Back to the roots - do traditional Maasai management strategies work towards resilience against unpredictable rainfall and grazing pressure in northern Tanzania?

Baumgartner, S.A.*; Treydte, A.C.†

* University of Hohenheim, Institute of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute)

† School of Life Sciences and Bioengineering, Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania

Key words: [rangeland management, rainfall variability, harvest rate, regrowth rate]

Abstract

Despite the importance for people´s livelihoods, many semi-arid African savannas are prone to heavy degradation due to overutilization by people, livestock and increased climate variability. Rangeland management, such as transhumance and deferred grazing systems, practiced by the Maasai in northern Tanzania, can be useful in combating the negative consequences of overuse and increasing rainfall variability. But little is known on how different rangeland regimes, practiced by the Maasai, impacts the productivity of these rangelands.

We collected data on regrowth rates under different rangeland management regimes (rainy season grazing land, dry season grazing land, and seasonal exclosures), different harvest rates (month, season) and additional, uncontrolled grazing (fenced, open plots). We conducted the experiment for two consecutive growing seasons 2019 (GS1) and 2019/2020 (GS2).

Grass regrowth rates were similar for all rangeland management regimes. During dry conditions in GS1 seasonally cut plots showed significantly higher grass regrowth compared to monthly cut plots, when fenced. Outside the fence grass regrowth was generally lower and similar for both harvest rates. During high rainfall conditions in GS2, seasonally cut plots showed higher grass regrowth independent of fencing. Regrowth rates of forbs were not impacted by any treatment during GS1. It increased by 5 times during GS2, and was significantly higher in the seasonally cut plots then.

Our results suggest that recovery phases between heavy grazing events is crucial to maintain forage provision of the rangelands. Uncontrolled additional grazing can hamper the rangeland productivity during times of low rainfall, but seem not to have influence when rainfall is frequent. Traditional rangeland management is based on the concept of granting seasonal recovery periods, which seems to be an effective way to maintain rangeland productivity despite intense harvest and unpredictable rainfall pattern. Implementation and control of grazing plans are crucial, particularly during times of drought.

Introduction

Despite the importance of ecosystem services (ESS) for people´s livelihoods, around 60% of the assessed ESS are at risk due to degradation or unsustainable use (Millennium Ecosystem Assessment 2005). Particularly semi-arid and arid regions such as African savannas are prone to heavy degradation due to overutilization by people and livestock and increased climate variability (IPCC 2014; Castellano und Valone 2007) Rangeland management can affect the long-term sustainability of rangeland-ecosystem use in arid and semi-arid regions (Bremer et al. 2001; Weber und Horst 2011; Verdoodt et al. 2010). Transhumance, traditionally practiced by the Maasai ethnic group in eastern Africa, has been an efficient grazing management system for decades to cope with unfavorable climatic events and high rainfall variability (O'Farrell et al. 2009). It allows the herders to adapt the location of grazing sites according to the season, environmental and rangeland conditions as well as to the type of livestock (Oba und Kaitira 2006). Moreover, the pastoralists in many regions of eastern Africa practice a deferred grazing system, which sets aside parts of the grazing land as calf-pasture and forage reserve during dry season. These exclosures contribute to the conservation of biodiversity and provide high plant biomass (Selemani et al. 2013). However, extensive logging during the 1940s and land use policies of the last few decades set incentives for pastoralists to settle down and to extend their cropping land. The establishment of large conservation areas resulted in land fragmentation and further increased the pressure on the remaining grazing land, with livestock densities of up to 3.8 TLU/ha (Oba und Kaitira 2006). Increasing fragmentation of the landscape and changing precipitation patterns are likely to further impact the sustainability of the Maasai pastoralism (Goldman und Riosmena 2013). Despite these challenges, little research has been done on the impact of different management regimes, practiced by the Maasai, on the rangeland vegetation under high grazing pressure and increasing rainfall variability.

The objective of our study was to evaluate the impact of high grazing pressure on the rangeland productivity under varying rainfall patterns. We experimentally tested how the provision of forage is changed by different ways of rangeland management and how different rates of forage removal impact the vegetation. We expected a positive impact of seasonal livestock exclusion on vegetation parameter and higher regrowth rates when the recovery time between harvest events increased.

Methods and Study Site

The study sites were located in the Maasai Steppe, Simanjiro district, Tanzania, which is characterized by a semi-arid savanna landscapes receiving bi-modal rainfall two of around 600 mm per annum (Miller 2015). In our study region, different rangeland management regimes are practiced: rainy season grazing land (RSGL), which is used for grazing during the rainy season, dry season grazing land (DSGL), which is used for grazing during the dry season and seasonal exclosures that are reserved for young and weak livestock to graze during dry season, among the Maasai known as Alalili (Mwilawa et al. 2008). Two Alalili, were selected together with two control sites in the surrounding RSGL and DSGL, respectively. The study sites were exposed to similar environmental conditions.

At each site, two blocks were established that comprised the following treatments: two fenced 1 x 1 m plots ('fenced') that were cut every month ('month') and after one growing season ('season'), respectively; two 1 x 1 m plots outside the fence ('open') that were cut every month and after one growing season, respectively. Grass and forbs were cut down to 2.5 cm above the ground at the beginning of each growing season. After every month and once after one growing season, depending on the treatment, the vegetation was cut again and dry matter of the regrown vegetation was measured and added up for the whole growing season. The cutting experiment was repeated for two consecutive growing seasons: March until June 2019 (Growing season 1), and November 2019 until February 2020 (Growing season 2). The data were analyzed using a linear mixed model with the fixed factors 'rangeland management' (RSGL, DSGL and Alalili), 'grazing' (fenced, open) and 'harvest rate' (month, season). Separate analyses were conducted for each growing season.

Results

Preliminary results show that the grass regrowth rate did not differ significantly between different types of rangeland management, neither during growing season 1, nor during growing season 2.

We found a significant interaction between 'grazing' and 'harvest rate' for the regrowth rate of grasses ($F_{1,33}$= 9.6, p= 0.003, see Figure 1) during growing season 1. Inside the fence, grass regrowth was higher when only harvested after the growing season ('season') compared to plots that were cut every month ('month'). Outside the fence the grass regrowth rate was similar for both harvest rates, and generally lower than inside the fence. During growing season 2, the grass regrowth rate was significantly higher for plots that were cut after one growing season compared to monthly cut plots. Fencing did not have a significant effect on the regrowth of grasses.

The regrowth rate of forbs in our sample plots was not influenced by any treatment during growing season 1. During growing season 2 forbs regrowth rates doubled ($F_{1,30}$= .04, p= 0.01) when plots were cut after one season compared to monthly cut plots. Mean forb regrowth rate during growing season 2 was around five times higher compared to growing season 1.

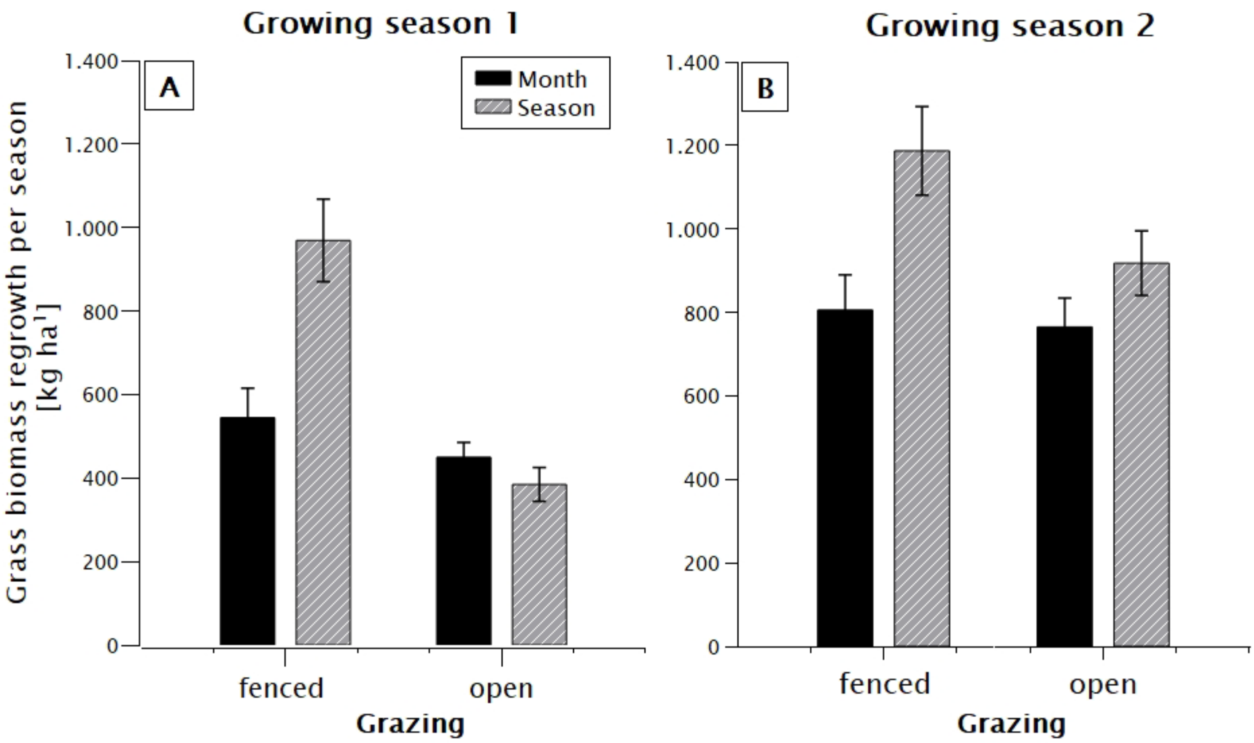

Figure 1 – Mean grass biomass [kg/ha] regrowth under different grazing accessibility (fenced and open) and different harvest rates (after each month: black bars; and after one season: gray bars) in the community of Loiborsiret, Tanzania. The graphs show the results of the two growing seasons March- June 2019 (Growing season 1) and November 2019 – February 2020 (Growing season 2). A) Significant interaction ($p<0.05$) between grazing and harvest rate. B) The harvest rate influenced the biomass regrowth rate significantly ($p<0.05$), fencing had no effect. Vertical bars represent ± 1 S.E..

Discussion [Conclusions/Implications]

Rainfall patterns are predicted to become less reliable over the next decades, particularly in sub- Saharan Savanna (IPCC 2014). Resilient rangelands and, thus, appropriate management of rangelands, are crucial. Traditional seasonally deferred grazing systems are common practice for many pastoralists in Eastern Africa (Mwilawa et al. 2008). Traditional rangeland management regimes, however, did not impact the provision of forage in our study, which might be due to the young age of our exclosures. Seasonal exclosures have been shown to provide higher ground cover and higher standing biomass compared to continuously grazed land, which is crucial for rangeland health and pastoralists. This positive effect got stronger, the older the exclosure was (Selemani 2014).

Different frequencies of simulated heavy grazing events were found to have a tremendous impact on the provision of grasses and forbs in semi-arid rangelands. Short recovery periods after a simulated heavy grazing events might hamper the forage provision of rangelands in the long run (Briske et al. 2008). Ideal duration and frequency of recovery periods are still under dispute and vary depending on the surrounding conditions (Müller et al. 2007). Higher grazing frequencies and animal density can result in higher forage quality for the livestock (Schönbach et al. 2012). On the other hand, long-term exclusion of herbivores was promoted a useful method to restore already degraded rangelands (Allington und Valone 2011). For this study, we did not imitate nutrient cycles or effects of trampling, which might have influenced the vegetation further (Lezama et al. 2016). Further research on grazing frequency is needed before giving final recommendations.

We found that additional, uncontrolled grazing of livestock and wildlife, had a strongly negative impact when environmental factors were unfavourable. Continuous high grazing pressure can undermine efforts of sustainable rangeland management, resulting in higher percentage of bare ground, lower standing biomass and lower biodiversity (Habtemicael et al. 2015).

We conclude that traditionally implemented seasonal recovery periods can be a suitable tool to maintain rangeland productivity under increasing variability of rainfall pattern and high grazing pressure. Grazing plans that include recovery periods are crucial for the rangeland functionality and should be implemented and controlled to avoid high and continuous grazing pressure, particularly in times of low precipitation.

Acknowledgements
We want to thank the Hans-Boeckler foundation for my PhD scholarship and the support. We are grateful to the Anton & Petra Ehrmann-foundation Graduate School "Water - People - Agriculture" for the research fund to conduct this research. We appreciate the cooperation and infrastructure provided by African People & Wildlife and the team of the Noloholo Environmental Center. This study would not have been feasible without the approval and help of the government of Loiborsiret and its staff as well as the Tanzanian Wildlife Research Institute. We have received great support from colleagues of the University of Hohenheim, who provided us with equipment and advice.

References
Allington, G. R. H.; Valone, T. J. 2011. Long-term livestock exclusion in an arid grassland alters vegetation and soil. In: *Rangeland Ecol. Manage.* 64 (4): 424–428. DOI: 10.2111/REM-D-10-00098.1.

Bremer, D. J.; Auen, L. M.; Ham, J. M.; Owensby, C. E. 2001. Evapotranspiration in a prairie ecosystem. Effects of grazing by cattle. In: *Agron. J.* 93 (2): 338–348. Online available at https://www.scopus.com/inward/record.uri?eid=2-s2.0-0035053993&partnerID=40&md5=e70bcbeda057b42c173c3400dfcb1306.

Briske, D. D.; Derner, J. D.; Brown, J. R.; Fuhlendorf, S. D.; Teague, W. R.; Havstad, K. M. et al. 2008. Synthesis Paper. Rotational Grazing on Rangelands: Reconciliation of Perception and Experimental Evidence. In: Rangeland Ecology & Management 61 (1): 3–17. Online verfügbar unter http://www.jstor.org/stable/25146745.

Castellano, M. J.; Valone, T. J. 2007. Livestock, soil compaction and water infiltration rate. Evaluating a potential desertification recovery mechanism. In: *J. Arid Environ.* 71 (1): 97–108. DOI: 10.1016/j.jaridenv.2007.03.009.

Goldman, M. J.; Riosmena, F. 2013. Adaptive capacity in Tanzanian Maasailand. Changing strategies to cope with drought in fragmented landscapes. In: *Global Environ. Change* 23 (3): 588–597. DOI: 10.1016/j.gloenvcha.2013.02.010.

Habtemicael, M.; Yayneshet, T.; Treydte, A. C. 2015. Responses of vegetation and soils to three grazing management regimes in a semi-arid highland mixed crop-livestock system. In: *Afr. J. Ecol.* 53 (1): 75–82. DOI: 10.1111/aje.12185.

IPCC 2014: Climate Change 2014. Impacts, Adaptation, and Vulnerability. Part B: Regional Aspecta. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Unter Mitarbeit von Barros, V.R., C.B. Field,D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma,E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.). Hg. v. Cambride University Press. Cambride University Press. Cambride, United Kingdom and New York, NY, USA.

Lezama, F.; Paruelo, J. M.; Acosta, A. 2016. Disentangling grazing effects. Trampling, defoliation and urine deposition. In: *Appl. Veg. Sci.* 19 (4): 557–566. DOI: 10.1111/avsc.12250.

Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being. Synthesis. Washington, DC.

Miller, B. W. 2015. Using geospatial analysis to assess the influence of land-use change and conservation on pastoralist access to drought resources. In: *Nomadic Peoples* 19 (1): 120–145. DOI: 10.3197/np.2015.190108.

Mwilawa, A. J.; Komwihangilo, D. M.; Kusekwa, M. L. 2008. Conservation of forage resources for increasing livestock production in traditional forage reserves in Tanzania. In: *Afr. J. Ecol.* 46: 85–89. DOI: 10.1111/j.1365-2028.2008.00934.x.

Oba, G.; Kaitira, L. M. 2006. Herder knowledge of landscape assessments in arid rangelands in northern Tanzania. In: *J. Arid Environ.* 66 (1): 168–186. DOI: 10.1016/j.jaridenv.2005.10.020.

O'Farrell, P. J.; Anderson, P. M. L.; Milton, S. J.; Dean, W. R. J. 2009. Human response and adaptation to drought in the arid zone. Lessons from southern Africa. In: *S. Afr. J. Sci.* 105 (1-2): 34–39. Online verfügbar unter https://www.scopus.com/inward/record.uri?eid=2-s2.0-67149089284&partnerID=40&md5=1469c7d6a4d965dc05039ca7f88b0499.

Schönbach, P.; Wan, H.; Gierus, M.; Loges, R.; Müller, K.; Lin, L. et al. 2012. Effects of grazing and precipitation on herbage production, herbage nutritive value and performance of sheep in continental steppe. In: *Grass and Forage Sci* 67 (4): 535–545. DOI: 10.1111/j.1365-2494.2012.00874.x.

Selemani, I. S. 2014. Communal rangelands management and challenges underpinning pastoral mobility in Tanzania. A review. In: *Livest. Res. Rural Dev.* 26 (5): 2. Online available at https://www.scopus.com/inward/record.uri?eid=2-s2.0-84899683577&partnerID=40&md5=d9f2fa2fc661f15a5a779f41401bd803.

Selemani, I. S.; Eik, L. O.; Holand, Ø.; Ådnøy, T.; Mtengeti, E.; Mushi, D. 2013. The effects of a deferred grazing system on rangeland vegetation in a north-western, semi-arid region of Tanzania. In: *Afr. J. Range Forage Sci.* 30 (3): 141–148. DOI: 10.2989/10220119.2013.827739.

Verdoodt, A.; Mureithi, S. M.; van Ranst, E. 2010. Impacts of management and enclosure age on recovery of the herbaceous rangeland vegetation in semi-arid Kenya. In: *J. Arid Environ.* 74 (9): 1066–1073. DOI: 10.1016/j.jaridenv.2010.03.007.

Weber, K. T.; Horst, S. 2011. Desertification and livestock grazing. The roles of sedentarization, mobility and rest. In: *Pastoralism* 1 (1). DOI: 10.1186/2041-7136-1-19.