Chapter 6

BODY CONDITION

Introduction

Yousef (1982), Spinage (1986) and Payne (1990) list a number of potential advantages that African antelope have over domestic livestock for meat production when they live under similar conditions in marginal areas. First, when they form multi-species assemblages, antelope make use of a wider spectrum of plant parts and species. Murray & Illius (1996) state that in parts of East Africa, ten or more species of grazing ungulate may be found in close proximity. Such species-rich communities are found in southern Africa as well. Within grazing antelope, different species show variation in diet selection according to grass height and variation in the selection of different parts of the grass plants (Jarman, 1974; Murray & Illius, 1996). Additionally, alongside grazing species there are also browsing antelope that select non-grass plants and feed from different heights within the vegetation. In contrast, cattle are bulk roughage grazers and are not very selective due to their wide flat muzzles (Wright & Connolly, 1995). Accordingly, the biomass of a multi-species assemblage of antelope is generally greater in a given area of habitat than is possible with domesticated cattle alone, with herbivore biomass being positively related to the number of species present (Murray & Illius, 1996).

Estimates of the biomass of game animals should, however, be accepted with caution as there are many variable assumptions in the calculations (Payne, 1990). The fact that a specific environment supports a high biomass of wild ungulates does not necessarily mean that productivity per unit area of land will be high. If the animals grow slowly, then most of the available feed would have to be used for maintenance purposes and annual off-take would be low.

A second advantage of antelope in marginal areas is that some species have evolved specialised physiological and behavioural adaptations to survive in their hot and dry climate (Yousef, 1982). An example is the ability of gemsbok (*Oryx gazella*) to reduce water loss via evaporative cooling (sweating) by undergoing hyperthermia without adverse health risks. Additionally, indigenous antelope tend to have a greater resistance to endemic diseases and can, therefore, be cropped in regions where domestic livestock cannot be utilised or are only marginally economic. However, it should not be assumed that the disease factor might be totally ignored in wild game (Payne, 1990).

Yousef (1982) states that wild ungulates produce a given quantity of meat more quickly than domestic livestock because they breed and grow more quickly on their preferred diet. Some studies have shown that indigenous wild ungulates are more efficient in converting the flora into animal protein than might be expected from the use of domestic livestock (Yousef, 1982). However, this is only the case in areas where domestic livestock are not well adapted to the environmental conditions, and Payne (1990) indicates that there is little evidence to suggest that indigenous wild ungulates are able to make better use of the food they consume than do domestic animals. It has been shown that in the same environment, the productivity of eland is inferior to that of Hereford cattle, with higher food consumption and more protein being required for each unit of meat produced (Taylor & Lyman, 1967). Watson, Graham & Parker (1969) estimated that the off-take of game animals under favourable conditions could be of the order of 10 % per annum on a sustained yield basis. This is similar to that achieved by an indigenous cattle herd, but much lower than what could be achieved with a well-managed modern integrated livestock unit.

Antelope have dressing percentages between 50 % and 65 % (Crawford, 1968; Payne, 1990), and these are comparable to dressing percentages of domestic cattle (Crawford, 1968; Payne, 1990). However, the percentage of lean meat is much higher in antelope than in domestic species (Ledger, 1963), with East African gazelles having a lean constant of 45 % compared to 32.5 % in Boran steers (the lean constant being the weight of carcass lean expressed as a percentage of the live animal). In well-fed adult Boran steers, the percentage of fat in the cold dressed carcass was 24 % (Ledger, 1990), compared to 2.5 % fat for wild ungulates (Crawford, 1968). The percentage fat on heifers is even higher because bulls and steers convert food into carcass gain more efficiently (age is also important, with young animals having less fat than adults). Allen and Kilkenny (1980) compared the carcass composition of 18 month-old

Friesian bulls and steers and showed that bulls had a fat percentage of 14 %, while steers had a fat percentage of 20 %. Ledger (1963) states that at dressing percentages of 60 %, domestic cattle may carry as much as 30 % fat content.

Not all of the above advantages apply when comparing mountain reedbuck or grey rhebok with domestic cattle at Sterkfontein. For example, domestic cattle are not often exposed to endemic diseases in this part of Africa, or are inoculated against them, so are not at a disadvantage in this regard, while the antelope in this region do not need to make use of physiological adaptations to conserve water loss. Moreover, there is generally plenty of freestanding water to suit the needs of cattle. Be that as it may, mountain reedbuck and grey rhebok often form part of multi-species assemblages in areas where they occur naturally, so information that improves utilisation is of value. Additionally, there are areas where these two species occur, especially the Karoo, where productivity of indigenous antelope such as mountain reedbuck will be higher than domestic cattle due to the unsuitability of the Karoo vegetation to hold large numbers of livestock.

Mountain reedbuck (*Redunca fulvorufula*) and grey rhebok (*Pelea capreolus*) utilise similar habitats in South Africa that are marginal for domestic livestock. In many areas they are sympatric. The favoured habitat of mountain reedbuck is grassland on steep slopes, up to 2200 m in the Drakensburg (Rowe-Rowe, 1994). They are selective grazers, feeding only on certain grass species and are water dependent (Irby, 1976). The living requirements of grey rhebok are grassland, where they occur on hills and mountains at high altitudes (up to 3300 m) (Rowe-Rowe, 1994). Grey rhebok feed selectively, almost entirely on forbs, and favour short, burnt veld for feeding (Beukes, 1984, 1988). They are independent of water for much of the year but will drink in winter when conditions are dry (see Chapter 5).

Mountain reedbuck are more abundant than grey rhebok and are regularly shot for their venison, which is palatable and normally free from parasites (Skinner, 1980). They have a high reproductive potential, may breed aseasonally and utilise marginal habitat without competing with livestock (Irby, 1975). They have the potential, therefore, to be harvested on a commercial basis (Skinner, 1980), although their dispersed social structure makes culling operations fairly inefficient.

Grey rhebok are less likely candidates for commercial meat production because they are less common and are not favoured for consumption. They form small social herds that stick to rigid territories (Beukes, 1984; see also Chapters 3 & 4) and are notoriously skittish. The high degree of difficulty involved in hunting them makes them unviable for cropping. For trophy hunting, however, they are highly marketable, although this is restricted to males with large horns. One advantage they have is that they eat forbs and, therefore, do not compete with many other ungulates, especially in marginal habitat.

Body condition can been defined in terms of levels of fat deposits in different parts of the body (Riney, 1955). In well-bred farm animals and northern hemisphere wild ungulates (deer) fat constitutes an important part of the overall carcass (see above), and the use of fat as an index of condition is implicit in growth rate principles. In African antelope, fat deposits are not consistently so well developed because of poorer nutrition, but it is still possible to distinguish three main centres of location of their fats: subcutaneous connective tissue, the abdominal cavity, and the inter-muscular connective tissue (Riney, 1955). These depots of fat serve as the principal fuel storage reserves of the body and can, therefore, be used as the main criterion for assessment of condition. Moreover, fat in wild ruminants is produced endogenously (Riney, 1955), making it a particularly useful index of the metabolic level and potential energy reserves of the animal. Fat could, therefore, be taken as a direct measure of condition, reflecting the goodness of physiologic adjustment of an animal with its environment.

There are a number of methods for measuring body condition. The kidney fat index, proposed by Riney (1955), is a quick and easy method of assessing body fat and is commonly used as an indicator of body condition in ungulates (Dauphine, 1975). It has been utilised by many authors, including Smith (1970) in East African ungulates, Sinclair & Duncan (1972) in tropical ruminants, Monro & Skinner (1979) in impala, Skinner (1980) in mountain reedbuck, and Dunham & Murray (1982) also in impala. Kidney weight is included in the index to allow comparison between animals of different sizes and, therefore, makes the assumption that kidney weight is proportional to body weight.

This assumption has been contested because there is evidence that kidney weight varies seasonally in some species (Batcheler & Clarke, 1970; Dauphine, 1975; Van Vuren & Coblentz, 1985). However, Spinage (1984) found in waterbuck (*Kobus ellipsiprymnus*) and Grant's gazelle (*Gazella granti*) that, although kidney weight did vary seasonally, it did not fluctuate sufficiently to bias a kidney fat index significantly. Van Vuren & Coblentz (1985) found that in feral sheep on Santa Cruz Island, California there was a linear relationship between kidney weight and body weight in adult sheep, but the kidneys of small sheep were larger in proportion to body weight than kidneys of larger sheep. They also found that kidney weights fluctuated seasonally and suggested that kidney fat index be adjusted for seasonal differences in kidney weight. In contrast, Shackleton & Granger (1989) found that kidney weights did not vary significantly seasonally in antelope species in the Transkei.

A second method of assessing body condition is the measurement of fat in one hind leg (buttock). Leg fat has been shown to correlate highly with total body fat in cattle (Butterfield, 1962) and eight East African antelope species (Smith, 1970). It can thus be used to estimate total body fat without dissecting a whole carcass.

A third and fairly commonly used method is the extraction of fat from the bone marrow of leg bones. Although it is a poor method for measuring changes in upper parts of condition scale, i.e. when animals have lots of fat (Riney, 1955), it has the advantage of allowing the assessment of animals that died weeks prior to collection. As material was available immediately after death, it was not necessary to make use of this factor. Also, it is a more complicated method that requires chemical extraction and was not considered for this study.

During the present study mountain reedbuck were being culled for management purposes and biological material was used to investigate body condition. Grey rhebok were not culled and because they were considered less common than mountain reedbuck and less desirable as a food product, no decision was taken to do so. There were two aims to this component of the study:

1) To determine levels of body fat in mountain reedbuck at Sterkfontein;
2) To investigate seasonal and sexual variation in body fat of mountain reedbuck.

The expected outcome of the second aim was that body fat and, therefore, body condition would vary seasonally, and that it would be lowest when environmental conditions were worst for the animals in terms of food supply. Additionally, reproductive status might also influence body condition.

To accomplish the above aims, the following questions were considered:

1. What are the dressing percentages of mountain reedbuck at Sterkfontein and are there any differences between the sexes?
2. Are there any seasonal differences in dressing percentages?
3. What are the kidney fat indices and leg fat percentages of mountain reedbuck at Sterkfontein?
4. Are there any differences between the sexes, between seasons, or between animals in different reproductive condition?
5. How do the two indices of body condition compare with each other?

The intended benefits to management were twofold. First, results should indicate whether animal numbers were kept at levels allowing high productivity, i.e. not too high or low. The presence of animals with excess fat during poor veld conditions would imply that more animals could be carried, while the presence of animals with very little body fat might indicate that there were too many animals. Second, knowing the condition of animals at different times of year allows culling to be carried out at appropriate times, depending on management requirements.

Methods

Study site and animals

This component of the study was primarily carried out at Sterkfontein but some material was also collected from Tussen die Riviere (TdR). Forty-one mountain reedbuck were culled at Sterkfontein between March 2000 and February 2002. Culling periods were divided into eight separate months under the following schedule: five animals were culled in March 2000, five in June 2000, five in September 2000, five in December 2000, six in May 2001, six in August 2001, five in November 2001, and four in February 2002. Numbers culled in the final two periods were reduced because a large number of mountain reedbuck died in heavy snowfalls in September 2001. In a typical culling period, two adult males, two adult females, and one juvenile of either sex were selected. The age and condition of adult mountain reedbuck were not known before they were shot, and because animals were located randomly, the selection was not considered biased.

The spacing of the culls, spanning eight different months over a two year period, meant that body condition of mountain reedbuck could be compared in both warm and cold periods as well as wet and dry periods. They hence covered times when animals had abundant food supplies available and times when food resources were limited. They also covered periods of differing reproduction condition. The months were categorised into seasons in the following way: autumn = February and March; winter = May and June; spring = August and September; and summer = November and December.

Forty-four mountain reedbuck were also culled at TdR over three separate culling periods, spanning one summer (December 1999) and two winters (June 2000 and 2001).

Body condition indices

At Sterkfontein, a maximum of two animals were shot in one day. Carcasses were bled where they were shot and transported to the slaughtering area within two hours. This time varied depending on whether another animal was to be shot in the same hunt. Biometric measurements (chest girth, neck girth and shoulder height) were recorded at the slaughter area and the carcasses weighed to the nearest 0.5 kg. After slaughter, dressed carcasses were left to hang for approximately one hour while other biological sampling was carried out, and then weighed. This was done for 16 males and 17 females. Due to the lack of cold storage facilities, carcasses could not be left to hang for 24 hours, as is often the procedure. Dressing percentages were, therefore, based on fresh weights. The dressed carcass in this case was the whole animal minus skin, head, legs below the knees and hocks (severed between the carpal and metacarpal bones or between the tarsal and metatarsal bones), and all internal organs and reproductive tracts.

As a means of assessing body condition, two indices of fat content were determined in addition to the dressing percentages. These were the kidney fat index (hereafter KFI) and leg fat percentage (LFP). To determine the KFI, both kidneys were extracted from the carcass along with all the perirenal fat. This included fat directly around the kidneys as well as fat lying on the inside surface of the abdominal wall, from the level of the kidneys to the pelvis. The kidneys were then separated from the fat and the two weighed independently. The KFI was calculated using the following equation:

$$KFI = (\text{kidney fat weight} / \text{kidney weight}) \times 100$$

The LFP was determined using the right hind leg (buttock) from the hock up to and including one half of the pelvis. The buttock was stored in a fridge for a minimum of 24 hours before being dissected. To assess fat content, the leg was completely separated into meat, bone, fat and sinew, by dissection. During the procedure, all processed parts were kept in closed plastic bags to avoid moisture loss. On completion of dissection, all parts were weighed separately.

At TdR animals were shot in larger numbers, twice during culls and once by hunters, so it was not possible to collect all the material as at Sterkfontein. During culls animals were selected randomly. The KFI was the only condition index measured because the hunters were paying for their carcasses.

Statistical methods

In view of the potential problem of kidney weight not being proportional to body weight, these two parameters were compared using log-log linear regression. The ratio of kidney weight to body weight was also analysed between seasons to determine whether the KFI should be adjusted to allow for any differences. Further analyses using KFI were then conducted in light of these findings. For the fat indices of Sterkfontein, simple linear regression was used to compare KFI and LFP. To investigate the seasonal variation in fat indices, as well as any differences between males and females, two-way ANOVAs were used. To investigate the possibility that KFI was related to body weight, linear regression analyses were carried out for males and females at both Sterkfontein and TdR. If necessary, the data were transformed, and the methods used described in the relevant sections.

Results

Sterkfontein Dam Nature Reserve

Carcass weights and dressing percentages

Adult rams averaged 29.9 kg (range 23.0 – 35.0 kg, n = 18) and adult ewes 28.0 kg (range 23.5 – 34.5 kg, n = 19) at Sterkfontein. In dressing percentages, there was little apparent difference between males and females within seasons, but there were small seasonal differences (Figure 25).

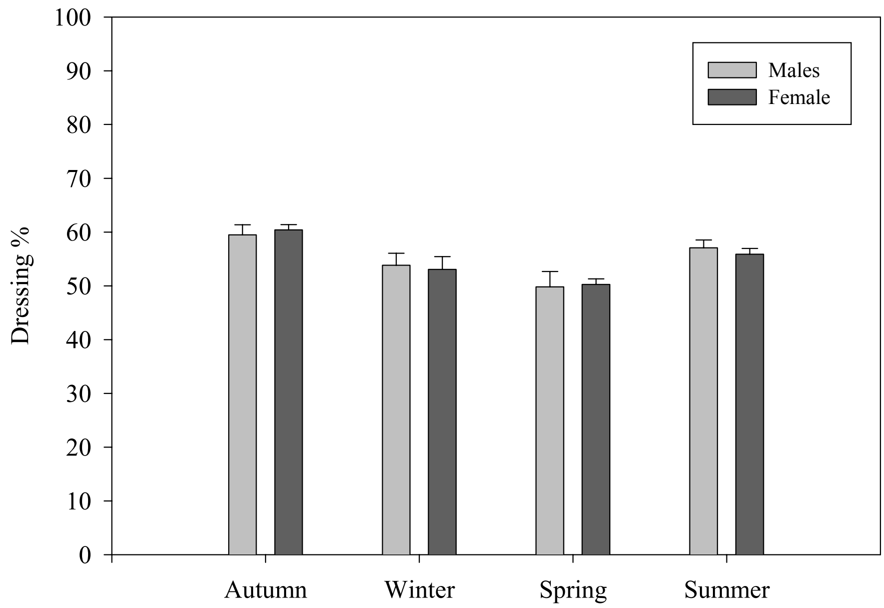

Figure 25. Seasonal variation in dressing percentages of male (n = 16) and female (n = 17) mountain reedbuck at Sterkfontein. Autumn = February/March, winter = May/June, spring = August/September, summer = November/December. Error bars represent standard error.

These differences were tested using a two-way ANOVA (Table 20). There was strong evidence of a difference between seasons but no evidence of a difference between genders and no interaction. Multiple pairwise comparisons using the Tukey test indicated that dressing percentages were lower in spring compared to autumn and summer, and lower in winter compared to autumn.

Table 20. Two-way ANOVA comparing dressing percentages of 33 mountain reedbuck between gender (16M: 17F) and between seasons at Sterkfontein.

Source of Variation	df	SS	MS	F	P
Gender	1	0.200	0.200	0.013	0.910
Season	3	376.335	125.445	8.194	< 0.001
Gender x season	3	5.448	1.816	0.119	0.948
Residual	25	382.734	15.309		
Total	32	774.010	24.188		

Regression analysis of kidney weight and body weight

To determine whether the effect of body weight (BW) on kidney weight (KW) was allometric, log-log linear regression analyses were carried out using data from all the animals (Figure 26a) and then with animals less than 20 kg excluded (Figure 26b). Male and female data were pooled because their scatter plots of BW against KW were very similar. When animals under 20 kg were included, the slope of the regression curve was less than 1, so the relationship was allometric (i.e. smaller animals had relatively larger kidneys). However, when the animals under 20 kg were excluded, the regression did not differ significantly from 1, so kidney weights varied proportionally relative to body weight. As a result, further analyses using the KFI were carried out with the data for animals under 20 kg removed.

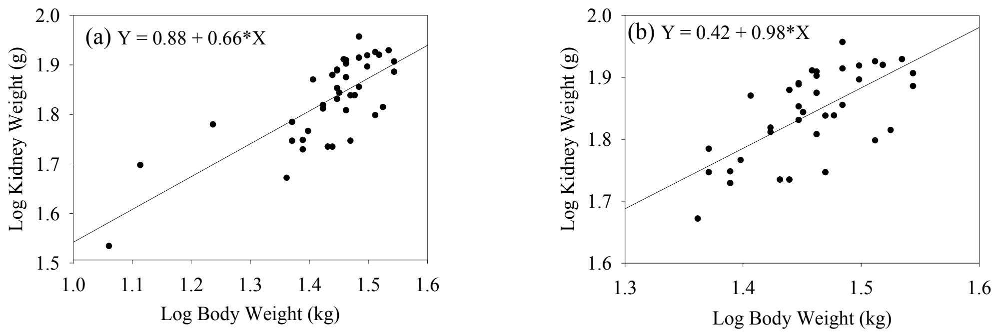

Figure 26. Log-log linear regression of mountain reedbuck body weight against kidney weight at Sterkfontein. (a) All animals (b) animals less than 20 kg excluded.

Females had more seasonal variation in KW than males (Figure 27), and spring (August/September) was the period when it was lowest. However, a two-way ANOVA comparing KW between genders and seasons (with animals under 20 kg excluded) found no differences between males and females or between seasons (Table 21). It was, therefore, not necessary to adjust the KFI according to seasonal variation in KW for animals over 20 kg.

Table 21. Two-way ANOVA comparing KW of 38 mountain reedbuck between gender (M18: F20) and seasons at Sterkfontein.

Source of Variation	DF	SS	MS	F	P
Gender	1	6.479	6.479	0.057	0.813
Season	3	644.418	214.806	1.893	0.152
Gender x season	3	254.135	84.712	0.747	0.533
Residual	30	3403.458	113.449		
Total	37	4393.101	118.732		

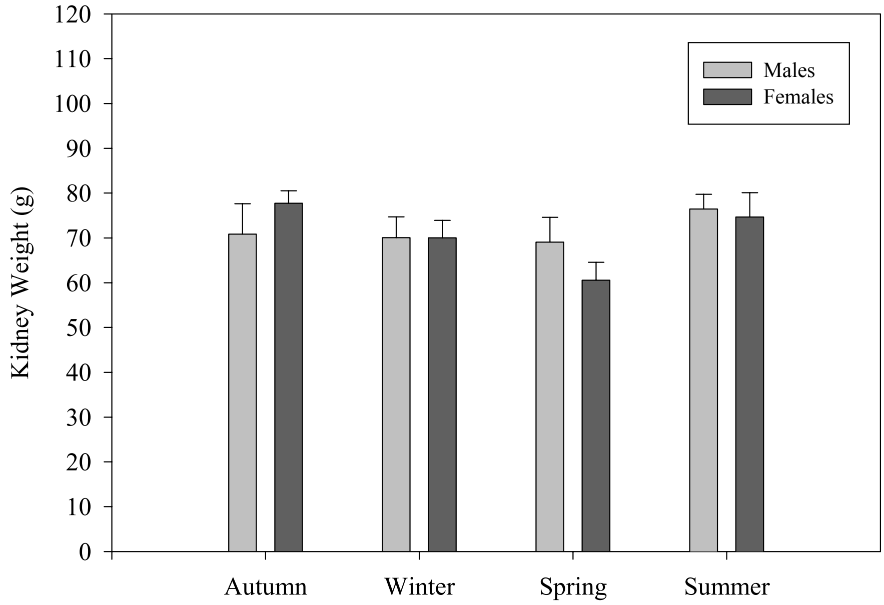

Figure 27. Seasonal variation in KW of mountain reedbuck at Sterkfontein. Autumn = February/March, winter = May/June, spring = August/September, summer = November/December. Error bars represent standard error.

Regression of LFP on KFI

The KFI and LFP were tested against each other using linear regression (Figure 28). There was a highly significant positive correlation between them ($t = 13.1$, $df = 37$, $p < 0.001$).

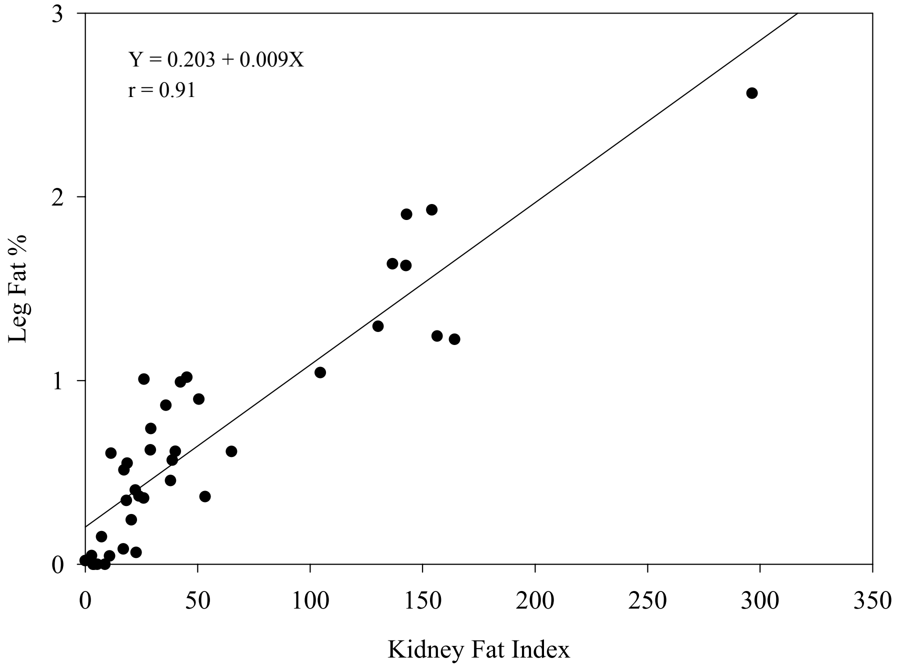

Figure 28. Linear regression comparing KFI with LFP in mountain reedbuck at Sterkfontein (n = 39).

Variation in body condition from KFI and LFP

Males had higher KFI than females in November/December and February/March (summer and autumn), while females had higher KFI than males in May/June and August/September (winter and spring) (Figure 29a). The same pattern was demonstrated by LFP (Figure 29b). Overall, fat indices were highest in winter (especially in females) and lowest in spring.

Differences in KFI between genders and between seasons were tested using a two-way ANOVA (Table 22). Data were log_{10} transformed. There was strong evidence of a difference between seasons but no evidence of a difference between genders, and no interaction. Multiple pairwise comparisons using the Tukey test indicated that the KFI were lower in spring than in autumn or winter.

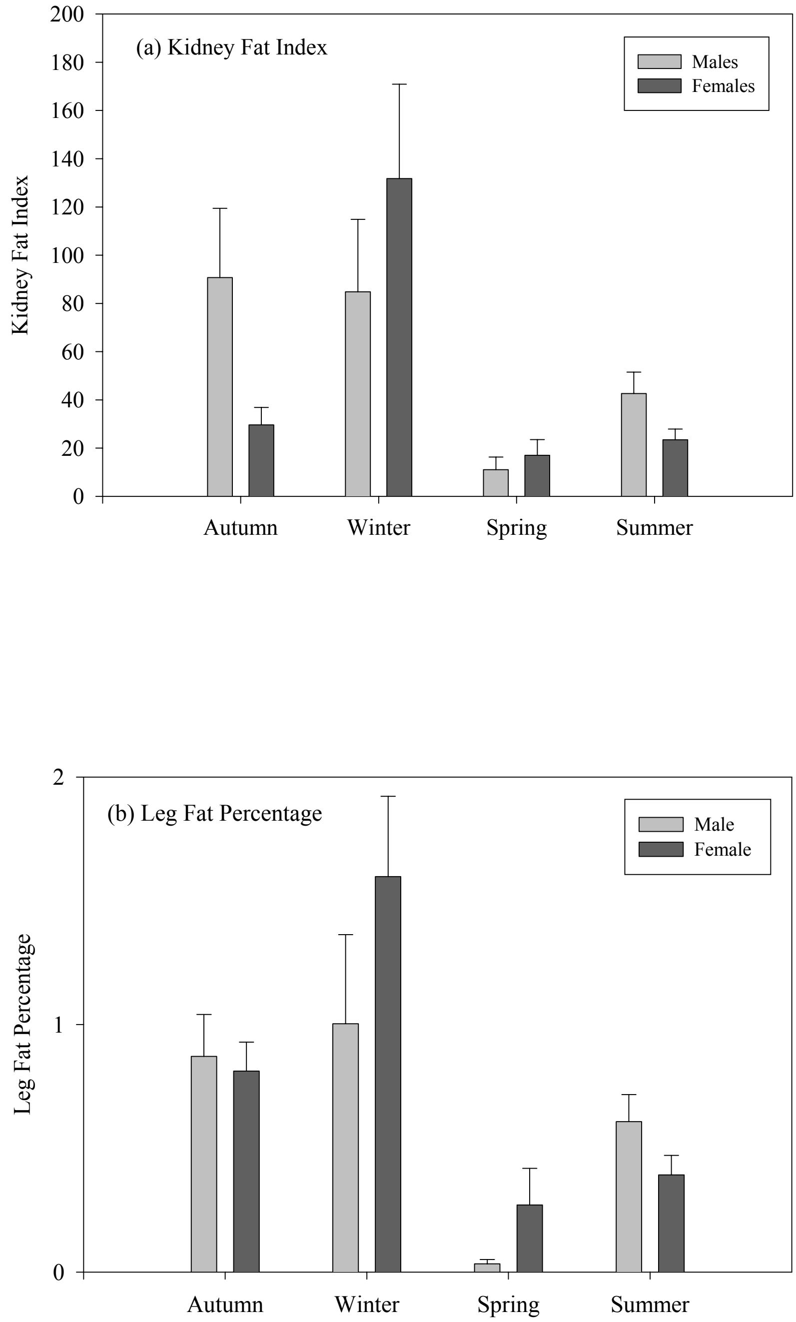

Figure 29. Seasonal variation in (a) KFI and (b) LFP for male and female mountain reedbuck at Sterkfontein. Autumn = February/March, winter = May/June, spring = August/September, summer = November/December. Error bars represent standard error.

Table 22. Two-way ANOVA comparing KFI of 38 mountain reedbuck between gender (18M: 20F) and between seasons at Sterkfontein. Data was Log_{10} transformed.

Source of variation	DF	SS	MS	F	P
Gender	1	0.003	0.003	0.015	0.903
Season	3	4.335	1.445	7.016	0.001
Gender x season	3	0.933	0.311	1.511	0.232
Residual	30	6.179	0.206		
Total	37	11.586	0.313		

Differences in LFP between genders and between seasons were also tested using a two-way ANOVA (Table 23). Data were arcsine transformed (percentage data). The reason a second two-way ANOVA was used rather than a three-way ANOVA, incorporating both KFI and LFP, was that these indices were measured using two independent methods. KFI was calculated as a ratio of fat to kidney weight, while leg fat was measured as a percentage of total leg weight. They were, therefore, incompatible and required different types of transformation. There was strong evidence of a difference between seasons but no evidence of a difference between genders and no interaction. Multiple pairwise comparisons using the Tukey test indicated that the LFP were lower in spring than winter, autumn and summer, and lower in summer than winter.

Table 23. Two-way ANOVA comparing LFP of 39 mountain reedbuck between gender (20M: 19F) and between seasons at Sterkfontein. Data were arcsine transformed.

Source of variation	DF	SS	MS	F	P
Gender	1	0.001	0.001	1.219	0.278
Season	3	0.039	0.013	15.616	< 0.001
Gender x season	3	0.004	0.001	1.470	0.242
Residual	31	0.026	0.001		
Total	38	0.068	0.002		

The arcsine transformation did not completely stabilise the variances of the LFP data, so a two-way ANOVA randomisation test was carried out to test the validity of the parametric test. Using mean squares as the test statistic and 5000 randomisations: $p = 0.323$ for differences between gender, and $p = 0.0004$ for differences between seasons.

To investigate the possibility that body condition was related to body weight, linear regression analyses were carried out for males and females at both Sterkfontein and TdR using the KFI (Figure 30). Animals under 20 kg were excluded. There were no linear relationships between body weight and KFI in any of the groups, although males at TdR were marginal (Males Sterkfontein: $r = 0.22$, $p = 0.391$; Males TdR: $r = 0.45$, $p = 0.052$; Females Sterkfontein: $r = 0.03$, $p = 0.91$; Female TdR: $r = 0.34$, $p = 0.11$).

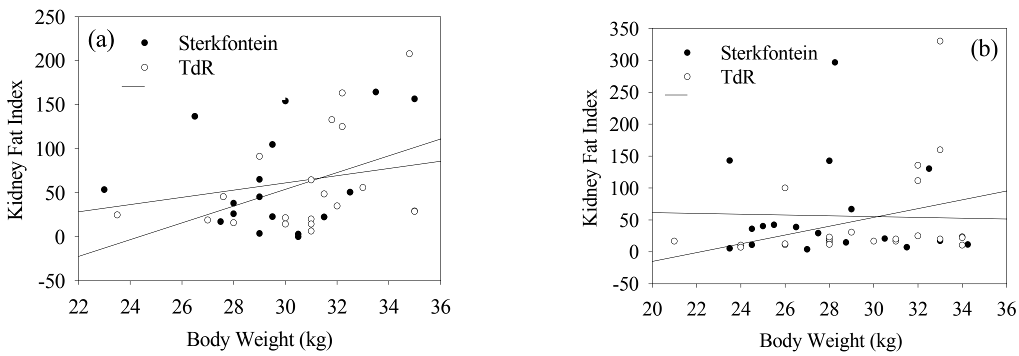

Figure 30. Linear regression comparing mountain reedbuck body weight with KFI for (a) males at Sterkfontein and TdR (b) females ate Sterkfontein and TdR. Animals under 20 kg were excluded.

The possibility exists that female reproductive condition affects body condition. However, a comparison of pregnant versus non-pregnant females using the KFI could only be done by pooling data from all seasons. Considering the seasonal differences shown in Figure 29, this was not attempted.

In September 2001, Sterkfontein experienced heavy snowfalls of 20 cm depth. Below freezing temperatures and strong winds occurred for one day, and there was considerable drifting of snow in places. The snow started melting on the second day, at which time mountain reedbuck and grey rhebok were counted and searches made for missing animals. It was determined that 51 % of mountain reedbuck and 27 % of grey rhebok died of hypothermia as a result of the snow (see Chapter 3). Fifteen mountain reedbuck and three grey rhebok carcasses were found before decomposition started, and KFI were measured in each. None of the animals examined had any perirenal fat at all.

Tussen die Riviere Nature Reserve

Adult rams averaged 31 kg (range 23.5 - 35 kg, n = 20) and adult ewes 30.2 kg (range 24.0 - 34 kg, n = 20) at TdR. Animals had more kidney fat in June than December, and in winter females appeared to have more kidney fat than males (Figure 31). These differences were tested using a two-way ANOVA, with data Log_{10} transformed (Table 24). There was strong evidence for a difference between summer and winter, but no evidence of differences between males and females. There was also no interaction.

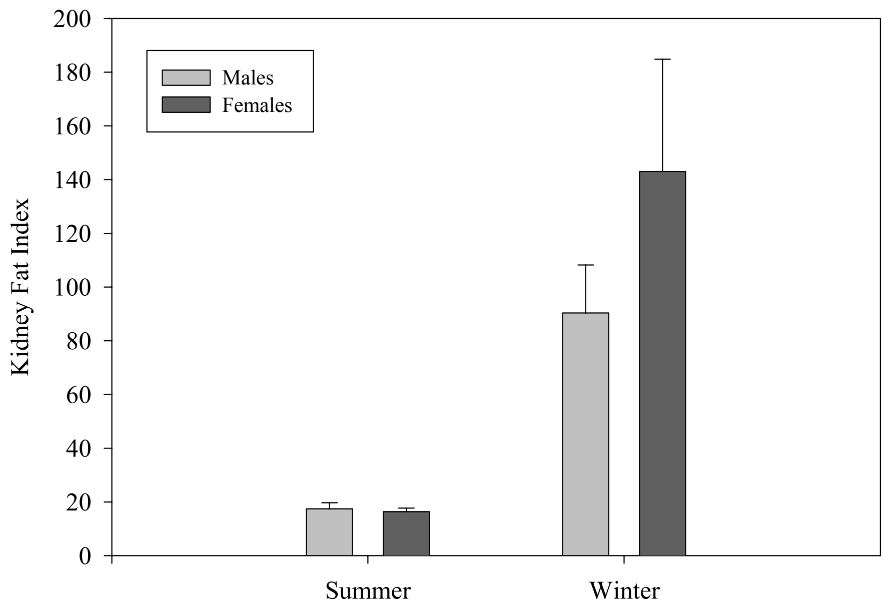

Figure 31. Seasonal variation in KFI for male and female mountain reedbuck at TdR. Error bars represent standard error.

Table 24. Two-way ANOVA comparing KFI of mountain reedbuck between gender and between seasons at TdR. Data were Log_{10} transformed.

Source of Variation	DF	SS	MS	F	P
Gender	1	0.055	0.055	0.946	0.336
Season	1	5.327	5.327	92.428	< 0.001
Gender x season	1	0.092	0.092	1.596	0.214
Residual	41	2.363	0.058		
Total	44	8.247	0.187		

To investigate whether the reproductive condition of females affected body condition at TdR, KFI were compared between pregnant and non-pregnant females in summer. There were no differences between pregnant and non-pregnant females ($t = -1.371$, df = 18, $p = 0.187$)

KFI and endoparasitic nematodes

A part of the present study involved the collection, quantification and identification of nematodes from the gastro-intestinal tract (GIT) of mountain reedbuck (see Chapter 7). To investigate whether there was any correlation between numbers of nematodes harboured and body condition, numbers of parasites from the abomasums, small intestines (SI) and large intestines (LI) were plotted separately against KFI (Figure 32). A Spearman Rank Correlation Coefficient found no evidence of a correlation between the numbers of parasites in either the abomasum or SI with KFI (Abomasum: $r = -0.13$, $p = 0.435$; S.I.: $r = 0.03$, $p = 0.843$). LI was not tested because Figure 32c indicated no correlation.

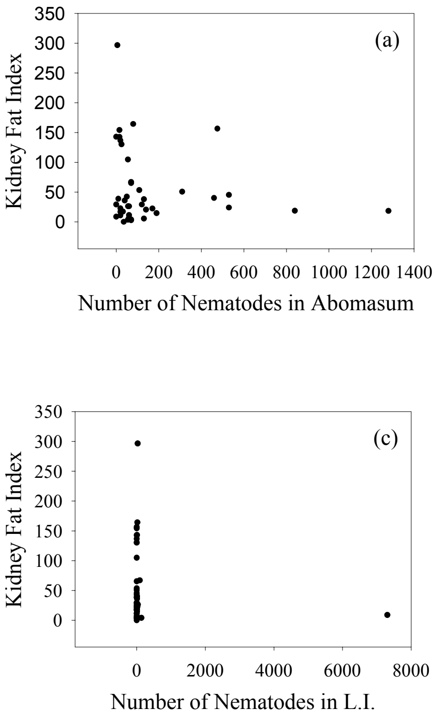

Figure 32. Scatter plots of KFI against (a) number of nematodes in the abomasum, (b) number of nematodes in the SI, (c) number of nematodes in the LI.

Discussion

Carcass weights

Body condition of mountain reedbuck was investigated at Loskop Dam Nature Reserve (Loskop) (Irby, 1975), and Mountain Zebra National Park (MZNP) (Skinner, 1980), using culled animals. Body weights of adult rams and ewes averaged 30.9 kg (range 21.8 - 37.6 kg) and 29.5 kg (range 23.0 – 35.2 kg) respectively at Loskop, while at MZNP they averaged 30.2 kg (range 24.0 – 35.5 kg) and 28.6 kg (range 24.5 – 33.8 kg) respectively. These values are very similar to those of mountain reedbuck at both Sterkfontein and TdR.

Seasonal differences in adult body weight were not tested for in the present study because the sample size per gender per season was low (n = 5). Unless the population is very well sampled, overall body mass is unlikely to be a very good estimate of body condition. An animal might be lighter simply because it is younger, rather than being undernourished, and if the population is not sampled randomly the results might over-represent a certain age group. In contrast to this, dressing percentages and fat indices take into account the size of the animals and will better reflect the condition of individuals. In this case, even with fairly small sample sizes, as long as only adults over 20 kg were used, the effect of body size was negated.

Dressing percentages

As found by Irby (1975) and Skinner (1980), dressing percentages of mountain reedbuck at Sterkfontein were consistent with those of other species of antelope (von La Chevallerie, 1970). Dressing percentages of males at Loskop averaged 60.6 % from March to June, 47.5 % from July to October, and 59.4 % from November to February (overall average 55.8 %) (Irby, 1975). In females they averaged 56.3 % from March to June, 51.7 % from July to October, and 58.6 % from November to February (overall average 55.5 %). These seasonal differences were significant, with the lowest values occurring between July and October. At MZNP dressing percentages in males were 54.2 % in March, 54.2 % in June, 55.5 % in September, and 57.5 % in December (overall average 55.3 %) (Skinner, 1980). In females averages were 52.4 % in March, 50.6 % in June, 50.6 % in September, and 52.2 % in December (overall average 51.5 %). Seasonal differences were not significant although males were found to dress out consistently heavier than females.

In the present study, dressing percentages of males were significantly higher in February/March (59.5 %) than August/September (49.8 %). The same pattern occurred in females (60.4 % in February/March; cf. 50.2 % in August/September). This differed from the pattern at MZNP, where the highest percentages occurred in December and lowest in June. At Loskop only three seasons were used, but dressing percentages were similar to those of Sterkfontein whereby they were lowest in the period July to October, which corresponds to late winter and spring.

The difference between Sterkfontein and MZNP may result from differences in vegetation types and weather patterns. MZNP falls within the South-Eastern

Mountain Grassland and Eastern Mixed Nama Karoo biome. The lesser differences between Sterkfontein and Loskop probably result from the slightly different choice of sampling periods. Rainfall patterns at Loskop are very similar to those of Sterkfontein, except that the summer rains at Loskop start in September (Irby, 1976), approximately one month later than at Sterkfontein. Annual rainfall averages 720 mm at Loskop compared to 680 mm at Sterkfontein.

In red deer stags and hinds on the Isle of Rhum, dressed carcass masses cycled annually as a result of a combination of environmental feeding conditions and reproductive condition (Mitchell *et al.*, 1976). In stags, dressed carcass mass was highest in autumn after a summer of good feeding conditions, but declined rapidly during the rut (autumn/early winter) when they were very active trying to acquire mates, while at the same time not feeding and undergoing acute starvation. After the rut their carcass masses continued to drop through the winter until better feeding conditions arrived in spring. Red deer hinds also showed well-defined annual cycles in dressed carcass mass, but these were asynchronous with stags. Lowest values occurred in spring and highest values in early winter, about two months after the rut when stags lost condition. Because females continued feeding through the rut, they did not lose condition at this time. In addition, there was a difference in the pattern of carcass mass change between milk hinds (females that are pregnant or lactating) and yeld hinds (females that are not pregnant or lactating during a specific year). Milk hinds had lower carcass masses throughout the year and also showed less variation in carcass mass. Yeld hinds had significantly higher carcass masses through the winter because they did not have the same energy costs of gestation and lactation that milk hinds faced.

Hewison *et al.* (1996) found that the dressed carcass mass of male roe deer in France varied seasonally, with a decrease in summer during the rut, and a continued fall through autumn. Male body mass was lowest in early winter before increasing in late winter to be maximal in spring. The dressed carcass mass of females also varied seasonally, being maximal in spring and lowest in summer. In contrast to males, there was no significant mass loss over winter. The asynchronous cycles in body mass of roe deer in France were attributed to differences in reproductive cycles. Males had lower carcass masses in early winter, at the end of the rut, while females had lower carcass masses in summer during the period of maximal maternal investment in reproduction. This period coincided with the last stages of gestation and the first two months of lactation. The increase in carcass mass of roe deer over winter in France (Hewison *et al.*, 1996) was in contrast to other studies on Cervidae that have shown decreases in body mass over winter (Anderson *et al.*, 1972; Mitchell *et al.*, 1976; Holand, 1992). This difference was thought to be partly a result of better environmental and feeding conditions over winter in France than in the other study sites.

Regression analysis of kidney weight and body weight

As with previous studies (Batcheler & Clarke, 1970; Dauphine, 1975; Spinage, 1984; and Van Vuren & Coblentz, 1985), although KW demonstrated a linear relationship with BW in mountain reedbuck at Sterkfontein, it was not directly proportional to BW. This appeared to be a result of smaller animals having relatively heavier kidneys. When animals under 20 kg were removed from the data sets, KW became more proportional to BW, with the slope of a log-log linear regression not differing from one. The KFI was thus found to be a reliable method of assessing body condition in mountain reedbuck when animals under 20 kg were excluded. Seasonal variation in KW, as found by Dauphine (1975) and Van Vuren & Coblentz (1985), that might influence the outcome of KFI results, were not found to be significant in mountain reedbuck at Sterkfontein. This concurred with a study by Spinage (1984) on waterbuck and Grant's gazelle, and a study on several antelope species in the Transkei (Shackleton & Granger, 1989).

Variation in body condition from KFI and LFP

Skinner (1980) found that there was some seasonal variation in KFI of mountain reedbuck at MZNP. Although no statistical analyses were conducted, males had a considerably higher KFI in June (KFI = 60.5) compared to March (9.6), September (26.1) and December (9.9). In females KFI was also highest in June (21.3), but there was not such a big difference compared with March (14.2), September (17.3) and December (19.4). Hanks (1981) suggested that a KFI value of > 80 indicates good condition, 40-80 medium condition, and < 40 poor condition. On average, therefore, at MZNP only males in June were in medium condition, while the rest were in poor condition. In contrast, at Sterkfontein, males were in good condition between February and June, medium condition in November/December, and poor condition in August/September. Females were in very good condition in May/June but poor condition for the rest of the year.

Comparisons of KFI at MZNP and Sterkfontein show some similarities and some differences. The main point of agreement is that both males and females had relatively high values in winter, (June at MZNP and May/June at Sterkfontein). KFI was highest for males in winter at MZNP, whereas at Sterkfontein it was second highest at this time. Nevertheless, values were still higher in winter at Sterkfontein than at MZNP. The highest values at Sterkfontein occurred in February/March (autumn), which was the time when KFI was lowest at MZNP.

In agreement with males, female KFI at Sterkfontein was lowest in August/September, but in contrast was not high in February/March. KFI in females at MZNP was lowest in March and highest in June, but values were very similar in all seasons. Comparing the two study sites, females at Sterkfontein had much higher values in winter than females at MZNP. Moreover, winter values at Sterkfontein were significantly higher than in other seasons within the same reserve.

At TdR mountain reedbuck were in good condition in June and poor condition in December, following the pattern at both MZNP (Skinner, 1980) and Sterkfontein. There were no differences between males and females.

At Sterkfontein LFP and KFI were highly correlated in both males and females, and both followed virtually an identical pattern of highs (winter) and lows (spring). LFP was significantly lower in August/September (spring) than in other months. In addition, it was significantly lower in November/December (summer) than May/June (winter).

In general, therefore, the seasonal patterns in dressing percentages and fat indices at Sterkfontein agreed that condition was lowest in spring, but differed in which season the animals were in best condition. KFI and LFP were highest in winter, while dressing percentages were highest in autumn at Sterkfontein. By the time winter arrived, dressing percentages were dropping. There was effectively a lag period, and body fat started being used up before kidney fat. This is probably related to predetermined physiological timing of fat deposition. However, as leg fat has been shown to directly correlate with total body fat (Butterfield, 1962; Smith, 1970), any decrease in dressing percentages should correspond with a simultaneous decrease in LFP. This did not occur at Sterkfontein. Instead LFP lagged behind dressing percentage in the same way as KFI.

Riney (1955) found that in red deer in New Zealand, fat was first deposited in bone marrow, followed by fat around the kidneys, intestines and stomach, and finally by subcutaneous fat on the back. Mobilisation of these fat deposits was then in the reverse order. This explains why decreases in kidney fat lags behind carcass fat in the dressed animals, but not why leg fat decreases at the same time as kidney fat. In red deer on Rhum, carcass mass, kidney fat and rump fat were all highest during the same periods (Mitchell *et al.*, 1976).

The poor condition of animals in spring can be explained by rainfall patterns. Winter in most parts of South Africa, including all four sites mentioned here, is characterised by very low rainfall. Rains only start in August or September, at which time the grazing is in its worst condition. At Sterkfontein, summer rainfall had barely started at the time of the spring culls (September 2000 and August 2001) so the veld would not have recovered from winter. Animals would, therefore, be expected to be in poor condition at this time. The vegetation types of Sterkfontein and Loskop also help explain the poor grazing conditions. Both reserves can be classified as falling within sour grassveld (Acocks, 1988), where the protein content of the grasses decreases markedly in winter. This leads to a decrease in nutritional quality of grazing for mountain reedbuck and a loss of condition.

Although there were no statistical differences between males and females in body condition, there was an asynchronous pattern demonstrated at Sterkfontein by both indices. Males were in better condition than females in November/December (summer) and February/March (autumn), while females were in better condition than males in May/June (winter) and August/September (spring).

A possible explanation for these differences might be as follows: Both genders were in their worst condition in spring, coinciding with the poorest feeding conditions. Between spring and summer the condition of the veld improved due to higher temperatures and rainfall, but the condition of females did not improve as much as that of males. This may have been because the period coincided with late stages of pregnancy, which would have led to increased energy requirements while males were free of such demands. Females then gave birth mainly in November and December (summer). Between summer and autumn, the condition of males increased markedly at a time when feeding conditions would have been at their best. The females at the same time only showed a slight improvement in body condition and this may have been due to the peak period of lactation (Skinner, 1980). So although feeding conditions were good, the energy demands of producing milk counteracted fat deposition to a certain extent.

Between autumn and winter, male condition dropped slightly, while that of females increased dramatically. Although mountain reedbuck can potentially breed aseasonally (Irby, 1979), they have a peak in breeding in April. Males do not have a defined rut (Irby, 1976; pers. obs.) as do impala and springbok (Skinner & Smithers, 1990) but they still have an increase in reproductive behaviour during this breeding season. Increased energy demands and decreased time for feeding might be expected to reduce their body condition. The significant improvement in female body condition was probably due to being released from the burden of lactation while feeding conditions were still good. Finally, between winter and spring, body condition dropped considerably in both sexes and this would have been due to the declining condition of the veld for grazing.

Similar reasons are given for asynchronous cycles in body condition for some cervid species, including red deer on Rhum (Mitchell *et al.*, 1976), caribou (reindeer) in Canada (Adamczewski *et al.*, 1987), and roe deer in France (Hewison *et al.*, 1996). Annual cycles in body condition in these species have been found to occur partly as a result of seasonal weather changes that affect feeding conditions, and partly as a result of differences in reproductive timing between males and females.

Norton (1989) found significant differences in KFI between males and females at Rolfontein and Doornkloof Nature Reserves in the Karoo, with males having lower values. The indices were very variable, especially for the females, with some individuals having almost no perinephric fat and several having indices of more than 150. The mean KFI for immatures was similar in the two sexes up to the age of 20 months, but after that the males' condition dropped to just over half that of the females. It was suggested that males were subject to greater stress than females. No seasonal differences were tested for because the culls were carried out within a single month at both sites (August at Rolfontein and June at Doornkloof). At Sterkfontein males had lower KFI values than females in June and August as well, but higher values at other times. It is possible, therefore, that had separate culls been carried out at Rolfontein and Doornkloof between November and March, males would have had higher KFI values than females. In this case, rather than males being subjected to more stress than females overall, differential physiological requirements of the sexes may have driven seasonal variation in body condition.

Actual KFI values could not be compared with those of the present study because the KFI were calculated in slightly different ways. Norton (1989) suggested that the high variability in condition showed that all individuals were not affected equally during dry periods. Juveniles had relatively low condition up the age of one year, after which fat deposits increased quickly. This was probably because in that first year most energy goes into growing rather than fat deposition (Norton, 1989).

Shackleton & Granger (1989) investigated variation in body condition of six antelope species (four grazers and two mixed feeders) in the Transkei using KFI and bone marrow fat index (BMI) in conjunction with phytomass and crude protein content of grasses and forbs. It was found that peak condition was attained during spring and summer, coinciding with the period when phytomass and crude protein levels were highest. Levels of crude protein, BMI and KFI increased in sequence with a lag of approximately one month between each factor. Crude protein increased in September, followed by BMI in October and finally KFI in November. It was also found that the peak in KFI was short lived, indicating the absence of storage of perinephric fat. Females appeared to maintain better condition than males throughout winter (Shackleton & Granger, 1989), and it was suggested that this might have been a result of males experiencing reduced vigour upon entering the winter period because of the rut in the months immediately preceding winter. At Sterkfontein and TdR, males were also in poorer condition than females in winter, although the difference was not significant. This lack of significance might be explained by the lack of a well-defined rut in mountain reedbuck.

Variation in condition between antelope species was found to occur within the same game reserve in the Transkei (Shackleton & Granger, 1989). Gemsbok and red hartebeest (both grazers) were in poor condition throughout, blue wildebeest (grazers) were intermediate, and eland and blesbok (mixed feeder and grazer respectively) were in good condition. The latter two species were consequently considered to be well suited to the reserve. The poor adaptability of gemsbok and red hartebeest to this region was also manifested in their poor reproductive rate. Using the same argument of good body condition and high reproductive rate, Skinner (1980) found that mountain reedbuck at MZNP were particularly well suited to the terrain they inhabited. It was also suggested that the lack of seasonal change in carcass characteristics could have indicated that MZNP was under stocked.

The total lack of kidney fat in mountain reedbuck found dead in the snow at Sterkfontein in September 2001 indicates that they did not have sufficient energy reserves to survive the cold spell. It also reinforces the fact that they would have been in their poorest condition at this time, as found during the culling operations. Animals were on the threshold of survival and their immediate food intake was keeping them alive. When unable to feed because of the snow, they would have used up the last of their body fat, exhausted their glycogen stores, and then finally have had to utilise protein for an energy source. This process is too slow over the short term and the result was death for many individuals. Although temperatures were cold at the time of the snowfalls, they were not as cold as temperatures that regularly occur at Sterkfontein in winter, and at these times very few mountain reedbuck died as a result of hypothermia (Chapter 3). If the snow had fallen in June when they had greater supplies of body fat, the animals would not have died in comparable numbers, if at all.

KFI and endoparasitic nematodes

High parasitic loads can cause morbidity, reduced production, and even death (Wilson *et al.*, 2002), so it might be expected that animals with high loads would generally be in poorer condition. There was, however, no correlation between numbers of nematodes and condition. Nematodes at Sterkfontein did not appear to adversely affect body condition in mountain reedbuck.

Nematodes in the abomasum comprised two species that occurred in approximately equal numbers. The more important species, *Haemonchus contortus* is a bloodsucker, and may remove significant amounts of circulating erythrocytes if they occur in sufficient numbers (Georgi & Georgi, 1990). Pathogenic effects result from the inability of the host to compensate for blood loss. Infections of up to 500 worms have been found to have little effect on growth production of sheep under conditions of satisfactory nutrition (Georgi & Georgi, 1990). During the present study numbers of *H. contortus* did not go above 500 worms per animal (if one takes into account that about half the worms were *L. schrenki*) thus, possibly explaining the lack of influence of these nematodes on body condition. Less is known about the debilitating effects of *Longistrongylus schrenki*, but they appeared to be insignificant in these numbers in this case.

The main nematode of the small intestine, *Cooperia yoshidai* may penetrate the epithelial surface of the small intestine and cause disruption that leads to villous atrophy and a reduction in the area available for absorption (Georgi & Georgi, 1990). It appeared that infections of these nematodes in mountain reedbuck at Sterkfontein were not high enough to cause a decrease in condition either.