Elephants mitigate the effects of cattle on wildlife and other ecosystem traits: experimental evidence

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Summary: The Kenya Long-term Exclosure Experiment (KLEE) has demonstrated that cattle reduce of grass cover, wildlife use, and soil nitrogen and phosphorus pools, and increase primary productivity and termite abundance. We demonstrate that the presence of mega-herbivores (elephants, mainly) reduces many of these these cattle effects. We provide evidence that this may be because the elephants reduce the most desirable (N-rich) forage, causing cattle to slow their extraction of (low-N) grasses, while simultaneously reducing tree cover.

Introduction

There have been many studies of wildlife ecology in Africa's arid-and semi-arid lands, and considerable experimental research of the effects of cattle on savanna ecosystems. However, most of this research has occurred in protected wildlife areas or livestock research stations, respectively. Although wildlife and livestock share much of their grassland ecosystems, have been virtual no experimental studies of livestock and wildlife in the vast rangelands that they share.

One the one hand, there is considerable evidence that livestock production has long been compatible with the maintenance of considerable biodiversity (Reid 2012), and sometimes continues to be (Ranglack and du Toit 2016, Kiffner et al. 2020, Tyrell et al. 2020). However, this does not mean that the relationship between livestock and biodiversity is without conflict (Reid 2012). At the very least, resources consumed by livestock and not available to wildlife (Young et al. 2018). Teasing apart these complex relationships ideally involves controlled replicated manipulations of both livestock and wildlife. The Laikipia ecosystem in Kenya is an ideal site for such research, encompassing a full range of land-use properties, with differing levels of livestock and wildlife.

Study Site and Methods

It was to fill these gaps in our understanding of the ecological relationships between livestock and biodiversity that we established the Kenya Long-term Exclosure Experiment (KLEE). The study site is a wooded savanna rangeland on black cotton soils located at 1800mm asl (0º 17' N, 36º 52' E) on Mpala Research Centre in Laikipia, Kenya (Young et al. 1997). Mpala Ranch and Conservancy maintain moderate levels of livestock production as well as a nearly full complement of native wildlife (less black rhinos). Since 1995, we have been excluding from 4 ha plots six different combinations of a) livestock (cattle; C), b) meso-wildlife (W), and c) mega-herbivores (elephants and giraffes; M).m The six treatments (O, C, W, WC, MW, MWC) were in arranged in three replicate blocks. See Figure 1.

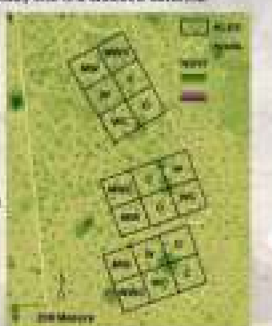

Figure 1

In each of the 18 experimental plots, we regularly carry out a) semi-annual estimates of herbaceous vegetation cover by species using pin frames, b) semi-annual dung counts of all larger mammal species, c) occasional counts of all trees >1m tall, and d) occasional assessments of soil nutrients and net primary productivity (NPP). For detail methods, see [Young et al. 1997, Young et al. 2018, Kimuyu et al. 2017, Charles et al. 2017, Sitters et al. 2020].

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1. Elephants reduce cattle foraging efficiency

It appears that cattle reduce their foraging efficiency in plots to which elephants have access (Figure 2). In these plots, cattle take more steps per minute, and fewer bites per minute, in plots from which megaherbivores have been excluded (Odadi et al. 2009). We suggest that this is because elephants are eating key forb species needed by cattle, but not by zebras (Odadi et al. 2013; Figure 3). Giraffes, the other megaherbivore excluded in these plots, do not feed on the herbaceous layer below 0.5m (Young and Isbell 1991), therefore these megaherbivore effects are presumably due entirely to elephants. The reduction in cattle use in plots accessible to elephants appears to have many cascading effects, demonstrated experimentally in KLEE.

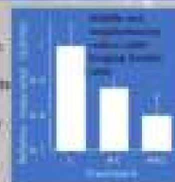

Figure 2

Figure 3

2. Elephants mitigate the competition between cattle and zebras

2a. Elephants mitigate reduction of grass (plant) biomass by cattle

In the absence of elephants, cattle reduced grass cover by 24-28%. Surprisingly however, in the plots to which elephants also have access, cattle reduced grass cover by only 14% (Young et al. 2005, Veblen et al. 2017; Figure 4). This is likely due to the reduction in cattle foraging with the presence of elephants (see above).

2b. Elephants mitigate reduction in zebra habitat use by cattle

In the absence of elephants, cattle reduce plot use by zebras by 72%, consistent with their large dietary overlap and their reduction in grass cover (Figure 4). Again however, in the plots to which elephants also have access, cattle reduced the presence of zebras by only 28% (Young et al. 2005). This is partly because elephant themselves compete with zebras (for grass), but also because elephants forage in a way that reduces cattle foraging (Odadi et al. 2009), leaving more behind for the zebras (see above).

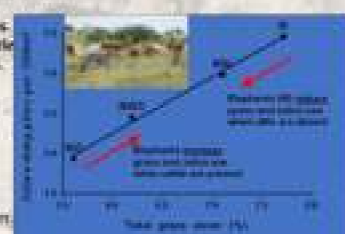

Figure 4

2c. Elephants mitigate reduction in other wildlife habitat use by cattle

This mitigation is part of a broader pattern in which cattle reductions in habitat use are by (especially grazing) wildlife (50% reductions) are less in the presence of elephants (Figure 5). Surprisingly, cattle reduced habitat use by browsers at least as much as by grazers (Kimuyu et al. 2017).

Figure 5

3. Elephants mitigate the soil nutrient depletion by cattle

Cattle also reduce soil Nitrogen and Phosphorus, likely through daily export to overnight bomas. But once again, the presence of elephants reverse this effect of cattle (Sitters et al. 2020; Figure 6). Here, the cause again may be suppression of cattle foraging, but may also include input of woody litter from elephants feeding on nitrogen-fixing *Acacia drepanolobium* trees (see also Landman et al 2019).

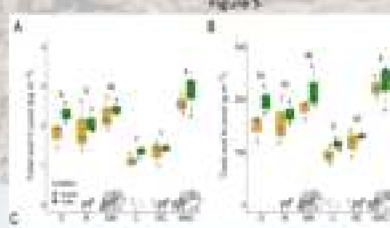

Figure 6

4. Elephants mitigate the stimulation of primary productivity by cattle

In grasslands, an absence of herbivores can result in self-shading among grasses, leading to "rank" vegetation that have reduce productivity (NPP). It has been suggested in several African ecosystems that moderate herbivory actually increases rangeland productivity by removing these dead shading leaves, even if sufficiently high grazing levels can reduce NPP. Data from KLEE confirm greater NPP in plots with cattle at moderate densities, measured independently with both moveable cages and satellite NDVI (Charles et al. 2017). However, this increase is reduced in the presence of megaherbivores (Charles et al. 2017; Figure 7). While this could be due the to suppression of cattle foraging by elephants mentioned above, it may also be a result to the reductions in NPP that occur at sufficiently high grazing intensity.

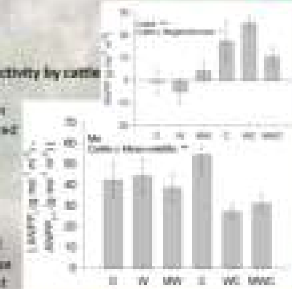

Figure 7

5. Elephants mitigate the bush encroachment (and termite abundance) caused by cattle

When cattle grazing is intense, it can be associated with increases in woody cover in semi-arid Africa ("bush encroachment"), perhaps because of reduction in the abundance of competing grasses (refs). In KLEE, we have some evidence of greater woody cover in plots with cattle even at moderate densities (Wilkerson et al. 2013), and in heavy grazing subplots (T. Young, unpublished data). Conversely, there is considerable evidence that elephants can reduce woody cover, and convert woodlands to grasslands (Guldemond & Aarde 2008). Similarly, the KLEE plots to which elephants have had access for the past 25 years have 18% fewer trees that plots from which they had been excluded (Charles et al. 2021). We have separately demonstrated with both natural variation and experimental tree thinning that there a complex implications for vegetation and other wildlife of reductions in tree density (Riginos and Grace 2008, Riginos 2015). This includes the pattern that greater densities of termite mounds were associated with cattle presence and greater tree density. Again, these appear to be reversed by megaherbivores (Charles et al. 2021; Figure 8).

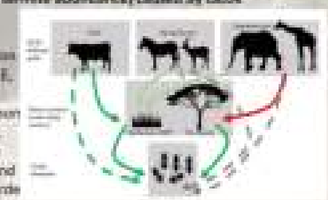

Figure 8

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