Census and ear-notching of black rhinos (*Diceros bicornis michaeli*) in Tsavo East National Park, Kenya

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Abstract

This paper updates the status of the black rhino population in Tsavo East National Park (NP). Data were acquired through aerial counts of the black rhino between 3 and 9 October 2010 using three fixed-wing husky aircrafts and a Bell 206L helicopter in an area of about 3,300 km^2. Based on previous sightings of rhinos, the area was divided into 14 blocks, with each block subdivided into 400 m transects. An aircraft flying at about 500 m above the ground was assigned to carry out the aerial survey following these transects within each block. Observers scanned for rhinos about 200 m on either sides of the flight paths. Intensive searches in areas with dense vegetation, especially along the Galana and Voi Rivers and other known rhino range areas was also carried out by both the huskies and the helicopter. The count resulted in sighting of 11 black rhinos. Seven of these individuals were ear notched and fitted with radio transmitters and the horns were tipped off to discourage poaching. Three of the seven captured rhinos were among the 49 animals translocated to Tsavo East between 1993 and 1999. The other four animals were born in Tsavo East. Two female rhinos and their calves were not ear-notched or fitted with transmitters. It is recommended that another count be carried out immediately after the wet season as the rhinos spend more time in the open areas while the vegetation is still green. The repeat aerail count is to include blocks north of River Galana.

Key words: Aerial count, black rhino, population size, Tsavo East National Park

Résumé

Ce document met à jour l'état de la population de rhinocéros noirs dans le Parc national de Tsavo Est. Les données ont été obtenues par des comptages aériens de rhinocéros noirs entre le 3 et le 9 octobre 2010 en utilisant trois avions Husky à ailes fixes et un hélicoptère Bell 206L dans une zone d'environ 3300 km^2. En se basant sur les observations précédentes de rhinocéros, on a divisé la région en 14 blocs, chaque bloc étant subdivisé en transects de 400 m. Un avion volant à environ 500 m au-dessus du sol était affecté à la réalisation des relevés aériens suivant ces transects dans chaque bloc. Les observateurs scrutaient les rhinocéros à environ 200 m de chaque côté de la trajectoire de vol. Des recherches intensives dans les zones ayant une végétation dense, surtout le long des rivières Galana et Voi et d'autres zones connues comme des habitats de rhinocéros ont également été effectuées par les avions et l'hélicoptère. Le comptage a permis l'observation de 11 rhinocéros noirs. Sept de ces rhinocéros ont été entaillés à l'oreille et munis d'émetteurs radio et leurs cornes ont été taillées pour décourager le braconnage. Trois des sept rhinocéros capturés étaient parmi les 49 animaux transférés à Tsavo Est entre 1993 et 1999. Les quatre autres animaux sont nés à Tsavo Est. Deux rhinocéros femelles et leurs veaux n'ont pas été entaillés à l'oreille ou équipés d'émetteurs. On recommande qu'un autre comptage soit réalisé immédiatement après la saison des pluies car le rhinocéros passe plus de temps dans les zones ouvertes lorsque la végétation est encore verte. Le comptage aérien doit être répété pour inclure des blocs se trouvant au nord de la rivière Galana.

Introduction

The black rhino (*Diceros bicornis)* suffered a rapid decline across Africa in the 1970s and 1980s, both in population size and range (Okita-Ouma et al., 2007; Milledge, 2007). The population size declined from about 65,000 animals in 1970 to fewer than 2,500 by 1992 (Milliken et al., 2009; Emslie et al., 2007; Milledge, 2007). Between the 1960s and 1992, the decline was less than half in large national parks like Tsavo East and West (Western, 1982; Gakahu, 1993). In Kenya, black rhino numbers dropped from an estimated 20,000 in 1970 to fewer than 400 animals by the 1990s (KWS, 2008; Okita-Ouma et al., 2007; Milledge, 2007). Tsavo East was one of the most severely impacted areas with the population declining from over 5,000 in the late 1960s to about ten animals in 1988 (Okita-Ouma et al., 2007), and only two individuals by 1991 (KWS, 2008).

Earlier in the 20th century, clearing of land for crop farming and settlement was the main cause for the decline of rhinos (WWF, 2004). However, during the last quarter of the 20th century, the drastic decline of black rhino numbers was largely due to the increased demand for rhino horn in the international markets (Vigne et al., 2007; WWF, 2004), resulting in an upsurge in poaching (Milledge, 2007). Other causes of decline have been poor security coverage of the rhino range due to inadequate resources such as finances, vehicles, personnel and equipment (Milledge, 2007).

Overall numbers of African black rhinos in the wild have continued to increase up to 4,200 as at 31 December 2007 (Emslie et al., 2007). Since 1995, the number of black rhinos in Kenya has increased by 55% with an annual growth rate of 4.5% (Emslie et al., 2007). However, populations in the intensive protection zones, especially in Tsavo East NP declined (KWS, 2008).

The intensive protection zone population in Tsavo East was established in 1993 (Brett, 1993). The first group of four black rhinos were translocated from Nairobi NP in 1993 (KWS, 2008; KWS, 2010). Sixteen more rhinos were translocated into the park from Solio in 1994 (KWS, 2008; KWS, 2010) and in 1996 12 were moved from Solio ranch (11) and Ngulia (1) to the Tsavo East free release area. More rhinos were translocated to the park in 1997 (1 from Oljogi), 1998 (1 from Lewa), and 1999 (15; 11 from Nairobi NP and 4 Oljogi) (KWS, 2010). By 1999, 49 black rhinos had been translocated into the park (KWS, 2010). Vigne et al. (2007) reported an estimated 56 black rhinos in Tsavo East NP. These estimates were revised to about 28 animals in 2009 (KWS, 2010). Twenty-seven black rhino carcasses have been sighted in Tsavo East between 1993 and 2010 (KWS, 2010). Most of the carcasses were reported between 2000 and 2006, most of them being because of poaching (KWS, 2010; Okita-Ouma et al., 2007; Milledge, 2007). The high rate of poaching resulted in the need to establish the current status of black rhinos in Tsavo East National Park. This clearly indicates the lack of routine monitoring and location of the Tsavo East rhinos in the period preceding this census, which is a prerequisite for securing and ensuring growth in any rhino population.

This paper outlines the present status of the black rhino in Tsavo East NP, compares our findings with those of Mulama and Okita (2002) and provides recommendations for the future long-term security management of these animals.

Materials and methods

Study site

The census was carried out in Tsavo East NP, South of the Galana River and North of the Voi River, in an area of about 3,300 km^2 (Fig. 1). The park has been described in detail by many researchers (Tolvanen, 2004; Smith & Kasiki, 2000; McKnight, 2000; Cobb, 1976). It was gazetted in 1948 and covers about 12,000 km^2 (Smith & Kasiki, 2000). It contains a high number of endangered and other species, making it an important biodiversity area (Smith & Kasiki, 2000). More than 324 species of birds and 32 species of large mammals occur in the park (Cobb, 1976), including elephants, giraffes, common zebras, Maasai giraffes and black rhinos (Leuthold, 1977; Wijgaarden, 1985).

Most of the southern part of the park is relatively flat with occasional inselbergs dotting the landscape. The lowest plains in the eastern part of the park rise to 150 masl and increase westwards to as high as 1200 masl in the Yatta Plateau (Tolvanen, 2004). The climate of the park has two distinct rainy seasons—the long rains experienced between March and May and the short rains between October and December. The driest months are January and February and June through September. Annual mean rainfall in the park varies according to altitude with the eastern part

receiving about 250 mm while the western part gets about 450 mm (KWS, 2008).

The park is in near semi-arid savannah with sparsely vegetated plains and extensive grasslands with a limited number of year-round water supplies. The Galana River flows through the park and is the major source of water throughout most of the year. Several seasonal streams such as Voi, Tiva and Mbololo, water pans/dams and swamps provide additional water during and immediately after the rains. Bushland/grassland savannahs are the predominant vegetation types whilst the semi-arid *Acacia–Commiphora* woodlands with *Premna, Bauhinia* and *Sericocomorpsis* scrub scattered with *Delonix elata* and *Melia volkensii* trees and interspersed with open plains are also common (McKnight, 2000). Along the rivers and seasonal streams, *Acacia elatior, Hyphaene compressa* and *Suaeda monoica* are commonly found. Vegetation density closely follows relief and rainfall and therefore the western part of the park has more dense vegetation (KWS, 2008).

The proximity of the park to Somalia, which is minimally governed, makes it an obvious target for Somali poachers looking for ivory and rhino horns (KWS, 2008). However, in the period 1975–1984, much of the poaching of rhinos in Tsavo East in particular was carried out by government staff (KWS, 2008).

Data collection and analysis

Data on the number of black rhinos was collected from 14 blocks using three fixed wing Husky aircrafts and a Bell 206L helicopter (Fig. 1). The block map was prepared based on previous sighting of rhinos in the park while road networks were used as boundaries to enable easy navigation. Each Husky carried one front seat observer (FSO) with the pilot assisting in spotting and navigating the aircraft too. Each block was projected to Universal Transverse Mercator (UTM) Zone 37S and a grid of 400 m spacing superimposed on each block. These grids served as transects along which the planes flew during the census period. An aircraft was asigned to each block. Observers scanned for rhinos about 200 m on either sides of the flight paths. Intensive searches in areas with dense vegetation, especially along Galana and Voi Rivers and other specific known rhino range areas were also carried out. All rhino sightings were recorded using a hand held Geographic Positioning Systems (GPS) receiver amd later the location data were downloaded as outlined by ESRI (2006), and ArcGIS 9.1 software was employed to analyze the data (ESRI, 2006).

The area under each counting block was calculated as described by ESRI (2006). Spatial analysis carried out included the creation of a rhino kernel density surface using a search radius of

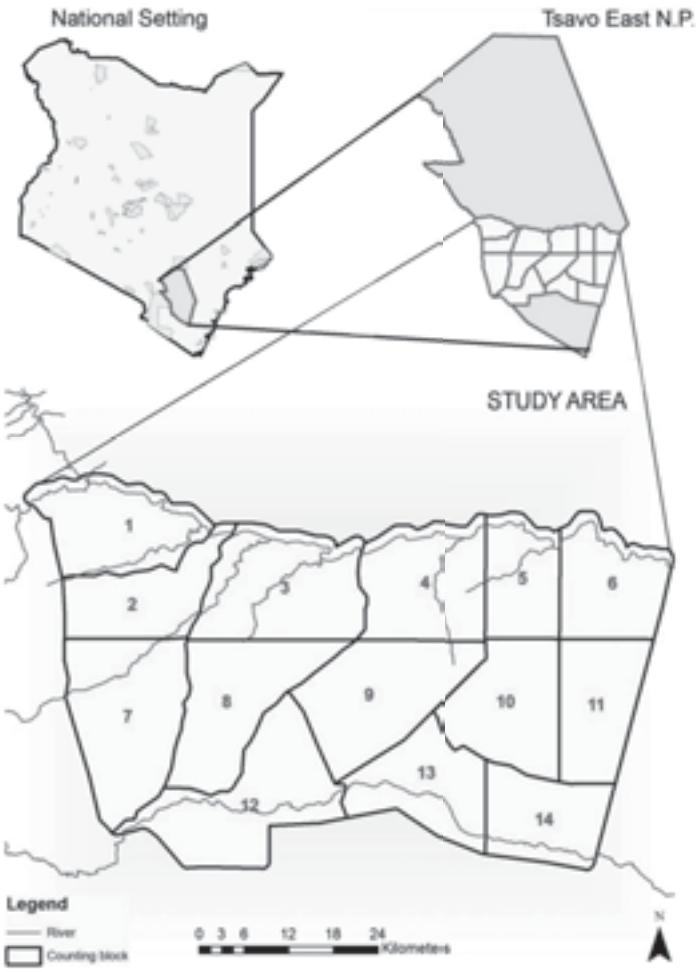

Figure 1. A map showing the study area and the blocks. Note that the aerial count was undertaken in the area between Galana and Voi Rivers respectively, an area of about 3,300km^2.

4.2 km, based on the maximum home ranges of rhinos reported (ESRI, 2006; Linklater et al., 2009). A rhino viewshed was also computed based on an Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) 30 m Digital Elevation Model (DEM) downloaded from National Aeronautics and Space Administration (NASA) site. The kernel and viewshed surfaces were visualized to deduce the location of the rhinos against elevation. Straight line distance surface-to-rivers was created. Distance values were extracted onto the rhino locations as described ESRI (2006).

Lastly, we used the average nearest neighbour (Euclidean distance) spatial statistic to test for the observed distribution of sighted rhinos in the study area (ESRI, 2006; Mitchell, 2005). We used the ratio of the observed mean distance by expected mean distance to establish whether the sightings were dispersed or clustered (Mitchell, 2005), which states that if a ratio is less than 1 the patterns exhibit clustering, but if it is greater than 1 the pattern is toward dispersion (Mitchell, 2005).

Results

The counting blocks had an area ranging from about 160 km^2 to about 320 km^2. The total area covered during the count was about 3,300 km^2. Each day, the three fixed-wing aircrafts flew 21 hours while the helicopter flew two hours. It took about 92 flying hours to cover an area of about 3,300 km^2, which translated to a search effort of about 35 km^2/hr. Fig. 2 presents the flight paths as flown during the systematic aerial survey and intensive search.

A total of 11 black rhinos (5 males, 4 females, and 2 unsexed) were sighted during the count, translating to an overall density of about 0.003/km^2. Out of these, 7 black rhinos (5 males and 2 females) were ear notched and fitted with radio transmitters. One of the two darted females was pregnant. The remaining four rhinos were not ear notched nor fitted with transmitters as they were two females with calves of less than 2 years old. The ratio of cow to calf was about 2:1. Three of the 7 captured rhinos were amongst the 49 translocated to Tsavo East between 1993 and 1999 as they bore the original ear notches from their source. The other four were born in Tsavo East, as they were unmarked (i.e. without ear notches).

The rhinos were sighted in Sobo (block 4), Boma ya Faru (block 3), Balgunda-punda Milia (block 8), and near the Mbololo River (block 3), between Boma ya Faru and Buffalo Wallows areas respectively (Fig. 3). The highest number of sightings were at Sobo and Boma ya Faru areas (Fig. 3). The rhinos were sighted about 0.9–10 km from the nearest river, about 2.8–13 km from dry water pans and about 19–30 km from wet water pans (Table 1). As most of the water pans near the sighted rhinos were dry and the wet water pans were far (19–30 km), the rhinos depended on water from the nearby Galana River. Distances were extracted from the river and water pans surface rasters created from the river and tributary network, dry and wet water pans for the Tsavo East NP. One rhino carcass was also recorded on the floodplains north of the Galana River. Fig. 4 shows the viewshed created based on the probable rhino home range. The nearest neighbour ratio of 2.12 (*Z-score = 6.40; P < 0.05*) was an indication that rhinos in Tsavo East NP were dispersed.

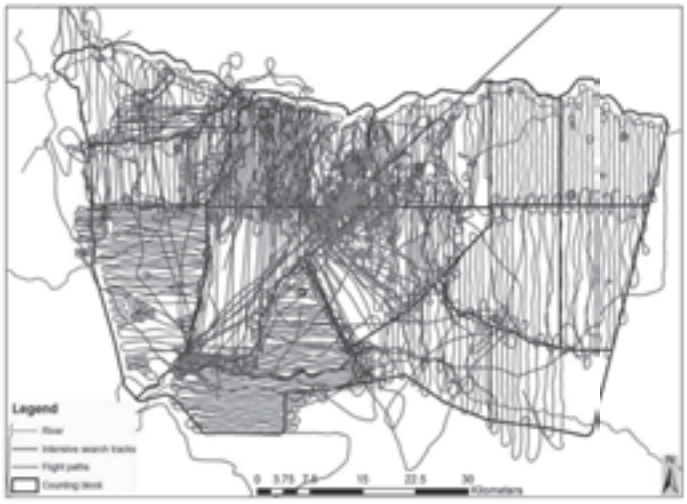

Figure 2. A map showing the flight paths and intensive search tracks that were flown during the aerial count of black rhinos in Tsavo East NP. Circling is an indication of intensive search and thick or tufted vegetation.

Discussion

There is an imminent decline in the black rhino population in Tsavo East NP. The reasons for this drastic decline are fourfold. First, the number of rhino security rangers in the park is below the recommended

Table 1. Distance of sighted rhinos from the nearest river or its tributary, dry and wet water pans in Tsavo East NP (October 2010)

Sightings	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Distance to rivers (km)	0.90	1.03	4.43	4.43	5.26	7.52	9.52	9.85
Distance to dry water pans (km)	12.85	10.85	8.52	5.67	8.88	3.89	2.80	7.35
Distance to wet water pans (km)	19.04	27.29	28.68	29.89	20.06	24.55	27.79	29.37

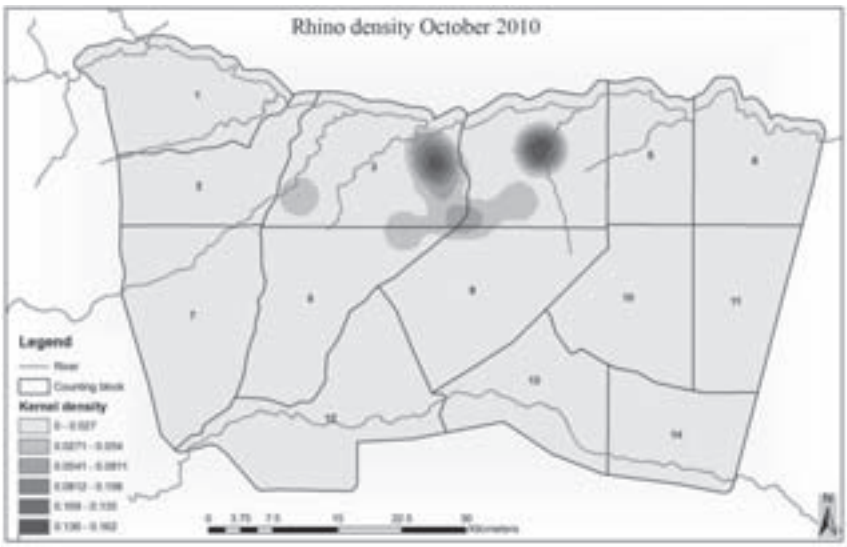

Figure 3. A map showing the kernel density of black rhinos in Tsavo East NP. Higher densities were close to natural sources of water (rivers).

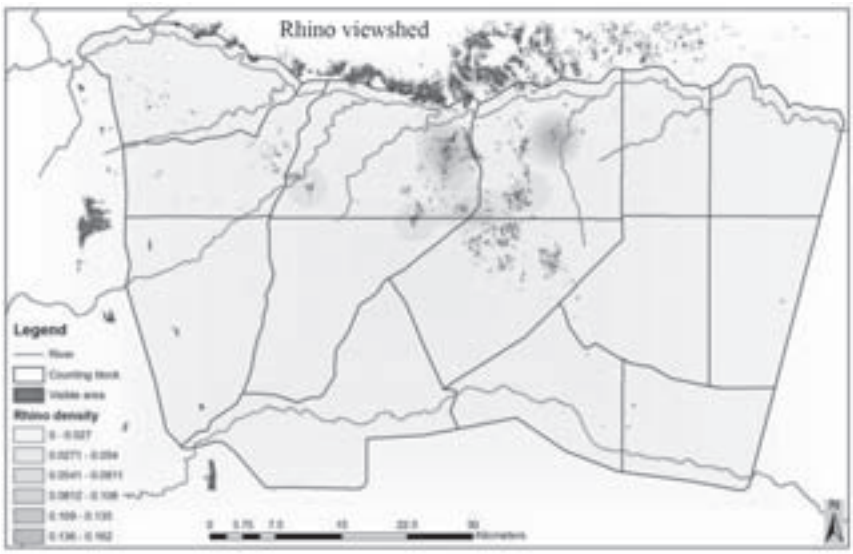

Figure 4. A map showing the rhino density in Tsavo East NP against vantaged visible areas. The visible areas are suitable sites for establishing more observation points to enhance rhino security. The Yatta Plateau borders the northern part of the rhino range and the escarpment offers potential sites for establishing observation points. The escarpment also acts as a barrier to the Galana River (an attraction factor for rhinos), which flows along the escarpment.

level. The minimum manpower density that should be in place for rhino protection is one active, trained and adequately equipped ranger per 20 km² (du Toit et al., 2006). This would have to be increased to one man per 10 km² where poaching pressures are high (du Toit et al., 2006). The 3,300 km² range of black rhinos in the park is expansive. This area requires about 170 rangers as recommended by du Toit et al. (2006). If the area of rhino concentration were to be narrowed down to about 1,100 km², about 55 rangers would be required to effectively provide security for the rhinos. Secondly, the proximity of Tsavo East to Somalia (KWS, 2008) coupled with the low ranger force has made the rhinos therein an obvious target by the Somali poachers (Okita-Ouma et al., 2007; Milledge, 2007). Thirdly, other rhino monitoring resources allocated to the rhino unit are not adequate (KWS, 2008; Okita-Ouma, Amin & Kock, 2007; Milledge, 2007), which limits coverage of the expansive rhino range. Fourth, during the wet season most roads in the park become impassable, further exposing the rhinos to danger.

The nearest neighbour ratio (~2) indicated a dispersed distribution pattern of rhinos in the southern part of Tsavo East NP. This wide dispersion makes the monitoring of these rhinos challenging. The reasons for the observed distribution pattern could be attributed to lack of habitat heterogeneity and/or the territorial nature of black rhinos (Estes, 1991). The dispersed distribution pattern poses a challenge to the understaffed security team entrusted with monitoring this population.

There are four reasons that there could be more black rhinos in the park than were counted. First, two black rhinos are known to definitely range in some areas, but were not sighted during the count (Oyugi pers. comm.; Lelesit pers. comm.). Some of these areas are swamps with mixed habitat with over 50% cover (Mukeka, 2010), which makes it difficult to spot black rhinos from the air. According to Hillman-Smith & Groves (1994), in mixed habitats 60% of daytime locations of black rhinos are in areas with lateral cover of over 50%. Second, it is possible that more black rhinos could have been occupying the riverine vegetation, which has 50% coverage and ridges (Hillman-Smith & Gloves, 1994). These areas have greener shrubs, making an ideal habitat for black rhinos, especially during the dry season. The dense vegetation cover and presence of ridges could have prevented sighting of rhinos from the air. This is supported by findings by Hitchins (1969) and Thompson (1971), who reported a direct relationship between density of black rhino and density of habitat. Densities of $\leq 1.7/km^2$ were reported in thicket habitats in Hluluwe Reserve, which supported about 26% more black rhinos than the open savannah habitat (Hitchins, 1969). Goddard (1967) established that local densities varied from $0.03/km^2$ to $1.3/km^2$ in Tsavo, depending on habitat, and $0.2/km^2$ in Olduvai, with $0.3/km^2$ in the mixed habitat of Ngorongoro. In Serengeti NP, which is more open, lower densities ranging from $0.02/km^2$ to $0.05/km^2$ have been recorded by Frame (1980). Third, the rhinos could have established their home range in the northern part of the park, which this survey did not cover. Assuming that rhinos occur in this area, this population was not counted, which could have contributed to the low numbers recorded. Fourth, the validity of counting black rhinos from the air has been questioned in the past (Goddard, 1967). For example, an aerial counts of black rhinos in Olduvai Gorge in Tanzania—where the population was already known—where 85% of the study area consisted of open plains studded with acacia scrub and *Acacia tortilis*, the results recorded sightings of only 50% of the known rhino population (Goddard, 1967). Therefore, results from aerial count of black rhinos should be treated with extreme caution (Goddard, 1967). It is also important to note that the number of rhinos detected from the air depends on the time of day the survey is conducted, activity and distribution patterns of the rhinos, characteristics of the rhinos, visibility conditions and the aircraft's altitude as discussed in detail by Goddard (1967). Based on the above, it is possible that the number of rhinos counted in Tsavo East could be only 50% of the actual number inhabiting the southern part of the park.

The population has been breeding, which is indicated by the fact that some of the captured rhinos were born in Tsavo East, two calves were sighted and one darted rhino was pregnant. The population is still small and its long term survival is questionable, as small populations are vulnerable to stochastic problems that can endanger their survival (Lacy, 1987). In the short term, environmental and demographic problems are likely to be more serious for small populations of rhinos (Lacy, 1987). Over the long-term, genetic problems will become significant if the rhino population remains small. Preliminary analyses suggest that for black rhinos at least 20–30 effective founders in a conservation unit are

desirable (Cumming, 1987; Foose 1987; Lacy 1987). Therefore, with the current population being below the recommended number, we propose management options as below.

To effectively manage the rhino population in Tsavo East, four options are suggested. These options should be discussed at different management levels and the best options adopted for implementation. The first is to search the possible areas suspected to have rhinos during the next census immediately after the wet season of April–May 2011. The black rhinos spend more time in the open when the vegetation is green (Linklater et al., 2009; Hitchins, 1969). If the number 11 is confirmed, then an additional 9 rhinos can be translocated to the park in order to increase their population to the recommended level of about 20-30 individuals. This should then be followed by enhanced security of the rhinos through available recommended staffing levels, finances and equipment. Second, the rhinos can be translocated to the Tsavo West NP intensive protection zone (IPZ). However, this option will likely result in poachers' crossing over from Tsavo East NP to Tsavo West NP, therefore exposing rhinos in the Tsavo West IPZ to poachers. The third option would be to establish a rhino sanctuary in Tsavo East followed by translocation of about nine rhinos into the sanctuary as well as providing recommended security personnel, finances and equipment. This will ensure that the recommended founder population of black rhinos is achieved and sustained for their long-term survival. The fourth option is to maintain the free ranging population but increase the KWS ranger force to the recommended levels and avail adequate financial resources and monitoring equipment.

Conclusions

In this paper we describe and explain the status of the black rhino population in Tsavo East NP. The population decreased by about 81% between 2001 and 2010. The main reason for the drastic decline is poaching. The minimum population of black rhinos in the park is 11 animals, whereas we estimate a maximum population of 15 to 20 animals. Provision of more resources (rangers, finances, vehicles and other equipment) as well as reviewing the park's security strategy will decrease the vulnerability of rhinos in the park.

Recommendations

In order to re-confirm the number of black rhinos in Tsavo East NP and secure the population, we recommend the following:

- Conduct a further census and fitting of transmitters after the next wet season with focus north of the Galana River and thickets.
- More security rangers to be posted in and around the rhino range to attain the recommended number for available rhinos.
- Apply more resources (finances, vehicle and other security patrol equipment) to the rhino surveillance team.
- Establish the actual rhino home range from the individuals fitted with radio transmitters.
- Review the current rhino security strategy and move patrol bases to the periphery of the rhino range.
- Establish more observation locations at raised ground vantage points where it is possible to sight rhinos and poachers using powerful binoculars or Internet protocol cameras.
- Split the ranger force into smaller units that can be placed strategically throughout the rhino range because monitoring these widely dispersed rhinos is a challenge.

Acknowledgements

We would like to thank the Director KWS, Julius Kipng'etich for approving funds to carry out this census. We thank all the personnel from Tsavo East Rhino Unit, the Wildlife Protection Unit, Biodiversity Research and Monitoring Unit, and KWS Headquarters (GIS and Species Department) for their participation. Special thanks go to Pilots Kennedy Shamalla, Moses Lelesist, Major (Rtd) Solomon Nyanjui, George Mwangi and Daniel Woodley for making the survey successful. Comments from Dr Samuel Kasiki on the first draft of this paper are greatly appreciated.

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