Agriculture, Ecosystems and Environment 257 (2018) 144–151

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

Short duration overnight cattle kraaling in natural rangelands: Implications for grass composition, quality, above ground biomass, species diversity and basal cover

Rangarirai Huruba[a,b,*], Tafadzwa Mlambo[a], Peter J. Mundy[a], Allan Sebata[a], Duncan N. MacFadyen[c]

[a] Department of Forest Resources & Wildlife Management, National University of Science & Technology, P.O. Box AC 939, Ascot, Bulawayo, Zimbabwe
[b] Debshan Ranch, P.O. Box 24, Shangani, Zimbabwe
[c] E Oppenheimer & Son (Pty) Limited, 6 St Andrew's Road, Parktown 2193, South Africa

ARTICLE INFO

Keywords:
Chronosequence
Diversity
Holistic management
Kraals
Nutrient hotspots
Savory

ABSTRACT

Short duration overnight cattle kraaling in natural rangelands is an innovative management practice aimed at improving grazing availability. We tested the ability of this practice to alter grass composition in favour of palatable species, increase aboveground grass biomass, species diversity and basal cover using a chronosequence consisting of sites kraaled 6, 12, 24 and 36 months prior to the study and compared them to the surrounding vegetation. We also determined grass quality in terms of fibre content, digestibility and nutrient content [nitrogen (N), phosphorus (P), calcium (Ca), potassium (K) and magnesium (Mg)] 12, 16 and 20 months after kraal use and in surrounding vegetation. Previously kraaled sites had higher proportions of palatable grass species, diversity, N, P, K and Mg than surrounding vegetation. Aboveground grass biomass and basal cover were lower in previously kraaled sites than surrounding vegetation, while grass fibre, digestibility and Ca content did not change with kraaling. These results demonstrate that establishing short duration overnight cattle kraals in natural rangelands improve grazing quality in terms of abundance of palatable grass species and grass nutrient content. However, improved grass quality attracted grazers such as warthogs (*Phacochoerus aethiopicus*), which reduced grass biomass and basal cover.

1. Introduction

In many regions of the world declining grass production in natural rangelands is a major concern to ranch managers (Frank et al., 1998; Peterson et al., 1998; Sandhage-Hofmann et al., 2015; Teague et al., 2011). Therefore innovative management practices are required to improve grass quality and biomass. One such practice is the short duration overnight cattle corralling (hereafter kraaling), which in Zimbabwe is a key component of the Savory holistic management and planned grazing system (Huruba et al., 2017; Savory and Butterfield, 1999; Sibanda et al., 2016). The planned grazing system is based on the principle that large migratory herds of wild grazers improve light availability to grass tillers through their trampling action and also enhance nutrient availability as a result of dung and urine deposition which improve nutrient redistribution (Savory and Butterfield, 1999). While in Zimbabwe the Savory holistic management and planned grazing system has been implemented together with short duration overnight kraaling in other parts of the world either of the practices are used separately. Setting up short duration overnight cattle kraals in natural rangelands aims at improving grass recruitment and growth, particularly in bare patches or alternatively to remove moribund material to stimulate new grass growth in areas with accumulated dead plant material (referred to as top hamper) which sheds the dormant buds (Sibanda et al., 2016). Savory and Parsons (1980) argued that the 'hoof action' of concentrated animals improved soil hydrologic properties through breaking up soil crusts and increasing water infiltration which enhances grass seedling emergence. Thus grass recruitment and growth is expected to improve following kraaling because plants will be able to capture sufficient resources (such as light, water, nutrients). Furthermore, with short duration overnight kraaling cattle will redistribute nutrients by grazing in the surrounding vegetation and excreting in the kraals (van der Waal et al., 2011). The short duration overnight kraaling system has been adapted from the traditional long term cattle corralling which was used as a way of protecting livestock against predation and theft (Blackmore et al., 1990; van der Waal et al., 2011). In addition to the accumulation of nutrients through dung and urine

* Corresponding author at: Department of Forest Resources & Wildlife Management, National University of Science & Technology, P.O. Box AC 939, Ascot, Bulawayo, Zimbabwe.
E-mail address: rangarirai.huruba@nust.ac.zw (R. Huruba).

https://doi.org/10.1016/j.agee.2018.02.004
Received 10 July 2017; Received in revised form 21 January 2018; Accepted 1 February 2018

deposition (Augustine, 2003; Blackmore et al., 1990), kraaling is expected to improve grass species composition through improved seed availability and emergence (Porensky and Veblen, 2015). For instance, moderate trampling action of cattle in kraals could improve grass seedling emergence (Winkel and Roundy, 1991).

The differences in periods of use implies that less dung will accumulate in the short duration kraals than in the traditional long term ones, influencing grass recruitment and growth differently (Reid and Ellis, 1995). For instance, with long term kraaling grass communities that develop after kraal use are largely dominated by one or two grasses species (Porensky et al., 2013; Veblen, 2012), while with short duration the grass community is more diverse consisting of as many as six species (Sibanda et al., 2016). Duration of kraal use could be as long as one year or more in the traditional long term system (Augustine, 2003; Blackmore et al., 1990; Muchiru et al., 2009) or as short as seven days in short duration kraaling (Huruba et al., 2017; Sibanda et al., 2016). Previously kraaled sites develop into nutrient hotspots which are attractive to grazing herbivores (Blackmore et al., 1990; Muchiru et al., 2009; Porensky and Veblen, 2015; Veblen, 2012), largely attributable to the high plant production potential and high quality forage (van der Waal et al., 2011). Therefore, kraaling within natural rangeland could result in the creation of a mosaic of heterogeneous grass patches rich in palatable grasses. The ability of short duration overnight cattle kraaling in natural rangelands to improve palatable grass species recruitment and growth and create nutrient rich patches has not been widely tested.

In areas where livestock, particularly cattle, are stocked at high densities and confined to fences overgrazing of the rangeland is common (Kaszta et al., 2017; Sandhage-Hofmann et al., 2015). Overgrazing results in the replacement of palatable grass species by unpalatable ones and a decline in the quality of grazing (Fynn, 2012; Whyte and Joubert, 1988). In order to reverse the decline in grass quality the proportion of palatable grass species in natural rangelands need to be increased (Pywell et al., 2002). Short duration overnight cattle kraaling could be used to increase the relative proportion of palatable grass species. With short duration overnight kraaling cattle harvest grass seeds and nutrients from different grazing patches during the day and deposit them in kraals overnight. After kraal use seed of different grass species that would have been deposited with dung establish, changing grass composition presumably in favour of palatable species (Sibanda et al., 2016). Understanding grass species composition changes as a result of kraaling will help inform management decisions relating to the improvements in grass quality.

During kraaling cattle destroy most plants through their trampling action, creating open patches suitable for grass seed germination (Cole, 1995; Huruba et al., 2017; McNaughton, 1976). Pywell et al. (2007) reported disturbance events that remove grass tufts as creating patches with low competitive conditions enabling rapid establishment of palatable grass species. The other benefit of trampling is that it breaks up soil crusts (Rutherford et al., 2012), enhancing grass germination success (Deines et al., 2007). Furthermore, trampling removes moribund material modifying microsite conditions allowing germination and establishment of different grass species (Huston, 1994). The short duration overnight cattle kraaling system aims to restore bare patches with crusted soils or improve grass growth in areas with moribund material. However, excessive trampling can be detrimental to grass growth as it can cause plant damage and result in soil compaction which reduces water infiltration rates (Abdel-Magid et al., 1987; Dunne et al., 2011; Warren et al., 1986). Plant community changes inside previously kraaled sites have also been attributed to nutrient and seed redistribution (Veblen, 2012). In addition during kraaling plant material is removed as a result of intense defoliation by the cattle facilitating grass establishment from seed (Western and Dunne, 1979). Although high dung deposition levels can kill plants as a result of the toxic effects of the high levels of nutrients (Porensky and Veblen, 2015) and the physical burial of the plants, in short duration kraaling (for example, seven days kraal use) dung accumulation may be insignificant to cause plant toxicity.

The amount of energy and nutrients that grazers acquire from consumed forage is determined by grass quality (Briske et al., 2008). Grass quality can be expressed in terms of fibre, nutrient content and digestibility. Good quality grass has low fibre, high nutrient content and digestibility. Nitrogen (N) and phosphorus (P) are important nutrient content proxies. For instance, N is a good index of grass crude protein content (Owen-Smith, 2005), while P content is a good indicator of plant growth (Snyman, 2002). Other studies have reported grasses in previously kraaled sites as less fibrous and richer in N and P than surrounding vegetation (Porensky and Veblen, 2015; Sibanda et al., 2016), making them nutrient rich hotspots similar to glades created as a result of traditional long term cattle kraaling (Anderson et al., 2010; Augustine and McNaughton, 2006; Blackmore et al., 1990; Coetsee et al., 2010; Muchiru et al., 2009; van der Waal et al., 2011).

Aboveground grass biomass, species diversity and basal cover are important indicators of grazing availability (Andrew, 1988). For instance, the amount of aboveground grass biomass in an area can be used to calculate its carrying capacity. Other studies found rangelands with higher grass species diversity to be more resistant to overgrazing than those with lower diversity (McNaughton, 1985; Zhu et al., 2012). Furthermore, diverse grass communities are likely to provide more palatable grass species (Callaway et al., 2005). Wang et al. (2011) found high grass diversity to reduce herbivore selectivity and promote more uniform use of different species. A good grass basal cover increases the resilience of rangelands to overgrazing by minimizing the impacts of soil erosion (Snyman, 1998). Therefore, it is important for ranch managers to employ management practices that increase aboveground grass biomass, species diversity and basal cover.

This study investigated the effect of setting up short duration (seven days) overnight cattle kraals in natural rangelands on grass species composition, quality, biomass, diversity and basal cover. We used a chronosequence spanning a range of times (6–36 months) since the last kraaling and compared these sites with the surrounding vegetation. We hypothesised that short duration overnight cattle kraaling: 1) alters grass composition of natural rangelands in favour of palatable species, 2) improve grass quality in terms of fibre (neutral and acid detergent fibre), nutrient content [N, P, calcium (Ca), potassium (K) and magnesium (Mg)] and digestibility and, 3) increases aboveground grass biomass, species diversity and basal cover.

2. Materials and methods

2.1. Study site

Debshan ranch is located in an open savanna in central Zimbabwe (29°13′E, 19°36′S; 1230 m elevation) and covers 800 km^2 (Fig. 1) (Huruba et al., 2017). The mean annual rainfall is 612 mm, and falls between October and April (Dunham et al., 2003). Mean annual temperature is 22.6 °C, with October (31.4 °C) the hottest month and July the coldest (8.5 °C). Debshan ranch is managed for both livestock production and wildlife conservation. Some of the common wild herbivores are plains zebra (*Equus burchelli*), hare (*Lepus capensis*), warthog (*Phacochoerus africanus*), common duiker (*Sylvicapra grimmia*), northern giraffe (*Giraffa camelopardalis*), bushpig (*Potamochoerus larvatus*), common eland (*Taurotragus oryx*), African elephant (*Loxodonta africana*), bohor reedbuck (*Redunca redunca*), sable antelope (*Hippotragus niger*), steenbuck (*Raphicerus campestris*), tsessebe (*Damaliscus lunatus*) and waterbuck (*Kobus ellipsiprymnus*). A 450 km^2 section of the ranch is dedicated to holistic grazing management which incorporates short duration overnight cattle kraaling, with 4500 cattle divided into 11 herds.

The landscape is gently undulating and covered in yellowish brown, medium- to coarse-grained loamy sands derived from granite and relatively infertile (Frost, 1999). On flatter ground, sandy clay loams derived from quartzite or epidosite are moderately fertile, fine-textured