Applying spatial behaviour and ecological interactions of predators to minimise human-wildlife conflict in Namibia

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Background

Human-wildlife conflict is an increasing and worldwide problem (Messmer, 2000; Treves and Karanth, 2003), even though a variety of mitigating methods have been proposed (Nyhus et al., 2003; Linnell et al., 1996; Shivik, 2004; Daly et al., 2006; Shivik, 2006). These include proactive methods to prevent the conflict (Daly et al., 2006; Shivik, 2006), methods that increase the value of the wildlife species to offset the costs of living with wildlife (e.g. regulated harvest of leopard in Uganda [Treves and Karanth, 2003], wildlife property rights on Namibian farmlands [McGranahan, 2008], eco-tourism, etc.), and reactive methods including compensation and removal of problem animals after-the-fact.

Predators form an important part of any ecosystem and it has been suggested that most ecosystems are actually top-down controlled (Estes et al., 2011) and therefore susceptible to trophic cascades when top-level predators are removed. The removal of top predators can cause meso-predator release (e.g. the removal of leopards in some areas, may lead to an increase in the number of caracals and black-backed jackals). Similar increase in meso-predator numbers has been shown in America for coyotes as a result of the loss of wolves, cougars or grizzly bears (Estes et al., 2011). Current conserved areas are insufficient to ensure the long-term survival of large, wide-ranging predators like leopards and cheetahs, both because of intra-guild hostility by larger, social predators like lions and spotted hyenas (Ritchie and Johnson, 2009) inside conserved areas and because of the minimum required number of individuals needed in a population to ensure genetic survival (Stuart, 1981; Lande, 1995) combined with the home range size requirements of these species. Thus it is not strange that the majority (90% - Marker et al., 2003) of surviving cheetahs in Namibia are found on farmlands outside formally conserved areas. It is therefore imperative to get buy-in from landowners outside formally conserved areas to ensure the long-term survival of these predator species.

Globally, the greatest thread to mammal biodiversity is habitat destruction or degradation(Schipper et al., 2008). However, for cheetahs in Namibia, direct killing by humans and the resulting change in population demographics, have been identified as the greatest contributors to their mortality rates (Marker et al., 2003). A number of management techniques have been demonstrated as effective in minimising livestock losses to predation (Shumann et al., 2004), but conflict with predators because of livestock or game losses are still a common on Namibian farms. Although the spatial ecology of both Namibian leopards (Marker and Dickman, 2005; Stander et al., 1997) and cheetahs (Marker et al., 2008) have been extensively studied using radio-tracking, their interaction with each other, and with smaller predators on Namibian farms are less clear. A better understanding of the ecological systems as it currently functions on Namibian farms, might be the key to better management and prevention of livestock losses.

One of the major reasons for farmer-predator conflict is that although everyone benefits from these ecosystem services, it is the farmers who have to bear the brunt of the costs. In a study done for the Red meat Producers Organisation the total annual costs of livestock depredation for small livestock farmers in South Africa was estimated as R 1 390 453 062 (Van Niekerk, 2010). For this reason, it can be assumed that the methods most likely to decrease conflict between farmers and predators, are those that will maximise the benefits and minimise the costs of predators on their land. The major predators perceived as a threat to their livelihoods by farmers in Northern Namibia, are leopards (*Panthera pardus*), cheetahs (*Acinonyx jubatus*), caracals (*Felis caracal*) and black-backed jackals (*Canis mesomelas*). Two of these predator species, are classified as vulnerable (*Acinonyx jubatus*, Durant et al., 2008) and near-threatened (*Panthera pardus,* Henschel et al., 2008) by the IUCN. Black-backed jackals in particular, is considered as a problem by some game farmers as well as communal farmers with large herds of goats and sheep (e.g. recent survey by CCF in four conservancies of the Greater Waterberg Complex). Since intra-guild interactions can have a huge impact on ecosystems (Sinclair et al., 2003; Estes et al., 2011), and the current human-predator conflict might largely be the result of changes in the predator species composition on farmland ecosystems (Beinart, 1998; Daly et al., 2006; Ritchie and Johnson, 2009), a better understanding of these interactions could lead to both better conservation and less human-wildlife conflict.

For livestock farmers to make an informed decision on the best anti-predation method for their specific circumstances, both ecological and agricultural information should be used. From a strictly (and short-term) agricultural point of view, the cost and relative efficiency of the different methods used to protect livestock from predation should be the most important factor. Other agricultural aspects to be considered, include the available infra-structure on the land, the availability of capital for farm infrastructure improvements, the sustainable stocking rates of the land, the long-term effects of the different techniques on the veld quality, the kind and breeds of livestock (and the marketing and other reasons for using these specific types), the topography and vegetation types of the land, the density of available water points and the quality and quantity of drinking water on the land, the size of the farm, etc.

However, especially for the long-term sustainability of whichever method is used, a number of ecological aspects are important as well:

1. Spatial ecology of the various predators. What factors determine home range sizes? What factors determine the location of core areas within home ranges? Are there preferred hunting areas within the home ranges of predators and what variables are important in the choice of "hunting areas" (if they exist)? Leopards in the Karoo side of the Cederberg Mountains made much more use of dry river beds than the mountains inside their territories, while those leopards in the Fynbos side tend to use all of their territory (Martins (2010)). Can habitat types have a similar effect on the use of their home ranges for Namibian predators? The habitat preferences of predators can influence his management options in two ways: 1. If different predator species (that prey on different kinds of livestock or age classes) prefer different habitat types, it may be possible to keep vulnerable livestock away from those high-risk habitats on his farm (provided there is enough low-risk alternative areas available) and 2. if the reason why certain predators prefer certain habitat types within their wide-ranging home ranges can be established (e.g. for hunting or by females with higher prey requirements for having their cubs), vulnerable livestock can be kept away from these habitats.

2. Diet and prey preferences. To what extend is there individual differences in prey preference and can a species-wide "index of prey preference" be established for each predator species? Are there other factors in addition to prey size and availability that determines prey preference? Is there any change in jackal diet where larger predators are present (and they can scavenge) compared to areas with few or no large predators? Linnell et al. (1999) claimed that "problem animals" do not exist and that predators probably only take prey (including livestock) according to availability (and with the obvious provisio that it is in the right size class for the predator). Is this true for all four of the Namibian predators under consideration? Two question concerning predator diet preferences can influence the management of a livestock farmer: 1. The diet preferences (if any) of the predator species on his farm impacting livestock or game production (i.e. if he can stock the farm with cheaper, but preferred prey species, his high-value game or livestock animals are less likely to be preyed on by these predators) and 2. the importance of individual prey preference of the predators on his land (i.e. if there are only some individuals that are preferring livestock as prey, removing them from his land might be a viable management option).

3. Is there any spatial interaction between the various predator species? Since leopards are known to kill and occasionally prey on all three the other predator species (cf. Bothma and Le Riche, 1994 with 15% of Kalahari leopard scats including black-backed jackal), does this have any spatial or behavioural effect? It has been claimed that caracals can deter jackals from some areas (Du Toit, 2013) and that caracals and jackals will occasionally kill each other's young. One of the major reasons for the increasing problems with jackals and caracals could be meso-predator release (Beinart, 1998), but the extend and importance of these interactions have not been studied in enough detail to know if it could be a significant reason for the reported increase in livestock depredation. If meso-predator release plays a role in Namibian ecosystems, it becomes important for farmers to maintain enough larger predators on their land to prevent future livestock losses from too many meso-predators.

4. The impact of seasonal behavioural changes. Cheetahs show seasonal peaks in their breeding in March and June, although they breed throughout the year (Marker et al., 2003). Although black-backed jackals in other areas are know to whelp from September to October (Bingham and Purchase, 2003), it is not sure if the same pattern holds in Northern Namibia. When there are young ones to feed, an increase in predation around the breeding site can be expected. They are also less likely to range as far for food during this period. By identifying probable den areas within the home range of a female predator or breeding pair, farmers can avoid having young or vulnerable livestock in those parts of his farm. It will therefore be useful to identify the factors used by the different predators species in choosing den sites.

Aims and objectives

The main aim of this research project is to provide farmers and other land managers dealing with human-predator conflict with a Decision Support System (Keen, 1980; Sprague, 1980) tool for mitigating human-predator conflict, thus contributing to the continual survival of predators on Namibian farmlands and possibly finding solutions with a wider application. It will therefore concentrate on those predator species that have a significant probability for conflict with humans as a result of livestock predation, i.e. cheetah, leopard, caracal and black-backed jackal. The approach is taken that a better understanding of the whole ecosystem, the farming system and ecological interactions between species, will benefit both wildlife and farmers.

Specific objectives to meet these aims are:

1. The advantages and disadvantages of different anti-predation methods need to be determined.
   (a) Determine which anti-predation methods are currently used by Namibian farmers.
   (b) Determine current livestock losses by Namibian farmers.
   (c) Determine any changes in predator numbers reported by Namibian farmers on their land.
   (d) Determine current stocking rates on Namibian farms.
   (e) Determine average costs of each anti-predation method used in Namibia.
   (f) Determine some of the advantages and disadvantages of anti-predation methods used worldwide from an agricultural perspective.
   (g) From these data, do a cost-benefit analysis of each method from an agricultural viewpoint.
2. The basic habitat preferences and spatial ecology of each predator species need to determined:
   (a) Determine home range sizes for breeding/territorial males and females of each predator species.
   (b) Determine the relative proportion of resident and non-resident individuals in the population of each predator species.
3. The behavioural explanation of the observed spatial distribution of the predator species needs to be explored:
   (a) Determine habitat use within their home ranges for each species. Determine if each species has areas within its home range or territory that are more used than the rest.
   (b) Build a predictive Dempster-Shafer expected density model for each factor and combination of factors that are likely to influence habitat use and density for each predator species and find the best predictive model for each species.
4. Diet and prey preferences needs to determined for each predator species:
   (a) Determine prey availability in different habitats and compare prey use to prey availability to determine prey preference for each species.
5. Individual variability in prey preference needs to be determined for each species:
   (a) Determine the individual degree of variance of prey preference within species. No individual will have exactly the same prey preference. Factors like habitat and availability will also influence individual predator diet. The degree of difference between the individuals and the average prey preference of the whole species sample will be measured and compared between the different species. This will give an indication of how likely it is that individuals of a certain prey species can become "problem individuals" that prefer livestock to other prey species.
6. Predator intra-guild interactions needs to be determined:
   (a) Determine if an increase in leopard numbers and a simultaneous decrease in cheetah numbers can be observed on a farm where previous studies were done.
   (b) Determine if there is any evidence of meso-predator release where larger predators have been extirpated.
   (c) Include the movement of other predator species in a predictive Dempster-Shafer GIS models as a negative factor and test the predictive power of this model for each predator species. It is hypothesised that Dempster-Shafer models that include data on the home ranges of other predator species, will have greater explanatory power than models that ignore other predator species vs the null hypothesis that there will be no significant difference.

Methods

1. A literature review will contribute mostly to objective 1 (available anti-predation methods), but will be important in the interpretation of data for all six objectives:
   (a) A full literature review will be done of human-predator conflict and the different solutions that have been tried worldwide, in order to find new methods that might work in Namibia.
   (b) The literature will also be used to determine home range sizes for breeding/territorial males and females of each predator species and the relative proportion of resident and non-resident individuals in the population of each predator species.
   (c) The diet preferences of each predator species will be determined from the literature. However, little could be found on the extend of individual variation in prey preferences for these predators (by contrast, see Matich et al., 2011 on sharks and Knopff and Boyce, 2007 on pumas) and other methods will be necessary for this purpose.

   (d) The general behaviour of each predator species will also be determined from the literature to interpret observed movements and to build the predictive Dempster-Shafer models.

2. A survey of Namibian farmers and conservancies will be used to provide data for objective 1:

   (a) The first survey will be as broad as possible. Basic information on current anti-predation methods used by livestock farmers, livestock losses to predators, perceived predator numbers, livestock numbers, farm sizes etc. will be collected.
   (b) A second survey, involving those farmers who indicated their willingness for participating in further research, will be conducted where farmers will provide the costs of their anti-predation methods, the numbers of predators killed and the livestock numbers still lost to predators and other causes on a monthly basis.

3. Tracking will be used to provide data for objective 2 (habitat preferences and spatial ecology) and objective 4 (diet and prey preferences). It will also contribute to objective 3 (behavioural explanation of distribution) and objective 5 (individual prey preferences):

   (a) Spoor tracking will be used to determine the individual spatial behaviour of the predator species. Trained trackers will follow fresh tracks of a single animal and record its spatial behaviour for the preceding 24 to 6 hour period with a CyberTracker GPS device.
   (b) Using tracks, any kill sites, hunting attempts and killed prey species will be recorded.
   (c) A combination of camera traps, circuit counts and track identification (claimed by Stein (2008) as less biased than the other two methods) will be used to determine available prey densities and species in each study area.

4. Capturing animals and GPS collars can be used to provide more data for objective 2 (spatial ecology) and objective 4 (diet), but are more likely to provide data for objective 6 (predator interactions) than any other method. This will only be done if the data from spoor tracking are insufficient to show interaction between the predator species and if enough funding can be sourced:

   (a) Depending on funding, adult predators of all four species will be captured using a combination of cage traps (for cheetahs, caracals and possibly leopards), soft traps (Kamler et al., 2008) and foot snares (Frank et al., 2003) for leopards. These predators will be fitted with GPS collars that can take hourly readings, as Martins (2010) has shown that daily distance travelled and habitat usage can be severely under-estimated when longer time periods between readings are used.
   (b) GPS collar data can be used to look for "hunting grounds" within the home ranges of each species. It is hypothesised that each species will have areas within its home-ranges that are preferred for hunting, and that the factors determining which area it is, will differ between species.
   (c) If any breeding females are collared, the den sites will be investigated and possible factors that determines choice of den sites, identified.
   (d) If non-resident predators are collared, the average distance they move will be recorded until either the end of the study period (and the drop-off of the collars) or the establishment of a new home range or territory.

5. Camera trapping will primarily be used to provide data for objective 6 (change in relative predator numbers), but also for objectives 4 and 5 (diet and individual preferences) :

   (a) Setting camera traps at the exact same spots where they had been set in the past, any possible changes in species composition and game densities can be determined. The claimed change in leopard and cheetah distribution will be investigated using this method.
   (b) From camera traps the relative availability and distribution of prey species can also be determined in order to determine preferences.
   (c) Camera traps can also indicate locations of high predator movement where there is a better chance of success for spoor tracking and/or capturing of predators.

6. Scat analysis will be used for objective 4 (diet and prey preference) and possibly objective 5 (individual preferences) if enough samples can be found:

   (a) To determine predator diet, predator scat that are found in the study areas, will be collected and analysed (Bothma and Le Riche, 1994, Moyo et al., 2006). This data will be used in conjunction with the tracking data and/or GPS cluster analysis (and possibly acceleration/deceleration points to include hunting attempts).

7. Analysis:

   (a) Objective 1: A basic cost-benefit analysis of both lethal and non-lethal methods used by actual farmers on actual Namibian farms will be done to determine the advantages and disadvantages of different anti-predation methods. This will only give short-term agricultural information. Using the literature, the possible long-term ecological effects and sustainability of each method as well as the possibility of using methods from other parts of the world will also be included and made public to farmers. The importance of the different predators for livestock losses in different habitat types and with different livestock (from the farmer surveys) will also be incorporated.

(b) Objective 2: The basic habitat preferences of the predator species will be analysed using a GIS with different layers for the different habitat factors (from existing ground-truthed GIS data).

(c) Objective 3: Predictive spatial Dempster-Shafer GIS models will be produced to hypothesize areas of higher usage by each predator species. This data will then be compared to the actual spatial observations of the predator species and order to determine the most important factor(s) in the spatial ecology of each predator species.

(d) Objective 4: Relative prey availability data as well as the data from the scat analysis, kill sites from spoor tracking and possibly cluster analysis of GPS data will be used to determine the prey preferences of each species using a preference index (e.g. Jacobs Index Cock, 1978; Jacobs, 1974).

(e) Objective 5: For each predator species, an index of overlap in prey preference between individuals will be determined in order to quantify individual preference and specialization by individuals of each species (Matich et al., 2011).

(f) Objective 6: Spatial Dempster-Shafer models that include the movement of other predator species will be tested to see if any spatial (or temporal) avoidance of other predators occur for each species.

(g) Finally the results from all these aspects will be included in a single Decision Support System (DSS) that will be made available to farmers and conservationists to determine the "best" course of action in different scenarios. Where there are more than one valid possibility, the DSS will also present the alternatives with their advantages and disadvantages.

Scientific contribution

1. This will be the first use of predictive Dempster-Shafer modelling for predator habitat use.

2. The use of spoor tracking (together with camera traps) for studying the spatial ecology of multiple predator species will be shown as a cheaper and useful alternative to more expensive and invasive methods like GPS or radio collaring.

3. The application of ecological data as part of a decision algorithm to help prevent predator-farmer conflict on livestock (and possibly game) farms will be demonstrated.

4. The different factors that influence predator use of their home range for different predators, will be investigated.

5. The spatial and behavioural effects of all four predator species on each other (if any) on Namibian farmlands will be investigated for the first time.

Conclusion

Two of the four predator species with a significant impact on livestock (and game) farming, are classified as vulnerable (*Acinonyx jubatus*) and near-threatened (*Panthera pardus*) by the IUCN (Schipper et al., 2008). Even though Namibia remains the global stronghold for free-roaming cheetahs, the survival of Namibian cheetahs are by no means secure. Because of their large home ranges and competition from larger social predators, formally conserved areas are not enough to ensure their survival. It is therefore imperative that practical solutions to human-predator conflict on Namibian farmlands be found. This project will make great strides in finding new solutions and applying existing solutions to human-wildlife conflict in Namibia in order for livestock farmers to farm with predators instead of fighting against nature.

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