Distribution and abundance of larger mammals in Kuzikus Wildlife Reserve

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Abstract

An estimation of larger herbivore abundance has important game management implications for wildlife managers in Africa. The current study compared different methods to estimate animal density in Kuzikus Wildlife Reserve situated on the edge of the Kalahari Desert in Namibia. The aim was to estimate animal abundance accurately and test the suitability of methods. The number of pellets on cleared areas around waterholes (clearance plots) proved to be an unreliable index method, but can be useful for information about rare species occurrence and distribution. The index obtained with road detections and tracks on clearance plots coincided with the data obtained by distance sampling in that the Springbok is the most abundant species on Kuzikus. Distance sampling was employed to obtain an estimate of abundance, calculating a detection probability curve for three species. Index methods, such as road detections are recommended to perform in addition to a distance sampling analysis as this can provide information about bias. Management implications are discussed.

Introduction

Accurate assessment of larger mammal populations is crucial for the success of environmental monitoring programs and wildlife management strategies in Africa. The difficulty in counting animals is that animals move and are not always detected. Walking line-transects for a distance sampling analysis is a method that confronts the problem of variation in animal detection. This technique has a strong theoretical background based on the principle that less animals are detected the further away they are from the observer (Buckland *et al* 2003). The prerequisite is that all animals on the line are detected with a 100% probability. A detection function is plotted for each species under study, whereof a density estimate can be drawn, given that animals are detected in their initial location and that measurements are correct. Alternative methods such as dung count, number of animal tracks and animal road detections provide an index of animal population (Krebs 2006).

Most studies using distance sampling were mainly performed in woodland habitats in East Africa and Central Africa (Waltert *et al* 2008, Plumptre 2000). To the authors' knowledge, the applicability of this method on game reserves in open African savannah ecosystems has not been tested so far. The main aim of this study was to perform a distance analysis of life mammal on a wildlife reserve in the Namibian Kalahari Desert in order to test its applicability and to provide density estimates for species important to wildlife management in the reserve. Data was collected for one month during September. The method was compared to simple index methods including dung and tracks around waterholes and animal detections on roads. Index methods can be useful in providing data about animal presence and absence, as well as in detecting animals that remained undetected in line transects and indicating caveats in a distance analysis (Waltert *et al* 2008, Focardi *et al* 2002, Plumptre 2000). Accumulated abundance data over the years can reveal population trends on the game reserves. Once the feasibility of the applied methods are tested, they can further be employed on different wildlife reserves, comparing population trends and impact of different management regimes such as hunting, game catching or both.

3 Methods

3.1 Study site and species

Kuzikus Wildlife Reserve is situated in the Namibian Central Kalahari Desert, 180km south-east of Windhoek at 1380m above sea level. The reserve is a 10 000ha fenced area, with the fence being about 2,4 meters high. Kuzikus is characterised by grass-covered dunes, salt-pans and *Acacia*-dominated savannah. The must abundant *Acacia* trees and shrubs are *A. erioloba, A. melifera, A. hebeclada, A. karoo*. Non-Acacia plants include *Boscia albitrunca, Grevia flava* and the introduced *Prosopis spp (Fabacea)*. Grasses that dominate the landscape are *Stipagrostis* and *Aristida*.

Kuzikus is home to larger herbivores such as Giraffe (*Giraffa camelopardalis*), Common Eland (*Tragelaphus oryx*), Greater Kudu (*Tragelaphus strepsicerus*), Blesbok (*Damaliscus pyrgagus phillipsi*), Springbok (*Antidorcas marsupialis*), Impala (*Aepycerus melampus*), Blue Gnu (*Gonnochaetes taurinus*), Black Gnu (*Gonnochaetes gnou*), Red Hartebeest (*Alcelaphus buselaphus*), Gemsbok (*Oryx gazella*), Burchels Zebra (*Equus burchelli*), Steenbok (*Raphicerus campestris*), Common Duiker (*Sylvicapra grimmia*) and the Black Rhinoceros (*Diceros bicornis bicornis*). In general, antelopes exhibit similar herd behaviour, such as forming bachelor herds, herds of females and young and territorial males. In Zebra, the group structure comprises small bachelor herds and female herds with a dominant stallion. Wildebeest species tend to form large herds up to 200 animals varying with food abundance (Estes, 1984).

Wildlife on Kuzikus is managed through hunting, game catching and translocations (*pers. comm*). The reserve is run as a tourist lodge, with no more than 10 tourists at a time. Daily game drives with a single car and walks with maximum 4 people are made throughout the reserve. The most common roads used for tourism are indicated (Figure 1).

The current study was carried out during the period of 8th September and 3rd

October 2009 daily and lasting between 8:30 to 10:30 in the mornings and 15:30 – 18:00 in the afternoons. Temperatures ranged from 11.9°C to 41.2°C during field work. The total rainfall in September was 20mm and humidity ranged from 2% to 63% during field work.

3.2 Index methods

To give an index about animal abundance, the number of tracks and pellets were recorded on clearance plots around three different waterholes in the reserve. The ground around waterholes was mainly sandy due to animal activity and soil erosion, which enabled to visualise tracks. Furthermore, waterholes were chosen as this increased the likelihood of detecting animals drinking overnight. Two plots were placed in each wind direction, giving a total of eight plots per waterhole. The plots were set five meters away from the water source and each other to ensure independence of plots. Plots were cleared of all tracks and pellets and the corners were marked with stone piles. Animal tracks were recorded the morning after the clearing. The length and width of the footprint were measured for species identification and the number of footprints (track) across the plot was counted. After an exposure time of four and seven days (after recommendations of Nunes & Skeats, 2009) animal pellets were identified and counted.

Another index method employed was road detections. When driving on roads in the reserve to the transect lines for distance sampling, all animals seen were recorded on a digital recorder (MicroTrack) taking species, location (road number), date, time and temperature. The mean number of animals seen per road was plotted.

3.3 Distance sampling

A systematic grid was superimposed on the map of the region covering a total area of 100km2 (Figure 2). Twenty squares of the grid (3.4 km2) were randomly selected in which the line-transect was placed centrally. Transects were 500m apart from each other, decreasing the likelihood that an animal was counted on more than one transect. One transect line was not walked as a Black Rhino was spotted on the line and posed too much danger. Similarly, transect on the west side of the reserve (refer to Figure 2) were omitted due to great activity of the Black Rhino. With the exception of 2 transects due to Rhino activity each line was between 1.13-1.25km, the length of which was 40 seconds on the GPS grid. Transects were repeated twice to obtain enough detections for the distance analysis and to account for varying detectability of animals (repeat 1 from September 7th to 19th, repeat 2 from September 21st to October 1st , refer to Appendix I). The total survey effort equated 40.49 km of 19 samples (38 transects). A line was walked between a Northern and Southern pole on the first repeat and Eastern and Western pole on the second repeat. The line-transect was walked against the wind when possible to remain undetected by animals. Transects that were walked in the morning on the first repeat were switched to the afternoon for the second repeat. This accounted for differences in animal activity/behaviour at the different times.

Prior to walking the line transects, observers were given 1 day training in basic field techniques. This included using the GPS (Global Positioning System), laser range finder and learning animal identification. During each transect, the same project leader was present.

The sighting distance, angle and cluster size were recorded once an animal was detected. Taking the angle to the animal and sighting distance, the perpendicular distance to the line could then be calculated using the Pythagoras theorem. The angle was taken using the compass function on the GPS, the sighting distance using the range finder and each observer counted the number of animals seen. Ancillary information such as age, sex and unusual features were also recorded where possible to aid in identifying each animal or group as individual and avoid recounting on the transect. A weather station was used to record the date, time, temperature and humidity for each sighting. Wind pressure (using the Beaufort scale), wind direction and cloud coverage were also estimated by the observer. Species identification and equipment use was verified by the project leader.

After the line transect had been walked in one direction, vegetation was recorded when walking back to the starting point. This was done at approximately 400m intervals, stopping 4 times to record the vegetation to give a broad description of the habitat.

The statistical software DISTANCE 5.0 (Laake *et al* 1993) was used to estimate density of the most abundant species (Springbok, Oryx and Blesbok) following the analysis approach and recommendations of Buckland *et al* (2003). For the model definition properties, cluster size for each species was taken as mean cluster size, as there was no evidence of a size bias. Data from the two repeats to each line was pooled as recommended by Buckland *et al.* 2001 to increase animal detections. Data was grouped into distance classes to improve model robustness (Buckland *et al* 2001). All data was right truncated by eye with a minimum of 5% of the detections. Half-normal, hazard rate, uniform and negative exponential key functions with cosine or simple polynomial adjustment terms were used to obtain a fit for the detection functions. The best fitted model was selected using the lowest Akaike Information Criterion (AIC), high Chi-squared goodness of fit values and low variance. The best models were then used to calculate density and estimate animal abundance on Kuzikus.

Vegetation zones were classified according to the dominant tree or shrub species using the same transect lines as for distance sampling. Every 250m on the transect line all trees and shrubs were counted within 30m radius (0.3 ha). Animal detections on line transects falling into these vegetation zones were grouped to visualize trends in habitat use.

4 Results

4.1 Vegetation zones

Acacia erioloba, Acacia melifera, Acacia hebeclada and *Grevia flava* were the most common plant species found (Figure 3). Vegetation zones were classified by eye combining these four species of bush and tree (Figure 4). Hereby line transects were grouped into vegetation zones in order to relate animal distribution to vegetation.

4.2 Line transects

Eleven species of antelopes including Zebra were detected during line transects with a total of 510 detections (Table 1) and 1606 animal counts. Only three species had more than 60 detections. Five species were encountered more than 20 times and two species had 11 and 13 detections. Eland and Giraffe were encountered more frequently on roads than on line transects (refer to road detections).

4.2.1 Animal Distribution

Animal distribution of the most common species was related to vegetation zones (Figure 5). Animal count was pooled across transects that were grouped into vegetation zones and the mean count per vegetation zone was taken for the distribution data. Springbok occurred throughout the area with a peak around the Main Gate and Hebeclada region. The Dunes and Pan 1 also had mean count of 35 animals. Similarly, Oryx was distributed evenly across the reserve, however in fewer numbers than the Springbok. A peak occurred in the Grassland area. Blesbok preferred the Dune, Erioloba and Grassland area and was hardly seen around the Pan environments. Blue Gnu herds were seen in the Dunes and the Erioloba tree dominated region as well as in Pan 1. Herds of Black Gnu mainly occurred in the Northern region of the reserve and by the Vulture Waterhole. Smaller herds of Zebras were detected by the Main Gate and Main Road as well as by the Pan 1 and *A. erioloba* dominated region.

4.2.2 Distance sampling

The keys that provided the best fit to the distance data to the three species with sufficient detections (>60) are presented in Figure 6. Density estimated was done for Springbok, Blesbok and Oryx (Table 2). There was no evidence of size bias for either species. Therefore the mean cluster size was used in the analysis. The Springbok was the most common species in Kuzikus with a density estimate of 0.14 animals/hectare. Oryx and Blesbok were about equally abundant with a density estimate of 0.07 and 0.08 animals/hectare respectively.

4.3 Road detections

In total, road detections were recorded for eight days on 18 roads and three waterholes. Note that some roads were repeated (Table 3). Twelve ungulate species were seen including the Springbok, Blesbok, Oryx, Blue Gnu, Black Gnu, Zebra, Hartebeest, Kudu, Giraffe, Eland, Impala and Steenbok. In total 905 animals were counted.

4.3.2 Animal Distribution

The roads were put in relation to vegetation zones visually. The same roads were visited up to five times.

Animal count per vegetation zone was plotted to illustrate animal distribution based on road detections (Figure 9).

Springbok were seen mostly in the Hebeclada region. Oryx were evenly distributed throughout the vegetation zones. No Blesbok was seen in the Dunes and in Pan1. Large Gnu herds were found in the region of Hebeclada and South. Similarly the Black Gnu occurred mainly in the Dunes and in the South. As with the Blue Gnu, Zebras were found in the *A. hebeclada* dominated environment and in the South of Kuzikus.

4.3.1 Index

Road detections indicate that Springbok and Oryx are the most common species found on Kuzikus (Figure 8). Blue Gnu and Zebra count was high followed by the Blesbok.

4.4 Tracks and pellets

Analysis of data of tracks and pellets revealed that the Springbok is most frequently detected on Kuzikus (Figure 10). Oryx were almost as many as Springbok, whereas no pellets of Oryx was found on clearance plots. The number of tracks of Blesbok was not more that of the other species detected. For both tracks and pellets the Steenbok and the Common Duiker were detected. The pellet data suggests that the Common Duiker is the most abundant species after the Springbok. No pellets of the Blue Gnu was found in clearance plots.

5 Discussion

Open savannah ecosystems seem to be ideal for walking line-transects as vegetation is sparse where animals can be detected easily and the ground is even, so that the observer can concentrate on animal detections. Such regions occur throughout the Kalahari Desert. The current study on Kuzikus Wildlife Reserve provides evidence that distance sampling can be a good technique to estimate abundance and density of larger mammal species in an open Savannah ecosystem.

Density and abundance was estimated reliably for two species: Springbok and Blesbok. Abundance estimates of other species need a higher rate of detection, as the recommended number for a reliable estimation of density is over 60 detections (Buckland *et al* 2003). This was obtained for three out of eleven species in the current study. An increase in detections can simply be achieved by more sampling repeats or by pooling seasons or years.

Animals, in turn, that detect the observer first, can pose a problem and might be a downside to open Savannah ecosystems. For reliable estimation of density, the distance sampling analysis relies on the broad shoulder around distance zero. The histogram of the Oryx – with over 60 detections - shows that there is no such shoulder around distance zero. Its estimation of density might therefore be unreliable, also supported by the high coefficient of variation. Here, more animals were detected further away from the line around 100 meters, where after the graph drops down. This is evidence that animals were not detected in their initial location – a violation of an assumption for distance sampling. This can lead to an underestimation of density (Buckland *et al* 2003). Oryx might have detected the observer first and then ran away a little. There is no such evidence for Springbok and Blesbok. Oryx seem to exhibit slightly better eyesight than Springbok (*pers. comm.*) and animals might have seen observers before smelling. This makes sense given the higher statue of the species. Better eyesight is further supported by the fact that there was no significant difference in animal detections when walking with the wind or against the wind (refers to appendix II). Furthermore Oryx are hunted more frequently on the reserve than Springbok or Blesbok and therefore might be more sensitive towards people on foot. An mere increase in detections might overcome the problem, as other studies also recommend repeat surveys for an increase in precision (Waltert *et al* 2008, Plumpre *et al* 2000) Else a different method needs to be employed for a reliable abundance estimation of Oryx.

A better eyesight might also be the reason why only one Giraffe was detected on foot on all the line-transects, whereas by car many Giraffes where seen. Giraffes like most other ungulates are habituated to tourist cars on the reserve and in general, animals respond differently to cars than to humans on foot (Beat about the bush). Human movement on foot is not as smooth and agile as animal movement and animals seem to notice that.

Data on road detections also show detections of Hartebeest and Kudu; species that were not detected during foot surveys. The indexes obtained by road detections coincide with the line transect data, showing that Springbok were the most abundant species on Kuzikus. However, line transect data shows that there should be more Blesbok than Oryx, whereas road detections suggest that there are more Oryx than Blesbok. This might demonstrate that road detections can be useful to see caveats in a distance analysis, given that the abundance estimation of Oryx has a high coefficient of variation and seems less reliable. Note that Blue Gnu and Zebra count on road detections can merely be so high because of herd building. The animal counts from the car on roads can be a useful indicator for reliability in distance analysis methods, also given that cars are less likely to cause disturbance due to habituation. Furthermore, road detection do not pose an extra survey effort to the observer as data was recorded while driving to the line-transects.

Tracks and pellet data also showed that Springbok was the most abundant animal on Kuzikus. No pellets were found of Oryx and according to the index, Blesbok is equally abundant to Kudu, Impala and Hartebeest, all species that were rarely detected on line transects and road detections. Furthermore, pellet data suggest that the Common Duiker is as abundant as the Springbok, whereas, again, this is not supported at all by the other two methods. The number of tracks is in accordance with the data obtained b road detections and by distance sampling indicating that the Springbok is the most abundance animal on Kuzikus. However, track data needs to be treated with care and identification of species might not be reliable. Sand around waterholes was often very deep so that tracks could not be measure accurately. Sometimes, plots were contaminated with too many tracks or tracks of vultures. The number of pellets around waterholes, does not provide a reliable index on animal abundance. However, its caveat might lie in the fact that clearance plots were placed closely around waterholes. The Oryx, for example, is independent of water (Estes, 1984) and the Common Duiker often places its territory around waterholes (Estes, 1984). Yet, tracks and signs can be useful to detect animals that are not otherwise seen such as the Impala. To achieve a better index, however, future studies should consider distributing clearance plots randomly across a habitat, rather than around waterholes, to ensure independence of plots, avoiding encounter with territorial species and contamination of too many tracks.

The line-transect method provides more data about animal distribution that the road detections. Both methods indicate that the Springbok is equally distributed throughout the reserve. However, interestingly road detections show a peak in an area dominated be *A. hebeclada*, whereas the line-transect data suggests that animals prefer *A. erioloba* habitat and the Pan 1 environment. However, these differences might be due to variation in detection, considering that the Pan 1 in road detections was only visited once and that roads might not exactly correspond to the line transect data. The Oryx occurs equally abundant throughout the reserve as indicated by both methods. The line-transect data provides a more detailed insight on animal distribution, largely because more data was collected. According to both methods, the Blesbok does not prefer Pan and Melifera environments. However, line-transect data suggests that Blesbok prefer Dunes which cannot be seen in road detection. This is a consistent difference between both methods for all species under study and might be due to the fact that the road allocated as dune environment only traverses the edge of the area instead of traversing through it. In fact, line-transect data shows that many Springbok, Oryx, Blesbok, Blue and Black Gnu roam in the Dunes not evident in road detections. Dune might be preferred by many animal species due to low human activity in this area of the reserve, including tourist game drives and hunting. Rain might also be a factor, as many animals migrate with rainfall and food abundance and Dunes received a lot of rain in the previous season (*pers. comm.*). Again, it needs to be mentioned that species of Gnu and Zebra can occur in large herds, which boost the animal count. Data of road detections shows that Zebra often occurs in the same areas as the Blue Gnu. Indeed, Zebras like to associate with the Blue Gnu as they like to feed in the areas where Wildebeest has grazed. Zebra also loose eyesight at dawn, and therefore aggregate with species that have better eyesight and similar herd structure.

For animal distribution, better data is gained from line-transects than from road detection. However, road detections can provide additional data on occurrence and compensate for variation in detectability. This is demonstrated by the detection of a large Blue Gnu herd in the South, which remained undetected on line transects.

6 Management Implications

For management purposes, such as game catching, it is recommended to base the animal abundance estimation of Springbok on the lower bound estimate of the 95% confidence interval. Spingbok can show extensive movement across large areas (Estes, 1984). Therefore the equal distribution of Springbok in Kuzikus can also be a result of movement and therefore double counting in the line-transects. Though there is no evidence for this, data should be treated with care. Unlike Springbok, Blesbok tend to exhibit a localised behaviour (Estes, 1984). However, current distribution data shows that the Blesbok is not evenly distributed across the reserve. This can influence results on abundance estimation, as a detection function was calculated globally – for the whole area – and data was not stratified according to vegetation zones. The number of Oryx is likely to be similar to the abundance estimate of Blesbok, as movement during line-transects can result in an underestimation of animal number. To be on the safe side for management purpose, it is recommended to stick to the lower bound values of the estimation (Springbok N ≈ 1037, Blesbok ≈ 542, and Oryx ≈ 500).

Future studies should resample the same transect-lines in order to detect and increase or decrease in animal population. Distance analysis seems to be a feasible method to estimate abundance of the most common species. To gain more precision in estimates, it is recommended to increase the number of repeats or carry out the same study twice a year and pool data.

Road detections when driving to and from a line-transect are useful to gain an independent insight into animal distribution, number and animal behaviour. Data can be used to realise and backup problems in the distance analysis. Even though animals are habituated to car noise, it is still recommended to do surveys on foot, as transect lines need to be randomly distributed across the area to avoid bias. After years of data collection using the same method, animals probably get habituated to researchers walking line-transects.

7 Acknowledgements

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8 References

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9 Graphs and Tables

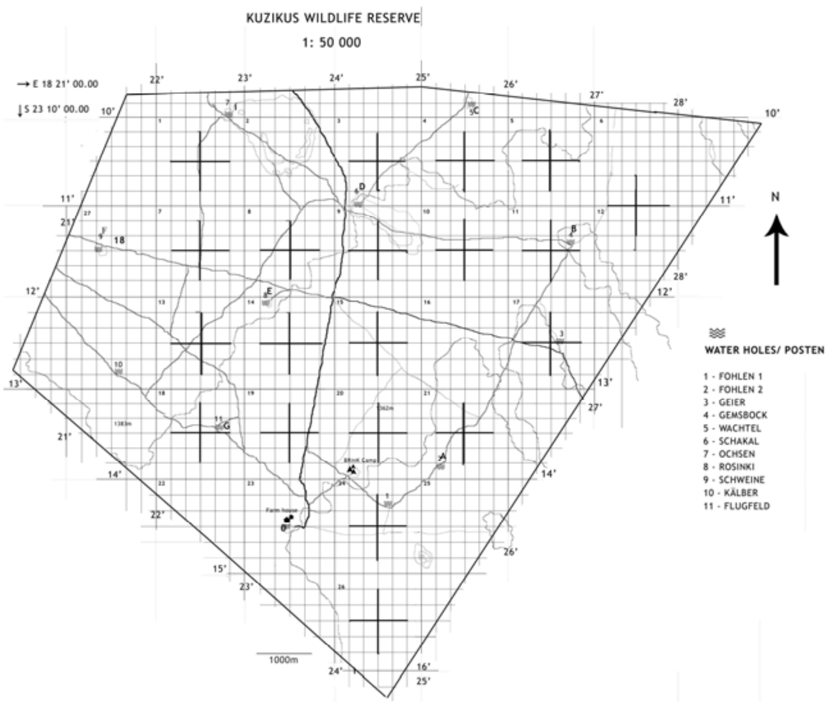

Figure 2: Map of Kuzikus Wildlife Reserve showing line-transects that were selected for distance sampling of larger mammals.

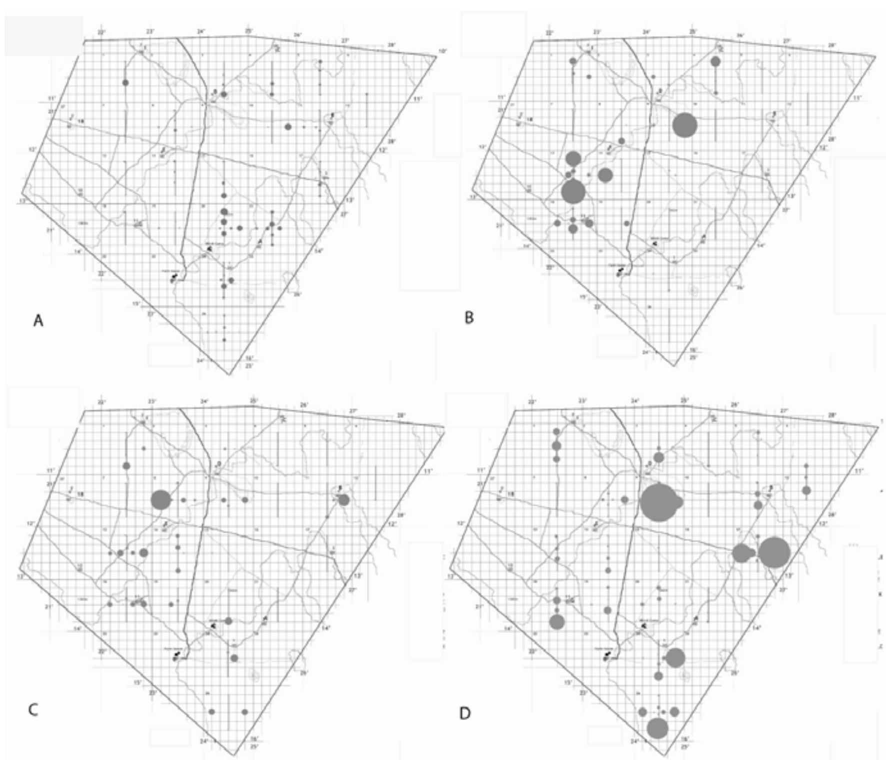

Figure 3: A A erioloba, B A melifera, C Acacia hebeclada, D Grevia flava

Table 1: Number of detections and cluster size range per animal species seen on Kuzikus. Once a group of 25 Blesbok was seen, but was excluded in the table due to abnormality, as most Blesbok occurred singly.

Species	Repeat 1	Repeat 2	Total	Max. cluster size
Springbok	104	96	200	25
Oryx	72	55	127	28
Blesbok	44	45	89	9
Blue Gnu	16	12	28	30
Black Gnu	18	6	24	18
Zebra	10	3	13	11
Hartebeest	4	7	11	9
Kudu	2	4	6	5
Impala	3	1	4	4
Eland*	0	3	3	2
Steenbok	2	1	3	2
Duiker	0	1	1	1
Giraffe*	1	0	1	1
Total	276	234	510	

*During road detection larger animal groups were sighted than on the line transect.

Table 2: Estimate of abundance N and its 95 % Confidence interval and estimate of density D per hectare, coefficient of variation %CV, average cluster size E(s) and number of detections n used in the analysis (within truncation distance) and truncation distance *w* in meters for each animal species.

Species	N	95% CI for N	D	%CV	E(s)	*w*	*n*
Springbok	1455	1037 - 2043	0.145	16.8	2.1	440	181
Blesbok	872	542 - 1401	0.087	23.8	2.9	350	74
Oryx	767	415 - 1418	0.077	31.9	3.2	400	113

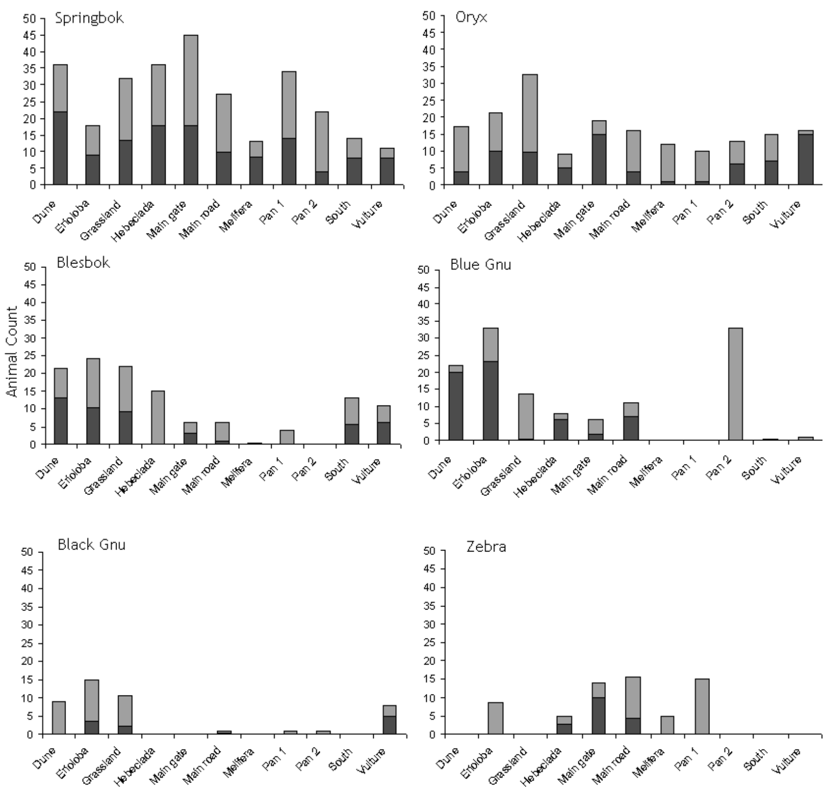

Figure 5: Animal distribution based on transect-line data across different vegetation zones throughout Kuzikus. Blue bars refer to the 1st repeat and red bars refer to the 2nd repeat of line-transects.

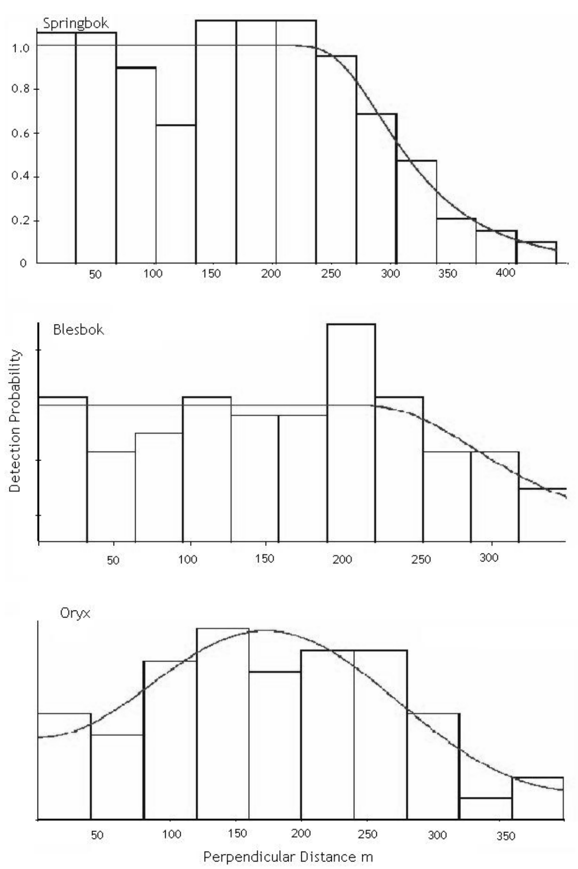

Figure 6: Histogram of perpendicular distances and fitted detection functions for Springbok, Blesbok and Oryx. Key functions were the hazard rate with cosine adjustment, the hazard rate with simple polynomial adjustment and the half normal with a cosine adjustment respectively.

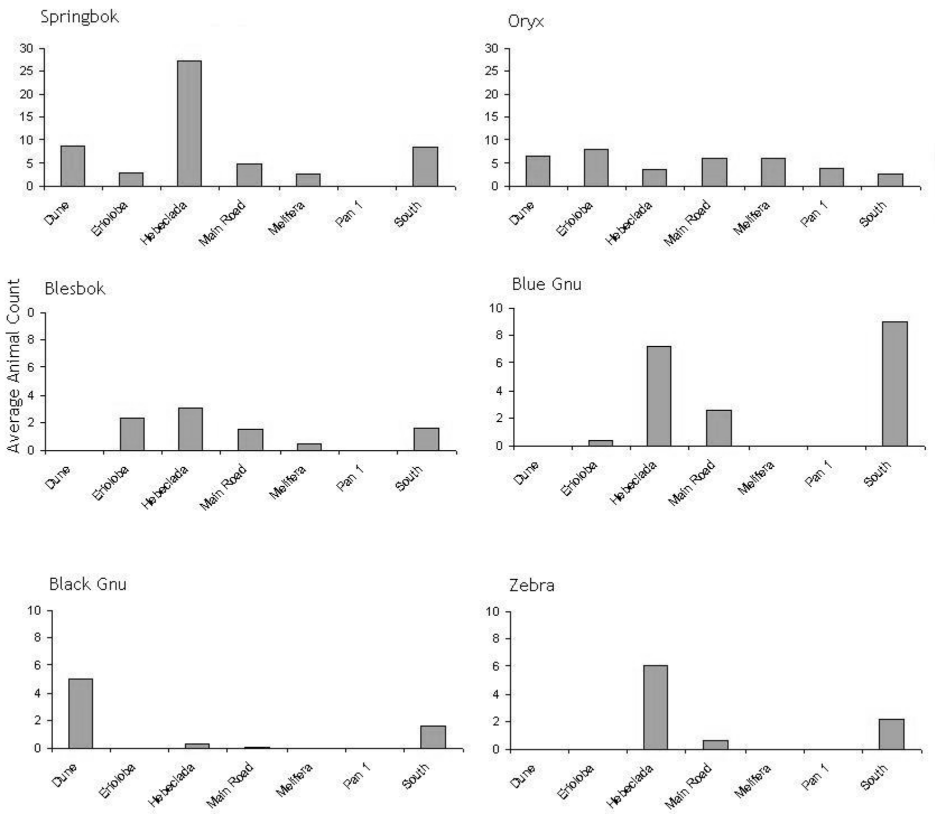

Figure 9: Animal distribution based on road detections (mean of counted animals per road) across different vegetation zones. Note that some vegetation zones are not traversed by roads.

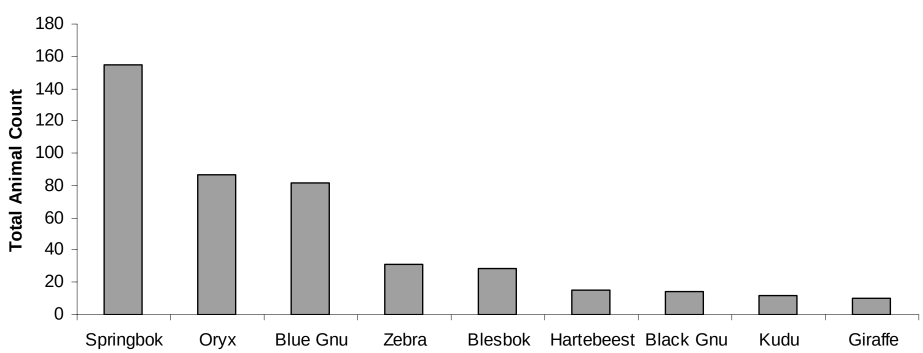

Figure 8: Animals species counted on 18 roads throughout the reserve.

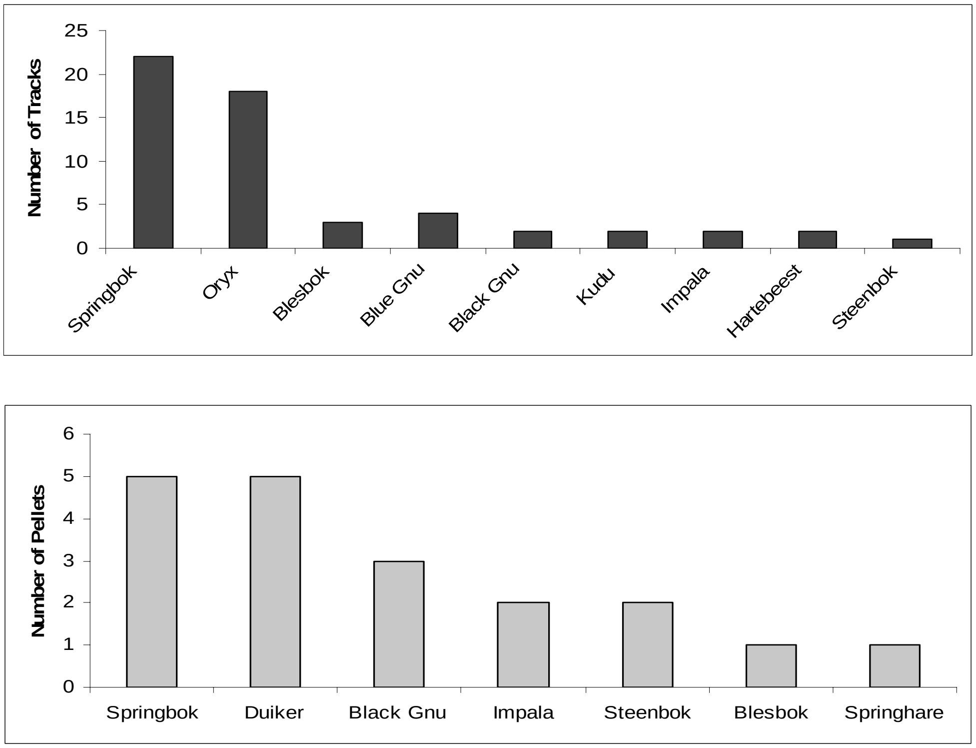

Figure 10: Number of tracks and pellets found in 5x5m plots for animal species.