Decomposition rates of organic material across herbivore treatments in a nutrient-rich semi-arid sodic savanna

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Introduction

Savannas occupy roughly 20% of the Earth’s terrestrial surface and represent the most widespread ecosystem within tropical and subtropical regions. Covering approximately 40% of the African continent, savannas are the largest biome in South Africa, encompassing more than a third of the country’s land area. Herbivory is an agent of disturbance and functions as one of the primary drivers of system dynamics in African savannas.

Current situation:

Large parts of protected African savannas are faced with numerous challenges, including heavy utilisation pressures from single-species domestic livestock at the expense of heterogeneous savanna herbivore communities (Erasmus et al. 2021). Despite extensive use of exclosure experiments to investigate herbivore impacts, there is little consensus on their direct and indirect effects on soil function, particularly on decomposition and nutrient availability, above- and belowground carbon sequestration.

Aim:

This study aimed to assess the intrinsic role of herbivores in soil-based decomposition and stabilisation in a herbivore-adapted semi-arid, stonitic African savanna through application of an extended, site-specific version of the Tea Bag Index (TBI) approach across three herbivore treatments with varying intensity.

Figure 1: Location of the Nkuhlu experimental site situated on the northern bank of the perennial Sabie River in the southern Kruger National Park, South Africa. (a) Aerial view of the *Nkuhlu experimental site*, indicating the location of experimental plots within the nutrient-rich sodic zone. (b) Map of the Nkuhlu exclosure and exclosures, Kruger National Park (b) South Africa.

Experimental design

Aim:

Studies on the intrinsic role of herbivores in soil-based decomposition and stabilisation in a herbivore-adapted semi-arid, stonitic African savanna through application of an extended, site-specific version of the Tea Bag Index (TBI) approach across three herbivore treatments with varying intensity.

Figure 2: Experimental layout and positioning of 25 plots across 3 herbivore treatments [1) Elephant exclosure, (2) Control, (3) LMH exclosure] with the sodic zone of the Nkuhlu exclosure.

Experimental plots

- Control
- Elephant exclusion
- LMH exclosure
- Sodic zone

Sampling

Figure 3: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Sampling method:

- Plot layout: 25 plots across 3 herbivore treatments with varying intensity.
- Sampling points: 10 tea bags were buried in a pair-wise design (green tea + rooibos tea).

Results

Figure 4: Experimental plot layout consisting of 10 tea bags buried in a pair-wise design (green tea + rooibos tea).

Discussion

Figure 5: Mean decomposition rates (k) and stabilisation factor (S) of undecomposed litter after a 3-month incubation period across 3 herbivore treatments within the Nkuhlu exclosure, Kruger National Park. Significant differences (p < 0.05) between herbivore treatments are indicated with different lowercase letters.

- Higher decomposition rates (k) in the presence of all LMH (Control) can be ascribed to LMH actively altering savanna structure, specifically to enhance decomposition factors.
- High intensity utilisation of savanna vegetation result in:
  - Lower levels of recalcitrant compounds in plant tissue
  - Lower soil temperatures
  - Decreased shading
- Lower microbial activity and associated decomposition

Conclusion

Figure 6: Mean decomposition rates (k) and stabilisation factor (S) of undecomposed litter after a 3-month incubation period across 3 herbivore treatments within the Nkuhlu exclosure, Kruger National Park. Significant differences (p < 0.05) between herbivore treatments are indicated with different lowercase letters.

- High level of decomposition led to higher levels of aboveground biomass resulting in:
  - Higher nutrient availability stimulate microbial activity and associated biogeochemical processes.
- Potential rate resulting in:
  - Lower levels of soil organic matter (SOM)
  - Increased microbial demand for organic C
  - Absence of herbivores lead to higher levels of aboveground biomass resulting in:
  - Higher decomposition
  - Lower soil temperatures

- LMH influence patch-specific soil nutrient availability through:
  - Higher intensity utilisation of savanna vegetation result in:
  - Lower levels of recalcitrant compounds in plant tissue
  - Lower microbial activity and associated decomposition

Take-away message

TBI-based decomposition studies provide a relatively easy way to obtain valuable information regarding system disturbances and their potential effect on ecosystem functioning. Studies aimed at understanding decomposition in habitats and the role of various influencing factors such as herbivory is essential to better understand and effectively manage soil function together with associated carbon cycling.

Figure 7: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 8: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 9: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 10: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 11: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 12: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 13: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 14: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 15: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.

Figure 16: Distribution of sampling points for the Tea Bag Index (TBI) approach within the experimental plots.