

PLANT FORM SELECTION AND DIETARY OVERLAP OF CATTLE AND GOATS ON A CONTINUOUSLY GRAZED RANGELAND

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JOSHI, M., RAWAT, Y.S. & SINGH, S.P. 1996. Plant form selection and dietary overlap of cattle and goats on a continuously grazed rangeland. Food-habits data for cattle (bullocks, calves, cows) and goats were obtained from a continuously grazed rangeland located between 1600 and 2000 m elevation in Kumaun Himalayas to provide dietary information under high and low extremes of forage availability. Cattle diet was dominated by grasses (82% of the total diet) in the wet season and dead herbaceous biomass (70%) in the dry season, while goat's diet was largely from woody plants and tall forbs (31 to 73%) in both seasons. Dietary overlap was significantly ($p < 0.01$) greater among cattle (0.72 to 0.95) than between cattle and goats (0.39 to 0.67) in both seasons.

Key words: Plant forms - forage preference - botanical composition - dietary overlap - cattle - goats.

JOSHI, M., RAWAT, Y.S. & SINGH, S.P. 1996. Pemilihan jenis tanaman dan pemakanan bertindih bagi lembu dan kambing di kawasan tanah ragut yang berterusan. Data mengenai tabiat pemakanan lembu (lembu jantan kembiri, anak lembu, lembu betina) dan kambing telah diperolehi daripada kawasan tanah ragut yang berterusan yang terletak di antara tanah tinggi 1600 dan 2000 m di Kumaun Himalaya untuk menyediakan maklumat pemakanan di bawah keupayaan makanan ternakan yang terlampau tinggi dan rendah. Pemakanan lembu didominasi oleh rumput (82% daripada jumlah pemakanan) pada musim lembab dan biojisim herba mati (70%) pada musim kering, sementara pemakanan kambing terutamanya adalah pokok-pokok berkayu dan herba berdaun lebar yang tinggi (31 hingga 73%) di kedua-dua musim. Pemakanan bertindih adalah ketara ($p < 0.01$) lebih besar di kalangan lembu (0.72 hingga 0.95) berbanding dengan lembu dan kambing (0.39 hingga 0.67) pada kedua-dua musim.

Introduction

Numerous studies have shown that ruminant animals graze selectively. The proportion of forage species in a grazing animal's diet is often not the same as is available (Theurer *et al.* 1976, Baker & Jones 1985, Ruyle & Bowns 1985, Ralphs *et al.* 1986). Comparative information on diet selection and herbage intake on different plant communities is important to an understanding of grazing strategies of ungulate species, and to an appreciation of their suitability for manipulating natural plant communities to meet either production or conserva-

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tion objectives (Hodgson & Eadie 1986). Common use or multispecies grazing takes advantage of differences in animal behaviour and forage preferences to more efficiently balance the use of diverse forage resource (Kirby *et al.* 1988).

Grasslands below 3000 m elevation in the Himalayas have resulted from clear-cutting and burning of forests which represent the natural vegetation (Singh 1991). Such grasslands have developed around human settlements and their areas are increasing with receding forest boundaries (Joshi 1991). All these grasslands are subject to free grazing with few regulations and are often grazed beyond their carrying capacities (Singh *et al.* 1988).

The objectives of this study were (i) to examine the botanical composition of diets of cattle (bullock, calf and cow) and goats, (ii) to determine forage preference for each, (iii) to evaluate dietary overlap and complementarity of grazing cattle and goats under high and low extremes of forage availability, and (iv) to determine whether the grassland would support high consumer biomass in mixed than in single populations.

Materials and methods

Study site

The study was conducted in Kumaun Himalaya, India. The study area (29° 27' to 29° 29' N ; 79° 23' to 79° 25' E) was located at an elevation of 1600 to 2000 m. Selected for the study was a 5.7-ha piece of the grassland (open grassland with a few scattered trees of original banj-oak *Quercus leucotrichophora* forest) where cattle and goats graze throughout the year. The vegetation was dominated by *Cymbopogon distans* (grass) (Joshi 1991). However, a small part of it (about one hectare) was planted with *Cupressus torulosa* (density, 310 individuals ha⁻¹) in 1980.

Climate

The climate of the study area is temperate monsoon. Of the total annual rainfall (2488 mm) about 75% occurs during the monsoon period (mid-June to mid-September). The mean maximum daily temperature varies from 12.1 °C (January) to 27.4 °C (May), and mean minimum from 3.5 °C (January) to 6.9 °C (July). Depending on climatic variations, the year is divisible into (i) a dry and warm summer season (March to mid-June), (ii) a wet and warm rainy season (mid-June to mid-September), and (iii) a cold and dry winter season (mid-September to February) (Joshi *et al.* 1994 a).

Measurements

A mixed cattle - goats herd, consisting of 6 bullocks, 8 calves, 18 cows and 17 goats (49 in total), was observed for food habit data seasonally in the months of September and December, representing wet and dry seasons respectively.

Since the objective was to characterize the natural foraging behaviour, animals were allowed to graze in the site freely with minimal herding. Consequently, it was not possible to design models such as completely randomized, randomized block and systematic design type. But this approach (lack of replication of plots within the site) is liable to "simple pseudoreplication" (Hurlbert 1984). However, the lack of replication in this case was unavoidable, given the objective of this study. According to Hurlbert (1984) replication is often impossible or lack of replication is unavoidable and in a situation like this, experiments involving unreplicated treatments may also be the only or best option.

Three similar individuals (average-sized, same sex) of each animal were marked and observed individually from < 1 m distance throughout the stay (from arrival at the site in the morning to departure in the evening) on each sampling date (once a month for each animal). All animals were accustomed to the study site before the experiment was begun, as they had been visiting the site for several years. Sample animals were the same and no other animal herd visited the site during the study period.

Animal diet was quantified using the bite rate x bite size x grazing time procedure (Allden & Whittaker 1970). The average contribution of various plant species with different growth from classes to animal diet was obtained following Joshi *et al.* (1994 b).

Preference ratio (PR) of an animal for a plant species was expressed as given in Crawley (1983):

$$PR = \frac{\text{Proportion of the plant species in animal diet}}{\text{Proportion of total biomass accounted for by this species}}$$

Preference ratio was calculated using the biomass values of September (dry season) and December (wet season) separately. Since the preference ratio for a plant species depends in part on the availability of alternative forage present in the community (Fitzgerald *et al.* 1986), it does not give an assessment of selection level which is universally valid.

Dietary overlap was quantified as proportional similarity that indicates the degree to which the two are identical (Negi *et al.* 1993), using expression of Schoener (1970) (see Zangerl & Bazzaz 1983).

$$DO_{ij} = 1 - 1/2 \sum_{h=1}^s [p_{ih} - p_{jh}]$$

where DO_{ij} is the degree of similarity of animal species i and j , P_{ih} (P_{jh}) is the proportion of response of a species i (j) in the state h (the resource state that is plant species). DO_{ij} values range from 0 to 1 with 1 being the maximum similarity.

All the plant species present in the study sites were categorized into growth forms, viz. (i) woody plants, (ii) tall forbs (> 30 cm tall plants with scattered leaves all along the erect stems, (iii) grasses, (iv) short forbs (\leq 30 cm tall plants with

leaves arranged in short umbrella-like structure, with or without arching stems, (v) cushion and spreading forbs, including cushion or rosette forming and prostrate forms.

The shoot biomass was harvested as close to the ground as possible, from ten randomly selected 1×1 m sample quadrats. The harvested samples were separated into live shoots (species-wise) and dead shoots (aggregate). The samples were dried at 60°C till constant weight and then weighed.

Results and discussion

Ground vegetation of the site consisted of grasses and forbs such as *Cymbopogon distans*, *Chrysopogon serrulatus*, *Arundinella nepalensis*, *Gnaphalium hypoleucum*, and *Dicliptera roxburghiana* (Table 1). The total number of species was 15 (12 herbs + 3 woody) (Joshi *et al.* 1994 c). The number of herb species was greater in the wet season (12) than in the dry season (5). The herb biomass was larger in the wet season (145 g m^{-2}) than in the dry season (5 g m^{-2}) (Table 1). On the basis of Importance Value Index (IVI) grass was the dominant growth form (Joshi 1994). The total dry matter production was $554 \text{ g m}^{-2} \text{ y}^{-1}$ (Joshi 1995).

Table 1. Species composition and herbage biomass (g m^{-2}) during the wet and dry seasons

Growth form/Species	Biomass (g m^{-2})	
	Wet season	Dry season
Woody species		
<i>Cupressus torulosa</i>	-	-
<i>Pinus roxburghii</i>	-	-
<i>Quercus leucotrichophora</i>	-	-
Tall forbs		
<i>Craniotome furcata</i>	1.3	A
<i>Gnaphalium hypoleucum</i>	4.0	0.1
<i>Scutellaria angulosa</i>	3.8	0.6
<i>Siwertia cardata</i>	2.0	A
Short forbs		
<i>Dicliptera roxburghiana</i>	1.9	2.9
<i>Micromeria biflora</i>	8.2	0.9
<i>Reinwardtia indica</i>	2.0	0.8
Cushion and spreading forbs		
<i>Oxalis corniculata</i>	0.3	A
Grasses and sedges		
<i>Arthraxon lanceolatus</i>	11.2	A
<i>Arundinella nepalensis</i>	2.6	A
<i>Chrysopogon serrulatus</i>	52.2	A
<i>Cymbopogon distans</i>	55.3	A
Total	144.8	5.3

A = absent

Botanical composition of diet

Cattle diets showed a strong dominance of live biomass during the wet season and of dead biomass during the dry season (Figure 1), while goats' diets were from live biomass in both seasons (Figure 1). A higher proportion of dead biomass in the cattle diets during dry season is understandable, since at higher stocking rate, where the rate of herbage consumption exceeds the rate of forage regrowth, the animals are forced to use all the available forage (Forbes 1988). Being well-adapted to browsing, goats preferred browsing on woody species rather than foraging close to ground surface on dead herbal biomass during the dry season (Figure 1). Herbivores, with different digestive systems, are able to benefit differentially from grazing, as against browsing (Crawley 1983). Because of their relatively smaller digestive tract, goats benefit more from selective browsing than other ruminants (Crawley 1983).

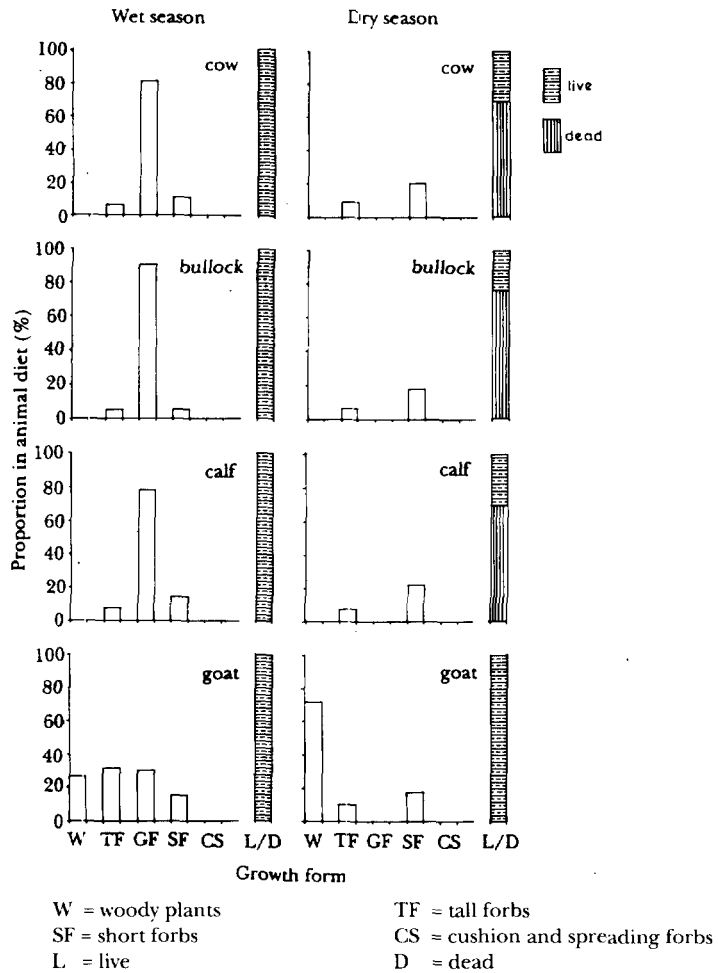


Figure 1. Diet composition (%) of cattle and goats by growth forms, based on live and dead biomass during the wet and dry seasons

Cory (1927) stated that the major difference between cattle and goats was the browsing done by goats. Saini *et al.* (1988) reported that in multi-tier pastures in semi-arid tropics, goats spent 72% and 94 % of their grazing time on browsing during wet and dry seasons respectively.

The animals' diet composition in relation to plant forms (Figure 1) indicated that bullocks and calves did not differ significantly from cows. Therefore, cows' diet composition was considered as representative of cattle diet when cattle and goats were compared. The animals' diet composition in relation to growth forms varied markedly across the seasons and animals (cow versus goat) (Figure 1).

In the wet season, when herb biomass and species richness were maximum, cows' diets were dominated by grasses (82 % of the diet) while goats' diets were more or less evenly distributed among the woody plants, tall forbs and grasses (23-32%). In the dry season, when few herbs and green leaves were available, most of the cows' diets were from dead herbaceous individuals, while goats' diets were dominated by leaves of the woody plants. In contrast, cattle avoided leaves of the woody plants in both the seasons. A pronounced shift from herbaceous vegetation to woody plants during the dry season indicates that goats are 'opportunistic' in foraging behaviour.

Forage preference

The use of preference ratios (proportion of plant species or species group in the diet divided by corresponding proportion in the stand) is recommended as the best way to express diet selection (Van Dyne *et al.* 1980). However, Hodgson and Grant (1981) have pointed out that such ratios are purely relative and have their limitations.

Preference ratio in relation to growth forms differed between the two seasons and between animal species (cow and goat) (Table 2). In response to greater availability of forage (wet season), cows showed high preference for short forbs, while goats preferred taller forms (woody plants and tall forbs). In the dry season cows preferred tall forbs while goats' preference was for woody plants and tall forbs (Table 2).

Table 2. Preference ratio for growth forms selected by cow and goat in the wet and dry seasons

Growth form	Cow		Goat	
	Wet season	Dry season	Wet season	Dry season
Woody plants	0	0	25.7	52.1
Tall forbs	3.7	17.4	15.9	17.8
Grasses	2.8	A	0.5	A
Short forbs	5.0	6.7	7.0	5.9
Cushion and spreading forbs	0	A	0	A

A = absent

Cattle are grazers (Bell 1978, Arnold 1980) and usually use their tongues to gather vegetation into their mouths before biting and tearing it off (Arnold 1980, Hodgson 1981). It seems that cushion and spreading forbs were too small to be easily foraged upon, and tall forbs, with their greater amount of structural tissues (Givnish 1987), were less preferred by cow during the wet season when the herbage biomass was at its peak. Short forbs of intermediate size, with limited amount of structural tissues and umbrella-like crown located at sufficiently higher levels from the ground (Givnish 1987), might have facilitated their preference by cow.

Preference of goats for taller forms in both the seasons is understandable since goats are basically browsers (Bell 1972, Arnold 1987, Upadhyay 1988) and are capable of removing individual leaves from a plant (Arnold 1985, Hodgson 1981). A high threshold for secondary compounds in goats enables them to consume large quantities of browse material (Upadhyay 1988). Woody plants are the main feed of goats but are not very much accepted by other animals; as such goats do not compete with other livestock (Upadhyay 1988).

Dietary overlap

Dietary overlap differed significantly ($p < 0.01$) between the two seasons and it was significantly broader between the animals of the same species, viz. between cow and bullock, cow and calf, etc. than between two animal species (cow and goat).

Greater dependence of both animals (cow and goat) on herb species and their similar proportions in the diets increased dietary overlap between cow and goat during the wet season. The higher proportions of dead biomass and leaves of woody plants in the diets of cows and goats respectively decreased overlap between them during the dry season.

Generally, broad overlaps have been found in the diets selected by animals of the same species but different in age. Hodge and Doyle (1967) compared 10-week-old lambs and yearlings on two types of pasture and found that they selected similar amounts of grass and clover. Similar results have been found in the diet selected by lambs and older sheep (Langlands 1969, Jamieson & Hodgson 1979) as well as bullocks, calves and cows (Pandey 1981). In the present study broad overlaps were found in the diets of cows and bullocks, bullocks and calves, and cows and calves (Figure 2).

Conclusion

Diets of cattle and goats under a continuously grazed rangeland were complimentary. Grasses dominated cattle diet, while goats depended more on taller forms. Based on the results of this study, it can be conservatively concluded that because of differences in forage preferences of cattle and goats, more animal units can be raised when cattle and goats are mixed, than when a single population is maintained. This would result in a more uniform use of the available forage resources while maintaining or improving production and diversity in the grazing land.

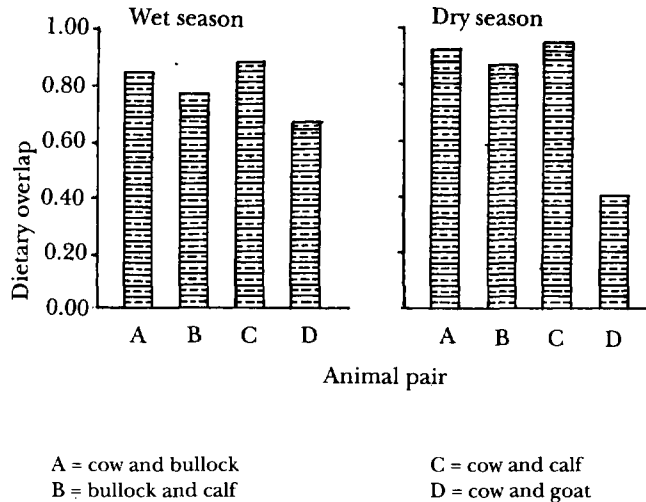


Figure 2. Dietary overlap (%) in animal pairs during the wet and dry seasons

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