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Vegetation dynamics in relation to land use within the high altitude alpine grasslands of Lesotho, southern Africa

Nico Smit, G. Janse van Rensburg
University of the Free State, Bloemfontein, South Africa
Corresponding author e-mail: smitgn@ufs.ac.za

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Introduction

The Kingdom of Lesotho is characterized by its unique geographical feature of being dominated by rugged mountainous terrain. It is also the only true alpine region in southern Africa that supports high plant species diversity. Large areas suffer from overgrazing and erosion, as well as over exploitation of its natural resources. The livestock industry in Lesotho has long been a vital component of the economic and social structure of the country and the alpine region is considered as an important grazing resource by local Basotho herdsmen. Consequently, a study was conducted with the two objectives: to determine the phytomass, grazing capacity and crude protein of the vegetation in two areas of the Lesotho alpine grassland with different grazing histories, and to assess the vegetation dynamics in relation to land use with specific reference to productivity, degradation and sustainability.

Materials and Methods

The study area is located in the Drakensberg Grassland Bioregion and the vegetation unit is described as Drakensberg Afroalpine Heathland on basalt at altitudes ranging from 2900 - 3400 m. The area receives summer rainfall, but also some precipitation from frost in winter. Winters are extremely cold with temperatures as low as -20^{o}C. The vegetation varies from grassland dominated by *Merxmuellera* species and dwarf karroid shrubs, notably *Helichrysum trilineatum*. Mires (wetlands) occur as depressions on the high-altitude plateau and are characterized by low grass-herb mire complexes with turf and tussock grassland patches.

Two areas of the Lesotho alpine grassland with different grazing histories were selected for study. The combined study area has a long history of communal grazing by sheep, goats, cattle, donkeys and horses, but due to differences in accessibility, the grazing intensity varied from severe to moderate. The Khalong-la-lithunya catchment area (28°53'S, 28°47'E) has a long history of severe grazing, while the Koti-Sephola catchment area (29°31'S, 29°12'E) was subjected to more moderate grazing.

Floristic surveys were conducted on four randomly selected northern slopes, two in the heavily grazed area and two in the moderately grazed area. The phytomass (dry mass) of the herbaceous plants (mainly grasses, but also forb species) on each of the four survey plots was determined during November 2010. All rooted herbaceous plants were harvested on a species basis in randomly placed quadrates (0.25 m^{2}) and a total of 30 quadrates were harvested per survey plot. Harvested plants were dried to a constant mass (70^{o}C) and weighed. From the herbaceous dry mass ha^{-1} measurements, an estimate of the grazing capacity of each site was calculated, using the formula proposed by Moore *et al.* (1985).

For the quantification of the phytomass of dwarf karroid shrubs a total of 25 *H. trilineatum* plants and another 25 of other shrub species were randomly selected during November 2010, their dimensions (height and canopy diameter) measured, then harvested and dried to constant mass (70˚C) and weighed. The twigs <2.0 mm were separated by hand from the twigs and stems >2.0 mm. Regression analyses were applied with the plant dry mass as dependent variable (3 categories: twigs <2.0 mm, twigs and stems >2.0 mm and total phytomass) and plant height and canopy diameter as independent variables. Three regression models were tested. The mean canopy diameter and multiplicative regression equation presented the best correlation with phytomass (Table 1). Belt transects of 0.5 x 200 m were laid out in each of the four survey plots. The canopy diameter of all dwarf karroid shrubs in these transects was measured and the plant phytomass calculated from the regression equations (Table 1).

Table 1: Results of the regression analyses of the relation between canopy diameter and phytomass of dwarf karroid shrubs: Multiplicative regression model: $Y = aX^b$, where y = estimated phytomass (dry mass), x = mean canopy diameter, a = log a.

Plant fraction	Regression equation	r	r^2	P
Helichrysum trilineatum				
Twigs < 2.0 mm	y = -3.57003X2.02229	0.97	0.94	<0.001
Twigs > 2.0 mm	y = -4.8230X2.43617	0.96	0.92	<0.001
Total plant	y = -3.37893X2.20763	0.98	0.96	<0.001
Other shrub species				
Twigs < 2.0 mm	y = -2.75945X1.72722	0.96	0.93	<0.001
Twigs > 2.0 mm	y = -2.8596X1.92878	0.96	0.93	<0.001
Total plant	y = -2.12475X1.8481	0.97	0.94	<0.001

Crude protein (CP) content of the harvested grasses (*Merxmuellera* spp.) and dwarf karroid shrubs (*H. trilineatum*) was obtained by determining the nitrogen contents by gas fusion using a Leco TC-400 apparatus and multiplying the total N-concentration by 6.25.

The Shapiro-Wilk test was used to test for normality of the herbaceous and shrub DM yields. An analysis of variance (ANOVA) (Statsoft Inc., 2004) was used to determine whether the phytomass values differed statistically between the two study areas with different grazing histories.

Results and Discussion

From the results it is clear that the vegetation of the two areas differ substantially (Table 2). The heavily grazed Khalong-la-lithunya catchment has a significantly (P<0.001) higher density and phytomass of dwarf karroid shrubs compared to the moderately grazed Koti-Sephola catchment. In direct contrast, the Koti-Sephola catchment has a significantly (P<0.001) higher herbaceous phytomass and grazing capacity compared to the Khalong-la-lithunya catchment area. In addition, species of only two grass genera (*Merxmuellera* and *Pentashistis*) were recorded in the Khalong-la-lithunya catchment, compared to species of three grass genera (*Merxmuellera*, *Pentashistis* and *Poa*) in the Koti-Sephola catchment area. While the moderately grazed area had higher plant diversity than the heavily grazed area, the species composition still appears low when compared with historical data from similar vegetation types in Lesotho.

Only two plant species - the grass *Merxmuellera macowanii* and the dwarf karroid shrub *Helichrysum trilineatum* - made up the bulk of the phytomass. There was a clear negative relationship between the two species with grazing intensity that appears to be the main driver that determines the abundance of these two species relative to each other. In the heavily grazed area, *M. macowanii* was largely replaced by *H. trilineatum*, despite the fact that *M. macowanii* is not considered a very palatable species with relatively low crude protein content of 4.15-4.55 % (Table 2). In contrast, the dwarf karroid shrubs have a much higher crude protein contents of 8.45-8.52 % (Table 2), but there exists no evidence that it is utilized by either domestic stock or indigenous wildlife species.

Table 2: Summary statistics of the survey of the vegetation of two areas of the Lesotho alpine grassland with different grazing histories (heavy grazing and moderate grazing) (SE = Standard Error of the mean) (DM = Dry mass)

Variable	Unit	Value (± SE)		P
		Heavy grazing	Moderate grazing	
Mean grass phytomass	kg DM ha^{-1}	1 014 (± 204)	3 299 (± 1 067)	< 0.001
Mean grazing capacity (grasses)	ha AU^{-1}	25.92 (± 4.8)	3.64 (± 1.2)	< 0.001
Mean crude protein - grasses	%	4.55 (± 0.05)	4.15 (± 0.1)	> 0.05
Mean karoid shrub density	plants ha^{-1}	90 666 (± 2400)	2 640 (± 500)	< 0.001
Mean shrub phytomass (< 2.0 mm)	kg DM ha^{-1}	1 756.5 (± 2.5)	52.3 (± 4.9)	< 0.001
Mean shrub phytomass (> 2.0 mm)	kg DM ha^{-1}	2 246.0 (± 35.0)	53.5 (± 5.2)	< 0.001
Mean shrub phytomass (total)	kg DM ha^{-1}	4 002.5 (± 38.5)	105.8 (± 10.1)	< 0.001
Mean crude protein - karoid shrubs	%	8.45 (± 0.1)	8.52 (± 0.09)	> 0.05

From this study it is evident that *H. trilineatum* increases under conditions of heavy grazing, especially by sheep that are known to be destructive short-grass grazers, and due to their numbers, most of the grazing effects can be ascribed to this species. From observations in the study area it is also evident that *H. trilineatum* appears to be intolerant of wet conditions and subsequently it is absent from areas subjected to long periods of inundation. Lesotho is known for its severely eroded landscape and the degradation of the high altitude catchment areas will invariably result in drier soil profiles, which will favour *H. trilineatum* and allow it to spread into areas which were previously too wet for this species to survive.

Grazing areas of Lesotho are communal and due to an increase in livestock populations and weak enforcement of grazing guidelines, overstocking is a common problem. Cultivation was extended to approximately 2 500 m above sea level in favourable places, while domesticated animals were driven higher and further into the highlands. Many rural communities in Lesotho rely on plants as a source of fuel and due to the lack of trees at altitudes above 2 400 m, karroid shrubs such as *H. trilineatum* are viewed by inhabitants as a valuable source of fuel for cooking and heating. *Helichrysum* species also have potential to be used as medicinal plants.

Owing to a very high annual precipitation, water is an extremely valuable resource of Lesotho. In view of the water limited nature of the southern African subregion, the health of the catchment areas in the high mountains of Lesotho is of critical importance. In addition, as the only true alpine region in southern Africa, it is of significant local and international importance, but unlike a true conservation area the Khalong-la-lithunya and Koti-Sephola catchment areas have no formal protection which left it vulnerable to over utilization.

Conclusion

The vegetation composition and productivity of the slopes of the various catchment areas are critical to the health and ecological functioning of the associated wetlands (mires). It is evident that prolonged heavy grazing resulted in a lowering of biodiversity on the slopes with grasses that are replaced by dwarf karroid shrubs. The low herbaceous phytomass in the heavily grazed areas is most likely the result of both the current state of heavy, continuous grazing, as well as the negative competition interaction between the shrubs (mainly *H. trilineatum*) and the herbaceous plants. In addition, there are strong indications that the environmental degradation caused by the heavy grazing resulted in drier soil profiles which benefited the establishment of *H. trilineatum*. Without reducing stocking rates and implementing sound grazing management systems that provide for extended rest periods, the restoration and preservation of this ecologically unique area is unlikely to be realized.

References

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