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Effects of range condition on the temporal diet selection by goats in steppe rangelands of Iran

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Abstract

One of the key factors in managing a rangeland is to determine the relative preference of its major plant species by the grazing livestock. Preference value of each plant species is affected by plant type, companion plants, availability by animals, phenological stage, climate condition, and the livestock species. We investigated the grazing behaviour of a native goat (Garizi) in the steppe rangelands of Iran, from May to November 2004. The study was conducted within or outside of an enclosure, representing a Good Condition (GC) or a Poor Condition (PC) rangeland, respectively. Flocks of six goats were selected randomly and their grazing behaviour was monitored by chronometers. Grazing preference was considered as the time goats had spent for grazing each plant species. The grazing season was divided into 4 grazing periods, 45 days each. Data recording in the GC and PC sites was repeated 3 times during each grazing period. The experiment was designed as the completely randomized blocks. In the GC site, grazing pressure on the perennial grass *Stipa barbata* and the perennial chenopod *Salsola rigida* was low at the beginning of the grazing period, but it was increased towards the end of the grazing season. In the PC site, the main grazing pressure was on noxious plants such as *Scariola orientalis*, *Launaea acanthoides*, and *Cousinia deserti*. For both GC and PC sites, the time of grazing had significant influences on relative abundances of annual plants and plant litter, which subsequently changed diet selection by the Garizi goat.

Key words: Preference value; Arid rangelands; Garizi goat; Yazd

1. Introduction

"Grazing preference" refers to the selective responses made by the animal to consume different plant species or plant parts, and it is essentially behavioural (Valentine 1990). According to Moghaddam (1998) the preference value of each plant species is dependent on animal (e.g. type, grazing preferences, age, pregnancy, and hunger) or non-animal (e.g. chemical composition, growth stage, frequency and palatability of companion plants, local and physical plant conditions) parameters. Holecheck et al.,, (1984) and Malecheck (1984) believe that diet selection is not only different between animal types, but it is also dependent on plant phenology, availability and climate conditions.

Relative availability of plant species may affect their selection by animals (Valentine 1990). Cook (1962) found high selection of palatable species when they were abundant, but lower selection as their relative frequency decreased. By contrast, Valentine (1990) found high selection from palatable species when they were not dominant

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species in the community, or even under moderate grazing pressure. Welch et al (1987) studied sheep grazing on 21 varieties of sagebrush and found 60-70% consumption from palatable varieties as compared with less than 15% from other varieties. In separate studies, Maywald et al.,, (1998) found different degrees of palatability for male or female stands of *Atriplex canscence*. Kronberg and Walker (1990) found greater importance of site condition than animal race; both Dakota and Idaho sheep preferred Dakota plant ecotypes more than Idaho's.

Palatability may differ during different times of a year, grazing season or even a day. Pain and Rayan (2000) found higher palatability in the evening than in the morning. A study on eight grass species of Great Basin, USA, revealed greater differences in their preference value during active growth than in dormant periods (Ganskopp et al., 1997). Beghstani and Arzani (2005) reported that climate conditions in the year of study can significantly affect the preference value of range plants. In the years with above average rainfall, the highest grazing preference was found for annual plants as well as for the perennial semi-shrub *Salsola rigida*; whereas in dry years perennial grass *Stipa barbata* gained the highest preference value.

To sum up the above literature, "preference value" is affected by plant type, companion plants, availability by animals, phenological stage, climate condition, and the livestock species.

This experiment was performed to find out major sources of goat diet in a steppe rangeland. The two critical questions this research was aimed to answer were: (1) how site condition may affect palatability of plant species for livestock grazing and (2) how diet selection may be changed over time. This experiment has been conducted as a case study in the steppe rangelands of central parts of Iran; however, its results and methods of investigation shall be applicable for similar rangelands within the country or across the globe.

2. Materials and methods

2.1. Study area

The study was conducted within two neighbouring sites that were located inside or outside the Nir Range Research Station (NRRS), Yazd, Iran. Both sites had been similarly managed before 1985, when the enclosure was made around the NRRS. The site inside NRRS had been enclosed from animal grazing for 13 years (1986-1999) and then moderately grazed under a rotational grazing system; hence, it was named as Good Condition (GC) site. Outside of the NRRS had been highly grazed during the all growth seasons so it was named as Poor Condition (PC) site (Table 1). Growth season in this area starts from early April and lasts till early June for annuals, but till late November for perennial shrubs. Grazing season starts from early June and continues till mid-November. According to the Amberge classification (Khalili 1981) the climate of the study area is cold and dry, and according to the bio-climatic classification (Sheidaei 1969), it is steppe rangeland. Average annual rainfall for a period of 19 years (1986-2005) is 144 mm. The total rainfall in the year of study (2004) was 208 mm. Major plant species, in the year of study, in the GC site were *Salsola rigida*, *Stipa barbata*, *Artemisia sieberi*, and the major plant species in the PC site were *Launea acanthoides* and *Scariola orientalis*. There were also some annual plant species and perennial herbs that their yield and abundance were highly dependent on the seasonal rainfall (Baghstani Maybodi 2006).

Table 1. Average yield and percent composition of the major plant species in the Good Condition (GC) and Poor Condition (PC) sites (2004).

Plant species	Yield (Kg/ha)		Percent composition	
	GC	PC	GC	PC
Salosa rigida	136.9	2.7	27.3	0.9
Artemisia sieberi	47.2	46.9	9.4	16.2
Stipa barbata	113.1	8.0	22.5	2.8
Noaea mucronata	8.9	16.2	1.8	5.6
Scariola orientalis	79.0	123.6	15.7	42.6
Launaea acanthodes	7.8	53.5	1.6	18.4
Other prennials	47.6	33.7	9.5	11.6
Sum of perennials	440.6	284.6	87.7	98.1
Sum of annuals	61.5	5.5	12.2	1.9

2.2. Methods

For measuring plant cover and forage production, 2×1 meter quadrates were used, with the total quadrate numbers in each site amounting to 150. Total plant cover was estimated by measuring the occupied plot area for each plant species. Herbage yield was measured by using the clipping method, in which plants were cut in 2 cm above soil surface. The current year growth of each harvested plant was then separated in the laboratory. The major livestock grazer in the area was native goat (Garizi), so it was selected for studying the preference values of range plants. For each site a separate goat flock was selected randomly. Each flock consisted of 6 goats, which were randomly selected at the time of the first measurement in June 2004. The grazing season (June-November) was divided into four grazing periods, 45 days each.

Grazing preferences of goats (for eating each plant species) was monitored via a chronometry method. In this method, grazing preference was calculated as the time goats were spending for grazing each plant species (Moghaddam, 1998, Baghestani Maybodi and Arzani, 2005). Sampling was conducted on selected goats within each flock, which were grazing in good condition (GC) or in poor condition (PC) sites. Data recording was repeated 3 times within each grazing period, and then averaged as one representative record for each grazing period. Data recording started 2 hours after goats began grazing in the morning. Each animal was monitored for 30 minutes. Preference values measured for each goat of a flock in repeated 3 times were averaged and considered as one replication for each grazing period. Data for each separate grazing cycle was analysed as a completely randomized block by using General Linear Modelling (GLM) in SAS statistical software (SAS institute 1996). The Duncan test was used to compare average times that animals had spent on grazing each plant species.

3. Results

Results for forage production and percent composition in both sites are presented in Table 1. Major plant species in the Good Condition site (GC) were *Salsola rigida*, *Stipa barbata*, *Scariola orientalis* and *Artmisia sieberi*, which respectively comprised 27.3, 22.5, 15.7 and 9.4 percentage of the total community composition (i.e. fraction of the total yield). In the Poor Condition site (PC), however, main plant species were *Scariola orientalis*, *Launea acanthoides*, *Artemisia sieberi* and *Noaea mucronata*, which respectively consisted 42.6, 18.4, 16.2, and 5.6 percentage of the total community composition. Perennial plants such as *Hertia angustifolia*, *Aellenia subaphylla*, *Stachys inflata*, *Euphorbia sp*, *Cousinia sp*, *Astragalus sp*, *Iris songarica*, and several other perennial plants were found in lower frequencies or in sparse distributions, totally contained 9.5 and 11.6 of total community composition, in GC and PC sites, respectively.

Difference in the annual composition between GC and PC sites was also significant, being 12.2 and 1.9 percent, respectively.

The preference value each plant species was significantly ($P<0.01$) varied at different times of the growth season (Table 2 and Table 3). Furthermore, temporal differences were observed within both good condition (GC, Table 2) and poor condition (PC, Table 3) sites. During the first grazing cycle in PC site, goats spent 83.5 percent of their time grazing only on *Salsola rigida* , *Stipa barbata* , *Artemisia sieberi* and annual plants. However, during the second, third, and fourth grazing cycles, the time that goats spent on these species decreased, being 68.2, 47.1, and 63.7 percent respectively. In the PC site, goats spent part of their grazing time on foraging noxious plant species such as *Scariola orientalis* , *Launea acanthoides* and *Causinia desertii*. Therefore, they spent shorter time, than that of GC site, on grazing more palatable species such as *Salsola rigida* , *Stipa barbata* , *Artemisia seeberi* and total annual plants. Fractions of the total time that goats spent for feeding on the palatable species in the PC site during first, second, and third grazing cycles were 47.4, 22.4, 7.1, and 8.8 percent respectively.

4. Discussion and conclusion

In the Good condition (GC) site, goats spent the longest grazing time (i.e. 30.2%) of their first grazing cycle on foraging annual plants. This led to a decreased grazing pressure on relatively palatable perennials such as *Salsola rigida* and *Stipa barbata*. Nevertheless, later in the growth season (third grazing cycle), annuals were disappeared from the field and the main grazing pressure was shifted on the perennial plants. A comparison between species preference value revealed a close correlation between percent

Table 2. Relative preference of Garizi goat for grazing the major plant species at different time periods of the grazing season, in Good Condition (GC) site. Data of each column show fraction of time (in percent) t
hat goats spent to graze each plant

Plant names / Days	0-45	45-90	90-135	135-180	Whole season July-November
Annuals	30.2 [a]	22.6 [b]	3.0 [bc]	0.2 [f]	14.0 [c]
Salsola rigida	36.0 [a]	28.6 [a]	32.2 [a]	24.9 [b]	30.4 [a]
Artemisia sieberi	0.7 [c]	2.3 [e]	2.5 [bc]	6.5 [c]	3.0 [de]
Stipa barbata	16.6 [b]	14.7 [c]	9.4 [b]	5.1 [cd]	11.5 [c]
Noaea mucronata	0.5 [c]	0.3 [e]	1.2 [c]	4.1 [cde]	1.5 [e]
Scariola orientalis	0.8 [c]	13.1 [c]	7.9 [bc]	0.7 [ef]	5.6 [d]
Launaea acantodes	3.7 [c]	2.1 [e]	2.3 [bc]	5.4 [cd]	3.4 [de]
Cousinia sp.	0.5 [c]	2.9 [e]	2.3 [bc]	0.2 [f]	1.5 [e]
Astragalus spp.	1.1 [c]	2.0 [e]	0.1 [c]	0.0 [f]	0.8 [e]
Iris songarica	0.0 [c]	1.7 [e]	0.1 [c]	0.0 [f]	0.5 [e]
Hertia angustifolia	0.0 [c]	0.1 [e]	0.1 [c]	0.0 [f]	0.1 [e]
Aellenia subaphyla	0.0 [c]	1.1 [e]	1.8 [bc]	0.0 [f]	0.7 [e]
Stachys inflata	0.0 [c]	0.0 [e]	0.2 [c]	0.3 [f]	0.1 [e]
Euphorbia	0.0 [c]	0.0 [e]	0.1 [c]	0.1 [f]	0.1 [e]
Other perennials	4.1 [c]	0.3 [e]	2.6 [bc]	2.4 [d ef]	2.3 [de]
litter	6.0 [bc]	8.2 [d]	34.3 [a]	50.0 [a]	24.6 [b]

Significant differences between means are compared by the Duncan (P<0.05) test and shown by alphabetic letters.

Table 3. Relative preference of Garizi goat for grazing the major plant species at different time periods of the grazing season, in Poor Condition (PC) site. Data of each column shows fraction of time (in percent) that goats spent to graze each plant.

Days Plant names	0-45	45-90	90-135	135-180	Whole season July-November
Annuals	23.5 [a]	5.4 [bcd]	0.8 [c]	0.4 [d]	7.6 [cd]
Salsola rigida	5.1 [cd]	9.5 [b]	1.2 [c]	2.0 [d]	4.4 [def]
Artemisia sieberi	6.1 [cd]	2.7 [cd]	2.7 [c]	5.0 [d]	4.1 [ef]
Stipa barbata	12.7 [bc]	4.8 [bcd]	2.4 [c]	1.4 [d]	5.3 [cde]
Noaea mucronata	2.0 [d]	1.0 [cd]	0.3 [c]	2.0 [d]	1.3 [fg]
Scariola orientalis	2.3 [d]	31.6 [a]	26.0 [a]	2.2 [d]	15.5 [b]
Launaea acantodes	4.4 [d]	4.2 [bcd]	12.6 [b]	9.9 [c]	7.8 [c]
Cousinia sp.	5.2 [cd]	9.7 [b]	12.7 [b]	33.0 [b]	15.2 [b]
Astragalus spp.	15.9 [b]	4.0 [bcd]	0.9 [c]	1.1 [d]	5.5 [cde]
Iris songarica	0.0 [d]	9.9 [b]	3.4 [c]	0.3 [d]	3.4 [ef]
Hertia angustifolia	0.0 [d]	0.0 [d]	0.4 [c]	0.1 [d]	0.1 [g]
Aellenia subaphyla	1. 1 [d]	3.1 [cd]	0.0 [c]	1.6 [d]	1.4 [fg]
Stachys inflata	0. 3 [d]	1.5 [cd]	2.7 [c]	1.9 [d]	1.6 [fg]
Euphorbia	0.0 [d]	0.0 [d]	0.0 [c]	0.0 [d]	0.0 [g]
Other perennials	6.8 [cd]	5.9 [bcd]	3.3 [c]	1.0 [d]	4.3 [ef]
litter	14.7 [b]	6.8 [bc]	30.5 [a]	38.2 [a]	22.5 [a]

Significant differences between means are compared by the Duncan (P<0.05) test and shown by alphabetic letters

composition of annuals in the community and their preference value for goats. In another separate study in the same area, Baghestani-Maybodi and Arzani (2005) also reported an increase in the preference value of annual plants as a result of increasing their presence.

Another interesting result of this experiment was the unique role of litter as a source of livestock fodder in dry areas. We found that the importance of litter in animal diet increases from early towards the late days of the grazing season. Weathering together with the sporadic rainfalls (during autumn and winter) softens the coarse parts of the litter and makes them more palatable for the grazing livestock (Baghestani Maybodi and Arzani 2005). In the third and fourth grazing cycles of this study, goats spent 50 and 38.2 percent of their time for grazing litter in GC and PC sites, respectively. Valentine (1990) has also reported that rain, snow, or morning dew soften the dry and coarse litters of plants and increase their preference value for animals.

Our results also emphasize the importance of fodder produced by semi-shrub *Artemisia sieberi*, which is a dominant species in the vast areas of dry rangelands in Iran. In the early stages of growth (April to mid-October) preference value of *Artemisia* is so low for Garizi goat that this species gained one of the lowest preference values within the plant communities of both GC and PC sites. At this period, goats spent more time for grazing the noxious spiny shrubs such as *Scariola*

orientalis, *Launea acanthoides* and *Cousinia desertii* than *Artemisia sieberi*. Livestock graze *Artemisia* only in autumn when seasonal rains elute essential oils from plant tissues and increase the palatability (Baghestani Maybodi, 2003, Moghaddam 1998). At this time goats spend up to 6.5 % of their grazing time on *Artemisia* (Table2). Baghestani Maybodi (2006) estimated that livestock graze only 14% of the current growth of *Artemisia* from May to October.

Plant litter or forage produced by *Artemisia sieberi* are more useful in years with milder autumn and winter, otherwise cold and frosty days in these seasons usually limit the livestock grazing in rangeland. In this regard, the climate conditions should be considered for calculating rangeland capacity in dry rangelands.

Total production, percent composition in the community and availability for animals are considered as the important factors affecting palatability of range plants for animal grazing (Holecheck et al., 1984, Malecheck et al., 1984, McKell 1989, Valentine 1990, Baghestani Maybodi and Arzani 2005). In the GC site of this study, lower diet selection from perennial *Salsola rigida* and *Stipa barbata* was because of their lower composition in the plant community, being 0.9 and 2.8 respectively (Table 1). On the other hand, goats preferred to graze noxious plants such as *Scariola orientalis*, *Causinia desertii*, and *Launea acanthoides* with lower preference value but higher frequency (Table 2). The contrasting result was found in GC site, where *Salsola rigida* and *Stipa barbata* gained higher preference value. These results imply that the preference value of a plant species is not a constant value, though it is highly dependent on the site condition (particularly plants composition) and on the time of animal grazing. Similar conclusions were also made in a separate study in the same area in year 2001 (Baghestani Maybodi and Arzani, 2005). Accordingly, when studying the preference values, constant data points should be monitored in different times, as in the heterogenous sites may lead to the experimental errors.

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