Road Construction in Protected Areas Good for Ecotourism, but Bad for Biodiversity Conservation: A case Study of Yankari Game Reserve, Nigeria

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By

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1.0 Introduction

The contribution of roads to economic development is globally recognized and countries allocate huge budgets for construction, upgrading and maintenance of roads (Karani, 2007). However, road construction and upgrading have tremendous impact on ecological resources since during these activities there is opening up of the earth surface as well as dust emission and pollution from burning fuels (Karani 2007). In research on the ecological effects of roads, Noss (2004) observed that an estimated one mile of road construction consumes about 48 hectares of habitat. Roads also directly reduce wildlife populations through mortality and habitat loss (Fahrig *et al*., 1995; Forman, 2000). Habitat loss is further increased for species that avoid habitats near roads (Reijnen *et al.,* 1996). Road construction and conservation of biodiversity aims are therefore at odds (Ledec *et al*., 2007). In fact, the most obvious direct effect of these impacts is evidenced by animal mortality on the road (Bissonette 2002).

Mortality of animal population on roads is due to road kill – a situation where wildlife is run over by automobiles. Records in some parts of the United States have shown that animals killed from automobile accidents are one major cause of the death of wildlife. Deer mortality increased by 500% when the I-75 road was completed through a major deer wintering area (Noss 2004). Further deaths may then arise for scavenging birds and other animals that feed on carrion from the roads(Speziale *et al*., 2008).Much evidence exists for mortality due to road-kills among bird species and other fauna (e.g. Table 1).A key factor in mortality from roads is the speed of travel of the vehicles(Case 1978, Staines 2001,). When roads are unpaved, they are a lot less dangerous because vehicles will be forced to move at low or regulated speed (Noss 2004).

The problems that roads bring are exacerbated when they cross reserves created to conserve biodiversity. For example, paved roads leading into forest reserves serve to increase the number of visiting tourists but this human disturbance can then itself be a problem to wildlife (Noss, 2004, Speziale *et al*. 2008).Although this may translate to more revenue accruing to the management of such reserves, increase in traffic tends to increase the incidence of road-kills. This is exemplified at Yankari Game Reserve in Nigeria. Recently in 2006, the government paved the Ahmadu Bello way leading to the Wikki camp of the reserve. Most motorists exceed the legal speed limit and as a result increase the risk of hitting animals. This project provides preliminary data on traffic mortality rates of wildlife within Yankari Game Reserve on the paved road and provides recommendations to reduce the problem. Such information is important for planning conservation strategies that will enhance the protection of wildlife generally in nature reserves (Speziale *et al.,* 2008).

1.1 Project History

This project is an outcome of a preliminary survey carried out on Standard-winged Nightjar (*Macrodipteryx longipennis*) for eight weeks in 2008, during their breeding season. This survey looked at the number of Nightjars killed by motorists on the major road leading to the Wikki Camp of the Yankari Game Reserve. The result of the survey showed that an average of eight birds was killed every week. Other animals killed included Western Hartebeest (*Alcelaphus buselaphus*), Genet (*Genetta* spp.) and White-faced Scops owl (*Otus senegalensis*).

1.2 Aim

To determine the rate of road kills on Ahmadu Bello way, Yankari Game Reserve.

Objectives are to determine:

1. which wildlife were killed on Ahmadu Bello Way
2. the days of the week with the highest mortality,
3. the average speed of motorists on the road
4. Any sections of the road that have greater risk of mortality to wildlife.

Table1: Examples of animals killed along roads

Species	Author	Region
American Kestrels Falco sparverius,	Varlandet al. 1993	North America
Barn Owls Tyto alba	Newton et al. 1991	United Kingdom
Northern Saw-whet Owl Aegolius acadicus and Eastern Screech Owl Otis asio,	Loos and Kerlinger 1993	Cape May Peninsula, New Jersey, USA
tropical forest birds	Novelli et al. 1988	Brazil
garter snakes	Dalrymple & Reichenbach 1984	Ohio, USA
granivorous birds	Dhindsa et al. 1988	Punjab, India
American crocodile Crocodylus acutus -	Kushlan 1988	America
Green iguanas Iguana iguana	Rodda, 1990	Venezuela
desert snakes	Rosen & Lowe 1994	Sonoran Desert, Arizona, USA
toads	van Gelder 1973	
a wide range of invertebrates, especially insects	H. C. Seibert & Conover, 1991	

2.0 Methodology

2.1 Study site

The survey was carried out on the Ahmadu Bello way of Yankari Game Reserve, a 42 Km stretch of road that leads into the camp of the Reserve from the entrance, and a 42km stretch of road in the reserve that is not paved. The survey lasted from May 2010 to April 2011.

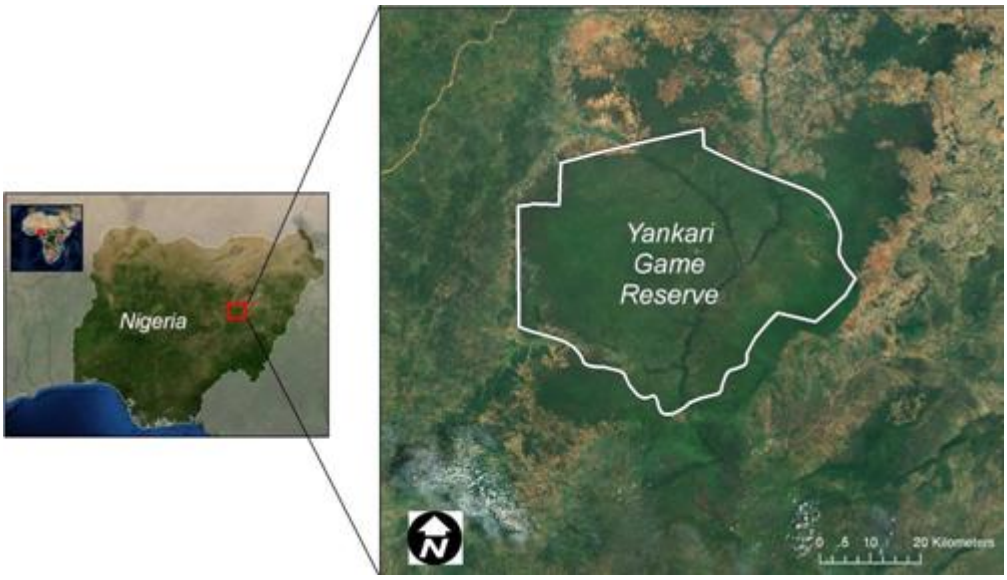

Figure 1: Map of Yankari Game Reserve, Bauchi

Yankari Game Reserve (9°45'N and10°30'E)is located 100 km south east of Bauchi town in Bauchi state with a total area of 2,244 km^2 in the east-central part of Nigeria. The Reserve records an average rainfall of about 1000 mm per year, which occurs between April and October (Crick and Marshall 1981). Yankari Game Reserve lies within the Sudan Savanna Zone (Geerling 1973) of Nigeria with a vegetation made up of swampy flood plain bordered by patches of forest, gallery forest and riparian forest, woodland Savanna (Crick and Marshall 1981). The Reserve was designated and opened as Nigeria's biggest National Park in 1991. It is the most popular destination for tourists in Nigeria and, as such, plays a crucial role in the development and promotion of tourism and ecotourism in Nigeria (Odunlami, 2000). The Reserve is bisected by the River Gaji. The Reserve affords exceptional opportunities for observing a wide variety of wildlife species in their natural habitat. One of the most frequently sighted species is the African Bush Elephant (*Loxodonta africana*). Other species include African Buffalo (*Syncerus caffer*), Olive Baboon (*Papio anubis),* Western Hartebeest (*Alcelaphus buselaphus.*), Waterbuck (*Kobus defassa*), Hippopotamus (*Hippopotamus amphibius*), Crocodile (*Crocodylus niloticus*), Grimm's Duiker (*Sylvicapra grimmia*), Lion (*Panthera leo*), Roan Antelope (*Hippotragus equinus*) Warthog (*Phacochoerus africanus*) etc. About 337 species of birds have been recorded (Ezealor, 2002). Of these, 130 are resident, 50 are Palearctic migrants and the rest are intra-African migrants that move locally within Nigeria and/or Africa. These birds include the Saddle-billed Stork (*Ephippiorhynchus senegalensis*), Martial Eagle (*Polemaetus bellicosus*), Abyssinian Ground Hornbill (*Bucorvus abyssinicus*), Narina's Trogon (*Apaloderma narina*) among others (Olokesusi, 1990, Tende *et al.* unpublished). The large congregation of the group of birds aforementioned made Yankari to be designated as an Important Bird Area (IBA – Ezealor 2002). The Ahmadu Bello

Way of the Reserve was paved in 2006 when the Bauchi state government took over the management of the reserve from the federal government.

2.2 Research Design

A 40km transect was taken along Ahmadu Bello Way which is tarred and others along game viewing tracks, which are not tarred to serve as a control. The tarred road was divided into 5km sections; making a total of 8 sections, this was done to check if all the road sections bear the same risk of mortality. .During the period of the survey (May 2010 to June 2011), the tarred transect was carried out 133 times, control transects of a total of 68km were carried out 210 times. The transects were traversed at random to cover all the days of the week. The visits were alternated between mornings and evenings. Morning surveys were between 0730hrs -1030hrs and in the evening surveys between 1530hrs – 1800hrs, at a speed of 15km/hr. All carcasses seen during this period were identified and recorded and a GPS coordinate taken to create a density map. Pictures of all encounters were taken for proper identification and pictorial documentation.

An observer was stationed at the gate at Maina Maji (beginning of the transect) and the gate at Wikki camp (end of transect), which is 42km. The time of departure, time of arrival, make and the identification number (plate number) of each vehicle going in and out of the reserve was recorded. This was used to calculate the number per hour and the average speed of motorists. The number of cars entering the reserve per day was gotten at the registration point at the entrance gate.

2.3 Statistical analyses

SPSS version 17 was used for Statistical analysis. We calculated the frequency of road-kills by months and days. For further analysis, the days of the week were combined into weekdays (Monday – Thursday) and weekends (Friday – Sunday).T tests were used to test effects of day and track on the frequency of road-kills. Mean number of cars for the days that had road kills were filtered out and a regression analysis was carried out to test the effect of number of cars on road kill. Frequency data for sections of the road was subjected to a Chi Square test to see if all areas of the road were at the same risk.

3.0 Results

3.1 Number of wildlife killed

A total of 169 animals were identified as road-kill along Ahmadu Bello Way over a period of one year of this study. The majority, 130 (77%) were birds, 22 (13.3%) reptiles and 15 (9.7%) were mammals (Waterbuck, Roan Antelope, Western Hartebeest, Grimm's Duiker and Civet (*Civettictis civetta*). Figure 2 shows the mean number of animals killed according to their groups. The bird with the highest mortality was the Helmeted Guinea fowl (*Numida galeatus).*No road kills were found on control tracks (One Sample T test t=23.98, df = 234, p<0.0001).

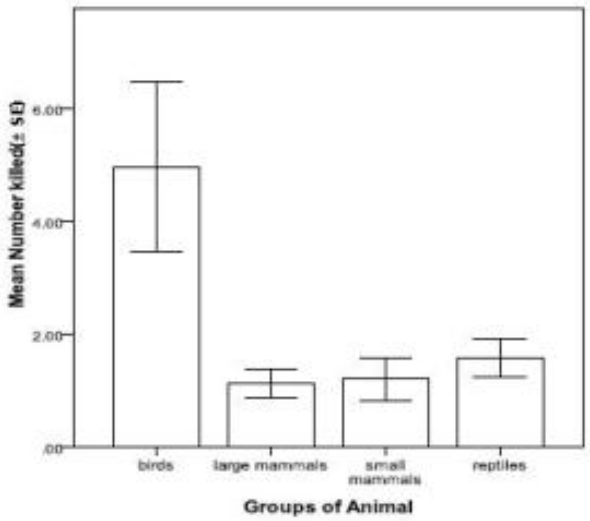

Figure 2: Mean number of animals killed per week

From top to bottom: Picture showing Western Hartebeest, a car which had an accident killing three of the five occupants, a Senegal Thick-knee (Burhinus senegalensis) and a Greyish Eagle Owl(Bubo cinerascens).

3.2 The days of the week with the highest mortality

The day with the highest mean number of animals killed was Saturday: 2.95±0.6 and the day with the lowest mean number of animals killed was Monday: 0.37±0.3 (see Figure 2). Days of the week were combined into weekday (Monday – Thursday) and weekend (Friday – Sunday) to elaborate on the result presented above (see Figure 3). There was a significant difference between the mortality of weekdays and weekends (independent Sample T- Test: t=-8.2, df=234, p<0.001). Figure 4 shows that there were more cars during the weekend, which also correlated positively with the mean number of animals killed on each day (Figure 5, One-way ANOVA $F_{1, 67}$=6.60, p=0.012, B=0.095).

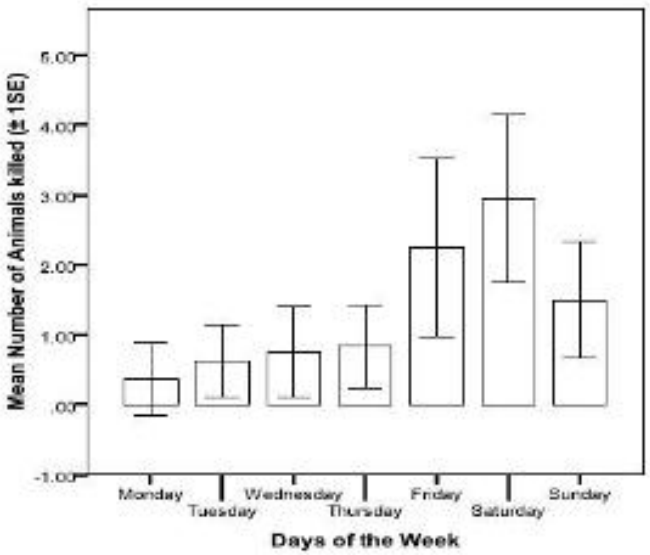

Figure 3: mean number of animals killed during the days of the week

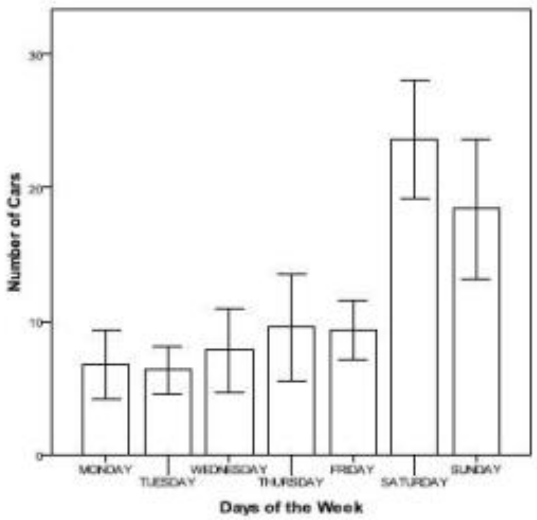

Figure 4: mean number of cars during the days of the week on a weekly basis

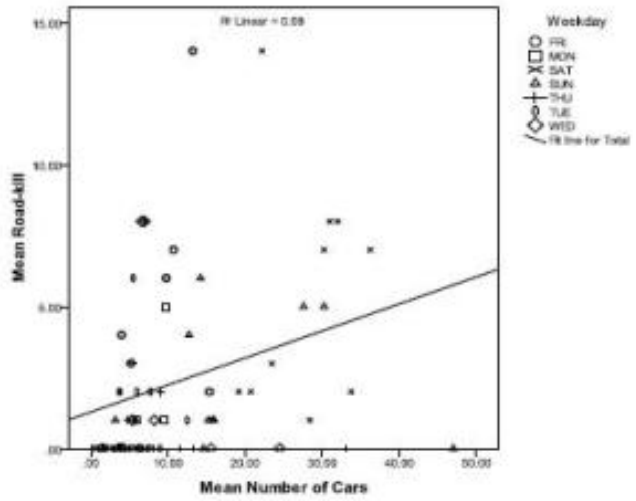

Figure 5: Correlation between the mean number of road-kills and number of cars during the days of the week on a weekly basis.

3.3 Sections with Highest Mortality

There was no significant difference in the frequency of all kills pooled across the eight sections ($\chi 2$= 5.6, df=7 p>0.5); suggesting that all the sections of the road posses the same level of risk of mortality to wildlife. The total per section is as follows:

Section 1 – 20	Section 2 – 17
Section 3 – 17	Section 4 – 22
Section 5 – 28	Section 6 – 27
Section 7 – 19	Section 8 – 19

3.4 Average Speed of Motorists

The average speed of motorist during the dry season was119.8 ±5.1km/h (N=64 cars).During the rainy season however, the speed reduced to 100.4± 0.5km/h (N=52 cars).

4.0 Discussion

4.1 Number of wildlife killed

The result here presented may be an underestimate of what is actually going on along the road as some of the dead animals may have been dragged away by carrion eating species. A typical example is the case of a Porcupine (*Hystrix cristata*) which was killed and only the spines and the blood was seen on the road. Searching the surrounding where the porcupine was killed revealed that it had been taken away by two hyenas (*Crocuta crocuta)* because of the presence of their paw prints. Nevertheless our results show that the paved road at Yankari leads to mortality of animals as a result of the high speeds of cars along it. It is important to note here that birds were the group with the highest mortality. This is of concern because of the status of the reserve as an Important Bird Area (IBA – Ezealor2002). This situation can be classified as a present threat and danger to the population of bird species in an IBA like Yankari. The gregarious behaviour of the Helmeted Guinea fowl (pers. obv.) may have been the reason why among the birds, they had the highest number of kill. There was a time when three were killed on a spot and various other incidents of

multiple fatalities. This agrees with the observation of Pons 2000, where he opined that the greatest effect of road traffic is on the number of birds killed annually. It is imperative to state here however, that some bird species have a healthy population in the reserve, which makes the number killed on the road to insignificant. Some of these species may be regarded as 'common birds', but birds that were regarded as common some years back in Yankari and other parts of the world are either 'endangered or extinct' today. The need to monitor common farmland birds lead to the establishment of Common Bird Census in the UK by British trust for Ornithology BTO (BTO.org, 2012).

The large mammals including species of large antelopes were not spared as Water Buck (*Kobus defassa*) and Roan Antelope (*Hippotragus equinus*) were among the dead (Appendix 1: list of all animals killed). More studies need to be carried out to understand the habitat use pattern of large mammals to mitigate against their collision. Large mammals with a long gestation period need to be protected from unnecessary catastrophic events that will further put pressure on their population that is already suffering from other ecological challenges like predation, poaching etc. The number of reptiles killed especially snakes was alarming; this may not be significant compare to their population. However, it is better to avoid causes of mortality that can be avoided. In a survey to determine the effect of road kill in an avian population quality, Bujoczek *et al*. 2011, found out that road-kill results in the random elimination of healthy individuals of a population. They also found out that predators on the other hand, only killed weaker individuals. The obvious conservation implication of this trend is the gradual consequence of driving such fragmented population to a critical stage or situation of decline (Hendrix and Kyhl, 2001).).

4.2 The days of the week with the highest mortality

Weekends have been shown to have higher rates of mortality. This is probably simply because of the increase in tourists' visits at weekends. Except for some rare occasions where other weekdays like Wednesday had a slight jump in the number of road kills, most road kills were recorded during weekends. The high number of mortality recorded during the weekend positively correlated with the number of vehicles plying the road. It therefore means that vehicular traffic is the major (if not the only) cause of mortality of animals observed on the road (Forman and Alexander 1998).This observation agrees with the suggestion of Pons 2000, where it was shown that speed and intensity of traffic are positively correlated with bird mortality. Furthermore, the

speed with which motorist ply the road is probably the main factor that causes the rate of mortality on the road (Romin & Bissonette 1996). It has been opined that (Havlick 2004) if motorists obey the stipulated speed limit (which is a maximum of 50km/h) and obey traffic rules such as 'Animals have the right of way' etc, the rate of vehicular accidents with wildlife will be drastically reduced.

4.3 Sections of the road with highest mortality

The different sections of the 42km Ahmadu Bello Way leading into the camp of the Yankari Game Reserve had the same risk of mortality to wildlife. This deviates from the suggestion by Havlick 2004, where he said individual segments of the same road can vary dramatically in how animals perceive, use, or cross them. Some stretches of road are simply more important and more deadly than others, and although our results on average do not show differences there were probably individual species' differences. During the survey, it was observed that some particular areas on the road are more deadly to some species than others. A typical example is the fact that more Nightjars (*Caprimulgus spp* and *Macrodipteryx spp)* were killed along10km section into the reserve from the main gate entrance

(Maina Maji gate). It was noticed that at the peak of their breeding season (April - June), they are often seen in their numbers resting on the road and are knocked down and killed by oncoming vehicles because they do not take off in time. They are found more on this section of the road probably because of the open nature of the habitat which allows them space to sally freely without colliding with tall trees and shrubs in their search for insects (Fry *et, al.,* 1993). This is not to underrate the fact that nightjars were also killed on other parts of the road as well.

4.4 Average speed of Motorists

The smooth and straight nature of the road allows for motorists to easily speed beyond the legal speed limit (*Pers. obv*.) With an average of 120km/h, motorists are most likely to kill any animals that attempts to cross the road should they hit them. This agrees with the assertion of Gunther *et al., 1998,* that vehicle speed was significantly related to collisions between vehicle and wildlife. The Animal crossings, which are modifications placed on the road where animals are known to habitually cross were constructed in a manner to reduce motorists' speed around the point. It has been observed that the animal crossing created during the road construction is not very effective in enforcing the average speed limits because of the large distance between each animal crossing from the other. The estimated average distance between two animal crossings is 4km (Pers. obv.).

We noted a slight reduction in the average speed at the peak of the rains. This observation may be because of the fear of vehicles skidding off the road. Furthermore, a more plausible explanation is the fact that elephants are found crossing the road at different point leaving behind them trails of debris (faeces, remnant of utilized plant parts etc) causing obstruction to free flow of traffic (pers. obv.). This forces motorists to reduce their speed. Further, it is important to highlight here that apart from the mortality on animals, there few occasions of road accidents during the period of this study involving humans to the extent of loss of lives.

5.0 Conclusion and Recommendation

The estimate given here is the lower limit of the number of animals killed within the study period. We believe that more animals may have been killed that were not recorded as not all animals remain visible after being hit. A study by Romin 1994 estimated that as many as 50% of deer hit on the road leave the area and may never be counted. Also, a lot of smaller animal may have killed which were not counted. As a consequence, urgent steps need to be taken to reduce the mortality of wildlife as a result of collision with vehicles.

Therefore, the management of the reserve should provide speed breakers on the road such as speed bumps, more animal crossings intervals and more sign posts warning motorists on the need to observe speed limits. Signposts will restrict motorist psychologically and speed breakers will restrict them physically. Awareness creation directed at tourist and other drivers may help influence tourist attitudes towards speed limit within the reserve and workshop for staff of the reserve on how to encourage tourists to observe speed limits and traffic rules in the reserve may be as important. Roadkill Prevention Vanguard (RPV) – a volunteer group with the aim of reducing road kill should be inaugurated to continue to carry out activities such as clearing vegetation around signposts to make them visible, monitor motorists' speed and monitor incidences of road kill. Eventually, there will be need to penalize offenders of road traffic regulations on the road. Motorists who ply the road above the official speed limit should be charged up to N50, 000 to serve as a deterrent to future offenders.

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Appendices

Appendix 1: list of animals killed

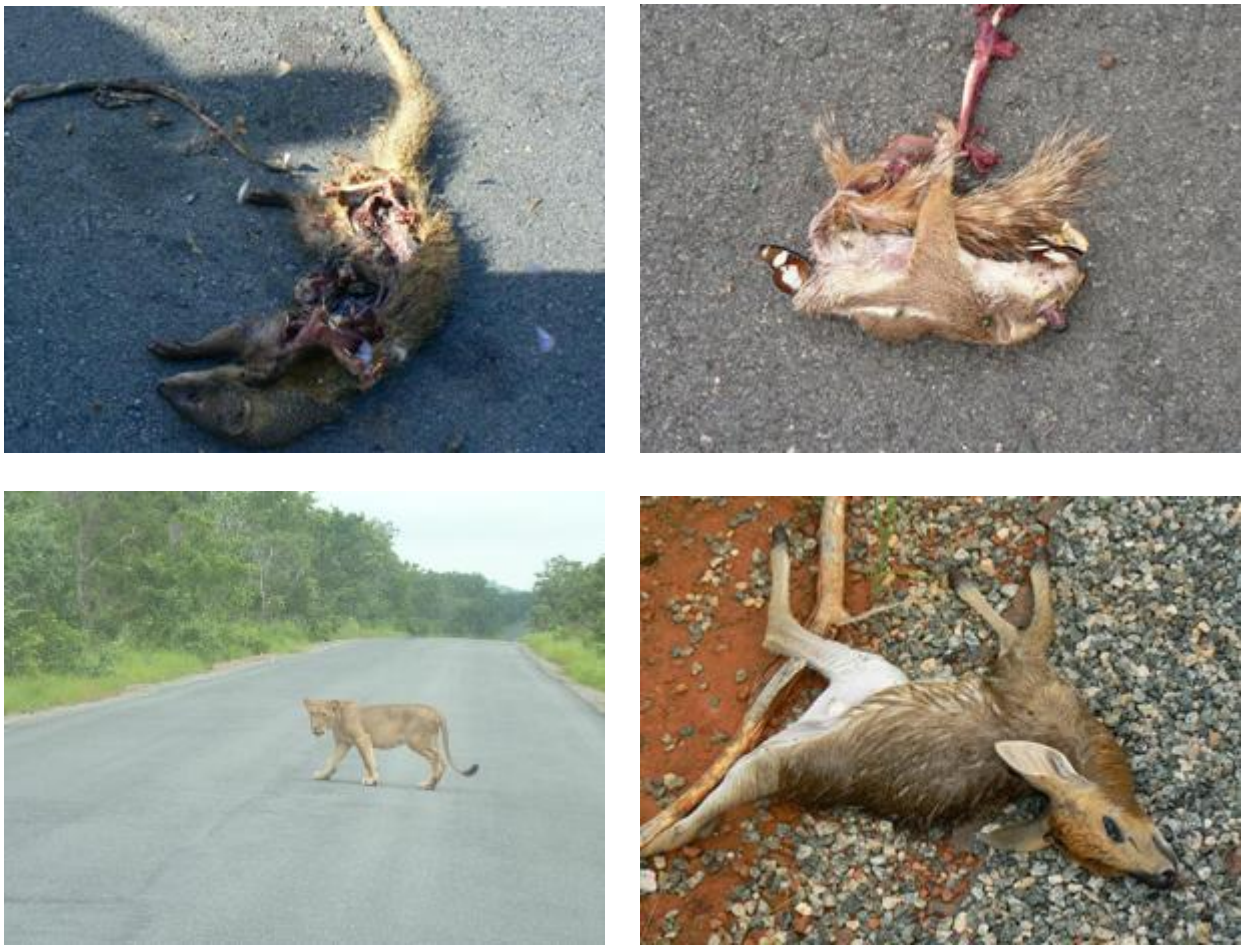
Species	
Frog (Bufo spp)	3
Lizards	12
Snakes	8
Palmnut Vulture (*Gypohierax angolensis*)	1
Dark-chanting Goshawk (*Melierax metabates*)	2
Helmeted Guineafowl (*Numida galeatus*)	29
Stone Partridge (*Ptilopachus petrosus*)	4
Senegal Thick-knee (*Burhinus senegalensis*)	2
Four-banded Sandgrouse (*Pterocles quadricinctus*)	2
Vinaceous Dove (*Streptopelia vinacea*)	6
Black-billed Wood Dove (*Turtur abyssinicus*)	3
Greyish Eagle-owl (*Bubo cinerascens*)	3
Rufous-cheeked Nightjar (*Caprimulgus rufigena*)	15
Standard-winged Nightjar (*Macrodipteryx longipennis*)	34
Grey-headed Kingfisher (*Halcyon leucocephala*)	2
Flappet Lark (*Mirafra rufocinnamomea*)	2
White-fronted Black Chat (*Myrmecocichla albifrons*)	1
Violet-backed Starling (*Cinnyricinclus leucogaster*)	1
Scarlet-chested Sunbird (*Chalcomitra senegalensis*)	1
Black-crowned Tchagra (*Tchagra senegalus*)	7
Purple Glossy Starling (*Lamprotornis purpureus*)	2
Green-winged Pytilia (*Pytilia melba*)	2
Bush Petronia (*Petronia dentata*)	5
Red-cheeked Cordon Bleu (*Uraeginthus bengalus*)	1
African Silverbill (*Euodice cantans*)	1
Cinnamon-breasted Rock Bunting (*Emberiza tahapisi*)	1
Gerbil (*Gerbilus spp*)	6
Ground Squirrel (*Xerus rutilus*)	4
Grimm's Duiker (*Sylvicapra grimmia*)	3
Common Genet (*Genneta genet*)	1
Crested Porcupine (*Hystrix cristata*)	1
Civet (*Civettictis civetta*)	1
Water Buck (*Kobus defassa*)	2
Roan Antelope (*Hippotragus equinus*)	1
Total	169

Appendix 2: pictures of different animals killed (caution: some pictures are graphic!)

Picture showing (clockwise from top left): A species of snake; Rufous-cheeked Nightjar; common Genet and White-fronted Black Chat




Picture showing (clockwise from top left): a Gerbil; Waterbuck that was knocked and bleeding from the nose – it eventually died; Civet Cat and a juvenile Puff Adder.



*Picture showing (clockwise from top left):Slender Mongoose; Ground Squirrel; Lion (*Panthera leo*) crossing the road – it could easily be a victim of road kill as well; Grimm's Duiker*




Picture showing (clockwise from top left): spot where a Porcupine was killed; three Helmeted Guinea fowl crushed; Western Hartebeest using the 'Animal Crossing' and a species of Lizard

Picture showing Flappet Lark; Scrub hare (Lepus saxatilis); Hoopoe (Upupa epops); Abyssinian Roller (Coracias abyssinicus). The last three in these pictures are from on-going survey.