

Factors influencing population dynamics of five antelope species in Ruma National Park, Kenya

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Abstract

Establishing and understanding causal influences on population dynamics of wildlife is essential prerequisite to formulate effective wildlife conservation strategies. This paper investigates how five antelope species (topi, oribi, impala, reedbuck and hartebeest) respond to changes in wildlife habitat, rainfall and competition with other grazers in Ruma National Park (RNP) using data for the past over 30 years (1976 – 2008). Data on habitat change were obtained by analyzing multi-temporal Landsat images from 1973 to 2005. Data on rainfall and population estimates of antelopes were obtained from park records from 1976 to 2008. Data were analyzed using diverse methods including correlation, linear regression and negative binomial regression. Regression analysis showed an overall insignificant increase in topi population, significant decline in the populations of impalas ($R^2 = 0.506$, $p = 0.042$), and insignificant decline in the populations of reedbuck, hartebeest and oribi. Modelling using negative binomial regression showed that the population changes of different antelopes were attributed to different factors except the Oribi whose decline could not be explained by any of the factors considered in this study. The population increase of topi was due to its preference of drier savannah habitat and low rainfall that prevailed in RNP. The population decline of impalas was attributed to decrease in rainfall and habitat change. The population decline of reedbuck was partly due to competition with topi and habitat destruction and degradation through uncontrolled burning and occurrence of droughts that dry out the preferred wetland habitats. The population decline of hartebeest was mainly due to competition with topi. Therefore, there is need to implement management interventions such as prescribed burning, artificial provision of water and translocation of topi to halt further population decline and prevent possible local extinction of affected antelopes in the park.

Key words: Antelopes, Population dynamics, Ruma National Park

INTRODUCTION

Establishing and understanding causal influences on population dynamics is essential in order to make effective decisions on management of wildlife. Past studies (Krebs, 2009; Newman and Macdonald, 2015; Owen-Smith, 1990; Ogutu, Piepho, Dublin, Bhola. and Reid, 2008; The Heinz Center, 2012) have shown that mammal population dynamics is driven by various factors including: rainfall fluctuation, predation, competition for food, habitat change, extreme weather conditions, diseases, and poaching (including bush meat hunting). Rainfall is the main climatic factor governing antelope population dynamics in African savannas (Ogutu and Owen-Smith, 2003; Ogutu et al., 2008; Owen-Smith and Ogutu, 2003). Ungulates have been shown to respond both to cumulative past rainfall and seasonal fluctuations in rainfall through changes in movements, reproduction and survival (Ogutu et al., 2008; Owen-Smith and Mills, 2006). For instance, variability in wet season rainfall controlled the population dynamics of Kudu (*Tragelaphus strepsiceros*) through its effects on food resources in Kruger National Park (Owen-Smith, 1990) whilst annual population changes in many African ungulates are dependent on variation in dry season rainfall (Ogutu and Owen-Smith, 2003; Ogutu et al., 2008). Food availability affected by dry season rainfall limits the growth of the migratory wildebeest population in Serengeti-Mara ecosystem (Mduma, Sinclair, and Hilborn, 1999). These findings suggest that changes in rainfall due to global warming may greatly alter the abundance and diversity of many African ungulates in future (Ogutu et al., 2008; The Heinz Center, 2012).

Although competition can be best studied by subjecting small mammals to experimental conditions (Neill, 1975; Park, 1962), past studies have documented competition for food among ungulates in natural conditions (Hudson, 1976; Sinclair, 1985; Singer, 1979). For example, the migratory wildebeests (*Connochaetus taurinus*) of Serengeti-Mara ecosystem are regulated by intraspecific competition (Sinclair, 1985). However, interspecific competition seems to work together with other factors to shape the structure and size of ungulate populations (Newman and Macdonald, 2015). Sinclair (1985) concluded that the

populations of zebra (*Equus burchelli*), topi (*Damaliscus korrigum*), impala (*Aepyceros melampus*), waterbuck (*Kobus defassa*) and warthog (*Phacochoerus aethiopicus*) in the Serengeti-Mara ecosystem are influenced by both interspecific competition and predation.

Habitat changes that reduce or fragment suitable habitat are likely to negatively affect the survival of relevant species. This may occur due to habitat alterations by (i) other species through overgrazing, removal of cover, or trampling of grass by large mammals, (ii) anthropogenic activities such as burning or cutting of vegetation or (iii) natural causes such as bush encroachment. Such habitat changes will ultimately reduce the species range of available or accessible habitat. The inverse relationship between range size and extinction probability (Gaston, 1994) suggests that range contractions will probably amplify the risk of local extinctions of species, including ungulates (Thuiller et al., 2005). The current advancement in geographical information systems (GIS) and readily available spatio-temporal remotely sensed data has made it feasible to assess more accurately habitat changes in multi-spatial landscapes. Understanding such changes is a vital prerequisite for effective habitat management interventions for species recovery.

The ungulate populations in RNP are subjected to many potential causal factors including poaching, habitat change, predation, lack of surface water, rainfall fluctuations, fires, interspecific competition, and inadequate management regime. However, due to unavailability of data this study focussed only on five antelope species: topi (*Damaliscus korrigum*), bohor reedbuck (*Redunca redunca*), Jackson's hartebeest (*Damaliscus jacksoni*), impala (*Aepyceros melampus*) and oribi (*Ourebia ourebi*). Another antelope that could be studied is the endemic roan antelope (*Hippotragus equinus langheldi*) but this species has already been extensively studied (Allsopp, 1979; Kimanzi, 2011; Kimanzi, 2012; Kimanzi et al., 2013, Kimanzi et al., 2015). This paper investigated how the 5 antelopes respond to changes in rainfall, habitat change and competition with other grazers using data for the past 30 years.

MATERIALS AND METHODS

Antelope population census

The population estimates of antelopes were collected by park personnel once or twice per year from 1976 to 2008. Total ground counts were conducted in 10 animal counting blocks using the method described by Sutherland (1996). Teams counted the animals in the 10 blocks simultaneously using vehicles as well as walking. To minimize counting bias the ground counts were conducted in the morning when most animals were actively feeding. More time was spent in areas with dense vegetation and rock outcrops. The data recorded during counts included census block, species name, and number of animals in each age and sex group.

Wildlife habitat data

Secondary data on wildlife habitat were obtained from Kimanzi (2011), who carried out a study on mapping and modelling of roan habitat and population in RNP. In this study he analyzed four multi-temporal Landsat images using remote sensing techniques to prepare vegetation maps for 1973, 1986, 2001 and 2005. However, the Landsat images of 1973 and 1986 could not be classified into the same vegetation classes as those of 2001 and 2005, due to differences in the sensors used in different years. The 1973 Landsat used the Multispectral Sensor (MSS) whilst the 1986 Landsat used the Thematic Mapper (TM). The other two Landsat images of 2001 and 2005 used the Enhanced Thematic Mapper (ETM+). Therefore, for the purpose of assessing the change in the wildlife habitat that is relevant to the antelopes studied, all the four maps were reclassified into two broad vegetation classes: the grazing habitat (all grassland types) and non-grazing habitat (forest, bushland and woodland).

Rainfall measurements

Rainfall data from 1976 to 2005 were obtained from park records that were collected from daily rain gauges located at the park headquarters. Monthly means were computed for the 30 year-period and used to define four rainfall seasons: long wet season (March to June), short wet season (September to November), short dry season (July and August), and long dry season (December to February) as shown in Figure 1. Apart from these four seasons the park rainfall was also summarized into two other components: annual and prior rainfall. The annual rainfall consisted of rainfall from March to February whilst the prior rainfall consisted of cumulative annual rainfall for 5 years preceding the animal count year. The 5 years were used because Owen-Smith and Mills (2006) showed that the effect of prior rainfall on antelopes is highest about 5 years prior to the count year. Prior rainfall could have a cumulative lagged influence on

the state of the vegetation and hence, on productive capacity of the vegetation (Owen-Smith and Mills, 2006). This will consequently affect the rate of population growth and hence population size.

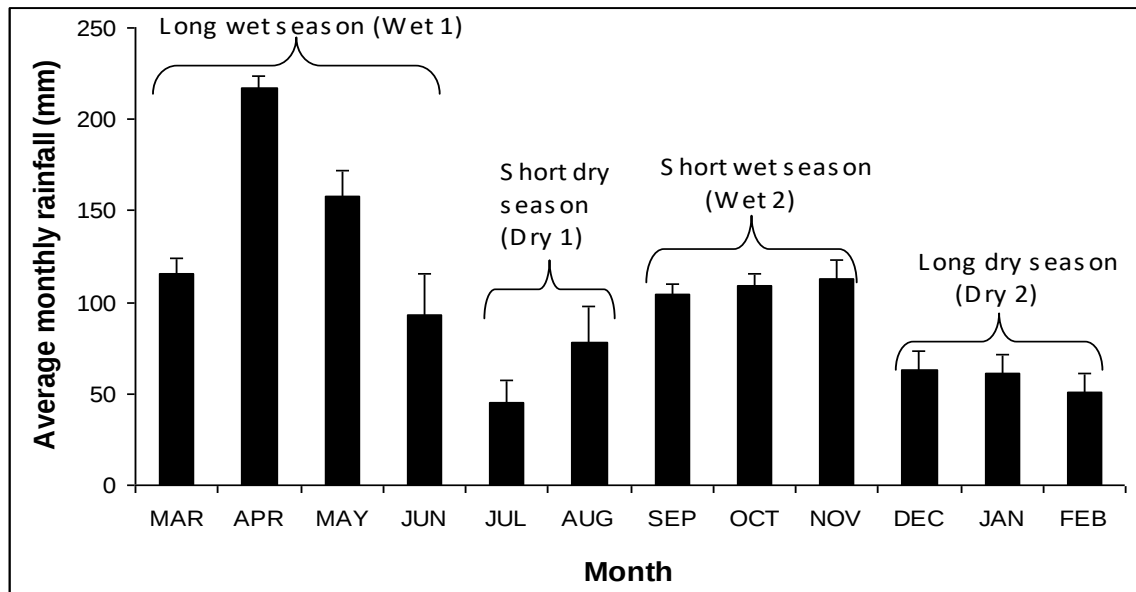


Figure 1: Changes in mean ($\pm$ SE) monthly rainfall for 30 years (1976 to 2005) in RNP. Seasonal rainfall was divided into four seasons.

Statistical data analysis and modelling

Data analysis and modelling involved relating abundance to the various components of rainfall, habitat and assessing how various antelope populations co-vary. Exploratory data analysis was done using graphs, correlation and linear regression analyses. Statistical modelling was carried out in R software for statistical computing (R Core Team Development, 2007) using the negative binomial regression, which has been shown to yield good results with overdispersed data (Crawley, 2007). Preliminary analysis showed that the data were overdispersed, that is, the residual deviance was far greater than the degrees of freedom.

Model assessment

A bootstrapping technique described by Manly et al., (2002) was used to validate the negative binomial regression model results. The idea behind bootstrapping is that when the only information available about a statistical population consists of a random sample from that population, then the best guide to what might be obtained by resampling the population is provided by resampling the sample (Manly et al., 2002). In this study, the technique was performed by resampling (with replacement) the population data to construct bootstrap samples, by leaving out two data values at a time. The coefficients of the bootstrap model were used to assess the variability and bias in the coefficients of the original best model.

RESULTS

Wildlife habitat change in RNP

Regression analysis using estimates from Landsat imageries showed that the grassland habitat (HAB) decreased significantly ($R^2 = 0.913$, $p = 0.003$) from about 9750 hectares in 1973 to 7829 hectares in 2005 (Figure 2). The decline, which was greatest between 1986 and 2001, seems to have been triggered by the long period of below-average rainfall that occurred from 1983 to 1988 (Figure 3).

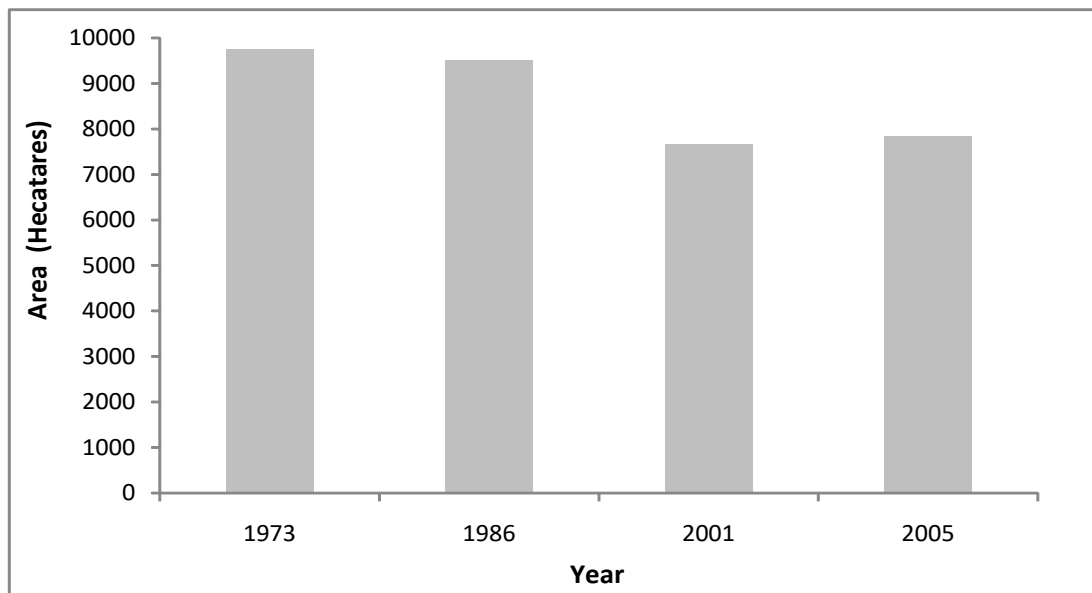


Figure 2: Changes in wildlife habitat (HAB) in RNP from 1973 to 2005

Rainfall fluctuations in RNP

Annual rainfall records (Figure 3) show that there were several years with poor rains in 1979 - 1981, 1985-86, 1987-88, 1999 - 2001 and 2004-05. Also, during the study period (1976-2005) there were three very wet years between 1981 and 1983 and in 1989-90. The fluctuations in the prior rainfall for the past 5 years before the animal count year followed a similar pattern to that of annual rainfall but with a lowest value in 1987-88 and a peak value in 1992-93 (Figure 3). A closer look at the seasonal rainfall records revealed diverse fluctuations in wet and dry season rainfall across the study period (Figure 4). With reference to the long wet season (Wet 1), there were three years with very low rainfall in 1985-86, 1987-88 and 2004-05 and two years with very high rainfall in 1990-91 and 1998-99. For the short wet season (Wet 2) there were four years with poor rains between 1978-81, 1998-99 and 2000-01. Likewise, for the short dry season (Dry 1), 2000-01 had exceptionally low rainfall whereas 1981-83 had relatively high rainfall. Also, for the long dry season (Dry 2), there were three years of poor rainfall in 1980-81, 1982-83 and 1998-1999 as well as three very wet years in 1978-79, 1992-93 and 2000-01.

Regression analysis on the rainfall fluctuations for the 30 years indicated an insignificant overall decrease in the annual rainfall, prior rainfall, long wet season rainfall, short wet season rainfall, long dry season rainfall but a significant overall decrease in the short dry season rainfall ($R^2 = 0.122$, $p = 0.029$). Correlation analysis showed significant positive correlation between the annual rainfall and short dry season rainfall ($r = 0.876$, $n = 30$, $p = 0.002$). There was also considerable but insignificant positive correlation between the prior rainfall and long dry season rainfall ($r = 0.540$, $n = 30$, $p = 0.134$) and annual rainfall ($r = 0.558$, $n = 30$, $p = 0.118$) as well as a negative correlation between the long dry season rainfall and short dry season rainfall ($r = -0.429$, $n = 30$, $p = 0.250$).

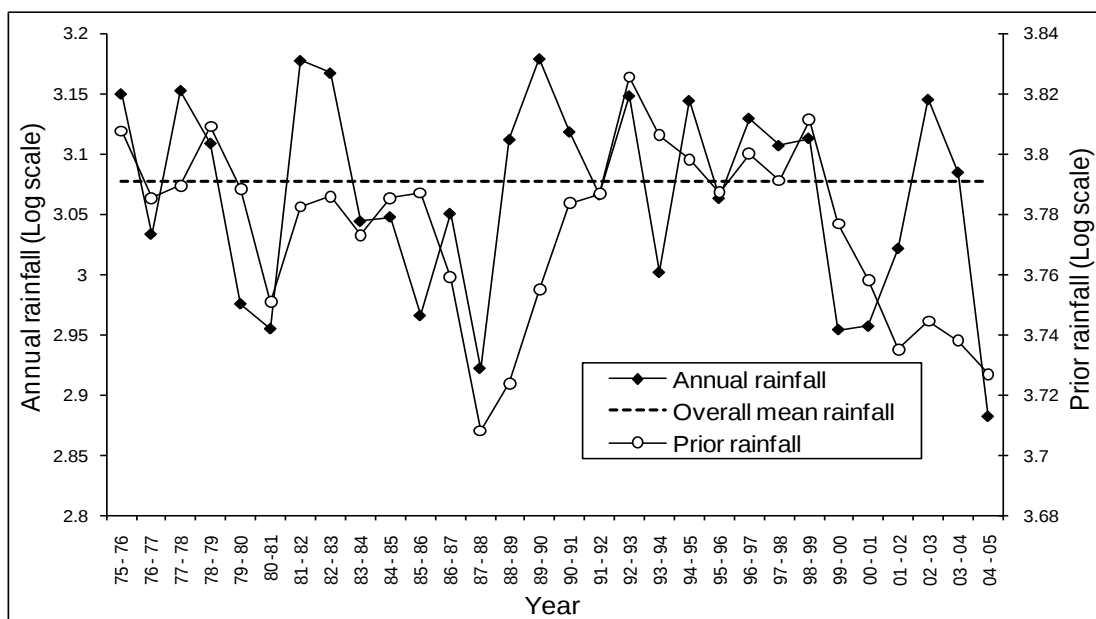


Figure 3: Changes in annual rainfall (ANR) and prior rainfall for the past 5 years (PA5YRS) before the animal count year in RNP. The overall mean rainfall was computed using rainfall for 30 years (1976 – 2005).

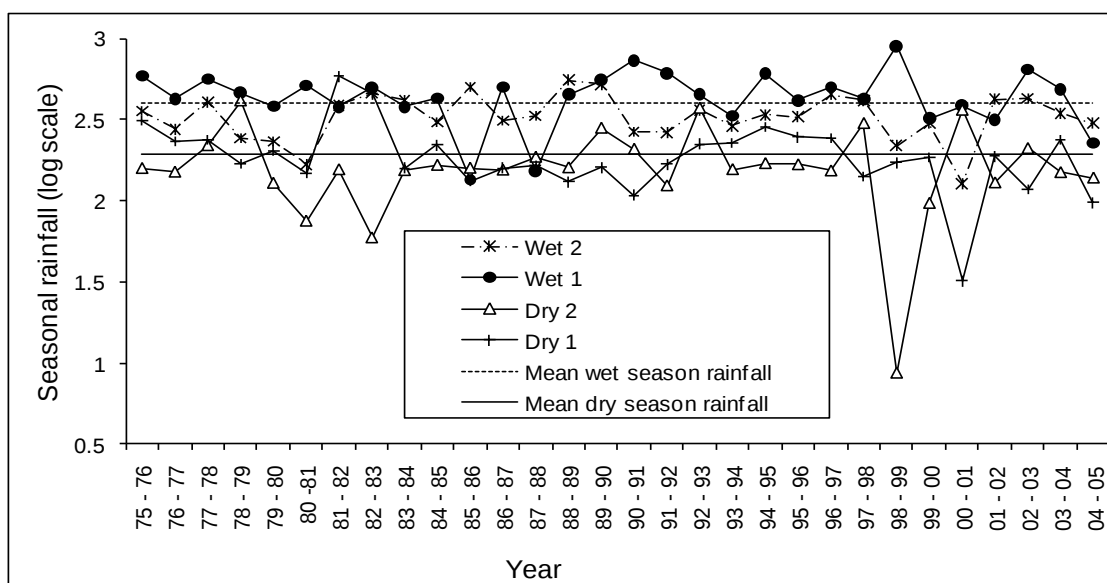


Figure 4: Changes in seasonal relative rainfall (log scale) in RNP. The seasonal rainfall was grouped into four seasons: Wet 1, Wet 2, Dry 1 and Dry2. Details of these abbreviations are given in Figure 1.

Antelopes population changes

Regression analysis of antelope populations in RNP showed different changes from 1976 to 2008, with one species indicating an overall increase and the rest showing overall decrease (Figure 5). Topi showed an insignificant overall increase in population but with small declines in population in 1986 and 1993. There was an overall significant decline in the populations of impala ($R^2 = 0.506$, $p = 0.042$) but with a slight increase in population from 1998 to 2004. There was insignificant overall decline in the populations of reedbuck, hartebeest and oribi. The population of reedbuck and hartebeest showed similar fluctuations with major population increases occurring in 1989 and between 1995 and 1998. The population of oribi was steady from 1976 up to 2005 beyond which it declined precipitously.

Some antelope populations were positively correlated while others were negatively correlated with each other in the park. Reedbuck were significantly positively correlated with hartebeest ($r = 0.721$, $n = 15$, $p = 0.023$) and significantly negatively correlated with topi ($r = -0.661$, $n = 15$, $p = 0.044$). Hartebeest were significantly positively correlated with oribi ($r = 0.716$, $n = 15$, $p = 0.020$) and significantly negatively correlated with topi ($r = -0.686$, $n = 15$, $p = 0.029$).

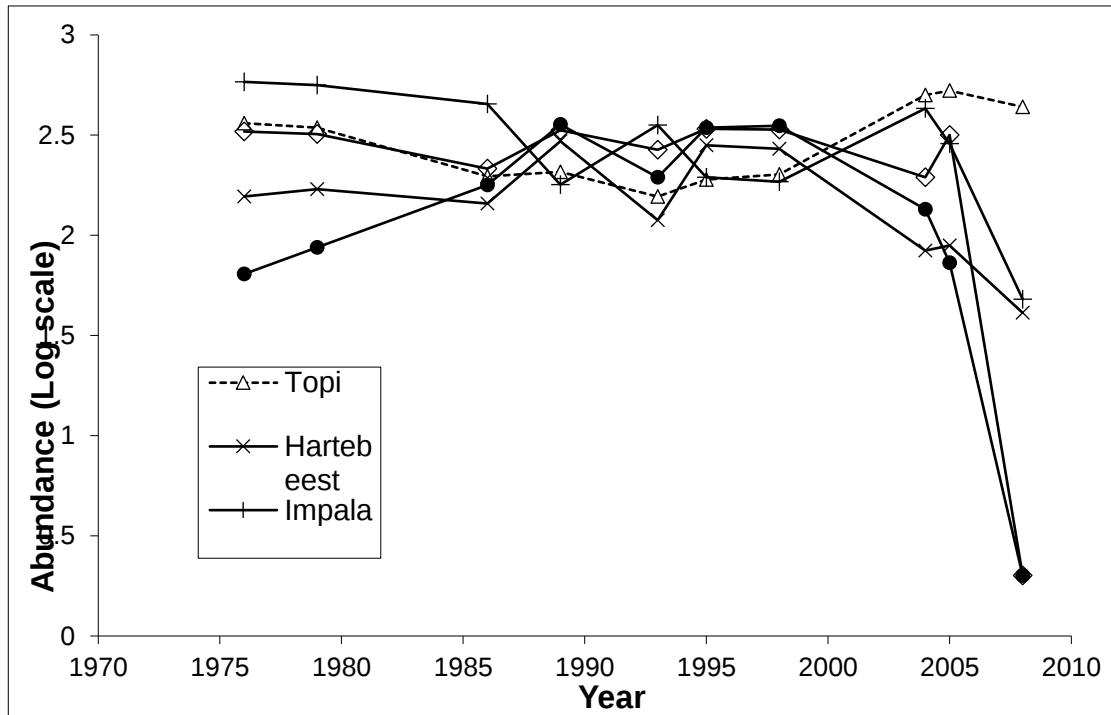


Figure 5: The changes in population (log scale) of topi, impala, reedbuck, hartebeest and oribi in RNP
Antelope population models

Negative binomial regression showed that the population decline of different antelope species was attributed to different factors except the Oribi whose decline could not be explained by any of the factors considered in this study. For some species the best model did not have adequate support or relative likelihood for it to be reliably considered alone for model inference. None of the best models had a relative likelihood equal to or greater than 0.95 (Table 1). Due to model selection uncertainty, the best model plus a couple of other models with AICc differences less than 7 ($\Delta AICc < 7$) were considered as valid models for such species as shown in Table 1.

The fluctuation in the abundance of impalas was attributed to significant changes in rainfall and grazing habitat as indicated by two competing plausible models in Table 1. Details of the predictor coefficients and associated significant values for all the plausible models for the impala as well as other antelope species are presented in Table 2. The Impala abundance was significantly correlated negatively with the long wet season (WET 1), short wet season (WET 2) and annual (ANR) rainfalls, which was against the expectation that high rainfall will boost the population. This negative effect of wet season and annual rainfalls suggests that excessive rains may have caused death of newly born impala through flooding. However, decrease in habitat (HAB) negatively influenced the abundance of impalas in the park as expected.

The abundance of topi was significantly positively correlated with the changes in the habitat but negatively correlated with the five year prior accumulated (PA5YRS), suggesting that this species prefers dry habitats with little rainfall. On the other hand, fluctuations in reedbuck population were significantly positively correlated with both the prior accumulated and annual rainfalls but negatively correlated with habitat change. This implies that rainfall fluctuations are more important for reedbucks than habitat, as the rainfall can influence changes in the habitat. Similarly, the fluctuations in hartebeest population were significantly positively correlated with the annual rainfall, long wet and short dry season rainfalls.

Table 1: Model selection statistics for the population dynamics of antelope species in RNP.

Species	Model	R ²	AIC	ΔAIC	Relative likelihood
Impala	HAB – ANR	0.53	116.18	0.000	0.492
	-WET1	0.34	117.25	1.070	0.288
	-WET2	0.30	117.79	1.610	0.220
Topi	HAB - PA5YRS	0.70	104.64	0.000	0.776
	-PA5YRS	0.51	107.12	2.480	0.224
Reedbuck	ANR – HAB	0.62	108.71	0.000	0.788
	PA5YRS - HAB	0.26	114.61	5.900	0.041
	ANR	0.33	111.77	3.060	0.171
Hartebeest	WET1 + DRY1	0.53	98.23	0.000	0.945
	ATR	0.42	103.91	5.680	0.055
Oribi	-	-	-	-	-

Notice that no variable could explain fluctuations in oribi population. Models considered to be the overall best models are written in bold. Model parameter abbreviations are described in Figures 1, 2, and 3.

Model assessment

The precision of the coefficients of all the variables in the best models was assessed by comparing the coefficients of the original best model with that of bootstrap models. This was necessary to validate the model results. For all the models the coefficients of the original best model were similar to those of bootstrap models (Table 3). The use of 95% confidence intervals confirmed that every predictor that was identified as significant by the original best model was also significant in the corresponding bootstrap models for all the four antelope species. Model performance was also assessed using the r^2 statistic, AICc and relative likelihood values (Table 1). Most of the best models had r^2 greater than 40% while others had high r^2 values greater than 70%. This implied that the models explained a substantial amount of variation in the data. For species with several plausible models only those with an AICc difference ($\Delta AICc$) less than 7 were considered for model inference as these are considered to have substantial empirical support. This implies that if the analyses are repeated with different data sets, these models will still be selected among the best models.

Table 2 shows the parameter coefficients and standard errors for the best models and other plausible models with $\Delta AICc < 7$ for relating the abundance of five antelopes with changes in rainfall components, abundance of other competing grazers and habitat in RNP. Table 3 on the other hand shows the population dynamics models (original best and bootstrap) estimated using negative binomial regression to identify factors influencing the population decline of four antelope species in RNP. Model predictor abbreviations are described in Figures 1, 2, and 3.

Table 2: The parameter coefficients and standard errors for the best models and other plausible models

Species	Model parameters																	
	HAB			ANR			WET1			WET2			DRY1			PA5YRS		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
Impala	0.0005	0.0002	0.0037	-0.001	0.0004	0.0202												
							-0.0015	0.0006	0.021									
										-0.0029	0.0014	0.0352						
Topi																-0.0024	0.0008	0.0028
	0.0003	0.0001	0.0215													-0.0035	0.0008	<0.0001
Reedbuck				0.0014	0.0007	0.0274												
	-0.0006	0.0002	0.0048	0.0021	0.0006	0.0002												
	-0.0006	0.0003	0.0506													0.0041	0.0021	0.0482
Hartebeest				0.0011	0.0004	0.0094												
							0.0014	0.0006	0.0142				0.0023	0.0009	0.0149			

Table 3: Population dynamics models (original best and bootstrap) estimated using negative binomial regression to identify factors influencing the population decline of four antelope species in RNP.

Species	Predictors	Best model				Bootstrap Models			
		Parameter estimate	Standard error	Lower 95%CI	Upper 95%CI	Parameter estimate	Standard error	Lower 95%CI	Upper 95%CI
Impala	HAB	0.0005	0.0002	0.0001	0.0009	0.0005	0.0000	0.0005	0.0005
	ANR	-0.001	0.0004	-0.0018	-0.0002	-0.0011	0.0000	-0.0011	-0.0010
Topi	HAB	0.0003	0.0001	0.0001	0.0005	0.0003	0.0000	0.0003	0.0003
	PA5YRS	-0.0035	0.0008	-0.0051	-0.0019	-0.0039	0.0001	-0.0041	-0.0038
Reedbuck	ANR	0.0021	0.0006	0.0009	0.0033	0.0021	0.0000	0.0021	0.0022
	HAB	-0.0006	0.0002	-0.0010	-0.0002	-0.0006	0.0000	-0.0007	-0.0006
Hartebeest	WET1	0.0014	0.0006	0.0003	0.0025	0.0013	0.0000	0.0012	0.0014
	DRY1	0.0023	0.0009	0.0004	0.0041	0.0025	0.0000	0.0024	0.0026

DISCUSSION

Antelope population changes

Out of the five antelope species studied, only topi population showed a slight overall increase, whereas all the rest showed overall population decline for the past 30 years. Impala populations declined significantly. Oribi, reedbuck and hartebeest showed overall insignificant declines. There is need to disentangle the causes of decline for each affected species and take intervention measures to avert further

population decline, promote population recovery, and ensure a continued existence of viable populations of each species in the park. This is essential to achieve one of the park's main objectives of maintaining high biological diversity.

Topi

The continued existence of high numbers of topi in the park over the past 30 years shows that the park as well as the changes in rainfall, habitat and population of other grazers provides a very suitable environment for this species. The findings of this study concur with earlier studies that have shown that topi prefers drier savannah habitat (IUCN SSC Antelope Specialist Group, 2008^a; Murray and Brown, 1993; Ogotu et al., 2008;) than other antelopes. Therefore, low rainfall scenario in the park may have enabled the topi to out-compete the other antelope species, and consequently increase in number at the expense of the other species. The negative correlation of topi population with both prior accumulated and annual rainfalls suggests that increased rainfall and consequent flooding may have caused deaths of topi individuals especially the newly born young. Results support this hypothesis as there was a very marked increase in annual rainfall between 1988 and 1990 as well as long wet season rainfall in 1994 - 1995 that was followed by a noticeable decline in the topi population in 1989 and 1995, respectively. However, although flooding in RNP may occur occasionally due to its location in a valley sandwiched between hills, this did not seem to cause a significant overall decrease in the topi population. Therefore, the topi population may not be adversely affected like other species by the continuing local and global climate change.

A couple of other factors may have made the topi population to remain stable in RNP. Firstly, they are able to dwell in various habitats including flood plains, dry areas of open savannah and open woodlands (AWF, 2009; IUCN SSC Antelope Specialist Group, 2008^a), which were readily available in the park. Secondly, topis are not only flexible in habitat requirements but also very flexible in reproduction and behaviour, which enable them to quickly adapt to changing environment). For instance, (i) when food supplies are good they conceive at different times of the year with shorter intervals between calves; and (ii) they are able to stall birth process if they sense immediate danger (AWF, 2009). Thirdly, they have precocial young that are able to follow the herd soon after birth without requiring conducive habitat cover for hiding them from predators (Sinclair et al., 2000). Therefore, decline in habitat could not cause decline in young topi population. Last but not least, topi synchronize their births with periods of plentiful food availability (Sinclair et al., 2000). When births occur synchronously then predators become satiated and survival of the remaining newborn animals increases according to the predator 'satiation' hypothesis (Rutberg, 1987).

Impala

The significant decline of impala population can be attributed to combined effects of rainfall and declining habitat. The decline in grassland habitat had a significant effect on the population decline. This is a bit contrary to expectation because impalas are mixed feeders (Murray and Brown, 1993) and therefore the effect of decline in grasses should be counteracted by utilizing more browsing material. Hence, the decline in grassland habitat is likely to have caused greater decline in the young impalas compared to the other age groups, due to exposure to predators. Impalas have non-precocial young (Sinclair et al., 2000), which need to be secluded for more than a week after birth in conducive tall grasslands against predators (AWF, 2009; IUCN SSC Antelope Specialist Group, 2008^b). Therefore, the survival of newly born young depends on availability of conducive tall grasslands for hiding them from predators. This is consistent with the predator 'avoidance' hypothesis (Ims, 1990). The significant decline in grassland habitats coupled with frequent occurrences of unpredictable fires throughout the park especially during the dry season may have contributed greatly to mortality of young impalas due to predation by hyenas in the park and consequently led to impala population decline. However, more research focussing on age-specific survival is needed to yield more confirmatory conclusions.

Impala population decline was also attributed to high wet season rains. Although impalas breed all year round, they have less synchronized births with the birth peaks coinciding with the wet rainfall seasons (Sinclair et al., 2000). This coincidence can be seen as beneficial because it ensures adequate food supplies for the young. However, when the rains are too high leading to flooding, this becomes disastrous for the young impala. A long term study by Ogotu et al., (2008) in Masai Mara National Reserve found out that young impalas drown to death during floods. The modelling results of this study, which shows significant negative correlations between impala population decline and wet season rains, concur with the findings of the earlier study.

Hartebeest

The hartebeest population did not decline significantly, which may suggest that they are better suited than other antelopes in this park. The hartebeest is a pure grazer that is not selective and quite tolerant of poor quality food as well as more tolerant of tall grass and woods than other plains antelopes (AWF, 2009). This makes them able to cope with the dry season, which is a very critical period for the survival of many grazers. In RNP there is low grazing pressure that allows a lot of grasses to grow tall, mature and dry out in the dry season. To utilize these dry season coarse grasses needs a special adaptation. Fortunately, the hartebeests have better skull morphological capability that enable them to utilize more coarse grasses than other antelopes during the dry season when forage availability is lowest (Schuette et al., 1998). Although hartebeests bear young throughout the year, their conception and breeding peaks are influenced by food availability (AWF, 2009; Sinclair et al., 2000), which ensures that many young are born when food is plentiful and hence their survival is enhanced. Since food availability is mainly influenced by rainfall, the modelling results showed that the hartebeest population was positively correlated with rainfall. Their newly born young are precocial (Sinclair et al., 2000) and thus able to follow their mothers without needing conducive breeding habitat for seclusion. Therefore, they employ the predator 'satiation' antipredatory behaviour (Rutberg, 1987) in protecting their newly born young.

Reedbuck

Although regression analysis showed insignificant overall decrease in reedbuck population from 1976 to 2008, the graphical illustrations demonstrate that its population declined precipitously from over 300 animals in 1998 to less than 10 in 2008. Clearly, this indicates that the reedbuck is faced with imminent local extinction in this park, unless urgent interventions are implemented. Failure to detect significant decline in reedbuck population may have been caused by the low population estimates in 1976, which might have been underestimates. Presumably, if the maximum population within the survey period (e.g. 1989 estimate) was used as a baseline, significant population decline of reedbuck will have been found. However, this was not investigated because this would have reduced the sample size to a level where the findings would be questionable. Modelling showed that they are negatively affected by decrease in both annual rainfall and prior accumulated rainfall. Reduced rainfall and occurrence of droughts will cause drying out of wetlands that are the preferred habitats for this species. The natural habitat for reedbucks is wet grasslands or reeds near water bodies (Wildlife Safari, 2010). Monitoring in Kruger National Park has shown that shrinking of these habitats has caused subsequent reduction in the number of reedbucks (Kruger National Park, 2010). Other two factors that could be playing a key role in reedbuck reduction in RNP are uncontrolled burning and poaching via snares. Burning removes the suitable vegetation cover for hiding the secluded non-precocial newly born young, which exposes them to high levels of predation by hyena.

Oribi

Although regression analysis showed an overall decline in oribi population, its population had remained steady from 1976 to 2005 and only showed decline in 2008. However, the decline could not be explained by rainfall fluctuations or habitat change. This implies that other factors, not considered in this study, might have been more important in explaining the overall decline in oribi population. Alternatively, the recorded small oribi population in 2008 may be an underestimate. The census method used in RNP of total counts in blocks was found to yield underestimates for small antelopes in Serengeti National Park, because they are small, secretive and can easily hide in tall grassland (Mduma, 1995). Therefore, the observed steady oribi population for 30 years (1976-2005) could imply that RNP provides a suitable habitat for this species, despite the habitat change and alteration. Studies of habitat preference in South Africa and Tanzania indicated that oribi preferred recently burned areas (Mduma and Sinclair, 1994; Rowe-Rowe, 1982). Therefore, the uncontrolled burning in RNP may be beneficial to this species.

CONCLUSIONS

Apart from topi, that increased insignificantly, all the other antelopes declined significantly (impala) or insignificantly (reedbuck, hartebeest, oribi). The two most important factors influencing antelope population dynamics in RNP are rainfall fluctuations and habitat change. Rainfall affected impala, topi, reedbuck and hartebeest whereas habitat change had impact on impala and topi. Therefore, there is

need to implement management interventions such as prescribed burning, artificial provision of water and translocation of topi to halt further population decline and prevent possible local extinction of affected antelopes in the park.

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