available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/biocon


# Herded cattle and wild grazers partition water but share forage resources during dry years in East African savannas

*Judith Sitters*[a,1], *Ignas M.A. Heitkönig*[a,*], *Milena Holmgren*[a], *Gordon S.O. Ojwang'*[b]

[a]*Resource Ecology Group, Centre for Ecosystem Studies, Wageningen University, P.O. Box 47, 6700 AA Wageningen, The Netherlands*
[b]*Department of Resource Surveys and Remote Sensing (DRSRS), P.O. Box 47146, Nairobi, Kenya*

ARTICLE INFO

*Article history:*
Received 28 February 2008
Received in revised form
21 November 2008
Accepted 5 December 2008
Available online 18 January 2009

*Keywords:*
Competition
Herbivory
Livestock
Pastoralism
Rainfall
Spatial distribution

ABSTRACT

Wild herbivore diversity and abundance have declined in African savannas for the past 20 years. Competition for forage resources between wild herbivore and livestock species might contribute to this decline, given habitat and diet overlap under conditions of resource limitation. Development of conservation and management strategies rely on understanding the spatial distribution of resources for livestock and wildlife, especially since the combination of transhumance pastoralism and wildlife conservation is common over Africa. We studied the distribution patterns of wild grazers in relation to cattle abundance, and distance to permanent and seasonal water bodies in semi-arid Kenya between 1983 and 2000. Cattle were abundant far from permanent water bodies during dry and wet years. Wild grazers less dependent on water also concentrated far from water during all years. Only wild grazer species more dependent on water remained concentrated close to water. Hence, wild grazers and cattle show spatial partitioning in the use of permanent and seasonal water bodies, but not in their forage resources. Our study provides no strong evidence of spatial displacement of wild grazers by cattle. We suggest that pastoralist decisions on cattle distribution do not need to negatively affect wildlife distribution and that coexistence can be possible through spatial partitioning. Our results show that pastoralist decisions play an important role in the interactions between livestock and wildlife in African savannas and that herd mobility is a key component in supporting sustainable use of resources for both wildlife and livestock.



## 1. Introduction

African savannas hold the earth's greatest diversity of wild large-herbivore species and have sustained these multi-species assemblages for millennia (du Toit and Cumming, 1999). However, a steady reduction in wild herbivore numbers and diversity has been observed for the past 20 years, attributed to a combination of factors, such as an increase in drought periods, land use change, poaching (Ottichilo et al., 2000a,b), and competition for forage resources between wildlife and livestock species (Prins, 1992; du Toit and Cumming, 1999; de Leeuw et al., 2001; Said, 2003). The potential competitive interactions between native wild herbivore species and introduced livestock species have large conservation implications since the combination of transhumance pastoralism and wildlife conservation is common across most African savannas (Prins, 1992, 2000; du Toit and Cumming, 1999). Global concerns on the competitive effects of livestock on

* *Corresponding author*. Tel.: +31 317 484041; fax: +31 317 484845.
E-mail addresses: judith.sitters@wur.nl (J. Sitters), ignas.heitkonig@wur.nl (I.M.A. Heitkönig), milena.holmgren@wur.nl (M. Holmgren), gojwang@yahoo.com (G.S.O. Ojwang').
[1] Present address: ETH Zürich, Institute for Integrative Biology, Universitätstrasse 16, CHN G 19, 8092 Zürich, Switzerland.
0006-3207/$ - see front matter 
doi:10.1016/j.biocon.2008.12.001

wildlife have increased in a variety of ecosystems (Prins, 1992; du Toit and Cumming, 1999; de Leeuw et al., 2001; Mishra et al., 2002; Said, 2003; Madhusudan, 2004; Steinfeld et al., 2007; Fankhauser et al., 2008; Yoshihara et al., 2008) and have led to diverse management actions, from creating more wildlife protected areas where livestock grazing is reduced (Mishra et al., 2002; Madhusudan, 2004) to community based management where local people are involved in, and benefit from, wildlife conservation (du Toit and Cumming, 1999; Yoshihara et al., 2008), or a combination of both (Georgiadis et al., 2007a).

The extraordinary diversity of wild herbivore assemblages in African savannas has been attributed to resource partitioning among herbivores in combination with high primary productivity and evolutionary history (Jarman and Sinclair, 1979; Murray and Illius, 1996; Prins and Olff, 1998; Olff et al., 2002). Body weight is a key species trait involved in resource partitioning and assumed to be the crucial factor determining inter-specific interactions (Prins and Olff, 1998). Many aspects of an animal's morphology, physiology and ecology vary allometrically with body weight (Western, 1979; Owen-Smith, 1988), from gut capacity and bite size, to food intake rate and feeding site selection (Owen-Smith and Cumming, 1993; Prins and Olff, 1998; Voeten and Prins, 1999). Body weight ratio is therefore used as an indicator of potential resource competition, expected to be strongest among herbivore species of similar body weight (Prins and Olff, 1998).

Introduced livestock species can overlap in resource use with wild herbivore species, because they have similar resource requirements to these wild herbivores, and they only share a relatively recent history of co-occurrence. This is thought to prevent resource partitioning with them (Fritz et al., 1996; Voeten and Prins, 1999; Prins, 2000). Competition for forage resources between two species is unavoidable if (1) their habitats overlap, (2) their diets overlap, and (3) their resources are limited (Wiens, 1989). There are some indications of both habitat (Lamprey, 1963; de Boer and Prins, 1990; de Bie, 1991) and diet overlap (Casebeer and Koss, 1970; Field, 1975; Hoppe et al., 1977; van Dyne et al., 1980; Voeten and Prins, 1999) between wild grazers and cattle. Wild grazers similar in body weight to cattle have a higher potential of resource competition with cattle, implying that these grazers are the ones most likely to be reduced in numbers and displaced by cattle (Prins and Olff, 1998; Mishra et al., 2002). Indeed, Voeten and Prins (1999) found that the resource use overlap between cattle and the comparably large zebra and wildebeest could result in resource competition under food-limited conditions. Although evidence for resource limitation has remained difficult to demonstrate in the field (Prins, 2000), extended dry seasons are known to negatively influence wild herbivore populations through reduced reproductive and survival rates, as during these dry periods low grass productivity probably limits the energy uptake of grazers (Sinclair, 1977; Prins, 1996; Ottichilo et al., 2000a). Hence, resource limitation is probably most acute during low rainfall periods (in accordance with Young et al., 2005 and Georgiadis et al., 2007b).

Savannas are social–ecological systems where pastoralists play an active role, especially in non-protected wildlife areas (Walker et al., 1981; Walker, 1993; Ludwig et al., 1997; Anderies et al., 2002; Georgiadis et al., 2007a). It is likely that pastoralist decisions on cattle distribution can influence the potential for resource competition with wildlife in these areas. Water availability during dry periods is an important factor structuring the livestock grazing system in arid (de Leeuw et al., 2001) and semi-arid savannas (Western, 1975; Bergström and Skarpe, 1999; Coppolillo, 2000). During periods of limited water availability, pastoralists tend to move their water-dependent cattle towards remaining water bodies (Western, 1975; Coppolillo, 2000; de Leeuw et al., 2001). Cattle concentration may cause local overgrazing, i.e., changes in plant structure and composition and habitat degradation around these water bodies (Andrew, 1988; Johnson, 1993; Pickup et al., 1998).

In this paper, we analyse the distribution of wild grazers in relation to cattle abundance and distance from water bodies during distinct periods of rainfall, between 1983 and 2000, in a Kenyan savanna, representative of semi-arid savanna ecosystems in East Africa (Pratt and Gwynne, 1977; Sombroek et al., 1982). We analyse the distribution in relation to both permanent (i.e., lakes and rivers) and seasonal water bodies with a more erratic availability, depending on local rainfall and topographic conditions (i.e., temporary streams, swamps and lakes), as well as proper maintenance (i.e.,, man-made pools and boreholes) (Dietz et al., 1986; de Leeuw et al., 1991). In this savanna ecosystem the transhumance Maasai pastoralists live mainly in temporary settlements, and move their cattle according to environmental conditions (Western, 1973). We hypothesize that the potential of competition for forage resources between cattle and wild grazers, and the displacement of wild grazers by cattle, is highest close to permanent water bodies during dry periods due to cattle concentration around these water bodies. More specifically, we predict that (1) during a resource limited period (i.e., low rainfall period) cattle are concentrated in areas close to permanent water bodies, and wild grazers in areas far from these water bodies as a result of, or to avoid, resource competition, (2) during a non-resource limited period cattle and wild grazers are more homogenously distributed across the landscape, (3) wild grazers that do occur close to permanent water bodies during a resource limited period tend to be more dissimilar in body weight to the cattle present there. However, we also expect seasonal water bodies – available during part of the dry period only – to play a role in the distribution of cattle and wild grazers. We hypothesize spatial partitioning in the use of seasonal water bodies between the two groups of herbivores, so wild grazers are able to fulfil their drinking water requirements and reduce the potential of competition for water resources. In order to test this expectation, we quantified the association between grazer species and type of seasonal water body.

## 2. Materials and methods

### 2.1. *Study area*

Kajiado district is a semi-arid district in Kenya located in the Rift Valley Province (between 1°0′–3°0′S and 36°5′–37°5′E) covering an area of 21,852 km$^2$ (Fig. 1). The general topography is characterized by vast plains with occasional volcanic hills