Serum Magnesium and Zinc Status of Wild Ungulates in the Swaziland Lowveld

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Serum magnesium (Mg) and zinc (Zn) were measured in 179 impala *(Aepyceros melampus),* 13 warthog *(Phacochoerus aethiopicus),* 6 kudu *(Tragelaphu strepsiceros),* 4 grey duiker *(Sylvicapra grimmia)* and 3 blue wildebeest *(Connochaetes taurinus)* from the Mlawula-Mbuluzi-Simunye Nature Reserve and Protected Area complex in the northeastern Swaziland lowveld from October 1985 to September 1986. Serum Mg was higher in the small concentrate selectors, duiker and warthog, than in kudu, a large browser, impala, an intermediate feeder, and wildebeest, a grazer. Serum Zn was higher in warthog and kudu than in impala, duiker and wildebeest. In impala Mg was higher in adults than in lambs, and was higher in the winter (June to September) when they were browsers than in the summer (December to February) when they were predominately grazers. Zn was higher in the spring (October to December) than in the winter (June to August). Zn was < 0.80 ppm in 18% of the adult females, and 0.80 to 0.89 ppm in 12% of the adult females and 23% of the lambs. In warthogs Zn was lowest in November at the end of the dry season, but there was no seasonal pattern in Mg. These results suggest that differences in feeding strategy, as well as other factors such as season, age class and sex can affect mineral status.

Key words: minerals, impala, kudu, blue wildebeest, warthog, grey duiker, blesbok

INTRODUCTION

Mineral deficiencies are a potential constraint for herbivore productivity throughout Africa (Schillhorn van Veen and Loeffler, 1990), and as such, are a potential constraint in conservation programs. Clinical signs and behaviors consistent with mineral deficiencies have been reported in several species of wild ungulates (Young et al. 1973; Zumpt and Heine, 1977; Langman, 1978), and Wilson and Hirst (1977) concluded that mineral deficiencies were among the factors responsible for the low rate of increase of roan *(Hippotragus equinus)* and sable *(H. niger)* antelope populations introduced into nature reserves in the Transvaal in South Africa. However, despite the apparent importance of minerals, there is little published information on the mineral status of ungulates and the factors which influence mineral status.

In the present paper we report the results of a study of the serum magnesium (Mg) and zinc (Zn) status of wild ungulates in Swaziland lowveld. Swaziland is a small country in southeastern Africa bordered by Mozambique on the east and by South Africa on the north, west and south. McDowel1 et al. (1984) reported that Swaziland is deficient in phosphorus, potassium, sodium, copper, iodine, selenium and zinc. It was not listed as deficient in magnesium, but deficiencies have been recorded in the South African province of Natal (Boyazoglu, 1976) which adjoins the southern border.

We evaluated the differences in serum Mg and Zn status between species with different feeding strategies, and the effect of age class, sex, and season. The mineral content may vary widely between plant species (Tolsma et al., 1987; Ben-Shahar and Coe, 1992), and there may be pronounced seasonal changes (du Toit et al., 1940; Tolsma et al., 1987). Thus, feeding strategy and season may affect the mineral status. Differences in the spatial distribution of segments of the population within the habitat (Anderson, 1972; Mason, 1976), and differences in the nutritional demands of different segments of the population may also affect mineral availability and requirements. We were also able to examine the effect of management as the management practices differed between the reserves. Body condition was poorer and tick burdens were higher in impala *(Aepyceros melampus)* in an overgrazed, unman aged area than in an adjacent managed area (Gallivan et al., 1995a, 1995b), and we postulated that impala in the unmanaged area would also have lower mineral levels.

METHODS

Study Area

This study was conducted in the 23,000 ha Mlawula-Mbuluzi-Simunye Nature Reserve and Protected Area complex (26 ° 12'5; 32°00E) in the northeastern Swaziland lowveld. The mean annual rainfall is approximately 700 mm (Tambankulu Estates, unpubl. obs.), with most of the rainfall in the summer from November to March when the average daily temperatures are 33/22 C (max/min). The winters are cool (25/7 C) and dry.

The ungulates were collected in the western part of the complex (altitude ± 200 m). Most of this area is over the basalt of the eastern Swaziland lowveld (Murdoch, 1970), but there are several rhyolite ridges associated with the Lubombo range, a large rhyolite intrusion along the border between Swaziland and Mozambique. The soil over the basalt is a lithomorphic vertisol with upper layers of clay over a soft iron pan at 70 to 150 cm depth. The Mg concentration is from 510 to 1030 ppm. The vertisol intergrades to a fersialitic soil on the rhyolite ridges where the Mg concentrations are 340 to 410 ppm. The "available" Zn is less than 2 ppm in soils throughout Swaziland (Murdoch, 1970).

The vegetation on the basalt is predominately *Acacia nigrescens, Sclerocarya birrea, Themeda triandra* savanna (lowveld, type 10) (Acocks, 1975), with a mixed *Combretum* spp. woodland on the rhyolite ridges. The northern part of Mbuluzi Nature Reserve was intensively managed and had a well developed grass sward. The remainder of the complex was overgrazed with extensive replacement of the perennial grasses by annual grasses and forbs, and bush encroachment by *Dicrostachys cinerea, Acacia* spp. and *Zizyphus mucronata.* At the time of this study there was an estimated 4000 + impala *(Aepyceros melampus)* , 100 blue wildebeest *(Connochaetes taurinus),* 400 kudu *(Tragelaphus strepsiceros),* 40 nyala *(Tragelaphus angasii),* 60 waterbuck *(Kobus ellipsiprymnus)* , 200 warthog *(Phacochoerus aethiopicus)* , 1 50 Burchell's zebra *(Equus burchelli)* and 12 white rhinoceros *(Ceratotherium simum),* as well as other smaller ungulates, in the reserve complex (K. Braun, pers. comm.). With the exception of the waterbuck, the majority of the ungulates were in the unmanaged area.

Sample Collection

Serum samples were collected from 179 impala, 13 warthog, 6 kudu, 4 grey duiker (*Sylvicapra grimmia)* and 3 blue wildebeest which were shot between October 1985 and September 1986, either during the culling program or for research purposes. Impala were collected monthly, with sample sizes of 6 to 24 animals per month. In most months an attempt was made to collect impala of all age and sex classes from both the managed and unmanaged areas. However, no lambs were collected in November and December and no adult females were collected in December and January when the lambs were dependent on nursing. The other species were collected at 1 to 3 month intervals when the opportunity arose. The sample sizes ranged from 1 to 4 animals per collection.

Immediately after the animals were shot blood samples from the severed carotid arteries were collected in uncoated 10 ml tubes which were immediately placed on ice. The blood was allowed to clot, and the serum was collected 8 to 12 hours later and frozen at -20oC. The serum Mg and Zn were later measured using atomic absorption spectroscopy (Welz, 1976). The animals were aged as lamb (< 12 mo), yearling (13 to 24 mo) or adult (> 24 mo), and four indices of body condition; visual body condition (VBC), packed cell volume (PCV), marrow dry weight (MDW) and kidney fat index (KFI), were measured (Gallivan et al., 1995a).

Data Analysis

The differences between species were tested using one-way analysis of variance (Zar, 1974). The effect of age class, month, sex and management (managed versus unmanaged areas) on Mg and Zn in impala was examined using general linear models (PROC GLM) (SAS Institute Inc., 1985). All of the results are based on the most parsimonious model obtained using backward elimination (Kleinbaum and Kupper, 1978). The relationships between Mg and Zn and the body condition indices were examined using linear regression.

RESULTS

Serum Mg was significantly higher in the duiker and warthog than in the kudu, impala and wildebeest (Table 1), and Zn was higher in warthog than in impala, duiker and wildebeest.

In impala Mg declined from October to February, then increased (Fig. 1). The serum Mg in the summer (December to February) was significantly lower than in the winter (June to August) ($P < 0.001$). Serum Zn also declined from October/November to February, but remained low (Fig. 2), with a slight increase in May. Zn was higher in the spring (October to December) than in the winter (June to August) ($P = 0.004$). Mg was significantly lower in lambs than in adults ($P = 0.015$), but Zn did not differ significantly ($P > 0.1$) between age classes. The serum Mg and Zn did not differ significantly between the sexes, nor between the managed and unmanaged areas. There were no significant relationships between Mg or Zn and any of the body condition indices (VBC, PCV, KFI and MDW).

In warthog serum Zn was significantly higher in October than in November and May ($P = 0.033$). The seasonal variation in Mg was not significant, but Mg was lowest in November. There were no significant differences between the age and sex classes, nor was there any relationship between Mg or Zn and the body condition indices.

McDowel1 et al. (1984) defined the critical level for serum Mg and Zn as < 20 ppm and <0.8 ppm respectively. Although no clinical signs of deficiency were observed, the serum Zn was below the critical level (0.8 ppm) in 7.4% of the impala, and 11.4% had low levels (0.80 to 0.89 ppm). The critical and low values were most common in adult females and lambs (Fig. 3), and there was a significant (P = 0.005) seasonal trend in the prevalence. In lambs and adult females the low values were common from January to March and from June to August (Fig. 4). The prevalence of the low levels did not differ between the managed and unmanaged areas (P > 0.5), but critical levels were more common in adult females in the unmanaged area (8/16) than in the managed area (1/7) (P = 0.10) in February, March, April and June.

The serum Mg was below the critical level (20 ppm) in 2.3% of the impala. All of the samples were collected in December and January, and all of the concentrations exceeded 15 ppm. None of the samples from the other species were below the critical levels for Mg or Zn .

DISCUSSION

There is limited information on the serum Mg and Zn of African ungulates. The serum Mg in the present study was higher than the reported values for impala, blue wildebeest and warthog (Drevemo et al., 1974; Keffen et al., 1987). This may be due to differences in Mg availability in soils and plants, or to the timing of the collections as seasonal values in impala and warthog were similar to the reported values. There are no published values for the serum Mg of kudu and duiker, nor for the serum Zn of any of the species in this study, although Zn was lower than the values reported for several species of wild ungulates in Natal (Keep, 1976) and for roan and sable antelope in the Transvaal (Wilson and Hirst, 1977).

The small browser (duiker) and small grazer (warthog) had a higher Mg than the large browser (kudu) , intermediate feeder (impala) and large grazer (wildebeest). This could indicate that serum Mg is higher in small, selective feeders. However, the high value in warthog may an anomoly. Warthog are normally short-grass grazers, but will feed on wide variety of plants and will root for underground rhizomes and roots (Smithers, 1983). Grasses had been replaced by forbs throughout much of the overgrazed area in the Mlawula complex, and the high serum Mg may have been caused by geophagia during feeding on rhizomes and roots. The serum Mg was similar in warthog and wildebeest in the highveld where the grass sward was intact (unpubl. obs.).

In the antelope the serum Mg was higher in the browsers, and was lowest in impala in the summer when they are primarily grazers (Dunham, 1980). The browser and intermediate feeder group also had a higher serum Mg than the grazers in the study of Drevemo et al. (1974), with the lowest value in mountain reedbuck *(Redunca fulvorufula),* a small, selective grazer (Smithers, 1983). There was no relationship between serum Mg and feeding preference in the study of Keep (1976).

Comparative information on the mineral content of browse and grasses is limited. The Mg content varies widely between species in both browse and grasses (Wilson and Hirst, 1977;

Tolsma et al., 1987; Ben-Shahar and Coe, 1992). There appears to be little seasonal variation in the Mg content of browse species, but the Mg content of the grasses varies seasonally (du Toit et al. 1940; Tolsma et al., 1987), and the Mg content of grasses in the Transvaal and Natal is lower during the winter (du Toit et al., 1940). Thus, the apparent differences serum Mg with feeding strategy may be due to differences in availability, but this needs to be explored further .

In impala the serum Mg was lower in the summer, and in lambs. The seasonal changes may have been caused by the shift to grazing, however, the Mg content grasses is highest during the summer (du Toit et al., 1940). The low serum Mg in the summer when mineral concentrations are highest is similar to the pattern reported for mineral deficiencies in other grazing ruminants (McDowell et al., 1984), and for serum Mg in cattle in the Caribbean (Wildeus et al., 1992). Even though the mineral content of grasses is relatively high, the increase in mineral content is less than the increase in protein and energy content of the grasses, and serum Mg declines during a period of rapid growth. The body condition of the yearling and adult male Impala improves markedly from December to April (Gallivan et al., 1995a), and adult females are nursing lambs which grow rapidly during the first six months of life (Fairall and Braack, 1976). The high growth rate of the lambs may account the lower serum Mg is this age class. There was no evidence of a decrease in serum Mg in kudu or duiker during the summer, and the serum Mg of warthog was low in November but had returned to normal values by February.

Serum Zn was significantly higher in the warthog than in impala, wildebeest and l duiker. The cause of this difference is unknown as warthog also had a higher serum Zn than wildebeest in the highveld (unpubl. obs.). There was no relationship between serum Zn and feeding strategy in the study of Keep (1976), and there is no comparative information on the Zn content of browse and grasses.

The decline in serum Zn in impala from October/November to February is similar to the pattern in serum Mg, and a decline in serum Zn has been reported in cattle in the Caribbean during the wet season (Wildeus et al., 1992). The low serum Zn from June to August may be due to low Zn availability in browse as soluble minerals are translocated out of the leaves (Tolsma et al., 1987). The increasing serum Zn in September and high levels in October/November were most likely due to mobilization of body protein and energy stores as all of the age and sex classes were in poor condition at the end of the dry season (Gallivan et al., 1995a).

While there were no clinical signs of Zn deficiency, values below the critical level of 0.80 ppm were common in nursing females, and in June when the body condition of females improved rapidly after the lambs were weaned (Gallivan et al., 1995a). Low values (0.80 to 0.89) occurred in lambs which were growing rapidly, and in females in the winter when body condition was improving (Gallivan et al., 1 995a). The prevalence of low serum Zn suggests that these segments of the population had high Zn requirements. This is consistent with the suggestion that the increased mineral requirements of lactating females are an important factor in the seasonal movements of ungulates in the Serengeti (Kreulen, 1975; McNaughton, 1 990). However, in populations where movements are restricted, either physically or behaviorally, intake may not match the increased requirements.

The only management effect was the apparent increase in the prevalence of critical values of Zn in adult females in the unmanaged area. This suggests that the changes in vegetation caused by overgrazing reduced Zn availability. Limitations in Zn intake in other segments of the population may have been confounded by limitations in protein/energy intake as impala in the unmanaged area were in poorer body condition than those in the managed area (Gallivan et al.,1995a).

CONCLUSIONS

The results of this study suggest that serum Mg and Zn are influenced by feeding strategy, season, age class and sex. The patterns differed between the two minerals, possibly reflecting differences in availability and/or requirements. The lack of a relationship between serum Zn and Mg and the body condition indices, and the limited effect of management in impala, may also reflect the balance between availability and requirements. Serum Zn was below the critical level (0.80 ppm) in adult females in summer and autumn, and low (0.80 to 0.89 ppm) in lambs in summer and winter and in adult females during the winter, suggesting that Zn intake was marginal in these two groups. The low serum Mg in impala in the summer, and the marginal Zn in adult female impala and lambs, indicate that mineral status is highly seasonal and determined by requirements, as well as availability. The occurrence of low and marginal values in a wide niche intermediate feeder such as impala suggest that minerals may be potentially limiting for narrow niche grazers.

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TABLE 1. Serum Mg and Zn in five species of ungulates in the Mlawula-Mbuluzi-Simunye Nature Reserve and Protected Area complex in the northeastern Swaziland lowveld from October 1985 to September 1986

Species	n	Mg (ppm)	Zn (ppm)
Impala *(Aepyceros melampus)*	179	30.2 ± 5.2[a,1]	1.12 ± 0.26[a]
Blue Wildebeest *(Connochaetes taurinus)*	3	28.2 ± 4.2[a]	1.02 ± 0.19[a]
Kudu *(Tragelaphus strepsiceros)*	6	33.9 ± 6.3[a,b]	1.30 ± 0.29[a,b]
Grey Duiker *(Sylvicapra grimmia)*	4	45.4 ± 3.5[c]	1.11 ± 0.15[a]
Warthog *(Phacochoerus aethiopicus)*	13	39.2 ± 8.6[b,c]	1.50 ± 0.34[b]

1: The values are presented as the mean ± 1 standard deviation. Values with the same superscript are not significantly different (P > 0.05).

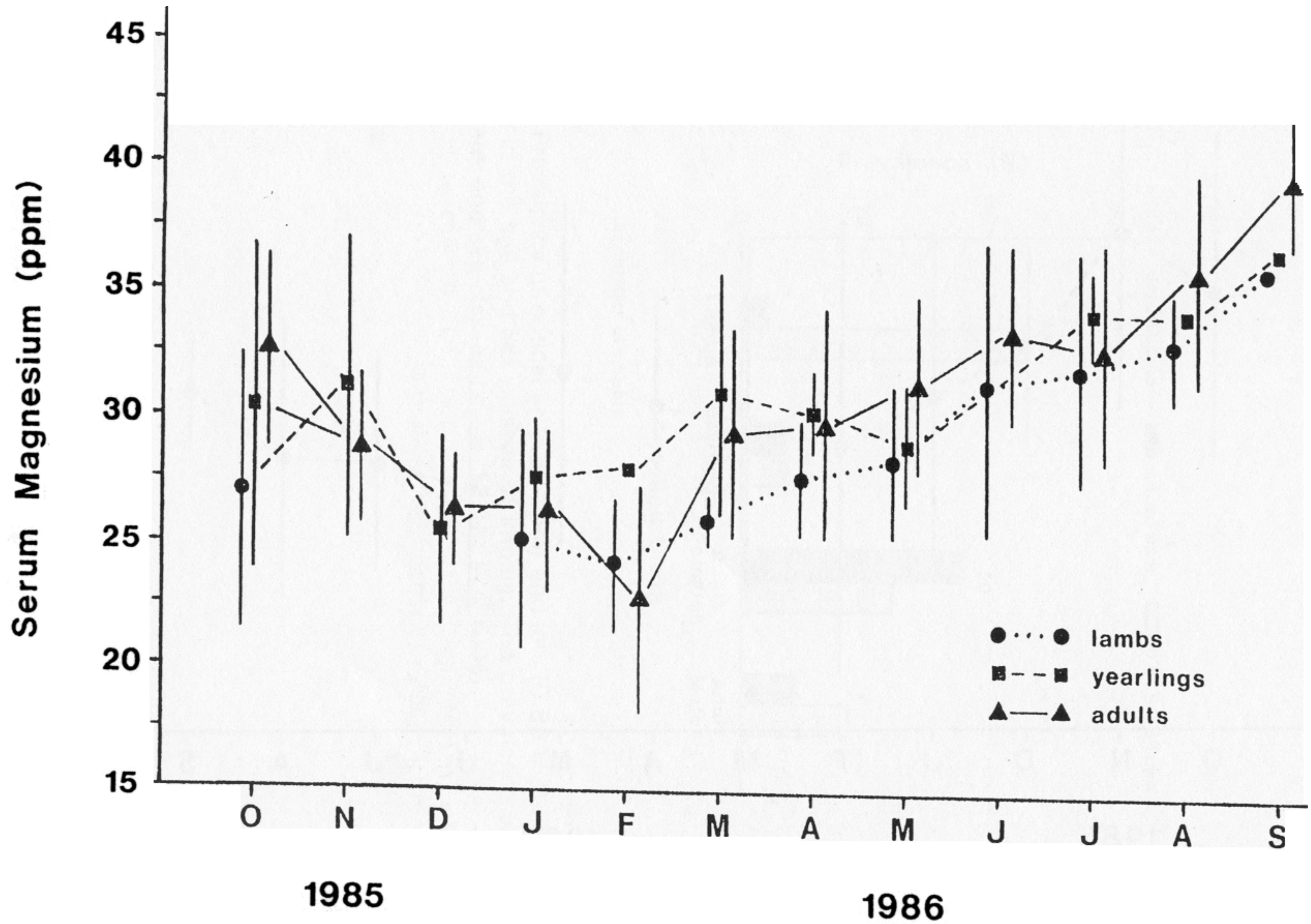

Figure 1. Seasonal changes in the serum Mg concentration in three age classes of impala in the Mlawula-Mbuluzi-Simunye Nature Reserve and Protected Area complex in the northeastern Swaziland lowveld from October 1985 to September 1986.

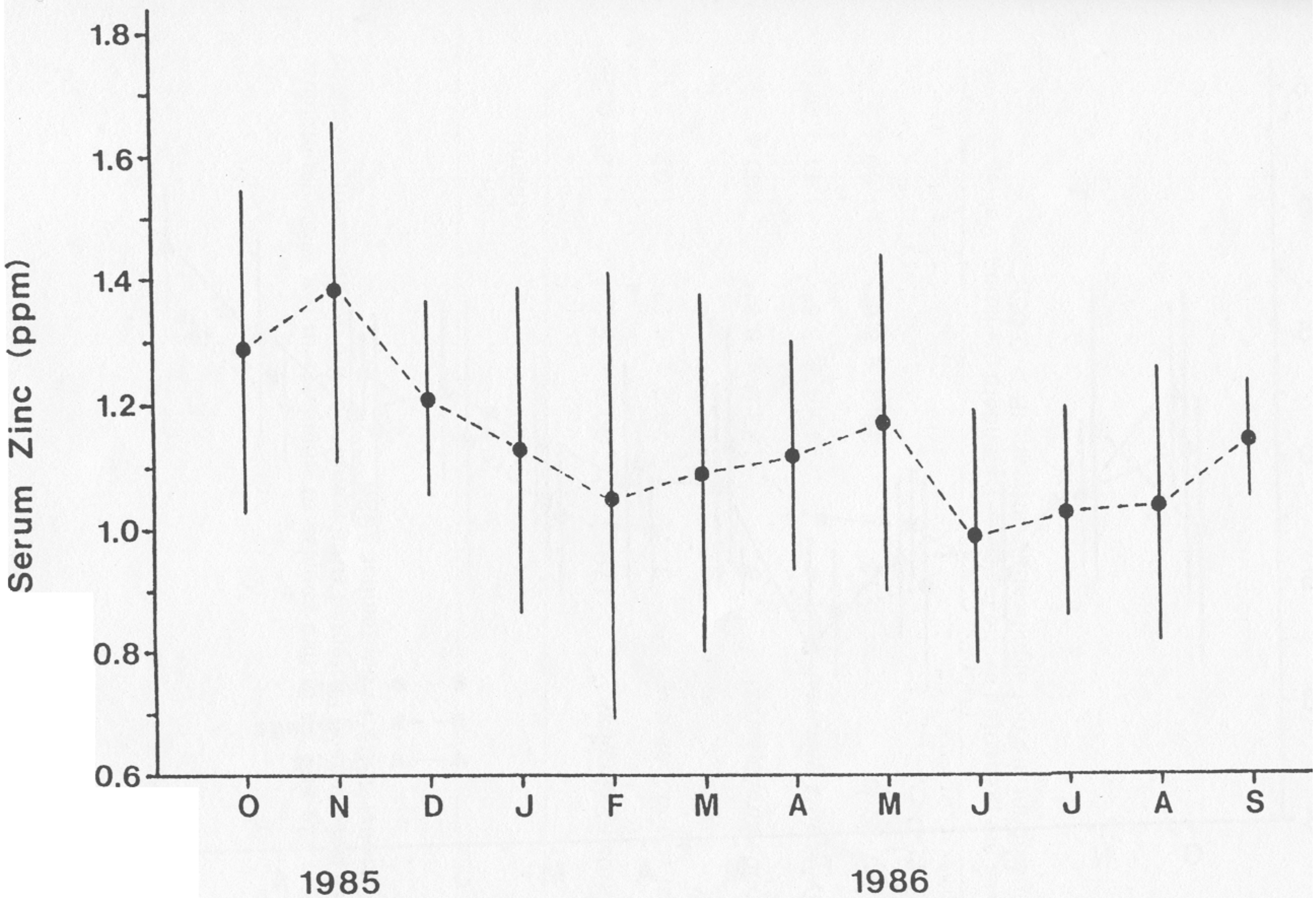

Figure 2. Seasonal changes in the serum Zn concentration in impala in the Mlawula-Mbuluzi-Simunye Nature Reserve and Protected Area complex in the northeastern waziland lowveld from October 1985 to September 1986.

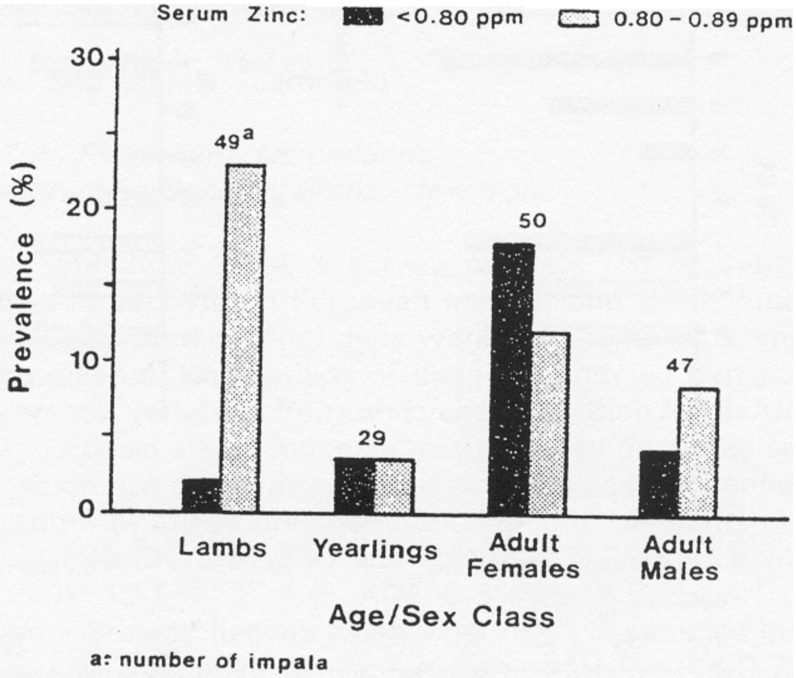

Figure 3. Prevalence of critical (<0.80 ppm) and low (0.80 to 0.89 ppm) values for serum Zn in the age and sex classes of impala. The prevalence varies significantly between age and sex classes (χ^2_6 = 13.19; $P < 0.05$).

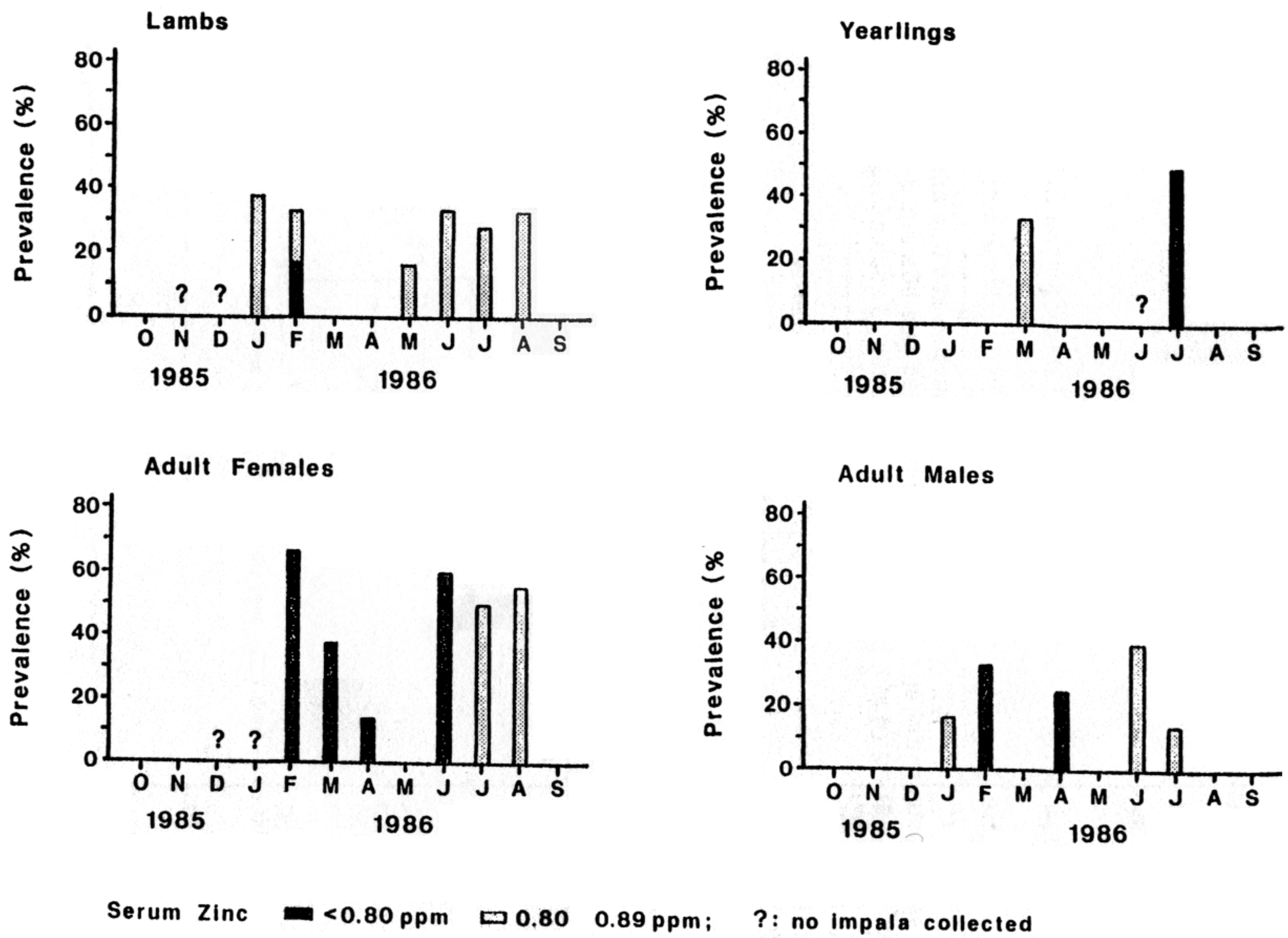

Figure 4. Seasonal changes in the prevalence of critical (<0.80 ppm) and low (0.80 to 0.89 ppm) values for serum Zn in the age and sex classes of impala.