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Human–Hyena (*Crocuta crocuta*) Conflict in the Tarangire Ecosystem, Tanzania

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Abstract: Interactions between people and large carnivores on shared landscapes can have harmful social and ecological consequences. Human–carnivore coexistence depends on an assemblage of sociological factors including effective management institutions that address the social costs of carnivore conservation and promote tolerance toward wildlife. In East Africa, large carnivores are particularly troublesome for herders who depend on livestock for subsistence and wellbeing. This paper provides an overview of human–hyena conflict in the Tarangire ecosystem of northern Tanzania. It presents descriptive results from a questionnaire survey (n = 1076) administered as part of an anthropological study (2019–2020; 2022; 2023) of human–wildlife interactions across twelve villages inhabited by Maasai agropastoralists. The survey instrument was designed through community-based participatory research methods to convey herder concerns about the impacts of spotted hyenas (*Crocuta crocuta*) on the livestock economy. Based on the perceptions and local ecological knowledge of Maasai interlocutors, the paper provides an overview of the spatial and temporal patterns of human–hyena interactions. Perceived frequencies of hyena attacks on kraaled livestock were unevenly distributed geographically, with those homesteads surrounding Manyara Ranch most heavily affected. Based on herder-reported livestock losses, the costs of depredation by spotted hyenas across the study area were estimated at approximately USD 904.84 per household per year. Most homesteads lacked fortified bomas and would benefit from the provision of lights and fencing materials to improve kraal structures. The paper's central finding is that spotted hyenas represent a pressing, everyday concern for local pastoralists. Unsurprisingly, herders *despise* hyenas and are intolerant of sharing landscapes with them. For carnivore conservation outside protected areas to thrive in Tanzania, conservationists and policy makers must engage more meaningfully with the lived experiences of local herders who bear the brunt of conservation costs on their livelihoods.

Keywords: human–carnivore conflict; human–wildlife conflict; human–wildlife coexistence; human dimensions of wildlife; human dimensions of conservation; local ecological knowledge; environmental anthropology; ecological anthropology; anthropology; East Africa; Tanzania; wildlife conservation; spotted hyena

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1. Introduction

Globally, large carnivore populations are trending downwards [1,2]. A variety of political and economic drivers have led to the intensification of human land uses and fragmentation of large carnivore habitats [3,4]. To address these declines in carnivore populations, conservation policies generally prioritize the establishment of protected areas, within which human activities are tightly regulated or prohibited [5]. In some cases, protected areas have helped carnivore populations recover, but they are limited to relatively small portions of whole ecosystems [6–8]. Large carnivores require connected landscapes to thrive given their sizeable home range requirements, which are necessary for ensuring access to prey [9]. Protected areas also run the risk of marginalizing human dimensions of ecosystems by dispossessing or even physically displacing local human

communities [10–26]. Considering these shortcomings of protected areas, carnivore biologists have come to consider ecological connectivity and the *coexistence* of carnivores and people outside formal protected areas to be of crucial conservation importance [9,27–29]. While there is considerable ecological research on carnivore dynamics on human-dominated landscapes, the human dimensions of coexistence including the social, cultural, political, and economic contexts that frame human–carnivore interactions are less studied, though a growing body of literature has begun to address these factors [9,30].

This paper focuses on human interactions with spotted hyenas (*Crocuta crocuta*) in the Tarangire ecosystem of northern Tanzania. It is based on ethnographic field research (2019–2020; 2022; 2023) that documented human–wildlife interactions across twelve administrative villages to the northeast of Tarangire National Park. Livestock depredation by spotted hyenas in the Tarangire ecosystem is well documented in the regional social–ecological literature on carnivore ecology [31–33]. However, the scale of the issue from the perspectives of local herders has not yet been systematically portrayed using sociological methods. The present study is grounded in the local social–ecological context, though the findings are salient for understanding human–carnivore coexistence more generally. The paper contextualizes hyena behavior toward livestock through the lens of herder perceptions and provides suggestions for managing coexistence in the Tarangire ecosystem.

2. Materials and Methods

2.1. Background on Hyenas

Hyenas are carnivorous mammals (Carnivora order; Feliformia suborder) in the family Hyaenidae. The family includes four distinct species of hyenas: the spotted hyena (*Crocuta crocuta*), the striped hyena (*Hyaena hyaena*), the brown hyena (*Parahyaena brunnea*), and the aardwolf (*Proteles cristata*). The present study focuses on human interactions with spotted hyenas. Spotted hyenas are the only remaining member of the *Crocuta* genus. They are the largest of the four hyena species and are the most ubiquitous large carnivore in Africa [34]. The International Union for Conservation of Nature (IUCN) Red List of vulnerable species classifies spotted hyenas as "Least Concern," though it notes a decreasing population trend [35]. In northern Tanzania, spotted hyenas are widely distributed and fulfill key ecosystem functions like the regulation of herbivore populations through predation and the reduction of disease transmission through consumption of animal carcasses.

Fully grown spotted hyenas are about a meter tall and weigh up to 70 kg (Figure 1). They have heavy forequarters and a strong large heart to facilitate long distance travel and endurance. Spotted hyenas can cover forty kilometers in a single night in pursuit of prey. Unlike striped hyenas, spotted hyenas are apex predators that compete directly with lions. They can take down wild ungulates at speed and can hunt up to 95% of their own prey. Coupled with this, they are highly adaptable and quick to supplement their diets by scavenging. Their jaws are strong, and their stomachs hold concentrated hydrochloric acid, allowing them to eat and digest a wide range of animal products including meat, skin, bones, and waste. Generally, spotted hyenas live for 12–18 years, though some live for up to 25 years.

Spotted hyenas inhabit a variety of habitats ranging from tropical rainforests to open grasslands and human-dominated landscapes. They are remarkably intelligent animals and are the most socially complex of all large carnivore species [34,36]. Spotted hyenas live in clans of 6–90 individuals with distinct but often overlapping territories [37]. These clans are highly structured socially with dominant females holding power at the top the hierarchy, with rank passed down matrilineally [38]. Hyena society is characterized by a fission–fusion dynamic, whereby large social groups break apart into smaller groups to forage before rejoining the main group later [37]. Spotted hyenas often hunt in small parties or as individuals. Unlike lions and other species of large carnivores, hyenas raise their offspring in dens to protect them from other predators [39]. Spotted hyenas reproduce quickly during periods of prey abundance, which often coincide with droughts when carcasses of wild mammals and livestock are plentiful. They generally die off or disperse as

prey becomes less available. As such, spotted hyenas appear to follow a "boom and bust" reproductive cycle.

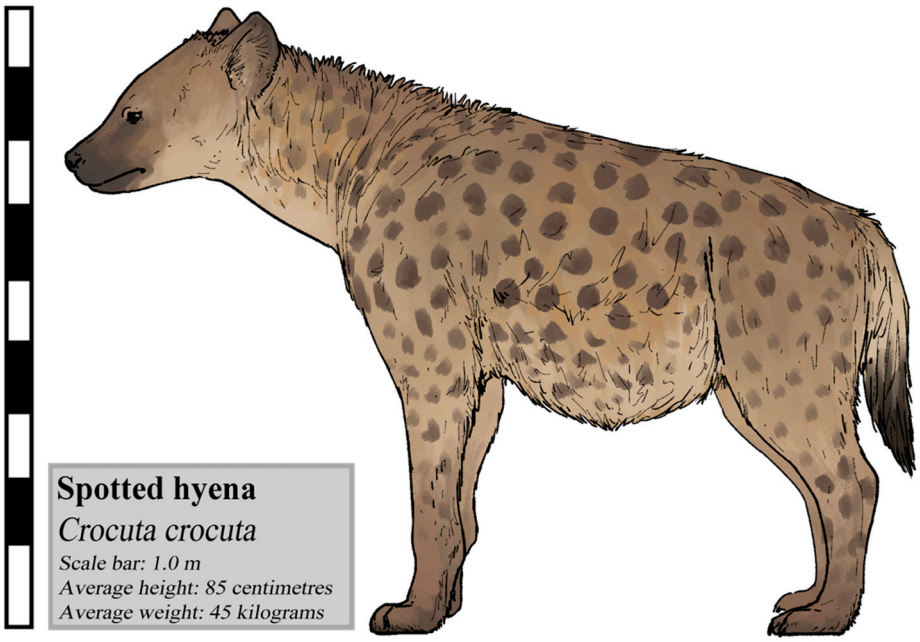

Figure 1. Side profile drawing of spotted hyena (*Crocuta crocuta*) prepared for publication by Connor Ashbridge.

2.2. Social–Ecological Context of Study Area

The Tarangire ecosystem covers approximately 25,000 km^2 of *Acacia* woodlands, savannahs, and *Commiphora* bushlands. It supports some of planet Earth's most diverse and abundant wildlife populations [40–42]. The climate is semi-arid with bimodal rainfall patterns that generally produce alternating long and short dry seasons (June–October and January–February), punctuated by short and long rainy periods (November–December and March–May). The centerpiece of the ecosystem is Tarangire National Park, which hosts a remarkable array of wild species, including a large population of elephants and numerous other species of endangered large mammals [43–51]. The total area of the park, however, is only 2850 km^2, which represents a small portion of the entire ecosystem. Its key ecological feature is the Tarangire River, which serves as the main source of water year-round and provides a vital lifeline for wildlife in the dry season. During the wet seasons, water is dispersed across the ecosystem, and wildlife moves outside the park into adjacent villages. From a conservation standpoint, ensuring the ecological connectivity of movement corridors outside the park is necessary for maintaining healthy wildlife populations. However, from a social point of view, dispersing wildlife brings costs to village communities living near the park in the forms of crop raiding [52], livestock depredation [27,32,33,53], property damage [54,55], and threats to physical safety [56].

Community-based conservation areas outside Tarangire National Park have emerged in recent years as potential strategies for securing wildlife habitats and safeguarding community livelihoods. These include Randilen Wildlife Management Area (WMA) and Manyara Ranch. Randilen WMA is governed through an authorized association of community representatives from eight member villages in collaboration with the Monduli District Government. In accordance with the WMA model, a portion of tourism revenue is distributed to member villages. The African Wildlife Foundation and Monduli District Government oversee Manyara Ranch on behalf of two partner villages via a conservation trust model. These two community-based conservation areas have thus far produced mixed results. Manyara Ranch has dispossessed local herders in the past [57,58], though it has recently shown signs of participatory reform [59]. Ecologically, it hosts high levels of large

mammals on par with national parks [60]. Similarly, Randilen WMA has evoked conflict in the past [61] but has had recent success in garnering community support for conservation through the dedicated efforts of Honeyguide Foundation [59,62]. Recent ecological studies point to rises in wildlife numbers in Randilen as well [63].

Areas to the northeast of Tarangire National Park are inhabited primarily by Arusha Maasai (hereafter Arusha) and Kisongo Maasai (hereafter Kisongo) agropastoralists. Oral accounts from Kisongo elders suggest that they have been present in the Tarangire ecosystem for roughly 200 years, after expanding southwards from Kenya into Tanzania sometime between the 16th and 18th centuries [64,65]. The Kisongo see themselves as "people of cattle" signifying the central role of livestock in their social and economic life. They uphold a pastoral mode of production supplemented by crop production, wage labour, and other business ventures, practiced as forms of diversification in a contemporary context [66–68]. The Kisongo rear cattle, goats, and sheep through a series of customary institutions including an age-set system, a gender-based division of labour, common property arrangements, and enforceable grazing norms. They cultivate mainly maize and beans to supplement their pastoral diet.

The Arusha speak a closely related Maa dialect and follow the same age-set system [69]. The core of their economy, however, is crop cultivation, including maize, beans, peas, and other crops like sunflowers that are grown primarily for commercial sale. The Arusha also greatly value livestock as economic stores of wealth and social capital in Maasai society, though their herd sizes are generally smaller than those of the Kisongo [59]. Oral life histories from Arusha elders suggest that they began settling the area in the 1950s during a period of land scarcity on Mount Meru [70,71]. They leveraged social, cultural, and economic ties with the Kisongo to expand into the areas throughout the late colonial and socialist periods and now enjoy a majority presence in most of the villages in the study area [62].

Twelve villages were selected as field sites given their locations in the central part of the Tarangire ecosystem (Figure 2): Oldonyo, Lolkisale, Nafco, Lengoolwa, Lemooti, Makuyuni, Naitolia, Mswakini Juu, Mswakini Chini, Olasiti, Esilalei, and Oltukai. Other than the Olasiti village, which is part of the Babati district and Manyara region, all the villages are part of the Monduli district and Arusha region. Oltukai and Esilalei are home almost exclusively to Kisongo Maasai; Mswakini, Makuyuni, Naitolia, Mswakini Juu, Mswakini Chini, and Olasiti are settled mostly by Arusha; Lolkisale, Lengoolwa, and Oldonyo are made up of mixed Kisongo and Arusha hamlets; and Lemooti is inhabited only by Kisongo.

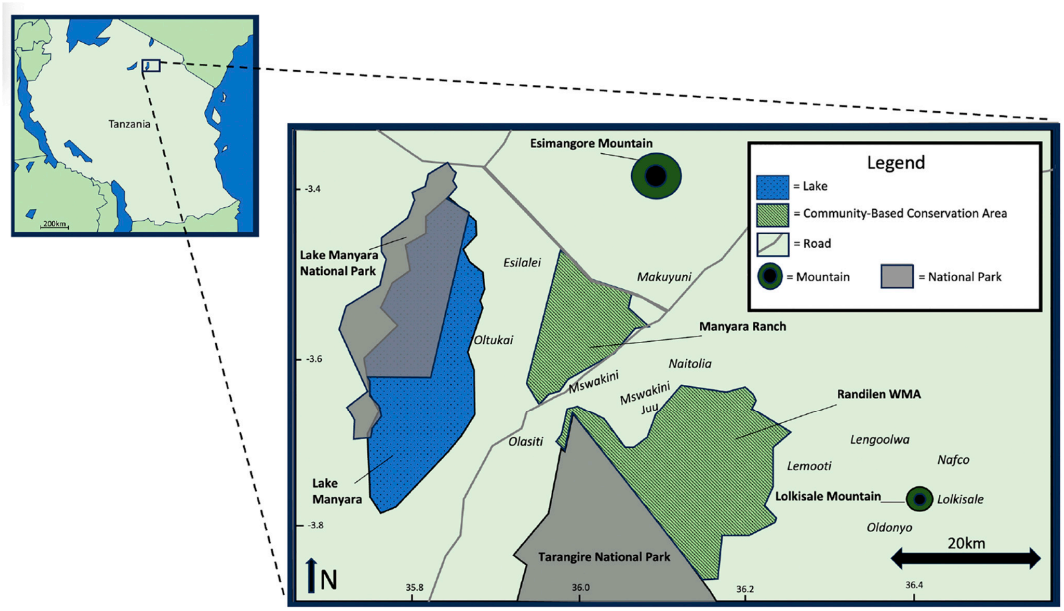

Figure 2. Map of the study area in the Tarangire ecosystem including major protected areas and general locations of villages (Raycraft 2022b:59; Raycraft 2023:3) [56,59].

2.3. Existing Literature on Hyena Dynamics in the Tarangire Ecosystem

Numerous independent ecological surveys have been carried out documenting the abundance and density of large carnivores in the Tarangire ecosystem [72–76]. However, a comprehensive carnivore monitoring program does not exist [43]. As Kiffner et al. (2022:238) write, "it is not presently clear how large each of the carnivore populations [in the Tarangire ecosystem] is in each of the land-use zones and the potential types of competition that are evident" [43]. Generally, ecological methods used to study carnivore populations in the ecosystem include individually identifying lions [77], systematic camera trapping [78], spoor surveys [79], and transect counts of herbivores that lead to carnivore sightings [60]. There is also a body of literature on local people's perceptions of large carnivores across village communities in the Tarangire ecosystem [31,33,52]. Recent studies suggest that the local ecological knowledge of pastoralists in East Africa may provide a fairly accurate representation of carnivore populations that can be used to triangulate ecological studies of carnivore abundance and density [80,81].

Kiffner et al. (2022) synthesize the existing literature to estimate the relative abundance and distribution of carnivores across the Tarangire ecosystem [43]. Of the four extant hyena species in the family Hyaenidae, only the striped and spotted hyena are found in the area. Little is known about the geographic distribution and behavior of the striped hyena [29,43], and some researchers have suggested that local pastoralists may not differentiate between striped and spotted hyenas (*Fisi* in kiSwahili; *Olng'ojine* in Maa) [82]. However, only one striped hyena was seen during the period of my field research—a carcass on the A104 highway adjacent to Manyara Ranch. Spotted hyenas were identified nightly across the study area, and local herders seemed to distinguish them from striped hyenas based on the bulkier bodies of spotted hyenas. Striped hyenas are mainly elusive scavengers [43] that do not seem to have a significant impact on the livestock economy.

As Kiffner et al. (2022) point out, spotted hyenas are abundant across the landscape and have the highest densities of all large carnivore species (lions, leopards, and cheetahs) [43]. While other large carnivores only seem to use human-dominated landscapes sporadically, spotted hyenas may permanently occupy village lands. Furthermore, whereas the population persistence of wild dogs, lions, and cheetahs in the Tarangire ecosystem are dependent on the frequency of retaliatory killings by herders and the presence of wild prey, spotted hyenas populations may not be constrained by the same factors. Carnivore biologists generally agree that prey density determines large carnivore carrying capacity [43,83,84]. However, the role of domestic livestock in supplementing carnivore diets has not been effectively quantified. This is especially significant for spotted hyenas, which kill more livestock than any other carnivore species in the Tarangire ecosystem by far, findings that have been replicated consistently across decades [29,32,85,86]. Studies of hyena diel activity patterns in Lake Manyara National Park reveal that they are almost entirely nocturnal [43]. This is in stark contrast to spotted hyenas in the Ngorongoro-Serengeti ecosystem, which are regularly active during the day [87]. These differences may be explained as a learned adaptation to avoid human interactions, as nocturnal species behavior is often positively correlated with human disturbances [39,88]. Unlike other large carnivores in the Tarangire ecosystem—like lions—hyena occupancy of village areas near Tarangire National Park seems to be *positively* correlated with human population density [43,79]. Thus, spotted hyenas seem to be able to thrive on village land in the Tarangire ecosystem, unlike other large carnivore species.

2.4. Data Collection and Analysis

Ethical reviews for research with human subjects were carried out by McGill University (REB File #: 479-0419) and the University of Lethbridge through the University of Alberta (Pro00130079; Pro00136507). The permit for conducting research in Tanzania was issued by the Tanzania Commission for Science and Technology (COSTECH) (Permit No. 2019-426-NA-2019-299), and further clearance letters were provided by regional, district, and local government offices.

Sixteen months of ethnographic fieldwork (June 2019–July 2020; June–July 2022; April–May 2023) provide the backdrop of this article. Twelve months of continuous fieldwork is considered the minimum standard in ethnographic field research at the doctoral level, and this was supplemented by two follow-up periods of two months coinciding with university semester breaks. Multi-sited field research was carried out across the twelve study villages in 2019–2020 with attention to human–wildlife interactions and community attitudes toward wildlife and conservation. During this period, people regularly expressed concerns about spotted hyenas, which seemed to visit people's bomas (homesteads) on a nightly basis to attack kraaled goats and sheep. Through a community-based, participatory research (CBPR) approach, local pastoralists and I designed a survey instrument to assess the generalizability of people's experiences with spotted hyenas across the entire study area for the purposes of communicating the scale of human–hyena conflict to conservationists and wildlife authorities. CBPR considers community members as equal partners in the design, implementation, and analysis of research to ensure that research is geared toward addressing issues of pressing social concern. Survey data were collected during the period of 2019–2020 and contextualized through ongoing participant observation in 2022 and 2023. Participant observation is a method in sociocultural anthropology involving emplaced fieldwork, ethnographic immersion, and observations of everyday life. While this study focused only on people's perceptions of human–hyena interactions, future studies could triangulate these findings with ecological variations in prey availability during the study periods, which may have affected hyena densities during this time.

Detailed descriptions of household structure and sampling procedures have been published elsewhere [56,62]. In the Maasai cultural context, one married man and multiple wives constitute a single household. Lists of all household heads across the study villages were prepared by hand, and two sampling frames were established: Male-headed households and female-headed households. Since male household heads outnumbered female household heads by a ratio of more than 5:1, a third sampling frame was established to reduce gender bias (females in male-headed households). Accordingly, the second wife of every husband surveyed was recruited for participation to even out gender discrepancies. Wives and husbands were surveyed separately to mitigate domestic power imbalances. Once the total numbers of household heads across the study area had been ascertained, Cochran's sample size formula was used assuming a 95% confidence interval and 5% margin of error to determine total sample sizes of male heads and female heads needed for the survey to be representative. Stratified random sampling was used to recruit survey respondents. Lists of household heads in each sub-village were numbered, and a proportionate number from each sub-village relative to the total population size was selected via a random number generator until the quota was reached. The town sub-villages of Makuyuni (Makuyuni Mjini) and Olasiti (Kibaoni A) were excluded from this survey since many residents were temporary migrants who did not keep livestock locally. The proportions were not exact, but recruitment numbers from each village were fairly representative of differences in population sizes across villages. In total, the survey was administered to 1076 people (547 male heads; 270 of female heads; and 259 females in male-headed households).

The survey instrument included a range of demographic profile questions, the results of which have already been published [59,62]. The remainder of the survey addressed topics related to the human–hyena conflict. The questions were close-ended, and responses were structured as adapted five-point Likert scales, four-point scales, yes or no binaries, three-point categorical options, and continuous numbers. Specifically, the survey assessed people's attitudes towards spotted hyenas (1–5 scale), the perceived importance of hyena conservation (yes or no), perceptions of benefits from hyenas (3-point scale), tolerance toward hyenas (3-point scale), perceived frequencies of hyena visits to bomas and attacks on livestock (5-point scales), perceived temporal distributions of hyena attacks by time of day and season (3-point scale), perceived spatial distributions of hyena attacks on livestock (3-point scale), perceived differences in hyena stock preference (3-point scale),

perceived changes in hyena population size and attack frequency over the past five years (5-point scale), views on potential conflict management strategies (yes or no), and numbers of livestock killed by hyenas over the past twelve months (continuous). Attitudes toward hyenas were defined in terms of the extent to which respondents liked or disliked hyenas. Tolerance was operationalized as people's willingness to share landscapes with hyenas without needing significant management interventions like population culling.

Response frequencies were calculated using SPSS Version 27 and organized thematically as part of a process of descriptive data analysis. The objective of data analysis was to provide a generalizable overview of human interactions with spotted hyenas across the entire study area. Surveys were completed at the participants' homesteads, and handheld GPS devices were used to record GPS coordinates. QGIS 3.28 software was used to map perceived frequencies of hyena attacks on kraaled livestock at homesteads on a five-point scale ranging from 'never' to 'every night'. The result is a map of human–hyena conflict hotspots based on the perceptions and local ecological knowledge of Maasai pastoralists.

3. Results

3.1. Pastoralist Perceptions of Hyena Attack Patterns

While carrying out participant observation in the villages surrounding Manyara Ranch (Oltukai, Esilalei, Makuyuni, Olasiti, Mswakini Chini, Mswakini Juu, and Naitolia), I was alarmed by the frequency of spotted hyena attacks on kraaled livestock at people's bomas—hyenas seemed to attack livestock every night. During discussions with herders, people lamented that hyenas were an everyday concern. To assess the representativeness of these personal observations and conversations, I asked survey respondents across the study villages to estimate the frequency of hyena visits to their bomas and the frequency of livestock attacks. More than half of the survey respondents (54%; n = 584) felt that hyenas visited their boma on a nightly basis. This result made clear the scale of the issue: the majority of households across the study area had become accustomed to nightly hyena attacks. Mapping these perceptions through GIS software revealed an uneven spatial distribution of conflict hotspots, with homesteads around Manyara Ranch reporting the most frequent attacks (Figure 3).

Significantly, when asked about the perceived attack frequency of hyenas on livestock, people's responses were lower but still concerningly high: 28% (n = 296) felt that hyenas attacked on a nightly basis, 16% (n = 170) reported that hyenas attacked a few times a week, 16% (n = 171) also reported having a few attacks per month, while 30% (n = 332) reported several attacks each year. Only 1% (n = 103) of respondents noted no hyena attacks on livestock. These findings point to the sheer scale of this issue in the Tarangire ecosystem. People perceive hyena attacks on their livestock to be frequent, everyday occurrences.

Just over two-thirds of the respondents (69%; n = 737) felt that hyenas attacked livestock more at night, and about the same number of respondents (69%; n = 744) felt that hyenas attacked their livestock more at the boma than while out grazing. When asked about whether hyenas attacked more in the wet season or dry season, 62% (n = 660) felt that there was no difference by season, though 36% (n = 382) reported more attacks during the wet season. About 60% (n = 639) of respondents suggested that hyenas attacked small stock more than large stock, a finding that aligns with previous studies [29]. Most survey respondents (90%) (n = 966) felt that hyenas were increasing in numbers over the past five years, and 88% (n = 947) reported that hyena attacks on livestock had been increasing over this period.

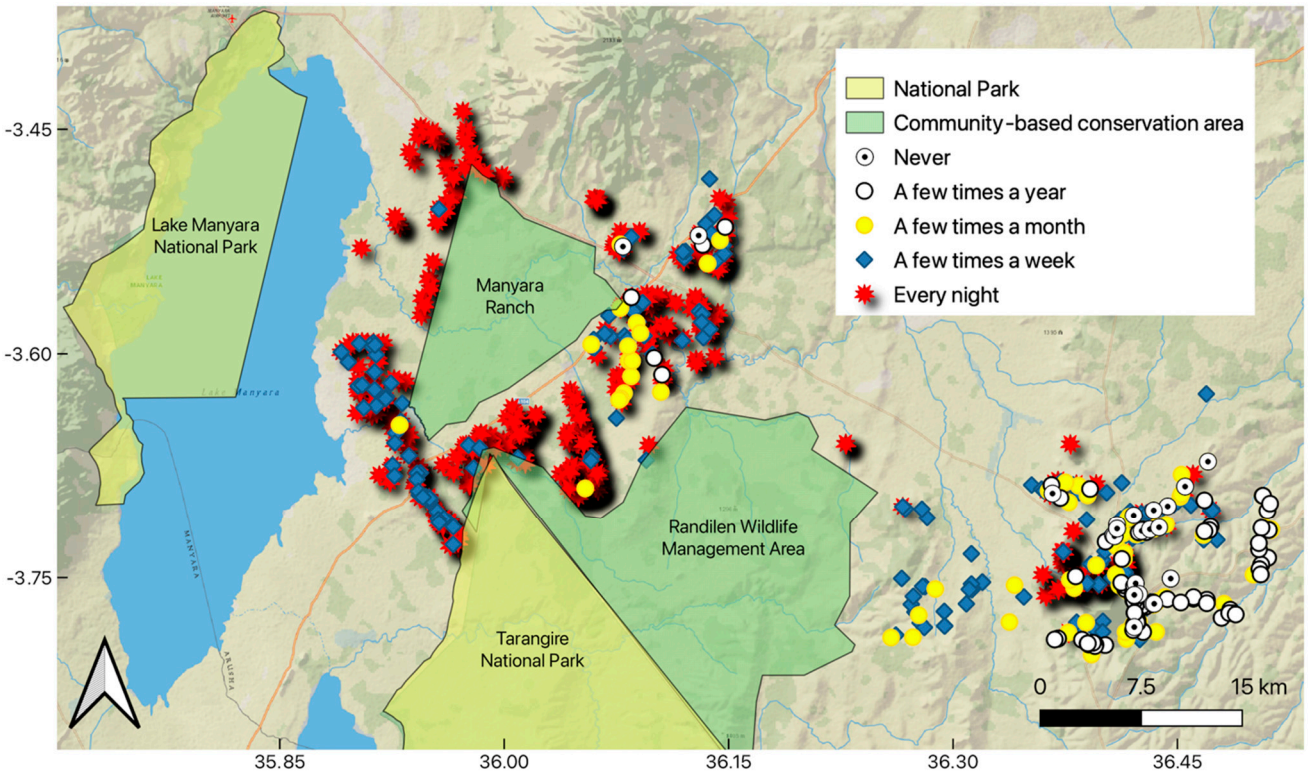

Figure 3. Conflict map of perceived frequency of attempted spotted hyena attacks on kraaled livestock based on household surveys administered in 2019–2020 across twelve villages in the Tarangire ecosystem (n = 1076). GPS points represent homesteads. The majority of homesteads around Manyara Ranch reported nightly attacks from hyenas, while the Lolkisale-side villages reported more variable frequencies. Further research into the social–ecological factors affecting hyena attack frequency on the Lolkisale side of Randilen WMA is needed. Basemap sources: National Geographic, Esri. Protected area shapefiles provided by Monduli District Government. Map produced in QGIS-LTR by author using GPS locations gathered during household surveys.

3.2. Economic Impacts of Spotted Hyenas

Herder perceptions reveal a snapshot measure of the costs of spotted hyenas on the livestock economy. Table 1 summarizes the reported livestock losses from hyenas over the twelve months preceding survey administration (2019–2020). As mentioned in Section 2.4, survey respondents were asked to report how many cows, sheep, goats, donkeys, and chickens were killed by spotted hyenas during the past twelve months preceding data collection. Sheep and goats were grouped together, since they are kept together in the same herds, and pastoralists do not count them separately. People's reported losses were not confirmed independently and should be taken with a grain of salt, as individuals may have felt motivated to exaggerate reported livestock losses with the hope of receiving compensation. However, it was communicated to respondents that this survey was for research purposes only.

The survey results provide a general sense of the economic scale of the issue. In total, people reported that 1842 cattle, 8381 sheep/goats, 691 donkeys, and 356 chickens were killed by spotted hyenas over the past twelve months (2019–2020). Since male household heads and wives shared the same herds, these totals are inflated, and per household figures provide a more accurate measure. Rounded to the nearest one, per household losses break down to an average of two cows, eight goats/sheep, one donkey, and zero chickens per survey respondent over a 12-month period, numbers that are in line with my personal observations of hyena attacks in the study villages. Assuming USD 300 per head of cattle, USD 40 for a sheep/goat, USD 120 for a donkey, and USD 8 for a chicken, hyena depredation over the study period amounted to about USD 904.84 per year in losses at the

household level from spotted hyena depredation. For pastoralists with an average annual income of less than USD 1500, these economic costs are very significant.

Table 1. Reported livestock and poultry losses from spotted hyena depredation over a twelve-month period.

	Cattle	Sheep/Goat	Donkeys	Chickens
Reported number of losses	1842	8381	691	356
Approximate number of losses per household	2	8	1	0
Approximate losses in USD per household	$514	$312	$77	$3

3.3. Preventative Measures

Pastoralists in the Tarangire ecosystem have limited infrastructure and capacity to manage the economic impacts of livestock depredation by hyenas. Current strategies for preventing attacks include the implementation of wire fencing around homesteads and livestock enclosures, and vigilantly guarding bomas at night. Importantly, boma structures in the study area represent permanent settlements and not seasonal, nomadic homesteads. Most people, however, could not afford additional fencing materials to improve security. Only around 1% (n = 143) of survey respondents had high-quality fortified inner livestock kraals in their bomas. Less than 1% (n = 83) had complete but unfortified bomas assembled from good-quality wood and bush materials. About 45% (n = 486) of respondents had medium-quality bush fences, and a small minority (3%; n = 283) had very low-quality fences made from sparsely assembled bushes. About 1% (n = 79) had totally porous inner fences. These findings suggest that despite the admirable efforts from local organizations like the Tarangire Lion Project and Tanzania People and Wildlife to provide local pastoralists with materials for building fortified bomas, much more work is needed in this regard. Just under half (47%; n = 501) of the survey respondents had no solar-powered lights outside their bomas. Thus, despite being mentioned by local herders during interviews as important ways to reduce the impacts of hyenas, most households still lack quality kraal fencing and lights. This seems to be an area where conservation and development interventions could have a positive impact, especially considering the promising results that predator-proofed bomas have been shown to produce [27,53,86,89].

3.4. Herder Attitudes and Tolerance

Unsurprisingly, people across the twelve study villages were extremely intolerant of spotted hyenas. Attitudes did not vary noticeably across genders, likely due to intra-household economic dependence on livestock. In terms of people's general attitudes toward the animals, 67% (n = 713) of survey respondents strongly disliked hyenas, and 13% (n = 134) disliked them. When asked if they thought hyena conservation was important, 81% (n = 867) of respondents said that it was not important. The majority of respondents (83%; n = 893) felt that hyenas only brought costs to people and did not have any benefits. As a measure of tolerance and willingness to coexist with spotted hyenas, people were asked whether they were happy living with hyenas, whether they were okay living with them as long as they did not attack their livestock, or whether they wanted hyenas to be eliminated. Only five people out of 1076 (.5%) said that they were happy coexisting with spotted hyenas. Around 37% (n = 394) were willing to coexist with the animals if hyenas did not attack their livestock, and 63% (n = 672) wanted hyenas completely eradicated.

Almost all respondents (89%; n = 957) felt that there were too many spotted hyenas around, and three-quarters (75%; n = 804) felt that the government should cull the spotted hyena population. When asked if people felt they should be allowed to kill hyenas to defend their livestock, 69% (n = 735) felt that they should be allowed to kill hyenas as needed to protect their herds.

4. Discussion

The use of sociological methods to engage with the perceptions of Maasai pastoralists reveals that spotted hyenas are frequent, everyday occurrences to the northeast of Tarangire National Park. While herders reported that hyenas sometimes attack grazing cattle, they mainly target kraaled small stock at night. Attacks on sheep/goats varied geographically, with homesteads around Manyara Ranch affected most heavily. Ecological research addressing the social and environmental factors driving patterns of livestock depredation on village land is greatly needed to triangulate the data presented here on pastoralist perceptions.

Frequent interactions with spotted hyenas engender significant socioeconomic consequences for local pastoralists in the form of livestock losses. Spotted hyenas also sometimes attack people, resulting in injuries and even deaths, though these are infrequent occurrences overall [56]. Though previous studies of carnivore dynamics in the Tarangire ecosystem have noted the high livestock depredation costs of spotted hyenas relative to other large carnivores, dedicated studies of hyena behavioral dynamics in the Tarangire ecosystem are still lacking. Existing studies of human perceptions reveal that hyenas are indeed detected on village land with far greater frequency than other large carnivores. Koziarski et al. (2016), for instance, found that people living in the Tarangire ecosystem were roughly ten times more likely to encounter hyenas than other carnivore species [31]. Some scholars have attributed these trends to the fact that hyenas are more vocal during the night and thus easier to detect [43]. This is a possible contributing factor, but the present study demonstrates that people detect them more because they frequently visit bomas and attack livestock on village land—the majority of survey respondents considered these to be everyday occurrences, reports that were triangulated through participant observation and sixteen months of emplaced fieldwork across the study villages.

Human–carnivore coexistence is a two-way street, and pastoralists often affect carnivore conservation outcomes through retaliatory killings. Since spotted hyenas mainly attack sheep/goats, and Kisongo Maasai do not value small stock as much as large stock, some researchers have suggested that hyenas seem to be less affected than other large carnivores by retaliatory killings [43,85,86]. While lions kill far fewer livestock than hyenas, Kissui (2008) documented that they are disproportionately persecuted by herders in retaliation, perhaps because they target grazing cattle more than hyenas do [85]. Another explanation seems to be that hyenas do not actively defend their kills as lions do, and are quick to flee and get out of range of spears and arrows [86]. Since most hyena depredation events occur at night, it is also often more challenging for people to kill hyenas given reduced visibility and the elusiveness of the attacks. Maasai do occasionally poison a carcass to leave out for hyenas [85], and it is worth noting that my ethnographic observations over the study period made clear that people do kill hyenas regularly to defend their stock (Figure 4). They do not, however, generally track down hyenas in response to depredation events in the same way that they do for lions, likely because lion kills generate more social capital for young warriors.

Given the paucity of demographic data on spotted hyenas in the Tarangire ecosystem, it is difficult to deduce how these responses from people affect hyena populations. Without baseline studies and long-term monitoring programs, it is currently unknown how human responses to livestock depredation affect hyena population dynamics in the long term [43]. As Kiffner et al. (2022) note, future research on the prey preferences and foraging strategies of spotted hyenas in the Tarangire ecosystem would generate valuable and needed knowledge in this ecological context [43]. It is currently unknown whether spotted hyenas have a source population in the core protected areas in the ecosystem and move into the villages at night or whether they live mostly in human-dominated areas. Local Maasai pastoralists suspect, as do I, that spotted hyenas in the Tarangire ecosystem have adapted to prey largely on sheep/goats and den almost exclusively in or near Maasai villages. This, however, is difficult to ascertain without carnivore monitoring data, especially since hyenas can traverse long distances each night in search of prey.

Figure 4. Photos of spotted hyena carcasses sent to author by an interlocutor from one of the study villages (names covered to maintain anonymity). The photo was sent with the explanation that spotted hyenas killed 12 sheep on 20 May 2023, and local Kisongo herders responded by killing four hyenas and injuring a few others.

Though perhaps not reliable as a standalone measure of hyena demographics, the fact that 90% (n = 966) of survey respondents felt that hyena numbers were increasing over the past five years merits further attention. This finding speaks to people's subjective experiences of hyena attacks becoming increasingly problematic for local livestock keepers, a sentiment that is valid in its own right. From an ecological point of view, it also points to the need for further research on spotted hyena abundance, density, and distribution in the Tarangire ecosystem. While a comprehensive research study in the Ngorongoro–Serengeti ecosystem is currently ongoing, spotted hyenas in the Tarangire ecosystem are understudied. The closest comparable project is the Tarangire Lion Project, which focuses mainly on lions but also attends to the full carnivore guild inside Tarangire National Park and on village lands. However, systematic studies exclusively focusing on hyena behavioral ecology outside Tarangire National Park are lacking (Kissui personal comm. 2020) [78]. Personal observations of spotted hyenas inside and around Tarangire National Park, and engagement with the local ecological knowledge of Maasai pastoralists living in villages to the northeast of the park, suggest that spotted hyenas may subsist primarily on small stock outside the park, rather than hunting inside. However, this suggestion would need to be explored through ecological research using camera traps, carnivore collaring, or e-DNA fecal sample and bone analysis at dens. For now, it could be taken as a hypothesis for further ecological investigation.

Assessment of the economic costs of livestock depredation by spotted hyenas revealed an area of major concern for the material wellbeing of local herders. As mentioned in the results section, it is certainly possible that reported livestock losses were exaggerated with the hopes of increasing people's chances of receiving compensation. More precise measures of exact livestock losses by large carnivores in the Tarangire ecosystem were generated systematically by Kissui et al. (2022) by tracking officially confirmed depredation events [29]. Nonetheless, reported livestock losses reveal herders' subjective interpretations of the scale of the issue in terms of their lived experiences. While perhaps not a precise reflection of actual livestock losses, higher numbers clearly signify an attempt to communicate a more significant issue, thus conveying qualitative significance. An important element of people's concerns about hyenas is that herders feel ill-equipped to reduce hyena impacts on the livestock economy. Most respondents had inadequate fencing and lighting to deter hyena attacks. Herders are forced to rely on vigilant guarding at night, though they are technically prohibited from killing hyenas to defend their stock. These constraints make it difficult to mitigate the costs of hyenas on a consistent basis.

The result of these socioeconomic impacts is that local pastoralists *despise* spotted hyenas and most would like to see them completely eradicated. This finding reinforces previous studies, like Bencin et al.'s (2016), which reported that local communities in the Tarangire ecosystem wanted the populations of spotted hyenas to be reduced [52]. The strikingly low levels of tolerance documented in this study are understandable and justified given the high costs that herders incur from hyenas and the lack of benefits they receive from them. One strategy proposed in the regional literature to improve tolerance towards large carnivores is to ensure that the benefits of carnivore conservation are equitably distributed to local communities. As Kiffner et al. (2022:11) contend, the conservation of large carnivore populations in the Tarangire ecosystem depends "on changing local attitudes, which could be facilitated by ensuring that local people accrue tangible and intangible benefits from the presence of large carnivores" [43]. Indeed, existing research demonstrates that direct economic benefits from carnivores may be less significant factors for determining local tolerance toward carnivores than intangible benefits [90]. However, my ethnographic research in the Tarangire ecosystem has revealed that local Maasai herders are primarily concerned with reducing the rampant *costs* of spotted hyenas, rather than the reception of benefits from them.

The significant economic costs of spotted hyenas necessitate improved management interventions. Herders consistently suggested subsidized wire fencing and high-luminosity motion sensor lights. Indeed, the provision of fortified boma structures has proven successful in reducing livestock depredation by spotted hyenas, efforts that have been led by local NGOs like Tanzania People and Wildlife and carnivore research programs like the Tarangire Lion Project [89]. However, given the scale of this issue, herders need further support to offset the significant losses they incur from livestock depredation.

The take-home message of this study is clear: spotted hyenas are a *major* problem for Maasai communities living in the Tarangire ecosystem. The lack of dedicated attention to this issue from government officials, policy makers, and wildlife practitioners has led to the erosion of local tolerance toward hyenas, undermining the prospects of human–carnivore coexistence. Further research on the demographics and foraging patterns of hyenas on village land is needed to contextualize the perceptions and lived experiences of local herders. Despite being largely overlooked by conservationists interested in the charismatic carnivore species coveted by the safari industry, spotted hyenas remain the most troublesome carnivore species for pastoralists living to the northeast of Tarangire National Park. Addressing human–hyena conflict in this area through collaborative participatory strategies spearheaded by local herders would go a long way toward building community-level trust in wildlife authorities, appreciation for conservation, and tolerance toward wildlife. It would also help promote human–carnivore coexistence to the benefit of wildlife and biodiversity.

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