Activity patterns & depredation upon livestock of spotted hyenas (*Crocuta crocuta*) in Ol Pejeta Conservancy

Aktivitetsmönster och predation på boskap av fläckig hyena (Crocuta crocuta) i Ol Pejeta Conservancy

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ABSTRACT

Many carnivores outside protected areas are declining as they are being killed for their involvement in depredation on livestock. More knowledge of when and why predators leaves protected areas are key questions in mitigating the human-wildlife conflict. Ol Pejeta Conservancy, Kenya, holds the one of the country's highest densities of predators, with approximately 100 spotted hyenas (*Crocuta crocuta*). Ol Pejeta is therefore a suitable site to learn more about the activity pattern of predators inside protected areas by analyzing photos from camera traps. The aim of this survey is to investigate the spatial and temporal movement pattern of spotted hyena and correlate it with moon phase and precipitation. If changes in clan size and attacks on livestock correlates with the environmental factors will also be studied. The results from this study showed that spotted hyenas walked out of the reserve after sunset and arrived before sunrise. Activity was higher when moonlight was bright compared to medium illuminance. Rainfall that arrived 30 days before had a negative correlation with activity, meaning that if precipitation was low the activity was higher. Group size mostly consisted of one or two individuals and could not be direct correlated to clan size nor to any environmental factor. Spotted hyena have had seven attacks upon livestock during this one year survey and could not be correlated with any temporal nor abiotic factors. Precaution during nighttime is preferable as the spotted hyenas are leaving the reserve even though they show a stronger preference for wild prey than livestock.

SAMMANFATTNING

Många rovdjur utanför skyddade områden minskar i antal då de dödas på grund av deras inblandning av boskapsattacker. Mer kunskap om när och varför rovdjur lämnar skyddade områden är nyckelfrågor i hur konflikten mellan människa och vilt hanteras. I Kenya ligger Ol Pejeta Conservancy som har ett av landets högsta rovdjursdensitet och med cirka 100 fläcka hyenor (*Crocuta crocuta*). Ol Pejeta är därför en lämplig plats att lära sig mer om aktivitetsmönstret hos rovdjur inom skyddade områden genom att analysera bilder från kamerafällor. Målet med denna studie är att undersöka de rumsliga och temporära rörelsemönstren hos fläckig hyena och korrelera det med månfas och nederbörd. Om förändringar i klanstorleken eller boskapsattacker beror på miljömässiga faktorer kommer också att undersökas. Resultat från denna studie visar att fläckiga hyenor går ut ur reservatet efter solnedgång och kommer tillbaka innan soluppgång. Aktiviteten var högre när månljuset var starkt jämfört med när månen lyste mellan ny- och fullmåne. Regn som kom 30 dagar innan hade en negativ korrelation med aktivitet, dvs att när regnfall var lågt så var aktiviteten högre. Gruppstorleken bestod mest utav en eller två individer och kunde inte direkt kopplas till klanstorleken eller med någon miljömässig faktor. Fläckiga hyenor har haft sju attacker på boskap under denna ettåriga studie och kunde varken kopplas till temporära eller abiotiska faktorer. Försiktighetsåtgärder under nattetid är föredraget då den fläckiga hyenan lämnar reservaten även om de visar en större preferens för vilt än boskap.

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INTRODUCTION

1.1 Background

Environmental issues such as global warming (Parmesan & Yohe 2003), ocean acidification (Doney *et al.* 2009) and habitat loss (Fahrig 2003) have become apparent in the last decade. With changes like these, many habitats become inhabitable for organisms to live in. Unlike many other environmental changes, the loss of biodiversity is irreversible (Mittermeier *et al.* 1998), which threatens many ecosystems. As the human population increases by the minute, more resources are needed to meet the demands a growing would population (Holden & Otsuka 2014). Legal and policy measures are important tools that makes it possible to protect habitats and species where exploitation would otherwise occur (Cain *et al.,* 2011). However, this is not always the case. Even with well-defined legislations, monitoring of the regulations can be very time- and cost consuming (Plumptre *et al.* 2014), which will lead to protection of species in theory, but not in practice.

Protected habitats such as national parks or nature reserves, are areas that aim to protect and improve wildlife and biodiversity. However, an increasing wildlife could result in a lower local welfare (Johannesen 2005). Therefore, protected areas are often subject to human-wildlife conflicts as it is often, if not always, based on utilitarian values (Newmark *et al.* 1993), such as depredation upon livestock (Kolowski & Holekamp 2006, Lindsey *et al.* 2013, Woodroffe *et al.* 2005) or crop damage (Graham *et al.* 2012). However, locals can benefit from wildlife as well and generate an income through ecotourism (MvNeely 2000, Wunder 2000). Whether locals or wildlife, or both, benefit from protected areas will depend on multiple reasons and it is important to understand the human and wildlife activities outside the protected areas as well. Even if wildlife populations are protected inside a reserve, they often migrate between the boarders of different management areas, where they may be exposed to hunting (Johannesen 2005). Movement patterns are therefore important to recognize as it can highly affect the demographic parameters within populations.

1.2 Movement pattern in protected areas

Many reserves use fencing as a tool to prevent predator attacks on surrounding livestock (Dickman 2010, Kesch *et al.* 2015, Ol Pejeta Conservancy 2016) or decrease road kill (Jodi *et al.* 2006). Gates, or wildlife corridors, are additionally used by many reserves to allow species to move freely in and out from the area (Pellis *et al.* 2015). There are numerous reasons why species will move from a protected area. It could be migrating species such as elephants (*Loxodonta africana*) and zebras (*Equus quagga*) that migrate to improve food quality (Schuette *et al.* 2016, Van de Perre *et al.* 2013) or spotted hyenas (*Crocuta crocuta)* that partly migrate to increase foraging quantity (Avgar *et al.* 2014).

In Laikipia District, Kenya, lays Ol Pejeta Conservancy that is a non-governmental organization (NGO) that strives to conserve wildlife. This conservancy uses electric fencing around the area to prevent predator attacks on surrounding livestock and thereby mitigate the human wildlife conflict. Furthermore, the fencing protects animals inside the reserve from poachers (Dickman 2010, Kesch *et al.* 2015, Ol Pejeta Conservancy 2016). Even though the fence serve positive functions, a completely closed area would disfavor many migrating species. Ol Pejeta therefore has three wildlife corridors in the northern part of the conservancy, which allows all animals, except rhinoceros due to the design of the fencing, to move in and out of the conservancy. As animals in Ol Pejeta can move to adjacent ranches and conservancies, monitoring becomes more difficult to practice. To have a better idea of which animals use these passages, camera traps have been installed at these corridors (Ol Pejeta Conservancy 2016). By having camera traps on a fixed position over a longer time, knowledge about trends in spatial and temporal use can be obtained (Rowcliffe *et al.* 2008).

1.3 The spotted hyena

Hyenas partly migrate to increase food resources (Avgar *et al.* 2014), but like many other terrestrial carnivores, the spotted hyena will change its activity due to several other factors. For example, human disturbance will lower the overall activity and promote an increased or complete nocturnal activity, compared to hyenas living in an undisturbed area (Kolowski *et al.* 2008). The spotted hyena is however generally seen as a nocturnal species even though they can be active during the day as well (Kruuk 1972). Environmental factors such as rainfall have been shown to promote depredation upon livestock (Kolowski & Holekamp 2006) and moonlight might influence hunting success (Cozzi *et al.* 2012). Furthermore, spotted hyenas are gregarious carnivores, which will also affect their movement pattern. They live in highly structured societies, so called clans, which is a hierarchy where one female dominates (East *et al.* 1993, Frank 1986, Holekamp *et al.* 2012). These clans are fission-fusion societies, meaning that the group pattern will change in response to short and long-term fluctuations in prey densities (Smith *et al.* 2008). Instead of hunting in groups, hyenas often hunt alone, which lower the hunting success, but drastically increase time spend at a carcass without competing for the meat (Smith *et al.* 2008). Even though the spotted hyena is an efficient hunter (Holekamp *et al.* 1997, Kruuk 1966), they scavenge as well (Kruuk 1966, Smith *et al.* 2013). Stealing prey from another, so called kleptoparasitism, is common between hyenas and lions (Trinkel & Kastberger 2005). Successful stealing from lions depends on their group size and if they are too few, lions usually end up as the winner (Cooper 1991, Trinkel & Kastberger 2005). Spotted hyenas have a broad dietary flexibility compared to other large carnivores in the African guild. Only buffalo (*Syncerus caffer*), giraffe (*Giraffa camelopardalis*) and plains zebra are avoided by hyenas, which reflects their opportunistic foraging behavior (Hayward 2006). However, local prey-preference have been observed and diet can change due to fluctuations in prey abundance (Holekamp *et al.* 1997), causing hyenas to prey on buffalos or zebras (Di Silvestre *et al.* 2000, Kruuk 1972).

By looking at the clan size and population density of spotted hyenas, a lot can be told about the habitat's carrying capacity. Holekamp *et al*. (2012) summarized different studies of the spotted hyena and saw that home range drastically decreases from 600 km^2 to below 100 km^2 with larger clans (>25 individuals) or higher density (>0.4 hyenas/km^2). This pattern, where more individuals require less space, indicates that the limiting factor is food availability. The spotted hyena may as well engage in territorial defense where the territory is much smaller than the home range (Holekamp *et al.* 1993, Smith *et al.* 2008).

The spotted hyena is a keystone predator that can survive in environments where other large predators, such as cheetahs (*Acinonyx jubatus*), lions (*Panthera leo*) and wild dogs (*Lycaon pictus*), have vanished (Trinkel 2009). Disappearance of the spotted hyena would therefore indicate a degraded habitat. Even if the presence of spotted hyenas may indicate a healthy ecosystem, the species is heavily disliked by farmers in Kenya and other countries in Africa (Lindsey *et al.* 2013, Romañach *et al.* 2007, Woodroffe *et al.* 2005). Attacks from carnivores cause not only an economical loss but also fear for themselves and future attacks (Conover 2001, Girmay *et al.* 2015). The intolerance of the spotted hyena has led to retaliatory killing, which is connected to the species decline (Holekamp *et al.* 1993, Kissui 2008, Patterson *et al.* 2004, Romañach *et al.* 2007). The spotted hyena is currently listed as "Least Concern" by IUCN, but the population trend is decreasing, mainly outside protected areas (Bohm & Höner 2015), which emphasize the importance of current and future areas for protection.

1.4 Aim

Changes in carnivore populations can cause trophic cascades as it will affect species on lower trophic levels (Fortin *et al.* 2005, Watts & Holekamp 2009). The spotted hyena is an important predator in the African ecosystem (DeVault *et al.* 2003, Holekamp *et al*. 2012), whose demographic parameters can be affected by its activity pattern (i.e. higher risk of retaliatory killing if it preys upon livestock). Studies on these activity patterns can thereby provide vital information about the outcome of a population. As a contributing cause of mortality is persecution, knowledge about when and where a predator attack has occurred may provide answers to why this conflict is ongoing.

The aim is to study what parameters affect the activity pattern of the spotted hyena. I will mainly be looking at two abiotic factors, rainfall and moonlight, to see why the spotted hyenas are moving in and out of reserve by analyzing photos from camera traps. I will also study the activity at a broader scale to see how it changes throughout the year. Furthermore, as hyenas have fission-fusion societies, it can reveal the prey density as the clans will be bigger with prey abundance (Holekamp *et al.* 1993, Smith *et al.* 2008). Therefore, I want to investigate if the clans are larger during certain periods, or if it correlates with environmental factors, as I will not be investigating prey density in this study. Finally, as there are existing data on hyena depredation upon livestock inside Ol Pejeta, I will be looking at these events to see if there is a correlation with the activity.

My questions for this study are:

(i) Do rainfall and/or moon phase influence activity pattern of the spotted hyena in and out of Ol Pejeta Conservancy?

(ii) Does time of the day influence the direction of the spotted hyenas at the wildlife corridors?

(iii) Do rainfall and/or moon phase influence the clan size of the spotted hyena within Ol Pejeta Conservancy?

(iv) Is depredation upon livestock correlated with activity pattern of the spotted hyena within Ol Pejeta Conservancy?

Hypothesis of following questions are:

(i) H_0: No environmental factors are affecting the activity pattern of the spotted hyena in Ol Pejeta Conservancy.
H_1: Environmental factors such as rainfall and moon phase influence the activity pattern of the spotted hyena in Ol Pejeta Conservancy.

(ii) H_0: The direction of spotted hyenas at the wildlife corridors is not influenced by time of the day.
H_1: The time of day influence the direction of spotted hyenas at the wildlife corridors.

(iii) H_0: No environmental factors are affecting the clan size of the spotted hyena in Ol Pejeta Conservancy.
H_1: Environmental factors such as rainfall and moon phase influence the clan size of the spotted hyena in Ol Pejeta Conservancy.

(iv) H_0: Depredation upon livestock is not correlated with the activity pattern of spotted hyenas Ol Pejeta Conservancy.
H_1: Depredation upon livestock is correlated with the activity pattern of spotted hyenas within Ol Pejeta Conservancy.

METOD

2.1 Study site

The study was conducted in Ol Pejeta Conservacy, Laikipia county, Kenya. The area is 360 km^2 with an altitude of approximately 1800 meters above sea level (Elevationmap 2017). The NGO aim to conserve wildlife by generating an income through ecotourism (Ol Pejeta Conservancy, 2016). The district is also used for pastoralism and agriculture, where the livestock are observed by a herder or more during the day and put in bomas (i.e. traditional fence) during the night.

The temperature in Ol Pejeta Conservancy is steady throughout the year as the equator run through the area and as the altitude is over 2000 meters in some parts of the conservancy, temperature during a year usually range from 10°C (min) to 22°C (max) (Safari bookings). Consequently, most of the habitat is semi-arid grassland. However, during the rain seasons, the change in habitat becomes evident. During October-December (most rainfall in November) and March-May (most rainfall in April), the landscape in Ol Pejeta thrives and becomes green due to the increasing precipitation.

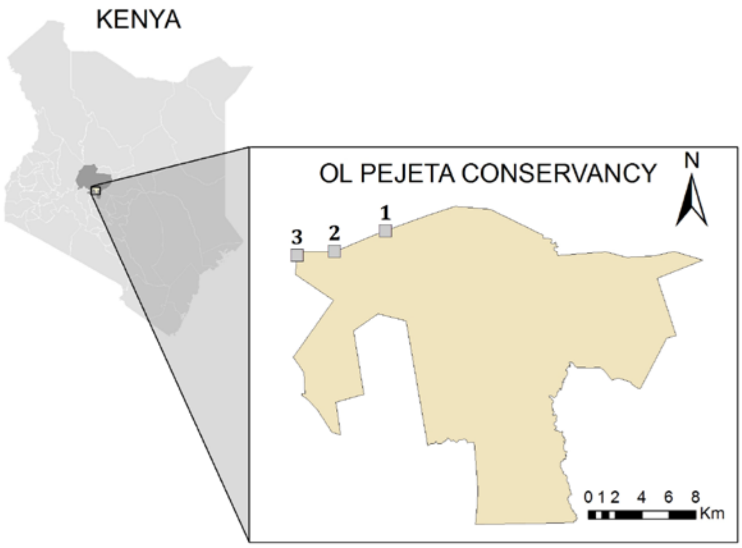

Figure 1: Ol Pejeta Conservancy in proportion to Laikipia (dark grey) and Kenya (light grey). The three wildlife corridors, illustrated as grey squares are shown with their respective number (not proportional to the rest of the map).

The major part of Ol Pejeta is surrounded by an electric fence where three wildlife corridors are placed in the northeastern part of the reserve (Fig. 1). Corridor 1 is 183 meters wide and corridor 2 and 3 are 34 meters wide. Only photos from corridor 2 and 3 will be analyzed due to time constraints. These corridors were chosen as a higher number of predators are found here in comparison to corridor 1. The corridors are made of wooden pillars that stand one meter tall with approximately 55 cm width between them, which serve as a fence for rhinoceros. In front of each corridor lays an area of soil, and by identification of footprints information of passing animals can be revealed. After observing all the footprints, the area is then raked every day by the rangers from Ol Pejeta.

Corridor 2 is placed in an open habitat with three cameras placed in different directions (Fig. 2). Camera A and C are placed at the two ends of the corridor, meaning that no animal can walk in or out from the conservancy without being caught on a photo. Camera B is placed at the center of the corridor, facing towards the outside of the reserve.

Corridor 3 is placed in a habitat with more vegetation and where a Masai tribe has been stationary since June 2015. There are three cameras at corridor 3 as well, but with different positioning compared to corridor 2 (Fig. 3). Camera B is not placed at the complete end of the corridor, which results in animals not being caught on photos if they walk along the higher fence.

Figure 2. Corridor 2 with an illustrated image showing how the cameras are placed in relation to the fence. Photograph and illustration made by Marielle Cambronero.

Figure 3. Corridor 3 with an illustrated image showing how the cameras are placed in relation to the fence. Photograph and illustration made by Marielle Cambronero.

2.2 Camera settings

This study will analyze the photos from the camera traps of spotted hyenas to see movement direction, when (time of day and season) and possibly why they tend to move as they do (Rowcliffe *et al.* 2008). All photos are taken by Reconyx HC600 Hyperfire cameras and will by default have information about the corridor it is placed in, what camera it is (A, B or C), temperature, moon phase, time and date. Detection range during daytime is 30.5 m (100 ft) and 18.2 m (60 ft) during dark hours using flash and infrared illuminator. This is however the maximum length of detection and can by attained by using Lithium or NiMH batteries. Alkaline batteries, that was used in this study until February 2017, are affected by cold and warm weather and do not provide the same power as the Lithium and NiMH batteries do (Reconyx Instruction Manual). The fact that alkaline batteries of varied brands were used instead of Lithium or NiMH batteries indicate that the cameras were not preforming at their best.

A total of six cameras were used in the study and the settings were not the same on all of them. By default, the camera will take 3 pictures per trigger with 1 second between pictures and no quiet period (i.e. no delay between triggers). Camera setting in this study did however vary between 3 or 5 pictures per trigger. Furthermore, picture interval within a trigger could differ between Rapidfire (2 pictures per second), 1 second, 3 seconds or 5 seconds. There was no quiet period on any camera, even though the second trigger could react several seconds after the last photo of the first trigger.

2.3. Structure of dataset

As all photos from one week were gathered every week, lots of photos with no significance for this study were obtained. To analyze photos of the spotted hyena more effectively, a staff member from Ol Pejeta was hired to organize the raw data into species-specific folder. This was later uploaded onto Dropbox to make it possible for analysis without being present at Ol Pejeta. Together with three other students, folders of our focal species (cheetah, elephants, jackals, leopard, lion and spotted hyena) were uploaded at Dropbox. The study group made a field trip to Ol Pejeta between the 14th -27th of November. This enabled us to talk to the staff member to standardize how the pictures were supposed to be sorted. In order for people to determine species in the same way as it is done now, we had to agree on one method. The field trip to Ol Pejeta Conservancy also made it possible to gather many months of data at once, instead of downloading the data from Dropbox.

To structure my dataset, I used Microsoft software Excel 2016. I organized the photos of spotted hyenas where every row gave information about passage, image number, corridor, camera, date, time, direction, group size, group id, moon phase, temperature and rainfall. A passage was counted when I was sure the animal was my focal species. Even if the folders had been sorted by the staff member of Ol Pejeta, I still did not use a photo if I found it untrustworthy. If a spotted hyena was caught by two or three cameras in one corridor, it would still only get one passage number.

Direction was decided by looking at what camera the hyena was moving in and from there imagine how the animal was walking. For most of the pictures it was quite clear if the direction was in, out, along or unknown, but sometimes it was not as easy. If the spotted hyena was only seen on 1/5 photos but the head in the direction of the corridor, then I assumed it was moving towards it in such pace that it was not captured on the remaining 4 pictures. If the animal however was caught on several photos, looking around, and then disappearing out of frame, I decided it was unknown because the direction could not be clear. Categories "in/out" was only given if I was certain the animal was outside the reserve and then going in, and vice versa. Thus, many photos were classified as "unknown" because I could not tell the direction the hyena came from, or that it came from one direction and went back the same way without passing the corridor. The same passage could be observed by two of the cameras in the same corridor, which gave pictures of the same individual from two angles. A good estimation of where the hyena was going could thereby be made. To guarantee that it was the same individual, the time and date of the photos were compared.

Hyenas were given the same group number if there were less than 5 minutes between two different individuals. It is very important that the two, or more individuals, were different spotted hyenas. If one individual had gone in a circle and then got caught on photo again, within 5 minutes, then I would not count this individual. However, seeing individuals is not an easy task, especially as spotted hyenas are mostly caught on photos during night with monochrome coloring. If I was unsure if a hyena had already been counted for, most likely would be that I gave that individual a new passage number with a group id of its own. The group size enabled me to estimate the clan size of the spotted hyenas and see how it changed during the survey.

Even though the cameras could display eight different moon phases during a month, it was noticed that the cameras did not have the same settings and could thereby show different moon phase on the same date. It was therefore safer to use the moon phase, given in percentage, from the webpage Weather Underground where Nanyuki was the city where the data was collected from. Temperature data was also taken from this webpage. Moon illumination percentage were then divided to three categorize: <25% moonlight = (1); 25-75% = (2) and 75-100% = (3). Why category (2) have a span of 50% moon light compared to the other two is because of the number of days on each lunar cycle. By dividing the cycle into three, equal amount of days during a year will be represented into each category.

Rainfall data was obtained daily from two places in Ol Pejeta: Kamok and Loirugrugu (Fig. 4). The distance to Loirugrugu from corridor 3 or corridor 2 is approximately 1.5 km whereas Kamok lays 9.3 km away from corridor 3 and 6.3 km from corridor 2.

2.4 Depredation upon livestock

Data of predator attacks upon livestock have been collected by the staff members of Ol Pejeta Conservancy. I only used data from the 12 months I had been analyzing photos from the camera traps. The three locations where hyenas had been found to depredate were two locations in Sirima and one in Moto (Fig. 4). In Sirima there are two water holes, which named the two sites as Sirima 1 and 2. Sirima is devoted to intense farming which have a surrounding fence. However, electricity are only active on some parts, causing wildlife to enter the area even though it is supposed to be predator-free (Nickson Ndiema, personal communication).

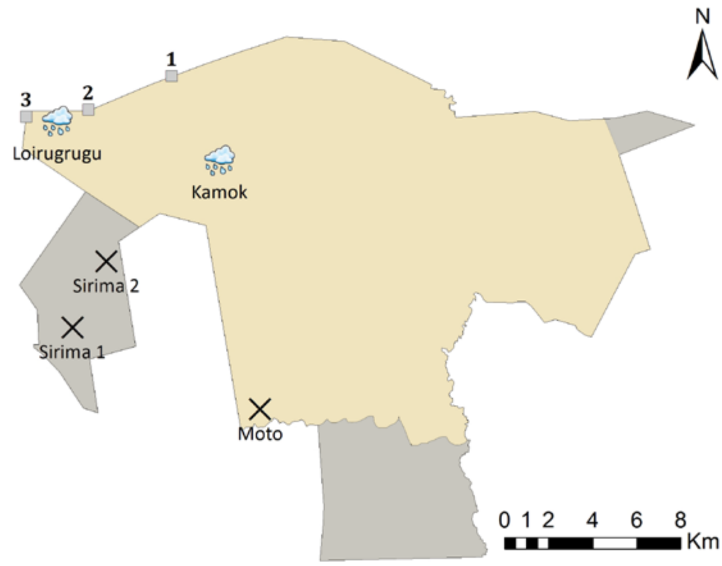

Figure 4. Map of Ol Pejeta Conservancy where the gray dots represent the three corridors, the rain clouds are the two locations where rain data was collected and the "X" is where predation upon livestock has been reported. Grey areas belong to Ol Pejeta but only partly have electrical fence.

2. 5 Software and statistical analysis

Maps of Kenya and Ol Pejeta are made in ArcGis 10.5. Illustrated images on the photos are made in Adobe Photoshop 2014. I structured my dataset in Microsoft Excel 2016 with dummy variables for almost all rows (except moonlight and rainfall), which was then imported into the statistical software R Studio (version 1.0.136). To answer my initial questions, I used ANOVA to see if there was a difference in activity due to moon phase, rainfall and temperature. When activity was recorded (i.e. spotted hyena caught on photo), it was of interest to see in what direction it was going. An ANOVA was thereby used as well. A post-hoc test was used to see what variables differed if an ANOVA gave significant p-value. For this study, Tukey's procedure was used as it is applicable on pairwise comparisons. Correlations between different parameters were done by using Pearson correlation coefficient, when the required assumptions had been fulfilled. A binomial test was used to see if there was a significant difference between two variables. For all statistical analysis, the level of significance was $p \leq 0.05$.

As there was inconsistency in how well the batteries were performing I found it useless to test which camera took most pictures. Sometimes the batteries had died before all data had been obtained, and sometimes two cameras had switched place. I therefore summarized how well a position had done instead of the actual camera. That is, position 2A is corridor 2 camera A, and even if camera A and C had switched place I still counted the pictures from 2C into 2A as it was on its position. Dates when camera batteries had died, passages were labeled as "Not available" rather than zero passages.

RESULTS

3.1 Camera traps performance

Photos from 30 May 2015 to 29 May 2016 were analyzed, with a total of 1646 passages. Out of the 1646 passages camera B only captured a spotted hyena once, in corridor 2. However, both camera A and C was frequently used in both corridors. Hyenas were captured 50.9% by camera A in corridor 2 and 4.4% in corridor 3, while camera C caught more photos in corridor 3 (33.2%) compared to corridor 2 (14.9%). Occasionally the same hyena was caught by two cameras in the same corridor, causing the percentage to exceed 100%. Raw data from 30 May 2015 to 27 May 2016 had most pictures on position 2A, but photos of hyenas were most frequently seen in 3C where 0.3% of the images had a registered passage. This is however an underestimation as several pictures contained the same spotted hyena but only one picture representing a passage.

Raw data of all animal species, including empty photos, usually varied from 19000-25000 pictures per month. December 2015 did however not follow this trend as it only contained about 8000 pictures. Another observation was that 7.6% of the 288 folders of raw data were completely empty, 8.3 % had batteries that died before the memory card was exchanged and 6.9% had cameras that were placed on the wrong position.

3.2 Environmental factors on activity pattern

Highest activity occurred in July 2015 with 358 passages and lowest activity was in November with only 37 passages. Mean passages per day was 5 hyenas (± 0.77) (standard error). Out of all registered passages, 94% occurred during dark hours 19-5 (1900-0559 h). Nighttime activity was significantly higher at moon phase 3 compared to phase 2 (binomial, 95% CI [0.44, 0.5], p=0.03) (Fig. 7). Number of days per phase were 116 days for phase 1, 124 days for phase 2 and 128 days for moon phase 3 with no standard error. The study started at moon phase 3 and ended with moon phase 2, causing fewer days for phase 1.

Rain did however have an effect on activity. Most evident was the effect of rainfall during the previous 30 days before the passage was registered (Pearson, df= 364, p <0.001, 95% CI [-0.33, -0.14]) (Fig. 5). Additionally, rainfall that had come during 7 days before had a correlation with the number of passages (Pearson, df= 364, p <0.001, 95% CI [-0.31, -0.12]). Both tests show that there is a negative correlation between number of passages per day with rainfall of the previous 7 or 30 days. No effect was found with the amount of rain that arrived the same day as the passages occurred or during previous 90 days (p >0.05).

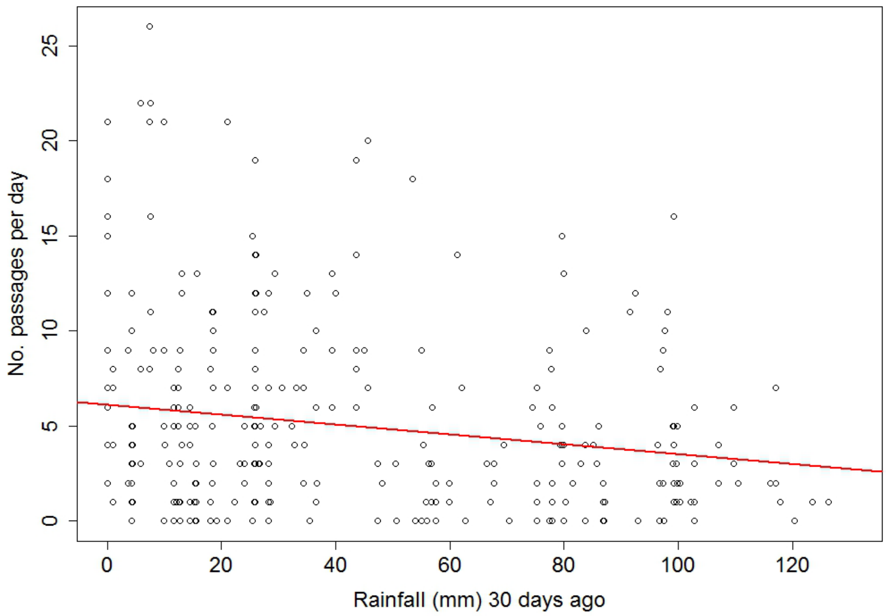

Figure 5. Scatter plot showing a negative correlation between rainfall (mm) of the previous 30 days with passages. Regression line shows that with every decreasing passage per day there is an increase of 40 mm of rain.

Direction was significantly different with what hour it was (ANOVA, df=3, *p*=0.039). A post-hoc analysis was conducted to see what groups differed in means. "In" and "Out" were the only groups that were significantly different (Tukey, *p*=0.0145) (Fig. 6). Hyenas walk out of the reserve at hour 19 significantly more than they walked in (Binomial, 95% CI [0,21, 0.39], *p*<0.001). The opposite occurred at 05 in the morning, when hyenas walk into the reserve significantly more than they walked out (Binomial, 95% CI [0.56, 0.79], *p*<0.001). This indicate that hyenas walk out from Ol Pejeta after sunset and returns before the sun has risen.

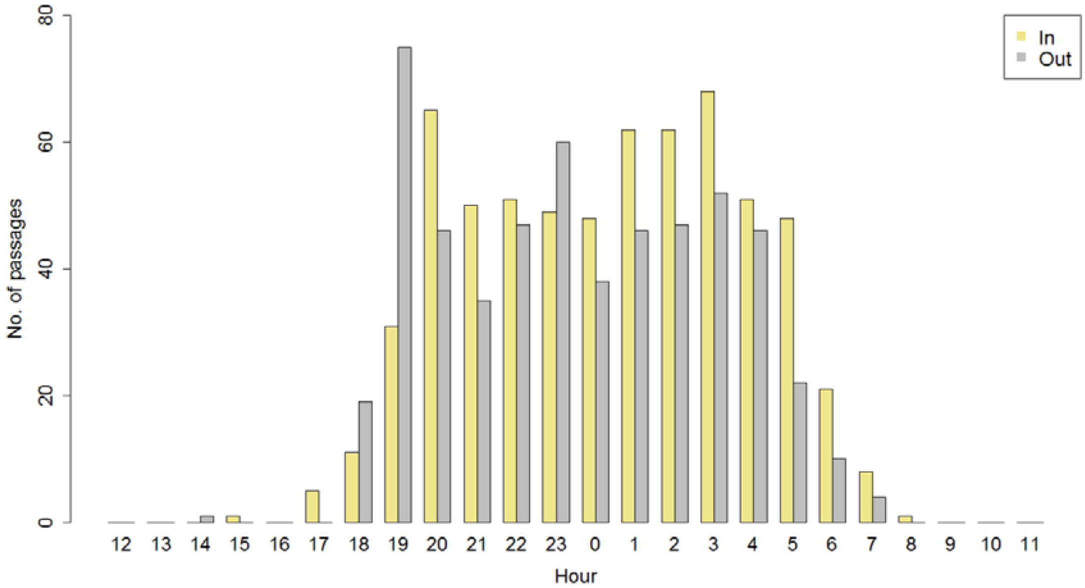

Figure 6. Barplot showing if spotted hyena is moving in or out of the reserve during what hour.

Mean temperature per day did not correlate with the activity (Pearson, $p > 0.05$). Temperature that was specified on each photo (i.e. when they were active) show a peak between 13-18°C (16°C ± 0.07).

3.3 Group size

Group size was extremely skewed towards groups with one induvial. Out of the 1646 passages, 64% belonged to groups with 1 individual. With 2 hyenas per group were 278 individuals, meaning that 139 (278/2) unique groups with two animals existed. Groups consisting of 1 and 2 hyenas were found during all months of the year.

Descriptive analysis of the group size in response to moon light was conducted to see if larger groups occurred during a certain moon phase (Fig. 7). Lone hyenas are distributed very similarly throughout the moon cycle, whereas larger groups are more commonly observed when moonlight is low.

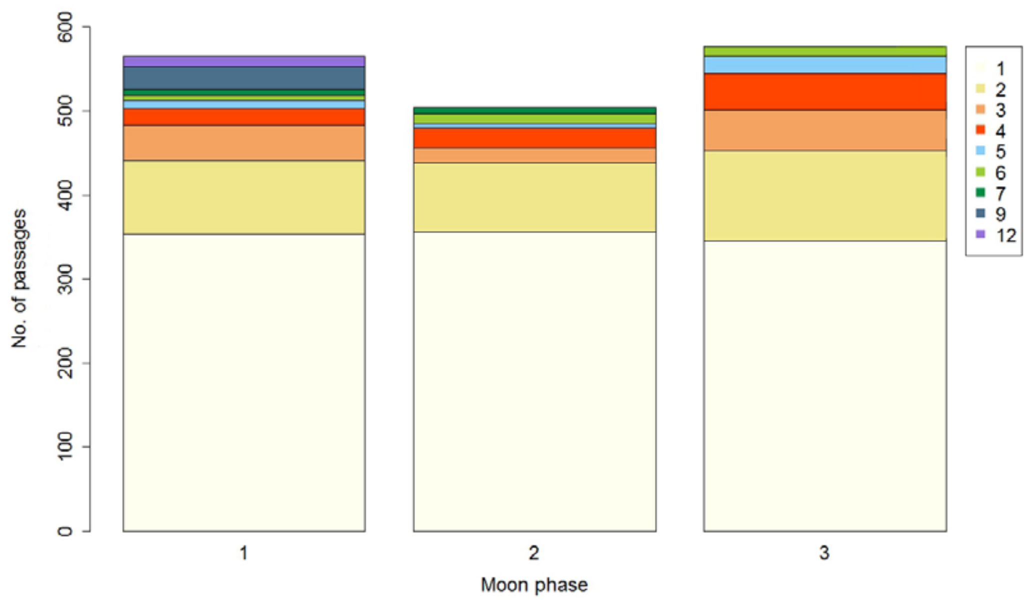

Figure 7. Barplot showing the three moon phases where full moon (3) had significantly more activity than phase 2. Legend represent the number of individuals per group. To see the number group ID (i.e. unique groups), divide the color of the group with its respective number.

3.4 Predation

Between end of May 2015 until May 2016 seven hyena attacks occurred in Ol Pejeta Conservancy. These attacks occurred five times in Sirima 1, once in Sirima 2 and once in Moto (Fig. 4). As there are only seven samples of depredation during an entire year statistical analysis could not be performed. The distance from corridor 3 to Moto is approximately 20 km. From corridor 3 to Sirima 1 and 2 is 11 km respectively 7 km. The attacks occurred irregularly between 25th of June 2015 until 29th of January 2016. Adult cattle were predated upon three times, as well as young bulls, where a calf was taken once by spotted hyena. Data on when the predation occurred were only mentioned once for nighttime and twice for attacks during the day. There was no indication that environmental factors influenced these attacks as moon percentage differed from 1–75% and rainfall varied as well.

When analyzing the photos, hyenas with prey in their jaws were found 16 times. These events occurred from the 26th of July 2015 to 26th of May 2016. Like the attacks upon livestock, no pattern was found here either. Hyenas were heading out and in of the reserve six times respectively, and four times the direction was unknown. Moonlight differed from 1–100% and group size normally consisted of one individual. The only pattern that was found was that it occurred during dark hours from 19 to 04. What the prey was could only be identified with certainty once and that was due to the pattern of the zebra leg.

DISCUSSION

4.1 Activity throughout the year

The activity was highest during July 2015 with 358 passages, which was an apparent peak compared to June and August that had the second highest activity with 222 respectively 198 passages. Lowest activity occurred in November and December with 37 and 43 passages. December probably represents an underestimation of activity as the camera traps failed in performance with less than half of the pictures the other months usually obtained. Without comparable data from previous years it is hard to estimate if the trends shown by hyenas are common or due to external factors. Corridor 2 is more frequently used with 1077 passages during the year compared to corridor 3 with 619 passages. As the Masai tribe moved next to corridor 3 in 2015, just before the data collection began, the lower activity could be a result of human avoidance (Kolowski *et al.* 2008).

The spotted hyenas in Ol Pejeta showed a significant difference in what time of the day they walked in or out of the reserve. Walking out of the reserve was more common at hour 19 in the evening whilst walking into Ol Pejeta occurred at hour 5 (Fig. 6). This might be an adaptation to avoid human disturbance, as there is a road outside the reserve with occasional activity during the day. This allows hyenas to explore the outside area when human activity is low and return before the sun is up. Another explanation could be avoidance of interspecific competition. Observations were made six times with hyenas taking its prey out from the reserve. Four out of the five hyenas were loners, which would have made them very vulnerable to kleptoparasitism by territorial lions inside Ol Pejeta (Trinkel & Kastberger 2005, Valeix *et al* 2012). However, observations of hyenas taking its prey into the reserve were made six times as well which can indicate better foraging conditions outside than inside. In either case, the sample size of hyenas with observed prey is too low to draw conclusions of why hyenas travel in and out from the reserve.

4.2 Environmental factors influence on activity

Significant negative correlation of rainfall with activity indicate that spotted hyenas are influenced by environmental factors (Fig. 5). Additionally, bright nights with lots of moonlight showed to have a significant higher activity than for moon phase 2 (Fig. 7). However, this correlation could not be found with temperature. The latter is not surprising as Ol Pejeta Conservancy lays on the equator with similar temperature throughout the year. Why rain that had come 7 or 30 days before had a negative correlation with activity can only be speculated about. One possible explanation is that grass will be scarce when there is low precipitation, which makes herbivores go to other places to graze. The grass will be green just a couple of days after the rain has arrive, causing a decreased camouflage for the hyenas. However, research on how the grass affect hunting success of hyenas has not been made and it is possible that the height or color of the grass does not inflict the hunting success to a great extend. Hyenas are pursuit predators and are not as dependent on a good camouflage as ambush predators are. As rain data was collected close to the corridors it is safe to assume that prey in the area moved further away from the corridors when rainfall was low. The increasing activity of spotted hyenas when rainfall was low could be an effect of an increasing foraging effort. As the majority of the data consisted of solitary hyenas, days with many passages consisted of many solitary individuals. This would go well with the findings that Holekamp *et al.* (2012) found in their review, that with lower clan size home ranges will be larger. Clan size is depending on prey availability, so even if it seems farfetched, the lack of rain could be the reason for smaller clan size which leads to bigger home ranges. As spotted hyenas can travel up to 80 km to forage (Kruuk 1966), it is not unlikely that hyenas from anywhere in Ol Pejeta were caught on photos when foraging. When rain is abundant, it attracts herbivores with fresh grass close to the corridors and the search effort decreases. This is an explanation based on the assumption that the clans' den site is inside the reserve, which means that they do not have to cross the corridors to forage.

Moon phase 3 had a significantly higher activity than for moon phase 2 (Fig. 7). Cozzi *et al*. (2012) did not find any correlation between the nocturnal activity of hyenas and moonlight, which makes the results in this study interesting, as it has not been observed before. However, only the study of Cozzi *et al.* (2012) has been investigating the impact of moonlight on hyenas. The impact of moonlight on activity may differ between countries or clans and research on the subject should therefore be made to draw conclusions of the result in this study. It is important to highlight that the higher activity in moon phase 3 only says that the hyenas are moving across the boarder more than for moon phase 2, and the reason for this is unknown. To find that answer requires a study where all species that cross the wildlife corridors are observe. To assume that either prey or predator will get an advantage during full moon is to simplify reality. Species use different primary sensory system (e.g. sight, olfaction) and will thereby get affected by moonlight differently rather than being a prey or a predator (Prugh & Golden 2014).

4.3 Assumptions of clan size

Earlier studies have been identifying clans where the observers looked at the unique spots of hyena's fur (Holekamp 1997, Smith *et al.* 2008), a method this study was not able to imitate. Even though the clan size(s) in Ol Pejeta could not be observed, trends in the fission-fusion society could be revealed by the group sizes (Smith *et al.* 2008). It is hard to draw any conclusions in the changing pattern of clan size by looking at group size per month as the sample size for groups with three hyenas or more were few. The absence of larger groups could be a coincidence rather than the truth, as the camera batteries were not fully charged. When one hyena was spotted, there could have been more individuals at the site but gone missing by the cameras. Either way, groups with three or more individuals were not observed every month of the year which still indicate that there is some change in the composition of the clans.

Groups with one or two hyenas shows an even distribution throughout the lunar cycle (Fig. 7). When looking at the groups with more than two individuals it becomes more difficult to see a pattern among the three phases. As the sample size becomes smaller, credibility in the results weakens. As the dataset of the group size were very much skewed towards one individual per group, statistical analysis was difficult to conduct without getting biased results. As the samples of the larger groups are so few it easily causes confusion when looking at the results from the rainfall. I previously speculated that the negative correlation of rainfall with number of passages per day could be an effect of an increasing foraging effort. With this in mind, it might seem contradicting as a group of 12 hyenas must be categorized as a day with at least 12 passages, and thereby rainfall should be low, which causes smaller groups. However, the plot in figure 5 only shows a correlation. When looking at the actual rainfall 30 days before the group of 12 hyenas were observed was 80 mm, which is a lot of rain of this area. More data on larger groups is therefore necessary to say if the group size is affected by rainfall or by the moon phase. More data is also required to say if the differences in group size can be an index of the clan size.

4.4 Predation

In total seven attacks on cattle occurred during this one-year study. Most incidents occurred in Sirima area, which focus on intense cattle use. Sirima is supposedly predator free and is not part of the wildlife area tourist normally visit. However, the area has suffered from attacks of other predators than spotted hyenas, which evidently shows that predators do exist there despite Sirimas predator-free reputation. The area is not completely protected by the electrical fence, and animals that walk out from Ol Pejeta by the wildlife corridors seem to find ways to enter Sirima. It might be so that attacks upon livestock will increase when prey density is low but such correlation was not found in this study. However, hyenas are not the main cause of predation in Ol Pejeta. Lions and leopards cause a much higher degree of depredation upon livestock, especially if looking at the damage per predator, as leopards are much fewer than hyenas in Ol Pejeta. Nevertheless, the loss of livestock is always a sad reality for farmers and the concentrated attacks in Sirima indicate implementations for higher safety needs to be prioritized. For instance, there can be more herders watching the livestock or deterrent devices that use light or sound.

The photos from the camera traps also revealed hyenas with their prey. As most of the photos contained small pieces of bones, identification of prey species was impossible, especially as many of the photos were blurry. The only prey that was identified with certainty was a zebra, due to the decent quality of the photo and the distinguished pattern of the zebra leg. The study of Hayward (2006) showed that zebra was one of the few prey species hyenas actively avoid which might explain that the kill was stolen from another predator. However, zebras do not wander completely safe from hyenas. The diet of spotted hyenas depends on availability, so if zebras graze in large numbers, hyenas will likely try to prey on a foal or a sick individual (Di Silvestre *et al.* 2000, Holekamp *et al.* 1997). The general pattern where hyenas with prey was spotted was very low, only 1%, which indicate that they do not usually take their prey across the border.

4.5 Performance of the camera traps

Unfortunately, there was an inconsistency throughout the survey in how the camera traps were maintained. Irregular exchange of batteries and memory card resulted in a total of 7.6% complete loss of pictures whereas 8.3% had folders with pictures, but not throughout the week, which indicate that the batteries had died. This is indeed unfortunate as it results in loss of valuable data. The quiet period of the camera traps where supposed to be zero and thereby taking pictures right after a trigger was done. However, the second trigger could be delayed by many seconds even though many animals where in front of the camera the whole time. This was probably due to low battery levels, as they were not fully charged when I visited the study site and was told that it did not affect the camera performance. Another downside was the use of various brands of batteries instead of the optimized Lithium or NiMH batteries. It is important to stress the significance of using good equipment to interpret the results correctly. How well the cameras are performing during nighttime is also much dependent on the recommended batteries (Reconyx Instruction Manual).

The different camera traps at the corridors had fixed position but still mix ups were made. The cameras could be mounted upside down or in the more common scenario, in 6.9% of all the folders, camera position had been mixed up. To be able to evaluate the position of the cameras, in order to improve the placement for example, it is important that the cameras are standardized. As this was not the case, not much can be said about the positioning of the camera traps and if they should be moved to improve capture rate.

Even if data was collected during an entire year only one hyena picture was found in camera B, corridor 2. This is very noteworthy as other animals were caught on that camera, as well as on camera B in corridor 3 where no hyena had been caught on photo. I believe the differences in activity per camera can be explained by several factors. First, hyenas that were caught on pictures usually took the same path, which could be out of reach from a particular camera. If this is a common pattern for the large predator remains unclear as I was unable to find literature on the subject. But if hyenas use the same pathway in and out from the conservancy, then the absence of them in camera 2B and 3B could be an effect of the other utilized routes. Secondly, as camera B in corridor 3 is not at the complete end of the wooden pillars, animals can walk along the high fence and not be caught by the camera. Finally, both cameras that were facing the corridors (i.e. 2B and 3A) caught animals that were in a more exposed area than the animals that crossed the corridors at the edges. Thus, animals at camera 2B and 3A were usually not as close to the camera as in 2A, 2C, 3C, and the flash had to work successfully in order to see what species that were caught on photo. As already discussed, the performance of the batteries was not the best which probably has led to many species passing unnoticed.

CONCLUSION

The aim of this study was get more knowledge about the activity pattern of spotted hyenas as the species is heavily disliked and suffers from persecution. With more knowledge of its behavior, increased awareness of especially farmers can result in higher tolerance towards hyenas. My questions for this study answered as follows:

(i) Both environmental factors influenced activity as rainfall had a significant negative correlation with activity, whilst moon phase 3 caused a significant higher activity than for moon phase 2.

(ii) The direction at the corridor is influenced by what hour it is. Hyenas at Ol Pejeta move out of the reserve significantly more than in (hour 19) and move into the reserve significantly more than out (hour 5).

(iii) Neither rainfall nor moon phase showed to influence the clan size. Statistical analysis could not be performed due to few samples of larger groups of hyenas.

(iv) Hyena activity did not influence depredation upon livestock within Ol Pejeta. Statistical analysis could not be performed due to few attacks by hyenas.

It is important to considerate that the high density of wildlife inside and around Ol Pejeta causes hyenas to forage on their natural prey. For many farmers around Kenya, high density of prey species may not exist which causes their livestock to be very vulnerable to predation. This emphasize the importance of protected areas, as they are not only important for endangered species, but as well for the ongoing human-wildlife conflict. As protected areas can sustain high densities of wild prey, predators will be more attracted to these areas than livestock near humans. This study has shed light upon some of the variables that influence the activity pattern of the spotted hyena within Ol Pejeta. A continuous research of the activity pattern is important as it could hopefully be useful in mitigating the human-wildlife conflict.

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LITERATURE

Avgar, T., Street, G., Fryxell, J.M. (2014). On the adaptive benefits of mammal migration. *Canadian Journal of Zoology*, vol. 92, pp. 481-490

Bohm, T., Höner, O.R. (2015). *Crocuta crocuta*. The IUCN Red List of Threatened Species 2015: e.T5674A45194782. Available at: http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T5674A45194782.en, Accessed 2016-11-03

Cain ML. William DB, Sally DH. (2011). Ecology. 2nd ed. Sinauer Associates Inc

Conover MR. (2001). Philosophy. In: Conover MR (ed). Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management, pp: 1-16. Lewis Publishers.

Cooper S.M. (1991). Optimal hunting group size: the need for lions to defend their kills against loss to spotted hyaenas. *African Journal of Ecology.* Vol. 29, pp 130-136

Cozzi G., Broekhuis F., McNutt J.W., Turnbull L.A., Macdonald D.V., Schmid B. (2012). Fear of the dark or dinner by moonlight? Reduced temporal partitioning among Africa'slarge carnivores. *Ecology,* vol. 93, pp. 2590-2599

DeVault T. L, Rhodes Jr. O. E., Shivik J.A. (2003). Scavenging by vertebrates: behavioral, ecological, and evolutionary perspectives on an important energy transfer pathway in terrestrial ecosystems. *Oikos*, vol. 102, pp. 225-234

Di Silvestre I., Novelli O., Bogliani G. (2000). Feeding habits of the spotted hyaena in the Niokolo Koba National Park, Senegal. *East African Wild Life Society*, vol. 38, pp. 102-107

Dickman A.J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation,* vol. 13, pp. 458-466

Doney SC, Fabry VJ, Feely RA, Kleypas JA. 2009. Ocean Acidification: The Other CO2 Problem. *Annual Review of Marine Science,* vol. 1, pp. 169-192

East M.L., Hofer H., Wickler W. 1993. The Erect 'Penis' Is a Flag of Submission in a Female-Dominated Society: Greetings in Serengeti Spotted Hyenas. *Behavioral Ecology and Sociobiology*, vol. 33, pp. 355-370

Elevationmap. WWW-link: http://elevationmap.net/unnamed-road-kenya?latlngs=(0.015449523738561313,36.86840057373047). Accessed 2017-04-11

Fahrig L. (2003). Effects of Habitat Fragmentation on Biodiversity. *Annual Review of Ecology, Evolution, and Systematics*, vol. 34, pp. 487-515

Fortin D., Beyer H.L., Boyce M.S., Smith D.W., Duchesne T. Mao J.S. (2005). Wolves Influence Elk Movements: Behavior Shapes a Trophic Cascade in Yellowstone National Park. *Ecology*, vol. 86, pp. 1320-1330

Frank L.G. (1986). Social organization of the spotted hyaena *Crocuta crocuta.*II. Dominance and reproduction*.* *Animal Behaviour*, vol. 34, pp. 1510–1527

Girmay M, Gadisa T, Yirga G. (2015). Livestock loss by the spotted hyena (*Crocuta crocuta*) in and around a waste dumping site in Northern Ethiopia. *International Journal of Biodiversity and Conservation,* vol. 7, pp. 50-53

Graham MD, Adams WM, Kahiro GN. (2012). Mobile phone communication in effective human–elephant conflict management in Laikipia County, Kenya. *Oryx*, vol. 46, pp. 137-144

Hayward M.W., (2006). Prey preferences of the spotted hyaena (Crocuta crocuta) and degree of dietary overlap with the lion (Panthera leo). *Journal of Zoology,* vol. 270, pp. 606–614

Holden ST, Otsuka K. (2014). The roles of land tenure reforms and land markets in the context of population growth and land use intensification in Africa. *Food Policy,* vol. 48, pp. 88-97

Holekamp K.E., Ogutu J.O., Dublin H.T., Frank L.G. Smale L. (1993). Fission of a Spotted Hyena Clan: Consequences of Prolonged Female Absenteeism and Causes of Female Emigration. *Ethology*, vol. 93, pp. 285-299

Holekamp K.E., Smale L., Berg R., Cooper S.M. (1997). Hunting rates and hunting success in the spotted hyena (*Crocuta crocuta*). *Journal of Zoology*, vol. 242, pp. 1-15

Holekamp K.E., Smith J.E., Strelioff C.C., Van Horn R.C., Watts H.E. (2012). Society, demography and genetic structure in the spotted hyena. *Molecular Ecology*, vol. 21, pp. 613–632

Jodi H, Zander L.W., Maya M.A. (2006). *Corridor Ecology: The Science and Practice of Linking Landscapes for Biodiversity Conservation*. Island Press

Johannesen A.B. (2005). Protected areas, wildlife conservation, and local welfare. *Ecological economics*, vol. 62, pp. 126–135

Kesch M.K., Bauer D.T., Loveridge A.J. (2015). Break on Through to the Other Side: The Effectiveness of Game Fencing to Mitigate Human - Wildlife Conflict. *BioOne,* vol. 45, pp. 76-87

Kissui B.M. (2008). Livestock predation by lions, leopards, spotted hyenas, and their vulnerability to retaliatory killing in the Maasai steppe, Tanzania. *Animal conservation*, vol. 11, pp. 422-432

Kolowski J.M., Katan D., Theis K.R., Holekamp K.E. (2007). Daily Patterns of Activity in the Spotted Hyena. *Journal of Mammalogy*, vol. 88, pp. 1017-1028

Kolowski JM, Holekamp KE. (2006). Spatial, temporal, and physical characteristics of livestock depredations by large carnivores along a Kenyan reserve border. *Biological* Conservation, vol. 128, pp. 529–541

Kruuk H. (1966). Clan-system and Feeding Habits of Spotted Hyaenas (*Crocuta crocuta* Erxleben). *Nature*, vol. 209, pp. 1257-1258

Kruuk H. (1972). The Spotted Hyena, A Study of Predation and Social Behavior. *Journal of Mammalogy*, vol. 54, pp. 553-554

Lindsey P.A, Havemann C.P., Lines R., Palazy L., Price A.E, Retief T.A, Rhebergen T., Van der Waal C. (2013). Determinants of Persistence and Tolerance of Carnivores on Namibian Ranches: Implications for Conservation on Southern African Private Lands. *Plos One*, vol. 8, pp. e52458

Mittermeier RA, Myers N, Thomsen JB, Da Fonseca JAB, Olivieri S. (1998). Biodiversity Hotspots and Major Tropical Wilderness Areas: Approaches to Setting Conservation Priorities. *Conservation Biology*, vol. 12, pp. 516–520

Newmark WD, Leonard NL, Sariko HI, Gamassa DM. (1993). Conservation attitudes of local people living adjacent to five protected areas in Tanzania. *Biological Conservation* (63): 177-183

Parmesan C, Yohe G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature*, vol. 421, pp. 37-42

Patterson B.D., Kasiki S.M., Selempo E., Kays R.W. (2004). Livestock predation by lions (*Panthera leo*) and other carnivores on ranches neighboring Tsavo National Parks, Kenya. *Biological Conservation,* vol. 119, pp. 507-516

Pellis A., Lamers M., Van der Duim R. (2015). Conservation tourism and landscape governance in Kenya: the interdependency of three conservation NGOs. *Journal of Ecotourism*, vol. 14, pp. 130–144

Plumptre AJ, Fuller RA, Rwetsiba A, Wanyama F, Kujirakwinja D, Driciru M, Nangendo G, Watson JEM, Possingham HP. (2014). Efficiently targeting resources to deter illegal activities in protected areas. *Journal of Applied Ecology*, vol. 51, pp. 714–725

Prugh L.R., Golden C.D. (2014). Does moonlight increase predation risk? Meta-analysis reveals divergent responses of nocturnal mammals to lunar cycles. *Journal of Animal Ecology,* vol. 83, pp. 504-514

Reconyx instruction manual. (2003) WWW-link: http://images.reconyx.com/file/HyperFireManual.pdf. Accessed 2017-04-11

Romañach S.S., Lindsey P.A., Woodroffe R. (2007). Determinants of attitudes towards predators in central Kenya and suggestions for increasing tolerance in livestock dominated landscapes. *Oryx*, vol. 41, pp. 185-195

Rowcliffe J. W., Field J., Turvey S. T., Carbone C. (2008). Estimating animal density using camera traps without the need for individual recognition. *Journal of Applied Ecology,* vol. 45, pp. 1228–1236

Safari bookings. WWW-link: https://www.safaribookings.com/olpejeta/climate #dryseason . Accessed 2017-04-11

Schuette P., Creel S., Christianson D. (2016). Ungulate distributions in a rangeland with competitors, predators and pastoralists. *Journal of Applied Ecology*, vol. 53, pp. 1066–1077

Smith J.E., Kolowski J.M., Graham K.E., Dawes S.E., Holekamp K.E. (2008). Social and ecological determinants of fission–fusion dynamics in the spotted hyaena. *Animal Behaviour*, vol. 76, pp. 619–636

Trinkel M. (2009). A keystone predator at risk? Density and distribution of the spotted hyena (Crocuta crocuta) in the Etosha National Park, Namibia. *Canadian Journal of Zoology*, vol. 87, pp. 941-947

Trinkel M., Kastberger G. (2005). Competitive interactions between spotted hyenas and lions in the Etosha National Park, Namibia. *African Journal of Ecology.* Vol. 43, pp. 220-224

Valeix M., Loveridge A.J., Macdonald D.W. (2012). Influence of prey dispersion on territory and group size of African lions: a test of the resource dispersion hypothesis. *Ecological Society of America*, vol. 93, pp. 2490-2496

Van de Perre F., Adriaensen F., Songorwa A.N., Leirs H. (2014). Locating elephant corridors between Saadani National Park and the Wami-Mbiki Wildlife Management Area, Tanzania*. African journal of ecology*, vol. 52, pp. 448-457

Watts H.E., Holekamp K.E. (2009). Ecological Determinants of Survival and Reproduction in the Spotted Hyena. *Journal of Mammalogy,* vol. 90, pp. 461-471

Woodroffe R., Lindsey P., Romañach S., Stein A., ole Ranah S.M.K. 2005. Livestock predation by endangered African wild dogs (*Lycaon pictus*) in northern Kenya. *Biological Conservation*, vol. 124, pp. 225–234

Wunder S. 2000.Ecotourism and economic incentives — an empirical approach. *Ecological Economics*, vol. 32, pp. 465–479

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