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Variety of Mammals (Dietary Classes and Body Sizes) on a Catena in Savanna Biome, Kruger National Park, South Africa.

Beanelri Janecke *

[1] Animal, Wildlife & Grassland Sciences, 205 Nelson Mandela road, Park West, University of the Free State, Bloemfontein, Free State Province, 9301, South Africa, ORCHID: 0000-0002-3570-9699.

* Correspondence: janeckbb@ufs.ac.za; Tel.: (+27) 51 401 9030

Abstract: Catenas are undulating hillslopes on a granite geology characterised by different soil types that create an environmental gradient (zones) from crest to bottom. Main aim was to determine mammal species (>mongoose) present on one catenal slope and its waterholes over three short survey periods. A total of 33 mammal species were observed with camera traps: 18 herbivore species, 10 carnivores, two insectivores, and three omnivore species. Eight species were small mammals, two dwarf antelopes, 11 medium, six large and six mega-sized mammals. Species richness was highest at waterholes (22 species), followed by midslope (19) and sodic patch (16) on the catena. Small differences were noted in species presence between different zones, and survey periods, but were not significant ($p = 0.5267$; $p = 0.9139$, respectively). Some species might not have been recorded because of drought, seasonal movement, or because they travelled outside the view of cameras. Movement of mammals inside Kruger Park is not restricted, except if they are bound by territorial boundaries, available space, or if they are habitat specific. Presence of different sized mammals from different feeding guilds possibly indicates a functioning catenal ecosystem. This knowledge can be beneficial in monitoring and conservation of species in the park.

Keywords: catena ecosystem; feeding guild; mammal richness; mud wallows; species presence; Stevenson-Hamilton Supersite; waterholes

1. Introduction

The landscape in the south of Kruger National Park has a granite geology and is dissected by a large density of streams and slightly undulating catenas [1]. A catena is a hillslope with different soil types and properties arranged in zones from its crest to its footslope. Particles travel downslope creating an environmental gradient in which different vegetation types are associated with the different soil types and soil properties of the zones [2].

It was hypothesised that some mammal species might use certain zones on the catena with higher frequency than others, since the diverse vegetation types create different habitats for mammals (food plants available, vegetation structure, space, cover, etc.). The aims of this study were to provide a basic list indicating dietary class and body size of mammal species (> mongoose) present in the different zones of one catenal slope, including three waterholes in close vicinity, and to compare the mammal species richness between three short survey periods. This study formed part of a larger multidisciplinary project [3] where certain abiotic and biotic components of this catenal ecosystem were investigated. The study area was deliberately kept small to enable the focus of the larger project to be on providing detail of each of these ecosystem components and to find links between them on a small-scale [4]. This proved to be an important multidisciplinary project that can be expanded to the granite supersite on a landscape scale. This specific study covered here forms the

foundation for numerous future research possibilities specifically on mammal species richness and how it might change under different environmental conditions. The impact of these species' presence on the catenal environment can also form an important part of future research and conservation efforts, especially the large to mega-sized mammals and the densities of animals.

2. Experiments

2.1 Study area

The park falls in the Savanna Biome and the study area in the Granite Lowveld vegetation type [5], consisting mainly of mixed woodland and thorn thickets [6]. The study was done on one catena, its closest outcrops and waterholes in the Southern Granite Supersite [1] of Kruger National Park, South Africa. The catena was divided into four zones based on differences in vegetation and soil types and its position on the hillslope [4]: Crest and midslope, sodic patch, footslope shrub veld, and a riparian area (around the dry drainage line of the Sabi River near Skukuza). The length of the catena from crest to drainage line is about 500 m (0.3 mile) and the width is about 2 km (1.2 mile) on its broadest part, but this is not a true representation of the surface area of the catena, since the zones differ in size. The normal annual rainfall of the area is 560 mm, but a drought was experienced during the study period and according to Skukuza Weather Data, only 194 mm rainfall was measured per year in the study period [3].

2.2 Methods

A total of 30 camera traps were distributed on the catena to give the best cover of each zone, the mud wallows on the catena, the nearby granite-boulder outcrops (inselbergs), and three closest permanent waterholes. All cameras used infrared flashes to also take images during the night. Cameras were positioned in such a way to be able to include small (> mongoose) to mega sized mammals [3], as far as possible. Game trials, open clearings, areas with longer distance view, termite mounds, and areas where obvious animal activity was noted were selected, but also some areas with denser vegetation to be representative of the area. Cameras were operational in the growing season during September 2015, March 2016 and March – April 2017 in order to compile the basic list of mammals present and to compare the data of similar survey periods spanning three years.

2.3 Data analyses

Data of all the cameras that were positioned in the same catenal zone were combined. The waterholes, mud wallows and granite boulder outcrops were treated as three additional zones / areas. For the purpose of this study, a trigger event is described as the image/s recorded of an individual or group of a mammal species triggering the motion sensor of the camera at a specific time. If the species could not be identified due to blurred photos, it was indicated as Unknown. The type of feeder and body size of each species present were confirmed by Estes [7] and tabulated. The total number of trigger events (in other words the number of observations) of each species was calculated per zone. The data was graphically presented as a colour gradient in different tables – white blocks indicate no observation of that species, while the darker the colour, the higher the total number of events/observations that were noted for that species. The three survey periods were included for each zone on this colour figure.

The Shapiro Wilk test was used to test for statistical normality of the data. Since data was not normally distributed, the Kruskal Wallis test was used to determine significant differences between mammal presence (indicated with a 1 if present and 0 if absent) in each catenal zone and between different survey periods, respectively. A 5% level of significance was used.

3. Results

The total of 33 mammal species can be subdivided in the following feeding guilds (Table 1): 18 herbivore species (seven grazers, six browsers, two mixed feeders and three general vegetarians), 10 carnivores, two insectivores, and three omnivore species. Eight species are classified as small mammals (mongoose, squirrel, etc.), two as dwarf antelopes (steenbok, duiker), 11 as medium (impala, leopard, etc.), six as large (zebra, lion, etc.) and six as mega-sized mammals (elephant, etc.).

Table 1. List of mammal species observed on the catena, granite outcrops and nearby waterholes.

Common name	Scientific name	Feeding guild	Size
Aardvark	*Orycteropus afer*	Insectivore	Medium
African wild dog	*Lycaon pictus*	Carnivore	Medium
Banded mongoose	*Mungos mungo*	Carnivore	Small
Black rhinoceros	*Diceros bicornis*	Browser	Mega
Blue wildebeest	*Connochaetes taurinus*	Grazer	Large
Buffalo (Cape)	*Syncerus caffer*	Grazer	Mega
Bushbuck	*Tragelaphus scriptus*	Browser	Medium
Chacma baboon	*Papio ursinus*	Omnivore	Medium
Civet	*Civettictis civetta*	Omnivore	Medium
Dwarf mongoose	*Helogale parvula*	Carnivore	Small
Elephant (African)	*Loxodonta africana*	Mixed feeder	Mega
Genet species	*Genetta* species	Carnivore	Small
Giraffe (South African)	*Giraffa giraffa* (*G. camelopardalis* - old name)	Browser	Mega
Greater kudu	*Tragelaphus strepsiceros*	Browser	Large
Grey / Common duiker	*Sylvicapra grimmia*	Browser	Dwarf
Hippopotamus	*Hippopotamus amphibius*	Grazer	Mega
Impala	*Aepyceros melampus*	Mixed feeder	Medium
Leopard	*Panthera pardus*	Carnivore	Medium
Lion (African)	*Panthera leo*	Carnivore	Large
Plains zebra	*Equus quagga*	Grazer	Large
Porcupine	*Hystrix africaeaustralis*	Vegetarian	Medium
Scrub hare	*Lepus saxatilis*	Vegetarian	Small
Serval	*Leptailurus serval*	Carnivore	Medium
Side-striped jackal	*Canis adustus*	Carnivore	Medium
Slender mongoose	*Galerella sanguinea*	Carnivore	Small
Spotted hyena	*Crocuta crocuta*	Carnivore	Large
Steenbok	*Raphicerus campestris*	Browser	Dwarf
Tree squirrel	*Paraxerus cepapi*	Vegetarian	Small
Vervet monkey	*Chlorocebus pygerythrus*	Omnivore	Small
Warthog	*Phacochoerus africanus*	Grazer	Medium
Waterbuck	*Kobus ellipsiprymnus*	Grazer	Large
White rhinoceros	*Ceratotherium simum*	Grazer	Mega
White tailed mongoose	*Ichneumia albicauda*	Insectivore	Small

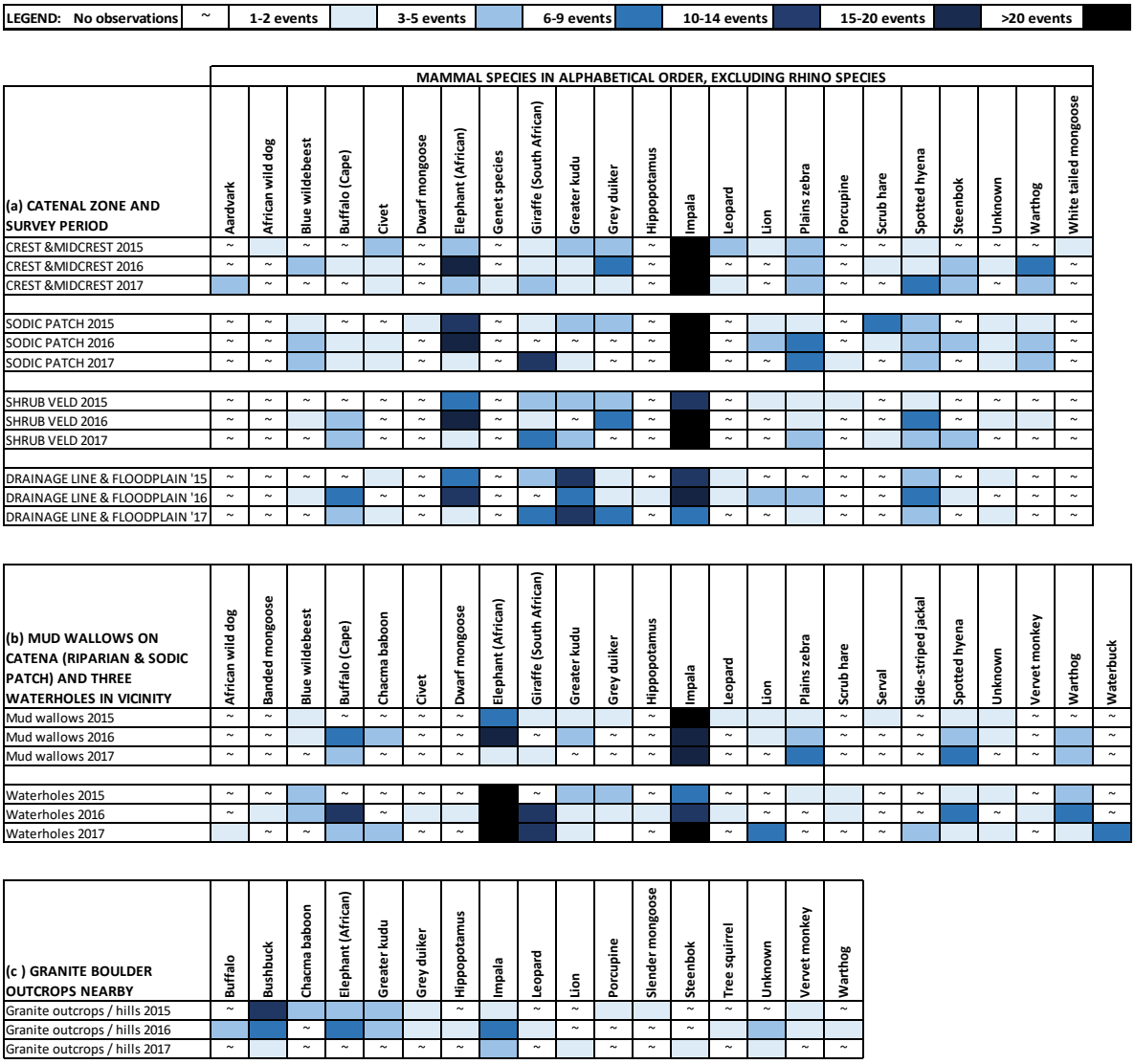

Figure 1. Mammal species (excluding rhino species) present in different zones during three survey periods: (**a**) catenal zones; (**b**) mud wallows, waterholes; and (**c**) granite boulder outcrops. The colour gradient is used to indicate number of events (observations) of each species in increasing number represented by darker colours.

Due to the global rhino poaching crisis, all detail of rhinoceros species that can be used to determine their exact location was removed from the figures and text. For the remainder of the species, their presence in each zone on the catena (Figure 1a) (including the additional zones/areas – Figure 1 b & c) was indicated for each survey period based on number of events/observations. The common species found in all zones, were buffalo, elephant, greater kudu, grey duiker, impala, and lion, while the species that were only absent from the granite-boulder outcrop area (Figure 1c), were blue wildebeest, giraffe, plains zebra, and spotted hyena. Steenbok (water-independent species, like the grey duiker) was only absent at the mud wallows and waterholes (Figure 1b). Mammal species richness was the highest at waterholes (22 species), followed by the midslope (19) and sodic patch (16) on the catena. Four species were found only at the waterholes and not on the catena, namely banded mongoose, side-striped jackal, vervet monkey, and waterbuck.

Small differences were noted in presence of some species in the different zones ($H = 2.227$, n = 96, $p = 0.5267$), and between survey periods ($H = 0.180$, n = 99, $p = 0.9139$) but they were not statistically significant. Species with darker colours on Figure 1 were observed with higher frequency (during different events – dates and/or times) on the cameras than species with lighter colours. However,

there was not enough evidence to test the hypothesis that species may be associated with specific zones. A longer time period is needed for the study and the zones are probably too small relatively to limit the mammals to one specific zone.

4. Discussion

The main focus of this study was to indicate mammal species presence (larger than mongoose) on the catena studied over three periods that can be used as a basis for further studies. The mammals on the list were divided into two main categories, namely feeding guild and size. Activity patterns of the mammals observed during the study period were covered in another study [3].

Different feeding guilds were represented in the data, from herbivores to carnivores, scavengers (i.e. jackal, hyena, etc.), insectivores, and omnivores. Herbivores were subdivided into the following dietary classes: grazers that feed mostly on grass and herbaceous material; browsers that feed mostly on leaf material from woody plants, including the concentrate selectors (steenbok and duiker) that select the more nutritious plant parts; mixed feeders that feed on grass and browse material; and general vegetarians that feed on plant material, such as roots, geophytes, bark, fruits, etc. Insectivores (feed mostly on insects such as ants and termites, and other invertebrates) and omnivores (feed on plant and animal material) [7, 8] were also noted. If mammals feed on different plant types it usually reduces competition for food resources and they can optimally utilize the diversity in vegetation resources in the same space [8]. These different feeding guilds can indicate a working ecosystem on the catena, especially if it can be linked to different habitats in the zones that include certain abiotic factors. The variety in mammal species were not only evident in the different feeding guilds and dietary classes represented, but also in different size classes noted (Table 1).

The zones of the catena consist of different densities of trees, shrubs and herbaceous plants. The riparian zone had the highest tree canopy cover (33.6% on a 100 m line transect), and the sodic area the lowest canopy cover (2.7%). The shrub veld had a 32% grass cover and the sodic patch 16% grass cover [9]. These zones create different habitats with a specific plant community associated with each zone. Mammal species richness was second highest at the midslope (19 species) followed by sodic patch (16), shrub veld (14), and riparian area (14) (Figure 1a).

Many similar species were observed across the catenal zones, the outcrops and waterholes. A few species could, however, be linked to specific zones or areas. The granite-boulder rock outcrops, and waterholes delivered some species that were absent in the zones on the catena. A higher than expected number of species were noted in vicinity of the outcrops (16 species, Figure 1c), possibly because mammals pass the nearby outcrops *en route* to one of the waterholes. Rock hyrax and klipspringer (their name literary means rock-jumper) are known to be in the area [6] and were expected to be present at these outcrops, because they are adapted to such a xeric habitat, but they were not captured on the cameras and thus not included in the results.

The waterholes had the highest mammal species richness (22 species), but it should be even higher since the smaller mammals were most probably missed because of the way the camera traps were set up to cover the entire waterhole and some of the surrounding area. Water-dependent species require water regularly and can range 5-6 km (non-mobile species: impala, bushbuck, warthog), or up to 10 km distances (mobile species: zebra, blue wildebeest) from water [10]. Some of the listed species (Table 1) will stay close to surface water, i.e. waterbuck and they were not expected at the catena. During the study period, an extreme drought was experienced and some mammals moved out of the study area in search of food and water. Hippo are known to graze several kilometers from water [6, 7], but they were observed quite far from the perennial waterbodies. It was found in the drainage line (riparian zone) of the study area (Figure 1) and at two of the nearest waterholes only during 2016. Mud wallows contained water during the 2015 and 2016 survey periods, but not during 2017. Mud wallows are depressions in the ground that fill with rainwater and hold the water for a certain period thereafter [3]. These wallows were favoured by species that cover their bodies with

mud (i.e. buffalo, elephant, warthog, etc.), while most of the mammals also quenched their thirst at the larger holes on the catena (14 species present in total, Figure 1b).

There were small differences between observations in the different survey periods (Figure 1). The Pareto charts for each survey period included in Janecke and Bolton [3] clearly indicate the differences in species presence and frequency of observations. Most of the differences can probably be ascribed to the extreme drought that reached its peak during 2016 and the beginning of 2017 in this area. Some of the smaller mammals were not observed during this period or with low numbers of observations (four mongoose species, tree squirrel, scrub hare). The vegetation was sparse and the ground bare during the drought, and it could not provide enough cover for mammals, while food resources became limited [3, 9 ,11]. The three waterholes covered in the study still provided drinking water in the drought, since they are filled with undergound water by solar pumps and windmills.

Kruger National Park is a large, open park (almost 20 000 km^2 – [6]) where the movement of mammals through the park is not limited, except if mammals are bound by their own intraspecies territorial boundaries, or by available space [12] and food (due to high numbers of animals, or geomorphological features, or accessibility of food sources), or if they are habitat specific (meaning they can only survive in a specific environment, or vegetation type), to name a few. Thus, a large variety of species that are present in the bigger park, can also be present at the granite catenas, and vice versa. Some mammal species may not have been recorded because of the extreme drought during the study period (lack of predator cover and food availability forced them to leave the area), normal movement or migration (they are only present during a certain season, or opportunistically arrive when conditions are right – which might have been outside the survey periods), or simply because they travelled outside the view of the cameras in the study area. There is thus scope for future studies to add to the basic list of mammals observed during this study to make it more complete, such as to include larger areas, a longer time period, a wetter period with normal precipitation, seasonal variation, other types of animals (i.e. birds, reptiles, amphibians, small rodents, invertebrates), etc. It is also known that the numbers of certain mammals (group sizes) can fluctuate seasonally due to availability of food – in summer they aggregate into large groups, while in winter or when conditions become less favourable, they break up into smaller groups and disperse more widely in search of food [12]. All of these factors and more can contribute to the total variety and species richness of the catenas inside the Southern Granite Supersite of Kruger National Park during different climatic, seasonal or environmental conditions.

5. Conclusions

A total of 33 mammal species was observed in the study area, including the two rhino species. A variety of mammals were present in the study area, but the basic list of mammals provided here can be expanded if a larger area in the same supersite can be included, as well as more camera traps (especially at the waterholes), and longer survey periods (including seasonal and climatic differences) can be used. On the one catena (hillslope) alone, 22 mammal species were found across all four zones, 22 species at the waterholes, 14 species at the mud wallows, and 16 species at the granite boulder outcrops. Some of these species were similar between different zones and areas, while a few species only occurred at the outcrops and waterholes, but were not observed on the catena. The hypothesis, that specific mammal species might frequent or associate with certain zone/s on the catena, could not be investigated properly in this current study probably due to the zones being too small to limit mammals to a specific zone in such an open, natural system. Most mammals also need to pass through certain zones to reach waterholes located outside the catena, but are still in close vicinity. Some species stay close to the waterhole, while others move longer distances away to feed. If more than one catena can be included in future studies, it could provide a better understanding of how these mammals use similar zones on other hillslopes in the area, and how the various feeding guilds interact with the environment on a landscape scale. Small differences were found in mammal species presence between the three survey periods, but the extreme drought limited species richness. The

presence of a variety of different sized mammals (small to mega-sized) from different feeding guilds (herbivores to carnivores and omnivores) and dietary classes (grazer to browser and mixed feeder) most probably indicate a functioning ecosystem consisting of various interlinked trophic levels. All the knowledge from this study can be beneficial in the monitoring and conservation of species in the Kruger National Park.

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