Seasonal composition and quality of livestock diets on small-holder mixed farms in the mid-hills zone of Nepal

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Abstract

Under the DFID-funded research project *'Strategies for improved fodder production in the dry season in the mid-hills of Nepal, using participatory research techniques'* a simple survey method was devised to obtain information on the seasonal collection and utilisation of livestock feeds. The survey included a simple method for recording the proportions of collected fodders of each type allocated to different types of livestock (cows and calves, buffaloes, oxen and goats). These data were used to estimate the amounts, composition and quality of diets offered to livestock with a view to help determine the requirements to improve diets.

Estimation of the amounts and quality of feeds offered to livestock required additional information on the weights, dry matter (DM) and useable fodder contents of local measures of fodder collection (mainly bhari back-loads). These were obtained from sample weighings and other field experience. Estimates of nutritive values of fodders were obtained from the literature including crude protein (CP), crude fibre (CF) and metabolisable energy (ME). Livestock holdings of each type were converted to adult equivalents (to include immature animals) since feeds were generally group-allocated to livestock types.

Expected seasonal differences in amounts and composition of diets were evident in the data. Estimated feed offer rates were realistic given the likely levels of refusals of offered feeds. Offer rates were highest in the rainy and early dry season and declined through the mid to late dry season. Proportions of cut grass and grazing were highest in the rainy and early dry seasons while proportions of tree fodders were highest in the dry season. Crop residues were used in cattle, oxen and buffalo diets through most of the year. Concentrate use increased in the dry season.

There were marked differences in diet composition between villages and species. Diets were similar in Gajuri Chhap and Gauthale, with lower proportions of crop residue and cut grass and higher proportions of tree fodders and grazing than other villages. Diets in Ange depended heavily on crop residues, while those in Chankhubesi and Tawari included relatively high proportions of cut grass. Buffalo diets contained higher proportions of crop residues, cut grass and tree fodders than cattle diets, while goat diets were based largely on tree fodders. Oxen grazed more than other types of livestock. Grazing and production objectives were also important factors determining diet composition and quality. The diet descriptions provided a useful base for discussion of requirements to improve livestock feeding.

Contents

1 Introduction

The work described in this paper was part of the research project 'Strategies for improved fodder production in the dry season in the mid-hills of Nepal, using participatory research techniques'. The project was funded by the UK Department for International Development (DFID) Renewable Natural Resources Research Strategy (RNRRS) Livestock Production Programme (LPP). The objective of the project was to develop increased and improved supplies of fodders for livestock on small-scale mixed farms in the mid-hills zones of Nepal.

Many factors affect the supply of feeds to small-holder farms, as described in the papers by Hendy, Vickers, Chhetri, Basukala, Kharel, Regmi and Kiff (2000) and Vickers, Hendy, Chhetri, Basukala, Kharel, Regmi and Kiff (2000). Changes in access to land and forest resources, and differences in the circumstances of households with respect to land holdings, household size and labour availability, affect the quantities and composition of available feeds. These factors may thus lead to differences in the seasonal amounts and diet composition of feeds offered to the different livestock in mixed-species holdings.

The requirements for additional or substitute feeds to improve the diets of livestock can only be determined once current diets and constraints are described. In particular, it will be important to understand seasonal changes in diets. Feed requirements are also dependent on the production objectives and productivity levels of different livestock species.

This paper presents the results of simple field surveys with farmers to describe the diets and the factors affecting the allocation of feeds to different livestock species as part of the process of determining requirements for additional feeds.

2 Methods

2.1 Field survey methods

A field survey was conducted by repeat-visit simple interview and discussion methods to obtain seasonal information on fodder collection and utilisation by households in the mid-hills zone of Nepal. The survey was conducted in five villages differing in altitude, access to cropland and forest, and proximity to markets, with 10 farmers selected during group discussions to represent the range of land and livestock holdings within each village. Survey visits to each household were made at two-month intervals over 14 months. Each visit involved a 20-30 minute discussion with each household (with members most directly involved in feed collection and allocation), to record the current livestock holding, daily amounts of different types of feeds collected (in local measures), sources of feeds (on or off-farm), daily grazing periods, estimated feed deficits, and current livestock production objectives and productivity. Additional single visit surveys established the land holdings, cropping patterns, on-farm tree holdings, household size, and labour constraints for fodder

collection for all households. The methods of site and household selection and details of the survey procedures are described by Hendy, Vickers, Chhetri, Basukala, Kharel, Regmi, and Kiff (2000).

Data on the allocation of feeds to livestock were obtained at each survey visit by discussing the amounts (in local measures) or proportions of each type of feed allocated to each type of livestock kept. In the survey, both the categorisation of feed types and the identification of livestock types were necessarily simplified. Feed types were classed as crop residues, crop thinnings, cut grass, tree fodders, grazing and concentrates. The proportional composition of each of these broad categories of feeds was discussed in the surveys to establish the proportions of specific fodders collected in each season (eg specific crop residues, grasses and tree species). Livestock types were classed simply as cattle (including milking cows, immatures and suckling calves), buffaloes (milking cows, immatures and calves), oxen and goats (adults and young). Estimates of the amounts of fodder provided by grazing for each type of livestock were made as described by Hendy et al (2000).

2.2 Preparation and analysis of data

The amounts of feeds collected by households (reported in local measures of bhari, doka and muta) were converted to dry matter (DM) weights of fodder on the basis of sample weighings of local measures. DM contents of the different fodders were taken from the literature (see review by see Kiff, Thorne, Pandit, Thomas and Amatya, 1999). Further adjustments were made for the proportions of consumable feeds in the collected fodder materials (thus discounting the amounts of twigs and branches in tree fodders, or inedible stems in stover residues). Estimates of the nutritive values of collected fodders were also taken from the literature (Kiff, Thorne, Pandit, Thomas and Amatya, 1999), using data for specific components of each category of fodders (eg tree species) where available or average values for the category otherwise. Estimates of crude protein (CP) and crude fibre (CF) contents of fodders were available for many species. Estimates of contents of metabolisable energy (ME) are not commonly available and were assumed from literature for similar types of feeds.

All these data were combined to estimate the amounts of DM and nutrients for each type of fodder offered to each type of livestock per day in each survey season, and thus total feed DM and the compositions of feeds offered. These amounts were related to livestock holdings of each type by converting the mixed-age holdings to 'adult equivalents' including immature animals at assumed relative liveweights of 0.66 of adults. Feed offer rates in subsequent analyses are thus presented as kg DM (or g CP, or MJ ME) per adult equivalent. Suckling young were excluded from adult equivalents as they consume relatively little of the collected fodder DM.

Certain key simplifications and assumptions made in this process need to be noted. First it is assumed that the species composition of each type of fodder fed to each type of livestock was the same as that in collected fodders. This is largely true in the case of cattle, buffaloes and oxen but not for goats. The latter receive a different mix of 'tree fodders' than other livestock types, containing more shrub and aromatic fodder species, though the effect of this difference on nutritive values is not likely to be very large. A further assumption was made that livestock of each broad class were group

fed the same diet composition (ie that milking cows would be fed the same diet composition as growing immature cattle). This is likely to be a reasonable assumption in the case of fodders but may not be for concentrate feeds. However, distinguishing the different sub-groups of each livestock type would have made the survey more cumbersome to conduct and most households do group feed their animals for most feeds.

Estimated rates of allocations of feeds to livestock adult equivalents were reviewed to ensure that they were within reasonably realistic bounds, and checked back with farmers and raw data sets in case of apparent errors. Some unexplained high estimates of feed offer rates remained in the data, however. In final analyses, extreme outlier data were excluded if the total feeds offered were above the mean plus three times the standard deviation for the particular livestock type. In this way 11, 10, 6 and 10 observations were removed from analyses (representing 4.5%, 3.3%, 2.5% and 2.7% of observations for cattle, buffaloes, oxen and goats respectively).

Data were analysed using Microsoft Excel, SPSS and Genstat statistical procedures. Data were available from 10 households in each of the five villages and eight seasons (except for two households lost from the survey in Chankhubesi in the last two surveys in March and May 1999). The approach to establishing valid analysis models is outlined in Hendy et al (2000). Final analyses of data on feeds offered and diet composition were conducted by GLM AoV procedures in SPSS. Most models included fixed factors of village, season, household size, livestock unit holdings and land holdings (the latter three factors each classified into four levels). There was some co-association of household size, land holdings and livestock holdings but the degree of independence was sufficient to allow testing of these effects separately in the same analysis models. Additional factors were tested where necessary to investigate effects of grazing (or not), livestock production objectives (represented by households selling milk or not) and the impacts of perceived shortages of feeds on the diets offered to different types of livestock.

3 Results

3.1 Amounts and composition of fodders allocated to each species of livestock

Over all villages and seasons, the amounts of feed dry matter (including fodders and concentrate feeds) offered to different types of livestock were at realistic levels, though higher than expected feed intakes, as shown in Table 1. Offer rates to oxen were notably lower than for milking cattle and buffaloes.

3.1.1 Village and season differences in feeds offered

The amounts of feeds offered differed significantly ($p<0.05$) between villages and seasons for all species and most feeds. Figure 1 illustrates the seasonal patterns of daily total feed offer rates (kg DM/head/day) for each type of livestock. Offer rates were highest in the July to November period and lowest in the late dry season for all

types of livestock (seasonal effects were highly significant in all cases, $p<0.001$), despite changes in feed composition and attempts to find alternative feeds in the late dry seasons.

Table 1 Overall feed dry matter offer rates to different types of livestock

	Daily allocation of feeds to different types of livestock			
	Cattle	**Buffaloes**	**Oxen**	**Goats**
Total daily feeds DM (kg/head)	10.7	14.1	9.2	1.65
Total daily feeds DM (1) (% liveweight)	4.28	4.03	3.07	6.6

1. Average adult liveweights estimated as: cattle 250kg, buffaloes 350kg, oxen 300kg and goats 25kg

Village differences are shown in Table 2. Offer rates were generally high in Tawari (except for goats) and Chankhubesi (except for cattle). In Ange, offer rates were particularly low for cattle and oxen but high for buffaloes and goats. Offer rates for both oxen and goats were low in Gajuri Chhap and Gauthale.

Table 2 Daily total feed offer rates to different types of livestock in survey villages (1)

	Daily feed offer rates kg DM/head/day (se)					
	Sig. of village effect	**Gajuri Chhap**	**Gauthale**	**Chan-khubesi**	**Tawari**	**Ange**
Cattle	xxx	9.9 (1.1)	11.1 (1.1)	9.8 (0.9)	13.8 (1.0)	8.9 (1.3)
Buffaloes	xxx	13.2 (1.1)	11.3 (1.0)	14.5 (1.5)	18.1 (0.9)	13.3 (0.8)
Oxen	xxx	7.7 (0.8)	7.8 (0.6)	10.5 (1.0)	12.7 (0.9)	7.4 (0.8)
Goats	xxx	1.38 (0.2)	1.55 (0.2)	1.81 (0.2)	1.63 (0.1)	1.88 (0.2)

1. Means of total feeds (fodders and concentrates) estimated over all seasons and other factors in GLM AoV models;
x, xx and xxx village effects significant at $p<0.05$, $p<0.01$ and $p<0.001$ respectively;

Seasonal patterns of utilisation differed between fodders, as might be expected. Crop residues and tree fodders were most utilised in the dry seasons and cut grass in the rains. Figure 2 illustrates these patterns of allocation for cattle. In addition, crop thinnings were used as collected during the main crop-growing season (in the July survey).

Seasonal patterns of allocation of fodders differed between villages. Village x season interactions were significant ($p<0.05$) for most fodders across all livestock types. Thus for crop residues, there was a consistent relatively high and aseasonal allocation in Ange compared to a moderately seasonal allocation in Gajuri Chhap and Gauthale and a more marked seasonal allocation in Chankhubesi and Tawari. Conversely for cut grass, seasonality of allocation was marked in Chankhubesi and Tawari and

relatively aseasonal in Ange. For tree fodder, seasonality was most marked in Gajuri Chhap and Gauthale. These patterns were largely repeated for other types of livestock and were clearly reflected in the fodder composition and nutrient contents of offered diets, as discussed in following sections. Village x season interactions were less evident for total feeds (though were either significant or close to significance for most types of livestock). For cattle, total feed allocation was slightly more seasonal in Gajuri Chhap and Gauthale and less seasonal in Chankhubesi and Tawari (though higher on average in the latter), as shown in Figure 3.

Patterns of grazing and the use of concentrates were generally less seasonal. There were significant effects for the apparent amounts of fodder derived from grazing to increase in the dry seasons for buffaloes and goats, though grazing contributed very little feed for buffaloes. Concentrate use also rose slightly in the late dry seasons (at least as a proportion of diets in sites where either constraints on the availability of other feeds were marked, as in Ange, or where milk production was important, as in Chankhubesi).

Concentrates were important components of diets of all types of livestock (see Table 3), comprising 3 and 18% of feeds DM offered (for cattle/oxen and for buffaloes respectively), and probably higher proportions of actual feed intakes. While there was little seasonal variation in the use of concentrates, there were significant village differences, with allocation rates significantly highest in Chankhubesi (for all types of livestock, and comprising up to 18% of feeds offered to buffaloes). Concentrates were also important in Ange, where they made the highest contribution to nutrient supply because of the low amounts and poor quality of fodders available. Concentrates were also fed to goats, both for breeding females and for fattening immatures.

Table 3 Percentage of concentrates in feeds allocated to different types of livestock in survey villages

	Percentage of concentrates fed (% total feeds DM) (1)					
	Gajuri Chhap	**Gauthale**	**Chan-khubesi**	**Tawari**	**Ange**	**Pooled se**
Cattle	4.8	3.6	8.8	6.4	3.5	1.7 x
Buffaloes	7.9	7.7	18.5	9.2	12.7	1.4 xxx
Oxen	4.0	2.8	7.9	6.4	5.4	1.1 xxx
Goats	6.1	7.6	13.0	7.9	10.2	1.6 x

1. Means estimated in GLM AoV models;
x, xx and xxx = F ratios for village effect significant at $p<0.05$, $p<0.01$ and $p<0.001$ respectively;

3.1.2 Village and season effects on diet composition

The average composition of feeds offered (over all seasons) for different livestock types in the five survey villages are illustrated in Figure 4. Village differences in the percentage contributions of individual feeds were significant for all feeds. Proportions of crop residues offered were lower in Gajuri Chhap and Gauthale for all types of livestock (less than 25% for bovines) and highest in Ange (over 40-60%). Crop thinnings appeared more important in Gajuri Chhap and Gauthale than in other

villages. Cut grass contributions were highest in Chankhubesi for all types of livestock and comprised over 40% of offered feeds for cattle and buffaloes. Grazing made the largest contributions in Gajuri Chhap and Gauthale and only a small contribution in Ange (only for cattle). Generally, feed compositions were similar in Gajuri Chhap and Gauthale and in Chankhubesi and Tawari, and different again in Ange.

Differences between livestock types in the composition of offered feeds were also significant. Buffaloes generally did not graze in any location; buffalo feeds contained high proportions of crop residues and cut grass, supplemented by higher proportions of tree fodders than offered to cattle. Grazing made a major contribution to oxen feeds in all villages except Ange. Otherwise, oxen were offered lower proportions of cut grass and slightly higher proportions of tree fodders than other cattle. Goat feeds consisted mainly of tree fodders and cut grass, comprising over 60-70% of offered feeds. The composition of feeds offered to goats varied less across villages than for other types of livestock.

The seasonal patterns of feed composition differed between livestock types and between villages (village x season interactions were significant for most feeds and village x season x livestock type interactions were significant for all feeds except concentrates). These differences are illustrated in Figure 5a for cattle and buffaloes and Figure 5b for oxen and goats. The most important features of these patterns include the degree of seasonality (the amount of change in feed compositions between seasons). This was more marked in Gajuri Chhap and Gauthale than in other villages, for all types of livestock, despite the relatively aseasonal contributions of grazing. In other villages, although the allocation of crop residue was seasonally marked, more consistency in feed compositions was provided by continued use of cut grass through the seasons. Seasonality of feed composition was least marked in Ange.

3.1.3 Impact of grazing on feeds offered and diet composition

Apart from the effects of villages and seasons, the most important influence on the composition of feeds offered to livestock was the practice of grazing. Overall, 48%, 61% and 25% of households grazed cattle, oxen and goats respectively. All households in Gajuri Chhap and over 60% of households in Gauthale grazed cattle and oxen in most seasons. Only two households in Chankhubesi grazed cattle and none in Ange (though some grazed occasionally in the dry season). In Tawari, most households grazed cattle and oxen until July 1998 after when several households adopted stall-feeding to produce milk for sale. Only two households still grazed cattle by March 1999. Grazing practices by most households were relatively constant between seasons.

The effects of grazing on the total amounts and composition of feeds offered are shown in Table 4. Grazing did not affect the total amounts of feeds offered to any type of livestock, but did significantly change the composition of feeds. For cattle, non-grazing households offered increased proportions of both crop residues and cut grass in place of grazed fodder. For oxen, with relatively high proportions of crop residue in feeds of grazed animals, non-grazing households offered increased proportions of both cut grass and tree fodder.

For goats, grazed fodder was replaced in non-grazing households mainly by tree fodder. For all livestock types, the proportion of concentrates fed was higher in non-grazing households, significantly so for cattle (many of these were stall-fed for milk production, as in Chankhubesi).

Table 4 Effects of grazing on the amounts and compositions of feeds offered to cattle, oxen and goats (1)

	Sig. of grazing effect	Feeds offered under different grazing regimes	
		Without	With
Cattle			
Total feeds offered kg/hd/day	ns	9.75 (1.0)	10.4 (1.2)
Grazing %	xxx	7 (4.3) ([2])	35 (5.0) ([2])
Crop residue %	ns	32 (4.2)	26 (5.0)
Cut grass %	ns	32 (4.5)	22 (5.2)
Tree fodder %	ns	13 (3.7)	13 (4.3)
Concentrates %	x	9.5 (1.7)	1.5 (1.9)
Oxen			
Total feeds offered	ns	8.67 (0.7)	9.80 (0.5)
Grazing %	xxx	4 (2.9) ([2])	39 (2.3) ([2])
Crop residue %	ns	35 (2.8)	32 (2.2)
Cut grass %	xxx	26 (2.5)	10 (1.9)
Tree fodder %	xxx	23 (2.2)	11 (1.8)
Concentrates %	ns	6.1 (1.0)	4.5 0.8)
Goats			
Total feeds offered	ns	1.68 (0.13)	1.60 (0.18)
Grazing %	xxx	1.5 (2.4) ([2])	36 (3.4) ([2])
Crop residue %	ns	3.0 (1.6)	5.4 (2.4)
Cut grass %	ns	30 (3.7)	22 (5.2)
Tree fodder %	xxx	51 (4.4)	26 (5.2)
Concentrates %	ns	11 (1.3)	7 (1.9)

1. Means of total feeds and composition % estimated (adjusted) over all seasons and other factors in GLM AoV models;
   x, xx and xxx village effects significant at $p<0.05$, $p<0.01$ and $p<0.001$ respectively;
   ns = not significant
2. Estimates of grazing feeds offered >0 due to adjustments in GLM AoV analyses

3.1.4 Household factors affecting the amounts and composition of feeds

Apart from the overriding effects of village, season and patterns of grazing, certain characteristics of households such as their size (number of persons), land holdings and livestock holdings were also associated with the amounts and composition of feeds offered. Household size was significantly ($p<0.05$) positively associated with the amount of grazing fodder in diets of cattle and oxen, the types of livestock grazing most. In consequence, the total amounts of feeds offered were also higher in larger households ($p<0.05$ for oxen). Diet compositions tended to be similarly affected with higher proportions of grazing fodder and lower proportions of tree fodders (though

not significantly) in larger households. Household size was not, however, consistently associated with the amounts or composition of feeds offered to buffaloes or goats.

Household land holdings were positively associated with the amounts of cut grass offered to cattle, buffaloes and oxen (though only significantly so for cattle, $p<0.01$). The amounts of tree fodders and total feeds offered also tended to increase with land holding size. There were no significant effects on diet composition. For goats, associations were not consistent but suggested that cut grass proportions increased ($p<0.05$) and tree fodders declined in households with larger land holdings.

Both the amounts and the composition of feeds offered to animals were significantly related to the size of livestock holdings. Cut grass, tree fodder and total feed amounts offered were consistently lower in larger livestock holdings (see Table 5). These effects were associated with changes in diet composition, with increasing proportions of crop residue and declining proportions of cut grass and tree fodders in the diets of animals in larger holdings.

Table 5 Associations of household, livestock holding and land holding size with the amounts of total feeds offered to different types of livestock

Livestock unit holding	Total feeds offered (kg DM/head/day) (1)			
	Cattle	**Buffaloes**	**Oxen**	**Goats**
	xx	x	xx	ns
0.1-2.5	13.3	17.0		1.76
2.5-5.0	12.1	14.3	11.5	1.61
5.0-7.5	10.2	13.4	8.33	1.65
> 7.5	7.60	11.7	7.86	1.58
Pooled se	0.96	1.0	0.74	0.14

1. Means estimated in GLM AoV models;
x, xx and xxx = F ratios for effect of household size significant at $p<0.05$, $p<0.01$ and $p<0.001$ respectively

3.1.5 Associations with livestock production objectives (for milk)

Feeds offered to milking cattle and buffaloes differed depending on the sales of milk by households. Households which sold milk tended to feed more crop residues, cut grass and total fodders to both cattle and buffaloes, and significantly more concentrates (about double the quantities fed in non-milking households, as shown in Table 6).

3.2 Nutrient contents of fodders allocated to each type of livestock

Village differences and seasonal changes in the composition of feeds offered to animals resulted in significant village and seasonal effects on nutrients offered and diet average quality, as measured by CP and ME content. Village x season interactions were also significant ($p<0.01$) for all types of livestock, confirming that

the seasonal patterns of nutrient contents were different between villages, as illustrated in Figure 6 for CP in diets of cattle and buffaloes. Nutrient contents were consistently higher and did not vary seasonally in Gajuri Chhap and Gauthale. Nutrient contents showed a marked seasonal pattern in Chankhubesi and Tawari, rising during the rainy season and declining in the dry. In Ange, nutrient contents remained low through the year, and were lowest in the mid-rains and early dry season.

Table 6 Average daily feeds offered to cattle and buffaloes in households selling or not selling milk

	Feeds offered (kg DM/head/day) (1)					
	Cattle Milk sales			Buffaloes Milk sales		
	No	Yes		No	Yes	
Crop residues	3.34	3.68		4.77	5.39	
Crop thinnings	0.56	0.61		0.63	1.08	
Cut grass	2.67	3.33		3.94	4.53	
Tree fodder	1.62	1.26		2.18	2.40	
Grazing	1.10	2.08	x	0.10	0.03	
Concentrates	0.48	0.82	x	1.05	2.03	xxx
Total fodders	9.28	10.96	p=0.09	11.62	13.44	
Total feeds	9.77	11.78	x	12.67	15.47	x

1. Means estimated in GLM AoV models;
x, xx and xxx = F ratios for effect of milk sales within species significant at $p<0.05$, $p<0.01$ and $p<0.001$ respectively

Between livestock types, average nutrient contents of diets were similar for cattle, buffaloes and oxen (108-110 g CP and 8.8 MJ ME/kg DM), but were higher for goats (130 g CP and 9.9 MJ ME/kg DM) due to the high content of tree fodders in their diets.

Other factors affecting diet composition, such as grazing, the size of livestock holdings and milk sales also affected nutrient contents. For cattle and oxen, the average contents of CP and ME were higher in diets of grazing animals (though not significantly). Significant season x grazing interactions suggested that this occurred mainly during the dry season, as illustrated in Figure 7 for cattle. Non-grazing cattle had similar quality diets to grazing animals in the rains but quality was reduced in the dry seasons with higher proportions of crop residues in diets. Diet changes with increasing size of livestock holdings (as outlined in section 3.2.4 above) resulted in trends for reduced nutrient contents in diets of all livestock types ($p<0.05$ for buffaloes and goats, as shown in Table 7).

Diet differences associated with the selling of milk by households resulted in feeding significantly more total nutrients (CP and ME) than by those not selling milk ($p<0.001$). Average diet quality offered by households selling milk was higher (but not significantly) than for those not selling 111 vs 109 g/kg DM CP for cattle and 109 vs 107 g/kg DM for buffaloes. ME concentrations did not differ, however, at an average 8.8 MJ/kg DM.

Table 7 Associations of livestock holding size with the content of crude protein in diets of different types of livestock

Livestock unit holding	Crude protein content of feeds offered (g/kg DM)			
	Cattle	Buffaloes	Oxen	Goats
	ns	x	ns	xx
0.1-2.5	112	114		130
2.5-5.0	112	105	109	130
5.0-7.5	107	106	109	134
> 7.5	105	106	107	127
Pooled se	3	2	2	2

1. Means estimated in GLM AoV models;
x, xx and xxx = F ratios for effect of livestock holding size significant at $p<0.05$, $p<0.01$ and $p<0.001$ respectively

3.3 The impact of feeding practices on livestock productivity

Estimates of the productivity of livestock were made for milk production of cattle and buffaloes. Only crude estimates of yields per adult cow or buffalo could be made from available data (without accounting for non-lactating animals in multiple cow holdings). However, milk yields estimated in this way differed between villages, being generally lower in Gajuri Chhap, Gauthale and Ange (maximum 2.5 l/day) than in Chankhubesi and Tawari (maximum 8 l/day), and changed as expected through seasons.

Associations of feeding and milk yields were initially investigated by multiple regression analyses over all villages and seasons. Yields were positively related to the amounts of total feeds and concentrates offered to both cattle and buffaloes ($p<0.05$). For cattle, milk yields were also associated with the amounts and proportions of cut grass in feeds ($p<0.05$). In multi-factor AoV models (as described in section 2.2), however, analyses including the crude protein content (g/kg DM) of diets as a linear covariate did not find consistently significant associations with yields (though the relationship approached significance for cattle ($b=0.013$, $p=0.06$).

4 Conclusions

4.1 Species differences in feed offer rates and diet quality

Feed amounts offered, and the composition and qualities of diets differed between species in ways which might be expected on theoretical grounds. Thus feed offer rates were higher to goats and lower to buffaloes and oxen (though note the limitations of assumptions of liveweights and DM contents of feeds in these data). Overall average feed offer rates were within reasonable ranges given the common practice of feeding in excess of expected intakes to allow refusals of poorer feeds to contribute to bedding and compost. Feed consumption rates (daily DM intakes as a

percentage of liveweight) are commonly in the range of 2.0 to 4.5% for bovines and 2.5-5% for goats, depending on the composition of diets offered, and ages and productive states of animals. The highest average daily feed DM offer rates in Tawari amounted to 4.0, 5.5% and 5.2% of liveweights of oxen, cattle and buffaloes. Observations from milking cows in Eastern Nepal fed diets similar to those reported in this survey showed recorded feed intake rates of 4.5 to 5.5% (Subba, Thorne, Walker, Wood and Sinclair (2000). The survey data thus appear to provide a reasonably realistic estimate of feed offer rates and diet composition.

Diet compositions also differed as might be expected between species (notably for goats with lower proportions of crop residues and cut grass and higher proportions of tree fodders). However, significant differences were also noted between cattle, buffaloes and oxen, mainly due to differences in the amounts of grazing. Oxen grazed most and were offered lower amounts (and proportions) of higher quality collected fodders. Diets of buffaloes were generally of the lowest average quality, due to higher proportions of crop residues. It is interesting to note that the simple survey procedure adopted was able to detect these differences.

4.2 Seasonal and village factors affecting diet composition and quality

The amounts and composition of feeds allocated to livestock clearly differed between villages and seasons in line with the patterns of feed resource availability shown by Hendy et al (2000). Feed offer rates (kg DM/head/day) and total nutrients offered (g CP/head/day) for cattle, buffaloes and oxen were generally highest in Tawari and lowest in Ange. Late dry season reductions in offer rates of total feeds and nutrients were evident for all types of livestock and in all villages. However, the degree of dry season reduction in nutrient supply varied between villages and types of livestock. This was due to markedly different seasonal patterns of average diet quality between villages (seen for all types of livestock). Nutrient contents were highest in all seasons in Gajuri Chhap and Gauthale (due to the aseasonal availability of grazing and high proportions of tree fodder in dry season diets). Nutrient contents were seasonally variable in Chankhubesi and Tawari (low in the mid-late dry season due to greater dependence on crop residues and lower proportions of dry season green fodders). In contrast in Ange, nutrient contents remained relatively low throughout the year but were lowest during the mid-rains to early dry season (due to a relative lack of cut grass).

In combination, the contrasting patterns of total feed dry matter availability and nutrient contents resulted in relatively higher dry season supplies of total nutrients for cattle and oxen in Tawari, Gajuri Chhap and Gauthale than in Chankhubesi and Ange. The relative advantages of the former villages were due to grazing in Gajuri Chhap and Gauthale but to relatively high total feed offer rates in Tawari (where livestock holdings were small and livestock to land ratios high). The contribution of grazing to this pattern is illustrated in the seasonal nutrient supplies to buffaloes (which did not graze). Dry season total nutrient supply was markedly reduced even in Gajuri Chhap and Gauthale (where, despite high quality feeds, high livestock holdings resulted in low total feed offer rates). Only in Tawari, with both high total feed offer rates and

high dry season tree fodder availability, were dry season nutrient supplies maintained to buffaloes.

Household circumstances of household size, land holdings and livestock holdings size also affected feed amounts and composition. Amounts of feeds offered tended to increase with larger households, larger land holdings and smaller livestock holdings. Amounts of higher quality feeds (either grazing, cut grass or tree fodders) also tended to increase with these factors though effects on diet composition and nutrient contents were not always significant.

Limitations of the descriptions of diets derived from the present survey should be noted. Seasonal diets are based on only six observations per year, and are averages of diets applied to all mature and immature animals of each livestock type. Diets may actually vary more frequently than this for specific animals depending on current status (dry, lactating, growing, working etc). Discussions with farmers suggest that some alterations in diets for such reasons do occur, though the scope for this is limited (except for the use of concentrates).

4.3 The impact of grazing

Apart from village and seasonal effects, grazing had the most impact on diets of cattle and oxen. Feed offer rates appeared similar for both grazing and non-grazing animals but feed compositions differed, with a higher proportion of better quality feeds (especially the sum of grazing and cut grass) for grazing animals. These differences resulted in improved average nutrient contents and greater amounts of nutrients offered under grazing. The method of estimation of grazing fodder supply adopted in the survey should be noted, however, relying on farmer estimates of the amounts of fodder collection replaced by grazing. These estimates appear reasonable but are untested.

4.4 Requirements to improve the quantity and quality of feeds offered

The results of the survey suggest that both the quantity and quality of feeds offered to animals need to be improved under different circumstances. While the amounts of feed DM and nutrients offered generally appeared to decline in the mid-late dry season, and would require supplementation, this was not the case for all types of livestock in all villages. For example, indigenous cattle at typical local levels of production in Gajuri Chhap, Gauthale and Tawari (particularly those grazing), and indigenous buffaloes in Tawari would not require much dry season supplementation. By contrast, all types of stock in Chankhubesi and Ange require additional feeds in the dry season. In situations such as in Ange, with generally low feed and nutrient offer rates, supplementation is required all year round.

However, the quality of feeds offered is low in many circumstances, except perhaps for goats (though the protein degradability characteristics of the high tree fodder diets of goats need to be checked). Selection by animals from offered feeds may allow

actual intakes to be of higher quality, but the scope for such increases is limited (offer rates are not grossly higher than anticipated intake requirements and the variation in quality within some types of offered feeds may not be marked). The basis for estimating nutrient contents of feeds in these survey data should also be noted, relying on limited reports of nutritive values and with no estimates of seasonal variations in quality. These limitations are, however, more likely to result in over-estimation of current feed values, especially in dry seasons, than in under-estimation.

This implies the need for increased allocations of higher quality feeds for most classes of livestock, especially milking cows and fattening immatures, thus substituting some of the poorer quality crop residue feeds. Some diet improvements are required even to raise productivity within the relatively low potential of indigenous livestock breeds. Diets of crossbred cattle producing milk for sale, as in Chankhubesi, are also currently inadequate for improved productivity (despite higher use of concentrates). Farmers often report health, reproduction and survival problems for higher grade cattle on unimproved diets.

4.5 Approaches to identification of feed requirements

Identification of the specific requirements to improve the amounts and composition of feeds offered is best carried out with reference to particular groups of animals taking account of current feeding and production objectives. The descriptions of average diets, as in these survey data, nevertheless illustrate several important points to consider in planning to improve livestock feeding. Firstly, there are different overall seasonal patterns of feed availability and quality, depending on the types of resources available in villages (as noted in section 4.2 above). The priorities for the types of extra feeds required vary somewhat between these patterns.

Secondly, seasonal differences in diet composition result in four basic types of diets provided to animals at different times of the year or by households in different resource circumstances. These may be described as diets based alternatively on grazing, crop residues, cut grass or tree fodders (these being major constituents and being associated with overall diet quality). The requirements to improve the feeding of animals differ to some extent between these diet types. Thus, cattle currently fed diets high in crop residues and cut grass may require high quality protein supplements (such as available from leguminous fodder trees and oil seed cake concentrates), while those on diets already high in tree fodders may require some substitution of these (and crop residues) with cut grass or stored dried grass.

Further, seasonal changes in the composition of diets may mean that more than one approach to improving diets is needed in individual households. Finally, improvements in diets are likely to require changes in the supply of more than one component (it is unlikely that changes in tree fodder availability alone will be adequate). Requirements to supplement these different diets will also depend on the nature of the protein content of diets, particularly the amounts of rumen degradable or non-degradable protein. Diets already containing high proportions of tree fodders may still require supplementation with feeds providing rumen-degradable protein because of the binding of protein by tannins in some tree fodders. Further analysis of

the protein quality of supplementary fodders may be required, or utilisation of local farmers' knowledge of nutrient qualities (as described by Thorne, Walker, Subba and Sinclair, 2000)

It is hoped that improved understanding of the current fodder supply circumstances and production objectives of households will help to develop improved approaches to diagnosing requirements for extra feeds on farms. Starting from knowledge of basic diet compositions as described above, and production objectives for particular animals, and noting the circumstances and options of households to improve fodder supplies, it should be possible to develop simple methods of estimating requirements for improving diets which could be applied by extension services in the field.

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Figure 1 Total feed dry matter offered per day to different types of livestock by seasons

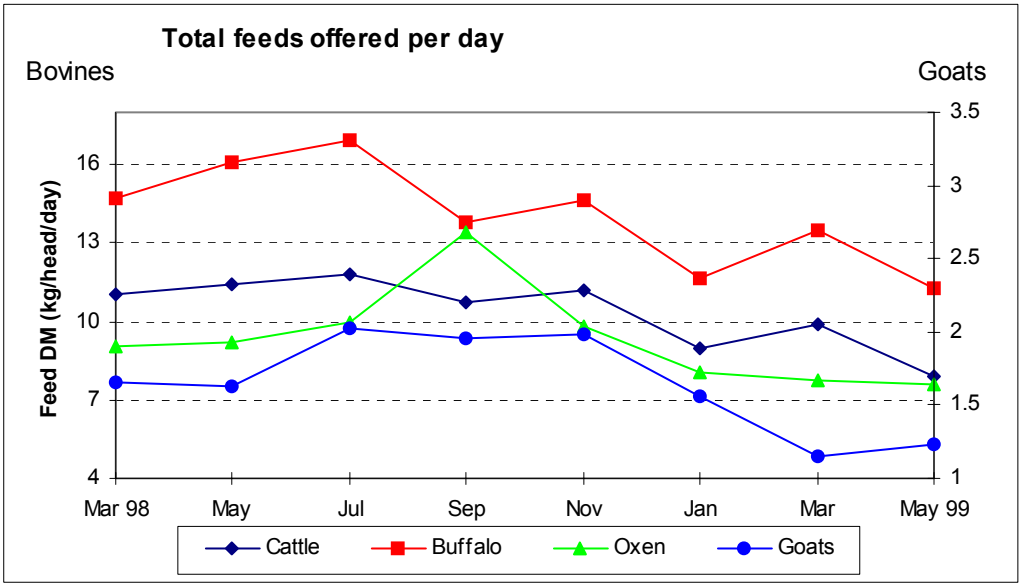
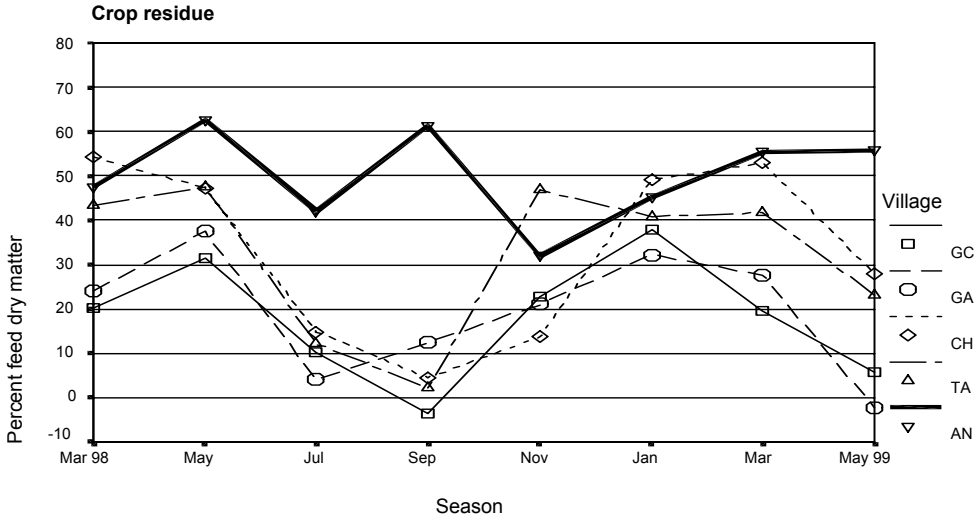
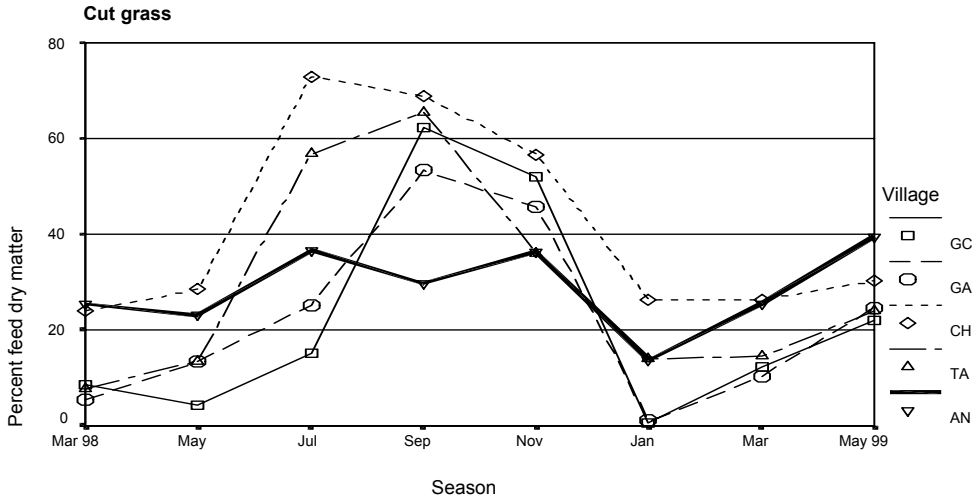


Figure 2 Seasonal patterns of diet composition for cattle in different survey villages





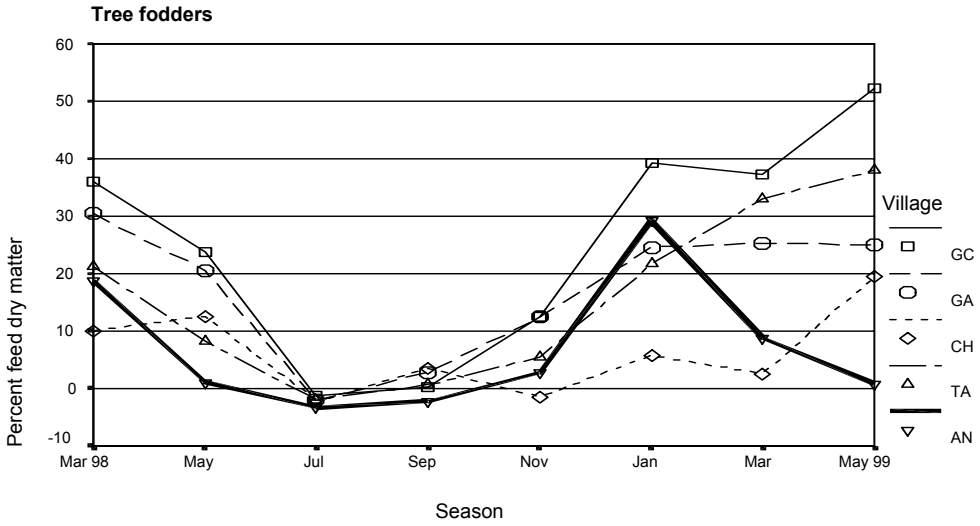


Figure 3 Seasonal amounts of feeds dry matter offered to different livestock types in survey villages

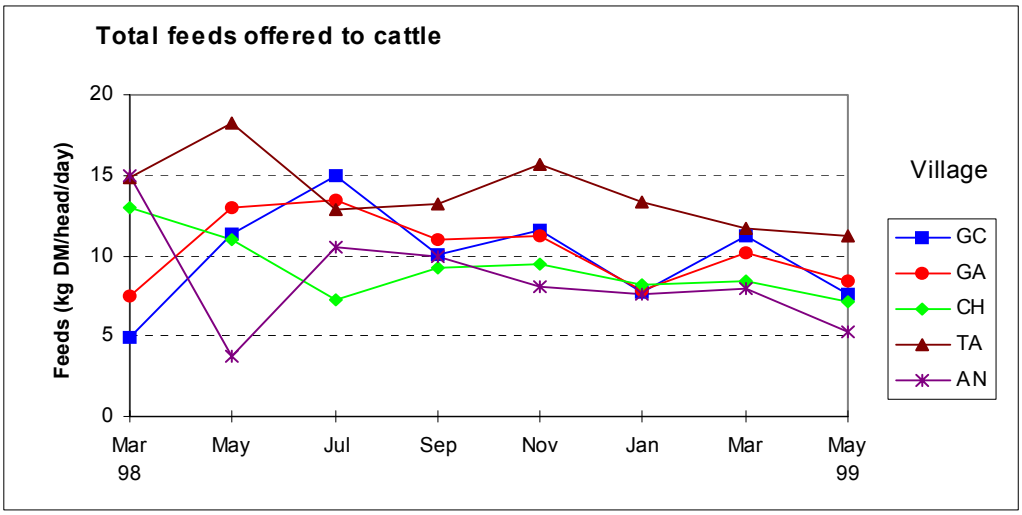


Figure 4 Annual average amounts of feeds offered and diet composition for different livestock types in survey villages

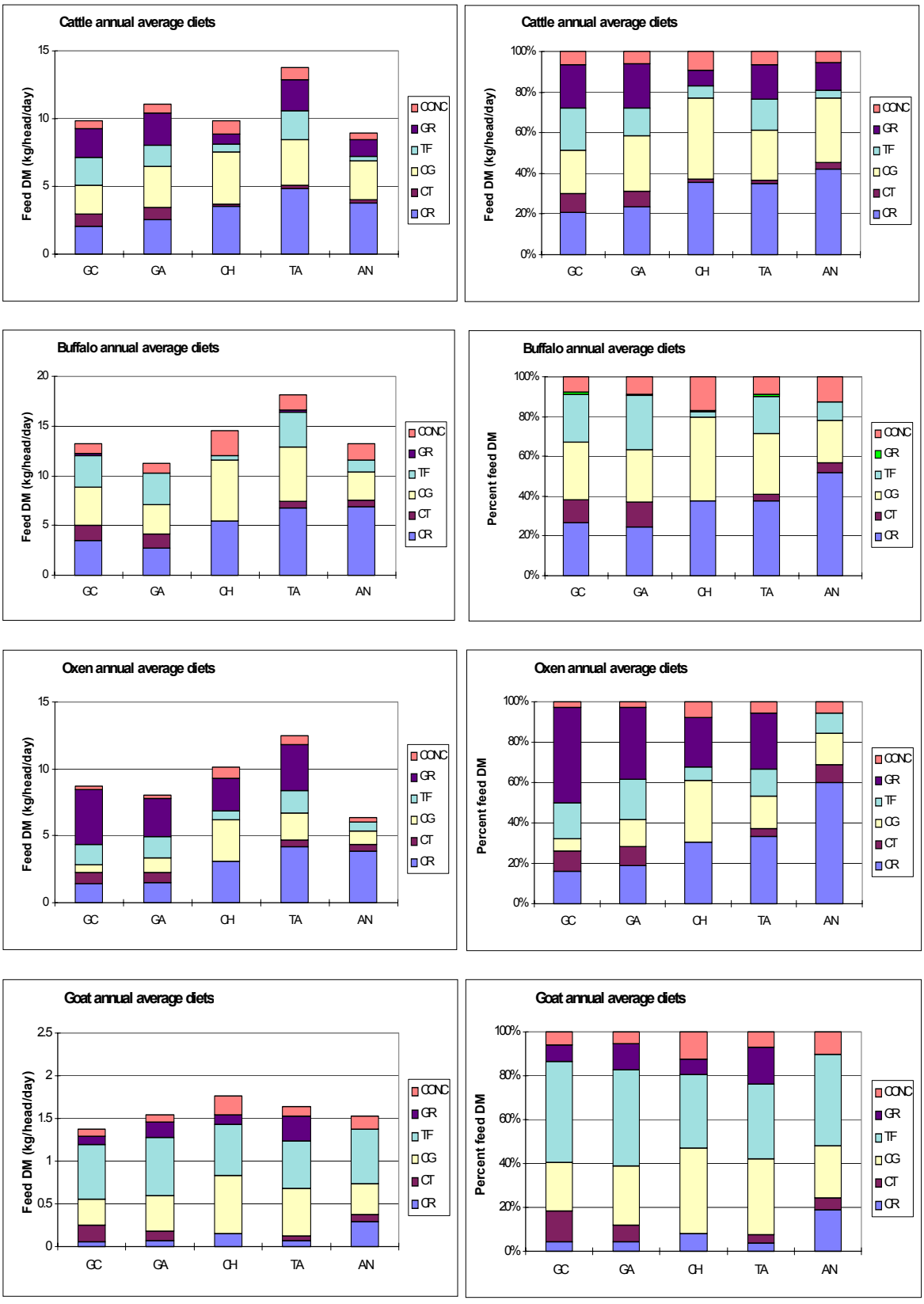


Figure 5a Seasonal diet compositions for cattle and buffaloes in different survey villages

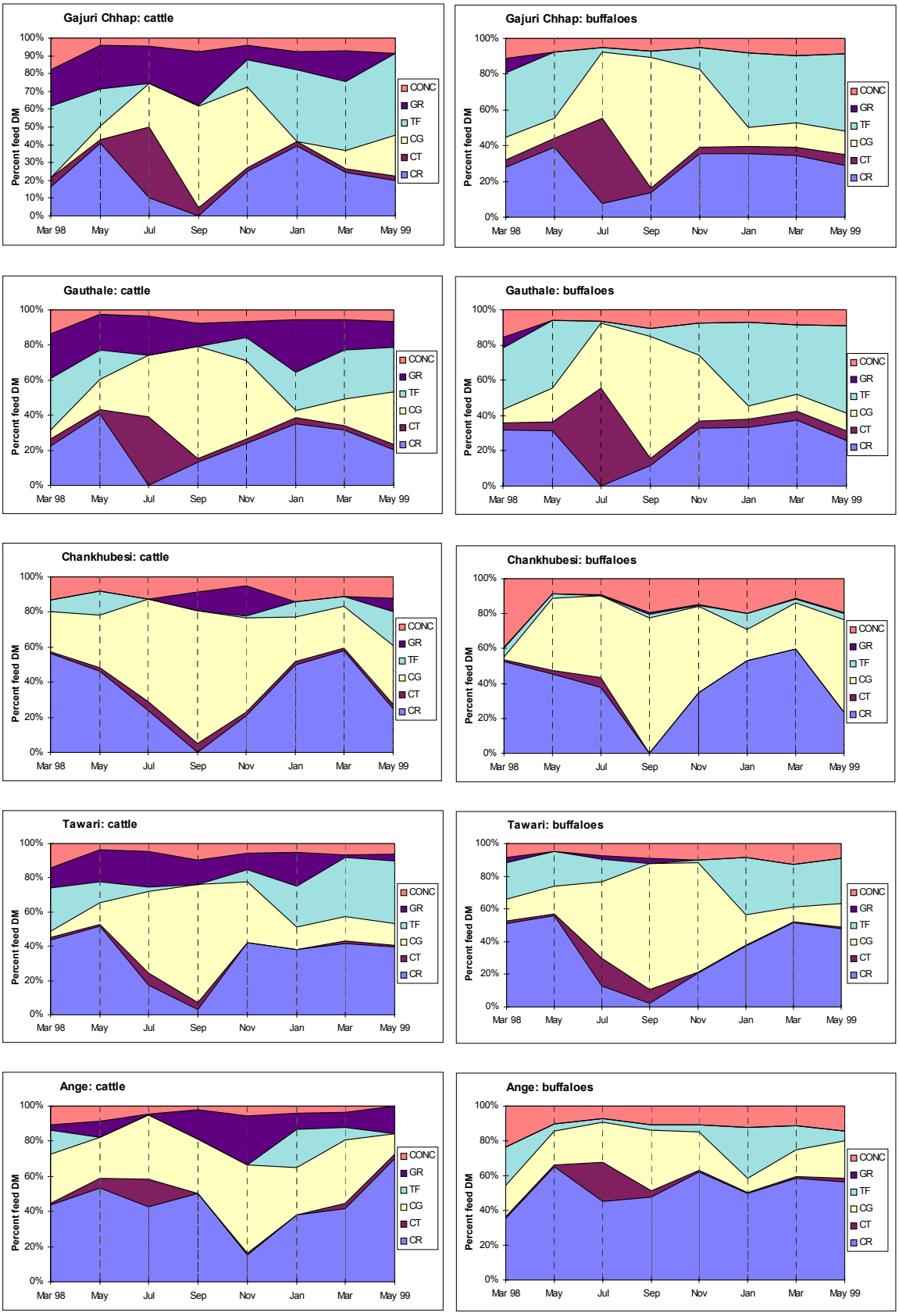


Figure 5b Seasonal diet compositions for oxen and goats in different survey villages

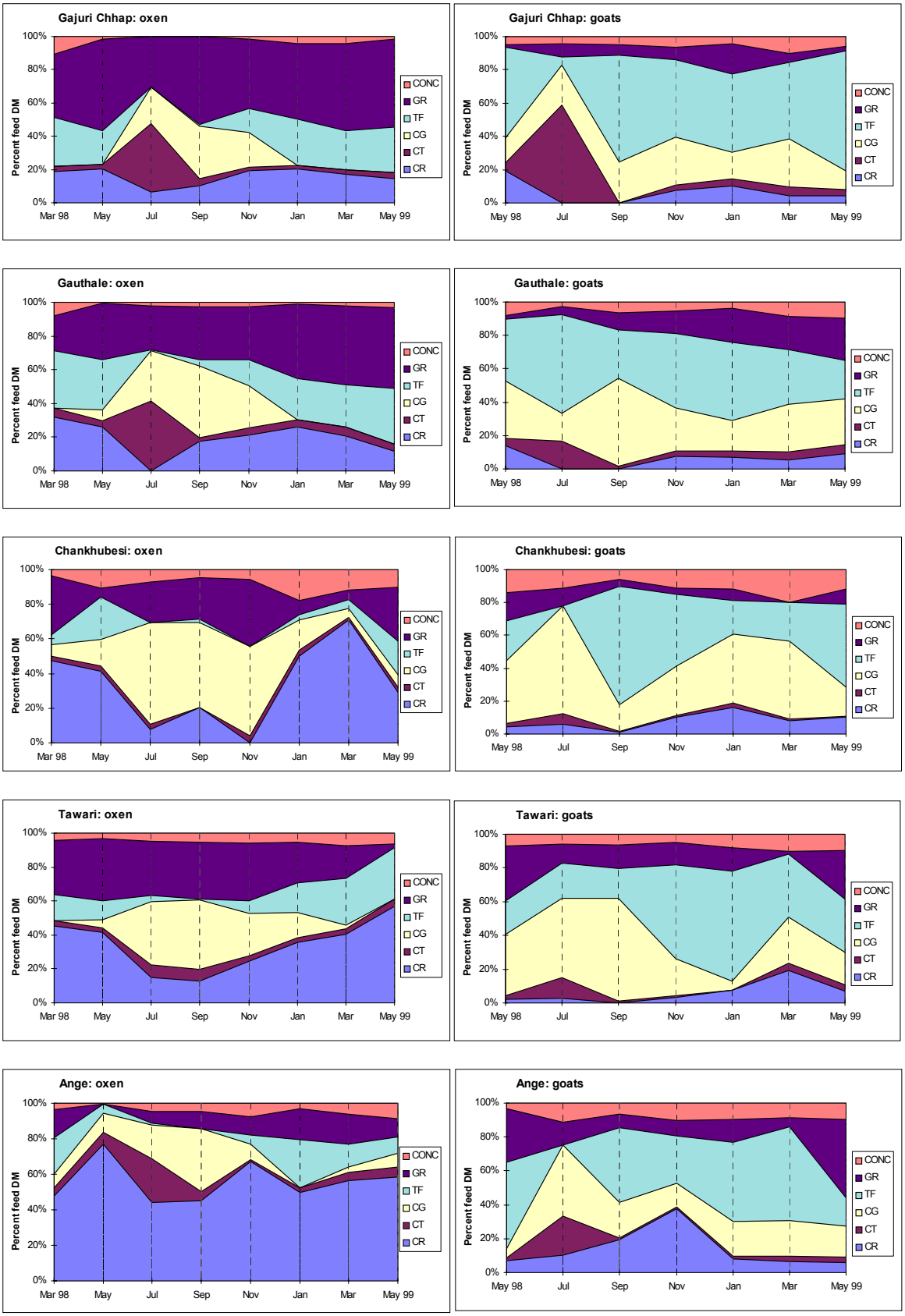


Figure 6 Total crude protein supply and content of feeds offered seasonally to cattle and buffaloes in different villages

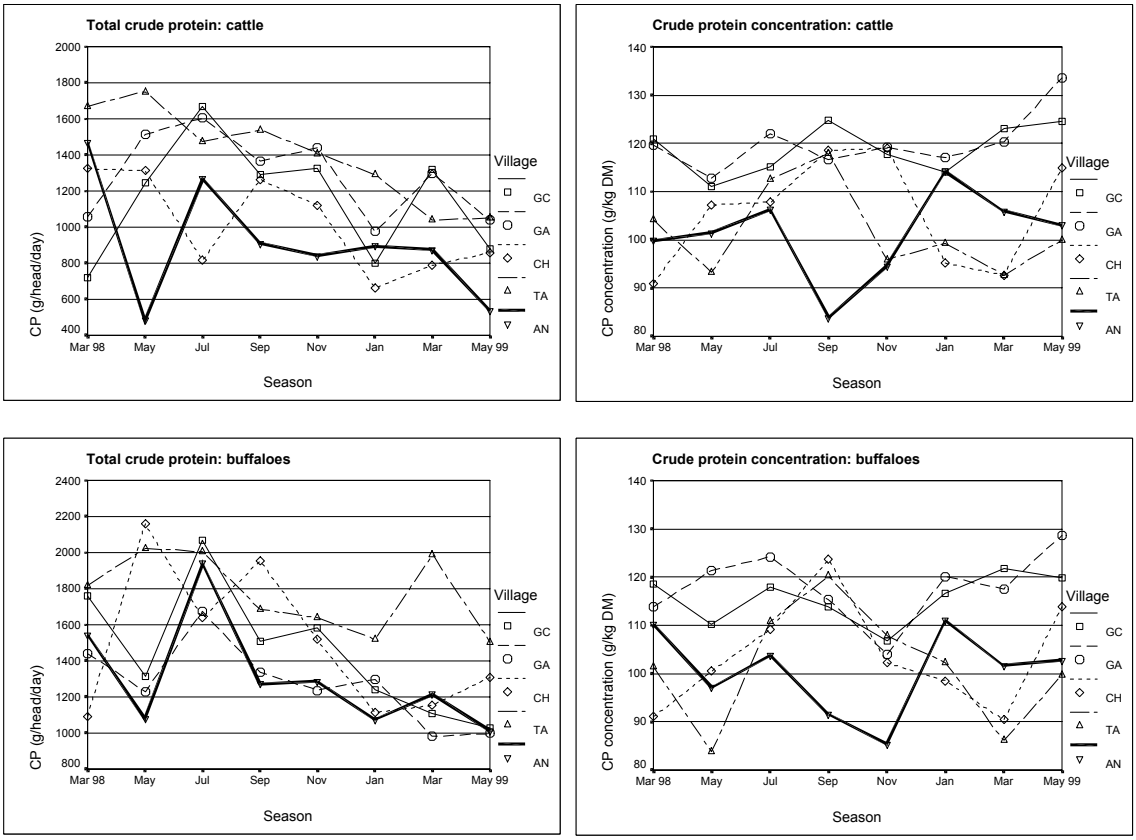


Figure 8 Seasonal changes in crude protein content of diets of grazing or non-grazing cattle