

Feeding Behaviour and Forage Nutrient Utilization by Goats on a Semi-Arid Reconstituted Silvopasture

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ABSTRACT : Seasonal variations in the feeding behaviour of Jamunapari and Barbari goat breeds and their utilization of browse and grass nutrients was evaluated in a promising 3-tier (*Leucaena leucocephala*-*Dichrostachys nutan*-*Cenchrus ciliaris*) reconstituted pasture during summer, rainy and winter season of the years 1987 and 1988. Distinct diurnal pattern of feeding was observed with both the breeds. Jamunapari goats spent significantly more time foraging during winter season (352.0 min) followed by summer (306.0 min) and least in rainy season (277.0 min). Though no significant difference was observed in the relative time spent by Barbari goats on grazing activities during summer and winter season, they spent significantly more ($p < 0.05$) time during rainy season as compared to other two seasons. The preference of grazing goats for certain plant

species in relation to others was evident with distinct seasonal and breed variations. DM intake (g/kg BW^{0.75}) varied significantly ($p < 0.05$) from season to season. Among the browse, *L. leucocephala* was preferred over *D. nutan* irrespective of breed over the seasons. There was no breed difference in DM intake, or proximate composition and nutrient digestibility of ingested herbage. The available nutrient content of ingested forage was found sufficient to meet the nutrient requirements of adult goats for maintenance (NRC, 1981). The reconstituted 3-tier pasture dominated by plant species like *L. leucocephala* and *Cenchrus* species appear to have great potential to sustain the nutrient requirement of goats without adverse seasonal fluctuations in pasture quality. (**Key Words**: Goats, Silvopasture, Intake, Feeding Behaviour, Nutrient Availability)

INTRODUCTION

Agroforestry system have been recognized as sustainable agro-ecological models to improve feed resources and reclaim degraded lands in different parts of the world. The concept of multiple uses of land for livestock, pasture and trees is incorporated in various models of silvopasture. The systems increase the overall yield of the land and make best use of resources while protecting against environmental degradation (Sharma and Bhattacharya, 1993). They are suitable for rearing of the domesticated animals and more so for goat production, as they readily consume woody perennials (Ricardi and Shimada, 1992).

Although the potential of silvopastoral systems in enhancing fodder production is now widely known, information is lacking on physiological and nutritional

aspects of animals foraging freely on reconstituted silvopastures. The objectives of the present study were to assess seasonal pattern of diet selection and nutrient utilization of Jamunapari and Barbari goats kept on a promising *L. leucocephala*-*Dichrostachys nutan*-*C. ciliaris* 3-tier silvopasture.

MATERIALS AND METHODS

Experimental site

The experiments were conducted at the Agroforestry Research Farm of Central Institute for Research on Goats, Makhdoom situated at 27°10'N latitude and 78°02'E longitude at an altitude of 169 MSL in Yamuna ravines. The general topography of the land is mostly undulating with relief difference of about 5-6 meters between low and top levels. The climate of the area is semi-arid to dry subhumid with distinct seasonal variability. The average temperature ranges between 6°C in winter to 44.5°C in summer. During the year 87-88 rainy season, the site recorded 300 mm of rain, all of it falling between July to September. Mean daily sunshine duration (minute) during

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summer (May-June), rainy (August-September) and winter (January-February) season of the experiment was 832, 762 and 639, respectively.

Animals

Healthy 2-4 year old adult males (12), six each of Jamunapari and Barbari breed were selected from larger research flock of the Institute. The animals were dipped and drenched before the onset of experiments and during the experimental period as per the general health calendar of the flock.

Pasture eco-system

6 year old synthesized 3-tier pasture comprising *L. leucocephala* (1,250 plants/ha) - *Dichrostachys nutan* (450 plants/ha) - *C. ciliaris* was selected for this study. The yearly forage production potential of the paddock from ground and above ground vegetation estimated as per the procedure described by Prajapati (1980) was 7,250 kg DM/ha. The carrying capacity of synthesized pasture was maintained @ 10 goats/ha on the basis of expected pasturage production and its utilization by goats at below 60% level.

Feeding management

Jamunapari and Barbari goats were housed together in a temporary thatched shelter constructed within the paddock. They were allowed to graze/browse from dawn to dusk daily so as to synchronise them with physiological developments in the pasturage. Goats were provided free access to water in the paddock, however, no supplementary ration was given to them. Lopping of trees shrubs was not allowed during grazing.

Observations on grazing behaviour

A team of minimum three scientists viz., one observer with a pair of binoculars, one time keeper with stopwatch and one writer recorded observations from 1 hour before sunrise to sunset during later half of each season i. e. summer, rainy and winter in the months of May-June, 1987, August-September, 1987 and January-February, 1988, respectively. A goat each of Jamunapari and Barhari was randomly chosen for observation from the group, point marked and followed. The observations related to extent of time devoted for feeding on the component species of pasture, movement from one plant to the other, mastication and rumination. Resting and other ingestive and eliminative activities were also recorded without interference or disturbance to the goats. Diet composition was estimated by recording feeding station intervals (FSI) (Schwartz et al., 1985). It was

assumed that the time spent at a plant species, reflects the proportion of that plant in the diet. The goats observed were fitted with pedometer to measure distance travelled by them daily within the paddock. All observations were made for the duration of the respective grazing periods. A different goat was observed on each occasion for the same length of time in the morning and in the afternoon.

Estimation of intake and digestibility

The intake and digestibility of composite vegetation derived by goats was determined during each season after 15 days adaptation period on the paddocks. The animals were fitted with faecal collection bags for 10 days to collect faeces after adaptation period seasonally. The total faecal output was weighed every 12 hr and sampled daily. Leaves of browse species and grasses which were of the same size and appearance as those ingested by goats were plucked by hands, sun-dried and stored during collection period for quality estimates of available forage. Pasturage and faecal samples were analysed for proximate composition (AOAC, 1980). The dry matter intake (DMI) was calculated using acid-insoluble residue (AIR) as indicator (Srivastva and Talpatra, 1962; Chaturvedi, 1971) by the following equation :

$$\text{DMI (g/d)} = \frac{\text{Total AIR output in faeces (g/d)}}{\% \text{ AIR in pasturage}} \times 100$$

where AIR was determined gravimetrically in total faecal dry matter output and representative plant material.

The apparent digestibility coefficients (D) of various nutrients for pasturage were indirectly computed as :

$$D = \frac{I - F}{I} \times 100$$

where I is the intake of DM or a nutrient component such as crude protein (CP), ether extract (EE), crude fibre (CF) and 'F' is the corresponding out put in faeces. This procedure considers total amount of a given nutrient excreted in the faeces by goats relative to the proportion of that nutrient available in the hand harvested representative composite herbage samples.

The obtained data were analysed for variance (Mead and Curnow, 1986) to determine the effect of season and breeds. When F-tests were significant, seasonal and breed means were compared for statistical differences using Student's 't' test.

RESULTS AND DISCUSSION

Ingestive behaviour

The goats remained in a healthy condition throughout during the experimental period. Daily time spent in browsing, grazing, resting, rumination etc. seasonally by goats has been given in table 1. Goats were found masticating inside the shelter till they come out for foraging on their own about half an hour before sunrise during summer and rainy seasons and 40-45 min after sunrise in winter. Initially, they preferred to move along the fence and avoided dense vegetation till sufficient sunlight was available. A major portion of goat's day was

spent in foraging irrespective of breed and season of the year. In general, goats spent significantly ($p < 0.05$) more time in winter season followed by summer and least in rainy season. Though significant difference was observed in the relative time spent by Barbari goats on foraging during summer and winter season they were found to spend significantly more time ($p < 0.05$) during rainy season compared to other seasons. Relative time spent by Jamunapari was significantly less ($p < 0.05$) than Barbari goats on this activity irrespective of season. Jaw movements of the goats remained unaffected due to seasonal or breed differences.

Table 1. Seasonal ingestive and eliminative behaviour of goats grazing a 3-tier silvipasture

Activity	Season/Breed						S.E.
	Summer		Rainy		Winter		
	J	B	J	B	J	B	
Time spent/d (min)							
Foraging	306.0 ^{bb}	408.0 ^{ba}	277.3 ^{cb}	481.4 ^{aa}	352.0 ^{ab}	420.2 ^{ba}	6.37
Rumination	64.0 ^{ba}	31.0 ^{cb}	203.0 ^{aa}	146.4 ^{ab}	55.2 ^{ba}	44.3 ^{bb}	5.70
Rest	248.7 ^{aa}	181.5 ^{ab}	128.3 ^{ba}	23.2 ^{cb}	139.6 ^{ba}	90.5 ^{bb}	6.41
Movements	58.2 ^{aa}	44.8 ^{ab}	38.3 ^{ba}	20.3 ^{cb}	33.2 ^b	33.1 ^b	1.06
Drinking	13.3 ^{aa}	9.6 ^{ab}	6.5 ^{ba}	5.4 ^{cb}	6.4 ^{bb}	7.6 ^{ba}	0.24
Jaw movements/min	65.0	66.0	63.0	68.0	65.0	62.0	0.18
Distance travelled (km/d)	3.1 ^b	3.2 ^b	3.7 ^b	3.9 ^b	5.0 ^a	4.9 ^a	0.06

J : Jamunapari; B: Barbari.

^{abc} : Means with different superscripts in each breed class indicate significant difference ($p < 0.05$) between seasons.

^{AB} : Means with different superscripts in each season indicate significant ($p < 0.05$) differences between breeds.

A diurnal pattern of foraging was observed in both the goat breeds. The morning feeding period commenced at day light and continued until mid morning (10:00 - 11:00 h). The second major meal began about 2-3 hr prior to sunset (15:00 to 17:30 h) and lasted upto half an hour before sunset irrespective of breed and season. A minor meal was seen to last about an hour at mid day especially during rainy and winter season. Similar pattern of feeding was observed by Askins and Turner (1972) and Solanki (1994) under extensive feeding of goats. However, it has been reported that diurnal pattern in goats may get modified by factors such as forage availability, environmental stress such as heat and rain, frequency of feeding and amount of feeding (Morand-Fehr, 1981 and Lu, 1988). During hot summer weather, goats may change feeding periods and harvest forage mostly during the night (Morand-Fehr, 1981) and avoid grazing during the day as observed in the present study. Two rest or very slow grazing periods in between 10:00 - 11:00 h and

13:00 - 14:00 h were observed implying thereby that goats avoid grazing/browsing during hotter part of the day. The goats were found to spend maximum time ($p < 0.05$) in resting during summer followed by winter and rainy season. Jamunapari appeared to spend significantly more time resting on the ground than Barbari goats ($p < 0.05$) throughout various seasons.

Goats were found to spend 19.2 - 26.6% of their time ruminating during rainy season which was significantly higher than the mean time spent by the two breeds on this activity in summer or winter season. Barbari goats were found to spend relatively less time ($p < 0.05$) on rumination as compared to Jamunapari irrespective of season. Bell and Lawn (1957) observed a wide range in the time spent in rumination from 202 to 792 minutes per day in apparently healthy goats. Similarly, Lu (1987) reported that average time spent in rumination could range from 329 to 420 min/day in goats depending upon the particle length of forage. Goats exhibit a distinct

diurnal pattern in rumination and spend a greater proportion of their time in this activity during the night hours (20:00 to 08:00 h) (Lu, 1988; Bell and Lawn, 1957). Rumination time has been apparently underestimated in our study due to difficulties of night time observations under range conditions. Forage particle length, amount consumed and thermal stress are some of the other factors affecting rumination time in goats (Lu, 1987; Appleman and Delouchi, 1958).

Though paddock had good vegetative cover, goats travelled 3.1 - 5.0 kms per day irrespective of breed during different seasons of the year to gather food of their choice. It was however observed that goats relatively travelled lesser distance in summer ($p < 0.05$) and rainy season as compared to winter season irrespective of breed. It has been reported that goats normally travel 3.5 kms/day in early spring months to almost 5.5 kms in winter months depending on forage availability, water sources, comfortable resting areas, season of the year, size of goat and other animal factors (Askins and Turner, 1972 and Lu, 1988). The locomotion associated with grazing and an increased amount of time spent obtaining food is important as it can account for a significant part of the total energy requirement in goats.

Goats were found to be very agile and inquisitive. They often jumped, dug holes below fences and fought with each other irrespective of breed or season of the year. Goats appear to evaluate the pasture vegetation upon arrival daily in spite of their prior experience or conditioning to the grazing site and vegetation. They prefer to direct the foraging path towards bushy areas.

Similar observations were recorded earlier by McMahan (1964), Milne (1991) and Solanki (1994).

Diet selection

Green and dense edible bio-mass covered the experimental paddocks in abundance throughout the experimental period. *Cenchrus ciliaris* along with *C. setigerous* and *Cynodon dactylon* were dominant grass species across treatment paddocks. Composition of browse mainly *L. leucocephala* and *Dichrostachys nutan* relative to grasses remained almost similar during different seasons.

The relative percent of foraging time spent by goats on various plant species varied markedly ($p < 0.05$) with season and breed (table 2). It was observed that although among browse goats spent more ($p < 0.05$) time on *L. leucocephala* compared to *D. nutan* irrespective of breed or season of use, there was significant seasonal difference ($p < 0.05$) in the extent of their relative ingestion by Jamunapari and Barbari goats. Principally, Jamunapari goats were found to spend most of their foraging time on browsing while Barbari preferred more grasses during summer and rainy season (figure 1). During late winter, when due to severe frost pasture grasses dry up and *D. nutan* sheds leaves, both Barbari and Jamunapari goats spent almost entire foraging period on still green leaves of *Leucaena*. The difference between diet selection pattern of these two breeds may be attributed to the fact that Barbari goats over the years have adapted well under stall feeding while browse constitutes the staple diet of Jamunapari goats in their current habitats - 'Chambal ravines'.

Table 2. Seasonal selection order of diet by goats grazing under 3-tier silvi-pasture (% total grazing hours)

Forage class	Season/Breed						S.E.
	Summer		Rainy		Winter		
	J	B	J	B	J	B	
Browse							
<i>L. leucocephala</i>	47.6 ^{ba}	34.4 ^{bb}	52.0 ^{ba}	16.6 ^{cb}	92.8 ^a	94.5 ^a	2.55
<i>D. nutan</i>	18.5 ^{aA}	10.6 ^{aB}	20.2 ^{aB}	4.4 ^{aA}	1.7 ^b	1.2 ^b	0.70
Grasses/Weeds and pods							
<i>Cenchrus ciliaris</i> , <i>Cynodon dactylon</i> , <i>C. setigerous</i>	33.9 ^{aB}	55.0 ^{ba}	27.8 ^{aB}	76.0 ^{aA}	5.5 ^b	4.3 ^c	2.33

J : Jamunapari ; B : Barbari.

^{abc} : Means with different superscripts in each breed class indicate significant difference ($p < 0.05$) between seasons.

^{AB} : Means with different superscripts in each season indicate significant ($p < 0.05$) differences between breeds.

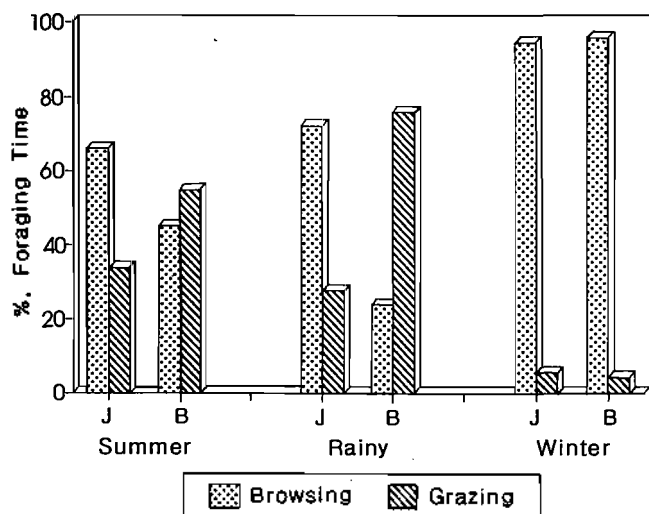


Figure 1. Percent foraging time spent by Jamunapari and Barbari goats seasonally on browsing and grazing.

The opportunistic feeding behaviour of goats has been reported by several workers including Merrill and Taylor (1981), Pfister and Malechek (1986), Lu (1988) and Nyamangara and Ndlovu (1995) and the results obtained in this study support this finding. The preference of grazing goats for certain plant species in relation to others is determined by factors like relative feed availability, environmental condition, prior experience, stocking rate and breed characteristics (Malechek and Provenza, 1981). Irrespective of breed, goats exhibited a strong preference to species and certain plant parts. Among the browse, they preferred *Leucaena* over *D. nutan*. The seasonal changes in feeding behaviour of goats and their particular liking towards tender leaves, buds, pods and fruits make them ideally adapted for selection of higher quality feed and as a result the composition of total biomass of pasture offered is rarely the composition apparently grazed (Warren et al., 1984).

Intake and digestibility of pasture

In spite of variation in the grazing preference between the goat breeds within a pasture eco-system, no significant difference was evident in proximate composition, DMI and nutrient digestibility of phytomass derived by Jamunapari and Barbari goats (table 3 and 4). However, DM intake per kg/BW^{0.75} ranged from 54.2 to 67.8 from summer to rainy season, with an annual mean of 61.8 g. The overall feeding pattern in ruminants is usually related to photoperiod, with larger, more frequent meals during the day, but this can be modified if the middle of the day is very hot as happens during summer when they eat more at night (Dulphy et al., 1980). Intake levels of 40-90 g DM/kg BW^{0.75} have been reported as normal for grazing ruminants (Cordova et al., 1978). The results obtained in the present study fall within this range although with significant ($p < 0.05$) seasonal variations. The goats irrespective of breed consumed enough DM for maintenance, even at the lowest level of intake during summer. Thus some extra feed was available for productive purpose like growth, pregnancy and lactation from the reconstituted 3-tier pasture throughout the year.

Dietary crude protein (CP) of diets selected by goats increased gradually from summer and peaked ($p < 0.05$) in winter season (table 3). This trend correspond to a decrease in grass component in the diets as winter season progressed. However, the nutrient density in terms of percent content of dietary TDN or DE did not exhibit any seasonal difference. The digestive CP or TDN content of ingested forage was sufficient to meet the nutrient requirement of adult male goats for maintenance plus moderate activity (NRC, 1981). The quality and quantity of tropical herbage is known to decline markedly during winter and summer seasons (McDowell, 1972; Topps and Oliver, 1978). Proteins and digestible nutrients tend to be the major nutrients which decline after rainy season with

Table 3. Seasonal proximate composition of forage ingested by goats grazing a 3-tier silvipasture (g/kg DM)

Nutrient	Season/Breed						S.E.
	Summer		Rainy		Winter		
	J	B	J	B	J	B	
Organic matter	898	894	904	905	910	909	0.52
Crude protein	138 ^b	125 ^b	147 ^b	139 ^b	170 ^a	169 ^a	1.50
Ether extract	38	33	51	29	34	35	0.13
Crude fibre	208 ^a	215 ^a	187 ^b	192 ^b	154 ^c	155 ^c	2.18
Total ash	102	106	96	95	90	91	0.52

J : Jamunapari; B : Barbari.

^{abc} : Means with different superscripts in each breed class indicate significant difference ($p < 0.05$) between seasons.

Table 4. Mean seasonal dry matter intake (DMI) and nutrient utilization of goats feeding on a 3-tier silvipasture

Parameter	Season/Breed						S.E.
	Summer		Rainy		Winter		
	J	B	J	B	J	B	
DMI (kg/100 kg LW)	2.2 ^a	2.5 ^b	3.0 ^a	2.9 ^a	2.7 ^b	2.9 ^a	0.04
DMI (g/kg W _{0.75})	54.6 ^a	56.4 ^b	67.8 ^a	64.2 ^a	61.2 ^b	66.7 ^a	0.80
Digestibility (%)							
DM	59.4	58.6	61.7	60.8	63.6	62.4	1.70
CP	64.5	66.3	68.8	67.8	73.2	74.1	3.47
EE	48.7	50.2	52.5	49.7	43.1	46.2	3.02
CF	61.3	60.5	64.4	65.2	54.6	55.4	4.06
Nutrient density (%)							
DCP	8.9 ^b	8.3 ^b	10.1 ^b	8.9 ^b	12.4 ^a	12.5 ^a	0.34
TDN	59.6	58.7	62.5	59.9	65.4	64.2	2.49
DE (Mcal/kg DM)	2.63	2.58	2.80	2.60	2.87	2.82	0.11

J : Jamunapari; B: Barbari.

^{abc} : Means with different superscripts in each breed class indicate significant difference ($p < 0.05$) between seasons.

the onset of winter in the natural pastures and this causes major constraint to ruminant productivity. The results of this study, however show that reconstituted *Leucaena - D. nutan - Cenchrus* silvipasture could provide fairly high levels of digestible CP and energy to goats without significant seasonal fluctuations. The findings confirm the observations of Van Soest (1982) and Harrington (1982) that feeding behaviour of goats enables them to vigorously select from the available vegetation and to consume a diet rich in metabolizable energy and protein than the feed offered. Opportunity for feed selection was optimized in the current study which was reflected in intake of composite vegetation of almost identical nutritive value. It may be inferred that the seasonal variability in the percent time spent on various plant strata between goat breeds in a multi-tier pasture ecosystem does not necessarily bring about change in the proximate composition and digestibility of ingested herbage. However, goats exhibit marked flexibility in diet selection when confronted with seasonal changes in the availability and nutritional quality of various constituent plant species.

CONCLUSIONS

This study reaffirms the opportunistic feeding habits of goats. The observed variation in feeding behaviour was probably a response to relative availability and quality of various trees and grasses during the period of study. Jamunapari and Barbari goats utilized the same plant spectrum but the relative percentage of time devoted to

various species differed seasonally. Quality of ingested herbage in terms of proximate composition and nutrient availability was fairly high in all seasons irrespective of goat breed. Multi-tier silvipastures offer great potential for simultaneous improvement in productivity of goats and their habitats in degraded lands.

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