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Research Application Summary

Assessing the mammalian diversity and abundance in Sickle bush's invasion of Queen Elizabeth National Park in Uganda

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Abstract

The invasive sickle bush (*Dichrostachys cinerea*), if not effectively managed, poses serious economic and environmental to most ecosystem functions and biodiversity in Sub-Saharan Africa. Little known about its impact on mammalian diversity and abundance in the invaded national parks in Uganda. Therefore, the objective of this study was to assess the diversity and abundance of mammals in *D. cinerea* affected areas of Queen Elizabeth National Park in Uganda. A cross-sectional study design that involved both qualitative and quantitative assessments was used with study sites selected through ground truthing information from the on-field rangers and records from Research and Monitoring Department of the protected area. Scan observations and total counts during the 2 km by 200 transect walks were undertaken to collect physical information useful for species diversity and abundance computation. Non-invaded areas in the Park were also scouted as controls for comparison. Results showed that the diversity of mammals differed significantly between the invaded and non-invaded habitats. Despite having a high Simpson's Diversity Index (SDI) of 0.7163, the sickle bush invaded habitat had a lower number of individual mammalian species than the non-invaded sites. Buffaloes accounted for the largest number of groups and individuals of large sized mammals in both strata, while the Uganda kob was highly concentrated in the non-invaded habitat.

Key words: *Dichrostachys cinerea*, ecosystem functions, Queen Elizabeth National Park, Uganda

Résumé

La faucille envahissante (*Dichrostachys cinerea*), si elle n'est pas gérée efficacement, pose de graves problèmes économiques et environnementaux à la plupart des fonctions écosystémiques et à la biodiversité en Afrique subsaharienne. Peu connu de son impact sur la diversité et l'abondance des mammifères dans les parcs nationaux envahis en Ouganda. Par conséquent, l'objectif de cette étude était d'évaluer la diversité et l'abondance des mammifères dans les zones touchées par D. cinerea du parc national Queen Elizabeth en Ouganda. Une conception d'étude transversale qui impliquait à la fois des évaluations qualitatives et quantitatives a été utilisée avec des sites d'étude sélectionnés grâce aux informations de vérification sur le terrain des gardes forestiers sur le terrain et aux enregistrements du Département de recherche et de surveillance de l'aire

protégée. Des observations par balayage et des comptages totaux au cours des 2 km par 200 marches de transect ont été entrepris pour collecter des informations physiques utiles pour le calcul de la diversité et de l'abondance des espèces. Les zones non envahies du parc ont également été repérées comme témoins à des fins de comparaison. Les résultats ont montré que la diversité des mammifères différait significativement entre les habitats envahis et non envahis. Malgré un indice de diversité de Simpson (IDS) élevé de 0,7163, l'habitat envahi par la faucille avait un nombre inférieur d'espèces de mammifères individuelles par rapport aux sites non envahis. Les buffles représentaient le plus grand nombre de groupes et d'individus de mammifères de grande taille dans les deux strates, tandis que le kob ougandais était fortement concentré dans l'habitat non envahi.

Mots clés : Dichrostachys cinerea, fonctions écosystémiques, Parc national Queen Elizabeth, Ouganda

Introduction

Invasive plant species, together with climate change and anthropogenic activities are the major drivers of ecosystem degradation, causing pollution, habitat change and associated negative effects such as species extinction and impairment of various ecosystem functions (Moleele *et al*., 2002). This not only affects the delivery of ecosystem goods, but also ecosystem services like water purification, resource cycling, pollination and a number of ecosystem regulatory services (Mudzengi *et al*., 2014; Havel *et al*., 2015; Gallardo *et al*., 2016). Human activities have turned many of such ecosystems into terrestrial islands, making them more vulnerable to invasion by alien species (Roques *et al*., 2001). Their continued interaction with invasive plants and other environmental disturbances only exacerbates the threats facing biodiversity and further contributes to global habitat destruction; hence global biodiversity loss (Marquet *et al*., 2005). If not effectively managed, both native and alien invasive plant species pose serious environmental threats to most ecosystem functions and biodiversity. Invasive plant species, therefore, disrupt the integrity of ecosystems by affecting native species richness, density and the entire biological balance (Kumar and Prasad, 2014). *Dichrostachys cinerea* is among the major native invasive plants that have invaded most areas of Queen Elizabeth National Park (QENP), one of the most popular destination sites in Uganda (Cozzens *et al*., 2020). *Dichrostachys cinerea* is a serious environmental and economic problem in QENP and Uganda at large. The objective of this study was to assess the diversity and abundance of mammalian species in *D*. *cinerea* affected areas of Queen Elizabeth National Park in Uganda.

Materials and Methods

The study was conducted in the Queen Elizabeth National Park which is located on the equator in the Albertine Rift Valley of western Uganda, and covers a 1978 km^2 area. A cross-sectional study design involving both qualitative and quantitative assessments, was adopted. A quantitative approach was used to collect data related to stand density and abundance of medium and large sized mammals.

Study sites were selected through ground truthing and information from the on-field rangers and records from Research and Monitoring Department of the protected area, Uganda Wildlife

Authority, Ministry of Tourism, Wildlife and Antiquities, Government of Uganda. Scan observations and total counts during the 2 km by 200 m transect walks through the study sites, were conducted throughout the 12 hours of the day, that is morning (8:00 -12.00 am), afternoon (12:00 – 4:00 pm) and evening hours (4:00 pm – 7:00 pm), so as to collect information on the selected mammalian species diversity and abundance. The transect walk survey was specifically used due to its efficiency and swift collection of large amounts of data within the limited time frame (Pearl, 2000). Scan observations and total counts were undertaken to ascertain the total number of individuals and their age structure, that is the number of infants, juveniles and adults within the invaded and non-invaded habitats.

Microsoft Word excel, 2013 was used for statistical analysis of the data variables. Simpson's diversity index (SDI) was used to determine variation in biodiversity of different medium and large mammalian and plant communities in Dichrostachys cinerea invaded and non-invaded study areas. This was computed from excel using the formula,

SDI = 1 – {Sum [n (n-1)] / N (N-1)

Where: **n** represents the number of individuals of each species; and **N** represents the total number of individuals of all species.

Jaccard's index was used to compare species diversity between the *D. cinerea* invaded and non-invaded habitats. This was calculated using the formula,

$$J = S_c / (S_a + S_b + S_c)$$

Where: S_a and S_b are the numbers of species unique to samples in the invaded and non-invaded habitats respectively; and Sc is the number of species common to the two samples (Kerkhoff *et al*., 2010).

Results

Eight species of large and medium sized mammals were encountered in the *D. cinerea* invaded and non-invaded sites (Table 1). The most dominant medium sized mammals in the non-invaded areas were the Uganda Kob, while the most common large mammal in this area was the Cape buffaloes. On the other hand, in the invaded habits, the water bucks (50%) and warthogs (46%) were the most common mammalian species encountered (Figure 1), while the keystone species encountered were buffaloes and elephants (Table 1).

Table 1. Abundance of Mammalian species in *D. cinerea* invaded and non-invaded areas in the Queen Elizabeth National Park in Uganda

Species encountered	Number of groups	Number of individuals
Invaded		
Waterbuck	11	67
Warthogs.	12	62
Buffaloes	6	66
Elephants	1	13
Giant forest hog	1	3
Wild pig	1	2
Subtotal	32	213
Non-invaded		
Uganda Kob	24	743
Buffaloes	10	158
Warthogs	9	57
Waterbuck	2	14
Elephants	1	8
Bushbuck	0	1
Subtotal	46	981
Grand Total	78	1194

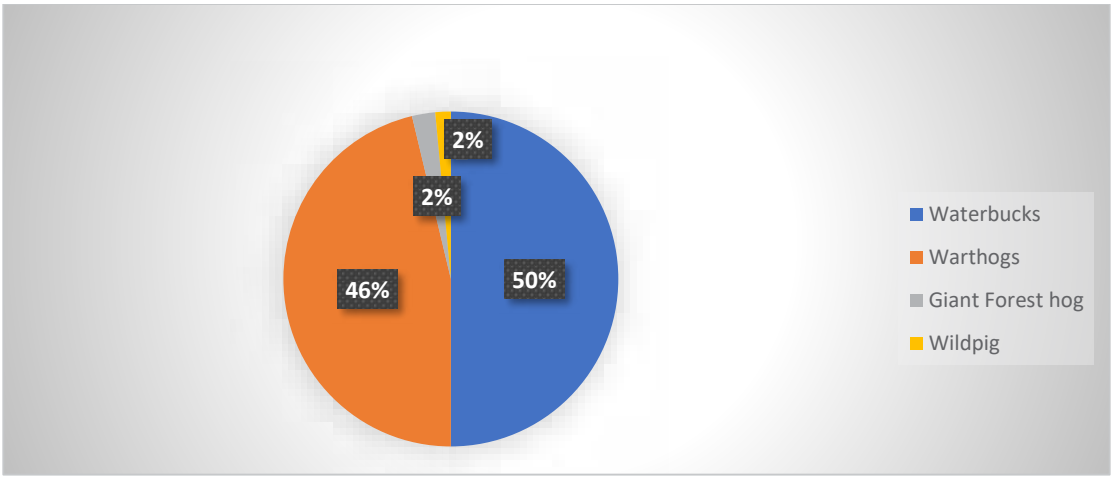

Figure 1. Proportion of groups of medium sized mammals encountered in the *D. cinerea* invaded areas of QENP

The results further reveal that there was a high number of individual animals encountered in non-invaded area than in the invaded areas throughout the different time frames of the study (Figure 2).

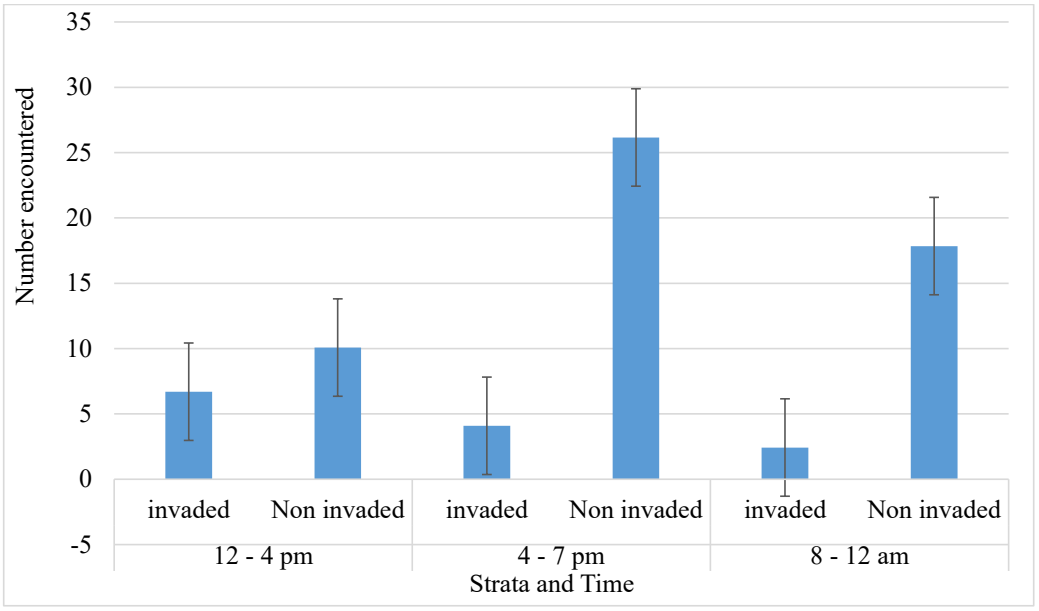

Figure 2. Number of mammals and groups encountered in the *D. cinerea* invaded and non-invaded areas between 8 am and 6:30 pm

However, Simpson's diversity index test showed a significant difference in species diversity between the *D. cinerea* invaded and non-invaded habitats (Fig. 3). The results reveal that the invaded habitat had a higher species diversity and evenness (SDI = 0.716) than the non-invaded habitat (SDI= 0.387).

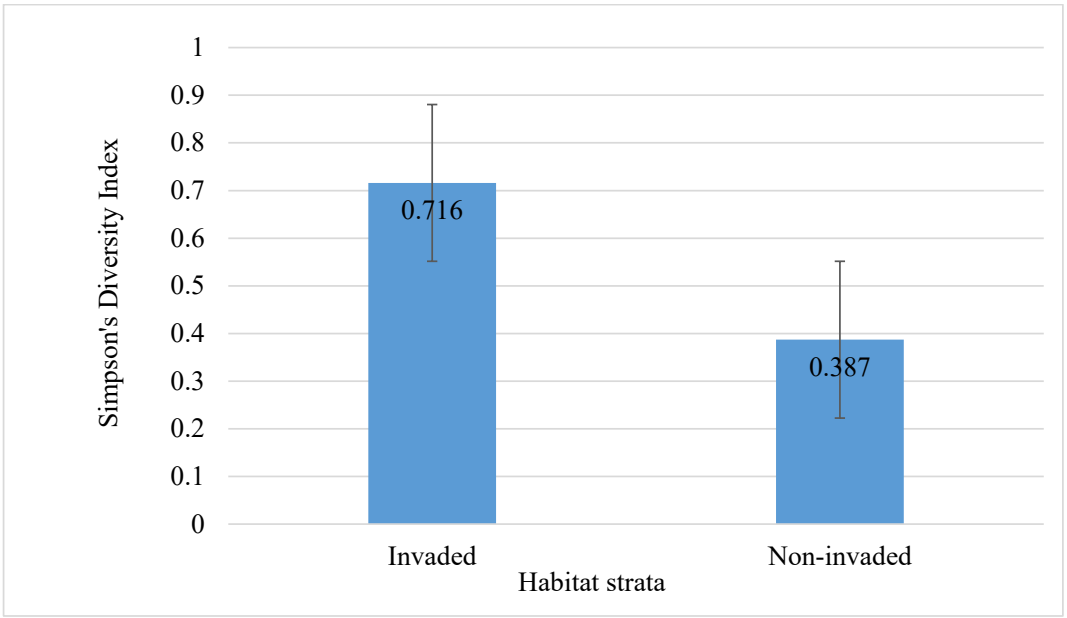

Figure 3. Species diversity and Evenness of mammals encountered in *Dichrostachys cinerea* invaded and non-invaded habitat areas in the Queen Elizabeth National Park in Uganda

Jaccard's index revealed that 50% (J=0.5) of the mammalian species were encountered in both the *D. cinerea* invaded and non-invaded study sites.

Based on age structure of medium and large sized mammals, more adults than infants and juvenile medium and large sized mammals were encountered in both strata (invaded and non-invaded). However, the number of adults, juveniles and infants encountered were higher in the non-invaded area than the invaded strata, throughout the day (Figs 4a, 4b and 4c).

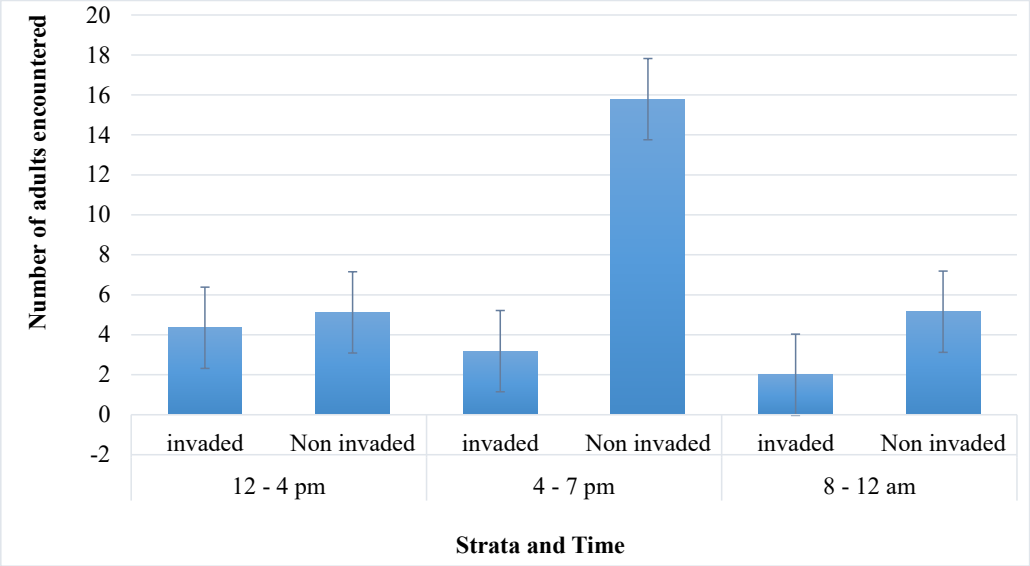

Figure 4a. Distribution of adults of medium and large sized mammals encountered in *D. cinerea* invaded and non-invaded strata of Queen Elizabeth National Park in Uganda

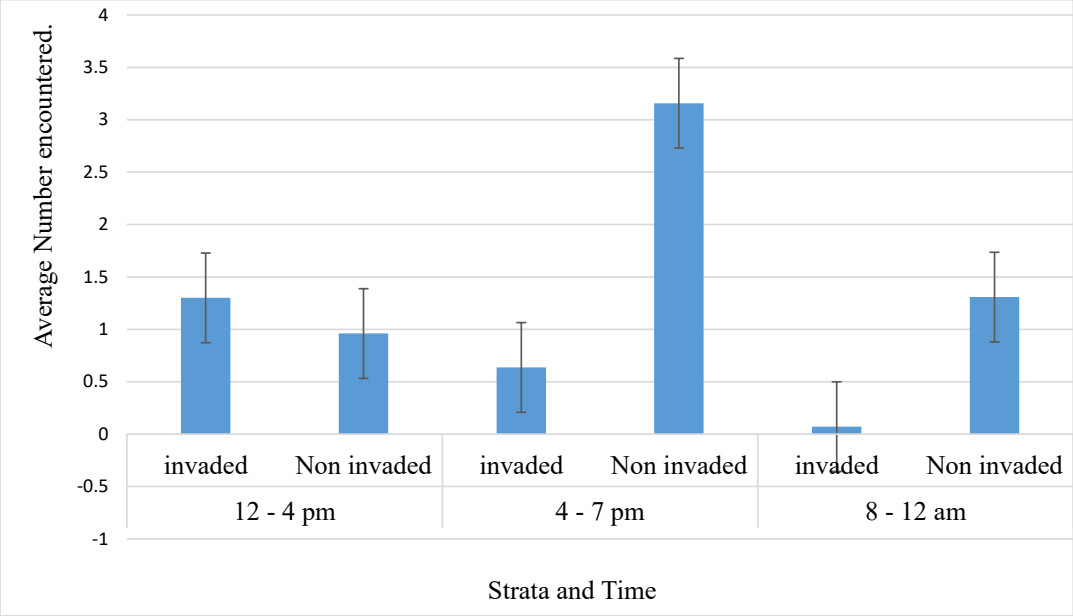

Figure 4b. Distribution of medium and large sized mammalian Infants encountered in *D. Cinerea* invaded and non-invaded strata of Queen Elizabeth National Park in Uganda

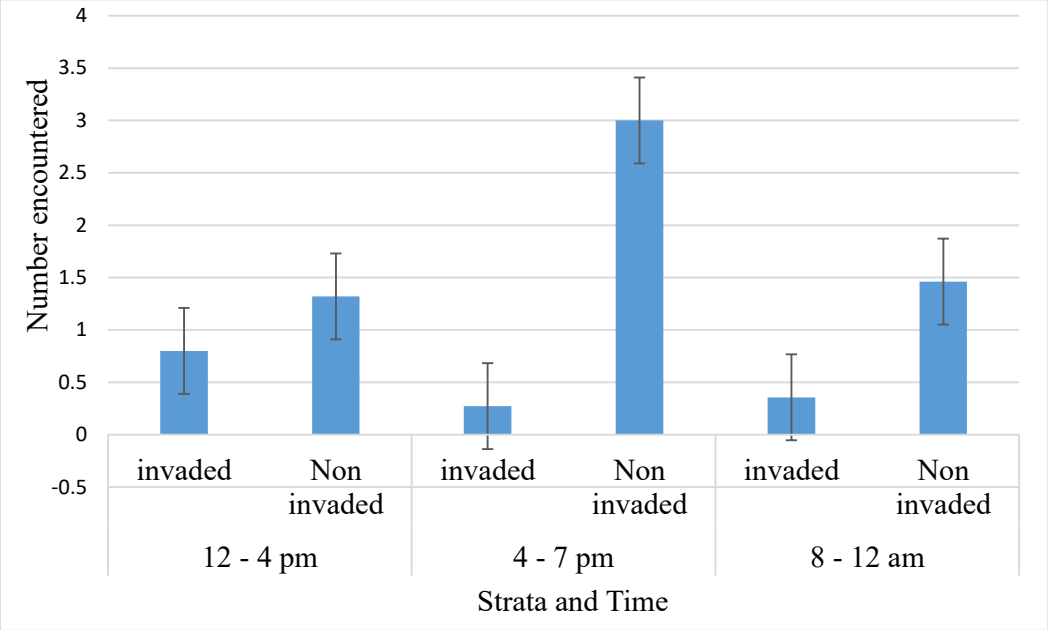

Figure 4c. Distribution of medium and large sized mammalian Juveniles encountered in *D. cinerea* invaded and non-invaded strata in the Queen Elizabeth National Park

Discussion

Mammalian abundance. The higher values of abundance of medium and large mammals in the non-invaded plots compared to the invaded areas (Fig. 2) can be explained by the possible injury caused by the invader plant which closed in on inter-plant spaces; the small mammals like warthogs were able to manoeuvre through the residual spaces left, without much obstruction. The higher density of woody and non-palatable herbaceous vegetation in the invaded area, created by the invasive sickle bush partly explains the difference in the abundance of medium and large mammals encountered in the invaded and non-invaded sites, with the increase in the woody plant cover leading to a reduction in the grass and other palatable herbaceous species cover (Kgosikoma and Mogotsi, 2013), which make up a larger percentage of food for most grazers. Thus the existence of medium and large mammals is threatened by *D. cinerea* invasion of the parks in Uganda.

Mammalian diversity and evenness. The peculiar differences in mammalian diversity and evenness between the *D. cinerea* invaded and non-invaded parts of the park, is explained partly by the mammalian size, which disadvantages the medium and large sized animals. Alteration of habitat structure by *D. cinerea* reportedly leads to reduced mammalian diversity and hence abundance in the invaded habitats (Mudzengi *et al*., 2014). Andrade-núñez and Aide (2010) reported that habitat variables that influence mammal species richness and composition are mostly vertical structure index, canopy cover, tree species diversity and percentage of grass.

It is also possible that some mammalian species are hypersensitive to obstruction by such invaders such as the Uganda Kobs whose diversity and evenness (Fig. 3 and Table 1) were markedly the higher in the non-invaded than in the invaded parts of the park. This observation still needs close investigation. It might also be true that the invasion of the habitat by this aggressive weed, occurs

at the expense of certain vegetation species that are otherwise preferred by certain mammals in the wild. Again, this also requires investigation (Blom *et al*., 2005; Randle *et al*., 2018; Adhikari *et al*., 2019). Our results underscore the significance of exploring effective strategies to mitigating this weed in the parks. Potential strategies have been proposed by Cozzens *et al*. (2020) who recommended use of clear cutting, controlled burning and animal exclusion from *D*. *cinerea* invaded areas. To what extent these innovations would be effective in Uganda, calls for extensive adaptation trials.

Conclusion

The results of this study reveal that the *D*. *cinerea* invaded habitat, despite having the highest species diversity index of 0.7163, had a lower number of individuals encountered than the non-invaded site. This phenomenon is attributed to the variations in vegetation structure between the invaded and non-invaded areas which highly determines the community structure, diversity and abundance of mammals in the different strata. More research, however, should be done to ascertain the effects of human activities on the distribution and abundance of medium and large sized mammals, and effectiveness of various interventions in the management of the invasive *D*. *cinerea*.

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