FEEDING STRATEGIES IN SMALLHOLDER CROP-LIVESTOCK SYSTEMS

A CASE STUDY FROM NEPAL

A Final Technical Report on Work Conducted
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INTRODUCTION

Seasonal variation in the availability of resources poses significant difficulties for farmers planning productive and sustainable management strategies (Gill, 1991).

It may be argued that these are particularly acute in mixed farming systems. Their crop and livestock components exhibit a high degree of mutual inter-dependence but seasonal fluctuations in the "requirements" of one component are often not in phase with the availability of resources from the other. This problem is widely observed in one of the major factors linking crops and livestock in mixed farming systems - the formulation of feeding strategies for manipulating the supply and utilisation of feed resources. For example, in the Nepalese system which forms the basis for this case study, a period of high demand for work from draught animals occurs during the late dry season (May - June). At this time of year, there is little fresh green fodder available and the crop residues that have been used to sustain animals through the dry period are usually close to exhaustion.

Under these conditions, farmers require a sophisticated knowledge of patterns of feed availability and the responses of animals to fluctuating nutrient supplies in order to implement feeding strategies for optimum production and sustainability. It is surprising, therefore, that the issues relating to seasonality of feed supplies in crop-livestock systems have recieved scant attention. This would appear to be an essential prerequisite for the design of research to assist farmers in developing such feeding strategies. The seasonal nature of feed supplies and its consequences for animal maintenance and production has been documented for more extensive systems (e.g. Coppock *et al*, 1986a, b). Studies in crop-livestock systems (refs) have generally focussed on the preparation of feed budgets. These can provide a useful overview of seasonality in feed supplies and their utilisation. However, they tend to aggregate much of the variation that must be accounted for - by the farmer or the researcher - in the detailed planning of practical feeding strategies.

The farming systems of Nepal's middle hills (1100 - 1700 meters above sea level) exhibit a range of crop-livestock interactions that are, in many ways, representative of crop-livestock systems in general. Crop residues make a significant contribution to the nutrient intakes of animals at certain times of the year (ref); draught animal power is needed to sustain the level of cropping required (ref) and manure is

carefully husbanded for the maintenance of soil structure and fertility (ref). In general terms, this high level of integration allows an adequate level of production from land holdings of restricted size through the intensification of resource use within the system.

The study described in this report comprised a quantitative assessment of seasonality in the availability and utilisation of feed resources at the individual farm level in the crop-livestock system of the middle hills of Nepal. Sources of variation in feed availability and utilisation amongst farms were also examined.

MATERIALS AND METHODS

The 15-month, on-farm study described in this report was established in June, 1993 in the *Terathum* and *Dhankhuta* Districts of Eastern Nepal. Data collection was concentrated on the smallholder farms of the middle altitude range (1100 - 1700 metres above sea level) that exhibit a high degree of integration of crops and livestock (ref).

Stratification and Selection of Participating Farmers

The study was stratified and participating farmers were selected to encompass a range of circumstances of feed availability and utilisation so that some of the principal factors affecting the use of feed resources might be evaluated. The basic stratification was designed to allow the effects of site and the ethnic group of the farm household to be studied. The importance of these two factors was identified during a series of field visits and a static, farm characterisation survey (Thorne, 1993) that were conducted in preparation for the main study.

Site

The site stratum encapsulated variation due to the combined effects of a range of environmental and socio-economic factors. Interviews with farmers suggested that these factors would include water availability (from direct precipitation *and* from irrigation opportunities); soil stability and fertility; access to markets and past exposure to new technologies. The four sites that were selected for the study and their main contrasting features are described in Table 1.

Table 1: *The four study sites and their main distinguishing features*.

Site	Main features
Angdim	A relatively humid site with the best access to markets for milk and vegetables. Wide involvement in local research and extension programmes.
Ankhisalla	A dry area with limited access to markets for livestock an other products. Southern aspect of the ridge driest.
Jirikhimti (*Angbung*)	A humid site but with limited access to markets. Research-outreach activities at *Angbung* but *Jirikhimti* considered the more productive area by farmers.
Phakchamara	Dry but with marketing arrangements for milk established. On-farm site for livestock research.

Ethnicity

A number of cultural factors that, in general, affect the behaviour of the farm household and its capacity to farm effectively, influence its ability to feed and manage livestock (Abington, 1992). The basic importance of ethnicity in determining this behaviour was confirmed by individual interviews, conducted during the preparatory field visits, with farmers belonging to both of the main ethnic

Table 2: *Reasons given by farmers for differences in the farming activities of members of* Matawali *and* Bahun *ethnic groups.*

Matawali	*Bahun*
More time devoted to religious obligations	More innovative
Must sacrifice more animals for religious purposes	First to adopt new technologies
Religion limits disposal of animals	Better educated
Do not use land in an optimum manner	Have better land
Use more alcohol	Keep more animals
More dependent on crops	

Source: Thorne (1993)

divisions (*Matawali* and *Bahun*) living at the study sites. *Matawali* and *Bahun* farmers had consistent perceptions of the different opportunities open to and the relative prosperity of the two groups (Table

2). As these appeared to differ considerably in ways that were likely to affect the utilisation of feed resources, the ethnic division was included as the second major stratum within the study.

Demarcation of Seasons

Reports in the literature (refs), and the preparatory work undertaken with farmers, suggested that there would be distinct seasonal differences in patterns of feed use. On completion of the study, this could be confirmed by visual examination of data describing the types of feeds used on individual farms (e.g. Figure 1a).

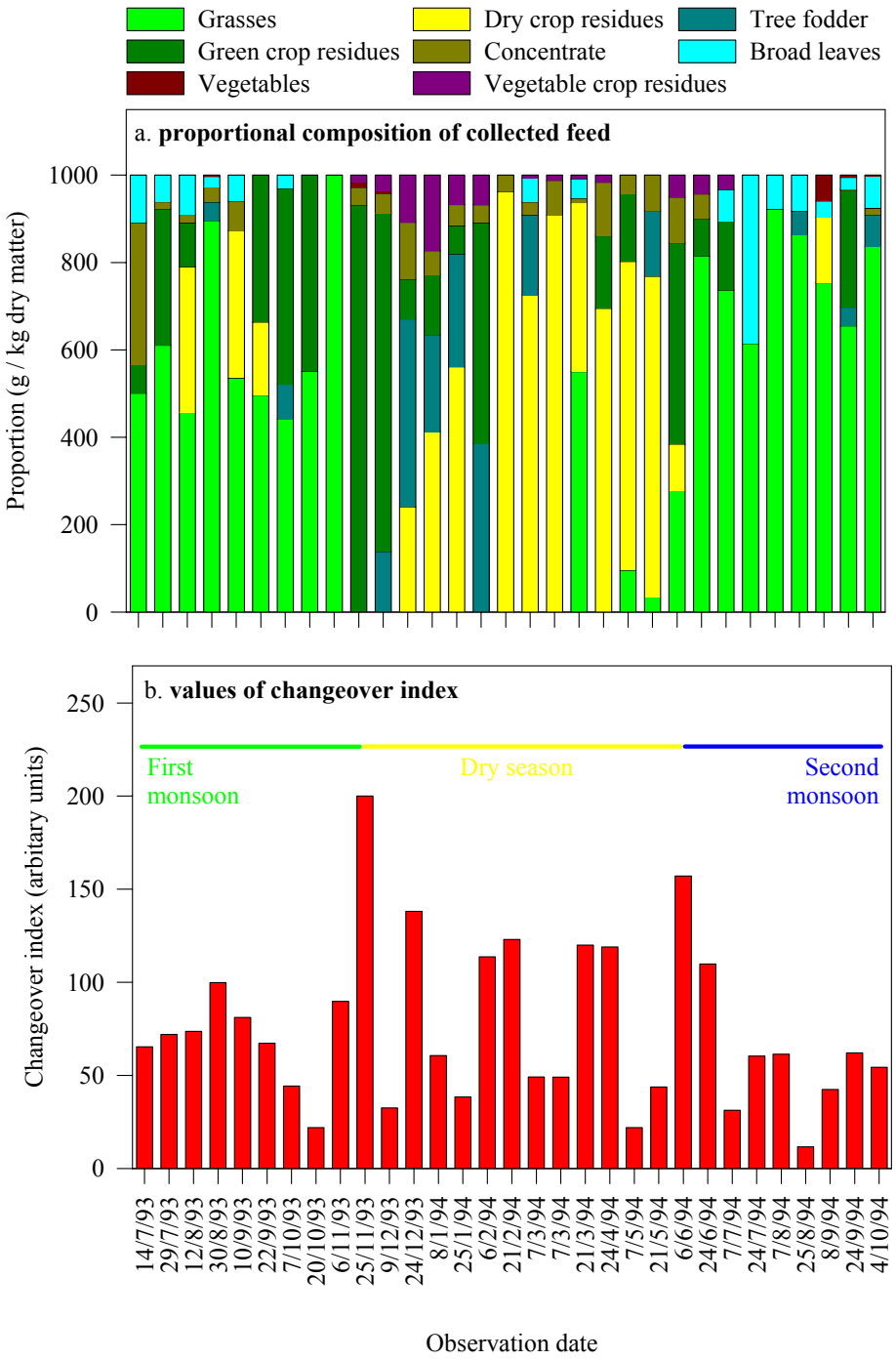
Broadly, the key feature of this seasonal change in feeding patterns was a switch from the use of feeding systems based on cut-and-carried grasses under monsoon conditions to crop residue-based diets during the dry season. In order to assist in accounting for the consequences of this seasonality for the utilisation of feed resources on the study farms, values of a changeover index (CI) were calculated for each monitoring visit to each farm:

$$CI = \sum_{(1 \,..\, n)} Q_{f,v} - Q_{f,v-1}$$

for feed types f = 1 .. n where $Q_{f,v}$ = quantity feed f offered during monitoring visit v

The CI was used to identify the points during the year which corresponded with the switch from the monsoon pattern of feed use to the dry season pattern and *vice versa*. The index aggregated changes in both the type and quantity of feeds used so that high values indicated the most marked changes in patterns of feed use which, it was surmised, would coincide with the seasonal changeover points in feeding patterns. The application of the CI in identifying changes in feeding patterns associated with seasons is illustrated in Figure 1b. The demarcation of seasons achieved by applying the CI to the data

Figure 1: *Example of seasonal patterns in the utilisation of cut-and-carried feed resources (*Chitra Bahadur Sunawar - Angdim*).*



for each farm was used to generate season (first monsoon *vs*. dry season *vs*. second monsoon) as a further, three-level factor for inclusion in the statistical analyses.

Participating Farmers

Thirty two farmers (eight from each site; 14 *Matawali* and 18 *Bahun*) agreed to participate in the study. During the fifteen months of data collection, three farmers (one from *Angdim*, one from *Jirikhimti* and one from *Phakchamara*) left their farms, breaking up their livestock holdings, in order to migrate to other areas. Data recorded at another *Phakchamara* farm were judged to be unreliable as the enumerator experienced difficulties in tracking the unusually high turnover of animals that formed part of the farmer's management regime. Consequently, the interpretation of the study reported here is based on data recorded on 28 farms. Of these, seven were at *Angdim*, eight at *Ankhisalla*, seven at *Jirikhimti* and six at *Phakchamara*. Thirteen of the farmers belonged to *Matawali* ethnic groups and 15 were *Bahun*.

Data Collection

The study was conducted during two monsoon seasons (June - September, 1993 and June - September, 1994) and one winter / dry season (October, 1993 - May, 1994).

Monitoring Visits

Data were collected from the farms at each of the four study sites by an enumerator based at the site. All data collection was based around a series of monitoring visits. Each farm received a monitoring visit at intervals of approximately 14 days giving a total of 32 sequential observations for each variable from each of the participating farms. Each visit started at approximately 06.00hours (h), coinciding with the first feeding events of the day, and was terminated after the final feeding event, usually around 17.00h. During the course of a visit, a complete record was made of feeding patterns for the day, of changes in the livestock holding's structure since the previous visit and of the bodyweights and productive outputs of individual animals.

Cut-and-carried Feeds

The main focus of the study was on cut-and-carried feeds in a system based, predominantly, on stall feeding. Data collected included quantitative estimates of feed utilisation and basic indicators of nutritive value (dry matter and crude protein contents).

Feed Utilisation

The utilisation of feeds associated with individual feeding events was recorded during each monitoring visit. Quantities of individual feeds (prior to any mixing) offered to each animal (or group of animals fed together) were measured using a suspended spring balance (Salter Ltd, United Kingdom) with a capacity of 50kg. Grasses from forests and crop terrace risers were generally collected as mixtures of species. In this case, quantities of the complete mix offered were recorded but species composition was estimated from a 1kg sub-sample, examined before the mixture was fed, to allow the more accurate estimation of the dry matter and crude protein supplied. Farmers generally collected any feed refusal (occasionally these were then offered to other animals in the holding). Weights of refused feeds were measured in the same way as the weights of offered feeds. Apparent intakes of each feed was then calculated by subtracting the quantity refused from the quantity offered.

Selectivity

In order to analyse the extent to which selection of cut and carried feeds offered accross livestock holdings was taking place, selection indices were calculated for each feed category during at each monitoring visit:

$$SI = \sum_{(1 \,..\, n)} WT$$

for animal A = 1 .. n where W = bodyweight of A raised to the power 0.75
T = time spent at pasture

Nutritive Value of Cut-and-carried Feeds

Information on the dry matter (DM) and crude protein (CP) contents of the feeds observed in use during the course of the study was derived from three sources:

- *Direct determinations of feeds sampled during the course of the study* - Representative, 0.5kg samples of feeds were taken by enumerators during monitoring visits. These were bagged and

returned to PAC, within three days, for preparation and analysis. DM contents of the fresh samples were measured by reserving 100g of coarsely ground feed material, drying it at 100 ± 5 ^{o}C for 48h and reweighing. The remainder of the sample was oven-dried at 50 ± 3 ^{o}C for 72h and ground in a heavy-duty, commercial coffee grinder to pass a 1mm screen. The resulting material was used for the determination of CP content using the method described by AOAC (1980).

- *Direct determinations of feeds sampled during the course of other studies conducted by Pakhribas Agricultural Centre* - some feeds were not sampled as their nutritive values have been widely documented in other studies conducted at PAC. Values for DM and CP (determined using the methods described above) were adopted for these feeds.
- *Book values* - For some feeds (< 20), samples from the current study and data from other studies were both unavailable. In these cases, representative values given by Gohl (1994) or Panday (1982) were used as rough estimates.

The Contribution of Grazing

Whilst the study was designed to focus on the management of cut-and-carried feeds, the preparatory visits suggested that, at certain times of the year, some farmers considered grazing to be an important, supplementary source of nutrients. Detailed assessment of intakes at grazing was beyond the scope of and resources available to the study. However, some indication of the contribution of grazing to nutrient supplies was required so that the extent to which this resource complemented the use cut-and-carried feeds might be assessed. During each farm visit the length of time spent grazing by individual animals within livestock holdings was recorded. These data were used to derive a quantitative, grazing index (GI) to indicate the contribution of grazing to nutrient intakes amongst monitoring visits to individual farms.

$$GI = \sum_{(1 \,..\, n)} WT$$

for animal A = 1 .. n where W = bodyweight of A raised to the power 0.75
T = time spent at pasture

The GI was used to evaluate the influences of the main factors on the complementarity of grazing and cut-and-carried feeds in meeting the year-round requirements for feed resources.

Herd Dynamics and Animal performance

Herd Structure

Changes in herd structure were recorded throughout the study. These included sales and purchases, births and deaths and temporary exits and entries. A number of temporary transfers or exchanges between neighbouring farmers were recorded, particularly with oxen and cattle. These generally involved the removal of an animal during a time of perceived feed shortage and its return when pressure on feed resources was reduced.

Bodyweight Changes and Productive Outputs

Patterns of bodyweight change in large ruminants (buffalo, breeding cattle and oxen) were estimated using “Weighbands” (Dalton Supplies Ltd, United Kingdom). Bodywights of goats were measured driectly using a cradle sling attached to the same suspended balances used in the estimation of feed intakes. Some farmers were reluctant to allow pregnant animals to be weighed in this way. In these cases, the equation of Yazman (1987), derived from measurements on the local, Nepali goat was used:

$$W = \frac{LG^2}{10500}$$

where W = body weight (kg), L = body length (cm)and G = heart girth (cm)

A series of comparisons of the predictions of this equation with measured body weights of goats on the study farms indicated errors of less than 10%.

In order to allow comparisons of feeding levels between animal types, metabolic body weights ($BW^{0.75}$) were calculated as body weight raised to the power of 0.75 for use in the derivation of some variables.

Most farmers participating in the study practised restricted suckling of buffalo and cattle, taking off part of the daily production for sale locally. During mid-lactation, animals were milked twice a day. Offtake at each milking was recorded by enumerators using locally produced, 0.5litre graduated measuring cyclinders.

Statistical Analyses

All statistical analyses were conducted using the standard directives and library procedures provided by Genstat 5, release 3.1 (Lawes Agricultural Trust, 1993)

The effects of the main factors and their interactions on values of the measured and derived variables in the data set were evaluated using a variance components analysis based on Genstat's REML directive. This allowed the effects of unbalanced factors to be evaluated within a multifactorial framework, and variances within and amongst farms to be compared.

With the exception of the data describing herd structures, categorical data (e.g. counts of different feeds observed in use) were treated in the same way as ordinal variables. The large number of observations suggested that assumptions of normality would not be broken for these variables. Application of the more powerful tests indicated that this was the case. Factor effects on other categorical variables were tested by the application of χ^2 tests for independent samples.

RESULTS

Structure and Size of Livestock Holdings

The basic nature of livestock holdings clearly plays a fundamental rôle in determining requirements for and patterns of utilisation of feed resources. A general description of holdings on the study farms is presented here in order to set the discussion of feed resources that forms the main thrust of this report in perspective.

Livestock holdings on the study farms comprised buffalo, breeding cattle, oxen and goats in varying proportions[1] at all sites. Considerable variation was observed amongst the farms studied in the sizes of livestock holdings (total $BW^{0.75}$) and the numbers of each class of livestock (averaged over all monitoring visits) observed in them (Table 3).

Some of this variation could be attributed to the effects of the main factors examined by the study. Mean holding sizes were similar at all sites. However, small but significant differences were observed between sites in the pattern of seasonal changes in holding sizes (Figure 2). With the exception of *Jirikhimti,* where holding sizes changed little between the monsoon and dry season, total holding $BW^{0.75}$ was generally higher during the dry season than during the monsoons ($P < 0.001$). Holding sizes also differed with the ethnic group of the farm household ($P < 0.05$) with *Bahun* farmers

[1] - *Matawali* farmers also keep pigs. However, herds are generally small (only one or two mature animals) and share few common feed resources with ruminant livestock. A consideration of pig feeding practices was, therefore, excluded from the current study.

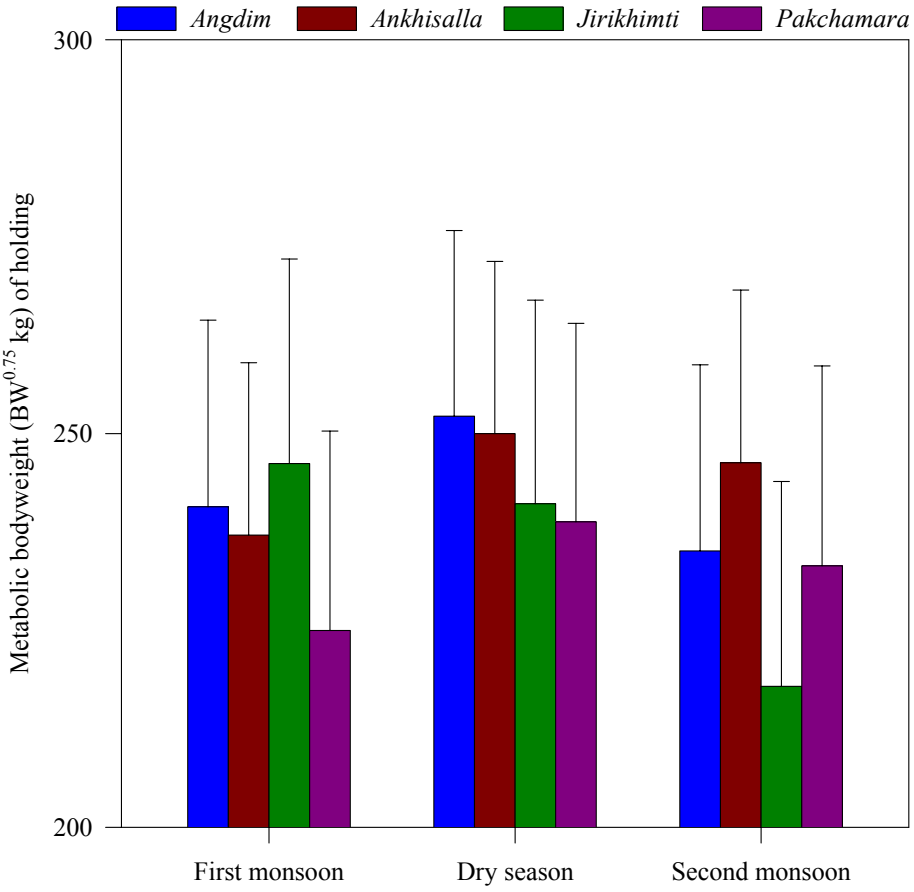
Table 3: *Range in animal type contribution to livestock holdings and total holding size observed accross the study farms*.

	Minimum	Maximum	Mean (Mode)
Total metabolic bodyweight in holding	70.6	384.9	240.1
Breeding buffalo	0	4	1.3 (1)
Growing buffalo	0	3	1.1 (1)
Breeding cattle	0	4	1.3 (1)
Growing cattle	0	4	2.0 (2)
Oxen	0	6	1.2 (1)
Mature goats	0	8	3.3 (3)
Growing goats	0	20	9.7 (9)

generally keeping larger holdings (mean $BW^{0.75}$ = 263.7; SE_M = 24.1) than *Matawali* farmers (mean $BW^{0.75}$ = 213.5). This difference was accounted for in part ($P < 0.001$) by a reduction in holding sizes on *Matawali* farms during the second monsoon whilst *Bahun* farmers maintained their larger holdings at a relatively constant size throughout the study.

Significant differences between ethnic groups in the structures of holdings at the start of the study were also observed (Figure 3). *Matawali* farmers tended to keep more cattle than *Bahun* farmers ($P < 0.01$) whilst *Bahun* farmers kept more buffalo and oxen in their holdings ($P < 0.05$). The ownership of buffalo amongst *Matawali* farmers was concentrated at *Angdim* and *Ankhisalla*. No significant differences were observed between farmers of different ethnic groups in the numbers of goats kept or

Figure 2: *Differences amongst sites in seasonal changes in total metabolic bodyweights of animals in livestock holdings*.

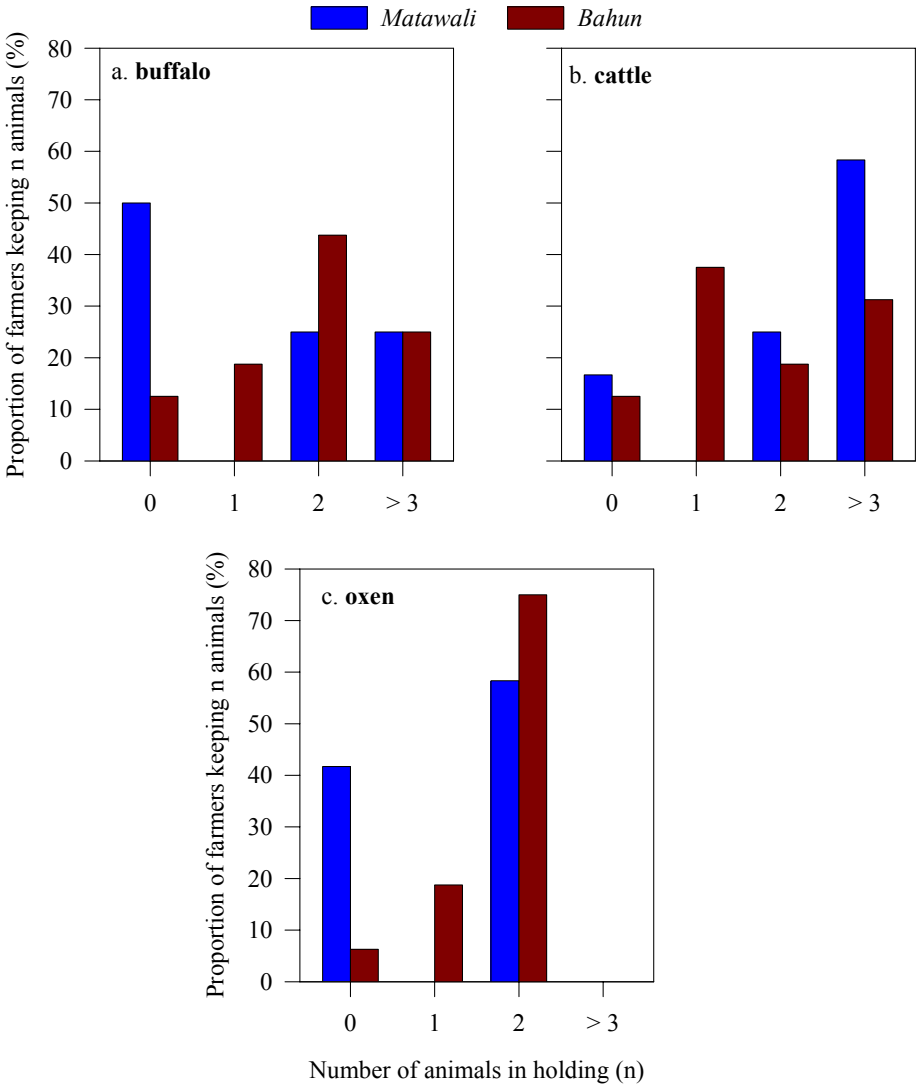


in the ownership of improved (crossbred) cattle or buffalo. No evidence was found of differences in the species composition of livestock holdings or in the use of improved animals amongst sites.

Seasonal Patterns in the Collection of Feed Resources

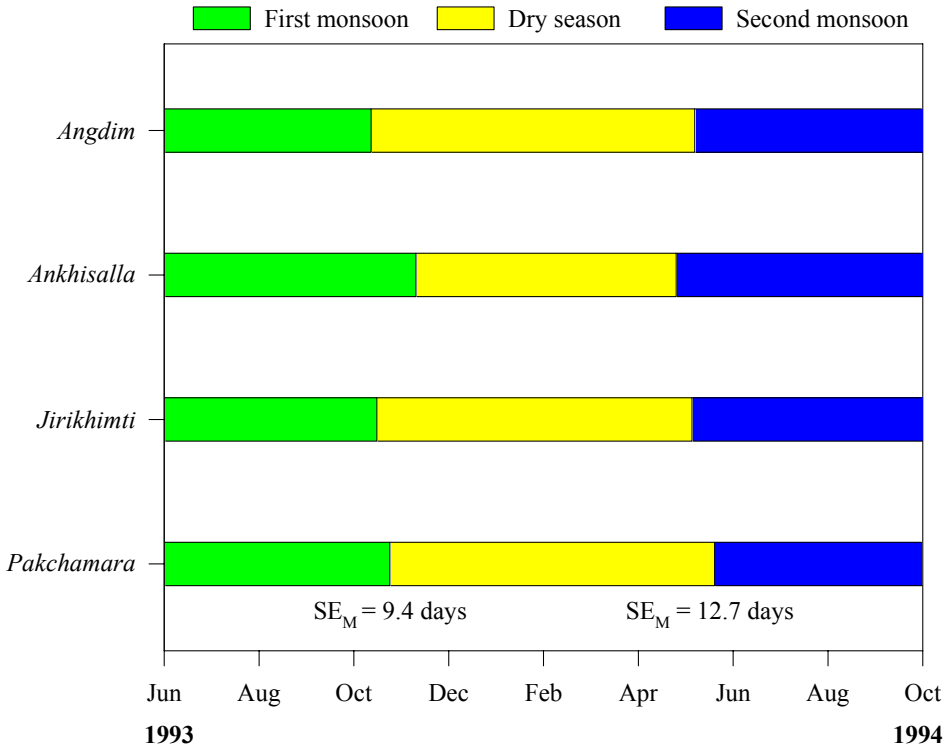
A change from the grass-based feeding practices associated with the monsoon season to the crop residue-based practices of the dry season was observed on all farms over a 65 day period between October and December of 1993. No significant differences were observed between M*atawali* and *Bahun* farmers in the mean date on which this change was made. However, farmers from *Ankhisalla*

Figure 3: *Differences between ethnic groups in structures of large ruminant holdings*.



generally adopted dry season feeding practices between 25 and 30 days later ($P < 0.01$) than farmers at the other three sites (Figure 4). No significant differences were observed between the two ethnic groups or the four sites in the timing of the return to monsoon feeding practices, which occured during early June, 1994 on the majority of farms. In consequence, farmers from *Ankhisalla* were observed using the crop residue-based, dry season feeding system for around 40 days less than farmers at the other sites ($P < 0.05$).

Figure 4: *Differences amongst sites in the changes between monsoon and dry season feeding practices.*



Cut and Carried Feeds

The range of feeds collected

A total of 258 different feeds were recorded being fed to animals accross the 29 participating farms during the course of the study. These could be differentiated into eight broad categories (grasses, green crop residues, broad-leaved herbaceous plants, vegetables, vegetable crop residues, tree fodder, dry crop residues and concentrates). The overall distribution of the individual feeds between these

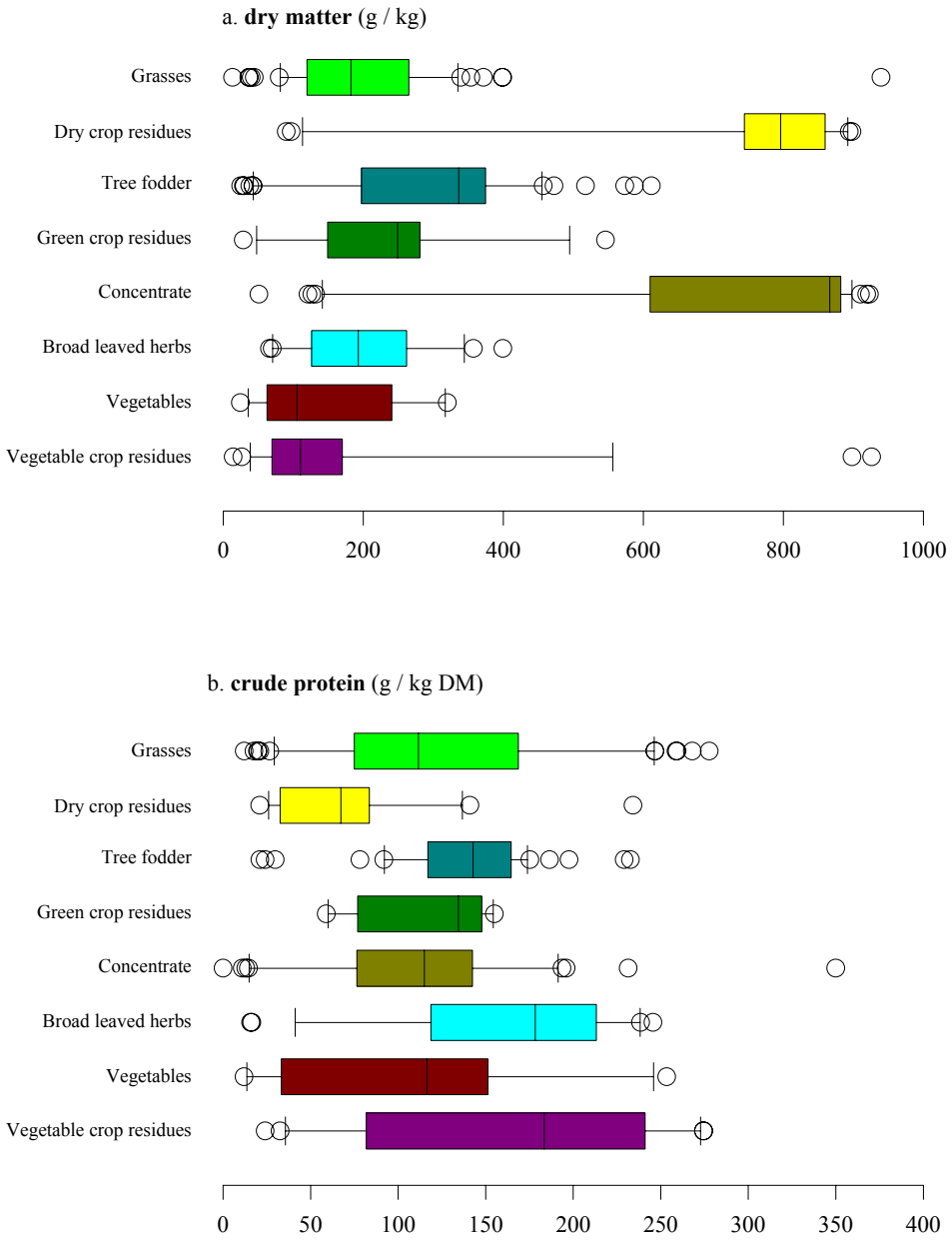
categories and, as a crude indicator of the relative significance of the eight categories of feed, the total collected dry matter recorded during the study for each are shown in Table 4.

Table 4: *Distribution, by category, of the feeds used on participating farms during the observation period.*

Feed category	No. of distinguishable examples recorded during the course of the study	Total collected dry matter recorded during the study (kg)
Grasses	72	11 379
Green crop residues	7	2 341
Broad-leaved herbaceous plants	20	870
Vegetables	14	98
Vegetable crop residues	24	260
Tree Fodder	60	2 582
Dry crop residues	17	6 257
"Concentrates"	43	1 164
Total	258	24 951

Grasses were the most diverse amongst the eight categories of feed and also contributed the highest proportion (almost 50%) of the total dry matter collected. In terms of dry matter collected, dry crop residues were second in importance to the grasses contributing around 25%. Tree fodder and green crop residues both contributed approximately 10% of the total dry matter collected. However, whilst only seven different types of green crop residue were observed in use, 60 different types of tree fodder were recorded accross the 29 farms.

Figure 5: *Variability in chemical compositions of the main feed categories used* [coloured bars = sd; whiskers = 95% of values; open circles = outliers].



Nutritional Characteristics of Collected Feeds

The mean DM and CP contents of the eight feed categories and variability within each category are summarised in Figure 5. Mean DM contents ranged from 148 g / kg for vegetables to 717 g / kg inconcentrates. Mean CP contents were lowest in dry crop residues (73 g / kg DM) and highest in vegetable crop residues (164 g / kg DM). However, the variability in within some feed

categories (DM - concentrate; CP - vegetable crop residues, vegetables, grasses) was almost as large as the variability accross all categories. Furthermore, this variation was not randomly distributed and could, depending on the category of feed under consideration, be accounted for by site, ethnic group, season or their interactions. These data are not presented in detail as they can only be regarded as indicators given the lack of a systematic programme of feed analysis in support of the work. However, notwithstanding this *caveat*, the main sources of variation in composition of each feed category are presented in Table 5.

Factors Affecting the Range of Feeds Cut-and-carried on Farms

Effects on Feed Diversity

The range of individual feeds collected and the number of categories that they represented were not consistent amongst all the farms studied. Several, systematic sources of variation could be identified.

Bahun farmers generally collected a larger number of different feeds ($P < 0.001$) that were spread more broadly accross the eight feed categories ($P < 0.001$) than *Matawali* farmers (Table 6). There appeared to be no significant effect of site on the mean number of feeds used although the pattern of variation observed reflected significant differences ($P < 0.05$, $SE_M = 0.43$) in the number of categories used. The mean numbers of feed categories used at *Angdim* (4.3) and *Jirkhimti* (4.5) were greater than at *Ankhisalla* (3.8) and *Phakchamara* (3.6). Highly significant effects of season ($P < 0.001$) on both the number of feeds collected and categories that they represented were observed (Figure 6). The number of feed categories represented was similar during both monsoon seasons but farmers collected feeds from more categories while using dry season feeding practices. In contrast, a significant reduction in the range of *individual* feeds collected was observed as a consequence of the change from the feeding practices used during the first monsoon season to those of the dry season. Furthermore, a return to the use of a wider range of feeds at the onset of the second monsoon was not generally observed in the case of individual feeds - although a significant, site.season, interaction term ($P <$

Table 5: *Summary of the main sources of variation in dry matter and crude protein composition within feed categories*.

Feed category	Site	Ethnic group	Season	Site x Ethnic group	Site x Season	Ethnic group x Season
Dry matter						
Grass	***	*	***	*	***	
Dry crop residues	***		***			
Tree fodder	***					
Green crop residues	**		*			
Concentrate	***	***		***		
Broad leaved herbs	*		***		*	
Vegetables						
Vegetable crop residues	***	*	***	**	**	***
Crude protein						
Grass	***	*	***	***	***	***
Dry crop residue	**		***		**	
Tree fodder		*	**		**	***
Green crop residue			***	*	*	
Concentrate	***			***		
Broad leaved herbs						
Vegetables						
Vegetable crop residues			***		*	***

0.001) indicated that this did occur amongst farmers at *Angdim* and *Jirikhimti*. A significant interaction ($P < 0.001$) was also observed between site and season in the number of categories represented. This appeared to be accounted for largely by relatively small changes in the diversity of feed use at *Phakchamara* accross the three seasons during which observations were made.

Table 6: *The effects of farmers' ethnic group on the range and categories of feeds collected for feeding all livestock held on the study farms.*

Ethnic group	Mean number of individual feeds collected on each visit	Mean number of feed categories represented amongst the feeds collected on each visit
Matawali	5.9	3.5
Bahun	8.1	4.6
SE_M	0.65	0.49

Effects on the Proportional Composition of Collected Feed Resources

No evidence was found to suggest that the proportion of each feed category in the collected feed was affected by the ethnic group of farmers.

Significant ($P < 0.05$) effects of site were restricted to differences in the proportions of concentrates, and the three categories of crop residues (dry, green and vegetable) in the collected feed (Table 7). Greater use of concentrate was made at *Angdim* and *Phakchamara* than at *Ankhisalla* or *Jirikhimti*. These differences did not appear to be associated with levels of crop residue utilisation as *Phakchamara* farmers used the largest proportion of dry crop residues whilst *Angdim* farmers used the smallest. Farmers at *Angdim* and *Jirikhimti* used larger proportions of green crop residues than those at *Ankhisalla* and *Phakchamara*. Vegetable crop residues formed only a small proportion of the total feed collected at all sites. However, the proportion used was particularly small at *Jirikhimti* and *Phakchamara*.

Figure 6: *Differences between seasons in the numbers of distinct feeds collected and the numbers of feed categories represented.*

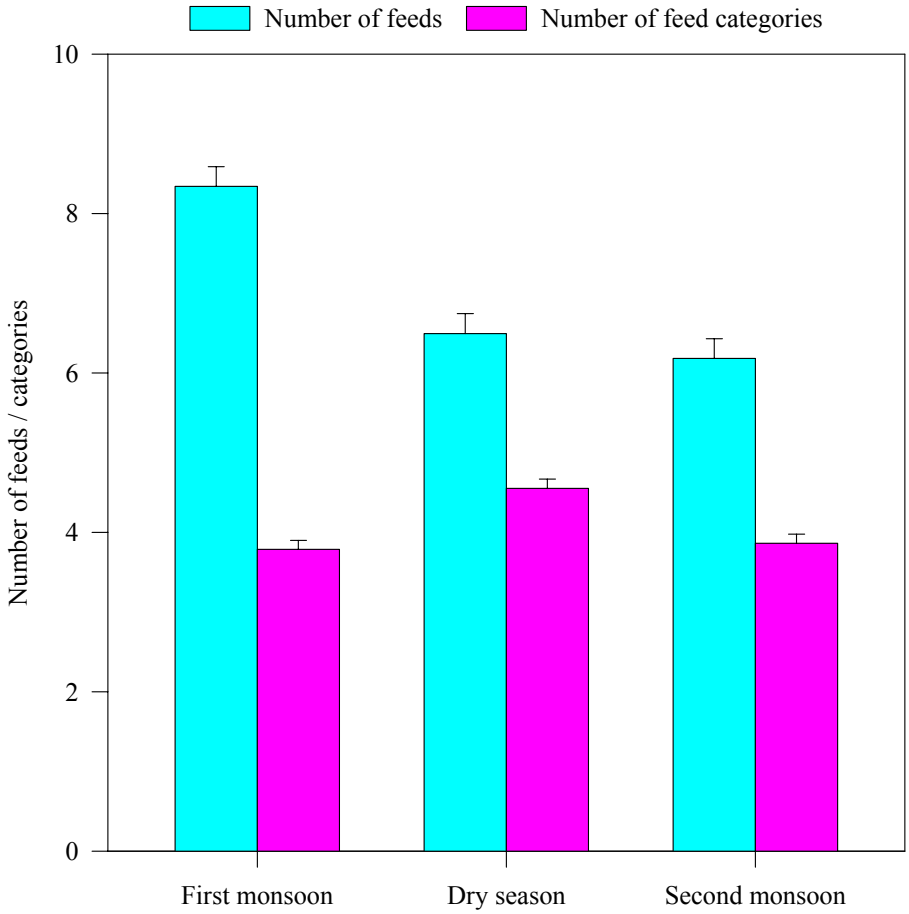


Figure 7 illustrates the general pattern of seasonal changes in the composition, by feed category, of collected feeds accross all the study farms. Significant differences ($P < 0.05$ - $P < 0.001$) between seasons were observed in the proportions of all feed categories in the material collected by farmers (with the exception of green crop residues). The change in feeding practices that takes place between the monsoon and dry seasons is clearly illustrated. During the monsoon season, the collected feed comprised of 600 - 650 g / kg as fed, grasses compared with 500 g / kg as fed, crop residues during the dry season. Increases, observed during the dry season, in the proportion of tree fodder and, to a lesser extent, green crop residues and concentrate were associated with this change from the use of grass to the use of crop residues as the main, basal feed. During all three seasons monitored over the

Table 7: *Effects of site on the mean proportions (g / kg as fed) of different feed categories in the fresh feed collected.*

Site	Concentrate	Dry crop residues	Green crop residues	Vegetable crop residues
Angdim	46	159	126	10
Ankhisalla	23	176	65	18
Jirikhimti	29	210	134	4
Phakchamara	51	254	81	4
SE_M	13	52	31	5

study period, these five categories of feed represented at least 940 g / kg as fed of total collections of fresh feed.

Seasonal changes in the proportions of the different feed categories in the collected were significantly ($P < 0.001$) affected by site (except in the cases of vegetables and vegetable crop residues). The more noteworthy of these interactions are summarised in Figure 8. Farmers at *Phakchamara* used large proportions of grass during the second dry season in comparison with farmers at the other sites where proportions were generally similar during both monsoon seasons. However, farmers at *Ankhisalla* collected more than twice the proportion of cut grass as part of their dry season feeding regimes than farmers at any of the other three sites. Proportions of dry crop residues in the feed collected during the dry season by farmers at *Phakchamara* were also higher than at the other sites were levels of use were, again, similar. The proportion of tree fodder was low in the feed collected by farmers at all sites during the two monsoon seasons. However, a wide range in the proportion used during the dry season was observed. The greatest contribution was made amongst farmers at *Ankhisalla* where the porportion in the collected feeds (207 g / kg as fed) was almost double that in feeds collected by farmers at *Angdim* (109 g / kg as fed).

Figure 7: *Seasonal changes in the proportional composition of the mixture of feed categories collected accross the 29 study farms.*

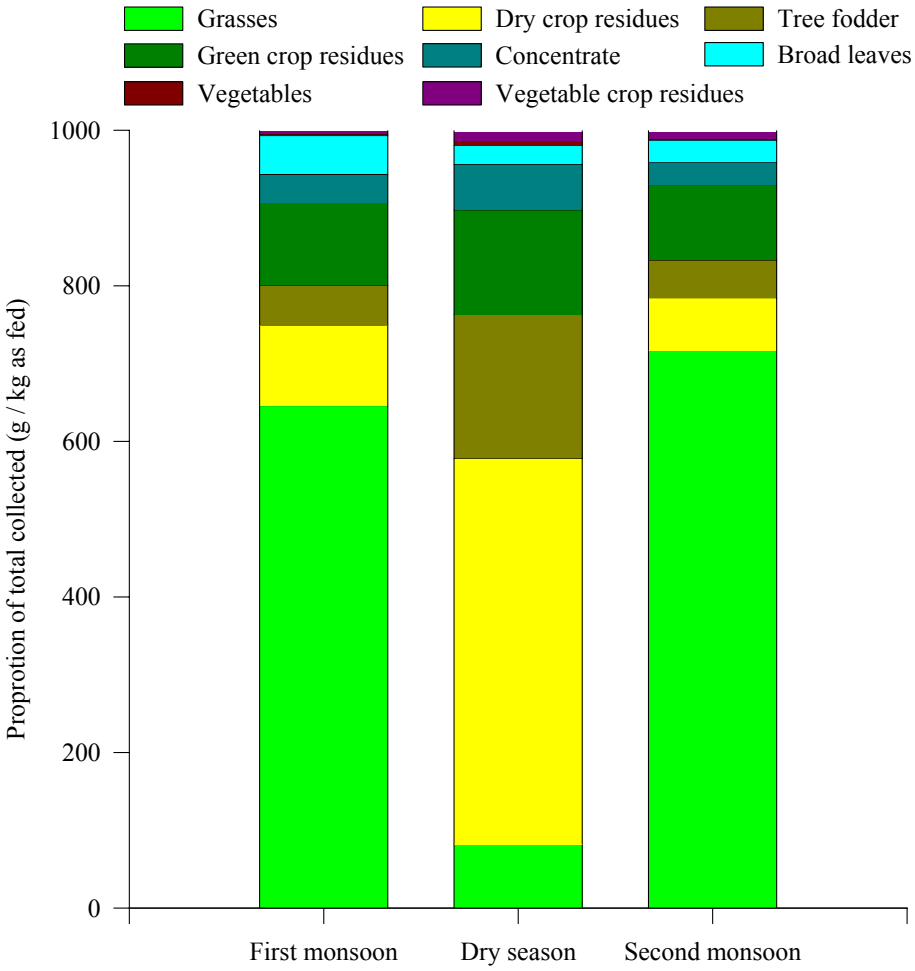
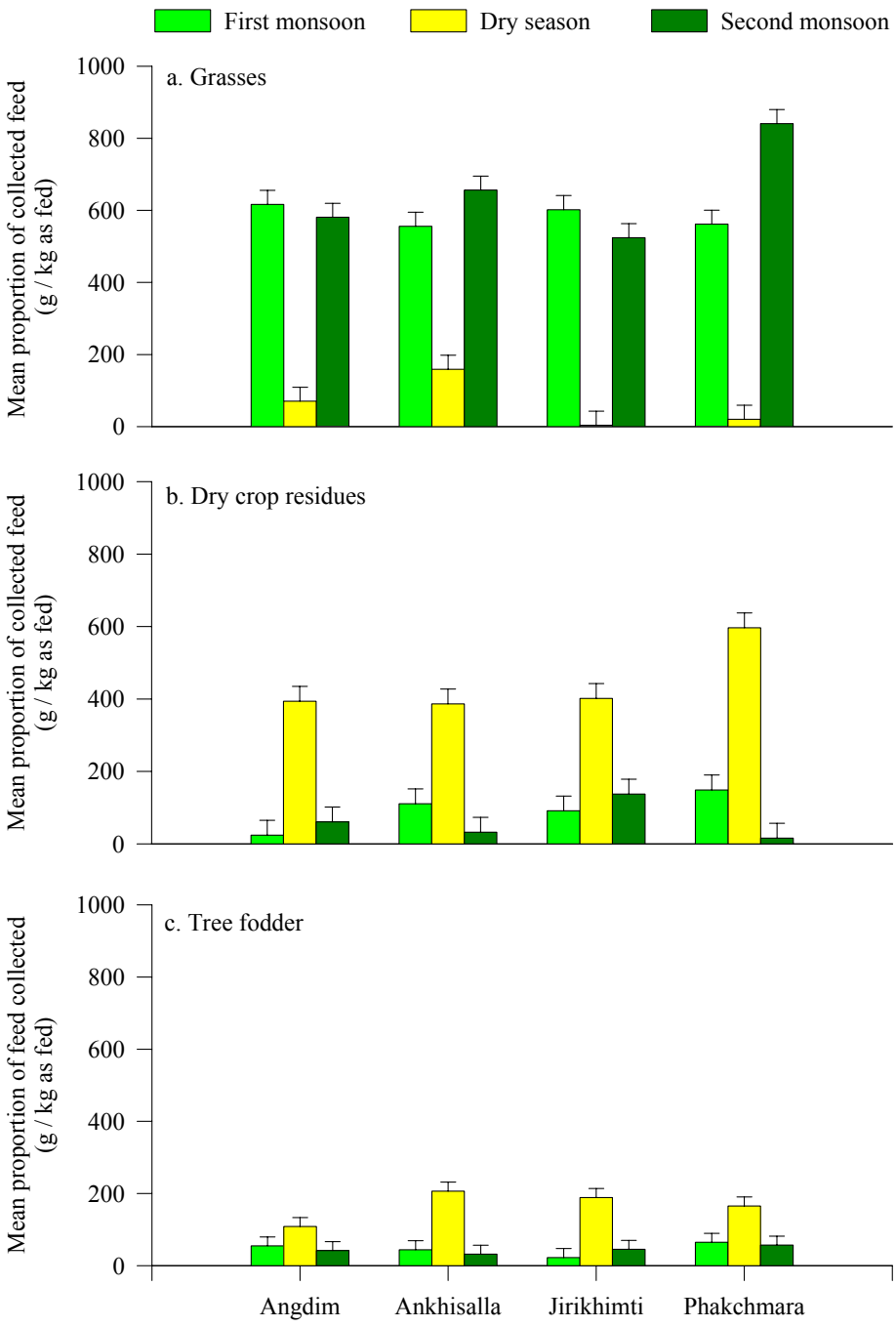


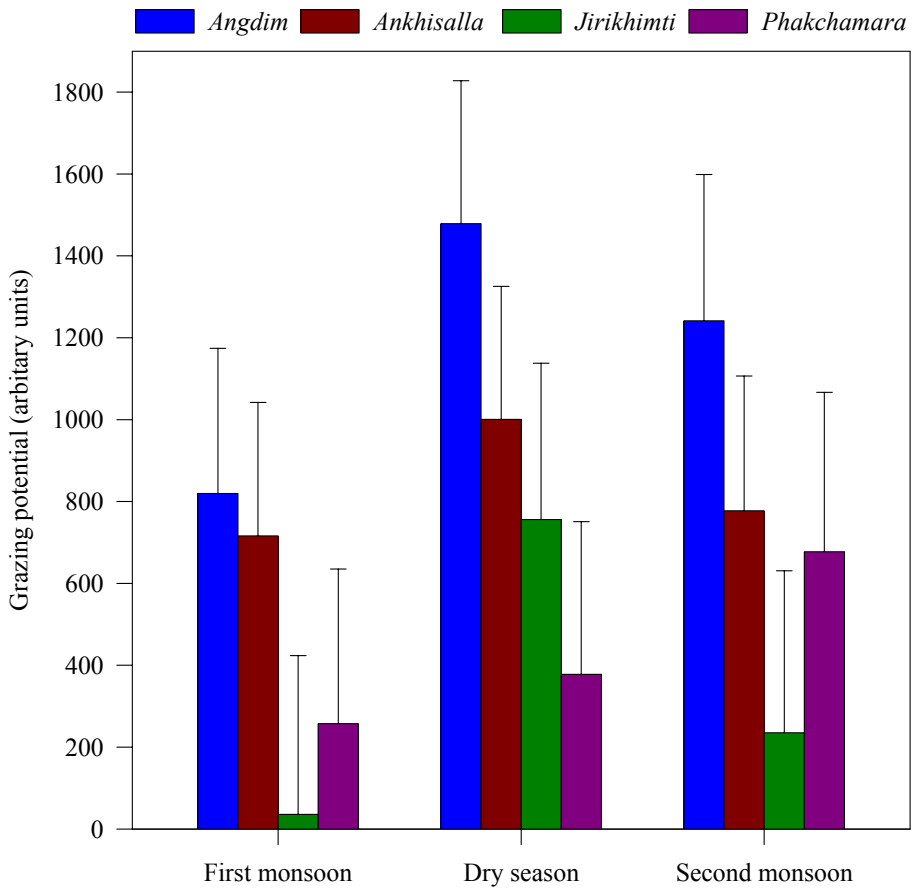
Figure 8: *Differences between sites in the seasonal patterns of use of grasses, dry crop residues and tree fodder.*



The Contribution of Grazing

The contribution of grazing to the feed resources of the study farms was seasonal in nature ($P < 0.001$). Farmers at all sites (with the possible exception of *Jirikhimti*) made heavy use of grazing during the dry season (Figure 9). However, the relative differences between monsoon and dry seasons were not consistent between sites ($P < 0.05$). Farmers at *Angdim* and *Ankhisalla* also made considerable use of grazing during monsoon seasons whilst farmers at *Jirikhmti* and *Phakchamara* appeared to restrict grazing during the wetter months to a minimum.

Figure 9: *Differences amongst sites in seasonal patterns in the utilisation of grazing to supplement cut-and-carried feeds*.



Nutrient Supplies

The contribution of cut-and-carried feeds to supplies of nutrients to the livestock holdings studied was determined by two main components, the total quantities of material collected for feeding and the density of nutrients in this feed. Variables associated with both of these components were influenced by the main factors studied.

Collection of Fresh Fodder

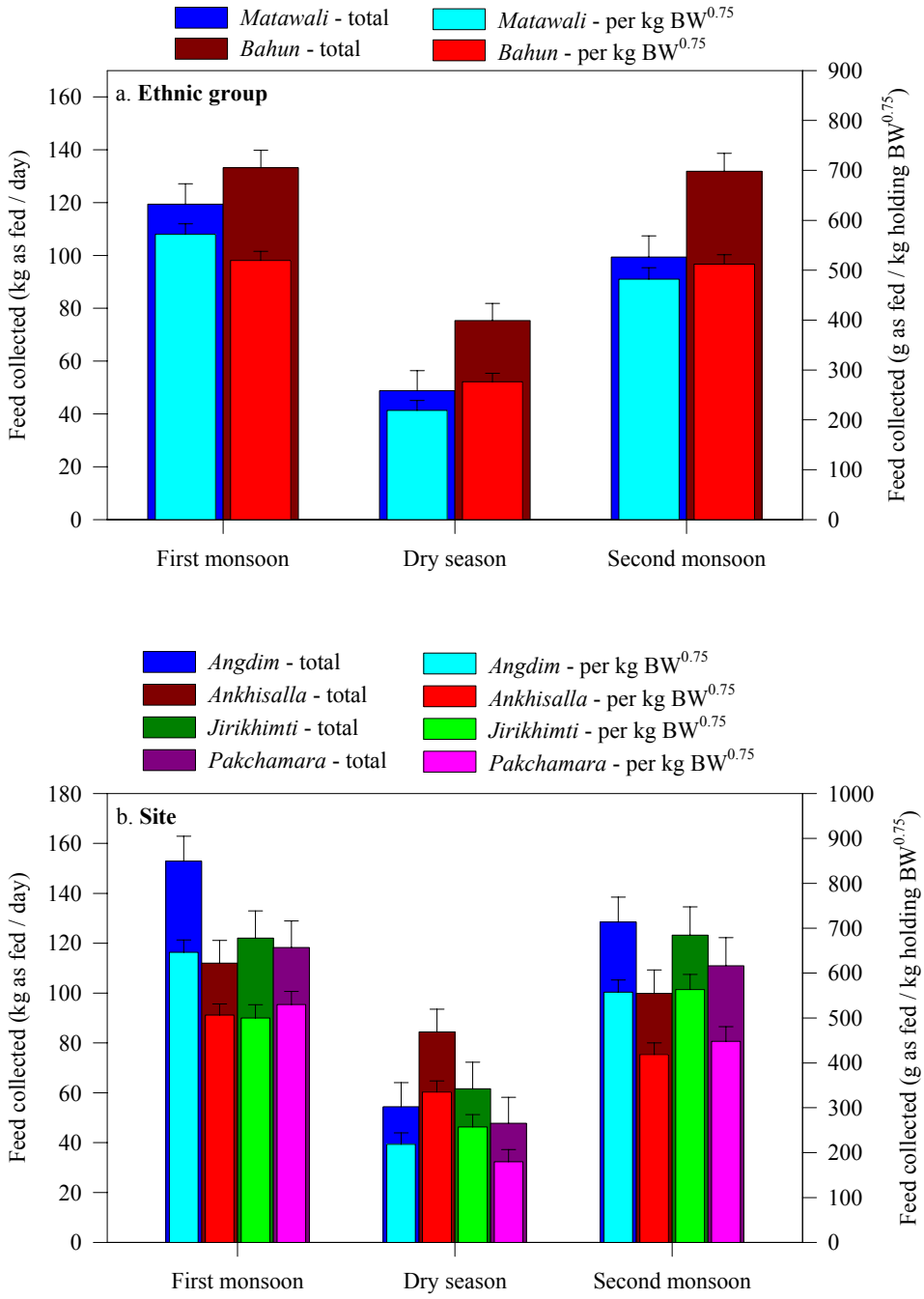
A marked seasonal pattern in the quantities of fresh fodder collected was observed on the farms of both ethnic groups and at all sites. This applied to total amounts collected ($P < 0.001$) and the quantities collected per kg $BW^{0.75}$ ($P < 0.001$). On average, quantities of feed collected during the dry season were approximately 25% smaller than those collected during the monsoon seasons.

Relative to levels of feed collection during the monsoon seasons, *Matawali* farmers collected smaller amounts of fodder during the dry season than *Bahun* farmers (Figure 10a). Although, *Matawali* farmers also maintained smaller livestock holdings, this interaction between ethnic group and season was also observed in levels of fodder collection per kg $BW^{0.75}$.

Seasonal patterns in fodder collection were also affected significantly by site ($P < 0.001$). Total collections of fresh fodder and amounts of fodder collected per kg $BW^{0.75}$ were both smaller during the dry season than during monsoons at all four sites (Figure 10b). However, farmers from *Ankhisalla* maintained fodder collection during the dry season at a level that was significantly higher ($P < 0.001$) than that achieved by farmers at the other three sites.

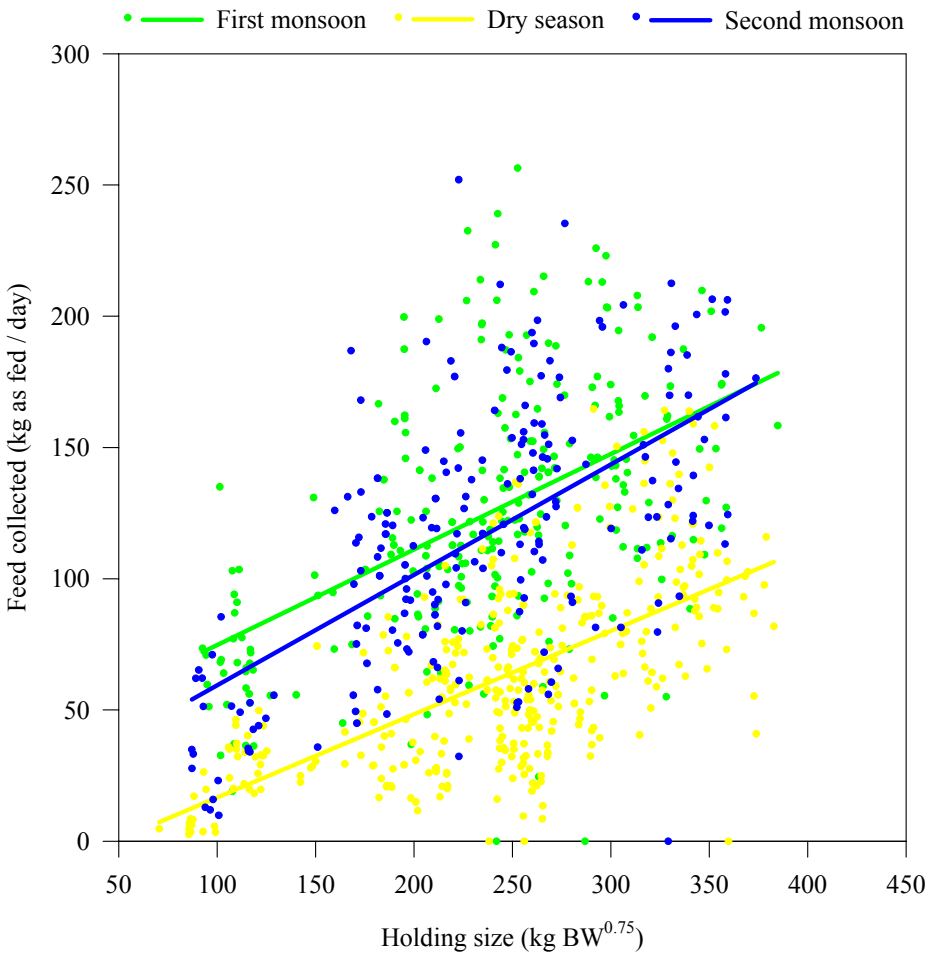
Figure 11 illustrates the relationship between the size of livestock holdings and levels of feed collection. A regression of the weight of fresh fodder collected on $BW^{0.75}$ in holdings accross all visits was highly significant ($P < 0.001$) but accounted for only 18.0% of the observed variation. Including the effect of season in the model significantly improved accuracy of fit ($P < 0.001$) with the revised

Figure 10: *Differences between ethnic groups and amongst sites in seasonal patterns in the collection of fresh feed materials.*



model accounting for 52.7% of the variation observed. The main feature of this improved model was its ability to account for the lower feeding levels of feeding observed during the dry season. The

Figure 11: *Relationships between holding sizes and quantities of fresh feeds collected during the two monsoons and the dry season.*



inclusion of an interaction term (holding $BW^{0.75}$ x season) tested for differences in the slopes of the regressions lines for each season. This term did not deliver a significant improvement in the accuracy of fit suggesting that farmers with larger holdings maintained similar feeding levels to farmers with smaller holdings during all three seasons during which observations were made.

Effects of Main Factors on Nutrient Density

Matawali farmers collected feeds that, on average, contained slightly more dry matter (390 *vs* 372 g / kg as fed; $P < 0.05$) but slightly less crude protein (98 *vs* 102 g / kg DM; $P < 0.05$) than *Bahun* farmers.

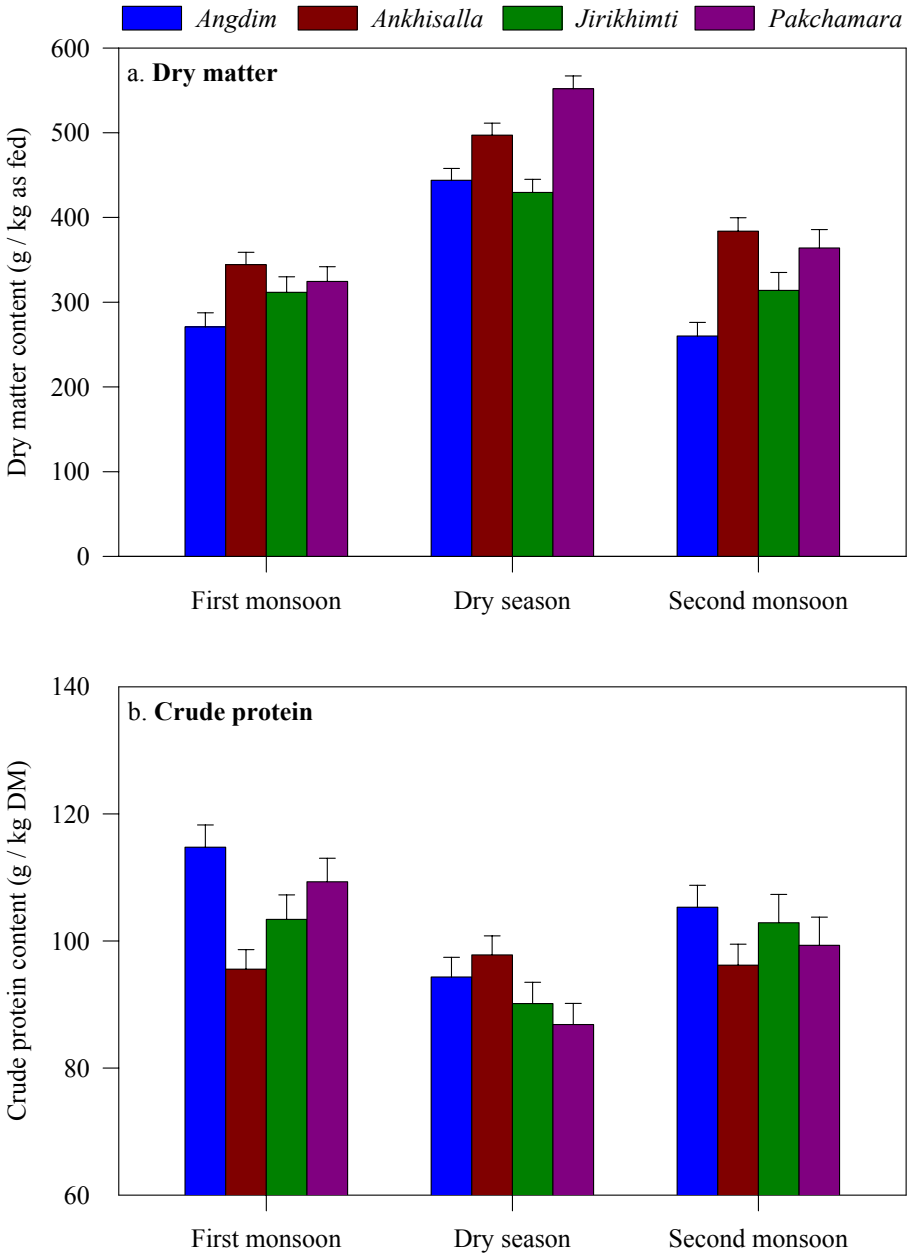
Feeds collected at *Ankhisalla* and *Pakchamara* contained significantly more ($P < 0.001$) dry matter (410 and 417 g / kg as fed) than feeds collected at *Angdim* and *Jirkhimti* (341 and 355 g / kg as fed). Significant seasonal differences were observed the dry matter contents of cut-and-carried feeds (Figure 12a) but these were not consistent between sites ($P < 0.001$). Feed dry matter contents were considerably higher during the dry season than during the two monsoon seasons at all sites. However, the effect was particularly pronounced at *Ankhisalla* and *Pakchamara* .

No significant differences were observed in the crude protein contents of feeds collected by the different ethnic groups or at the different sites. Crude protein contents of cut -and-carried feed was generally lower during the dry season ($P < 0.001$) and, again, the effect was not consistent amongst the four sites ($P < 0.001$). The feed collected by farmers at *Ankhisalla* was relatively uniform in crude protein content throught the year so that, during the monsoon season, it contained less protein than feed collected at other sites but, during the dry season, it contained more (Figure 12b). At the other three sites, crude protein contents of feed collected during the dry season were lower, to varying degrees, than those observed during the monsoon seasons.

Effects of Main Factors on Supplies of Dry Matter and Crude Protein

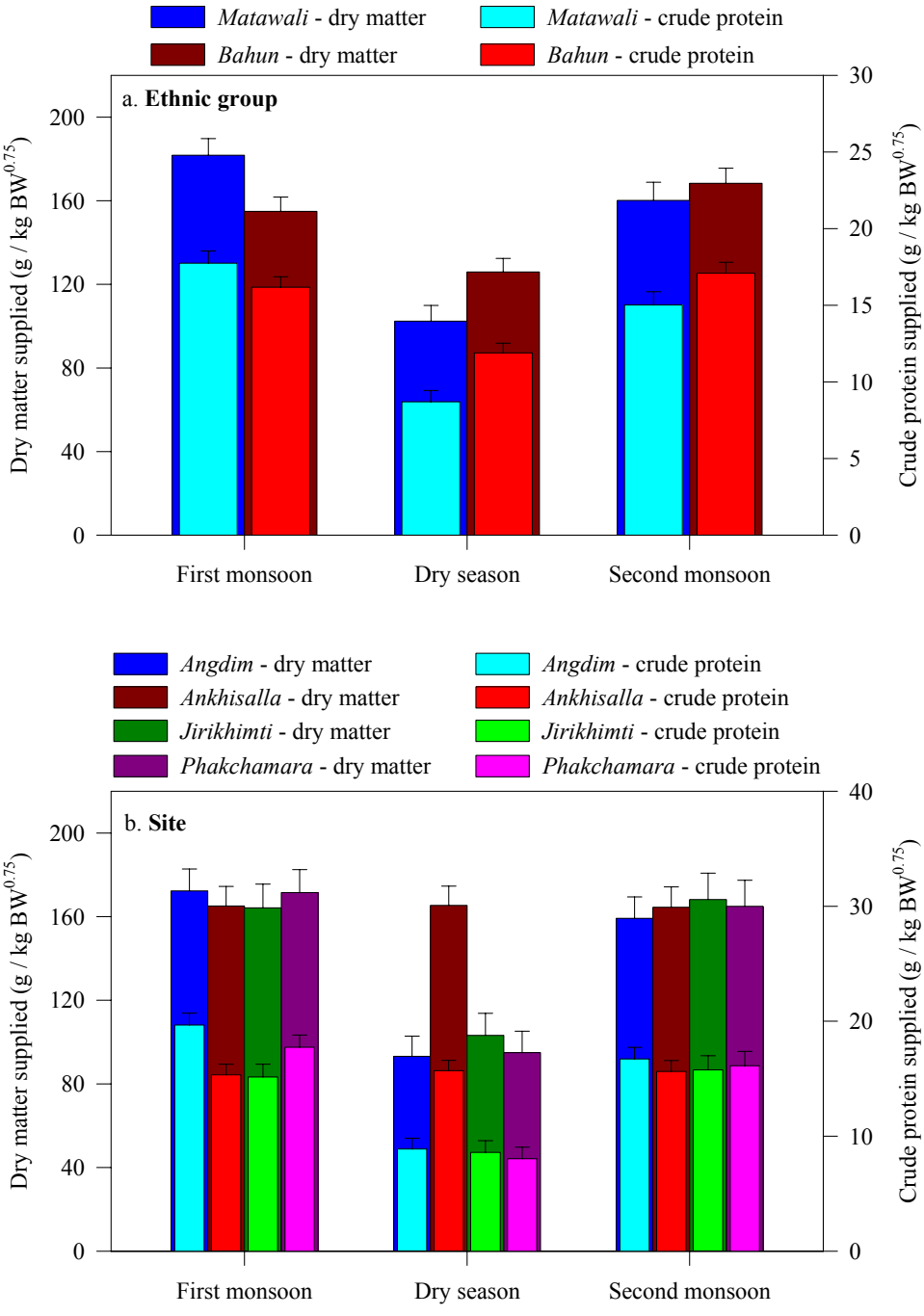
The balance, described above, between quantities of fresh fodder collected and levels of dry matter and crude protein in the collected feeds would have been responsible for determining amounts of dry matter and protein supplied to animals in the holdings. The effects of ethnic group, site and season on dry matter and protein supplies are summarised in Figure 13.

Figure 12: *Differences in mean dry matter and crude protein contents of collected feed resources amongst the four study sites*.



During the dry season, animals on *Matawali* farms were supplied with significantly less ($P < 0.001$) dry matter and crude protein than those on *Bahun* farms (Figure 13a). However, during the monsoon

Figure 13: *Differences between ethnic groups and amongst sites in seasonal patterns in mean levels of dry matter and crude protein supplied to holdings.*



seasons, *Matawali* farmers supplied similar, or larger, quantities of dry matter and protein to their animals than *Bahun* farmers.

Seasonal patterns in dry matter and crude protein supplies were similar on farms at *Angdim*, *Jirikhimti* and *Pakchamara* (Figure 13b). At all three sites, dry matter and protein supplies during the dry season were at between 59% and 68% of levels observed during the monsoons. In marked contrast with this situation, farmers at *Ankhisalla* appeared able to maintain supplies of dry matter and crude protein from the feeds cut-and-carried during the dry season at levels that were very similar to those of the monsoon seasons ($P < 0.001$).

Refusal of Collected Feeds

Refusal Rates

Highly significant differences ($P < 0.001$) were observed amongst the eight feed categories in the proportions of offered feed refused. Overall, refusal rates were highest with broad leaved herbaceous plants but almost no refusals of concentrates were recorded suring the course of the study. Levels of refusals of some feed categories (dry crop residues, concentrates) remained constant accross the study period (Figure 14) whilst others (grasses, green crop residues, tree fodder, broad leaves) displayed marked differences in refusal rates between seasons ($P < 0.001$). Broad leaves and green crop residues were consumed more readily during the dry season whilst grasses and tree fodder were consumed more readily during the monsoons.

Differences between ethnic groups ($P < 0.05$) and amongst sites ($P < 0.001$) in the seasonal distribution of refusals were also observed (Figure 15). Refusal rates during the monsoon seasons were lower in the holdings of *Bahun* farmers than on *Matawali* farms but were similar for both groups during the dry season. Refusal rates observed at *Ankhisalla* were higher during the dry season than during the first monsoon. This situation was reversed at the other three sites. However, with the onset of the second monsoon, refusal rates did not generally revert to the levels observed during the first monsoon.

Figure 14: *Differences between the eight major feed categories in seasonal patterns in refusal rates*.

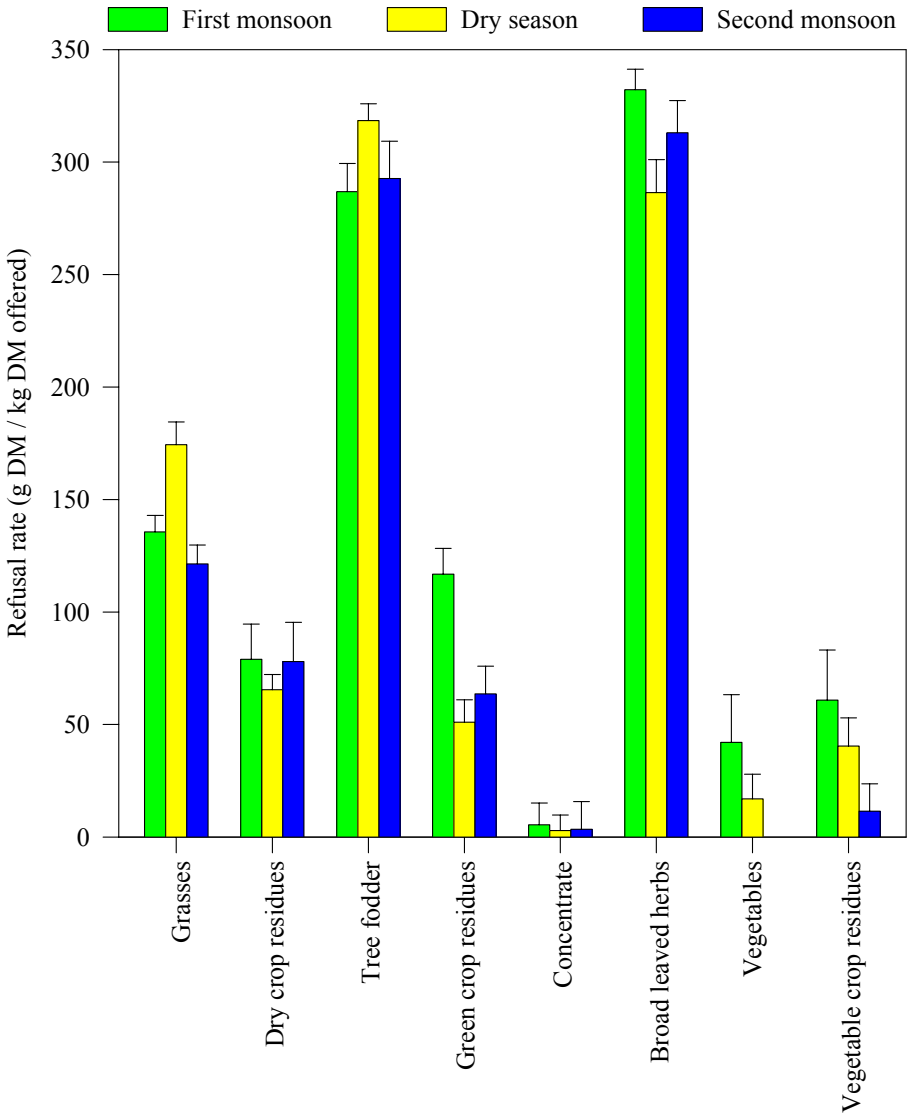
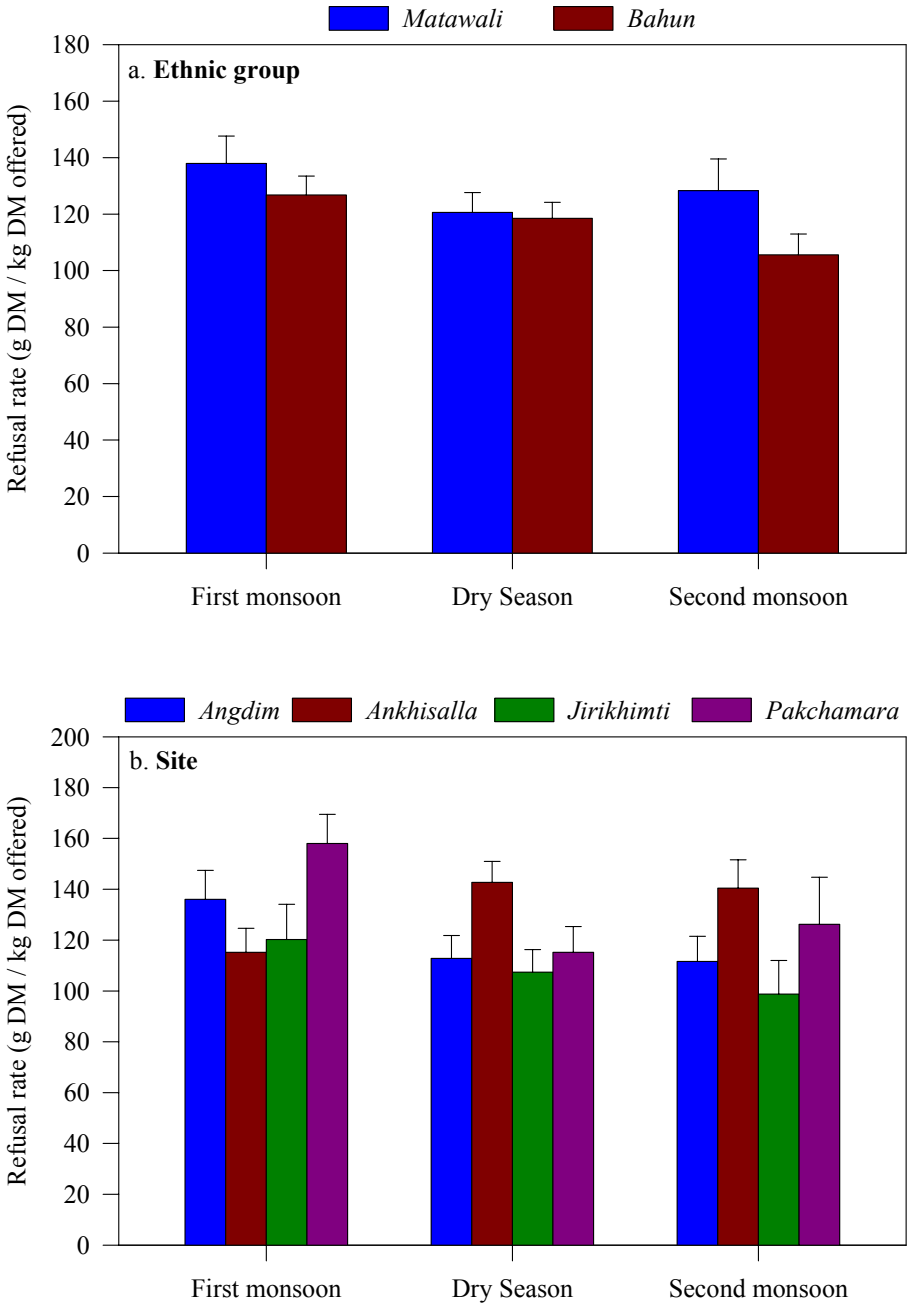


Figure 15: *Differences between ethnic groups and amongst sites in seasonal patterns in refusal rates*.



Selectivity Amongst Feed Categories Accross Livestock Holdings

Figure 16a shows mean selectivity indices, calculated for the eight feed categories. Large and highly significant ($P < 0.001$) differences were observed amongst feed categories. It appeared that animals selected most strongly against broad-leaved herbaceous plants and tree fodder whilst concentrates were consistently consumed at high levels, regardless of the other feed categories offered with them. Grasses also appeared to be selected against but the three categories of crop residues were all consumed preferentially by livestock. Selectivity for or against individual feed categories was consistent amongst seasons with the exception ($P < 0.001$) of grasses (Figure 16b) and tree fodder (Figure 16c). The preference of livestock for both of these feed categories was much reduced when they were used during the dry season in comparison with when they were fed during the monsoon seasons.

Nutrient Intakes

Potential intakes of dry matter and crude protein are determined by their levels in the cut-and-carried feed offered. However, the differences observed in selectivity amongst feed categories and seasons might be expected to modify observed intakes at the holding level. Highly significant interactions of ethnic group and site on season were observed in the data describing intakes of dry matter and crude protein. These are summarised in Figure 17.

Differences due to ethnic group and site in seasonal patterns of both dry matter and crude protein intakes were similar to those observed in levels supplied. Notably, seasonal patterns was more prominent on *Matawali* farms than on *Bahun* farms ($P < 0.001$) and farmers at *Ankhisalla* appeared more able to maintain supplies of dry matter and crude protein throughout the year than farmers at other sites ($P < 0.001$). However, a comparison of Figure 17b with Figure 13b suggests that differences in dry matter and crude protein *intakes* amongst sites may have been more pronounced than differences in dry matter and crude protein *supplied*.

Figure 16: *Differences in mean selectivity indices for the eight major feed categories and summary of significant (P < 0.001) interactions of feed category with season.*

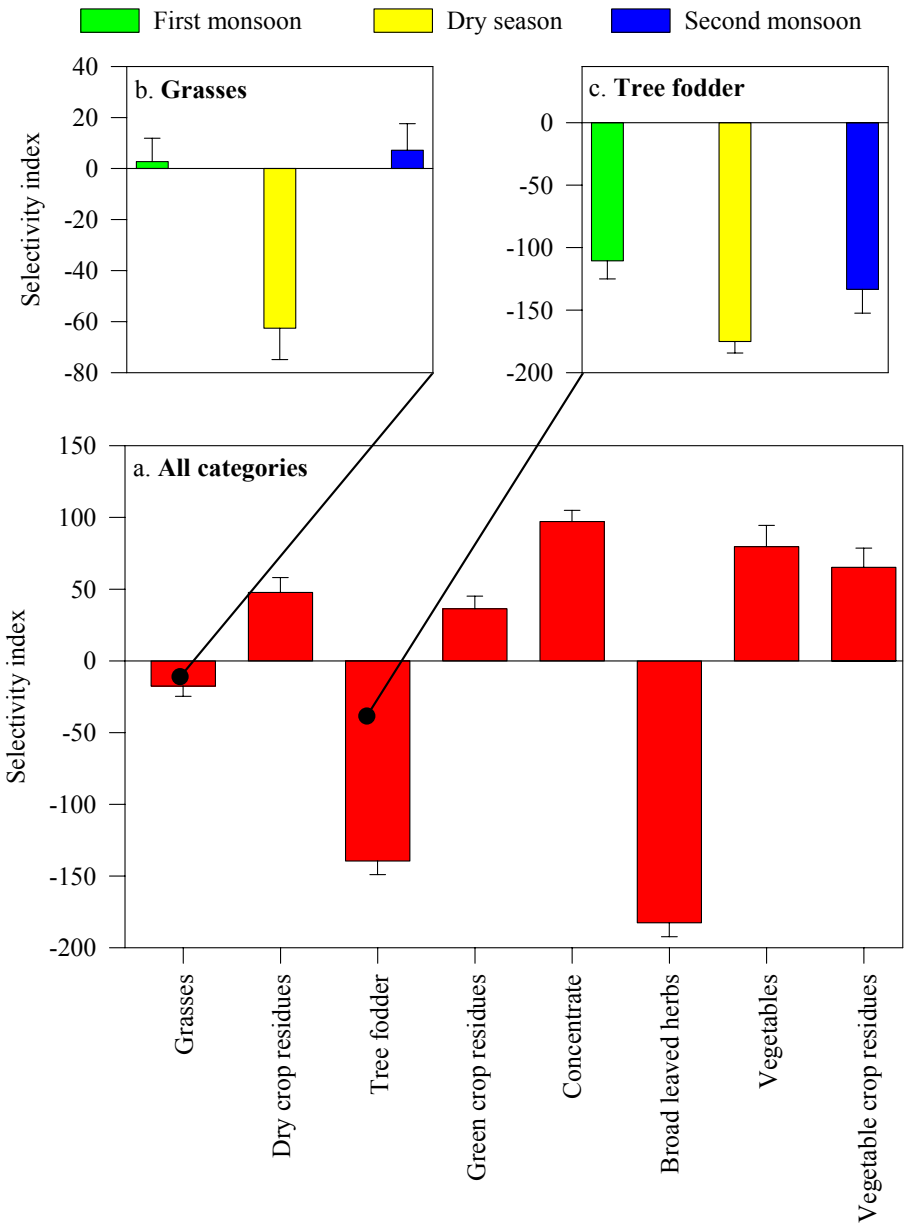
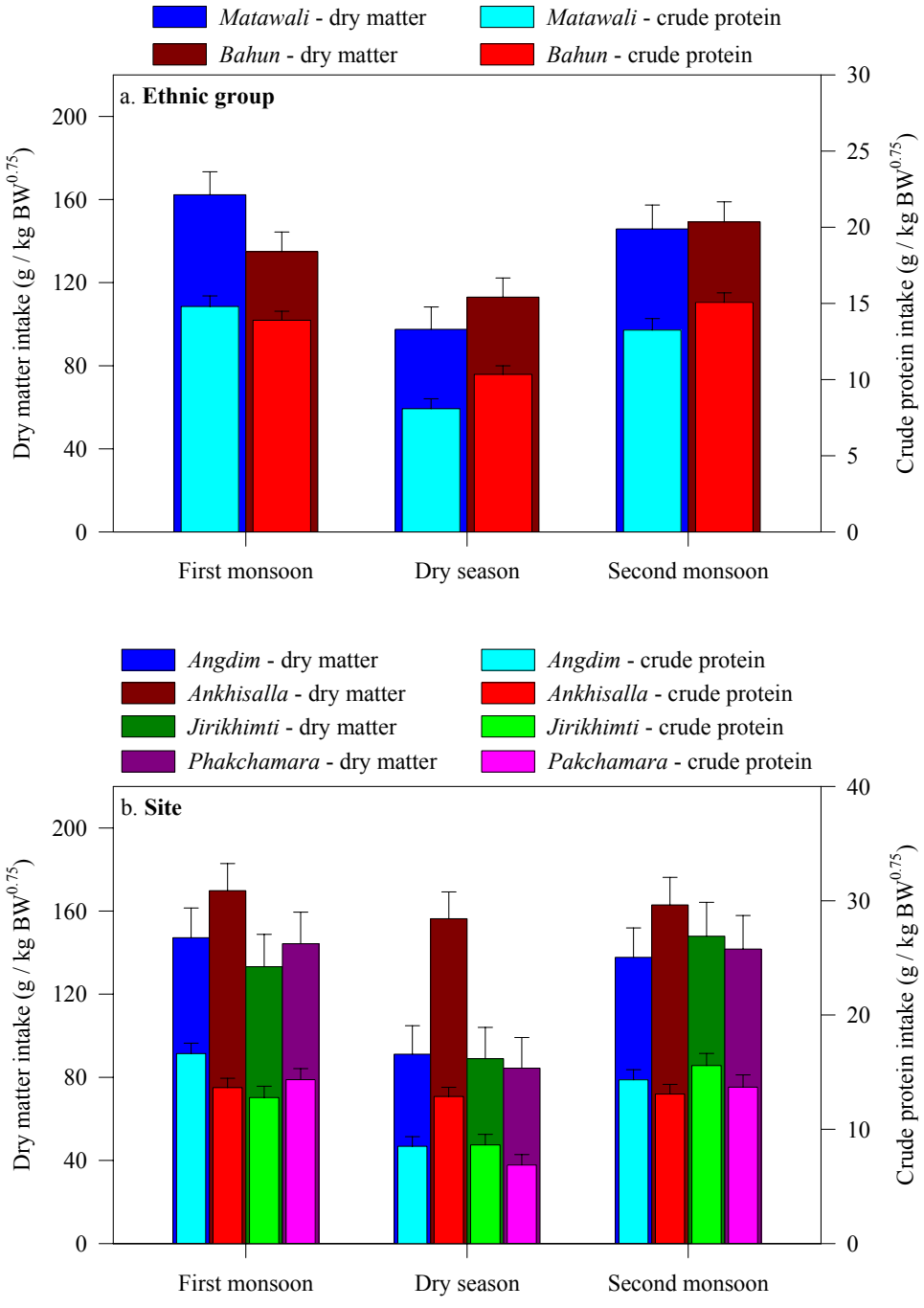


Figure 17: *Differences between ethnic groups and amongst sites in seasonal patterns in intakes of dry matter and crude protein.*



Contributions of Individual Feed Categories to Nutrient Intakes

Large and highly significant differences ($P < 0.001$) were observed in the relative contributions of the different feed categories to intakes dry matter and crude protein in the holdings studied (Table 1). Grasses and dry crop residues appeared to form the most important components of basal rations whilst the most important supplementary sources of protein were concentrates and tree fodder. However, the relative contributions of the different feed categories to intakes of dry matter and crude protein were also affected, to varying degrees, by site, ethnic group and the season during which they were collected.

Table 1: *The contributions of the eight feed categories to dry matter and protein supplies accross all holdings during all seasons*.

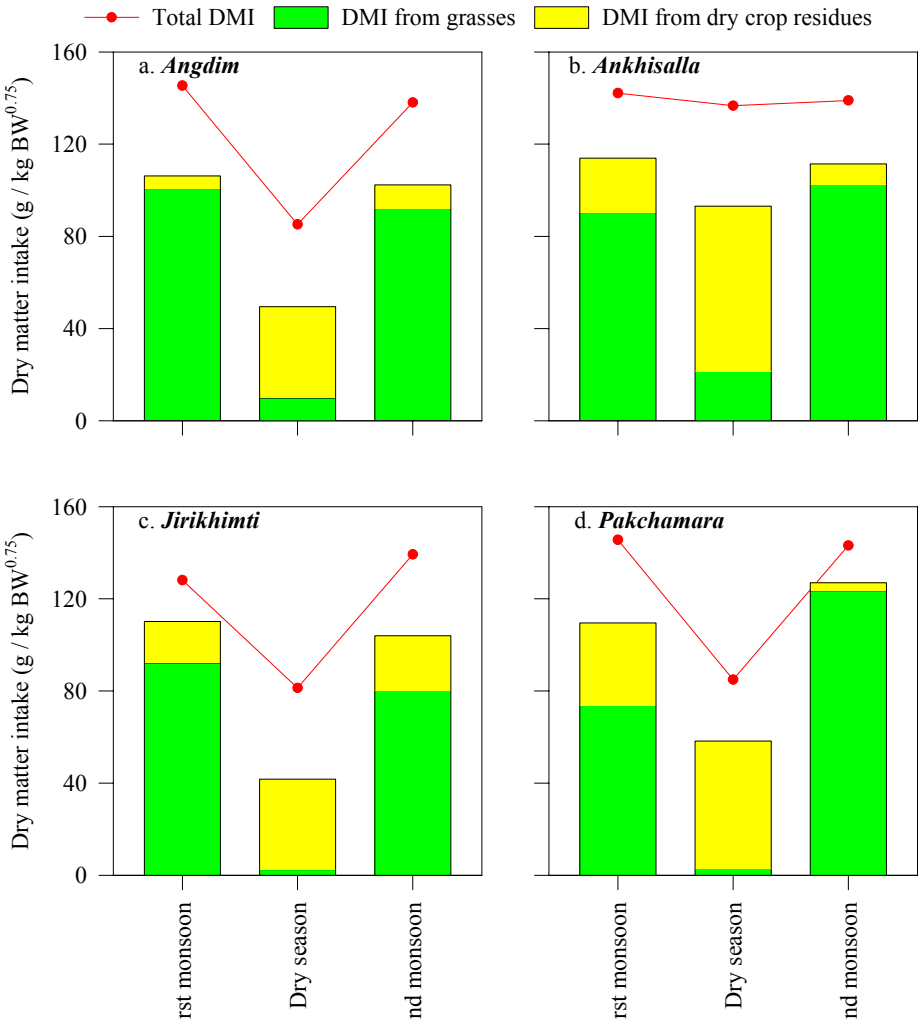
Feed category	Proportion of collected dry matter supplied (g / kg DM)	Proportion of collected crude protein supplied (g / kg CP)
Broad-leaved herbaceous	27	46
Concentrate	46	56
Dry crop residues	230	177
Grass	480	472
Green crop residues	115	118
Tree fodder	83	113
Vegetables	4	3
Vegetable crop residues	15	15

Utilisation of Basal Feeds

No significant differences were observed between ethnic groups in the relative contributions of the main basal ration components to intakes of dry matter and crude protein.

The proportion of total dry matter intakes contributed by grasses and dry crop residues together did not fall below 513g / kg at any time during the study period. Intakes of these two feed categories were similar at all sites during the two monsoon seasons (Figure 18). During the dry season at *Ankhisalla*, where little variation in total dry matter intakes was observed amongst seasons, intakes of dry matter from dry crop residues and, to a lesser extent, from grasses were significantly higher ($P < 0.001$ in both cases) than at the other three sites.

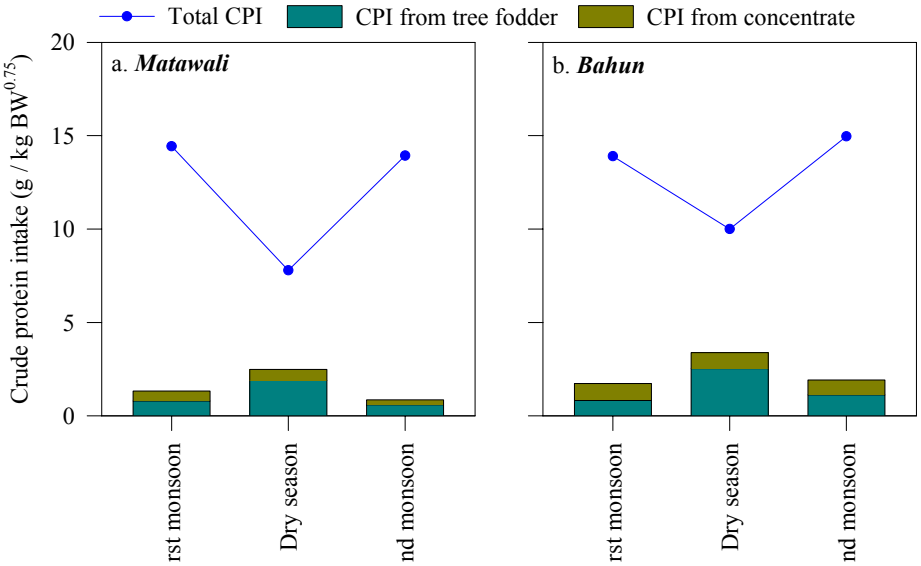
Figure 18: *The combined effects of site and season on mean contributions of the main basal feed categories to dry matter intakes (DMI).*



Supplementation Strategies

Figure 19 illustrates the differences between the two ethnic groups that were observed in patterns of supplement usein relation to total crude protein intakes over the three seasons. Concentrates made a greater contribution to total protein intakes on *Bahun* farms than on *Matawali* farms during all seasons ($P < 0.001$). However, within each ethnic group, the contribution of concentrate to intakes of crude protein did not appear to be affected by season. Levels of crude protein intake from tree fodder were similar on *Matawali* and *Bahun* farms during the monsoon seasons but significantly higher on *Bahun* farms during the dry season ($P < 0.001$).

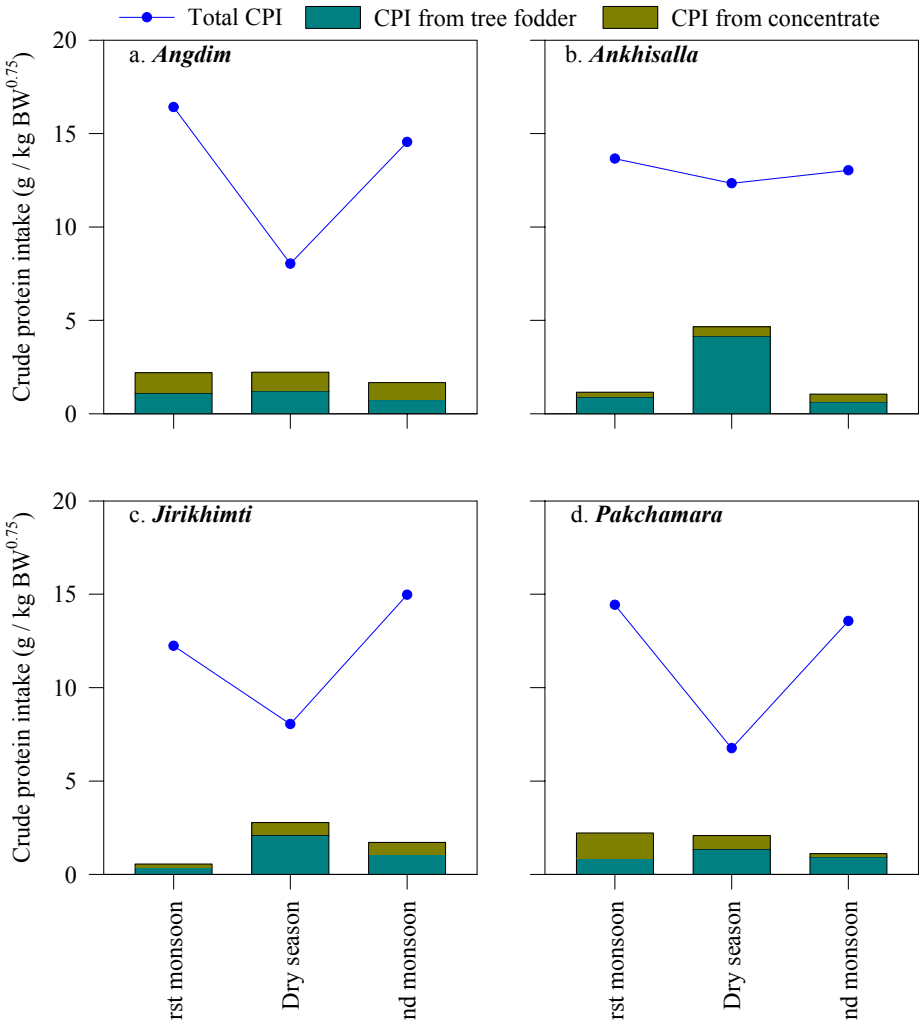
Figure 19: *The combined effects of ethnic group and season on mean contributions of the main supplement feed categories to crude protein intakes (CPI).*



The extent to which supplements were used to maintain protein intakes also differed significantly amongst sites (Figure 20). Concentrates contributed a larger proportion of crude protein intakes at *Angdim* and *Pakchamara* than at *Ankhisalla* and *Jirikhimti* but, at the latter two sites, the contribution of tree fodder was greated than at the former two sites. With the exception of the second monsoon season at *Pakchamara*, crude protein intakes from concentrate did not change appear to change to any great extent with season. The large differences observed amongst sites in intakes of crude protein from

tree fodder could be attributed, mainly, to differences in dry season utilisation. Overall, animals on holdings at *Angdim* and *Pakchamara* received the smallest proportions of their crude protein intakes from tree fodder and levels remained constant over the year. Farmers at *Ankhisalla* and *Jirikhimti* made more use of tree fodder to supplement protein intakes but this use was concentrated in the dry season.

Figure 20: *The combined effects of site and season on mean contributions of the main supplement feed categories to crude protein intakes (CPI).*



DISCUSSION

Structure and Size of Livestock Holdings

Differences in holding sizes on the farms studied were considerable with the largest farm supporting more than five times the standing metabolic body weight of the holding on the smallest. Clearly, large livestock holdings require greater access to feed resources in order to maintain similar levels of performance. Reliable data on farm sizes are difficult to obtain due to the fragemented nature of land holdings and the reluctance of farmers to provide this kind of information out of a fear that it might be used in the imposition of taxes. However, data from an intial survey (Thorne, 1993) suggested that land holdings probably did not exhibit a five-fold variation in size accross the four study sites. This would suggest that the larger holdings are maintained through differences in the availability or accessibility of feed resources either through greater recourse to off-farm fodder resources such as grazing or common property forest resources or as a result of differences in the types of cropping practised. For example farmers with a larger proportion of *khet* (irrigated rice) land are likely to have greater quantities of crop residues available during the dry season than farmers growing only maize and millet on rainfed *bari* land.

A number of individual instances of temporary exits (stated by farmers as being necessary as a result of feed shortages) were observed during the course of study. However, there was little evidence that the short-term manipulation of holding sizes was employed widely as a means of coping with periodic feed shortages. Although statistically significant, seasonal differences in holding sizes were small in percentage terms and, in most cases, farmers appeared to support slightly larger holdings during the dry season (due possibly to the accumulation of body reserves over the preceding monsoon). This situation is, perhaps, not surprising as all farmers in a particular area are likely to be in broadly, similar situations with respect to seasonality in the availability of feed resources. They might all, therefore, be expected to structure their holdings in a similar manner leaving few with the excess capacity for absorbing the surplus animals of others. As all farmers would wish to maintain the maximum number of animals during the monsoon season slaughter or sale prior to the dry season would probably also not be considered a viable option due to likely difficulties in finding animals for re-stocking.

Differences were observed between *Matawali* and *Bahun* farmers in both the size and structure of livestock holdings. Whilst these may have been related in part to differences in land holding sizes and cropping patterns, the fact that *Matawali* farmers apparently needed to reduce holding sizes as a result of the late arrival of the 1994 monsoon suggests there may also be a link with ability to manage feed resources and that *Matawali* livestock holdings are more susceptible to chronic shortages of feeds. Observed differences in holding structures generally reinforced the perception that *Matawali* farmers are less advantaged than *Bahun* farmers. Buffalo are more highly valued in the Eastern Hills of Nepal because of their higher yields of milk high in butterfat and the larger volume of manure that they produce. However, they are also more expensive to purchase and require much more feed than cattle. *Bahun* farmers generally kept larger buffalo holdings than *Matawali* farmers who appeared to generate the productive outputs required of large ruminants by keeping cattle in larger numbers than *Bahun* farmers. Attitudes to the keeping of oxen were ambivalent in both groups as there were long periods of the year (significantly during dry season feed shortages) when these animals were unproductive apart from contributing relatively small amounts of manure (Thorne, 1993). Generally farmers stated that they kept oxen beacuse there was no guarantee that they would be able to hire them from other farmers at times of peak demand for draught animal power. A larger proportion of the *Bahun* farmers than of *Matawali* farmers participating in the study appeared to be able to afford this luxury. Buffalo keeping amongst *Matawali* farmers was concentrated at two of the sites. At *Angdim* this may have been due to the availability of a well developed marketing arrangements for milk although these were also in place at *Jirikhimti* and *Phakchamara* where relatively few Matawali farmers kept buffalo in preference to cattle. Furthermore, at *Ankhisalla*, farmers of both ethnic groups complained of a lack of market opportunities for livestock and other products but still kept buffalo in relatively large numbers. It is also possible that the distribution of better land between the two ethnic groups may have been maore equitable at *Angdim* and *Ankhisalla* promoting more the maintainence of more similar holdings. Clearly, whilst the inclusion of a site stratum in the study for highlighting differences in opportunities and practices may be useful the underlying causes of these differences require more detailed investigation if the opportunities open to less advanteged groups of farmers are to be improved.

Seasonal Patterns in the Collection of Feed Resources

The nature of the seasonal constraints upon feed availability in the hill systems of Nepal has been widely percieved in general terms (....., Thorne, 1993). This study was conducted in order to provide a quantitative analysis of seasonal feed shortages and their consequences for nutrient supplies that could assist in the future design of interventions in the feeding systems practised that would allow the improvement of livestock nutrition year-round.

A number of initial conclusions may be drawn from the initial descriptive analysis that was presented in Figure 4. Despite the differences in the structure and size of the livestock holdings of *Matawali* and *Bahun* farmers, no differences were apparent in the timing of seasonal patterns of feed resource utilisation. This would suggest that any differences in the ability of the two groups to keep animals may be due to the quanitities than to the basic nature of the feed resources available to them. Other studies would appear to suggest that it is unlikely that the main ethnic groups have widely different access to technical knowledge (Rusten and Gold, Thapa *et al*, in review, Thorne *et al*, in preparation) although there may be some socio-economic constraints on the maintainence of feed supplies that operate differently between the two ethnic groups.

Cut-and-carried Feeds

The Range of Feeds Collected

The large range of different feeds available to farmers on the study farms is striking and indicates that, for effective management of feeding strategies, farmers are likely to require a detailed knowledge of their effects on animal performance and the most effective combinations. Studies conducted with tree fodder have indicated that this level of knowledge is available to farmers and can, indeed, be highly sophisticated (Rusten and Gold, Thapa *et al*, in review) and that it appears to be effective in discriminating different types of tree fodder on the basis of indicators of feed quality (Thorne *et al*, in preparation). Interviews with farmers conducted during the study suggested that a similar level of indigenous knowledge may be available with regard to the quality of more widely used grasses - at least at the level of ranking between different species. However, many types of grass that, whilst

collected individually in small quanitites, in combination often made up large proportions of the material fed were not even assigned names by some farmers.

Nutritional Characteristics of Collected Feeds

Classification of the individual feed types into categories proved useful for identifying broad differences in feed availabilities and feeding strategies due to site, ethnic group and season. However, DM and CP compositions of feed types within categories remained extremely variable suggesting that this approach would not be particulary effective as a means of reducing the analytical burden when attempting to develop modifications to exisiting feeding strategies. For example, whilst basing an analysis of seasonal feed supplies on simple feed calendars of the use of main categories derived from farmer interviews might greatly reduce the amount of effort required for data collection, this approach would be unlikely to furnish robust estimates of nutrient supplies.

Factors Affecting the Range of Cut-and-carried Feeds Used on Farms

Effects on Feed Diversity

The differences observed between ethnic groups in the range of feeds used might result from a number of causes relating to resource availability and farming practice. It was beyond the scope of the current study to examine these issues in detail. However, it is possible that these reasons might include differences between ethnic groups in the range of crops grown (and therefore the range of crop residues available for feeding); in the availability of labour for more widespread fodder collection; in the extent of access to private forest resources, and in the extent to which novel on-farm fodder resources have been adopted (e.g. tree fodder and forage legumes, although there is little evidence of widespread plantings of the latter).

Whatever their cause, these differences could, in certain circumstances, have considerable consequences for the quality of the diets consumed. In general, the availability of a wider range of feeds offers the possibility of more effective combining of feeds to provide diets that are balanced for a wider range a of nutrients. Thapa et al (in review) have demonstrated that Nepalese farmers appreciate

the benefits of combining tree fodder from different sources that they consider to offer differences in quality. If these come from a wider range of types, the effect is more likely to be enhanced.

Effects on the Proportional Composition of Collected Feed Resources

The Contribution of Grazing

The main focus of the study was on cut-and-carried feeds as, given the quality of pasture and the density of livestock on farms in the Middle Hills of Nepal, it seems likely that grazing makes a relatively small contribution to nutrient intakes, overall. The differences in grazing potential observed (see figure 9) indicate clearly that farmers regard grazed fodder as a dry season fodder resource that might to an extent compensate for the relatively limited availability of cut-and-carried feeds at this time of year. Farmers percieved large differences in the availability of grazing resources at the different four study sites (Thorne, 1993) and this is borne out by the data presented in Figure 9. Grazing was used to a greater extent and more consistently over the three seasons studied at Angdim and Ankhisalla whilst farmers at *Jirikhimti* and *Phakchamara* had little access to grazing, particularly during the dry season. It is not possible to judge the extent to which because of the arbitary nature of the gazing potential units.

Nutrient Supplies

Collection of Fresh Fodder

The quantity of fodder collected on farms on which the use of cut-and-carried feeds plays a major role represents an upper limit on supplies of nutrients to animals in the livestock holding. It may, therefore, be taken to represent feed availability - although this must be considered as encompassing limitations that result from practical constraints such as the availability of labour for fodder collection as well as from the physical availability of feed biomass.

The marked seasonal pattern in the availability of feed resources on farms in the Nepalese Middle Hills that has been imputed as a result of discussions with farmers (e.g. Conlin and Falk, Thorne, 1993) was

confirmed by the quantitative observations of the current study. In terms of the total amounts of fodder collected, this would appear to be represented by a reduction of around 25% (on average) in feed availability during the dry season in comparison with the wet season.

The regression analysis presented in Figure 2 indicates that, whilst there was considerable variation in individual observations of feeding levels, there was also a fairly strong, basic relationship between the size of livestock holdings and the quantities of feed collected. This suggests that all the farmers studied adopted similar basic strategies in cut-and-carry feeding. There was no evidence that some farmers attempted to specialise by keeping fewer animals on a relatively high plane of nutrition in order to improve the efficiciency of a particular aspect of performance such as milk production. This is perhaps not surprising given the multi-purpose use of animals in typical holdings in the Middle Hills and, in particular, the need for careful husbandry of manure compost in order to promote the efficient cycling of nutrients.

The lack of an observed interaction between the effects of holding size and season on levels of feed collection (illustrated by the parallel nature of the regression lines in Figure 2 for different seasons) provides further evidence of a relative uniformity in feeding strategies amongst farms. Although the reduction in quantities of feed collected during the dry season was large, it was not (apparently) affected by holding size. This would tend to suggest that the relationship between holding size and feed availability may be determined more by a minimum acceptable level of intake during the dry season than by feed availability during the monsoon. As discussed above, there was no evidence that farmers attempted to reduce holding sizes during the dry season in order to maintain levels of production year-round. Such an approach may be impracticable due to difficulties in disposing of and re-aquiring animals on such a short term basis but the general conclusion of these observation must be that farmers in the study area take a dynamic approach to rationing. In doing so, and are prepared to allow large seasonal differences in intakes of nutrients from cut and carried fodder. Whilst there may be some compensation from dry season grazing, it is unlikely that performance remains unaffected by such seasonality in the availability of the better quality cut-and-carried feeds.

The rationing system practised by farmers in the Middle Hills must clearly be dynamic in nature with an important role being played by body reserves accumulated during monsoon seasons. Given their complex knowledge of other, specific feed-related issues (e.g the nutritive value of tree fodders Thapa et al, Thorne et al) it seems likely that farmers also possess some appreciation of the importance of interactions between current and previous nutrition. If researchers are to assist farmers in developing improved feeding strategies to cope with changing circumstances, these must also be dynamic in nature and an evaluation of the extent of existing knowledge within the farming community would appear to be a prequisite for them to be effectively applied on farms.

However, while most (although not all) of the farmers studied fitted this general pattern and experienced some degree of dry season feed shortage, there was strong evidence that the actual extent of the deficit could be influenced by the circumstances of the individual farmer. Despite their generally smaller livestock holdings, *Matawali* farmers actually appeared to experience greater difficulty in maintaining levels of feed supply during the dry season. Differences between *Matawali* and *Bahun* farmers in the quantities of feed supplied to holdings were more pronounced during the dry than wet seasons which would suggest that holding sizes may be determined by wet season feed supplies rather than dry season. This would appear to indicate that the dry season is a time for coping rather than a strict limitation on potential levels of production from their livestock.

Effects of Main Factors on Nutrient Density

The information on DM and CP contents of the collected feeds offer some indications of the likely exetnt of variation in the quality of cut-and-carried feeds over the farming year.

Differences between ethnic groups were small but statistically significant indicating that, overall, *Matawali* farmers used diets that were higher in dry matter but contained less protein than those used by *Bahun* farmers. These differences might be viewed as being consistent with the use of poorer quality feeds by *Matawali* farmers. However, the holding structures on *Matawali* farms differed in comprising less Buffalo but more cattle so they may, in fact, have reflected a planned difference in feeding practices for the different animal types rather than a lack of opportunity for optimising the quality of fodder used.

Differences in the composition of fodder collected amongst sites were more pronounced than between ethnic groups but these differences were not consistent amongst seasons. Differences in dry matter content appeared to reflect the different agro-environmental characteristics of the sites as percieved by the participating farmers. Dry matter contents of the feeds collected in the dry season at *Ankhisalla* and *Phakchamara* - identified as dry sites by farmers - were much higher than those of feeds collected at *Angdim* and *Jirikhimti*. It is likely that these differences arose, at least in part, from differences in the cropping systems and practices adopted to deal with the drier conditions.

Significant differences in protein contents of diets were restricted to differences between sites in seasonal patterns. Farmers at *Ankhisalla* appeared to be most succesful in maintaining protein levels during the dry season which was associated with greater reliance on tree fodder in dry season diets.

Effects of Main Factors on Supplies of Dry Matter and Crude Protein

The combined effects of differences in the quanitity and quality of fodder collected at different sites and by farmers of different ethnic groups result in differences in the supplies of dry matter and crude protein to animals in the livestock holding.

The observed differences between *Matawali* and *Bahun* farmers appear to suggest that, whilst levels of feeding of dry matter and protein are likely to be similar during periods of relative plenty, *Matawali* farmers may find maintaining offer rates during the dry season more problematical that *Bahun* farmers. These differences were considerable during the dry season with *Matawali* farmers offering, on average, 19% less dry matter and 27% less protein accross their holdings than *Bahun* farmers. This level of difference might well be expected to cause significant differences in levels of performance.

The most striking differences in seasonal patterns of nutrient supply were due to effects of site, specifically the apparent lack of a seasonal deficit in supplies of dry matter and crude protein that was observed on the farms at *Ankhisalla*. This appeared to be due to both the larger quantities of feed collected and the higher densities of dry matter and crude protein in feeds collected at *Ankhisalla*.

Refusal of Collected Feeds

Refusal Rates

Selectivity Amongst Feed Categories Accross Livestock Holdings

Nutrient Intakes

The differences between sites in the seasonality of feeding practices clearly illustrate the importance of proper targetting of interventions in feeding strategies. Farmers at *Ankhisalla*, are better able to make use of monsoon feed resources than farmers at other sites and might not therefore be the prime target for interventions to extend the use of dry season feed resources. They could also provide indicators of ways of improving feed resource availability at other sites. To generate general interventions for particular systems in feeding strategies it is suggested that, within these specific systems, advantaged groups should be identified and the factors that convey these advantages isolated.

Contributions of Individual Feed Categories to Nutrient Intakes

Utilisation of Basal Feeds

Supplementation Strategies

Both ethnic groups practised dry season supplementation in their holdings, but *Bahun* famers appeared to use tree fodder, in particular, during the dry season to better effect in maintaining protein intakes than *Matawali* farmers (see Figure 19).

At *Ankhisalla*, where total dry matter intakes were maintained at the similar levels during both the dry and monsoon seasons, the use of relatively high levels of protein supplementation (Figure 20) also allowed dry season, crude protein intakes to be preserved at monsoon season levels. Relatively high levels of dry season protein supplementation were also observed at *Jirikhimti*. However, the lower dry matter intakes observed during the dry season meant that this strategy was not adequate for maintaining levels of crude protein intake at monsoon season levels.

CONCLUSIONS

1. The data presented illustrate the complexity of evaluating the supply and utilisation of feed resources in smallholder farming systems.

2. They confirm the need for this type of analysis of exisiting situations if effective interventions in these types of sytem are to be developed and effectively targeted.

3. The methods used in this study are not recommended as, whilst reasonably accurate in terms of the quantitative detail that they can provide, they are excessively time-consuming .

RECOMMENDATIONS

1. Further funding should be sought to allow a more detailed analysis of the data set in order that

- the effects of the observed differences in feeding strategies on livestock performanvce may be evaluated;
- Differences in feed allocation strategies for different types of animals in the holdings studied may be investigated.

2. Given the importance of the information collected there is a need to develop appropriate methods for the analysis of feed supply and utilisation. This is likely to be difficult as informal information gathering used alone is unlikely to provide the necessary level of detail whilst quantitative monitoring is, as we have seen, excessively demanding. It is suggested that funding should be sought for an international workshop on the subject that would allow experiences to be discussed and an approach to be formulated in the form of a proposal for funding.

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