Nutritional Quality of Available Forages for Small Stock during a Drought in an Arid Pastoral Landscape in South Africa

M. I. Samuels
Agricultural Research Council, South Africa

F. L. Müller
Agricultural Research Council, South Africa

C. F. Cupido
Agricultural Research Council, South Africa

M. B. V. Swarts
Agricultural Research Council, South Africa

L. F. Cyster
University of the Western Cape, South Africa

Nutritional quality of available forages for small stock during a drought in an arid pastoral landscape in South Africa

Samuels, M.I[*§]; Müller, F.L[*†]; Cupido, C.F[*]; Swarts, M.B.V[*]; Cyster, L.F[§]
*Agricultural Research Council – Animal Production: Range and Forage Sciences; §Department of Biodiversity and Conservation Biology. University of the Western Cape. † Agricultural Research Council – Animal Production: South African National Forage Genebank

Key words: [three to five key words; separated by semicolons]

Abstract

This study aimed to assess the nutritional quality of the available forage species during a drought in an arid pastoral system in South Africa. Forage biomass was collected during the wet and dry seasons whilst following livestock herds consisting of boer goats, swakara sheep and mixed breed sheep, in both the summer and winter rainfall regions of the pastoral system. Mineral nutrient content in the plant species revealed that the forages utilized by the livestock generally contained adequate concentrations of Mg, Ca, Na, and K to meet the dietary requirements of the small stock in both the winter and summer rainfall areas. Zinc concentrations in more than half of the forages sampled in the summer rainfall area, during both wet and dry seasons, however, were below the required concentrations for small stock. When considering all plant species utilised, the diets were generally adequate in all mineral nutrients. However, none of the forage species contained sufficiently high concentrations of protein to meet the minimum requirements for small stock. These findings therefore show that pastoralists have to deal with chronic low levels of protein during droughts, and their inability to purchase supplementary feed, or to cultivate fodder crops, or temporary emigrate out of the system puts their livelihoods at high risk to climate change.

Introduction

Approximately 80 % of South Africa's land surface is classified as semi-arid to arid of which approximately 82 % of these areas are used for agricultural activities, and only14 % of this area receive sufficient rainfall for arable crop production. The remainder of the agricultural land is used for extensive livestock production, forestry and wildlife/nature conservation (Jordaan et al. 2013). Under these semi-arid and arid conditions, the most extensive agricultural activities are livestock (sheep, goats, cattle and ostriches) farming under rangeland conditions where livestock make use of the natural veld. However, along with low annual precipitation, these semi-arid and arid rangelands are, in many instances, also subjected to recurrent droughts, cyclic long-term droughts, extreme temperatures and marginal edaphic conditions (Jordaan et al. 2013). During these dry periods, livestock production in these rangelands is often severely reduced due to the lack of adequate good quality, nutritious forage available to the livestock, and these shortcomings are exaggerated during periods of prolonged droughts (Palmer and Ainslie 2006; Samuels et al. 2016, Müller et al. 2019).

Several studies have assessed foraging tendencies and diet selection of multiple livestock species in semi-arid to arid areas under herding systems (Samuels et al., 2016, Schroeder et al. 2019). These foraging tendencies however, are influenced by drought, which can trigger plant compositional changes in rangelands, and by doing so influence forage availability and quality for small ruminants (Finch et al. 2016). Schroeder et al. (2019) evaluated the diet selection of herded boer goats, pure-bred swakara sheep, and mixed breed sheep during the 2016 – 2017 drought in the semi-arid pastoral system of Steinkopf in the Northern Cape Province of South Africa. These authors found that livestock within these pastoral systems rely greatly on the availability of annual herbs during the wet season, but due to the drought extending into the second year (2017), these annual herbs became less prevalent in the rangelands, and livestock had to alter their forage choices to include perennial leaf succulent forage species. This ability of livestock to effectively utilise available rangeland resources to minimise the impacts of the drought is an important finding, however, little is known about the quality of these modified diets during periods of drought in semi-arid to arid pastoral systems in South Africa. This study aimed to determine the mineral nutrient and protein content of perennial rangeland forages during the 2016 – 2017 drought in the semi-arid pastoral area of Steinkopf, where Nama and Succulent Karoo biome vegetation are present. We hypothesised that even though a large variety of species are utilised by the livestock, due to the impact of the prevailing drought conditions, the nutritional quality of the plant species eaten by the livestock will generally be poor and inadequate to fulfil livestock diets. We also hypothesise that different livestock breeds will access different quality diets due to differences in feeding preferences.

Materials and Methods

Diet selection was observed and recorded for boer goats (*Capra hircus*), mixed breeds of sheep (*Ovis aries*) and pure bred Swakara (formerly known as Karakul) sheep during the dry and contracted wet seasons in both the Nama Karoo (summer rainfall) and Succulent Karoo (winter rainfall) biomes in the Steinkopf pastoral area. The feeding selections observed by Schroeder et al. (2019) represent the diets of livestock for the wet and dry season for both biomes. Based on the diets of these livestock, samples of the different plants consumed in each season in each of the biomes were collected. For each plant species collected, plant materials were harvested from a minimum of five individuals which made up one sample. This was done to minimize the variability that may exist between individuals of the same species. Three replicates of each species were collected in each season and biome. After collection, the plant samples were oven dried at 60 ˚C until a constant mass was achieved. The dried samples were thereafter milled using a stainless steel laboratory blender after which the samples were passed through a 0.5 mm mesh sieve to ensure uniformity of the milled samples. The dry, milled samples were thereafter digested using a sulphuric-peroxide digestion method (Moore and Chapman 1986). Using the aqueous solution, the total magnesium (Mg), calcium (Ca), Zinc (Zn), sodium (Na) and potassium (K) concentrations were determined using an atomic absorption spectrophotometer (Unicam Unlimited, Cambridge, UK) using certified standards for these elements (Merck Millipore (Pty) Ltd). Total nitrogen (N) concentration in the digest was determined by direct titration with 0.01 M HCl after Kjeldahl distillation using a Büchi Nitrogen Distillation Unit (model K-300, Labotec, Büchi, Switzerland). The N content (%) in the samples obtained was multiplied by a factor of 6.25 to obtain the crude protein (CP) content (%) (McDonald et al. 2010). Mineral nutrient content in all plant species consumed in the wet and dry seasons in each of the vegetation biomes, as well as differences in mineral nutrient content in diets between the different livestock breeds were compared in SPSS (IBM Corporation, Armonk, NY, USA) using an one-way ANOVA with an LSD post-hoc test.

Results

Results from the study indicate that there was large variability in the nutritional quality of different forage species within the rangeland as indicated in the large range in Table 1. On average, the plant species that were eaten by the livestock contained sufficiently high concentrations of Mg, Ca, Zn, Na and K for maintenance in small stock (Table 1). However, when looking at individual species, between 15 % and 20 % of forages consumed were deficient in Zn in the dry and wet seasons, respectively, in the Succulent Karoo biome, as well as 68 % and 49 % of forage species that were Zn deficient in the dry and wet season, respectively, in the Nama Karoo biome (results not shown). Concentrations of Mg, Zn, Na and K in the diets of the livestock did not differ between the wet and dry season or between Nama and Succulent Karoo biomes. However, Ca concentrations in livestock diets in the wet season of the Nama Karoo biome was significantly higher than in the dry season in the Nama Karoo biome, as well as both wet and dry season diets in the Succulent Karoo biome (Table 1). Crude Protein concentrations however, were found to below the 7 – 8 % minimum requirements for maintenance of small stock (Meissner 2000), and this was found in both wet and dry seasons of both Nama Karoo and Succulent Karoo biomes (Table 1). Generally however, the dry season forages contained lower concentrations of CP than forages utilised in the wet season, and this was found in both Nama and Succulent Karoo biomes (Table 1).

When considering the plant species eaten by the different livestock breeds in the arid pastoral system, it was found that the diets of all small stock groups evaluated generally did not differ in Mg and Zn concentrations in both wet and dry seasons or between the Nama and Succulent Karoo biomes (Table 2). Within the Succulent Karoo, no differences in Ca concentrations in the diets of goats, mixed breed sheep and swakara sheep were observed (Table 2). However, in the Nama Karoo, Ca concentrations in the diets during the wet season of all three small stock groups evaluated were significantly higher than those in the dry season. These however, did not differ between the different small stock groups (Table 2). Conversely, no differences in Na concentrations in the diets of the three small stock groups were observed between the wet and dry season of the Nama Karoo biome, but Na concentrations in the diets consumed in the wet season in the Succulent Karoo in all three small stock groups were significantly higher than those consumed in the dry season. In the Nama and Succulent Karoo biomes however, no differences in Na concentrations in the forages consumed by the different small stock groups were observed in the wet and dry seasons, respectively (Table 2).

Table 1: Nutritional quality (mean ± SEM and range) of small stock diets in the wet and dry seasons of the arid pastoral systems in the Nama and Succulent Karoo biomes. Differences in nutritional quality of the diets between seasons and biomes are indicated by different letters.

			Mg (g/kg)	Ca (g/kg)	Zn (g/kg)	Na (g/kg)	K (g/kg)	Crude Protein (%)
Succulent Karoo	**Dry Season**	**Mean ± SEM**	4.2 ± 1.0**a**	10.4 ± 0.9**a**	0.03 ± 0.001**a**	4.4 ± 0.7**a**	9.5 ± 0.9**a**	1.4 ± 0.1**a**
		Range	1.3 - 15.4	4.6 - 18.1	0.02 - 0.03	1.2 - 11.2	4.2 - 16.9	0.3 - 2.3
	Wet Season	**Mean ± SEM**	3.6 ± 0.5**a**	12.3 ± 1.0**a**	0.03 ± 0.005**a**	7.0 ± 1.1**a**	11.2 ± 1.0**a**	2.4 ± 0.2**b**
		Range	0.8 - 9.5	5.7 - 25.5	0.01 - 0.12	0.5 - 16.2	4.7 - 24.8	1.1 - 4.4
Nama Karoo	**Dry Season**	**Mean ± SEM**	5.3 ± 0.6**a**	11.6 ± 0.7**a**	0.02 ± 0.002**a**	4.6 ± 0.7**a**	9.1 ± 1.0**a**	1.8 ± 0.1**a**
		Range	0.7 - 10.0	7.4 - 17.3	0.01 - 0.05	1.0 - 8.7	2.5 - 18.6	0.8 - 3.3
	Wet Season	**Mean ± SEM**	5.3 ± 0.9**a**	15.7 ± 1.8**b**	0.03 ± 0.009**a**	3.8 ± 1.1**a**	12.6 ± 1.1**a**	2.1 ± 0.2**b**
		Range	0.8 - 18.9	8.0 - 36.6	0.01 - 0.21	0.5 - 19.4	3.7 - 23.0	0.9 - 4.4
	Significance		**$F_{(3,80)}$ = 1.325, p = 0.273**	**$F_{(3,80)}$ = 3.337, p = 0.024**	**$F_{(3,80)}$ = 0.553, p = 0.648**	**$F_{(3,80)}$ = 2.391, p = 0.075**	**$F_{(3,80)}$ = 2.516, p = 0.065**	**$F_{(3,80)}$ = 5.284, p = 0.002**

Table 2: Nutritional quality (mean ± SEM) different small stock breed diets in the wet and dry seasons of the arid pastoral systems in the Nama and Succulent Karoo biomes. Differences in nutritional quality of the diets between breeds, seasons and biomes are indicated by different letters.

	Species/Breed	Season	Mg (g/kg)	Ca (g/kg)	Zn (g/kg)	Na (g/kg)	K (g/kg)	Crude Protein (%)
Succulent Karoo	mixed sheep	Dry	4.2 ± 1.0a	10.4 ± 0.9a	0.03 ± 0.001a	4.4 ± 0.7a	9.5 ± 0.9a	1.4 ± 0.1a
		Wet	3.4 ± 0.4a	12.1 ± 1.1ab	0.04 ± 0.005a	7.1 ± 1.1cd	11.4 ± 1.1abc	2.3 ± 0.2bc
	Swakara	Dry	4.3 ± 1.0a	10.0 ± 0.9a	0.03 ± 0.001a	4.5 ± 0.8ab	9.3 ± 0.9a	1.4 ± 0.1a
		Wet	3.7 ± 0.5a	12.2 ± 1.0ab	0.03 ± 0.005a	7.5 ± 1.2cd	11.2 ± 1.1abc	2.4 ± 0.2c
	Goats	Dry	4.7 ± 1.1a	10.8 ± 1.0a	0.03 ± 0.001a	5.0 ± 0.8ab	9.8 ± 1.0ab	1.4 ± 0.1a
		Wet	4.2 ± 0.6a	12.8 ± 1.2ab	0.04 ± 0.006a	8.4 ± 1.2d	10.8 ± 0.8abc	2.6 ± 0.2c
Nama Karoo	mixed sheep	Dry	5.3 ± 0.9a	11.8 ± 0.9ab	0.02 ± 0.003a	4.8 ± 0.8ab	8.7 ± 1.2a	1.8 ± 0.2ab
		Wet	5.4 ± 1.1a	17.9 ± 2.4c	0.03 ± 0.013a	3.9 ± 1.1a	12.6 ± 1.2bc	2.1 ± 0.2bc
	Swakara	Dry	5.6 ± 0.7a	12.0 ± 0.8ab	0.02 ± 0.002a	4.5 ± 0.7ab	9.5 ± 1.1a	1.9 ± 0.2abc
		Wet	5.7 ± 1.1a	16.9 ± 2.2c	0.03 ± 0.012a	3.2 ± 1.0a	13.6 ± 1.3c	2.2 ± 0.3bc
	Goats	Dry	5.1 ± 0.7a	11.2 ± 0.8a	0.02 ± 0.002a	4.5 ± 0.7ab	8.8 ± 1.0a	1.8 ± 0.2ab
		Wet	5.3 ± 1.0a	15.6 ± 1.9bc	0.02 ± 0.002a	4.2 ± 1.2a	12.4 ± 1.3bc	2.1 ± 0.2bc
	Significance		**$F_{(11,202)}$ = 0.906, p = 0.535**	**$F_{(11,202)}$ = 3.435, p < 0.001**	**$F_{(11,202)}$ = 0.857, p = 0.583**	**$F_{(11,202)}$ = 2.551, p = 0.005**	**$F_{(11,202)}$ = 2.135, p = 0.020**	**$F_{(11,202)}$ = 3.539, p < 0.001**

Discussion and conclusion

In this study we evaluated the mineral nutrient (Mg, Ca, Zn, K and Na) and crude protein content in the forages consumed by different small stock breeds in an arid pastoral system in South Africa, during a drought. We hypothesised that even though a large variety of species are utilised by the livestock, due to the impact of the prevailing drought conditions, the nutritional quality of the plant species eaten by the livestock will generally be poor and inadequate. This is because mineral nutrient availability to plants decreases with increased soil moisture limitation (da Silva et al. 2011). Our results on protein content supports this hypothesis as all of the analysed forages were well below the minimum requirements for small stock (Tainton et al. 2000), and this was found in both wet and dry seasons in both Nama and Succulent Karoo biomes. These protein deficiencies during droughts could lead to significant loss in livestock productivity, reduced growth and also have various other negative impacts on livestock health (Meissner 2000). However, based on the findings of the current study, and at least for the mineral nutrients evaluated, the forages available to the small stock during the drought, contains adequate concentrations of all the mineral nutrients evaluated. This was true for all elements except for Zn, which was found to be very low in several forage species in both the Nama and Succulent Karoo biomes. As the drought persist for longer periods, this could mean that several forage species, which contain adequate concentration of Zn, could become less dominant in livestock diets, resulting in potential Zn deficiencies. It is therefore suggested that the small stock maintained only on the rangeland resources during a drought, be tested for Zn deficiencies and should be supplemented with Zn if possible. Sub-clinical Zn deficiencies in livestock adversely affects spermatogenesis, testicular growth and the development of the

primary and secondary sex organs in males, and also all phases of the reproductive process in the female from oestrus to parturition and lactation. This, in turn, could explain the low weaning percentages experienced by small stock farmers in the Steinkopf communal area in South Africa.

We also hypothesised that different livestock breeds will access different quality diets due to differences in feeding preferences. Goats are generally browsers and sheep grazers and therefore, it is expected that these breeds have different feeding preferences and thus, also access different quality diets. Samuels et al. (2016) followed livestock in the Namaqualand Granite Renosterveld vegetation in the Succulent Karoo biome and found that different livestock breeds accessed different forage resources, and Müller et al. (2019) found that these diets also differed in nutritional quality. The current results however, indicate that different small-stock breeds within the arid pastoral system in both Nama and Succulent Karoo biomes, during the drought, accessed diets that did not differ significantly in quality, in the wet and dry seasons respectively, and this could potentially be due to the limited number of forage species available to the livestock during the drought.

In conclusion, based on the results from the study, farmers utilising these arid rangelands, especially during periods of drought, are at risk of livestock developing protein deficiencies and as a result, farmers will have to deal with reduced livestock productivity. It is therefore suggested that farmers utilising the arid rangelands in the Nama and Succulent Karoo biomes, especially during periods of drought, invest in protein supplementation for their livestock to maintain more productive herds. Also, only a limited number of mineral nutrients were assessed in this study while several other essential mineral nutrients including phosphorous would still be assessed. This is especially true for essential micronutrients or trace elements which may be deficient in the livestock diets during periods of drought.

Acknowledgements

The South African National Research Foundations is thanked for their financial contribution towards the completion of this project.

References

da Silva, E.C., Nogueira, R.J.M.C., da Silva, M.A., de Albuquerque, M.B. 2011. Drought Stress and Plant Nutrition. Plant Stress 5: 32-41.

Jordaan, A.J., Sakulski, D., Jordaan, A.D. 2013. Interdisciplinary drought risk assessment for agriculture: The case of communal farmers in the Northern Cape Province, South Africa. S. Afr. J. Agric. Ext. 44 – 58.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D., Morgan, C.A., Sinclair, L.A., Wilkinson, R.G. 2010. Animal nutrition (7th edn). New York: Longman.

Meissner, H.H. 2000. Nutrient supplementation of the grazing animal. In: Tainton, N.M (ed.), Pasture management in South Africa. Pietermaritzburg: University of Natal Press. pp 96–115.

Moore, P.D., Chapman, S.B. 1986. Methods in plant ecology. 2nd edn. Blackwell Scientific Publications.

Müller, F.L., Samuels, M.I., Cupido, C.F., Swarts, M.B.V., Amary, N.M., Hattas, D., Morris, C., Cyster, L.F., Boatwright, J.S. 2019. The impacts of season and livestock management strategy on the quality of diets selected by goats and sheep in the semi-arid rangelands of Namaqualand. South Africa. Afr. J. Range Forage Sci. 2019; 36: 105-114

Samuels, I., Cupido, C., Swarts, M.B., Palmer, A.R., Paulse, J.W. 2016. Feeding ecology of four livestock species under different management in a semi-arid pastoral system in South Africa. Afr. J. Range Forage Sci. 2016; 33: 1 – 9.

Schroeder, A., Samuels, M.I., Swarts, M., Morris, C., Cupido, C.F., Engelbrecht, A. 2019. Diet selection and preference of small ruminants during drought conditions in a dryland pastoral system in South Africa. Small Ruminant Research 176: 17–23.