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Truman P. Young
University of California, Davis

Duncan N. Kimuyu
Karatina University, Kenya

Kari E. Veblen
Utah State University

Corinna Riginos
The Nature Conservancy

Judith Sitters
Vrije Universiteit Brussel, Belgium

See next page for additional authors

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The XXIV International Grassland Congress / XI International Rangeland Congress (Sustainable Use of Grassland and Rangeland Resources for Improved Livelihoods) takes place virtually from October 25 through October 29, 2021.

Proceedings edited by the National Organizing Committee of 2021 IGC/IRC Congress

Published by the Kenya Agricultural and Livestock Research Organization

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Presenter Information

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

Truman P. Young^{1,2}, Duncan N. Kimuyu^{3,2}, Kari E. Veblen⁴, Corinna Riginos⁵,
Judith Sitters⁶, Lauren Porensky⁷, Wilfred O. Odadi^{8,2}

¹Department of Plant Sciences, University of California, Davis, CA, USA

²Mpala Research Centre, P.O. Box 555, Nanyuki, Kenya

³Department of Natural Resource Management, Karatina University, Karatina, Kenya

⁴Department of Wildland Resources and Ecology, Utah State University, Logan, UT

⁵The Nature Conservancy, Lander, Wyoming, USA

⁶Ecology and Biodiversity, Department of Biology, Vrije Universiteit Brussel, Belgium

⁷USDA-ARS Rangeland Resources Research Unit, Fort Collins, CO 80526, USA

⁸Department of Natural Resource Management, Egerton University, Egerton, Kenya

Key words: competition; co-existence; livestock

Abstract

On rangelands worldwide, cattle interact with many ecosystem components, most obviously with soils, plants, and other large herbivores. Since 1995, we have been manipulating the presence of cattle, mesoherbivores, and mega-herbivores (elephants and giraffes) in a series of eighteen 4-ha (10-acre) plots at the Kenya Long-term Exclosure Experiment. We have demonstrated a wide array of cattle effects on this savanna rangeland, including their reduction of grass cover, wildlife use, and soil nitrogen and phosphorus pools, but their increase of primary productivity and termite abundance. Strikingly, we demonstrate that the presence of mega-herbivores (elephants, mainly) reduces the sizes of these cattle. We provide further experimental evidence that this may be because the elephants are reducing 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, there have been virtually no experimental studies of livestock and wildlife in the vast rangelands that they share.

On 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 presence.

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 (0° 17' N, 36° 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). The six treatments (O, C, W, WC, MW, MWC) were arranged in three replicate blocks.

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)

Results and Discussion

This experiment has yielded many fascinating patterns concerning the relationship between livestock and wildlife. The overall tenor of these studies is that cattle have pervasive ecosystem impacts, but that the presence of mega-herbivores (elephant, mainly) mitigate many of these effects. We present here a summary of this research, carried out by KLEE researchers.

1. Elephants reduce cattle foraging efficiency

It appears that cattle reduce their foraging efficiency in plots to which elephants have access. 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 eaten by zebras (Odadi et al. 2013). 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.

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 24-26%. 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). 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 (see above). 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 elephants 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).

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 by wildlife (50% reductions) are less in the presence of elephants. Surprisingly, cattle reduced habitat use by

browsers at least as much as by grazers (Kimuyu et al. 2017), and this suppression is also reduced by the presence of elephants

3. Elephants mitigate the soil nutrient depletion by cattle

Cattle also reduce soil N and P, likely through daily export to overnight bomas. But once again, the presence of elephant reverses this effect of cattle (Sitters et al. 2020). Here, the cause again may be suppression of cattle foraging, but may also include input of woody litter from elephants feeding on *Acacia* trees (see also Landman et al 2019).

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 has reduced 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). While this could be due to the 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.

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 (Guldmond and Aarde 2008). Similarly, the KLEE plots to which elephants have had access for the past 25 years have 18% fewer trees than 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 are 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).

Conclusions

It is encouraging that megaherbivores (mainly elephants, here) reduce the mainly negative effects of cattle in this savanna rangeland. However, it appears that a prime reason that this mitigation occurs is that elephants reduce the foraging of cattle, effectively reducing their ecosystem impacts, but also presumably reducing their own productivity, at a potential cost to livestock operators.

Acknowledgements

This research was carried out under Government of Kenya research clearance permit No. NCST/RCD/12B/012/42. We would like to thank Frederick Erii, John Lochikuya, Mathew Namoni, Jackson Ekadeli, and Stephen Ekale for their invaluable assistance in the field. We also thank the Mpala Research Centre and its staff for their logistical support. The KLEE enclosure plots were built and maintained by grants from the James Smithson Fund of the Smithsonian Institution (to A.P. Smith), The National Geographic Society (Grants 4691-91, 9106-12, and

9986-16), The National Science Foundation (LTREB DEB 97-07477, 03-16402, 08-16453, 12-56004, 12-56034, and 19-31224), to T.P. Young, C. Riginos, and K.E. Veblen.

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