CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

An unexpected population of brown hyena in southern Namibia – how remote it really is?

BACHELOR'S THESIS

Prague 2020

Kristýna Stehlíková

Supervisor: doc. Ing. Karolína Brandlová, Ph.D.

Consultant: Ing. Viktor Neštický

Declaration

I hereby declare that I have done this thesis entitled *An unexpected population of brown hyena in southern Namibia – and how to remote it really is?* independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague

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Kristýna Stehlíková

Acknowledgements

I would like to express my sincere thanks to my supervisor doc. Ing. Karolína Brandlová, Ph.D. for her cooperation, patience and professional guidance during the writing of my bachelor thesis. I would also like to thank to my consultant Ing. Viktor Neštický for his advices and for providing me all the materials that I used for analyses. My gratitude also belongs to my parents and friends for their moral support during all my studies.

Abstract

This bachelor thesis consists of two parts. The first, theoretical part is a summary of brown hyena (*Parahyaena brunnea*) habitat and nutritional requirements based on geographical location and natural conditions. Furthermore, it summarizes the behavioural and mating system of brown hyenas and their relations with other carnivores. It is also describing the relations between brown hyenas and local farmers, the conflicts that arise between them and possible solutions that should lead to the better system of conservation of brown hyena.

The practical part then analyses current population of brown hyena in the Kumkum reserve, southern Namibia. It is based on data from camera traps collected there by a team of researchers from our university who run study focused on leopards (*Panthera pardus*). The outcomes of this thesis are possible measures for improvement of the relations between humans and brown hyenas and methods for future conservation of this species. This thesis may serve as a basis for a future research.

Key words: brown hyena, population, ecology, habitat, conservation

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List of the abbreviations used in the thesis

GPS (Global Positioning System)

IUCN (International Union for Conservation of Nature)

CZU (Czech University of Life Sciences in Prague)

ZSL (Zoological Society of London)

CTAT (Camera Trap Analyses Tool)

CTS (Camera Trap Station)

1. Introduction

Brown hyena (*Parahyaena brunnea*) is an endemic species to southern Africa and south-west Angola (Mills & Hofer 1998; Wiesel 2015). The biggest population (about 4,642 animals) of brown hyena is set to Botswana (Wiesel 2015), where most of the researches were also run. The occurrence in Namibia is sporadic throughout the country land, mainly along the coast (Lindsey et al. 2013).

Solitary, nocturnal life (Mills 1978) and wide territories that can reach up to 480 km^2 (Mills 1982a, b) are the three main characteristic of brown hyena. Those conditions bring many challenges for researchers during monitoring of this species. Direct observation is difficult as brown hyenas are hard to find, often disappear in the dark and researches can not get too close to them. One of the options for research are radio-collars. They provide exact position of the animal so it can be followed even during night. That makes them ideal for observation of animal behaviour and social interactions. On the other hand, radio-collars are expensive, the installation on neck can be stressful for the animal and range of their signal is rather small. Camera trap survey is more suitable for assessment of distribution, density and activity pattern of brown hyenas. This method is cheaper, less time consuming and provides exact data for analysis. But it also has several limitations such as need of appropriate survey design and location of camera traps or recognition of individual animals. Those limitations are reason why the population of brown hyena is not yet well described in many areas and the data about population size can vary by thousands of individuals.

This work summarises the so far collected data about brown hyenas from four main research areas, namely Central Kalahari, Southern Kalahari, Namibian coast and Limpopo province in South Africa. It describes how the behaviour, social structure of the clan or diet can vary within different natural conditions. What is the influence of other predators on brown hyenas' diet and habitat selection or what impact have human doing on the populations. Problematics of the conservation and what challenges it brings is also discussed. In the second part, conditions in research area the Kumkum farm are described together with brief analysation of data from photo traps collected in the area during different research.

2. Literature Review

2.1. Ecology of brown hyena

Listed as a near threatened species by the IUCN, brown hyena's population is estimated between 5,000 to 8,000 individuals (IUCN, 2015). Although previously placed in the same genus as the striped hyena (*Hyaena hyaena*, genus *Hyaena)*, Koepfli *et al.* (2006) place this species in its own genus *Parahyaena* (IUCN, 2015). Brown hyenas are a medium sized, doglike carnivore, mostly active during the night. They show typical signs of family Hyaenidae, which they belong to. Brown hyenas are higher at shoulders than at hips, with massive shoulders and head, muzzle board and short with robust teeth adapted for cracking bones. Even though brown hyenas live in small clans and most of the members are related, they forage solitarily, mostly during the night (Wilson, Mittermeier & Cavallini 2009). They are primarily scavengers of vertebrates remains however they are supplementing their diet with insect, reptiles, bird's eggs, wild fruits and vegetable (Mills & Mills, 1978). Their diet and thus also movement patterns and territory size mostly depend on the year season and habitat composition they live in.

2.1.1. Habitat requirements

For many species, the selection of habitat is an important determinant of population persistence, whereas factors such as landscape attributes or resource availability can strongly affect occupancy rates (Rostro-Garcia et al. 2015). More than the half of the population of brown hyenas is inhabiting large territories (up to 480 km^2) which they share with number of other individuals of both sexes (Mills 1982a, b). Unlike other large carnivore living in arid zones, brown hyenas are resident to their territories. Only the size of their territory may vary as the seasons change (Estes & Otte 2012). It was suggested that brown hyenas can be flexible in their use of habitat at a landscape scale (Welch et al. 2015). Generally, they live in areas with annual rainfall from less than 100 mm to about 650 mm per year (Mills 1998a). They inhabit various natural habitats from deserts and semi-deserts areas to open scrub and open woodland savanna or the Namibian coast (Wilson, Mittermeier & Cavallini 2009).

2.1.1.1. Arid and semi-arid environment

The landscape in arid and semi-arid areas, where most of the population of brown hyena lives, is composed primally by wind-blown dunes. The vegetation is poor, mainly formed by open shrub or tree savannah with tall grasses (Mills & Mills 1982). The dunes can be broken by a riverbed as it is in the middle of the Kalahari. Brown hyenas inhabiting these areas are nocturnal, solitary scavengers living in clans whose territories decay either in the dunes or near by the riverbed. In the dunes, the carrion remains have low density and are more even distributed throughout the land. Mostly because of the lack of ungulate abundance in this area. As the scattering of food items throughout the dunes is randomly distributed, brown hyenas are forced to search for their forage randomly which makes their territories wider. On the other hand, brown hyenas with territories in areas near by the riverbed tend to forage more extensively thanks to the higher occurrence of ungulate remains. Although the territory along the riverbed seems more beneficial for hyenas, most of the clans still prefer their dens located in the dunes. That has two main reasons. First, they choose the dunes likely for not being disturbed by other big carnivores that live along the riverbed like lions or spotted hyenas. Second, brown hyenas can find there wild fruits which are exclusive to those areas and seem to be important part of brown hyenas' diet. They use wild fruits as a source of moisture and vitamins (Mills & Mills 1982). Mills & Mills (1982) then suggest that the dunes could be essential areas for brown hyenas to live in, especially for those living in or around the Kalahari.

2.1.1.2. Mountain environment

Mountain areas provide variable climatic conditions with extremely high level of biodiversity (MacDonald, Gaigher, Gaigher & Berger, 2003). Most of the lands are not usable for farming but they are used for leisure or ecotourism. Lower level lying areas are then used for livestock, game and agricultural farming (Williams et al. 2018). In mountains, leopards (*Panthera pardus*) and brown hyenas are the only resident large carnivores (Knott, Knott, Kruger & Van der Waal, 2003). The population of leopards in the western part of Soutpansberg Mountains, where the hyenas are also resident, is suffering from a population decline due to the illegal human activity (Williams, Williams, Lewis & Hill, 2017). The absence of leopards could negatively affect the population of brown hyenas in these areas as leopards provide them foraging opportunities (Mills, 2015; Slater & Muller, 2014; Stein, Fuller & Marker, 2013).

2.1.1.3. Coastal environment

The coastal areas of the south-west Africa are unique due to the juxtaposition of an unproductive terrestrial habitat and a productive marine habitat. Those areas are arid with occurrence of large and small mammals and marine animals but no other large carnivore except brown hyenas can be found there. The only competitor of brown hyena along the coast is black-backed jackal (*Canis mesomelas*) (Wiesel 2010). Brown hyenas adapted for living in this area by being active even during the day. This is a response on adult Cape fur seals (*Arctocephalus pusillus pusillus)* being more absent from the colony and thus the seal pups, which represent the major food source for brown hyenas in this area, more vulnerable. That leads to the fact that brown hyenas there are actively killing seal pups to feed on them. Hunting is poorly developed for brown hyenas (Kruuk 1976) although they can become specialists in hunting certain species with good success (Mils 1978). Even though the coastal areas provide main food sources for brown hyenas, they still have their dens placed in the inland areas of Namibian Desert. Brown hyenas only visit the coast for feeding on seal pups and other marine animal carrions. There is also evident difference in movement between the time during and outside the seal pupping season. Brown hyenas spend significantly longer time in coastal areas during the pupping season (Wiesel 2010).

2.2. Social and reproductive behaviour

Brown hyenas live in clans where the members defend a common, fixed territory (Kingdon & Hoffmann 2013). The size of the territory is significantly affected by the distribution of food resources and it vary from 200 up to 500 km^2 and can overlap with territory of another clan. While the size of the clan is determined by the type of food in the territory (Mills 1990). The composition of members and hierarchy of the clan then vary according to different geographical locations. The differences may be based on environmental factors or diet (Owens & Owens, 1995).

2.2.1. Clan structure and relation between individuals

In general, the clan can be composed by solitary female hyena and her cubs or containing several females and their offspring of different ages. Adult males either remain with their clan, immigrate and find a new clan or became nomadic (Owens & Owens 1979b, Mills 1990). Because the core of the clans is made of adult females and their cubs, most of the clan is always related (Wilson, Mittermeier & Cavallini 2009). Female offspring remain in the clan after reaching adulthood and help to take care of the younger ones. On the other hand, male offspring usually leave the clan, mostly by force, after about 24 to 36 months of age, to become a part of other clan or live nomadic life. If the subadult male hyena remains in the natal clan, he does not participate on reproduction of the clan (Owen & Owens, 1995). In the southern Kalahari, the clans are smaller, mostly with just one or two adult females (Mills, 1990). There was recorded no dominance hierarchy and fighting between group members is uncommon (Mills, 1982b, 1990). Brown hyenas living in this area are promiscuous, nomadic males' mate with the clan females (Mills, 1982b) and group living males do not play any part in the reproduction but assist at feeding the cubs (Mills 1982a). In the central Kalahari, brown hyenas live in clans from one to five related adult females with natal males staying in the clan for up to 40 months of age. One dominant, usually immigrant, male is also part of the group. At the den, all females of the clan and the natal males most closely related to the cubs show high development of non-parental aid, adoption included (Owens & Owens, 1984).

2.2.2. Communication and interactions

Brown hyenas live in small social groups where most of the members are related to one another. Each group occupies a large territory which area can reach up to 480 km^2 and the overlap between two neighbouring territories in never more than 20% (Mills 1981, 1982a, b). They spend most of their time alone and the main form of communication between them is olfactory (Wilson, Mittermeier & Cavallini 2009). Brown hyenas deposit scent marks from anal glands throughout their territories and faeces at the latrines, mostly placed along the boundaries (Mills et al. 1980; Mills 1981).

2.2.2.1. Scent marking

Pasting is typical for all four *hyaenid* species but deposition of two different secretions is unique only to the brown hyenas (Wilson, Mittermeier & Cavallini 2009). Lipid-rich white secretion is distinguishable for human nose for up to 30 days and it is thought to have function in territory marking and defence. On the other hand, more watery black secretion appears unscented after few hours. It is thought to serve as a signal that hyena has recently foraged in the area. That allows other group members to avoid unproductive areas and it minimizes competition of group members for resources (Wilson, Mittermeier & Cavallini 2009). Pastings are placed on grass stalks, bushes or rocks and they are very well distributed (Kingdon & Hoffmann 2013). Most pasting occurs in central parts of the territory where residents spend most of their time. However, the frequency of pasting and over-pasting is higher along the territory boundaries. Very little pasting is done by individuals when they are outside their territory (Wilson, Mittermeier & Cavallini 2009). Latrines are often associated with landmarks as trees, bushes or roads (Wilson, Mittermeier & Cavallini 2009). They are dislocated throughout the territory with higher abundance around the boundaries. Boundary latrines are also visited more frequently. Some latrines are used only for a short period, while other latrines are used on a long-time scale (Skinner & Van Aarde 1981; Mills 1982a).

2.2.2.2. Interactions between hyenas from different clans

Due to the size of their territory and thanks to the good scent marking along the boundaries, brown hyenas from different social groups do not meet each other very often. The neighbouring clans still do have some overlap of their territories though, so occasional contact cannot be avoided (Mills et al. 1980). The result of these meetings

varies depending on the sexes of the animals concerned. Hyenas of the same sex are agonistic towards each other, whereas those of opposite sex usually ignore one another (Mills 1983). This behaviour is a phenomenon found also in several carnivore species including lions (*Panthera leo*) (Schaller 1972), black-backed jackals (Moehlman 1979) or bat-eared foxes (*Otocyon megalotis*) (Lamprecht 1979). The form of non-agonistic and agonistic behaviour between neighbours varies from two animals ignoring each other, to them resorting physical combat. Mills (1983) divided those interaction into five categories. From ignoring, where two animals pay no attention to each other. Greeting, when two hyenas from different social group performed greeting ceremony. Avoidance, where one or both animals turned in the opposite direction when spotted each other. Aggression, where one or both animals showed aggressive tendencies, followed by scratching the ground with their forefeet (Mills 1981). To direct physical contact by neck-biting complemented by yelling and growling of the winner. Although brown hyenas of the same sex from neighbouring clans show aggression against each other, group living males are not aggressive towards nomadic males as they are responsible for mating with the group living females. This shows that hyenas are able to distinguish between neighbours and nomadic males (Mills 1982a).

2.2.2.3. Interactions between group members

Aggression between group members is rare. When two group members meet, most often at the den, they perform the greeting ceremony. One of the functions of the greeting may be appeasement (Mills 1981). By sniffing at the anal pouches of other, the animals remain familiar with individual smells of group members and they can later recognize each other's pastings (Mills et al. 1980). The greeting ceremony is an important element in the maintenance of group cohesion (Mills 1983) and it can vary depending on the group structure. In the southern Kalahari, brown hyena clans do not show strict hierarchy. When they occasionally gather around some larger carcass, neither age nor sex category of animals have clear priority in feeding. Frequent intragroup behaviour is muzzle-wrestling which is predominantly performed by subadults (Mills1983). It takes biting on the side of face or neck and pulling each other downwards. Unlike neck-biting, it is less aggressive and there in no clear winner or loser (Owens & Owens 1978). When muzzle-wrestling with adults, subadults may be trying to integrate into the group and keep a good relationship with older members of the group. Between two subadults it is, on the other

hand, competition for a place in the group and it often appears to be more aggressive. Muzzle-wresting between two adults is rare. Allogrooming is also practiced by hyenas and it has either sanitary function or it can strengthen social bonds, mostly between adults and subadults (Mills1983). In the central Kalahari, brown hyenas show linear hierarchy within each sex. The clan is composed by one immigrant alpha male that is dominant to all other clan females and males. The highest-ranking female shares the same rank as the alpha male and together they have the longest feeding time of all members. Lower-ranking hyenas spend significantly more time lying or circling around the carcass area, waiting until more dominant members of clan feed themselves. Dominant females have also higher mating rank and their cubs have higher possibility to survive till maturity. Alpha males copulate with clan females more often than nomadic males. The dominant/submissive interactions and behaviour between members is mostly initiated by the subordinate individual, by adopting a submissive posture (Owens & Owens 1996). Those differences in social dominance and behaviour are possibly results of various natural conditions and different abundance of food and water sources.

2.2.3. Reproductive and parental behaviour

Brown hyenas are non-seasonal breeders with litters range from one to four cubs. According to the researches in the southern Kalahari, mating consists of multiple copulation attempts lasting from 5 to 90 minutes. During this time, both animals may occasionally show aggression towards each other (Skinner 1976, Goss 1986). Cubs are born in dens, toothless and with their eyes closed. A single hole in the ground serves as a den but reused old aardvark (*Orycteropus afer*) burrow or a cave can be used as well (Skinner 1976, Goss 1986). Dependence on the den is long and weaning occurs late. In the first three months, cubs leave the den hole only in presence of their mother, when she comes to nurse them, eventually with other adult clan member. From the age of four month, the cubs slowly switch to the solid diet so older members of clan bring animal remains to the den for them. Starting tenth moth, cubs begin extensive, very often solitary foraging movements away from the den. Weaning then occurs approximately at 12-16 months of age (Wilson, Mittermeier & Cavallini 2009). In southern Kalahari, cubs are raised typically in the same den as they were born, and the den is not shared with other clan females or their cubs. On the other hand, in central Kalahari, communal denning appears to be quite common. Cubs of multiple females, usually of different ages, are

raised together. Cubs in this social system are born in a solitary den and then transported to the communal den in age before four months. During time, movement between several dens is common, the cubs are transported by adults or at a later age they move themselves (Wilson, Mittermeier & Cavallini 2009). The full body size is reach within about 30 months of age (Estes & Otte 2012).

Fig. 1: Female brown hyena and her two cubs at the den

2.3. Diet

Brown hyenas are primally scavengers of vertebrate remains supplementing their diet with wide range of wild fruits, insects, birds' eggs and sometimes small animals that they are able to catch themselves (Skinner 1976, Owens & Owens 1978, Mills & Mills 1978, Maude & Mills 2005). Hunting skills are highly ineffective, unspecialized and largely unsuccessful, direct only to small animals (Kruuk 1976, Mills1978). Brown hyenas forage alone mainly during the night and do not cooperate in hunting of feeding. Group members are tolerant to each other though, especially at large food items (Wilson, Mittermeier & Cavallini 2009). Mills (1982b) suggests that the size of brown hyena territory is affected by the distribution of food items in the territory. And that the number of brown hyenas inhabiting the territory depends on the quality of the food in it. The composition of brown hyenas diet then varies with different natural and geographical conditions.

2.3.1. Food sources

In the southern Kalahari up to 58 different food types were found during the faecal analysis (Mills & Mills, 1978). The most common prey eaten by brown hyenas during the year is springbok (*Antidorcas marsupialis*), gemsbok (*Oryx gazella*), red hartebeest (*Alcelaphus buselaphus caama*) and steenbok (*Raphicerus campestris*). During the time between December and February also other small canids such as bat-eared foxes and black-backed jackal appear in brown hyenas' diet as this is the time when newborn cubs appear, and they are easy prey for hyenas (Mills & Mills 1978). Another part of brown hyenas' diet in southern Kalahari is made up by insects, which are mostly eaten by incident or together with other food items. Last, but also very important food source in southern Kalahari are wild fruits. Especially tsama (*Citrullus lanatus*) and gemsbok cucumber (*Acanthosicyos naudiniana*) are very important as a source of moisture and vitamin C in this arid area (Mills & Mills, 1978). In central Kalahari brown hyena was found to be an opportunistic scavenger, feeding on a wide variety of food types. The primary components of diet during the rainy season are remains of giraffe (*Giraffa camelopardalis*), gemsbok and wildebeest (*Connochaetes taurinus*) which most of them is located along riverbeds. During the dry season hyenas feed mostly on small widely scattered items such as bones, insect, reptiles, ostrich's (*Struthio camelus*) eggs (Fig. 2),

rodents and birds (Owens & Owens, 1978). The diet of brown hyenas living along the Namibian coast is much less varied, with cape fur seals' pups making the major part of it (Skinner & Van Aarde 1981, Siegfried 1984). In farming areas in Guateng and Limpopo provinces, South Africa, cattle and medium-sized to small mammals are the main food source for brown hyenas (Skinner, 1976).

Fig. 2: Brown hyena with ostrich egg

2.3.2. Water sources

Brown hyenas do not depend on standing water. In arid environments like the Kalahari, no free surface water or rains are available during the eight months of the lean season (Wilson, Mittermeier & Cavallini 2009). Brown hyenas do not get much moisture from the carrions like other carnivore as they are already dry by the time hyenas feed on them (Mills & Mills, 1978). That is the reason why brown hyenas supplement their diet of wild fruits such as tsama or gemsbok cucumber and other. They can be found exclusively in the dunes and are an important source of moisture and vitamins (Mills & Mills, 1982). In areas with permanent artificial water sources, like Zingela Game Reserve in Limpopo Province, brown hyenas drink water on a daily basis and the consumed amount of wild fruits and vegetable is therefore lower (Faure et al. 2019).

2.4. The influence of land management and season on the diet and movement patterns of brown hyena

2.4.1. The influence of land management

Brown hyenas in south Africa live either in national parks or wildlife managed areas and cattle areas. National parks as protected areas seemed essential for conservation of the species in a long-time scale. However least researches show that cattle and wildlife managed areas could be also very important for conservation of this species although they bring some disadvantages for hyenas too (Maude & Mills, 2005).

2.4.1.1. Wildlife managed and cattle areas

In cattle areas, livestock carcasses represent the main food sources during whole year and other species are fed on only as they are available during the seasons. The difference in food sources between the seasons is low. No hunting of livestock by brown hyenas was ever recorded except for few individuals whose removal from the area solved the problem (Maude & Mills, 2005). All the carrions brown hyenas feed on die naturally or are killed by other large carnivores living in the same area, such as lions, spotted hyenas, leopards or black-backed jackals. Brown hyenas are unfortunately repeatedly accused by farmers of killing livestock and they are persecuted for it. Despite the persecution brown hyenas can benefit from the presence of farmers and livestock and they are one of the few large carnivores able to survive alongside the farms and still maintain viable populations. That could be an important factor for a future conservation of the species outside of the protected areas (Maude & Mills, 2005).

2.4.1.2. National parks

The food sources in protected areas are mainly affected by the seasonal changes. In the peak season when large herbivores are present there is abundance of zebra (*Equus quagga*) and wildebeest carrions which are killed by other large carnivore. Brown hyenas, except of scavenging on these remains, supplement their diet on many reptiles, insect and ostrich's eggs. In the lean season, when large herbivores are no longer present, brown hyenas must scavenge on old carrions from the peak season and many other smaller mammals and reptiles which makes their diet more diverse. Brown hyenas are adaptable in their diet and they are able to eat almost anything, except grass or herbage. That gives

them the benefit to survive in marginal areas where food and drinkable water is scarce and other large carnivore would not survive (Mills, 1990).

2.4.2. Influence of season

Brown hyenas live in well-defined territories, but they change their seasonal home range to follow the food distribution. In areas where the seasonal food environment is variable brown hyenas show greater fluctuation in seasonal home range. On the other hand, in areas where the food environment is more stable, they have higher level of home range retention (Maude et al., 2018). In the areas of northern Botswana that are part of the Kalahari Desert we can observe two seasons during the year that have effect on the behaving of brown hyenas. The peak and lean season.

2.4.2.1. Peak season

The peak season starts when zebra and wildebeest migration arrive to the area along with the start of the rains (Brooks, 2003). This season is rich for many mammalian species from small and large herbivores to various kinds of carnivores. Thanks to the lions, cheetah (*Acinonyx jubatus*), spotted hyenas and other larger carnivore that kill herbivores such as zebra and leave unfinished carrions after themselves, brown hyenas have many opportunities for feeding. Due to the higher density of carcases brown hyenas are not forced to look for food items for a long distance which means that their territory in this season can be smaller (Maude et al., 2018). However, they still supplement their diet with small mammals, reptiles, insect and wild fruits (Maude & Mills, 2005).

2.4.2.2. Lean season

The lean season starts when the migration of zebra and wildebeest leaves the area because there is no drinkable surface water anymore (Brooks, 2003). Brown hyenas in this season increase their dietary span and feed on greater number of species then in the peak season. Zebra and wildebeest remain an important source of food even though they are almost entirely absent. Brown hyenas visit and reutilise old carcasses from the peak season. The home range of brown hyenas in the lean season is larger rather than in the peak season as the distribution of food items is more extensive. There is also a bigger overlap between the territories of neighbouring clans (Maude et al., 2018).

2.5. Relations between brown hyenas and other predators

The competitive interactions between carnivores are an important factor influencing the structure and dynamics of the ecosystem they are part of (Linnell & Strand 2000; Caro & Stoner 2003; Ritchie & Johnson 2009). The presence of apex predators, for example, reduces the inter-species competition for prey between meso-carnivores as apex predators provide extra scavenging opportunities for food specialists and scavengers like brown hyena (Crooks & Soule 1999; Prugh et al. 2009; Ritchie & Johnson 2009). Brown hyenas are distributed through most of the southern Africa (Fig. 3). Researches show that the densities of brown hyenas are higher in areas where the apex predators are present and the dominant food items in their diet are quite like those in the diet of larger predators (Yarnell et al. 2013).

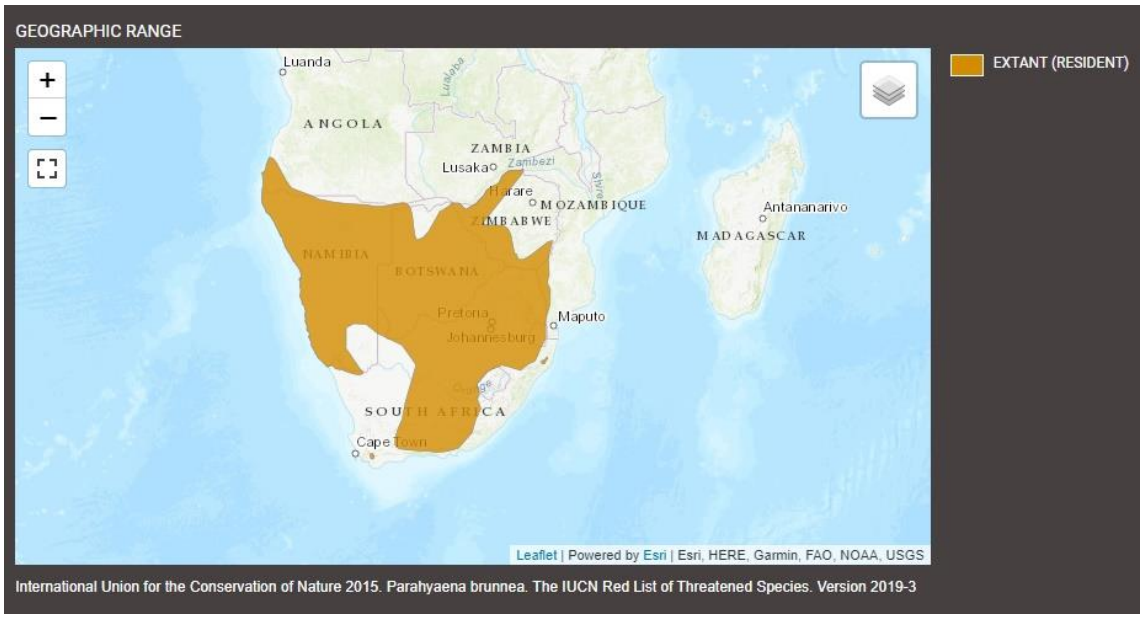

Fig. 3: Geographic range of brown hyena

2.5.1. Relationship with lions

Lions have a broad habitat tolerance, absent only from tropical rainforest and the interior of the Sahara Desert (Nowell and Jackson 1996). Their distribution is scattered through the central and southern parts of Africa, often in small isolated areas (Fig. 4). Lions, as a large carnivore, are dominant to brown hyenas. They provide many scavenging opportunities for them as they frequently kill large herbivores to which brown hyenas would not have access in any other way. Brown hyenas learnt how to live alongside lions and how to benefit from them, even though they can be easily killed by lions when comes to the physical conflict. Brown hyenas keep at least 200 meters distance from lions feeding on prey and wait long enough after lions leave the carrion before they come closer themselves. Lions, same as hyenas, live inside and outside the protected areas but they also occur in cattle areas where they kill livestock. Brown hyenas are often accused from that instead of lions or other larger carnivores and their persecution is thus unjustified (Maude & Mills 2005).

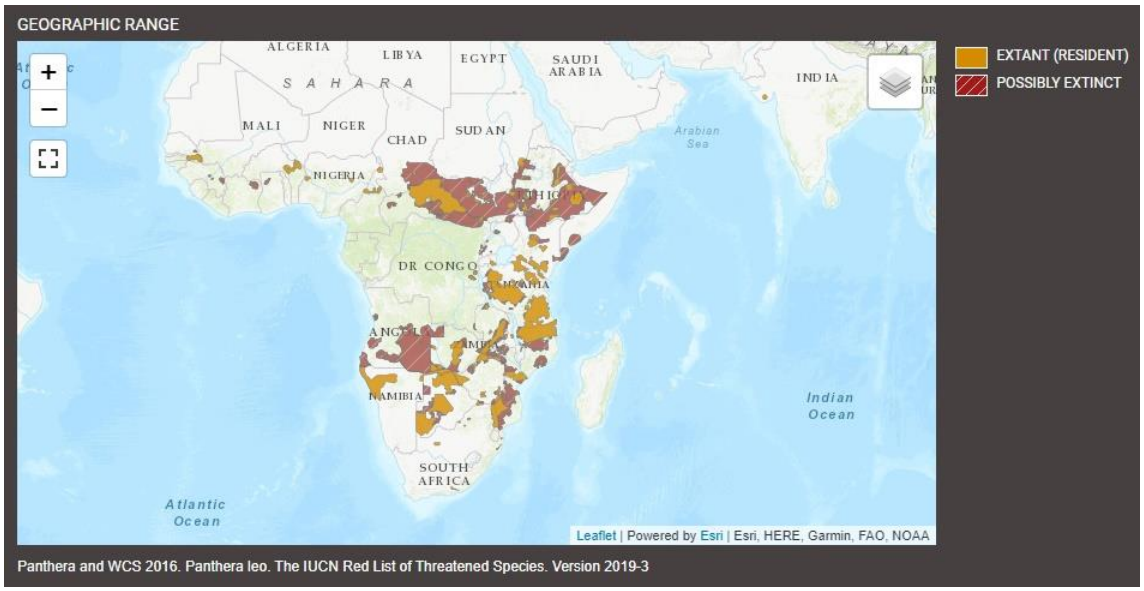

Fig. 4: Geographic range of lion

2.5.2. Relationship with spotted hyenas

Spotted hyenas are present in all habitats including semi-desert, savanna and open woodland, dense dry woodland, and even montane habitats (Young and Evans 1993, East and Hofer 2013). They are distributed in most of the parts of central and southern Africa except for areas in South Africa, southern Namibia and rain forest around the equator

(Fig. 5). Although spotted and brown hyenas belong to the same family, *Hyaenidae*, they differ in many ways. Unlike browns' spotted hyenas often kill larger herbivores themselves and they do not hunt or feed solitarily, but in clans. For living they prefer areas with higher density of large ungulates as savannah or semi-desert areas. On the other hand, brown hyenas tend to place their dens in dessert areas and the dunes. That is likely a response to spotted hyenas and other large carnivores not living in these areas and thus not disturbing brown hyenas and their cubs at the dens. It appears that, in general, when the density of spotted hyenas is high in the area, the density of brown hyenas would be lower. That is because spotted hyenas are dominant to browns' even when no food is involved. When the occurrence of them is high, they can deprive brown hyenas of a significant amount of food as they easily dislodge them from founded carcasses (Mills & Mills 1983; Mills 1990).

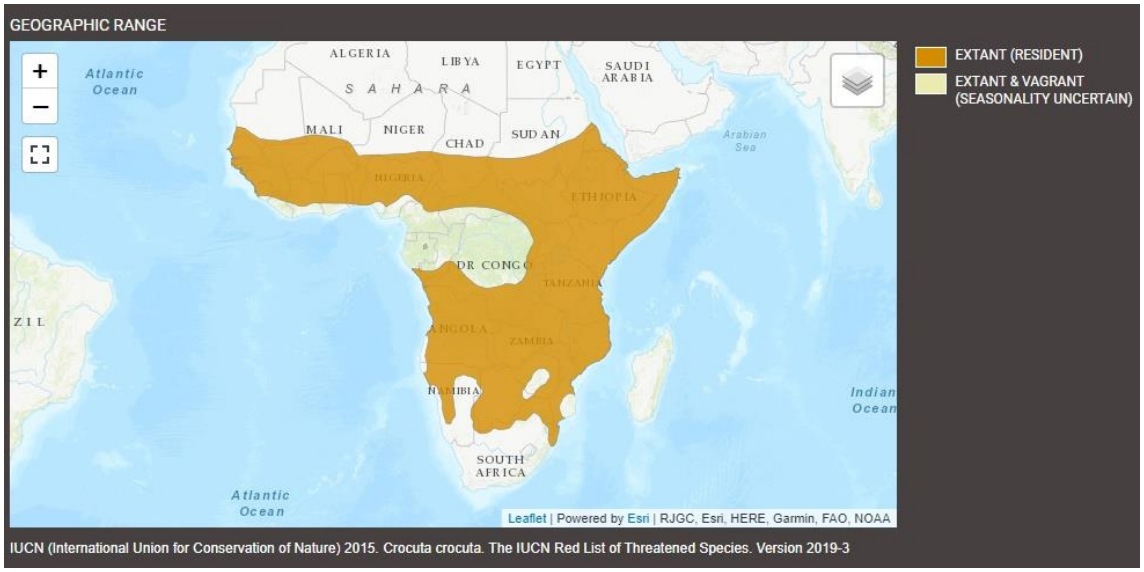

Fig. 5: Geographic range of spotted hyena

2.5.3. Relationship with leopards and cheetahs

In many areas of Namibia and South Africa brown hyenas inhabit quarters where only leopards and cheetah are present. Leopards occur in the widest range of habitats among any of the world cats (Nowell and Jackson 1996). They are found in the desert and semi-desert regions of southern Africa in Namibia and Botswana. There are remnant populations in the arid regions of North Africa in Egypt, as well as the Arabian Peninsula. They persist in rugged montane regions of southwest Asia in Iran, in a varied range of

landscapes in India and in the savanna grasslands of East and southern Africa (IUCN 2019) (Fig. 6). In areas where apex predators often occur, leopards hang the remains of their prey on branches high above the ground so no other carnivore could steal them. But in areas where no other large predators are present, they leave them on the ground for later (Karanth & Sunquist 2000; Stein et al. 2013). That makes a great opportunity for brown hyenas living in the same areas for feeding easily on the remains. Dominance of one species over another is unclear and it mostly depends on the situation and individuals that come into conflict. There are records of brown hyenas being dominant to leopards and stealing food from them, but leopards can be dominant over hyenas as well (Owens & Owens 1978; Mills 1990).

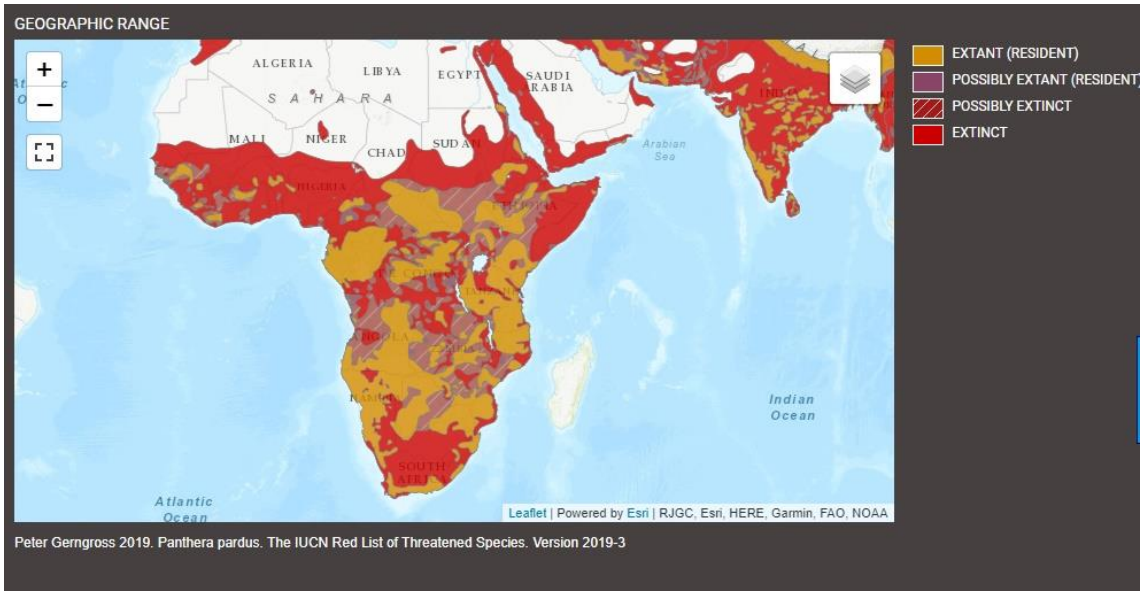

Fig. 6: Geographic range of leopard

In Africa, cheetahs are found in a wide range of habitats and ecoregions, ranging from dry forest and thick scrub through to grassland and hyperarid deserts, such as the Sahara (IUCN SSC 2007a, b, 2012; Durant et al. 2014). They are only absent from tropical and montane forest (Young and Evans 1993). Their distribution through the land is scattered into small separated areas (Fig. 7). Cheetahs unlike leopards were observed to be only subordinated to brown hyenas. Hyenas steal the prey from cheetahs (Fig. 8), and they can also directly chase them away from the carrion (Mills 1990, 1991). These facts are supported by a research that shows a high dietary overlap between brown

hyenas' diet and that of leopards and cheetahs in quarters where only these three species are present as a representative of large predators (Stein et al. 2013).

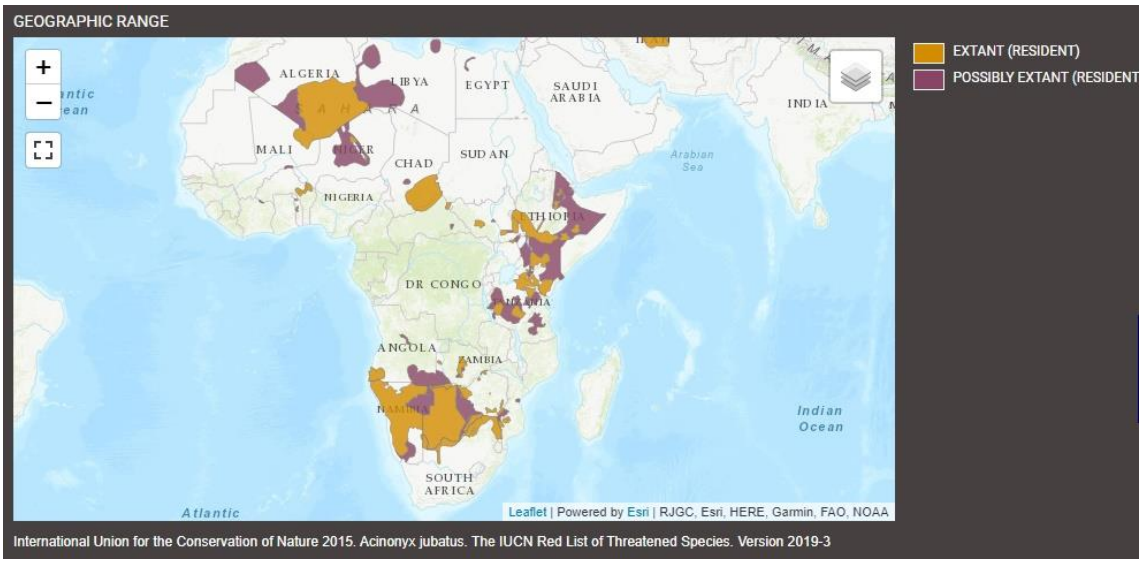

Fig. 7: Geographic range of cheetah

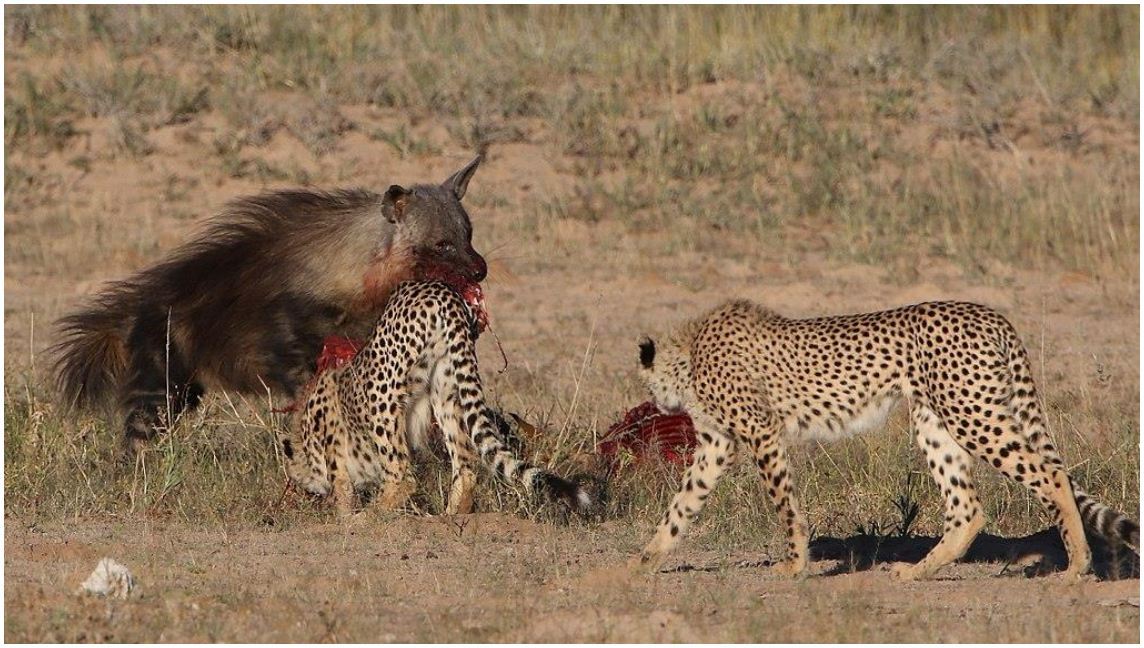

Fig. 8: Brown hyena stealing from cheetah

2.5.4. Relationship with black-backed jackals

Black-backed jackals are found in a wide variety of habitats including arid coastal desert (Dreyer and Nel 1990), montane grassland (Rowe-Rowe 1982), open savanna (Wyman 1967, Kingdon 1977, Lamprecht 1978, Moehlman 1983, Fuller et al. 1989, Estes 1991), woodland savanna mosaics (Smithers 1971, Loveridge and Macdonald 2002) and farmland. Their distribution in Africa is separated in two main areas. First is the area of southern Africa, from Angola to South Africa. Second extends to areas from Somali Peninsula to Tanzania (Fig. 9). Black-blacked jackals live primarily in areas without apex predators to avoid conflicts with them. In those areas brown hyenas do not have enough of carrion remains just due to the lack of the predators that would kill larger ungulates and provide a food source for hyenas. Therefore, they supplement their diet with small mammals, insect, eggs and other items which are also important components of jackals' diet. That creates a large dietary overlap between brown hyenas and black-backed jackals. Feeding on same food items can lead to the competition for food between those two species (Owen & Owens 1978; Yarnell et al. 2013). Sometimes brown hyenas can even deprive jackals from a significant amount of food. Both species can be killed by apex predators and they alter their diet due to the dispersion and availability of food items (Kaunda & Skinner 2003; Maude & Mills 2005). While black-backed jackals avoid areas where large predators are present as they pose a threat for them, brown hyenas rather search for these areas as they can benefit from the predators' kills. Despite this fact the territories of those two species overlap considerably.

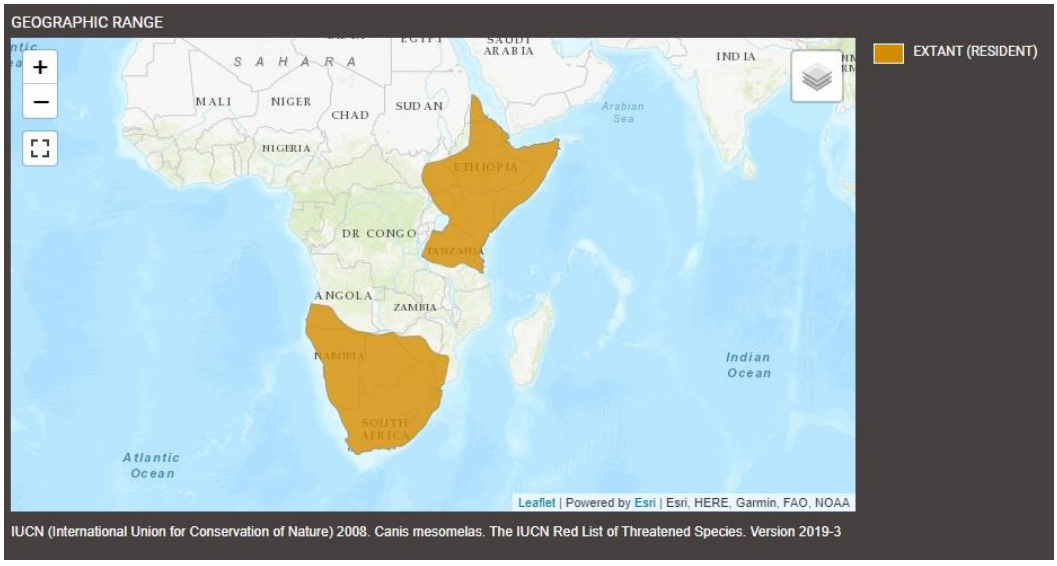

Fig. 9: Geographical range of black-backed jackal

2.6. Interactions with farmers and conservation

Protected areas are important link in wildlife conservation. Restricted contact with humans, controlled hunting and prohibition of poaching are essential factors for stabilisation of species populations. However protected areas also bring some challenges as well. One of the most important problems of protected areas is providing insufficient space for species to maintain viable populations (Kent & Hill 2012). For carnivora and *hyaenida* as well comes another challenge. Those wide-ranging territorial species mostly cannot be contained within boundaries of often small and isolated areas designed for their protection (Woodroffe & Ginsberg 2000; Smith et al. 2011). Larger predators like brown hyena are able to maintain stable populations in those areas and the populations are sometimes even more numerous than in other places which may be result of higher abundance of prey and good protection from unnatural death. Unfortunately, with higher density of the species members, often in enclosed or fragmented areas, comes higher risk of inbreeding and transmission of diseases. This leads to the fact that non-protected areas could be also important in conservation of those species, brown hyena included (Woodroffe & Ginsberg 2000; Smith et al. 2011). The loss of habitat is considered as a major factor that is affecting the survival of predators outside the protected areas. The increase of human population results in enlargement of agricultural land and thus reduction of natural space for wild animals. Human tolerance towards carnivores is affected by several factors. Most importantly it is a financial impact-imposed trough livestock or wildlife losses, misconceptions and prejudice (Graham et al. 2005). This all then leads to conflict between local landowners and the predators (Nowell & Jackson 1996; Sunquist & Sunquist 2001). Even though, some populations in non-protected areas are considered as essential for conservation of the species as a whole (Woodroffe & Ginsberg 1998, 2000) and it has been assumed that if such species cannot be conserved in multi-use landscapes then they probably cannot be conserved at all (Woodroffe et al. 2005). In many areas successful carnivore conservation will be dependent on achieving coexistence between carnivora and people (Lindsey at al. 20013). Recent researches show that density and occupancy of brown hyenas in agricultural land is significantly lower than in protected areas (Thorn et al. 2011a) and the species may be particularly vulnerable to loss of habitat. Nevertheless, populations of brown hyena persist in areas of commercial farmland and there are suggestions that such environment could be advantageous for them

(Skinner & van Arde 1987; Maude & Mills 2005). It is likely that livestock carrions on farmlands provide more reliable source of food for brown hyenas and there is also lower level of competition from other predators which allows them to feed undisturbed (Kent & Hill 2012). Despite those benefits and in addition to habitat loss, brown hyenas face other challenges. Some farmers, mostly in Botswana, still believe that brown hyenas are responsible for killing their livestock. As a result, hyenas are victims of persecution by trapping, poisoning or shooting (Wiesel et al. 2008). Those serious measures are mostly introduced by older farmers or by those who suffer higher losses of livestock (Lindsey et al. 2013). In other cases, trapping or poisoning can be incidental. Traps and poisoned food are primally aimed at other predators like cheetah, leopard or black-backed jackal that are responsible for the losses (Kent 2011). This of course do not justify the farmers to put the poison traps on their land. Most of the species is listed as at least vulnerable by the IUCN and they suffer from a certain level of threat already. In this case farmers should be more aware of the consequences of their doing and try to use alternative means to keep the predators away from their grounds. Many farmers on the other hand wish to have brown hyenas and other carnivores on their land. As a reason they say that those animals are not problematic or do not kill too much, they have value for ecotourism and trophy hunting, or they have ecological role. In case of brown hyenas, some farmers are positive towards their role in cleaning the bush from carcasses and therefore getting rid of possible spread of diseases or parasites (Lindsey at al. 2013). Due to the research that was run by Lindsey (2013) on Namibian farmlands, the most common combination wanted by farmers at their lands is brown hyena, leopards and cheetahs and the least tolerated predators are lions followed by wild dogs (*Lycaon pictus*) and spotted hyenas. In specific circumstances all six of predators are either tolerated or wanted by the farmers. In general, those species are more wanted on smaller farms that have higher income from wildlife, higher biodiversity and lower income from livestock. Farmers from those farms are younger, mostly German or English speaking. The biggest overlap of territory of brown hyenas is with leopards. Those two species are the most tolerated among Namibian ranches, South Africa and Zimbabwe but also in some agricultural areas in Botswana that could be important to maintain population links between the other countries (Winterbach et al. 2017). Leopards are beneficial for farmers for their ecotourist value and trophy hunting and brown hyenas perceived to impose few costs (Lindsey et al. 2013). Thanks to the practically similar occurrence (with some exceptions) of those two species, leopards play

a very important role in brown hyenas' life. They provide a significant part of food sources for hyenas and at the same time leopards do not pose a major threat as hyenas are often dominant to them. Unfortunately, leopards face the same problem as hyenas. They are persecuted by farmers for killing livestock and the persecution is often even on a larger scale (Lindsey at al. 2013). Leopards are listed as vulnerable by the IUCN's Red List (2019), their population trend is decreasing, and they are believed to be extinct in more than a half of the original range. In conservation of the brown hyena it is important not to only take measurements to protect this specific species. As brown hyenas are quite dependant on larger predators with their diet, the protection of those species must be also considered. Assuming that significant reduction of large predator population could possibly lead to the food deprivation of brown hyenas and to the population decline as well. It is therefore important to cooperate with other research teams that work on conservation of other species like lions, leopards, cheetahs and many others.

3. Aims of the Thesis

The objective of this thesis was to summarize already known data about brown hyena behaviour, mating system, diet, relations with other predators and human in connection with conservation measures. Those data were organised from all the available sources into a literature review. This review then served as a source of information for the data analysis. The aim of the practical part was to go trough the data collected by research team in Namibia and get a basic overview about the population of brown hyena living there. Describe and discuss the importance of relations between brown hyenas and leopards and submit possible conservation measures for brown hyenas. This should then serve as a basis for a future research in the study area.

4. Methods

4.1. Study area

The Kumkum farm covers a total area of 461 km^2 and is situated in southern Namibia in region Karas. South border of the farm is defined by the Orange river which also represents the state border of Namibia and South Africa. Farm is divided into four sectors, namely Kumkum, Pelgrimsrust, Pella drift and Kambreek (Fig. 10). The habitat is poor, mainly composed by shrub, plain grasslands and rocky mountains (Fig. 11). The main water sources are smaller riverbeds leaking from the Orange river, several natural dams, boreholes and two troughs (Fig. 12). The most common herbivores in this area are klipspringer (*Oreotragus oreotragus*), eland (*Taurotragus oryx*), mountain zebra (*Equus zebra*), greater kudu (*Tragelaphus strepsiceros*), gemsbok and springbok. From predators, it is mainly leopard, striped polecat (*Ictonyx striatus*) or honey badger (*Mellivora capensis*).

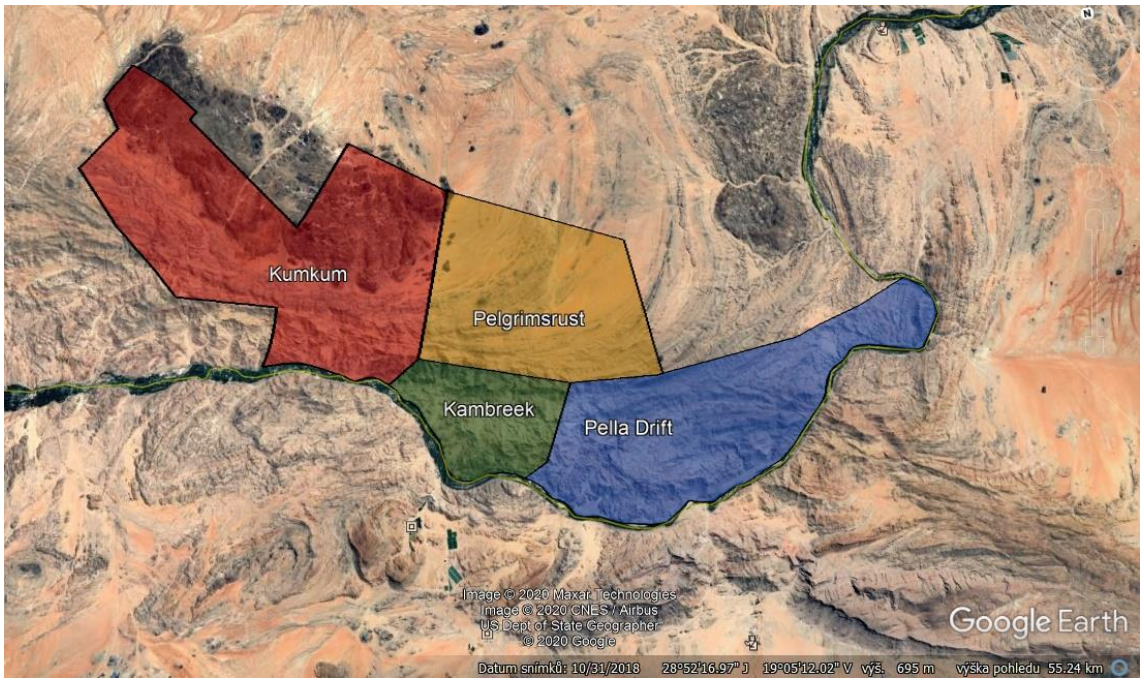

Fig. 10: The Kumkum farm with individual sectors

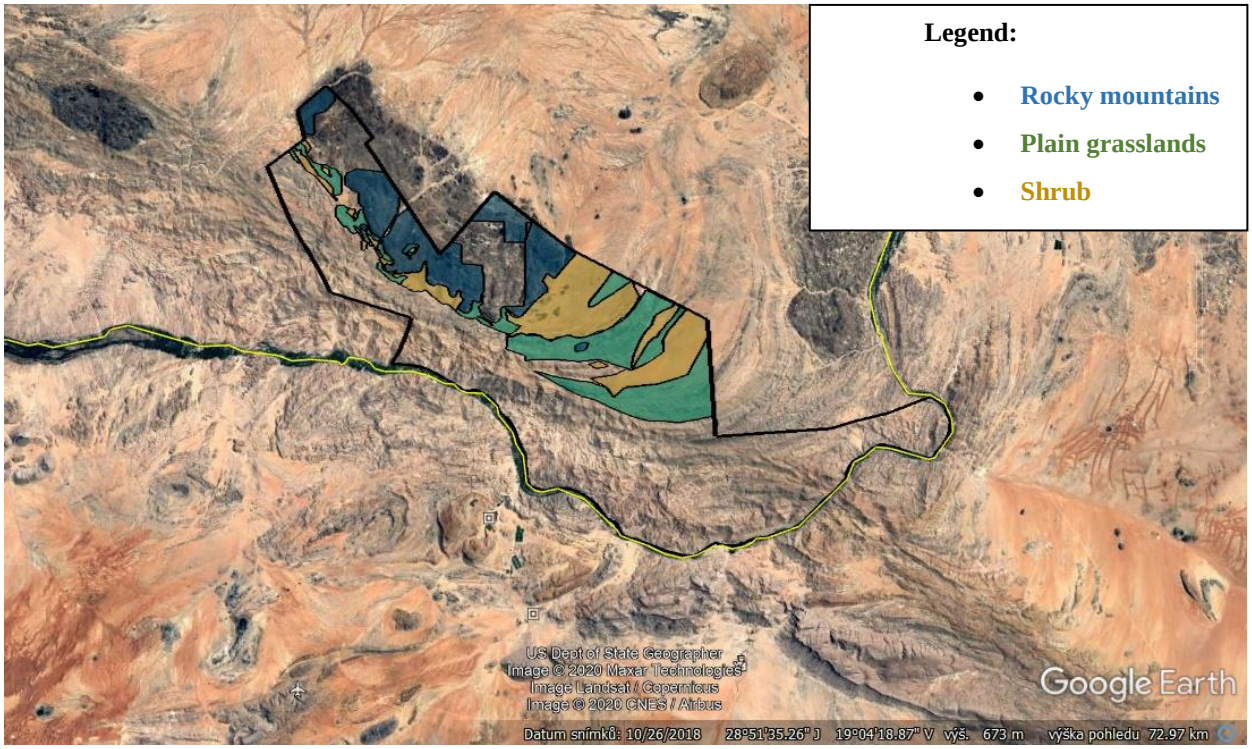

Fig. 11: Habitat in the two main sectors (Kumkum, Pelgrimsrust)

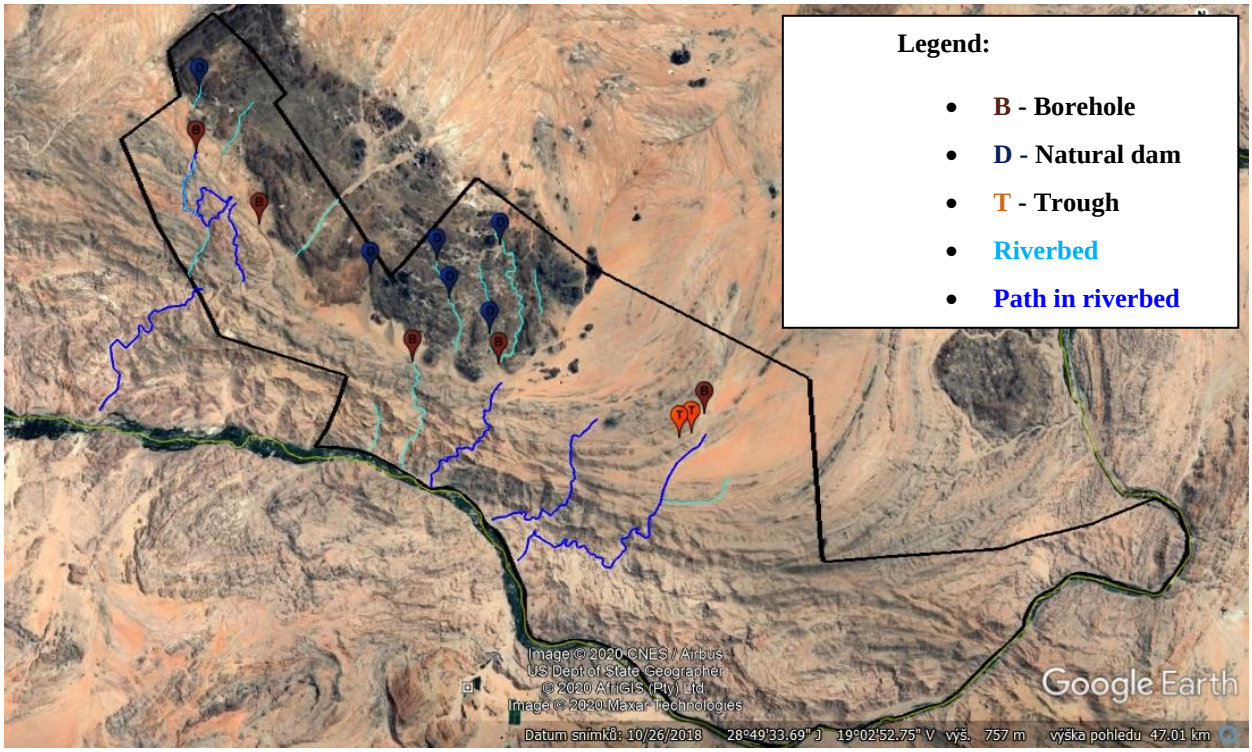

Fig. 12: Water sources in the study area

4.2. Survey design

Data used in this thesis are by-product from research focused on leopards that is run in the same area, the Kumkum farm, since 2018. The research is lead by Ing. Viktor Neštický from *Department of Animal Science and Food Processing* at *Faculty of Tropical AgriSciences* (*CZU*) who also provided me all the necessary data.

The survey is based on by-catch data collection design. Forty camera traps (28 UOVision UV 535 Panda, 11 Bushnell Trophy CamHD, 1 Browning Strike Force micro HD) were used for collection of the data. Those cameras were deployed into twenty stations, each station with two cameras on opposite sides of game trails. Height in which they were attached was about 40 cm above the ground (Henschel & Ray 2003). In connection with that, the sensitivity was set to normal and camera was set to take videos for 10 seconds to prevent blurred images that are common on night-photo mode. A pilot study was run from 1st of June to 25th of July 2018 to test different camera locations for optimal results. Because the survey is focused on leopards, final camera stations were selected according to the presence of leopard tracks and scats recorded during the pilot study. Camera station were placed primarily in natural straits of the dry riverbeds as this increases the capture chances when wildlife uses the game path. According to the size, the study area was divided into two sectors with each having approximately 255 km^2. Camera stations in the first sector (Fig. 13) were gradually placed from 25th of July till 8th of October 2018. From 29th of September, cameras were one by one collected and recovered, this lasted till 8th of October when the last camera from the first sector was recovered. After the recovery cameras were again gradually placed to the selected locations in the second sector (Fig. 14), first two cameras were placed at 3rd of October. All the cameras in sector two were then collected and recovered till 23rd of December 2018. The sampling period was set for 60 days in each sector as this is the period considered to be short enough to prevent population changes such as births, deaths or migration in big cat species (Karanth and Nichols 2002). Each 24-hour period was counted as one capture occasion. As leopards but also brown hyenas are nocturnal (Bailey 1993; Mills 1978) each occasion lasted from noon till noon of the next day.

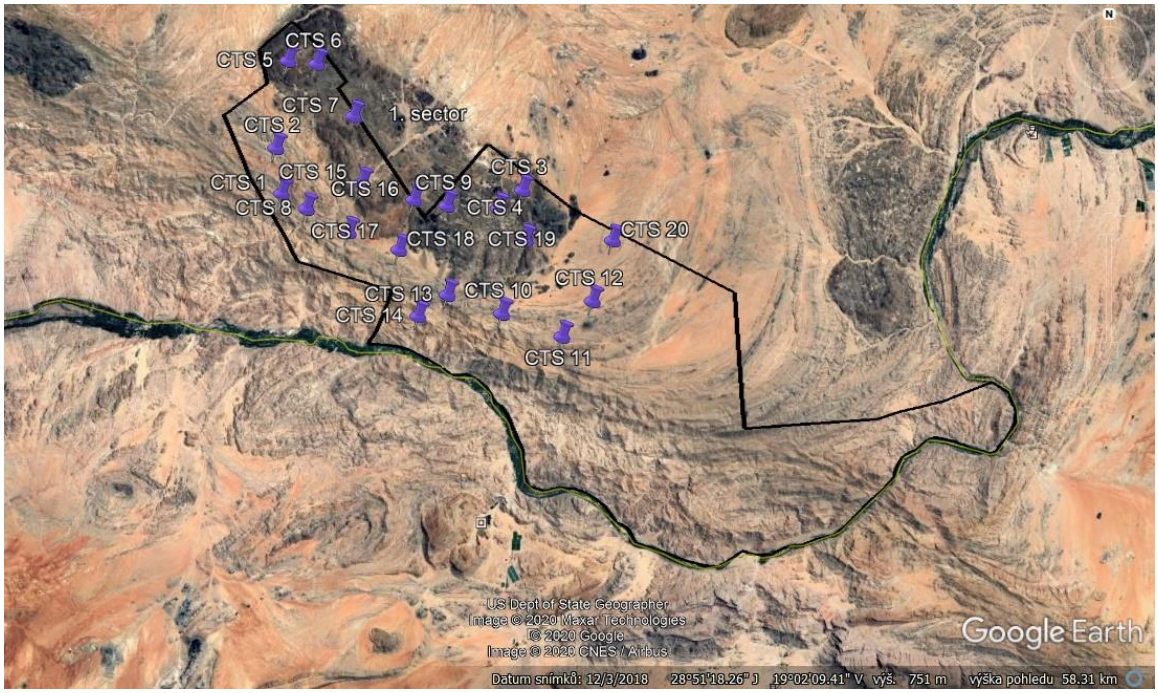

Fig. 13: Deployment of camera trap stations in the first sector

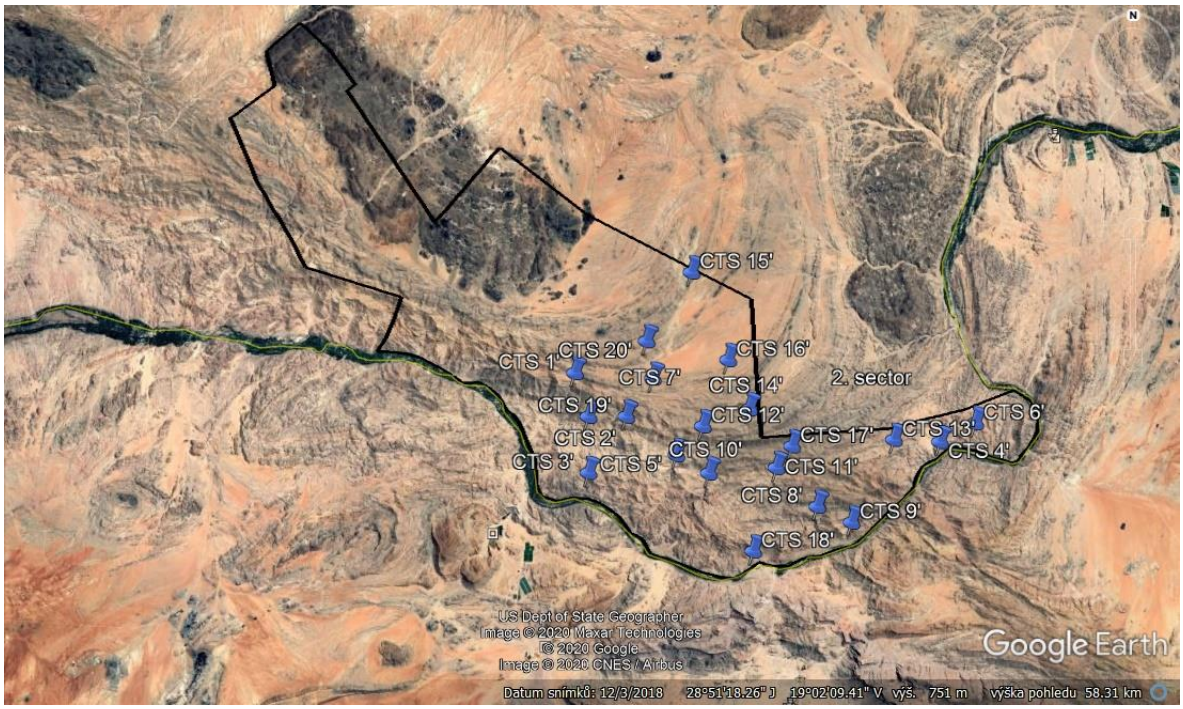

Fig. 14: Deployment of camera trap stations in the second sector

4.3. Data analysis

Data analysis was carried out using software developed by the Zoological Society of London (ZSL) to process images from camera trap arrays – Camera Trap Analyses Tool (CTAT, Amin et al. 2016). I got already prepared database in the ZSL software from Ing. Neštický which he created from the collected data from camera traps. The database contains information about cameras used such as numbers of single cameras, location, date of installation and recovery, number of records and species recorded. The information about different species then include number of records and their date, trapping rate, distribution and activity pattern.

5. Results

During the survey period, brown hyena was captured by 5 camera trap stations (CTS) in 11 occasions. In case of CTS 15, CTS 19 and CTS 7B it was one-time event when hyena was just passing by or sensed the bait made of cattle remains originally set to attract leopards, tried to feed on it and then left. At CTS 11, there were two records within two consecutive days (25th and 26th of September 2018) approximately about the same time. From those data it is most likely that it was just one individual which returned for the prey. At CTS 20B, the first occasion was on 6th of October early in the morning and then at the same day but late in the evening which makes it two sampling events by the survey design. This event is probably similar to that of CTS 11. In second case of CTS 20B, there are records from 20th, 21st, 23rd and 24th of November. Video from 20th of November captures just part of the animal on its move away from the camera sight. For that it is not possible to compere it with the rest of the records as brown hyena individuals can be recognized by the stripes on their front legs which are missing in this record. Yet it is still possible to recognize that the animal is not injured as it walks normally. On the other hand, the individual from the record on 21st of November has some injury on right ear and right front leg as it is clearly limping on it. I also have some records from 29th of July (it is not part of this survey) from the CTS 2 where is captured brown hyena with injury on the same leg (Fig. 15). It could be possible that it is the same animal and the injury is long-term. The last two records then captured the same individual as it has similar striping on its left front leg (Fig. 16a, b). This means that during five-day period at least two different brown hyenas were recorded by the CTS 20B.

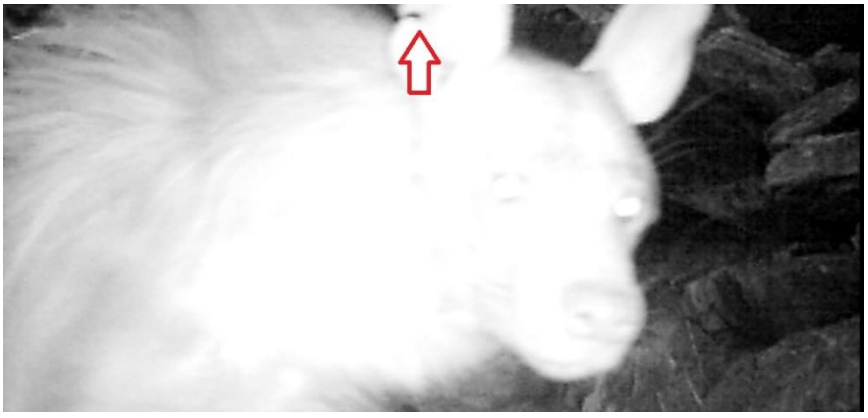

Fig. 15: Injury on ear of brown hyena, CTS 20B, 21.11.2018

Fig. 16a: Brown hyena, CTS 20B, 23.11.2018

Fig. 16b: Brown hyena, CTS 20B, 24.11.2018

As mentioned previously, I got also several data that are not part of the study run from 25th of July till 23rd of December. Those data were obtained from CTS 2 during the pilot study from 25th to 29th of July when the cameras at this station were still deployed (Fig. 17). Even though those records are not included in the leopard survey, they will be used for this thesis as they bring important information about population of brown hyena in the research area. One hyena was captured in three occasions. First on 25th of July in the early morning, it was probably drag to the place by the smell of cattle bait. Then it returned the same day in the evening and once again on 28th of July. Thanks to the high-quality video, I can say it was the same animal as the striping on its leg is similar (Fig. 18a, b). Second animal was captured on 29th of July in two occasion, first in the morning and then it returned at night. This brown hyena has same injuries as the one captured later, on 21st of November by CTS 20B (Fig. 19). After a more thorough examination of the records is clear that it was the same animal. Furthermore, I was able to recognize that this brown hyena is a female and at the time she probably had small cubs as her mammary glands were swollen from breastfeeding (Fig. 20).

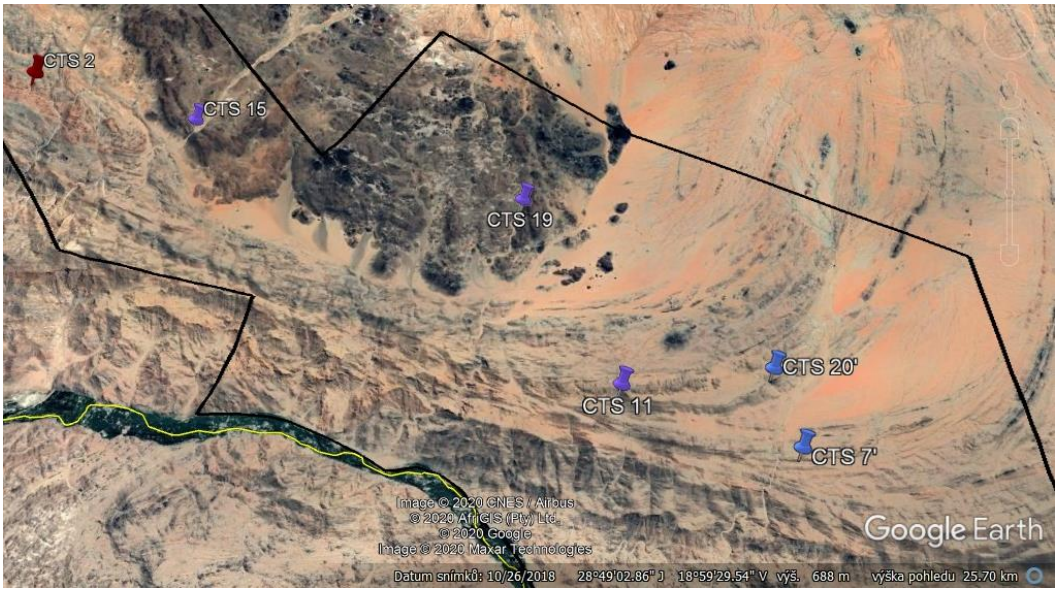

Fig. 17: CTS with brown hyena records, CTS 2 highlighted

Fig. 18a: Brown hyena, CTS 2, 25.7.2018

Fig. 18b: Brown hyena, CTS 2, 28.7.2018

Fig. 19: Brown hyena with visible injuries, CTS 2, 29.7.2018

Fig. 20: Swollen mammary glands of injured hyena, CTS 2, 29.7.2018

6. Discussion

Collected data confirmed the presence of brown hyena population in research area. There were recorded at least two individuals. One of them is adult female which is likely to be actively reproducing due to the swollen mammary glands captured in the video. The gender of second brown hyena is unclear but it is more probable that it would also be a female, eventually male genetically related to the first hyena. The chance it would be nomadic male just passing by the territory is less likely. Unfortunately, there in not enough data to determinate if there were more than two brown hyenas captured as the records are often in a bad quality, from different sides of the hyena or there is just a part of that animal. Natural conditions within the Kumkum farm seem to be beneficial for brown hyenas. The area is protected by farm owners, so it provides haven for a wide variety of animal species. There is abundance of large and small herbivores such as klipspringer, greater kudu, steenbok or red hartebeest. From smaller carnivore it is for example black-backed jackal, bat-eared fox, small-spotted genet (*Genetta genetta*) or stiped polecat. The only two larger predators in this area are leopard and brown hyena which means there is no threat from other large carnivore. The population of leopards should theoretically provide a significant part of food sources for brown hyenas. For confirmation of this hypothesis it would be necessary to do a scat examination from both species in the future to find out if there is actual overlap between their diets. Understanding diet, food acquisition, and interrelationships between predators that are exceedingly reliant on private land is crucial for their conservation (Williams et al. 2018). High dietary overlap with leopards and evidence supporting scavenging behaviour suggests that leopards could potentially provide brown hyenas with scavenging opportunities, and thus function as a keystone species for brown hyenas on private land (Williams et al. 2017). Conservation management plans that adopt a multi-species approach are required to preserve leopards and consequently provide food security for scavengers like brown hyenas, which supply important ecosystem services through their feeding habits (Beasley, Olson, & DeVault, 2015). This is probably also the case of the Kumkum farm and similar measures for conservation could be used there as well. This study has several limitations. First, the survey was aimed on leopards which means that the baits, camera settings and length of survey were all set to collect data about different species with distinct behaviour than brown hyena. Records of hyenas are just by-product

and therefore there is not much of the data to study. Another problem is that the Kumkum farm has area about 461 km^2 which is approximately also the average size of brown hyenas' territory (Mills 1982a, b). Even though the whole area was covered by photo traps, records of brown hyena are only from Kumkum and Pelgrimsrust sector. This may be because those two sectors crate borders of the clans' territory and the rest of their territory lies outside the farm. On the other hand, the lack of data from Pella Drift and Kambreek sector could be just coincidence. It is up to a future research to clarify this hypothesis. Despite all the limitations is obvious that the research area represents significant part of brown hyena territory. It is now important to describe the population in detail, set exact natural conditions in the territory, describe the diet by scat analysis, dependence of brown hyenas' diet on leopards' kills and most importantly the relationship with local farmers not only from the Kumkum farm but from adjacent areas as well. This should help to determinate brown hyena population in different conditions then previous researches like those run in central and southern Kalahari or along the Namibian coast. The future research would not have to contain just data collected from photo traps by by-catch method and faecal collection, but also collaring of some individuals and direct observation.

7. Conclusions

Not many researches were run on Namibian farmlands so far. The populations of brown hyena in Namibia are scattered throughout the country land (Lindsey et al. 2013) but they are not mapped very well. There is potential that the population of Namibian hyenas is bigger than previously thought. One example for all could be the Kumkum farm. From what the local farmers told to my colleagues, the population there is not unexpected as brown hyenas have been present in those areas since they can remember. But they also confirmed that lately the number of hyenas seems to be bigger than expected. This is positive information, for it means that the area is potentially beneficial for brown hyena population growth. Namibian farmlands provide areas free from lions, wild dogs or spotted hyenas but with substantial numbers of leopards and cheetahs. This creates good potential for brown hyena populations (Stuart et al. 1985). Such farmland areas may be strongholds for brown hyenas because, as scavengers, they do not pose a critical threat to livestock (Steinet al. 2010) but are able to access carcasses as food. For a future conservation, it will be important to spread more detailed information among local farmers. This should bring closer awareness about the species and explain the benefits which result from presence of brown hyena on farmers' lands. Important step is also cooperation with programmes focused on leopard conservation. Leopards play important part in Namibia wildlife ecosystem and their conservation has potential in conservation of other species, brown hyena included.

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