Contrasts in grazing management and diet between goat herds owned by two ethnic groups in Rajasthan, India.

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Abstract

The monitoring of goats was used to investigate the diets consumed by goats belonging to specialist goat keepers (from the Gayri community) and smallholder mixed farmers (from the Tribal community) who kept goats in one village in Rajasthan, India. It was found that Tribals' goats spent about twice as much time walking to look for feed, reflecting the distances from the homesteads to the grazing areas used. Differences were most pronounced in the summer season when feed shortages are considered to be most acute. A major difference was in access to lopped tree fodder, which was very restricted for Tribal goat keepers. Tribal goat keepers were generally very much more dependant on grazing in the hill areas than the Gayris. The Gayris access to Acacia nilotica, a relatively good quality tree fodder for this region, was relatively high, but in an interesting contrast Acacia leucophloea was much more important to the poorer goat keepers. This was probably due to the ability of this species to prosper in poor land, such as the hill areas, and also the preference of goat keepers for other species due to the sporadic incidences of toxicity of A. leucophloea pods. The study illustrated how, even in a single village, goats belonging to different ethnic groups can be managed in different ways and have different diets. The monitoring techniques, as applied in this study, were unable to define closely the goats' diets. Interventions to improve the utilisation of A. leucophloea pods and to generally increase the availability of tree fodder could benefit Tribal goat keepers in particular.

Keywords: Goats; Grazing; Diets; Tree fodders

1. Introduction

Goat keeping is an important source of income, milk and manure for farmers in arid and semi-arid areas of India. Goats may be kept by small-holder crop farmers, by pastoralists with large goat herds and in small herds by the landless. The reasons for keeping goats, the production systems and production constraints can be diverse. Feed shortages are a widespread constraint during the dry season in arid and semi-arid areas such as Rajasthan, India. Indeed, feed shortages appear to be one factor in the increasing importance of goats and the decline of cattle populations in Western Rajasthan (Robbins, 1994).

Udaipur District, Rajasthan, India is a hilly area which receives about 650 mm per year of rainfall. The valleys are populated and used for crop production with some irrigation from

wells. The hills used to be forested, but much of the forest has become degraded due to poorly managed use for grazing and fire wood. Feed scarcity, water shortages and disease were reported as being the major constraints in five villages surveyed in Udaipur District, including Khakad village, where this study was conducted. Goat keepers' perceptions of constraints varied between villages in the same district and between different ethnic groups (Conroy and Rangnekar, 2000).

Small-scale farmers in less developed countries can be highly heterogeneous, and more homogeneous sub-groups of farmers need to be identified as target groups for particular innovations (Werner, 1993). Agrawal (1994) has described how different ethnic groups can have different farming and livestock keeping traditions, which lead to different uses of resources such as village commons, and how interventions aimed at improving the lot of villagers can disadvantage some groups. Conroy (2000) reviewed the impact of 15 silvipasture development projects in India, where part of the common grazing lands were fenced off to allow regeneration and management of the vegetation. While buffalo-keepers tended to benefit, other livestock keepers could be seriously disadvantaged. Goat and sheep keepers could be obliged either to sell their animals or migrate for several months if they were unable to use traditional grazing areas. In many cases it is, therefore, important to have considerable information available on the various farming and livestock production systems before interventions can be developed.

In spite of the widely recognised importance of feed scarcity as a constraint to livestock keeping, there is remarkably little published information on the diets of livestock under on-farm conditions. For stall-fed production systems, feeds can be monitored by weighing feed offered and refused, coupled to analysis of feed samples (Nyaata et al., 2000). For production systems which involve grazing it is very much more difficult to monitor what is consumed. Hoeggel et al. (1994) estimated the availability of fodder from four commonly-used fodder tree species in the Ajmer District of Rajasthan, and were able to make comparisons between villages on this basis. Sankhyan (1995) described the diets selected by grazing sheep during the wet season on an on-station farm near Jaipur, Rajasthan. This study used mouth grab and hand picked samples of pasture. More extensive studies have been undertaken in Mexico, where Ramirez (1999) described studies on the diets of grazing goats and sheep. Diet composition was estimated from esophageal fistula samples. However, this invasive technique is mainly suitable for on-station rather than on-farm studies.

Wilson (1957) described a monitoring technique used to study the browsing behaviour of goats in Uganda, and was able to list 28 species of plants which the goats consumed with some indication of their relative importance. More recently, Bennison et al. (1998) used a similar technique to investigate the effects of supplementation and trypanosomosis infection on diet selection and grazing behaviour of cattle in The Gambia. Again it proved possible to define the diet in some detail. While monitoring studies have previously been used under close researcher control, usually on-station, the technique appeared suitable for use in on-farm situations under looser supervision. It could potentially provide semi-quantitative data on diets and grazing behaviour in this poorly researched but important area.

This paper describes the use of monitoring of goats owned by goat keepers from two ethnic groups. Monitoring was used to investigate seasonal husbandry and grazing behaviour, and the types of feed consumed. An attempt was made to identify the most important feeds consumed during the summer season when feed shortages are generally regarded as being

particularly severe. The information was intended to help identify feed-related constraints and interventions aimed at easing these constraints.

2. Materials and methods

Goat monitoring was established in Khakad village, Udaipur District, in early May 1998 and continued until mid May 1999. Khakad is situated in a valley which is irrigated by wells. The valley is enclosed by rocky hills which are now largely deforested. There are three seasons, the wet (monsoon) season which normally starts in mid June and ends in October, followed by a cool dry winter season until March, and then a hot dry summer season. The area suffers from periodic droughts caused by the failure of the monsoon rains. The farming calendar is largely controlled by these seasons.

There are two major communities in Khakad who keep goats. For the Tribal community livestock keeping is generally a secondary activity, after crop production. They may also work as hired labourers for part of the year. Goats are kept mainly for income (goat sales); milk and some meat are produced for domestic consumption. Kidding occurs mainly in the winter season (November to February) with some kids being born in the summer season (March to June). Gayri goat keepers specialise in keeping livestock: large ruminants, sheep and goats. Livestock numbers have decreased in recent years mainly due to feed shortages, with sheep keeping now being rare. Goats are kept for income (goat sales) and milk (which is also sold), and to a lesser extent for manure. Most Gayris do not consume meat for religious reasons. They generally have large herds, or manage large numbers of goats belonging to the extended family. Kidding takes place mainly around the end of the rainy season/start of the winter season (September to November). Thus there are differences in management objectives, with milk production being of major importance for the Gayris but not to Tribal goat keepers. Differences in husbandry reflected are in the different kidding seasons.

Both Wilson (1957) and Bennison et al. (1998) took observations every five minutes using a series of codes to represent the activities of the animals. The same approach was adopted in this study, modifying the coding system to its particular requirements. Monitors were recruited from both of the local goat-keeping communities. Each monitor selected two female goats from within their own community herds. The goats selected were lactating at the time of selection. Monitors followed a single goat on each day of monitoring. Each monitoring period lasted for four consecutive days where each goat was monitored for two days per monitoring period; the goat to be monitored on any particular day being chosen at random. Observations were taken every five minutes from before the goats left the homestead to after they returned in the evening, to include all of the grazing time. The goat activity, type of feed, the location of the goats and, where possible, the name of the feed were noted by monitors. Data were entered onto spreadsheets and transferred to a database. Here, the numbers of counts for each feed type and activity for individual goats for each day of monitoring were extracted. Activity, feed type and location codes are given in Table 1.

Table 1
Codes for activities, feed types and locations

Code number	Activity	Feed type	Location description
0	Not defined	Not feeding	Homestead area
1	Feeding	Lopped tree fodder	Bottom of hills

2	Walking	Grazed (not lopped) tree fodder or grass	Slopes of hills
3	Resting	Dried leaves	Top of hills
4	Other	Concentrates	Not used
5	Not used	Other	Not used

Statistical analysis (means and ANOVA) was performed using Statistical Package for Social Scientists (release 9.0.0, SPSS Inc, Chicago, USA). A more detailed analysis was conducted by considering each observation period as an individual experiment and, within each, the date was used as a blocking factor. Bartlett's test for homogeneity of variance was used to explore variances of data from different observation periods. Each observation was analysed for each period (where appropriate) and the analyses summarised for the effect of ethnicity and the interaction with date of observation. The statistical significance of the differences in the number of counts per goat per day between Gayris' and Tribals' goats was investigated using the 95% confidence intervals for Gayris' goats counts minus counts for Tribals' goats for each period. Positive values indicate significantly higher ($P<0.05$) counts for Gayris' goats, negative values indicate higher ($P<0.05$) counts for Tribals' goats. If the confidence interval included the value 0, differences were regarded as non-significant ($P>0.05$).

Named feed codes were developed in the course of the monitoring and are given in the results. Total counts per named feed for each monitoring period were extracted, and daily average counts for each period of monitoring calculated to identify the most frequently-occurring named feed codes.

Details of the monitoring periods are given in Table 2. The monsoon rains started on 10 June 1998, between periods 3 and 4. In 1999 the rains started on 18 June, after the monitoring had been completed.

Table 2
Periods of monitoring

Monitoring period	Dates	Season
1	2 to 5 May 1998	Summer (hot and dry)
2	16 to 19 May 1998	Summer (hot and dry)
3	2 to 5 June 1998	Summer (hot and dry)
4	16 to 19 June 1998	Wet (monsoon)
5	2 to 5 July 1998	Wet (monsoon)
6	16 to 19 July 1998	Wet (monsoon)
7	2 to 5 September 1998	Wet (monsoon)
8	17 to 20 November 1998	Winter (cool and dry)
9	17 to 20 January 1999	Winter (cool and dry)
10	17 to 20 March 1999	Winter (cool and dry)
11	17 to 20 May 1999	Summer (hot and dry)

Very limited location code data were collected during monitoring period 1 as the codes were being developed at this time, and limited named feeds data were collected during monitoring periods 5, 6, 10 and 11 and so have not been analysed.

3. Results

Data presented

For the major activities, locations and feed types consumed, the overall data were highly skewed. Mean and median values were, however, similar in all cases, so only mean values are presented. Variances generally differed between periods, so that the standard error was not regarded as a good summary statistic. Statistically significant differences between Gayris' and Tribals' goats counts are indicated where found, together with non-significant differences. Where there was insufficient data to conduct a meaningful analysis this is also indicated.

Goat activities

Gayris' goats spent an average of 10.5 counts per day resting (standard error 0.29, n = 235), with little seasonal trend (data not shown). Overall, Tribals' goats rested significantly more that Gayris' goats ($P<0.05$). Tribals' goats rested significantly more ($P<0.05$) than Gayris' goats in periods 5, 6, 7, 10 and 11, but significantly less ($P<0.05$) in Periods 2 and 9. Tribals' goats resting counts tended to be particularly high during periods 5, 6 and 7 (up to 27.7 counts per goat per day in period 7), but with considerable variation between goats. To some extent resting counts were a reflection of when the monitors started and finished monitoring, and so were particularly susceptible to artefacts arising from the practices of individual monitors.

There was an overall mean of 71.1 counts per day grazing (standard error 0.67, n = 450), with goats from the Gayri community herds spending more time grazing (74.1 versus 67.8). For activities, interactions between date and ethnicity did not achieve statistical significance for any of the observation periods ($P>0.05$). Mean numbers of counts per goat per day by observation period for both ethnic groups are given in Table 3, together with details of the number of days of observation per period and the significance of the differences between the

two ethnic groups for each monitoring period. Differences in grazing counts between herds were statistically significant (P<0.05) during periods 1, 4, 5, 6, 7, 8, 10 and 11. For seven out of eleven observation periods, Gayris' goats grazed for longer than those of Tribal goat keepers. For period 8, this was reversed, with Tribals' goats grazing for longer.

Table 3
Goat grazing: mean numbers of counts per goat per day by observation period for Gayri and Tribal herds. The number of observations per period is given in goat days and the statistical significance of differences between counts for each period indicated in the Tribal Mean column.

Period[a]	Gayri		Tribal	
	Mean	No. of goat days of observation	Mean[b]	No. of goat days of observation
1	96.4	7	76.9*	16
2	84.1	16	82.4ns	20
3	79.7	12	75.1ns	16
4	85.6	9	75.2*	17
5	86.1	24	62.2*	28
6	85.5	27	60.9*	27
7	70.4	28	58.2*	20
8	58.4	28	64.9*	12
9	56.2	28	58.2ns	10
10	70.8	28	61.2*	21
11	76.3	28	72.0*	28

[a] See Table 2 for details of dates and seasons corresponding to period codes.
[b] ns = non significant, P>0.05 *(Table 3 here)*

Tribals' goats spent an average of almost twice as much time walking as the Gayris' goats (34 counts per goat per day for Tribals' goats, 16 counts per goat per day for Gayris' goats). Table 4 presents mean data on walking counts for each period by ethnic group. In all monitoring periods Gayris' goats spent significantly (P<0.05) less time walking than Tribals' goats. There was little seasonal trend apparent in the walking counts for Tribals' goats. Gayris' goats tended to walk more in periods 7 and 8, September and November, and less in the summer months.

Table 4
Goat walking and goat location at the bottom of hills: mean numbers of counts per goat per day by observation period for Gayri and Tribal herds

	Walking		Bottom of hills	
Period[a]	Gayri	Tribal	Gayri	Tribal[b]
1	15.7	36.4*	0.0	3.9na
2	13.9	31.1*	1.8	37.3na
3	15.3	29.7*	2.8	21.7na
4	10.4	33.8*	3.6	16.7na
5	15.1	34.3*	17.3	34.7*
6	17.9	36.9*	26.6	27.1ns
7	22.5	37.6*	22.7	38.4*
8	20.2	30.9*	17.9	32.1*
9	17.2	28.3*	5.5	23.8na
10	11.9	33.0*	3.2	30.7na
11	11.0	36.9*	4.6	42.9*

[a] See Table 2 for details of dates and seasons corresponding to period codes. Details of the number of days of observations for each monitoring period is given in Table 3.

[b] ns = non significant, P>0.05
na = not analysed as there were too few counts for Gayris' goats in these periods

Goat locations

Gayris' goats tended to spend more time near the homestead than Tribal goat herds (averages 81.8 and 50.8 counts per goat per day, respectively). The hills were far more important as grazing areas to the Tribals' goats, with the lower parts of the hills being more important than the higher parts. However, mean values are misleading as the use of the hills was highly seasonal, particularly for Gayris' goats. Table 4 presents mean counts for goats located in the bottom of the hills, which illustrates seasonal patterns in the use of this area together with differences between ethnic groups.

In periods 5, 6, 7 and 8, July to November (during the monsoon season and the start of the winter season), both Tribal and Gayri herders took their goats to the hills. Gayri herdsmen did not use the hills to a major extent outside of these periods. In contrast, Tribal herdsmen used the hills for most of the year. Only in period 6 were the differences between ethnic groups in the use of the bottom of the hills found to be non significant (P>0.05). The seasonal increase in walking by the Gayris' goats appeared to be associated with the seasonal use of the hills, which are further from the homesteads than other grazing areas.

Table 5
Goat location: middle and top of hills. Mean counts per goat per day by ethnic group and monitoring period for periods 5, 6, 7 and 8 (wet season and immediately post wet season)

Location and period[a]	Gayri	Tribal[b]
Slopes of hills		
5	32.3	20.5*
6	39.9	32.7ns
7	16.2	32.3*
8	1.8	23.0na
Top of hills		
5	16.9	13.1ns
6	19.1	32.6*
7	0.0	38.1na
8	0.0	16.8na

[a] See Table 2 for details of dates and seasons corresponding to period codes. Details of the number of days of observations for each monitoring period is given in Table 3.
[b] ns = non significant, P>0.05
na = not analysed as there were too few counts for Gayris' goats in these periods

Table 5 illustrates the use of the middle and top of hills for grazing during the periods when Gayri herdsmen use the hills. Gayris' goats were observed significantly more (P<0.05) than Tribals' goats on the slopes of the hills in period 5 and to the same extent in period 6. Tribals' goats tended to spend more time in the tops of the hills in periods 6 and 7 than in other periods, and for all periods except period 5 Tribals' goats used the tops of the hill more than Gayris' goats.

Feed types consumed by goats

Lopped trees, grazed tree fodder or grass, and dried leaves were the most commonly used types of feeds. The Tribal goat keepers had a much reduced access to lopped tree fodder compared to Gayri goat keepers (3.4 compared to 11.9 counts per goat per day on average for all periods). Dried leaves tended to be a larger component in the diet of Tribal goats (14.2 compared to 8.5 counts per goat per day). Concentrates appeared to be used more by Tribal goat keepers (3.5 compared to 0.5 counts per goat per day), although the methodology used was probably not a good indicator of concentrate use. Again, there were large differences between monitoring periods. Table 6 gives mean values for lopped tree fodder, grazed tree fodder or grass, and dried leaf use during each monitoring period. An exceptionally high number of counts for lopped tree fodder was found for Tribals' goats in period 1, but otherwise this average was below 5 counts per goat per day. In contrast, Gayri herds averaged above 5 counts per goat per day except in periods 5, 6 and 7 (after the monsoon rains), when neither ethnic group used much lopped tree fodder. Other than during the four periods mentioned above, Gayris' goats consumed more lopped tree fodder than Tribals' goats (P<0.05). From November to June (the winter and summer seasons), lopped tree fodder was an important component of the diet of Gayris' goats.

Table 6
Mean values for lopped tree fodder by ethnic group and period

	Lopped tree fodder		Grazed tree fodder or grass		Dried leaves	
Period[a]	Gayri	Tribal[b]	Gayri	Tribal[b]	Gayri	Tribal[b]
1	21.9	21.3ns	39.0	12.1*	29.7	29.8ns
2	20.1	2.9*	33.7	51.1*	31.3	23.0*
3	17.0	1.6*	48.4	46.1ns	11.7	24.4*
4	16.9	1.7*	63.7	48.6*	5.6	20.6*
5	1.9	0.6na	84.5	54.9*	0.0	3.9na
6	1.3	0.7na	85.7	57.6*	0.0	0.2na
7	0.3	0.3na	72.4	56.2*	0.3	0.2na
8	9.9	4.6*	46.4	49.7ns	1.0	3.6*
9	26.7	4.0*	25.0	32.2ns	5.6	11.2*
10	18.6	2.6*	42.4	36.1ns	9.9	17.0*
11	11.9	2.8*	40.5	37.5ns	22.4	26.6ns

[a] See Table 2 for details of dates and seasons corresponding to period codes. Details of the number of days of observations for each monitoring period is given in Table 3.
[b] ns = non significant, P>0.05
na = not analysed as there were too few counts for Gayris' goats in these periods

There were highly significant (P<0.001) interactions between date and ethnicity observed in periods 2, 3 and 4; those in period 11 also achieved statistical significance (P<0.05). No significant interactions were observed in the other monitoring periods. The interactions appeared to be largely due to day to day fluctuations in the use of lopped tree fodder by Gayri goat keepers. For example, as can be seen in Table 7, on 3 June the Gayris' goats consumed relatively little lopped tree fodder (5.3 counts per goat) compared to the other three days of the monitoring period (about 20 counts per goat). There were also marked day to day fluctuations in the grazed component of the Gayris' goats diets (including dried leaves). Variability in the diets of the Tribals' goats did not appear to be linked to these fluctuations.

Table 7
Daily use of different feed types by ethnic group in monitoring period 3, mean counts per goat per day ± standard deviation

Date	Ethnic group	Lopped tree	Grazed tree or grass	Dried leaves
2 June 98	Tribal	1.3 ±1.5	50.3 ±16.8	28.3 ±11.6
2 June 98	Gayri	19.7 ±1.2	48.3 ±7.8	17.0 ±4.4
3 June 98	Tribal	1.8 ±2.2	46.0 ±18.3	22.3 ±11.8
3 June 98	Gayri	5.3 ±2.1	43.0 ±8.5	11.3 ±2.1
4 June 98	Tribal	1.3 ±1.5	40.5 ±10.3	20.5 ±4.7
4 June 98	Gayri	22.0 ±3.6	55.3 ±4.2	4.7 ±2.1
5 June 98	Tribal	2.3 ±1.7	47.5 ±8.7	26.8 ±11.5
5 June 98	Gayri	21.0 ±9.5	47.0 ±8.5	13.7 ±1.5

The mean counts per goat per day for the consumption of grazed fodder trees and grass are given in Table 6. Significant (P<0.05) date x ethnicity interactions were observed in grazed fodder consumption counts during period 5 only. This appeared to be due to day to day fluctuations in grazing counts for both herds. Significant (P<0.05) differences in grazed feed counts were observed between Tribals' and Gayris' goats in periods 1, 2, 4, 5, 6 and 7, with

Gayris' goats having higher counts for all these periods except period 2. Similar seasonal trends were observed in the consumption of grazed fodder by the goats from the two ethnic groups. Grazed fodder, as a component of the diet of Gayris' goats, was greatest in periods 5 and 6, and for Tribals' goats in periods 5, 6 and 7.

Data on the consumption of dried leaves is also given in Table 6. No significant ($P>0.05$) interaction between date and ethnicity was observed for any period. Significant differences ($P<0.05$) between ethnic groups were observed in periods 2, 3, 4, 8, 9 and 10, with Tribals' goats consuming more dried leaves than Gayris' goats except in period 2. Dried leaves were consumed in relatively large amounts in the summer season, but not consumed after the rains start and when green grass was available. Consumption then slowly built up over the winter season.

Named feeds

The most frequently-occurring named feeds during periods 1, 2, 3 and 4 (summer and the start of the monsoon season) are given in Table 8. Of a total of 19,085 records, 12,407 records were of the goats feeding. Only named feeds with more than 248 records (2% of the total feeding codes) are listed.

Table 8
Named feeds consumed by grazing goats, May-June 1998 (Monitoring periods 1 to 4 inclusive), expressed as average counts per goat per day ± standard deviation (n=113) and as % of the total feeding counts during these periods

Feed code	Local name	Scientific name (where known)	Average counts per goat per day	% of total feeding counts
1	Runjiya leaves	Acacia leucophloea	3.1 ±3.5	3.7
2	Negad leaves	Derris indica	6.1 ±3.7	8.0
3	Kanje leaves		1.9 ±2.0	2.4
4	Dry grass and pods of shrubs		10.1 ±6.3	11.2
5	Unknown shrub or tree leaves		2.1 ±2.6	2.2
6	Green grass		2.9 ±2.6	3.3
7	Mango tree leaves	Mangifera indica	3.0 ±1.6	4.0
8	Fallen ber leaves	Ziziphus mauritiana	7.4 ±1.4	9.8
9	Desi babool leaves and pods	Acacia nilotica	11.8±8.3	12.7
10	Rujadi twigs		3.6 ±1.9	4.0
11	Green dhobadi or hariyali		4.2 ±3.9	5.0
12	Aankada green leaves		2.5 ±2.3	2.5

The 12 named feeds in Table 8 accounted for 68.8% of all the feeding codes over these periods. Excluding the poorly-defined named feeds, dry grass and pods of shrubs and unknown shrub or tree leaves, the 10 named feeds accounted for 55.4% of the total feeding

counts. Thus, the monitors were only able to define the diet in fairly broad terms due to its complexity and the difficulty of identifying all of its components.

There were marked seasonal variations in the utilisation of these feeds, and differences between the two ethnic groups for some of them, most notable for Acacia nilotica and Acacia leucophloea. Table 9 presents mean data for the number of counts recorded for these two species by monitoring period and ethnic group, and where there was sufficient data to enable statistical analysis the significance of the differences observed. Tribal goat keepers generally used A. nilotica to a much lesser extent than Gayris, except in period 8 where this was reversed. By contrast, A. leucophloea was used more by Tribal goat keepers than Gayris. A. leucophloea was an important tree fodder for the Tribal herds in the summer season, and was used throughout much of the year. In contrast, it was used only in winter by Gayri goat keepers, and even then in relatively low quantities.

Table 9
Differences in counts of Acacia nilotica and Acacia leucophloea by period and ethnic group (mean counts per goat per day)

Period[a]	A. nilotica		A. leucophloea	
	Tribal	Gayri	Tribal	Gayri
1	7.6	24.3*	9.2	0.0
2	5.2	24.1*	5.8	0.1
3	5.1	6.7	4.4	0.0
4	5.1	10.2*	4.9	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	1.1	0.3	2.4	0.0
8	4.2	0.8*	5.4	1.4*
9	2.6	0.8	3.7	1.1
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0

[a] See Table 2 for details of dates and seasons corresponding to period codes. Details of the number of days of observations for each monitoring period is given in Table 3.

* Differences between ethnic groups for counts of the particular *Acacia* sp. statistically significant ($P<0.05$) at that period. No other periods were analysed due to the high number of observations with zero counts in these periods.

4. Discussion

Goat activities

Feeding counts for Gayris' goats tended to be higher than those for Tribals' goats largely due to differences in Periods 5 and 6, in July, during the monsoon season when green grass was available. Tribals' goats tended to rest more in the monsoon season than in May and June; a trend not observed for Gayris' goats. As green grass was said by goat keepers to be in plentiful supply at this time of the year, there appeared to be another constraint to grazing. One explanation is that labour supply restrictions may limit the grazing time for Tribal goats, as goat keepers may also have crops to tend. Another is that Tribal herders may not have

wanted to take the goats onto the tops of the hills during wet weather. Grazing was said to be inhibited by rain. Goat keepers generally kept their goats at the homestead if it was raining, although this did not appear to have an adverse impact on the grazing time of the Gayris' goats. Otherwise, the periods spent grazing were very similar. Bennison et al. (1998) reported that cattle spent 72 to 78% of their time feeding during the nine to ten hour per day period when they were taken grazing. This is equivalent to 6.5 to 7.8 h feeding, similar to 4.7 to 8.0 h grazing which can be estimated from this study (number of counts multiplied by five minutes). The greater range recorded here was probably because monitoring was sustained over the three different seasons of the year, and grazing was managed under normal commercial conditions rather than the researcher controlled conditions used by Bennison et al. (1998).

Walking increased after the rains started as the goats were taken to the newly-grown grass, particularly in the hills. In summer, increased walking by Tribals' goats probably reflected the increasing distances needed to travel to find scarce feed. The feed supply for Gayris' goats was apparently not so restricted; a view consistent with discussions with the two groups of goat keepers.

Goat locations

Gayri herdsmen only take their goats to the higher hill areas just after the rains when freshly grown grass was available. In contrast, the Tribal herdsman used the hills during most of the year. Only at the height of summer were the tops of the hills not used, due to excessive heat, lack of water and poor grazing. The longer periods spent near the homestead by the Gayris' goats was consistent with the relatively low number of counts related to walking.

Feed types

The greatest difference in the fodder component of the diet of Tribal and Gayri goats was in the extent of the use of lopped tree fodder. Lopped tree fodder included some of the more nutritious components of the diet, such as A. nilotica, which has highly nutritious pods as well as leaves (FAO, 1998). Goat keepers from both communities considered that the Gayris' goats were better fed and more productive than those of the Tribal community. This appeared to be due, in large part, to the differences in access to lopped tree fodder. This was because the Gayris purchase lopping rights from land owners, whereas Tribal goat keepers generally do not purchase lopping rights. Gayris were also said to purchase more concentrates and generally manage their goats better which were probably also important factors. Clearly, interventions aimed at improving the availability of lopped tree fodder would be of potential benefit, particularly to Tribal goat keepers.

Time spent consuming grazed tree fodder or grass had a generally inverse relationship to the time spent consuming lopped tree fodder for the Gayris' goats. Grazed fodder consumption by Tribals' goats was relatively constant, except for the atypically low figure in Period 1. Dry leaf consumption was at its highest in the summer season, during the periods of seasonal feed scarcity. This was probably because they represent the least attractive feed type available to the goats, and so were consumed in the absence of sufficient alternatives. Further, there was a general trend for Tribals' goats to spend more time consuming dried leaves than Gayris' goats. This was consistent with the opinion of the goat keepers that feed supply for Tribals' goats is generally more constrained. Monitoring the consumption patterns of the feed of last

resort, dried leaves in this case, may be a useful way of investigating the seasonality of feed constraints and differences between herds.

Named feeds

One of the objectives of this study was to define the diets consumed by grazing goats, particularly in the summer season. In the event, the complexity of the diet and difficulty in identifying all of its components limited the extent to which this could be achieved. Bennison et al. (1998) were able to describe the diet of grazing cows in some detail using a monitoring technique. The cows mainly grazed on dryland grasses, and the consumption of seven species accounted for 84% of the time spent feeding, two of these species accounting for 55% of the time feeding. Goats usually select their diet from a much wider range of plants than cattle. Ramirez (1999) found that monthly goat diets were composed of approximately 22 browse plants, Wilson (1957) identified 28 plant species consumed by goats, the most frequently consumed species accounting for just 13% of the total feeding counts. If a more detailed picture of the species composition of the diet is required some training of the monitors on species identification will be required.

Possible interventions

In the summer season A. nilotica is one of the few high quality feeds available for goats in this region. Acacia leucophloea also has highly nutritious pods, and leaves of moderate to poor digestibility, with both leaves and pods containing about 20% crude protein (Wood and Badve, unpublished data). It is an important fodder tree in Rajasthan and elsewhere in India. In Ajmer District, Rajasthan, it was found to constitute 75% of loppable fodder trees on common lands and 47% on private lands in villages with shallow and rocky soils (Hoeggel et al., 1994). However, the pods can be toxic (Bhadoria and Gupta, 1981; Katiyar, 1981) and, for this reason, the species was not as popular with goat keepers as A. nilotica.

It was notable that the Gayris used A. nilotica to a much greater extent than Tribal goat keepers during the summer season when feed was scarce. This accounted for much of the difference in utilisation of lopped fodder in monitoring period 2. The relative importance of A. leucophloea to the Tribal goat keepers was also noteworthy. A. leucophloea is capable of growing in very poor soils, which probably accounts for it being widespread in communal grazing areas (Hoeggel et al., 1994). Tribals' goats are more regularly grazed in these communal areas accounting for the relative importance of this species. However, this means that the Tribals' goats are also more at risk from the threat of toxicity posed by the use of this fodder.

Bhadoria and Gupta (1981) found hydrocyanic acid in the leaves, buds, flowers and pods of A. leucophloea, with up to 987 ppm in the pods. This is well in excess of the 200 ppm of HCN regarded as toxic to livestock. Katiyar (1981) and Krishna and Katoch (1989) have reported incidents of livestock being killed by hydrocyanic acid poisoning. Interventions to improve the utilisation of A. leucophloea would be of particular benefit to the Tribal goat keeping community in this village, and of users of communal grazing lands more generally. Such interventions could include simple methods of detoxifying the pods.

Access to tree fodder was clearly important in the dry season. Improved management of the use of the hill areas, possibly coupled to tree planting, would enable trees to recover and increase the production of tree fodder. This could, potentially, be of particular benefit to

Tribal goatkeepers who are currently the major users of these resources. Improved hill grazing may also be of use to the Gayri community. However, as noted by Agrawal (1994) and Conroy (2000), the successful implementation of improved management has many social and political dimensions. Changes do not necessarily bring benefits to the target communities and must be implemented with considerable care.

5. Conclusions

Goat monitoring, using members of the goat-keeping communities as monitors, has been able to investigate the grazing behaviour and diet of goats. Key differences in the diets of goats from the two communities investigated have been identified together with differences in where the goats were grazed. The technique allows semi-quantitative estimates of differences to be made. It also enables a more detailed analysis of the diet to be made than could be achieved by interview and survey techniques, and usefully complements such techniques. The technique as applied was unable to closely define the goats' diets.

Tribal goat keepers were more reliant on the use of the hill areas for grazing than Gayri goat keepers. To reach their grazing areas, Tribals' goats have to walk about twice as much as Gayris' goats. Tribals' goats have more limited access to lopped fodder trees. Notable differences were observed in the relative use of two important tree species, A. nilotica and A. leucophloea. Better access to A. nilotica is probably an important factor in the perceived superior diet of Gayris' goats. However, the relative importance of A. leucophloea to Tribal goat keepers was illustrated. Interventions to improve the utilisation of A. leucophloea would be of particular benefit to the poorer sections of the goat keeping communities in this area. Improved management of the use of the hill areas, possibly coupled to tree planting, would enabled trees to recover and increase the production of feed particularly in the dry season. This could, potentially, be of particular benefit to Tribal goat keepers who are currently the major users of these resources.

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