Seasonal body condition indices of mountain reedbuck (*Redunca fulvorufula*) in two areas of South African Highveld: the grassland and Karoo biomes

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Abstract

Mountain reedbuck (*Redunca fulvorufula*) occupy marginal habitat that is rarely used by cattle. They are fecund, produce good quality meat and have the potential to be cropped commercially. Body condition indices including dressing % (DP), kidney fat indices (KFI), leg fat percentages (LFP) and leg muscle percentages (LMP) were investigated at two nature reserves in the Free State Province, South Africa, to examine seasonal and sexual differences and apply the findings to management decisions. Forty-one animals were shot at Sterkfontein Dam Nature Reserve (Sterkfontein) during eight separate operations over a two-year period. Forty-four animals were shot at Tussen die Riviere Nature Reserve (TdR) during three periods. All results reported are for adult animals. At Sterkfontein, DP was lower in spring compared to autumn, KFI were lower in spring than winter, and LFP were lower in spring than winter and autumn. At TdR, KFI in males were lower in summer than winter. Seasonal patterns of body condition were mainly related to seasonal weather patterns and changes in reproductive condition. For effective harvesting, mountain reedbuck should be cropped in autumn and winter. This would give any remaining animals a better chance of surviving the spring period before the rains when grazing conditions are at their worst.

Keywords: Mountain reedbuck, *Redunca fulvorufula*, dressing percentage, kidney fat index, leg fat, leg muscle, season, reproductive condition, harvesting
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Introduction

The game farming industry in South Africa is expanding (Rudder, 2000) and venison production is on the increase (Van der Merwe & Saayman, 2003). There is a growing demand to meet this supply (Van der Merwe & Saayman, 2003) and this partially results from an increased perception among consumers that venison is a healthy, low fat alternative to other red meats. There is a need to increase knowledge of venison production and improve cropping practices for certain game species that could be farmed more efficiently and harvested on a commercial scale. Much work has been done on the springbok (*Antidorcus marsupialis*) in this regard because the meat is highly palatable (Von la Chevallerie, 1970) and can be farmed alongside domestic livestock with little competition. As a result mixed farming with springbok and livestock has become very successful (Fairall *et al.*, 1990). Less work has been done on other antelope species. In addition to the commercial demand for venison, there is an increasing need for sources of protein amongst the disadvantaged, ever increasing human populations.

African antelope have both advantages and disadvantages in terms of meat production when compared with domestic livestock (Spinage, 1986; Payne, 1990). Indigenous species are generally better adapted to the climate of Africa and often have greater resistance to endemic diseases (Yousef, 1982). They generally have superior dressing % than domestic cattle (Payne, 1990), depending on the method of husbandry used for the latter, and have a much higher percentage of lean meat (Ledger, 1963; 1990). When they form multi-species assemblages, antelope make use of a wider spectrum of plant species, resulting in a greater biomass per ha (Murray & Illius, 1996). This does not, however, necessarily translate into higher productivity, and there is little evidence to suggest that they are able to make better use of the food they consume than do domestic animals (Payne, 1990). It has been shown that in the same environment, the productivity of eland (*Tragelaphus oryx*) is inferior to that of Hereford cattle (*Bos indicus*) (Taylor & Lyman, 1967) and that the off-take of game animals under favourable conditions is much lower than what could be achieved with a well-managed modern integrated livestock unit (Watson *et al.*, 1969; Skinner, 1984). Farming with wild antelope would, therefore, be most beneficial under a mixed farming scheme.

Mountain reedbuck (*Redunca fulvorufula*) use steep rocky hillsides and mountain slopes that are, at best, marginal for most ungulate species (Skinner & Smithers, 1990). The spatial separation that results from this habitat selection means that they compete very little with other grazers and could form the basis of mixed species farming in regions where there is lots of steep terrain. Commercial cropping may be possible in mountain reedbuck because they are fecund and produce good quality, edible meat (Skinner, 1980). The aim of the present study was to investigate body condition indices in mountain reedbuck and explore any seasonal variation that could be used in management decisions.

Materials and Methods

The study was conducted at two Provincial Nature Reserves within the Free State Province of South Africa. The first, Sterkfontein Dam Nature Reserve (hereafter Sterkfontein) (S 28° 24', E 29° 02'), has a land area of 11 000 ha and altitudes varying between 1 700 and 2 350 m. It has a mild climate with an average temperature of 17 °C, and summer rainfall averaging 680 mm. Occasional snow and frequent burning have a major influence on the vegetation. Sterkfontein falls mainly within the Moist Cool Highveld Grassland (Bredenkamp & Van Rooyen, 1996), and in pristine condition is dominated by the grass species *Themeda triandra*.

The second site, Tussen die Riviere Nature Reserve (TdR) (S 30° 30', E 26° 07'), has an area of 22000 ha with altitudes between 1200 and 1500 m. The mean temperature is 18 °C and annual summer rainfall averages 420 mm. Tussen die Riviere falls in the Eastern Mixed Nama Karoo (Hoffman, 1996) and has a complex mix of grass and shrub dominated vegetation types.

Mountain reedbuck were culled at both sites under different schedules as part of their general management strategies. Most of the results of the present paper are taken from animals collected at Sterkfontein where the timing of the culls and numbers of animals per cull were set before the beginning of the study. This allowed approximately even numbers of males and females to be sampled on a seasonal basis. A total of 41 animals were shot over a two-year period, using eight separate culls carried out at three-month intervals. Approximately five animals were shot during each of the following months: March, June, September and December 2000; May, August and November 2001; and February 2002. In a typical culling period an attempt was made to sample two adult males, two adult females and one juvenile of either sex. These juveniles were selected without knowing their age and body condition, with the result that only three weighed < 20 kg. The remaining animals all weighed > 23 kg. For statistical analyses of seasonal variations in body condition indices (see below), data from two culling periods were pooled according to season (March 2000 + February 2002 = autumn; June 2000 + May 2001 = winter; September 2000 + August 2001 = spring; December 2000 + November 2001 = summer), which meant that each season was represented by a minimum of 4 adult males and 4 adult females. The numbers of animals over 23 kg culled per season were as follows: Males: autumn n = 5, winter n = 5, spring n = 4, summer n = 4; Females: autumn n = 3, winter n = 6, spring n = 6, summer n = 5.

After being shot, carcasses were bled immediately, transported to the slaughtering area within two hours and weighed to the nearest 0.5 kg. After slaughter, dressed carcasses were left to hang for approximately one hour before being weighed. Due to the lack of cold storage facilities carcasses could not be left to hang for 24 hours, so dressing % were based on warm weights. The dressed carcass in this case was the whole animal minus skin, head, legs below the knees and hocks, and all internal and reproductive organs. During the dressing process, females were checked for pregnancy and lactation, and all foetuses were weighed.

Four indices were measured to assess body condition. These were dressing %, kidney fat index (hereafter KFI), leg fat % (LFP) and leg muscle % (LMP). Dressing % = (dressed weight / carcass weight) x 100. 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 = (kidney fat weight / kidney weight) x 100.

The LFP and LMP were determined using the right hind leg of each animal from the hock up to and including one half of the pelvis. This was stored in a fridge for a minimum of 24 hours before being processed. To assess muscle and 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 to the nearest 0.1 g. The LFP and LMP were then calculated using the following equations: LFP = (leg fat weight / total leg weight) x 100; LMP = (leg muscle weight / total leg weight) x 100.

Previous studies have found that kidney weights (KW) are not always directly proportional to body weights (BW) because smaller animals may have relatively heavy kidneys (Batcheler & Clarke, 1970; Dauphine, 1975; Van Vuren & Coblentz, 1985). In such cases, an allometric relationship between KW and BW would affect the KFI, and would make it an unreliable measure of body condition. To test for an allometric relationship and, therefore, to check the validity of using KFI, KW and BW from Sterkfontein were compared using log-log linear regression analyses. Previous studies have also shown that KW can be affected by season, which would also influence KFI. To test this, the ratios of KW to BW were compared between seasons using a 2-way ANOVA to determine whether the KFI should be adjusted to allow for any seasonal differences. Further analyses using KFI were then conducted in light of the results of the above two tests. A further complication arises if body condition is influenced by age because comparisons would only then be valid using animals of similar age. Because juveniles can be differentiated from adults using BW, age differences in body condition were tested for using linear regression analyses comparing BW with dressing %, KFI, LFP, and LMP.

Patterns of variations in the four indices were compared using a Spearman Rank Correlation Coefficient to determine if they were compatible units for measuring body condition. Seasonal variations were then examined for each index. It was necessary to test males and females separately because of gender differences. For males, separate 1-way ANOVA's were conducted for each index to test for seasonal differences, using four animals per season. Only territorial animals were included in the analyses. The different indices could not be compared in the same test because they used different units.

In females, the situation was more complicated because some animals were pregnant while others were not. Many factors, including pregnancy, can affect body condition and these might confound any effects of seasonal variation. Comparisons would then only be valid for females in similar reproductive condition. However, because of the seasonality of births that occurred in mountain reedbuck at Sterkfontein (and in fact anywhere in South Africa), females culled in February/March were virtually all not pregnant, females culled in May/June and August/September were virtually all pregnant, while females culled in November/December were either in late pregnancy or were lactating. Moreover, foetuses were smaller in pregnant females during May/June than during August/September. No seasonal comparisons were, therefore, possible for females at similar stages of pregnancy. Instead, comparisons were made between three seasons, May/June, August/September, and November/December, knowing that females were at different stages of pregnancy in each season. Odd females that did not fit into their respective categories were excluded from the analyses, as were females from February/March (due to small sample size).

At TdR a total of 44 mountain reedbuck were culled/hunted during three time periods. The timing of these culls (December 1999, June 2000, and June 2001), as well as the numbers and sex ratios of animals were not determined beforehand, so material was collected on an opportunistic basis. Animals were shot at night using spotlights and were, therefore, selected randomly. It was only possible to collect KFI from the carcasses. Summer and winter variation in KFI was tested for adult males using a Student's t-test. For females, it was possible to compare pregnant animals with non-pregnant (but lactating) animals in a single summer season (December 1999) using a Student's t-test.

Results

Body weights and KW of mountain reedbuck (> 23 kg body mass) culled at Sterkfontein are shown in Table 1. Seasonal and gender variations in the four body condition indices are shown in Figure 1. To test whether these indices were correlated they were compared using a Spearman's Rank Correlation Coefficient.

There were strong correlations between dressing % and KFI (r = 0.465, n = 32, P = 0.008), dressing % and LFP (r = 0.432, n = 30, P = 0.017), and KFI and LFP (r = 0.911, n = 36, P < 0.001). Leg muscle % was not correlated with dressing % (r = 0.235, n = 30, P = 0.209), KFI (r = -0.078, n = 36, P = 0.65), or LFP (r = -0.145, n = 36, P = 0.396).

Table 1 Seasonal variation in body and kidney weight of adult mountain reedbuck culled at Sterkfontein. Values are means and standard deviations. Pregnancy, lactation and foetus masses are included

	Season	Body weight (kg)	Kidney weight (g)	Proportion pregnant (& lactating)	Average foetus mass (g)
Male	Feb/Mar (Autumn)	31.8 ± 5.0 (n = 5)	70.8 ± 15.1 (n = 5)		
	May/Jun (Winter)	28.9 ± 1.6 (n = 5)	70.1 ± 10.3 (n = 5)		
	Aug/Sep (Spring)	29.1 ± 1.3 (n = 4)	69.0 ± 11.1 (n = 4)		
	Nov/Dec (Summer)	29.4 ± 1.5 (n = 4)	76.4 ± 6.6 (n = 4)		
Female	Feb/Mar (Autumn)	28.7 ± 3.9 (n = 3)	77.7 ± 4.8 (n = 3)	1/3 (1/3)	8
	May/Jun (Winter)	29.3 ± 3.8 (n = 6)	70.0 ± 9.4 (n = 6)	5/6 (0/6)	65
	Aug/Sep (Spring)	26.2 ± 2.9 (n = 6)	60.6 ± 9.8 (n = 6)	6/6 (0/6)	713
	Nov/Dec (Summer)	28.1 ± 2.3 (n = 5)	74.7 ± 12.1 (n = 5)	1/5 (4/5)	1150

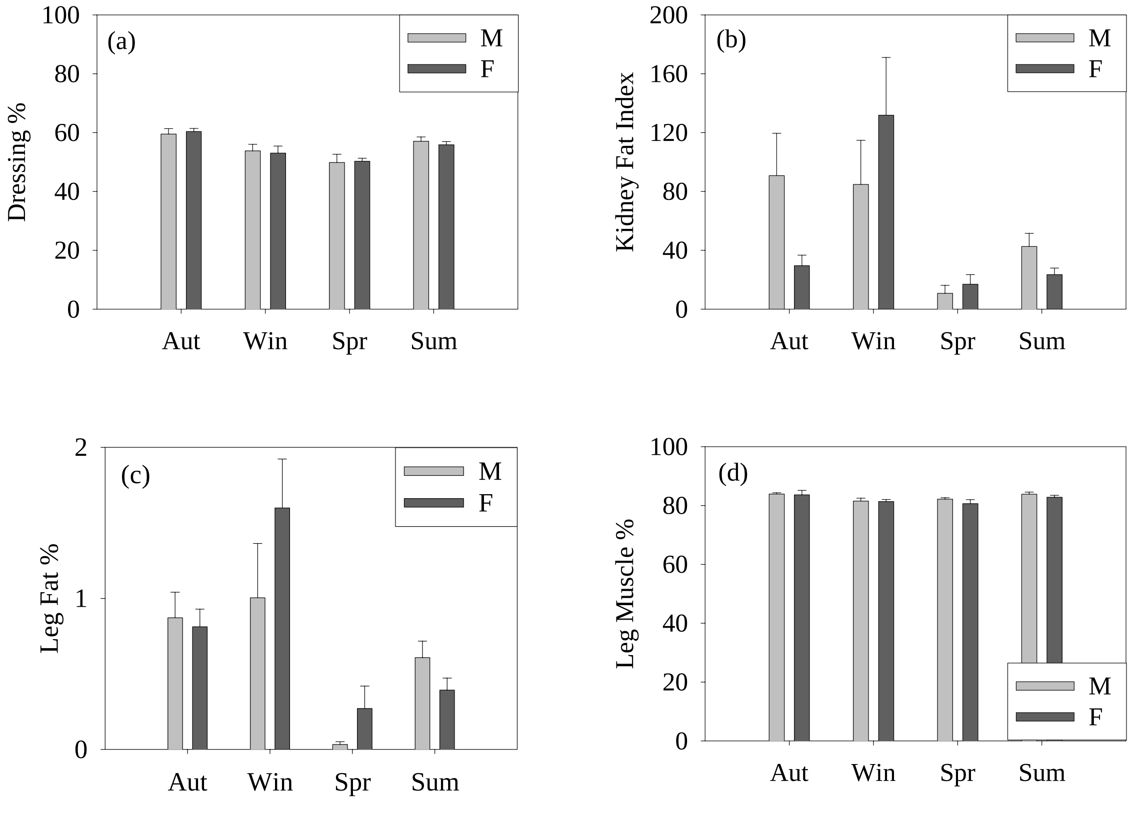

Figure 1 Seasonal variation in (a) dressing %, (b) kidney fat index, (c) leg fat % and (d) leg muscle % for male and female mountain reedbuck at Sterkfontein. Autumn = February/March, winter = May/June, spring = August/September, summer = November/December. Error bars represent standard error

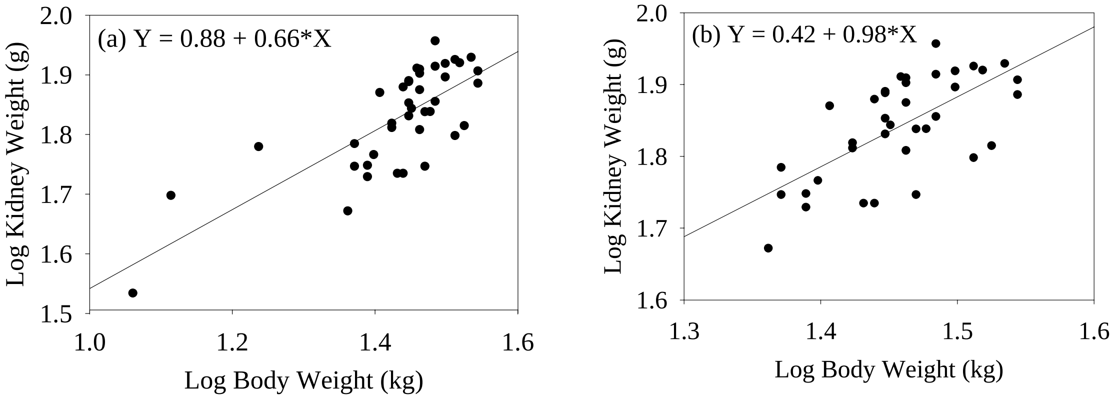

Figure 2 Log-log linear regression of mountain reedbuck BW against KW at Sterkfontein. (a) All animals (b) animals less than 20 kg excluded

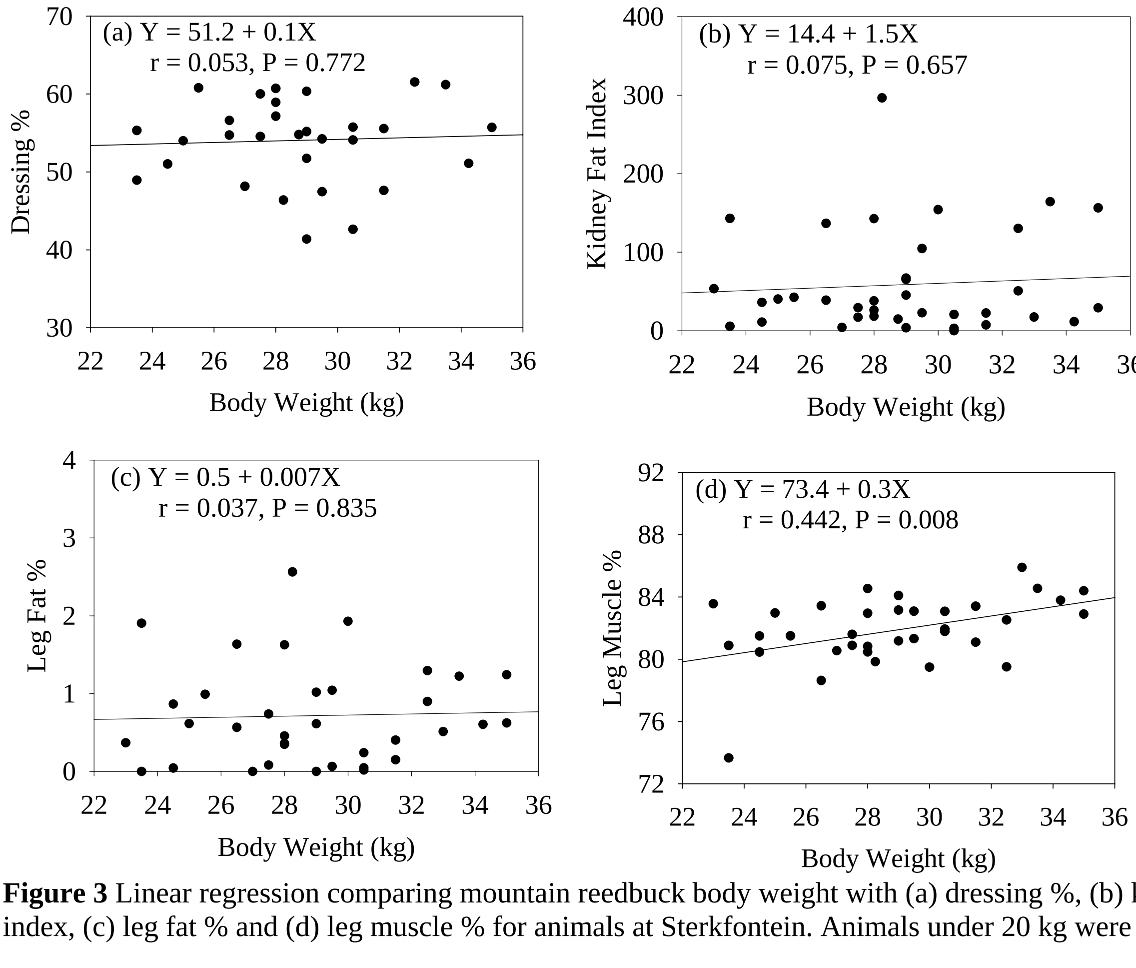

Figure 3 Linear regression comparing mountain reedbuck body weight with (a) dressing %, (b) kidney fat index, (c) leg fat % and (d) leg muscle % for animals at Sterkfontein. Animals under 20 kg were excluded

To determine whether the effect of BW on KW was allometric and, therefore, to check the validity of using KFI as an index of body condition, log-log linear regression analyses were carried out using data from all the animals (Figure 2a) and then with animals less than 20 kg excluded (Figure 2b). Male and female data were pooled because their scatter plots 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 KW varied proportionally relative to BW. As a result, further analyses using the KFI were carried out with the data for animals under 20 kg removed.

The seasonal variation in KW was tested using a 2-way ANOVA (with animals under 20 kg excluded). No differences were found between males and females (ANOVA: F = 0.057, df = 1, P = 0.813) or between seasons (ANOVA: F = 1.893, df = 3, P = 0.152). It was, therefore, not necessary to adjust the KFI according to seasonal variation in KW for animals over 20 kg.

To investigate the possibility that body condition indices were related to BW (age), linear regression analyses were carried out for animals at Sterkfontein comparing BW with dressing %, KFI, LFP, and LMP (Figure 3). Animals under 20 kg were excluded. There was no linear relationship between BW and dressing %, between BW and KFI, or between BW and LFP, but there was a linear relationship between BW and LMP. Body condition, represented by dressing %, KFI and LFP, was not influenced by BW, so all animals over 20 kg could be compared together for these indices.

Seasonal differences within three indices (dressing %, KFI, LFP) were investigated separately for males and females (Table 2). Comparisons were not made for LMP data because they were found to correlate with BW (see above). For males, three separate 1-way ANOVA's were performed using data from territorial males only in all four seasons (n = 4 males per season). For females, three separate 1-way ANOVA's were performed using data from three seasons (autumn data were excluded due to small sample size). Multiple pairwise comparisons were made using the Tukey test.

Table 2 Statistical analyses of seasonal variations in three body condition indices (dressing %, kidney fat index, KFI and leg fat %, LFP). In cases where the result was significant (*), the pairwise comparisons indicate which seasons differed, and which had lower values (e.g. spring < autumn indicates that spring values were significantly lower than autumn values). For ANOVA, multiple pairwise comparisons were made using the Tukey test. NS = not significant

	Body condition index	Statistical test used	Statistical result	Pairwise comparisons
Males	Dressing %	1-way ANOVA	(F = 3.98, df = 3, P = 0.038) *	Spring < Autumn
	KFI	1-way ANOVA	(F = 3.78, df = 3, P = 0.044) *	Spring < Winter
	LFP	1-way ANOVA	(F = 6.16, df = 3, P = 0.010) *	Spring < Winter Spring < Autumn
Females	Dressing %	1-way ANOVA	(F = 2.84, df = 2, P = 0.098)	NS
	KFI	1-way ANOVA	(F = 8.12, df = 2, P = 0.005) *	Spring < Winter
	LFP	1-way ANOVA	(F = 11.6, df = 2, P = 0.002) *	Spring < Winter Summer < Winter

At TdR adult rams averaged 31 kg (range 23.5 - 35 kg, n = 19) and adult ewes 30.2 kg (range 24.0 – 34.0 kg, n = 20). Seasonal variation in KFI of mountain reedbuck at TdR is shown in Figure 4. Males had higher KFI in June than December (t = -5.48, df = 17, P < 0.001), while seasonal differences between females were not tested. In summer, there was no difference in KFI between pregnant and non-pregnant females (t = -1.37, df = 18, P = 0.187).

Discussion

Body weights and dressing % of mountain reedbuck were previously investigated at the Loskop Dam Nature Reserve (Loskop) (Irby, 1975) and the 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 were very similar to BW of mountain reedbuck at Sterkfontein and TdR.

Dressing % of mountain reedbuck at Sterkfontein was consistent with those of mountain reedbuck at Loskop (Irby, 1975) and MZNP (Skinner, 1980), and they were consistent with dressing % of other African antelope species (Von la Chevallerie, 1970). At Loskop, dressing % averaged 55.8% for males and 55.5 % for females (Irby, 1975), while at MZNP they averaged 55.3% and 51.5% respectively (Skinner, 1980). Seasonal variation at Loskop was significant, with the lowest values occurring between July and October. This was similar to Sterkfontein, where dressing % was lowest during August/September (spring). Rainfall at Loskop and Sterkfontein is similar, both in quantity (720 mm per year at Loskop cf. 680 mm at Sterkfontein) and seasonality, although the summer rains at Loskop start approximately one month later than at Sterkfontein (Irby, 1976). Although the vegetation types of the two sites are different (Low & Rebelo, 1996), the similar rainfall patterns result in new spring grass growth at similar times of year, assuming average rainfall and, therefore, grazing conditions improve at similar times. In contrast to Loskop and Sterkfontein, there were no significant seasonal differences in dressing % at MZNP (Skinner, 1980).

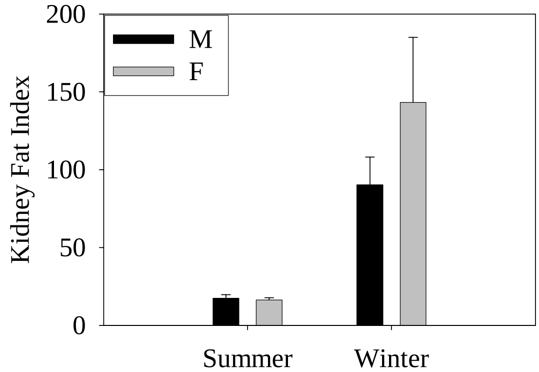

Figure 4 Seasonal variation in kidney fat index for male and female mountain reedbuck at Tussen die Riviere. Error bars represent standard error

Kidney fat indices in mountain reedbuck were previously investigated at MZNP (Skinner, 1980). 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). Kidney fat indices were also high in winter at Sterkfontein and TdR, although the highest values for males at Sterkfontein occurred in autumn. 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.

Although previous studies have suggested that KFI is not the most reliable technique for assessing body condition, mainly because of variations in KW with age or season (Batcheler & Clarke, 1970; Dauphine, 1975; Van Vuren & Coblentz, 1985), the present study found that it was reliable when animals < 20 kg were excluded. This was because KW varied proportionally relative to BW in animals > 20 kg and did not vary seasonally. This concurred with a study on waterbuck and Grant's gazelle (Spinage, 1984) and a study on several antelope species in the Transkei (Shackleton & Granger, 1989).

Leg fat % has not previously been measured in mountain reedbuck. At Sterkfontein, LFP was significantly lower in August/September (spring) than in other months, especially May/June (winter).

As measures of body condition, KFI and LFP complemented each other very well and showed strong correlation between seasons. Males and females followed an almost identical pattern of highs and lows.

Dressing % also correlated with KFI and LFP, with all three showing poorest condition in spring. However, dressing % were highest in autumn, while KFI and LFP were highest in winter. By the time winter arrived, dressing % were dropping, so there was a lag period between the drop in dressing % and the drop in KFI and LFP. 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 % associated with dropping body fat should correspond with a simultaneous decrease in LFP. This did not occur at Sterkfontein. Instead LFP lagged behind dressing % in the same way as KFI. In addition to complementing each other, dressing %, KFI, and LFP were not affected by BW, so were reliable indicators for animals > 20 kg.

The seasonal variation in body condition of mountain reedbuck can be explained by rainfall patterns and changes in reproductive condition. 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 nutrients in grazing are very low and grass is lignified. 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 had time to recover from winter. Animals would, therefore, be in poor condition at this time. The vegetation type of Sterkfontein also helps explain the poor grazing conditions because it falls within the 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 apparent differences between males and females in body condition were not tested, there was an asynchronous pattern demonstrated at Sterkfontein by both KFI and LFP. Males were in better condition than females in summer and autumn, while females were in better condition than males in winter and 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 (Robbins, 1993) 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). Therefore, although feeding conditions were good, the energy demands of producing milk counteracted fat deposition.

Between autumn and winter, male condition dropped slightly, while that of females increased dramatically. Although mountain reedbuck can potentially breed aseasonally (Irby, 1979), in South Africa they have a peak in breeding in April. Males do not have a defined rut (Irby, 1976; personal observation) as do males of some species such as impala (*Aepyceros melampus*) (Skinner & Smithers, 1990), but they still have an increase in reproductive behaviour. 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 veld condition.

Similar reasons are given for asynchronous cycles in body condition for some cervid species, including red deer (*Cervus elaphus*) on Rhum (Mitchell *et al*., 1976), caribou (*Rangifer tarandus*) in Canada (Adamczewski *et al*., 1987) and roe deer (*Capreolus capreolus*) 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 male and female mountain reedbuck 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 immature animals 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.

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, 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 tested.

In September 2001, Sterkfontein experienced heavy snowfalls of 20 cm depth. Freezing temperatures and strong winds occurred for 24 h, and there was drifting of snow up to 1 m depth in places. The snow started melting on the second day, at which time mountain reedbuck were counted, and searches made for missing animals. It was determined that 51% of mountain reedbuck died of hypothermia as a result of the snow. Fifteen carcasses were found before decomposition started, and KFI were measured in each. None of the animals examined had any perirenal fat at all, indicating 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. 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 (Taylor, 2004). If the snow had fallen in June when they had greater supplies of body fat, the animals might not have died in comparable numbers.

Conclusions

Dressing % of mountain reedbuck at Sterkfontein was highest in autumn, after which they started declining during winter. Kidney fat indices and LFP were highest in winter, and these dropped during spring as a result of poor feeding conditions. These results suggest that cropping operations would be best conducted in autumn and winter to get the highest dressed weights or the highest fat content, respectively. A second advantage of cropping at these times is that population densities would be reduced during winter so there would be more grazing available per animal during late winter and spring, coinciding with the time when it is in shortest supply. This would decrease the chances of starvation of those animals left, and allow them to build up body condition faster when feeding conditions improve after rains.

Because of the strong correlation between the three body condition indices, it is suggested that measuring two of the three indices would suffice to assess condition. This would reduce the effort required in measurement. Because of the slight difference in timing of the decline in dressing % compared to KFI and LFP, dressing % should be one of the indices measured. The KFI was found to be a valid method of assessing body condition and was a more practical, less time-consuming technique than LFP. Although the latter is an accurate measure of total body fat (Butterfield, 1962; Smith, 1970), the very strong correlation between it and the KFI indicates the latter is an adequate predictor of LFP.

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