Seasonal patterns of livestock feed collection and deficits for 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 objectives of the survey were to describe the seasonal patterns of feed collection, deficits and allocation to different livestock, with as much quantification as possible but without complex and costly recording, weighing, and data handling procedures. At the same time the survey should involve useful discussion with farmers about feed needs at different times of year as a basis for jointly determining the requirements for additional feed resources on farms.

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 10-30 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, feed allocation to each type of livestock, 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 expected seasonal patterns of feed collection were evident, with higher collections of cut grass and grazing fodder in the rainy season and of tree fodders and crop residues in the dry season. Fodder collection was positively associated with land holdings, tree holdings and household size (labour availability), as well as with livestock holdings (though collection rates were not sufficient for the larger livestock holdings). The quality of feeds collected was higher for households in villages where grazing was practised. Three different seasonal patterns of nutrient collection and contents were noted between villages, with higher and less seasonal collection in Gajuri Chhap and Gauthale, more seasonal collection (low in the dry season) in Chankhubesi and Tawari, and low collection in the rainy season in Ange. Most households reported deficits of fodders in the dry season, and in some circumstances through the rainy as well. Understanding household circumstances with regard to all factors affecting feed availability will help to define the most appropriate feed development interventions.

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 zone of Nepal.

Livestock are a crucial component of the hill farming system in Nepal. They contribute to household subsistence and incomes, draught power and the recycling of nutrients essential for the fertilisation of cultivated land. Traditionally, communal grazing areas and off-farm fodder resources have been important for feeding livestock. Increasing pressures on land, together with changing access rights to some communal resources, have led to a decrease in the availability of off-farm fodder resources and the loss or closing of grazing. Households have to rely increasingly on farm-produced fodders, including poorer quality crop residues. Seasonal feed shortages are becoming more severe, particularly for higher quality feeds, and farmers report this as limiting livestock holdings and productivity in many areas. Poorer community members are especially affected by these constraints because of their limited land holdings and lower capacity to produce or purchase supplementary feeds and chemical fertilisers.

A preliminary aim of the project is to identify the major factors affecting the availability and demand for fodders, and to describe fodder utilisation in order to identify feeding constraints and requirements. While some research is available to describe seasonal patterns of fodder availability (at least qualitatively, see for example Neopane, Gatenby and Chemjong, 1990 and Van der Grinten, 1997), there is much less quantitative understanding of the interplay of the many factors that may affect fodder availability and requirements. Improved understanding of these factors may help to better identify the fodder constraints and requirements of farmers in different circumstances, as well as to improve the design and conduct of field survey methods to diagnose additional fodder needs.

This paper reports the results of simple field surveys with farmers to describe seasonal and village resource factors affecting fodder collection and deficits. A companion paper (Vickers, Hendy, Chhetri, Basukala, Kharel, Regmi and Kiff, 2000) describes the sources of fodders on- and off-farm, and the effects of household factors on fodder collection. Hendy, Vickers, Chhetri, Basukala, Kharel, Regmi and Kiff (2000) describe the factors affecting the allocation of fodders to different livestock types and holdings.

2 Methods

2.1 Field survey methods

Surveys of fodder collection and allocation to livestock by households were conducted over a 14-month period from March 1998 to May 1999. A simple survey method was devised to be conducted by repeat interviews with farmers to provide as much quantification as possible but without complex and costly recording, weighing, and data handling procedures. Details of the methods are provided in an interim report of the project (Hendy, Vickers, Chhetri and Basukala, 1999) and summarised below.

Surveys were carried out in five villages in the mid-hills zone of central Nepal, selected to represent different circumstances with respect to altitude, access to markets and the mix of land and livestock holdings maintained by households. These are summarised in Table 1.

Table 1 Locations and characteristics of villages selected for fodder research work

	Gajuri Chhap (GC)	**Gauthale (GA)**	**Chan-khubesi (CH)**	**Tawari (TA)**	**Ange (AN)**
District	Dhading	Dhading	Kavre	Sindhu-palchok	Kavre
Altitude (masl) (1)	Low	Low	Mid	Mid	High
Access to markets (2)	Close	Distant	Close	Distant	Distant

1. Low = <1000m, mid = 1000-1500m, high = >1500m
2. Close = < 1hr walk, distant = >1 hr walk

Ten households were selected in each village to take part in the surveys, through group consultation with farmers to identify the key factors determining fodder demand and supply. Key factors were identified as (1) livestock holdings and ratios to land holdings, (2) the mix of irrigated and dryland land holdings (khet and bari land respectively), and (3) the production objectives of livestock keepers (in particular whether milk production for sale from cows or buffaloes was practised). Other factors peculiar to specific communities and locations were also identified, including the ethnic group of farmers, access to grazing resources, access to forest or other common property sources of fodders, and the general wealth of households. Households were selected to cover the range of these factors as far as possible in each village (see Hendy et al 1999 for details).

During the survey year, data were collected on land holdings, tree holdings, household size, labour availability and constraints for fodder collection in a series of single visit surveys and farm visits. Fodder and livestock information was collected in surveys at two-monthly intervals from March 1998 to May 1999 conducted by interview with

the household members directly involved in livestock feeding. This information included the reported daily collection of fodders of different types (in local measures, bhari, doka and muta). Fodder types were distinguished as crop residues, crop thinnings, cut grass and tree fodders. For each of these types, the amounts of fodder derived from on- or off-farm sources was reported, and the contributions of specific crops, grasses or trees were estimated as percentages of the total amounts collected. Estimates of the amounts of fodder derived from grazing were obtained by recording the daily duration (hours) of grazing and the estimated amounts of cut-grass fodder that would have had to be collected if animals had not been grazing. Given that most grazing households practise systems of mixed grazing and stall-feeding there seemed to be little difficulty in interpreting and reporting this information. Regression analysis showed a generally close linear relationship between the amounts of reported grazing (converted to livestock unit hours) and the estimates of grazing fodder collection. Finally estimates of the daily availability of different types of concentrates were reported.

At the same time as reporting fodder collection, farmers were asked to consider their current shortages of fodders (if any). Shortages (deficits) were estimated for each fodder type (again in local measures) in relation to the amounts required to maintain all livestock in good condition and to allow locally expected levels of productivity. This provided an estimate of the degree of sufficiency of current fodder collection and a means to estimate the total requirements for fodders from the farmers' perspective.

Information was also collected on the daily allocation of feeds to different types of livestock (as reported by Hendy et al 2000).

Livestock information collected in the two-monthly surveys included the current holdings of different species, sexes and ages of animals, estimates of household total daily production and sales of milk, monthly production and sales of ghee, and bi-monthly sales of animals. In addition, households reported the current seasonal ranking of their main objectives in the feeding of livestock (amongst milk production, calf survival, manure production, ghee production, and maintenance/survival).

2.2 Preparation and analysis of data

Data on fodder collection were converted to dry matter using the results of sample weighings of local measures and literature information. Further corrections were estimated for the proportions of collected materials not regarded as potential fodder (eg tree branches and crop stover stems) in order to estimate the amounts of feeds collected and available for allocation to animals. Estimates of nutrients collected were made using nutritive values reported in the literature (see Kiff, Thorne, Pandit, Thomas and Amatya, 1999) and the species compositions of the collected fodders where possible. (If nutritive value information was not available for specific fodders, average values for the category of fodder were used, eg for crop residues or tree fodders). Information on the allocation of feeds to animals was checked to ensure that these were within realistic bounds, providing extra confidence that the reported amounts of fodders collected were sensible as well as a prompt for checking back with farmers and the raw data sets. For final analyses, 12 cases out of 400 (3%) were

discarded as unexplainably high levels of 'fodder collection per livestock unit' (more than three times the standard deviation above the mean).

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). During preliminary analyses a wide range of factors was tested for associations with fodder collection variables. Factors most associated included village and season, household size, livestock holdings and composition, land holdings and composition, and production objectives (particularly for milk sales). Other factors affecting fodder collection included the practice of grazing (or not). Although there was some co-association of household size, land holdings and livestock holdings, the degree of independence was sufficient to allow testing of these effects separately in the same analysis models. Analyses reported in this paper were finally conducted by GLM AoV procedures in SPSS, with fixed factors of village, season, household size, livestock unit holdings and land holdings (the latter three factors each classified into four levels). Covariate factors of the percentage of khet land in total land holdings, the percentage of cattle livestock units in the total livestock unit holding and the amount of milk sales were included in the model to take some account of these factors. Grazing was included as a fixed factor in separate reduced analyses without village interactions as the practice of grazing was to some extent associated with village. Parallel analyses were conducted for key variables by multiple regression analyses in Genstat with all factors as continuous independent factors except village, season and grazing. Significance levels of factors were similar in the two analyses.

3 Results

3.1 Characterisation of survey villages and households

Villages differed in several aspects of land and livestock holdings, access to fodder resources and the practice of grazing, as illustrated in Table 2. Total land holdings were much the highest in Gajuri Chhap and smallest in Chankhubesi and Ange, though Ange had the highest proportion of khet (bunded irrigated land). A relatively low proportion of households had khet land in Chankhubesi and Tawari.

Livestock holdings were highest in Gauthale and Gajuri Chhap and lowest in Chankhubesi. Importantly, the former villages retained most access to off-farm grazing land. Most households in all villages kept goats. Holdings of other livestock types were variable between villages. Only in Gajuri Chhap and Gauthale did many households keep both cattle and buffaloes; in other villages, households tended to hold either one or the other (cattle in Chankhubesi and buffaloes in Tawari and Ange). Most households in Gajuri Chhap and Gauthale also kept oxen compared with relatively few households in Chankhubesi, Tawari and Ange. Most cattle in Chankhubesi were crossbreds of mixed grades producing milk for sale to a local milk collection centre. A milk collection centre opened near Tawari during the survey year (July 1998).

The practise of grazing differed between villages. Most households in Gajuri Chhap and Gauthale grazed some animals but few households in Chankhubesi and Ange.

Table 2 Land and livestock holdings by households in survey villages

	Gajuri Chhap	Gauthale	Chan-khubesi	Tawari	Ange
Household size					
Average persons	6.6	7.9	5.2	6.3	6.3
Land holdings					
Total land (ro) (1)	23.7	13.4	11.6	16.5	12.3
H'holds with khet (%)	90	80	50	50	100
Khet land % total	17	12	14	8	52
Trees on farm (n)	49	31	36	18	29
Livestock holdings					
Livestock units (2)	7.4	7.7	3.3	4.1	5.0
LU/land ropani (2)	0.32	0.63	0.31	0.26	0.48
Cattle %LU	29	12	53	20	17
Buffalo %LU	35	42	23	46	58
Households grazing (%) (3)	75	80	40	62	27

1. Average land holdings in Ropani (20 ro/ha)
2. One Livestock unit (LU) = one adult indigenous cow of 250 kg (buffalo = 1.5 LU, oxen 1.2, goats 0.1 LU) (after Pradhan 1987); crossbreds 1.2 times indigenous species LUs
3. Households reporting any type of animal grazing in any season (converse = no animals ever grazing)

3.2 Village and seasonal patterns of fodder collection

3.2.1 Amounts of fodders collected

The amounts and composition of fodders collected by households clearly differed between villages and seasons (effects generally significant at $p<0.001$), as illustrated in Figure 1.

Overall, the expected seasonal pattern of higher total fodder availability in the rainy and early dry seasons (July to November surveys) was evident. Crop residues and tree fodders were generally most available or collected in the dry seasons, and crop thinnings and cut grass in the rainy and early dry season. Fodder collection by grazing continued through the year but differed significantly between villages ($p<0.001$, with households in Gajuri Chhap and Gauthale grazing most and those in Ange least).

Seasonal patterns of fodder collection differed somewhat between villages (interaction effects were significant for all fodder types at $p<0.05$). In Ange, crop residues were collected (or used) throughout the year, with much purchased for use in the rainy and early dry season period due to the relative shortages of cut grass, crop thinnings and

grazing at that time. Households in Gajuri Chhap and Gauthale collected less crop residues than in other villages, but showed more marked seasonal variations and higher peak collections of tree fodders. Households in Chankhubesi and Ange collected less tree fodders and did not increase collections markedly in the dry season.

3.2.2 Composition of collected fodders

These patterns of fodder collection resulted in significant differences between villages and seasons in compositions of fodders available for households, as shown in Table 3 and Figure 2. Most notable was the very high proportion of crop residues in collected fodders in Ange. Compositions were similar in Gajuri Chhap and Gauthale and in Chankhubesi and Tawari. These compositions have implications for the amounts of nutrients and the nutrient density of collected fodders, as discussed in section 3.6, and for livestock diets as presented in Hendy et al (2000).

Table 3 Average daily amounts and composition of fodders collected in survey villages (1)

	Gajuri Chhap	Gauthale	Chan-khubesi	Tawari	Ange
Amounts of fodders collected (kg DM/day)					
Total fodder	40	49	35	44	28
Total fodder per LU (2)	8.0	5.6	8.5	10.5	7.1
Composition of fodder (% total)					
Crop residues	16	21	32	29	49
Crop thinnings	9	6	0	3	3
Cut grass	16	16	39	26	33
Tree fodders	35	33	19	27	10
Grazing	25	26	10	15	8

1. Means estimated over all seasons and other factors in GLM AoV models; village effects highly significant ($p<0.001$)
2. Fodder dry matter collected per livestock unit per day

The specific composition of broad categories of feeds collected was determined for crop residues and tree fodders, since components of these differ to some extent in nutritive values. Crop residues included the dry post-harvest residues of many crops, principally the straws of rice (48% of total residues) and wheat (3%), and stovers of maize (24%) and millet (6%). Maize cob sheaths provided a further 12% of crop residue fodders. A small amount of vegetable crop waste and by-product was also available in Chankhubesi. The mix of residues available differed significantly between villages, as shown in Table 4. In most villages, rice and maize provided most residues. In Ange, millet replaced much of the maize while in Tawari there was relatively less rice and maize cobs were an important source of feeds.

Table 4 Average annual composition of crop residue fodders used in different villages

Crop residue	Percentage of total crop residue fodder provided by different crops within villages (1)				
	GC	GA	CH	TA	AN
Rice straw	53	45	51	27	65
Wheat straw	3	0	5	5	4
Maize cob	3	11	14	25	6
Maize stover	26	31	21	33	8
Millet stover	0	0	5	10	16
Legume haulm	6	8	1	4	0
Veg residues	0	0	2	0	0

1. GC = Gajuri Chhap; GA = Gauthale; CH = Chankhubesi; TA = Tawari and AN = Ange

Over 40 different species of trees provided fodder across the survey villages. The most commonly used species were Khanyu, (16% of collected tree fodder overall), Timila (9%), Kutmiro (8%), Dudhilo (8%), Gogan (7%), Tanki (6%), Sal (4%), Bakhre (4%), Sajh (4%) and Pati (3%). Khanyu was notable as the only tree species used in all villages. Villages differed in the relative importance of these species, and in the numbers of species available, as summarised in Table 5. While households in Gajuri Chhap and Gauthale used about 40 different species, those in Ange had access to only seven (and only three species accounted for over 90% of the tree fodder used).

Table 5 Average annual composition of tree fodders used in different villages

Tree species		Percentage of total tree fodder provided by different species within villages				
		GC	GA	CH	TA	AN
Khanyu	*Ficus semicordata*	30	11	6	2	30
Timila	*Ficus auriculata*			15	29	
Kutmiro	*Litsea monopetala*	7		21		42
Dudhilo	*Ficus neriifolia*				31	
Gogan	*Sauraria nepalensis*				28	
Tanki	*Bauhinia purpurea*	17	5			
Sal	*Shorea robusta*		12			
Bakhre	*Spermadictyan suaveolens*	6	7			
Sajh	*Terminalia alata*		8			
Pati	*Buddleia asiatica*			9		22
Others		40%	57%	49%	10%	6%
Total number of species used		39	41	28	20	7

1. GC = Gajuri Chhap; GA = Gauthale; CH = Chankhubesi; TA = Tawari and AN = Ange

The composition of cut grass also differed between villages and by seasons, including a wide range of grasses and herbs, but was too varied to characterise. While households attempted to collect fresh green material in each season, the DM and nutrient contents probably changed with season, though this was not measured in these data.

For concentrates, three major types were distinguished in the survey; dutto (rice bran), pit (maize bran, often with wheat and/or barley brans) and pinna (oilseed cakes). Concentrate use was reported either in dry weights (kg), or dry weights converted from local volume measures (such as mana). These concentrates were actually commonly fed in wet form mixed with water. Pittu may be cooked with water, then called 'kundo'. Various mixes of cooked concentrates with chopped tree leaves and salt were fed in different households. Concentrates were both home produced and purchased (as in Chankhubesi). Purchased concentrates were mainly locally available milling brans but some commercially mixed dairy concentrates were purchased in Chankhubesi.

3.3 Farm resource factors affecting fodder collection

Village differences in the amounts of fodders collected were partly due to access to off-farm resources, as discussed by Vickers *et al* (2000). Farm resources also affected the ability to produce fodders (though the amounts collected are also determined by need). Home production of fodders was estimated by calculating household annual total collections of on-farm crop residues, cut grass and tree fodders. Table 6 shows these totals for households with different holdings of bari and khet land. The amounts of crop residue collected increased with khet land holdings (p=0.06), particularly for households with low bari holdings. The latter observation was mainly due to high collections of crop residues from the khet lands in Ange (where need was also greatest).

Table 6 Annual total collection of on-farm fodders by households with different land holdings

	Annual total collection on-farm ('000 kg DM)				**Significance of effects (2)**	
	Khet land holdings (ropani)				**Bari**	**Khet**
Bari land	0	0-5	>5	Overall	**land**	**land**
Crop residues						
1-6	2.8	2.7	6.9	3.3	ns	p=0.06
6-12	2.5	4.3	5.8	4.2		
>12	2.4	2.9	4.0	2.9		
Overall	2.6	3.5	5.3	3.5		
Cut grass						
1-6	2.9	2.8	2.7	2.8	ns	xx
6-12	3.0	4.7	3.0	4.0		
>12	3.8	3.6	5.6	4.1		
Overall	3.3	3.9	4.0	3.7		
Tree fodder						
0-6	1.5	1.5	1.2	1.5	xx	ns
6-12	1.4	2.6	1.3	2.0		
>12	2.0	3.0	4.4	2.9		
Overall	1.7	2.4	2.6	2.2		

1. Means estimated over all seasons and other factors in GLM AoV models,
x, xx and xxx effects significant at $p<0.05$, $p<0.01$ and $p<0.001$ respectively; ns = not significant

Availability of cut grass increased with both bari and khet land holdings (though significantly only with khet), households with both large bari and large khet holdings collecting most. Amounts of tree fodders collected increased most with increases in bari land holdings (most trees on farms occurring on bari land). However, there appeared to be some increase with larger khet land holdings amongst households with the most bari land (though this interaction was not significant).

3.4 The availability of concentrates

Overall, concentrates contributed about 6% of the total feeds dry matter collected, about 2.6 kg concentrates per household per day. The availability of concentrates differed significantly between villages (as shown in Table 7), with more available in Chankhubesi, Tawari and Ange than in other villages.

Table 7 The availability of concentrate supplements in survey villages (1)

	Gajuri Chhap	Gauthale	Chan-khubesi	Tawari	Ange
Concentrates available					
(kg DM/day)	1.7	1.9	3.8	3.2	2.5
(kg DM/LU/day)	0.4	0.3	1.1	0.7	0.5
(% total feeds DM)	5.6	4.2	11.5	6.2	7.0

1. Means estimated over all seasons and other factors in GLM AoV models; village effect significant ($p<0.001$) for all variables
2. Combining all types of concentrate mixes

The amounts of concentrates available were similar through all seasons and not related to household size or land holdings. Availability increased in households with larger livestock holdings but not sufficiently to maintain concentrate availability per livestock unit which declined with larger holdings. Other factors associated with the availability of concentrates included the percentage of khet land in total land-holdings and the amounts of milk sales by the household. Total concentrate utilisation by households increased with both these factors, as shown in Table 8.

Table 8 Associations of household land and livestock holding composition and livestock production objectives with the amounts of concentrates available (1)

	Covariate regression coefficients and (significance) (1)	
Factor	**Total concentrates**	**Concentrates per LU**
Khet % total land	0.02 (*)	0.005 (*)
Cattle % LU	-0.003	-0.002
Milk sales	0.49 (***)	0.10 (***)

1. Linear covariate effects estimated in GLM AoV models with main effects of village, season, household size, livestock holding and land holding
*, ** and *** regression coefficients significantly different from 0 at $p<0.05$, 0.01 and 0.001 respectively

The former association was due to the utilisation of concentrates to supplement high crop residue diets, as in Ange. Households selling milk relied heavily on concentrates (as shown in Hendy *et al* 2000).

In addition, the use of concentrate feeds was related to grazing, being greater in households not grazing. The origin of this association may be an attempt by non-grazing households to compensate for lower total fodder availability (as in Ange), or may be because of the practice of stall-feeding cattle and buffaloes for milk production (as in Chankhubesi and Tawari).

3.5 Nutrient composition of collected fodder

As an indication of the overall nutritive values of collected fodders, the contents of crude protein, crude fibre and metabolisable energy were estimated as described in section 2.2. The total amounts of nutrients collected showed similar seasonal patterns to that of total fodders, rising through the rainy and early dry seasons, as shown in Figure 3. Villages differed significantly ($p<0.001$) both in the total amounts of nutrients collected and in collection rates per livestock unit, as shown in Table 9. Nutrient collection per LU was greatest in Tawari and Chankhubesi (partly because of greater concentrate availability in the latter) and least in Gauthale and Ange (because of the high livestock holdings in Gauthale and the low quality of feeds collected in Ange).

Table 9 Nutrients collected and nutrient contents over all collected feeds in survey villages (1)

	Gajuri Chhap	Gauthale	Chan-khubesi	Tawari	Ange
Nutrients collected (total)					
Crude protein (g/day)	4637	4630	4276	5483	2620
ME (MJ/day)	357	355	342	466	216
Nutrients per LU (2)					
Crude protein (g/LU/day)	939	715	1090	1181	776
ME (MJ/LU/day)	69.4	53.9	87.7	100.5	64.6
Nutrient in feeds (2)					
Crude protein (g/kg DM)	121	127	116	110	108
ME (MJ/kg DM)	8.95	9.68	9.27	9.41	8.62
Nutrient in fodders (3)					
Crude protein (g/kg DM)	121	127	108	106	106
ME (MJ/kg DM)	9.2	9.4	8.5	9.2	8.2

1. Means estimated over seasons May 98 to May 99 and other factors in GLM AoV models; village effects significant ($p<0.01$) for all variables except ME concentration ($p=0.06$)
2. Nutrient collection and concentrations estimated over all feeds including concentrates
3. Nutrient concentrations estimated over fodders only

The quality of fodders collected was highest in Gajuri Chhap and Gauthale, with higher proportions of grazing and lower proportions of crop residues collected than in other villages. Seasonal patterns of fodder quality differed between villages

(interaction of season x village significant at $p<0.01$). Thus nutrient content of collected fodders was relatively aseasonal in Gajuri Chhap and Gauthale but more seasonally variable in Chankhubesi and Tawari. In Ange, collection of nutrients per LU was lowest in the rainy season because of high dependence on crop residues and low collections of cut grass at that time.

Nutrient availability was related to livestock holdings in the same way as fodder collection (lower availability at higher holding sizes, $p<0.001$). Neither household size nor land holdings were significantly associated with nutrient contents in collected feeds or with collection rates per LU, though trends were evident consistent with their effects on the composition of collected fodders, as described by Vickers *et al* (2000). Grazing was a significant factor, however. Households reporting grazing collected fodders of higher average quality and collected more nutrients per LU than those not grazing ($p<0.01$).

3.6 Fodder deficits and total fodder requirements

At the same time as reporting fodder collection, households reported their estimated deficits of each type of fodder in each season. The sum of reported deficits plus collections provided some estimate of total feed requirements for different households.

3.6.1 Reported fodder deficits

A high proportion of households (0.76) reported deficits of some fodder, with similar proportions in all villages (Table 10). Over 90% of households reported deficits in the late dry seasons compared to only 21% in September. Overall, a higher proportion of households reported deficits of tree fodders than of other fodders (0.62 compared to 0.52 for cut-grass and 0.49 for crop residues).

Deficits were most commonly reported in the late dry season, as is commonly expected (see Figure 4). Nevertheless, a substantial proportion of households reported deficits from the early dry season, particularly in villages with larger livestock holdings (Gajuri Chhap and Gauthale). Also, in all villages but Chankhubesi and Tawari, at least 20% of households reported shortages through the rainy season (July and September surveys). Village, season and interaction effects were all significant, suggesting that seasonal patterns of reporting of deficits varied between locations.

Analyses of household factors associated with the reporting of deficits showed few consistent trends. Only the smallest households (<3 persons) appeared more likely to report fodder deficits (>90% cf <75%, $p=0.08$,). Only those households with the lowest livestock holdings (<2.5 LU) or highest land holdings (>24 ropani) appeared less likely to report deficits (72% vs 76-84% for households with larger livestock holdings and 61% vs 74-87% for those with smaller land holdings respectively, though these differences were not statistically significant). Grazing households were more likely to report fodder deficits than those not grazing (83% cf 73%, $p<0.05$), possibly because they also had the largest livestock holdings.

Table 10 Percentage of households reporting deficits of fodder, amounts of deficits and estimated fodder requirements in survey villages

	Sig. (1)	Gajuri Chhap	Gauthale	Chan-khubesi	Tawari	Ange
Households reporting deficits (%) (2)	ns	82	82	78	74	75
Fodder deficits (3) (kg DM/day)						
Total fodder deficit	ns	24.2	25.6	17.5	20.8	22.2
Fodder deficit per LU	ns	3.9	3.7	4.4	4.5	5.9
Deficit % of collection	-	49	66	52	43	83

1. Means estimated over all seasons and other factors in GLM AoV;
x, xx and xxx = F ratios for village effect significant at $p<0.05$, 0.01 and 0.001 respectively (ns = not significant)
2. Households reporting some deficit of any fodder (converse = households never reporting deficits of any fodder
3. Deficit amounts calculated over all households, including those not reporting deficits

The amounts of deficits reported by households were very variable. Reviews during the survey suggested that interpretations of the question differed somewhat between interviewers and households, particularly in the early surveys which appeared to over-estimate deficits. Nevertheless some expected trends were observed in the data, such as seasonal effects. Over all fodders, deficits reported by households averaged 22 kg DM per day (4.5 kg DM/LU per day). Differences between villages were generally not significant, though reported deficits (per LU) appeared least in Gajuri Chhap and Gauthale (Table 10). Deficits per LU appeared highest in Ange, which also had the lowest fodder collection and poorest nutrient contents in collected fodders (cf Tables 3 and 10). Deficits ranged from 43% of reported fodder collection in Tawari to 83% in Ange, these representing the average amounts of additional feeds required in the different villages (from the farmers' perspective).

The seasonal pattern of deficits was, as expected, larger in the late dry seasons and lower through the rains and early dry season, as illustrated in Figure 5. Deficits were still reported in the July survey, early in the rainy season (though large deficits reported from Ange at that time are probably over-estimates since most households coincidentally reported high collections of fodders). Nevertheless it still appeared that deficits in July were higher from households and villages not grazing (relying on collected fodder) and lower in Gajuri Chhap and Gauthale where more animals grazed. Village x season interaction effects were highly significant ($p<0.001$), confirming the differences of seasonal patterns between villages.

The seasonal composition of deficits partly reflected the fodders available when deficits were reported (see Figure 6). Reported deficits of crop residue were higher in the dry seasons. Deficits of cut-grass and tree fodder were less seasonal.

Otherwise, deficits per LU were consistently (but not significantly) greater in smaller households, as might be expected if fodder collection was constrained by labour availability. Deficits per LU were significantly greater in households with smaller livestock holdings ($p<0.01$). Households with larger holdings thus had both lower

fodder availability and lower reported deficits. The reason for this apparently perverse association is not clear. It may be due to under-estimation of fodder needs in larger livestock holdings but could also be due to differences in the composition of livestock holdings (larger holdings had a higher proportion of oxen and smaller holdings a higher proportion of goats, the latter having a higher feed requirement per LU than the former).

3.6.2 Estimated fodder deficits

Fodder deficits may also be estimated from the survey data by an alternative method, by estimating the amounts of fodders collected by households reporting either 'none' or 'some' deficits of fodder (as shown in Table 11).

Table 11 Amounts of fodders collected by households reporting fodder deficits or not in survey villages (1)

		Fodder amounts (kg DM/LU/day)				
	Deficit (2)	**Gajuri Chhap**	**Gauthale**	**Chan-khubesi**	**Tawari**	**Ange**
Total fodder collected	No	6.46	7.71	9.56	10.9	10.0
	Yes	6.22	5.89	6.99	9.90	7.03
Apparent fodder deficit		0.24	1.82	2.57	1.0	2.97

1. Means estimated over all seasons and other factors in GLM AoV models, adjusted for unequal sub-class representation amongst effects; village effect significant at $p<0.01$; deficit effect significant at $p<0.05$; interaction not significant
2. Yes = households reporting some deficit of some fodder (converse = households not reporting deficits of any fodder)

Over all fodders, households collected significantly more fodder if they reported no deficits (8.92 cf 7.21 kg DM/LU/day, $p<0.05$). The difference, or apparent deficit, (1.71 kg DM/LU/day) was smaller than the amounts of deficits actually reported by households. Apparent deficits estimated in this way were largest in Ange, Chankhubesi and Gauthale, a pattern which fits better with reported collection rates in these villages (see Table 3) than the reported deficit amounts shown in Table 10.

3.6.3 Estimated fodder requirements

The sum of fodder collection and deficits provides a measure of total fodder requirements under local circumstances. These are shown in Table 12 for each village, calculated on the basis of the alternative methods for estimating deficits. Based on the amounts of deficits reported by households, overall average fodder requirements were estimated at 12.7 kg DM/LU/day (for the given mix of livestock species and fodders available). Based on the differences between households with and without deficits, total feed requirements averaged 10.5 kg DM/LU/day.

Table 12 Average daily requirements for fodders estimated from reported and calculated amounts of fodder deficits

	Gajuri Chhap	Gauthale	Chan-khubesi	Tawari	Ange
Estimates from reported deficits (1)					
Total fodder required	64	75	52	65	50
Fodder required per LU	11.9	9.4	12.9	15.0	13.0
Estimates from calculated deficits (2)					
Fodder required per LU	8.2	7.4	11.1	11.5	10.7

1. Estimated from sum of reported amounts of fodder collection and deficits for individual households
2. Estimated from the difference in reported amounts of collected fodders for households either reporting or not reporting fodder deficits

Seasonal and village differences in total feed requirements (estimated from the sum of collections and deficits for households) are shown in Figure 7. Seasonal and village differences in total feed requirements are reduced compared to differences in feed collection and deficits (as would be expected if households were able to accurately report these amounts). They are still variable in the period of the early surveys, however, but do not show any particular seasonal trends. The latter trends might be expected if seasonality of livestock production and feed demand was marked.

These methods provide only a crude estimate of total requirements, since actual requirements will depend on the species of livestock to be fed, production objectives and the mix of fodders available. Further comments on fodder requirements for individual species are made in the companion paper by Hendy et al (2000).

4 Conclusions

4.1 Fodder collection

Both the amounts and compositions of collected fodders differed between villages and seasons. Differences between villages were explained partly by differences in access to off-farm resources (these were less restricted in Gauthale and Gajuri Chhap than in other villages) but were also dependent on the types of farm land resources available. The latter also partly determined the mix of crop residues available, with more rice straw produced from khet land, and more maize and millet from bari land. Other differences between households and villages in the numbers, types and productivity of trees available on-farm will also affect tree fodder collection.

Apart from these effects, various household characteristics (labour availability, livestock holdings and land holdings) also influence the collection of some types of fodders (as reported by Vickers et al 2000).

Factors affecting the amounts and composition of fodders collected also affected the nutrient contents of fodders. Three seasonal patterns of fodder collection and nutrient contents were apparent. In Gajuri Chhap and Gauthale, there was greater continuity in feed and nutrient supplies across seasons than in other villages, probably mainly due to the high contribution of grazing. In Chankhubesi and Tawari a more seasonal pattern of fodder composition and nutrient contents was evident, with seasonally high collections of cut grass making a major contribution. In Ange, with restricted availability of cut grass (perhaps because of low land holdings, high intensity of cultivation on available khet, and lack of off-farm sources), fodder and nutrient supplies were restricted during the normal peak supply periods in the rains and early dry seasons.

The method for estimating the amounts of fodder provided by grazing appeared reasonable (grazing and non-grazing households appeared to collect similar amounts of total fodders per livestock unit, though the composition and quality of fodders collected was different). It should be noted, however, that estimates of nutrient contents of collected feeds were dependent on a limited range of estimates of nutritive values of fodders and did not account for seasonal variations in these. This may result particularly in the over-estimation of nutrient contributions by grazing and cut grass in the later dry season periods (though households do attempt to find green fodders at these times).

4.2 Estimation of fodder deficits and requirements

According to reports by households, large deficits of fodders were noted in most households and villages. Deficit amounts were reported as between 42 % (in Tawari) and 83% (in Ange) of current fodder collection rates, implying requirements to increase production of fodders by these amounts. However, there are indications from discussions with farmers, as well as from inconsistencies in the data (such as large deficits reported at the same time as large collections of fodders) that reported deficits may be over-estimates of actual needs in the early surveys. Further analyses with selected data may provide better estimates of deficits and total feed requirements in different circumstances.

Alternative approaches to estimating deficits by difference between the amounts of fodders collected by households with and without deficits result in lower estimates ranging from 3% of current fodder collection (in Gajuri Chhap) to 41% (in Ange). These estimates are also difficult to interpret because they are derived from differences between different households. Households may report that they are short of fodder in a variety of different circumstances (ranging from large livestock holdings by small households, even with low production objectives, to small livestock holdings with high production objectives). This method may therefore under-estimate deficits, though total feed requirements calculated on this basis appear reasonable in relation to expected feed offer rates.

Both methods of estimating deficits suffer from the difficulties of interpretation of feed needs under different livestock production objectives. They also probably do not take adequate account of the special requirements to supply particular feeds to improve the present diets of animals. The estimates of the amounts of total feeds

required per livestock unit should thus be interpreted with care and should not be used uncritically as an estimate of needs.

A better method of discussing feed deficits with farmers will be required. It is suggested in the paper by Kiff et al (2000) that this should be derived from discussions about the feed needs of specific groups of livestock. The method used in the survey, to ask about deficits in relation to the amounts of each fodder collected, may not provide sufficient focus for reliable responses.

Reports of the seasonal timing of the occurrence of deficits may have been more reliable than the amounts of deficits. If this is the case, then deficits were noted by most households in all seasons except July and September. Even in July, deficits were reported by most households in Tawari, Chankhubesi and Ange, on the grounds that cut grass production did not increase sufficiently until at least a month after the start of the rains. Thus, increases in fodder supplies may be needed for some households in most seasons, rather than only in the late dry season (though deficits were reported by almost all households at that time).

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Figure 1 Seasonal amounts of fodders collected in different villages

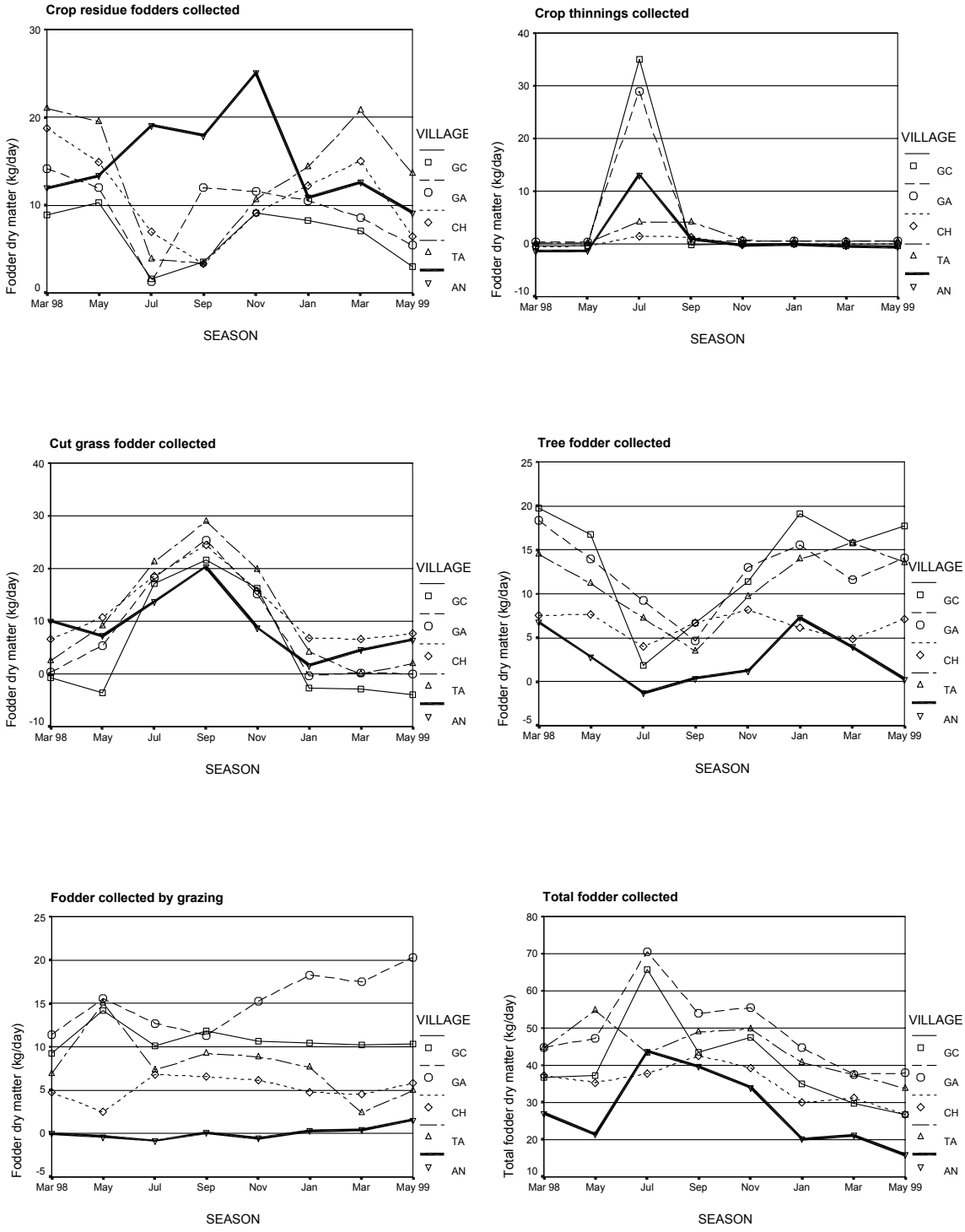

Figure 2 Composition of collected fodders in seasons and villages

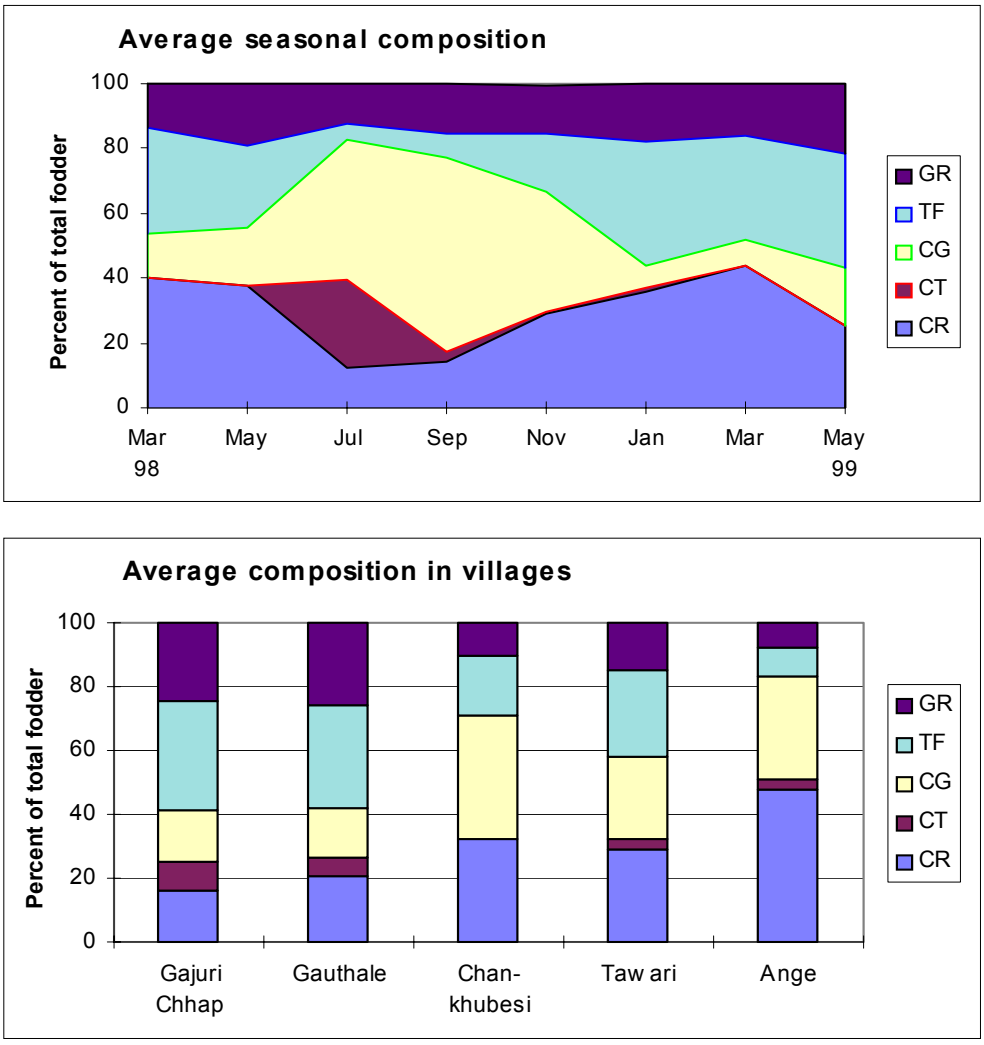

Figure 3 Seasonal crude protein collection and content in collected fodders

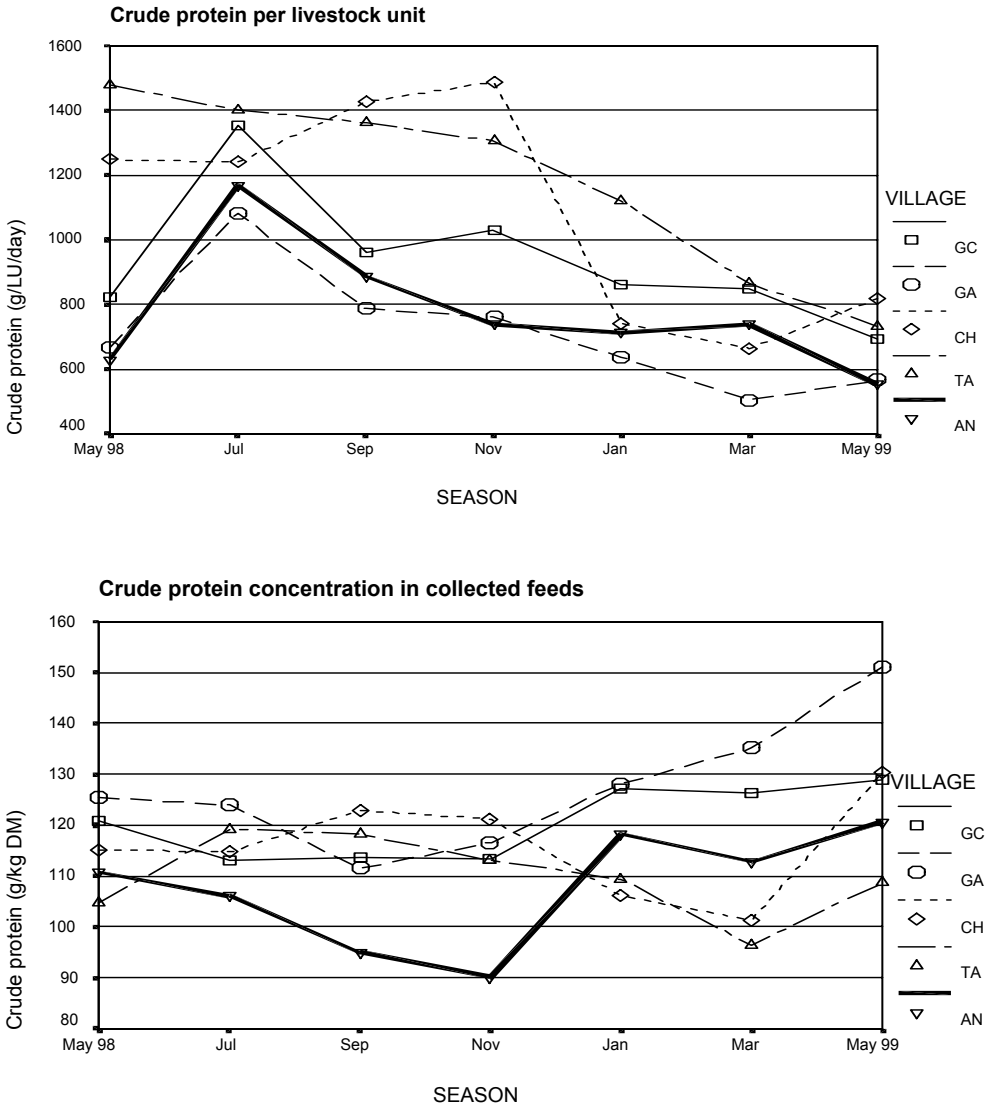

Figure 4 Seasonal proportions of households reporting shortages of some fodders in different villages

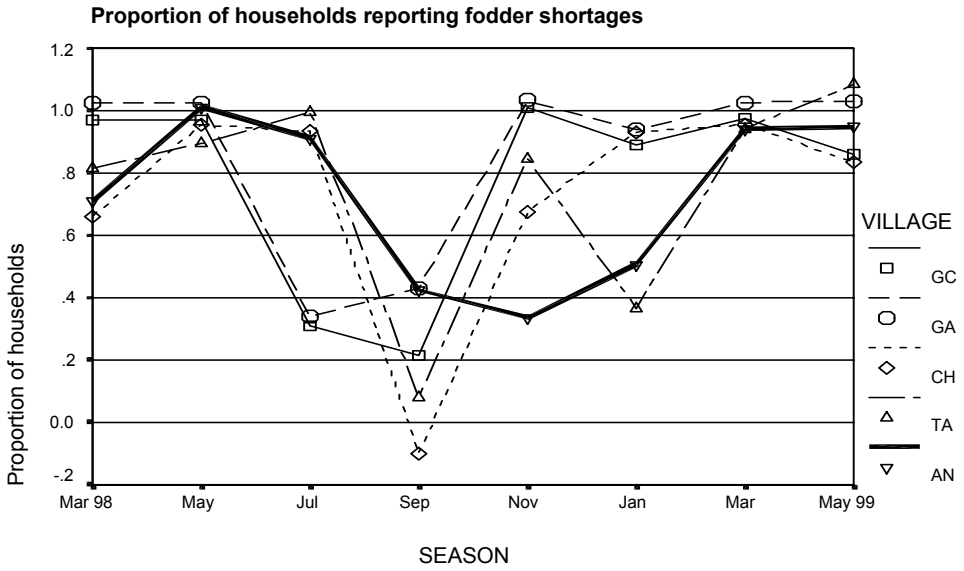

Figure 5 Amounts of seasonal fodder deficits in survey villages.

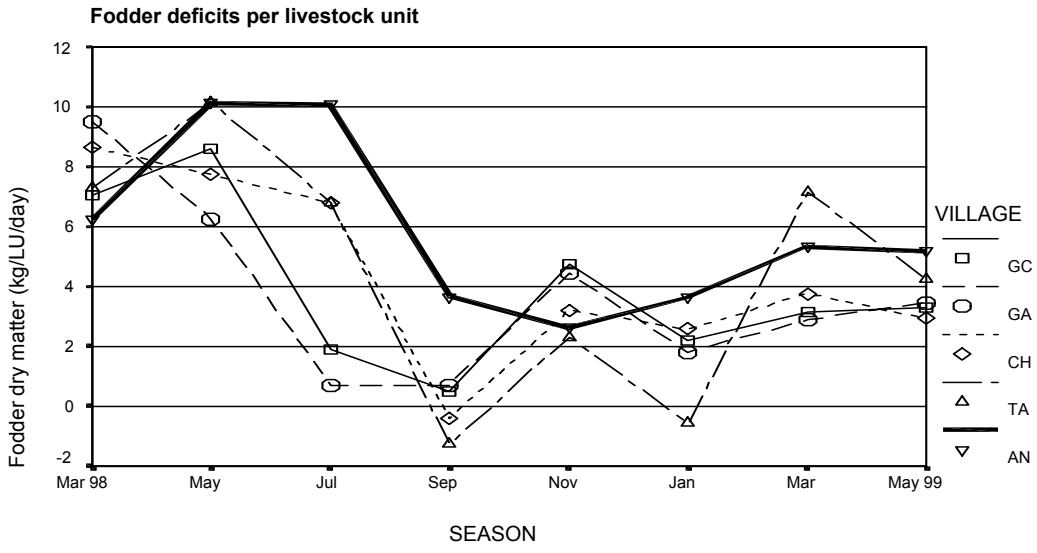

Figure 6 Seasonal amounts and composition of reported feed deficits

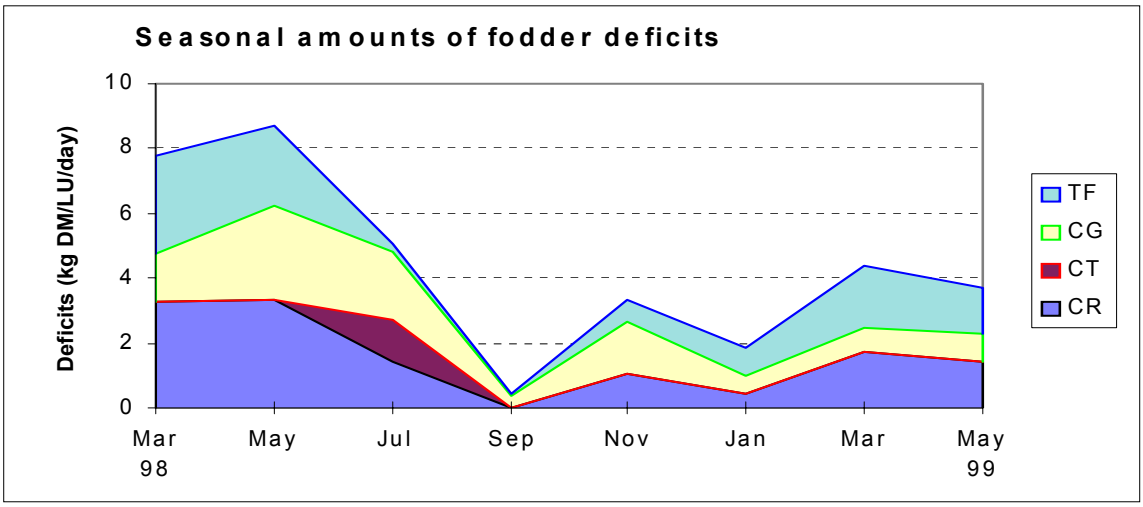

Figure 7 Seasonal total feed requirements per livestock unit estimated from the sum of collections and deficits reported by households in survey villages