125.89	179.65	188.71	142.22	105.14	152.96	107.34
TIV by remaining species	146.66	203.31	192.56	218.58	141.93	201.48	174.11	120.35	111.29	157.78	194.86	147.04	192.66
TIV by trees	115.86	120.01	0.00	0.00	127.95	154.43	65.06	134.82	135.07	145.65	163.41	137.77	132.60
TIV by shrubs	73.37	100.86	148.75	197.71	71.41	57.24	73.99	37.13	48.21	63.22	35.57	60.99	65.50
TIV by herbs	110.76	79.13	151.25	102.29	100.64	88.33	160.94	128.05	116.72	91.13	101.02	101.25	101.90

Key for winter communities

BZT=*Butea-Zizyphus-Themeda* community, ADT=*Acacia - Dodonaea - Themeda* community
DH=*Dodonaea-Heteropogon* community, OC= *Otostegia - Chrysopogon* community
ADC=*Acacia - Dodonaea - Chrysopogon* community, ADH=*Acacia - Dodonaea - Heteropogon* community
CGP= *Celtis -Gymnosporia- Poa* community, PBI=*Pinus-Berberis-Imperata* community
PIC=*Pinus-Indigofera-Chrysopogon* community, PBG=*Pinus-Berberis- Gentiana* community
QPA=*Quercus-Parrotiopsis- Adiantum* community, QBF=*Quercus-Berberis-Fimbristylis* community
PBP=*Prunus - Berberis - Poa* community.

Table 13. Raunkierian and quantitative Life form spectra of winter communities of Gadoon Hills, District Swabi.

Life form	R/Q	Communities												
		BZT	ADT	DH	OC	ADC	ADH	CGP	PBI	PIC	PBG	QPA	QBF	PBP
Geophytes	R	4.55	4	5.55	0	8.33	6.25	5.88	0	0	16.67	38.1	5	17.39
	Q	1.45	2.63	1.75	0	5.5	3.96	4.59	0	0	8.44	23.71	11.28	8.62
Hemicryptophytes	R	22.73	12	33.33	26.32	16.67	9.38	29.41	16.67	27.78	5.56	4.76	10	4.34
	Q	23.01	12.92	28.46	22.14	13.69	11.86	23.68	19.98	24.34	2.55	1.99	4.94	1.89
Lianas	R	0	0	0	0	0	0	0	0	0	5.56	4.76	0	0
	Q	0	0	0	0	0	0	0	0	0	1.44	1.5	0	0
Megaphanerophytes	R	4.55	24	0	0	8.33	31.25	5.88	11.11	11.11	16.67	23.81	15	21.74
	Q	38.62	40	0	0	42.65	51.48	21.69	44.94	45.02	48.55	54.47	45.92	44.2
Nanophanerophytes	R	36.36	36	22.22	36.84	29.17	18.75	17.65	16.67	22.22	22.22	14.29	30	30.43
	Q	24.46	33.62	49.58	65.9	23.8	19.08	24.66	12.38	16.07	21.07	11.86	20.33	21.83
Therophytes	R	31.82	24	38.89	36.84	37.5	34.38	41.18	55.56	38.89	33.33	14.29	40	26.08
	Q	12.46	10.83	20.21	11.96	14.35	13.63	25.37	22.7	14.57	17.94	6.48	17.52	23.45

R: Raunkierian Life form

Q: Quantitative Life form

Table 14. Raunkierian and quantitative Leaf size spectra of winter communities of Gadoon Hills, District Swabi.

Leaf spectra	R/Q	Communities												
		BZT	ADT	DH	OC	ADC	ADH	CGP	PBI	PIC	PBG	QPA	QBF	PBP
Leptophylls	R	18.18	40	38.89	47.37	41.67	31.25	41.18	27.78	38.89	16.67	4.76	30	13.04
	Q	23.47	47.32	35.76	54.38	65.33	45.04	42.03	61.36	74.79	40.73	1.8	22.1	22.21
Mesphylls	R	13.64	8	0	10.53	8.33	6.25	0	11.11	11.11	16.67	9.52	0	13.04
	Q	42.14	9.55	0	2.48	3.55	5.73	0	2.03	2.12	5.32	4.78	0	24.15
Microphylls	R	50	44	50	42.11	41.67	56.25	52.94	61.11	50.00	61.11	76.19	65	73.91
	Q	26.12	39.52	57.49	43.14	26.88	45.11	56.51	36.61	23.09	45.67	86.13	75	53.64
Nanophylls	R	18.18	8	11.11	0	8.33	6.25	5.88	0	0	5.56	9.52	5	0
	Q	8.27	3.61	6.75	0	4.23	4.11	1.45	0	0	8.27	7.29	2.9	0

R: Raunkierian Life form

Q: Quantitative Life form

Table 15. Degree of Homogeneity of summer and winter plant communities of Gadoon Hills, District Swabi.

Communities	Summer Aspect						Communities	Winter Aspect					
	A	B	C	D	E	Remarks		A	B	C	D	E	Remarks
BZT	0	13	3	2	3	Heterogeneous	BZT	1	11	2	5	3	Heterogeneous
ADT	6	8	8	2	2	Heterogeneous	ADT	5	9	7	2	2	Heterogeneous
DH	1	6	5	2	2	Heterogeneous	DH	3	5	7	1	2	Heterogeneous
ZC	4	10	3	3	3	Heterogeneous	OC	5	5	5	1	3	Heterogeneous
ADC	6	8	4	3	3	Heterogeneous	ADC	7	7	4	3	3	Heterogeneous
ADH	7	10	9	2	2	Heterogeneous	ADH	11	9	8	1	2	Homogeneous
AGA	4	7	2	3	2	Heterogeneous	CGP	5	4	2	5	1	Heterogeneous
PBI	1	5	5	1	4	Heterogeneous	PBI	4	3	6	1	4	Heterogeneous
PIC	2	7	5	1	3	Heterogeneous	PIC	1	9	4	1	2	Heterogeneous
PBP	0	3	7	1	5	Heterogeneous	PBG	0	10	3	1	4	Heterogeneous
QPV	1	1	8	5	2	Heterogeneous	QPA	1	7	7	4	2	Heterogeneous
QBF	2	3	10	2	2	Heterogeneous	QBF	2	7	6	2	2	Heterogeneous
PIP	9	8	5	5	0	Homogeneous	PBP	3	12	4	3	1	Heterogeneous

Key for communities is given in Table 9 & 12.

Table 16. Similarity indices of summer plant communities (Based on Importance Values).

	BZT	ADT	DH	ZC	ADC	ADH	AGA	PBI	PIC	PBP	QPV	QBF	PIP
BZT	X												
ADT	34.17	x											
DH	36.19	31.41	x										
ZC	29.09	25.44	41.28	x									
ADC	24.63	44.25	34.33	42.36	x								
ADH	25.64	41.84	16.65	19.19	22.71	x							
AGA	17.69	24.79	25.23	18.16	18.82	46.18	x						
PBI	7.12	2.69	10.19	10.70	8.60	9.84	10.00	x					
PIC	11.68	5.86	14.51	15.47	13.47	11.77	12.51	69.56	x				
PBP	4.42	2.46	2.46	5.33	4.35	7.16	2.13	51.79	44.36	x			
QPV	0.00	0.00	0.00	2.87	3.06	4.66	0.00	4.74	3.56	28.38	x		
QBF	1.96	0.00	0.00	2.87	2.58	2.43	3.59	23.20	23.42	45.50	33.85	x	
PIP	0.00	0.00	0.00	2.87	2.58	3.27	3.59	13.70	13.07	19.61	15.03	29.35	x

Key for communities is given in Table 9.

Table 17. Similarity indices of winter plant communities (Based on Importance Values).

	BZT	ADT	DH	OC	ADC	ADH	CGP	PBI	PIC	PBG	QPA	QBF	PBP
BZT	X												
ADT	16.26	x											
DH	18.05	15.61	x										
OC	13.72	12.58	19.60	x									
ADC	12.06	23.11	14.55	16.98	x								
ADH	11.67	21.13	8.67	10.48	11.61	x							
CGP	9.56	10.07	13.85	9.39	11.21	11.08	x						
PBI	1.88	1.32	2.83	4.43	5.18	3.94	4.46	x					
PIC	5.07	3.66	5.86	7.66	7.38	5.09	6.91	36.82	x				
PBG	0.99	0.00	0.00	0.00	2.50	2.74	0.00	24.68	21.41	x			
QPA	0.73	1.32	0.00	0.00	1.74	0.46	0.00	3.60	3.08	15.15	x		
QBF	0.99	0.00	0.00	0.00	1.57	2.14	2.42	13.17	11.52	22.47	19.73	x	
PBP	0.00	0.00	0.00	0.00	1.57	2.18	7.56	6.66	6.28	11.23	9.89	16.85	x

Key for communities is given in Table 12.

Table 18. Species diversity, richness and maturity of the summer and winter plant communities of Gadoon Hills, District Swabi.

Communities	Summer Aspect			Communities	Winter Aspect		
	Species diversity	Species richness	Species maturity		Species diversity	Species richness	Species maturity
BZT	0.07	1.53	53.81	BZT	0.07	1.56	54.76
ADT	0.08	1.79	46.00	ADT	0.08	1.76	45.83
DH	0.1	1.31	51.88	DH	0.1	1.51	47.22
ZC	0.1	1.52	47.39	OC	0.12	1.31	48.42
ADC	0.1	1.62	46.96	ADC	0.09	1.62	49.13
ADH	0.05	2.14	42.00	ADH	0.05	2.41	39.38
AGA	0.08	1.51	47.22	CGP	0.09	1.45	47.65
PBI	0.13	1.04	64.00	PBI	0.12	1.16	57.65
PIC	0.12	1.14	55.29	PIC	0.14	1.17	52.94
PBP	0.11	0.92	71.33	PBG	0.11	1.12	58.24
QPV	0.08	1.06	76.67	QPA	0.08	1.38	62.78
QBF	0.29	0.89	61.76	QBF	0.1	1.24	57.78
PIP	0.12	1.38	44.40	PBP	0.16	1.39	49.05

Key for communities is given in Table 9 & 12.

Cluster Analysis (Summer Aspect)

Based on cluster analysis the summer vegetation (13 communities each) following two associations could be recognized. Each one is confined to definite altitude and characteristic habitat features composed of characteristic species which is briefly discussed below:

I. Dry Tropical Vegetation

The summer vegetation of this association consisted of seven communities which are further divided into the following two sub-groups.

A. Dry Tropical deciduous association

It consisted of *Butea-Zizyphus-Themeda* community (BZT), *Dodonaea-Heteropogon* community (DH), *Zizyphus-Chrysopogon* community (ZC), *Acacia-Dodonaea-Themeda* community (ADT) and *Acacia-Dodonaea-Chrysopogon* community (ADC). The cluster analysis of these stands indicates similarities or correlation between these communities growing at altitude 400 to 650 m. The common trees were *Butea frondosa, Acacia modesta, Acacia catechu, Flacourtia indica* and *Mallotus philippensis*. The dominant shrubs were *Carissa spinarum, Dodonaea viscosa, Gymnosporia royleana, Justicia adhatoda, Otostegia limbata, Sageretia theezans, Zizyphus nummularia. Apluda mutica, Aristida adscensionis, Heteropogon contortus, Dichanthium annulatum, Chrysopogon aucheri* and *Themeda anathera* were the common grasses of this association (Fig. 5).

B. Subtropical association

Based on cluster analysis this association was recorded at altitude 800-1350 m comprising *Acacia-Dodonaea-Heteropogon* community (ADH) and *Acacia-Gymnosporia-Apluda* community (AGA). The dominant trees of this association were *Acacia catechu, Acacia modesta, Celtis australis* and *Grewia optiva. Carissa spinarum, Gymnosporia royleana, Dodonaea viscosa* and *Indigofera heterantha* were the common shrubs of this association. The common grasses recorded in this zone were *Apluda mutica, Heteropogon contortus, Chrysopogon aucheri* and *Themeda anathera* (Fig. 5).

2. Temperate Vegetation

The cluster analysis displayed the six communities of this zone into the following two groups.

A. *Pinus roxburghii* association

The *Pinus* association of this zone comprised of communities *Pinus-Berberis-Imperata* community (PBI) and *Pinus-Indigofera-Chrysopogon* community (PIC) growing at altitude 1750 and 1850 m, respectively. These communities dominated by *Pinus roxburghii*, were adjacent to human population area severely disturbed by anthropogenic activities. The common shrubs of this association were *Berberis lycium* and *Indigofera heterantha* (Fig. 5).

B. *Quercus* association

This association consisted of *Pinus-Berberis-Plantago* community (PBP), *Quercus-Parrotiopsis-Viola* community (QPV), *Quercus-Berberis-Fimbristylis* community (QBF) and *Prunus - Indigofera - Poa* community (PIP). These stands were found at high altitude (1950-2250 m) comparatively less disturbed, dominated by *Quercus dilatata, Quercus incana, Parrotiopsis jacquemontiana Lonicera quinquilacularis, Cotoneaster bacillaris, Vibernum cotinifolium* and *Prunus cornuta* in tree layer. The dominant shrubs of this zone were *Berberis lycium, Indigofera heterantha, Lonicera hypoleuca* and *Sarcococa saligna.* The herbaceous layer consisted of pteridophytes like *Adiantum venustum, Asplenium adiantum nigrum, Ceterach dalhousiae* and *Cheilanthes marantae* along with other temperate herbs like *Bergenia ciliate, Bistorta amplexicaulis, Valeriana jatamansii* and *Viola serpens.* The common grasses were *Fimbristylis dichotoma, Phalaris minor* and *Poa annua* (Fig. 5).

Principal Coordinate Analysis (Summer Aspect)

PCA classified the 13 communities of summer vegetation in to three groups and two outliers (Fig. 6). Similar communities are closer to one another while dissimilar communities were placed apart. The largest group was composed of six communities (ZC, AGA, ADH, BZT, DH and ADC) growing at low altitude (400-1350 m). ADT (Group IV) appeared as outlier of this group. Group II was comprised of PBP, QBF and PIP communities growing at high altitude (1950-2250m). QPV was

recorded as outlier of group II due to poor herbaceous layer. PBI and PIC were placed in group III by DCA due to similarities in their importance values (Fig. 6).

Cluster Analysis of Winter aspect

Cluster analysis of winter vegetation divided 13 communities inhabiting Gadoon Hillls into the following two associations.

1. **Dry Tropical Zone**

The vegetation of this association consisted of seven communities which are further distributed into the following two associations.

A. Dry Tropical deciduous association

This association consisted of *Butea-Zizyphus-Themeda* community (BZT), *Dodonaea-Heteropogon* community (DH), *Otostegia -Chrysopogon* community (OC) and *Celtis-Gymnosporia- Poa* community (CGP). The cluster analysis of these stands indicates similarities or correlation between these communities growing at altitude 400 m, 500m, 600 m and 1350 m, respectively. The common trees of this zone were *Butea frondosa, Acacia modesta, Acacia catechu, Flacourtia indica* and *Mallotus philippensis*. The dominant shrubs of this association were *Carissa spinarum, Dodonaea viscosa, Gymnosporia royleana, Justicia adhatoda, Otostegia limbata, Sageretia theezans, Zizyphus nummularia. Apluda mutica, Aristida adscensionis, Heteropogon contortus, Dichanthium annulatum, Chrysopogon aucheri* and *Themeda anathera* were the common grasses of this association.

B. Subtropical association

Based on cluster analysis this association was recorded at altitude 800-1350 m comprising *Acacia - Dodonaea - Themeda* community (ADT), *Acacia-Dodonaea-Chrysopogon* community (ADC) and *Acacia-Dodonaea-Heteropogon* community (ADH). The dominant trees of this association were *Acacia catechu, Acacia modesta,* and *Grewia optiva. Carissa spinarum, Gymnosporia royleana, Dodonaea viscosa* and *Indigofera heterantha* were the common shrubs of this association. The common grasses recorded in this zone were *Heteropogon contortus, Chrysopogon aucheri* and *Themeda anathera.*

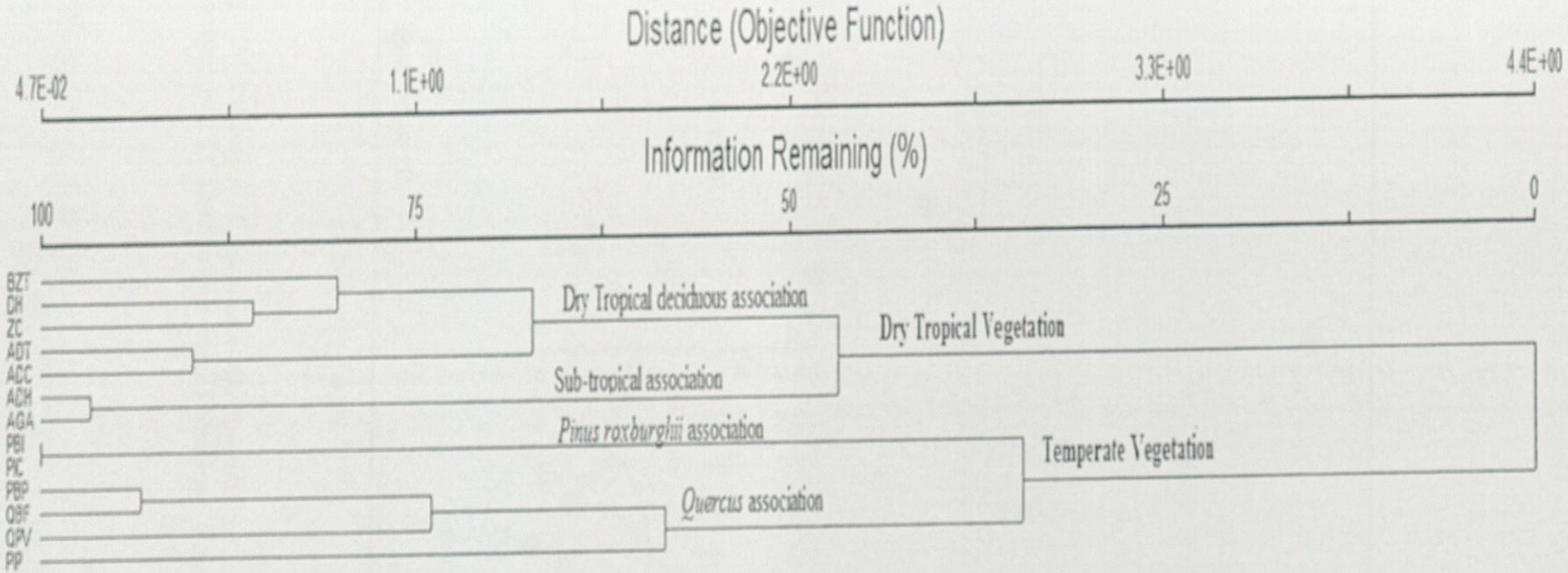


Fig. 6. Cluster analysis of 13 communities of Gadoon Hills, District Swabi during Summer Aspect.

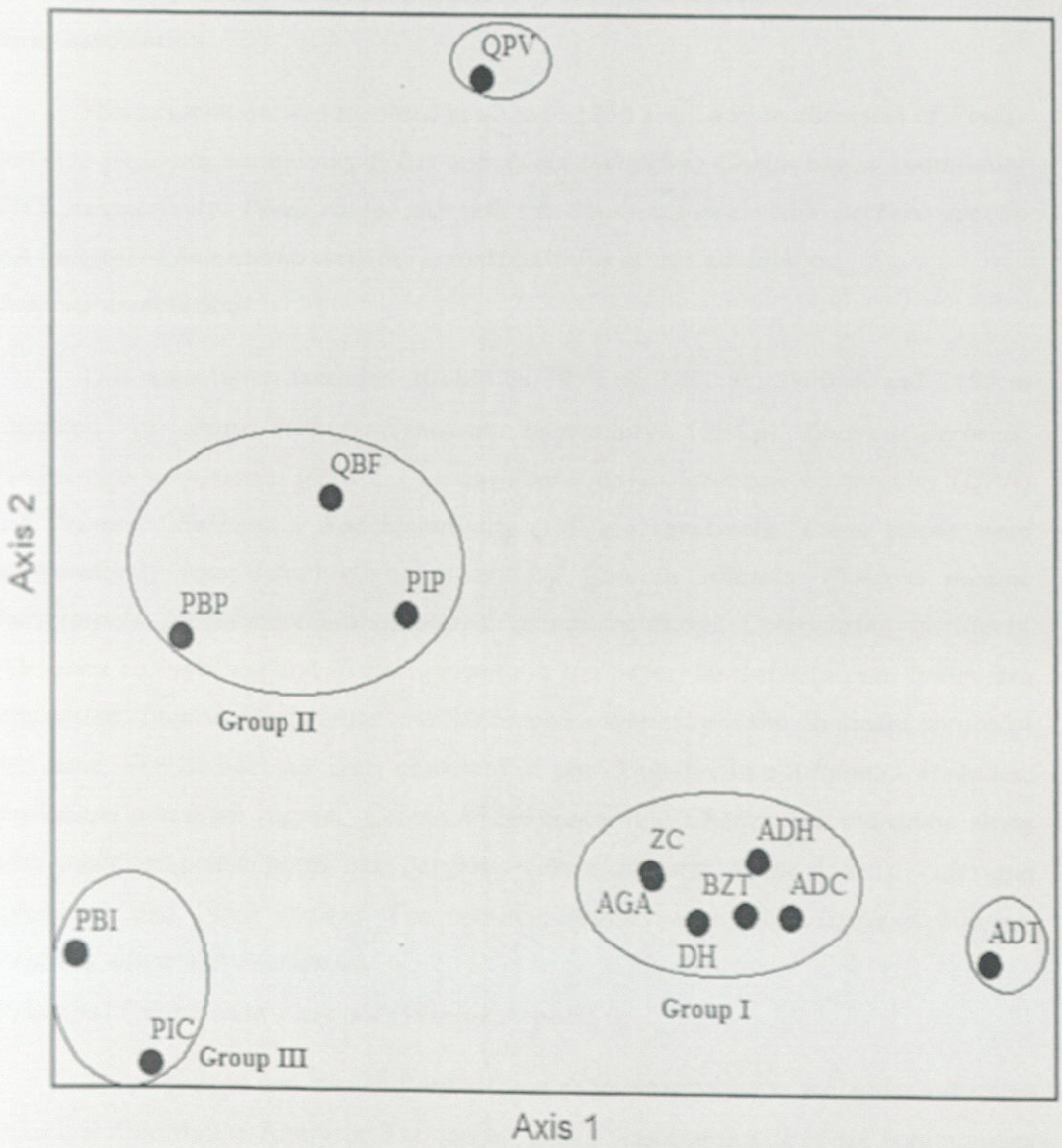


Fig. 7. Principal Coordinate Ordination of Gadoon Hills showing grouping of 13 Communities during Summer Aspect.

2. **Temperate Zone**

Pinus association and *Quercus* association were the two groups recognized for this zone through cluster analysis comprised of six communities.

A. ***Pinus* association**

This association was recorded at altitude 1750 and 1850 m consisted of *Pinus-Berberis-Imperata* community (PBI) and *Pinus-Indigofera-Chrysopogon* community (PIC), respectively. *Pinus roxburghii* was the dominant tree while *Berberis lycium* and *Indigofera heterantha* were the common shrubs of this association.

B. ***Quercus* association**

This association recorded at altitude 1950 m, 2050 m, 2100 m and 2250 m consisted of *Pinus-Berberis-Gentiana* community (PBG), *Quercus-Berberis-Fimbristylis community* (QBF), *Quercus-Parrotiopsis-Adiantum* community (QPA) and *Prunus - Berberis - Poa* community (PBP), respectively. These stands were comparatively less disturbed, dominated by *Quercus dilatata, Quercus incana, Parrotiopsis jacquemontiana Lonicera quinquilacularis, Cotoneaster bacillaris, Vibernum cotinifolium* and *Prunus cornuta* in tree layer. *Berberis lycium, Indigofera heterantha, Lonicera hypoleuca* and *Sarcococa saligna* were the dominant shrubs of this zone. The herbaceous layer consisted of pteridophytes like *Adiantum venustum, Asplenium adiantum nigrum, Ceterach dalhousiae* and *Cheilanthes marantae* along with other temperate herbs like *Bergenia ciliate, Bistorta amplexicaulis, Valeriana jatamansii* and *Viola serpens*. The common grasses were *Fimbristylis dichotoma, Phalaris minor* and *Poa annua*.

Principal Coordinate Analysis (Winter Aspect)

Three groups and two outliers of winter vegetation were recognized through Principal Coordinate Analysis. The largest group was composed of six communities (CGP, OC, BZT, DH, ADH, and ADC) growing at low altitude (400-1350 m). ADT appeared as outlier of this group. Group II was comprised of PBP, QBF and PBG communities growing at high altitude (1950-2250m). QPA was recorded as outlier of group II due to poor herbaceous layer. PBI and PIC were placed in group III by PCA due to similarities in their importance values.

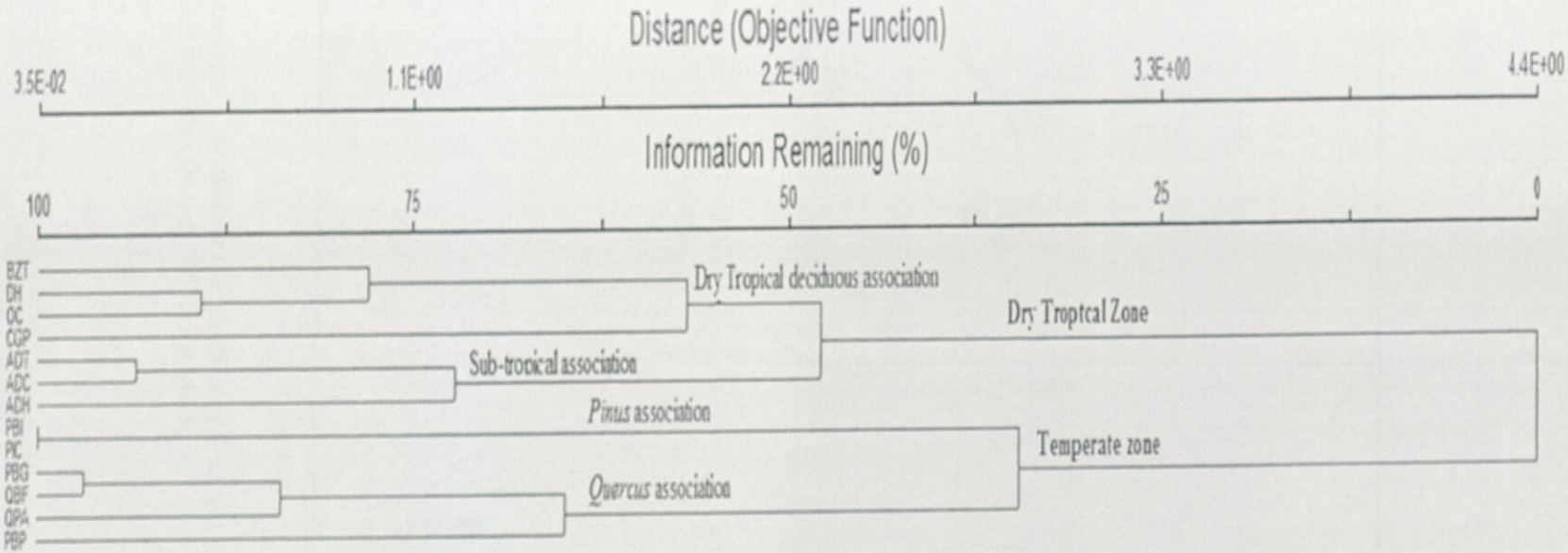


Fig. 8. Cluster analysis of 13 communities of Gadoon Hills, District Swabi during Winter Aspect.

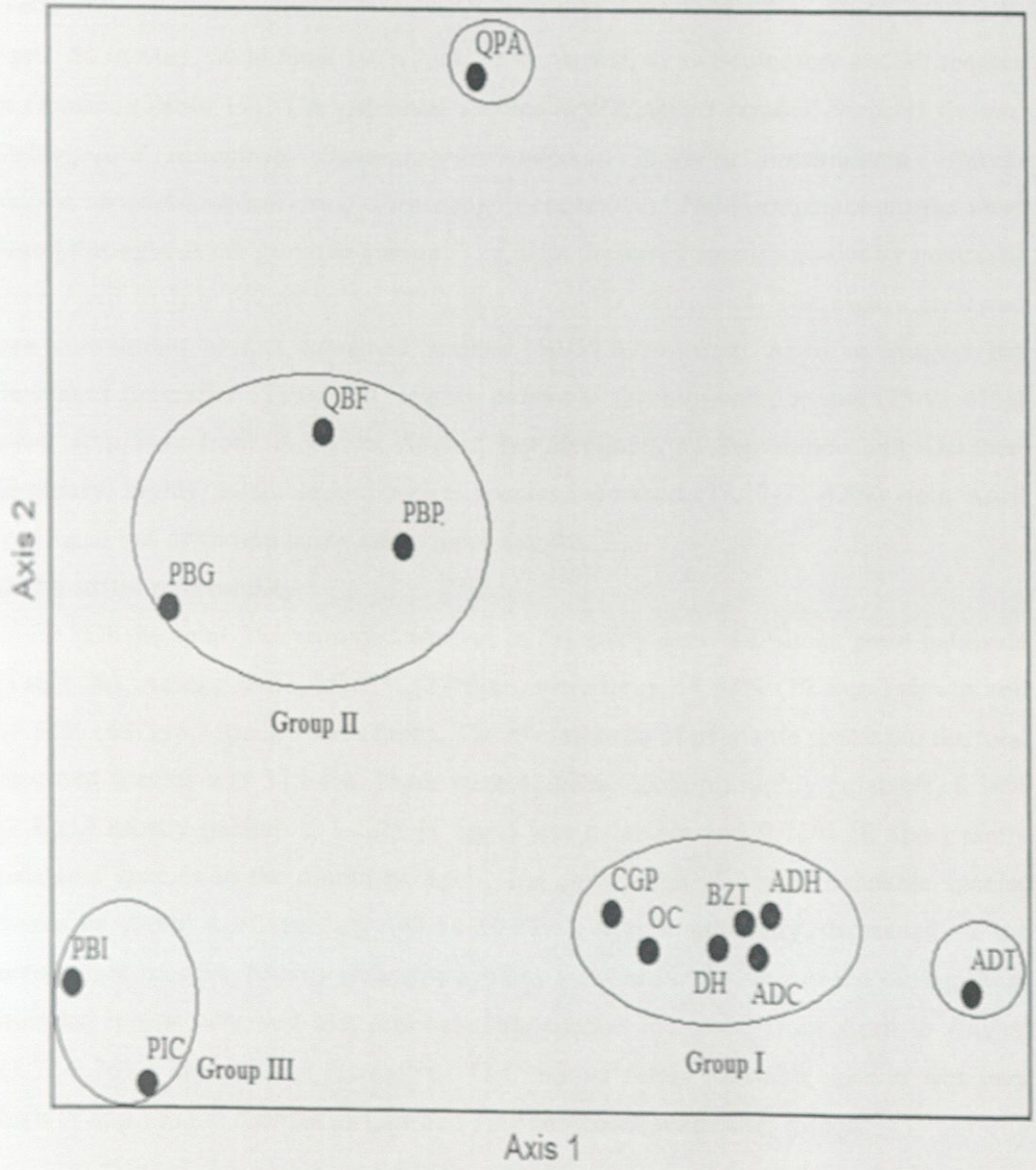


Fig. 9. Principal Coordinate Ordination of Gadoon Hills showing grouping of 13 Communities during Winter Aspect.

4. Degree of palatability

Seasonal availability of palatable species

Climate and phenological stage are the two main factors defining seasonal availability of fodder species. It was observed that there were 57 species available in April, 56 in May, 60 in June, 59 in July, 55 in August, 42 in September and 30 species in October (Table 19). The perennial species like *Zizyphus jujuba, Berberis lycium, Debregeasia salicifolia, Gymnosporia royleana, Zizyphus nummularia, Apluda mutica, Aristida adscensionis, Chrysopogon aucheri* and *Heteropogon contortus* were found throughout the growing season. The most preferred species gradually increased from April to July (42.68 to 48.78%) and thereafter decreased. The highly preferred tree component almost remained similar (50-59.09%) from April to August but decreased thereafter (Table 19). Highly palatable shrubby components (75-91.67%) were abundant from April to August but declined in September and October. Similarly, highly palatable herbaceous species increased (29.17-35.42%) from April to August but dwindled in the subsequent months.

Differential palatability

Of the total 260 recorded species in the study area, 82 plants were palatable (Table 20). Among them, 26.83% (22 Spp.) were trees, 14.63% (12 Spp.) shrubs and 58.54% (48 Spp.) species were herbs. The overall ratio of palatable species to the total recorded species was 31.54%. There were 42.68% (35 Spp.) highly palatable, 8.54% (7 Spp.) mostly palatable, 1.22% (1 Spp.) less palatable and 9.76% (8 Spp.) rarely palatable species in the month of April. The percentage of highly palatable species increased from April to July (42.68-48.78%), which gradually decreased in the subsequent months. Mostly palatable species showed inconsistent trend during these months. It was observed that non palatable species increased from April to August (7.32-9.76%) but reduced thereafter. The number rarely palatable species was very high (9 spp.) in the months of June and July compared with other months.

Table 19. Seasonal availability (%) of some important palatable trees, shrubs and herbs of Gadoon Hills.

	Degree of Palatability	April	May	June	July	August	September	October
Trees	Hp	54.55	59.09	54.55	54.55	50.00	22.73	13.64
	Mp	9.09	13.64	9.09	9.09	18.18	13.64	4.55
	Rp	9.09	4.55	13.64	9.09	4.55	4.55	4.55
	Np	27.27	22.73	22.73	27.27	27.27	18.18	9.09
Shrubs	Hp	75.00	75.00	91.67	91.67	91.67	66.67	50.00
	Mp	25.00	25.00	0.00	0.00	0.00	0.00	0.00
	Rp	0.00	0.00	8.33	8.33	0.00	0.00	0.00
	Np	0.00	0.00	0.00	0.00	8.33	8.33	8.33
Herbs	Hp	29.17	33.33	35.42	35.42	35.42	31.91	27.08
	Mp	4.17	2.08	2.08	0.00	0.00	0.00	0.00
	Lp	2.08	0.00	0.00	0.00	0.00	0.00	0.00
	Rp	10.42	6.25	10.42	12.50	6.25	8.51	6.25
	Np	0.00	2.08	6.25	4.17	2.08	2.13	0.00

Table 20. Seasonal availability and palatability of some plants in Gadoon Hills, District Swabi.

	Species	April	May	June	July	August	September	October
	Tree layer							
1	*Acacia catechu* (L.f.) Willd.	Hp	Hp	Hp	Hp	Hp	-	-
2	*Acacia modesta* Wall.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
3	*Acacia nilotica* (L.) Delile.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
4	*Ailanthus altissima* (Mill) Swingle	Np	Np	Rp	Rp	Mp	Mp	-
5	*Albizia lebbeck* (L.) Bth.	Np	Np	Np	Np	Np	-	-
6	*Butea frondosa* Roxb.	Np	Np	Np	Np	Np	-	-
7	*Celtis australis* L.	Hp	Hp	Hp	Hp	Hp	Hp	-
8	*Cotoneaster bacillaris* Wall. ex Lindle.	Hp	Hp	Hp	Hp	Mp	Mp	-
9	*Ficus palmata* Forssk.	Hp	Hp	Mp	Mp	Mp	Np	-
10	*Flacourtia indica* (Burm. f.) Merrill	Rp	Rp	Rp	Np	Np	Np	-
11	*Grewia optiva* Drum.ex.Burret.	Hp	Hp	Hp	Hp	Hp	Hp	-
12	*Lonicera quinquilacularis* Hardw.	Np	Np	Rp	Rp	Mp	Mp	Mp
13	*Melia azedarach* L.	Np	Hp	Hp	Hp	Hp	-	-
14	*Morus alba L.*	Hp	Hp	Hp	Hp	Hp	-	-
15	*Morus indica L.*	Hp	Hp	Hp	Hp	Hp	-	-
16	*Parrotiopsis jacquemontiana* Dcne	Rp	Mp	Mp	Hp	Hp	-	-
17	*Pinus roxburghii* Sergent	Np	Np	Np	Np	Np	Rp	Rp
18	*Prunus cornuta* (Wall ex Royle) Steud.	Hp	Hp	Hp	Hp	Hp	-	-
19	*Quercus dilatata* Lindley	Mp	Mp	Np	Np	Np	Np	Np
20	*Quercus incana* Roxb.	Mp	Mp	Np	Np	Np	Np	Np
21	*Vibernum cotinifolium* D. Don.	Hp	Hp	Hp	Mp	Rp	-	-
22	*Zizyphus jujuba* Mill.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
	Shrub layer							
1	*Berberis lycium* Royle.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
2	*Carissa spinarum* auct. non L.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
3	*Debregeasia salicifolia* (D. Don) Rendle	Hp	Hp	Hp	Hp	Hp	Hp	Hp
4	*Gymnosporia royleana* Wall	Hp	Hp	Hp	Hp	Hp	Hp	Hp
5	*Indigofera heterantha* L.	Hp	Hp	Hp	Hp	Hp	-	-
6	*Mimosa himalayana* Gamble	Hp	Hp	Hp	Hp	Hp	-	-
7	*Otostegia limbata* Bth.	Mp	Mp	Rp	Rp	Np	Np	Np
8	*Rosa moschata* non J. Herrm.	Hp	Hp	Hp	Hp	Hp	-	-
9	*Sageretia theezans* (L.) Brongn.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
10	*Zizyphus nummularia* Buem.f. Weight	Hp	Hp	Hp	Hp	Hp	Hp	Hp
11	*Rubus ellipticus* Smith	Mp	Mp	Hp	Hp	Hp	Hp	-
12	*Rubus ulmifolius* Schott.	Mp	Mp	Hp	Hp	Hp	Hp	-
	Herb layer							
1	*Ajuga bracteosa* Wall. Benth.	-	Rp	-	-	-	-	-
2	*Ajuga parviflora* Benth.	Rp	-	-	-	-	-	-
3	*Anagallis arvensis* L.	-	-	Mp	-	-	-	-

4	*Arthraxon prionodes* (Steud.) Dandy.	-	Hp	Hp	Hp	Hp	-	-
5	*Apluda mutica* L.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
6	*Aristida adscensionis* L.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
7	*Artemisia vulgaris* L.	Rp	Np	Np	-	-	-	-
8	*Avena sativa* L.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
9	*Bergenia ciliata* (Haw) Sternb.	-	-	Rp	-	-	-	-
10	*Bistorta amplexicaulis* (D.Don) Green	-	-	-	Rp	-	-	-
11	*Boerhaavia diffusa* L.	Rp	-	-	-	-	-	-
12	*Chrysopogon aucheri* (Boiss.) Stapf	Hp	Hp	Hp	Hp	Hp	Hp	Hp
13	*Cynodon dactylon* (L.) Pers.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
14	*Dichanthium annulatum* (Forssk.) Stapf.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
15	*Digitaria sanguinalis* (L.) Scop.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
16	*Duchesnea indica* (Andr.) Focke	-	-	-	-	-	Rp	Rp
17	*Euphorbia hirta* L.	Rp	-	-	-	-	-	Rp
18	*Euphorbia prostrata* Ait.	-	-	-	-	-	-	-
19	*Fimbristylis dichotoma* (L.) Vahl.	-	-	-	-	-	Rp	Rp
20	*Fragaria vesca* Lindle.ex Hk. f.	-	-	-	Rp	Rp	-	-
21	*Gallium aparine* L.	-	Hp	Hp				
22	*Gentiana kurru* Royle	Rp	-	-	-	-	-	-
23	*Geranium wallichianum* D. Don. ex Sweet	Rp	-	-	-	-	-	-
24	*Hedera helix* L.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
25	*Heteropogon contortus* (L.) P. Beauv.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
26	*Imperata cylindrica* (L.) P. Beauv.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
27	*Medicago polymorpha* L.	Hp	-	-	-	-	-	-
28	*Micromeria biflora* (Ham.) Bth.	-	-	-	-	Rp	-	-
29	*Myriactus wallichii* Less.	-	-	-	-	-	-	-
30	*Oenothera rosea* Soland.	-	-	-	-	-	Rp	-
31	*Origanum vulgare* L.	-	-	Rp	Rp	-	-	-
32	*Pennisetum orientale* L. C. Rich.	-	Hp	Hp	Hp	Hp	Hp	-
33	*Phalaris minor* Retz.	-	-	-	Hp	Hp	Hp	Hp
34	*Plantago lanceolata* L.	-	-	-	Rp	-	-	-
35	*Plantago major* L.	-	-	Rp	-	-	-	-
36	*Poa annua* L.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
37	*Potentilla supina* L.	-	-	-	-	Rp	-	-
38	*Rumex dentatus* L.	Mp	Mp	Np	Np	-	-	-
39	*Salvia moocroftiana* Wall.	-	-	-	-	-	Rp	-
40	*Schoenoplectus litoralis* Schrad.	Mp	Rp	Np	Np	Np	Np	-
41	*Sonchus asper* L.	-	-	Hp	Hp	Hp	-	-
42	*Sorghum helepense* (L.) Bern.	Hp	Hp	Hp	Hp	Hp	Hp	-
43	*Taraxacum officinale* Weber.	-	Rp	Rp	Rp	-	-	-
44	*Themeda anathera* (Nees) Hack.	Hp	Hp	Hp	Hp	Hp	Hp	Hp
45	*Tulipa stellata* Hk.f.	LP	-	-	-	-	-	-
46	*Urtica dioca* L.	-	-	Rp	-	-	-	-

47	*Valeriana jatamansii* Jones.	-	-	-	Rp	-	-	-
48	*Viola serpens* Wall.	-	Lp	-	-	-	-	-

Key: Hp=highly palatable, Mp= mostly palatable, Lp=less palatable Rp=rarely palatable and Np= non palatable

5. Measurement of Range Productivity

a. Productivity of shrubs

The highest fresh biomass (25000 Kg/ha and 25500 Kg/ha) among the shrubs was provided by *Dodonaea* at 450 m and 500 m (Table 21). The remaining stands produced 7000 Kg/ha, 6400 Kg/ha, 12460 Kg/ha, 10450 Kg/ha and 5040 Kg/ha fresh biomass at 400 m, 600 m, 650 m, 800 m and 1350 m, respectively.

Berberis lycium produced maximum shoot biomass of 9000 Kg/ha at 1750 m with a declining trend with increasing altitude. *Berberis* had a biomass of 8500 Kg/ha, 8700 Kg/ha, 7800 Kg/ha and 6400 Kg/ha at 1850m, 1950m, 2100m and 2250 m, respectively. Insignificant differences in fresh biomass of *Otostegia limbata* were found among the communities located at 400 m (994 Kg/ha) and 450 m (967 Kg/ha) but it showed increase in biomass at altitude 500 m (1962 Kg/ha) and 600 m (2468 Kg/ha). *Otostegia* produced biomass of 1410 Kg/ha at altitude 650 m (Table 21). *Zizyphus nummularia* showed increasing trend with increase in the altitude from 400 m to 600 m (Table 21). However, the biomass of *Zizyphus nummularia* in the unprotected (25678 Kg/ha) community was higher compared with protected (19862 Kg/ha) stand at 600 m and 650m, respectively. *Carissa spinarum* produced fresh biomass of 630 Kg/ha, 600 Kg/ha, 1450 Kg/ha and 1326 Kg/ha at 400m, 450m, 600 m and 800 m, respectively. *Gymnosporia royleana* recorded in four communities gave biomass of 8400 Kg/ha, 6280 Kg/ha, 6940 Kg/ha and 12000 Kg/ha at altitude 400 m, 450 m, 800 m and 1350 m, respectively.The fresh biomass recorded at 400 m was higher than altitude 450 m but increased in the subsequent stands (Table 21). *Indigofera heterantha* showed no significant differences in biomass productivity between at altitude 2100 m (9024 Kg/ha) and 2250 m (9952 Kg/ha) but it was low (7025 Kg/ha) at 1350 m. However, the harvest was 10090 Kg/ha at altitude 1850m. The biomass for *Myrsine africana* was 1071 Kg/ha, 1102 Kg/ha, 2049 Kg/ha and 523 Kg/ha at altitude 400m, 800m, 1950m and 2100m, respectively.

The biomass of *Justicia adhatoda* harvested at altitude 400 m, 500 m and 600 m, exhibited an increase with increasing altitude. *Sageretia theezans* provided 1500 Kg/ha of fresh biomass at altitude 450 m. Nonetheless, the biomass was greater in the unprotected (3200 Kg/ha) stand than the protected (1276 Kg/ha) stand. The biomass of *Sarcococa saligna* enhanced with increasing altitude (Table 21).

b. Productivity of herbs

The biomass of *Micromeria* ranged from 230 Kg/ha (1850 m) to 392 Kg/ha (450 m) showing significant differences among productivity at various altitudes. *Chrysopogon aucheri* was the most common grass species. It varied from altitude 500m to 1850 m. It exhibited inconsistent behavior in the biomass with altitudinal gradient. The highest biomass (4320 Kg/ha) was harvested at 1850 m, followed by 2860 Kg/ha (600 m) while the lowest (1140 Kg/ha) at 1350 m (Table 21).

Heteropogon contortus had altitudinal variation in biomass levels. The greater (1285 Kg/ha) was recorded at 400 m and the lowest (720 Kg/ha) at 650 m. *Oxalis corniculata* showed insignificant differences in biomass values (Table 21). Significant differences were found in biomass productivity among the communities in which *Fimbristylis dichotoma* was recorded. *Fimbristylis* produced from 880 Kg/ha (650 m) to 7780 Kg/ha (2100 m). The fresh biomass of *Themeda anathera* ranged from 250 Kg/ha (600 m) to 495 Kg/ha (400 m). The fresh biomass productivity of *Themeda* at different altitude showed significant differences (Table 21). For *Euphorbia hirta* the biomass was greater at 400 m (1120 Kg/ha) and 500 m (1200 Kg/ha), while in the remaining stands it had low production (Table 21).

Cynodon dactylon exhibited insignificant differences at 500 m (770 Kg/ha), 600 m (750 Kg/ha) and 650 m (700 Kg/ha), but it increased to 1160 Kg/ha at 1350 m. A gradual decline occurred in biomass of *Dichanthium annulatum* with increasing altitude. It produced 1410 Kg/ha, 1370 Kg/ha, 1330 Kg/ha and 800 Kg/ha fresh biomass at 400 m, 450 m, 500 m and 1850 m, respectively. *Plantago lanceolata* showed a rang from 253 Kg/ha (1850 m) to 1114 Kg/ha (1950 m) with significant differences at different altitudes (Table 21).

Adiantum incisum at 450 m and 600 m produced fresh biomass of 950 Kg/ha and 850 Kg/ha, respectively. *Adiantum venustum* present at 650 m, 800 m and 2050 m showed increasing trend in the biomass productivity with rising altitude. *Ajuga bracteosa* at 1750 m, 2100 m and 2250 m provided fresh biomass of 1350 Kg/ha, 1420 Kg/ha and 1450 Kg/ha, respectively. The differences were significant in biomass productivity at 800 m (1000 Kg/ha), 1850 m (1150 Kg/ha) and 1950 m (1225 Kg/ha) for *Ajuga parviflora*. The fresh biomass was 1320 Kg/ha (altitude=500 m) and 2300 Kg/ha (altitude=1350 m), with significant differences for *Apluda mutica*. The differences were insignificant among the biomass production of *Aristida adscensionis*

in protected and unprotected stands at 600 m and 650m. However, productivity was better (1480 Kg/ha) at 500 m. *Asplenium adiantum-nigrum* had inconsistent trend in biomass productivity with altitudinal variation. The highest (1400 Kg/ha) biomass of *Asplenium* was recorded at 800 m. *Boerhaavia diffusa* showed increasing trend in productivity with rising altitude up to 800 m (1700 Kg/ha). It was absent above this altitude in the investigated area (Table 21).

The biomass produced by *Cyperus niveus* was 200 Kg/ha, 130 Kg/ha and 175 Kg/ha at 500 m, 600 m and 1350 m, respectively. The biomass of *Duchesnea indica* was 1950 Kg/ha at 1750 m and 1910 Kg/ha at 1850 m with insignificant differences. The biomass of *Echinops echinatus* showed significant differences among unprotected (2100 Kg/ha) and protected (1890 Kg/ha) stands at 600 m and 650 m, respectively. *Filago spathulata* produced 625 Kg/ha and 600 Kg/ha biomass at 800 m and 1350 m, respectively (Table 21).

Table 21. Fresh biomass (Kg/ha) of some common shrubs and herbs at different altitude of Gadoon Hills, District Swabi.

Communities	BZT	ADT	DH	ZC	ADC	ADH	AGA	PBI	PIC	PBP	QPV	QBF	PIP	Species Total
Altitude (m)	400	450	500	600	650	800	1350	1750	1850	1950	2050	2100	2250	
A. Shrub layer														
Berberis lycium Royle.	----	----	----	----	----	----	----	9000	8500	8700	----	7800	6400	40400
Carissa spinarum auct. non L.	630	600	----	1450	----	1326	----	----	----	----	----	----	----	4006
Dodonaea viscosa (L.) Jacq.	7000	25000	25500	6400	12460	10450	5040	----	----	----	----	----	----	91850
Gymnosporia royleana Wall	8400	6280	----	----	----	6940	12000	----	----	----	----	----	----	33620
Indigofera heterantha L.	----	----	----	----	----	----	7025	----	10090	----	----	9024	9952	36091
Justicia adhatoda L.	6025	----	8254	8924	----	----	----	----	----	----	----	----	----	23203
Myrsine africana L.	1071	----	----	----	----	1102	----	----	----	2049	----	523	----	4745
Otostegia limbata Bth.	994	967	1962	2468	1410	----	----	----	----	----	----	----	----	7801
Sageretia theezans (L.) Brongn.	----	1500	----	3200	1276	----	----	----	----	----	----	----	----	5976
Sarcococa saligna (Dene) Duel	----	----	----	----	----	----	----	----	----	----	----	5600	7690	13290
Zizyphus nummularia Buem.f. Weight	9640	12480	15900	25678	19862	----	----	----	----	----	----	----	----	83560
Shrubs total biomass	33760	46827	51616	48120	35008	19818	24065	9000	18590	10749	----	22947	24042	344542
B. Herb layer														
Adiantum incisum Forssk.	----	950	----	850	----	----	----	----	----	----	----	----	----	1800
Adiantum venustum D.Done	----	----	----	----	1050	1150	----	----	----	----	2500	----	----	4700
Ajuga bracteosa (Wall.) Benth.	----	----	----	----	----	----	----	1350	----	----	----	1420	1450	4220
Ajuga parviflora Benth.	----	----	----	----	----	1000	----	----	1150	1225	----	----	----	3375
Apluda mutica L..	----	----	1320	----	----	----	2300	----	----	----	----	----	----	3620
Aristida adscensionis L..	----	----	1480	900	950	----	----	----	----	----	----	----	----	3330
Asplenium adiantum nigrum L..	----	----	----	----	----	1400	----	----	----	----	800	----	1170	3370

Bourbousia diffusa L.	1400	----	1650	----	----	----	1700	----	----	----	----	----	----	4750
Ceterach dalhousiae (Hk.) C. Chr.	----	----	----	----	----	----	----	----	----	----	1900	----	1200	3100
Chrysopogon aucheri (Boiss.) Stapf	----	----	1540	2860	2180	2150	1140	1450	4320	----	----	----	----	15640
Conyza canadensis (L.) Cronquist	----	----	----	1500	1300	----	----	----	----	----	----	----	----	2800
Cynodon dactylon (L.) Pers.	----	----	770	750	700	----	1160	----	----	----	----	----	----	3380
Cyperus niveus Retz.	----	----	200	130	----	----	175	----	----	----	----	----	----	505
Dichanthium annulatum (Forssk.) Stapf.	1410	1370	1330	----	----	----	----	----	800	----	----	----	----	4910
Digitaria sanguinalis (L.) Scop.	1750	----	----	----	----	----	----	----	----	----	----	----	----	1750
Duchesnea indica (Andr.) Focke	----	----	----	----	----	----	----	1950	1910	----	----	----	----	3860
Echinops echinatus Roxb.	----	----	----	2100	1890	----	----	----	----	----	----	----	----	3990
Euphorbia hirta L.	1120	800	1200	750	770	----	----	----	----	----	----	----	----	4640
Filago spathulata C. Presl.	----	----	----	----	----	625	600	----	----	----	----	----	----	1225
Fimbristylis dichotoma (L.) Vahl.	----	----	----	1152	880	----	----	----	----	2700	1870	7880	3375	17857
Gallium aparine L.	----	----	----	----	----	----	----	562	455	466	----	----	----	1483
Gentiana kurru Royle	----	----	----	----	----	----	----	----	----	93	----	80	75	248
Geranium wallichianum D. Don. ex Sweet	----	----	----	----	----	888	----	1120	----	----	----	----	1841	3849
Heteropogon contortus (L.) P. Beauv.	1285	945	1171	745	720	1200	----	----	1160	----	----	----	----	7226
Imperata cylindrica (L.) P. Beauv.	----	----	----	----	----	----	----	1204	334	----	----	----	----	1538
Micromeria biflora (Hamm.) Bth.	252	392	360	364	328	250	334	345	230	322	----	----	----	3177
Oxalis corniculata L.	358	----	264	289	204	----	395	286	247	----	----	----	----	2043
Phalaris minor Retz.	----	----	----	----	----	----	----	----	962	----	----	930	710	2602
Plantago lanceolata L.	----	----	----	----	----	----	----	300	253	1114	----	696	----	2363
Rumex dentatus L.	----	----	----	----	----	----	800	----	756	----	----	----	----	1556
Stellaria media (L.) Cyr.	----	----	----	----	----	----	----	320	----	----	----	310	----	630

Themeda anathera (Nees) Hack.	495	368	----	250	377	450	446	----	----	----	----	----	----	2386
Trichodesma indica (L.) R.Br.	----	----	----	----	----	250	240	310	----	----	----	----	----	800
Valeriana jatamansii Jones.	----	----	----	----	----	----	----	----	----	563	605	----	----	1168
Verbascum thapsus L.	470	----	465	510	425	----	----	----	----	----	----	----	----	1870
Herbs total biomass	**8540**	**4825**	**11750**	**13150**	**11774**	**9363**	**9290**	**9197**	**12577**	**6483**	**7675**	**11316**	**9821**	**125761**
SUMMARY														
Altitude (m)	400	450	500	600	650	800	1350	1750	1850	1950	2050	2100	2250	
Shrubs total biomass	33760	46827	51616	48120	35008	19818	24065	9000	18590	10749	----	22947	24042	344542
Herbs total biomass	8540	4825	11750	13150	11774	9363	9290	9197	12577	6483	7675	11316	9821	125761
Grand Total	**42300**	**51652**	**63366**	**61270**	**46782**	**29181**	**33355**	**18197**	**31167**	**17232**	**7675**	**34263**	**33863**	**470303**

6. Mineral Composition of Some Key Palatable Species

A. Macrominerals

i. Trees

The palatability and macromineral contents including calcium, potassium, magnesium, sodium and nitrogen of tree species are given in Table 22 and Table 23, respectively.

Calcium: Calcium contents ranged from 19.31 ppm (vegetative stage of *Q. dilatata*) to 261 ppm (reproductive stage of *Celtis*) (Fig. 9). Significant differences occurred among all phenological stages of all the trees, except *Celtis* and *Grewia* (Appendix 28). In *Acacia* Ca contents were 163.7 ppm (vegetative stage) and 164.4 ppm (reproductive stage), which abruptly increased to 251.1 ppm in post-reproductive stage. Vegetative (255.9 ppm), reproductive (261 ppm) and post-reproductive (254.6 ppm) stages of *Celtis* showed no significant differences in Ca levels. In *Cotoneaster*, the Ca contents increased significantly with maturity. The Ca contents in *Cotoneaster* were 68.15 ppm, 105.3 ppm and 197.8 ppm for vegetative, reproductive and post-reproductive stages respectively. Vegetative (251.6 ppm) reproductive (246.2 ppm) and post-reproductive (255.2 ppm) stages of *Grewia* had no significant differences in Ca concentration. The reproductive stage (232.9 ppm) of *Morus* had significantly high Ca level than vegetative (130.3 ppm) and post-reproductive (154.1 ppm) stages. In *Parrotiopsis*, the Ca concentrations increased with maturity. The Ca contents in *Parrotiopsis* were 51.27 ppm, 201.7 ppm and 221.8 ppm for vegetative, reproductive and post-reproductive stages respectively. The Ca contents at reproductive (234.2 ppm) and post-reproductive (230.6 ppm) stages of *Prunus* had no significant differences but it went to extremely low at vegetative (100.8 ppm) stage. The Ca levels had significant differences among the various phenological stages that increased with maturity in *Q. dilatata*, *Q. incana* and *Vibernum* (Table 23).

Potassium: K levels varied from 27.06 ppm (vegetative stage of *Celtis*) to 27.25 ppm (post-reproductive stage of *Q. incana*) in the investigated trees (Table 23). Insignificant differences in potassium concentration were observed among the various shrubs and among the phenological stages (Appendix 28); although a slight gradual increase in *Acacia*, *Cotoneaster*, *Grewia*, *Q. dilatata*, *Q. incana* and in *Vibernum* was recorded (Table 23; Fig.10). The reproductive stages of *Celtis* (27.12 ppm), *Morus*

(27.16 ppm), *Parrotiopsis* (27.17 ppm) and *Prunus* (27.12 ppm) had slightly higher K contents than the vegetative and post-reproductive stages of all these species (Fig.10).

Magnesium: Significant differences in Mg contents were recorded among the different trees while insignificant differences occurred among the different phenological stages (Appendix 28). Magnesium contents ranged from 8.395 ppm (post-reproductive stage of *Q. incana*) to 11.12 ppm (vegetative stage of *Celtis*). In *Acacia* the Mg was 10.44 ppm, 10.57 ppm and 9.973 ppm at vegetative, reproductive and post reproductive stages, respectively. The reproductive stage of *Celtis* (9.677 ppm) and *Grewia* (10.34 ppm) had lower Mg contents than vegetative and post reproductive stages. Magnesium contents in *Cotoneaster* were similar in reproductive (9.895 ppm) and post reproductive (9.8 ppm) stages but it was slightly higher in vegetative (10.18 ppm) stage. In *Morus* (10.57 ppm) and *Prunus* (11.04 ppm) the reproductive stage had higher Mg concentration compared with other two stages. A slight decrease in Mg levels was observed in *Parrotiopsis, Q. dilatata* and *Q. incana* with maturity. *Vibernum* had a slight increase in Mg concentration with maturity (Table 23; Fig.11).

Sodium: Sodium concentration varied from 4.423 ppm (reproductive stage of *Prunus*) to 11.52 ppm (post-reproductive stage of *Grewia*). Significant differences in sodium contents were recorded among the various trees (Appendix 28). Phenological stages showed insignificant differences. A slight increase in Na levels was seen in *Celtis, Grewia* and *Q. dilatata* with maturity. *Morus* exhibited a slight decrease in Na level with maturity. The reproductive stage of *Acacia* (6.163 ppm), *Cotoneaster* (5.394 ppm), *Parrotiopsis* (8.375 ppm), *Prunus* (4.423 ppm) and *Q. incana* (6.341 ppm) had low Na contents than other phenological stages. Na concentrations recorded for *Vibernum* were 7.163 ppm, 9.061 ppm and 6.287 ppm in vegetative, reproductive and post reproductive stages respectively (Table 23; Fig.12).

Nitrogen: Nitrogen contents ranged from 0.923% (post-reproductive stage of *Q. incana*) to 4.253% (reproductive stage *Morus*). The differences were insignificant among the trees and among the different phenological stages (Appendix 28). The nitrogen contents reduced with advancing maturity in *Celtis, Cotoneaster, Grewia, Parrotiopsis, Q. dilatata* and *Q. incana* (Table 23). In *Acacia* the observed N contents were 2.732 %, 2.524 % and 2.819 % for vegetative, reproductive and post-reproductive stages respectively. The vegetative and post-reproductive stages of *Morus* had 3.366% and 2.960% N, respectively. At reproductive stages it was higher

than all the trees. The vegetative (2.522 %) and reproductive (2.571 %) stages of *Prunus* had similar N % concentrations but it decreased to 1.853 % in post-reproductive stage. The reproductive stage of *Vibernum* showed slightly higher N % level compared with other phenological stages (Fig.13).

ii. **Shrubs**

The palatability and macromineral contents including calcium, potassium, magnesium, sodium and nitrogen of 8 shrubs (Table 24) are provided in Table 25.

Calcium: Calcium contents ranged from 14.35 ppm (post-reproductive stage of *Berberis*) to 254.5 ppm (reproductive stage of *Indigofera*). Significant differences were found among all phenological stages of all the shrubs, except *Debregeasia* and *Indigofera* (Appendix 29). In *Berberis* Ca contents were 91.88 ppm (vegetative stage) and 82.06 ppm (reproductive stage), which abruptly decreased to 14.35 ppm in post-reproductive stage. Vegetative and reproductive stages of *Dodonaea* showed no significant differences in Ca concentration but it increased significantly to 99.4 ppm in the post-reproductive stage. The Ca contents increased to 108.7 ppm (reproductive stage) from 106.7 ppm (vegetative stage) in *Gymnosporia* but decreased to 100.8 ppm at the post reproductive stage. *Debregeasia* and *Indigofera* with mean concentration of 251.53 ppm and 251.5 ppm respectively had no significant differences among them and between the various phenological stages (Fig. 14). The Ca contents in *Justicia* were 202 ppm, 252.7 ppm and 240.3 ppm in the three consecutive phenological stages. Ca levels of *Rosa* were 144.2 ppm (vegetative stage) and 147.6 ppm (reproductive stage) that abruptly increased to 236.9 ppm in the post-reproductive stage. In *Zizyphus* calcium contents were 249.6 ppm (vegetative stage) and 231.5 ppm (post-reproductive stage) but significantly decreased to 92.17 ppm in reproductive stage (Fig. 14).

Potassium: Potassium contents varied from 26.89 ppm (*Justicia*) to 27.16 ppm (*Dodonaea* & *Zizyphus*) (Table 25; Fig. 15). Significant differences in potassium concentration were observed among the shrubs but the differences in phenological stages were insignificant (Appendix 29). Potassium levels were more or less similar in all species of shrubs. However, a slight increase was recorded in *Dodonaea*, *Indigofera* and *Rosa* at maturity (Fig. 15). *Justicia* had low potassium contents than the other analyzed species.

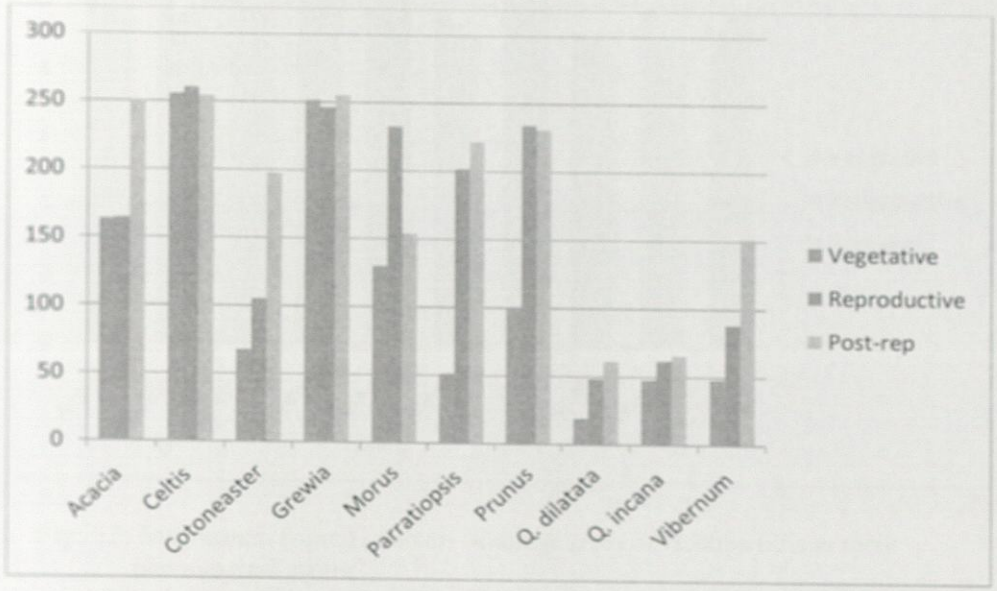


Fig. 10. Calcium (ppm) contents in forage trees of Gadoon hills at three phenological stages.

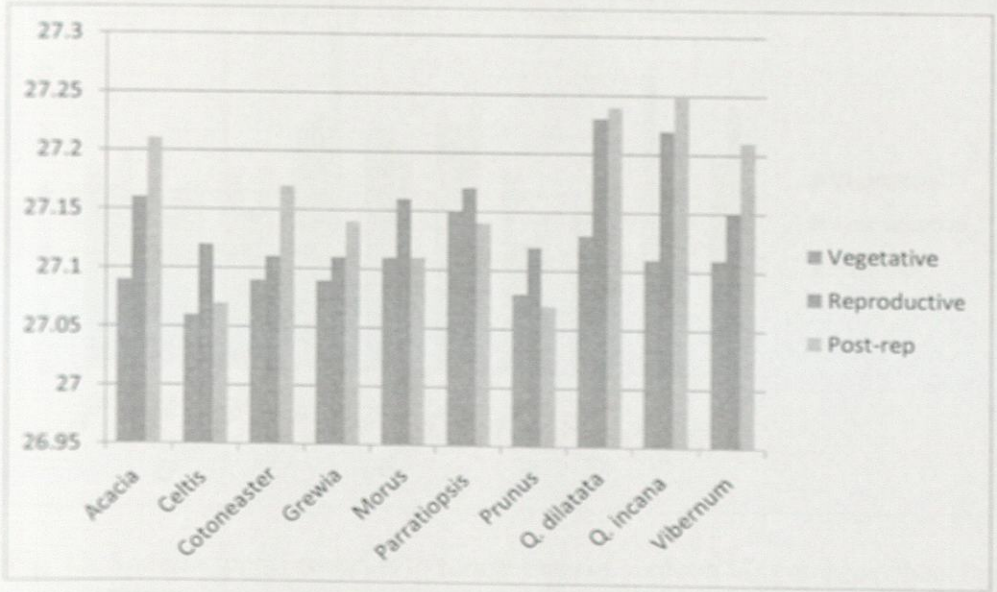


Fig. 11. Potassium (ppm) contents in forage trees of Gadoon hills at three phenological stages.

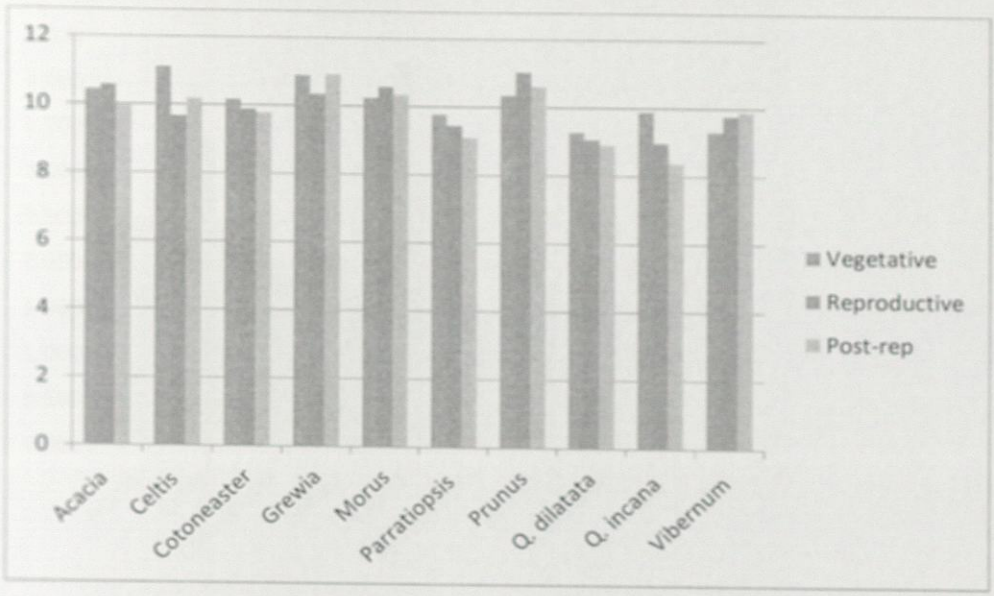


Fig. 12. Magnesium (ppm) contents in forage trees of Gadoon hills at three phenological stages.

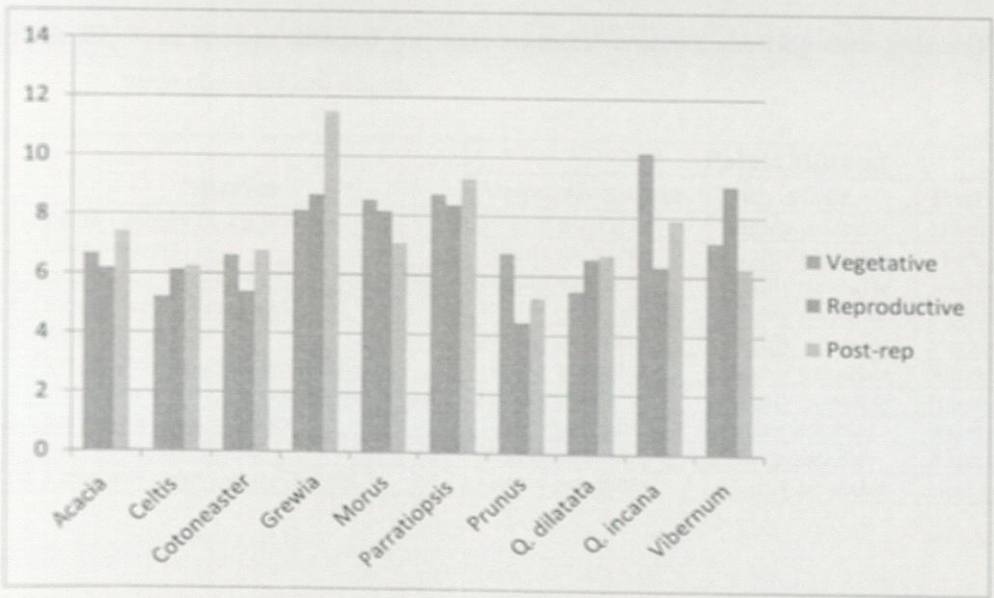


Fig. 13. Sodium (ppm) contents in forage trees of Gadoon hills at three phenological stages.

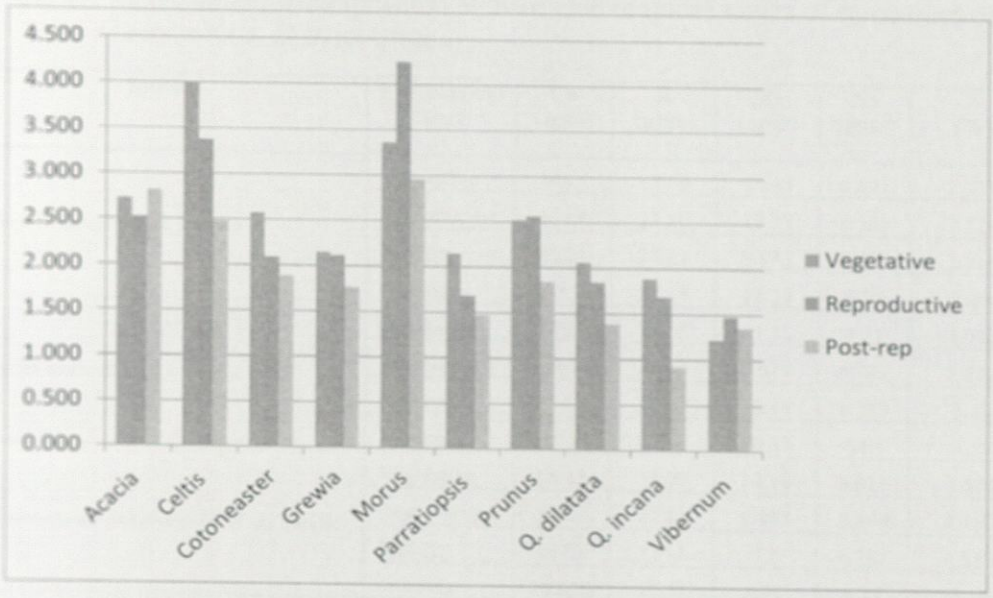


Fig. 14. Nitrogen (%) contents in forage trees of Gadoon hills at three phenological stages.

Table 22. Tree species selected for macro-mineral analysis showing their palatability at three phenological stages.

Species	Palatability at		
	Vegetative stage	Rep stage	Post-rep stage
1. *Acacia catechu* (L.f.) Willd.	Highly palatable	Highly palatable	Highly palatable
2. *Celtis australis* L.	Highly palatable	Highly palatable	Highly palatable
3. *Cotoneaster bacillaris* Wall. ex Lindle.	Highly palatable	Highly palatable	Rarely palatable
4. *Grewia optiva* Drum.ex.Burret.	Highly palatable	Highly palatable	Highly palatable
5. *Morus indica* L.	Highly palatable	Highly palatable	Highly palatable
6. *Parrotiopsis jacquemontiana* Dcne.	Highly palatable	Highly palatable	Rarely palatable
7. *Prunus cornuta* (Wall ex Royle) Steud.	Highly palatable	Highly palatable	Rarely palatable
8. *Quercus dilatata* Lindley	Highly palatable	Less palatable	Rarely palatable
9. *Quercus incana* Roxb.	Highly palatable	Less palatable	Rarely palatable
10. *Vibernum cotinifolium* D. Don.	Highly palatable	Highly palatable	Less palatable

Table 23. Macro-mineral composition at three phenological stages of some trees of Gadoon hills, District Swabi.

Species	Phenological stage	Ca (ppm)	K (ppm)	Mg (ppm)	Na (ppm)	N (%)
1.*Acacia catechu* (L.f.) Willd.	Vegetative	163.7	27.09	10.44	6.671	2.732
	Reproductive	164.4	27.16	10.57	6.163	2.524
	Post-rep	251.1	27.21	9.973	7.422	2.819
	Average	**193.07**	**27.15**	**10.33**	**6.75**	**2.69**
2.*Celtis australis* L.	Vegetative	255.9	27.06	11.12	5.21	4.005
	Reproductive	261	27.12	9.677	6.132	3.379
	Post-rep	254.6	27.07	10.19	6.229	2.48
	Average	**257.17**	**27.08**	**10.33**	**5.86**	**3.29**
3.*Cotoneaster bacillaris* Wall. ex Lindle.	Vegetative	68.15	27.09	10.18	6.621	2.579
	Reproductive	105.3	27.11	9.895	5.394	2.097
	Post-rep	197.8	27.17	9.8	6.792	1.888
	Average	**123.75**	**27.12**	**9.96**	**6.27**	**2.19**
4.*Grewia optiva* Drum.ex.Burret.	Vegetative	251.6	27.09	10.9	8.148	2.152
	Reproductive	246.2	27.11	10.34	8.684	2.114
	Post-rep	255.2	27.14	10.94	11.52	1.772
	Average	**251.00**	**27.11**	**10.73**	**9.45**	**2.01**
5.*Morus indica* L.	Vegetative	130.3	27.11	10.26	8.545	3.366
	Reproductive	232.9	27.16	10.57	8.163	4.253
	Post-rep	154.1	27.11	10.35	7.067	2.96
	Average	**172.43**	**27.13**	**10.39**	**7.93**	**3.53**
6.*Parrotiopsis jacquemontiana* Dcne.	Vegetative	51.27	27.15	9.78	8.74	2.154
	Reproductive	201.7	27.17	9.463	8.375	1.69
	Post-rep	221.8	27.14	9.101	9.255	1.474
	Average	**158.26**	**27.15**	**9.45**	**8.79**	**1.77**
7.*Prunus cornuta* (Wall ex Royle) Steud.	Vegetative	100.8	27.08	10.37	6.764	2.522
	Reproductive	234.2	27.12	11.04	4.423	2.571
	Post-rep	230.6	27.07	10.62	5.254	1.853
	Average	**188.35**	**27.09**	**10.68**	**5.48**	**2.32**
8.*Quercus dilatata* Lindley	Vegetative	19.31	27.13	9.278	5.488	2.066
	Reproductive	48.69	27.23	9.087	6.574	1.846
	Post-rep	61.64	27.24	8.91	6.721	1.387
	Average	**43.21**	**27.20**	**9.09**	**6.26**	**1.77**
9.*Quercus incana* Roxb.	Vegetative	47.92	27.11	9.895	10.19	1.893
	Reproductive	62.21	27.22	8.985	6.341	1.686
	Post-rep	65.85	27.25	8.395	7.913	0.923
	Average	**58.66**	**27.19**	**9.09**	**8.15**	**1.50**
10.*Viburnum cotinifolium* D. Don.	Vegetative	48.48	27.11	9.315	7.163	1.224
	Reproductive	88.72	27.15	9.79	9.061	1.478
	Post-rep	151.5	27.21	9.903	6.287	1.353
	Average	**96.23**	**27.16**	**9.67**	**7.50**	**1.35**

Magnesium: Significant differences in Mg contents were recorded among the different shrubs and among the different phenological stages (Appendix 29). Magnesium contents ranged from 8.243 ppm (reproductive stage of *Berberis*) to 13.08 ppm (reproductive stage of *Justicia*) (Table 25; Fig. 16). The vegetative (9.083 ppm) and post-reproductive (9.077 ppm) stages of *Berberis* showed no significant differences. However, it declined (8.243 ppm) with maturity. In *Dodonaea* the Mg concentration was similar at vegetative and reproductive (10.26 ppm) stages, which increased (10.91 ppm) at post reproductive stage. Reduced magnesium contents were recorded in the post-reproductive (9.638 ppm) stage of *Gymnosporia* than its vegetative (10.58 ppm) and reproductive (10.56 ppm) stages. *Indigofera* and *Rosa* showed no significant differences among their phenological stages in magnesium levels. The reproductive stage of *Justicia* (13.08 ppm) and *Zizyphus* (11.03 ppm) comparatively had higher Mg contents than other stages (Fig. 16).

Sodium: Sodium concentration ranged from 1.555 ppm in *Berberis lycium* (vegetative stage) to 7.879 ppm in *Zizyphus* (reproductive stage) (Fig. 17). Significant differences in sodium contents were recorded among the various shrubs and among the different phenological stages of the same plant (Appendix 29). Similar sodium levels were observed in vegetative (1.555 ppm) and reproductive (1.568 ppm) stages of *Berberis* while it increased to (2.079 ppm) at the post-reproductive stage. A slight gradual decrease in sodium contents were recorded at various phenological stages of *Debregeasia* and *Indigofera* with maturity (Table 25). Reproductive (3.146 ppm) stage of *Dodonaea* showed significant differences in Na concentration than vegetative (2.837 ppm) and post-reproductive (2.03 ppm) stages. Vegetative (1.694 ppm) and post-reproductive (1.644 ppm) stages of *Gymnosporia* had less Na contents than reproductive (2.403 ppm) stage. Reproductive stage of *Justicia* (13.08 ppm) and *Zizyphus* (7.879 ppm) showed higher sodium contents than the other two stages. The vegetative and post-reproductive stages of *Justicia* had 4.463 ppm and 5.716 ppm Na contents respectively (Table 25). In *Zizyphus*, the recorded Na contents were 2.295 ppm and 7.349 ppm for vegetative and post-reproductive stage, respectively. A gradual decrease in the Na contents was observed with maturity in *Rosa*. It was 3.713 ppm, 2.235 ppm and 1.798 ppm in the vegetative, reproductive and post-reproductive stages (Fig. 17).

Nitrogen: Significant differences were observed in the nitrogen contents among the various investigated shrubs and among the different phenological stages of the same

plant (Appendix 29). Nitrogen contents varied from 0.042% (*Gymnosporia*) to 3.660% (*Indigofera*). Reproductive stage (2.070%) of *Berberis* had higher nitrogen contents than vegetative (1.895%) and post-reproductive (1.561%) stages (Table 25). The same trend was also recorded for *Debregeasia* having higher N percentage in reproductive (2.141%) stage than vegetative (1.173%) and post-reproductive (0.885%) stages. The nitrogen contents reduced with advancing maturity in *Dodonaea*. It was 2.192%, 1.564% and 1.348% for vegetative, reproductive and post-reproductive stages respectively (Table 25). *Gymnosporia* showed extremely low nitrogen contents than all other shrubs. The reproductive (0.547%) stage had higher nitrogen contents than vegetative (0.042%) and post-reproductive (0.169%) stages in *Gymnosporia*. The highest nitrogen contents among all shrubs and phenological stages were observed for *Indigofera* at the reproductive stage. The vegetative and post-reproductive stages had 0.757% and 2.154%, respectively. The nitrogen levels in *Justicia* were 2.945%, 2.475% and 2.933% in vegetative, reproductive and post-reproductive stages respectively. Higher nitrogen concentration was recorded in the vegetative stage of *Rosa* than the other two stages. In *Zizyphus*, a gradual increase in the nitrogen concentration was observed with maturity (Fig. 18).

iii. **Grasses**

The palatability and macro-mineral contents including calcium, potassium, magnesium, sodium and nitrogen are given in Table 26 and Table 27, respectively.

Calcium: ANOVA revealed significant differences in calcium concentration among the various grasses and among the different phenological stages (Appendix 30). Calcium contents ranged from 23.32 ppm (post-reproductive stage of *Schoenoplectus*) to 35.24 ppm (reproductive stage of *Digitaria*). The Ca contents in *Apluda* were 25.1 ppm, 24.46 ppm and 24.1 ppm while in *Schoenoplectus*, 27.36 ppm, 23.5 ppm and 23.32 ppm for vegetative, reproductive and post-reproductive stages, respectively (Table 27). In both these species, the Ca contents decreased with maturity. At reproductive stage of *Aristida* (31.14 ppm), *Digitaria* (35.24 ppm) and *Pennisetum* (29.85 ppm) had higher Ca levels than vegetative and reproductive stages (Table 27). The Ca levels had significant differences among the various phenological stages that increased with maturity in *Chrysopogon*, *Heteropogon* and *Themeda* (Fig. 19).

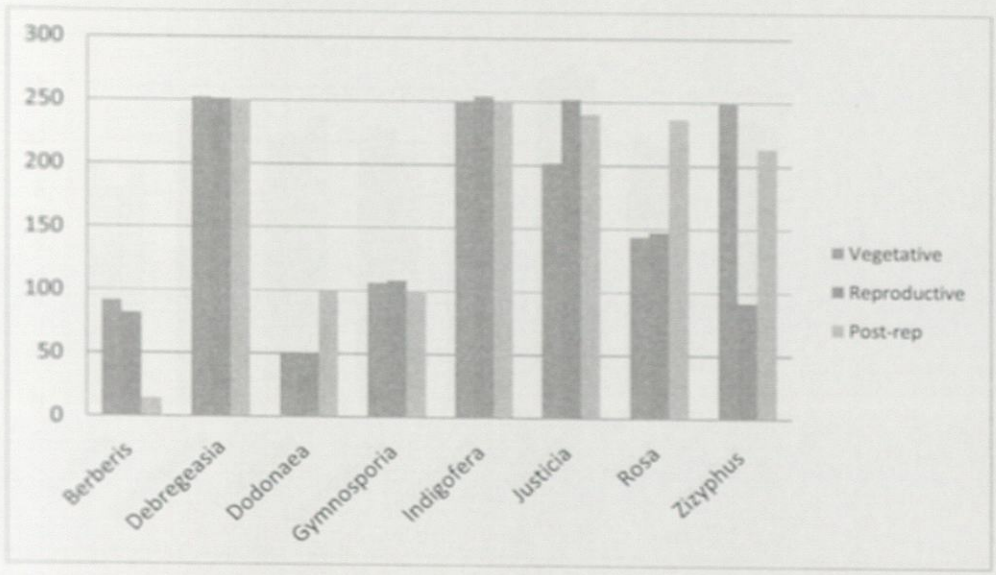


Fig. 15. Calcium (ppm) contents in forage shrubs of Gadoon hills at three phenological stages.

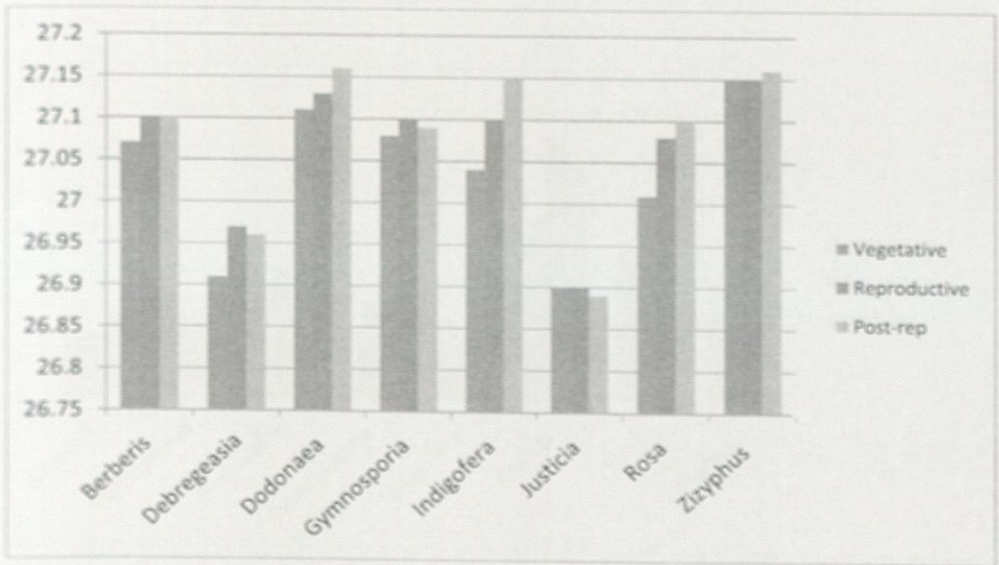


Fig. 16. Potassium (ppm) contents in forage shrubs of Gadoon hills at three phenological stages.

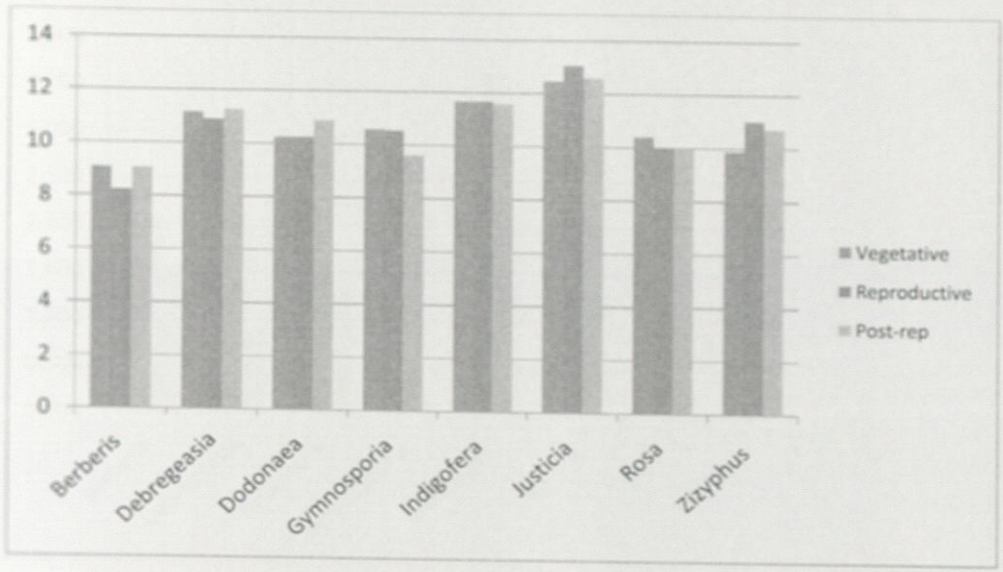


Fig. 17. Magnesium (ppm) contents in forage shrubs of Gadoon hills at three phenological stages.

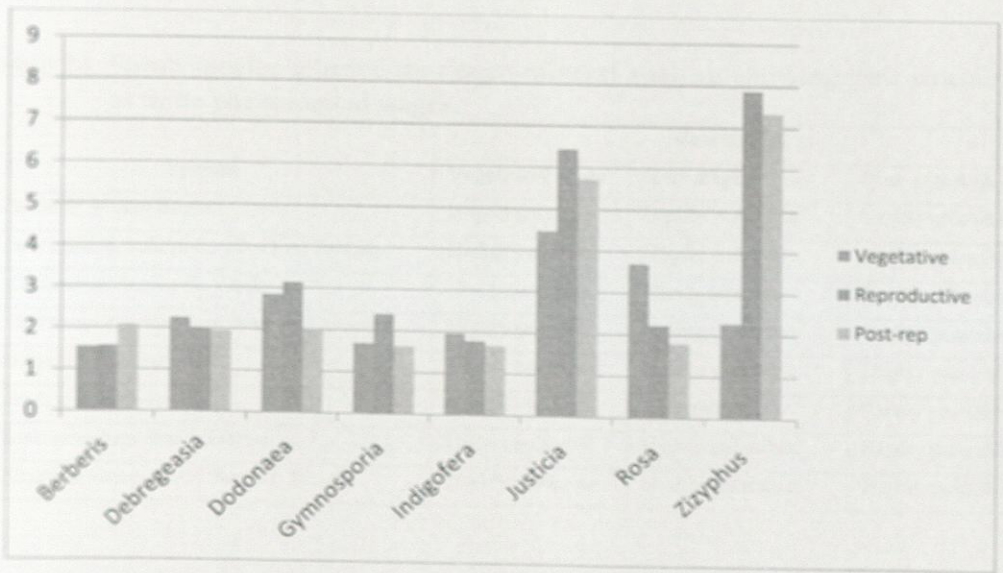


Fig. 18. Sodium (ppm) contents in forage shrubs of Gadoon hills at three phenological stages.

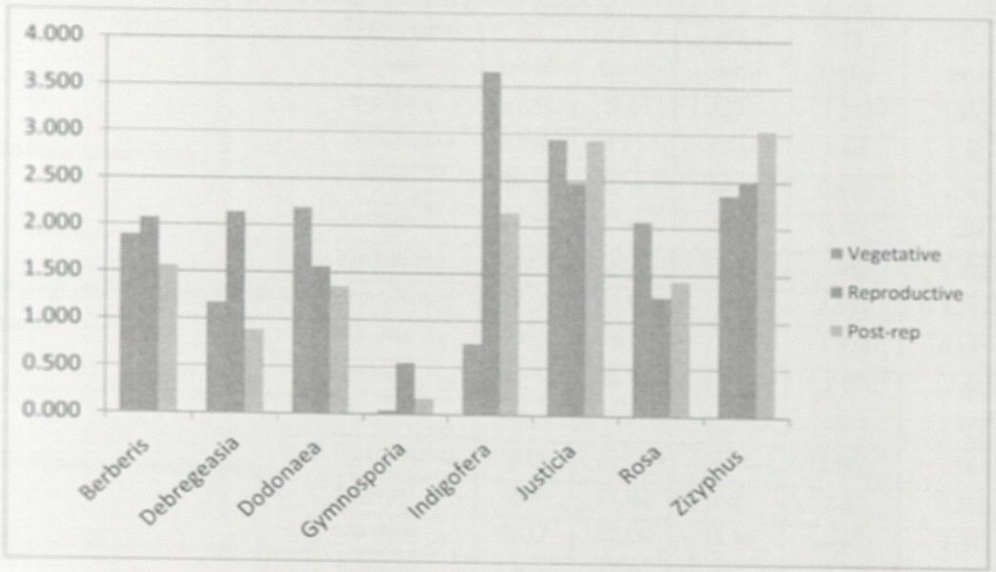


Fig. 19. Nitrogen (%) contents in forage shrubs of Gadoon hills at three phenological stages.

Table 24. Shrub species selected for macro-mineral analysis showing their palatability at three phenological stages.

Species	Palatability at		
	Vegetative stage	Rep stage	Post-rep stage
1.Berberis lycium Royle.	Highly palatable	Highly palatable	Highly palatable
2.Debregeasia salicifolia (D. Don) Rendle	Highly palatable	Highly palatable	Highly palatable
3. Dodonaea viscosa (L.) Jacq.	Non palatable	Non palatable	Rarely palatable
4. Gymnosporia royleana Wall ex Lawson	Highly palatable	Highly palatable	Highly palatable
5.Indigofera heterantha L.	Highly palatable	Highly palatable	Highly palatable
6.Justicia adhatoda L.	Non palatable	Non palatable	Rarely palatable
7.Rosa moschata non J. Herrm.	Highly palatable	Highly palatable	Highly palatable
8.Zizyphus nummularia Buem.f. Weight	Highly palatable	Highly palatable	Highly palatable

Table 25. Macro-minerals composition of some forage shrubs of Gadoon hills. District Swabi (at three penological stages).

Species	Phenological stage	Ca (ppm)	K (ppm)	Mg (ppm)	Na (ppm)	N (%)
1.Berberis lycium Royle.	Vegetative	91.88	27.07	9.083	1.555	1.895
	Reproductive	82.06	27.1	8.243	1.568	2.07
	Post-rep	14.35	27.1	9.077	2.079	1.561
	Average	62.76	27.09	8.80	1.73	1.84
2.Debregeasia salicifolia (D. Don) Rendle	Vegetative	252.4	26.91	11.16	2.254	1.173
	Reproductive	251.5	26.97	10.91	1.994	2.141
	Post-rep	250.7	26.96	11.29	1.952	0.885
	Average	251.53	26.95	11.12	2.07	1.40
3. Dodonaea viscosa (L.) Jacq.	Vegetative	51.5	27.11	10.26	2.837	2.192
	Reproductive	51.08	27.13	10.26	3.146	1.564
	Post-rep	99.4	27.16	10.91	2.03	1.348
	Average	67.33	27.13	10.48	2.67	1.70
4. Gymnosporia royleana Wall ex Lawson	Vegetative	106.7	27.08	10.58	1.694	0.042
	Reproductive	108.7	27.1	10.56	2.403	0.547
	Post-rep	100.8	27.09	9.638	1.644	0.169
	Average	105.40	27.09	10.26	1.91	0.25
5. Indigofera heterantha L.	Vegetative	250.1	27.04	11.69	1.969	0.757
	Reproductive	254.5	27.1	11.68	1.779	3.66
	Post-rep	249.9	27.15	11.6	1.681	2.154
	Average	251.50	27.10	11.66	1.81	2.19
6. Justicia adhatoda L.	Vegetative	202	26.9	12.48	4.463	2.945
	Reproductive	252.7	26.9	13.08	6.444	2.475
	Post-rep	240.3	26.89	12.62	5.716	2.933
	Average	231.67	26.90	12.73	5.56	2.78
7. Rosa moschata non J. Herrm.	Vegetative	144.2	27.01	10.42	3.713	2.066
	Reproductive	147.6	27.08	10	2.235	1.263
	Post-rep	236.9	27.1	9.992	1.798	1.433
	Average	176.23	27.06	10.14	2.58	1.59
8. Ziziphus nummularia (Burm. f.) Wight & Arn.	Vegetative	249.6	27.15	9.895	2.295	2.356
	Reproductive	92.17	27.15	11.03	7.879	2.485
	Post-rep	213.5	27.16	10.74	7.349	3.041
	Average	185.09	27.15	10.56	5.84	2.63

Potassium: K levels varied from 24.05 ppm (vegetative stage of *Pennisetum*) to 28.12 ppm (vegetative stage of *Aristida*) in the investigated species. Statistical analysis showed significant differences in K contents among the various grasses and among the different phenological stages (Appendix 30). The reproductive and post-reproductive (27.02 ppm) stages of *Apluda* had similar K contents but the vegetative stage had higher levels. The K concentrations abruptly decreased in *Aristida*, *Heteropogon* and *Schoenoplectus* while increased in *Chrysopogon* and *Digitaria* with maturity in all the analyzed grasses (Fig. 20). The reproductive stages of *Pennisetum* (26.86 ppm) and *Themeda* (27.03 ppm) had higher K contents than the vegetative and post-reproductive stages of all these grass species (Table 27).

Magnesium: Magnesium contents varied from 8.121 ppm (post-reproductive stage of *Heteropogon*) to 9.651 ppm (post-reproductive stage of *Digitaria*). Significant differences in Mg contents were recorded among the different grasses and among the different phenological stages (Appendix 30). In *Pennisetum*, the Mg levels were 9.64 ppm, 9.45 ppm and 9.46 ppm for vegetative, reproductive and post reproductive stages, respectively (Table 27). The reproductive stage of *Chrysopogon* (9.527 ppm) and *Themeda* (9.243 ppm) had higher Mg contents than vegetative and post reproductive stages. *Schoenoplectus* had no significant differences in Mg at vegetative (8.655 ppm) and reproductive (8.665 ppm) stages but it ran slightly higher at post-reproductive (9.112 ppm) stage. It slightly increased in *Apluda* and *Digitaria* while it showed slight decrease in *Aristida* and *Heteropogon* with maturity (Table 27).

Sodium: Significant differences in sodium concentration were recorded among the various grasses (Appendix 30). Phenological stages had insignificant differences. It varied from 1.145 ppm (post-reproductive stage of *Heteropogon*) to 2.051 ppm (reproductive stage of *Pennisetum*). A slight gradual decline in Na concentration was observed in *Chrysopogon*, *Digitaria* and *Schoenoplectus* with maturity. In *Heteropogon*, the Na levels were 1.756 ppm, 1.787 ppm and 1.145 ppm for vegetative, reproductive and post reproductive stages, respectively. The reproductive stage of *Apluda* (1.969 ppm) and *Pennisetum* (2.051 ppm) had significantly high Na levels than at other phenological stages (Table 27). In *Aristida*, the vegetative (1.552 ppm) and reproductive (1.569 ppm) stages had no significant differences but it was comparatively low in post-reproductive (1.213 ppm) stage. However, in *Themeda* the reproductive (1.648 ppm) and post reproductive (1.641 ppm) stages had no significant difference while it was low in vegetative (1.238 ppm) stage (Table 27).

Nitrogen: Nitrogen contents ranged from 0.854% (vegetative stage of *Heteropogon*) to 2.021% (reproductive stage of *Chrysopogon*). Statistical analysis showed significant differences in the nitrogen contents among the various grazed grasses and among the different phenological stages (Appendix 30). The nitrogen contents increased with advancing maturity in most of the analyzed grasses like *Digitaria, Heteropogon, Schoenoplectus* and *Themeda* (Fig. 23). In *Apluda*, the observed N contents were 0.961 %, 1.012 % and 0.897 % for vegetative, reproductive and post-reproductive stages respectively. N % levels in vegetative (1.094 %) and reproductive (1.095 %) stages of *Aristida* were similar while in post-reproductive (0.991 %) stage it declined. The reproductive stages of *Chrysopogon* (2.021%) and *Pennisetum* (1.763%) had significantly higher N levels than other phenological stages (Table 27).

B. Micro-minerals

i. Trees

The micro-mineral contents including cadmium, chromium, copper, iron, nickel, lead, zinc and manganese of forage tree species are given in Table 28.

Cadmium: Significant differences among the various phenological stages were observed for Cd levels while insignificant differences occurred among trees (Appendix 31). Cadmium ranged from 0.203 ppm (vegetative stage of *Prunus*) to 0.222 ppm (vegetative stage of *Q. dilatata*). A slight increase occurred among the three phenological stages of *Acacia, Cotoneaster, Parrotiopsis* and *Q. incana* with advancing maturity (Table 28). The reproductive stage of *Celtis* (0.215 ppm) and *Prunus* (0.205 ppm) had slightly higher Cd contents than the vegetative and post-reproductive stages while in *Grewia* (0.212 ppm) this Cd concentration was slightly lower in reproductive stage than the other two stages. The Cd concentrations of *Morus* were 0.216 ppm, 0.215 ppm and 0.208 ppm while in *Q. dilatata* 0.222 ppm, 0.218 ppm and 0.212 ppm for vegetative, reproductive and post-reproductive stages respectively. Cd levels declined with advancing maturity in both the species. Insignificant differences were observed among the vegetative (0.218 ppm), reproductive (0.218 ppm) and post-reproductive (0.216 ppm) stages.

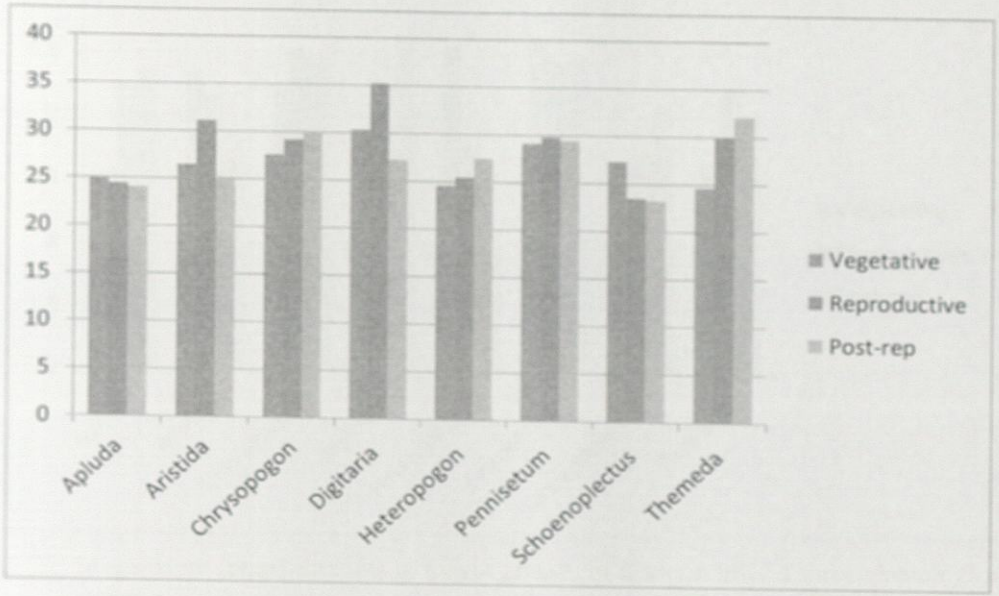


Fig. 20. Calcium (ppm) contents in forage grasses of Gadoon hills at three phenological stages.

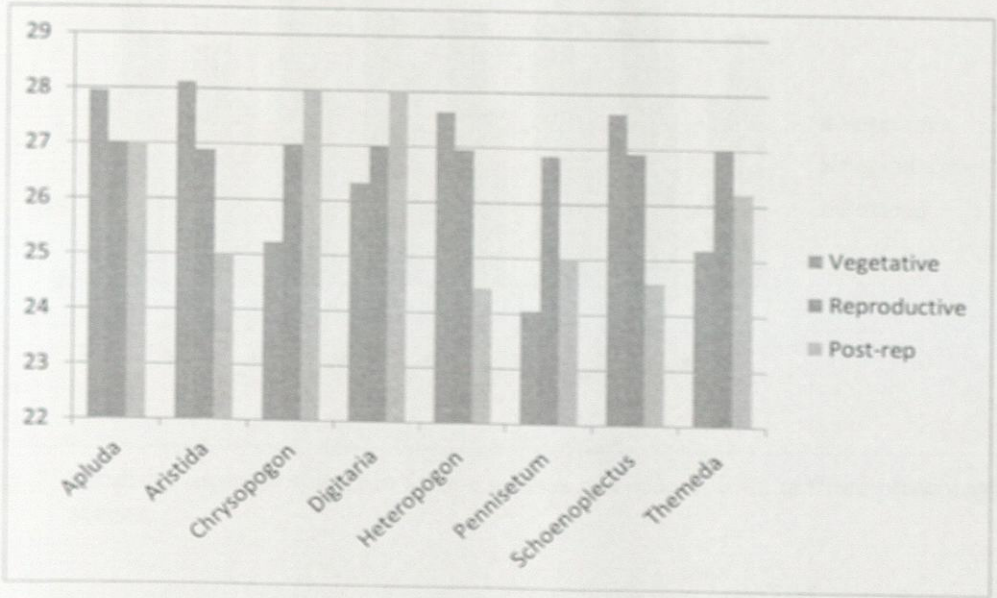


Fig. 21. Potassium (ppm) contents in forage grasses of Gadoon hills at three phenological stages.

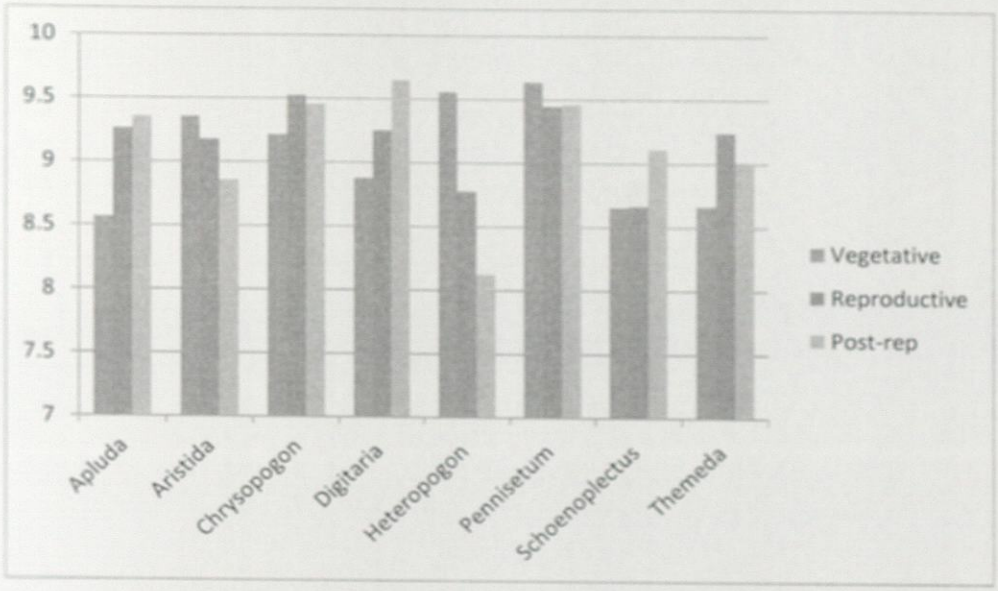


Fig. 22. Magnesium (ppm) contents in forage grasses of Gadoon hills at three phenological stages.

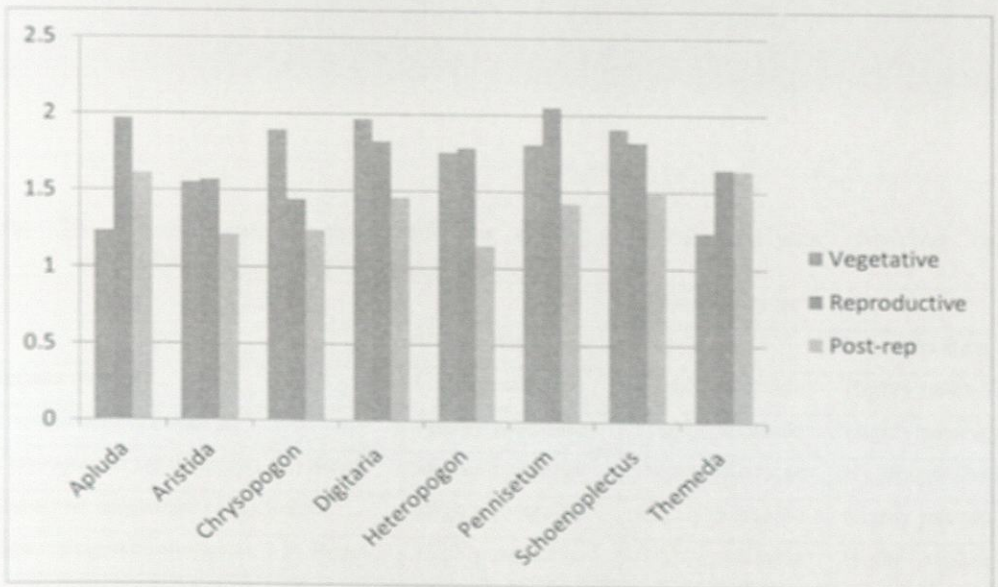


Fig. 23. Sodium (ppm) contents in forage grasses of Gadoon hills at three phenological stages.

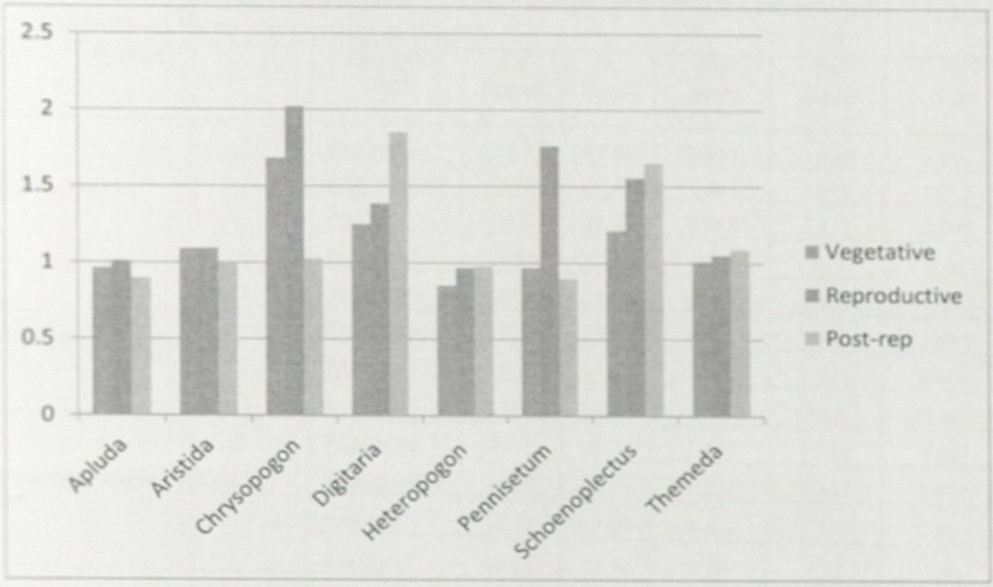


Fig.24. Nitrogen (%) contents in forage grasses of Gadoon hills at three phenological stages.

Table 26. Grass species analyzed for macro-mineral analysis showing their palatability at three phenological stages.

Species	Palatability at		
	Vegetative stage	**Rep stage**	**Post-rep stage**
1. Apluda mutica L.	Highly palatable	Highly palatable	Highly palatable
2. Aristida adscensionis L.	Highly palatable	Highly palatable	Highly palatable
3. Chrysopogon aucheri (Boiss.) Stapf	Highly palatable	Highly palatable	Highly palatable
4. Digitaria sanguinalis (L.) Scop.	Highly palatable	Highly palatable	Highly palatable
5. Heteropogon contortus (L.) P. Beauv.	Highly palatable	Highly palatable	Highly palatable
6. Pennisetum orientale L. C. Rich.	Highly palatable	Highly palatable	Highly palatable
7. Schoenoplectus litoralis Schrad.	Highly palatable	Less palatable	Non palatable
8. Themeda anathera (Nees) Hack.	Highly palatable	Highly palatable	Highly palatable

Table 27. Macro-mineral composition of some forage grasses of Gadoon hills, District Swabi at three phenological stages.

Species	Phenological stage	Ca (ppm)	K (ppm)	Mg (ppm)	Na (ppm)	N (%)
1.Apluda mutica L.	Vegetative	25.1	27.95	8.565	1.234	0.961
	Reproductive	24.46	27.02	9.263	1.969	1.012
	Post-rep	24.1	27.02	9.355	1.612	0.897
	Average	24.55	27.33	9.06	1.61	0.96
2.Aristida adscensionis L.	Vegetative	26.51	28.12	9.354	1.552	1.094
	Reproductive	31.14	26.89	9.181	1.569	1.095
	Post-rep	25.23	25.01	8.856	1.213	0.991
	Average	27.63	26.67	9.13	1.44	1.06
3.Chrysopogon aucheri (Boiss.) Stapf	Vegetative	27.6	25.23	9.217	1.896	1.684
	Reproductive	29.25	26.99	9.527	1.445	2.021
	Post-rep	30.12	27.99	9.457	1.241	1.023
	Average	28.99	26.74	9.40	1.53	1.58
4.Digitaria sanguinalis (L.) Scop.	Vegetative	30.35	26.34	8.877	1.968	1.251
	Reproductive	35.24	27	9.251	1.824	1.388
	Post-rep	27.23	28.01	9.651	1.458	1.857
	Average	30.94	27.12	9.26	1.75	1.50
5.Heteropogon contortus (L.) P. Beauv.	Vegetative	24.62	27.64	9.556	1.756	0.854
	Reproductive	25.5	26.96	8.777	1.787	0.967
	Post-rep	27.54	24.45	8.121	1.145	0.977
	Average	25.89	26.35	8.82	1.56	0.93
6.Pennisetum orientale L. C. Rich.	Vegetative	29.14	24.05	9.64	1.811	0.968
	Reproductive	29.85	26.86	9.45	2.051	1.763
	Post-rep	29.45	25	9.46	1.423	0.899
	Average	29.48	25.30	9.52	1.76	1.21
7.Schoenoplectus litoralis Schrad.	Vegetative	27.36	27.65	8.655	1.911	1.214
	Reproductive	23.5	26.92	8.665	1.825	1.555
	Post-rep	23.32	24.58	9.112	1.492	1.654
	Average	24.73	26.38	8.81	1.74	1.47
8.Themeda anathera (Nees) Hack.	Vegetative	24.65	25.19	8.668	1.238	1.012
	Reproductive	29.99	27.03	9.243	1.648	1.054
	Post-rep	32.13	26.21	9.011	1.641	1.089
	Average	28.92	26.14	8.97	1.51	1.05

Chromium: It ranged from 0.095 ppm (vegetative stage of *Vibernum*) to 1.547 ppm (reproductive stage of *Q. incana*) in the investigated tree leaves (Table 28). No significant differences were recorded in Cr contents among the trees. However, various phenological stages of analyzed trees exhibited significant differences (Appendix 31). All the trees showed a slight increase in Cr levels with advancing maturity, except *Celtis, Morus* and *Q. incana*. The reproductive stage (0.926 ppm) of *Celtis* had comparatively low Cr contents than vegetative (0.956 ppm) and post-reproductive (0.976 ppm) stages. In *Morus* the vegetative (0.443 ppm) and reproductive (0.437 ppm) stages had no significant difference; however, it slightly became higher at post-reproductive (0.554 ppm) stage. Similarly, the vegetative (1.46 ppm) and reproductive (1.547 ppm) stage of *Q. incana* had similar Cr levels but it extremely low in post-reproductive (0.114 ppm) stage. *Vibernum* has the least Cr levels compared with other tree species (Table 28).

Copper: Insignificant differences in copper contents were noticed among the trees and among different phenological stages (Appendix 31). It ranged from 0.045 ppm (reproductive stage of *Prunus*) to 0.118 ppm (vegetative stage of *Q. incana*). A slight decrease in Cu contents was observed in *Acacia, Celtis, Parrotiopsis* and *Vibernum* with maturity. The vegetative, reproductive and the post-reproductive stages of *Grewia* had 0.109 ppm, 0.071 ppm and 0.086 ppm copper concentrations respectively. The reproductive (0.095 ppm) stage of *Morus* had higher Cu contents than vegetative (0.086 ppm) and the post-reproductive (0.062 ppm) stages while in *Prunus* opposite trend was observed for reproductive (0.045 ppm) stage compared with other two stages. In *Cotoneaster, Q. dilatata* and *Q. incana* the reproductive and the post-reproductive stages had similar Cu levels but it was greatly higher in vegetative stage (Table 28).

Iron: Fe contents varied from 1.859 ppm (reproductive stage of *Cotoneaster*) to 8.874 ppm (post-reproductive stage of *Grewia*). Fe contents significantly differed among the trees and among the phenological stages (Appendix 31). At reproductive stage all trees had low Fe levels than vegetative and post-reproductive stages except *Celtis* and *Morus*. In *Acacia* no significant differences were noticed among vegetative and reproductive stages but post-reproductive stage had high Fe level. In *Cotoneaster* there were 3.308 ppm and 3.108 ppm Fe while in *Morus* it was 3.705 ppm and 3.804 ppm, in vegetative and post-reproductive stages respectively, showing insignificant differences. The vegetative stages of *Prunus* (4.334 ppm), *Q. incana* (4.779 ppm) and

Vibernum (6.789 ppm) had higher Fe levels than reproductive and post-reproductive stages. The reproductive and post-reproductive stages had similar Fe contents in respective trees (Table 28).

Nickel: Ni concentration increased in *Celtis*, *Q. dilatata* and *Q. incana* but decreased in *Acacia* and *Vibernum* with advancing maturity (Table 28). It ranged from 0.175 ppm (vegetative stage of *Prunus*) to 0.338 ppm (vegetative stage of *Vibernum*). Significant differences in Ni levels were found among the phenological stages while the difference among the various trees was insignificant (Appendix 31). The reproductive stage (0.218 ppm) of *Cotoneaster* had low Ni level than vegetative (0.245 ppm) and post-reproductive (0.245 ppm) stages. In *Grewia* the reproductive (0.312 ppm) and post-reproductive (0.3 ppm) stages had no significant differences while vegetative stage (0.232 ppm) had low Ni concentration. The differences in the vegetative (0.336 ppm), reproductive (0.327 ppm) and post-reproductive (0.33 ppm) stages of *Morus* were insignificant. *Parrotiopsis* (0.315 ppm) and *Prunus* (0.206 ppm) had higher Ni contents in reproductive stages when compared with their vegetative and post-reproductive stages (Table 28).

Lead: Statistical analysis revealed significant differences in Pb concentrations among the phenological stages and among the forage trees (Appendix 31). It varied from 0.48 ppm (post-reproductive stage of *Prunus*) to 1.224 ppm (reproductive stage of *Q. dilatata*). Pb contents decreased in *Cotoneaster*, *Grewia* and *Prunus* with maturity. The reproductive stages of *Acacia* (0.499 ppm), *Celtis* (0.719 ppm), *Q. incana* (0.638 ppm) and *Vibernum* (0.717 ppm) had low Pb levels compared with their vegetative and post-reproductive stages. In *Morus*, the reproductive (0.858 ppm) and post-reproductive (0.86 ppm) stages had insignificant difference in Pb concentrations but it was slightly higher in vegetative (0.934 ppm) stage. The reproductive stages of in *Parrotiopsis* (0.807 ppm) and *Q. dilatata* (1.224 ppm) had significantly higher Pb levels than other two stages in both the forage trees (Table 28).

Zinc: All the phenological stages of the investigated trees had inconsistent trend in Zn levels except *Celtis* and *Q. dilatata* which showed a slight decrease in Zn concentrations towards maturity. Zn contents ranged from 0.117 ppm (reproductive stage of *Prunus*) to 0.485 ppm (vegetative stage of *Grewia*). Insignificant differences were recorded in Zn contents among the phenological stages and among the various trees (Appendix 31). Reproductive (0.313 ppm) stage of *Morus* had high Zn level than vegetative (0.259 ppm) and post-reproductive (0.268 ppm) stages. In *Grewia*, low Zn

contents were observed in reproductive (0.181 ppm) stage compared with vegetative (0.485 ppm) and post-reproductive (0.299 ppm) stages. All the three phenological stages had significant differences among themselves. *Acacia, Cotoneaster, Parrotiopsis, Prunus, Q. incana* and *Vibernum* all had low Zn concentrations in reproductive stages when compared with vegetative and post-reproductive stages (Table 28).

Manganese: Mn contents had significant differences among the phenological stages but the differences were insignificant among the trees (Appendix 31). Mn contents ranged from 0.163 ppm (reproductive stage of *Cotoneaster*) to 1.302 ppm (post-reproductive stage of *Q. dilatata*). The reproductive stages of *Acacia* (0.179 ppm), *Celtis* (0.198 ppm), *Cotoneaster* (0.163 ppm), *Grewia* (0.331 ppm) and *Parrotiopsis* (0.177 ppm) had low while *Morus* (0.346 ppm), *Prunus* (0.367 ppm) and *Q. incana* (0.871 ppm) had higher Mn levels compared with vegetative and reproductive stages. The vegetative and reproductive stages of *Acacia, Celtis, Cotoneaster* and *Parrotiopsis* had no significant differences among themselves while in *Grewia* these phenological stages had significant difference. In *Q. dilatata* and *Vibernum* Mn concentration reduced with advancing maturity (Table 28).

ii. **Shrubs**

The micro-mineral contents including cadmium, chromium, copper, iron, nickel, lead, zinc and manganese of forage shrubs are given in Table 29.

Cadmium: Cadmium concentration ranged from 0.205 ppm (*Gymnosporia, Justicia* and *Zizyphus*) to 0.217 ppm (post-reproductive stage of *Debregeasia*). Statistical analysis showed insignificant differences among the shrubs and among the various phenological stages (Appendix 32). In *Berberis*, the Cd contents were similar (0.212 ppm) in vegetative and reproductive stages that decreased slightly to 0.211 ppm in post reproductive stage. A slight increase in Cd contents was observed among the three phenological stages of *Debregeasia* and *Justicia* with maturity. In *Debregeasia* it was 0.209 ppm, 0.215 ppm and 0.217 ppm while *Justicia* had 0.205 ppm, 0.211 ppm and 0.212 ppm for vegetative stage, reproductive stage and post-reproductive stage, respectively. *Dodonaea* had high Cd contents in vegetative stage (0.213 ppm) than reproductive (0.208 ppm) and post-reproductive (0.209 ppm) stages. *Gymnosporia* showed the reverse trend regarding Cd levels from that of *Debrrgesia* towards maturity. Vegetative, reproductive and post-reproductive stages of

Gymnosporia had 0.212 ppm, 0.207 ppm and 0.205 ppm, respectively. The Cd levels in the vegetative and post- reproductive stages of *Indigofera* were 0.214 ppm and 0.211 ppm respectively but it was higher in the reproductive stage (0.215ppm). *Rosa* species had similar Cd contents (0.212 ppm) in vegetative and post-reproductive stages but it was higher in the reproductive stage (0.214 ppm). Cd level was higher in the reproductive stage (0.208 ppm) of *Zizyphus* than vegetative (0.206 ppm) and post-reproductive (0.205 ppm) stages (Table 29).

Chromium: No significant differences were occurred in Cr concentration among the different shrubs. However, significant differences were observed among various phenological stages (Appendix 32). It ranged from 0.006 ppm (*Dodonaea*) to 0.967 ppm (*Indigofera*) among the shrub species (Table 29). The concentration increased with maturity in *Dodonaea, Gymnosporia* and *Zizyphus*. The recoded Cr concentration in *Dodonaea* was 0.006 ppm, 0.067 ppm and 0.234 ppm, in *Gymnosporia* 0.287 ppm, 0.312 ppm and 0.447 ppm while in *Zizyphus* 0.485 ppm, 0.493 ppm and 0.599 ppm for vegetative, reproductive and post-reproductive stages respectively. Inconsistent behavior regarding the Cr concentration was seen at different phenological stages of the other species. *Berberis* had higher Cr contents in reproductive stage (0.914 ppm) than the vegetative (0.725 ppm) and post-reproductive (0.707 ppm) stages. *Debrrgesia* showed similar trend for reproductive stage (0.663 ppm) while comparing with vegetative (0.512 ppm) and post-reproductive (0.62 ppm) stages. Cr contents were greater in reproductive stage (0.967 ppm) of *Indigofera* than vegetative stage (0.892 ppm) but it abruptly decreased in the post-reproductive stage (0.196 ppm). The reproductive stage (0.284 ppm) of *Justicia* had low Cr level than the vegetative (0.293 ppm) and post-reproductive (0.369 ppm) stages.

Copper: The level of copper ranged from 0.031 ppm (reproductive stage of *Berberis*) to 0.123 ppm (post-reproductive stage of *Berberis*). Copper contents significantly differed among the shrubs and among different phenological stages (Appendix 32). In *Debrrgesia*, the copper contents showed no significant differences between vegetative (0.058 ppm) and reproductive (0.059 ppm) stages but an increase to 0.073 ppm in post- reproductive stage was seen. A gradual decrease in Cu contents was observed towards maturity in *Indigofera* while this decline was abrupt in *Rosa* towards maturity. The Cu contents in *Indigofera* were 0.068 ppm, 0.066 ppm and 0.054 ppm while *Rosa* had 0.074 ppm, 0.055 ppm and 0.05 ppm in vegetative, reproductive and post-reproductive stages respectively. The copper contents were 0.06 ppm in the

vegetative stage of *Berberis*, which increased to 0.123 ppm in post- reproductive stage but it decline to extremely low level at reproductive stage (0.031 ppm). *Dodonaea* had low Cu contents in the post-reproductive stage (0.05 ppm) compared with vegetative (0.076 ppm) and reproductive (0.079 ppm) stages. The reproductive and post-reproductive stages of *Gymnosporia* had similar (0.053 ppm) Cu levels but it was greater in the vegetative (0.062 ppm) stage. The reproductive stages of *Justicia* (0.079 ppm) and *Zizyphus* (0.069 ppm) had higher Cu contents than the other two stages (Table 29).

Iron: Significant differences in Fe contents were recorded among the shrubs and among the various phenological stages (Appendix 32). Fe contents ranged from 1.819 ppm (reproductive stage of *Berberis*) to 12 ppm (reproductive stage of *Gymnosporia*). Fe contents decreased in *Dodonaea* and *Indigofera* with maturity while the rest of the shrubs showed inconsistent Fe contents in their phenological stages. In *Dodonaea*, it was 10.41 ppm, 6.948 ppm and 2.873 ppm while *Indigofera* had 6.579 ppm, 2.883 ppm and 2.124 ppm in vegetative, reproductive and post-reproductive stages, respectively. The post-reproductive stage (6.747 ppm) of *Berberis* had higher Fe concentration than vegetative (2.989 ppm) and reproductive (1.819 ppm) stages. Insignificant differences in Fe contents were recorded among reproductive (3.549 ppm) and post-reproductive (3.852 ppm) stages of *Debregeasia* but it was significantly higher in vegetative stage (5.444 ppm). The reproductive stage of *Gymnosporia* had the highest Fe contents (12 ppm). However, it fell to extremely level at post-reproductive stage (2.442 ppm) than vegetative stage (6.12 ppm). *Justicia* had 2.503 ppm, 1.893 ppm and 5.408 ppm Fe at vegetative, reproductive and post-reproductive stages, respectively. Fe levels were higher in vegetative stage (6.339 ppm) of *Rosa* that decline at reproductive (2.148 ppm) and post-reproductive (2.735 ppm) stages without any significant differences. Fe contents in the reproductive (7.849 ppm) stage of *Zizyphus* were higher than the vegetative (5.246 ppm) and post-reproductive (6.374 ppm) stages (Table 29).

Table 28. Micro-minerals composition of some fodder tree leaves of Gadoon hills, District Swabi (at three penological stages).

Species	Phenological stage	Cd (ppm)	Cr (ppm)	Cu (ppm)	Fe (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	Mn (ppm)
1.Acacia catechu (L.f.) Willd.	Vegetative	0.207	1.036	0.08	3.497	0.212	0.829	0.22	0.231
	Reproductive	0.21	1.077	0.07	2.813	0.21	0.499	0.13	0.179
	Post-rep	0.211	1.128	0.07	6.848	0.198	0.935	0.19	0.232
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**
2.Celtis australis L.	Vegetative	0.212	0.956	0.09	3.845	0.2	0.91	0.19	0.264
	Reproductive	0.215	0.926	0.09	4.799	0.207	0.719	0.15	0.198
	Post-rep	0.21	0.976	0.06	2.384	0.215	0.754	0.12	0.247
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**
3.Cotoneaster bacillaris Wall. ex Lindle.	Vegetative	0.209	1.155	0.1	3.308	0.245	0.643	0.22	0.213
	Reproductive	0.211	1.228	0.07	1.859	0.218	0.592	0.14	0.163
	Post-rep	0.216	1.247	0.07	3.108	0.245	0.535	0.18	0.222
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**
4.Grewia optiva Drum.ex.Burret.	Vegetative	0.216	1.347	0.11	6.027	0.232	0.933	0.49	0.411
	Reproductive	0.212	1.418	0.07	3.145	0.312	0.642	0.18	0.331
	Post-rep	0.221	1.425	0.09	8.874	0.3	0.606	0.3	0.597
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**
5.Morus indica L.	Vegetative	0.216	0.443	0.09	3.705	0.336	0.934	0.26	0.194
	Reproductive	0.215	0.437	0.1	7.213	0.327	0.858	0.31	0.346
	Post-rep	0.208	0.554	0.06	3.804	0.33	0.86	0.27	0.207
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**

6.Parrotiopsis jacquemontiana Dene.	Vegetative	0.21	1.289	0.1	4.866	0.265	0.683	0.16	0.226
	Reproductive	0.213	1.366	0.09	2.643	0.315	0.807	0.12	0.177
	Post-rep	0.219	1.372	0.08	4.167	0.243	0.733	0.19	0.196
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**
7.Prunus cornuta (Wall ex Royle) Steud.	Vegetative	0.203	0.696	0.06	4.334	0.175	0.932	0.12	0.247
	Reproductive	0.205	0.811	0.05	2.52	0.206	0.717	0.12	0.367
	Post-rep	0.204	0.822	0.05	2.824	0.176	0.48	0.13	0.297
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**
8.Quercus dilatata Lindley	Vegetative	0.222	0.296	0.1	2.111	0.312	0.987	0.24	0.678
	Reproductive	0.218	0.333	0.07	1.949	0.321	1.224	0.22	0.986
	Post-rep	0.212	0.463	0.07	2.45	0.326	0.844	0.17	1.302
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**
9.Quercus incana Roxb.	Vegetative	0.214	1.46	0.12	4.779	0.268	0.802	0.23	0.734
	Reproductive	0.218	1.547	0.06	2.051	0.287	0.638	0.15	0.871
	Post-rep	0.219	0.114	0.06	2.716	0.337	0.727	0.19	0.762
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**
10.Vibernum cotinifolium D. Don.	Vegetative	0.218	0.095	0.09	6.789	0.338	0.816	0.26	0.248
	Reproductive	0.218	0.198	0.08	2.652	0.325	0.717	0.16	0.28
	Post-rep	0.216	0.22	0.07	3.894	0.3	0.732	0.28	0.283
	Average	**0.217**	**0.171**	**0.080**	**4.445**	**0.321**	**0.755**	**0.233**	**0.270**

Nickel: Ni contents ranged from 0.109 ppm (vegetative stage of *Justicia*) to 0.184 ppm (vegetative stage of *Zizyphus*). Significant differences in Ni contents were found among the phenological stages while the difference among the various shrubs was insignificant (Appendix 32). Ni contents increased in *Indigofera* and *Justicia* but dropped in *Gymnosporia* with maturity. In the *Indigofera* Ni contents were 0.146 ppm, 0.148 ppm and 0.18 ppm while *Justicia* had 0.109 ppm, 0.117 ppm and 0.138 ppm in vegetative, reproductive and post-reproductive stages respectively. The vegetative, reproductive and post-reproductive stages in *Gymnosporia* had 0.174 ppm, 0.171 ppm and 0.157 ppm respectively. The reproductive stage (0.152 ppm) of *Berberis* had high Ni level than vegetative (0.129 ppm) and post-reproductive (0.13 ppm) stages. Similar trend regarding Ni level was observed in vegetative (0.121 ppm), reproductive (0.14 ppm) and post-reproductive (0.133 ppm) stages of *Debregeasia*. In *Dodonaea*, the reproductive stage (0.159 ppm) had low Ni contents than vegetative (0.162 ppm) and post-reproductive (0.168 ppm) stages. Similar trend was also observed at the reproductive stages of *Rosa* and *Zizyphus* regarding Ni contents (Table 29).

Lead: Pb contents ranged from 0.08 ppm (reproductive stage of *Justicia*) to 0.8 ppm (post-reproductive stage of *Zizyphus*). ANOVA revealed significant differences among the phenological stages but insignificant difference among the shrubs (Appendix 32). Pb contents decreased in *Debregeasia* and *Rosa* while increased in *Zizyphus* with maturity. The Pb contents in *Debregeasia* were 0.489 ppm, 0.245 ppm and 0.138 ppm while *Rosa* had 0.428 ppm, 0.409 ppm and 0.313 ppm in vegetative, reproductive and post-reproductive stages respectively. The Pb levels recorded for vegetative, reproductive and post-reproductive stages were 0.452 ppm, 0.571 ppm and 0.8 ppm respectively. In *Berberis*, the Pb contents in vegetative (0.583 ppm), reproductive (0.595 ppm) and post-reproductive (0.557 ppm) stages differed insignificantly. In *Dodonaea*, the reproductive stage (0.316 ppm) had low Pb concentration than vegetative (0.452 ppm) and reproductive (0.505 ppm) stages. The reproductive stages of *Gymnosporia* and *Indigofera* had significantly higher Pb levels than other two stages in both the forage shrubs. The vegetative and reproductive stages of *Justicia* had very low levels of Pb but it was significantly higher in the post-reproductive stage (0.3 ppm).

Zinc: Significant differences were found in Zn contents among the phenological stages while the differences among the various shrubs were insignificant (Appendix

32). Zn contents ranged from 0.082 ppm (post-reproductive stage of *Berberis*) to 0.371 ppm (post-reproductive stage of *Justicia*). In *Berberis*, Zn contents showed insignificant difference among vegetative (0.232 ppm) and reproductive (0.231 ppm) stages but it reduced significantly in post-reproductive (0.082 ppm) stage. Reproductive (ppm) stage of *Debregeasia* had low Zn level than vegetative (0.24 ppm) and post-reproductive (0.232 ppm) stages. In *Dodonaea*, no significant differences were recorded for vegetative (0.18 ppm) and reproductive (0.177 ppm) stages but Zn increased significantly in post-reproductive (0.274 ppm) stage. *Gymnosporia* had greater Zn contents in reproductive (0.336 ppm) stage than vegetative (0.302 ppm) and post-reproductive (0.263 ppm) stages. Zn contents reduced in *Indigofera* with maturity. *Justicia* had no significant differences among vegetative and reproductive stages that increased in post-reproductive (0.371 ppm) stage (Table 29). In *Rosa* and *Zizyphus*, the reproductive stages had low levels of Zn than vegetative and reproductive stages in both shrubs.

Manganese: Mn contents ranged from 0.077 ppm (post-reproductive stage of *Berberis*) to 0.432 ppm (post-reproductive stage of *Debregeasia* & vegetative stage of *Gymnosporia*). Mn contents were significantly different among the phenological stages but were insignificantly different among shrubs (Appendix 32). In *Berberis* and *Gymnosporia*, Mn contents reduced but it increased in *Justicia* with maturity. Mn contents in *Berberis* were 0.13 ppm, 0.122 ppm and 0.077 ppm while *Gymnosporia* had 0.432 ppm, 0.375 ppm and 0.241 ppm in vegetative, reproductive and post-reproductive stages, respectively. The vegetative, reproductive and post-reproductive stages of *Justicia* had 0.099 ppm, 0.141 ppm and 0.148 ppm respectively. The reproductive stage (0.265 ppm) of *Debregeasia* had low Mn level than the vegetative (0.361 ppm) and post-reproductive (0.432 ppm) stages. Similar trend regarding Mn contents were recorded for *Dodonaea* and *Rosa* species. In *Indigofera* post-reproductive (0.255 ppm) stage had significantly low Mn contents than vegetative (0.338 ppm) and reproductive (0.358 ppm) stages. *Zizyphus* showed no significant difference among vegetative (0.188 ppm) and reproductive (0.187 ppm) stages but it increased in post-reproductive (0.283ppm) stage (Table 29).

Table 29. Micro-minerals composition of some forage shrubs of Gadoon hills, District Swabi (at three penological stages).

Species	Phenological stage	Cd (ppm)	Cr (ppm)	Cu (ppm)	Fe (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	Mn (ppm)
1.Berberis lycium Royle.	Vegetative	0.212	0.725	0.06	2.989	0.129	0.583	0.232	0.13
	Reproductive	0.212	0.914	0.031	1.819	0.152	0.595	0.231	0.122
	Post-rep	0.211	0.707	0.123	6.747	0.13	0.557	0.082	0.077
	Average	**0.206**	**0.526**	**0.064**	**6.490**	**0.180**	**0.608**	**0.250**	**0.219**
2.Debregeasia salicifolia (D. Don) Rendle	Vegetative	0.209	0.512	0.058	5.444	0.121	0.489	0.24	0.361
	Reproductive	0.215	0.663	0.059	3.549	0.14	0.245	0.211	0.265
	Post-rep	0.217	0.62	0.073	3.852	0.133	0.138	0.232	0.432
	Average	**0.206**	**0.526**	**0.064**	**6.490**	**0.180**	**0.608**	**0.250**	**0.219**
3. Dodonaea viscosa (L.) Jacq.	Vegetative	0.213	0.006	0.076	10.41	0.162	0.452	0.18	0.233
	Reproductive	0.208	0.067	0.079	6.948	0.159	0.316	0.177	0.18
	Post-rep	0.209	0.234	0.05	2.873	0.168	0.505	0.274	0.198
	Average	**0.206**	**0.526**	**0.064**	**6.490**	**0.180**	**0.608**	**0.250**	**0.219**
4. Gymnosporia royleana Wall ex Lawson	Vegetative	0.212	0.287	0.062	6.12	0.174	0.523	0.302	0.432
	Reproductive	0.207	0.312	0.053	39	0.171	0.761	0.336	0.375
	Post-rep	0.205	0.447	0.053	2.442	0.157	0.455	0.263	0.241
	Average	**0.206**	**0.526**	**0.064**	**6.490**	**0.180**	**0.608**	**0.250**	**0.219**
5. Indigofera heterantha L.	Vegetative	0.214	0.892	0.068	6.579	0.146	0.474	0.283	0.338
	Reproductive	0.215	0.967	0.066	2.883	0.148	0.784	0.219	0.358
	Post-rep	0.211	0.196	0.054	2.124	0.18	0.526	0.18	0.255
	Average	**0.206**	**0.526**	**0.064**	**6.490**	**0.180**	**0.608**	**0.250**	**0.219**

6. Justicia adhatoda L.	Vegetative	0.205	0.293	0.067	2.503	0.109	0.093	0.313	0.099
	Reproductive	0.211	0.284	0.079	1.893	0.117	0.08	0.316	0.141
	Post-rep	0.212	0.369	0.069	5.408	0.138	0.3	0.371	0.148
	Average	**0.206**	**0.526**	**0.064**	**6.490**	**0.180**	**0.608**	**0.250**	**0.219**
7. Rosa moschata non J. Herrm.	Vegetative	0.212	0.135	0.074	6.339	0.156	0.428	0.225	0.247
	Reproductive	0.214	0.135	0.055	2.148	0.153	0.409	0.159	0.17
	Post-rep	0.212	0.01	0.05	2.735	0.163	0.313	0.17	0.216
	Average	**0.206**	**0.526**	**0.064**	**6.490**	**0.180**	**0.608**	**0.250**	**0.219**
8. Ziziphus nummularia (Burm. f.) Wight & Arn.	Vegetative	0.206	0.485	0.062	5.246	0.184	0.452	0.301	0.188
	Reproductive	0.208	0.493	0.069	7.849	0.176	0.571	0.182	0.187
	Post-rep	0.205	0.599	0.061	6.374	0.179	0.8	0.266	0.283
	Average	**0.206**	**0.526**	**0.064**	**6.490**	**0.180**	**0.608**	**0.250**	**0.219**

iii. Grasses

The micro-mineral contents including cadmium, chromium, copper, iron, nickel, lead, zinc and manganese of some analyzed grasses are given in Table 30.

Cadmium: Cadmium contents ranged from 0.12 ppm (post-reproductive stage of *Apluda*) to 0.203 ppm (reproductive stage of *Schoenoplectus*) among the grasses. Statistical analysis showed significant differences among the various phenological stages while insignificant differences among the various grasses (Appendix 33). *Pennisetum* and *Themeda* showed a slight increase among the three phenological stages while opposite trend was recorded for *Apluda*, *Aristida* and *Heteropogon* with advancing maturity (Table 30). The reproductive stage of *Chrysopogon* (0.171 ppm), *Digitaria* (0.199 ppm) and *Schoenoplectus* (0.203 ppm) had slightly higher Cd contents than the vegetative and post-reproductive stages.

Chromium: ANOVA revealed no significant differences in Cr contents among the different grasses but differences were significant among various phenological stages (Appendix 33). Chromium concentration ranged from 0.01 ppm (reproductive and post-reproductive stages of *Apluda*) to 0.356 ppm (post-reproductive stage of *Schoenoplectus*) in the investigated grasses (Table 30). In *Chrysopogon*, the Cr levels were 0.102 ppm, 0.101 ppm and 0.1 ppm for vegetative, reproductive and post-reproductive stages respectively, showing no significant differences. The Cr contents slightly increased in *Aristida* and *Schoenoplectus* while it decreased in *Pennisetum* and *Themeda* with advancing maturity. In *Apluda*, the Cr contents were 0.02 ppm, 0.01 ppm and 0.01 ppm for vegetative, reproductive and post-reproductive stages, respectively. These values were the lowest among all the analyzed grasses. The reproductive (0.141 ppm) and post-reproductive (0.14 ppm) stages of *Digitaria* had similar Cr value with lowest at vegetative (0.121 ppm) stage. The reproductive (0.218 ppm) stage of *Heteropogon* had higher Cr levels than vegetative (0.185 ppm) and post-reproductive (0.179 ppm) stages (Table 30).

Copper: Insignificant differences in copper contents were recorded among the different grasses. It ranged from 0.025 ppm (post-reproductive stage of *Aristida*) to 0.067 ppm (vegetative stage of *Apluda*). Phenological stages revealed significant differences through ANOVA (Appendix 33). A slight and gradual decline was recorded in Cu contents in *Apluda*, *Digitaria* and *Pennisetum* with advancing

maturity. The reproductive stage of *Aristida* (0.038 ppm) and *Themeda* (0.039 ppm) had higher Cu levels compared with vegetative and post-reproductive stages. Cu levels increased in *Chrysopogon* and *Heteropogon* with advancing maturity. The reproductive (0.037 ppm) stage of had low Cu contents than vegetative (0.04 ppm) and post-reproductive (0.042 ppm) stages (Table 30).

Iron: In *Apluda* and *Pennisetum* Fe contents decreased while in *Digitaria*, *Heteropogon* and *Schoenoplectus* it increased with advancing maturity (Table 30). Fe contents ranged from 1.587 ppm (vegetative stage of *Schoenoplectus*) to 11.31 ppm (vegetative stage of *Themeda*). Significant differences in Fe contents were recorded among the different grasses and among the different phenological stages (Appendix 33). The reproductive stage of *Aristida* (2.165 ppm) and *Chrysopogon* (2.165 ppm) had higher Fe levels compared to their vegetative and post-reproductive stages (Table 30). The vegetative (11.31 ppm) and reproductive (11.3 ppm) stages of *Themeda* had similar Fe concentrations but it turned down to 9.87 ppm in post-reproductive stage (Table 30).

Nickel: Ni contents varied from 0.078 ppm (reproductive stage of *Apluda*) to 0.186 ppm (post-reproductive stage of *Digitaria*). Significant differences in Ni contents were found among the phenological stages and among the various grasses (Appendix 33). It decreased in *Chrysopogon* and *Heteropogon* while in *Digitaria* and *Schoenoplectus* it increased with advancing maturity. The reproductive stage of *Aristida* (0.128 ppm), *Pennisetum* (0.116 ppm) and *Themeda* (0.107 ppm) had high Ni level than vegetative and post-reproductive stages. The vegetative (0.105 ppm) stage of *Apluda* had high Ni concentration than reproductive (0.078 ppm) and post-reproductive (0.079 ppm) stages (Table 30).

Lead: Pb contents increased in *Aristida*, *Chrysopogon*, *Pennisetum* and *Themeda* with advancing maturity (Table 30). Pb contents ranged from 0.158 ppm (vegetative stage of *Aristida*) to 0.502 ppm (reproductive stage of *Schoenoplectus*). Statistical analysis revealed insignificant differences in Pb concentrations among the phenological stages and among the grasses (Appendix 33). In *Apluda*, the reproductive (0.23 ppm) and post-reproductive (0.23 ppm) stages had similar Pb concentrations but it went slightly low at vegetative (0.2 ppm) stage. The reproductive stages of *Digitaria* (0.325 ppm),

Heteropogon (0.399 ppm) and *Schoenoplectus* (0.502 ppm) had greater Pb contents compared with their vegetative and post-reproductive stages (Table 30).

Zinc: Zn contents ranged from 0.09 ppm (vegetative stage of *Heteropogon*) to 1.224 ppm (post-reproductive stage of *Apluda*) (Table 30). Insignificant differences were recorded in Zn contents among the various grass species through ANOVA (Appendix 33). Phenological stages showed significant differences through statistics. Zn contents increased in *Apluda, Chrysopogon* and *Schoenoplectus* while decreased in *Aristida, Digitaria* and *Pennisetum* with advancing maturity. The reproductive (0.1 ppm) and post-reproductive (0.1 ppm) stages of *Heteropogon* had similar Zn levels but it was low in the vegetative (0.09 ppm) stage (Table 30). The vegetative (0.38 ppm) and reproductive (0.385 ppm) stages of *Themeda* had insignificant differences regarding Zn levels but it went low in the post-reproductive (0.269 ppm) stage.

Manganese: Mn contents fluctuated from 0.079 ppm (post-reproductive stage of *Schoenoplectus*) to 0.249 ppm (reproductive stage of *Pennisetum*). There were significant differences among the phenological stages but difference among the different grasses were insignificant (Appendix 33). The differences were insignificant in *Apluda* at reproductive (0.192 ppm) and post-reproductive (0.19 ppm) stages but vegetative (0.185 ppm) stage differed significantly. In *Aristida* and *Chrysopogon* Mn quantity increased while it decreased in *Digitaria* and *Schoenoplectus* with advancing maturity. The reproductive (0.249 ppm) stage of *Pennisetum* had higher Mn contents compared with vegetative (0.196 ppm) and post-reproductive (0.236 ppm) stages. In *Themeda,* inconsistent trend was observed in Mn concentration. In *Heteropogon* Mn contents were 0.1 ppm, 0.1 ppm and 0.11 ppm for vegetative, reproductive and post reproductive stages, showing no significant difference (Table 30).

Table 30. Micro-minerals composition of some forage grasses of Gadoon hills, District Swabi at three phenological stages.

Species	Phenological stage	Cd (ppm)	Cr (ppm)	Cu (ppm)	Fe (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	Mn (ppm)
1.Apluda mutica L.	Vegetative	0.15	0.02	0.067	2.283	0.105	0.2	1.212	0.185
	Reproductive	0.13	0.01	0.064	2.197	0.078	0.23	1.231	0.192
	Post-rep	0.12	0.01	0.059	2.187	0.079	0.23	1.224	0.19
	Average	**0.150**	**0.272**	**0.036**	**10.827**	**0.096**	**0.423**	**0.345**	**0.205**
2.Aristida adscensionis L.	Vegetative	0.189	0.035	0.034	2.141	0.124	0.158	0.231	0.089
	Reproductive	0.183	0.044	0.038	2.165	0.128	0.164	0.221	0.098
	Post-rep	0.148	0.046	0.025	2.142	0.1	0.21	0.215	0.112
	Average	**0.150**	**0.272**	**0.036**	**10.827**	**0.096**	**0.423**	**0.345**	**0.205**
3.Chrysopogon aucheri (Boiss.) Stapf	Vegetative	0.152	0.102	0.029	2.139	0.121	0.284	0.291	0.099
	Reproductive	0.171	0.101	0.033	2.165	0.115	0.297	0.297	0.102
	Post-rep	0.141	0.1	0.035	2.151	0.108	0.326	0.315	0.119
	Average	**0.150**	**0.272**	**0.036**	**10.827**	**0.096**	**0.423**	**0.345**	**0.205**
4.Digitaria sanguinalis (L.) Scop.	Vegetative	0.169	0.121	0.038	1.811	0.1	0.298	0.283	0.101
	Reproductive	0.199	0.141	0.034	1.827	0.115	0.325	0.255	0.098
	Post-rep	0.134	0.14	0.032	1.951	0.186	0.312	0.242	0.091
	Average	**0.150**	**0.272**	**0.036**	**10.827**	**0.096**	**0.423**	**0.345**	**0.205**
5.Heteropogon contortus (L.) P. Beauv.	Vegetative	0.158	0.185	0.029	1.963	0.126	0.319	0.09	0.1
	Reproductive	0.144	0.218	0.03	1.965	0.102	0.399	0.1	0.1
	Post-rep	0.124	0.179	0.034	2.148	0.099	0.373	0.1	0.11
	Average	**0.150**	**0.272**	**0.036**	**10.827**	**0.096**	**0.423**	**0.345**	**0.205**

6.Pennisetum orientale L. C. Rich.	Reproductive	0.194	0.077	0.047	2.293	0.116	0.461	0.231	0.249
	Post-rep	0.199	0.049	0.039	2.286	0.11	0.472	0.218	0.236
	Average	**0.150**	**0.272**	**0.036**	**10.827**	**0.096**	**0.423**	**0.345**	**0.205**
7.Schoenoplectus litoralis Schrad.	Vegetative	0.187	0.229	0.04	1.587	0.103	0.484	0.184	0.108
	Reproductive	0.203	0.353	0.037	1.969	0.107	0.502	0.192	0.094
	Post-rep	0.169	0.356	0.042	2.1	0.118	0.497	0.179	0.079
	Average	**0.150**	**0.272**	**0.036**	**10.827**	**0.096**	**0.423**	**0.345**	**0.205**
8.Themeda anathera (Nees) Hack.	Vegetative	0.125	0.3	0.037	11.31	0.089	0.382	0.38	0.194
	Reproductive	0.159	0.269	0.039	11.3	0.107	0.392	0.385	0.184
	Post-rep	0.166	0.248	0.031	9.87	0.092	0.496	0.269	0.236
	Average	**0.150**	**0.272**	**0.036**	**10.827**	**0.096**	**0.423**	**0.345**	**0.205**

Nutritional analysis of Some Key Palatable Species

Trees

Proximate composition

The results of proximate analysis (Table 31) are given below.

Dry Matter (DM %)

Insignificant differences in dry matter contents were observed among the analyzed tree leaves and among the different phenological stages. It ranged from 91.11% (vegetative stage of *Grewia*) to 95.21% (post-reproductive stage of *Quercus dilatata*). In *Celtis*, *Q. dilatata* and *Q. incana* DM increased while declination was recorded in *Cotoneaster*, *Parrotiopsis*, *Prunus* and *Vibernum* with advancing maturity (Table 31). *Acacia* (93.18%), *Grewia* (91.11%) and *Morus* (91.86%) had low concentration of dry matter in their reproductive stages compared with other growth stages.

Ash contents (Total minerals)

Ash contents (total mineral) in tree leaves ranged from 3.80% (reproductive stage of *Q. dilatata*) to 23.32% (reproductive stage of *Celtis*) (Table 31). ANOVA showed insignificant differences in ash contents among the different trees species. Phenological stages had significant differences. Total minerals in *Cotoneaster* and *Prunus* increased with advancing growth stages. The remaining species had inconsistent trend in ash contents. The post-reproductive stage of *Acacia* (6.30%), *Grewia* (10.68%), *Parrotiopsis* (6.68%), *Q. dilatata* (3.80%), *Q. incana* (4.29%) and *Vibernum* (6.95%) had low ash values compared with other phenological stages. The reproductive stage of *Celtis* and *Morus* had higher ash levels than other growth stages.

Crude fiber (CF %)

Crude fiber contents increased in *Celtis*, *Morus* and *Q. incana* with maturity (Table 31). Insignificant differences were recorded in CF contents among the tree leaves but the differences were significant among the various phenological stages. Crude fiber contents among the tree species ranged from 7.45% (vegetative stage of *Morus*) to 34.73% (post-reproductive stage of *Q. incana*) (Table 31). *Acacia*, *Cotoneaster* and *Vibernum* showed decline in crude fiber values with advancing age. In *Grewia*, the reproductive (27.93%) stage had significantly higher crude fiber contents than the vegetative (9.24%) and post-reproductive (11.88%) stages. The vegetative (21.69%) and post-reproductive (21.21%) stages of *Parrotiopsis* had no

significant differences in crude fiber values but it was higher in the reproductive (23.08%) stage. In *Prunus* the crude fiber levels were 26.37%, 17.85% and 20.24% in vegetative, reproductive and post-reproductive stages respectively. The reproductive (34.01%) stage of *Q. dilatata* had high crude fiber than the vegetative (26.74%) and post-reproductive (31.96%) stage. There was significant difference in the crude fiber values among the phenological stages of *Q. dilatata.*

4. **Ether extract or Crude fat (EE %)**

Ether extract contents ranged from 0.54% (vegetative stage of *Grewia*) to 31.06% (vegetative stage of *Q. dilatata*) in the tree species (Table 31). ANOVA revealed significant differences in EE% contents among the different tree leaves and among the various phenological stages. In *Celtis*, *Parrotiopsis* and *Q. dilatata* EE values went down with advancing maturity. The vegetative (7.46%) and reproductive (5.36%) stages of *Acacia* had significant differences in ether extract values but it was significantly high in the post-reproductive (30.92%) stage. In *Cotoneaster*, The vegetative (23.17%) and post-reproductive (22.57%) stages had no significant difference in crude fat but it was very low in reproductive (7.49%) stage. Ether extract in the reproductive stage of *Grewia* and *Prunus* had higher concentrations compared with other phenological stages. In *Morus*, the vegetative (21.32%) stage had high crude fat contents than reproductive (6.53%) and post-reproductive (8.52%) stages. In *Q. incana*, ether extracts in vegetative (6.35%) and post-reproductive (6.32%) stages were similar but it was significantly higher in the reproductive (14.83%) stage. Crude fats in *Vibernum* were 4.54%, 1.07% and 10.74% for vegetative, reproductive and post-reproductive stages respectively.

5. **Crude Protein (CP %)**

Crude protein contents in *Celtis, Cotoneaster, Grewia, Parrotiopsis, Q. dilatata* and *Q. incana* decreased with advancing growth stages (Table 31). The vegetative (15.76%) and reproductive (16.07%) stages of *Prunus* had insignificant differences in CP levels but it decreased at post-reproductive (11.58%) stage. Crude protein levels ranged from 5.77% (post-reproductive stage of *Q. incana*) to 26.58% (reproductive stage of *Morus*) among tree species. The differences in crude protein contents were insignificant among tree leaves and among the different phenological stages. In *Acacia*, crude protein levels in vegetative (17.07%) and post-reproductive (17.62%) stages were similar but it decreased in reproductive (15.78%) stage. The

reproductive stages of *Morus* (26.58%) and *Vibernum* (9.24%) had high crude protein values compared with other phenological stages (Table 31).

6. **Moisture contents**

Moisture contents enhanced in *Cotoneaster, Parrotiopsis, Prunus* and *Vibernum* while it declined in *Celtis* and *Q. dilatata* with advancing maturity (Table 31). The vegetative (5.9%) and reproductive (5.9%) stages of *Q. incana* had similar moisture contents but it dropped down in post-reproductive (5.1%) stage. ANOVA indicated insignificant differences in moisture contents among the different tree species and significant difference among the various phenological stages. Moisture contents ranged from 4.8% (post-reproductive stage of *Q. dilatata*) to 8.9% (reproductive stage of *Grewia*) among the trees. The vegetative (6.2%) and post-reproductive (6.3%) stages of *Acacia* had no significant difference in moisture contents but it slightly increased in reproductive (6.8%) stage. In *Grewia*, moisture levels were 8.2%, 8.9% and 7.4% in vegetative, reproductive and post-reproductive stages respectively. The vegetative and post-reproductive stages of *Morus* had similar moisture contents (6.1%) but it significantly increased in reproductive (8.1%) stage.

7. **Organic matter (OM %)**

Organic matter declined in *Cotoneaster, Parrotiopsis* and *Prunus* while increased in *Q. dilatata* with advancing maturity. ANOVA revealed insignificant differences in organic matter contents among the various tree species (Table 31). Phenological stages showed significant differences. Organic matter contents ranged from 68.64% (reproductive stage of *Celtis*) to 90.44% (post-reproductive stage of *Q. dilatata*) in the investigated tree leaves (Table 4). In *Acacia* insignificant differences in OM occurred in vegetative (85.92%) and reproductive (86.88%) stages but it decreased in post-reproductive (83.31%) stage. The reproductive stages of *Celtis* (68.64%) and *Morus* (76.31%) had significantly low organic matter contents than other phenological stages. *Grewia, Q. incana* and *Vibernum* showed insignificant difference among the various growth stages (Table 31).

8. **Nitrogen free extracts (NFE %)**

Nitrogen free extract levels dwindled in *Celtis, Parrotiopsis, Prunus* and *Q. dilatata* with advancing maturity. Significant differences were recorded in NFE contents among the different tree species and among the various phenological stages. The NFE levels in the analyzed tree species ranged from 42.64% (reproductive stage of *Cotoneaster*) to 85.13% (vegetative stage of *Q. dilatata*) (Table 31). Nitrogen free

extract in vegetative (63.64%) and reproductive (58.39%) stages of *Acacia* had significant differences but it became high in the post-reproductive (84.41%) stage. The reproductive stages of *Cotoneaster* (42.64%) and *Vibernum* (42.68%) had low NFE values than other growth stages. Significantly higher NFE value was observed in the reproductive stage of *Grewia*. Vegetative (43.07%) and post-reproductive (45.09%) stages of *Grewia* had no significant differences. In *Morus*, the post-reproductive (61.86%) stage had significantly low NFE levels. The other growth stages had no significant differences. Nitrogen free extracts in *Q. incana* were 59.68%, 67.85% and 61.59% for vegetative, reproductive and post-reproductive stages respectively.

9. Carbohydrates

The carbohydrate contents increased with advancing maturity in *Celtis*, *Morus* and *Q. dilatata*. Carbohydrate levels ranged from 33.17% (vegetative stage of *Celtis*) to 76.05% (reproductive stage of *Vibernum*) in the investigated tree leaves (Table 31). The differences were insignificant among the tree species and significant among the various phenological stages. In *Acacia*, the vegetative (61.39%) and reproductive (65.74%) stages had insignificant differences in carbohydrate contents but significant decrease occurred in the post-reproductive (34.78%) stage. Reproductive (65.92%) stage of *Cotoneaster* had significantly higher carbohydrate value compared with other growth stages. while in *Grewia* the same phenological stage had significantly low contents than other stages. In *Parrotiopsis*, the reproductive (74.06%) and post-reproductive (73.28%) stages had insignificant differences in carbohydrate concentration but it was slightly low in vegetative (68.41%) stage. Carbohydrate value in the reproductive stage of *Prunus* (59.52%) and *Q. incana* (64.46%) was significantly low than other phenological stages. The post-reproductive (63.92%) stage of *Vibernum* had low carbohydrate contents compared with its other growth stages.

10. Total digestible nutrient (TDN %)

Total digestible nutrients in *Celtis*, *Parrotiopsis*, *Prunus*, *Q. dilatata* and *Q. incana* decreased with advancing age. It ranged from 36.97% (post-reproductive stage of *Grewia*) to 149.04% (vegetative stage of *Q. incana*) in the analyzed trees (Table 5). Total digestible nutrients varied significantly among the tree leaves and among the phenological stages. Significantly higher TDN contents were recorded in the post-reproductive stage of *Acacia* compared with other phenological stages. The

reproductive stages of *Cotoneaster* (50.36%) and *Vibernum* (49.90%) had low TDN values than other growth stages. Total digestible nutrients in the reproductive (84.37%) stage of *Grewia* were significantly higher than other phenological stages. In *Morus*, TDN levels were similar in vegetative (84.18%) and reproductive (85.75%) stage but it decline in post-reproductive (73.43%) stage.

11. Gross energy (GE)

Gross energy decreased in *Celtis, Morus, Parrotiopsis, Q. dilatata* and *Q. incana* with advancing maturity among the tree species. Gross energy ranged from 257.89 Kcal/g (post-reproductive stage of *Grewia*) to 1073.28 Kcal/g (vegetative stage of *Q. incana*) among the trees (Table 32). Significant differences in GE occurred among the trees and among the phenological stages. The post-reproductive (826.57 Kcal/g) stage of *Acacia* had significantly higher gross energy compared with its other growth stages. In *Cotoneaster* (358.99 Kcal/g) and *Vibernum* (324.74 Kcal/g), the GE was significantly low at reproductive stage than other phenological stages. Significantly higher GE was recorded in the reproductive (593.08 Kcal/g) stage of *Grewia* compared with other stages. Gross energy in vegetative (469.91 Kcal/g) and reproductive (474.07 Kcal/g) stages of *Prunus* had no significant difference but it significantly declined in post-reproductive (387.09 Kcal/g) stage.

12. Digestible energy (DE)

Digestible energy ranged from 1.63 Mcal/Kg (post-reproductive stage of *Grewia*) to 6.57 Mcal/Kg (vegetative stage of *Q. incana*) among the analyzed tree species (Table 32). In *Celtis, Parrotiopsis, Prunus, Q. dilatata* and *Q. incana* digestible energy decreased with maturity. The differences were significant in DE among the tree species and among the various phenological stages. *Cotoneaster* (2.22 Mcal/Kg) and *Vibernum* (2.20 Mcal/Kg) had least DE at reproductive stage than other phenological stages. In *Acacia*, the post-reproductive (4.50 Mcal/Kg) stage had significantly higher digestible energy compared to its other phenological stages. The reproductive (3.72 Mcal/Kg) stage of *Grewia* had significantly higher digestible energy than its other stages. In *Morus*, the vegetative (3.71 Mcal/Kg) and reproductive (3.78 Mcal/Kg) stages had similar digestible energy but it slightly declined in the post reproductive (3.24 Mcal/Kg) stage.

Table 31. Proximate composition of some fodder tree species of Gadoon Hills, District Swabi.

Species	Phenological stage	DM %	OM %	Moisture %	CF %	EE %	CP %	Ash %	NFE %	Carbohydrate %
1.Acacia catechu (L.f.) Willd.	Vegetative	93.76	85.92	6.24	25.03	7.46	17.07	7.83	63.64	61.39
	Reproductive	93.18	86.88	6.82	24.13	5.36	15.78	6.3	58.39	65.74
	Post-rep	93.71	83.31	6.29	19.19	30.92	17.62	10.39	84.41	34.78
	Average	**93.55**	**85.37**	**6.45**	**22.78**	**14.58**	**16.82**	**8.17**	**68.81**	**53.97**
2.Celtis australis L.	Vegetative	91.55	73.49	8.45	13.64	15.29	25.03	18.07	80.47	33.17
	Reproductive	91.95	68.64	8.05	15.22	10.85	21.12	23.32	78.55	36.67
	Post-rep	92.35	74.39	7.65	17.84	3.25	15.5	17.97	62.19	55.65
	Average	**91.95**	**72.17**	**8.05**	**15.57**	**9.80**	**20.55**	**19.79**	**73.74**	**41.83**
3.Cotoneaster bacillaris Wall. ex Lindle.	Vegetative	94.86	88.06	5.14	20.03	23.17	16.12	6.79	71.26	48.77
	Reproductive	93.36	86.52	6.64	8.56	7.49	13.11	6.84	42.64	65.92
	Post-rep	93.06	85.13	6.94	7.52	22.57	11.8	7.94	56.75	50.77
	Average	**93.76**	**86.57**	**6.24**	**12.04**	**17.74**	**13.68**	**7.19**	**56.88**	**55.15**
4.Grewia optiva Drum.ex.Burret.	Vegetative	91.85	80.16	8.15	9.24	0.54	13.45	11.69	43.07	66.17
	Reproductive	91.11	80.43	8.89	27.93	10.28	13.21	10.68	70.99	56.94
	Post-rep	92.55	78.95	7.45	11.88	1.08	11.08	13.61	45.09	66.79
	Average	**91.84**	**79.85**	**8.16**	**16.35**	**3.97**	**12.58**	**11.99**	**53.05**	**63.30**
5.Morus indica L.	Vegetative	93.92	79.69	6.08	7.45	21.32	21.03	14.23	70.11	37.34
	Reproductive	91.86	76.31	8.14	15.23	6.53	26.58	15.55	72.03	43.19
	Post-rep	93.85	80.59	6.15	15.44	8.52	18.5	13.26	61.86	53.58
	Average	**93.21**	**78.86**	**6.79**	**12.71**	**12.12**	**22.04**	**14.35**	**68.00**	**44.70**

6.Parrotiopsis jacquemontiana Dcne.	Vegetative	94.46	87.16	5.54	21.69	5.29	13.46	7.3	53.29	68.41
	Reproductive	93.13	86.44	6.87	23.08	1.83	10.56	6.68	49.02	74.06
	Post-rep	91.88	83.26	8.12	21.21	0.76	9.21	8.62	47.93	73.28
	Average	**93.16**	**85.62**	**6.84**	**21.99**	**2.63**	**11.08**	**7.53**	**50.08**	**71.92**
7.Prunus cornuta (Wall ex Royle) Steud.	Vegetative	92.92	83.92	7.08	26.37	1.4	15.76	9.01	59.61	66.76
	Reproductive	92.33	82.07	7.67	17.85	6.48	16.07	10.25	58.33	59.52
	Post-rep	91.33	78.46	8.67	20.24	0.66	11.58	12.88	54.02	66.22
	Average	**92.19**	**81.48**	**7.81**	**21.49**	**2.85**	**14.47**	**10.71**	**57.32**	**64.17**
8.Quercus dilatata Lindley	Vegetative	93.27	85.57	6.73	26.74	31.06	12.91	7.7	85.13	41.6
	Reproductive	94	90.2	6	34.01	8.51	11.53	3.8	63.85	70.16
	Post-rep	95.21	90.44	4.79	31.96	7.32	8.67	4.77	57.5	74.45
	Average	**94.16**	**88.74**	**5.84**	**30.90**	**15.63**	**11.04**	**5.42**	**68.83**	**62.07**
9.Quercus incana Roxb.	Vegetative	94.09	87.8	5.91	29.3	6.35	11.83	6.29	59.68	69.62
	Reproductive	94.12	89.83	5.88	32.31	14.83	10.54	4.29	67.85	64.46
	Post-rep	94.92	85.23	5.08	34.73	6.32	5.77	9.7	61.59	73.14
	Average	**94.38**	**87.62**	**5.62**	**32.11**	**9.17**	**9.38**	**6.76**	**63.04**	**69.07**
10.Vibernum cotinifolium D. Don.	Vegetative	94.42	86.34	5.58	26.97	4.54	7.65	8.08	52.82	74.15
	Reproductive	93.31	86.36	6.69	18.74	1.07	9.24	6.95	42.68	76.05
	Post-rep	91.97	83.12	8.03	17.93	10.74	8.46	8.84	54.01	63.92
	Average	**93.23**	**85.27**	**6.77**	**21.21**	**5.45**	**8.45**	**7.96**	**49.84**	**71.37**

Key: DM: Dry matter, OM: Organic matter, CF: Crude fiber, EE: Ether extract, CP: Crude protein, NFE: Nitrogen free extract.

13. Metabolized energy (ME %)

Metabolized energy varied significantly among the tree species and among the different phenological stages. Metabolized energy fluctuated from 2.10 Mcal/Kg (post-reproductive stage of *Grewia*) to 7.09 Mcal/Kg (vegetative stage of *Q. incana*) within the tree species (Table 32). ME decreased with advancing age in *Celtis, Parrotiopsis, Prunus, Q. dilatata* and *Q. incana*. *Cotoneaster* (2.69 Mcal/Kg) and *Vibernum* (2.67 Mcal/Kg) had low levels of ME at reproductive stages than other phenological stages. The post-reproductive (5.00 Mcal/Kg) stage of *Acacia* had significantly higher ME than its other phenological stages. The reproductive (4.21 Mcal/Kg) stage of *Grewia* had significantly higher ME than other stages. The vegetative (4.20 Mcal/Kg) and reproductive (4.27 Mcal/Kg) stages of *Morus* had insignificant differences but it significantly went down in post-reproductive (3.72 Mcal/Kg) stage.

II. Cell wall constituents

The results of cell wall constituents (Table 33) are narrated below.

1. Neutral detergent fiber (NDF)

NDF levels swayed from 29.51% (vegetative stage of *Celtis*) to 114.50% (reproductive stage of *Q. incana*) among the leaves of trees (Table 33). NDF values among all the investigated tree species decreased in *Grewia* while increased in *Celtis* with maturity. Insignificant differences were recorded in NDF contents among the different analyzed tree species through ANOVA and significant differences among the various phenological stages. The NDF contents in vegetative (38.98%) and post-reproductive (38.54%) stages of *Acacia* had insignificant difference but it was high in reproductive stage (46.52%) stage. The vegetative (41.48%) and post-reproductive (41.56%) stages of *Cotoneaster* had similar NDF values but it was low in reproductive (34.07%) stage. In *Morus*, the different growth stages showed insignificant differences in NDF concentrations. NDF levels in *Parrotiopsis* were 40.52%, 47.57% and 45.59% for vegetative, reproductive and post-reproductive stages respectively. The vegetative (62.53%) and reproductive (61.00%) stages in *Q. dilatata* showed insignificant difference in NDF contents but it significantly increased in post-reproductive (71.57%) stage. The reproductive stage of *Q. dilatata* and *Vibernum* had significantly higher NDF levels than other phenological stages. *Prunus* showed low NDF contents in vegetative (36.11%) stage. The other growth stages had no significant difference (Table 33).

Table 32. Different types of energies available to livestock in forage tree species of Gadoon Hills, District Swabi.

Species	Phenological stage	GE (Kcal/g)	TDN %	DE (Mcal/Kg)	ME (Mcal/Kg)
1.Acacia catechu (L.f.) Willd.	Vegetative	544.85	75.57	3.33	3.82
	Reproductive	492.1	69.12	3.05	3.53
	Post-rep	826.57	102.08	4.5	5
	Average	**621.17**	**82.26**	**3.63**	**4.12**
2.Celtis australis L.	Vegetative	678.07	96.39	4.25	4.74
	Reproductive	613.36	93.57	4.13	4.62
	Post-rep	455.57	73.3	3.23	3.71
	Average	**582.33**	**87.75**	**3.87**	**4.36**
3.Cotoneaster bacillaris Wall. ex Lindle.	Vegetative	695.43	85.7	3.78	4.27
	Reproductive	358.99	50.36	2.22	2.69
	Post-rep	546.57	68	3	3.48
	Average	**533.66**	**68.02**	**3.00**	**3.48**
4.Grewia optiva Drum.ex.Burret.	Vegetative	299.93	50.34	2.22	2.69
	Reproductive	593.08	84.37	3.72	4.21
	Post-rep	257.89	36.97	1.63	2.1
	Average	**383.63**	**57.23**	**2.52**	**3.00**
5.Morus indica L.	Vegetative	641.04	84.18	3.71	4.2
	Reproductive	577.34	85.75	3.78	4.27
	Post-rep	509.97	73.43	3.24	3.72
	Average	**576.12**	**81.12**	**3.58**	**4.06**
6.Parrotiopsis jacquemontiana Dcne.	Vegetative	445.9	62.94	2.77	3.25
	Reproductive	385.81	57.53	2.54	3.01
	Post-rep	354.69	56.06	2.47	2.95
	Average	**395.47**	**58.84**	**2.59**	**3.07**
7.Prunus cornuta (Wall ex Royle) Steud.	Vegetative	469.91	70.28	3.1	3.58
	Reproductive	474.07	69.02	3.04	3.52
	Post-rep	387.09	63.3	2.79	3.27
	Average	**443.69**	**67.53**	**2.98**	**3.46**
8.Quercus dilatata Lindley	Vegetative	840.09	102.87	4.54	5.03
	Reproductive	567.04	75.8	3.34	3.83
	Post-rep	503.89	68.02	3	3.48
	Average	**637.01**	**82.23**	**3.63**	**4.11**
9.Quercus incana Roxb.	Vegetative	1073.28	149.04	6.57	7.09
	Reproductive	629.37	80.95	3.57	4.05
	Post-rep	507.6	72.67	3.2	3.69
	Average	**736.75**	**100.89**	**4.45**	**4.94**
10.Vibernum cotinifolium D. Don.	Vegetative	428.91	62.13	2.74	3.22
	Reproductive	324.74	49.9	2.2	2.67
	Post-rep	453.99	63.88	2.82	3.29
	Average	**402.55**	**58.64**	**2.59**	**3.06**

2. **Acid detergent fiber (ADF)**

ADF levels of *Celtis* and *Morus* increased while it decreased in *Grewia* with advancing maturity. ADF concentrations ranged from 16.51% (vegetative stage of *Celtis*) to 100.00% (reproductive stage of *Q. incana*) in the investigated tree leaves (Table 33). Insignificant differences in ADF contents were achieved among the leaves of trees. Phenological stages exhibited significant differences in ADF contents. The reproductive stage of *Acacia* (34.52%) and *Q. incana* (100.00%) had high ADF values than other growth stages. *Cotoneaster* showed the opposite trend in ADF contents at reproductive stage. In *Parrotiopsis*, the reproductive (31.55%) and post-reproductive (30.56%) stages had similar ADF concentration but went down at the vegetative (26.51%) stage. *Prunus* and *Q. dilatata* showed no significant differences among the investigated phenological stages. The vegetative (28.01%) and reproductive (29.51%) stages of *Vibernum* had insignificant difference in ADF concentrations but it significantly declined post-reproductive (23.52%) stage.

3. **Acid detergent lignin (ADL %)**

Significant decreased ADL contents were observed in *Morus*, *Parrotiopsis* and *Prunus* with advancing age. *Q. dilatata* and *Vibernum* displayed increased ADL with advancing maturity. ADL concentrations ranged from 0.50% (vegetative stage of *Vibernum*) to 32.50% (reproductive stage of *Q. incana*) in the analyzed tree species (Table 33). ANOVA revealed significant differences in ADL contents among the different tree leaves and among the various phenological stages. The reproductive and post-reproductive stages of *Acacia*, *Celtis* and *Grewia* had insignificant differences in ADL values among themselves but these contents were very low at vegetative stages. The ADL concentrations in the vegetative stage of *Acacia*, *Celtis* and *Grewia* were 13.49%, 2.00% and 8.02% respectively. In *Cotoneaster*, the lignin contents were very high in the reproductive (7.01%) stage compared with vegetative (4.50%) and post-reproductive (3.51%) stages. Highly significant differences in ADL values were obvious among the analyzed growth stages of *Q. incana*. The ADL values in the leaves of *Q. incana* were 2.50%, 32.50% and 19.53% for vegetative, reproductive and post-reproductive stages respectively.

Table 33. Cell wall constituents of some forage trees of Gadoon Hills, District Swabi.

Species	Phenological stage	NDF %	ADF %	Lignin %	Hemi-cellulose %	Cellulose %
1.Acacia catechu (L.f.) Willd.	Vegetative	38.98	26.99	13.49	11.99	12.49
	Reproductive	46.52	34.52	17.51	12.01	16.01
	Post-rep	38.54	24.52	16.52	14.01	7.01
	Average	41.35	28.68	15.84	12.67	11.84
2.Celtis australis L.	Vegetative	29.51	16.51	2	13.01	12.51
	Reproductive	35.52	19.01	7	16.51	8.5
	Post-rep	36.07	21.04	6.51	15.03	12.02
	Average	33.70	18.85	5.17	14.85	11.01
3.Cotoneaster bacillaris Wall. ex Lindle.	Vegetative	41.48	27.99	4.5	13.49	22.49
	Reproductive	34.07	23.05	7.01	11.02	15.03
	Post-rep	41.56	28.04	3.51	13.52	20.03
	Average	39.04	26.36	5.01	12.68	19.18
4.Grewia optiva Drum.ex.Burret.	Vegetative	67.7	35.11	8.02	32.6	25.58
	Reproductive	52.5	30.5	16.5	22	13.5
	Post-rep	42.56	22.53	16.02	20.03	5.51
	Average	54.25	29.38	13.51	24.88	14.86
5.Morus indica L.	Vegetative	31	17.5	6.5	13.5	10
	Reproductive	32.5	20	4	12.5	15
	Post-rep	30.5	20.5	2.5	10	16.5
	Average	31.33	19.33	4.33	12.00	13.83
6.Parrotiopsis jacquemontiana Dcne.	Vegetative	40.52	26.51	13.01	14.01	12.01
	Reproductive	47.57	31.55	12.02	16.02	16.52
	Post-rep	45.59	30.56	2	15.03	27.05
	Average	44.56	29.54	9.01	15.02	18.53
7.Prunus cornuta (Wall ex Royle) Steud.	Vegetative	36.11	24.07	11.53	12.04	11.53
	Reproductive	41	23.5	3.5	17.5	19.5
	Post-rep	40.5	24.5	3.5	16	20
	Average	39.20	24.02	6.18	15.18	17.01
8.Quercus dilatata Lindley	Vegetative	62.53	49.02	3	13.51	40.52
	Reproductive	61	49.5	4	11.5	43.5
	Post-rep	71.57	47.05	9.51	24.52	35.54
	Average	65.03	48.52	5.50	16.51	39.85
9.Quercus incana Roxb.	Vegetative	65	49	2.5	16	46
	Reproductive	114.5	100	32.5	14.5	63.5
	Post-rep	64.1	47.57	19.53	16.52	26.04
	Average	81.20	65.52	18.18	15.67	45.18
10.Vibernum cotinifolium D. Don.	Vegetative	46.02	28.01	0.5	18.01	27.01
	Reproductive	68.03	29.51	2	38.52	22.01
	Post-rep	43.04	23.52	12.51	19.52	10.51
	Average	52.36	27.01	5.00	25.35	19.84

4. Hemicelluloses

Hemicellulose concentration in *Grewia* and *Morus* declined, but it increased in *Acacia* with advancing age. Insignificant differences were recorded in hemicelluloses contents among the different tree species and significant differences among the various phenological stages. Hemicelluloses swayed from 10.00% (post-reproductive stage of *Morus*) to 38.52% (reproductive stage of *Vibernum*) in the analyzed trees (Table 33). The reproductive stage of *Celtis* (16.51%), *Parrotiopsis* (16.02%), *Prunus* (17.50%) and *Vibernum* (38.52%) had high hemicelluloses than other growth stages. The other growth stages had insignificant differences in hemicelluloses values. Hemicelluloses value recorded for *Vibernum* in reproductive stage was significantly higher than all other tree species. In *Cotoneaster* (11.02%), *Q. dilatata* (11.50%) and *Q. incana* (14.50%), the reproductive stage had low hemicelluloses values than vegetative and post-reproductive stages.

5. Celluloses

Cellulose contents increased from 5.51% (post-reproductive stage of *Grewia*) to 63.50% (reproductive stage of *Q. incana*) in the analyzed tree leaves (Table 33). ANOVA showed insignificant differences in cellulose concentrations among the different tree species and significant differences among the various phenological stages. Cellulose contents in *Morus*, *Parrotiopsis* and *Prunus* improved but in *Grewia* and *Vibernum* it decreased with advancing maturity. The reproductive stage of *Acacia* (16.01%), *Q. dilatata* (43.50%) and *Q. incana* (63.50%) showed high celluloses contents than vegetative and post-reproductive stages. Significant differences were found among the various growth stages of these tree species. In *Celtis* (8.50%) and *Cotoneaster* (15.03%), the reproductive stage had low cellulose concentrations than other phenological stages.

B. Shrubs

I. Proximate composition

The results of proximate analysis (Table 34) are presented below.

1. Dry Matter (DM %)

The dry matter in the analyzed shrubs ranged from 89.42% (vegetative stage of *Berberis*) to 95.70% (post-reproductive stage of *Zizyphus*) (Table 34). Significant differences in DM% were obvious among the shrubs and among the different phenological stages through ANOVA. Dry matter enhanced in *Berberis* and *Zizyphus* while it decreased in *Indigofera* with advancing maturity. The reproductive stage of

Gymnosporia (94.75%) and *Justicia* (94.53%) had high %age of dry matter than the vegetative and post-reproductive stages. The reproductive (90.80%) and post-reproductive (91.30%) stages of *Debregeasia* had no significant differences. It was high at the vegetative (93.55%) stage. The reproductive (93.08%) stage of *Dodonaea* had low DM % than its vegetative (94.31%) and post-reproductive (93.47%) stages. The DM was very high in the vegetative (93.47%) stage of *Rosa* than its reproductive (90.81%) and post-reproductive (91.00%) stages.

2. **Ash contents (total minerals)**

Statistical analysis showed insignificant differences in ash contents among the different shrubs. Phenological stages had significant differences. Ash contents (total mineral) in shrubs leaves ranged from 4.57% (reproductive stage of *Berberis*) to 17.27% (post-reproductive stage of *Debregeasia*) (Table 34). The vegetative (4.63%) and reproductive (4.57%) stages of *Berberis* had insignificant differences but it ran high in the post-reproductive (7.29%) stage. *Debregeasia* had high mineral contents at all the phenological stages compared with other analyzed shrub species. In *Debregeasia*, the ash contents were 16.41%, 15.83% and 17.27% in vegetative, reproductive and post-reproductive stages, respectively. The reproductive (6.84%) and post-reproductive (6.88%) stages of *Dodonaea* had insignificant differences but it was slightly higher in the vegetative (7.83%) stage. The reproductive stage of *Gymnosporia* (11.13%) and *Justicia* (10.95%) had greater total minerals compared with other phenological stages. The ash contents in vegetative (10.47%) and reproductive (10.30%) stages of *Indigofera* had no significant differences but it was slightly higher in post-reproductive (11.49%) stage. The ash contents in the reproductive (7.18%) stage of *Rosa* were extremely low than other growth stages. Overall there was inconsistent trend of either decrease or increase in the investigated shrubs in ash contents except *Zizyphus* which showed a slight increase with maturity.

3. **Crude fiber (CF %)**

Crude fiber levels ranged from 9.62% (post-reproductive stage of *Dodonaea*) to 29.42% (vegetative stage of *Rosa*) (Table 34). The differences were insignificant among the shrubs but significant among the phenological stages. The CF contents of *Berberis* were 19.57%, 28.08% and 28.49% for vegetative, reproductive and post-reproductive stages, respectively. The vegetative (17.09%) and reproductive (16.50%) stage of *Debregeasia* had insignificant difference but it ran higher in the post-reproductive (20.79%) stage. The reproductive (21.49%) stage of *Dodonaea* had

extremely higher CF contents than the vegetative (11.66%) and post-reproductive (9.62%) stages. The reproductive stage of *Gymnosporia* (16.36%) and *Justicia* (13.75%) had low crude fiber contents compared with other phenological stages. In *Indigofera* the total minerals were 13.96%, 14.37% and 13.37% in vegetative, reproductive and post-reproductive stages respectively. The reproductive (23.11%) and post-reproductive (23.61%) stages of *Rosa* had similar total minerals but it was significantly higher in vegetative (29.42%) stage. A slight and gradual increase was recorded in *Zizyphus* with advancing maturity.

4. **Ether extract or Crude fat (EE %)**

ANOVA revealed insignificant differences in EE contents among the different shrubs while significant differences occurred among the phenological stages. EE contents ranged from 0.97% (reproductive stage of *Berberis*) to 24.85% (vegetative stage of *Zizyphus*) in the investigated shrub species (Table 34). In *Berberis*, the EE% contents were 2.01%, 0.97% and 1.18% for vegetative, reproductive and post-reproductive stages respectively. EE% levels in *Debregeasia* gradually increased while it decreased abruptly in *Zizyphus* with advancing growth stages. The reproductive (5.37%) and post-reproductive (5.35%) stages of *Dodonaea* had similar EE% but it was significantly higher in vegetative (8.48%) stage. The reproductive (7.70%) stage of *Gymnosporia* had slightly greater EE than vegetative (6.45%) stage but it was extremely low in post-reproductive (1.21%) stage than the aforesaid stages. *Indigofera* had in EE no significant difference among the analyzed phenological stages. Low contents of EE were determined in vegetative (2.99%) and reproductive (1.79%) stages of *Justicia* while it was extremely higher in the post-reproductive (13.80%) stage. In *Rosa*, the reproductive (2.20%) and post-reproductive (2.20%) stages had similar EE% but it was low in the vegetative (1.07%) stage.

5. **Crude Protein (CP %)**

Insignificant differences in crude protein contents prevailed among the shrubs but the differences were significant among the phenological stages. Crude protein levels ranged from 0.26% (vegetative stage of *Gymnosporia*) to 22.88% (reproductive stage of *Indigofera*) in the analyzed shrub leaves (Table 34). In *Dodonaea*, crude protein levels decreased while increased in *Zizyphus* with advancing age. Crude protein contents in *Berberis* were 11.84%, 12.94% and 9.76% for vegetative, reproductive and post-reproductive stages respectively. The reproductive stage of *Debregeasia* (13.38%) and *Indigofera* (22.88%) had higher crude protein

concentrations than the vegetative and post-reproductive stages. The crude proteins contents recorded in the reproductive stage of *Indigofera* were the highest while *Gymnosporia* had the least CP contents among all the analyzed shrubs species. CP % contents in *Gymnosporia* were 0.26%, 3.42% and 1.05% in vegetative, reproductive and post-reproductive stages respectively. *Justicia* and *Rosa* had the lowest crud proteins compared with other phenological stages.

6. **Moisture contents**

Moisture contents in the analyzed shrubs ranged from 4.30% (post-reproductive stage of *Zizyphus*) to 10.58% (vegetative stage of *Berberis*) (Table 34). Statistically the differences were significant in moisture contents among the shrub species and among the various phenological stages. Moisture contents decreased in *Berberis* and *Zizyphus*; while it increased in *Indigofera* with advancing maturity. In *Debregeasia*, moisture levels were 6.45%, 9.20% and 8.70% in vegetative, reproductive and post-reproductive stages respectively. The reproductive (6.92%) and post-reproductive (6.53%) stages of *Dodonaea* had no significant differences in moisture contents but it was slightly low in the vegetative (5.69%) stage. moisture levels in reproductive stage of *Gymnosporia* and *Justicia* were low compared with other growth stages. In *Rosa* the reproductive (9.19%) and post-reproductive (9.0%) stages had insignificant differences but it went low in the vegetative (6.53%) stage.

7. **Organic matter (OM %)**

ANOVA indicated insignificant differences in organic matter contents among the shrub leaves. Phenological stages showed significant differences. Organic matter contents ranged from 74.03% (post-reproductive stage of *Debregeasia*) to 87.96% (reproductive stage of *Berberis*) in the investigated shrub species (Table 34). Significant decline was observed in OM in *Debregeasia* and *Indigofera* while slightly increased in *Zizyphus* with advancing maturity. Organic matter contents were higher in all the phenological stages of *Berberis*. The vegetative (84.78%) and post-reproductive (85.95%) stages of *Berberis* showed insignificant difference in organic matter contents. in *Dodonaea*, OM were 86.47%, 86.24% and 86.60% for vegetative, reproductive and post-reproductive stages respectively, exhibiting insignificant differences. Organic matter contents in the reproductive (83.62%) and post-reproductive (83.95%) stages of *Gymnosporia* had insignificant differences but it was slightly high in the vegetative (85.49%) stage. Similarly the vegetative (83.98%) and reproductive (83.58%) stages of *Justicia* had similar organic matter contents but it ran

higher in post-reproductive (85.64%) stage. In *Rosa*, the post-reproductive (80.85%) stage had low organic matter contents but these were similar in vegetative (83.13%) and reproductive (83.63%) stages.

8. **Nitrogen free extracts (NFE %)**

NFE levels in the analyzed shrub species ranged from 36.79% (post-reproductive stage of *Dodonaea*) to 74.29% (vegetative stage of *Zizyphus*) (Table 34). Insignificant differences were recorded in NFE contents among the different analyzed shrubs while significant differences were recorded among the phenological stages. The reproductive (54.04%) and post-reproductive stages (53.84%) of *Berberis* had insignificant differences in NFE. However, it was low in the vegetative (48.64%) stage. *Debregeasia* also followed the same trend (Table 34). The reproductive stage of *Dodonaea* (50.39%), *Gymnosporia* (43.85%) and *Indigofera* (59.65%) had higher NFE than the vegetative and post-reproductive stages. The reproductive stage of *Justicia* (47.43%) and *Rosa* (49.58%) showed opposite trend regarding nitrogen free extracts. In *Zizyphus*, NFE decreased with advancing maturity.

9. **Carbohydrates (%)**

The differences in carbohydrate concentrations were insignificant among the shrub leaves and significant differences among the various phenological stages. Carbohydrate levels ranged from 41.91% (vegetative stage of *Zizyphus*) to 81.69% (post-reproductive stage of *Gymnosporia*) in the investigated shrubs (Table 34). Carbohydrate contents increased with advancing maturity in *Berberis, Dodonaea* and *Zizyphus*. The remaining shrub species showed inconsistent trend regarding carbohydrate composition. The reproductive stage of *Debregeasia* (58.18%), *Gymnosporia* (72.51%) and *Indigofera* (54.72%) had low carbohydrate contents compared with vegetative and post-reproductive stages. *Justicia* (66.32%) and *Rosa* (73.53%) showed high carbohydrate contents in their reproductive stage than other phenological stages.

Table 34. Proximate composition of some forage shrubs of Gadoon Hills, District Swabi.

Species	Phenological stage	DM %	OM %	Moisture %	CF %	EE %	CP %	Ash %	NFE %	Carbohydrate %
1. Berberis lycium Royle.	Vegetative	89.42	84.78	10.58	19.57	2.01	11.84	4.63	48.64	70.93
	Reproductive	92.53	87.96	7.47	28.08	0.97	12.94	4.57	54.04	74.05
	Post-rep	92.88	85.59	7.12	28.49	1.18	9.76	7.29	53.84	74.65
	Average	**91.61**	**86.11**	**8.39**	**25.38**	**1.39**	**11.51**	**5.50**	**52.17**	**73.21**
2.Debregeasia salicifolia (D. Don) Rendle	Vegetative	93.55	77.14	6.45	17.09	3.31	7.33	16.41	50.59	66.49
	Reproductive	90.8	74.97	9.2	16.5	3.41	13.38	15.83	58.32	58.18
	Post-rep	91.3	74.03	8.7	20.79	4.49	5.53	17.27	56.78	64.01
	Average	**91.88**	**75.38**	**8.12**	**18.13**	**3.74**	**8.75**	**16.50**	**55.23**	**62.89**
3.Dodonaea viscosa (L.) Jacq.	Vegetative	94.31	86.47	5.69	11.66	8.48	13.7	7.83	47.37	64.29
	Reproductive	93.08	86.24	6.92	21.49	5.37	9.78	6.84	50.39	71.09
	Post-rep	93.47	86.6	6.53	9.62	5.35	8.42	6.88	36.79	72.83
	Average	**93.62**	**86.44**	**6.38**	**14.26**	**6.40**	**10.63**	**7.18**	**44.85**	**69.40**
4.Gymnosporia royleana Wall ex Lawson	Vegetative	93.05	85.49	6.95	18.27	6.45	0.26	7.56	39.49	78.78
	Reproductive	94.75	83.62	5.25	16.36	7.7	3.42	11.13	43.85	72.51
	Post-rep	91.2	83.95	8.8	18.63	1.21	1.05	7.25	36.95	81.69
	Average	**93.00**	**84.35**	**7.00**	**17.75**	**5.12**	**1.58**	**8.65**	**40.10**	**77.66**
5.Indigofera heterantha L.	Vegetative	93.1	82.64	6.9	13.96	2.58	4.73	10.47	38.63	75.33
	Reproductive	90.44	80.14	9.56	14.37	2.54	22.88	10.3	59.65	54.72
	Post-rep	89.7	78.21	10.3	13.37	2.56	13.46	11.49	51.18	62.18
	Average	**91.08**	**80.33**	**8.92**	**13.90**	**2.56**	**13.69**	**10.75**	**49.82**	**64.08**
6.Justicia adhatoda L.	Vegetative	93.42	83.98	6.58	20.85	2.99	18.41	9.44	58.27	62.59
	Reproductive	94.53	83.58	5.47	13.75	1.79	15.47	10.95	47.43	66.32
	Post-rep	94.09	85.64	5.91	18.04	13.8	18.33	8.45	64.54	53.51

	Average	94.01	84.40	5.99	17.55	6.19	17.40	9.61	56.75	60.81
7.Rosa moschata non J. Herrm.	Vegetative	93.47	83.13	6.53	29.42	1.07	12.91	10.34	60.27	69.15
	Reproductive	90.81	83.63	9.19	23.11	2.2	7.9	7.18	49.58	73.53
	Post-rep	91	80.85	9	23.61	2.2	8.96	10.16	53.92	69.69
	Average	**91.76**	**82.54**	**8.24**	**25.38**	**1.82**	**9.92**	**9.23**	**54.59**	**70.79**
8.Zizyphus nummularia Buem.f. Weight	Vegetative	92.57	81.48	7.43	16.2	24.85	14.72	11.09	74.29	41.91
	Reproductive	95.38	84.23	4.62	17.29	18.87	15.53	11.15	67.47	49.83
	Post-rep	95.7	84.37	4.3	17.75	5.22	19.01	11.33	57.61	60.14
	Average	**94.55**	**83.36**	**5.45**	**17.08**	**16.31**	**16.42**	**11.19**	**66.46**	**50.63**

Key: DM: Dry matter, OM: Organic matter, CF: Crude fiber, EE: Ether extract, CP: Crude protein, NFE: Nitrogen free extract.

10. Gross energy (GE)

Gross energy ranged from 255.63 Kcal/g (post-reproductive stage of *Gymnosporia*) to 697.28 Kcal/g (vegetative stage of *Zizyphus*) in the analyzed shrub leaves (Table 35). Insignificant differences in GE were recorded among the different shrub leaves through statistical analysis. Phenological stages showed significant differences. Gross energy, among all the shrub species increased only in *Zizyphus* with advancing maturity. The reproductive stage of *Berberis* (435.50 Kcal/g), *Debregeasia* (423.05 Kcal/g), *Gymnosporia* (347.77 Kcal/g) and *Indigofera* (464.22 Kcal/g) had higher gross energy than the vegetative and reproductive stages. In *Dodonaea*, the vegetative (405.68 Kcal/g) and reproductive (412.91 Kcal/g) stages had no significant difference in gross energy but significantly declined in post-reproductive (293.35 Kcal/g) stage. *Justicia* (362.50 Kcal/g) and *Rosa* (376.62 Kcal/g) had low gross energy in their reproductive stages compared with other growth stages.

11. Total digestible nutrient (TDN %)

Total digestible nutrients showed insignificant differences among the shrub leaves while phenological stages exhibited significant differences. Total digestible nutrients ranged from 42.81% (post-reproductive stage of *Gymnosporia*) to 89.29% (vegetative stage of *Zizyphus*) in the analyzed shrub leaves (Table 35). In *Zizyphus*, total digestible nutrients decreased with advancing age. The remaining shrubs species showed inconsistent trend regarding TDN with advancing maturity. The reproductive and post-reproductive stages of *Berberis* and *Debregeasia* showed insignificant differences while TDN contents were low in the vegetative stage of both the species. *Dodonaea* (59.35%), *Gymnosporia* (51.44%) and *Indigofera* (70.55%) had high total digestible nutrients in their respective reproductive stages compared with other phenological stages. In *Justicia* (55.73%) and *Rosa* (58.08%), the reproductive stages had low total digestible nutrients than vegetative and post-reproductive stages.

12. Digestible energy (DE)

Digestible energy ranged from 1.89 Mcal/Kg (post-reproductive stage of *Gymnosporia*) to 3.94 Mcal/Kg (vegetative stage of *Zizyphus*) in the investigated shrub leaves (Table 35). Insignificant differences in DE were observed among the shrub species while phenological stages had significant differences. In *Berberis*, the DE in reproductive (2.80 Mcal/Kg) and post-reproductive (2.79 Mcal/Kg) stages were similar but it was low in the vegetative stage. The reproductive stage of *Debregeasia*

(3.02 Mcal/Kg), *Gymnosporia* (2.27 Mcal/Kg) and *Indigofera* (3.11 Mcal/Kg) had higher digestible energy than the vegetative and reproductive stages. The vegetative (2.47 Mcal/Kg) and reproductive (2.62 Mcal/Kg) stages of *Dodonaea* had insignificant differences in digestible energy but DE significantly declined in post-reproductive (1.90 Mcal/Kg) stage. The reproductive stage of *Justicia* (2.46 Mcal/Kg) and *Rosa* (2.56 Mcal/Kg) had low digestible energy when compared with other phenological stages. Digestible energy, among all the shrub species increased only in *Zizyphus* with advancing maturity.

13. Metabolized energy (ME %)

Metabolized energy exhibited insignificant differences among the different shrub species but significant differences were observed among the phenological stages. Metabolized energy ranged from 2.36 Mcal/Kg (post-reproductive stage of *Gymnosporia*) to 4.43 Mcal/Kg (vegetative stage of *Zizyphus*) in the analyzed shrub leaves (Table 35). In *Zizyphus*, ME declined with advancing age. The remaining shrubs species showed inconsistent trend regarding ME with advancing maturity. The reproductive and post-reproductive stages of *Berberis* and *Debregeasia* showed insignificant differences while ME was low in the vegetative stage of both the species. *Dodonaea* (3.09 Mcal/Kg), *Gymnosporia* (2.74 Mcal/Kg) and *Indigofera* (3.59 Mcal/Kg) had high metabolized energy in their respective reproductive stages compared with other phenological stages. In *Justicia* (2.93 Mcal/Kg) and *Rosa* (3.04 Mcal/Kg), the reproductive stages had low metabolized energy than vegetative and post-reproductive stages.

II. Cell wall constituents

The results of cell wall constituents (Table 36) are narrated below.

1. Neutral detergent fiber (NDF)

In *Debregeasia*, *Indigofera* and *Rosa* NDF concentrations decreased with advancing age. It ranged from 25.54% (vegetative stage of *Dodonaea*) to 60.03% (post-reproductive stage of *Justicia*) among the shrubs (Table 36). Insignificant differences were noticed in NDF contents among the different analyzed shrubs through statistics and significant differences among the various phenological stages. In *Berberis*, the reproductive (52.55%) and post-reproductive (51.00%) stages had insignificant difference but the differences were quit high than vegetative (40.56%) stage. The reproductive (37.54%) stage of *Dodonaea* had greater NDF levels compared with other phenological stages. NDF contents increased in *Justicia* with

advancing growth stages. *Zizyphus* had no significant difference among all the phenological stages.

2. **Acid detergent fiber (ADF)**

ADF concentrations ranged from 14.52% (vegetative stage of *Dodonaea*) to 46.45% (vegetative stage of *Debregeasia*) among the shrub leaves (Table 36). Insignificant differences in ADF levels were obtained among the shrub leaves. Phenological stages had significant differences in ADF contents. The reproductive (34.03%) and post-reproductive (33.50%) stages of *Berberis* had similar ADF levels but it was low in vegetative (25.54%) stage. In *Debregeasia* and *Rosa*, ADF concentration decreased with maturity. The reproductive (23.52%) stage of *Dodonaea* had high ADF than vegetative (14.52%) and post-reproductive (17.03%) stage. Similar ADF contents were recorded for *Gymnosporia* in vegetative (18.53%) and reproductive (18.54%) stages. In *Indigofera*, the same trend was followed by vegetative (34.00%) and reproductive (34.50%) stages. In *Gymnosporia*, post-reproductive (21.52%) stage had slightly higher ADF contents while these contents were low in compared with aforesaid phenological stages. Maturity served to increase the ADF concentrations in *Justicia*. In *Zizyphus*, the reproductive (18.50%) stage had low ADF contents than vegetative (22.01%) and post-reproductive (21.01%) stage.

3. **Acid detergent lignin (ADL %)**

The differences were significant in ADL contents among the shrubs and among the phenological stages. ADL concentrations ranged from 0.50% (post-reproductive stage of *Dodonaea*) to 12.00% (vegetative stage of *Rosa*) in the analyzed shrub leaves (Table 36). In *Berberis*, the reproductive (11.51%) stage had extremely higher ADL contents than vegetative (3.51%) and post-reproductive (4.00%) stage. Abrupt decrease in ADL levels were observed in *Debregeasia*, *Dodonaea*, *Justicia* and *Rosa* with advancing age. *Gymnosporia* showed abrupt increase with gain in maturity. *Zizyphus* showed inconsistent trend in ADL concentration at phenological stages. The ADL contents in *Zizyphus* were 1.50%, 1.00% and 3.00% for vegetative, reproductive and post-reproductive stages, respectively.

Table 35. Different types of energies available to livestock in forage shrubs of Gadoon Hills, District Swabi.

Species	Phenological stage	GE (Kcal/g)	TDN %	DE (Mcal/Kg)	ME (Mcal/Kg)
1. Berberis lycium Royle.	Vegetative	376.64	57.1	2.52	2.99
	Reproductive	435.5	63.58	2.8	3.28
	Post-rep	420.48	63.2	2.79	3.26
	Average	**410.87**	**61.29**	**2.70**	**3.18**
2.Debregeasia salicifolia (D. Don) Rendle	Vegetative	359.15	59.2	2.61	3.09
	Reproductive	423.05	68.6	3.02	3.51
	Post-rep	402.72	66.55	2.93	3.41
	Average	**394.97**	**64.78**	**2.85**	**3.34**
3.Dodonaea viscosa (L.) Jacq.	Vegetative	405.68	56.05	2.47	2.95
	Reproductive	412.91	59.35	2.62	3.09
	Post-rep	293.35	43.15	1.9	2.37
	Average	**370.65**	**52.85**	**2.33**	**2.80**
4.Gymnosporia royleana Wall ex Lawson	Vegetative	309.39	46.13	2.03	2.5
	Reproductive	347.77	51.44	2.27	2.74
	Post-rep	255.63	42.81	1.89	2.36
	Average	**304.26**	**46.79**	**2.06**	**2.53**
5.Indigofera heterantha L.	Vegetative	274.12	44.97	1.98	2.45
	Reproductive	464.22	70.55	3.11	3.59
	Post-rep	371.62	60.08	2.65	3.13
	Average	**369.99**	**58.53**	**2.58**	**3.06**
6.Justicia adhatoda L.	Vegetative	468.39	68.85	3.04	3.52
	Reproductive	362.5	55.73	2.46	2.93
	Post-rep	582.49	77.06	3.4	3.88
	Average	**471.13**	**67.21**	**2.97**	**3.44**
7.Rosa moschata non J. Herrm.	Vegetative	467.79	70.95	3.13	3.61
	Reproductive	376.62	58.08	2.56	3.04
	Post-rep	402.54	63.25	2.79	3.27
	Average	**415.65**	**64.09**	**2.83**	**3.31**
8.Zizyphus nummularia Buem.f. Weight	Vegetative	697.28	89.29	3.94	4.43
	Reproductive	622.82	80.77	3.56	4.05
	Post-rep	475.51	68.22	3.01	3.49
	Average	**598.54**	**79.43**	**3.50**	**3.99**

Key to the words: GE: Gross energy, TDN: Total digestible nutrients, DE: Digestible energy, ME: Metabolized energy

4. Hemicelluloses

Hemicelluloses ranged from 3.51% (reproductive stage of *Debregeasia*) to 28.01% (post-reproductive stage of *Justicia*) among the shrubs (Table 36). The differences were insignificant among the shrubs but were significant among the phenological stages. The reproductive stage of *Berberis* (18.52%), *Dodonaea* (14.01%) and *Zizyphus* (13.50%) showed high hemicelluloses contents while in *Debregeasia* (3.51%) and *Indigofera* (6.50%) these contents were low in reproductive stage than other phenological stages. The reproductive (10.52%) and post-reproductive (10.51%) stages had similar hemicelluloses level in *Gymnosporia* but these were slightly low in the vegetative (9.01%) stage. The vegetative (18.03%) and reproductive (17.02%) stages had insignificant differences regarding hemicelluloses concentration but it ran higher in the post- reproductive (28.01%) stage. Hemicelluloses contents in *Rosa* were 17.50%, 17.51% and 16.51% for vegetative, reproductive and post-reproductive stages respectively, exhibiting insignificant difference.

5. Celluloses

Cellulose concentrations among the different shrub leaves differed insignificantly but significant differences occurred among the various phenological stages. Cellulose contents ranged from 7.01% (vegetative stage of *Dodonaea*) to 31.47% (vegetative stage of *Debregeasia*) in the analyzed shrub leaves (Table 36). The reproductive stage of *Dodonaea* (15.52%), *Indigofera* (30.00%) and *Rosa* (20.51%) showed high hemicelluloses contents than vegetative and post-reproductive stages. In *Berberis* and *Justicia*, cellulose levels increased while decreased in *Debregeasia* with advancing maturity. The vegetative (14.02%) and reproductive (14.03%) stages of *Gymnosporia* had similar cellulose concentration but it declined in the post-reproductive (12.51%) stage. In *Zizyphus*, the reproductive (14.50%) and post-reproductive (14.51%) stages had similar cellulose levels but it was slight high in the vegetative (16.51%) stage.

Table 36. Cell wall constituents of some forage shrubs of Gadoon Hills, District Swabi.

Species	Phenological stage	NDF %	ADF %	Lignin %	Hemi-cellulose %	Cellulose %
1. Berberis lycium Royle.	Vegetative	40.56	25.54	3.51	15.02	21.53
	Reproductive	52.55	34.03	11.51	18.52	22.02
	Post-rep	51	33.5	4	17.5	28.5
	Average	**48.04**	**31.02**	**6.34**	**17.01**	**24.02**
2. Debregeasia salicifolia (D. Don) Rendle	Vegetative	51.45	46.45	11.99	5	31.47
	Reproductive	39.12	35.61	3.01	3.51	30.09
	Post-rep	37.02	32.02	1	5	27.51
	Average	**42.53**	**38.03**	**5.33**	**4.50**	**29.69**
3. Dodonaea viscosa (L.) Jacq.	Vegetative	25.54	14.52	6.51	11.02	7.01
	Reproductive	37.54	23.52	5.51	14.01	15.52
	Post-rep	29.04	17.03	0.5	12.02	11.52
	Average	**30.71**	**18.36**	**4.17**	**12.35**	**11.35**
4. Gymnosporia royleana Wall ex Lawson	Vegetative	27.54	18.53	2.5	9.01	14.02
	Reproductive	29.06	18.54	3.01	10.52	14.03
	Post-rep	32.03	21.52	8.51	10.51	12.51
	Average	**29.54**	**19.53**	**4.67**	**10.01**	**13.52**
5. Indigofera heterantha L.	Vegetative	42.5	34	5.5	8.5	27
	Reproductive	41	34.5	2.5	6.5	30
	Post-rep	40	32	4.5	8	26
	Average	**41.17**	**33.50**	**4.17**	**7.67**	**27.67**
6. Justicia adhatoda L.	Vegetative	39.06	21.03	5.01	18.03	15.52
	Reproductive	47.05	30.03	1.5	17.02	25.53
	Post-rep	60.03	32.02	1.5	28.01	29.01
	Average	**48.71**	**27.69**	**2.67**	**21.02**	**23.35**
7. Rosa moschata non J. Herrm.	Vegetative	46	28.5	12	17.5	16
	Reproductive	44.02	26.51	5	17.51	20.51
	Post-rep	42.02	25.51	4.5	16.51	19.51
	Average	**44.01**	**26.84**	**7.17**	**17.17**	**18.67**
8. Zizyphus nummularia Buem.f. Weight	Vegetative	30.02	22.01	1.5	8	16.51
	Reproductive	32	18.5	1	13.5	14.5
	Post-rep	31.52	21.01	3	10.51	14.51
	Average	**31.18**	**20.51**	**1.83**	**10.67**	**15.17**

Key to the words: NDF: Neutral detergent fiber, ADF: Acid detergent fiber

Table 37. Proximate composition of some forage grasses of Gadoon Hills, District Swabi.

Species	Phenological stage	DM %	OM %	Moisture %	CF %	EE %	CP %	Ash %	NFE %	Carbohydrate %
1.Apluda mutica L.	Vegetative	94.25	7.45	24.64	8.65	5.64	5.75	86.8	52.13	72.51
	Reproductive	95.6	8.11	22.48	10.47	6.32	4.4	87.49	51.78	70.7
	Post-rep	94.62	9.98	26.38	7.34	9.39	5.38	84.64	58.47	67.91
	Average	**94.82**	**8.51**	**24.50**	**8.82**	**7.12**	**5.18**	**86.31**	**54.13**	**70.37**
2.Aristida adscensionis L.	Vegetative	95.02	7.56	27.31	5.96	5.18	4.98	87.46	50.99	76.32
	Reproductive	95	8.46	32.61	5.27	6.84	5	86.54	58.18	74.43
	Post-rep	92.37	7.69	35.62	8.65	8.96	7.64	84.68	68.56	67.07
	Average	**94.13**	**7.90**	**31.85**	**6.63**	**6.99**	**5.87**	**86.23**	**59.24**	**72.61**
3.Chrysopogon aucheri (Boiss.) Stapf	Vegetative	93.84	9.63	28.34	8.68	9.38	6.16	84.21	62.19	66.15
	Reproductive	95.91	5.04	36.47	11.46	12.63	4.09	90.87	69.7	66.77
	Post-rep	94.26	4.58	35.96	7.87	8.97	5.74	89.68	63.12	72.84
	Average	**94.67**	**6.42**	**33.59**	**9.34**	**10.33**	**5.33**	**88.25**	**65.00**	**68.59**
4.Digitaria sanguinalis (L.) Scop.	Vegetative	95.85	6.57	24.94	7.59	6.38	4.15	89.28	49.63	75.31
	Reproductive	95.15	4.73	33.09	9.46	8.68	4.85	90.43	60.8	72.29
	Post-rep	92.14	4.37	35.81	11.53	9.91	7.86	87.77	69.48	66.33
	Average	**94.38**	**5.22**	**31.28**	**9.53**	**8.32**	**5.62**	**89.16**	**59.97**	**71.31**
5.Heteropogon contortus (L.) P. Beauv.	Vegetative	94.95	7.62	23.59	6.91	6.94	5.05	87.33	50.11	73.48
	Reproductive	95.17	4.71	25.21	8.41	6.04	4.83	90.45	49.2	76.01
	Post-rep	95.54	3.75	31.29	9.98	7.92	4.46	91.79	57.4	73.89
	Average	**95.22**	**5.36**	**26.70**	**8.43**	**6.97**	**4.78**	**89.86**	**52.24**	**74.46**
6.Pennisetum orientale L. C. Rich.	Vegetative	93.45	6.58	26.58	12.62	10.95	6.55	86.87	63.28	63.3
	Reproductive	95.1	8.57	27.85	14.71	11.02	4.9	86.54	67.04	60.81
	Post-rep	94.95	8.68	25.61	10.65	6.48	5.05	86.27	56.47	69.14

	Average	94.50	7.94	26.68	12.66	9.48	5.50	86.56	62.26	64.42
*7.Schoenoplectus litoralis*Schrad.	Vegetative	95.36	8.35	23.86	8.21	9.68	4.64	87.01	54.74	69.12
	Reproductive	94.91	8.26	25.29	12.64	9.72	5.09	86.65	61	64.29
	Post-rep	92.58	6.95	29.64	9.94	6.27	7.42	85.63	60.22	69.42
	Average	**94.28**	**7.85**	**26.26**	**10.26**	**8.56**	**5.72**	**86.43**	**58.65**	**67.61**
8.Themeda anathera (Nees) Hack.	Vegetative	92.03	6.84	25.54	8.59	5.37	7.97	85.19	54.31	71.23
	Reproductive	93.77	8.35	37.33	5.34	6.59	6.23	85.41	63.84	73.49
	Post-rep	95.64	7.51	24.65	5.64	8.49	4.36	88.13	50.65	74
	Average	**93.81**	**7.57**	**29.17**	**6.52**	**6.82**	**6.19**	**86.24**	**56.27**	**72.91**

C. Grasses

1. Proximate composition

The results of proximate analysis (Table 37) for grasses are presented below.

1. Dry Matter (DM %)

Dry matter augmented in *Heteropogon* and *Themeda* while it decreased in *Aristida, Digitaria* and *Schoenoplectus* with advancing growth stages. The dry matter in the investigated grasses ranged from 92.03% (vegetative stage of *Themeda*) to 95.91 (reproductive stage of *Chrysopogon*) (Table 37). In *Pennisetum*, the reproductive (95.10%) and post-reproductive (94.95%) stages had no significant difference in DM % but it was low in the vegetative (93.45%) stage. Statistical analysis revealed significant differences in DM among the different grasses and among the various phenological stages. The reproductive stage of *Apluda* (95.60%) and *Chrysopogon* (95.91%) had high %age of dry matter than the vegetative and post-reproductive stages.

2. Ash contents (total minerals)

Ash contents (total mineral) enhanced from 3.75% (post-reproductive stage of *Heteropogon*) to 9.98% (post-reproductive stage of *Apluda*) (Table 37) among the grasses. *Aristida* (8.46%) and *Themeda* (8.35%) had higher ash contents at reproductive stages than other stages. Total mineral showed significant differences among the different grasses and among the different phenological stages. *Chrysopogon, Digitaria, Heteropogon* and *Schoenoplectus* had decreased ash contents while in *Apluda* and *Pennisetum* it increased with advancing maturity.

3. Crude fiber (CF %)

Significant improvement in CF contents occurred in *Aristida, Digitaria, Heteropogon* and *Schoenoplectus* with advancing growth stages. Crude fiber contents in grasses enhanced from 22.48% (reproductive stage of *Apluda*) to 37.33% (reproductive stage of *Themeda*) (Table 37). Statistical analysis revealed significant differences in CF contents among the different grasses. Phenological stages exhibited insignificant differences. The reproductive (22.48%) stage of *Apluda* had low CF contents than the vegetative (24.64%) and post-reproductive (26.38%) stages. The reproductive (36.47%) and post-reproductive (35.96%) stages of *Chrysopogon* had similar total minerals but it was very low in vegetative (28.34%) stage. In *Pennisetum*, the CF contents were 26.58%, 27.85% and 25.61% for vegetative, reproductive and post-reproductive stages respectively. The vegetative (25.54%) and post-reproductive

(24.65%) stages had no significant difference in CF levels but it was extremely higher in reproductive (37.33%) stage.

4. **Ether extract or Crude fat (EE %)**

Crude fat contents went high from 5.27% (reproductive stage of *Aristida*) to 14.71% (reproductive stage of *Pennisetum*) among grasses (Table 37). In *Digitaria* and *Heteropogon* EE contents gradually increased with advancing maturity. Insignificant differences in EE contents were recorded among the different grasses and significant differences among the various phenological stages. The reproductive stage of *Apluda* (10.47%), *Chrysopogon* (11.46%), *Pennisetum* (14.71%) and *Schoenoplectus* (12.64%) showed high level of crude fat compared with other growth stages. the vegetative (5.96%) and reproductive (5.27%) stages of *Aristida*, had insignificant difference in EE levels but it went higher in post-reproductive (8.65%) stage. The vegetative (8.59%) stage of *Themeda* had high concentration of ether extracts compared with reproductive (5.34%) and post-reproductive (5.64%) stages.

5. **Crude Protein (CP %)**

Crude protein levels increased in *Apluda, Aristida, Digitaria* and *Themeda* with advancing growth stages. Crude protein contents increased from 5.18% (vegetative stage of *Aristida*) to 12.63% (reproductive stage of *Chrysopogon*) among the grasses (Table 37). The differences were significant among the grasses and among the different phenological stages. The reproductive (12.63%) stage of *Chrysopogon* had extremely higher CP contents than vegetative (9.38%) and post-reproductive (8.97%) stages. In *Heteropogon*, the CP contents were 6.94%, 6.04% and 7.92% for vegetative, reproductive and post-reproductive stages respectively. The vegetative (10.95%) and reproductive (11.02%) stages of *Pennisetum* had similar CP concentrations but it significantly declined in post-reproductive (6.48%) stage. *Schoenoplectus* also had the same trend in CP levels.

6. **Moisture contents**

ANOVA revealed significant differences in moisture contents among the grasses and among the phenological stages. Moisture contents increased in *Digitaria* and *Schoenoplectus* while it declined in *Heteropogon* and *Themeda* with advancing age. Moisture contents in the investigated grasses ranged from 4.09% (reproductive stage of *Chrysopogon*) to 7.97% (vegetative stage of *Themeda*) (Table 37). In *Apluda* (4.40%) and *Chrysopogon* (4.09%) moisture contents were significantly low in reproductive stage compared with other growth stages. The vegetative (4.98%) and

reproductive (5.00%) stages of *Aristida* had similar moisture levels but it enhanced at post-reproductive (7.64%) stage. In *Pennisetum*, moisture levels were 6.55%, 4.90% and 5.05% in vegetative, reproductive and post-reproductive stages respectively.

7. **Organic matter (OM %)**

Organic matter contents ranged from 84.21% (vegetative stage of *Chrysopogon*) to 91.79% (post-reproductive stage of *Heteropogon*) in the analyzed grass species (Table 37). Significant differences in organic matter contents were recorded among the various grasses and among the different phenological stages through statistics. The vegetative (86.80%) and reproductive (87.49%) stages of *Apluda* had insignificant difference in OM contents but significantly declined in post-reproductive (84.64%) stage. Organic Matter contents significantly declined in *Aristida*, *Pennisetum* and *Schoenoplectus* while increased in *Heteropogon* and *Themeda* with advancing maturity. The reproductive (90.87%) and post-reproductive (89.68%) stages of *Chrysopogon* had no differences but it was extremely low at vegetative (84.21%) stage. The reproductive (90.43%) stage of *Digitaria* had high organic matter levels compared with other growth stages.

8. **Nitrogen free extracts (NFE %)**

NFE increased in *Aristida* and *Digitaria* with advancing maturity. Significant differences were obvious in NFE contents among the different analyzed grasses and among the various phenological stages. NFE levels among the grasses varied from 49.20% (reproductive stage of *Heteropogon*) to 69.70% (reproductive stage of *Chrysopogon*) (Table 37). The vegetative (52.13%) and reproductive (51.78%) stages of *Apluda* had similar NFE contents but at post-reproductive (58.47%) stage they were high. *Heteropogon* also followed the same trend in NFE contents. The reproductive stage of *Chrysopogon* (69.70%) and *Themeda* (63.84%) had significantly higher NFE concentrations compared with other growth stages. The other phenological stages had insignificant difference. In *Pennisetum*, NFE levels were 63.28%, 67.04% and 56.47% in vegetative, reproductive and post-reproductive stages, respectively. The reproductive (61.00%) and post-reproductive (60.22%) stages of *Schoenoplectus* had insignificant differences in nitrogen free extracts but it was low in the vegetative (54.74%) stage.

9. **Carbohydrates**

Carbohydrate contents increased from 60.81% (reproductive stage of *Pennisetum*) to 76.32% (vegetative stage of *Aristida*) in the analyzed grasses (Table

37). The differences were significant among the grass species and among the various phenological stages. Significant decline was recorded in carbohydrate contents in *Apluda*, *Aristida* and *Digitaria* with advancing growth stages. In *Chrysopogon* and *Themeda*, these contents increased with advancing maturity. The reproductive (76.01%) stage of *Heteropogon* had high carbohydrate contents compared with vegetative (73.48%) and post-reproductive (73.89%) stages. *Pennisetum* (60.81%) and *Schoenoplectus* (64.29%) had low carbohydrate contents in reproductive stage compared with other growth stages.

10. Gross energy (GE)

Gross energy among the grasses increased in *Apluda*, *Aristida*, *Digitaria* and *Heteropogon* with advancing maturity (Table 38). Significant differences in GE were noticed among the different grasses and among the various phenological stages. Gross energy ranged from 420.28 Kcal/g (vegetative stage of *Heteropogon*) to 636.71 Kcal/g (reproductive stage of *Chrysopogon*) in the investigated grasses (Table 38). The reproductive (636.71 Kcal/g) stage of *Chrysopogon* had higher GE compared with other phenological stages. *Themeda* followed the same trend for gross energy. The other growth stages had insignificant differences. In *Pennisetum*, gross energy were 564.86, 606.33 and 488.49 Kcal/g in vegetative, reproductive and post-reproductive stages respectively. The vegetative (468.26 Kcal/g) stage of had low gross energy than other growth stages.

11. Total digestible nutrient (TDN %)

Total digestible nutrients ranged from 58.07% (reproductive stage of *Heteropogon*) to 83.08% (reproductive stage of *Chrysopogon*) in the studied grasses (Table 38). In *Aristida* and *Digitaria*, total digestible nutrients increased with advancing maturity. The remaining grasses displayed inconsistent trend in TDN levels with advancing growth stages. TDN contents showed significant differences among the different grasses and among the phenological stages. The vegetative (61.49%) and reproductive (61.22%) stages of *Apluda* had similar TDN levels but it ran higher in post-reproductive (69.08%) stage. *Heteropogon* followed similar trend in TDN contents. The reproductive stage of *Chrysopogon* (83.08%) and *Themeda* (75.35%) had higher TDN concentrations compared with other growth stages. The other growth stages had insignificant difference in TDN levels. The vegetative (75.27%), reproductive (79.92%) and post-reproductive (66.82%) stages of *Pennisetum* had significant differences among themselves. In *Schoenoplectus*, the reproductive

(72.49%) and post-reproductive (71.26%) stages had similar contents but it was very low in the vegetative (64.72%) stage.

12. Digestible energy (DE)

Digestible energy increased with advancing maturity in *Aristida* and *Digitaria*. Significant differences in DE among the different grasses and among the different phenological stages were observed. It ranged from 2.56 Mcal/Kg (reproductive stage of *Heteropogon*) to 3.66 Mcal/Kg (reproductive stage of *Chrysopogon*) in the analyzed grasses (Table 38). The vegetative and reproductive stages of *Apluda* and *Heteropogon* had similar DE values. It went high in the post-reproductive stage. DE values in *Apluda* were 2.71, 2.70 and 3.05 Mcal/Kg while in *Heteropogon* 2.60, 2.56 and 3.00 Mcal/Kg for vegetative, reproductive and post-reproductive stages respectively. The reproductive (3.66 Mcal/Kg) stage of *Chrysopogon* had higher DE concentrations compared with other growth stages. *Themeda* showed similar trend in DE contents. The vegetative (2.85 Mcal/Kg) stage of *Schoenoplectus* had low DE values compared with other phenological stages. The other growth stages had insignificant difference. *Pennisetum* had significant differences among the different phenological stages.

13. Metabolized energy (ME %)

Metabolized energy ranged from 3.04 Mcal/Kg (reproductive stage of *Heteropogon*) to 4.15 Mcal/Kg (reproductive stage of *Chrysopogon*) in the analyzed grasses (Table 38). Metabolized energy showed significant differences among the different grasses and among the phenological stages. Metabolized energy in *Aristida* and *Digitaria*, increased with advancing maturity. The vegetative (3.19 Mcal/Kg) and reproductive (3.18 Mcal/Kg) stages of *Apluda* had similar ME values but it ran higher in the post-reproductive (3.53 Mcal/Kg) stage. *Heteropogon* followed similar trend. ME values in *Heteropogon* were 3.08, 3.04 and 3.48 Mcal/Kg for vegetative, reproductive and post-reproductive stages respectively. In *Chrysopogon*, the reproductive (4.15 Mcal/Kg) stage had high ME concentrations than other growth stages. *Themeda* also had the same situation. In *Pennisetum*, ME values were 3.80, 4.01 and 3.43 Mcal/Kg in vegetative, reproductive and post-reproductive stages respectively. In *Schoenoplectus*, the reproductive (3.68 Mcal/Kg) and post-reproductive (3.62 Mcal/Kg) stages had similar ME levels but it was low in vegetative (3.33 Mcal/Kg) stage.

Table 38. Different types of energies available to livestock in forage shrubs of Gadoon Hills, District Swabi.

Species	Phenological stage	GE (Kcal/g)	TDN %	DE (Mcal/Kg)	ME (Mcal/Kg)
1.Apluda mutica L.	Vegetative	442.53	61.49	2.71	3.19
	Reproductive	451.98	61.22	2.7	3.18
	Post-rep	485.42	69.08	3.05	3.53
	Average	**459.98**	**63.93**	**2.82**	**3.30**
2.Aristida adscensionis L.	Vegetative	422.55	59.98	2.64	3.12
	Reproductive	479.89	68.58	3.02	3.5
	Post-rep	580.32	81.29	3.58	4.07
	Average	**494.25**	**69.95**	**3.08**	**3.56**
3.Chrysopogon aucheri (Boiss.) Stapf	Vegetative	522.49	73.62	3.25	3.73
	Reproductive	636.71	83.08	3.66	4.15
	Post-rep	552.7	74.79	3.3	3.78
	Average	**570.63**	**77.16**	**3.40**	**3.89**
4.Digitaria sanguinalis (L.) Scop.	Vegetative	428.07	58.53	2.58	3.06
	Reproductive	543	72.1	3.18	3.66
	Post-rep	617.75	82.67	3.64	4.13
	Average	**529.61**	**71.10**	**3.13**	**3.62**
5.Heteropogon contortus (L.) P. Beauv.	Vegetative	420.28	59.04	2.6	3.08
	Reproductive	433.43	58.07	2.56	3.04
	Post-rep	521.31	68.06	3	3.48
	Average	**458.34**	**61.72**	**2.72**	**3.20**
6.Pennisetum orientale L. C. Rich.	Vegetative	564.86	75.27	3.32	3.8
	Reproductive	606.33	79.92	3.52	4.01
	Post-rep	488.49	66.82	2.95	3.43
	Average	**553.23**	**74.00**	**3.26**	**3.75**
7.Schoenoplectus litoralis Schrad.	Vegetative	468.26	64.72	2.85	3.33
	Reproductive	542.67	72.49	3.2	3.68
	Post-rep	514.96	71.26	3.14	3.62
	Average	**508.63**	**69.49**	**3.06**	**3.54**
8.Themeda anathera (Nees) Hack.	Vegetative	453.54	64.06	2.82	3.3
	Reproductive	524.44	75.35	3.32	3.81
	Post-rep	424.34	59.67	2.63	3.11
	Average	**467.44**	**66.36**	**2.92**	**3.41**

II. Cell wall constituents

The findings of cell wall constituents (Table 39) are stated below.

1. Neutral detergent fiber (NDF)

NDF values increased in *Apluda, Pennisetum* and *Themeda* while decreased in *Schoenoplectus* with advancing maturity. NDF levels ranged from 53.14% (post-reproductive stage of *Schoenoplectus*) to 57.04% (reproductive stage of *Digitaria*) in the investigated grasses (Table 39). Insignificant differences were recorded in NDF contents among the different analyzed grass species through statistical analysis and significant differences among the various phenological stages. The remaining grass species showed inconsistent trend in NDF levels with advancing growth stages. The reproductive stage of *Aristida* (71%), *Chrysopogon* (74%) and *Digitaria* (75.04%) had higher NDF values compared with other phenological stages. In *Heteropogon*, NDF values in vegetative (71.35%) and reproductive (72.50%) stages had no significant differences but it was low in the post-reproductive (67.39%) stage.

2. Acid detergent fiber (ADF)

With advancing growth stages ADF values decreased in *Aristida, Digitaria, Pennisetum, Schoenoplectus* and *Themeda*. ADF concentrations ranged from 27.53% (post-reproductive stage of *Schoenoplectus*) to 49.50% (reproductive stage of *Chrysopogon*) in the analyzed grasses (Table 39). The grasses and different phenological stages showed insignificant differences in ADF. In *Apluda*, ADF levels were 45.56%, 47.50% and 42.32% in vegetative, reproductive and post-reproductive stages respectively. Significant difference was recorded in ADF values among the vegetative (45.15%), reproductive (49.50%) and post-reproductive (47.25%) stages of *Chrysopogon*. ADF contents were similar at the vegetative (36.54%) and post-reproductive (37.42%) stages of *Heteropogon*. It improved at reproductive (45.00%) stage.

3. Acid detergent lignin (ADL %)

ANOVA revealed insignificant differences in ADL contents among the different grasses while the differences were significant at phenological stages. ADL concentrations ranged from 1.90% (post-reproductive stage of *Aristida*) to 43.50% (reproductive stage of *Chrysopogon*) in the investigated grasses (Table 39). Lignin contents decreased in *Aristida, Digitaria* and *Pennisetum* with advancing age. Insignificant differences were recorded among the vegetative (2.70%), reproductive (2.50%) and post-reproductive (2.60%) stages of *Apluda*. The ADL contents in

Chrysopogon were 37.40%, 43.50% and 31.64% for vegetative, reproductive and post-reproductive stages respectively. *Heteropogon* had high lignin value in the reproductive (28.50%) stage compared with its other growth stages. *Schoenoplectus* also followed the same trend in lignin concentration. In *Themeda*, the reproductive (2.00%) and post-reproductive (2.00%) stages had similar lignin contents but it was high in the vegetative (3.91%) stage.

4. **Hemicelluloses**

The differences were significant in hemicelluloses contents among the grasses and among their phenological stages. Hemicelluloses ranged from 16.69% (vegetative stage of *Themeda*) to 34.81% (vegetative stage of *Heteropogon*) in the studied grasses (Table 39). Hemicelluloses values increased in *Apluda*, *Pennisetum*, *Schoenoplectus* and *Themeda* with advancing maturity. In *Aristida*, hemicelluloses were 21.99%, 26.50% and 25.05% in vegetative, reproductive and post-reproductive stages respectively, exhibiting insignificant difference. The vegetative (23.87%) and reproductive (24.50%) stages of *Chrysopogon* had no significant difference in hemicelluloses values but it declined in post-reproductive (18.69%) stage. The reproductive (31.52%) and post-reproductive stages (30.00%) had no differences in *Digitaria* but the vegetative (25.20%) stage had low value. Reproductive (27.50%) stage of *Heteropogon* had significantly low hemicelluloses compared with other growth stages.

5. **Celluloses**

Cellulose values ranged from 5.50% (reproductive stage of *Chrysopogon*) to 44.00% (reproductive stage of *Apluda*) in the investigated grass species (Table 39). Statistical analysis showed insignificant differences in cellulose concentrations among the different grasses and significant differences among the various phenological stages. Cellulose contents decreased in *Aristida* and *Themeda* with advancing age. *Apluda* (44.00%) and *Heteropogon* (15.00%) followed similar trend in cellulose values, having higher concentrations in reproductive stage than other phenological stages. In *Chrysopogon*, the post-reproductive (15.11%) stage had high cellulose contents than vegetative (6.95%) and reproductive (5.50%) stages. *Digitaria* had insignificant differences in cellulose contents for reproductive (27.04%) and post-reproductive (27.40%) stages but it was slightly higher in vegetative (29.60%) stage. *Schoenoplectus* also followed similar trend. *Pennisetum* had 41.15%, 42.00% and

38.03% in vegetative, reproductive and post-reproductive stages respectively, exhibiting insignificant differences.

Table 39. Cell wall constituents of some forage grasses of Gadoon Hills, District Swabi.

Species	Phenological stage	NDF %	ADF %	Lignin %	Hemicellulose %	Cellulose %
1.Apluda mutica L.	Vegetative	65.36	45.56	2.7	19.8	41.86
	Reproductive	72	47.5	2.5	24.5	44
	Post-rep	73.24	42.32	2.6	30.92	38.82
	Average	**70.20**	**45.13**	**2.60**	**25.07**	**41.56**
2.Aristida adscensionis L.	Vegetative	68.04	46.05	2.5	21.99	42.25
	Reproductive	71	44.5	2	26.5	41
	Post-rep	66.37	41.32	1.9	25.05	38.42
	Average	**68.47**	**43.96**	**2.13**	**24.51**	**40.56**
3.Chrysopogon aucheri (Boiss.) Stapf	Vegetative	69.02	45.15	37.4	23.87	6.95
	Reproductive	74	49.5	43.5	24.5	5.5
	Post-rep	65.94	47.25	31.64	18.69	15.11
	Average	**69.65**	**47.30**	**37.51**	**22.35**	**9.19**
4.Digitaria sanguinalis (L.) Scop.	Vegetative	72.15	46.95	13.05	25.2	29.6
	Reproductive	75.04	43.52	11.51	31.52	27.01
	Post-rep	69.85	39.85	8.55	30	27.4
	Average	**72.35**	**43.44**	**11.04**	**28.91**	**28.00**
5.Heteropogon contortus (L.) P. Beauv.	Vegetative	71.35	36.54	24.6	34.81	10.04
	Reproductive	72.5	45	28.5	27.5	15
	Post-rep	67.39	37.42	26.77	29.97	9.35
	Average	**70.41**	**39.65**	**26.62**	**30.76**	**11.46**
6.Pennisetum orientale L. C. Rich.	Vegetative	68.87	47.65	5.5	21.22	41.15
	Reproductive	71.5	47.5	4.5	24	42
	Post-rep	72.01	42.85	3.92	29.16	38.03
	Average	**70.79**	**46.00**	**4.64**	**24.79**	**40.39**
*7.Schoenoplectus litoralis*Schrad.	Vegetative	59.94	38.75	4.6	21.19	33.15
	Reproductive	54.5	29.5	7.5	25	21
	Post-rep	53.14	27.53	3.37	25.61	22.56
	Average	**55.86**	**31.93**	**5.16**	**23.93**	**25.57**
8.Themeda anathera (Nees) Hack.	Vegetative	64.25	47.56	3.91	16.69	42.15
	Reproductive	68	42.5	2	25.5	39.5
	Post-rep	71.92	39.51	2	32.41	36.51
	Average	**68.06**	**43.19**	**2.64**	**24.87**	**39.39**

DISCUSSION

DISCUSSION

1. Floristic Composition and its Characteristics

Regional flora always saves time and provides precise information. Floristic composition is a reflection of physiognomy, floristic diversity, environmental and biotic influences. The flora of Gadoon Hills, District Swabi comprised of 260 plant species belonging to 211 genera and 90 families. Of them, 77 families were Dicots, 7 Monocots, 4 Pteridophytes and 2 Gymnosperms. Our findings are in line with Hussain *et al.*, (2004) who reported 256 species belonging to 90 families from the various parts of District Swat. They also reported bryophytes, pteridophytes, gymnosperms, monocots and dicots in their area. The present list had 67% similarity in species composition with Chagharzai Valley, District Buner enlisted by Sher & Khan (2007). Similar floristic list was also presented by Sher *et al.* (2011) with whom there is agreement in terms of species. This might be explainable due to similar environmental protocol as the area is adjacent to Buner. In the present endure the leading family was Asteraceae with 23 species which was followed by Poaceae (18 spp.), Lamiaceae (13 spp.), Rosaceae & Papilionaceae (each with 11 spp.) and Brasicaceae (10 spp.). Asteraceae, and Poaceae were the largest families from coastal desert plain of southern Sinai, Egypt as reported by El-Ghani & Amer (2003). Thus, our results support their findings. Durrani *et al.* (2005) reported 202 species of 45 plant families from Harboi rangeland (Kalat, Pakistan). Asteraceae, Papilionaceae, Poaceae, Brassicaceae and Lamiaceae were also the leading families in their investigation. While studying the flora of Mastuj, District Chitral, Hussain *et al.* (2007) recorded that Asteraceae (11 spp.), Papilionaceae (10 spp.), Rosaceae (9 spp.), Brassicaceae and Polygonaceae (5 spp. each) were the leading families in terms of number of species. Our results agree with them. Similarly, Sher & Khan (2007) recorded Asteraceae as the leading family with 21 individuals followed by Papilionaceae (12 spp.), Lamiaceae (10 spp.), Poaceae and Rosaceae (each with 9 spp.) from Chagharzai Valley, District Buner. Mood (2008) also reported Asteraceae (22 species), Chenopodiaceae (16 species), Brassicaceae (11 species), Lamiaceae (10 species), Caryophyllaceae (9 species), Poaceae (8 species), Fabaceae (8 species) and Boraginaceae (8 species) as the dominant families. Perveen *et al.* (2008) recorded Poaceae (12 sp.) as the largest family followed by Papilionaceae (7 sp.) and Asteraceae (6 sp.) from Dureji game reserve. Similarly, Qureshi (2008) identified

Poaceae (18.38%), Fabaceae (8.82%), and Amaranthaceae (5.15%) as the leading plant families from Sawan Wari of Nara Desert. Böcük *et al.* (2009) reported Asteraceae (72 sp.) as the largest family under natural and anthropogenic effects in Phrygia Region (Central Anatolia, Turkey). Yemeni & Sher (2010) prepared a floristic list of 189 species belonging to 74 families from Asir Mountain of the Kingdom of Saudi Arabia. Asteraceae was the dominating family in their study area. Durrani *et al.* (2010) enlisted Asteraceae, Fabaceae, Poaceae, Brassicaceae, Lamiaceae and Boraginaceae as important families in the protected area of Aghberg rangelands of Quetta Pakistan.

The ecological characteristics of the flora such as life form and leaf spectra were studied in order to evaluate the biotic and anthropogenic interference responsible for the present vegetation structure and physiognomy. Life form and leaf spectra are important because it shows the ecological amplitude and tolerance of the species (Cain & Castro, 1959). The biological spectrum of Gadoon Hills showed that therophytes and megaphanerophytes were the most abundant. The dominance of therophytes and phanerophytes is the characteristic life forms of many areas as reported by a number of studies (Costa *et al.*, 2007; Sher & Khan, 2007; Manhas *et al.*, 2010; Yemeni & Sher, 2010). Frequent therophytes and chamaephytes are the indicator of typical desert life form spectrum (El-Ghani & Amer, 2003). The dominance of therophytes and microphylls indicated that the investigated area was under heavy biotic pressure due to deforestation and over grazing. Our findings are in line with those of Durrani *et al.* (2010), Yemeni & Sher (2010) and Sher & Khan (2007) who also recorded similar results in their areas. The life form is a vegetative form of plant body but it is a hereditary adjustment to environment (Cain & Castro, 1959). In the present endure it was found that the grasses were dominant in xeric conditions while pteridophytes and other sciophytes were present below forest canopy and moist conditions. Life form and leaf size spectra indicate climatic and human disturbance of a particular area (Sher & Khan, 2007; Durrani *et al.* 2010; Yemeni & Sher, 2010). Taxing the vegetation of Gadoon Hills in many ways such as cutting and lopping of trees, extraction of fuel wood, clearing of forests for cultivation and grazing land and setting natural vegetation to fire, the increasing population has shaped the present landscape, the very reflection of the human needs and socioeconomic conditions. Agriculture stands on the top and livestock industry ranks

second. Forests are gradually dwindling through illicit cutting and insufficient regeneration due to heavy grazing combined with soil degradation and increasing desiccation of the environment. Many plant species were decreasing in the area. It would be the moral and ethical duty of the local people to protect the plant resources. Most of the medicinal plants were uprooted for burning purposes and grazed by the livestock. It therefore, seemed appropriate to manage the grazing system. Most of the fuel wood and timber wood was extracted from these forests. Even fruiting trees were also grazed by animals and used for burning. The forests were refuge for valuable and endangered animals. Further study is needed to quantify the data and suggest plans for the conservation of the area.

2. Ethnobotanical profile

Man has been using plants for different needs for time immemorial. The people of Gadoon Hills also have a rich traditional knowledge regarding the use of local flora for various purposes. The aboriginals depend on agriculture, fuel and timber wood selling, livestock and other natural resources of the area for earning their daily livelihoods. Gadoon Hills have rich plant diversity in relation to local uses. These included medicinal (149 Spp.), fodder (82 Spp.), fuel wood (59 Spp.), vegetable (26 Spp.), thatching/ roofing and sheltering (25 Spp.), fruit yielding (22 Spp.), fencing (17 Spp.), ornamental (16 Spp.), timber wood and poisonous (14 Spp. each), agricultural tools making (10 Spp.) and honeybee (8 Spp.) while 30 species have no known local uses. Similar ethnobotanical profile from other parts of Pakistan have been reported (Durrani *et al.*, 2010; Hazrat *et al.*, 2010; Hussain *et al.*, 2004, 2005, 2007) and the uses of plants agree with present findings.

The use of medicinal plants appears to be major utility. These plants are mostly used as crude powders, decoction, herbal tea, juices or sometimes cooked with flour, sugar and ghee (Halwa). Some of the plants are used individually, while others in mixture. Many plant species have single or multiple medicinal uses. Sher & Hussain (2009) reported that medicinal plants are an important source of drugs in traditional system of medicine. Among such plants *Acacia modesta*, *Acorus calamus*, *Adiantum incisum*, *Ajuga bractiosa* , *Ammi visnaga*, *Berberis lycium*, *Calotropis procera*, *Coriandrum sativum* , *Cucimus prophetarum* , *Fumaria indica*, *Mentha longifolia* , *Mentha spicata* , *Morus alba*, *M. indica* , *Oxalis corniculata*, *Plantago lanceolata* , *Punica granatum* , *Valeriana jatamansii*, *Verbascum thapsus* and *Viola*

serpens are commonly used to cure various ailments. Our findings agree with them as these plants are also used for curing various ailments in Gadoon Hills. Sher *et al.*, (2011) also reported the same plants used for similar diseases in traditional system of health care in Chagharzai valley, District Buner. Some of the plants such as *Paeonia emodi, Zizyphus oxyphylla, juglan regia* and almond etc. were purchased from the market for preparing some recipes advised by local hakims as these plants are not available locally. Fifty seven percent of the local plants are used as medicine. The findings agree with those of Hazrat *et al.*, (2010), Sher *et al.*, (2003, 2004), Hussain *et al.*, (2004, 2005, 2007), and Ibrar *et al.*, (2007) with respect to medicinal uses. Khan & Khatoon (2007) also presented useful plants of Gilgit and some of the uses and species agree with the present findings.

Trade of medicinal plants is not a common practice in Gadoon Hills however; some medicinal plants like *Acacia modesta* (gum Acacia), *Acorus calamus, Berberis lycium, Valeriana jatamansii* and *Viola Spp.* are collected occasionally by shepherds while grazing their goats and sheep and sold to local market. The main focus of these herders is on their livestock having no soft corner for the regeneration and conservation of plant diversity specifically medicinal plant species. Resultantly valuable medicinal and other plants are grazed and trampled. It therefore, becomes important to manage the grazing system and encourage the sustainable use of these plants.

Livestock is a very important component of the rural life. Free grazing is the common practice in the investigated area. Grazing alters the spatial heterogeneity of vegetation, influencing ecosystem processes and biodiversity (Adler *et al.*, 2001; Durrani *et al.*, 2005; Ibrar *et al.*, 2007). Some 82 (31.54%) plant species are used as fodder. The present findings suggest that the excessive dependence on fodder species particularly trees and shrubs have increased their vulnerability. Some important trees (*Acacia catechu, Celtis australis, Cotoneaster bacillaris, Grewia optiva, Melia azedarach, Morus indica, Parrotiopsis jacquemontiana, Prunus cornuta, Quercus dilatata, Q. incana* and *Vibernum cotinifolium*) and shrubs like *Berberis lycium, Debregeasia salicifolia, Gymnosporia royleana, Indigofera heterantha, Rosa moschata* and *Zizyphus nummularia* play a pivotal role as forage for livestock particularly in springs and summers. The present findings agree with Roothaert & Franzel (2001) who reported indigenous knowledge and farmer's preferences about the use of 160 species of trees and shrubs as fodder in Keneya. Ajaib *et al.*, (2010)

and Sardar & Khan (2009) also reported some palatable shrub species that are being over grazed. Hence, our findings are in line with them. Grasses are usually protected in patches for winter feeding in the study area. Before the commencement of winter, the grasses are harvested, dried and put into a stake. The harvesting is done collectively, and then during the bare and cold months of winter, these are fed to the domestic animals. The most common fodder grasses are *Apluda mutica, Aristida adscensionis, Arthraxon prionodes, Avena sativa, Chrysopogon aucheri, Cynodon dactylon, Dichanthium annulatum, Digitaria sanguinalis, Heteropogon contortus, Imperata cylindrica, Pennisetum orientale, Sorghum helepense* and *Themeda anathera*. Haq *et al.* (2010) reported 258 fodder species including trees, shrubs, grasses and forbs from Nandiar Valley Western Himalaya; they concluded that stake grasses are the only available fodder in hilly areas during winter and the same is true for present findings in the investigated area. The findings also agree with those of Badshah & Hussain (2011) who reported farmer's preferences for fodder species as some species are the same as reported in the present study.

People living in Gadoon Hills are mostly poor and lack the basic facilities. They depend on fuel wood for domestic and livelihood earning. The most common plant species used as fuel for domestic purposes are *Ailanthus altissima, Broussonetia papyrifera, Debregeasia salicifolia, Dodonaea viscosa* and *Gymnosporia royleana* along with other shrub species. The branches and cones of *Pinus wallichiana* and *P. roxburghii* are source of fuel wood. *Acacia catechu, A. modesta, Bauhinia variegata, Butea frondosa, Melia azedarach, Mallotus philippensis, Morus* spp., *Quercus spp.* are sold outside the area. Nearly twenty-two percent of the total recorded plant species were used as fuel wood. Most of the economically important plants like *Pinus wallichiana, P. roxburghii, Acacia catechu, A. modesta, Bauhinia variegata* and *Quercus spp.* are decreasing due to over cutting. All these species, which have high fuel value, are severely damaged. These include *Acacia catechu, A. modesta, Dodonaea, Melia* and *Quercus*, which are decreasing in the area. Similar findings were reported by many workers from their respective area (Khan, 2000; Awan, 2000; Ogunkunle & Oladele, 2004; Ajaib *et al.*, 2010; Haq *et al.*, 2010).

Food availability is another problem in the area due to inaccessibility and deprived purchase power of the local inhabitants. Therefore, women and young girls collect the wild vegetables from their nearby area to fulfill their needs. Twenty-six species are being used as vegetables and pot-herbs comprising about 10% of the total

reported plants. The cultivated species are *Allium cepa*, *Allium sativum*, *Brassica compestris* and *Luffa cylindrica*. Wild species included *Amaranthus viridis*, *Asparagus officinalis*, *Chenopodium album*, *Malva neglecta*, *Medicago polymorpha*, *Mentha longifolia* and *Portulaca oleraceae*. Wild vegetables have also been reported by many workers from other areas (Sher *et al.*, 2011; Barkatullah *et al.*, 2010; Hussain *et al.*, 2005; Ibrar *et al.*, 2007; Begum *et al.*, 2005) and all studies include the presently reported species.

Thatching, sheltering and roofing are other important economic uses of local vegetation (Badshah *et al.*, 1996; Sher *et al.*, 2003; Hussain *et al.*, 2004; Ibrar *et al.*, 2007). Barkatullah *et al.*, (2010) and Sher *et al.*, (2011) reported 11 and 25 plant species, respectively used for this purpose from their study areas. In the present endure 25 (9.62%) plant species including *Ailanthus altissima*, *Dodonaea viscosa*, *Indigofera heterantha*, *Justicia adhatoda*, *Morus alba*, *Quercus spp.*, *Saccharum spontaneum* and *Saccharum bengalense* are used for thatching, sheltering and roofing by local people. Our findings are in line with as similar plants are used for the same purposes.

Fruit yielding are economically important, but the wild fruits plants are decreasing continuously due to biotic pressure. In the present endure 22 plant species (8.46%) were recorded as edible fruits. Among them six species, *Diospyrus kaki*, *Diospyrus lotus*, *Morus alba*, *Punica granatum*, *Pyrus pashia*, and *Zizyphus jujuba* are cultivated. The remaining species including *Berberis lycium*, *Celtis australis*, *Rubus ulmifolius*, *Zizyphus nummularia*, *Ficus cairica*, *Ficus palmata*, *Fragaria indica* are wild. Sher *et al.*, (2011), Barkatullah *et al.*, (2010), Ibrar *et al.*, (2007), Begum *et al.*, (2005) and Hussain *et al.*, (2005) also reported almost similar species from adjoining parts, thus strengthening the present findings. Wild fruit plants are generally neither protected nor marketed. They are frequently subjected to grazing, lopping for fuel wood or other purposes. This has not only reduced the natural vegetation cover but also threatened some of the species.

Free livestock grazing is a common practice in Gadoon Hills, therefore, the people protect their crop fields and livestock shed by planting thorny, bushy or spiny plants along crop fields and sheds. *Berberis lycium*, *Gymnosporia royleana*, *Opuntia dilleni*, *Otostegia limbata*, *Rosa moschata*, *Rubus spp.*, *Zanthoxylum aromatum* and *Zizyphus nummularia* are important species for this purpose. Similar utility of these

species have also been reported by Durrani, (2000), Hussain *et al.* (2005, 2007) and Ibrar *et al.*, (2007).

Sixteen plant species (6.15%) were classified as ornamental plants. Among them *Cynodon dactylon*, *Mirabilis jalapa*, *Narcissus tazzeta*, *Nerium indicum*, and *Tinospora cordifolia* were cultivated while *Adiantum venustum*, *Asparagus adscendens*, *Rhododenron arborium* and *Rosa moschata* are wild. Although ornamental plants are commercially not exploited yet they have a good potential source of income generation. *Adiantum*, *Narcissus*, *Asparagus*, *Rosa* and *Jasminum* are strong candidates for commercialization.

Poisonous plants can prove fatal and some cause reaction. Many other studies (Dogan & Ok, 2000; Dogan *et al.*, 2005; Hazrat *et al.*, 2007; Ozturk *et al.*, 2008; Barkatullah *et al.*, 2010) have also reported such plants. In the present investigation fourteen plant species (5.38%) including *Datura innoxia*, *Euphorbia helioscopia*, *Polygonum barbatum* and *Urtica dioca* are considered poisonous to man, livestock or fish. These poisonous plants can be exploited as source of medicines.

Extraction of wood in large quantities for timber and fuelling on daily basis from natural vegetation is a matter of great concern (Ogunkunle & Oladele, 2004; Hussain *et al.*, 2005, 2007; Barkatullah *et al.*, 2010). Forests easily fulfill the requirements of the local people, but the activities of the timber maphia have greatly damaged the natural vegetation (Hussain *et al.*, 2005; Ibrar *et al.*, 2007). In the present study 14 (5.38%) species including *Ailanthus altissima*, *Melia azedarach*, *Morus spp.* *Pinus roxburghii*, *Pinus wallichiana*, *Pistacea integrima*, *Platanus orientalis*, and *Salix* are used as timber wood. An effort is needed to restore the rehabilitation of these plants for better future.

Being deprived and due to poor socioeconomic conditions the tribal in Gadoon Hills carry out agriculture in primitive traditional way by using traditional wooden/iron tools. The present study recorded eleven species (4.23%) that are being used for making agricultural appliances including ploughs, sticks, sickle handles, axe handles, pullies, knife handles and other agricultural appliances. *Acacia nilotica*, *Albizia lebbeck*, *Cotoneaster bacillaris Parrotiopsis jaequimontiana* and *Quercus spp* are preferred in this respect. Similar traditional uses of wooden appliances have been reported by other workers (Sher *et al.*, 2011; Barkatullah *et al.*, 2010; Ibrar *et al.*, 2007).

Commercial honey production in Gadoon Hills could be an important income generation. The people collect honey from the wild and use for their own need.

Honeybees visit eight species (3.08%). *Acacia modesta*, *Justicia adhatoda*, *Plectranthus rogosus*, *Sarcococa saligna* and *Zizyphus spp.* are important plant species for honey bees. Honey obtained from *Plectranthus rogosus*, and *Zizyphus spp.* is considered to be the best quality, which is extensively used in the preparation of traditional medicines.

It is a worldwide settled fact that indigenous communities have acquired knowledge through trial and errors about plants and other natural resources on which they are immediately dependent. But this fragile knowledge is disappearing due to erosion of traditional cultures. The same is true for Gadoon Hills where the younger generation knows nothing about the economic uses of the local vegetation. Thirty plant species (11.54%) were declared as weeds by the local people while collecting the data. These species may have some economic uses in other parts of the country. The area is under heavy biotic pressure in the form of deforestation and overgrazing, which has been considerably reduced regeneration of woody plants. Human population explosion, uprooting of medicinal plants by the local people, and other casual factors are responsible for habitat loss, soil erosion and proper functioning of ecosystems. There is dire need to conserve the biodiversity of the area in order to provide the resources and resource alternatives for our own survival in future.

3. Range Vegetation Structure

A. Edaphology

Gadoon hills are characterized by a great diversity of soil due to wide differences in natural factors leading to the soil formation such as parent material, relief, time, climate and living matter. Other activities like deforestation, erosion, overgrazing and compaction due to trampling of livestock also lend a hand to modify the soil. The colour of the soil varied greatly in Gadoon hills. The light colour soil was present in open places with poor vegetation cover. Dark colour soils were present in the communities/stands that supported *Quercus dilatata* and *Acacia catechu* forests. Similar dark colour soils have been reported by Hussain & Ilahi (1991). Thus, our findings agree with them. These communities also accumulated thick layers of litter on the ground. Our results support the findings of Daubenmire (1974) and Hussain & Ilahi (1991) who also reported thick litter layers under the canopy of thick forests in their study areas. Durrani (2000) also reported variation in soil colour and texture in Harboi rangeland.

Soil texture in Gadoon hills varied from sandy to sandy loam. Texture of the soil play a key role in water and nutrient relation in soil. Similar soil texture was also reported by Hussain *et al.*, (2000) during vegetation studies on Ghalegay hills, District Swat. The yellowish brown colour of the soil may be due to low drainage because of hard bed rocks present beneath the thin layer of soil. The decay process of the litter layer in Gadoon hills was very slow, particularly in *Quercus* forests, probably because of low moisture contents, lack of sufficient microorganisms and might there are other constraints. Resultantly, a thick layer was always present beneath these forests imparting black colour to the soil. Soil erosion was common ecological problem in many parts of Gadoon hills. Similar soil losses due to erosion were recorded during vegetation studies in District Swat (Hussain *et al.*, 1995, 1992). Deforestation and overgrazing of shrubby component in the area are the two main factors which had amplified soil losses due to erosion. Resultantly, the shrubby components had stunted growth and the herbaceous layer was mostly dominated by grasses.

Moisture, erosion, weathering, litter and soil heterogeneity are responsible for amendments in soil composition. These factors also cause variations in soil nutrients. In arid and semiarid areas, the high soil pH cause disturbance in availability and solubility of soil nutrients (Brady, 1990, 1999). The soil pH of Gadoon hills varied from 5.2 to 7.64 in different stands. This might be one of the causes of non-availability of soil minerals to the plants.

Macro and micro-minerals in the soil play a significant role in plant growth, development and setting of flowers and fruits. The Ca levels in the soil of Gadoon hills ranged from 19.63 to 213.95%. Khan *et al.*, (2007b) reported higher concentration of Ca, Cu, Zn and Na contents in the pasture soil of Rakh Khiare Wala, Punjab. Cu, Zn and Na were also found in low concentration compared with pasture soil of Rakh Khiare Wala. Our results disagree with their findings. It is concluded that the soil of Gadoon hills was facing a number of threats which need proper management for sustainable use.

B. Vegetational Features

Vegetation structure is the organization of the individuals in space that form a stand. The five levels of vegetation structure are floristic composition, community/stand structure, physiognomy, life form structure and biomass structure. Physiognomy is the external appearance of vegetation. Floristic composition, physiognomy and structure of the vegetation depend upon the local flora. A natural

community is admixture of unequal successful species. The dominant species not only affect the structure and function of subordinate species but also determined the structure and diversity of community (Hussain & Ilahi, 1991). Kashian *et al.* (2003) reported that classification, composition and distribution of plant communities are at the core of vegetation science for centuries.

Based on cluster analysis the summer and winter vegetation (13 stands) of Gadoon Hills have been classified into three distinct vegetation types i.e. dry tropical (400-650 m), sub-tropical (800-1350 m) and temperate (1750-2250 m) zones, at different altitudinal confines. Ahmed *et al.* (2007) stated the relationship between vegetation types, elevation, soil composition and soil mineral contents as decisive factors to describe the plant diversity. Each zone possesses characteristics in physiognomy and structure. Similarly, each unit is sufficiently large enough to permit its differentiation from other such units. Kaul & Sarin (1994) described a mixed oak-blue pine forest in between 1600-1900 m in Bahadarwah hills, India. Coventry (1929) reported mixed forest of *Pinus walichiana* and *Quercus incana* in lower temperate zone between 1600-2600 m in the Punjab. Similarly, Champion *et al.* (1965) and Hussain & Ilahi (1991) described lower temperate forests consisting of *Pinus wallichiana* and *Quercus incana* in between 1600-1900 m. Thus, our findings agree with them.

The overall floristic list of the area was composed of 260 species but only 118 plant species (106 species in summer and 99 species in winter) were encountered during sampling of communities. On the basis of importance values, 21 species acquired the status as first, second and third dominants in various communities of summer vegetation; while 23 species in winter aspect attained the same status. *Acacia modesta, Butea frondosa, Mallotus philippensis, Dodonaea viscosa, Zizyphus nummularia, Otostegia limbata, Sageretia theezans, Justicia adhatoda, Themeda anathera, Heteropogon contortus, Digitaria sanguinalis, Dichanthium annulatum, Apluda mutica, Aristida adscensionis* and *Micromeria biflora* were the common species in these communities during both the seasons of tropical deciduous zone. Sub-tropical vegetation of the area was composed of two communities in summer and winter aspect, supporting the common species like *Acacia catechu, Butea frondosa, Celtis australis, Grewia optiva, Dodonaea viscosa, Gymnosporia royleana, Indigofera heterantha, Heteropogon contortus, Themeda anathera, Chrysopogon aucheri, Asplenium adiantum-nigrum, Geranium wallichianum, Chrysopogon aucheri*

and *Cyperus niveus*. While *Pinus roxburghii, Quercus dilatata, Quercus incana, Prunus cornuta, Lonicera quinquilacularis, Lonicera hypoleuca, Parrotiopsis jacquemontiana, Vibernum cotinifolium, Berberis lycium, Rhododenron arborium, Sarcococa saligna, Imperata cylindrica, Duchesnea indica, Plantago lanceolata, Geranium wallichianum, Ajuga bractiosa, Gallium aparine, Gentiana kurru, Fimbristylis dichotoma, Valeriana jatamansii, Viola serpens, Ceterach dalhousiae, Bergenia ciliata, Bistorta amplexicaulis* and *Hedera helix* were the common species of temperate forests.

The survival and organization of a community reflects the plant type and habitat conditions under which they grow (Malik, 1986). In lower Gadoon hills, the tree layer, particularly *Acacia modesta*, was restricted to steep slopes and inaccessible sites in patches, absolutely due to excessive cutting and browsing or highest fuel wood value for tobacco barns all such factors were very common in the study area. Shah *et al.* (1991) recorded the differences among various communities due to exposure, microclimate, edaphic and biotic factors. *Acacia modesta*, being a keystone species of the area produces a desert like situation in its absence. Aggressive *Dodonaea viscosa* was well distributed. Most of the annual forbs were replaced by perennial grasses. Similar findings have been reported by many workers in their studies (Beg & Khan, 1980; Hussain & Shah, 1989; Hussain *et al.*, 1992; Badshah *et al.*, 1996; Awan *et al.*, 2001).

Forests in Gadoon Hills are still dwindling through tree cutting and poor regeneration due to heavy grazing combined with soil degradation and increasing desiccation of environment under small erratic precipitation. The grasslands are heavily grazed over prolonged periods beyond their carrying capacity. As a result, unpalatable, spiny and poisonous species like *Otostegia limbata, Dodonaea viscosa* and *Justicia adhatoda* have increased. Our results are in line with Mosugelo *et al.* (2002) who also reported the scrubland vegetation increased from 5% to 33% while the woodland vegetation decreased from 60% to 30% in northern Chobe National Park (Botswana). Salvatori *et al.* (2003) also suggested that vegetation in 46% of the Reserve area was converted from scrubland to grassland, possibly as a result of fire and grazing pressure. Prolonged overgrazing have denuded the land and exposed the soil to water and wind erosion in the present investigated area. Consequently, it has suffered heavily and to a point of no return. Largely as a result of many centuries of human interference the vegetation is highly heterogeneous and almost entirely open.

The vegetation is represented only by relics here and there especially in protected places. These relics however do permit rebuilding of picture of original vegetation to a certain extent but they too are under heavy pressure. Trees have gone and scrub took over. Elsewhere scrubs too, have been replaced by grassland. Our results do support the findings of some other workers (Hussain & Shah, 1989; Hussain *et al*., 1992, 1997; Chughtai & Ghawas, 1976) who also reported that the original vegetation of Swat has been replaced by open scrubs and grasslands, through deforestation, terrace cultivation, overgrazing and fire.

Khan *et al.*, (2010) reported *Quercus* as co-dominant at high altitude. Beg & Khan (1980, 1984) reported three plant communities in dry Oak forest zone in Swat. The upper parts of Gadoon Hills has Chir pine forest alone or mixed with *Quercus dilatata* and *Q. incana* as well in tree layer. The shrub layer is more or less developed; the herbaceous layer is rather poorly represented. The shrub layer is dominated usually by one or two species such as *Berberis lycium* and/or *Indigofera heterantha*. These are the remnants of climax ban oak forests which, in the past used to cover the vast areas. It suffered heavily human disturbances. These species have palatable foliage, durable wood and good fuel wood. Deforestation, trampling, soil erosion and over-grazing were the crucial ecological factors in the destruction of original vegetation and degradation. Similar findings were also recorded in other studies (Hussain & Shah, 1989; Hussain *et al*., 1992, 1997; Chughtai & Ghawas 1976) in the adjoining areas.

Life form and leaf size spectra

The life forms of different species recorded from Gadoon Hills were classified into major types after Raunkiare (1934). Biological spectrum is an important ecological tool in the description of structure of vegetation (Mueller-Dombois & Ellenberg, 1974; Shah *et al.*, 1991; Hussain *et al.*, 1995). Saxina *et al*. (1987) described that biological spectrum is formed when all the species of plants of a community are classified into life form classes and their ratio expressed in percentage. Life form and leaf size spectra are important physiognomic attributes which has been widely used in vegetation studies as indicators of climate, microclimate and mesoclimate (Cain, 1950; Shimwell, 1971). Raunkiaer (1934) stated that the climate of a region is characterized by life form. However, deforestation, overgrazing and habitat degradation modify the proportion of life forms. Biological spectra are useful in comparing geographically widely separated vegetation stands and are also regarded

as an indicator of existing situation. Occurrence of similar biological spectrum in different regions indicate similar environment.

In the present endeavor the Raunkiarian value and quantitative values do not coincides each other. Raunkiarian value of flora of different plant communities indicated that therophytes and nanophanerophytes were dominant life forms during summer and winter seasons. Quantitatively, nanophanerophytes and megaphanerophytes were dominant life forms in most of the plant communities both in summer and winter. Cain & Castro (1959) and Shimwell (1971) reported that therophytes are the indicator of desert and highly disturbed environment. Malik *et al.* (1994, 2001) observed therophytes as the major life form class in the moist temperate part of Dhirkot. Barik & Misra (1998) reported therophytes as dominant group in grassland ecosystem of South Orissa. The present findings regarding the dominance therophytes agree with them. Shrubs replaced the trees due to excessive cutting for timber and fuel wood in the investigated area. Nanophanerophytes are the indicators of harsh unfavorable climatic conditions as exist in the present investigated area. Similar results regarding the dominance of nanophanerophytes were also observed in Harboi rangeland (Durrani, 2000). Although, Gadoon Hills has great potential for the growth of trees and shrubs if properly managed.

Raunkiarian leaf size spectra indicated the dominancy of microphyllous species in plant communities of Gadoon Hills during summer and winter seasons. They were followed by leptophylls. Quantitatively, leptophylls were dominant followed by microphylls. Higher percentage of leptophylls was observed in the dry subtropical semi-evergreen forest of Kotli Azad Jammu and Kashmir (Malik & Hussain, 1990). The present findings agree with them. Microphyllous and leptophyllous leaf size spectra are excellent strategic measures of plants to manage with adverse environmental and deteriorated habitat conditions because of overgrazing and deforestation. Cain & Castro (1959) and Tareen & Qadir (1987, 1993) stated that microphylls are usually characteristic of steppes, while leptophylls are characteristic of hot deserts. Greller (1988) described that the relationship between small leaves and desert climate is one of the important adaptive features for retaining moisture. The soil in hilly areas is generally poorly developed therefore roots feels difficulty in assimilating water. Saxina *et al.* (1987) reported that with the increasing altitude the percentage of microphylls also increased. Our findings support their results because in the present study the Raunkiarian value of microphylls was

high throughout, at all altitudes. Oosting (1956) described that leaf size acquaintance may help in understanding of physical process of plants and communities. The present investigation also recorded that the plant communities of Gadoon Hills is under intense environmental and biological stresses which have modified the vegetation pattern of the studied area. The Raunkiarian and quantitative spectra differ because Raunkiarian spectra are based on number of species whereby all species have equal importance irrespective of the numerical strength. Since quantitative spectra are based on numerical data such as density, cover, frequency and importance value, therefore the outcome is entirely different. Quantitative spectra are more close to the natural situation present actually in the field.

Homogeneity of Communities

The plant communities inhabiting Gadoon Hills during summer and winter were mostly heterogeneous. Only two communities, one each in summer and winter were, homogeneous. The homogeneous nature of communities was credited to few species that had uniform distribution. Similar homogenous vegetation in overlapping manner was also observed by Ali & Malik (2010a) in the green belt and parks of Islamabad city. The majority of the communities showing heterogeneity might be due to the presence of large number of annuals particularly grasses and habitat and state of degradation, overgrazing, trampling and soil erosion in the study area. Although the sites lie within the same general climate but differ in soil condition. Deforestation, overgrazing and other anthropogenic activities were the main culprits responsible for the degradation of phytodiversity of the investigated area. Malik & Husain (2008) and Shiyomi *et al.* (2001) recorded similar results in their study. The present findings are similar to them. Durrani (2000) also recorded 60% heterogeneity in plants communities of Harboi range, which are similar to the present case.

Similarity Indices

The degree of similarity between two communities allows merging them into one association or vegetation type. The greater similarity indices between the summer plant communities was observed between PIC and PBI (69.56%) communities and PBP and PBI (51.79%) communities. The similarity value between PBP and QBF communities was 45.50% and 41.28% between ZC and ADC communities. While during winter greater similarity was found between PBI and PIC (36.82%) communities and PBI and PBG (24.68%) communities. The remaining communities were dissimilar. Our results are in line with Hussain *et al.* (1997) who reported

highest similarity values between the plant communities inhabited on slopes with similar aspect and habitat conditions while low similarity values were recorded between plant communities having differences in habitat features. Hussain & Malook (1984) and Shah *et al.* (1991) reported that differences among the plant communities were because of topography, exposure, biotic interference and soil erosion.

Species Diversity, Richness and Maturity

Species diversity refers to the variety and variability among the organisms and ecosystem complexes in which they occur. It is an important feature of any vegetation type which not only reflects health of vegetation but also its productivity (Hussain, 1989). Ardakani (2004) stated that species diversity is the most important index used to evaluate the ecosystem biodiversity. Many studies recognizes the relationship among species diversity, species richness, climate and other ecological factors (Vetaas, 2000; Nautiyal *et al.*, 2001; Kala & Mathur, 2002, Hussain and Ali, 2006; Panthi *et al.*, 2007; Peer *et al.*, 2001, 2007). In the present study the highest index of diversity (0.29) was observed for *Quercus-Berberis-Fimbristylis* community during summer while the lowest value (0.05) was recorded for *Acacia-Dodonaea-Heteropogon* community. During winter highest value for index of diversity (0.16) was observed for *Prunus-Berberis-Poa* community. The lowest value (0.05) was observed for *Acacia-Dodonaea-Heteropogon* community. Habib *et al.* (2011) observed the highest species diversity (2.71) in Garhi Dopatta Hills at low altitude which decreased with increasing altitude. Our findings disagree with them. This might be the cause in our case that the recorded data showed inconsistent behavior regarding the relationship between species diversity and altitude. Highest species diversity was recorded in comparatively more disturbed communities. Kumar & Bhutt, (2006) and Ram *et al.* (2004) related lower plant diversity with deforestation, human interaction, collection of medicinal plants and quick disappearance of annual plants because of unfavorable conditions. Species diversity in Gadoon Hills was high in summer that decreased in winter because many annuals and geophytes disappeared during winter. Similar findings have been reported in many studies (Hussain & Ali, 2006; Peer *et al.*, 2001, 2007; Habib *et al.*, 2011) that support the present trend.

Species richness refers to variety and species density. Shimida & Wilson (1985) reported that species richness in an area depends upon the combined effects of habitat diversity, mass effects and ecological equivalency. Species richness was more or less similar in all the plant communities in both the seasons of Gadoon Hills. It was

generally high in the area during both the summer and winter communities. It ranged from 0.89 (*Quercus-Berberis-Fimbristylis* community) to 2.14 (*Acacia - Dodonaea - Heteropogon* community) in summer communities while during winter it varied from 1.12 (*Pinus-Berberis- Gentiana* community) to 2.41 (*Acacia - Dodonaea-Heteropogon* community). Our findings agree with Qadir & Ahmad (1989) and Durrani (2000) who reported high species richness in their findings. Tareen & Qadir (1987, 1990, 1991) observed low species richness/ diversity for plant communities of Quetta.

The maturity index during summer varied from 42 (*Acacia-Dodonaea-Heteropogon* community) to 76.67 (*Quercus-Parrotiopsis-Viola* community) while in winter the maturity index ranged from 39.38 (*Acacia-Dodonaea-Heteropogon* community) to 62.78 (*Quercus-Parrotiopsis-Adiantum* community). The highest maturity index in the studied area was due to the presence of shrubs and perennial grasses. Similarly, the observed maturity index in the plant communities of Harboi rangelands was high (Durrani, 2000) that supports our results.

4. Degree of Palatability

A. Seasonal availability of palatable species

Livestock, being an important industry, is playing a key role in the uplift of socioeconomic conditions of the inhabitants of Gadoon hills. Vegetationally and climatically the area can be divided as dry tropical, sub-tropical (lower Gadoon) and temperate (Upper Gadoon) regions. Temperate part is mostly covered with snow in winter months. Hence the people of the upper Gadoon migrate to lower parts for the sack of their animals in winter due to unavailability of forage. The area is a free rangeland coupled with grazing flocks of goats and sheep, declared as Guzara forest in 1961. The tree branches are cut and fed to the animals like buffaloes and cows in homes. A total of 82 plant species were palatable in the study area. Among them 22 species were trees, 12 species shrubs and 48 species were herbs. Omer *et al*., (2006) and Hussain & Durrani (2009a) also reported some trees, shrubs and herbs consumed as forage by animals from their study areas. The highly preferred tree species almost remained similar from April to August but decreased thereafter. The shrubby component of the existing palatable species was observed as valuable for goats and sheep while grasses for other livestock. Highly palatable shrubs were plentiful from April to August that decreased in September and October. Similarly, highly palatable

herbaceous species increased from April to August but decreased in the subsequent months. The present results agree with Omer *et al.*, (2006) and Hussain & Durrani (2009a) who also reported decreased productivity during winter in the high altitude pastures of Northern area and Harboi rangelands, respectively.

B. Differential Palatability

Grazing is the most economical way of utilizing rangeland vegetation and resource management. Palatability is a plant characteristic that refers to the relish with which plants or its parts or feed is consumed as stimulated by the sensory impulses of grazing animal (Heath *et al.*, 1985). While preference refers to selection of a plant species by the animal as a feed. Animal factors such as differential preference for forage species, age, stage of pregnancy, general health and hunger of animal; and plant factors including seasonal availability, degree of maturity, growth stage, phenology, morphological and chemical nature, relative abundance of associated species, accessibility to plants/sites and climate affect palatability (Grunwaldt *et al.*, 1994; Nyamangara & Ndlovu, 1995). Eighty two plant species were palatable among the total floristic list recorded in the study area. The remaining species possessed very low population therefore their palatability was not observed.

Among the 22 species of trees, *Albizia lebbeck* and *Butea frondosa* were absolutely non palatable even in the scarcity of forage plants in the investigated area. *Ailanthus altissima* was non palatable in April and May but it was rarely palatable in subsequent months and mostly palatable in August and September. *Ficus palmata* was highly palatable in April and May but gradually become rarely palatable and non palatable with maturity. *Flacourtia indica* was rarely palatable during April to June but non palatable thereafter. *Quercus dilatata, Q. incana* and *Pinus roxburghii* were non palatable but their tender leaves were usually mixed with grasses and wheat straw and fed to the animals in winter months under compulsion when no other forage was available in the range. Similar findings were recorded by Hussain & Durrani (2009a) and Kayani *et al.* (2007) for *Juniperus excelsa*. Our results are in line with them. Non palatability of these species at specific phenological stage may be due to the presence of certain phenolics, alkaloids and / or saponins and other poisonous or harmful substances. Many such studies have also related non palatability of plant species with the presence of secondary metabolites (Gardner *et al.*, 1996; Reyna & Gonzalez., 1996; Makulbekova, 1996; Kayani *et al.*, 2007; Hussain & Durrani, 2009). Secondary metabolites inhibit the enzyme activities (Borua & Das, 2000; Cremer & Eichner,

2000) and thus having a negative ecological role in plant herbivore interaction (Kayani *et al.*, 2007). These chemical features are considered anti-nutritional factors that reduce the palatability.

The people of Gadoon Hills mostly prefer goat rearing compared to sheep. This is probably due to greater availability of shrubs in the area to feed their animals even in the drought. Goat usually prefer shrubby components of the rangeland while sheep prefer grasses and forbs (Grunwaldt *et al.*, 1994; Wilson *et al.*, 1995; Khan, 1996). Likewise, Wahid (1990) reported that sheep and goat diet consisted of 53 to 81% shrubs in different rangelands of Balochistan. Among the shrubs, only one species (*Otostegia limbata*) was mostly palatable in April and May but it subsequently become rarely and non palatable with the passage of time. The remaining species are highly palatable. Evergreen shrubby component, particularly *Berberis lycium, Debregeasia salicifolia, Gymnosporia royleana* and *Zizyphus nummularia* were thickly populated and considered the best forage species by shepherds for their animals. Being highly palatable *Indigofera heterantha* also supplement these species in spring and summer as forage for livestock. The present findings disagree with Mori & Rehman (1997) and Rasool *et al.* (2005) who reported that the rangelands of Balochistan are deficient in nutritive forage. The present rangelands have enough forage with quality.

The availability of the herbaceous species is related to the degree of rainfall. The herbaceous component of the investigated area were highly palatable or mostly palatable if available except *Schoenoplectus litoralis* which is mostly palatable in April and rarely palatable in May and become non palatable thereafter. *Artemisia vulgaris* was rarely palatable in April andt non palatable later on. Similarly, *Rumex dentatus* was mostly palatable in April and May but becomes non palatable in the subsequent months. Perennial grasses like *Apluda mutica, Aristida adscensionis, Avena sativa, Chrysopogon aucheri, Cynodon dactylon, Dichanthium annulatum, Digitaria sanguinalis, Heteropogon contortus, Imperata cylindrica, Pennisetum orientale* and *Themeda anathera* were usually protected in patches for winter feeding. These grasses are harvested, dried and put into a stake. Haq *et al.* (2010) also reported that stake grasses are the only available fodder in hilly areas during winter and this is what is being practiced in the area.

Overgrazing is an important ecological factor in rangelands. The nomadic way of grazing serves to reduce the platable cover which ultimately reduces the species

diversity (Liu *et al.*, 1996; Hickman *et al.*, 1996; Batanouny, 1996; Makulbekova, 1996; Adler *et al.*, 2001; Ibrar *et al.*, 2007; Hussain & Durrani, 2007, 2008). Rasool *et al.* (2005) stated that the grazing system in Balochistan consists of 74% nomadic. Loesser *et al.* (2007) recorded remarkable loss of cover and species diversity due to grazing associated with drought in Arizona grasslands. Curtin (2002) described that differences in site productivity and plant tolerance to grazing were great that vary with climatic conditions. In the present investigation it was observed that nomadic way of grazing rather overgrazing reduced the palatable cover and diversity. It is concluded that Gadoon hills is an important rangeland that needs proper scientific management.

5. Productivity of shrubs and herbs

The sustainable use of plant resources depends upon the amount and dynamics of biomass productivity as influenced by climate, altitude and soil characteristics. Biomass is a measure of community's resources tied up in different species and is one of the best indicators of species importance within plant community (Hussain & Durrani, 2007). Altitude is one of the most important factors in determining the phytodiversity that strongly influences the temperature, especially in the temperate region, and the availability of soil moisture and nutrients (Soethe *et al.*, 2008). Olff *et al.* (2002) described the significance of plant biomass as component of the global carbon cycle and have implications for the distribution and abundance of herbivores. Many studies have reported the spatial distribution of phytomass in plateau and grassland ecosystems (Yang *et al.*, 2009; Epstein *et al.*, 1997; Jobbagy *et al.*, 2002; Sala *et al.*, 1988; Hussain & Durrani, 2007, 2009a). However, the pattern of phytomass with altitudinal variation is less understood concept than the pattern of phytodiversity.

Dodonaea viscosa, one of the most common and productive shrubs growing between altitudinal range 430-1345 m, produced biomass that varied from 5040 Kg/ha to 25500 Kg/ha. *Dodonaea* showed significant increase in fresh biomass from 430 m up to 500 m but it decreased with further increase in altitude (up to 1345 m). Namgail *et al.* (2011) recorded low biomass at foothills and at higher slopes and higher biomass in between these two extremes (a hump shaped relationship between aboveground phytomass and altitude) and concluded that this relationship was due to low rainfall and trampling/excessive grazing at lower slopes by livestock, and low

temperature and low nutrient levels at higher slopes. Similar trend in biomass productivity with altitudinal gradient were also found for *Otostegia limbata* and *Zizyphus nummularia* in the present investigation. *Carissa, Gymnosporia* and *Indigofera* showed inconsistent trend with fluctuation in altitude. *Berberis* showed a gradual decline but *Justicia* had increase in biomass productivity with increasing altitude. Similarly, the herbaceous component also had inconsistent trend in biomass productivity along the altitudinal gradient in the investigated area. Pande (2005) estimated that herbs and shrubs contributed minimum towards total biomass than trees in tropical dry deciduous disturbed teak (*Tectona grandis*) forests. Hussain & Durrani (2007) also observed a decline in biomass due to low rainfall, high temperature and other anthropogenic activities in Harboi rangelands. This agrees with present findings.

The total fresh biomass of different shrubs and herbs varied with altitudinal variations. The highest total biomass (shrubs and herbs) was observed at 500 m (63366 Kg/ha) and 600 m (61270 Kg/ha) because the tree layer has been completely destroyed and the biomass of these communities was mostly contributed by *Dodonaea viscosa* and *Zizyphus nummularia*. The lowest total biomass for shrubs and herbs was recorded at 2050 m (7675 Kg/ha) under the thick canopy of trees (*Quercus* forests). Similar trend in biomass productivity was observed for other herbs and shrubs also. Our findings agree with Pande & Patra (2010) who recorded low biomass in open canopy forests compared with closed canopy forests. The lowest biomass of shrubs and herbs might be due to closed form communities having no spaces for shrubs and herbs. Kumar *et al.* (2011) also reported that the herb biomass and net primary productivity decreased significantly ($P < 0.01$) with increase in the forest age. Thus our results are also in line with them.

The present study suggests that the biomass productivity of shrubs and herbs severely declined due to low rainfall during the investigated years. Most of the shrubs and herbs were observed with the symptoms of temporary wilting during the study. The significant relationship between rainfall and biomass productivity of some rangelands have been observed in many similar studies (Hussain & Durrani, 2007, Durrani *et al.*, 2005; Farooq, 2003). It is concluded that there is no uniform trend regarding biomass productivity along with altitudinal variations of the different species in the present case. This might be due to the fact that Gadoon hills are highly disturbed forests. Besides, altitude other factors like deforestation, overgrazing and depletion of soil due to erosion, ecological amplitude of the species and the presence

of thick canopy in some communities are responsible for this fluctuation in biomass productivity.

6. Mineral composition of some key palatable species

A. Macro-minerals

Minerals besides constituents of body fluids as electrolytes protect and maintain the structural components of the body organs and tissues. Minerals play a vital role in growth, reproduction, health and proper functioning of the animal's body. The rangelands support about 30 million herds of livestock, which play a key role in Pakistan's annual export income (Anon., 2006). Jones & Martin (1994) reported that grazing of livestock is an important component and the most suitable land use of land management system in nonagricultural marginal areas. Livestock usually derive most of their nutrients from the feed they consume; however, significant quantities of minerals may be obtained from water and soil sources (McDowell, 2003). Poor nutrient availability is the main cause of different physiological disorders, pitiable health and diseases in the livestock of this region (Hussain & Durrani, 2008). Adequate quantities of all the necessary nutrients obligatory for a given physiological stage are needed for good health and productivity of livestock (Yusuf *et al.*, 2003). Meager animal growth and reproductive problems can directly be related to mineral deficiencies caused by low mineral concentration in soils and associated forages even under satisfactory forage supply (Tiffany *et al.*, 2000). It is said that species with higher Ca, Mg and K in their leaves are more useful for livestock because disorders in animals are due to deficiency of Ca, Mg and other electrolytes (Khan *et al.*, 2004b; Ashraf *et al.*, 1992; Irigoyen *et al.*, 1992). Calcium plays a vital role in support, rigidity and strength of the plant body is indispensible. The least potassium level required for the proper metabolic activities of animal bodies is 0.5 ppm otherwise its deficiency adversely affects the plant growth (Anon., 1985; Rahim *et al.*, 2008). Nitrogen is a major constituent of all amino acids, which are the building blocks of all enzymes, which control virtually all biological processes (Brady & Weil, 1999).

I. Trees

In the present study the calcium contents in tested tree leaves ranged from 19.31 ppm to 261 ppm. Slightly higher Ca contents were also recorded in the forage grasses of arid pastures than the minimum recommended levels in the diets of ruminants (Khan *et al.*, 2006b; Rahim *et al.*, 2008; Sultan *et al.*, 2007, 2010).

Significant differences were found among all phenological stages of all the trees except *Celtis* and *Grewia* that showed insignificant differences among themselves. In *Acacia* Ca contents were similar in vegetative and reproductive stages but abruptly increased in post-reproductive stage. *Morus* and *Prunus* showed conflicting trend in Ca levels. Significant increase in Ca concentration in mature forage plants were observed for different forage plant species (Ashraf *et al.*, 2005; Khan *et al.*, 2005b; Hussain & Durrani, 2008). In the present investigation the same is true for *Cotoneaster, Parrotiopsis, Q. dilatata, Q. incana* and *Vibernum* because significant increase with maturity in Ca levels was observed for these tree species.

The least potassium level required for the proper metabolic activities of animal bodies is 0.5 ppm otherwise its deficiency adversely affects the plant growth (Anon., 1985; Rahim *et al.*, 2008). In the present endure recorded potassium contents in all the tested trees at all the phenological stages were high than the least required value. Potassium is an essential nutrient that activates many enzyme systems (Rahim *et al.*, 2008). Espinoza *et al.*, (1991) and Tiffany *et al.*, (2001) reported occasional fluctuations in K contents but this level declined with advancing maturity. The findings of the present analysis are in line with them because the similar fluctuation in potassium concentration was observed among the phenological stages. Potassium levels increased in *Acacia, Cotoneaster, Grewia, Q. dilatata, Q. incana* and in *Vibernum* with maturity. In herbaceous plants and grasses K concentrations were high at early growing stage (Akhtar *et al.*, 2007; McDowell, 1992). The present results are not in line with them. The remaining species had insignificant difference in vegetative and post-reproductive stages but the reproductive stage showed slightly high K contents.

Magnesium contents in the investigated tree leaves ranged from 8.395 ppm to 11.12 ppm. High concentration of Mg was observed in a number of forage plants (Canali *et al.*, 2005). The same is true for forest tree species analyzed from Gadoon Hills. On the other hand it differed from Velasquez-Pierera *et al.* (1997) and Rojas *et al.* (1995) who reported low Mg concentrations in different plant species in their studies. Significant differences in Mg contents were recorded among the different trees while insignificant differences were there among the different phenological stages. A slight decrease in Mg levels was observed in *Parrotiopsis, Q. dilatata* and *Q. incana* with maturity. *Vibernum* had a slight increase in Mg concentration with

maturity. The other tree species showed inconsistent trend regarding Mg levels at various phenological stages.

Significant differences in sodium contents were recorded among the various trees. Sodium concentration ranged from 4.423 ppm to 11.52 ppm in the browsed tree leaves. Phenological stages had insignificant difference. Forage sodium concentrations increased significantly ($P<0.001$) with the maturity of forage plants from summer to winter (Ashraf *et al.*, 2005; Khan *et al.*, 2005a, 2007). Our results are in line with them because Na contents increased in *Celtis, Grewia* and *Q. dilatata* with maturity. *Morus* showed a slight decrease in Na level with maturity. Deficiency of sodium in various forage plants from different regions have been reported in various studies (Khan *et al.*, 2006a, 2007; Tiffany *et al.*, 2000; Espinoza *et al.*, 1991). In the present case low Na contents were found in the reproductive stage of *Acacia, Cotoneaster, Parrotiopsis, Prunus* and *Q. incana* compared to other phenological stages.

Nitrogen is a major constituent of all amino acids. They are the building blocks of all enzymes that virtually control all biological processes (Brady & Weil, 1999). Appreciable crude protein and minerals have been recorded in some *Acacia* species including *Acacia brevispica, Acacia nubica, Acacia tortilis, Acacia seyal, Acacia nilotica* and *Acacia mellifera* (Abdulrazak *et al.*, 2000). Different studies reported relatively high N contents in some tree legume having potential input as protein feed resources for ruminants especially for browsing goats (Ondiek *et al.*, 1999, 2000; Abdulrazak *et al.*, 2001; Adjorlolo *et al.*, 2001; Nantoume *et al.*, 2001). In the present study N % contents ranged from 0.923% to 4.253%, sufficient enough to meet the livestock requirement. Insignificant differences were recorded in the nitrogen contents among the various browsed tree leaves and among the different phenological stages. *Celtis, Cotoneaster, Grewia, Parrotiopsis, Q. dilatata* and *Q. incana* had reduced N concentrations with advancing maturity in most of the investigated tree species. In *Acacia, Morus, Prunus* and *Vibernum* the observed N contents were inconsistent. Bignami *et al.* (2005) also recorded inconsistencies in leaf N content in their investigation.

In the present study, it is concluded the macro-mineral contents recorded in the leaves of selected trees at three phenological stages were sufficient enough that might meet the requirements of the grazing animals. These tree forages could be an excellent source of minerals for growing human population exerting pressure on

natural resources. Unfortunately, intensive cutting of these trees is a common practice in the area as no attention has been paid to the conservation and regeneration of this national wealth. It was suggested that further studies for determining micro-mineral, proximate composition, tannins, phenolics, and digestibility of these tree leaves is needed.

II. Shrubs

Calcium, an essential part of the plant cell wall, provides support, rigidity and strength. The present study showed that calcium contents were quite high in all the tested shrubs at all the phenological stages that might fulfill the requirements of grazing animals. Calcium contents ranged from 14.35 ppm to 254.5 ppm. Significant differences were found among all phenological stages of all the shrubs except *Debregeasia* and *Indigofera*. In *Berberis* Ca contents were similar in vegetative stage and reproductive stage, which abruptly decreased to in post-reproductive stage. Vegetative and reproductive stages of *Dodonaea* showed same trend Ca concentration but it increased significantly in the post-reproductive stage. Increased Ca contents were recorded in reproductive stage in *Gymnosporia* but decreased in the post reproductive stage. *Debregeasia* and *Indigofera* had no significant differences among them and between the various phenological stages. The Ca contents in the reproductive stage of *Justicia* were than other phenological stages. Ca levels in *Rosa* were insignificantly different in vegetative stage and reproductive stage but abruptly increased in the post-reproductive stage. Khan *et al.* (2006a) reported slightly higher Ca contents in the forage grasses of arid pastures than the minimum recommended levels in the diets of ruminants, and our findings agree with them. Extremely low calcium contents in reproductive stage of *Zizyphus* were determined compared with other two stages. Similarly, low levels of Ca were observed in the post-reproductive stage (maturity) of all the species except for *Justicia, Rosa* and *Zizyphus*. There is a disagreement between our findings and those of Ashraf *et al.* (2005) and Khan *et al.* (2005b) who reported significant increased in Ca concentration in mature forage plants.

Potassium is an essential nutrient that activates many enzyme systems. Its deficiency adversely affects the plant growth and metabolism (Rahim *et al.*, 2008). Physiological functions of livestock require at least 0.5 ppm potassium (Anon., 1985). The high potassium contents recorded in the present study in all the analyzed shrubs at all the phenological stages might be sufficient for grazing ruminants. It varied from

26.89 ppm to 27.16 ppm. Significant differences in potassium concentration were observed among the various shrubs but the differences in phenological stages were insignificant. However, a slight increase was recorded in *Dodonaea, Indigofera* and *Rosa* with maturity. The present findings regarding the higher concentration of Potassium in the early stages of most of the shrubs are in line with Akhtar *et al.* (2007) also reported that herbaceous plants and grasses are nutritionally rich at early growing stage. McDowell (1992) also reported that the concentration of potassium decreased with advancing maturity. In the present investigation it has been found that *Justicia* had low potassium contents than the other species studied. This species is usually not preferred by the animals because animals prefer K rich forage plants.

Magnesium contents ranged from 8.243 ppm to 13.08 ppm. Significant differences in Mg contents were recorded among the different shrubs and among the different phenological stages. The vegetative and post-reproductive stages of *Berberis* had no significant differences that declined with maturity. In *Dodonaea* the Mg concentration was similar at vegetative and reproductive stages, which increased at post reproductive stage. Reduced magnesium contents were recorded in the post-reproductive stage of *Gymnosporia* than its vegetative and reproductive stages. *Indigofera* and *Rosa* showed no significant differences among their phenological stages in magnesium levels. The reproductive stage of *Justicia* and *Zizyphus* comparatively had higher Mg contents than other stages. Canali *et al.* (2005) support our findings who also reported high concentration of Mg in a number of forage plants.

Significant differences in sodium contents were recorded among the various shrubs and among the different phenological stages of the same plant. Sodium concentration ranged from 1.555 ppm to 7.879 ppm. Sodium levels were similar in vegetative and reproductive stages of *Berberis* but it increased in the post-reproductive stage. *Debregeasia, Indigofera* and *Rosa* showed a gradual decrease in sodium contents with advancing maturity. Reproductive stage of *Dodonaea, Justicia,Gymnosporia* and *Zizyphus* showed higher Na concentration than vegetative and post-reproductive stages. Khan *et al.* (2006b, 2007) and Tiffany *et al.* (2000) reported deficiency of sodium in various forage plants from different regions therefore; our results are contradictory with them.

Nitrogen is an important nutritional element for plants. It is a major constituent of all amino acids, which are the building blocks of all proteins, including the enzymes, which control virtually all biological processes (Brady & Weil, 1999).

Nitrogen contents varied from 0.042% to 3.660%. Significant differences were observed in the nitrogen contents among the various investigated shrubs and among the different phenological stages of the same plant. Reproductive stage of *Berberis, Debregeasia, Gymnosporia* and *Indigofera* had higher nitrogen contents while *Justicia* and *Rosa* showed reduced N levels than vegetative and post-reproductive stages. In *Zizyphus,* a gradual increase in the nitrogen concentration was observed with maturity. Bignami *et al.* (2005) observed inconsistencies in leaf N contents during the growing season. The present findings agree with them because no regular trend was recorded in the investigated shrubs analyzed for nitrogen contents.

III. Grasses

Calcium contents of grasses ranged from 23.32 ppm to 35.24 ppm. In *Apluda* and *Schoenoplectus* it decreased with maturity. The reproductive stage of *Aristida, Digitaria* and *Pennisetum* had higher Ca levels than vegetative and post-reproductive stages. Slightly higher Ca contents were also recorded in the forage grasses of arid pastures than the minimum recommended levels in the diets of ruminants (Khan *et al.*, 2006b; Rahim *et al.*, 2008; Sultan *et al.*, 2007, 2010). These findings agree with the present results. The Ca levels increased with maturity in *Chrysopogon, Heteropogon* and *Themeda.* Ashraf *et al.* (2005) and Khan *et al.* (2005b) also reported high Ca concentration in mature forage plants for different forage plant species which support our findings in this respect.

In the present study potassium contents in all the tested grasses at all the phenological stages were higher than the least required value. Potassium levels varied from 24.05 ppm to 28.12 ppm in the investigated species. The minimum potassium level required for the proper metabolic activities of animal bodies is 0.5 ppm as its deficiency adversely affects the plant growth (Anon., 1985; Rahim *et al.*, 2008). Potassium is an essential nutrient that activates many enzyme systems (Rahim *et al.*, 2008). Statistical analysis showed significant differences in potassium concentration among the various grasses and among the different phenological stages. Potassium concentrations abruptly decreased in *Aristida, Heteropogon* and *Schoenoplectus* with advancing maturity. Espinoza *et al.* (1991) and Tiffany *et al.* (2001) reported occasional fluctuations in K contents but this level declined with advancing maturity. This is what we also report in the present case. Nonetheless, K levels increased in *Chrysopogon* and *Digitaria* with maturity. In *Chrysopogon* and *Digitaria* the findings of the present study were contradictory with Espinoza *et al.* (1991) and Tiffany *et al.*

(2001) who reported decreased amount of K in their studies. Akhtar *et al.* (2007) and McDowell (1992) had reported high K concentrations in herbaceous plants and grasses at early growing stage. The same is true for *Apluda, Aristida, Heteropogon* and *Schoenoplectus* in the present investigation.

Magnesium contents ranged from 8.121 ppm to 9.651 ppm. The reproductive stage of *Chrysopogon* and *Themeda* had higher Mg contents. Like the present findings high concentration of Mg has been reported in a number of forage plants (Canali *et al.*, 2005). A slight decrease in Mg levels was recorded in *Aristida* and *Heteropogon* with maturity. This agrees with Velasquez-Pierera *et al.* (1997) and Rojas *et al.* (1995) who also reported low Mg concentrations in different plant species in their studies. The remaining investigated grasses had inconsistent trend in Mg contents.

Significant differences in sodium contents were recorded among the various grass species. It swayed from 1.145 ppm to 2.051 ppm. Sodium deficiency in various forage plants from different regions have been reported in various studies (Khan *et al.*, 2006a, 2007; Tiffany *et al.*, 2000; Espinoza *et al.*, 1991). The present results are in line with them because a slight gradual decrease in Na concentration was observed in *Chrysopogon, Digitaria* and *Schoenoplectus* with maturity. The reproductive stage of *Apluda* and *Pennisetum* had significantly high Na levels than at other phenological stages. Ashraf *et al.* (2005) and Khan *et al.* (2005a, 2007) reported high Na contents in some forage plant species with the maturity from summer to winter. The present findings also showed similar trend.

Nitrogen is a major constituent of all amino acids, which are the building blocks of all enzymes, which control virtually all biological processes (Brady & Weil, 1999). Significant differences in the nitrogen contents were recorded among the investigated grasses and among the different phenological stages. In the present investigation, nitrogen contents ranged from 0.854% to 2.021%. The nitrogen contents increased with advancing maturity in most of the analyzed grasses like *Digitaria, Heteropogon, Schoenoplectus* and *Themeda*. The reproductive stages of *Chrysopogon* and *Pennisetum* had significantly higher N levels than other phenological stages. Our findings are in line with Abdulrazak *et al.* (2000) who reported appreciable minerals in some *Acacia* species. Various studies in the world reported relatively high N contents in some tree legume; having potential input as protein feed resources for ruminants, especially for browsing goat (Ondiek *et al.*, 1999, 2000; Abdulrazak *et al.*, 2001; Adjorlolo *et al.*, 2001; Nantoume *et al.*, 2001).

The remaining grasses showed inconsistent trend in N% with advancing maturity. Thus our results are supported by the findings of Bignami *et al.* (2005) who also recorded inconsistencies in leaf N content in their investigation.

Before the commencement of winter, the grasses are harvested, dried and put into a stake. These grasses are then fed during the bare and cold months of winter. The present study concluded that locals have some logic behind their said activity because these grasses have sufficient macro-mineral contents that might execute the necessities of the dependent animals.

B. Micro-minerals

Trace elements though required in very minute quantities, but their importance could not be under rated in the growth and metabolism of human and animal health. Most of the trace elements have antagonizing effects for macro-minerals. The main sources of these minerals are water and soil upon which the forage plant species grow (McDowell, 2003). The uptake of these micro-nutrients in plants is essential for plant growth and development (Koike *et al.*, 2004). Mineral deficiencies can inhibit forage digestibility and herbage intake that ultimately decrease livestock production efficiency (Provenza, 1996; Khan *et al.*, 2005b). At the same time if these minerals are in excess then they cause severe physiological disturbances. Heavy metals affect the nutritive values of agricultural products and also have deleterious effect on human beings. National and international regulations on food quality have set the maximum permissible levels of toxic metals; hence heavy metals in food should be in safe limits (Radwan & Salama, 2006; Sobukola *et al.*, 2008). Livestock rearing is a common practice in Gadoon hills by the locals to earn their daily commodities. Poor livestock health and productivity at secondary level is the main problem in the area. In order to know the cause of this problem, trees (10 Spp.), shrubs and grasses (8 Spp. each) were analyzed for micro-mineral quantification at three phenological stages in the present investigation.

I. Trees

In the investigated trees, cadmium concentration ranged from 0.203 ppm to 0.222 ppm. Farooq *et al.*, (2008) and Radwan & Salama (2006) reported the highest levels of Cd, in strawberries, cucumber, dates spinach and other vegetables. The reproductive stage of *Celtis* and *Prunus* also had higher Cd contents therefore; our findings are in line with them. Sobukola *et al.* (2010) recorded low Cd levels in some fruits and vegetables in Nigeria. In the present study decreased Cd levels were found

in *Morus* and *Q. dilatata* particularly during reproductive and post- reproductive stages. Similarly, insignificant differences in the concentration of metals were determined in most of the vegetables (Fytianos *et al*., 2001). *Vibernum* had the same trend among the different phenological stages.

Ahmad *et al.* (2009) reported greater levels of Cr that may cause toxic effects in grazing animals from Salt Range, Pakistan. In the present investigation Cr concentrations ranged from 0.095 ppm to 1.547 ppm which was within safe limits. Our results agree with Sharma *et al*., (2006) who also reported heavy metal contents particularly the chromium within the safe limits. Significant differences were observed in Cr contents among various phenological stages of the analyzed trees. This is due to growth stages where accumulation time differed.

Insignificant differences in copper contents were recorded among the different trees and among different phenological stages. Copper toxicity is very rare in animals when adequate supply of iron and Zn is present in diet. The concentration of copper in the analyzed trees ranged from 0.045 ppm to 0.118 ppm. Sobukola *et al.*, (2010) reported the lowest copper levels in some fruits and leafy vegetables from Nigeria. In the present investigation decreased copper contents were observed in *Acacia, Celtis, Parrotiopsis* and *Vibernum* with maturity. Gonzalez-V *et al*., (2006) also reported decrease in mineral ion concentration with maturity in the case of legumes and grasses. The reproductive stage of *Morus* had higher Cu contents than other stages while in *Prunus* opposite trend were observed for reproductive stage. This higher concentration of copper was within safe limits in the present case.

Phosphate absorption is being depressed by very high levels of iron while its deficiency decreases resistance to diseases. Fe contents ranged from 1.859 ppm to 8.874 ppm in the present investigated trees. Significant differences in Fe contents were recorded among the different trees and among the different phenological stages. Espinoza *et al*., (1991) also reported variations in Fe concentrations in their study in Florida. Hussain & Durrani (2008) also reported variation in Fe contents of different forage plants and the present findings are in line with them.

Contents of Ni greater than 1000 ppm in the diet are toxic to most animals. High concentration of Ni has been reported in many studies (Tokalioglu & Kartal, 2005; Sobukola *et al*., 2010 & Ahmad *et al*., 2009). In the present analyzed tree Ni contents ranged from 0.175 ppm to 0.338 ppm. Our results are contradictory to them. Pb contents ranged from 0.48 ppm to 1.224 ppm in the analyzed forage trees. Lead

concentrations decreased in *Debregeasia* and *Rosa* while increased in *Zizyphus* with maturity. The other forage trees showed no regular trend in Pb levels. Similarly, Malik *et al.*, (2010) also observed variations in the lead contents in forage plants. Sobukola *et al.*, (2010) and Ahmad *et al.*, (2009) reported high concentration of lead in some vegetable and forages. The findings of the present study depict safe levels of Pb in the investigated species.

Zinc concentration in grasses of northern rangelands of Pakistan was not affected by maturity or change in climate (Sultan *et al.*, 2008a) and the same trend was observed in the present study because all the phenological stages of the investigated trees had inconsistent trend in Zn levels except *Celtis* and *Q. dilatata* which showed a slight decrease in Zn concentrations with advancing maturity. In this case Zn contents ranged from 0.117 ppm to 0.485 ppm with insignificant differences among the phenological stages and among the various trees. Malik *et al.* (2010) reported relatively higher Zn levels in grasses than broad leaved. Our findings are supported by them as low Zn levels were recorded for all analyzed forage trees.

Mn contents had significant differences among the phenological stages but also recorded similar levels of plant Mn in Florida. Similarly, Hussain & Durrani (2008) also reached to almost similar conclusions regarding Mn concentration in plants.

II. Shrubs

Cadmium concentration ranged from 0.205 ppm to 0.217 ppm showed insignificant difference among the different shrubs and among the various phenological stages. Fytianos *et al.* (2001) reported no significant differences in the concentration of metals in most of the vegetables analyzed. The present findings are in line with them. A slight increase was observed among the three phenological stages of *Debregeasia* and *Justicia* with maturity. The reproductive stages of *Indigofera*, *Rosa* and *Zizyphus* had higher Cd levels than the other two stages. The other shrubs showed inconsistent trend in Cd concentrations at various phenological stages. The

Cd level in the present endure was below the critical values. Similar to the present results low Cd concentration was observed in some fruits and vegetables in Nigeria (Sobukola *et al.*, 2010). However, Farooq *et al.*, (2008) and Radwan & Salama (2006) reported high levels of Cd in strawberries, cucumber, dates spinach and other vegetables.

Chromium (Cr) plays important role in the synthesis of fatty acids and cholesterols, metabolism of carbohydrates, proteins, lipids and has also been proved that it facilitates the action of insulin. Oral administration of 50 ppm of Cr has been associated with growth depression and liver and kidney damages in experimental animals. In the present investigation Chromium concentration ranged from 0.006 ppm to 0.967 ppm in the investigated shrubs species which is lower than the toxic level. The concentrations of Cr observed in the pasture forage plants from Salt Range (Pakistan) are significantly higher than the critical levels (Ahmad *et al.*, 2009). In the present study significant differences in Cr contents was recorded among various phenological stages but insignificant difference among the different shrubs. Chromium concentration increased with maturity in *Dodonaea*, *Gymnosporia* and *Zizyphus*. On the other hand mineral ion concentration decreased with increase in age both in the case of legumes and grasses (Gonzalez-V *et al.*, 2006). Inconsistent behavior regarding the Cr concentration was recorded in different phenological stages of the other species. Sharma *et al.*, (2006) reported that different vegetables had Cr within the safe limits and this agrees with our findings.

Copper is necessary along with iron because it is required in red cell maturation. It is also important for normal bone formation. Symptoms of copper deficiency vary among species. Anemia is the general symptom along with depressed growth and bone abnormalities. Copper toxicity is very rare in animals when adequate supply of iron and Zn is present in diet. The concentration of copper ranged from 0.031 ppm to 0.123 ppm in the present analysis of forage shrubs. Copper contents significantly differed among the different shrubs and among different phenological stages. In *Debrrgesia* the copper contents showed no significant difference in vegetative and reproductive stages but increased in post- reproductive stage. A gradual decrease in Cu contents was observed in *Indigofera* while this decline was abrupt in *Rosa* with maturity. Gonzalez-V *et al.* (2006) also reported decrease in mineral ion concentration with maturity in the case of legumes and grasses. The reproductive stages of *Justicia* and *Zizyphus* had higher Cu contents than the other

two stages. The overall concentration of Cu was lower than the safe limits. Similarly, Sobukola *et al.*, (2010) also recorded the low copper levels in some fruits and leafy vegetables from Nigeria.

Iron is a constituent of blood pigment, haemoglobin, muscle protein, myoglobbulin and various enzymes. The deficiency of iron may cause anemia and a decrease resistance to diseases. High iron contents may cause nutritional problems by decreasing phosphate absorption. Significant differences in Fe contents were recorded among the different shrubs and among the different phenological stages. Fe contents ranged from 1.819 ppm to 12 ppm in the analysis of shrubs commonly grazed by animals in the study area. Fe contents decreased in *Dodonaea* and *Indigofera* with maturity. The results are in line with those of Gonzalez-V *et al.*, (2006). Some analyzed shrubs showed inconsistent Fe contents in their phenological stages. Hussain & Durrani (2008) also reached to similar conclusion. The post-reproductive stage of *Berberis* had higher Fe concentration than vegetative and reproductive stages. Insignificant difference in Fe contents was recorded among reproductive and post-reproductive stages of *Debregeasia* but it was significantly higher in vegetative stage. Like the present study, Espinoza *et al.*, (1991) also reported variations in Fe concentrations in plants of Florida. The overall concentration of Fe in all the shrubs was low.

Ni is present in RNA in rather high concentrations. It is also essential for urease activity in rumen microbes. Levels of Ni greater than 1000 ppm in the diet are toxic to most animals. In the present investigation the Ni contents ranged from 0.109 ppm to 0.184 ppm in different shrubs analyzed which is within the safe permissible limits. Ni contents increased in *Indigofera* and *Justicia* but decreased in *Gymnosporia* with maturity. High concentration of Ni has been reported in many studies (Tokalioglu & Kartal, 2005; Sobukola *et al.*, 2010 & Ahmad *et al.*, 2009) but the present investigation showed Ni within safe limits.

Lead is one of the most common causes of accidental poisoning in human and domestic animals. Lead concentration of 80 ppm in forages could be toxic to horses but cattle could tolerate 200 ppm or more. In the present study lead contents ranged from 0.08 ppm to 0.8 ppm. This is in contradiction to some workers (Sobukola *et al.*, 2010; Ahmad *et al.*, 2009) who reported high concentration of lead in some vegetable and forages. Results of the present study showed significant difference among the phenological stages but insignificant difference among the forage shrubs. Similarly,

Malik *et al.*, (2010) also observed variations in the lead contents in some forage plants and this strengthens the present findings.

Zn is present in carbonic anhydrase (found in RBC) which play a key role in eliminating CO2. Zn is also an activator of many other enzymes. Dwarfism and absence of sexual maturation are important symptoms in severe Zn deficiencies. Malik *et al.* (2010) reported that Zn concentration was relatively higher in grasses than broad leaved species. Our findings agree with them as low Zn levels were recorded for all shrubs in the present study. Significant difference was found in Zn contents among the phenological stages while the difference among the various shrubs was insignificant. Zn contents ranged from 0.082 ppm to 0.371 ppm which was within safe limit. Zinc concentration in grasses of northern rangelands of Pakistan was not affected by maturity or change in climate (Sultan *et al.*, 2008) and similar results are reported in the present case. Likewise Hussain & Durrani (2008) also observed same trend.

Mn is required to activate several enzymes such as arginase and thiaminase. A major symptom of manganese deficiency in most animals is bone abnormality. Manganese is considered to be the least toxic of the trace elements to birds and mammals. Manganese between 50 and 125 ppm affects haemoglobin formation in lambs and mature rabbits. Mn contents ranged from 0.077 ppm to 0.432 ppm. This is within safe limit. Similar levels of plant Mn have already been reported in Florida (Espinoza *et al.*, 1991) and in Pakistan (Khan *et al.*, 2006, 2007; Hussain & Durrrani, 2008).

It is concluded that micro-minerals concentrations available in these forage plants to the grazing livestock were very low, hence this might be, one of the causes responsible for the pitiable health and productivity of the grazing animals in Gadoon hills.

III. Grasses

Cadmium concentration ranged from 0.12 ppm to 0.203 ppm with significant differences among the various phenological stages. These grasses had insignificant differences in Cd. Fytianos *et al.*, (2001) also recorded insignificant differences in the concentration of various metals in most of the vegetables. High levels of Cd, in strawberries, cucumber, dates, spinach and other vegetables were reported in various studies (Farooq *et al.*, 2008; Radwan & Salama 2006). Low Cd contents were found in *Apluda, Aristida* and *Heteropogon* with advancing maturity. Our results are similar

to those of Sobukola *et al.* (2010) who recorded low Cd levels in some fruits and vegetables in Nigeria. Hussain & Durrrani (2008) also support the present findings.

Various phenological stages of the investigated grasses had significant differences while no significant differences in Cr contents among the different grass species were observed. Ahmad *et al.*, (2009) reported that high Cr levels may cause toxic effects in grazing animals of the area. Chromium concentration ranged from 0.01 ppm to 0.356 ppm in the investigated grasses. It increased in *Aristida* and *Schoenoplectus* while decreased in *Pennisetum* and *Themeda* with advancing maturity. Extremely low Cr contents were analyzed in *Apluda*, among all the grasses. The remaining grass species exhibited inconsistent Cr levels at three phenological stages. Our findings are in line with Sharma *et al.*, (2006) and Hussain & Durrrani (2008) who reported heavy metal contents particularly the chromium within the safe limits.

Insignificant differences in copper contents were recorded among the different grasses but significant differences were present in phenological stages. The levels of copper ranged from 0.025 ppm to 0.067 ppm. Sobukola *et al.*, (2010) reported the low copper levels in some fruits and leafy vegetables from Nigeria, which agree with our findings. Fe contents swayed from 1.587 ppm to 11.31 ppm. Espinoza *et al.*, (1991) also reported variations in Fe concentrations in plants.

Ni contents below 1000 ppm in the diet are harmless to most animals. Tokalioglu & Kartal (2005) reported high concentration of Ni in their study. In the present case Ni contents ranged from 0.078 ppm to 0.186 ppm showing that Ni contents in different grasses are within safe limits. The findings agree with those of Sobukola *et al.* (2010) and Ahmad *et al.* (2009). Pb contents ranged from 0.158 ppm to 0.502 ppm in the investigated grasses. Sobukola *et al.*, (2010) and Ahmad *et al.*, (2009) reported high concentration of lead in some forages plants. Malik *et al.*, (2010) also recorded variations in the lead contents in their study and this is what is being reported in the present study.

ANOVA observed insignificant differences in Zn concentration among the various grasses but significant differences were recorded among phenological stages. Zn contents ranged from 0.09 ppm to 1.224 ppm. Sultan *et al.*, (2008) reported that Zinc concentration in grasses of northern rangelands of Pakistan was not affected by maturity or change in climate thus negating the present findings. Grasses had high Zn concentration than broad leaved (Malik *et al.*, 2010) species. Our findings disagree

with them as low Zn contents were determined in the present case. Mn contents ranged from 0.079 ppm to 0.249 ppm in present study. Khan *et al.*, (2006, 2007) recorded low Mn contents in some plants from Pakistan and this is what we also noticed. Mn contents had significant differences among the phenological stages but insignificant difference among the different grasses. Espinoza *et al.*, (1991) also recorded similar levels of Mn in in forage plants.

7. Nutritional analysis of Some Key Palatable Species

Livestock grazing in rangelands is the most effective land use in rangeland ecosystem (Jones & Martin, 1994). Range animal productivity depends upon the nutritive quantity and quality of plants available to grazing livestock. Pasha (1998) reported that Pakistan is deficient by 40 and 80% in forage and concentrates feed, respectively. The dietary demands of the range animals vary with age and physiological functions of livestock such as growth maintenance, gestation, fattening and lactation etc. Animal feed is divisible into fibrous and non-fibrous components. In ruminants, fiber fractions (celluloses and hemicelluloses) are easily digestible that provide energy. Sarwar *et al.*, (2009) argued that the existing feed resources of Pakistan are only providing 62 and 74% of required crude protein (CP) and total digestible nutrients, respectively resulting in low yield of livestock in the country. It has been reported that protein-calories malnutrition deficiencies is a major factor responsible in nutritional pathology (Roger *et al.*, 2005). Ganskopp & Bohner (2001) stated that it becomes necessary for the range managers to understand the nutritional dynamics of forage to sustain adequate growth and reproduction of animals.

I. Trees

A. Proximate composition

Dry matter in the analyzed tree leaves ranged from 91.11% to 95.21%. Ashraf *et al.* (1995) and Kramberger & Klemencic (2003) recorded increase in dry matter concentrations with advancing maturity and the present dry matter levels in *Celtis*, *Q. dilatata* and *Q. incana* also increased with advancing age. Tufarelli *et al.*, (2010) reported significant differences in dry matter contents of legumes and forbs while in the present study, insignificant differences in dry matter contents were found among the tree species and among their phenological stages. Our findings are similar to those of Ganskopp & Bohner (2001) who also recorded high concentration of dry matter at pre-reproductive stage than other growth stages. *Cotoneaster*, *Parrotiopsis*, *Prunus*

and *Vibernum* exhibited a decline in dry matter contents with advancing time. Hussain & Durrani (2009) reported increased dry matter levels in some forage shrubs and grasses at maturity. Our results regarding *Cotoneaster, Parrotiopsis, Prunus* and *Vibernum* are contradictory with them.

All the phenological stages of *Celtis* and *Morus* had higher ash levels among trees. Similarly forage shrubs including *Indigofera gerardiana, Myrsine africana, Impatiens bicolor* and *Adhatoda vesica* had high ash values (Sultan *et al.* 2010). Sultan *et al.,* (2008a, c) also reported higher ash contents in some grasses and forage trees from Chagharzai Valley District Buner, which is similar in climate to the present location. Total mineral in tree leaves increased from 3.80% to 23.32%. Hussain & Durrani, (2009) also reported similar trend. *Cotoneaster* and *Prunus* followed the same trend in ash contents.

Adetuyi & Akpambang (2006) reported that crude fiber is deleterious to the digestibility of forage plants. Crude fiber varied from 7.45% to 34.73% among trees. In the present endure crude fiber contents, in *Celtis, Morus* and *Q. incana* increased with maturity and this what has been reported by Cherney *et al.* (1993), Distel *et al.* (2005) and Sultan *et al.* (2008a) these workers also recorded increased fiber and lignin contents in various plant species with advancing growth stages. However, their findings showed decline in crude fiber with advancing growth stages of *Acacia, Cotoneaster* and *Vibernum*. Significantly, higher concentrations of crude fiber were observed in the reproductive stage of *Grewia, Q. dilatata* and *Parrotiopsis*. Holechek *et al.,* (1998) and Naseem *et al.*, (2006) also recorded high contents of crude fiber in different plant species.

Ether extract contents ranged from 0.54% to 31.06% in the analyzed tree species. Adetuyi & Akpambang (2006) reported greater ether extract contents in *Sorghum bicolor.* Seeds of *Carthamus oxyacantha* and *Eruca sativa* had greater amount of crude fats compared with their leaves (Bukhsh *et al.*, 2007). In the present case reproductive stage of *Grewia* and *Prunus* had higher crude fiber levels. In *Celtis, Parrotiopsis* and *Q. dilatata* crude fat values decreased significantly with advancing maturity. The remaining tree species had inconsistent trend in ether extract concentrations. Hussain & Durrani, (2009) also recorded inconsistent ether extracts values in some grasses and shrubs from Harboi hills.

Proteins required as structural and functional bio-molecules in the metabolism of the animal bodies come from nutrition (Holechek *et al.*, 1998). Khodzhaeva *et al.*

(2002) reported proteins content in *Rumex confertus*. Roger *et al.* (2005) reported that protein level in green leafy vegetables ranged from 20.48 to 41.66%. In the present study crude protein levels were low ranging from 5.77% to 26.58%. Like the present findings crude proteins decrease with maturity in a number of forage species (Distel *et al.*, 2005; Ganskopp & Bohner 2001. 2003; Khan *et al.* 2002; Hussain & Durrani, 2009). In the present study *Celtis, Cotoneaster, Grewia, Parrotiopsis, Q. dilatata* and *Q. incana* had decreased proteins with advancing growth stages. Similarly Bruno-Soares *et al.* (2011) also reported a linear decrease in leaf CP contents of *Cistus salvifolius* with time. The post-reproductive stage of *Prunus* also had low protein contents. The reproductive stages of *Morus* and *Vibernum* had high crude protein values. Like Robles & Boza (1993) and Kononov *et al.*, (2005) who recorded the highest crude protein yield in some forage plants, this study reports the same trend.

Moisture contents in the analyzed tree species ranged from 4.8% to 8.9%. It increased in *Cotoneaster, Parrotiopsis, Prunus* and *Vibernum* while decreased in *Celtis Q. dilatata* and *Q. incana* with advancing maturity. *Acacia* and *Morus* had high moisture contents in reproductive stage. Our findings are in line with Sultan *et al.* (2008a) as in the present investigation organic matter declined in *Cotoneaster, Parrotiopsis* and *Prunus* with advancing maturity. However, organic matter concentrations in *Q. dilatata* increased with advancing time. Organic matter contents ranged from 68.64% to 90.44% in the investigated tree leaves. *Grewia, Q. incana* and *Vibernum* showed insignificant difference in organic matter levels among the various growth stages.

Liu (1993) recorded low values for NFE in the forage plants of arid lands. In the present case, NFE contents ranged from 42.64% to 85.13%, which is quite higher. Hussain & Durrani (2009) also reported high NFE values for some shrubs and grasses from Harboi Rangelands. The present findings are also in line with Liu (1993) who recorded similar trend of NFE in plants from arid rangelands. Carbohydrate levels ranged from 33.17% to 76.05% among the tree leaves. Carbohydrate contents in *Celtis, Morus* and *Q. dilatata* increased with advancing growth stages. Kamalak (2006) also reported increased carbohydrate levels in *Glycyrrhiza glabra* at pre-bud, mid and late flower stages. An increase or decrease has been reported by other workers (Hussain & Durrani, 2009; Sultan *et al.*, 2007, 2008c).

Total digestible nutrients ranged from 36.97% to 149.04% among the analyzed trees. Total digestible nutrients in *Celtis, Morus, Parrotiopsis, Prunus, Q. dilatata* and *Q. incana* decreased with advancing age. Significantly higher TDN contents were observed in the post-reproductive stage of *Acacia*. The reproductive stages of *Cotoneaster* and *Vibernum* had low TDN values than other growth stages. Total digestible nutrients in the reproductive stage of *Grewia* were significantly higher than other phenological stages. Our findings differ from Hussain & Durrani, (2009) and Liu (1993) who recorded insignificant differences in TDN concentrations in some grasses and shrubs at various growth stages.

Hussain & Durrani, (2009) and Sultan *et al.*, (2007) reported a decline in Gross energy, digestible energy and metabolized energy in their study for some range grasses and shrubs. Our findings agree with them as Gross energy, digestible energy and metabolized energy among the tree species also decreased in *Celtis, Morus, Parrotiopsis, Q. dilatata* and *Q. incana* with advancing growth stages. However, Kamalak (2006) observed an increase in various kinds of energies in *Glycyrrhiza glabra* at pre-bud, mid and late flower stages. Robles & Boza (1993) also recorded insignificant differences in these energies in some forage plants.

B. Cell wall constituents

Increase in NDF contents in many forage plant species with maturity have been reported in a number of studies (Hussain & Durrani, 2009; Sultan *et al.*, 2007; Kramberger & Klemencic, 2003; Ganskopp & Bohnert 2001; Ashraf *et al.*, 1995; Andrighetto *et al.*, 1993). In the present study NDF contents increased with advancing growth stages only in *Celtis*. NDF levels ranged from 29.51% to 114.50% in the investigated tree leaves. NDF increased/decreased in different analyzed species with age. Cherney *et al.*, (1990) also recorded low NDF contents in inflorescence than in other morphological stages. The reproductive stage of *Acacia, Q. dilatata* and *Vibernum* had significantly higher NDF levels than other phenological stages. The remaining trees showed insignificant differences.

ADF concentrations ranged from 16.51% to 100.00% in the investigated tree leaves. Ashraf *et al.*, (1995) recorded increase in ADF in some fodder species at different growth stages. ADF concentrations increased with advancing maturity in some of the species while in other cases it decreased. The findings agree with Cherney *et al.* (1993), Kramberger & Klemencic (2003), Sultan *et al.* (2007) and

Hussain & Durrani (2009) who recorded increase in ADF concentrations with advancing growth stages.

Holecheck *et al.* (1998) and Kramberger & Klemencic (2003) reported that lignin is not only indigestible but also retards the digestibility of the complex carbohydrates. The reproductive and post-reproductive stages of *Acacia, Celtis* and *Grewia* had no significant differences in ADL levels but these contents were very low in their vegetative stages. *Q. dilatata* and *Vibernum* showed increase in ADL values with advancing maturity. The present inquiry agree with Hussain & Durrani (2009) and Sultan *et al.*, (2007) who observed improved lignin concentrations with maturity of forage plant species. However, in some cases ADL decreased with advancing age. Hussain & Durrani (2009) and Robles & Boza (1993) reported high lignin contents in grasses and shrubs.

Cellulose and hemicellulose are the digestible feed components in the rumen and large intestine through microorganism's activities in animals (Holecheck *et al.*, 1998). Hemicellulose concentrations in *Grewia* and *Morus* declined while it increased in *Acacia* with advancing age. *Celtis*, *Parrotiopsis*, *Prunus* and *Vibernum* had high hemicelluloses in their reproductive stage. In *Cotoneaster*, *Q. dilatata* and *Q. incana* low levels of hemicelluloses were recorded in reproductive stage. Hussain & Durrani (2009) related variations in the amount of structural carbohydrates with seasonal changes as well as with phenology of plant. A similar trend was observed in the present study. Cellulose contents ranged from 5.51% to 63.50% in the analyzed tree leaves. Maturity served to increase cellulose contents in *Morus, Parrotiopsis* and *Prunus*. *Grewia* and *Vibernum* showed opposite trend with advancing growth stages.

II. Shrubs

A. Proximate composition

Tufarelli *et al.* (2010) recorded significant differences in dry matter concentration in some legumes and forbs. In the present investigation the dry matter in the analyzed shrubs ranged from 89.42% to 95.70%. Highest dry matter was recorded in *Zizyphus*. The present findings agree with Kononov *et al.* (2005) who reported the high dry weight yield in *Medicago falcata*. Dry matter increased in *Berberis* and *Zizyphus* with advancing maturity and this in line with Ashraf *et al.* (1995) and Kramberger & Klemencic, (2003) also reported increasing dry matter with advancing age. Our results are in contradiction while considering the trend exhibited by *Indigofera*, regarding the DM % decline with advancing phenological stages. Dry

matter contents increased with advancing age in some forage shrubs and grasses (Hussain & Durrani, 2009). Ganskopp & Bohnert (2001) reported high concentration of dry matter at pre-reproductive stage than other growth stages. In the present study the dry matter was high in the vegetative stage of *Rosa* than other phenological stages.

Insignificant differences occurred in ash contents among the different shrubs but differences were significant among the phenological stages. As a whole inconsistent trend i.e. decrease or increase was observed in ash contents among the shrubs. Our results parallel with Hussain & Durrani (2009) in this respect who also reported inconsistent trend in ash contents of some grasses and shrubs. Sultan *et al.*, (2008a, c) also observed similar trend. Sultan *et al.* (2010) reported high ash levels in some shrubs including *Indigofera gerardiana, Myrsine africana,* and *Adhatoda vesica* and herb *Impatiens bicolor*. The present study also reports similar trend.

Crude fiber contents forms an important basis for the classification of feeds into roughage and concentrates. All feeds with 18% or more crude fiber on dry matter basis are classified under roughage and those with less than 18% under concentrates. Crude fiber is an important fraction in determining the digestibility of forage plants (Adetuyi & Akpambang, 2006). Crude fiber levels in the analyzed shrub species ranged from 9.62% to 29.42%. Fiber and lignin contents increased over time in forage plants (Cherney *et al.*, (1993; Distel *et al.*, 2005; Sultan *et al.*, 2008a). A slight and gradual increase was recorded in *Berberis* and *Zizyphus* with advancing maturity in the present case. The remaining shrub species showed inconsistency in crude fiber concentrations. Holechek *et al.* (1998) and Naseem *et al.* (2006) reported high crude fiber contents in various plants. Similarly, most of the analyzed shrubs from Gadoon hills were high in crude fiber except *Indigofera* and vegetative and post-reproductive stages of *Dodonaea*.

Fats and oil are important sources of stored energy in plants and animals. Ether extracts or crude fats contains true fats (glycerides of fatty acids) which are saponifiable and pseudofats like free fatty acids, cholesterol, lecithin, chlorophyll, alkali substances, volatile oils and resins. Bukhsh *et al.*, (2007) reported that the seeds of *Carthamus oxyacantha* and *Eruca sativa* had more crude fats than leaves. Adetuyi & Akpambang (2006) reported crude fat in *Sorghum bicolor*. In the present investigated shrubs crude fat contents ranged from 0.97% to 24.85%. In *Debregeasia*, crude fat levels gradually increased while it decreased abruptly in *Zizyphus* with advancing maturity. Hussain & Durrani (2009) reported differences in crude fat

contents were significant between pre- and post reproductive stages of grasses and shrubs and thus agrees with present results.

Structural and functional role of proteins cannot be ignored in living organisms. Therefore sufficient amount is necessary for animal's body metabolism (Holechek *et al.*, 1998). In the present investigation significant differences in crude proteins contents were found among the different phenological stages of the analyzed shrub leaves. Khodzhaeva *et al.* (2002) reported the high proteins in the aerial part of the *Rumex confertus*. In the present study crude protein levels ranged from 0.26% to 22.88% in the analyzed shrub species. Our findings differ from Roger *et al.* (2005) who reported that protein level of green leafy vegetables ranged from 20.48-41.66%. Crude protein contents in different forage species declined with time (Distel *et al.*, 2005; Ganskopp & Bohnert 2001; Khan *et al.* 2002; Hussain & Durrani, 2009). Kononov *et al.* (2005) recorded the highest crude protein yield for *Rumex acetosa* and this support the present results.

Moisture content of feed is significant in calculating the cost per unit weight of feeds. Generally feed with more than 11% moisture get mouldy and spoiled. Moisture contents in the analyzed shrubs ranged from 4.30% to 10.58%. Hussain & Durrani (2009) also reported inconsistent behavior of moisture contents in some forage plants. Although, the plant material processed for chemical analysis is dried, yet the structural composition of plant varies in retention of plant moisture in different parts and at different age periods. Leaves, stems, roots and fruits have differential capability of maintaining moisture. In the present case, the differential trend of retaining moisture even after drying is species and part specific. Moisture is needed for maintaining the chemical frame work of different chemicals which vary in the level.

As reported by Sultan *et al.*, (2008a) a decrease in organic matter in some grasses with advancing maturity occurred like the present investigation where a significant decline was observed in OM in *Debregeasia* and *Indigofera*. This strengthens our findings. OM contents increased in *Zizyphus* with advancing growth stages. The remaining shrubs showed inconsistent trend in OM. Organic matter contents ranged from 74.03% to 87.96% in the investigated shrub species. Organic matter contents were higher in all the phenological stages of *Berberis*. Nitrogen free extract levels in the analyzed shrub species ranged from 36.79% to 74.29%, which was high than reported by Liu (1993) for other arid land pasture plants. In *Zizyphus*,

NFE decreased with advancing maturity. In *Berberis*, the reproductive and post-reproductive stages had insignificant differences in nitrogen free extracts but it was low in the vegetative stage. *Debregeasia* also followed the same trend. Hussain & Durrani, (2009) also observed high NFE values for some forage plants.

Total digestible nutrients ranged from 42.81% to 89.29% among shrub leaves. There was variation in TDN among species and phenological stages showing inconsistent trend. Hussain & Durrani (2009) and Liu (1993) also reported insignificant differences in the phenological stages of some grasses and shrubs.

Gross energy, digestible energy and metabolized energy in the analyzed shrubs had insignificant differences. However, phenological stages differed significantly. Similarly, Hussain & Durrani (2009) and Sultan *et al.*, (2007) reported decline in gross energy, digestible energy and metabolized energy in their study for some range grasses and shrubs. The results of Robles & Boza (1993) are in line with our conclusions as they reported insignificant differences in metabolized energy contents of shrubs, perennial herbaceous species and annual rangeland species. *Justicia* and *Rosa* had low gross energy, digestible energy and metabolized energy in their reproductive stages compared with other phenological stages.

B. Cell wall constituents

NDF contents in the present study ranged from 25.54% to 60.03% among the shrub species showing variability among species and in phenological stages. The results are in line with the findings of Ganskopp & Bohnert (2001, 2003), Kramberger & Klemencic (2003), Andrighetto *et al.*, (1993) and Sultan *et al.*, (2007), who also reported variation among forage plants and at different growth stages. Cherney *et al.*, (1990) recorded low NDF value in inflorescence.

ADF concentrations ranged from 14.52% to 46.45% in the investigated shrub leaves. ADF concentrations among tested plants varied. Similarly, Ashraf *et al.*, (1995) also observed increase in NDF and ADF in fodder species at different growth stages. ADF concentrations increased with maturity in shrubs and grasses (Cherney *et al.*, 1993; Kramberger & Klemencic 2003; Sultan *et al.* 2007; Hussain & Durrani 2009) and is what, the present study also reported. However, ADF concentrations decreased in *Debregeasia* and *Rosa* with maturity and this deviates from the general trend already reported. The findings agree with Cherney *et al.*, (1990) who reported lower NDF and ADF in reproductive stage.

Lignin which occurs in the woody parts of the plants like stem, husk, stalks and seed coats has absolutely no feeding value in any species as it is not digestible, instead it depresses the digestibility of the cellulose and other complex carbohydrates (Holecheck *et al.*, 1998; Kramberger & Klemencic, 2003). ADL concentrations ranged from 0.50% to 12.00% in the present analyzed shrub species. The findings agree with those of Robles & Boza (1993) and Hussain & Durrani (2009) who also reported high lignin contents in grasses and shrubs. Abrupt decrease regarding ADL levels were observed in *Debregeasia, Dodonaea, Justicia* and *Rosa* with advancing age. The results of the present endure differ from those of Sultan *et al.*, (2007) and Hussain & Durrani (2009) who observed enhanced ADL contents with maturity of plants. However, ADL contents in *Gymnosporia* increased abruptly with advancing maturity. *Berberis* and *Zizyphus* showed inconsistent trend in ADL concentration with regards to phenological stages. Hemicelluloses ranged from 3.51% to 28.01% in the analyzed shrub species. Holecheck *et al.* (1998) reported that due to microorganisms' activity in the rumen and large intestine of the livestock, celluloses and hemicelluloses are capable of digestion. Variation in the amount of structural carbohydrates occurred with seasonal changes as well as with growth stages of plant (Hussain & Durrani 2009).

III. Grasses

A. Proximate composition

Significant differences in dry matter values have been observed in some legumes and forbs (Tufarelli *et al.*, 2010). This agrees with our findings as significant differences were recorded among the different grasses and among the various phenological stages. Dry matter in the investigated grasses ranged from 92.03% to 95.91%. Kononov *et al.* (2005) also reported the high dry weight yield in *Medicago falcata*. Ashraf *et al.*, (1995) and Kramberger & Klemencic, (2003) recorded increase in dry matter with advancing age. In the present case dry matter also improved in *Heteropogon* and *Themeda* at advanced growth stages. Ganskopp & Bohnert (2001) reported high concentration of dry matter at pre-reproductive stage than other growth stages. The reproductive stage of *Apluda* and *Chrysopogon* had high %age of dry matter than other growth stages. However dry matter decreased in *Aristida, Digitaria* and *Schoenoplectus* with advancing growth stages. Hussain & Durrani (2009) also reported increase in dry matter concentrations in some shrubs and grasses with advancing maturity from Harboi rangelands.

Sultan *et al.* (2010; 2008a, c) reported high ash concentrations in some forage plants while in our case it ranged from 3.75% to 9.98%. In the present study ash contents in *Apluda* and *Pennisetum* increased with advancing maturity. Our findings are supported by Hussain & Durrani (2009) who also recorded increasing ash values in *Artemisia maritima* and *Perovskia atriplicifolia* with advanced growth stage. However, ash contents in *Chrysopogon, Digitaria, Heteropogon* and *Schoenoplectus* decreased with advancing age. Increased crude fiber and lignin levels with age have been observed by other workers (Cherney *et al.*, 1993; Distel *et al.*, 2005; Sultan *et al.*, 2008a). Their results are in line with us as we also observed significant increase in CF values in *Aristida, Digitaria, Heteropogon* and *Schoenoplectus* with advancing maturity. High values of crude fiber have been observed in various plant species by Holechek *et al.*, (1998) and Naseem *et al.*, (2006). Our findings agree with them. in the present study crude fiber contents ranged from 22.48% to 37.33% in grasses.

Bukhsh *et al.*, (2007) reported that seeds of *Carthamus oxyacantha* and *Eruca sativa* contained sufficient amount of crude fats compared with leaves. The present study also recorded high crude fat contents in grasses species that ranged from 5.27% to 14.71%. In *Digitaria* and *Heteropogon* crude fat contents gradually increased with advancing maturity. Adetuyi & Akpambang (2006) determined ether extract in *Sorghum bicolor*. Our findings also agree with Hussain & Durrani (2009) who recorded significant differences in crude fat contents between pre- and post reproductive stages of grasses and shrubs.

Holechek *et al.* (1998) reported that sufficient proteins are necessary for animal's body metabolism. Maturity cause an increase in crude proteins levels in may forage plant species (Ganskopp & Bohnert 2001; Khan *et al.* 2002). Distel *et al.*, (2005) and Hussain & Durrani, (2009) also reported similar trend in CP concentrations with advancing growth stages. In the present investigation crude protein levels increased in *Apluda, Aristida, Digitaria* and *Themeda* with advancing maturity. Khodzhaeva *et al.*, (2002) reported the content and composition proteins in the aerial part of the *Rumex confertus*. *Pennisetum* and *Schoenoplectus* had low proteins contents in post-reproductive stage. Roger *et al.* (2005) reported that protein level of green leafy vegetables ranged from 20.48-41.66%. However, in the present investigation grasses had CP contents from 5.18% to 12.63%.

The moisture contents showed an inconsistent trend among the grasses and between the growth stages within the same species. Similar observation has been reported by Hussain & Durrani (2009) and Roger *et al.* (2005). Organic Matter contents significantly declined in *Aristida, Pennisetum* and *Schoenoplectus.* Our findings are in line with Sultan *et al.,* (2008a) who also reported decrease in organic matter in some grasses with advancing growth stages.The vegetative and reproductive stages of *Apluda* had insignificant difference in OM contents but significantly declined in post-reproductive stage. Organic matter, in *Heteropogon* and *Themeda* increased with advancing age. Nitrogen free extract levels increased in *Aristida* and *Digitaria* with advancing maturity. The NFE value of the present study was high than reported by Liu, (1993) for other arid land pasture plants. The vegetative and reproductive stages of *Apluda* and *Heteropogon* had similar NFE contents but it ran higher in post-reproductive stage. The reproductive stage of *Chrysopogon* and *Themeda* had significantly higher NFE concentrations than other phenological stages. Our findings agree with Hussain and Durrani (2009) who also reported high NFE values for some shrubs and grasses from Harboi Rangelands.

Carbohydrate contents ranged from 60.81% to 76.32% in the analyzed grasses. The inconsistent trend recorded in the present investigation agree with many workers (Hussain and Durrani, 2009; Sultan *et al.,* 2007). The total digestible nutrients increased with advancing maturity in some of the grasses while it decreased in other cases. Thus inconsistent trend for TDN was similar reported by other studies (Hussain & Durrani, 2009; Liu, 1993). Hussain & Durrani, (2009) and Sultan *et al.,* (2007) reported decline in various types of energies in range plants. In the present study an increase or decreases was recorded in these energies that depended upon the species and phenological stage of species. The findings of Robles & Boza (1993) are in line with our results as they reported insignificant differences in metabolized energy of forage plants.

B. Cell wall constituents

NDF levels ranged from 53.14% to 57.04% in the investigated grasses. Neutral detergent fiber values increased in *Apluda, Pennisetum* and *Themeda* with advancing maturity. This agrees with Ganskopp & Bohnert (2001), Kramberger & Klemencic (2003), Andrighetto *et al.,* (1993) and Sultan *et al.,* (2007) who observed increased NDF with advancing age in some forages. Some investigated grass species

showed inconsistent trend in NDF levels with advancing growth stages. Cherney *et al.*, (1990) recorded low NDF value in reproductive stage than in other morphological components. On the other hand Hussain & Durrani (2009) reported high levels of NDF in forage plants from Harboi hills. The level of ADF varied from 27.53% to 49.50% among grasses. ADF values decreased in *Aristida, Digitaria, Pennisetum, Schoenoplectus* and *Themeda* with advancing growth stages. Contrarily, Cherney *et al.*, (1993), Kramberger & Klemencic (2003), Sultan *et al.* (2007) and Hussain & Durrani (2009) reported increase in ADF concentrations with maturity in some forage plants. Ashraf *et al.*, (1995) recorded increase in NDF and ADF in fodder species at different growth stages.

Lignin is indigestible and retards digestibility of the cellulose and other complex carbohydrates (Holecheck *et al.*, 1998; Kramberger & Klemencic, 2003). In the present case high lignin contents ranging from 1.90% to 43.50% were recorded. This agree with Robles & Boza (1993) and Hussain & Durrani (2009) who noticed high lignin contents in grasses and shrubs. Sultan *et al.*, (2007) and Hussain & Durrani (2009) also observed improvement in ADL contents with maturity of plants. However, in the present study lignin decreased in some grasses like *Aristida, Digitaria* and *Pennisetum* with advancing age but *Heteropogon* and *Schoenoplectus* exhibited high lignin contents at reproductive stage than other stages.

Hemicelluloses ranged from 16.69% to 34.81% in the analyzed grasses. There were variations as in some cases it declined and in others it enhanced with maturity. Likewise Hussain & Durrani (2009) reported variation in the amount of structural carbohydrates with seasonal changes as well as with growth stages of forage species. Cellulose values ranged from 5.50% to 44.00% in the analyzed grass species. Cellulose contents decreased in *Aristida* and *Themeda* with advancing growth stages. An inconsistent trend for forage plants for cellulose levelswas reported by many workers (Hussain & Durrani 2009; Sultan *et al.*, 2007; Kramberger & Klemencic, 2003) and we also noticed a similar situation. Thus variation might be due to accumulation and storage capability of the forage plants and soil conditions.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

GENERAL CONCLUSIONS AND RECOMMENDATIONS

1. The study was conducted during 2009 and 2010 to understand the vegetation-habitat relationship, structure, productivity, palatability, mineral composition and nutritional analysis of some key palatable forage plants.
2. The study showed that the flora of Gadoon Hills, consisted of 260 plant species belonging to 211 genera and 90 families. Of them, 77 families were Dicots, 7 Monocots, 4 Pteridophytes and 2 Gymnosperms. Asteraceae Poaceae, Lamiaceae, Rosaceae, Papilionaceae, Brasicaceae, Euphorbiaceae, Moraceae and Polygonaceae were important families.
3. The biological spectrum showed that therophytes and megaphanerophytes were the most abundant. Leaf spectra indicated that microphylls were dominant followed by leptophylls.
4. Ethnobotanical information revealed that most of the plant species (57.31%) were medicinal followed by forage species.
5. Based on cluster analysis the vegetation was classified into dry tropical (400-650 m), sub-tropical (800-1350 m) and temperate (1750-2250 m) zones.
6. The physical and chemical analysis of habitat features revealed that the flora, vegetation structure and its productivity is governed by temperature, soil moisture and altitude. Soil nutrients appeared to be playing secondary role in shaping the vegetation.
7. It was observed that there were 57 species available in April, 56 in May, 60 in June, 59 in July, 55 in August, 42 in September and 30 species in October.
8. Of the 82 palatable plants, 22 Spp. were trees, 12 Spp. shrubs and 48 species were herbs. These included 42.68% highly palatable, 8.54% mostly palatable, 1.22% less palatable and 9.76% rarely palatable species.

9. The total fresh biomass of different shrubs and herbs varied with altitudinal variations. The highest total biomass (shrubs and herbs) was observed at 500 m (63366 Kg/ha) and 600 m (61270 Kg/ha). The lowest total biomass for shrubs and herbs was recorded at 2050 m (7675 Kg/ha) under the thick canopy of trees (*Quercus* forests).
10. Macro-mineral (Ca, K, Mg, Na, and N) contents recorded in the leaves of selected trees, shrubs and grasses at three phenological stages were sufficient enough for the grazing livestock.
11. Micro-minerals (Cd, Cr, Cu, Fe, Ni, Pb, Zn and Mn) concentrations available in forage plants was very low for the livestock, hence this may be, one of the causes responsible for the pitiable health and productivity of the grazing animals in Gadoon hills.
12. The proximate composition and cell wall constituents of the tested forage plants showed significant differences among the various species and among the different phenological stages. The DM, CF, EE, CP, NFE, TDN, NDF, ADF and total carbohydrates increased with advancing maturity.
13. The locals depend upon the tree and shrubby species for fuel and timber wood therefore deforestation, trampling, soil erosion and over-grazing were the crucial ecological factors in the destruction of original vegetation and degradation.

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 sources for fuel/timber could be provided and the area should be banned for 10 years to promote shrubs and tree cover.

3. There is a dire need to promote ethics for the conservation and improvement of natural vegetation that will manage the soil erosion. Soil is being eroded very rapidly due to lack of vegetation cover.
4. Marketing policies for livestock and medicinal plants should be regulated and upgraded as at present there is no such facility.
5. 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.
6. A balance between the food supply, nutrient input, livestock population and human influences will be critical for long term sustainability.
7. Ecological and socioeconomic problems are needed to address through research and developmental programs.
8. Recreational activities are needed to start in the area by government tourism department for income generation that can be used for its development.

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APPENDICES

Appendix 1: Comprehensive list of plants of each category of economic use.

S. No.	Species	M	Fd	Fw	V	Tsr	Fr	O	Fe	P	Tw	At	Hb	W
1.	*Acacia catechu* (L.f.) Willd.	+	+	+	-	-	-	-	+	-	-	+	-	-
2.	*Acacia modesta* Wall.	+	+	+	-	-	-	-	+	-	-	+	+	-
3.	*Acacia nilotica* (L.) Delile.	+	+	+	-	-	-	-	+	-	+	+	-	-
4.	*Achillea millefolium* L.	+	+	-	-	-	-	-	-	-	-	-	-	-
5.	*Achyranthes aspera* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
6.	*Acorus calamus* Linn.	+	-	-	-	-	-	-	-	-	-	-	-	-
7.	*Adiantum incisum* Forsk.	+	-	-	-	-	-	+	-	-	-	-	-	-
8.	*Adiantum venustum* D.Done	+	-	-	-	-	-	-	-	-	-	-	-	-
9.	*Aerva javanica* (Burm. f.) Juss.	+	-	-	-	-	-	-	-	-	-	-	-	-
10.	*Ailanthus altissima* (Mill) Swingle	+	+	+	-	+	-	-	-	-	+	-	-	-
11.	*Ajuga bractiosa* Wall. Benth.	+	-	-	-	-	-	-	-	-	-	-	-	-
12.	*Ajuga parviflora* Benth.	+	-	-	-	-	-	-	-	-	-	-	-	-
13.	*Albizia lebbeck* (L.) Bth.	+	-	+	-	+	-	+	-	-	+	+	-	-
14.	*Allium cepa* L.	+	-	-	+	-	-	-	-	-	-	-	-	-
15.	*Allium griffithianum* Boiss.	+	-	-	-	-	-	-	-	-	-	-	-	-
16.	*Allium jacquemontii* Kunth	+	-	-	-	-	-	-	-	-	-	-	-	-
17.	*Allium sativum* L.	+	-	-	+	-	-	-	-	-	-	-	-	-
18.	*Amaranthus spinosus* L.	+	-	-	+	-	-	-	-	-	-	-	-	-
19.	*Amaranthus viridis* L.	+	-	-	+	-	-	-	-	-	-	-	-	-
20.	*Ammi visnaga* (L.) Lamk.	+	-	-	-	-	-	-	-	-	-	-	-	-
21.	*Anagallis arvensis* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
22.	*Androsace rotundifolia* Hardw.	-	-	-	-	-	-	-	-	-	-	-	-	+
23.	*Antirrhinum orontium* L.	-	-	-	-	-	-	-	-	-	-	-	-	+
24.	*Apluda mutica* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
25.	*Arabidopsis wallichii* (H.&T.) N. Busch.	-	-	-	-	-	-	-	-	-	-	-	-	+
26.	*Arenaria serpyllifolia* L.	-	-	-	-	-	-	-	-	-	-	-	-	+
27.	*Aristida adscensionis* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
28.	*Artemisia vulgaris* L.	+	-	-	-	-	-	-	-	-	-	-	-	-

29.	*Arthraxon prionodes* (Steud.) Dandy.	-	+	-	-	-	-	-	-	-	-	-	-	-
30.	*Asparagus adscendens* Roxb.	-	-	-	+	-	-	+	-	-	-	-	-	-
31.	*Asplenium adiantum nigrum* L.	-	-	-	-	-	-	+	-	-	-	-	-	-
32.	*Avena sativa* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
33.	*Bauhinia variegata* L.	+	-	+	+	+	-	+	-	-	+	-	-	-
34.	*Berberis lycium* Royle.	+	+	-	-	-	+	-	+	-	-	-	-	-
35.	*Bergenia ciliata* (Haw) Sternb.	+	-	-	-	-	-	-	-	-	-	-	-	-
36.	*Bidens cernua* L.	-	-	-	-	-	-	-	-	-	-	-	-	+
37.	*Bistorta amplexicaulis* (D.Don) Green	+	-	-	-	-	-	-	-	-	-	-	-	-
38.	*Boerhaavia diffusa* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
39.	*Boerhavia procumbens* Banks ex Roxb.	+	-	-	-	-	-	-	-	-	-	-	-	-
40.	*Bombax ceiba* Linn.	-	-	-	-	-	-	+	-	-	-	-	-	-
41.	*Brassica compestris* L.	-	+	-	+	-	-	-	-	-	-	-	+	-
42.	*Broussonetia papyrifera* (L.) L'Herit. ex Vent.	-	+	+	-	-	-	-	-	-	-	-	-	-
43.	*Buddleja asiatica* Lour.	-	-	-	-	-	-	-	-	-	-	-	-	+
44.	*Bupleurum subuniflorum* Boiss. & Heldr.	-	-	-	-	-	-	-	-	-	-	-	-	+
45.	*Butea frondosa* Roxb.	-	-	+	-	-	-	-	-	-	-	-	-	-
46.	*Buxus wallichiana* Baill.	+	-	+	-	+	-	-	-	+	-	-	-	-
47.	*Calendula arvensis* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
48.	*Calendula officinalis* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
49.	*Calotropis procera* (wild) R.Br.	+	-	-	-	-	-	-	-	+	-	-	-	-
50.	*Caltha alba* Jacq ex Comb.	+	-	-	-	-	-	-	-	-	-	-	-	-
51.	*Cannabis sativa* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
52.	*Capsella bursa-pestoris* Medic.	+	-	-	-	-	-	-	-	-	-	-	-	-
53.	*Carissa spinarum* auct. non L.	-	+	-	-	-	-	-	+	-	-	-	-	-
54.	*Carthamus oxycantha* M.B.	+		-	-	-	-	-	-	-	-	-	-	-
55.	*Cassia fistula* Linn.	+	-	+	-	-	-	+	-	-	-	-	-	-
56.	*Cedrela serrata* Royle.	+	-	+	-	+	-	-	-	-	-	-	-	-
57.	*Celosia cristata* L.	-	-	-	-	-	-	-	-	-	-	-	-	+
58.	*Celtis australis* L.	+	+	+	-	-	+	-	-	-	-	+	-	-
59.	*Cerastium dichotomum* L.	+	-	-	-	-	-	-	-	-	-	-	-	-

60.	*Cerastium fontanum* Baumg.	+	-	-	-	-	-	-	-	-	-	-	-	-
61.	*Ceterach dalhousiae* (Hk.) C. Chr.	-	-	-	-	-	-	-	-	-	-	-	-	+
62.	*Cheilanthes marantae* (L.) Domin.	-	-	-	-	-	-	-	-	-	-	-	-	+
63.	*Chenopodium album* L.	+	-	-	+	-	-	-	-	-	-	-	-	-
64.	*Chenopodium ambrosioides* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
65.	*Chenopodium murale* L.	+	+	-	-	-	-	-	-	-	-	-	-	-
66.	*Chrysopogon aucheri* (Boiss.) Stapf	-	+	-	-	-	-	-	-	-	-	-	-	-
67.	*Cichorium intybus* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
68.	*Cirsium arvense* (L.) Scop.	-	-	-	-	-	-	-	-	-	-	-	-	+
69.	*Colebrookea oppositifolia* Sm.	-	-	-	-	-	-	-	-	-	-	-	-	+
70.	*Consolida ambigua*(L.) Ball & Hey-wood	-	-	-	-	-	-	-	-	-	-	-	-	+
71.	*Convolvulus arvensis* L.	+	+	-	-	-	-	-	-	-	-	-	-	-
72.	*Convolvulus pluricaulis* Choisy	-	+	-	-	-	-	-	-	-	-	-	-	-
73.	*Conyza canadensis* (L.) Cronquist	-	-	-	-	-	-	-	-	-	-	-	-	+
74.	*Conyza crispus* Pourr.	-	-	-	-	-	-	-	-	-	-	-	-	+
75.	*Coriandrum sativum* L.	+	-	-	+	-	-	-	-	-	-	-	-	-
76.	*Coronopus didymus* (L.) Sm.	+	-	-	-	-	-	-	-	-	-	-	-	-
77.	*Cotoneaster bacillaris* Wall. ex Lindle.	-	+	+	-	-	-	-	-	-	-	+	-	-
78.	*Crotalaria medicaginea* Lam.	-	-	-	-	-	-	-	-	-	-	-	-	+
79.	*Cucumis prophetarum* L.	+	-	-	-	-	-	-	-	+	-	-	-	-
80.	*Cuscuta reflexa* Roxb.	+	-	-	-	-	-	-	-	-	-	-	-	-
81.	*Cynodon dactylon* (L.) Pers.	-	+	-	-	-	-	+	-	-	-	-	-	-
82.	*Cyperus niveus* Retz.	-	-	-	-	-	-	-	-	-	-	-	-	+
83.	*Cyperus rotundus* Linn.	-	+	-	-	-	-	-	-	-	-	-	-	-
84.	*Dalbergia sissoo* Roxb.	+	-	+	-	-	-	-	-	-	+	-	-	-
85.	*Datura innoxia* Mill.	+	-	-	-	-	-	-	-	+	-	-	-	-
86.	*Debregeasia salicifolia* (D. Don) Rendle	+	+	+	-	-	+	-	-	-	-	-	-	-
87.	*Delphinium denudatum* Wall. ex H, & T.	+	-	-	-	-	-	-	-	-	-	-	-	-
88.	*Dichanthium annulatum* (Forssk.) Stapf.	-	+	-	-	-	-	-	-	-	-	-	-	-
89.	*Dicliptera roxburghiana* Nees	+	+	-	-	-	-	-	-	-	-	-	-	-
90.	*Digitaria sanguinalis* (L.) Scop.	-	+	-	-	-	-	-	-	-	-	-	-	-

91.	*Diospyrus kaki* L.	-	+	+	-	-	+	-	-	-	-	-	-	-
92.	*Diospyrus lotus* L.	-	-	+	-	-	+	-	-	-	-	-	-	-
93.	*Dodonaea viscosa* (L.) Jacq.	+	-	+	-	+	-	+	+	-	-	-	-	-
94.	*Duchesnea indica* (Andr.) Focke	+	-	-	-	-	-	-	-	-	-	-	-	-
95.	*Echinops echinatus* Roxb.	-	-	-	-	-	-	-	-	-	-	-	-	+
96.	*Epilobium brevifolium* Don.	-	-	-	-	-	-	-	-	+	-	-	-	-
97.	*Equisetum arvense* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
98.	*Eruca sativa* L.	+	+	-	+	-	-	-	-	-	-	-	-	-
99.	*Eryngium biebersteinianum* Nevski ex Bobrov.	+	+	-	-	-	-	-	-	-	-	-	-	-
100.	*Euphorbia cornigera* Boiss.	+	-	-	-	-	-	-	-	+	-	-	-	-
101.	*Euphorbia helioscopia* L.	+	-	-	-	-	-	-	-	+	-	-	-	-
102.	*Euphorbia hirta* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
103.	*Euphorbia prostrata* Ait.	+	-	-	-	-	-	-	-	-	-	-	-	-
104.	*Ficus carica* L.	+	+	-	-	-	+	-	-	-	-	-	-	-
105.	*Ficus palmata* Forssk.	+	+	-	-	-	+	-	-	-	-	-	-	-
106.	*Ficus racemosa* L.	+	-	+	-	-	+	-	-	-	-	-	-	-
107.	*Ficus religiosa* L.	+	-	+	-	-	-	-	-	-	-	-	-	-
108.	*Filago spathulata* C. Presl.	-	-	-	-	-	-	-	-	-	-	-	-	+
109.	*Fimbristylis dichotoma* (L.) Vahl.	-	-	-	-	-	-	-	-	-	-	-	-	+
110.	*Flacourtia indica* (Burm. f.) Merrill	-	-	-	-	-	+	-	-	-	-	-	-	-
111.	*Foeniculum vulgare* Miller.	+	-	-	-	-	-	-	-	-	-	-	-	-
112.	*Fragaria indica* Andrew	+	-	-	-	-	+	-	-	-	-	-	-	-
113.	*Fragaria vesca* Lindle.ex Hk. f.	+	-	-	-	-	+	-	-	-	-	-	-	-
114.	*Fumaria indica* (Hsskn) H.N.	+	-	-	-	-	-	-	-	-	-	-	-	-
115.	*Gallium aparine* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
116.	*Gentiana kurru* Royle	+	-	-	-	-	-	-	-	-	-	-	-	-
117.	*Geranium nepalensis* Sweet	+	-	-	-	-	-	-	-	-	-	-	-	-
118.	*Geranium wallichianum* D. Don. ex Sweet	+	-	-	-	-	-	-	-	-	-	-	-	-
119.	*Grewia optiva* Drum.ex.Burret.	-	+	+	-	-	-	-	-	-	-	-	-	-
120.	*Gymnosporia royleana* Wall ex Lawson	-	+	+	-	-	-	-	+	-	-	-	-	-
121.	*Hedera helix* L.	-	+	-	-	-	-	-	-	-	-	-	-	-

122.	*Heteropogon contortus* (L.) P. Beauv.	-	+	-	-	-	-	-	-	-	-	-	-	-
123.	*Hypericum perforatum* L.	-	-	-	-	-	-	-	-	-	-	-	-	+
124.	*Imperata cylindrica* (L.) P. Beauv.	-	+	-	-	-	-	-	-	-	-	-	-	-
125.	*Indigofera heterantha* L.	-	+	+	-	+	-	-	-	-	-	-	-	-
126.	*Inula cappa* (Ham.) DC.	-	-	-	-	-	-	-	-	+	-	-	-	-
127.	*Inula racemosa* Hk. f.	-	-	-	-	-	-	-	-	+	-	-	-	-
128.	*Justicia adhatoda* L.	+	-	+	-	+	-	-	-	-	-	-	+	-
129.	*Kickxia ramosissima* (Wall) Janchen.	-	-	-	-	-	-	-	-	-	-	-	-	+
130.	*Korthalsella opuntia* (Thunb.) Merrill	-	-	-	-	-	-	-	-	-	-	-	-	+
131.	*Lactuca serriola* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
132.	*Lathyrus aphaca* L.	-	+	-	+	-	-	-	-	-	-	-	-	-
133.	*Lepidium apetalum* Willd.	+	-	-	-	-	-	-	-	-	-	-	-	-
134.	*Lespedeza juncea* (L.f) Persoon	+	+	-	-	-	-	-	-	-	-	-	-	-
135.	*Leucas urticifolia* (Vahl) R.Br.	-	-	-	-	-	-	-	-	-	-	-	-	+
136.	*Linum strictum* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
137.	*Lithospermum officinale* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
138.	*Litsea deccanensis* Gamble	+	-	-	-	-	-	-	-	-	-	-	-	-
139.	*Lonicera hypoleuca* Dcne.	-	-	+	-	-	-	-	-	-	-	-	-	-
140.	*Lonicera quinquilacularis* Hardw.	-	+	+	-	-	-	-	-	-	-	-	-	-
141.	*Luffa cylindrica* (L.) Roem.	-	-	-	+	-	-	-	-	-	-	-	-	-
142.	*Mallotus philippensis* Muell.	-	-	+	-	-	-	-	-	-	-	-	-	-
143.	*Malva neglecta* Waller.	-	+	-	+	-	-	-	-	-	-	-	-	-
144.	*Malva parviflora* L.	+	+	-	+	-	-	-	-	-	-	-	-	-
145.	*Malvastrum coromandelianum* L.	-	-	-	-	-	-	-	-	-	-	-	-	+
146.	*Medicago denticula* Willd.	+	+	-	+	-	-	-	-	-	-	-	-	-
147.	*Medicago polymorpha* L.	-	+	-	+	-	-	-	-	-	-	-	-	-
148.	*Melia azedarach* L.	+	+	+	-	+	-	-	-	-	+	-	-	-
149.	*Melothria heterophylla* Cogn.	+	-	-	-	-	-	-	-	-	-	-	-	-
150.	*Mentha longifolia* (L.) Huds	+	-	-	+	-	-	-	-	-	-	-	-	-
151.	*Mentha spicata* L.	+	-	-	+	-	-	-	-	-	-	-	-	-
152.	*Micromeria biflora* (Ham.) Bth.	+	-	-	-	-	-	-	-	-	-	-	-	-

153.	*Mimosa himalayana* Gamble	-	+	+	-	-	-	-	-	-	-	-	-	-
154.	*Mirabilis jalapa* L.	-	-	-	-	-	-	+	-	-	-	-	-	-
155.	*Miscanthus nepalensis* (Trin.) Hack.	-	+	-	-	-	-	-	-	-	-	-	-	-
156.	*Morus alba* L.	+	+	+	-	+	+	-	-	-	+	-	-	-
157.	*Morus indica* L.	+	+	+	-	+	+	-	-	-	+	-	-	-
158.	*Musa sapientum* L.	+	-	-	-	-	+	-	-	-	-	-	-	-
159.	*Myriactus wallichii* Less.	-	-	-	-	-	-	-	-	-	-	-	-	+
160.	*Myrsine africana* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
161.	*Narcissus tazzeta* L.	-	-	-	-	-	-	+	-	-	-	-	+	-
162.	*Nasturtium officinale* R.Br.	-	-	-	+	-	-	-	-	-	-	-	-	-
163.	*Nerium indicum* Mill.	-	-	-	-	+	-	+	-	+	-	-	-	-
164.	*Neslia apiculata* Fisch. Mey. & Ave Lall.	-	-	-	-	-	-	-	-	-	-	-	-	+
165.	*Oenothera rosea* Soland.	+	-	-	-	-	-	-	-	-	-	-	-	-
166.	*Opuntia dilleni* Haw.	+	-	-	-	-	+	+	+	-	-	-	-	-
167.	*Origanum vulgare* L.	+	+	-	-	-	-	-	-	-	-	-	-	-
168.	*Otostegia limbata* Bth.	+	-	+	-	-	-	-	+	-	-	-	-	-
169.	*Oxalis corniculata* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
170.	*Papaver rhoeas* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
171.	*Parratiopsis jacquemontiana* Dcne.	-	+	+	-	+	-	-	-	-	-	+	-	-
172.	*Pennisetum orientale* L. C. Rich.	-	+	-	-	-	-	-	-	-	-	-	-	-
173.	*Pergularia daemia* (Forssk.) Chiov.	-	+	-	-	-	-	-	-	-	-	-	-	-
174.	*Periploca aphylla* Dcne.	+	-	-	-	-	-	-	-	-	-	-	-	-
175.	*Phalaris minor* Retz.	-	+	-	-	-	-	-	-	-	-	-	-	-
176.	*Phyllanthus maderaspatensis* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
177.	*Pinus roxburghii* Sergent	+	-	+	-	+	-	-	-	-	+	-	-	-
178.	*Pinus wallichiana* A.B Jackson.	+	-	+	-	+	-	-	-	-	+	-	-	-
179.	*Pistacia integrima* J.L.Stewart ex Brandis	+	+	+	-	-	-	-	-	-	+	-	-	-
180.	*Plantago lanceolata* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
181.	*Plantago major* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
182.	*Platanus orientalis* L.	+	-	+	-	+	-	-	-	-	+	-	-	-
183.	*Plectranthus rugosus* Wall.ex. Bth.	+	+	-	-	-	-	-	-	-	-	-	+	-

184.	*Poa annua* L.	-	+	-	-	-	-	-	-	-	-	-	-	-	-
185.	*Polygala abyssinica* R. Br.ex Fresen.	-	-	-	-	-	-	-	-	-	-	-	-	-	+
186.	*Polygonum barbatum* L.	-	-	-	-	-	-	-	-	+	-	-	-	-	-
187.	*Polygonum paronychioides* C. A. Mey.ex Hohen	-	-	-	-	-	-	-	-	+	-	-	-	-	-
188.	*Polygonum plebejum* R. Br.	-	-	-	-	-	-	-	-	+	-	-	-	-	-
189.	*Populus euphratica* Olivier	-	+	+	-	+	-	-	-	-	+	-	-	-	-
190.	*Portulaca oleracea*L.	-	-	-	+	-	-	+	-	-	-	-	-	-	-
191.	*Potentilla anserina* L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-
192.	*Potentilla supina* L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-
193.	*Primula denticulata* Sm.	+	-	-	-	-	-	-	-	-	-	-	-	-	-
194.	*Prunus cornuta* (Wall ex Royle) Steud.	-	+	+	-	-	-	-	-	-	-	+	-	-	-
195.	*Pueraria tuberosa* (Roxb. ex Willd.) DC.	-	-	-	-	-	-	-	-	-	-	-	-	-	+
196.	*Punica granatum* L.	+	-	+	-	-	+	-	-	-	-	-	-	-	-
197.	*Pyrus pashia* Ham ex. D. Done	+	-	+	-	-	+	-	-	-	-	-	-	-	-
198.	*Quercus dilatata* Lindley	-	+	+	-	+	-	-	-	-	-	+	-	-	-
199.	*Quercus incana* Roxb.	-	+	+	-	+	-	-	-	-	-	+	-	-	-
200.	*Ranunculus muricatus* L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-
201.	*Rhazya stricta* Dcne.	-	-	+	-	-	-	-	-	-	-	-	-	-	-
202.	*Rhododenron arborium* Smith.	+	-	+	-	-	-	-	-	-	-	-	-	-	-
203.	*Rhus cotinus* L.	-	-	+	-	-	-	-	-	-	-	-	-	-	-
204.	*Riccinis communis* L.	+	-	+	-	-	-	-	-	-	-	-	-	-	-
205.	*Rosa moschata* non J. Herrm.	+	+	+	-	-	-	+	+	-	-	-	+	-	-
206.	*Rubus ellipticus* Smith	+	+	+	-	-	+	-	+	-	-	-	-	-	-
207.	*Rubus ulmifolius* Schott.	+	+	+	-	-	+	-	+	-	-	-	-	-	-
208.	*Rumex dentatus* L.	+	+	-	+	-	-	-	-	-	-	-	-	-	-
209.	*Rumex hastatus* L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-
210.	*Rumex vesicarius* L.	+	-	-	-	-	-	-	-	-	-	-	-	-	-
211.	*Saccharum bengalense* Ritz.	-	-	-	-	+	-	-	+	-	-	-	-	-	-
212.	*Saccharum spontaneum* L.	-	-	-	-	+	-	-	+	-	-	-	-	-	-
213.	*Sageretia theezans* (L.) Brongn.	-	-	+	-	+	-	-	-	-	-	-	-	-	-
214.	*Salix tetrasperma* Roxb.	-	+	+	-	+	-	-	-	-	+	-	-	-	-

215.	*Salvia lanata* Roxb.	-	-	-	+	-	-	-	-	-	-	-	-	-
216.	*Salvia moocroftiana* Wall.	+	-	-	-	-	-	-	-	-	-	-	-	-
217.	*Sarcococca saligna* (Dene) Duel	+	-	-	-	-	-	-	-	-	-	-	+	-
218.	*Saussurea heteromalla* (D.Don.) Hand-Mazz	+	-	-	-	-	-	-	-	-	-	-	-	-
219.	*Schoenoplectus litoralis*Schrad.	-	+	-	-	-	-	-	-	-	-	-	-	-
220.	*Scrophularia scabiosifolia* Bth.	+	-	-	-	-	-	-	-	-	-	-	-	-
221.	*Sedum ewersii* Ledeb.	+	-	-	-	-	-	-	-	-	-	-	-	-
222.	*Sida cordata* (Burm.f) Borss-Waalkes	+	-	-	-	-	-	-	-	-	-	-	-	-
223.	*Silene conoidea* L.	-	+	-	+	-	-	-	-	-	-	-	-	-
224.	*Silene vulgaris* (Moench) Carcke	-	+	-	-	-	-	-	-	-	-	-	-	-
225.	*Sisymbrium orientale* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
226.	*Solanum nigrum* L.	+	-	-	+	-	-	-	-	-	-	-	-	-
227.	*Solanum surratense* Burm.f.	+	-	-	-	-	-	-	-	-	-	-	-	-
228.	*Sonchus arvensis* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
229.	*Sonchus asper* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
230.	*Sonchus auriculata* L.	-	+	-	-	-	-	-	-	-	-	-	-	-
231.	*Sorghum helepense* (L.) Bern.	-	+	-	-	-	-	-	-	-	-	-	-	-
232.	*Stellaria media* (L.) Cyr.	-	+	-	-	-	-	-	-	-	-	-	-	-
233.	*Tagetus minuta* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
234.	*Taraxacum officinale* Weber.	+	-	-	-	-	-	-	-	-	-	-	-	-
235.	*Taxus wallichiana* Zucc.	-	-	+	-	+	-	-	-	-	-	-	-	-
236.	*Thalictrum foliolosum* DC.	+	-	-	-	-	-	-	-	-	-	-	-	-
237.	*Themeda anathera* (Nees) Hack.	-	+	-	-	-	-	-	-	-	-	-	-	-
238.	*Thlaspi perfoliantum* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
239.	*Thymus serphyllum* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
240.	*Tinospora cordifolia* (DC.) Meirs	+	-	-	-	-	-	+	-	-	-	-	-	-
241.	*Tribulus terrestris* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
242.	*Trichodesma indica* (L.) R.Br.	+	-	-	-	-	-	-	-	-	-	-	-	-
243.	*Trifolium repens* L.	+	+	-	+	-	-	-	-	-	-	-	-	-
244.	*Tulipa stellata* Hk.f.	-	-	-	-	-	-	-	-	+	-	-	-	-
245.	*Urtica dioca* L.	-	-	-	-	-	-	-	-	+	-	-	-	-

246.	*Valeriana jatamansii* Jones.	+	-	-	-	-	-	-	-	-	-	-	-	-
247.	*Verbascum thapsus* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
248.	*Veronica didyma* Tenore	+	-	-	-	-	-	-	-	-	-	-	-	-
249.	*Vibernum cotinifolium* D. Don.	-	+	+	-	-	+	-	-	-	-	-	-	-
250.	*Vicia saiva* L.	-	+	-	+	-	-	-	-	-	-	-	-	-
251.	*Viola serpens* Wall.	+	-	-	-	-	-	-	-	-	-	-	-	-
252.	*Viola stocksii* Boiss.	+	-	-	-	-	-	-	-	-	-	-	-	-
253.	*Viscum album* L.	-	-	-	-	-	-	-	-	-	-	-	-	+
254.	*Vitex negundo* L.	+	-	+	-	+	-	-	+	-	-	-	-	-
255.	*Withania somnifera* (L.) Dunal.	+	-	-	-	-	-	-	-	-	-	-	-	-
256.	*Woodfordia fruticosa* (L.) Kurz	-	-	+	-	-	-	-	-	-	-	-	-	-
257.	*Xanthium strumarium* L.	+	-	-	-	-	-	-	-	-	-	-	-	-
258.	*Zanthoxylum aromatum* D.C.	+	-	+	-	-	+	-	+	-	-	-	-	-
259.	*Zizyphus jujuba* Mill.	+	+	+	-	-	+	-	-	-	-	+	+	-
260.	*Zizyphus nummularia Buem.f. Weight*	+	+	+	-	-	+	-	+	-	-	-	+	-

Key: M =Medicinal sp., Fd =Fodder sp., Fw =Fuel wood sp., V =Vegetables and potherb sp., Tsr =Thatching/Sheltering and Roofing, Fr =Fruits sp., Fe =Fencing sp., O =Ornamental sp., P =Poisonous sp., Tw =Timber wood sp., At =Agricultural Tools sp., Hb =Honey bee sp., W =Weeds

Appendix 2
Summer Aspect
Phytosociological attributes of *Butea-Zizyphus-Themeda* community (BZT)
Altitude: 400 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Butea frondosa Roxb.	Mp	Mes	2.5	100	889.3	13.23	8.85	93.82	115.90
Shrub layer									
Butea frondosa Roxb.	Np	Mes	0.4	40	4.75	2.12	3.54	0.50	6.16
Carissa spinarum auct. non L.	Np	Mic	0.4	30	3.25	2.12	2.65	0.34	5.11
Dodonaea viscosa (L.) Jacq.	Np	Mic	1.1	80	5.75	5.82	7.08	0.61	13.51
Gymnosporia royleana Wall	Np	Mic	0.3	30	1.75	1.59	2.65	0.18	4.43
Justicia adhatoda L.	Np	Mic	1.2	70	0.8	6.35	6.19	0.08	12.63
Myrsine africana L.	Np	Na	0.4	40	2.25	2.12	3.54	0.24	5.89
Otostegia limbata Bth.	Np	Mic	0.3	30	0.75	1.59	2.65	0.08	4.32
Zizyphus nummularia Buem.f. Weight	Np	Lp	1.9	90	22.5	10.05	7.96	2.37	20.39
Herb layer									
Boerhaavia diffusa L.	Th	Na	0.4	40	1	2.12	3.54	0.11	5.76
Delphinium denudatum Wall. ex H & T.	Th	Mic	0.4	40	1	2.12	3.54	0.11	5.76
Dichanthium annulatum (Forssk.) Stapf.	Hc	Mic	1	60	1.5	5.29	5.31	0.16	10.76
Digitaria sanguinalis (L.) Scop.	Hc	Lp	1.4	60	1.5	7.41	5.31	0.16	12.88
Euphorbia hirta L.	Th	Na	0.6	40	1	3.17	3.54	0.11	6.82
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1.5	70	1.75	7.94	6.19	0.18	14.32
Malva parviflora L.	Th	Mic	0.4	40	1	2.12	3.54	0.11	5.76
Micromeria biflora (Ham.) Bth.	Th	Mic	0.7	50	1.25	3.70	4.42	0.13	8.26
Oxalis corniculata L.	Th	Mic	0.7	40	1	3.70	3.54	0.11	7.35
Silene vulgaris (Moench)	Th	Na	0.4	30	0.75	2.12	2.65	0.08	4.85
Tagetus minuta L.	Th	Mic	0.4	40	1	2.12	3.54	0.11	5.76
Themeda anathera (Nees) Hack.	Hc	Lp	2.2	80	2	11.64	7.08	0.21	18.93
Verbascum thapsus L.	Th	Mes	0.3	30	2	1.59	2.65	0.21	4.45

Appendix 3
Summer Aspect
Phytosociological attributes of *Acacia - Dodonaea - Themeda* community (ADT)
Altitude: 450 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Acacia catechu (L.f.) Willd.	Mp	Lp	0.5	30	181.47	2.56	2.61	19.19	24.36
Acacia modesta Wall.	Mp	Lp	1.1	50	331.26	5.64	4.35	35.03	45.02
Butea frondosa Roxb.	Mp	Mes	0.2	20	77.99	1.03	1.74	8.25	11.01
Ficus palmata Forssk.	Mp	Mes	0.4	30	119.38	2.05	2.61	12.62	17.28
Flacourtia indica (Burm. f.) Merrill	Mp	Mic	0.3	20	27.47	1.54	1.74	2.90	6.18
Mallotus philippensis Muell.	Mp	Mic	0.3	30	99.82	1.54	2.61	10.56	14.70
Shrub layer									
Acacia nilotica (L.) Delile.	Np	Lp	0.5	40	2.25	2.56	3.48	0.24	6.28
Carissa spinarum auct. non L.	Np	Mic	0.2	20	0.50	1.03	1.74	0.05	2.82
Dodonaea viscosa (L.) Jacq.	Np	Mic	4.3	100	35.25	22.05	8.70	3.73	34.47
Gymnosporia royleana Wall ex Lawson	Np	Mic	1.1	50	10.75	5.64	4.35	1.14	11.13
Mallotus philippensis Muell.	Np	Mic	0.4	30	6.75	2.05	2.61	0.71	5.37
Mimosa himalayana Gamble	Np	Lp	0.2	20	0.50	1.03	1.74	0.05	2.82
Otostegia limbata Bth.	Np	Mic	0.8	50	3.75	4.10	4.35	0.40	8.85
Sageretia theezans (L.) Brongn.	Np	Lp	0.8	60	11.25	4.10	5.22	1.19	10.51
Ziziphus nummularia Bucm.f. Weight	Np	Lp	1.2	70	24.00	6.15	6.09	2.54	14.78
Herb layer									
Adiantum incisum Forsk.	G	Na	0.6	50	1.25	3.08	4.35	0.13	7.56
Artemisia vulgaris L.	Ch	Mic	0.1	10	0.25	0.51	0.87	0.03	1.41
Dichanthium annulatum (Forssk.) Stapf.	Hc	Mic	1.2	70	1.75	6.15	6.09	0.19	12.43
Euphorbia hirta L.	Th	Na	0.4	40	1.00	2.05	3.48	0.11	5.64
Euphorbia prostrata Ait.	Th	Lp	0.5	40	1.00	2.56	3.48	0.11	6.15
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	0.9	60	1.50	4.62	5.22	0.16	9.99
Melothria heterophylla Cogn.	Th	Mic	0.1	10	0.25	0.51	0.87	0.03	1.41
Micromeria biflora (Ham.) Bth.	Th	Mic	0.7	50	1.25	3.59	4.35	0.13	8.07
Saussurea heteromalla (D.Don.) Hand-Mazz	Th	Mic	0.5	40	1.00	2.56	3.48	0.11	6.15
Themeda anathera (Nees) Hack.	Hc	Lp	1.6	100	2.50	8.21	8.70	0.26	17.17
Tulipa stellata Hk.f.	G	Lp	0.6	60	1.50	3.08	5.22	0.16	8.45

Appendix 4
Summer Aspect
Phytosociological attributes of *Dodonaea-Heteropogon* community (DH)
Altitude: 500 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Shrub layer									
Dodonaea viscosa (L.) Jacq.	Np	Mic	3.5	100	27.25	23.33	12.05	43.43	78.81
Justicia adhatoda L.	Np	Mic	1	50	7.50	6.67	6.02	11.95	24.64
Otostegia limbata Bth.	Np	Mic	0.6	40	3.75	4.00	4.82	5.98	14.80
Zizyphus nummularia Buem.f. Weight	Np	Lp	1.1	60	9.75	7.33	7.23	15.54	30.10
Herb layer									
Apluda mutica L.	Hc	Lp	0.6	50	1.25	4.00	6.02	1.99	12.02
Aristida adscensionis L.	Hc	Lp	0.7	40	1.00	4.67	4.82	1.59	11.08
Boerhaavia diffusa L.	Th	Na	0.4	30	0.75	2.67	3.61	1.20	7.48
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	0.7	50	1.25	4.67	6.02	1.99	12.68
Cynodon dactylon (L.) Pers.	Hc	Lp	0.7	50	1.25	4.67	6.02	1.99	12.68
Cyperus niveus Retz.	G	Lp	0.5	30	0.75	3.33	3.61	1.20	8.14
Dichanthium annulatum (Forssk.) Stapf.	Hc	Mic	1.1	70	1.75	7.33	8.43	2.79	18.56
Euphorbia hirta L.	Th	Na	1.2	80	2.00	8.00	9.64	3.19	20.83
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1.7	90	2.25	11.33	10.84	3.59	25.76
Micromeria biflora (Ham.) Bth.	Th	Mic	0.6	40	1.00	4.00	4.82	1.59	10.41
Oxalis corniculata L.	Th	Mic	0.4	30	0.75	2.67	3.61	1.20	7.48
Verbascum thapsus L.	Th	Mcs	0.2	20	0.50	1.33	2.41	0.80	4.54

Appendix 5
Summer Aspect
Phytosociological attributes of *Zizyphus* - *Chrysopogon* community (ZC)
Altitude: 600m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Shrub layer									
Carissa spinarum auct. non L.	Np	Mic	2.1	60	7.75	9.13	5.50	8.83	23.47
Dodonaea viscosa (L.) Jacq.	Np	Mic	0.4	40	1	1.74	3.67	1.14	6.55
Justicia adhatoda L.	Np	Mic	0.3	20	1.75	1.30	1.83	1.99	5.13
Ougeigia limbata Bth.	Np	Mic	5.1	100	19.5	22.17	9.17	22.22	53.57
Rhazya stricta Dene.	Np	Mic	0.6	40	4.75	2.61	3.67	5.41	11.69
Sageretia theezans (L.) Brongn.	Np	Lp	1.9	70	10.5	8.26	6.42	11.97	26.65
Zizyphus nummularia Buem.f. Weight	Np	Lp	3.3	100	26.5	14.35	9.17	30.20	53.72
Herb layer									
Achyranthes aspera L.	Th	Mes	0.2	20	0.5	0.87	1.83	0.57	3.27
Adiantum venustum D.Donc	G	Na	0.1	10	0.25	0.43	0.92	0.28	1.64
Aristida adscensionis L.	Hc	Lp	0.4	40	1	1.74	3.67	1.14	6.55
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	2.6	100	2.5	11.30	9.17	2.85	23.33
Conyza canadensis (L.) Cronquist	Th	Lp	0.3	30	0.75	1.30	2.75	0.85	4.91
Cynodon dactylon (L.) Pers.	Hc	Lp	0.6	40	1	2.61	3.67	1.14	7.42
Cyperus niveus Retz.	G	Lp	0.4	30	0.75	1.74	2.75	0.85	5.35
Echinops echinatus Roxb.	Th	Mic	0.3	30	0.75	1.30	2.75	0.85	4.91
Euphorbia hirta L.	Th	Na	0.1	10	0.25	0.43	0.92	0.28	1.64
Fimbristylis dichotoma (L.) Vahl.	G	Mic	0.6	50	1.25	2.61	4.59	1.42	8.62
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	0.9	70	2	3.91	6.42	2.28	12.61
Micromeria biflora (Ham.) Bth.	Th	Mic	0.7	50	1.25	3.04	4.59	1.42	9.06
Oxalis corniculata L.	Th	Mic	0.6	40	1	2.61	3.67	1.14	7.42
Sonchus asper L.	Th	Mes	0.4	30	0.75	1.74	2.75	0.85	5.35
Themeda anathera (Nees) Hack.	Hc	Lp	0.7	70	1.75	3.04	6.42	1.99	11.46
Verbascum thapsus L.	Th	Mes	0.4	40	0.25	1.74	3.67	0.28	5.69

Appendix 6
Summer Aspect
Phytosociological attributes of *Acacia-Dodonaea-Chrysopogon* community (ADC)
Altitude: 650 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Acacia modesta Wall.	Mp	Lp	4.4	100	957.4	21.89	9.26	85.56	116.71
Zizyphus jujuba Mill.	Mp	Mic	0.3	20	96.6	1.49	1.85	8.63	11.98
Shrub layer									
Acacia modesta Wall.	Np	Lp	0.4	40	3.5	1.99	3.70	0.31	6.01
Calotropis procera (wild) R.Br.	Np	Mes	0.6	50	5	2.99	4.63	0.45	8.06
Dodonaea viscosa (L.) Jacq.	Np	Mic	3	90	23.5	14.93	8.33	2.10	25.36
Otostegia limbata Bth.	Np	Mic	0.6	40	3.5	2.99	3.70	0.31	7.00
Rhazya stricta Dcne.	Np	Mic	0.2	20	0.5	1.00	1.85	0.04	2.89
Sageretia theezans (L.) Brongn.	Np	Lp	0.8	50	2.5	3.98	4.63	0.22	8.83
Zizyphus nummularia Buem.f. Weight	Np	Lp	1.3	80	12	6.47	7.41	1.07	14.95
Herb layer									
Adiantum venustum D.Donc	G	Na	0.1	10	0.25	0.50	0.93	0.02	1.45
Aristida adscensionis L.	Hc	Lp	0.4	40	1	1.99	3.70	0.09	5.78
Calendula arvensis L.	Th	Na	0.1	10	0.25	0.50	0.93	0.02	1.45
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	2.3	100	2.5	11.44	9.26	0.22	20.93
Conyza canadensis (L.) Cronquist	Th	Lp	0.2	20	0.5	1.00	1.85	0.04	2.89
Cynodon dactylon (L.) Pers.	Hc	Lp	0.7	50	1.25	3.48	4.63	0.11	8.22
Origanum vulgare L.	Ch	Mic	0.3	30	0.5	1.49	2.78	0.04	4.31
Echinops echinatus Roxb.	Th	Mic	0.3	30	0.75	1.49	2.78	0.07	4.34
Euphorbia hirta L.	Th	Na	0.3	30	0.75	1.49	2.78	0.07	4.34
Fimbristylis dichotoma (L.) Vahl.	G	Mic	0.6	50	1.25	2.99	4.63	0.11	7.73
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1	70	1.75	4.98	6.48	0.16	11.61
Micromeria biflora (Ham.) Bth.	Th	Mic	0.5	30	0.75	2.49	2.78	0.07	5.33
Oxalis corniculata L.	Th	Mic	0.4	30	0.75	1.99	2.78	0.07	4.83
Themeda anathera (Nees) Hack.	Hc	Lp	1.1	70	1.75	5.47	6.48	0.16	12.11
Verbascum thapsus L.	Th	Mes	0.2	20	0.5	1.00	1.85	0.04	2.89

Appendix 7

Summer Aspect

Phytosociological attributes of *Acacia - Dodonaea - Heteropogon* community (ADH)

Altitude: 800 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Acacia catechu (L.f.) Willd.	Mp	Lp	2.2	90	918.39	11.17	7.14	45.31	63.62
Acacia modesta Wall.	Mp	Lp	0.3	30	99.47	1.52	2.38	4.91	8.81
Acacia nilotica (L.) Delile.	Mp	Lp	0.5	40	65.45	2.54	3.17	3.23	8.94
Ailanthus altissima (Mill) Swingle	Mp	Mic	0.4	30	74.40	2.03	2.38	3.67	8.08
Albizia lebbeck (L.) Bth.	Mp	Lp	0.1	10	28.65	0.51	0.79	1.41	2.71
Butea frondosa Roxb.	Mp	Mes	0.5	40	148.41	2.54	3.17	7.32	13.03
Celtis australis L.	Mp	Mic	0.2	20	70.83	1.02	1.59	3.49	6.10
Ficus palmata Forssk.	Mp	Mes	0.1	10	50.93	0.51	0.79	2.51	3.81
Flacourtia indica (Burm. f.) Merrill	Mp	Mic	0.2	10	57.69	1.02	0.79	2.85	4.65
Grewia optiva Drum.ex.Burret.	Mp	Mic	0.9	50	467.12	4.57	3.97	23.04	31.58
Shrub layer									
Carissa spinarum auct. non L.	Np	Mic	0.7	60	2.75	3.55	4.76	0.14	8.45
Dodonaea viscosa (L.) Jacq.	Np	Mic	1.8	90	12.25	9.14	7.14	0.60	16.88
Gymnosporia royleana Wall	Np	Mic	0.6	60	1.50	3.05	4.76	0.07	7.88
Mallotus philippensis Mucll.	Np	Mic	0.6	60	7.75	3.05	4.76	0.38	8.19
Mimosa himalayana Gamble	Np	Lp	0.3	30	0.75	1.52	2.38	0.04	3.94
Myrsine africana L.	Np	Na	0.8	60	6.50	4.06	4.76	0.32	9.14
Herb layer									
Adiantum venustum D.Donc	G	Na	0.5	30	0.75	2.54	2.38	0.04	4.96
Ajuga parviflora Benth.	Th	Mic	0.5	40	1.00	2.54	3.17	0.05	5.76
Asplenium adiantum nigrum L.	G	Mic	1.1	50	1.25	5.58	3.97	0.06	9.61
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	1.4	60	1.50	7.11	4.76	0.07	11.94
Filago spathulata C. Presl.	Th	Mic	0.1	10	0.25	0.51	0.79	0.01	1.31
Geranium wallichianum D. Don. ex Sweet	Th	Mic	0.6	50	1.25	3.05	3.97	0.06	7.08
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1.6	80	2.00	8.12	6.35	0.10	14.57
Micromeria biflora (Ham.) Bth.	Th	Mic	0.5	50	1.25	2.54	3.97	0.06	6.57
Oenothera rosea Soland.	Th	Mic	0.1	10	0.25	0.51	0.79	0.01	1.31
Sida cordata (Burm.f) Borss-Waalkes	Th	Mic	0.2	20	0.50	1.02	1.59	0.02	2.63
Taraxacum officinale Weber.	Th	Mic	0.3	30	0.75	1.52	2.38	0.04	3.94
Themeda anathera (Nees) Hack.	Hc	Lp	1.5	80	2.00	7.61	6.35	0.10	14.06
Trichodesma indica (L.) R.Br.	Th	Na	0.3	30	0.75	1.52	2.38	0.04	3.94
Tulipa stellata Hk.f.	G	Lp	0.8	30	0.75	4.06	2.38	0.04	6.48

Appendix 8
Summer Aspect
Phytosociological attributes of *Acacia-Gymnosporia-Apluda* community (AGA)
Altitude: 1350 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Acacia catechu (L.f.) Willd.	Mp	Lp	2.5	100	1209.42	17.61	11.76	89.65	119.02
Ailanthus altissima (Mill) Swingle	Mp	Mic	0.2	20	25.86	1.41	2.35	1.92	5.68
Celtis australis L.	Mp	Mic	0.2	20	70.83	1.41	2.35	5.25	9.01
Shrub layer									
Dodonaea viscosa (L.) Jacq.	Np	Mic	1.1	70	12.00	7.75	8.24	0.89	16.87
Gymnosporia royleana Wall ex Lawson	Np	Mic	1.5	80	12.00	10.56	9.41	0.89	20.86
Indigofera heterantha L.	Np	Lp	0.8	40	6.00	5.63	4.71	0.44	10.78
Herb layer									
Apluda mutica L.	Hc	Lp	1.7	90	2.25	11.97	10.59	0.17	22.73
Boerhaavia diffusa L.	Th	Na	0.6	40	1.00	4.23	4.71	0.07	9.01
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	0.6	50	1.25	4.23	5.88	0.09	10.20
Cynodon dactylon (L.) Pers.	Hc	Lp	0.5	30	0.75	3.52	3.53	0.06	7.11
Cyperus niveus Retz.	G	Lp	0.7	40	1.00	4.93	4.71	0.07	9.71
Filago spathulata C. Presl.	Th	Mic	0.2	20	0.50	1.41	2.35	0.04	3.80
Micromeria biflora (Ham.) Bth.	Th	Mic	0.4	30	0.75	2.82	3.53	0.06	6.40
Oxalis corniculata L.	Th	Mic	1.1	70	1.75	7.75	8.24	0.13	16.11
Rumex dentatus L.	Th	Mes	0.4	40	1.00	2.82	4.71	0.07	7.60
Sida cordata (Burm.f) Borss-Waalkes	Th	Mic	0.3	30	0.75	2.11	3.53	0.06	5.70
Themeda anathera (Nees) Hack.	Hc	Lp	1.2	60	1.50	8.45	7.06	0.11	15.62
Trichodesma indica (L.) R.Br.	Th	Na	0.2	20	0.50	1.41	2.35	0.04	3.80

Appendix 9
Summer Aspect
Phytosociological attributes of *Pinus-Berberis-Imperata* community (PBI)
Altitude: 1750 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Pinus roxburghii Sergent	Mp	Lp	4.3	100	4915.76	20.48	10.42	90.19	121.08
Quercus dilatata Lindley	Mp	Mic	0.4	40	444.85	1.90	4.17	8.16	14.23
Shrub layer									
Berberis lycium Royle.	Np	Mic	3.6	100	35.24	17.14	10.42	0.65	28.21
Pinus roxburghii Sergent	Np	Lp	0.5	40	1.00	2.38	4.17	0.02	6.57
Pyrus pashia Ham ex. D. Donc	Np	Mcs	0.2	20	7.50	0.95	2.08	0.14	3.17
Herb layer									
Ajuga bractiosa Wall. Benth.	Th	Mic	0.6	50	12.50	2.86	5.21	0.23	8.29
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	1.3	90	3.50	6.19	9.38	0.06	15.63
Duchesnea indica (Andr.) Focke	Th	Mic	1.1	70	4.25	5.24	7.29	0.08	12.61
Gallium aparine L.	Th	Lp	0.5	40	1.00	2.38	4.17	0.02	6.57
Geranium wallichianum D. Don. ex Sweet	Th	Mic	0.8	50	2.00	3.81	5.21	0.04	9.05
Imperata cylindrica (L.) P. Beauv.	Hc	Lp	4.3	100	13.75	20.48	10.42	0.25	31.15
Micromeria biflora (Ham.) Bth.	Th	Mic	0.9	60	1.50	4.29	6.25	0.03	10.56
Oxalis corniculata L.	Th	Mic	0.7	60	1.50	3.33	6.25	0.03	9.61
Plantago lanceolata L.	Hc	Mic	1	60	4.00	4.76	6.25	0.07	11.09
Stellaria media (L.) Cyr.	Th	Lp	0.4	40	1.00	1.90	4.17	0.02	6.09
Trichodesma indica (L.) R.Br.	Th	Na	0.4	40	1.00	1.90	4.17	0.02	6.09

Appendix 10
Summer Aspect
Phytosociological attributes of *Pinus-Indigofera-Chrysopogon* community (PIC)
Altitude: 1850 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Pinus roxburghii Sergent	Mp	Lp	3.9	100	6360.37	17.65	10.64	94.51	122.79
Quercus dilatata Lindley	Mp	Mic	0.5	40	280.92	2.26	4.26	4.17	10.69
Shrub layer									
Berberis lycium Royle.	Np	Mic	0.9	60	9	4.07	6.38	0.13	10.59
Indigofera heterantha L.	Np	Lp	4	100	45	18.10	10.64	0.67	29.41
Pinus roxburghii Sergent	Np	Lp	0.3	30	3.25	1.36	3.19	0.05	4.60
Pyrus pashia Ham ex. D. Done	Np	Mcs	0.1	10	1.5	0.45	1.06	0.02	1.54
Herb layer									
Ajuga parviflora Benth.	Th	Mic	0.5	40	1	2.26	4.26	0.01	6.53
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	4.8	100	15	21.72	10.64	0.22	32.58
Dichanthium annulatum (Forssk.) Stapf.	Hc	Mic	0.3	30	0.75	1.36	3.19	0.01	4.56
Duchesnea indica (Andr.) Focke	Th	Mic	0.8	50	1.25	3.62	5.32	0.02	8.96
Gallium aparine L.	Th	Lp	0.5	50	1.25	2.26	5.32	0.02	7.60
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1.6	80	3.25	7.24	8.51	0.05	15.80
Imperata cylindrica (L.) P. Beauv.	Hc	Lp	0.8	60	1.5	3.62	6.38	0.02	10.03
Micromeria biflora (Ham.) Bth.	Th	Mic	0.2	20	0.5	0.90	2.13	0.01	3.04
Oxalis corniculata L.	Th	Mic	0.7	40	1	3.17	4.26	0.01	7.44
Phalaris minor Retz.	Th	Mic	1.1	40	2.25	4.98	4.26	0.03	9.27
Plantago lanceolata L.	Hc	Mic	0.7	50	1.25	3.17	5.32	0.02	8.51
Rumex dentatus L.	Th	Mcs	0.4	40	1	1.81	4.26	0.01	6.08

Appendix 11
Summer Aspect
Phytosociological attributes of *Pinus-Berberis-Plantago* community (PBP)
Altitude: 1950 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Pinus roxburghii Sergent	Mp	Lp	1.8	100	4598.83	6.79	9.35	69.97	86.11
Quercus dilatata Lindley	Mp	Mic	2.4	100	1708.09	9.06	9.35	25.99	44.39
Quercus incana Roxb.	Mp	Mic	0.6	60	161.56	2.26	5.61	2.46	10.33
Shrub layer									
Berberis lycium Royle.	Np	Mic	3.7	100	40.00	13.96	9.35	0.61	23.92
Myrsine africana L.	Np	Na	3.6	90	13.50	13.58	8.41	0.21	22.20
Quercus dilatata Lindley	Np	Mic	0.4	40	8.25	1.51	3.74	0.13	5.37
Rhododenron arborium Smith.	Np	Mcs	0.4	40	6.00	1.51	3.74	0.09	5.34
Herb layer									
Ajuga parviflora Benth.	Th	Mic	0.8	60	1.50	3.02	5.61	0.02	8.65
Fimbristylis dichotoma (L.) Vahl.	G	Mic	1.8	60	7.75	6.79	5.61	0.12	12.52
Gallium aparine L.	Th	Lp	0.8	60	1.50	3.02	5.61	0.02	8.65
Gentiana kurru Royle	Th	Lp	1.5	80	2.00	5.66	7.48	0.03	13.17
Hedera helix L.	L	Mic	0.3	30	0.75	1.13	2.80	0.01	3.95
Micromeria biflora (Ham.) Bth.	Th	Mic	0.7	50	3.75	2.64	4.67	0.06	7.37
Plantago lanceolata L.	Hc	Mic	5.9	90	13.50	22.26	8.41	0.21	30.88
Stellaria media (L.) Cyr.	Th	Lp	0.5	50	1.25	1.89	4.67	0.02	6.58
Valeriana jatamansii Jones.	G	Mic	1.3	60	4.00	4.91	5.61	0.06	10.57

Appendix 12

Summer Aspect

Phytosociological attributes of *Quercus-Parratiopsis-Viola* community (QPV)

Altitude: 2050 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Parratiopsis jacquemontiana Dcne	Mp	Mic	3.9	100	159.58	19.60	8.70	11.48	39.77
Quercus dilatata Lindley	Mp	Mic	0.8	80	799.17	4.02	6.96	57.48	68.46
Quercus incana Roxb.	Mp	Mic	0.7	70	228.39	3.52	6.09	16.43	26.03
Vibernum cotinifolium D. Don.	Mp	Mic	0.8	70	59.54	4.02	6.09	4.28	14.39
Taxus wallichiana Zucc.	Mp	Lp	0.2	20	32.64	1.01	1.74	2.35	5.09
Shrub layer									
Parratiopsis jacquemontiana Dcne	Np	Mic	1.4	90	24.70	7.04	7.83	1.78	16.64
Quercus dilatata Lindley	Np	Mic	0.6	60	9.00	3.02	5.22	0.65	8.88
Quercus incana Roxb.	Np	Mic	0.5	50	7.50	2.51	4.35	0.54	7.40
Herb layer									
Adiantum venustum D.Done	G	Na	2	80	9.50	10.05	6.96	0.68	17.69
Asplenium adiantum nigrum L.	G	Mic	0.7	60	4.00	3.52	5.22	0.29	9.02
Bergenia ciliata (Haw) Sternb.	G	Mes	1.1	60	7.75	5.53	5.22	0.56	11.30
Bistorta amplexicaulis (D.Don) Green	Th	Mes	0.6	50	2.25	3.02	4.35	0.16	7.52
Ceterach dalhousiae (Hk.) C. Chr.	G	Mic	1	70	8.00	5.03	6.09	0.58	11.69
Cheilanthes marantae (L.) Domin.	G	Mic	0.8	60	7.75	4.02	5.22	0.56	9.79
Fimbristylis dichotoma (L.) Vahl.	G	Mic	1.1	50	9.75	5.53	4.35	0.70	10.58
Hedera helix L.	L	Mic	0.5	40	6.00	2.51	3.48	0.43	6.42
Valeriana jatamansii Jones.	G	Mic	1	60	4.00	5.03	5.22	0.29	10.53
Viola serpens Wall.	Th	Mic	2.2	80	10.75	11.06	6.96	0.77	18.79

Appendix 13
Summer Aspect
Phytosociological attributes of *Quercus-Berberis-Fimbristylis* community (QBF)
Altitude: 2100 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Pinus roxburghii Sergent	Mp	Lp	0.6	40	846.71	1.64	3.81	13.61	19.06
Quercus dilatata Lindley	Mp	Mic	3	100	4960.18	8.20	9.52	79.72	97.44
Quercus incana Roxb.	Mp	Mic	0.6	60	326.87	1.64	5.71	5.25	12.61
Shrub layer									
Berberis lycium Royle.	Np	Mic	1.6	80	16.50	4.37	7.62	0.27	12.26
Indigofera heterantha L.	Np	Lp	1.4	80	12.00	3.83	7.62	0.19	11.64
Myrsine africana L.	Np	Na	0.8	50	7.50	2.19	4.76	0.12	7.07
Quercus dilatata Lindley	Np	Mic	0.6	50	7.50	1.64	4.76	0.12	6.52
Quercus incana Roxb.	Np	Mic	0.7	60	9.00	1.91	5.71	0.14	7.77
Sarcococca saligna (Denc) Duel	Np	Mic	0.5	30	4.50	1.37	2.86	0.07	4.30
Herb layer									
Ajuga bractiosa Wall. Benth.	Th	Mic	0.5	50	1.25	1.37	4.76	0.02	6.15
Androsace rotundifolia Hardw.	Th	Mic	0.1	10	0.50	0.27	0.95	0.01	1.23
Avena sativa L.	Th	Lp	0.7	60	1.50	1.91	5.71	0.02	7.65
Fimbristylis dichotoma (L.) Vahl.	G	Mic	19.2	100	19.50	52.46	9.52	0.31	62.30
Gentiana kurru Royle	Th	Lp	1.2	60	1.50	3.28	5.71	0.02	9.02
Phalaris minor Retz.	Th	Mic	1.3	60	1.50	3.55	5.71	0.02	9.29
Plantago lanceolata L.	Hc	Mic	2.2	60	2.75	6.01	5.71	0.04	11.77
Salvia moocroftiana Wall.	Th	Mes	0.1	10	0.50	0.27	0.95	0.01	1.23
Sedum ewersii Ledeb.	Th	Lp	0.5	40	1.00	1.37	3.81	0.02	5.19
Stellaria media (L.) Cyr.	Th	Lp	1	50	1.25	2.73	4.76	0.02	7.51

Appendix 14
Summer Aspect
Phytosociological attributes of *Prunus - Indigofera - Poa* community (PIP)
Altitude: 2250 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Cotoneaster bacillaris Wall. ex Lindlc.	Mp	Mes	0.8	60	251.07	2.42	5.41	10.99	18.82
Lonicera quinquilocularis Hardw.	Mp	Mic	1	80	672.28	3.03	7.21	29.42	39.66
Prunus cornuta (Wall ex Royle) Steud.	Mp	Mes	0.8	40	851.88	2.42	3.60	37.28	43.31
Quercus dilatata Lindley	Mp	Mic	0.6	20	258.63	1.82	1.80	11.32	14.94
Quercus incana Roxb.	Mp	Mic	0.2	20	151.30	0.61	1.80	6.62	9.03
Shrub layer									
Berberis lycium Royle.	Np	Mic	1.5	80	21.00	4.55	7.21	0.92	12.67
Indigofera heterantha L.	Np	Lp	1.7	80	9.50	5.15	7.21	0.42	12.77
Lonicera hypoleuca Dene.	Np	Mic	0.6	60	9.00	1.82	5.41	0.39	7.62
Quercus dilatata Lindley	Np	Mic	0.3	30	4.50	0.91	2.70	0.20	3.81
Quercus incana Roxb.	Np	Mic	0.4	30	4.50	1.21	2.70	0.20	4.11
Rosa moschata non J. Herrm.	Np	Mic	0.3	30	4.50	0.91	2.70	0.20	3.81
Sarcococca saligna (Dene) Duel	Np	Mic	1.8	40	8.25	5.45	3.60	0.36	9.42
Herb layer									
Ajuga bractiosa Wall. Benth.	Th	Mic	0.5	40	1.00	1.52	3.60	0.04	5.16
Asplenium adiantum nigrum L.	G	Mic	0.3	20	0.50	0.91	1.80	0.02	2.73
Ceterach dalhousiae (Hk.) C. Chr.	G	Mic	0.1	10	0.25	0.30	0.90	0.01	1.21
Epilobium brevifolium Don.	Th	Na	0.1	10	0.25	0.30	0.90	0.01	1.21
Fimbristylis dichotoma (L.) Vahl.	G	Mic	1.8	40	4.75	5.45	3.60	0.21	9.27
Fragaria vesca Lindle.ex Hk. f.	Hc	Mic	0.1	10	0.25	0.30	0.90	0.01	1.21
Gentiana kurru Royle	Th	Lp	1.2	60	1.50	3.64	5.41	0.07	9.11
Geranium wallichianum D. Don. ex Sweet	Th	Mic	1.7	60	4.00	5.15	5.41	0.18	10.73
Medicago polymorpha L.	Th	Na	3.4	50	7.50	10.30	4.50	0.33	15.14
Myriactis wallichii Less.	Th	Mic	0.1	10	0.25	0.30	0.90	0.01	1.21
Phalaris minor Retz.	Th	Mic	0.5	40	1.00	1.52	3.60	0.04	5.16
Plantago major L.	G	Mes	3.1	80	5.75	9.39	7.21	0.25	16.85
Poa annua L.	Th	Lp	9.7	80	10.75	29.39	7.21	0.47	37.07
Potentilla supina L.	Th	Mic	0.1	10	0.25	0.30	0.90	0.01	1.21
Urtica dioca L.	Th	Mic	0.3	20	0.50	0.91	1.80	0.02	2.73

Appendix 15
Winter Aspect
Phytosociological attributes of *Butea-Zizyphus-Themeda* community (BZT)
Altitude: 400 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Butea frondosa Roxb.	Mp	Mes	2.5	100	889.3	13.89	8.70	93.28	115.86
Shrub layer									
Butea frondosa Roxb.	Np	Mes	0.4	40	4.75	2.22	3.48	0.50	6.20
Carissa spinarum auct. non L.	Np	Mic	0.4	30	3.25	2.22	2.61	0.34	5.17
Dodonaea viscosa (L.) Jacq.	Np	Mic	1.1	80	5.75	6.11	6.96	0.60	13.67
Gymnosporia royleana Wall	Np	Mic	0.3	30	1.75	1.67	2.61	0.18	4.46
Justicia adhatoda L.	Np	Mic	1.2	70	0.8	6.67	6.09	0.08	12.84
Myrsine africana L.	Np	Na	0.4	40	2.25	2.22	3.48	0.24	5.94
Otostegia limbata Bth.	Np	Mic	0.3	30	0.75	1.67	2.61	0.08	4.35
Zizyphus nummularia Buem.f. Weight	Np	Lp	1.9	90	22.5	10.56	7.83	2.36	20.74
Herb layer									
Adiantum incisum Forsk.	G	Na	0.3	30	0.75	1.67	2.61	0.08	4.35
Amaranthus viridis L.	Th	Mic	0.3	30	0.75	1.67	2.61	0.08	4.35
Boerhaavia diffusa L.	Th	Na	0.5	50	1.25	2.78	4.35	0.13	7.26
Dichanthium annulatum (Forssk.) Stapf.	Hc	Mic	1.5	70	5.5	8.33	6.09	0.58	15.00
Digitaria sanguinalis (L.) Scop.	Hc	Lp	1.6	80	4.5	8.89	6.96	0.47	16.32
Euphorbia hirta L.	Th	Na	0.5	50	1.25	2.78	4.35	0.13	7.26
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1.7	80	2	9.44	6.96	0.21	16.61
Micromeria biflora (Ham.) Bth.	Th	Mic	0.6	40	1	3.33	3.48	0.10	6.92
Oxalis corniculata L.	Th	Mic	0.3	30	0.75	1.67	2.61	0.08	4.35
Sonchus arvensis L.	Th	Mes	0.3	30	0.75	1.67	2.61	0.08	4.35
Sorghum helepense (L.) Bern.	Hc	Mic	0.3	30	0.75	1.67	2.61	0.08	4.35
Taraxacum officinale Weber.	Th	Mic	0.2	20	0.5	1.11	1.74	0.05	2.90
Themeda anathera (Nees) Hack.	Hc	Lp	1.4	100	2.5	7.78	8.70	0.26	16.74

Appendix 16
Winter Aspect
Phytosociological attributes of *Acacia - Dodonaea - Themeda* community (ADT)
Altitude: 450 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Acacia catechu (L.f.) Willd.	Mp	Lp	0.5	30	181.47	2.67	2.73	19.22	24.62
Acacia modesta Wall.	Mp	Lp	1.1	50	331.26	5.88	4.55	35.08	45.50
Butea frondosa Roxb.	Mp	Mes	0.2	20	77.99	1.07	1.82	8.26	11.15
Ficus palmata Forssk.	Mp	Mes	0.4	30	119.38	2.14	2.73	12.64	17.51
Flacourtia indica (Burm. f.) Merrill	Mp	Mic	0.3	20	27.47	1.60	1.82	2.91	6.33
Mallotus philippensis Muell.	Mp	Mic	0.3	30	99.82	1.60	2.73	10.57	14.90
Shrub layer									
Acacia nilotica (L.) Delile.	Np	Lp	0.5	40	2.25	2.67	3.64	0.24	6.55
Carissa spinarum auct. non l..	Np	Mic	0.2	20	0.50	1.07	1.82	0.05	2.94
Dodonaea viscosa (L.) Jacq.	Np	Mic	4.3	100	35.25	22.99	9.09	3.73	35.82
Gymnosporia royleana Wall ex Lawson	Np	Mic	1.1	50	10.75	5.88	4.55	1.14	11.57
Mallotus philippensis Muell.	Np	Mic	0.4	30	6.75	2.14	2.73	0.71	5.58
Mimosa himalayana Gamble	Np	Lp	0.2	20	0.50	1.07	1.82	0.05	2.94
Otostegia limbata Bth.	Np	Mic	0.8	50	3.75	4.28	4.55	0.40	9.22
Sageretia theezans (L.) Brongn.	Np	Lp	0.8	60	11.25	4.28	5.45	1.19	10.92
Zizyphus nummularia Buem.f. Weight	Np	Lp	1.2	70	24.00	6.42	6.36	2.54	15.32
Herb layer									
Adiantum venustum D.Don	G	Na	0.6	50	1.25	3.21	4.55	0.13	7.89
Arabidopsis wallichii (H.&T.) N. Busch.	Th	Mic	0.5	40	1.00	2.67	3.64	0.11	6.42
Cerastium dichotomum l..	Th	Mic	0.3	30	0.75	1.60	2.73	0.08	4.41
Conyza canadensis (L.) Cronquist	Th	Lp	0.3	30	0.75	1.60	2.73	0.08	4.41
Dichanthium annulatum (Forssk.) Stapf.	Hc	Mic	1.1	60	1.50	5.88	5.45	0.16	11.50
Euphorbia cornigera Boiss.	Th	Na	0.2	20	0.50	1.07	1.82	0.05	2.94
Euphorbia prostrata Ait.	Th	Lp	0.3	30	0.75	1.60	2.73	0.08	4.41
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1	70	1.75	5.35	6.36	0.19	11.90
Micromeria biflora (Ham.) Bth.	Th	Mic	0.8	60	1.50	4.28	5.45	0.16	9.89
Themeda anathera (Nees) Hack.	Hc	Lp	1.3	90	2.25	6.95	8.18	0.24	15.37

Appendix 17
Winter Aspect
Phytosociological attributes of *Dodonaea-Heteropogon* community (DH)
Altitude: 500 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Shrub layer									
Dodonaea viscosa (L.) Jacq.	Np	Mic	3.5	100	27.25	24.48	11.76	42.91	79.15
Justicia adhatoda L.	Np	Mic	1	50	7.50	6.99	5.88	11.81	24.69
Otostegia limbata Bth.	Np	Mic	0.6	40	3.75	4.20	4.71	5.91	14.81
Zizyphus nummularia Buem.f. Weight	Np	Lp	1.1	60	9.75	7.69	7.06	15.35	30.11
Herb layer									
Apluda mutica L.	Hc	Lp	0.5	40	1.00	3.50	4.71	1.57	9.78
Aristida adscensionis L.	Hc	Lp	0.7	60	1.50	4.90	7.06	2.36	14.32
Boerhaavia diffusa L.	Th	Na	0.7	50	1.25	4.90	5.88	1.97	12.75
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	0.3	30	0.75	2.10	3.53	1.18	6.81
Cynodon dactylon (L.) Pers.	Hc	Lp	0.7	50	1.25	4.90	5.88	1.97	12.75
Cyperus niveus Retz.	G	Lp	0.3	20	0.50	2.10	2.35	0.79	5.24
Dichanthium annulatum (Forssk.) Stapf.	Hc	Mic	0.8	50	1.25	5.59	5.88	1.97	13.45
Euphorbia hirta L.	Th	Na	0.4	30	0.75	2.80	3.53	1.18	7.51
Filago spathulata C. Presl.	Th	Mic	0.1	10	0.25	0.70	1.18	0.39	2.27
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1.8	100	2.50	12.59	11.76	3.94	28.29
Micromeria biflora (Ham.) Bth.	Th	Mic	0.5	50	1.25	3.50	5.88	1.97	11.35
Oxalis corniculata L.	Th	Mic	0.1	10	0.25	0.70	1.18	0.39	2.27
Saussurea heteromalla (D.Don.) Hand-Mazz	Th	Mic	0.3	30	0.75	2.10	3.53	1.18	6.81
Taraxacum officinale Weber.	Th	Mic	0.9	70	2.00	6.29	8.24	3.15	17.68

Appendix 18
Winter Aspect
Phytosociological attributes of *Otostegia - Chrysopogon* community (OC)
Altitude: 600 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Shrub layer									
Carissa spinarum auct. non L.	Np	Mic	2.1	60	7.75	10.05	6.52	9.23	25.80
Dodonaea viscosa (L.) Jacq.	Np	Mic	0.4	40	1	1.91	4.35	1.19	7.45
Justicia adhatoda L.	Np	Mic	0.3	20	1.75	1.44	2.17	2.08	5.69
Otostegia limbata Bth.	Np	Mic	5.1	100	19.5	24.40	10.87	23.21	58.49
Rhazya stricta Dcne.	Np	Mic	0.6	40	4.75	2.87	4.35	5.65	12.87
Sageretia theezans (L.) Brongn.	Np	L.p	1.9	70	10.5	9.09	7.61	12.50	29.20
Zizyphus nummularia Buem.f. Weight	Np	L.p	3.3	100	26.5	15.79	10.87	31.55	58.21
Herb layer									
Amaranthus viridis L.	Th	Mes	0.2	20	0.5	0.96	2.17	0.60	3.73
Aristida adscensionis L.	Hc	L.p	0.7	50	1.25	3.35	5.43	1.49	10.27
Chrysopogon aucheri (Boiss.) Stapf	Hc	L.p	1.9	100	2.5	9.09	10.87	2.98	22.94
Conyza canadensis (L.) Cronquist	Th	L.p	0.2	20	0.5	0.96	2.17	0.60	3.73
Cynodon dactylon (L.) Pers.	Hc	L.p	0.7	50	1.25	3.35	5.43	1.49	10.27
Fumaria indica (Hsskn) H.N.	Th	L.p	0.3	30	0.75	1.44	3.26	0.89	5.59
Heteropogon contortus (L.) P. Beauv.	Hc	L.p	1.3	60	1.5	6.22	6.52	1.79	14.53
Micromeria biflora (Ham.) Bth.	Th	Mic	0.3	30	0.75	1.44	3.26	0.89	5.59
Oxalis corniculata L.	Th	Mic	0.2	20	0.5	0.96	2.17	0.60	3.73
Sonchus asper L.	Th	Mes	0.2	20	0.5	0.96	2.17	0.60	3.73
Taraxacum officinale Weber.	Th	Mic	0.6	50	1.25	2.87	5.43	1.49	9.79
Themeda anathera (Nees) Hack.	Hc	L.p	0.6	40	1	2.87	4.35	1.19	8.41

Appendix 19
Winter Aspect
Phytosociological attributes of *Acacia-Dodonaea-Chrysopogon* community (ADC)
Altitude: 650 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Acacia modesta Wall.	Mp	Lp	4.4	100	957.4	21.78	8.85	85.44	116.08
Zizyphus jujuba Mill.	Mp	Mic	0.3	20	96.6	1.49	1.77	8.62	11.88
Shrub layer									
Acacia modesta Wall.	Np	Lp	0.4	40	3.5	1.98	3.54	0.31	5.83
Calotropis procera (wild) R.Br.	Np	Mcs	0.6	50	5	2.97	4.42	0.45	7.84
Dodonaea viscosa (L.) Jacq.	Np	Mic	3	90	23.5	14.85	7.96	2.10	24.91
Otostegia limbata Bth.	Np	Mic	0.6	40	3.5	2.97	3.54	0.31	6.82
Rhazya stricta Dene.	Np	Mic	0.2	20	0.5	0.99	1.77	0.04	2.80
Sageretia theezans (L.) Brongn.	Np	Lp	0.8	50	2.5	3.96	4.42	0.22	8.61
Zizyphus nummularia Buem.f. Weight	Np	Lp	1.3	80	12	6.44	7.08	1.07	14.59
Herb layer									
Adiantum incisum Forsk.	G	Na	0.3	20	0.5	1.49	1.77	0.04	3.30
Arabidopsis wallichii (H.&T.) N. Busch.	Th	Mic	0.3	30	0.75	1.49	2.65	0.07	4.21
Aristida adscensionis L.	Hc	Lp	0.7	50	1.25	3.47	4.42	0.11	8.00
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	1.8	90	2.25	8.91	7.96	0.20	17.08
Euphorbia prostrata Ait.	Th	Mic	0.2	20	0.5	0.99	1.77	0.04	2.80
Filago spathulata C. Presl.	Th	Mic	0.2	20	0.5	0.99	1.77	0.04	2.80
Fimbristylis dichotoma (L.) Vahl.	Th	Na	0.8	60	1.5	3.96	5.31	0.13	9.40
Gallium aparine L.	Th	Lp	0.4	40	1	1.98	3.54	0.09	5.61
Heteropogon contortus (L.) P. Beauv.	G	Mic	1.2	80	2	5.94	7.08	0.18	13.20
Linum strictum L.	Th	Lp	0.3	30	0.75	1.49	2.65	0.07	4.21
Micromeria biflora (Ham.) Bth.	Hc	Lp	0.2	20	0.5	0.99	1.77	0.04	2.80
Oxalis corniculata L.	Th	Mic	0.4	40	1	1.98	3.54	0.09	5.61
Sonchus asper L.	Th	Mcs	0.2	20	0.5	0.99	1.77	0.04	2.80
Taraxacum officinale Weber.	Th	Mic	0.4	40	1	1.98	3.54	0.09	5.61
Themeda anathera (Nees) Hack.	Hc	Lp	1.2	80	2	5.94	7.08	0.18	13.20

Appendix 20
Winter Aspect
Phytosociological attributes of *Acacia - Dodonaea - Heteropogon* community (ADH)
Altitude: 800 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Acacia catechu (L.f.) Willd.	Mp	Lp	2.2	90	918.39	12.43	7.14	45.30	64.87
Acacia modesta Wall.	Mp	Lp	0.3	30	99.47	1.69	2.38	4.91	8.98
Acacia nilotica (L.) Delile.	Mp	Lp	0.5	40	65.45	2.82	3.17	3.23	9.23
Ailanthus altissima (Mill) Swingle	Mp	Mic	0.4	30	74.40	2.26	2.38	3.67	8.31
Albizia lebbeck (L.) Bth.	Mp	Lp	0.1	10	28.65	0.56	0.79	1.41	2.77
Butea frondosa Roxb.	Mp	Mes	0.5	40	148.41	2.82	3.17	7.32	13.32
Celtis australis L.	Mp	Mic	0.2	20	70.83	1.13	1.59	3.49	6.21
Ficus palmata Forssk.	Mp	Mes	0.1	10	50.93	0.56	0.79	2.51	3.87
Flacourtia indica (Burm. f.) Merrill	Mp	Mic	0.2	10	57.69	1.13	0.79	2.85	4.77
Grewia optiva Drum.ex.Burret.	Mp	Mic	0.9	50	467.12	5.08	3.97	23.04	32.09
Shrub layer									
Carissa spinarum auct. non L.	Np	Mic	0.7	60	2.75	3.95	4.76	0.14	8.85
Dodonaea viscosa (L.) Jacq.	Np	Mic	1.8	90	12.25	10.17	7.14	0.60	17.92
Gymnosporia royleana Wall	Np	Mic	0.6	60	1.50	3.39	4.76	0.07	8.23
Mallotus philippensis Mucll.	Np	Mic	0.6	60	7.75	3.39	4.76	0.38	8.53
Mimosa himalayana Gamble	Np	Lp	0.3	30	0.75	1.69	2.38	0.04	4.11
Myrsine africana L.	Np	Na	0.8	60	6.50	4.52	4.76	0.32	9.60
Herb layer									
Adiantum venustum D.Donc	G	Na	0.2	20	0.50	1.13	1.59	0.02	2.74
Ajuga bracteosa Wall. Benth.	Th	Mic	0.3	30	0.75	1.69	2.38	0.04	4.11
Ajuga parviflora Benth.	Th	Mic	0.2	20	0.50	1.13	1.59	0.02	2.74
Anagallis arvensis L.	Th	Lp	0.4	40	1.00	2.26	3.17	0.05	5.48
Asplenium adiantum nigrum L.	G	Mic	0.9	50	1.50	5.08	3.97	0.07	9.13
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	0.7	50	1.25	3.95	3.97	0.06	7.98
Fumaria indica (Hasskn) H.N.	Th	Lp	0.3	30	0.75	1.69	2.38	0.04	4.11
Geranium wallichianum D. Don. ex Sweet	Th	Mic	0.4	30	0.75	2.26	2.38	0.04	4.68
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1.5	90	2.25	8.47	7.14	0.11	15.73
Micromeria biflora (Ham.) Bth.	Th	Mic	0.2	20	0.50	1.13	1.59	0.02	2.74
Oenothera rosea Soland.	Th	Mic	0.2	20	0.50	1.13	1.59	0.02	2.74
Oxalis corniculata L.	Th	Mic	0.1	10	0.25	0.56	0.79	0.01	1.37
Papaver rhoeas L.	Th	Mic	0.2	20	0.50	1.13	1.59	0.02	2.74
Solanum nigrum L.	Th	Mic	0.2	20	0.50	1.13	1.59	0.02	2.74
Taraxacum officinale Weber.	Th	Mic	0.6	50	1.25	3.39	3.97	0.06	7.42
Themeda anathera (Nees) Hack.	Hc	Lp	1.1	70	1.75	6.21	5.56	0.09	11.86

Appendix 21
Winter Aspect
Phytosociological attributes of *Celtis -Gymnosporia- Poa* community (CGP)
Altitude: 1350 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Celtis australis L.	Mp	Mic	0.2	20	70.83	1.45	2.47	61.15	65.06
Shrub layer			0	0	0.00	0.00	0.00	0.00	0.00
Dodonaea viscosa (L.) Jacq.	Np	Mic	1.1	70	12.00	7.97	8.64	10.36	26.97
Gymnosporia royleana Wall ex Lawson	Np	Mic	1.5	80	12.00	10.87	9.88	10.36	31.11
Indigofera heterantha L.	Np	Lp	0.8	40	6.00	5.80	4.94	5.18	15.92
Herb layer									
Apluda mutica L.	Hc	Lp	1.6	100	2.50	11.59	12.35	2.16	26.10
Boerhaavia diffusa L.	Th	Na	0.2	20	0.50	1.45	2.47	0.43	4.35
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	0.7	50	1.25	5.07	6.17	1.08	12.32
Cynodon dactylon (L.) Pers.	Hc	Lp	0.6	40	1.00	4.35	4.94	0.86	10.15
Cyperus niveus Retz.	G	Lp	0.9	50	1.25	6.52	6.17	1.08	13.77
Filago spathulata C. Presl.	Th	Mic	0.2	20	0.50	1.45	2.47	0.43	4.35
Micromeria biflora (Ham.) Bth.	Th	Mic	0.3	30	0.75	2.17	3.70	0.65	6.53
Oxalis corniculata L.	Th	Mic	1.1	70	1.75	7.97	8.64	1.51	18.12
Poa annua L.	Th	Lp	2.7	70	1.75	19.57	8.64	1.51	29.72
Solanum nigrum L.	Th	Mic	0.2	20	0.50	1.45	2.47	0.43	4.35
Sorghum helepense (L.) Bern.	Hc	Mic	0.2	20	0.50	1.45	2.47	0.43	4.35
Taraxacum officinale Weber.	Th	Mic	0.4	40	1.00	2.90	4.94	0.86	8.70
Themeda anathera (Nees) Hack.	Hc	Lp	1.1	70	1.75	7.97	8.64	1.51	18.12

Appendix 22
Winter Aspect
Phytosociological attributes of *Pinus-Berberis-Imperata* community (PBI)
Altitude: 1750 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Pinus roxburghii Sergent	Mp	L.p	4.3	100	4915.76	20.00	10.20	90.49	120.69
Quercus dilatata Lindley	Mp	Mic	0.4	40	444.85	1.86	4.08	8.19	14.13
Shrub layer									
Berberis lycium Royle.	Np	Mic	3.6	100	35.24	16.74	10.20	0.65	27.60
Pinus roxburghii Sergent	Np	L.p	0.5	40	1.00	2.33	4.08	0.02	6.43
Pyrus pashia Ham ex. D. Done	Np	Mes	0.2	20	7.50	0.93	2.04	0.14	3.11
Herb layer									
Ajuga bractiosa Wall. Benth.	Th	Mic	0.4	30	0.75	1.86	3.06	0.01	4.94
Chrysopogon aucheri (Boiss.) Stapf	Hc	L.p	1.5	100	2.50	6.98	10.20	0.05	17.23
Duchesnea indica (Andr.) Focke	Th	Mic	0.6	50	1.25	2.79	5.10	0.02	7.92
Gallium aparine L.	Th	L.p	0.7	50	1.25	3.26	5.10	0.02	8.38
Geranium wallichianum D. Don. ex Sweet	Th	Mic	1.1	60	1.50	5.12	6.12	0.03	11.27
Imperata cylindrica (L.) P. Beauv.	Hc	L.p	4.5	100	12.50	20.93	10.20	0.23	31.36
Micromeria biflora (Ham.) Bth.	Th	Mic	0.6	50	1.25	2.79	5.10	0.02	7.92
Oenothera rosea Soland.	Th	Mic	0.2	20	0.50	0.93	2.04	0.01	2.98
Oxalis corniculata L.	Th	Mic	0.6	50	1.25	2.79	5.10	0.02	7.92
Phalaris minor Retz.	Th	Mic	0.2	20	0.50	0.93	2.04	0.01	2.98
Plantago lanceolata L.	Hc	Mic	0.9	70	1.75	4.19	7.14	0.03	11.36
Potentilla supina L.	Th	Mic	1	60	2.75	4.65	6.12	0.05	10.82
Rumex dentatus L.	Th	Mes	0.2	20	0.50	0.93	2.04	0.01	2.98

Appendix 23
Winter Aspect
Phytosociological attributes of *Pinus-Indigofera-Chrysopogon* community (PIC)
Altitude: 1850 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Pinus roxburghii Sergent	Mp	Lp	3.9	100	6360.37	18.48	11.11	94.49	124.08
Quercus dilatata Lindley	Mp	Mic	0.5	40	280.92	2.37	4.44	4.17	10.99
Shrub layer									
Berberis lycium Royle.	Np	Mic	0.9	60	9	4.27	6.67	0.13	11.07
Indigofera heterantha L.	Np	Lp	4	100	45	18.96	11.11	0.67	30.74
Pinus roxburghii Sergent	Np	Lp	0.3	30	3.25	1.42	3.33	0.05	4.80
Pyrus pashia Ham ex. D. Don	Np	Mes	0.1	10	1.5	0.47	1.11	0.02	1.61
Herb layer									
Ajuga parviflora Benth.	Th	Mic	0.4	40	1	1.90	4.44	0.01	6.36
Chrysopogon aucheri (Boiss.) Stapf	Hc	Lp	5	90	13.5	23.70	10.00	0.20	33.90
Dichanthium annulatum (Forssk.) Stapf.	Hc	Mic	0.4	30	2	1.90	3.33	0.03	5.26
Duchesnea indica (Andr.) Focke	Th	Mic	0.7	40	2.25	3.32	4.44	0.03	7.80
Gallium aparine L.	Th	Lp	0.4	40	1	1.90	4.44	0.01	6.36
Heteropogon contortus (L.) P. Beauv.	Hc	Lp	1.5	80	4.5	7.11	8.89	0.07	16.06
Imperata cylindrica (L.) P. Beauv.	Hc	Lp	0.6	50	1.25	2.84	5.56	0.02	8.42
Micromeria biflora (Ham.) Bth.	Th	Mic	0.3	30	0.75	1.42	3.33	0.01	4.77
Oxalis corniculata L.	Th	Mic	0.6	50	1.25	2.84	5.56	0.02	8.42
Potentilla supina L.	Th	Mic	0.4	30	0.75	1.90	3.33	0.01	5.24
Rumex dentatus L.	Th	Mes	0.3	30	0.75	1.42	3.33	0.01	4.77
Plantago lanceolata L.	Hc	Mic	0.8	50	2.5	3.79	5.56	0.04	9.38

Appendix 24
Winter Aspect
Phytosociological attributes of *Pinus-Berberis-Gentiana* community (PBG)
Altitude: 1950 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Pinus roxburghii Sergent	Mp	L.p	1.8	100	4598.83	7.76	10.10	70.17	88.03
Quercus dilatata Lindley	Mp	Mic	2.4	100	1708.09	10.34	10.10	26.06	46.51
Quercus incana Roxb.	Mp	Mic	0.6	60	161.56	2.59	6.06	2.47	11.11
Shrub layer									
Berberis lycium Royle.	Np	Mic	3.7	100	40.00	15.95	10.10	0.61	26.66
Myrsine africana L.	Np	Na	3.6	90	13.50	15.52	9.09	0.21	24.81
Quercus dilatata Lindley	Np	Mic	0.4	40	8.25	1.72	4.04	0.13	5.89
Rhododenron arborium Smith.	Np	Mes	0.4	40	6.00	1.72	4.04	0.09	5.86
Herb layer									
Ajuga bractiosa Wall. Benth.	Th	Mic	0.6	40	1.00	2.59	4.04	0.02	6.64
Ajuga parviflora Benth.	Th	Mic	0.3	30	0.75	1.29	3.03	0.01	4.33
Bergenia ciliata (Haw) Sternb.	G	Mes	0.4	40	1.00	1.72	4.04	0.02	5.78
Bistorta amplexicaulis (D.Don) Green	Th	Mes	0.3	30	0.75	1.29	3.03	0.01	4.33
Fimbristylis dichotoma (L.) Vahl.	G	Mic	2	50	6.25	8.62	5.05	0.10	13.77
Gallium aporine L.	Th	L.p	0.6	40	1.00	2.59	4.04	0.02	6.64
Gentiana kurru Royle	Th	L.p	4.5	80	3.25	19.40	8.08	0.05	27.53
Hedera helix L.	L	Mic	0.3	30	0.75	1.29	3.03	0.01	4.33
Plantago lanceolata L.	Hc	Mic	0.6	50	1.25	2.59	5.05	0.02	7.66
Urtica dioca L.	Th	Mic	0.3	30	0.75	1.29	3.03	0.01	4.33
Valeriana jatamansii Jones.	G	Mic	0.4	40	1.00	1.72	4.04	0.02	5.78

Appendix 25
Winter Aspect
Phytosociological attributes of *Quercus-Parratiopsis-Adiantum* community (QPA)
Altitude: 2050 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Parratiopsis jacquemontiana Dcne	Mp	Mic	3.9	100	159.58	23.08	8.85	11.91	43.83
Quercus dilatata Lindley	Mp	Mic	0.8	80	799.17	4.73	7.08	59.63	71.44
Quercus incana Roxb.	Mp	Mic	0.7	70	228.39	4.14	6.19	17.04	27.38
Taxus wallichiana Zucc.	Mp	Lp	0.2	20	32.64	1.18	1.77	2.44	5.39
Viburnum cotinifolium D. Don.	Mp	Mic	0.8	70	59.54	4.73	6.19	4.44	15.37
Shrub layer									
Parratiopsis jacquemontiana Dcne	Np	Mic	1.4	90	24.70	8.28	7.96	1.84	18.09
Quercus dilatata Lindley	Np	Mic	0.6	60	9.00	3.55	5.31	0.67	9.53
Quercus incana Roxb.	Np	Mic	0.5	50	7.50	2.96	4.42	0.56	7.94
Herb layer									
Adiantum incisum Forsk.	G	Na	0.6	30	0.75	3.55	2.65	0.06	6.26
Adiantum venustum D.Donc	G	Na	1.4	80	3.25	8.28	7.08	0.24	15.61
Asplenium adiantum nigrum L.	G	Mic	0.5	40	1.00	2.96	3.54	0.07	6.57
Bergenia ciliata (Haw) Sternb.	G	Mes	0.9	50	1.25	5.33	4.42	0.09	9.84
Bistorta amplexicaulis (D.Don) Green	Th	Mes	0.3	30	0.75	1.78	2.65	0.06	4.49
Ceterach dalhousiae (Hk.) C. Chr.	G	Mic	0.9	60	2.75	5.33	5.31	0.21	10.84
Cheilanthes marantae (L.) Domin.	G	Mic	0.7	50	3.75	4.14	4.42	0.28	8.85
Duchesnea indica (Andr.) Focke	Th	Mic	0.5	50	1.25	2.96	4.42	0.09	7.48
Fimbristylis dichotoma (L.) Vahl.	G	Mic	0.6	40	1.00	3.55	3.54	0.07	7.16
Fragaria vesca Lindle.ex Hk. f.	He	Mic	0.4	40	1.00	2.37	3.54	0.07	5.98
Hedera helix L.	L	Mic	0.3	30	0.75	1.78	2.65	0.06	4.49
Valeriana jatamansii Jones.	G	Mic	0.4	40	1.00	2.37	3.54	0.07	5.98
Viola serpens Wall.	Th	Mic	0.5	50	1.25	2.96	4.42	0.09	7.48

Appendix 26
Winter Aspect
Phytosociological attributes of *Quercus-Berberis-Fimbristylis community* (QBF)
Altitude: 2100 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Pinus roxburghii Sergent	Mp	Lp	0.6	40	846.71	2.83	3.85	13.63	20.30
Quercus dilatata Lindley	Mp	Mic	3	100	4960.18	14.15	9.62	79.84	103.60
Quercus incana Roxb.	Mp	Mic	0.6	60	326.87	2.83	5.77	5.26	13.86
Shrub layer									
Berberis lycium Royle.	Np	Mic	1.6	80	16.50	7.55	7.69	0.27	15.51
Indigofera heterantha L.	Np	Lp	1.4	80	12.00	6.60	7.69	0.19	14.49
Myrsine africana L.	Np	Na	0.8	50	7.50	3.77	4.81	0.12	8.70
Quercus dilatata Lindley	Np	Mic	0.6	50	7.50	2.83	4.81	0.12	7.76
Quercus incana Roxb.	Np	Mic	0.7	60	9.00	3.30	5.77	0.14	9.22
Sarcococca saligna (Dene) Duel	Np	Mic	0.5	30	4.50	2.36	2.88	0.07	5.32
Herb layer									
Ajuga bractiosa Wall. Benth.	Th	Mic	0.4	40	1.00	1.89	3.85	0.02	5.75
Androsace rotundifolia Hardw.	Th	Mic	0.4	40	1.00	1.89	3.85	0.02	5.75
Avena sativa L.	Th	Lp	1.2	60	1.50	5.66	5.77	0.02	11.45
Duchesnea indica (Andr.) Focke	Th	Mic	0.2	20	0.25	0.94	1.92	0.00	2.87
Fimbristylis dichotoma (L.) Vahl.	G	Mic	5.3	90	12.25	25.00	8.65	0.20	33.85
Fragaria vesca Lindle.ex Hk. f.	Hc	Mic	0.3	30	0.75	1.42	2.88	0.01	4.31
Gentiana kurru Royle	Th	Lp	1.1	50	1.25	5.19	4.81	0.02	10.02
Phalaris minor Retz.	Th	Mic	0.6	40	1.00	2.83	3.85	0.02	6.69
Plantago lanceolata L.	Hc	Mic	1	60	1.50	4.72	5.77	0.02	10.51
Poa annua L.	Th	Lp	0.7	40	1.25	3.30	3.85	0.02	7.17
Sedum ewersii Ledeb.	Th	Lp	0.2	20	0.50	0.94	1.92	0.01	2.87

Appendix 27
Winter Aspect
Phytosociological attributes of *Prunus - Berberis - Poa* community (PBP)
Altitude: 2250 m

Name of Species	LF	LS	D	F	C	RD	RF	RCC	IVI
Tree layer									
Cotoneaster bacillaris Wall. ex Lindle.	Mp	Mes	0.8	60	251.07	3.49	5.83	11.08	20.39
Lonicera quinquilacularis Hardw.	Mp	Mic	1	80	672.28	4.37	7.77	29.66	41.79
Prunus cornuta (Wall ex Royle) Steud.	Mp	Mes	0.8	40	851.88	3.49	3.88	37.58	44.96
Quercus dilatata Lindley	Mp	Mic	0.6	20	258.63	2.62	1.94	11.41	15.97
Quercus incana Roxb.	Mp	Mic	0.2	20	151.30	0.87	1.94	6.67	9.49
Shrub layer									
Berberis lycium Royle.	Np	Mic	1.5	80	21.00	6.55	7.77	0.93	15.24
Indigofera heterantha L.	Np	Lp	1.7	80	9.50	7.42	7.77	0.42	15.61
Lonicera hypoleuca Dene.	Np	Mic	0.6	60	9.00	2.62	5.83	0.40	8.84
Quercus dilatata Lindley	Np	Mic	0.3	30	4.50	1.31	2.91	0.20	4.42
Quercus incana Roxb.	Np	Mic	0.4	30	4.50	1.75	2.91	0.20	4.86
Rosa moschata non J. Herrm.	Np	Mic	0.3	30	4.50	1.31	2.91	0.20	4.42
Sarcococca saligna (Dene) Duel	Np	Mic	1.8	40	8.25	7.86	3.88	0.36	12.11
Herb layer									
Ajuga bractiosa Wall. Benth.	Th	Mic	0.6	40	1.25	2.62	3.88	0.06	6.56
Asplenium adiantum nigrum L.	G	Mic	0.3	30	0.75	1.31	2.91	0.03	4.26
Ceterach dalhousiae (Hk.) C. Chr.	G	Mic	0.4	30	0.75	1.75	2.91	0.03	4.69
Fimbristylis dichotoma (L.) Vahl.	G	Mic	0.9	60	1.50	3.93	5.83	0.07	9.82
Fragaria vesca Lindle.ex Hk. f.	Hc	Mic	0.4	40	1.00	1.75	3.88	0.04	5.67
Gentiana kurru Royle	Th	Lp	0.3	30	0.75	1.31	2.91	0.03	4.26
Geranium wallichianum D. Don. ex Sweet	Th	Mic	0.4	40	1.00	1.75	3.88	0.04	5.67
Plantago major L.	G	Mes	0.5	50	1.25	2.18	4.85	0.06	7.09
Poa annua L.	Th	Lp	8.6	90	11.00	37.55	8.74	0.49	46.78
Urtica dioca L.	Th	Mic	0.3	30	0.75	1.31	2.91	0.03	4.26
Viola serpens Wall.	Th	Mic	0.2	20	0.50	0.87	1.94	0.02	2.84

Appendix 28

ANOVA-Macro-minerals of some trees at three phenological stages.

ANOVA Calcium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	146231.8	9	16247.98	10.20216	1.98214	2.456281
Columns	26567.04	2	13283.52	8.340764	0.002733	3.554557
Error	28666.84	18	1592.602			
Total	201465.7	29				
ANOVA Potassium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.041853	9	0.00465	4.217669	0.004551	2.456281
Columns	0.021087	2	0.010543	9.562311	0.001481	3.554557
Error	0.019847	18	0.001103			
Total	0.082787	29				
ANOVA Magnesium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	10.24165	9	1.137961	7.039378	0.000237	2.456281
Columns	0.57622	2	0.28811	1.782236	0.196699	3.554557
Error	2.909817	18	0.161657			
Total	13.72769	29				
ANOVA Sodium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	47.40349	9	5.267055	3.875956	0.006969	2.456281
Columns	1.508727	2	0.754363	0.555126	0.583519	3.554557
Error	24.46028	18	1.358905			
Total	73.3725	29				
ANOVA Nitrogen						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	14.38452	9	1.59828	15.17897	1.081206	2.456281
Columns	1.89834	2	0.94917	9.014327	0.001939	3.554557
Error	1.895323	18	0.105296			
Total	18.17819	29				

Appendix 29

ANOVA-Macro-minerals of some shrubs at three phenological stages.

ANOVA -Calcium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Shrubs	130417.5	7	18631.08	10.90627	0.000101	2.764199
Phenological stages	1766.059	2	883.0295	0.516908	0.607311	3.738892
Error	23916.06	14	1708.29			
Total	156099.7	23				
ANOVA -Potassium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Shrubs	0.170263	7	0.024323	49.35145	8.430009	2.764199
Phenological stages	0.0079	2	0.00395	8.014493	0.004788	3.738892
Error	0.0069	14	0.000493			
Total	0.185063	23				
ANOVA-Magnesium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Shrubs	28.15402	7	4.022003	23.32447	1.0821	2.764199
Phenological stages	0.00576	2	0.00288	0.016702	0.983456	3.738892
Error	2.414119	14	0.172437			
Total	30.5739	23				
ANOVA -Sodium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Shrubs	59.63594	7	8.51942	5.536439	0.003248	2.764199
Phenological stages	2.780408	2	1.390204	0.903439	0.427537	3.738892
Error	21.54307	14	1.538791			
Total	83.95942	23				
ANOVA -Nitrogen						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Shrubs	13.24869	7	1.89267	4.504762	0.008062	2.764199
Phenological stages	0.621814	2	0.310907	0.739993	0.494883	3.738892
Error	5.882083	14	0.420149			
Total	19.75259	23				

Appendix 30
ANOVA-Macro-minerals of some grasses at three phenological stages.

ANOVA Calcium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	116.5033	7	16.64332	2.640243	0.05788	2.764199
Columns	12.31501	2	6.157504	0.976807	0.400759	3.738892
Error	88.25193	14	6.303709			
Total	217.0702	23				
ANOVA Potassium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	8.251196	7	1.178742	0.688938	0.680471	2.764199
Columns	3.425833	2	1.712917	1.001147	0.392302	3.738892
Error	23.95337	14	1.710955			
Total	35.6304	23				
ANOVA Magnesium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.401656	7	0.200237	1.29233	0.322493	2.764199
Columns	0.043053	2	0.021526	0.138931	0.871473	3.738892
Error	2.169193	14	0.154942			
Total	3.613901	23				
ANOVA Sodium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.320317	7	0.04576	0.779721	0.614708	2.764199
Columns	0.563285	2	0.281642	4.799044	0.025868	3.738892
Error	0.821621	14	0.058687			
Total	1.705223	23				
ANOVA Nitrogen						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.425938	7	0.203705	2.642086	0.057753	2.764199
Columns	0.232474	2	0.116237	1.507612	0.255289	3.738892
Error	1.079403	14	0.0771			
Total	2.737815	23				

Appendix 31

ANOVA-Micro-minerals of some trees at three phenological stages.

ANOVA Cadmium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Trees	0.000483	9	5.360042	4.15142	0.004936	2.456281
Phenological stage	4.87214	2	2.430016	0.188414	0.829884	3.554557
Error	0.000232	18	1.29014			
Total	0.00072	29				
ANOVA Chromium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Trees	4.805974	9	0.533997	7.395867	0.000173	2.456281
Phenological stage	0.052244	2	0.026122	0.361792	0.701377	3.554557
Error	1.299638	18	0.072202			
Total	6.157856	29				
ANOVA Copper						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Trees	0.002942	9	0.000327	2.745729	0.03257	2.456281
Phenological stage	0.003235	2	0.001618	13.59031	0.000253	3.554557
Error	0.002143	18	0.000119			
Total	0.00832	29				
ANOVA Iron						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	33.98167	9	3.775741	1.417356	0.252221	2.456281
Columns	7.619673	2	3.809836	1.430155	0.265195	3.554557
Error	47.95079	18	2.663933			
Total	89.55213	29				
ANOVA Nickel						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.077196	9	0.008577	15.22099	1.06206	2.456281
Columns	0.001065	2	0.000533	0.945186	0.407067	3.554557
Error	0.010143	18	0.000564			
Total	0.088405	29				
ANOVA Lead						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.350186	9	0.03891	2.266021	0.066736	2.456281
Columns	0.091772	2	0.045886	2.672312	0.096332	3.554557
Error	0.309076	18	0.017171			
Total	0.751033	29				
ANOVA Zinc						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.098865	9	0.010985	3.988896	0.006042	2.456281
Columns	0.023975	2	0.011988	4.353032	0.028705	3.554557
Error	0.04957	18	0.002754			
Total	0.17241	29				

ANOVA Manganese						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2.068798	9	0.229866	17.86047	3.12047	2.456281
Columns	0.04041	2	0.020205	1.569933	0.235251	3.554557
Error	0.231662	18	0.01287			
Total	2.340871	29				

Appendix 32
ANOVA-Micro-minerals of some shrubs at three phenological stages.

ANOVA Cadmium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.000148	7	2.111142	2.561822	0.063571	2.764199
Columns	4.75021	2	2.381001	0.288503	0.753733	3.738892
Error	0.000115	14	8.23001			
Total	0.000268	23				
ANOVA Chromium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Shrubs	1.400629	7	0.20009	6.420562	0.001615	2.764199
Phenological stages	0.029159	2	0.01458	0.467834	0.635805	3.738892
Error	0.436295	14	0.031164			
Total	1.866083	23				
ANOVA Copper						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.00064	7	9.14221	0.230288	0.970857	2.764199
Columns	0.000129	2	6.45002	0.162556	0.85155	3.738892
Error	0.005555	14	0.000397			
Total	0.006324	23				
ANOVA Iron						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	48.92714	7	6.989592	0.875873	0.548656	2.764199
Columns	10.68473	2	5.342364	0.669457	0.527635	3.738892
Error	111.722	14	7.980143			
Total	171.3339	23				
ANOVA Nickel						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.008335	7	0.001191	9.745555	0.000188	2.764199
Columns	0.000281	2	0.00014	1.148877	0.345145	3.738892
Error	0.001711	14	0.000122			
Total	0.010327	23				
ANOVA Lead						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.584958	7	0.083565	4.071504	0.012231	2.764199
Columns	0.004549	2	0.002275	0.110821	0.895876	3.738892
Error	0.287342	14	0.020524			
Total	0.876849	23				
ANOVA Zinc						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.060296	7	0.008614	3.280352	0.027861	2.764199
Columns	0.004863	2	0.002432	0.926029	0.41908	3.738892
Error	0.036762	14	0.002626			
Total	0.101922	23				

ANOVA Manganese						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.186902	7	0.0267	7.600887	0.000697	2.764199
Columns	0.003637	2	0.001819	0.51768	0.606875	3.738892
Error	0.049179	14	0.003513			
Total	0.239718	23				

Appendix 33
ANOVA-Micro-minerals of some grasses at three phenological stages.

ANOVA Cadmium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.008693	7	0.001242	3.935931	0.014001	2.764199
Columns	0.002082	2	0.001041	3.299859	0.066968	3.738892
Error	0.004417	14	0.000316			
Total	0.015192	23				
ANOVA Chromium						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.246671	7	0.035239	38.62261	4.250045	2.764199
Columns	0.001149	2	0.000575	0.629804	0.547133	3.738892
Error	0.012773	14	0.000912			
Total	0.260594	23				
ANOVA Copper						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.002421	7	0.000346	22.35898	1.412015	2.764199
Columns	5.21453	2	2.61485	1.68334	0.221248	3.738892
Error	0.000217	14	1.552101			
Total	0.00269	23				
ANOVA Iron						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	201.1258	7	28.73226	270.9182	7.56012	2.764199
Columns	0.070819	2	0.03541	0.333878	0.72169	3.738892
Error	1.484772	14	0.106055			
Total	202.6814	23				
ANOVA Nickel						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.004094	7	0.000585	1.299718	0.319375	2.764199
Columns	8.01245	2	0.42275	0.088992	0.915366	3.738892
Error	0.006299	14	0.00045			
Total	0.010473	23				
ANOVA Lead						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.268126	7	0.038304	66.5043	1.15402	2.764199
Columns	0.007053	2	0.003526	6.122477	0.012291	3.738892
Error	0.008063	14	0.000576			
Total	0.283242	23				
ANOVA Zinc						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2.677574	7	0.382511	612.3843	2.60125	2.764199
Columns	0.001967	2	0.000983	1.574211	0.241728	3.738892
Error	0.008745	14	0.000625			
Total	2.688285	23				

ANOVA Manganese						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.066776	7	0.009539	38.422	4.40128	2.764199
Columns	0.00064	2	0.00032	1.289036	0.306308	3.738892
Error	0.003476	14	0.000248			
Total	0.070892	23				