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Herd Size-Dependent Effects of Restricted Foraging Time Allowance on Cattle Behavior, Nutrition, and Performance☆,☆☆

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ABSTRACT

We tested the influence of herd size on the effects of restricted foraging time on cattle *(Bos indicus)* foraging behavior, nutrition, and performance in a Kenyan savanna rangeland. Using a randomized block design, we compared weight gain, forage intake, diet selection, dietary crude protein (CP) and digestible organic matter (DOM), bite and step rates, distance travelled, and activity time budgets between steers allowed unlimited foraging time (DNG) in predator-free areas with those herded diurnally in predator-accessible areas in large (200 steers; LDG), medium (150 steers; MDG), or small (100 steers; SDG) herds and corralled at night. Daily weight gain was greater ($P < 0.01$) in DNG (0.61 kg) or SDG (0.56 kg) than in LDG (0.19 kg) or MDG (0.29 kg) but did not differ ($P = 0.591$) between DNG and SDG. Likewise, daily organic matter intake was greater ($P < 0.05$) in DNG (6.2 kg) or SDG (5.4 kg) than in LDG (3.7 kg) or MDG (3.7 kg) but did not differ ($P = 0.288$) between DNG and SDG. Grazing time was lower ($P < 0.01$) in DNG (42.2%) than in LDG (71.3%), MDG (72.2%), or SDG (69.5%), while the reverse was the case for ruminating and/or resting time (47.1%, 12.1%, 11.9%, and 10.3% in DNG, LDG, MDG, and SDG, respectively). Bite rate was lower in DNG (13.1 bites · min^{-1}) than LDG (21.0 bites · min^{-1}; $P = 0.068$), MDG (27.7 bites · min^{-1}; $P = 0.13$) or SDG (26.2 bites · min^{-1}; $P = 0.007$). However, diet selection, CP, DOM, step rate, and distance travelled did not differ among treatments. Our findings demonstrate subdued negative effects of restricted foraging time when cattle are herded diurnally in small-sized herds. Application of this strategy could reduce the need for eliminating wild carnivores to facilitate unrestricted foraging time for cattle.

Introduction

Night corralling is a common animal husbandry practice in tropical rangelands worldwide. In African savanna rangelands, this practice serves various purposes, including protection of livestock from predators or theft, and collection of manure in integrated crop-livestock systems. In addition, corralling has been suggested to be a key driver of heterogeneity across pastoral savanna landscapes through accumulation of nutrients and subsequent emergence of lush, nutritious, and palatable forage at abandoned corralling sites (Young, 1995; Augustine, 2004; Veblen, 2012; Donihue et al., 2013). Notably, on the basis of this latter function, the use of temporary livestock corrals in restoring degraded land and improving wildlife habitats is fast gaining prominence in African rangelands, especially in parts of eastern Africa.

Although corralling can be advantageous in many ways, its downside is that it effectively limits the amount of time animals can access forage resources, thereby potentially suppressing livestock productivity. Indeed, several studies have shown that allowing livestock unlimited foraging time enhances weight gain through increased forage intake (Joblin, 1960; Khombe et al., 1992; Ayantunde et al., 2000a, 2000b; Ayantunde et al., 2002). Therefore conflict often arises between the need for corralling for protection from predators and/or manure collection and the need for livestock to have unrestricted grazing time allowance for improved production performance. This conflict is often heightened in rangelands where manure is needed for crop production or where livestock predation risk is high.

In east African savanna rangelands where livestock and wildlife often share land, the conflict between the need for corralling and unrestricted foraging is primarily driven by relatively high risk of predation of nocturnally foraging livestock. This is because the benefit of enhanced livestock performance associated with additional foraging at night can be negated by increased predation losses (Wigg and Owen, 1973). Therefore many livestock owners seeking to improve livestock productivity and profitability through unrestricted 24-h grazing time consider elimination of wild carnivores as a key prerequisite (King, 1983; Bayer, 1986; Lamarque et al., 2009). Although some ranchers adopt a more wildlife-friendly approach by creating predator-free zones for nighttime

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livestock grazing, leaving the rest of their properties accessible to wildlife, others are less accommodating and entirely exclude predators and other wildlife. This latter approach is not consistent with biodiversity conservation and maintaining multiple value principles of sustainable rangeland management. Consequently, there is a need to explore grazing management techniques that enhance livestock performance without compromising the conservation of predators and other wildlife. One such strategy could involve manipulating the livestock stocking rate to minimize intraspecific competition among diurnally foraging livestock and lessen the need for extended grazing during nighttime. However, such an intervention requires a thorough understanding of the effects of a restricted foraging time allowance on livestock nutrition and performance and whether such effects are modulated by stocking rate.

While the impacts of restricted foraging time on livestock behavior, nutrition, and productivity have been extensively investigated (Joblin, 1960; Smith, 1961; Wigg and Owen, 1973; King, 1983; Nicholson, 1987; Fernandez-Rivera et al., 1996; Ayantunde et al., 2000a, 2000b; Ayantunde et al., 2002), little is known about the role of herd size in moderating such impacts. In this study, we investigated the effects of restricted foraging through nighttime corralling on cattle nutrition and production performance and whether such effects depend on herd size. Working in a semiarid savanna rangeland in central Kenya, we compared foraging behavior, nutrition, and performance between cattle herds allowed unlimited access to forage in predator-free areas with those herded diurnally in small-sized (100 steers·herd^{-1}), medium-sized (150 steers·herd^{-1}), and large-sized (200 steers·herd^{-1}) herds that were corralled at night in predator-accessible areas. We controlled the overall stocking rate while maintaining the different herd sizes, and thus the different herd sizes represent different stocking rates (low, moderate, and high, respectively) in the landscape. We hypothesized that because intraspecific competition should become less intense with decreasing herd size, food intake and performance of cattle with limited foraging time would be greatest in small-sized herds and lowest in large-sized herds. We further predicted that the negative effects of restricted foraging time allowance would be less pronounced in small than in large herds.

Materials and Methods

Study Area

The study was conducted at Ol Pejeta Conservancy (OPC; lat 00°00′15″N, long 36°57′49″E) in Laikipia County, Kenya. The conservancy covers an area of 370 km^2 within the Laikipia plateau, which is bounded by Mt. Kenya to the east and the Aberdare Range to the west. Rainfall averages approximately 700 mm annually and is generally bimodally distributed, with peaks from March to May (long rains) and October to December (short rains). The mean annual maximum and minimum temperatures are 28°C and 12°C, respectively.

Black cotton soil is the dominant soil type. Four distinct vegetation types are discernible: a mosaic of grassland, *Acacia drepanolobium* Sjøstedt (whistling thorn) mixed woodland, *Euclea divinorum* Hiern (magic guarri) bushes, and riverine woodland dominated by *Acacia xanthophloea* Benth. (yellow fever tree). Several other plant species such as *Carissa edulis* (Forssk.) Vahl (Egyptian carissa), *Psiadia punctulata* (DC.) Vatke, and *Scutia myrtina* (Burm. f.) Kurz (cat-thorn) comprise the woody vegetation layer. The herbaceous layer is dominated by the perennial grasses, *Themenda triandra* Forsk. (red oat grass), *Cynodon* spp. Rich., *Pennisetum stramineum* Peter (Masai grass), and *Pennisetum mezianum* Leeke (bamboo grass).

Ol Pejeta Conservancy hosts approximately 68 species of mammals and carries one of the highest wildlife densities in Kenya. The major wild mammalian herbivores include plains zebra *(Equus burchelli)*, African buffalo *(Syncerus caffer)*, hartebeest *(Alcelaphus buselaphus)*, eland *(Tragelaphus oryx)*, oryx *(Oryx gazella beisa)*, waterbuck *(Kobus ellipsiprymnus)*, impala *(Aepyceros melampus)*, Thompson's gazelle *(Gazella thompsonii)*, Grant's gazelle *(Gazella granti)*, African elephant *(Loxodonta africana)*, and giraffe *(Giraffa camelopardalis)*. Notably, OPC also hosts some of the most endangered animals in the world, including black rhino *(Diceros bicornis)*, white rhino, and Grevy's zebra *(Equus grevyi)*. Several species of large carnivores are also present, including African lion *(Panthera leo)*, spotted hyena *(Crocuta crocuta)*, cheetah *(Acinonyx jubatus)*, leopard *(Panthera pardus)*, and African wild dog *(Lycaon pictus)*.

Cattle *(Bos indicus)* are the primary livestock species. The conservancy currently hosts the largest herd of pure Boran cattle in the world (5 500 head). Two other indigenous cattle breeds have also been introduced into the conservancy viz. "Ankole" from Uganda (100 head) and the Jiddu Boran from Somalia (40 head). In addition, there are 750 head of cattle of mixed local breeds purchased from pastoral communities in Kenya's northern rangelands. In addition to cattle, 300 sheep of the Dorper breed are reared in OPC.

Experimental Design and Animals

We took advantage of the fact that OPC cattle are managed under two different grazing regimens. The first regimen involves daytime herding of cattle in groups of varying sizes during daytime followed by nighttime corralling. Cattle herding is practiced in the conservation area (30 351 ha), which is also accessible to other livestock species (primarily sheep) and all guilds of wild mammals. Under the second grazing regimen, cattle are allowed to forage freely in predator-free areas throughout day and night (24 h) without herding or corralling. At the time of our study, there were three predator-free areas (total area = 4 047 ha)—Sirima (2 833 ha), Loidien (809 ha), and Maili Saba (405 ha)—all created in 2005–2006 using predator-proof barriers. These areas also contain several wild herbivores that were enclosed during predator-proof fencing. However, megaherbivores (elephants, giraffes, and rhinos) are excluded from these areas. To determine whether this exclusion affected woody vegetation cover, we used Google Earth to estimate tree/shrub canopy intercept survey along forty-eight 1-km transects randomly distributed equally across the conservation and predator-free areas and found no significant difference ($P = 0.695$, $F = 0.2$, $n = 48$) between these areas (data not shown). As such, the absence of megaherbivores in the predator-free areas was unlikely to influence our results. On the basis of the tropical livestock unit (TLU; 1 TLU = 290 kg live weight), the combined stocking rate of livestock and wild grazers and intermediate feeders is approximately equal between the conservation area (2.7 ha · TLU^{-1}) and predator-free areas (2.8 ha · TLU^{-1}).

Taking advantage of the existing setup at OPC comprising distinct management areas and grazing regimens, we created a randomized block design with four grazing treatments replicated across three time blocks. The blocks were the sampling periods starting from 21 February to 15 April 2010, 26 October to 30 November 2010 and 31 January to 9 March 2011 (Table 1). Weather conditions varied among these periods,

Table 1
Location of treatment herds in Ol Pejeta Conservancy at different sampling periods (experimental blocks) during the experiment.

Treatments	Time periods (experimental blocks)		
	21 February to 15 April 2010	26 October to 30 November 2010	31 January to 9 March 2011
[1]DNG	Loidien	Sirima	Maili Saba
[2]LDG	Sedai	Loirugrug	Morani
[3]MDG	Gatune	Ngerenyi	Kambi Punda
[4]SDG	Gatune	Kona Mbaya	Kambi Punda

[1] Day and night grazing.
[2] Day grazing, large-sized herd.
[3] Daytime grazing, medium-sized herd.
[4] Daytime grazing, small-sized herd.

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