Common invasive weed species in the central and south western rangelands of Uganda

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ABSTRACT

A study was conducted in the central and southwestern rangelands of Uganda covering the districts of Kiboga, Nakasongola, Nakaseke, Kyankwanzi, Masindi, Isingiro, Mbarara, Sembabule and Kiruhura, to identify the key invasive weed species that pose a threat to pasture and livestock production in the rangelands. Sampling points were established in five farms per district. The selected farms had relatively similar pasture and grazing management conditions (paddock grazing, continuous grazing and rested areas) which were then stratified in valley, slope, hill tops and improved pastures. A Modified-Whittaker sampling plot was used to collect the herbaceous vegetation, which was sorted, identified and counted to compute species diversity (richness and evenness), species dominance and similarity. A total of 33 herbaceous species were identified, with seven species being invasive (*Sida rhombifolia, Urena lobata, Lantana camara, Mimosa pudica, Elephantopus scaber, Rivina humilis* and Leonotis nepetifolia) and two common weeds (*Amaranthus* and *Solanum incanum*). There was high species diversity in all sampling areas, which is reflective of lack of concerted efforts in pasture production, but also an adaptive strategy to the precarious climatic conditions in the rangelands especially under low input production systems. Strategies should be made to establish drought tolerant and nutritious pastures; including designing and implementation of ecologically sound invasive weed control measures.

Key words: Invasive weeds, rangelands, species diversity, species dominance, species, Uganda

RÉSUMÉ

A study was conducted in the central and southwestern rangelands of Uganda covering the districts of Kiboga, Nakasongola, Nakaseke, Kyankwanzi, Masindi, Isingiro, Mbarara, Sembabule and Kiruhura, to identify the key invasive weed species that pose a threat to pasture and livestock production in the rangelands. Sampling points were established in five farms per district. The selected farms had relatively similar pasture and grazing management conditions (paddock grazing, continuous grazing and rested areas) which were then stratified in valley, slope, hill tops and improved pastures. A Modified-Whittaker sampling plot was used to

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INTRODUCTION

Sustainable pasture production is key element in ruminant livestock production, since pastures provide the cheapest source of feed for ruminants. Globally, over 26% of the land is covered by pasture and fodder crops, translating into 70% of the world agricultural area (Henry *et al.,* 2018). The worlds' grasslands are faced with challenges that threaten their existence, which include conversion into croplands, plantation forests, and encroachment by thickets and shrubs (Asner *et al.,* 2004; Zziwa *et al.,* 2012; Byenkya *et al.,* 2014) and invasion by noxious weeds (Wilcove *et al.,* 1998). These factors are driving considerable reduction in grasslands over the years and greatly impact the quantity and quality of feed for livestock production. This subsequently affects the production and productivity of ruminants and decimates efforts to attain sustainable development and meeting the increasing demand for livestock products.

Grassland species diversity and other plant community responses to grazing may be strongly influenced by management practices. According to Heitschmidt and Taylor (1991), grazing systems are tools which allow grassland managers to control the frequency and duration of grazing and non - grazing periods to optimize livestock and plant performance and sustain desirable plant community composition. While a landscape-scale approach to evaluating community susceptibility to colonization and impact by invasive species is likely to provide key insights, few studies have done this quantitatively. Like other natural or semi-natural systems, rangelands are subject to plant invasions and this has consequences for the structure, function and composition of rangeland ecosystems and so for the biodiversity that they support (Lonsdale and Milton, 2002).

Grasslands are of profound benefit in Uganda, where more than 90% of the ruminants are produced in grazing systems (Mugerwa and Zziwa, 2014). The livestock sub-sector contributes 5.2% of the total agricultural gross domestic product and 12.7 % of the national GDP (Nalubwama *et al.,* 2011). Therefore, the need to harness grazing resources cannot be over emphasized. Grazing management plays a great role in management of grasslands, conservation and maintenance of a favorable diversity of pasture species to provide the required quantity and quality of feed that can stimulate production to meet the demand for livestock products. This study was intended to: (i) outline the nature of the threat that invasive plant species pose to Ugandan rangelands; (ii) describe the mechanism by which invasive species affect rangelands systems and, in particular, the biodiversity that they support; (iii) discuss the significance of invasive species for the monitoring of rangeland biodiversity.

MATERIALS AND METHODS

Study location. The study was carried out in nine districts in South Western and Central Cattle Corridor (Table 1) of Uganda, implementing the MOBIP project under Disease Control Zone (DCZ) 1 (Masindi , Kiboga, Nakasongola, Nakaseke and Kyankwanzi) and DCZ 2 (Isingiro, Mbarara, Sembabule and Kiruhura). Sampling points were instituted in five farm each district, with relatively similar pasture and grazing management conditions (paddock grazing, continuous grazing and rested areas) which were then stratified in valley, slope, hill tops and improved pastures.

Table 1. Study Areas

District	Sub-county	Parish	Village
Kiboga	Kapeke	Kayera	Kinyunyu
	Kapeke	Kyayimba	Nyamiringa
	Kapeke	Kasega	Budimbo
	Dwaniro	Lwankonge	Lwantanga
	Dwaniro	Dwaniro	Bakijula
Kyankwanzi	Butemba T/C	Butemba	Kanywamahuri
	Butemba T/C	Kamirambazzi	Kakifurukwa
	Butemba T/C	Lwebisiriza	Kyampagi
	Kyankwanzi	Rwemiganda	Ranch No.8
	Kyankwanzi	Lubiri	Mpango
Masindi	Kimengo	Kinjunubwa	Kyangamwoyo
	Kimengo	Kijunjubwa	Bukooba
	Kimengo	Kimengo	Karangwe
	Kimengo	Kimengo	Karwara Kididima
	Miirya	Kigulya	Kigezi
Nakaseke	Ngoma TC	Central Ward	Kalyabulo
	Ngoma TC	Central Ward	Kololo Zone
	Ngoma SC	Kigweri	Kisalizi
	Kinoni	Bulyamushenyi	Kyabigulu
	Kinoni	Biduku	Konono
Nakasongola	Migeera TC	West Ward	Kyabacweezi
	Migeera	West Ward	Biizibitukula
	Nabiswera	Kyangogolo	Matuugo-Kimengo
	Town Council	Central Ward	Wakibombo
	Kakooge	Katuugo	Kiralamba
Isingiro	Masha	Nyamitsindo	Nyamitsindo
	Masha	Nyamitsindo	Kakyeka
	Masha	Rwetango	Rwetango
	Kashumba	Kashumba	Kashumba
	Kashumba	Kashumba	Kijenje
Mbarara	Bubaare	Rugarama	Rugarama
		Rugarama	Kitojo

		Kashaka	Kashaka
		Kashaka	Rushasha
		Kashaka	Nshizi
Kiruhura	Nyakashashara	Nyakahita	Nyakahita
	Nyakashashara	Nyakahita	Nyakabingo
	Nyakashashara	Nyakahita	Kikama
	Sanga TC	Rwabarata	Rwabarata
	Sanga TC	Rwabarata	Kigarama
Sembabule	Lugusulu	Kawanda	Kyetume
	Lugusulu	Kawanda	Kawanda
	Lugusulu	Lwentale	Kasongi
	Lugusulu	Lwentale	Lwentale
	Ntusi	Ntusi	Ntusi

Field plot layout and sample collection. A Modified-Whittaker plot measuring 20m × 50m (Figure 1) was placed with the long axis parallel to the environmental gradient (Stohlgren *et al.,* 1995). In each plot of 1000m^2 was nested subplots of three different sizes. A 5m × 20 m (100 m^2) subplot in the center, two 2m × 5m (10m^2) subplots in opposite corners and ten 0.5m × 2m (1m^2) subplots (six arranged systematically inside and adjacent to the 1000m^2 plot perimeter and four arranged systematically outside and adjacent to the 100m^2 subplot perimeter. All herbaceous vegetation in the nested subplots was harvested and displayed on a tarpaulin, sorted into different species, identified and counted.

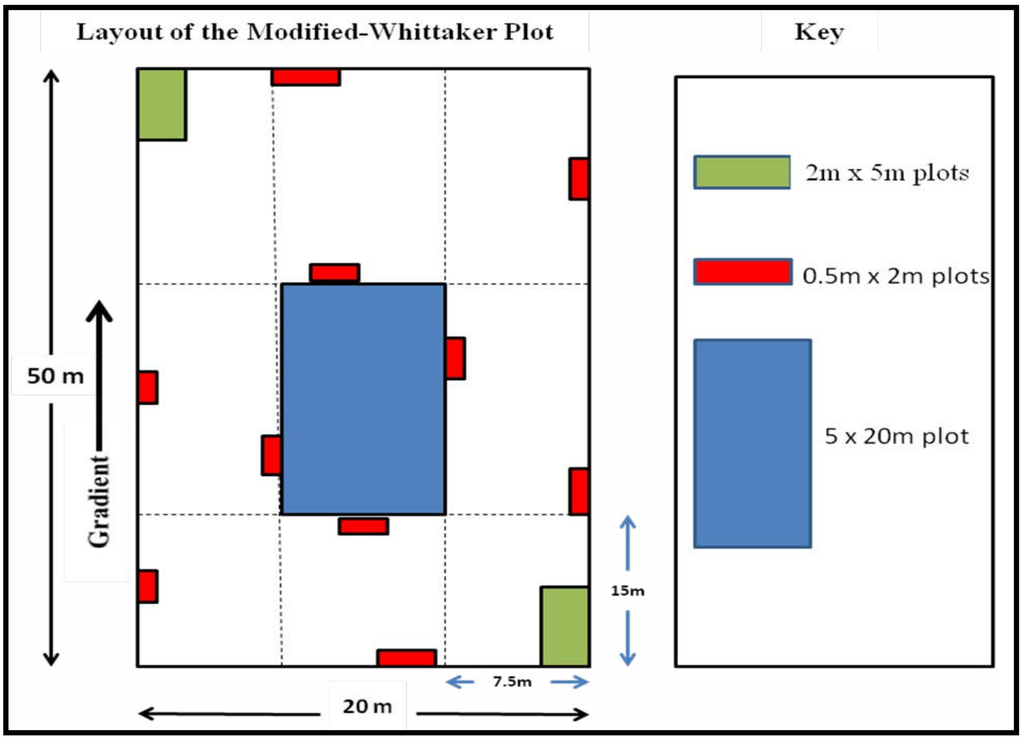

Figure 1. Field layout of a Modified-Whittaker plot design showing the three different sizes of sample plots nested into a large plot of 50 X 20 m

Computation of Diversity Indices

Species diversity was determined using Shannon-Wiener's diversity index (H′) (Itô, 2007; Bibi and Ali, 2013).

$$H^1 = -\sum\left[\left(\frac{n_i}{N}\right)\times \ln\left(\frac{n_i}{N}\right)\right]$$

Where n_i is the number of individuals of each species and N is the total number of individuals in the community.

Species dominance was determined using Simpson's index (D) was used to determine the measure of dominance of the different species as described in Itô, 2007; Bibi and Ali, 2013.

$$D = \sum \frac{n_i(n_i - 1)}{N(N-1)}$$

Where n_i is the number of individuals of each species and N is the total number of individuals in the community.

Determination of species similarity

In order to compare the different communities, the fraction of species shared between samples was calculated using Jaccard's index of similarity (Vargas, 1996).

$$J = \frac{S_c}{S_a + S_b + S_c}$$

Where S_a and S_b are the numbers of species unique to samples a and b, respectively, and Sc is the number of species common to the two samples.

RESULTS AND DISCUSSION

Species identification and count. A total of 33 species were identified (Table 2). There were more invasive weed species (shade red) in the valleys (6) than on hills (3), slopes (3) and improved pastures (3). Sida rhombifolia is the most wide spread invasive species followed by Urena lobata, Lantana camara, and Mimosa pudica, while Elephantopus scaber, Rivina humilis and Leonotis nepetifolia were found in vallies. Amaranthus and Solanum incanum were noted as common weeds, which are increasing in most farmlands.

Table 2. Botanical names of pastures and invasive weeds and their counts

Sampling Location Valleys	Average Number in 30m²	Sampling Location Hills	Average Number in 30m²
Cyperus polystachyos	7010	*Eleusine indica*	2050
Desmodium uncinatum	2540	*Bracharia*	970
Eleusine indica	1300	*Paspalum distichum*	180
Sida rhombifolia	1080	*Solanum incanum*	60
Amaranthus	1050	*Sida rhombifolia*	60
Justicia exigua	760	*Urena lobata*	50
Indigofera trita	560	*Lantana camara*	20
Brachiaria	530		0
Mimosa pudica	450		0
Paspalum distichum	430	Slopes	0
Justicia exigua	260	*Chamaecrista rotundifolia*	580
Digitaria abyssinica	160	*Digitaria abyssinica*	320
Eleusine Africana	120	*Paspalum distichum*	230
Chamaecrista rotundifolia	120	*Eleusine indica*	230
Digitaria scararum	70	*Amaranthus*	130
Comelina bengalensis	40	*Sida rhombifolia*	120

Verginalis	40	*Cyperus polystachyos*	30
Megathyrsus maximus	30	*Asparagus africanus*	30
Elephantopus scaber	30	*Urena lobata*	20
Urena lobate	20	*Sporobolus pirimidalis*	10
Sporobolus piramidalis	20	*Lantana camara*	10
Rivina humilis	20	*Digitaria scararum*	10
Panicum maximum	20	*Solanum incanum*	10
Leonotis nepetifolia	10	*Panicum maximum*	10
Centrosema pubescens	10		
Improved pastures	0		
Boma Rhodes	700		
Paspalum distichum	70		
Mimosa pudica	250		
Centella aziatica	180		
Eleusine indica	30		
Panicum maximum	20		
Hyperhenia rufa	20		
Chamaecrista rotundifolia	20		
Lantana camara	10		
Cyperus polystachyos	10		
Sida rhombifolia	10		

Species diversity and dominance. Species diversity was higher in the valley (H1= 2.0433), followed by slopes (H1 = 2.0082), hills (H1 = 1.3027) and lowest under improved pastures (H1 = 1.2653) (Table 3). Species Dominance was highest on hills (D = 0.364202), followed by improved pastures (D = 0.335093), valley (D = 0.197365) and lowest in slope (D = 0.164625).

Among grazing systems, the rested grazing lands had high species diversity (H1 = 1.1226), followed by continuous grazing systems (H1 = 1.0273) and lowest in paddock grazing systems (H1 = 0.6349). While species dominance was highest in paddock, followed by continuous grazing and lowest in rested areas.

Valleys and slopes exhibited high species richness and evenness, which was within the acceptable ranges of 1.9 – 3.5 for ecologically balanced ecosystems (Krebs, 1989) while the hill tops and improved pastures had lower species richness and evenness but with higher species dominance. The lower species richness and evenness on hills may be attributed to low soil fertility (soil erosion was evident in all sites) which restricts growth of few species that can grow under low soil fertility levels while in improved pastures, the efforts to reseed, over sow and routine management lead to dominance of desirable species. However, the presence of invasive weeds even under improved pastures indicates the need for more vigilant control measures as these have a potential to reduce pasture production and constrain livestock production.

The high species richness and evenness in the valley is attributed to the conducive conditions in the valley, especially the water and soil conditions, since the valley receives fertile soil eroded from hills, which enables favorable growth of all species. The continuous grazing systems normally practiced may also contribute to enhanced biodiversity in the valley, slopes and hill tops compared to improved pastures.

Species similarity. Slopes and hill tops had the highest Jaccard's index followed by that between valley and slopes (Table 4). The higher Jaccard's index for slopes and hill tops and valley and slope could be attributed to the closeness to one another and the similarity in management practices which are different from that of improved pastures.

Table 3. Species diversity (Richness and Evenness) and dominance

Location	Shannon's H1 index	Simpson's D index
Valley	2.0433	0.197365
Slopes	2.0082	0.164625
Hill tops	1.3027	0.364202
Improved pastures	1.2653	0.335093
No grazing (rested lands for at least 1 year)	1.1226	0.4147
Paddock grazing systems	0.6349	0.7590
Continuous grazing systems	1.0273	0.4630

Table 4. Jaccard's indexes of species similarity

Location	Valley	Gentle slope	Hill	Paddocked
Valley	1.0	0.37	0.2	0.19
Slope	0.37	1.0	0.4	0.24
Hill	0.2	0.4	1.0	0.25
Improved pastures	0.19	0.24	0.25	1.0

Current invasive weed control practices. Invasive weed species are often a result of malicious introduction, un intended introduction, and dispersal by grazing animals to areas with conducive environments for their proliferation. A naturalized and non-economical weed species can also become invasive when it continuously builds a seed reserve and out competes native species, or when there are changes in the environmental and soil parameters that make weeds more dominant over palatable species. Example of such changes include;

i. Frequent and prolonged droughts subject palatable pastures to intense grazing limiting their reproduction and growth, while allowing weeds to recruit in numbers.
ii. High grazing pressures also alters the competition between pastures and weeds to favor rapid growth of weeds and making them invasive.
iii. Reduced soil fertility limits the growth of productive pastures and increase the dominance of weeds, which may recruit in high numbers and become invasive
iv. Frequency of fire use also alters the growth rhythm of pastures and weeds and may favor the rapid growth of fire resistant/tolerant weeds at the expense of palatable pastures

It was observed that none of the current weed control practices is informed by knowledge about the cause of weed invasion. The current control measures are;

i. Use of selective herbicides (e.g., 2-4 D) eliminate broad leaved weeds
ii. Hiring out land infested by weeds to cultivators for annual crop production for at least two seasons. It is known that invasion by Lantana camara increases soil fertility and can hence be ploughed and used for production of crops

like maize, beans, sweet potatoes, ground nuts. During weeding practices during crop production ends up uprooting the weeds and exhaust the soil seed bank over two to three season and thereafter, the land is returned back into a grassland for livestock grazing.

iii. Direct efforts to uproot and burn invasive weeds especially Urena lobata, Lantana camara, and Mimosa pudica. This practice is noted to be costly to farmers. The notion that Lantana camara increases soil fertility is indicative that reduced soil fertility is among the factors increasing the invasiveness of this weed

Therefore, instead of investing in the uproot and burn, and leasing out land for crop cultivation, efforts in practices that increase soil fertility should be taken into consideration. These may include;

i. Judicious stocking rates to avoid overgrazing and soil compaction
ii. Rotational grazing systems which enable soil and pastures to rejuvenate
iii. Over sowing with pasture legumes to fix nitrogen
iv. Addition of fertilizers; e.g., uniform spread of manure in areas likely to have decreased soil fertility and use of inorganic fertilizers where possible
v. Night kraaling practices, where the night kraal is moved to different places over time so as to aid uniform distribution of manure on the farm and stimulate growth of palatable pastures

CONCLUSION AND RECOMMENDATIONS

Although the rested grazing areas and areas under continuous grazing systems had a higher species diversity than paddock grazing systems, their diversity index is below the required index for ecologically balanced ecosystems (1.9 – 3.5) as described by Krebs, 1989. This therefore indicates than continuous grazing and resting of land, which are more natural management systems, are subjected to degradation and are characteristic of low productive systems compared to paddock systems where specialized pastures are maintained to improve the production of animals.There is wide spread of invasive species in the rangelands with seven species being invasive (*Sida rhombifolia, Urena lobata*, *Lantana camara*, *Mimosa pudica*, *Elephantopus* scaber, *Rivina humilis* and *Leonotis nepetifolia*) and two common weeds (*Amaranthus* and *Solanum incanum).*

None of the currently used weed control measures is based on the evidence of factors that caused their invasiveness in grazing areas. As such, the measures are not ecologically sound, more expensive, compromise availability of grazing land for some time and are not sustainable. Therefore, there is need for establishment of drought tolerant and nutritious pastures so as to develop specialized pasture systems for commercial livestock production. Sensitization of stakeholders in sustainable and productive rangeland management and grazing systems for commercialized beef production systems is also essential. Designing and dissemination of ecologically sound invasive weed control measures, that are based on evidence of factors that increased the invasiveness of such species should be undertaken.

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STATEMENT OF NO CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this paper.

REFERENCES

Asner, G. P., Townsend, A. R., Bustamante, M. M. C., Nardoto, G. B. and Olander, L. P. 2004. Pasture degradation in the central Amazon: Linking changes in carbon and nutrient cycling with remote sensing. *Global Change Biology* 10 (5): 844–862. https://doi.org/10.1111/j.1529-8817.2003.00766.x

Bibi, F. and Ali, Z. 2013. Measurement of diversity indices of avian communities at Taunsa Barrage Wildlife Sanctuary, Pakistan. *Journal of Animal and Plant Sciences* 23 (2): 469–474.

Byenkya, G. S., Mugerwa, S., Barasa, S. and Zziwa, E. 2014. Land use and cover change in pastoral systems of Uganda: Implications on livestock management under drought induced pasture. *African Crop Science Journal* 22 (1986): 1013–1025.

Henry, B., Murphy, B., and Cowie, A. 2018. Sustainable land management for environmental benefits and food security - A synthesis report for the GEF. January, 127. https://doi.org/10.13140/RG.2.2.25084.39041

Itô, Y. 2007. Recommendations for the use of species diversity indices with reference to a recently published article as an example. *Ecological Research* 22 (4): 703–705. https://doi.org/10.1007/s11284-006-0057-1

Krebs. 1989. Ecological methodology. Harper and Row, New York. https://books.google.co.ug/books/about/Ecological_Methodology.html?id=1GwVAQAAIAAJ&redir_esc=y

Mugerwa, S. and Zziwa, E. 2014. Drivers of grassland ecosystems' deterioration in Uganda. *Applied Science Reports* 2 (3): 103-111.

Nalubwama, S. M., Mugisha, A. and Vaarst, M. 2011. Organic livestock production in Uganda: Potentials, challenges and prospects. *Tropical Animal Health and Production*, 43 (4): 749–757. https://doi.org/10.1007/s11250-011-9780-x

Richardson, D.M., Pysek, P., Rejmánek, M., Barbour, M.G., Panetta, F.D. and West. C.J. 2000. Naturalization and invasion of alien plants: concepts and definitions. *Diversity and Distributions* 6: 93–107.

Stohlgren, T. J., Falkner, M. B. and Schell, L. D. 1995. A Modified-Whittaker nested vegetation sampling method. Vegetatio, 117 (2): 113–121. https://doi.org/10.1007/BF00045503

Vargas, R. R. and J. M. 1996. The Probabilistic Basis of Jaccard's Index of Similarity. *Systematic Biology* 45 (3): 380-385.

Wilcove, D. S., Rothstein, D. Dubow, J., Phillips, A. and Losos, E. 1998. Quantifying threats to imperiled species in the United States: Assessing the relative importance of habitat destruction, alien species, pollution, overexploitation, and disease. *BioScience* 48 (8):607–615.https://doi.org/10.2307/1313420.

Yorks, T. P., West, N. E. and Capels, K. M. 1992. Vegetation differences in desert shrublands of western Utah's Pine Valley between 1933 and 1989. *Journal of Range Management* 45 (6): 569–578. https://doi.org/10.2307/4002574

Zziwa, E., Kironchi, G., Gachene, C., Mugerwa, S. and Mpairwe, D. 2012. The dynamics of land use and land cover change in Nakasongola district. *Journal of Biodiversity and Environmental Sciences* 2 (5): 61–73.