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COOPERATE WITH

Brighton Doctoral College: Research Proposal

Applicant: Eve Hills

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1. Indicative title

Factors affecting leopard habitat and prey selection in the Meru Conservation Area (MCA).

2. Context and Rationale

Among large predators, leopards (*Panthera pardus*) have the widest distribution of all felid species, occupying a diverse range of habitat types from deserts, rainforests and mountains, to urban and agricultural areas (Ray, Hunter and Zigouris, 2005; Athreya *et al.*, 2013; Jacobson *et al.*, 2016). The dietary plasticity and behavioural flexibility of the leopard facilitates their successful occupation of highly modified human-dominated landscapes, given sufficient human tolerance to their presence in such environments (Athreya *et al.*, 2016; Braczkowski *et al.*, 2018). For example, even in heavily populated areas (400 people/km^2) leopards can live close to humans by preying mostly on livestock and domestic dogs, and finding cover in agricultural and crop lands (Athreya *et al.*, 2013; Braczkowski *et al.*, 2018). Despite such ecological flexibility, leopards face numerous anthropogenic threats including, habitat destruction and fragmentation, prey depletion due to competition for resources with domestic species, bushmeat poaching, hunting for trophies and conflict with humans (Jacobson *et al.*, 2016; Wolf and Ripple, 2016; Stein *et al.*, 2016; Sidhu *et al.*, 2017). Consequently, in the past 20 years, leopard populations have experienced 63-75 % range loss, worldwide, far greater than the average 53 % for most large predators (Ripple *et al.*, 2014; Abade *et al.*, 2018). In Africa, the leopard has lost 48-67 % of their historical range with marked reductions in both north and west Africa (Jacobson *et al.*, 2016). However, the species is predicted to experience further population decline throughout its Sub- Saharan African range given the high level of prey depletion (Wolf and Ripple, 2016) and loss of habitat caused by a growing human population (Stein *et al.*, 2016).

Kenya's vast array of national reserves and parks make it one of the most important countries for leopard conservation in Africa, by providing protection to substantial proportions of the leopards extant range (Jacobson *et al.*, 2016). Leopards present an important economic asset for Kenya, indeed, tourism is one of Kenya's leading industries, contributing >13 % of the GDP, and >10 % of the national employment sector (Ogutu *et al.*, 2016). As an apex predator, the leopard also carries out vital ecosystem functions such as the regulation of herbivore populations, which in turn maintains ecosystem health (Ripple *et al.*, 2014). Despite the ecological and economic importance of leopards the current lack of data on leopard ecology hinders the development of conservation strategies (Abade *et al.*, 2018; KWS, 2018).

One area likely to be of great importance to leopard conservation is the Meru Conservation Area (MCA) in Kenya, where a complex of reserves and national parks provide viable habitat and key resources for a wide range of biodiversity (KWS, 2010). However, in an effort to address a growing population and the fulfilment of self-sufficiency in food production, Kenya's government has sought to increase the productivity of the country's arid and semi-arid lands (ASAL's) through agriculture and intensive livestock production (Southgate and Hulme, 1996). Thus, over the past few decades, Kenya's MCA has witnessed a steady immigration of agricultural and livestock households into its northern, western and southern buffer zones (Otuoma, 2004). The situation has led to increased competition among wildlife, livestock and agriculturalists. Consequently, the MCA has increasingly observed complex interactions between conservation and socio-economic needs of the households occupying its buffer zones (Otuoma, 2004). Many of the triggers of these interactions include land use changes and disputes arising from conflicts of interest among pastoralists, agriculturists and conservationists with wildlife being the common ground of contention (Otuoma, 2004). The current demographics and threats facing this leopard population are, however, unknown. Using both quantitative and qualitative methodology this research aims to determine the availability of preferred leopard prey and habitat, identify hotspots of human-leopard-conflict, and investigate the potential for conflict resolution.

3. Literature Review

3.1. Threats to the species

The leopard is arguably the least studied member of the large carnivore guild (Rafiq, 2018). This is a likely consequence of the assumption that leopards are resistant to the threats facing other large carnivores. The leopard is a large, solitary and elusive felid, which is also the most wide-ranging, occurring across much of Africa and Asia (Nowell and Jackson, 1996; Balme *et al.*, 2014; Jacobson *et al.*, 2016). Leopards have the most catholic diet of all large felids (Hayward and Kerley, 2005; Jacobson *et al.*, 2016), and their ecological plasticity has enabled them to persist in areas where other large predators have been extirpated (Athreya *et al.*, 2013; Athreya *et al.*, 2016). However, hunting for leopard skins and lethal retaliation for loss of livestock or attacks on humans have impacted certain populations, and habitat loss and prey depletion are also major causes of the leopards decline (Ray, Hunter and Zigouris, 2005; Jacobson *et al.*, 2016).

The leopard was recently re-graded as Vulnerable on the IUCN Red List (Stein *et al.*, 2016), and is listed on both Appendix I of the Convention of International Trade in Endangered Species (CITES) (Friedmann and Traylor-Holzer, 2008; Jacobson *et al.*, 2016), and Kenya's Wildlife and Conservation Management Act 2013, highlighting the growing concern over its conservation status (Williams *et al.*, 2017). However, the leopards broad adaptability in diet and habitat, and their secretive nature, make deciphering the relative importance of factors affecting its density, such as habitat type, prey abundance, and anthropogenic disturbance, particularly challenging (Havmøller *et al.*, 2019).

Previous research has identified a number of correlates of leopard density. A review on large predator abundance by Carbone, Pettorelli and Stephens (2010), highlighted prey abundance as the most influential factor. Balme, Hunter and Slotow (2007) and Bhattarai and Kindlmann (2012), suggest that in addition to prey density, catchability of prey might also be an important factor in fine-scale habitat selection by leopards. Another commonly assumed predictor of large felid densities and likelihood of their long-term persistence is protected area size (Woodroffe and Ginsberg, 1998). Balme, Slotow and Hunter (2010), addressed edge and disturbance effects on leopard density and found that it declined along a gradient from the centre of a protected area to the neighbouring, unprotected landscape. A study from Thailand found that leopards avoided areas with high levels of human activity, and proximity to heavily trafficked roads (Ngoprasert, Lynam and Gale, 2007). In Nepal, site use appears to be affected by humans, although leopard densities did not appear to be influenced by direct anthropogenic disturbance due to encroachment into a protected area (Carter *et al.*, 2015), and in South Africa some leopard populations had high populations in unprotected areas (Swanepoel, Somers and Dalerum, 2015). In India leopards have adapted to landscapes dominated by agriculture where they occur in relatively high densities (Athreya *et al.*, 2013).

Reliable estimates of leopard population demographics, distribution and threat require greater levels of research (Jacobson *et al.*, 2016). Long term data on leopard populations is almost entirely absent, with the exception of the Phinda Game Reserve, South Africa (Balme, Slotow and Hunter, 2009). More research is needed to better understand the threats facing the leopard across different parts of its range (Jacobson *et al.*, 2016).

3.2. Protected areas

Protected area networks are cornerstones of conservation effort and could shield leopard populations from the pressures of land-use change (Jacobson *et al.*, 2016). Indeed, well-managed protected areas can facilitate leopard population recovery (Askerov *et al.*, 2015). However, the efficacy of a protected area relies on the ecological characteristics of the target species (Rodrigues *et al.*, 2004). In the case of the leopard (and other large predator) conservation, many protected areas lack sufficient resources, or are too small to meet the extensive spatial requirements of the populations they aim to protect (Linnell *et al.*, 2001; Brashares, Arcese and Sam, 2001). Even where the habitat is productive, the wide-ranging behaviour of large predators, such as leopards, often leads them to cross park boundaries where they are accidentally, or deliberately, killed by people (Loveridge *et al.*, 2007). Indeed, the resultant edge effect is often enough to cause the decline or extirpation of a protected population (Woodroffe and Ginsberg, 1998). Ultimately, protected areas are important components of conservation strategies, particularly as ranges diminish, but local regulations governing poaching, or retaliatory killing may be more important than protected area boundaries in certain cases (Athreya *et al.*, 2013).

3.3. Human-Felid conflict

As protected areas become more isolated and landscape alteration increases, trans-boundary issues are likely to become more pronounced (Harcourt, Parks and Woodroffe, 2001). Consequently, developing strategies to manage human-caused mortality and encourage the coexistence of humans and large felids adjacent to protected areas has become a crucial goal in large felid conservation (Lute *et al.*, 2018; Van Cleave *et al.*, 2018; Nawaz, Swenson and Zakaria, 2008). Addressing this issue in East Africa, is particularly important because the region holds some of the greatest diversity of large predators in the world (Van Cleave *et al.*, 2018). However, the factors that determine the nature of human-felid conflict are varied (Inskip and Zimmermann, 2009). Many are location or species-specific and the nature of a given conflict will be determined by a unique combination of factors (Inskip and Zimmermann, 2009). For instance, in Scandinavia, Andrén et al., (2006) found that economic loss provided a proximate motive for killing predators, although it was apparent that reprisals resulted from an endemic hatred of the Eurasian lynx (*Lynx lynx*). Other cultural or economic influences such as traditional lion hunts, in Kenya (Frank, 2011), or the potential to derive income from the sale of body parts (Karanth and Gopal, 2005), must also be considered. Given the precarious conservation status of many large felids, effective human-felid conflict management is crucial, yet also highly complex as it must merge human needs with those of felid populations (Inskip and Zimmermann, 2009).

4. Research Questions

1. What are the predictors of leopard occurrence and habitat use in core protected areas of the Meru Conservation Area (MCA) versus human dominated buffer zones?

- Relative abundance and where possible occupancy/density of leopards will be determined using a network of remote camera 'traps' in a sample of core and buffer zones of the MCA to compare these two major types of land use in terms of leopard occurrence.
- Home range metrics and habitat use via resource selection function (RSF) or equivalent approaches, will be compared between core and buffer zones. Where possible this will be achieved via live capture and GPS tracking of leopards. Individual leopard detection histories may also be compiled from camera traps to meet the same aims if invasive methods are not feasible.

2. What is leopard diet composition in core areas of the MCA versus the buffer zones?

Dietary data will be collected using a combination of faecal macro-analysis and stable isotope analysis, and continuous follow direct observations.

3. What is the extent of leopard depredation of livestock in the MCA buffer zones?

Little is known about the extent of leopard depredation attempts and successful attacks in the MCA. It will be necessary to descriptively establish how often these events occur and where.

4. **What is the perception of leopards and other wild carnivores by residents in the MCA buffer zones?**

Effective conflict mitigations are reliant on an in-depth understanding of community attitudes and social characteristics. A qualitative approach will be used to determine how leopards are perceived in areas experiencing conflict via in-depth interviews with a sample of occupants in the MCA buffer zones.

5. Research approach and proposed methods

The first stage of this PhD will be a literature review on leopard populations, conservation and distribution, which will form the basis of the thesis first chapter.

Initial fieldwork will comprise establishing a remote camera monitoring network to determine difference in leopard occurrence across a sample of areas in the MCA including core and buffer zones. Placement of the cameras will be informed from topographic maps and satellite imagery to identify and locate habitat features such as trails, roads, rivers, forests and areas of human habitation. Proposed camera locations will then be plotted in GIS to achieve optimal camera density and coverage of habitat features. Feasibility of these locations and field evidence of leopard activity will be used in the field to further refine the protocol with assistance from park rangers, considering factors such as access, safety, and leopard behaviour, and controlling for habitat type.

Concurrently/consequently field work will involve establishment of a programme of interviews with communities in buffer zones. This qualitative work will start with visiting villages in the buffer zones and building relationships with homeowners and herds people in 'hotspot' areas of potential conflict.

This will be followed by collection of data on leopard diet, spatial behaviour and habitat use in the different zones, using a combination of survey methods. Leopard live capture and GPS/VHF tracker attachment if feasible will target a sample size of at least 7 leopards using soft-hold foot snares. Diet data will be gathered from incidental observations and direct follows of collared/uncollared leopards and by collection of scats for faecal analysis. Short-term/long-term dietary composition from a sample of scats in each of buffer and core areas is envisaged via macro-analysis of faecal content and stable isotope analysis. The data gathered in this study using a mixed methods approach will provide important information on leopard movement, prey and habitat use in the MCA, to be integrated with human perception data to inform strategies for leopard-human coexistence and leopard conservation.

6. Timescale and research planning

Time Period	Activity
Year 1	• Conduct literature review • Complete induction for PhD, ethics, risk assessment & GIS training • Plan field data collection methods including identifying areas of higher levels of livestock depredation in liaison with the Kenya Wildlife Service (KWS) (field and desk-based) • Identify target communities and preliminarily liaise with them as supported by Dr Chelysheva (field-based) • Develop interview study design as supported by Dr Adams (desk-based) • Identify sites for camera network deployment • Start camera 'trap' survey • Start interviews
Year 2	• Complete camera survey • Complete interviews • Analyse initial data • Start live trapping and collaring if appropriate • Conduct leopard follows and scat collection • Write methods chapter of thesis and consolidate literature review as first chapter
Year 3	• Conduct laboratory faecal analysis. • Analyse data. • Write remaining chapters of thesis.

7. References

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