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# Characteristics and distribution of livestock losses caused by wild carnivores in Maasai Steppe of northern Tanzania

**Batistino P. Mponzi**,[1] Department of Natural Resources and Environmental Management, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA

**Christopher A. Lepczyk**,[2] Department of Natural Resources and Environmental Management, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA *Ca10044@auburn.edu*

**Bernard M. Kissui**,[3] African Wildlife Foundation, P.O. Box 2658, Arusha, Tanzania

***Abstract:*** Agricultural development accelerates the loss of habitat for many wildlife species and brings humans and animals in close proximity, resulting in increased human–wildlife conflict. In Africa, such conflicts contribute to carnivore population declines in the form of human retaliation for livestock depredation. However, little knowledge exists about when and where carnivores attack livestock. Given this need, our objectives were to (1) understand the spatial and temporal variation of human–carnivore conflict and (2) identify conflict-prone areas. We addressed these objectives in 18 Tanzanian villages of the Maasai Steppe using livestock depredation data on lions (*Panthera leo*), spotted hyenas (*Crocuta crocuta*) and leopards (*Panthera pardus*) from 2004 to 2007. Over the 4-year period, 1,042 carnivore attacks occurred on livestock, with >50% due to hyenas; shoats (goats and sheep) were the most commonly depredated livestock. Livestock depredation was unevenly distributed across villages. About 39% of all recorded attacks occurred in Selela, followed by Emboreet (16%), and Loiborsoit (11%), while Esilalei, Oltukai, and Engaruka all had >5% of all attacks. Villages with <1% of all attacks on livestock included Losirwa, Terat, Naiti, and Minjingu. Spotted hyenas attacked livestock more during the night and when livestock were in bomas (enclosures where livestock is kept, especially at night), while lions and leopards depredated at similar rates by time of day and location. Livestock depredation was highest during the wet season. Carnivore attacks on livestock could be reduced both by avoiding wildlife migration and dispersal areas during the wet season and by building stronger bomas. Because large carnivore populations are declining, our findings identify possible alternatives to reduce human–carnivore conflicts, thus, facilitating large carnivore conservation efforts in landscapes where large carnivores and livestock co-exist.

***Key words:*** human dimensions, human–wildlife conflicts, leopard, lion, Maasai Steppe, spotted hyena

The increase in human population, coupled with technological development, has put enormous pressure on wildlife and their habitats (Holmern 2007). A greater number of humans means that more land is needed for agricultural and pastoral activities to grow crops and produce livestock to sustain themselves. In developing countries, agricultural activities, such as shifting cultivation, have resulted in significant habitat destruction and fragmentation through encroachment, land clearing, and human settlement (Yihune 2009). As a consequence of the resulting habitat loss, wildlife movement can be affected, particularly for migratory species and those characterized by large home ranges, such as large felids (Shemweta and Kidegesho 2000, Woodroffe 2000). Moreover, as wildlife habitat is converted to agricultural or other human uses, people and wildlife are living in increasingly close proximity to one another, which may exacerbate conflicts (Yihune 2009). Human–wildlife conflicts occur when either human or wildlife actions or ecological needs have a negative impact on the other (Madden 2004, Messmer 2009), such as when elephants

[1]Present address: Institute of Development Studies (IDS), Mzumbe University, P.O. Box 1, Mzumbe-Morogoro, Tanzania

[2]Present address: School of Forestry and Wildlife Sciences, Auburn University, 3301 Forestry and Wildlife Sciences, Auburn, AL 36849, USA

[3]Present address: School for Field Studies, Center for Wildlife Management Studies, P.O. Box 304, Karatu, Tanzania

**Figure 1**. Female lions loafing. *(Photo by Batistino P. Mponzi)*

(*Loxodonta* spp.) or zebras (*Equus* spp.) eat agricultural crops or when humans retaliate against wildlife for agricultural damage (Treves 2007).

Wildlife damage, including crop raiding, attacks on humans, and livestock predation, are usually followed by indiscriminate retaliation by humans (Packer et al. 2005, Kissui 2008, Goldman 2010). In Africa, such retaliation has been linked to the decline of lions (*Panthera leo*; Figure 1), leopards (*Panthera pardus*), and cheetahs (*Acinonyx jurbatus*) and the disappearance of African wild dogs (*Lycaon pictus*; Ogada et al. 2003, Patterson et al. 2004, Packer et al. 2005). Carnivores are more likely to be killed than are herbivores when they cause damage because of perceived danger to humans and the general lack of compensation for livestock losses (Treves et al. 2006, Holmern et al. 2007, Ikanda and Packer 2008). Such perceptions pose significant challenges for carnivore conservation (Kissui 2008). Thus, a better understanding of the nature and causes of human–carnivore conflict is needed for carnivore conservation efforts to be successful.

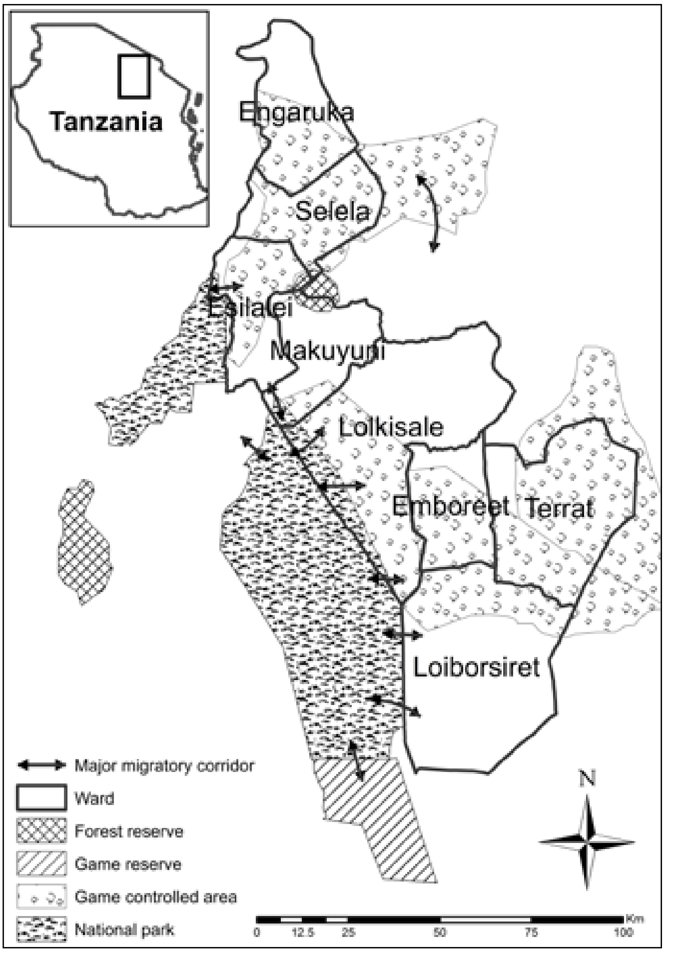


**Figure 2**. Map of the Maasai Steppe in the northern Tanzania showing Tarangire National Park and Lake Manyara National Park, the Mkungunero Game Reserve, game controlled areas, Simanjiro North and South, Lolkisale, Mto wa mbu, forest reserves (Nuo and Losimingori), and major wildlife migratory corridors.

In the Maasai Steppe of northern Tanzania, spotted hyenas (*Crocuta crocuta*), leopards, and lions are sympatric with one another and are responsible for most repeated livestock depredation (Kissui 2008). The spotted hyena is a social carnivore that lives in territorial groups, called clans, which prey on wildebeests (*Connochaetes taurinus*), zebras, and Thompson's gazelles (*Gazella thomsonii*). Hyenas are active both during night and day and are capable of traveling very long distances (Mills and Hoffer 1998) and changing their behavior in response to human activities (Cardillo et al. 2004). Lions, like hyenas, are also social carnivores, living in territorial groups called prides, and surviving on a broad range of prey species, often including wildebeests, zebras, buffaloes (*Syncerus caffer*), and warthogs (*Phacochoerus africanus*; Scheel and Packer 1991, Kissui and Packer 2004). Though lions are active primarily at night, they also hunt during the daytime. Leopards exhibit even greater behavioral plasticity than hyenas and lions. In particular, leopards are found from desert to forest ecosystems, and they can easily change their prey dependence, activity patterns, and habitats in response to anthropogenic pressures. Such behavioral plasticity has provided leopards with a greater ability to survive compared to other species in human-altered landscapes (Nowell and Jackson 1996, Woodroffe 2000).

To date, little work has been done to investigate factors that may increase human–carnivore conflict in the Maasai Steppe (Kissui 2008). In particular, more information is urgently needed regarding when and where carnivores are depredating livestock. Such information will assist conservation stakeholders to adopt best practices to reduce depredation. Given this need, the objectives of this study were to (1) understand the spatial and temporal distribution of human–carnivore conflict and (2) identify conflict prone areas.

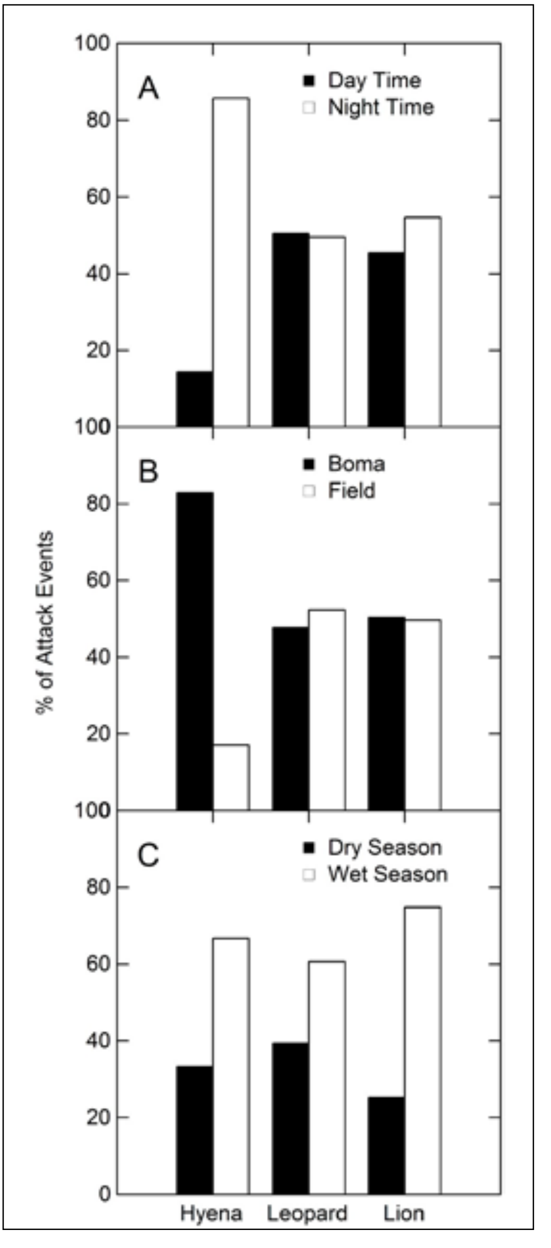


**Figure 3**. The percentage of depredation events caused by hyenas, leopards, and lions by (A) time of the day, (B) location (bomas [enclosures] or fields), and (C) season. Black bars are from the dry season; white bars are from the wet season.

## Study area

The Maasai Steppe is a 35,000 km$^2$ area in Tanzania composed of the Tarangire National Park (TNP), Lake Manyara National Park, Mkungunero game reserve, several game control areas, several villages, and open steppe (Figure 2; Prins 1987). In Tanzania, wildlife protection status decreases from national parks where there is near total protection of wildlife (including game species), through game reserves, which allow regulated hunting, to game control areas, where some human activities, such as agriculture, are allowed (Wildlife Conservation Act 1974). The 2 national parks encompass about 10% of the Maasai Steppe, and the rest is covered by about 20 villages. There were about 350,000 pastoralists with a 3.9% population growth rate during the inter-census period between 1998 and 2002 (Tanzania Population and Housing Census 2002). The average annual intercensal population growth rate for 2002 and 2012 for the Manyara and Arusha regions that encompass the Maasai Steppe were 3% and 2%, respectively (Tanzania Population and Housing Census 2002).

The Maasai Steppe is classified as arid rangeland forming part of the Somali-Maasai bio-geographical region. The predominant vegetation type is comprised of riverine forest with species that include *Ficus* spp. and *Acacia siberiana*. Swamps are dominated by *Cyperus* spp., and elephant grasses; the woodland vegetation is dominated by *A. tortilis*, *A. commiphora*, *A. mellifera*, *Terminalia brownie*, and *Adnsonia digitata*, forming an extensive mixed woodland (Pratt and Gwynne 1977). The grassland is dominated by *Cyperus* spp., elephant grass, and water-specific species in swampy areas.

Lions, hyenas, and leopards are the most common large carnivores in the Maasai Steppe that engage in livestock depredation (Kissui 2008). Because cheetahs and wild dogs are in smaller numbers and rarely involved in livestock depredation, we considered only lions, leopards, and hyenas in our analysis. In the Maasai Steppe, livestock typically are housed at night in a boma (a 1.5 to 2 m high and 1 to 1.5 m wide walled enclosure) made of thorny acacia tree branches, other thorny bushes, and occasionally wooden poles (Kissui 2008, Ukio 2010). A livestock depredation database has been maintained and managed by the Tarangire Lion Project (TLP) for 18 villages in the Maasai Steppe. Tarangire and Manyara National parks form a small part of the Maasai Steppe, which is a migratory ecosystem with animals spending the wet season (November to May)

**Table 1**. Number of livestock attacks by spotted hyenas (*Crocuta crocuta*), leopards (*Panthera pardus*), and lions (*Panthera leo*) from 2004 to 2007 across each of the 18 villages in the Massai Steppe.

| Ward name | Village name | Carnivore attacks on livestock | | | Total attacks |
|---|---|---|---|---|---|
| | | Spotted hyenas | Leopards | Lions | |
| Emboreet | Emboreti | 108 | 26 | 34 | 168 |
| | Loiborsoit | 44 | 54 | 26 | 124 |
| Engaruka | Egaruka Chini | 35 | 17 | 5 | 57 |
| | Engaruka Juu | 7 | 5 | 7 | 19 |
| Esilalei | Esilalei | 25 | 10 | 19 | 54 |
| | Losirwa | 0 | 0 | 2 | 2 |
| | Oltukai | 54 | 2 | 10 | 66 |
| Loiborsiret | Loiborsiret | 19 | 3 | 22 | 44 |
| Lolkisale | Lolkisale | 9 | 2 | 9 | 20 |
| | Minjingu | 0 | 0 | 6 | 6 |
| Makuyuni | Mswakini Chini | 6 | 0 | 1 | 7 |
| | Mswakini Juu | 4 | 2 | 9 | 15 |
| | Naiti | 0 | 0 | 4 | 4 |
| | Makuyuni | 8 | 3 | 14 | 25 |
| Selela | Selela | 214 | 86 | 108 | 409 |
| | Mbaashi | 4 | 2 | 3 | 9 |
| Terat | Kimotorok | 7 | 3 | 2 | 12 |
| | Terat | 0 | 1 | 1 | 1 |
| Total | | 544 | 216 | 282 | 1,042 |

**Table 2**. Number of attacks on different livestock (cattle, shoats [cross between goas and sheep], donkeys, calves, and dogs) by spotted hyena (*Crocuta crocuta*), leopard (*Panthera pardus*), and lion (*Panthera leo*) from 2004 to 2007 in the Massai Steppe.

| | Prey | | | | | |
|---|---|---|---|---|---|---|
| Predator | Cattle | Shoats | Donkeys | Calves | Dogs | Total |
| Spotted hyenas | 22 | 439 | 65 | 17 | 1 | 544 |
| Leopards | 5 | 193 | 12 | 4 | 2 | 216 |
| Lions | 170 | 62 | 40 | 9 | 1 | 282 |
| Total | 197 | 694 | 117 | 30 | 4 | 1,042 |

in the dispersal areas (to the east and north of the 2 national parks) and the dry season (June to November) in the core protected areas of the 2 national parks. Outside the core protected areas, TLP has collected and maintained data on human–carnivore conflicts since 2003.

## Methods

In each study village, there were 1 to 2 enumerators trained by the TLP to record livestock depredation events. All enumerators were able to accurately distinguish among lions, leopards, and hyenas morphologically and behaviorally (Kissui 2008). When a depredation event occurred, the following information was collected: date, time of attack (day or night), predator involved (lion, hyena, or leopard), the fate of the predator (killed, injured, or escaped), livestock attacked (cattle, shoat [cross between a goat and a sheep], sheep, donkey, calf, or dog), the fate of the attacked livestock (killed or injured), the owner of the livestock, village and sub-village, and site of attack (grazing fields or in a boma). The villages were visited twice a month by a TLP staff to collect depredation information and to interview livestock owners for further verification and clarification of the events.

In addition to the TLP data, we also obtained spatial data from 3 different organizations and government agencies in Tanzania. Specifically, the administrative boundaries data were obtained from the International Livestock Research Institute (ILRI) website (<http://www.ilri.org/gis>) geographic information systems (GIS) section. These boundary data were created by ILRI and Tanzania's National Census Bureau using census maps (1:50,000) of population and housing from data collected in 2002. The GIS data on protected areas were obtained from the Tanzania Wildlife Research Institute and Tanzania National Parks GIS units. The third GIS database on village centers was created in ArcMap 9.3.1, using coordinates obtained from Google Earth. The GIS data for major wildlife corridors was created in ArcMap using maps from Kissui (2008). All shapefiles were projected to World Geodetic System 1984 (WGS 84) UTM Zone 37 S.

Maps were produced at the ward level, which is an administrative level comprised of villages, because this was the finest scale map available. An average ward in our study area was about 1,100 km$^2$, with about 8,800 residents (obtained from GIS layer from ILRI). Livestock depredation data from villages belonging to the same ward were summed then analyzed and mapped in ArcGIS. Analyses of depredation events by each species in relation to village, location, time of day, and season were carried out with contingency tables. A chi-square contingency test was used to examine the relationship between depredation event, location, time of day, and season. All statistical analyses were conducted in Systat 10. Unless otherwise noted, a $P$ value of ≤0.05 was considered significant.

## Results

From January 2004 to December 2007, 1,042 carnivore attacks on livestock were reported, with more depredation events occurring in 2004 and 2007 than in the other years (404, 161, 149, and 328 for years 2004, 2005, 2006, and 2007, respectively). Of the 1,042 attacks, 52% ($n$ = 544) were by hyenas, 27% ($n$ = 282) were by lions, and 20% ($n$ = 216) were by leopards (Table 1). The level of attacks by each carnivore differed with respect to each prey ($\chi^2_8 = 479.5$, $P < 0.001$). Specifically, hyenas and leopards

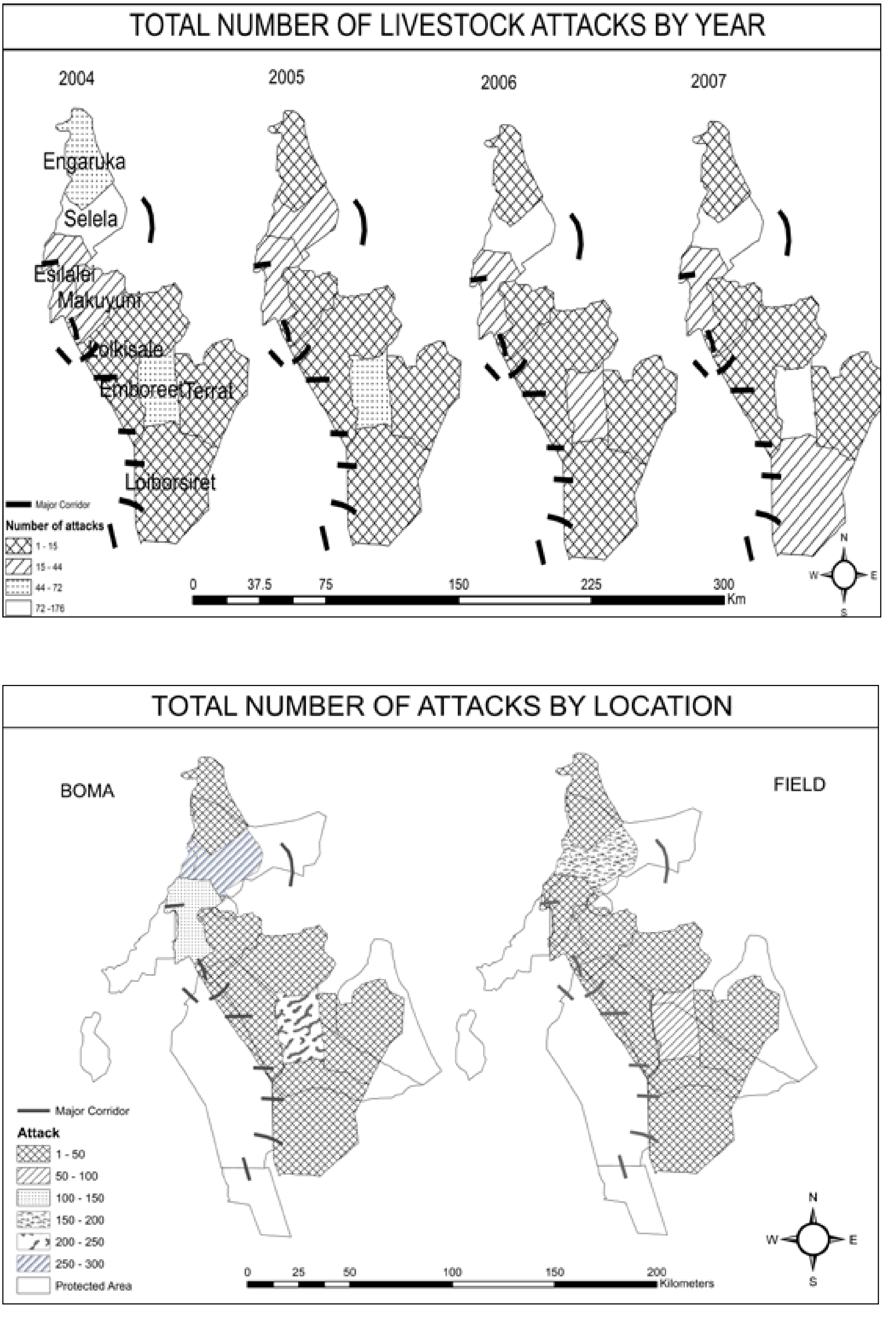


**Figure 5**. Location in the Maasai Steppe of total ward-level depredation events in the field versus boma.

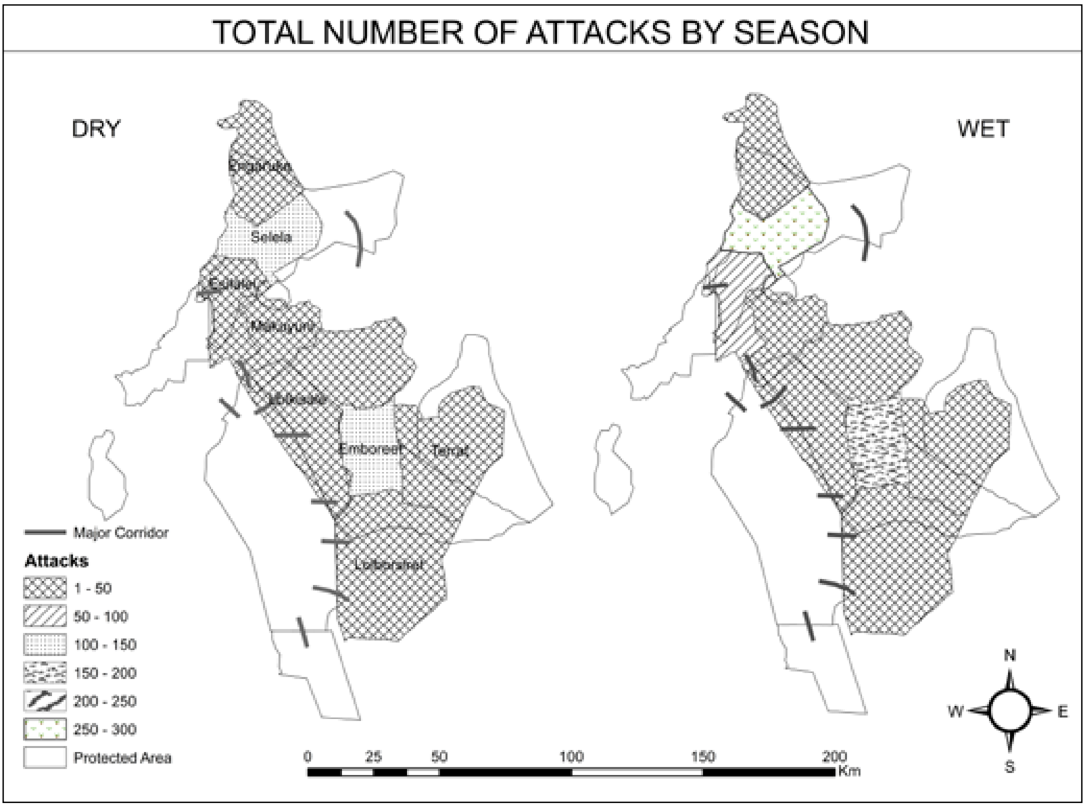


**Figure 6**. Location in the Maasai Steppe of total ward-level depredation events by season.

primarily attacked shoats, whereas, lions primarily attacked cattle and donkeys (Table 2). Reciprocally, of the 1,042 attacks, shoats were the most commonly attacked (66%), compared to dogs, which were rarely attacked (0.4%; Table 2).

Livestock depredation was unevenly distributed throughout the Maasai Steppe ($\chi^2_{34}$ = 162.6, $P < 0.001$), with a few villages having a large number of attack events and many others having very few (Table 1). Specifically, the village of Selela accounted for nearly 40% of all carnivore attacks, and, when combined with Emboreti and Loiborso, it accounted for >66% of all attacks (Table 1). Hyena attacks were more common during the night, when livestock were in the boma (Figure 3; $\chi^2_1$ = 50.9, $P < 0.001$), whereas leopard ($\chi^2_1$ = 0.01, $P$ = 0.92) and lion ($\chi^2_1$ = 0.8, $P$ = 0.34) attacks on livestock were similar during the day and night (Figure 3). Leopards ($\chi^2_1$ = 0.25, $P$ = 0.62) and lions ($\chi^2_1$ = 0.01, $P$ = 0.92) did not exhibit difference in the number of attacks between the grazing areas and the bomas, whereas most hyena attacks occurred in bomas (Figure 3; $\chi^2_1$ = 42.7, $P$ < 0.001). Seasonally, all carnivores attacked more livestock during the wet than dry season over all 4 years (Figure 4; $P < 0.05$ for each species).

Depredation events differed among villages, with most concentrated in the 2 wards, Emboreet and Selela (Table 1). One third of depredation events occurred in Emboreet and Selela. Notably, these 2 wards contained the most depredation events across years (Figure 4), whether or not livestock were in a boma (Figure 5), and regardless of season (Figure 6).

## Discussion

We found that hyenas, leopards, and lions exhibited different predation behaviors and patterns, with lions depredating larger livestock (cattle and donkeys) compared to hyenas and leopards, which depredated smaller animals (goats, sheep, and calves). Our findings correspond to previous studies in the region (Kissui and Packer 2004, Patterson et al. 2004, Kissui 2008). Differences among predators are most likely due to differences in their size, strength, and behavior. For example, lions are much larger bodied and stronger than hyenas and leopards, and are, thus, able to kill larger prey. In addition, lions typically live and move in larger groups than do hyenas or leopards, and this might also explain why lions are able to take cattle and donkeys more often than do hyenas and leopards.

Hyenas depredated livestock more at night in the bomas than during the day when livestock were in the grazing areas (Figure 3). Attacks by lions and leopards exhibited little difference in terms of time (day or night) and location (boma or field) of their attacks (Figure 3). In the Maasai Steppe, livestock are taken to the grazing areas between 0800 and 1000 hours and returned to the bomas between 1600 and 1700 hours. In the grazing areas, livestock are usually accompanied by 1 to 3 herders, depending on the herd size. Thus, the lower number of hyena depredations during the day may be due to the fact that herders accompany the livestock and deter hyena attacks on livestock. Although bomas offer some protection against carnivore attacks, they are not very strong structures, and, thus, carnivores can either break through the walls or jump over them; alternatively, livestock can break out of the boma in the presence of carnivores (Kissui 2008).

The temporal variability in livestock predation by the 3 predators could partly be explained by the migratory nature of ungulates within the Maasai Steppe ecosystem. Many of the migratory animals spend much of the dry season (June to October) in the national parks, and wet season (November to May) outside the national parks in the game reserves and game controlled areas, which is where the villages are located. Most of the migratory ungulates move to dispersal areas to the northern and eastern sides of the national parks during the wet season and return to the parks during the dry season using similar routes (Figure 2). Thus, increased livestock depredation during the wet season may be a consequence of increased presence of carnivores that follow the ungulate migrations into the dispersal areas in village land. Both lions and hyenas follow the migratory ungulates (Tanzania Lion Project, unpublished data), and it is possible that even leopards could be moving with the ungulate migration, owning to concurrent increase in livestock predation by leopards in the wet season (Kissui 2008).

## Management implications

We recommend several management actions be taken to reduce carnivore attacks on livestock. First, villagers could improve the strength of bomas to prevent carnivores from breaking through or jumping over them. By improving the bomas, predation on livestock could be greatly reduced, especially by hyenas. Second, most of attacks occur during the wet season when ungulates are emigrating from the national parks. Increased vigilance in the wet season can be achieved by having adults, rather than young boys, participate more in livestock grazing. The conflict-prone areas should be avoided by herders during the wet season, thereby reducing encounter rates between predators and livestock. For instance, the spatial locations of attacks can be used as a basis for identifying safe and conflict-prone areas to implement conflict mitigation activities in targeted areas, thus, reducing the cost and improving monitoring and evaluation of intervention. These approaches can reduce human–wildlife conflict and lead to reduced destruction of both livestock and carnivores. One common outcome of predator attacks on livestock is retaliatory killing of predators, such as noted here and elsewhere (Ikanda and Packer 2008, Kissui 2008). As a result, human–carnivore conflicts can lead to agricultural areas becoming ecological traps for predators (Northrup et al. 2012).

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## Literature cited

Cardillo, M., A. Purvis, W. Sechrest, J. L. Gittleman, and G. M. Mace. 2004. Human population density and extinction risk. PLoS Biology 2:909–914.

Goldman, M. J., J. R. Pinho, and J. Perry. 2010. Maintaining complex relations with large cats: Maasai and lions in Kenya and Tanzania. Human Dimensions of Wildlife 15:332–346.

Holmern, T. 2007. Livestock loss caused by predators outside the Serengeti National Park, Tanzania. Biological Conservation 135:518–526.

Ikanda, D., and C. Packer. 2008. Ritual versus retaliatory killing of African lions in the Ngorongoro Conservation Area, Tanzania. Endangered Species Research 6:67–74.

Kissui, B. M. 2008. Livestock predation by lions, leopards, spotted hyenas, and their vulnerability to retaliatory killing in the Maasai Steppe. Animal Conservation 11:422–432.

Kissui, B. M., and C. Packer. 2004. Top-down population regulation of a top predator: lions in the Ngorongoro Crater. Biological Sciences 271:1867–1874.

Madden, F. 2004. Creating coexistence between humans and wildlife: global perspectives on local efforts to address human–wildlife conflict. Human Dimensions of Wildlife 9:247–257.

Messmer, T. A. 2009. Human–wildlife conflict: emerging challenges and opportunities. Human Wildlife Conflicts 3:10–17.

Mills, G., and H. Hofer. 1998. Hyaenas: a status survey and conservation action plan. IUCN/SSC/Hyaena Specialist Group, Gland, Switzerland.

Northrup, J. M., G. B. Stenhouse, and M. S. Boyce. 2012. Agricultural lands as ecological traps for grizzly bears. Animal Conservation 15:369–377.

Nowell, K., and P. Jackson. 1996. Wild cats status survey and conservation action plan. IUCN/SSC/ cat Specialist Group, Gland, Switzerland.

Ogada, M. O., R. Woodroffe, N. O. Oguge, and L. G. Frank. 2003. Limiting depredation by African carnivores: the role of livestock husbandry. Conservation Biology 17:1521–1530.

Packer, C., D. Ikanda, B. M. Kissui, and H. Kushnir. 2005. Lion attacks on humans in Tanzania. Nature 436:927–928.

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

Pratt, D. J., and M. D. Gwynne (editors). 1977. Rangeland management and ecology in East Africa. Hodder and Stoughton, London, United Kingdom.

Prins, H. H. T. 1987. Nature conservation as an integral part of optimal landu in East Africa: the case of Maasai ecosystem in Tanzania. Biological Conservation 40:141–161.

Scheel, C., and C. Packer. 1991. Group hunting behaviour of lions: a search for cooperation. Animal Behaviour 41:697–709.

Shemweta, D. T. K., and J. R. Kidegesho. 2000. Human–wildlife conflict in Tanzania: what research and extension could offer to conflict resolution. Proceedings of the First University-wide conference of Morogoro-Tanzania. Sokoine University of Agriculture, 3, 569–576.

Tanzania Population and Housing Census. 2002. Population census, village statistics. Volume 3. National Bureau of Statistics, Dar Es Salaam, Republic of Tanzania..

Treves, A. 2007. Balancing the needs of people and wildlife: when wildlife damages crops and prey on livestock. Tenure Brief 7.

Treves, A., R. B. Wallace, L. Naughton-Treves, and A. Morales. 2006. Co-managing human–wildlife conflicts: A review. Human Dimensions of Wildlife 11:1–14.

Ukio. 2010. Husbandry practices and mitigation of human–carnivore conflicts: a case of the Maasai Steppe, Tanzania. Thesis, University of Kwazulu Natal, South Africa.Wildlife Conservation Act.1974. Wildlife Conservation Act of Tanzania. Dar Es Salaam, United Republic of Tanzania.

Woodroffe, R. 2000. Predators and people: using human densities to interpret declines of large carnivores. Animal Conservation 3:165–173.

Yihune, M., A. Bekele, and Z. Tefera. 2009. Human–wildlife conflict in and around the Simien Mountains National Park, Ethiopia. Sinet 32:57–64.

**Batistino P. Mponzi** is an assistant lecturer at the Institute of Development Studies, Mzumbe University in Tanzania where he teaches various subjects on environmental and natural resources management issues, including waste management, environmental auditing, environmental management, environmental impact assessment, land-use planing, remote sensing and geographic information systems (GIS). He earned his M.Sc. degree in natural resources and evironmental management, majoring in geospatial data analysis and modelling (remote sensing and GIS) at the University of Hawaii–Manoa in 2011. Currently, he also works as a national consultant to FAO in UNREDD+ project to asses historical land-cover change using LANDSAT images for the whole of Tanzania. Previously, he was an assistant lion researcher for the Tarangire Lion Research Project, studying the movements, dynamics, and demorgraphies of the lions in the Tarangire-Manyara ecosystem.

**Christopher A. Lepczyk** is an associate professor in the School of Forestry and Wildlife Sciences at Auburn University. He was previously an associate professor of ecosystem management in the Department of Natural Resources and Environmental Management and a cooperating faculty member in the Department of Biology and the Program in Ecology, Evolution, and Conservation Biology at the University of Hawaii–Manoa. He received a dual doctorate in fisheries and wildlife, and ecology, evolutionary biology, and behavior from Michigan State University and conducted his post-doctoral research at the University of Wisconsin–Madison. His research focuses on interdisciplinary questions related to people, landscapes, ecosystems, and animals, with a goal of improving conservation, management, and policy.

**Bernard M. Kissui** (photo unavailable) serves as the center director at the SFS-Center for Wildlife Management Studies, Tanzania chapter. He is responsible for administration of center operations including staff, finance and academic program management and planning, and program delivery and evaluation; he oversees the center's five-year research plan. He is also the lead principal investigator of the Tarangire Lion Project. He received his Ph.D. degree in ecology, evolution and behavior at the University of Minnesota, USA, in 2008, and has co-authored several peer-reviewed publications. His research interests include ecology, population dynamics, and conservation and management of wildlife populations in human-dominated landscapes. Most of his research has focused on the African lion, especially on dynamics of large carnivore populations. He has experience in working with local communities on human–lion conflict mitigation.