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Impacts of large herbivores on plant species diversity and range condition around water points in waterberg plateau park, central Namibia

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ABSTRACT:

Scarcity of water is a major challenge for organisms living in arid and semi-arid regions of the world. To alleviate this problem, ranch and park managers resort to provision of year-round water to animals through construction of artificial water points. This has led to prolonged local occupancy and high densities of animals around water points resulting in environmental degradation, loss of ecosystem heterogeneity and productivity. In Namibia, this practice is common in livestock ranches and national parks. The objective of this study is to determine the impact of large herbivores on plant species diversity and range condition along a distance gradient around five selected water points in the Waterberg Plateau Park. Plant species identifications and inventories were done in plots demarcated at 0m, 100m, 200m, 300m and 500m along four transects radiating from each water point. Range condition was compared using proportions of increaser and decreaser grasses. Results showed that the use of increaser/decreaser concept is inappropriate in rangelands naturally dominated by what are classified as 'decreaser' species because, functionally these species may not respond in a decreaser fashion, especially in sandveld ecosystems. High herbivore trampling pressure and over-utilization of vegetation has led to significant declines in species richness and diversity close to water points, the so-called sacrifice zone (piospheres).

Keywords:
Degradation, Large herbivores, Range condition, Waterberg Plateau Park, Water point.

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INTRODUCTION

African savannas have an evolutionary history of high levels of grazing and browsing (de Klerk, 2004). This significantly modifies vegetation structure and composition, reducing the growth and reproduction of individual plants, and influencing competitive outcomes and community composition (de Klerk, 2004). In the savanna biome, reduced competition from grass communities in overgrazed areas inevitably leads to an increase in the density of the woody species (Tainton, 1999). In most cases these changes are irreversible because of the effect on the grasses of the woody species, which compete strongly for moisture (Tainton, 1999).

In arid and semi- arid National parks and Game reserves, where there is a scarcity of water, animals are provided with perennial water as a management practice (Parker and Witkowski, 1999; Thrash, 1998). These artificial watering points may lead to large herbivores, some of which would normally migrate in search of water during dry periods, becoming sedentary. The result of that is a year-round grazing and browsing of rangeland with an increase in utilization pressure around water points (Brits *et al*., 2002).

Apart from these specific direct effects, the establishment of artificial water points also maintains high level of herbivory and trampling pressure around water points. Plants and animals that are not directly affected by the presence of water are often affected by the presence of large numbers of grazing and browsing animals and the results of their activities around water points (James *et al.,* 1999). Herbivores are generally thought to enhance plant diversity by their direct consumption of competitively dominant plant species and indirect effects on plant competition (Olff and Ritchie, 1998). Consequently, management of herbivores has become a crucial component in efforts to restore or maintain biodiversity (Olff and Ritchie, 1998). However, herbivores may sometimes have weak or even negative effects on plant diversity (Olff and Ritchie, 1998), depending on the relative abundance of browsers and grazers as well as selectivity of foraging by different herbivores (Augustine and McNaughton, 1993).

Namibia is the driest country south of the Sahel (Seely and Jacobson, 1994) and therefore the provision of year-round water to animals through artificial water points is common in this country, especially in livestock farms and national parks. According to Mphinyane (2001), uneven use of rangelands by herbivores has been, and continues to be a major problem confronting range resource managers. Therefore, due to the aggregation of large herbivores around water points in Waterberg Plateau Park, especially during dry seasons, large herbivores may particularly pose a great threat to the vegetation around water points through the year-round herbivory and trampling, and changes in soil physical and chemical properties.

Study area

The study was carried out in Waterberg Plateau Park (WPP), central Namibia. It is located 280 km northeast of Windhoek and 64 km east of Otjiwarongo (Fig. 1). The park lies between 20° 24′ S and 17° 14′ E, and covers an area of 46 949 ha. It falls within the "Tree Savanna and Kalahari Woodland" vegetation types of

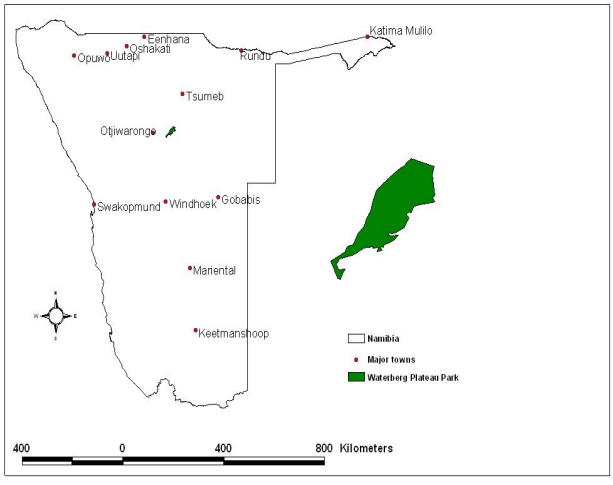

Figure 1: Location of Waterberg Plateau Park in Namibia

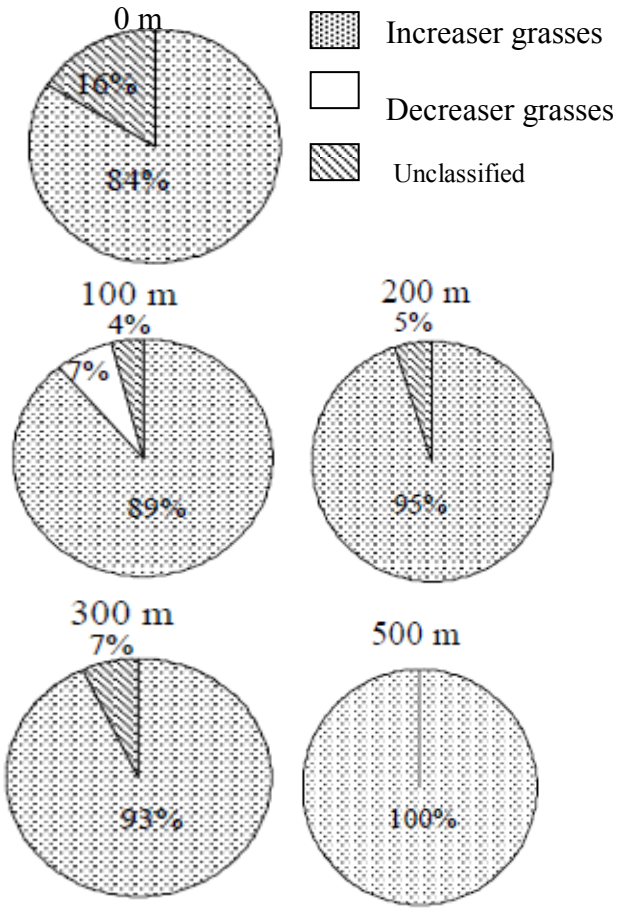

Figure 2: Comparison of mean relative proportions of increaser, decreaser and unclassified grasses species at five distances from water points in Waterberg Plateau Park, Central Namibia.

Namibia and consists mainly of a variety of deciduous trees and shrubs, and "hard" grasses (Erckie, 2007). The main physical feature is the sandstone plateau which lies between 1550 m and 1850 m above sea level and between 100 m to 300 m above the surrounding plains (Erckie, 2007). The WPP falls within the climatic region known as Hot steppe, which is dry and deficient in rainfall, experiences an annual mean temperature above 18°C and receives summer rainfall (Erckie, 2007). The annual average number of days with rainfall is 40-50 and the deviation of the annual rainfall ranges between 25-30% (Erb, 1993).

Animals found in the WPP include black rhino *(Diceros bicornis)* white rhino (*Ceratotherium simum*), roan antelope (*Hippotragus equinus*) and sable antelope (*Hippotragus niger*) (Schneider, 1993; Du Preeze, 2000). Most of the animals in the WPP were translocated from other parts of the country (between 1975 and 1985) by the then Department of Nature Conservation to ensure the survival of rare and endangered species (Schneider, 1993). This makes the Waterberg Plateau Park a sanctuary for the game species with the objective of breeding and to provide stock for the reintroduction of species to other areas in Namibia where they naturally occur (Erckie, 2007). Due to scarcity of water and mineral deficiency in the soils, the animals are provided with artificial water points and salt licks in the park. The large herbivores are mainly confined to the plateau, where all the artificial watering points are situated, and their numbers are only manipulated through translocation and introduction (Erckie, 2007).

The provision of artificial water points on the plateau may have resulted in high levels of herbivory around the water points, which may in turn lead to a disappearance of some plant species and maybe a colonization of new plant species that are tolerant of the disturbance caused by large herbivores. This may further have resulted in species with wide and contiguous distribution getting separated and isolated into small sub-populations (Rajendra *et al.,* 2011). Such changes can make the ecosystem vulnerable to perturbation, resulting in a permanent loss or change of the biological diversity of the area. Consequently, this leads to changes in vegetation community patterns and ecosystem functioning (Mysterud, 2006). This study therefore aims to determine the impact of those large herbivores on plant species diversity and range condition around water points in WPP.

Experimental design

Five artificial water points in the Waterberg Plateau Park were selected for this study. Four line-transects starting as close as possible to, and radiating away from each water point in the northeast, northwest, southeast and southwest directions, respectively; were surveyed. Three nested square plots of

1m x 1m, 5m x 5m and 20m x 20m (Barbour *et al.*, 1987), at distances of 0m, 100m, 200m, 300m and 500m from the water trough, were demarcated along each transect. The 1 m x 1 m plots were nested within the 5m x 5m and the 5m x 5m were nested in the 20m x 20m. Coordinates of each plot were recorded at the reference corner, to allow for future monitoring.

Measurement of plant attributes

For this study, all woody plants with a basal circumference of ≥16 cm (and generally >3m in height) were considered as trees and woody plants ≤3.0m in height and/or less than 16cm basal circumference were considered as shrubs and saplings (Walker, 1976). These could be single or multi-stemmed individuals fitting the above-mentioned characteristics. An individual woody plant was considered to be in a plot if the center of its base was included within the plot. For thicket forming species, all individuals were treated as shrubs and saplings, even if they were taller than 3 m or had stem circumferences greater than 16 cm (Walker, 1976). In this study, saplings were included with the shrubs based on their height and basal circumference, as these did not qualify to be considered as trees.

In each plot, all woody plants were counted and identified to species level. Each herbaceous plant species (grasses and forbs) was also identified and all forbs were counted. All plants not identified in the field were collected for identification and verification at the National Botanical Research Institute in Windhoek.

Data analysis

Plant species richness and diversity (Shannon-Wiener diversity index, H') were calculated for each plot (Krebs, 1989; Binu *et al.,* 2011) and their differences H' among distances from the water were tested using the Kruskal-Wallis test. Grass species were categorized into decreaser or increaser species based on literature sources. Species that could not be categorized as either decreasers or increasers were termed "unclassified" species. The mean relative proportion of the grass cover for each functional group (decreaser, increaser or unclassified) was calculated per distance from the water and a Chi-square test was used to test for differences in the mean relative proportions of the different grass functional groups among the different distances from the water points.

RESULTS

There were significant differences in plant species diversity and species richness between 0m and the other four distances from the water ($H = 44.697$, $df = 4$, $p<0.001$ and $H = 48.495$, $df = 4$, $p<0.001$, respectively). Both species diversity and species richness were significantly lower at 0 m than at the other distances from the water point (Table 1). No significant differences were detected among the other distances from the water point.

There were significant differences in the mean relative proportions of increaser, decreaser and unclassified grasses among distances from the water ($\chi^2= 51.655$, $df = 8$, $p<0.001$). There were much higher observed than expected frequencies of increaser grass species at all the distances from the water. There were much lower observed frequencies than expected of unclassified grasses and the almost complete absence of decreaser grasses throughout the study area (Figure 2).

DISCUSSION

Both species richness and diversity were lowest closest to (0m), and highest furthest (500m) away from the water point, but there were no significant differences from 100m and further away from the water point (Table 1). This decrease in species richness and diversity is the result of the high intensities of browsing, grazing and trampling by large herbivores around the water points. Trampling may induce physiological changes that lead to a change in competitive interactions among plant species, altering plant species richness, evenness and diversity. This has been reported to inhibit primary

Table 1: Comparisons of mean Shannon-Wiener diversity indices and species richness among five distances from the water. Similar superscripts among distances indicate no significant difference for each variable.

Distance from Water point (m)	Mean H' (± Standard Error)	Mean Species Richness (± Standard Error)
0	0.20 ± 0.079^{a}	0.90 ± 0.315^{c}
100	1.41 ± 0.099^{b}	6.70 ± 0.413^{d}
200	1.53 ± 0.062^{b}	7.80 ± 0.388^{d}
300	1.44 ± 0.072^{b}	6.85 ± 0.530^{d}
500	1.42 ± 0.091^{b}	7.70 ± 0.553^{d}

production (de Mazancourt *et al.,* 1999). Hence, very few tolerant species (sometimes no species at all) were found within 20 m of the water. The above argument is supported by Mysterud (2006) who noted that herbivory may decrease plant species richness, depending on factors such as grazing or browsing intensity and nutrient availability. In areas very close to the water point, trampling is much more important than grazing/browsing since animals graze or browse less there due to their sheer numbers. The trampling itself results in potential browse/graze material being lost under hoof action.

Changes in plant species dominance at various distances from the water point may further demonstrate the impact of large herbivores around water points. *Stipagrostis hirtigluma* subsp. *pearsonii*, the common grass species at 0m (albeit, with a very low cover compared to grass species at further distances) is an annual pioneer grass which is not highly palatable to grazers (Muller, 1984). Grass species generally dominating at further distances include *Eragrostis pallens*, *Aristida stipitata* subsp. *stipitata* and *Aristida stipitata* subsp. *graciliflora*. These *Aristida* subspecies are woody, pioneer grasses, which have little forage value (Muller, 1984). *Eragrostis pallens* is a coarse, densely tufted perennial, a climax grass of the central and northern Kalahari, which is abundant in the *Terminalia sericea*-veld (Muller, 1984). Theabove-mentioned dominant Aristidae (*Aristida* and *Stipagrostis*) species are typically found in the arid regions of southern Kalahari (Scholes *et al*., 2002). Although these species are not very palatable to herbivores, their presence in the study area may not necessarily indicate that large herbivore disturbance has resulted in a degradation of the rangeland, as they are known to naturally occur in undisturbed Kalahari sandveld.

Common woody species in the study area were *Ochna pulchra, Terminalia sericea*, *Combretum collinum*, *Combretum psidioides* and *Acacia ataxacantha*. The above-mentioned woody species also confirm those commonly found in the park by Erb (1993). According to Mapaure (2001), species, which survive better in disturbed areas, will increase in numbers through proliferation of originally present cohorts and/or by invasion. This process leads to changes in the species composition, richness and diversity of the rangeland (Mapaure, 2001). Rangelands that have undergone such changes may then be maintained at the new state by large herbivores and fire (Mapaure, 2001). In his study, Mapaure (2001) observed that species like *Terminalia sericea* and *Combretum collinum* had a high potential to increase with large herbivore (elephant) disturbance, particularly on loose sands. Therefore, although species such as *Terminalia sericea* and *Combretum collinum* naturally occur on loose sands, they may increase in numbers when these areas are disturbed, therefore changing the species diversity of the area.

Another reason that may further explain the species composition within the study area may be the distribution of water points in the park. Water points that are too far apart may result in gaps of un-utilized areas of the rangeland, whereas water points that are too close to each other may cause severe over-utilization and

trampling of the rangeland (Du Toit and Van Rooyen, 2002). The shortest distances between the artificial water points in the Waterberg Plateau Park do not exceed 6 km. Considering that mobile water-dependent indigenous large herbivores are readily able to forage up to 10 km from water (Thrash, 2000), the areas between water points in the WPP, are easily accessible to large herbivores. These areas are therefore in danger of over-utilization by large herbivores with increasing impact that may lead to bush encroachment (Du Toit and Ebedes, 2002), changing the species composition of the area. Such a change may also affect other large herbivore species such as the Roan and Sable antelope which are endangered species. These animals require tall grass in which to forage and in which their young may remain hidden, and are thus usually associated with areas of low herbivore use intensity (Thrash *et al*., 1995).

It should however be noted that the higher levels of degradation at the water points in comparisons to distances further away from the water may not be avoided (Mphinyane, 2001). This is because even those areas that are properly stocked may be degraded near the water points, due to the fact that around water points large herbivores aggregate in a small area; feeding, trampling, defecating and urinating (Mphinyane, 2001). Such impacts may lead to changes in species composition (Mapaure *et al.*, 2011), and a decrease in species richness and diversity around the water points as shown in this study. With increasing distance from the water there is an exponential increase in the size of the feeding area. Therefore the impact of large herbivores decreases and become negligent at greater distances from the water, depending on how far from the water points the animals are able to travel (James *et al*., 1999) and the spatial arrangement of water points. These observations are important in the management of artificial water points when decisions have to be made with respect to when and which water points to close or open in order to maintain ecological integrity of the rangeland.

CONCLUSIONS

Plant species richness and species diversity were significantly lower around water points in the Waterberg Plateau Park. This is a result of high intensities of herbivory and trampling, which led to only a few tolerant species to no species at all surviving at the water points. It is therefore concluded that large herbivores led to a decline in plant species richness and diversity around water points in the Waterberg Plateau Park. This study could not determine the condition of the range with the increaser-decreaser concept, and therefore no concrete conclusion was drawn regarding the condition of the range using that method. It should however be noted that the results of species richness and diversity generally suggested high degradation around water points due to large herbivore activities.

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REFERENCES

Augustine DJ and McNaughton SJ. 1993. Ungulate effects on the functional species composition of plant communities: Herbivore selectivity and plant tolerance. *Journal of Wildlife Management*. 62:1165- 1183.

Barbour MG, Burk JH and Pitts WD. 1987. Terrestrial Plant Ecology: Second edition. The Benjamin/ Cummings Publishing Company, Inc.

Binu T, Chandrashekara UM and Rajendran A. 2011. Floristic diversity along an altitudinal gradient of Mannavan Shola forest in Southern Western Ghats of Kerala. *Journal of Research in Biology*. 2:101-109.

Brits J, van Rooyen MW and van Rooyen N. 2002. Ecological impact of large herbivores on the woody vegetation at selected watering points on the eastern basaltic soils in the Kruger National Park. *African Journal of Ecology*. 40:53-60.

de Klerk JN. 2004. Bush Encroachment: in Namibia. Report on Phase 1 of the Bush Encroachment Research, Monitoring and Management Project. Ministry of Environment and Tourism, Government of the Republic of Namibia.

de Mazancourt C, Loreau M and Abbadie L. 1999. Grazing Optimization and Nutrient Cycling: Potential Impact of Large Herbivores in a Savanna System. *Ecological Applications*. 9:784-797.

Du Preeze P. 2000. Analysis of the reproduction, population characteristics and the use of space of Black rhino, *Diceros bicornis* (Linnaeus 1758) in the Waterberg Plateau Park, Namibia. MSc Thesis, Department of Biological Sciences, University of Zimbabwe.

Du Toit JG and Ebedes H. 2002. Drinking patterns and drinking behaviour. In: Bothma, J. du P. (ed.) Game ranch management. Van Schaik Bublishers.

Du Toit JG and Van Rooyen N. 2002. The design and location of waterholes. In: Bothma, J. du P. (ed.) Game ranch management. Van Schaik Bublishers.

Erb KP. 1993. The Roan Antelope *(Hippotragus eguinus*, Desmarest 1804), its ecology in the Waterberg Plateau Park. MSc. Thesis, University of Stellenbosch, South Africa.

Erckie JB. 2007. Assessing the effects of grazing intensity by large herbivores on species diversity and abundance of small mammals at Waterberg Plateau Park, Namibia. MSc. Thesis, University of Namibia, Windhoek.

James CD, Landsberg J and Morton SR. 1999. Provision of watering points in the Australian arid zone: a review of effects on biota. *Journal of Arid Environments*. 41:87-121.

Krebs CJ. 1989. Ecological methodology. University of British Columbia, Harper Collins.

Mapaure I. 2001. Small-scale variations in species composition of miombo woodland in Sengwa, Zimbabwe: the influence of edaphic factors, fire and elephant herbivory. *Systematics and Geography of Plants*. 71:935-947.

MET. 1986. *Waterberg Plateau Park management plan*. Ministry of Environment and Tourism, Namibia, N11/2/5, Report.

Mphinyane WN. 2001. Influence of livestock grazing within piospheres under free range and controlled conditions in Botswana. Ph.D Thesis, University of Pretoria, South Africa.

Muller MAN. 1984. Grasses of South West Africa/ Namibia. Directorate of Agriculture and forestry, Department of Agriculture and Nature Conservation, South West Africa/ Namibia.

Mysterud A. 2006. The concept of overgrazing and its role in management of large herbivores. *Wildlife Biology*. 12:129-141.

Olff H and Ritchie ME. 1998. Effects of herbivores on grassland plant diversity. *Trends in Ecology and Evolution*. 13: 261-266.

Parker AH and Witkowski ETF. 1999. Long term impacts of abundant perennial water provision for game on herbaceous vegetation in a semi-arid African savanna woodland. *Journal of Arid Environments*. 41:309-321.

Scholes RJ, Dowty PR, Caylor K, Parsons DAB, Frost PGH and Shugart HH. 2002. Trends in Savanna Structure and Composition along an Aridity Gradient in the Kalahari. *Journal of Vegetation Science*. 13:419-428.

Schneider I. 1993. Waterberg Plateau Park. Shell Namibia.

Seely MK and Jacobson KM. 1994. Desertification and Namibia: a perspective. *Journal of African Zoology*. 108:21-36

Radcliffe-Smith A. 1996. Euphorbiaceae. *Flora Zambesiaca*. 9:1-337.

Rajendra KS, Joshua J, Sunderraj SFW and Kalavathy S. 2011. Habitat preservation is a concern for conserving of *Heliotropium rariflorum* Stocks. in the forest of North Gujarat Region (NGR), Gujarat, India. Journal of Research in Biology. 1:30-37.

Tainton NM. 1999. Veld management in Southern Africa. University of Natal Press Pietermaritzburg.

Thrash I, Theron GK and Bothma Jdu P. 1995. Dry season herbivore densities around drinking troughs in the Kruger National Park. *Journal of Arid Environments*. 29:213-219.

Thrash I. 1998. Impact of large herbivores at artificial watering points compared to that at natural watering points in Kruger National Park, South Africa. *Journal of Arid Environments*. 38:315-324.

Thrash I. 2000. Determinants of the extent of indigenous large herbivore impact on herbaceous vegetation at watering points in the north-eastern lowveld, South Africa. *Journal of Arid Environments*. 44**:**61-72.

Walker BH. 1976. An approach to the monitoring of changes in the composition and utilization of woodland and savanna vegetation. *South Africa Journal of Wildlife Research*. 6:1-32.

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