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Transhumance livestock production in the Northern Areas of Pakistan: Nutritional inputs and productive outputs

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Abstract

The Northern Areas of Pakistan form a mountainous, semi-arid region in which subsistence mixed farming is the predominant economic activity for the majority of the population, which numbers around 1 million. Following a period of relative isolation, construction of the Karakoram Highway and the ensuing development activity have been catalysts for rapid infrastructural and social change over the last two decades. In the study reported here, feed resources for the livestock enterprise, which is largely made up of cattle, goats and sheep, were studied in detail over the course of a single winter feeding season. Productive outputs including liveweight change, milk production and reproductive performance were also quantified over a full year. The aim of the study was to provide a quantitative description of the system and to assess the extent to which proximity to a major highway influenced livestock husbandary. Six villages across the region were selected for study as part of a 2 × 3 factorial design with one village per cell of the study design. Factors consisted of two geographical transects and three agro-ecological zones. Transects were the Karakoram Highway (KKH) transect which enjoyed relatively good transport infrastructure and the Gilgit Ghizer Region (GGR) transect where infrastructure was more limited. Agro-ecological zones were the single, transitional and double cropping zones. One village per transect from each of the three main agro-ecological zones was chosen for study with 6–7 households within each village studied. Results showed that feed resources per household did not vary significantly according to transect or zone but cattle numbers per household were higher in the GGR transect than in the KKH transect indicating a heavier reliance on subsistence livestock production in this transect. Live weight and body condition of livestock in the Northern Areas changed markedly over the annual cycle. Losses of live weight were in the order of 10% over winter while summer gains during the summer season averaged 35% of initial live weight. There were differences between transects, with animals in the KKH gaining less weight in summer but showing higher milk yield (in cattle) and better reproductive performance. The results indicate a typical system of smallholder livestock production with heavy reliance on cereal by-products, a mix of livestock species and a relative scarcity of stored feed resources relative to overall livestock holdings. This study also suggests that proximity to the main highway running through the Northern Areas is associated with a reduced but more feed-efficient livestock production system.

Keywords: Livestock system; Pakistan; Productivity; Smallholder; Nutrient supply

1. Introduction

The Northern Areas of Pakistan lie at the junction of the Karakoram, Western Himalayan, and Hindu Kush mountain ranges. Over 1 million people live in the Northern Areas of

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Pakistan, with most deriving a substantial proportion of their income from livestock and agriculture (AKRSP, 2000). Although precipitation is scant in this semi-arid area, water is abundant in the form of glacial snowmelt, which is used to irrigate parcels of land via elaborate systems of irrigation channels (Kreutzmann, 1988). The use of irrigation has led to the development of two distinct land-use types within the region. Areas within the valley floors which receive irrigation are relatively productive and can support one or two arable crops per year (Saunders, 1983). In higher areas where irrigation is not used, the ground supports scrub vegetation. However, at higher altitudes, precipitation is greater, and temperate pastures and sparse coniferous woodlands occur (Omer, 2003).

The agro-pastoral system found in the Northern Areas includes subsistence arable cropping, fruit production, livestock production, and to an increasing extent, cash-cropping (Saunders, 1983). The livestock enterprise is reliant on arable production, in that feeds are dominated by arable by-products. Conversely, arable production relies on inputs of farm-yard manure from the livestock system. Livestock are thus part of an integrated system, and the keeping of livestock serves multiple purposes (Nuesser and Clemens, 1996). Trading in livestock is limited and livestock are mainly kept for subsistence purposes. A survey of farmers' reasons for keeping livestock indicated domestic milk supply as being the primary purpose of livestock keeping with dung production also featuring strongly (Clemens, 2005). Livestock are also important as sources of draught power for tillage of arable fields.

A key feature of livestock production in the Northern Areas of Pakistan is the practice of transhumance (Schmidt, 2000). Livestock are kept within the village during winter and stall-fed on cereal by-products, lucerne hay and kitchen waste (Wardeh, 1989). Animals are also allowed to free-graze on fallow arable fields and on winter pastures close to the village. During summer, animals move in stages to high-altitude alpine pastures where they are tended by family members (Nuesser and Clemens, 1996). This movement of animals out of villages and onto pastures has the dual role of exploiting the nutritional resources of high pastures as well as avoiding damage to arable crops during the summer months. In the autumn, livestock are returned to the villages to complete the annual transhumance cycle (Nuesser and Clemens, 1996).

The Northern Areas have been subject to rapid development in the last two decades as a result of two main factors. First, the construction of the Karakoram Highway (KKH), linking the Northern Areas to the rest of Pakistan and to China, has led to dramatic improvement in communication infrastructure (Kamal and Nasir, 1998). The result has been an increase in movement of commodities and people, and hence increased competition in local markets, opening up of external markets for local produce, and an increase in the opportunity for migration out of the region for employment and education (Streefland et al., 1995). The second main stimulus for change has been the activity of the various agencies of the Aga Khan Development Network, notably the Aga Khan Rural Support Programme (AKRSP), along with government departments and other non-governmental organizations (NGO's) which have catalysed a large number of small infra-structure projects including irrigation channels, link roads, and micro-hydro-electric schemes (AKRSP, 2000). The pace of development has not been uniform across the Northern Areas. Areas close to the Karakoram Highway tend to be at a more advanced stage of development than more remote areas (Kamal and Nasir, 1998).

The current study was set up to investigate the use of nutritional resources within the livestock enterprise in the Northern Areas of Pakistan. Nutritional inputs to livestock, productive outputs from livestock, and the relationship between these two, were compared in two geographically distinct transects one of which lay along the Karakoram Highway and the other of which lay along a side valley. Our expectation was that households close to the Karakoram Highway would place less emphasis on subsistence livestock production, because of their increased opportunities for off-farm employment and education which would reduce their labour pool. On the other hand, we expected the livestock enterprise in these households to show higher productive output per unit of nutritional input because of greater effort being focussed on fewer animals.

2. Materials and methods

2.1. Study design

The research was conducted according to a 2×3 factorial design, with factors consisting of two geographical transects and three agro-ecological zones. Two transects formed the main comparison of the study. The first transect, termed the KKH transect, lay along the Karakoram Highway and its associated transport infrastructure. The second transect, termed the GGR transect, lay within the Gilgit-Ghizer region and was served only by roads accessible by 4×4 vehicles, with a limited length of metalled road. Selection of study villages within transect was stratified by agro-ecological zone. The three agro-ecological zones were the so-called single (above 2300 m; SCZ), transitional (1850–2300 m; TCZ), and double-cropping zones (below 1850 m; DCZ). In the single and double-cropping zones, one and two arable crops per year are grown, respectively. In the transitional zone, one main crop and one subsidiary crop are generally grown. Six study villages were selected at the start of the project, with one lying in each of the six cells of the 2×3 factorial design (Fig. 1). Selection of villages was based on the advice of local experts. Villages were chosen to be as representative as possible of those within the cell.

Following village selection, a baseline survey was conducted to gather basic information on household size, livestock holdings, and other socio-economic parameters. Six or seven households per village were then selected on the

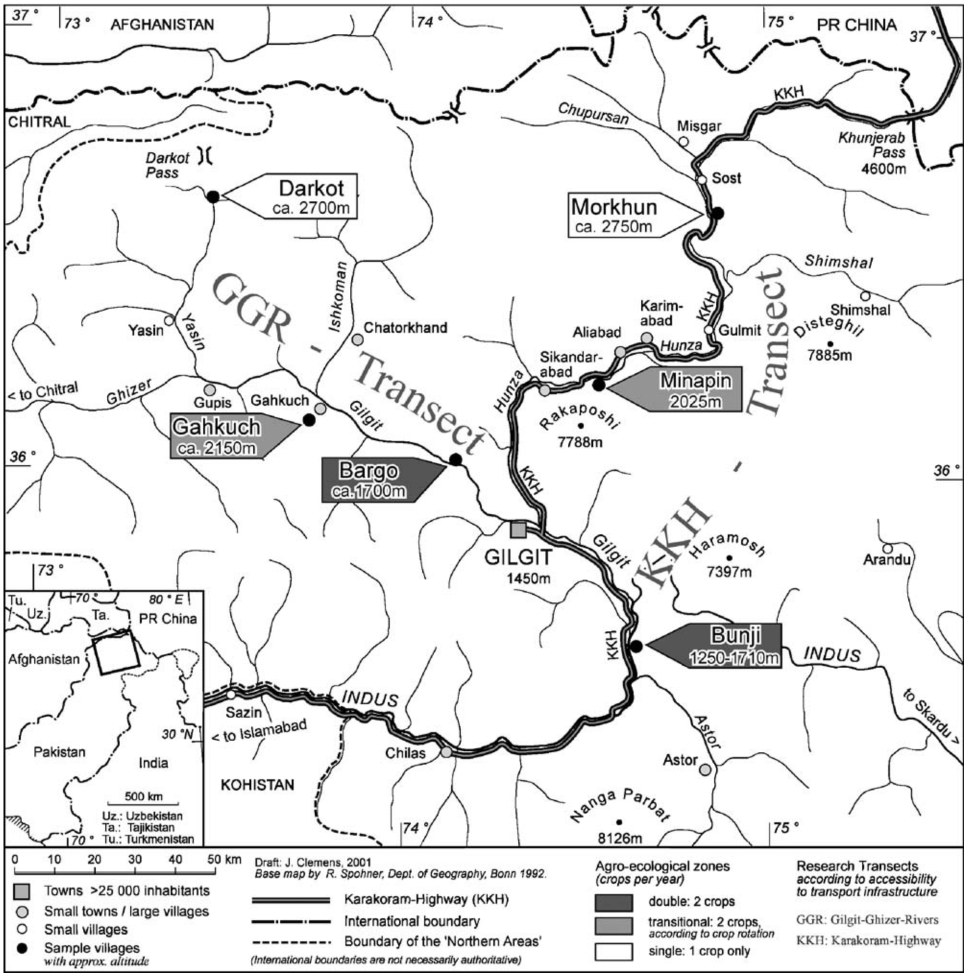

Fig. 1. Map of study region showing location of study villages within transects.

basis of the baseline survey, using a stratified, random sampling method to ensure that the full range of flock/herd size was covered by the sample (Rahman, 2002).

2.2. Characterisation of herd composition

During an initial visit to study households (October/November, 1999) an inventory of all livestock present in study households was constructed. To do this, each animal was individually tagged and its sex noted. Farmers were asked to estimate the age and the timing of last parturition of each mature female animal.

2.3. Estimation of fodder availability at the start of winter

Fodder resources which accumulate over the summer growing season are harvested and stored in dedicated fodder stores in the autumn for use over the winter season. The quantity of stored feed per household was estimated at the start of the winter season (Oct/Nov) to determine the availability of fodder for use over the winter season. The linear dimensions of all fodder stores were measured and scale diagrams produced for each household. The proportion of each store occupied by various feed types was then subjectively estimated. This allowed feed resources per household to be estimated by volume. Estimates of the density of each feed type on each of the three sampling occasions were made by measuring the weight of a large sub-sample of feed of known volume. The weight of each major feed type per household was then calculated from volume and density estimates. Feed resource availability was also calculated in terms of metabolisable energy and digestible crude protein using published estimates of nutritive value (MAFF, 1975).

2.4. Estimation of feed offered to livestock over winter

Livestock are generally stall-fed over winter and estimates of feed offered to different livestock species per household were made over the winter season. A selected individual from each household was given simple data recording sheets and a spring balance and briefed to make estimates of the amount of feed offered to different livestock species on one day per week over the entire winter season. Each record included feed type, animal species, weight of feed and number of animals in the group. Over 18,000 individual records were collected across all the study villages for the whole winter season. The quality of the data was monitored during visits to the study sites on the three main sampling occasions.

2.5. Measurement of live weight and body condition score

All livestock in study households were weighed and body condition scored during the first household visit in October and November 1999. Live weight was measured following an overnight fast using a portable electronic balance comprised of two weigh bars (Tru Test Series 700, Sydney, Australia) and a locally constructed, demountable crate. Standard body condition scoring techniques were used for cattle (Lowman et al., 1976) and for goats and sheep (Russel et al., 1969). Repeated measurements of live weight and body condition score were made for all livestock at intervals of approximately two months for a 12-month period.

2.6. Lactation parameters

Simple data recording sheets for milk yield from cows were prepared using Urdu text and distributed to the farmers with domestic measuring jugs. During the first visit, at least one person per household (preferably the woman who was mostly engaged in animal activities) was asked to take responsibility for weekly data recording. The selected person was trained and requested to record milk offtake for one full day per week. One of the research team also recorded milk offtake of each individual lactating cow of the study household during their periodic visits. Morning and evening milk offtake data were recorded for one full day per week over the winter period. These data were used to calculate mean daily offtake for domestic consumption or sale. Since it was impossible during the current study to accurately estimate milk consumed by the calves it was not possible to estimate total milk yield. Milk offtake was therefore used as a surrogate to allow comparisons between households. Difficulties in obtaining true milk yields are inherent to this type of study (Roderick et al., 1999).

2.7. Reproductive performance

Data on calving interval, parturition dates and outcomes, and number of offspring produced in each selected household over the 12 month study period was collected. Some of the information required a longer time scale to be useful (such as calving interval). For this reason herd data collected as part of a livestock-focused survey (Rahman, 2002) was combined with event data (e.g. any offspring born since last visit) collected during periodic visits. Information on reproductive parameters were collected through event recording during each visit. Overall reproductive performance in the selected households was determined by dividing the number of offspring born in each household during the study period by the number of mature females kept by those households. These measures were calculated separately for each livestock species.

2.8. Data analysis

The influence of transect and agro-ecological zone on stored feed resources and the amount of feed offered to livestock were analysed using residual maximum likelihood (REML) analysis (Patterson and Thompson, 1971). Fixed terms in the REML model were transect, zone and their interaction. Household was entered as a random term (equivalent to a block term in analysis of variance) to allow for variation between households within a village when datasets included within-household information (e.g. individual animal data such as liveweight change and milk offtake). For datasets where household averages formed the unit of measurement (e.g. herd composition and prolificacy data) zone and transect were treated as fixed effects in the REML model. In these datasets, because sample sizes were relatively small, significance values should be treated with a degree of caution. Sex ratio data was expressed as percentage of mature animals of each species that were male.

3. Results

3.1. Livestock holdings

Householders in the GGR transect kept greater numbers of cattle per household than those in the KKH transect ($P < 0.001$; Table 1). Numbers of sheep and goats kept by householders were not significantly influenced by transect. There was some evidence for an effect of agro-ecological zone on the numbers of goats kept by householders, with those in the DCZ keeping more than those in the SCZ and those in the TCZ keeping the lowest numbers. The influence of zone was more marked in the case of sheep, with higher numbers of sheep being kept at higher altitudes especially in the KKH transect. However, when livestock holdings were expressed in terms of total metabolic liveweight held by each household, transect and zone means were not significantly different.

3.2. Stored feed

Estimates of the amount of stored feed per household (wheat straw, lucerne, maize stovers, wild grass hay) at the start of the winter season in each zone and transect are shown in Table 2. The total amount of feed stored per household was similar in the two transects averaging 2.8 tonnes DM per household. Feed storage tended to be greater at higher altitude agro-ecological zones, reflecting the longer winter season ($P < 0.1$) but feed storage was highest in the TCZ. Feed storage in the GGR TCZ was higher than the other

Table 1
Mean numbers of cattle, goats and sheep per household and mean metabolic liveweight ($LW^{0.75}$) per household at the start of winter 2000 in the selected study villages of Northern Pakistan

Transect	SCZ	TCZ	DCZ	Transect mean		
Number of cattle						
GGR	5.7 (±1.62)	12.3 (±2.18)	6.0 (±1.39)	8.2 (±1.27)	Zone *P*-value	0.039
KKH	4.2 (±0.72)	3.8 (±0.44)	3.8 (±0.68)	3.9 (±0.36)	Transect *P*-value	0.001
					Zone × transect *P*-value	0.038
Zone mean	4.9 (±0.94)	8.4 (±1.67)	4.9 (±0.80)	6.1 (±0.76)		
Number of goats						
GGR	12.8 (±13.00)	10.9 (±8.52)	17.5 (±6.22)	13.6 (±5.57)	Zone *P*-value	0.298
KKH	13.2 (±13.00)	3.8 (±1.79)	28.0 (±6.11)	15.0 (±5.36)	Transect *P*-value	0.860
					Zone × transect *P*-value	0.670
Zone mean	13.0 (±9.31)	7.6 (±4.76)	22.8 (±4.36)	14.3 (±3.87)		
Number of sheep						
GGR	4.2 (±3.50)	5.3 (±1.65)	3.8 (±0.76)	4.5 (±1.29)	Zone *P*-value	0.002
KKH	15.2 (±0.19)	3.3 (±1.82)	0.3 (±2.19)	6.3 (±1.78)	Transect *P*-value	0.306
					Zone × transect *P*-value	0.001
Zone mean	9.7 (±1.82)	4.4 (±1.25)	2.1 (±1.97)	5.4 (±1.10)		
Metabolic liveweight per household						
GGR	413.4 ± (121.86)	646.5 ± (181.81)	467.1 ± (251.24)	516.3 ± (113.17)	Zone *P*-value	0.881
KKH	423.1 ± (91.45)	227.1 ± (47.56)	544.4 ± (167.93)	398.2 ± (72.55)	Transect *P*-value	0.408
					Zone × transect *P*-value	0.297
Zone mean	418.3 ± (76.19)	452.9 ± (115.88)	505.8 ± (151.51)	458.8 ± (68.68)		

GGR: Gilgit Ghizer Region; KKH: Karakoram Highway; DCZ: double cropping zone; TCZ: transitional cropping zone; SCZ: single cropping zone. Values presented are means. Values in parentheses denote standard errors of means.

GGR zones and lower in the KKH TCZ than the other KKH zones, leading to a significant zone by transect interaction ($P < 0.01$) and reflecting the pattern of livestock holdings in the TCZ (see Table 1). Feed storage expressed as metabolisable energy and digestible crude protein stored per household, directly mirrored the corresponding values for DM storage, indicating that the balance of lucerne, the major source of digestible crude protein, and cereal by-products, the major energy source, did not vary greatly between households.

3.3. Feed offered to cattle

Cattle were the major recipients of feed offered over the winter season (68.5% of total DM). When feed offered to cattle was broken down by zone and transect some highly significant variation was apparent (Table 3). Householders in the KKH transect fed significantly more fodder (DM, ME and CP) to their cattle ($P < 0.001$) than those in the GGR transect, despite having fewer cows per household (see Table 1). There was also evidence for a zone effect, with

Table 2
Mean of available dry matter (DM), metabolisable energy (ME), crude protein (CP) per household at the start of winter 2000 in the selected study villages of Northern Pakistan

Transect	SCZ	TCZ	DCZ	Transect mean		
DM (kg/ household)						
GGR	2545 (±503.1)	4961 (±907.9)	1846 (±732.5)	3215 (±523.1)	Zone *P*-value	0.037
KKH	3029 (±229.5)	2045 (±266.7)	2277 (±463.0)	2450 (±208.1)	Transect *P*-value	0.118
					Zone × transect *P*-value	0.004
Zone mean	2787 (±273.5)	3615 (±641.6)	2061 (±418.2)			
ME (GJ/ household)						
GGR	19.4 (±4.23)	38.5 (±7.49)	13.2 (±5.69)	24.5 (±4.24)	Zone *P*-value	0.039
KKH	21.6 (±1.94)	14.8 (±2.53)	16.8 (±3.54)	17.7 (±1.64)	Transect *P*-value	0.092
					Zone × transect *P*-value	0.006
Zone mean	20.5 (±2.25)	27.6 (±5.28)	15.0 (±3.24)			
CP (kg/household)						
GGR	207.6 (±47.78)	415.8 (±80.90)	133.1 (±50.01)	260.1 (±45.34)	Zone *P*-value	0.03
KKH	257.9 (±34.83)	143.7 (±24.42)	169.3 (±39.72)	190.3 (±21.75)	Transect *P*-value	0.098
					Zone × transect *P*-value	0.002
Zone mean	232.8 (±29.20)	290.3 (±58.39)	151.1 (±30.95)			

GGR: Gilgit Ghizer Region; KKH: Karakoram Highway; DCZ: double cropping zone; TCZ: transitional cropping zone; SCZ: single cropping zone. Values presented are means. Values in parentheses denote standard errors of means.

Table 3
Average daily feed dry matter (DM), crude protein (CP) and metabolisable energy (ME) offered per animal per household to cattle during winter in the study villages of the Northern Areas

Transect	SCZ	TCZ	DCZ	Transect mean		
DM offered (kg/day/ animal)						
GGR	3.8 (±0.35)	3.9 (±0.31)	3.5 (±0.09)	3.7 (±0.16)	Zone *P*-value	0.067
KKH	6.4 (±0.90)	5.5 (±0.65)	4.4 (±0.35)	5.5 (±0.41)	Transect *P*-value	0.001
					Zone × transect *P*-value	0.067
Zone Mean	5.1 (±0.54)	4.7 (±0.45)	3.9 (±0.21)			
CP (g offered /day/animal)						
GGR	185.6 (±18.90)	303.2 (±22.35)	229.4 (±11.85)	242.7 (±15.50)	Zone *P*-value	0.066
KKH	467.1 (±82.40	351.4 (±36.55	267.5 (±22.50	361.9 (±35.20)	Transect *P*-value	0.001
					Zone × transect *P*-value	0.002
Zone Mean	326.3 (±50.65)	327.3 (±22.43)	248.5 (±17.48)			
ME offered (MJ/day/ animal)						
GGR	21.4 (±2.05)	26.6 (±2.10)	22.6 (±0.90	23.7 (±1.13)	Zone *P*-value	0.024
KKH	42.5 (±6.78)	35.4 (±4.00)	23.9 (±1.93)	33.9 (±3.15)	Transect *P*-value	0.001
					Zone × transect *P*-value	0.017
Zone Mean	31.9 (±4.65)	31.1 (±3.21)	23.2 (±1.41)			

GGR: Gilgit Ghizer Region; KKH: Karakoram Highway; DCZ: double cropping zone; TCZ: transitional cropping zone, SCZ: single cropping zone. Values presented are means. Values in parentheses denote standard errors of means.

Table 4
Mean percentage liveweight change over (a) winter, Oct–Feb and (b) summer, Feb–Aug. Transect, zone and species means are presented

	DCZ	TCZ	SCZ	Zone averages		
(a) Winter						
GGR						
Cow	−6.6 (±1.21)	−3.1 (±1.14)	−5.2 (±1.30)	−4.3 (±0.77)	Zone *P*-value	0.124
Goat	−6.1 (±3.61)	−10.0 (±1.41)	−11.6 (±1.49)	−8.9 (±1.66)	Transect *P*-value	0.661
Sheep	−17.4 (±3.95)	−12.4 (±2.68)	−6.7 (±12.07)	−13.7 (±2.37)	Species *P*-value	0.002
					Zone × transect *P*-value	0.499
GGR average	−7.4 (±2.70)	−7.3 (±0.96)	−9.8 (±1.21)	−8.1 (±1.06)	Zone × species *P*-value	0.114
					Transect × species *P*-value	0.672
KKH						
Cow	−3.3 (±4.61)	−7.1 (±2.15)	−0.1 (±2.02)	−2.7 (±1.57)	Zone × transect × species *P*-value	0.185
Goat	−11.5 (±1.33)	4.4 (±5.73)	−14.0 (±1.81)	−12.2 (±1.17)		
Sheep	−4.0 (±0.00)	−5.2 (±4.85)	−11.1 (±1.99)	−10.2 (±1.83)		
KKH average	−11.0 (±1.29)	−4.4 (±2.45)	−10.8 (±1.27)	−10.1 (±0.91)		
(b) Summer						
GGR						
Cow	27.3 (±5.09)	21.6 (±3.37)	31.4 (±4.11)	25.2 (±2.41)	Zone *P*-value	0.007
Goat	31.6 (±3.61)	24.3 (±4.03)	65.2 (±5.02)	41.3 (±2.88)	Transect *P*-value	0.077
Sheep	47.7 (±8.64)	29.7 (±4.87)	62.8 (±10.59)	37.8 (±4.61)	Species *P*-value	<0.001
					Zone × transect *P*-value	<0.001
GGR average	32.5 (±2.98)	24.1 (±2.33)	56.2 (±4.13)	36.1 (±1.98)	Zone × species *P*-value	0.023
					Transect × species *P*-value	0.807
KKH						
Cow	19.5 (±1.58)	22.1 (±4.11)	8.4 (±5.22)	13.9 (±3.60)	Zone × transect × species *P*-value	0.019
Goat	41.6 (±4.39)	75.6 (±13.78)	29.1 (±3.07)	36.9 (±2.84)		
Sheep	34.2 (±0.00)	50.6 (±9.07)	37.0 (±4.42)	38.8 (±3.98)		
KKH average	40.4 (±4.15)	41.6 (±6.64)	29.2 (±2.60)	33.8 (±2.15)		

Values in parentheses represent standard errors of means.

Table 5
Average numbers of mature male cattle as a percentage of total numbers of mature cattle in the study villages of the Northern Areas

	Transect	SCZ	TCZ	DCZ	Transect mean		
Males (percent of total)	GGR	54.3 (±6.95)	39.9 (±5.18)	38.4 (±4.88)	44.2 (±5.51)	Zone *P*-value	0.808
	KKH	12.0 (±3.38)	7.6 (±5.18)	26.7 (±8.07)	14.0 (±3.92)	Transect *P*-value	0.047
						Zone × transect *P*-value	0.487
	Zone Mean	33.2 (±5.86)	25.8 (±5.50)	34.2 (±6.39)			

GGR: Gilgit Ghizer Region; KKH: Karakoram Highway; DCZ: double cropping zone; TCZ: transitional cropping zone; SCZ: single cropping zone. Values presented are means. Values in parentheses represent standard errors of means.

cattle receiving more feed per household at higher altitude agro-ecological zones ($P < 0.1$ for DM and CP; $P < 0.05$ for ME). This effect was stronger in the KKH transect than in the GGR transect leading to a significant zone by transect interaction ($P < 0.1$ for DM; $P < 0.05$ for ME and CP).

3.4. Liveweight change

Seasonal liveweight change in animals greater than 1 year of age is presented in Table 4. Animals lost an average of 8.9% of their body weight during the winter season (Table 4). Sheep and goats lost more ($P < 0.01$) weight (10.5%) than cattle (3.9%). Liveweight change over winter was not significantly affected by transect or agro-ecological zone. Animals gained an average of 35.2% of their initial live weight over the summer season. Again, this weight change was not uniform across species with cattle gaining less weight ($P < 0.001$; 22.3%) than sheep or goats (39.3%; Table 4). Summer weight gain was significantly affected by agro-ecological zone ($P < 0.01$; Table 4) but the variation was not systematic. This was reflected in a significant transect by zone interaction ($P < 0.001$; Table 4) with animals in the SCZ tending to gain more weight in the GGR transect with animals in the other zones gaining more weight in the KKH transect. Animals tended to gain more weight in summer in the GGR transect than in the KKH transect ($P < 0.1$; Table 4). Body condition score changed, broadly in parallel to live weight.

3.5. Sex ratio and reproductive performance

The percentage sex ratio favoured males to a greater extent in the GGR transect than in the KKH transect ($P < 0.05$; Table 5) with almost half the herd being composed of male animals in the GGR transect. Zone did not significantly influence sex ratio (Table 5).

Prolificacy (number of offspring born per mature female per year) was significantly greater ($P < 0.05$) for all livestock species in the KKH transect than in the GGR transect (Table 6). Cattle and goats produced more offspring per mature female in the lower agro-ecological zones ($P < 0.05$; Table 6) but, for sheep, the number of offspring per mature female was highest in the TCZ and slightly lower in the SCZ with the lowest values being found in the DCZ ($P < 0.05$; Table 6).

3.6. Milk offtake

Milk offtake was significantly affected by transect and zone and there was a significant interaction between transect

Table 6
Household averages for numbers of offspring born between Oct. 1999 and Oct. 2000 per mature female for cattle, goats and sheep in the study villages of the Northern Areas

Transect	SCZ	TCZ	DCZ	Transect mean		
Number of calves born per mature cow						
GGR	0.44 (±0.04)	0.51 (±0.05)	0.65 (±0.05)	0.53 (±0.03)	Zone *P*-value	0.039
KKH	0.69 (±0.10)	0.90 (±0.08)	0.86 (±0.08)	0.82 (±0.05)	Transect *P*-value	0.02
					Zone × transect *P*-value	0.692
Zone Mean	0.56 (±0.08)	0.7 (±0.07)	0.75 (±0.05)			
Number of kids born per mature doe						
GGR	0.55 (±0.05)	0.71 (±0.09)	0.85 (±0.18)	0.70 (±0.07)	Zone *P*-value	0.037
KKH	0.82 (±0.07)	0.93 (±0.18)	0.97 (±0.03)	0.90 (±0.10)	Transect *P*-value	0.023
					Zone × transect *P*-value	0.354
Zone Mean	0.77 (±0.08)	0.82 (±0.15)	0.91 (±0.08)			
Number of lambs born per mature ewe						
GGR	0.49 (±0.08)	0.77 (±0.20)	0.52 (±0.10)	0.59 (±0.12)	Zone *P*-value	0.032
KKH	1.18 (±0.14)	1.12 (±0.03)	0.66 (±0.20)	0.95 (±0.16)	Transect *P*-value	0.043
					Zone × transect *P*-value	0.341
Zone Mean	0.78 (±0.11)	0.94 (±0.17)	0.59 (±0.07)			

GGR: Gilgit Ghizer Region; KKH: Karakoram Highway; DCZ: double cropping zone; TCZ: transitional cropping zone; SCZ: single cropping zone. Values presented are means. Values in parentheses represent standard errors of means.

Table 7
Average daily offtake of milk from cattle in the selected households during the period November 1999–December 2000

Transect	SCZ	TCZ	DCZ	Transect mean		
Milk offtake per day (l)						
GGR	0.9 (±0.04)	3.2 (±0.05)	1.4 (±0.07)	2.3 (±0.05)	Zone *P*-value	0.01
KKH	2.1 (±0.08)	1.8 (±0.05)	1.9 (±0.09)	2.9 (±0.06)	Transect *P*-value	0.04
					Zone × transect *P*-value	<0.01
Zone mean	1.8 (±0.06)	2.8 (±0.05)	1.6 (±0.06)			

GGR: Gilgit Ghizer Region; KKH: Karakoram Highway; DCZ: double cropping zone; TCZ: transitional cropping zone; SCZ: single cropping zone. Values presented are means. Values in parentheses represent standard errors of means.

and zone (Table 7). Average milk offtake was significantly higher in the KKH transect than in the GGR transect ($P < 0.05$). Households in the TCZ had higher average milk offtake than in the other two zones ($P < 0.01$) although this was wholly due to the very high milk offtake in the TCZ village of the GGR transect. The high milk offtake values in this cell also led to a highly significant interaction between zone and transect ($P < 0.01$).

4. Discussion

Livestock feeding practices in the Northern Areas of Pakistan have been the subject of several surveys and studies based on rapid appraisal techniques (Saunders, 1983; Wardeh, 1989; Nuesser and Clemens, 1996; Kamal and Nasir, 1998) but the current study represents the first systematic and regional investigation based on actual measurements. The picture that emerges is of a livestock enterprise which is heavily reliant on crop residues as an energy source for livestock. The protein component of the feed resource arises, to a large extent, from the cultivation of lucerne which is stored and fed over the winter months. This concurs with the conclusions of previous anecdotal studies (Wardeh, 1989). However, the systematic study design and direct measurements used in the present study allowed a more detailed picture of feeding practices to be developed.

The total mass of livestock held per household did not differ greatly across the study region and was not influenced by agro-ecological zone or transect. However, the numbers of cattle kept in the KKH transect was lower than in the GGR transect. This may reflect a generally lower reliance on livestock production in this transect since opportunities for cash-cropping and off-farm income are greater as a result of the better transport infrastructure (Wright et al., 2005). The Karakoram Highway has allowed better access for the marketing of cash crops such as potatoes and for tourists providing opportunities for tourist-related income (Kreutzmann, 1995), and this appears to be at the expense of traditional livestock production activity. Despite the lower numbers of cattle held per household in the KKH transect, the amount of winter feed stored per household did not differ between transects. As a result, the amount of feed offered per cow was greater in the KKH transect. The overall picture is therefore one of lesser reliance on livestock in the KKH transect but of better fed livestock. Lower numbers of livestock fed greater amounts per head results in a greater proportion of available feed being available for productive purposes rather than for maintenance functions. Storage of feed for winter appeared to be relatively well planned across the study region, with the amount of feed stored reflecting the numbers of animals to be fed.

A key feature of this system is the practice of transhumance whereby livestock spend the winter season primarily within the village precincts feeding on cereal by-products while the summer season is spent grazing temperate, high pasture areas. The effect of this transhumance practice on seasonal change in live weight and body condition is clearly demonstrated by our data. The extreme seasonal changes in these parameters are notable with animals gaining an average of 35% of their late-winter body weight over the summer season. This extensive accumulation of body reserves over the summer season emphasises the critical importance of high pasture resources to the livestock enterprise and indeed, to the livelihoods of the human population of Pakistan's Northern Areas. Seasonal change in body reserves is a feature of most extensive livestock production systems with reserves being accumulated during periods of food abundance to sustain livestock during periods of food scarcity (Sahani and Sahni 1976). In most systems, storage of body reserves is supplemented by physical storage of feed resources by farmers for use during periods of scarcity. The current system is no exception but our data suggest that accumulation of body reserves is the major sink for storage of resources in the system under study.

Winter loss of live weight was lower than subsequent summer gain in live weight. This is partly explained by a component of growth in the data; although analysis was restricted to animals greater than 1 year old, a substantial component of the herd was still growing and this tended to reduce the effect of winter weight loss and to increase subsequent summer weight gains. However, even body condition gains were higher in summer than losses during the winter suggesting that the summer under study was a particularly good one. Obviously, a number of years of data would be necessary to gain a full understanding of the seasonal dynamics of herd weight and condition but this was beyond the scope of the current study and the results must therefore be viewed with appropriate caution.

Some geographical variation in live weight change was apparent in the data. Summer liveweight gains were greater in the GGR transect than in the KKH transect. This may reflect better pasture resources or simply a lower proportion of the herd being taken to high pasture areas in the KKH transect (Clemens, 2005). With increased educational and employment opportunities close to the KKH the availability of herders for livestock on high pastures, a job traditionally carried out by children, has declined (Wright et al., 2005). There is evidence of an increasing trend towards retaining livestock within the village precincts over summer in the KKH transect (J. Clemens, pers. commun.) denying these animals the opportunity for the extensive repletion of body reserves which is obviously possible.

Other features of herd dynamics and demography pointed to a slightly less intensive livestock enterprise in the GGR transect than in the KKH transect. A large proportion of males appeared to be retained in contrast to the KKH transect which had a much higher proportion of females. This may have related to a greater reliance on draught power in the GGR transect where access to mechanisation was less (Clemens, 2005). Reproductive efficiency also appeared to be higher in the KKH transect; in the case of cattle this may be explained by the better feeding of individual cattle although similar trends in reproductive efficiency were evident for sheep and goats. This may simply point to more advanced husbandry techniques in the KKH region.

Milk production data also emphasised the greater nutritional efficiency of livestock production in the KKH transect. The higher milk offtake data in the KKH transect pointed to a more intensive pattern of livestock production in this transect.

5. Conclusions

The study suggests that proximity to good transport links within the Northern Areas are likely to lead to a lower reliance on traditional livestock keeping as an economic activity. This, coupled with the available fodder being distributed amongst lower number of animals, particularly of cattle, that are kept by householders, may help to relieve the oft-referred to ‘‘feed deficit’’ in the Northern Areas (Wardeh, 1989) as further infrastructural development occurs. However, the consequences of the changes in the numbers of livestock on grazing impacts on pasture resources in the Gilgit region are not clear and would merit further study.

The efficiency (productive output per nutritional input) of various livestock production and reproductive parameters was higher in the KKH transect than in the GGR transect reflecting perhaps the more advanced stage of development found along the KKH. Matching of feed resources with requirements led to greater output per animal. The reasons for the reduced cattle numbers in the KKH transect may relate to a decreased need to store capital in livestock with more awareness of other ways of saving. Decreased availability of labour for livestock tending in both summer and winter may also have played a role. Finally, a reduced reliance on livestock as an income source with the increasing prominance of cash crops such as potatoes and other forms of non-farm income, may also have diverted effort away from livestock. Livestock are still regarded as an important component of the domestic subsistence economy in both transects. If livestock are to become a means of generating cash income then the issue of marketing of livestock products and competition from external sources will need to be addressed.

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