Pak. J. Bot., 41(2): 539-554, 2009.

SEASONAL AVAILABILITY, PALATABILITY AND ANIMAL PREFERENCES OF FORAGE PLANTS IN HARBOI ARID RANGE LAND, KALAT, PAKISTAN

[1]FARRUKH HUSSAIN AND MUFAKHIRAH JAN DURRANI[2]

[1]Department of Botany, University of Peshawar, Peshawar, Pakistan
[2]Department of Botany, University of Balochistan, Quetta, Pakistan

Abstract

Harboi rangeland Kalat, Pakistan, covering an area of 22351 ha, lies between 29° N and 66°, 45 to 67°E. The altitude varies from 2900 to 3300 m with dry temperate climate. The active growing season lasts from April to October with seasonal and annual variation in rainfall and temperature. The precipitation is mostly received during winter from western depression. The area receives regular snowfall during winter. A study was conducted for two consecutive years to assess the seasonal availability, palatability and animal preferences of forage plants. It was observed that the seasonal availability of forage, palatability and preferences of goats and sheep varied in their botanical composition throughout the growing season. There were 129 palatable species including 50.4% (65 species) highly palatable, 41.1% (53 species) mostly palatable, 4.65% (6 species) less palatable and 3.87% (5 species) rarely palatable species in the area. It was found that in 99 species (63%) shoots/whole plants were used; in 30 species (19%) foliage/leaves were used while in 29 species (18%) floral parts were consumed. Goats browsed on 104 species including 60% herbs, 27% shrubs, 12% grasses and 1% tree species. Sheep consumed 98 species that included 54% herbs, 22% shrubs, 23% grasses and 1% tree species. The percentage availability of palatable species declined after October due to cold dormant season and this is the part of the year where livestock suffer the most. At this stage animal are compelled to utilize even non-palatable forage. Further study is needed to evaluate the nutritional and mineral status of some of the important plants. The rangeland has the potential for improvement provided proper ecological management practices and local participation of the community is involved.

Introduction

Rangelands are important in resource management. Grazing is the most economical way of utilizing rangeland vegetation. Of the total area of 34.7 million ha of Balochistan, the rangeland cover some 30 million ha. Afzal *et al.*, (1993) classified rangelands of Balochistan into excellent (3.2%), very good (9.5%), good (8.1%), fair (17%), poor (33.7%) and non grazable (28.5%) condition. While FAO (Anon., 1995) broadly classified these rangelands as poor (62%), medium (25%) and high (13%) potential ranges that respectively produce annually less than 50, 60 and 190 Kg DM/ha. In Balochistan, about 20 million small ruminants are present including 54% sheep and 46% goats as the major livestock (Anon., 1998). More than 90% of small ruminants are owned by transhumants. Generally, 60% of small ruminants are herds of up to 100 animals. Mori & Rehman (1997) and Rasool *et al.*, (2005) stated that the rangelands of Balochistan are deficient in nutritive forage by 29-33%. Almost 90% of the small ruminants including goats and sheep get their forage and nutrient requirements from grazing lands.

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 (Wahid, 1990; Kababia *et al.,* 1992; Grunwaldt *et al.,* 1994; Nyamangara & Ndlovu, 1995). It has been frequently observed that sheep generally prefer grasses and forbs more than shrubs; while goats prefer shrubs (Wilson *et al.,* 1995; Huston, 1978; Grunwaldt *et al.,* 1994; Khan, 1996). Lope & Stuth (1984) reported that degree of dietary overlap between sheep and goats is greater in dry season because of limited forage availability. Black & Kenney (1984 a, b) reported that sheep prefer fresh feed over dried feed because of taste, odour or feel. Pfister & Malechek (1986) found that fruits and flowers were seasonally important in animal diet. Migongo-Bake & Hansen (1987) reported that in East Africa sheep feed usually consist of more than 50% grasses during all seasons, while shrub component of their diet tends to increase during dry seasons. Wahid (1990) reported that sheep and goats diet consisted of 53 to 81% shrubs in different rangelands of Balochistan. Vallentine (1990) reported that goats consumed 25% grasses, 5% forbs, and 70% browse during different seasons. Kababia *et al.,* (1992) reported that goats consumed 79 to 86% dry matter of bushes in winter, spring and summer. Nyamangara & Ndlovu (1995) observed that feed selection of animals varied with season. Hussain & Mustafa (1995) reported that 58% of the total species were used as forage by goats and sheep in Nasirabad valley (Hunza). Lichacar *et al.,* (1996) stated that shrubs provide green fodder in the absence of annuals. Many studies concluded that over grazing reduces palatable cover and species diversity (Liu *et al.,* 1996; Hickman *et al.,* 1996; Batanouny, 1996; Makulbekova, 1996; Hussain & Chaghtai, 1984; Hussain & Durrani, 2007, 2008). Rasool *et al*., (2005) stated that the grazing system in Balochistan consists of 74% nomadic, 21% transhuminant and 5% sedentary type. Omer *et al*., (2006) stated that forage production was high during spring in dry temperate rangeland in Northern areas of Pakistan.

The review indicates that no work on the availability, palatability and animal preferences of forage plants of Pakistan in general and Harboi rangeland especially is available. The only available references on the ecology of Harboi rangeland are those of Durrani *et al*., (1996, 2005), Durrani & Hussain, (2005) and Hussain & Durrani (2007, 2008). Keeping in view the lack of information and importance of rangeland, the present study was conducted to assess i) seasonal availability of forage plants, ii) differential palatability by parts and iii) forage preferences by grazing animals. The findings will help rangeland ecologists to suggest ways and means to improve this and similar other rangelands in Pakistan.

Materials and Methods

The location, climate and other ecological characteristics of vegetation of the investigated area have been given in detail in our previous papers (Durrani *et al*., 2005; Durrani & Hussain, 2005; Hussain & Durrani, 2007).

Seasonal availability of forage species: Every month for two consecutive years (1997, 1998) the number of available forage species with the foliage such as grasses, herbs, shrubs and tree species were counted to see their seasonal availability. The dormant plants with no foliage were considered non-available.

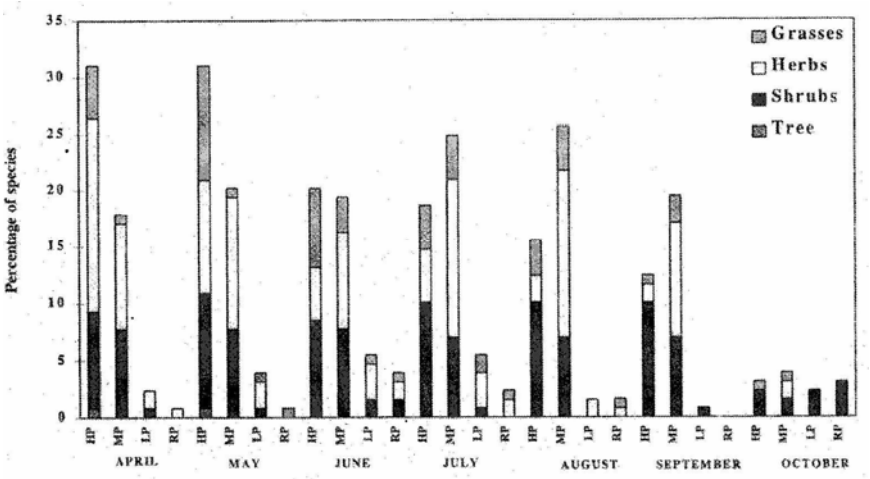

Fig. 1. Availability of palatable species during different months.

Differential palatability of forage: Differential palatability of plants was recorded by daily observing the grazing goats and sheep for two consecutive years (1997 and 1998) from April to October consecutively. The observations were taken fortnightly for 2-3 hours in morning at the on-set of grazing and then in the afternoon between 4-5 p.m. The field observations were further confirmed from knowledge gathered from local herders/ shepherds. Plants were classified into following palatability classes:

1. Non Palatable (NP): Not grazed by animals at any stage; possibly toxic or harmful.
2. Highly Palatable (HP): Species, which were preferred the most by livestock.
3. Mostly Palatable (MP): Species with average preference by the livestock.
4. Less Palatable (LP): Species with less preference.
5. Rarely Palatable (RP): Species rarely grazed under compulsion when no other forage was available.

Differential palatability of plant parts and animal preference: The palatable species were further classified by animal preferences (goats & sheep) and parts grazed (leaves, shoots, floral parts).

Results and Discussion

Seasonal availability of palatable species: Seasonal availability of palatable fodder species depended upon the phenological stage, which in turn depended upon the climate (Table 1). It was observed that there were 64 species available in April, 87 in May, 68 in June, 72 in July, 6 in August, 46 in September and 13 species in October. The evergreen perennial species like *Juniperus excelsa*, *Ephedra intermedia*, *Convolvulus leiocalycinus*, *Prunus spp.*, and *Pennisetum orientale* were found through out the growing season. The most preferred species gradually increased from April to August (17.85 to 32.57%) and thereafter they decreased. The highly and mostly preferred shrubby component almost remained similar (8.5-10.07) from April to September (Fig. 1). Highly palatable herbaceous species were abundant (17%) during April but decreased thereafter. Most of the highly palatable grasses were available during May and June (10.00 and 6.98%) compared to other months. The present findings agree with those of Omer *et al.*, (2006) who reported decreased productivity during winter in the high altitude pastures of Northern parts of Pakistan.

Table 1. Seasonal availability and Palatability of plants in Harboi rangeland, Kalat.

S. No.	Species	April	May	June	July	August	September	October
	a. Tree							
1.	*Juniperus excelsa* M. Bieb.	HP	HP	NP	NP	NP	NP	MP
	b. Shrubs							
1.	*Acantholimon munroanum* Aitch & Hemsl.	HP	HP	HP	HP	HP	HP	-
2.	*Acantholimon polystachyum* Boiss	HP	HP	HP	HP	HP	HP	-
3.	*Aerua javanica* (Burm. F) Juss	MP	MP	MP	MP	-	-	-
4.	*Artemisia maritima* L.	HP	HP	NP	NP	NP	HP	-
5.	*Astragalus* 97-53 L.	HP	HP	HP	HP	HP	HP	-
6.	*Astragalus* 97-8	HP	HP	HP	HP	HP	HP	-
7.	*Astragalus anisacanthus* Boiss	-	HP	HP	HP	HP	HP	-
8.	*Astragalus psilocentros* Fisch	-	HP	HP	-	-	-	-
9.	*Caragana ambigua* Stocksii	HP	HP	HP	-	-	-	-
10.	*Clematis graveolens* Lindl.	-	-	-	MP	MP	MP	MP
11.	*Clematis orientalis* L.	-	-	MP	MP	MP	MP	-
12.	*Colutea armata* Hemsl. & Lace.	MP	MP	MP	MP	MP	MP	-
13.	*Convolvulus leiocalycinus* Boiss.	HP	HP	HP	HP	HP	HP	HP
14.	*Ebenus stellata* Boiss	MP	MP	MP	-	-	-	-
15.	*Ephedra intermedia* Schrenk var *glauca* (Regel) Stapf.	HP	HP	HP	HP	HP	HP	HP
16.	*Gaillonia eriantha* Jaud & Spach	MP	MP	MP	-	-	-	-
17.	*Haloxylon griffithii* (Moq.) Bunge ex Boiss	-	-	LP	HP	HP	HP	RP
18.	*Hertia intermedia* (Boiss.) O. Ktze	MP	MP	NP	NP	NP	NP	-
19.	*Isodon rugasos* (Wall ex Bth) Codd	-	-	-	HP	HP	HP	-
20.	*Lonicera hypoleuca* Dcne	MP	MP	MP	MP	MP	MP	-
21.	*Nepeta juncea* Bth	LP	LP	LP	MP	MP	Mp	MP
22.	*Nepeta* sp.	-	-	-	LP	MP	MP	-
23.	*Onobrychis cornuta* (L.) Desv	MP	MP	MP	MP	MP	MP	-
24.	*Perovskia abrotanoides* Karel	-	NP	RP	HP	HP	HP	RF

Table 1. (Cont'd.).

S. No.	Species	April	May	June	July	August	September	October
25.	*Perovskia atriplicifolia* Bth	NP	NP	RP	HP	HP	HP	RP
26.	*Prunus eburnea* Aitch	HP	HP	HP	HP	HP	LP	-
27.	*Prunus* sp.	HP	HP	HP	HP	HP	HP	HP
28.	*Rosa lacerans* Boiss & Buhse	MP	MP	NP	NP	NP	NP	-
29.	*Salvia cabulica* Bth	MP	MP	MP	MP	MP	MP	-
30.	*Sophora griffithii* Stocks	NP	NP	MP	HP	HP	HP	-
31.	*Spiraea boissieri* Schneider	MP	MP	MP	MP	MP	MP	-
	c. Herbs							
1.	*Achillea santolina* L.	-	-	MP	Mp	MP	-	-
2.	*Adonis aestivalis* L.	HP	HP	-	-	-	-	-
3.	*Allium dolichostylum* Vved	-	MP	-	-	-	-	-
4.	*Alyssum desertorum* Stafp	HP	HP	-	-	-	-	-
5.	*Alyssum linifolium* Staph ex WIlld	HP	HP	-	-	-	-	-
6.	*Alyssum marginatum* Steud ex Willd	HP	HP	-	-	-	-	-
7.	*Alyssum szovitzianum* F & M.	HP	HP	-	-	-	-	-
8.	*Asparagus capitatus* Baker	-	MP	MP	MP	MP	-	-
9.	*Astragalus gomphobobium* Bth ex Bunge	-	-	MP	MP	-	-	-
10.	*Astragauls* sp. 97–151	-	-	HP	HP	-	-	-
11.	*Bupleurum exaltatum* Bieb	-	-	LP	LP	LP	-	-
12.	*Bupleurum linearifolium* D.C.	-	LP	LP	LP	-	-	-
13.	*Ceratocephalla falcatus* (L.) Pers.	HP	-	-	-	-	-	-
14.	*Ceratocephalla testiculata* (Crantz) Roth	HP	-	-	-	-	-	-
15.	*Chenopodium album* L.	HP	HP		HP	HP	HP	-
16.	*Chenopodium botrys* L.	-	MP	-	Mp	MP	-	-
17.	*Chenoppodium foliosum* (Moench) Ashers	-	MP	-	-	-	-	-
18.	*Chenopodium hybridum* L.	-	-	-	MP	MP	MP	-

Table 1. (Cont'd.).

S. No.	Species	April	May	June	July	August	September	October
19.	*Convolvulus arvensis* L.	-	-	HP	HP	HP	-	-
20.	*Conyza bonariensis* (L.) Cronguist	-	-	-	-	HP	HP	-
21.	*Cousinia onopordioides* Ledeb	NP	NP	MP	MP	MP	-	-
22.	*Cousinia* sp.	NP	MP	-	-	-	-	-
23.	*Descurainea sophia* (L.) Webb & Berth	-	HP	-	-	-	-	-
24.	*Echinops echinatus* Rox b.	-	MP	MP	-	-	-	-
25.	*Epilobium* sp.	-	-	-	-	MP	MP	-
26.	*Eremerus persicus* (Jaub & Spach) Boiss	MP	MP	MP	MP	-	-	-
27.	*Eremostachys vicarys* Benth.	-	-	MP	MP	MP	MP	-
28.	*Euphorbia granulata* Forssk.	-	-	-	MP	MP	MP	-
29.	*Euphorbia prostrata* Ait	-	-	MP	MP	Mp	MP	-
30.	*Farsetia heliophila* Bunge ex Coss	-	HP	HP	HP	-	-	-
31.	*Filago hurdwarica* (DC.) Wagenitz	-	HP	-	-	-	-	-
32.	*Fumaria indica* (Hausskn.) H.N.	MP	MP	-	-	-	-	-
33.	*Gagea pseudo-reticulata* Vved.	MP	-	-	-	-	-	-
34.	*Gagea* sp.	MP	-	-	-	-	-	-
35.	*Galium aparine* L.	-	HP	-	-	-	-	-
36.	*Gnaphalium luteoalbum* L.	-	MP	-	-	-	-	-
37.	*Gypsophila lignosa* Hemsl & Lace	-	MP	MP	MP	MP	MP	-
38.	*Heliotropium brahuicum* Stocks	MP	MP	-	-	-	-	-
39.	*Holosteum umbellatum* L.	HP	HP	-	-	-	-	-
40.	*Hypecoum pendulum* L.	HP	HP	-	-	-	-	-
41.	*Kochia stellaris* Moq.	-	-	-	MP	MP	MP	-
42.	*Lactuca auriculata* Wall. Ex DC.	-	RP	RP	RP	RP	-	-
43.	*Lactuca orientalis* (Boiss.) Boiss	-	RP	-	-	-	-	-
44.	*Lactuca persica* Boiss	RP	RP	-	-	-	-	-

Table 1. (Cont'd.).

S. No.	Species	April	May	June	July	August	September	October
45.	*Lithorspermum arvense* L.	HP	HP	-	-	-	-	-
46.	*Malcolmia africana* (Linn.) R. Br.	HP	HP	HP	-	-	-	-
47.	*Malcolmia* sp.	-	-	-	MP	MP	MP	-
48.	*Malcolmia strigosa* Boiss	-	HP	-	-	-	-	-
49.	*Malva neglecta* Wallr.	MP	MP	MP	MP	MP	-	-
50.	*Marrubium vulgare* L.	-	-	-	HP	HP	HP	-
51.	*Medicago lupulina* L.	-	HP	HP	-	-	-	-
52.	*Medicago polymorpha* L.	-	-	-	HP	-	-	-
53.	*Minuartia meyeri* (Boiss.) Bornm	HP	HP	-	-	-	-	-
54.	*Neslia apiculata* Fisch & Mey & Avelal	HP	HP	HP	HP	MP	MP	-
55.	*Nonnea caspica* (Willd) G. Don	MP	-	-	-	-	-	-
56.	*Orobanche cernua* Loeffl	LP	LP	LP	LP	-	-	-
57.	*Peganum harmala* L.	-	RP	RP	RP	-	-	-
58.	*Polygala hohenackeriana* Fisch & Mey	HP	HP	-	-	-	-	-
59.	*Polygonum paronychioides* C.A. Mey	HP	HP	-	-	-	-	-
60.	*Polygonum* sp.	-	-	-	LP	LP	LP	-
61.	*Salsola kali* L.	-	-	-	MP	MP	-	-
62.	*Senecio* sp.	-	MP					-
63.	*Silene brahuica* Boiss	-	LP	LP	-	-	-	-
64.	*Solanum nigrum* L.	-	-	-	-	-	MP	MP
65.	*Sonchus maritimus* L.	-	-	-	MP	MP	-	-
66.	*Stellaria alsinoides* Boiss & Buhse	HP	HP	-	-	-	-	-
67.	*Taraxacum officinale* Weber.	-	MP	MP	MP	MP	MP	MP
68.	*Trichodesma stocksii* Boiss	-	MP	MP	-	-	-	-
69.	*Tulips polychrome* Stapf.	HP	-	-	-	-	-	-
70	*Valerianella oxyrrhyncha* Fisch & Mey	HP	HP	-	-	-	-	-

Table 1. (Cont'd.).

S. No.	Species	April	May	June	July	August	September	October
71.	*Veronica biloba* L.	HP	HP	-	-	-	-	-
72.	*Veronica didyma* Tenore	HP	HP	-	-	-	-	-
73.	*Zizyphora clinopodioides* Lam	-	-	-	-	MP	MP	-
74.	*Zizyphora tenuior* L.	HP	HP	-	-	-	-	-
	d. Grasses and grass-like							
1.	*Aristida* sp.	-	-	MP	MP	MP	MP	-
2.	*Aristida adscensionsis* L.	-	-	-	MP	MP	MP	MP
3.	*Boissera squarrosa* (Soland) Nevski	-	HP	HP	-	-	-	-
4.	*Bothriochloa ischaemum* (L.) Keng	-	-	-	MP	MP	-	-
5.	*Bromus sericeus* Drobov.	HP	HP	-	-	-	-	-
6.	*Bromus tectorum* L.	HP	HP	-	-	-	-	-
7.	*Carex* sp. (i)	-	-	HP	HP	-	-	-
8.	*Carex* sp. (ii)	-	-	HP	HP	-	-	-
9.	*Cymbopogon jwarancusa* (Jones) Schult	-	LP	LP	LP	-	-	-
10.	*Eragrastis minor* Host	-	HP	HP	HP	HP	-	-
11.	*Festuca arundinacea* Schreb	-			HP	HP	-	-
12.	*Hordeum bogdannii* Wilensky	-	HP	HP	LP	-	-	-
13..	*Pennisetum orientale* L.	HP	HP	HP	HP	HP	HP	HP
14.	*Phalaris* sp.	-		MP	MP	MP	-	-
15.	*Piptatherum vicarium* (Grig.) Rozher	MP	MP	MP	-	-	-	-
16.	*Poa sinaica* Steud	-	-	HP	HP	HP	-	-
17.	*Poa bulbosa* L.	HP	HP	-	-	-	-	-
18.	*Polypogon fagax* Nees ex Steud	-	RP	RP	RP	RP	-	-
19.	*Schismus arabicus* Nees	HP	HP	-	-	-	-	-
20.	*Stipa pennata* L.	HP	HP	HP	HP	-	-	-
21.	*Tetrapogon villosis* Desf	-	HP	HP	-	-	-	-
22.	*Unidentified grass* (97–108)	-	HP	-	-	-	-	-
23.	*Unidentified grass* (97–150)	-	-	MP	MP	MP	MP	-

Key: HP=Highly Palatable. MP =Mostly Palatable. LP=Less Palatable. RP=Rarely Palatable

Differential palatability: The overall vegetation cover in the Harboi rangeland is governed by low, erratic and undependable rainfall, short growing season and eroded exposed steep soils. The palatable plants become more susceptible to grazing and trampling under such habitat conditions. Of the total 145 recorded species (Durrani *et al.,* 2005; Durrani & Hussain, 2005), 129 were palatable (Table 1). Among them, 50.4% (65 Spp.) were highly palatable, 41.1% (53 Spp.) mostly palatable, 4.65% (6 Spp.) less palatable and 3.87% (5 Spp.) species were rarely palatable. The overall ratio of palatable species to the total recorded species was 44.83% highly palatable, 36.55% most palatable, 4.14% less palatable and 3.44% rarely palatable. Sixteen species including *Euphorbia falcata, Euphorbia granulata, Euphorbia maddenii, Euphorbia multifurcata, Hyoscyamus pusillus, Onosma dichroanthum, Juncus articulata, Juncus inflexus, Juncus* spp., and *Melica persica* were non palatable probably due to presence of phenolics, alkaloids and / or saponins and other poisonous or harmful substances (Vallentine 1990; Munday & Morris, 1978; Gardner *et al.,* 1996; Reyna & Gonzalez., 1996; Malulbekova, 1996; Kayani *et al*., 2007). It becomes difficult to sharply distinguish between poisonous and non-poisonous plants as animals acquire aversion to food due to unpleasant feelings of physical discomfort caused either by presence of toxins, or excess of nutrients, or by nutrient deficient food. This is manifested when grazing animals no longer take interest even for preferred food or when offered alternatives (Provenza, 1995). Most plants are poisonous only when eaten in large amounts at particular stage that might provide nutritive forage when consumed in small amounts or mixed with other forage.

Juniperus excelsa was the only tree species, whose tender leaves and shoots became highly preferred by sheep and goats under compulsion during early spring and late winters (Fig. 1) when no other forage was available in the range. On the contrary, Hussain & Mustafa (1995) and Gyamtosho *et al.,* (1996) reported *Juniperus* species to be non palatable. Kayani *et al*., (2007) reported phenolics, alkaloids and saponins in juniper. These chemical features are considered anti-nutritional factors that reduce the palatability. These animals might have adapted to digest juniper because of dietary habit of eating a particular feed during early life. It is suggested that saliva may conjugate with the volatile oils and tannins to render them non-toxic (Nymangara & Ndlovu, 1995**;** Robbin *et al.,* 1991). Among the 31 shrubs, 17 (13.18%) and 14 species (10.85%) were respectively highly and mostly palatable. *Rosa lacerans* and *Hertia intermedia* were preferred mostly at flowering stage as floral parts were consumed. *Artemisia maritima* was highly preferred during early spring and late summer, while it was not grazed from June to August. *Perovskia* spp., *Sophora griffithii, Haloxylon griffithii* and *Nepeta juncea* were preferred over other species from July to September only.

Of the 74 (57.36%) palatable herbs, 32 (24.81%) species were highly palatable, 33 (25.58%) mostly palatable, 5 (3.87%) less palatable and 4 (3.10%) rarely palatable (Table 1). Among the 23 (17.83%) grasses, 15 (11.63%) and 6 species (4.65%) were respectively highly and mostly palatable; while *Cymbopogon jawarancusa* and *Polypogon fagus* were least palatable. Kayani *et al.,* (2007) reported phenolics and alkaloids in *Cymbopogon jawarancusa* that are negative factors in palatability. The grazing season in Harboi range starts from the first week of April and terminates in last week of October. It is freely grazed by mixed herds of sheep, goats and camels. The vegetation is consumed by grazing livestock as soon as it is produced. Annuals like *Bromus sericeus, Bromus tectorum, Schismus arabicus, Ceratocephala falcata, C. testiculata* and bulbous geophytes including tulips that appear abundantly during early spring are over grazed before attaining maturity. A few growing within the thickets of spiny or obnoxious plants that escape grazing might reach maturity.

Table 2. Percent palatable species by life form as browsed by goats and sheep.

Life form	Browsed by goats	Browsed by sheep
Total species browsed	104	98
a. Tree (%)	1	1
b. Shrubs (%)	27	22
c. Herbs (%)	60	54
d. Grasses (%)	12	23

Table 3. Classification of palatable plants by browsed preferred parts by livestock (Goats & Sheep).

Parts browsed	No. of species	% Species
1. Shoots/Whole plants	99	63
2. Leaves/Foliage	30	19
3. Floral/ Fruiting parts	29	18

Preferences by grazing animals: The relative seasonal availability of plant composition and its morphological and chemical nature affects the relative palatability. Among the palatable species, goats grazed on 104 (80.62%) species including one tree (1%), 27% shrubs, 60% herbs and 12% grasses (Table 2). Sheep browsed on 98 (75.97%) species comprising of one tree (1%), 22% shrubs, 54% herbs and 23% grasses (Table 2). Camels preferred *Convolvulus leiocalycinus, Perovskia abrotanoides, Gailonia eriantha* and *Spiraea boissieri* among shrubs, while *Descurainia sophia, Lithospermum arvense, Cousinia onopordioides, Cousinia* sp., *Echinops echinatus, Malva neglecta, Salsola kali* and *Trichodesma stocksii* were mostly preferred herb species. The livestock preferred most of the shrubs in the Harboi range that contributed 33-39% in their diet selection during April to August. While from September onwards animals were forced to consume low quality forage due to non availability of good quality forage. *Artemisia maritima, Caragana stocksii, Astragalus* spp., *Ephedra intermedia, Ebenus stellata, Haloxylon griffithii, Convolvulus leiocalycinus, Prunus* spp., *Perovskia* spp., and *Sophora griffithii* were the most preferred shrubs that have become stunted and deformed in response to over grazing. Wahid (1990) also reported some of these shrubs to be preferred by livestock in other rangelands of Balochistan. Mukulbelova (1996) and Batanouncy (1996) also stated that goat, sheep and camels prefer *Artemesia* while *Haloxylon* is less preferred. Sheep gain higher digestible energy by selecting nutritious diet than goats. Sheep prefer to utilize high cellulose forage such as graminoids and forbs. However, in the absence of grasses, they browse on bushes and shrubs. Dutoit & Alard (1996) considered sheep grazing good for maintaining plant diversity and subsequent mineral diversity in rangeland.

Differential palatability by parts consumed: It was observed that shoots/whole plants were grazed in 99 species (63%) whereas in 30 species (19%) foliage/leaves were used and in 29 species (18%) floral parts were grazed (Table 3). Fruits and flowers are seasonally important in animal's diet as they might have high level of cell soluble and proteins than leaves (Pfister & Malecheck, 1986). Nyamangara & Ndlouv (1995) also observed increasing preference for floral parts over vegetative parts at different phenological stages. *Hertia, Sophora* and *Rosa* were preferred only at flowering/fruiting stage. Similarly, vegetative buds of shrubs are particularly high in cell soluble and crude protein (Holechek *et al.,* 1998). The findings also agree with those of Hussain & Mustafa (1995) who reported preference of floral parts and fruiting parts by grazing animals in the pastures of Nasirabad valley, Hunza.

The livestock preferred foliage of 19% species as leaves of nearly all forage plants generally have high crude protein, phosphorus and low fibre and lignin contents than woody stems (Holechek *et al.*, 1998; Hussain & Mustafa, 1995; Durrani, 2000). Similarly, green soft herbaceous parts, besides having good taste, odour and feel, are easily digestible. Animals generally prefer fresh foliage over dried and non succulent forage that can be eaten faster. Many grasses accumulate phenolics, alkaloids, saponins and silica that reduce digestibility and palatability (Holechek *et al.*, 1998; Kayani *et al.*, 2007). However, leaves and stems of grasses have high cellulose and low lignin concentration than forbs and shrubs that changes their palatability.

The selectivity of forage by grazing animals directly depends upon the amount and type of available herbage. Annual forbs/grasses besides important in nutritional contribution also reduce grazing pressure on palatable perennial species. Annuals and geophytes were available at the time when most of the shrubby plants were dormant. On the other hand, when annuals reach to dormant stage, the shrubby forage became available in Harboi range. The palatability of plants also changed with the nutritional needs of animals. In the present study 93% of preferred species were short-lived annuals. Of them, 55.4% are available during early spring. The plant preferences of livestock shifted with the seasonal phenological cycle. The preference for herbaceous species was highest during April and May that lowered during October. This pattern was well correlated with the availability of grasses, which were available in higher percentage from April to June, and thereafter they decreased gradually. The most preferred species by livestock from April to June were *Poa* spp., *Piptatherum, Bromus* spp., and *Schismus*. While *Stipa* spp., *Tetrapogon* spp., and *Festuca* spp., were the most desired species during June and July. *Aristida* spp., and *Eragrostris* spp., were preferred form July to October. *Pennisetum orientale* was available and preferred by livestock through out the growing season in the present study. This might be due to lack of any anti-nutritional substance in this grass as reported by Kayani *et al*., (2007). Non- or less-palatable grasses including *Melica persica* and *Cymbopogon jwarancusa* increased in the range. This agrees with Wahid (1990) and Saleem (1993) who stated that *Cymbopogon jwarancusa* has spread over majority of the grazing lands in Balochistan owing to its low palatability and high intensity of past livestock grazing. It, therefore, becomes necessary to frequently change bedding and feeding grounds for maintaining a healthy palatable cover.

Most of the species that were highly preferred by goats were available (38.46%) during May. Only 7-9% of the grasses were available during May and June that declined further in September (Fig. 2). The availability of highly and most preferred shrub species was relatively constant from May to September (11.54%) which decreased to 2.88% from October onwards. Some 16 to 18% highly preferred herbaceous species were available in April and May followed by their decline in subsequent months. There was an increase in the most preferred species from April to July (6.73 to 15.38%) but they drastically decreased to 1.92% in October. The percentage of least preferred species by the livestock went high during July (Fig. 2).

Sheep had variety of choices for fodder during May, as 36.73% of highly preferred species were present. The %age availability of preferred shrubs gradually increased from April to July (5 to 9%) and remained almost constant upto September. The fodder choices were limited to only 2% species during October (Fig. 3). The %age of highly preferred herbs was relatively greater (17.35%) in April and May that dropped off to 5% during June (Fig. 3). The species ranked low in preference were less in June and July compared to other months. It is stated that sheep grazing reduced species number and therophytes as compared to donkey grazing in Rhine valley in Germany. In Harboi rangeland goats, sheep and some camels that graze in mixed herds, which is reportedly better than single species grazing.

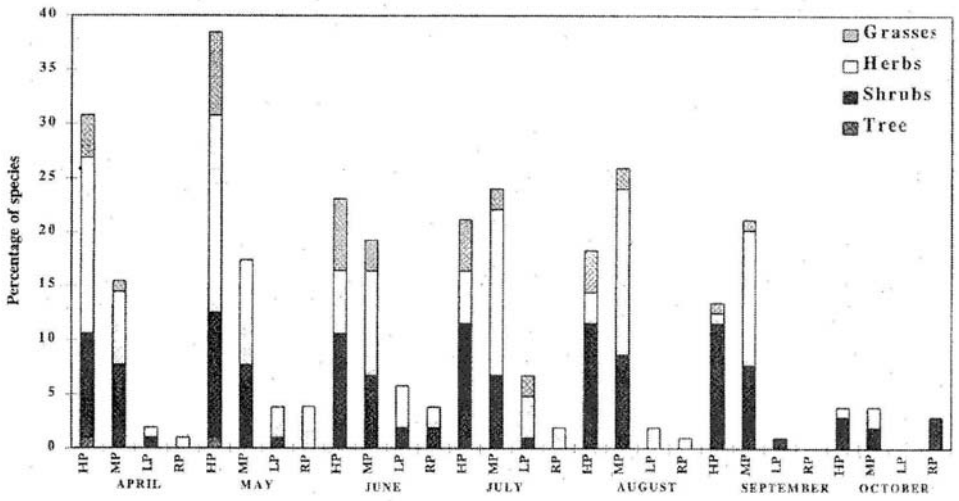

Fig. 2. Preferences of goats during different months.

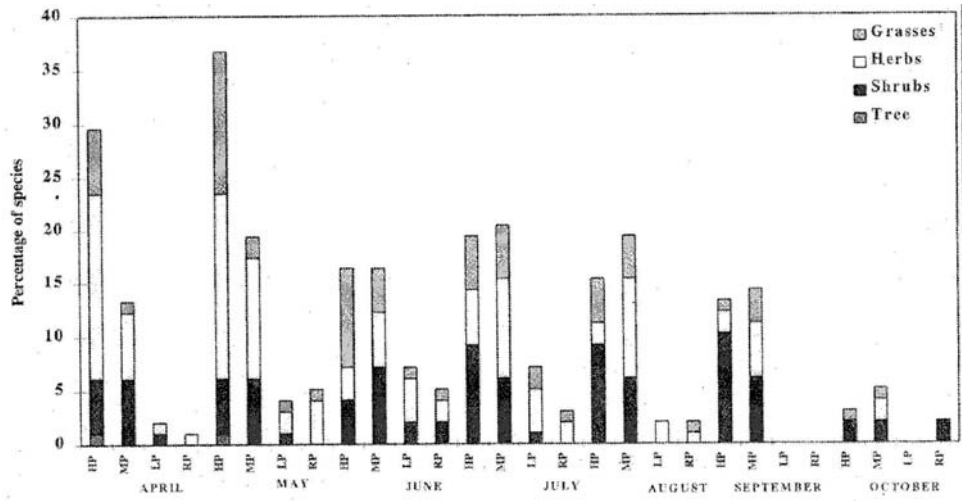

Fig. 3. Preferences of sheep during different months.

Since the range vegetation varied greatly in seasonal availability of forage, palatability, nutritive value and productivity, therefore grazing animals obviously select the most palatable plants first. Resultantly, low quality or non-palatable plants replace good quality forage plants under poor management. Although, some of the preferred species such as *Artemisia, Solanum, Senecio, Peganum, Chenopodium, Taraxacum, Euphorbia, Astragalus, Clematis, Conyza, Descurania, Kochia, Malva, Salsola* and *Salvia* although might be harmful to livestock owing to their unfavourable chemical composition (Kayani *et al*., 2007) or texture, yet they were grazed under compulsion due to scarcity of forage in the area. It might be quite possible that poor health and death loses of livestock in Harboi range are partly due to continuous consumption of such harmful species. *Peganum harmala, Euphorbia prostrata, Sophora* and *Perovskia atriplicifolia* are generally not palatable in other parts of the country (Hussain & Mustafa,

1995), but they are grazed in Harboi range. Wahid (1990) reported that the livestock in some rangelands of Balochistan (Loralai, Kalat) are capable to digest highly lignified feed like *Artemisia*, *Pervoskia* and *Juniperus*, which is not preferred in other regions, and this might be true in the present case. Forage deficiency compels livestock to eat harmful amount of even poisonous plants. The chemical composition of forage is a key factor determining palatability, which needs to be investigated. The effective constituents associated with palatability are situation specific rather than universal. Fresh forage with high crude protein, fats, sugar and cellulose contents are highly digestible and are therefore preferred. While plants with high fibre, lignin, silica, low magnesium and phosphorus, high secondary plants metabolites and low digestibility are less preferred by livestock. On a good grazing land, poisonous and less palatable plants face intense competition from vigorous high producing forage plants as there is great variety of fodder choices available to grazing livestock (Vallentine, 1990). However, in the present case non-palatable plants face less competition because of poor and sparse vegetation of palatable species. Less grazed plants frequently gain an advantage over highly grazed plants, which induces a shift in competitive interactions, contribute to changes in soil, phytomass and plant composition over a period of time. High stocking rate reduces vegetation cover and productivity of rangeland (Gillen & Sims, 2004).

In the present study, the preference for grasses by sheep ranged in between 15.91% to 34.09% from April to June that declined gradually towards September. The availability of preferred herbaceous species was 56.82 to 53.97% from April to May that declined to 31.82% in June but increased again to 40.81% during July due to emergence of summer annuals after summer rains. During September/October, the cold season imposes dormancy in plants that decreased the availability of forage plants. The preference for shrubs by sheep was 27.27 to 34.9% during April to June, which declined to 22.65% in July due to availability of other preferred herbaceous species. The preference for shrubs by sheep once again went to 39.47% in August when other forage species became deficient. From September onwards the livestock had fewer choices for forage species. Sheep and goats now browse *Haloxylon griffithii*, *Artemisia maritima* and *Sophora griffithii* during this period. During this time the animals become weak and less productive. This agrees with the findings of Rehman (2002) who reported that livestock gain maximum weight at the end of summer grazing in high altitude pastures of Pakistan. In the present study forage is available during early spring and summer.

Animals spend more time for feeding in forage deficient rangelands. The livestock face severe forage deficiency in Harboi rangeland from September onward owing to decline of overall vegetation cover due to on set of dormant condition. Sheep and goats may walk upto 10 Km in search of preferred energy rich feed in degraded Harboi rangeland. Goats can distinguish between bitter, salt, sweet, sour with a variety of dietary alternatives that enable them to choose from a wider range of plant species than sheep (Mohammad, 1989). Goats often readily shift to herbaceous species when shrubs become highly unpalatable. *Convolvulus leiocalycinus* and *Prunus* spp., were most preferred shrubs through out the grazing season. The availability of shrub species preferred by goats was 38.38% to 40.74% from April to June, which gradually increased with the disappearance of herbaceous component. The availability of preferred herbaceous species by goats was 52 to 55.38% during April to May and thereafter it decreased. The preferred grass component available to goats was 10 to 18.51% from April to June that reduced to 5.4% during September. Nyamanagava & Ndlova (1995) also observed that grasses were preferred from January to March while herbs and shrubs were preferred from May to

November. This is what is happening in the Harboi Rangeland. Likewise, Grunwaldt *et al.,* (1994) stated that goats walking up a steep gradient might require upto 10 times more energy as walking on the plain to reach tender preferred shrubby twigs. There is a tremendous potential to improve carrying capacity of this rangeland by managing grazing system including range-animal nutritional status, stocking rate, type of forage species and animals and season of use. Seasonal grazing definitely affects physical and chemical features of soil (Melinda *et al*., 2004). Although, Harboi rangeland is a protected forest but grazing of livestock and collection of forest resources by locals is common feature due to lack of strict implementation of laws. It is recommended that appropriate stocking rate (Sardar, 1992; Gillen & Sims, 2004) during the growing season and proper livestock management techniques might improve rangeland productivity and species diversity (Mori & Rehman, 1997; Farooq, 2003). It also suggested that further work be carried out to evaluate the important forage plants for their nutritional and mineral composition, which is an important factor in improving health and productivity of livestock.

Acknowledgements

The authors are thankful to Forest authorities Kalat for allowing to carry ecological investigation in the rangeland. MJD is thankful to University of Balochistan for providing an opportunity to carry this study at University of Peshawar towards her Ph.D. The help of Mr. Saeed-ur-Rehman in the field is highly acknowledged. The authors are thankful to Mr. S. Ghulam Mohammad for his help in the preparation of graphs and valuable suggestion during this study.

References

Afzal, J., A.S. Alvi and S.N. Mirza.1993. Potential for rehabilitation of degraded rangelands of Balochistan. *Pak. J. For*., 43: 99-106.

Anonymous. 1995. *Land and Range Resource Management issues and Food Security in Balochistan.* Arid Zone Research Institute, Quetta.

Anonymous. 1998. *Livestock Census 1996. Balochistan* Vol. II. Part-4. Agricultural Census Organization Statistics Division, Govt. of Lahore.

Batanouny, K.H. 1996. Biodiversity in the rangelands of the Arab countries. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress 1995, Salt Lake City Utah. Pp. 39 - 40.

Black, J.L. and P.A. Kenney. 1984a. Factors affecting diet selection by sheep. I. *Aust. J. Agric. Res*., 35: 551-563.

Black, J.L. and P.A. Kenney. 1984b. Factors affecting diet selection by sheep. II. Height and density of pasture. *Aust. J. Agric. Res*., 35: 565-578.

Durrani, M.J. 2000. *Ecological evaluation of some Rangeland plants of Harboi Hills, Kalat, Balochistan.* Ph.D. Thesis. Department of Botany, University of Peshawar.

Durrani, M.J. and F. Hussain. 2005. Ethnoecological profile of plants of Harboi rangeland, Balochistan. *Int. J. Biol. & Biotech*., 2: 15-22.

Durrani, M.J., F. Hussain and S. Rehman. 2005. Ecological characteristics of plants of Harboi rangeland, Kalat, Balochistan. *J. Trop. Subtrop. Bot*., 13: 130-138.

Durrani, M.J., S.A. Shahwani and F. Hussain. 1996. Phytosociological studies of Iskalku rangelands, District Kalat. *J. Sci & Technol*., 20: 29-33.

Dutiot, T. and D. Alard. 1996. Mineral contents and plant diversity in Chalk grassland under different management. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress 1995, Salt Lake City Utah. pp. 122-123.

Farooq, M.U. 2003. Some suitable and sustainable strategies for improving rangeland productivity in Pakistan. *Pak. J. Forest.*, 53: 193-199.

Gardner, D., B. Stegelmeter, K. Panter and L. James. 1996. Teratogenic and hepatotoxic range plants. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress. 1995. Salt Lake City, Utah. pp. 171-172.

Gillen, R.L. and P.L. Sims. 2004. Stocking rate, precipitation and herbal production on sand sagebrush grassland. *Jour. Range Managmt*., 57: 148-152.

Grunwaldt, E.G., A.R. Pedrani and A.I. Vich. 1994. Goat grazing in arid piedmont of Argentina. *Small Ruminant Research*, 13: 211-216.

Gyamtosho, P., J. Noeberger and M. Menzi. 1996. Existing status and potential for sustainable improvement of high altitude rangelands of Bhutan. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress. 1995. Salt Lake City, Utah. pp. 195-196.

Heath, M.E., R.F. Barnes and D.S. Metcalfe. 1985. *Forages: The Science of Grassland Agriculture.* Iowa State University, Iowa, Aimes.

Hickman, K., D. Hartnett and R. Cochran. 1996. Effects of grazing systems and stocking rates on plant diversity in Kansas tall grass prairie. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress 1995, Salt Lake City Utah. pp. 228-229.

Holechek, J.L., R.D. Pieper and C.H. Herba. 1998. *Range Management. Principles* and *Practices.* 3rd Edition. Prentice Hall, Upper Saddle River, New Jersey, 07458.

Hussain, F. and G. Mustafa. 1995. Ecological studies on some pasture plants in relation to animal use found in Nasirabad Valley, Hunza, Pakistan. *Pak. J. Pl. Sci.*, 1: 255-262.

Hussain, F. and S.R. Ghughtai. 1984. The effect of overgrazing on the development of herbaceous vegetation of Zangilora, Quetta, Balochistan. *Pakistan*, 9: 29-38.

Hussain, F., and M.J. Durrani. 2008. Forage productivity of arid temperate Harboi rangeland, Kalat, Pakistan. *Pak J. Bot*., 39(5): 1455-1470.

Hussain, F. and M.J. Durrani. 2008. Mineral composition of some range grasses and shrubs from Harboi rangeland Kalat, Pakistan. *Pak. J. Bot*., 40(6): 2513-2523.

Huston, J.E. 1978. Symposium. Dairy goats. Forage utilization and nutrient requirements of the goats. *J. Dairy. Sci.*, 61: 988-993.

Kababia, D., S. Landan, A. Perevolostsky, Y. Vecht, L. Eliasof and S. Zeltzer. 1992. The feeding behaviour of milking goats in woody rangeland in the Judean Mountains. *Hasssadch*, 72: 1536-1540.

Kayani, S.A., A.Masood, A.K.K. Achakzai and S. Anbreen. 2007. Distribution of secondary metabolites in plants of Quetta-Balochistan. *Pak. J. Bot*., 39: 1179-1179.

Khan, I.I. 1996. Biodiversity depletion with respect to Human and livestock population in Indian Desert. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress 1995, Salt Lake City Utah. pp. 286-287.

Lichacar, S., R.M. Love, D.W. Rains and H.M. Laude. 1996. The effect of some California soil on the early growth of *Atriplex polycarpa* (Terr.) Wats. and *Atriplex repanda* Phil. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress 1995, Salt Lake City Utah. pp. 300-301.

Liu, D., J. Yun, X. Hao and S. Meng. 1996. Grassland deterioration and control measures in arid and semi - arid region in China. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress 1995, Salt Lake City Utah. pp. 320-321.

Makulbekova, G.B. 1996. The ecological evaluation of the present condition of rangeland vegetation of Kazakhistan deserts. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress 1995, Salt Lake City Utah. pp. 338-339.

Melinda, A.W., M.J. Trlica, G.W. Frasier and J.D. Reeder. 2002. Seasonal grazing affects soil physical properties of a montane riparian community. *Jour. Range Managmt*., 55: 49-56.

Migongo-Bake, W. and R.M. Hensen. 1987. Seasonal diets of camels, cattle, sheep and goats in a common range in Eastern Africa. *J. Range Mange*., 40: 76-79.

Mohammad, N. 1989. Rangeland management in Pakistan. ICIMOD, Kathmandu, Nepal.

Mori, P. and S. Rehman. 1997. Rangeland Rehabilitation in Balochistan (The experience of Kanak Valley). FAO Project (F.O. - GCP/INT/542/ITA).

Munday, B.L. and D.I. Morris. 1978. *Tasmanian plants toxic for animals.* Pub. Tasmanian Deptt. Agric. 101 pp.

Nyamangara, M.E. and L.R. Ndlovu. 1995. Feeding behaviour, feed intake, chemicals and botanical composition of the diet of indigenous goats raised on natural vegetation in a semi-arid region of Zimbabwe. *J. Agri. Sci.,* 124: 455-461.

Omer, R.M., A. J. Hester, I. J. Gordon, M. D. Swaine and S. M. Raffique. 2006. Seasonal changes in pasture biomass, production and off take under transhumance system in Northern Pakistan. *Jour. Arid Environments*, 67: 641-660.

Pfister, J.A. and J.C. Malechek. 1986. Dietary selection by goats and sheep in a deciduous woodland of North Eastern Brazil. *J. Range Mange*., 39: 24-28.

Provenza, F.D. 1995. Postingestive feed back as an elemental determinant of food reference and intake in ruminants. *J. Range Manage*., 48: 2-17.

Rasool, E., A. Rehman and Ihsanullah. 2005. Livestock feed resources: A case study in Asghra-Wazulum Valley, Balochistan. On line Document. http://cnrit.edu/conf/isnh/post-online/post0110. dated 24-6-2005.

Rehman, A.R. 2002. *Seasonal availability and utilization of feed resources and their impact on the nutrition of livestock in an agro-pastoral system of the Hindu Kush- Karakoram-Himalayan region of Pakistan.* Ph.D. Thesis. University of Aberdeen, UK.

Reyna, V.J. and L.A. Gonzalez. 1996. Poisonous noxious weeds from Coahuila, Mexico. In: *Proc. Rangelands. In a sustainable biosphere*. (Ed.): N.E. West. 5th International Congress 1995, Salt Lake City Utah. pp. 580-581.

Saleem, M. 1993. Ecology of *Chrysopogon aucheri* and *Cymbopogon jwarancusa* III. Morphology and defoliation response. *Pak. J. For*., 43: 106-118.

Sardar, M.R. 1992. Carrying capacity and range condition of Hazarganji-Chiltan National Park. *Pak. J. For*., 42: 36-44.

Suss, K. and A. Schwab. 2007. Sheep versus donkey grazing or mixed treatment: results from a 4-year field experiment in Armerio-Festucetum trachyphyllae sand vegetation. *Phytocoenologia*, 37: 135-160.

Vallentine, J.F. 1990. *Grazing Management.* Academic Press, USA.

Wahid, A. 1990. *Dietary composition and nutritional status of sheep and goats grazing in two rangeland types in Balochistan, Pakistan.* Ph. D. Thesis, Oregon State University.

Wilson, A.D., J.H. Leigh, N.L. Hindley and W.E. Mulham. 1995. Comparison of the diets of goats and sheep on a *Easuarina cristata - Heterodendrram oleifolium* woodland community in Western New South Wales. *Aust. J. Ex. Agri. Anim. Husb.*, 15: 45-53.

(Received for Publication 20 December 2007)