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Full Length Research Paper

Determination of carnivores prey base by scat analysis in Samburu community group ranches in Kenya

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This study determined the prey base for four main carnivores found in Samburu community group ranches and grazing area, Lion (*Panthera leo*), Leopard (*Panthera pardus*), Wild dog (*Lycaon pictus*) and Hyaena (*Crocuta crocuta, and Hyaena hyaena)*. A total of 96 scat samples including, 8 from Lion, 16 Leopards', 2 Wild dogs', and 70 Hyaenas' were collected, identified and microscopically analyzed for prey hair characterisation. At least 50 different hairs from every scat sample were mounted on slides and microscopically characterized using details from reference hairs. Hairs from 18 depredated species both domestic and wild ungulates were recovered from the scat samples. Predated species were identified, as either domestic (Cow, Sheep, Goat, Donkey, and Camel) or wild ungulate prey (Grant's gazelle, plain Zebra, Grevy's Zebra, Impala, Waterbuck, Dikdik, Eland, lesser Kudu, greater Kudu, Baboon, rock Hyraxes, Elephant and Oryx). The carnivores showed a relatively high kill of wild ungulate prey compared to domestic prey. Camel was the most preferred domestic animal by both the Lion and the leopard, while wild Dog and Hyaena preferred cow and donkey respectively. Grevy's zebra contributed highest to the lion's diet while the Plain zebra was most preferred by the leopard. Both the hyaena and the Wild dog had a preference for the waterbuck. The Hyaena had the highest domestic depredation, while all the other big cats depredated more on wild ungulates

Key words: Scat, group ranch, domestic, wild ungulate, prey, depredation.

INTRODUTION

Livestock predation by large carnivores and their retaliatory persecution by pastoralists are worldwide conservation concerns; this has resulted in an escalation of Human-carnivore conflict (Madhusudan and Mishra, 2003). The poor understanding of the ecological and social underpinnings of this human–wildlife conflict in many parts of the world hampers effective conflict management and conservation programs (Bagchi and Mishra, 2006). The livestock - carnivore conflict is frequently observed in regions with underdeveloped economies which create conservation antagonism. Due to enormous livestock depredation, pastoralists have over the years developed a strong negative attitude towards the involved carnivores and retaliatory actions threaten the survival of most of the large cats in Kenya and around the world (Michael, 2008 and Mishra et al., 2003). The basic information on the extent of livestock predation and their importance in large cats' diet is lacking (Madhusudan and Mishra, 2003), there is therefore need for crosscutting applied research (Ogada et al., 2003). To some extent livestock remain vulnerable to carnivores compared to wild ungulates, and this could be attributed to an increase in the population of one of the problem carnivore, or decreased wild ungulates population (Madhusudan and Mishra, 2003). The diet of a carnivore reflects both the availability of its potential prey, as well as a suite of morphological, behavioral and physiological adaptations that allow the individual to locate, capture, ingest and digest a variety of prey taxa (Kok et al., 2004).

Scat analyses are widely used to determine food habits of carnivores. However, the degree to which the relative frequencies of identifiable remains represent the actual

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proportion of prey types eaten is not known (Floyd et al.,1978). Feeding patterns can be compared to prey abundances to assess functional feeding responses. A functional response is defined as the change in the number of prey consumed in relation to prey abundance (Barteil and Knowlton, 2005). Variable and sometimes large amounts of predator hair has been reported in carnivore feces at a range of 18 - 48%, indicating the need for appropriate hair identification which may not necessary be as a result of predation (Gamberg and Atkinson, 1988). The completeness of prey hair recovery from carnivore scat reported by Gamberg and Atkinson (1988) indicates that prey hair identification provides a good basis for diet reconstruction. Different mammals have hair of different length, thickness, and macro-structure, which may affect the hair's ability to be broken down by digestive enzymes (Gamberg and Atkinson, 1988). Leprince et al. (1980) reported that feathers ingested by raptors underwent digestive changes because of the action of pepsin. This degradation was as a result of the hydrolysis of protein that acts as cement for the keratin component of the feathers. Keratin is a highly resistant molecule requiring a keratinase or a specific reducing enzymatic system with proteases for digestion to occur (Leprince et al., 1980). Hair is similar in composition to feathers, and its degradation in the carnivore stomach may render hair unrecognizable and unrecoverable from feces. There are reports on differences in hair recovery between different carnivores which are due to the differences in digestibility of this prey component between predator species that may be attributed to differences in gastric acidity and the animals' feed retention time (Johnson and Aldred, 1982). Most of the big cats produce scat that have an overall similar appearance but different in sizes. The scats frequently occur as loose accumulations encountered at resting sites, near large kills, and for leopards at trail crossings. Scat may also be accumulated at den sites of females with cubs. Hyaenas deposit their large white scat at prominent latrine sites. Due to the high bone content constituting their meal, hyaena scat is usually white upon drying and weighs about 150 grams for the spotted hyaena. Lion scats are particularly difficult to find, this is due to its high protein content and also the fact that it is very quickly taken up and consumed by other wildlife, particularly the scavengers. Lion scat must therefore be very quickly collected once produced. The droppings are segmented with a diameter of at least 40mm. Leopard droppings are smaller than that of adult lion with a diameter of 20 – 30 mm. The cheetah droppings are 25 - 35 mm in diameter and accumulations have been recorded to occur at specific trees regularly used for playing (or to hoist the prey) by the cat (Chris and Tilde, 2000).

Wildlife conservation in Africa is a dynamic pursuit, constantly requiring new approaches as the challenges facing it change over time. Kenya's wildlife is a case in point, where the principal challenge to wildlife populations in the 1970s and 1980s was poaching. This was countered largely by fencing and security enforcement. Poaching of large mammals has been drastically reduced since the 1980s, trends in wildlife populations in Kenya however show a 50% decline over the last 20 years alone (Norton-Griffiths, 1999), suggesting other severe challenges. An emergent challenge, among others, has been the increased human-wildlife conflict due to the rapid rise in Kenya's human population over the last two decades. Demand for arable land and settlement is causing ever-closer interaction between humans and wildlife. This is leading to conflict, and livestock depredation. The vast savannas of laikipia and samburu currently support large numbers of wildlife with great potential for exploitation as a tourist attraction. Tourism, if practiced in community grazing lands and private ranches, can account for up to 50% of total income (Frank, 1998). However, this has not been the case in much of this area because residents have been culling predator populations and their ungulate prey to a level that is not useful for tourism. There is room for predator populations in this livestock producing area if effective conservation practices, including proper livestock husbandry methods, are put in place (ogada et al., 2003). Of the six big predators in Kenya, one is endangered, the wild dog (*Lycaon pictus*), two are vulnerable, lion (*Panthera leo*) and cheetah (*Acinonyx jubatus*), two are conservation-dependent, spotted and striped hyenas (*Crocuta crocuta* and *Hyaena hyaena)*, and only one is of lesser concern, the leopard (*Panthera pardus*). Management and conservation of these predators outside protected areas will depend largely on how communities, largely pastoral, tolerate their coexistence. There has been a severe flare up in human-predator conflict in Kenya in recent years. This has been in the form of livestock depredation by large carnivores and retaliatory killing of predators by pastoral communities. Current management of problem carnivores in the form of responsive shooting, trapping and relocation is unsustainable. More recently, affected communities have increasingly been poisoning predators. Cases of spearing or shooting of predators further affect population sizes. There is thus need to gather more ecological and socio-economic data in order to come up with sustainable solutions. This study was aimed at assessing carnivore food habits and ecology via scat analyses, to identify specific carnivores in the study area, determine actual animals preyed upon by carnivores in community environment, and determine the overall preferred prey, both domestic and wild ungulates for each of the carnivores.

STUDY AREA AND METHODS

Study area

The study was carried out in community grazing lands and

Figure 1. Map of the study area showing the community owned group ranches, Kenya Wildlife protected areas and community grazing areas.

community sanctuaries (Namunyak, West Gate, Nkaroni, Lodungogwe, Ngilai West) in Samburu district, located in the North Eastern province, 400 Km north of Nairobi (Figure 1). The area is at an altitude of 800 -1230m, with a mean annual rainfall of 250 - 500 mm, which is bimodal in the months of March - April and October - November. The main economic activity in Samburu is pastoralism, livestock predation is then one of the main economic constrains to the pastoralist, this is occasioned by a habitat of vegetation of acacia drywood land, shrub-grassland and arid land.

Scat collection and identification

Scats from four carnivores namely; Leopard, Hyaena, Lion and Wilddog were opportunistically collected in the study area, and identified using field study guides (Chris and Tilde, 2000) and information from the community elders. The GPS location of every scat collected was marked and data recorded as geo-references to show points of collection and spatial distribution.

Reference hair collection (RHC)

Hairs from different animals of interest were plucked with their roots from the skin, normally at a kill site, and when skin samples were provided by the Kenya wildlife services. Hair with the root was mounted permanently on a slide with DPX, a hair mounting medium and a cover slip, and labeled as RHC. Details about the hair were microscopically established under 10 time's magnification and recorded. The detailed hair characteristic were established and used for identification; these included the ratio of medulla to cortex, hair root appearance (dotted or clear), appearance of the hair medulla and cortex (Figure 2). A calibrated eyepiece was used for hair cortex and medulla width measurements. A RHC was established by a collection of 34 different animal hairs (data not shown).

Scat analysis and carnivore diet identification

Fresh scats were dried in the open air outside for up to two days

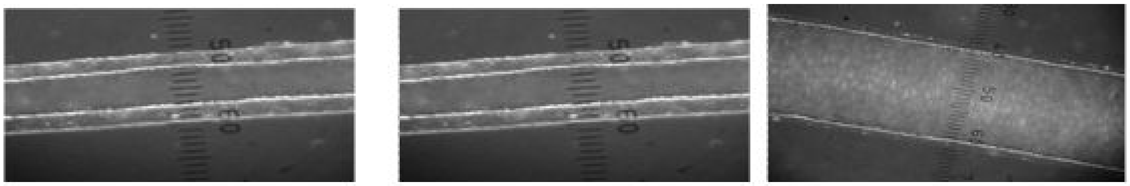

Figure 2. Photographs of hairs under a graduated eye piece at X10 maginification showing some of the RHC used for hair identification. Slide 1 impala reference hair, Slide 2, Grevy's zebra reference hair, Slide 3, goat reference hair.

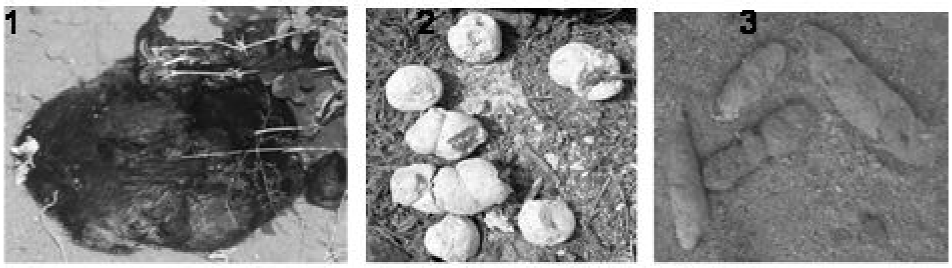

Figure 3. Scats types identified in the study area as Lion (1), Hyaena (2) and Leopard (3) Scat.

and covered to ensure they were not tampered with. Dry scats ready for analysis were soaked in a hair-sampling basin (30 x 20 cm) divided into 10 sampling areas each of 60 cm^2. Soaking was done with equal volumes of hot water and 70% ethanol for a minimum of 10 minutes, depending on the scat type. At least 10 hairs from each of the ten sampling squares in the basin were carefully removed from the homogeneous soaked scat and placed into a separate Petri-dish with 70% ethanol for one hour. Clean hair was then removed from ethanol and dried. Five pieces of hair were selected from each of the 10 sampling squares and mounted on microscope slide or stored in a polythene bag to be mounted later. At least 50 hairs with roots were selected and mounted from each scat sample. All the different hair types represented in the scat were sampled and mounted.

Mounting of hair on slides

The hairs' roots were first characterized by placing them under a microscope at X10 magnification; those with the roots were placed on a clean microscope slide and covered with a drop of DPX. A cover slip was then placed on and allowed to dry on the bench overnight. The hairs were then examined under the microscope at X10 magnification, and details recorded. The medulla and cortex were clearly visible and distinct and were thus characterized with ease. Scat not analyzed was dried and stored in polythene bags for later analysis.

Data analysis

The frequency of occurrence of individual prey species in different carnivore scats was determined by examining 50 hairs, randomly selected from each scat.

Biomass (Y) of a prey consumed by a carnivore to produce a single field –collectable scat was estimated by the linear relation Y= 1.980 + 0.035X, where X is the average body weight of the prey species involved, this enabled the conversion of frequency of occurrences of prey hairs recovered from scat to the relative number of prey consumed (Bagchi and Mishra, 2006). The relative prey consumed was calculated from the daily food requirements of the involved carnivore whereas the numbers of individual consumed was determined based on the relative biomass consumed, and the average body weight of the involved prey (Mishra et al., 2002), adjusted by a third, since a third of ungulate body weight is inedible (Bagchil and Mishral, 2006). Data on prey body weight and carnivore daily food requirements was obtained from literature (Kingdon, 2003).

RESULTS and DISCUSSIONS

Scat identification

A total of 96 scat samples were collected and identified as Lion (*Panthera leo*), Leopard (*Panthera pardus*), Wild dog (*Lycaon pictus*), and Spotted and Striped hyaena (*Crocuta crocuta, and Hyaena hyaena*). The following scats were analyzed for prey hair identification, including, Lion (n = 8) Leopard (n =16), Wild dog (n = 2), and hyaena (n = 70) in the four group ranches under study (Figure 3)

Carnivore diet

The relative importance of prey consumed by all four carnivores species studied is detailed in Table 1. The wild ungulates preys were relatively the most preferred compared to domestic prey by three of the carnivores under study. Only the Wild-dog had a relatively high kill of domestic prey at 2.5% compared to a 1.7% of the wild ungulate. This could be attributed to the low number of

Table 1. The Contribution of domestic and wild ungulates prey species in the carnivore annual diet. N = 96.

	Type of domestic prey					Type of wild ungulates prey												
	Cow	**Sheep**	**Goat**	**Donkey**	**Camel**	**G-gazelle**	**Zebra-plains**	**Zebra-grevy**	**Impala**	**W/buck**	**Dikdik**	**Eland**	**Kudu-lesser**	**Kudu-greator**	**Baboon**	**Rock hyra**	**Elephant**	**Oryx**
Lion																		
Frequency of occurrence (n= 8 scats)	2	5	0	4	1	4	3	4	4	5	0	3	2	0	2	0	0	0
Per cent of prey contribution to annual diet	1.7	1.1	0	1.5	1.9	1.2	2.8	4.7	1.1	3.2	0	4.3	1.6	0	0.4	0	0	0
Relative number of animals killed	1	1	0	1	1	1	1	1	1	1	0	1	0	0	1	0	0	0
Leopard																		
Frequency of occurrence (n=16 scats)	6	5	3	10	3	6	5	0	1	11	2	2	1	1	2	2	0	0
Per cent of prey contribution to annual diet	8.2	1.7	1	5.4	8.4	2.6	6.7	0	0.4	10	.4	4.1	0.6	0.9	0.5	0.4	0	0
Relative number of animals killed	1	1	1	1	1	1	1	0	1	1	2	1	1	1	1	3	0	0
Wild dog																		
Frequency of occurrence (n=2 scats)	2	0	1	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
Per cent of prey contribution to annual diet	2.2	0	0.3	0	0	0	0	0	0	1.5	0.2	0	0	0	0	0	0	0
Relative number of animals killed	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Hyaena																		
Frequency of occurrence (n=70 scats)	43	23	16	39	12	34	34	3	11	58	11	8	1	0	21	13	2	3
Per cent of prey contribution to annual diet	2.6	3.4	2.3	9	1.5	6.6	20	2.2	1.9	24	1.1	7.4	0.3	0	2.4	3	32	3.5
Relative number of animals killed	3	4	3	4	2	4	3	1	2	4	7	1	1	0	2.4	1.2	13	1.4

samples (n=2) available for analysis, and hence not giving the true picture of the animal's diet. The wild dog was shown to have fed on cows and goats amongst the domestic animals and waterbuck plus dikdik to a lesser extent among the wild ungulates. Though pastoralists in the study area indicated to have had very aggressive encounters with the wild dogs, we did not record much activity by this carnivore, which was evidenced by the few scats collected during the study period. In Kenya wild dogs have been classified as endangered (Ogada et al., 2003) which explains the reason for the few encounters. They are also very mobile, with a home range of 200 - 2000 Km^2 (Kingdon, 2003).

The hyaena showed a distinct difference in diet composition from the four other carnivores, with the wild ungulates contributing 81.1 and 18.8% domestic prey. Among the wild ungulates, the waterbuck contributed the highest annual percent (24%) diet contribution, followed by plain zebra (20%). On the other hand the donkey formed the highest percent (9%) diet contribution among the domestic prey. This was followed by the sheep at 3.4% and cow at 2.6%. The hyaena was the most problematic carnivore having recorded the highest number of kills both domestic (16) and wild ungulates (44). Out of the 18 prey studied only the greater kudu did not contribute towards the hyenas' annual diet requirement. *Crocuta crocuta*

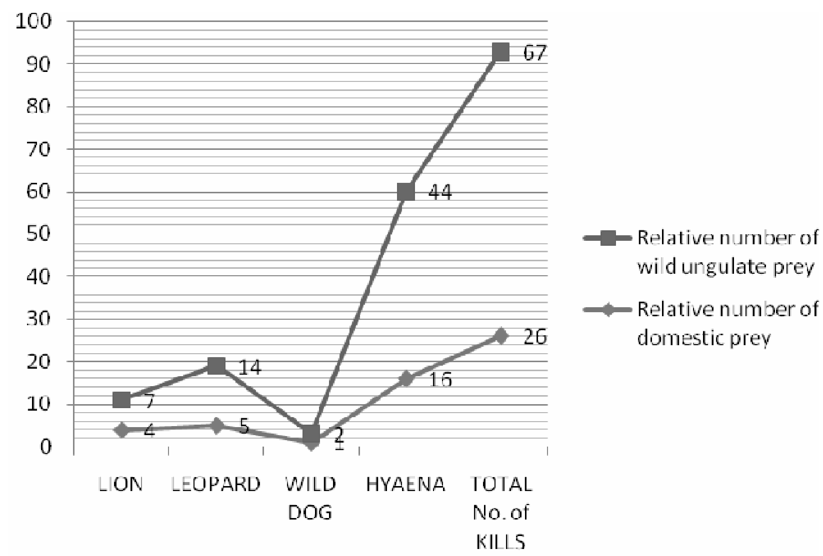

Figure 4. Relative number of kills by the four carnivores.

and *Hyena hyaena* are both found in the study area and require consistent supply of food all year round. *Hyena hyaena* is omnivorous as well as opportunistic and is known to kill large prey the size of adult donkey though not when the animals are alert. Small animals like rodents and foxes are however snapped and in addition the carnivore feeds on fruits that provide the moisture required (Kingdon, 2003). The study focused on hair identification from both the domestic and wild ungulate prey species, however there remained lots of unidentified prey remains and hair from other non ungulates that could be explained by the wide range of feeding behavior of the hyaena. Sported hyaena is a scavenger and an opportunistic carnivore, feeding on remains of other carnivores and humans. Its kills are rather due to prey vulnerability not abundance, Kingdon (2003) which was reflected in our study where the waterbuck, due to its vulnerability formed a substantial contribution among the wild ungulates. However we recorded a good representation of the zebra in the hyaena diet, though zebras are known to be fast and have a well organized group protection, the hyaena may have fed on zebra remains from lion kills.

The leopards' annual diet almost equaled both the domestic prey (24.7%) and the wild ungulate (26.6%). The cat's diet has been shown to reflect easy catch, with individual animals developing local and individual tastes (Kingdon, 2003). Though the wild prey formed relatively a higher contribution the leopard was shown to have fed more on camels (8.4%) followed by cows (8.2%), with plain zebra contributing 6.7% of the leopards' diet. The leopard was shown to have fed on all the five domestic preys but never killed Grevy's Zebra, Oryx and Elephant among the wild ungulate prey. About 50% of remains in the leopard scat were not identified; this could be due to the fact that the cat has a very diverse food choice, ranging from rodents, birds, and even arthropods. This observation has been made even in areas with a high population of antelopes of all sizes and age (Joseph et al., 2007). The lion had a preference of Grevy's zebra (4.7%) followed by eland (4.3%) and waterbuck (3.2%), which agrees with the observation by Kingdon (2003) that most of the lion prey are mammals weighing up to 300 - 1000 kgs. The wild ungulate formed 19.3% of the lion's diet compared to 6.2% for the domestic prey, with the camel (1.9%) and cow (1.7%) constituting highest. About 75% of lions scat hair remains were not identified, the study only focused on wild ungulates and domestic prey but the lion is in record to feed on small kills (rats, reptiles, fish) in times of famine (Kingdon, 2003), which formed a substantial period of this study. The lion showed no evidence of having killed goats but did kill all the other four domestic prey under study, which was noted by other writers that lions develop a liking for livestock that could be due to their age, hunting inability, low densities of their natural prey as well as husbandry measures practiced by livestock keepers (Stander, 1990; Ogada et al., 2003; Woodroffe and Frank, 2005). Amongst the wild ungulate prey under study the Dikdik, lesser Kudu, Baboon, rock Hyraxes, Elephant and Oryx did not contribute to the lions' diet (Table 1).

The study showed that all the four carnivores killed more wild ungulate prey, than domestic prey animals. The hyaena had the highest domestic kills followed by the leopard. The lion and wild -dog respectively indicated less involvement. At the same time a similar involvement was observed with all the big cats as relating to the wild ungulate prey. The hyaena recorded the highest kill followed by the leopard, with the lion and wild dog having the least kills respectively (Figure 4). The findings of this study, through scat analysis indicates occurrence of a negative interactions between humans and wildlife thus a situation of real economic and social human - wildlife conflict (Messmer, 2000). The study identified the involved carnivores and gave an indication of the extent of their involvement, and thus the carnivore(s) to be targeted for conflict management strategies. Livestock keepers have different attitudes towards carnivores that they perceive to have been greatly involved (Kellert, 1981) this usually leads to retaliatory reactions against the perceived problem carnivore (Messmer and Berryman 2009). This study through hair analysis from carnivore scats showed the problem carnivore(s) causing livestock losses through depredation. The information thus provided would find application in future conflict management voiding possible controversies when the perceived problem carnivores are killed in the place of the actual carnivore (Messmer et al., 2001). Improper handling of conflicts can be a source of continued public frustration particularly when scientific and technical data such as the one generated from this study lacks (Messmer and Berryman, 2009). Such information is essential for providing workable solutions in human-wildlife management. We reported higher kills on wild ungulates by carnivores compared to domestic prey, this information if used to change the perceptions of the livestock keepers experiencing losses to carnivores will go a long way in managing the human-wildlife conflicts in the study area (Conover, 2002).

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