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Evaluation of the social-economic impacts of hyena attacks on humans and livestock in the Nyang'whale district of Tanzania

Noela Samwel Hello^{1*}, Rosemary Peter Mramba¹ and Doreen Jeremiah Mrimi¹

Abstract

Background The spotted hyena (*Crocuta crocuta*) is one of the carnivore species that frequently comes into conflict with humans. These conflicts are attributed to their scavenging foraging behaviour and their ability to occupy habitats close to human settlements. In Tanzania, the Geita region has recently experienced an increase in livestock and human attacks by hyenas. However, there are limited studies examining the extent of these attacks and the associated social-economic impacts. Thus, this study evaluated the social impacts and economic losses due to spotted hyena attacks in the Nyang'whale district in the Geita region.

Materials and methods The study was carried out in three villages in the Nyang'whale district, namely Wavu, which is close to the Mienze Forest Reserve; Bukungu, which is far from the forest but surrounded by many hills; and Izunya, which is far from the forest and the hills. Data collection was done through household surveys, focus group discussions, and key informant interviews. A Chi-square test assessed the association between hyena fear and daily activities across villages. Poisson regression compared the number of livestock attacked by hyenas by village and species. Linear regression analysis compared financial losses due to livestock attacks and reductions in working time due to hyena fear across villages.

Results There was a significant variation in the frequency of livestock and human attacks between the villages. The frequency of livestock attacks was lower in Bukungu village, but human attacks were highest in this village. The Wavu village, which is close to the forest, had the highest livestock number and attacks, but no human attacks were reported. The hyena attacks had created fear, which had changed the daily routines of the villagers. The village with the most human attacks reported a high rate of school dropouts, while the one with the most livestock attacks reported a reduction in sleeping time at night to watch livestock. Economic losses due to livestock attacks averaged \$300.5 per household per year, while losses due to reduced working time were equivalent to \$285.6 per household per year.

Conclusion Given that villages with a large number of livestock experienced more livestock attacks and fewer human attacks, this suggests that hyenas may target humans when their food resources are limited. Therefore, conducting further studies to assess the hyena population and the availability of their natural prey is crucial for formulating effective intervention strategies. Additionally, villagers should be educated on ways to control human and livestock attacks based on the animals' ecology and behaviour.

Keywords Human-wildlife conflicts, Socioeconomic impacts, Spotted hyena, Livestock

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Background information

Throughout history, human interactions with wildlife have shaped societies and the natural environment [1, 2]. In ancient times, humans relied on hunting and gathering for survival, which brought them into direct contact with wildlife [3, 4]. However, as agriculture developed, humans began to cultivate crops and raise livestock, leading to increased conflict with wildlife that preyed on crops or livestock [5, 6]. With time, human settlements expanded into wildlife habitats due to population growth, increasing the frequency of conflicts. These conflicts have had significant impacts on both human communities and wildlife populations, leading to economic losses, damage to property, and sometimes loss of human and animal life [7–9]. Today, human-wildlife conflicts continue to be a major challenge in many parts of the world, exacerbated by factors such as habitat loss, climate change, and human encroachment into wildlife habitats [10–13].

Although human-wildlife conflicts are a global issue, their prevalence is higher in developing countries, where communities often depend heavily on agriculture and natural resources for their livelihoods [14, 15]. These conflicts arise due to competition between humans and wildlife for resources such as pasture, water, crops, and livestock. The spotted hyena (*Crocuta crocuta*) is one of the carnivores involved in extensive conflicts with humans in areas where they coexist in Africa, Asia, and parts of the Middle East [16–19]. In Africa, conflicts between humans and hyenas are common, especially in countries like Kenya, Tanzania, Ethiopia, Botswana, and South Africa, where hyena populations thrive in a variety of habitats, including savannas, grasslands, and semi-arid regions [20–22].

The encounters between hyenas and humans are increased by their scavenging feeding behaviour in human settlements, predation of livestock, and adaptability to diverse habitats [23–25]. The socioeconomic impacts of human-hyena conflicts vary in extent and magnitude depending on the geographical locations and economies of the countries involved [7, 9]. In developing countries, livestock graze near protected areas during the dry season when food resources are scarce [26–28]. At night, livestock are kept in poor enclosures, increasing the risk of depredation by hyenas due to their nocturnal behaviour [29–31]. Further, livestock vulnerability to hyena attacks varies between species due to differences in body size and behaviour, as well as between age groups [32, 33]. Similarly, some groups in the human population may also be vulnerable to hyena attacks, such as children, elderly individuals, and women [34, 35].

As with other nations in Africa, Tanzania is experiencing an increase in hyena attacks targeting both livestock and humans [31, 36, 37]. Economic losses due to livestock

death have been shown in various part of the country [35, 38–40], but the studies did not consider losses due to reduced working time, hospital bills for injured people, and reduced manpower. Hyenas may also have social impacts on overall life, such as a reduction in sleeping time at night to watch livestock, a reduction in evening gatherings, and school dropouts due to fear [9, 41].

Compensation for damages caused by wildlife is a widely implemented strategy worldwide aimed at alleviating the financial burdens faced by individuals affected by wildlife activities, including crop destruction, livestock predation, injuries, and death [42–44]. By providing financial support or resources, these compensation schemes seek to foster coexistence between humans and wildlife, ultimately promoting conservation efforts while addressing the needs of local communities [45]. However, in developing countries, compensation programs are often underdeveloped or entirely absent [10]. Tanzanian government does not provide compensation for wildlife conflict; rather, financial support is offered as a consolation to individuals impacted by wild animals [46–48]. Currently, the government pays about 714 USD in consolation for an individual who has lost life, 375 USD for an individual who has suffered permanent disability, and 107 USD for temporary injuries [49]. Consolation payments for crop damage and livestock loss due to wildlife attacks vary based on the distance from protected areas and livestock species involved, with payments ranging from 5.3 USD to 53.5 USD [49]. However, the consolation is often criticised as insufficient compared to the actual losses, covering less than 20% of the actual loss [48, 50]. This creates an economic burden for farmers who have lost livestock and sustained injuries.

Although hyena attacks occur in various parts of Tanzania, there are differences between these areas in terms of landscape, people's lives, and behaviour, which should be understood before formulating interventions to address area-specific challenges. Hyena conflicts are common in pastoral and agro-pastoral communities because these communities typically live in areas that overlap with wildlife habitats, especially near conservation areas, where resources such as water and grazing land are shared between humans and wildlife [51–53]. Pastoral systems rely on livestock rearing and long-distance grazing to adapt to changing rainfall, while agro-pastoral systems combine crop farming with livestock rearing and may involve some extent of mobility to optimize grassland use [52, 54, 55].

Nyang'whale district is one of the areas in the Geita region with extensive human-hyena conflicts, as is frequently reported by local news outlets. The Geita region is situated in a zone of extensive protected areas, including Rubondo Island National Park, Maswa Game

Reserve, and Kigosi National Park, which provide suitable habitats for hyenas. The district consists of undulating hills, which, together with the Mienze Forest Reserve, serve as immediate sources of spotted hyenas. The local communities in the Nyang'whale district are agro-pastoralists, and they rely on farming and livestock rearing for their livelihood [35, 56]. This dual dependence on agriculture and animal husbandry increases the community's vulnerability to economic losses from hyena attacks. However, few studies have investigated the reasons behind the increase in human and livestock attacks in the district. A study by Cyprian [35] documented incidents of livestock and human attacks in the Geita region, but it did not explore the full extent of economic losses and social impacts. The current frequency of the attacks underscores the need for detailed investigations into the economic losses and social impacts to inform immediate action. Therefore, this study aimed to (i) determine the social impacts of spotted hyena attacks and (ii) quantify the economic losses resulting from attacks on livestock and humans by spotted hyenas.

Material and methods

Study area

This study was conducted in the Nyang'whale district, located south of Lake Victoria, which is between 32° and 39° east and between 3° and 12° south of the equator [57]. Nyang'whale is one of the five administrative districts within the Geita region in north-western Tanzania (Fig. 1). The district has a land area of 1,450 km.² and

a population of 225,803 people as per the 2022 census [58]. The district experiences a tropical climate with an average annual temperature of 22 °C and rainfall ranging between 900 and 1200 mm. Rainfall in the region is fairly consistent throughout the year, with short rains typically occurring from September to December. This is followed by a dry period from January to February, after which long and heavy rains generally commence in March and last until the end of May [56]

The vegetation of Nyang'whale district consists of riverine forests, riverine thickets, open woodland, and floodplain grassland [59]. The Mienze forest and undulating land with hills and mountains provide suitable habitats for hyenas. The vegetation of the Mienze forest consists of savanna grasslands and shrublands, Miombo woodlands, and thickets (Minkoff 2019). The dominant plant species in the forest include bloodwood (*Pterocarpus angolensis*), African black wood (*Dalbergia melanoxylon*), *Mikania cordata*, *Combretum molle*, *Bersama abyssinica*, *Acalypha ornate*, *Acacia brevispica*, *Acacia tortilis*, *Acacia tanganyikensis*, *Acacia senegal*, *Acacia mellifera*, *Acacia kirkii*, *Acacia seyalvar*, *Acacia Drepanolobium*, *Acacia sieberiana*, *Acacia polyacantha*, *Bidens pilosa*, *Anthocleista grandiflora*, *Pistia stratiotes*, and *Corchorus aestuans* [60, 61]. Although there is no scientific report on wild animals in the Mienze Forest Reserve, some participants in the study noted that signs and sightings of animals such as impala (*Aepyceros melampus*), warthog (*Phacochoerus africanus*), and various small mammals have been observed in the forest.

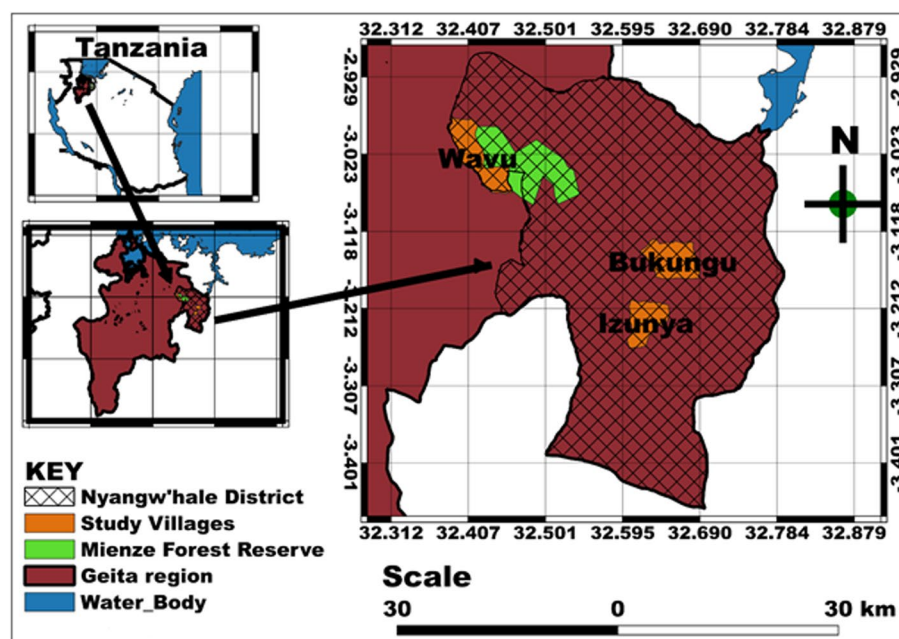


Fig. 1 A map of the Nyang'whale district showing study villages (created by the author using QGIS software lima version 3.32.2 (QGIS, 2023))

Farming is the main economic activity of the district, where a wide range of crops, namely maize, paddy, sunflower, lentils, cassava, cotton, and chickpeas, are produced [56]. Other economic activities are livestock keeping, beekeeping, small-scale mining, and fishing [62]. The common livestock species kept are cattle, goats, sheep, chickens, and donkeys [56].

Research approach and design

The study adopted a mixed-methods research approach. A quantitative research approach was used to assess the economic impacts of spotted hyena attacks, while a qualitative research design was used to assess the social impacts of hyena attacks. Additionally, we used a cross-sectional research design to assess the economic losses and social effects of hyena attacks within the study area. This approach allowed us to gather data from participants at a single point in time, providing a snapshot of the current economic losses and social impacts in the affected communities.

Sampling and sample size determination

The study was conducted in three villages that were purposefully selected based on their distance from hills and the Mienze Forest Reserve. These villages are Wavu, which is very close to the forest reserve; Bukungu, which is far from the forest reserve but surrounded by hills; and Izunya, which is far from the forest and the hills (Fig. 1). Additionally, a simple random sampling technique was used to select the households for the survey. The sample size was determined based on the number of households in the district using the formula developed by Yamane as cited by [63], which is given as:

$$n = \frac{N}{1 + N(e^2)}$$

where: n = sample size, N = study population, and e = sampling error.

A sampling error of 5% was adopted and the total number of households in the study village was 8,975. Therefore, based on the formula above, a sample of 382 households was randomly selected from the study villages for the household survey. The sampling process began by consulting the village chairman to obtain the total count of households in the village, ensuring a reliable and complete list for selection. Each household was then assigned a unique identification number, creating a structured framework for randomization. Using computer software designed for random sampling, these identification numbers were randomly generated, giving each household an equal chance of selection.

The study employed convenience sampling to select village members for focus group discussions, involving 8–10 participants and ensuring representation from both genders. This was done to capture the diverse roles, experiences, and perspectives each gender may have concerning hyena conflicts in their communities. Additionally, participants were required to have lived in the district for at least ten years, as longer-term residents were expected to have greater familiarity with hyena-related incidents. Two focus group discussions were conducted in each village. Eight key informants were purposefully selected, including the district game officer, district medical officer, three ward executive officers, and three village chairmen, who were all contacted face-to-face for their interviews.

Data collection

Four methods of data collection were used in this study: household survey, focus group discussions, key informant interviews, and direct observations. A structured questionnaire was used for the household survey to gather information such as human livestock attacks in the previous two years (2022 and 2023), the type and number of livestock killed by hyenas, time of human and livestock attacks, place of the attack, financial losses caused by livestock losses, and hospital expenses due to human attacks. The community and wildlife officers used different techniques to determine whether livestock were killed or attacked by spotted hyenas, such as tracks and signs around the scene, noise during the attack, and injury patterns. Additionally, information related to social impacts such as reduced working time, reduced social gatherings, reduced sleeping time due to watching livestock, and school dropouts due to the fear of hyena attacks was collected. Reduced working time referred to hours lost during the day time that would be used for working in the farms, herding livestock, or casual labour. Because hyenas are more active at night, working late or early in the morning increases the risk of attacks. Therefore, we determined the number of hours spent working on the farm when there was no threat of hyena attacks and the hours spent when there were hyena threats. Using this information, we calculated the number of working hours lost per day. Focus group discussions and key informant interviews were used to obtain in-depth information about the hyena conflicts in the district.

Data analysis

Data collected from the field were first coded in Excel for viewing and cleaning. Descriptive statistics were conducted to obtain the mean, standard deviation,

and standard error. The data were then imported into R version 4.3.2 for further analysis. The assumptions for normality were checked by using histograms and the Shapiro–Wilk test. A Chi-square test was used to determine the associations between the effect of hyena fear on daily activities in the villages. Poisson regression analysis was used to compare the number of livestock kept by households and the number of livestock killed by hyenas between villages and livestock species. Further, a linear regression was used to compare financial losses due to livestock attacks by hyenas and reduced working time due to fear of hyenas between the villages and livestock species. In this method, the number of livestock lost per household was converted to monetary value based on the market price in the Geita region, while the number of reduced working time due to the fear of hyenas was converted to monetary value based on wage payments in the villages. Few working hours per day reduce the income earned from casual labour. The obtained monetary values were used as response variables.

Results

General aspects of the households

A total of 384 households were visited for interviews, with 136 from Bukungu village, 101 from Wavu village, and 147 from Izunya village. Approximately 55% of the respondents were male, and the majority of the respondents had primary education (Table 1). The age of the respondents ranged from 18 to 84 years, with the majority aged 31–40 years. About 76.3% of the households kept livestock, and children were the main herders. The traditional livestock housing, called a kraal or a boma was the main structure for keeping the livestock. Kraals are constructed using wooden poles or tree branches that are driven into the ground at regular intervals. The vertical poles may be reinforced with horizontal ones or filled with clay soil to close the gaps between them.

Livestock production by the households

The number of livestock per household differed significantly between the livestock species ($\chi^2_{3, 290}=110.30$, $p<0.001$) and the villages ($\chi^2_{3, 290}=345.62$, $p<0.001$). The number of cattle was higher compared to the other

Table 1 General information about the households interviewed

Variable	Levels	Frequency	Percentage
Sex	Male	211	54.9
	Females	173	45.1
Education level	Informal	81	21.1
	Primary	288	75.0
	Secondary	13	3.4
	College	2	0.5
	Above 70	24	6.3
Age (years)	18-30	109	28.4
	31-40	125	32.6
	41-50	71	18.4
	51-60	32	8.3
	61-70	23	6.0
Household size (number of people)	2-5	81	21.1
	6-10	224	58.3
	11-15	74	19.3
	16-20	5	1.3
	Above 20	24	6.3
The family keep livestock	Yes	293	76.3
	No	91	23.7
Livestock house	Kraal (traditional house)	313	98.1
	Concrete walls with a roof	6	1.9
Livestock herder	Children	195	69.4
	Adults	86	30.6
Human attacks by hyenas in the last 2 years	Yes	24	6.3
	No	360	93.7
Livestock killed by hyenas in the last 2 years	Yes	151	39.3
	No	233	60.7

livestock species ($p < 0.001$, Fig. 2). Despite the fact that the number of families that kept cattle was fewer than those that kept goats, the herd size of cattle varied greatly, ranging from 1 to 105 animals per household. The Wavu village ($t_{2,213} = 10.675$, $p < 0.001$) and Izunya village ($t_{2,213} = 2.464$, $p = 0.014$) had more livestock compared to the Bukungu village. Further, pairwise comparison showed that the number of livestock in the Izunya and Wavu villages differed significantly ($t_{2,213} = -8.521$, $p < 0.001$), but there was no significant difference between the number of livestock in Izunya and Bukungu villages.

Livestock attacks by hyenas

About 151 families (39.3%) experienced livestock attacks by hyenas during the last two years. The number of

livestock attacked by hyenas ranged from 1 to 30 animals per household. The majority of the attacks (93.5%) happened at night, while the rest happened in the morning or evening. The number of livestock attacked by hyenas per household differed significantly between the livestock species ($\chi^2_{3,148} = 12.228$, $p = 0.006$) and the villages ($\chi^2_{2,149} = 35.805$, $p < 0.001$, Fig. 3). The attacks on cattle ($t_{3,148} = -2.461$, $p = 0.014$) and dogs ($t_{3,148} = -2.653$, $p = 0.008$) were lower than those on goats, but there was no significant difference between the number of sheep and goats attacked ($p = 0.238$). The Wavu village, which also has the highest number of livestock and is closest to the Mienze forest reserve, has experienced more livestock attacks compared to the Bukungu ($t_{2,149} = -5.362$, $p < 0.001$) and Izunya ($t_{2,149} = -3.630$, $p = 0.0004$) villages.

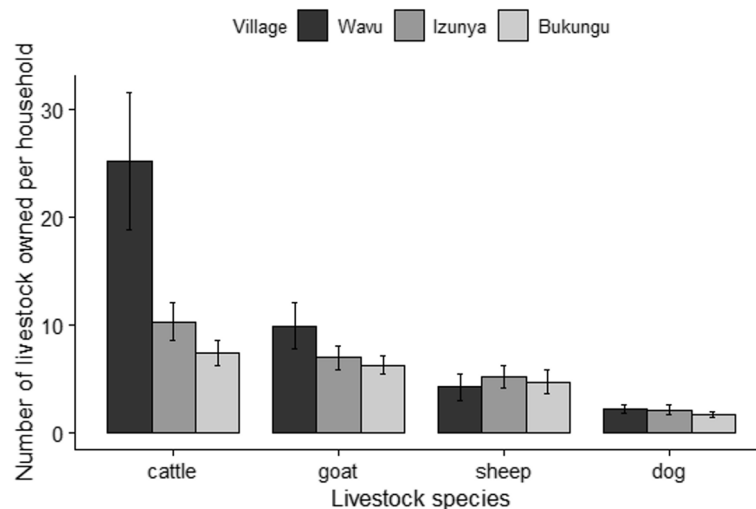


Fig. 2 The mean number of livestock per household (mean $\pm$ SD) in the study villages (Noela field data 2024)

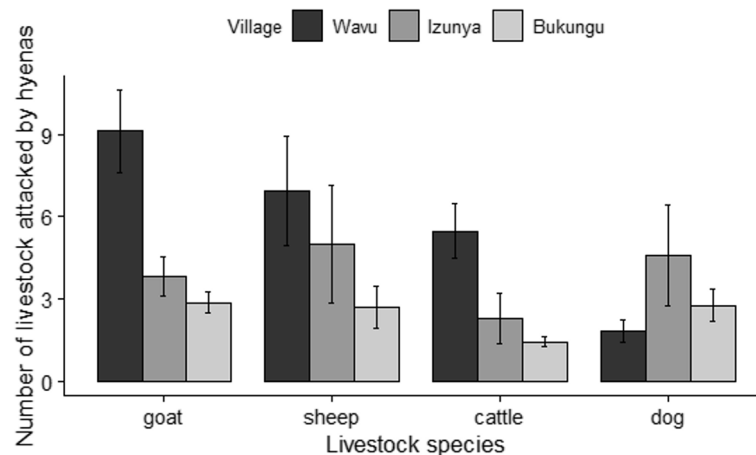


Fig. 3 The number of livestock attacked by hyenas per household during the last two years (mean $\pm$ SE) in the study villages (Noela field data 2024)

Human attacks by the hyena

A total of 24 occasions of human attacks were reported in two villages, of which 17 (70.8%) were from Bukungu village and 7 from Izunya village. Out of the 24 reported human attacks, victims survived in only 16 instances. No human attacks were reported in Wavu village. The majority of the attacks (58.3%) happened in the evening, while the rest occurred in the morning. Additionally, out of the 24 attacks, 18 (75%) involved children, 3 (8.3%) involved women, and 3 (8.3%) involved both a mother and a child. Eleven attacks (45.8%) happened at home, 8 (33.3%) on the way back home, 4 (16.7%) in the crop field, and 1 (0.41%) while herding livestock.

The effects of the fear of hyena attack on daily activities of the villagers

In all villages, the majority of the respondents reported having changed their daily routines, escorted their

children on their way to school, and disliked hyenas in response to hyena attacks. School dropouts due to hyena attacks were less frequent compared to the other effects (Fig. 4). The majority of respondents from Bukungu village pointed out changing daily routines and reduced working time as the main effects of the fear of hyena attacks (Table 2). Conversely, the majority of respondents from Wavu and Izunya villages, which also experienced the highest livestock attacks, reported spending the night watching their livestock, resulting in a reduction in their sleeping time. The majority of respondents from the Wavu village further reported suffering from stress and anxiety due to hyena fear (Table 2). Unexpectedly, school dropouts due to the fear of hyena attacks were highest in the Wavu village, which also did not report any human attacks by hyenas (Table 2).

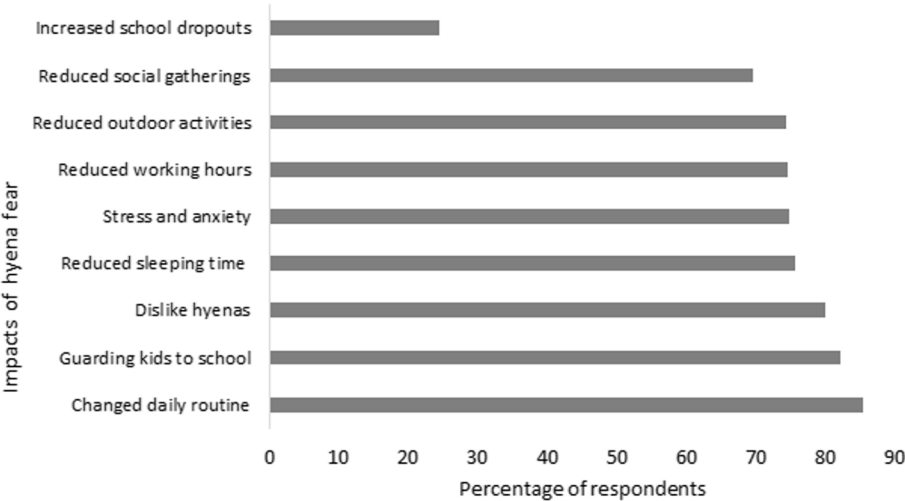


Fig. 4 Percentage of respondents who reported being affected by the fear of a hyena attack, and adjustments happened in their lives in response to the fear (Noela field data 2024)

Table 2 Effect of the fear of hyena attacks on different activities in the study areas. The values in the table indicate the number of households that reported the effect, and the values in the brackets indicate percentages. Within a row, values without a common superscript differ significantly ($p < 0.05$)

Effects of hyena fear	Bukungu (N = 136)	Wavu (N = 147)	Izunya (N = 101)	Chi square	P values
School dropouts	40 (29.4) ^a	43 (42.6) ^b	11 (7.5) ^c	43.38	< 0.001
Reduced working time	110 (80.9) ^a	80 (79.2) ^a	96 (65.3) ^b	11.89	0.002
Reduced social gatherings	80 (59.5) ^a	82 (81.2) ^b	104 (70.7) ^{ab}	12.96	0.001
Reduced outdoor activities	85 (62.5) ^a	86 (85.1) ^{bc}	114 (77.6) ^c	16.91	< 0.001
Escorting children to school	101 (74.3) ^a	88 (87.1) ^b	126 (85.7) ^{bc}	8.69	0.012
Reduced sleeping time	76 (55.9) ^a	92 (91.1) ^{bc}	122 (82.9) ^{bc}	46.05	< 0.001
Increased stress and anxiety	80 (58.8) ^a	90 (89.1) ^b	117 (79.6) ^{bc}	31.12	< 0.001
Dislike hyenas	99 (72.8) ^a	88 (87.1) ^b	116 (75.5) ^a	7.453	0.024
Changed daily routine	116 (85.3) ^a	88 (87.1) ^a	123 (83.6) ^a	0.56	0.752

Economic losses due to hyena attacks

The economic losses presented here were incurred due to the loss of livestock, reduced working time due to fear of hyena attacks in the morning and evening, and hours spent escorting children to and from school. On average, the villagers lose 2 working hours per day by either starting work late in the morning or finishing work early in the evening, as the majority of attacks happen in the evening and in the morning. After converting the lost hours into monetary values, it was observed that households lose an average of 0.9 USD per day, equivalent to 285.6 USD per year per household. The losses due to reduced working time were significantly lower in the Wavu village compared to the Bukungu village ($t_{2,306} = -5.394$, $p < 0.001$), but did not differ between Izunya and Bukungu villages ($t_{2,149} = -1.130$, $p = 0.259$, Fig. 5). On average, the hospital bills incurred per victim amounted to 90 USD for medication, surgeries, and inpatient care. Losses due to livestock attacks averaged 300.5 USD per household per year and were significantly higher in Wavu village compared to Bukungu village ($t_{2,304} = 4.839$, $p < 0.001$, Fig. 5), but did not differ between the Izunya and Bukungu villages. The majority of the livestock losses were related to cattle attacks (Fig. 6).

Result from focus group discussions and key informant interviews

Eighty percent of responses from focus group discussions and key informant interviews indicated that hyena attacks were driven by food scarcity. This shortage resulted from the growing human population in Nyang'hwale District, which led to the hunting of herbivores in the hills and the Mienze Forest Reserve. Consequently, hyenas resorted to attacking humans and livestock as alternative food sources. Additionally, the rainy season was identified as

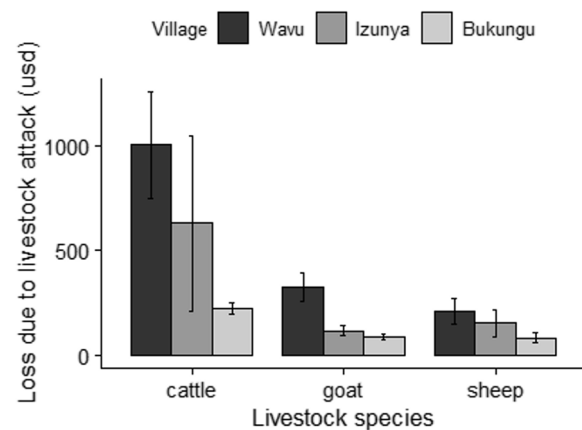


Fig. 6 Economic losses per household due to livestock attacks by hyenas during the last two years (Noela field data 2024)

the period with the highest frequency of attacks. Furthermore, the rainy season was recognised as the time with the highest frequency of attacks (Table 3). Some participants also highlighted that the presence of livestock carcass remains near villages attracts hyenas (Table 4). Ward executive officers, village chairmen, and district game officers reported that the primary cause of hyena attacks on livestock is the scarcity of small herbivores, the natural prey of hyenas.

Discussion

The study examined the social and economic impacts of hyena attacks in the Nyang'hwale district in northern Tanzania, which borders the Mienze Forest Reserve and is surrounded by hills. The findings reveal livestock attacks are prevalent in the district, particularly in the village situated near the forest reserve. On the other hand, human attacks are prevalent in the Bukungu village,

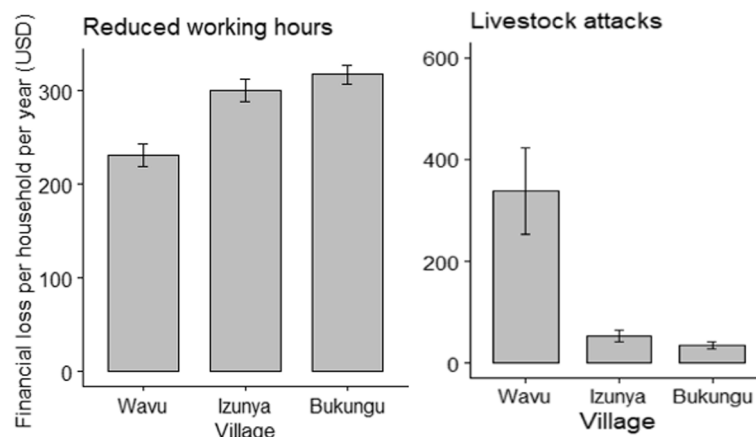


Fig. 5 Financial losses per household per year from reduced working time due to fear of hyena attacks and livestock loss to hyena attacks (mean $\pm$ SE) (Noela field data 2024)

Table 3 Thematic analysis of the results from focus group discussion

Theme	Key Responses	Quotation
Driver of hyena attack	Shortage of food	<i>"Due to the increase in the human population, herbivores are now scarce, leading hyenas to come into our homes targeting livestock and, at times, humans"</i>
	Remains of carcasses	<i>"Carcasses left near settlement attract hyenas, as they know where they can find food"</i>
Livestock grazing area	Close to farm	<i>"Grazing near the farms makes our livestock and child herders vulnerable"</i>
	In the forest	<i>"Hyenas hide in the Mienze Forest Reserve, where they wait for humans searching for firewood or children passing to school, and then attack them easily."</i>
	In the hills	<i>"Sometimes, people graze livestock in the hills where they encounter hyenas because there are large caves in the hills that can accommodate even 100 hyenas."</i>
Season of the attacks	Rainy season	<i>"Attacks occurs during the rainy season where there are crops grown in the farms therefore, they have advantage of hiding themselves and walk near to human settlement"</i> <i>"We never used to see hyenas this close to our homes, but now they are coming almost every night, especially in the rainy season."</i>
	Dry season	<i>"Even in the dry season they become desperate and attacks"</i>
Changes over time	Increasing	<i>"Ten years ago, we hardly ever had a problem with hyenas. Now, the attacks are so frequent that everyone is affected."</i>

Table 4 Thematic analysis of the results from key informant interview

Themes	Key responses	Quotation
Drivers of hyena attack	Waste disposal	<i>"Improper waste disposal near villages is attracting hyenas. They are scavengers by nature, so access to food waste close to human settlements is a key driver of increased encounters."</i>
	Shortage of prey	<i>"The decline in natural prey due to habitat loss and poaching is pushing hyenas to hunt livestock. Without a balanced ecosystem, these conflicts are inevitable."</i>
	Poor livestock enclosures	<i>"Some villagers do not build livestock enclosures; animals just sleep in an open area during the night; this makes it easy for hyenas to enter in."</i>
Impacts	Injuries	<i>"We see more cases of people injured by hyenas, especially during rainy seasons. These patients often need long-term care, and the fear of attacks increases stress and anxiety across the community."</i> <i>"Beyond physical injuries, the psychological trauma from hyena attacks leads to higher stress levels, affecting overall health in the community. This is an overlooked consequence that affects everyone, even those who haven't been directly attacked."</i> <i>"In many cases, herders have learnt to anticipate hyena behaviour, recognising patterns in their movements. This knowledge helps them protect their livestock, but it also highlights the constant vigilance required."</i>
	School attendance	<i>"Children are missing school because of the fear of encountering hyenas on their way. Parents often keep them home when attacks are reported nearby."</i> <i>"Sometimes schools are closed temporarily when attacks increase"</i> <i>"We call for the government to kill all hyenas."</i>
	Financial losses	<i>"The cost of repairing damaged enclosures and replacing lost livestock is a financial strain that many families cannot bear repeatedly. This cycle of loss impacts the entire community's financial stability."</i> <i>"Without compensation or support, the financial losses from hyena attacks push some families further into poverty, making it difficult for them to recover or invest in better protections."</i>

which is far from the forest but surrounded by hills. The fear of hyena attacks has disrupted the daily activities of the villagers, leading to adjustments such as reducing working and sleeping time, escorting children to school, and even increasing school dropouts to mitigate hyena attacks. These practices have significant impacts on both the social life and economic well-being of the villagers.

Hyenas are primarily scavengers, but they are also opportunistic hunters and may occasionally prey on humans, particularly when other food sources are scarce [24, 37, 64]. Hyenas may also attack humans when they

feel threatened or are defending territories [65, 66]. The attacks, in particular, target the human groups that are perceived as vulnerable [34, 67]. Consistent with this, our study found that the majority of attacks involved children and women, who are often viewed as vulnerable. Further, respondents in our study pointed out that hyenas consumed the body parts of victims who did not survive the attacks, except for the head and legs. This indicates that the attacks were not related to territorial defence or a response to being threatened; rather, they were acts of hunting. This finding reinforces other studies that

reported spotted hyenas attacking people, resulting in injuries and deaths [37, 68, 69]. The human attacks were reported in the two villages located far from the forest reserve, a finding that is in line with previous studies [22, 70]. This suggests that hyenas may venture farther into human-populated areas when their natural habitats or resources are limited or when prey availability decreases closer to reserve boundaries [22, 71]. This highlights the need for targeted strategies to mitigate conflicts in these distant villages, which could include enhancing community awareness.

The hyena attacks on humans have created fear; hence, the villagers have changed their daily routine in response. These include escorting children to school, starting working late in the morning and stopping early in the evening, and reducing outdoor activities and social gatherings. As a result, the villagers lose productive hours, which reduces daily output in activities such as farming and casual labour [72, 73]. Further, the fear of hyenas causes social instability like psychological distress, as it has also been observed in other studies [9, 18, 74, 75]. There was a substantial reduction in working hours in Bukungu village, which had more instances of human attacks. In addition, school dropout was prevalent in Wavu and Bukungu villages. Human-wildlife conflict can contribute to school dropouts directly through fear of attack [76–78] or indirectly by requiring children to work in the fields to protect livestock and crops from wild animals [76, 79, 80]. The latter case may apply to Wavu village, which reported the highest dropout rate despite no recorded human attacks. These findings highlight the broader social implications of human-wildlife conflict, where the need for safety and livelihood protection can compromise educational opportunities and long-term community development. Fear has also heightened hatred toward hyenas, with the majority of villagers wishing for their elimination, as reported in similar studies elsewhere [9, 35]. These aspects have implications for both the social life and economic gains of the villagers, as well as the conservation of hyenas.

The majority of livestock attacks occur at night when hyenas are most active, a pattern also noted by [37, 81]. This nocturnal behaviour forces villagers to remain vigilant and stay awake at night to guard their livestock, a practice that not only disrupts sleep but also places additional physical and mental strain on community members. In Wavu village, where this practice is particularly common due to higher frequencies of livestock attacks, villagers face even greater challenges. Despite these livestock attacks, no human injuries have been reported in Wavu, which may indicate that hyenas are less inclined to attack people in areas where livestock—an accessible food source—is abundant. Previous studies by [81,

82], have reported a comparable relationship. The big livestock herds in Wavu are often housed in inadequate enclosures due to the high costs associated with constructing larger, more secure structures. These poorly designed enclosures may not provide sufficient protection against predators, leaving livestock vulnerable to attacks [22, 29, 30]. The financial burden of building robust enclosures can be particularly challenging for smallholder farmers [10]. Consequently, the lack of proper enclosures not only increases the risk of livestock losses but also contributes to ongoing tensions between human communities and wildlife, as farmers face the dual challenge of safeguarding their animals while managing limited financial resources.

The Mienze forest plays a crucial ecological role as a natural habitat for hyenas, supporting their population and providing essential resources for their survival. At the same time, livestock keepers heavily rely on the forest for grazing their animals and other resources, particularly during dry seasons when other pastures become scarce. However, participants in the KIIs and FGDs indicated that hyena attacks are more common during the rainy season. At this time, crops are growing in the fields, providing hiding places for hyenas close to human settlements. In addition, adults are normally busy with farming activities during this season, leaving the livestock herding responsibility to children. This observation aligns with the previous studies by [25, 70, 81]. Furthermore, the findings from the FGDs and KIIs indicated that hyena attacks on livestock have escalated in recent years since 2020. They attributed this rise in attacks to the depletion of wild herbivores, which serve as the hyenas' primary prey. However, there are no studies of herbivore populations in the area, thus making it difficult to confirm the extent of their decline or establish a direct causal link between reduced herbivore numbers and the rise in hyena attacks. Nevertheless, previous studies by [25, 36, 83, 84] have indicated that hyena attacks on livestock tend to increase when their natural prey is depleted, suggesting that similar dynamics could be at play in this region. There was also a notable variation in attacks on livestock species, with goats and sheep being more frequently targeted than cattle. This can be attributed to their smaller body size, as hyenas, being medium-sized predators, may encounter difficulties when attacking cattle. Calves and sick animals are typically targeted, as they are more vulnerable. Similar findings have been reported in studies conducted in Kenya, Ethiopia, and various parts of Tanzania [9, 40, 85, 86]. This observation highlights the importance of adopting tailored livestock management practices, stressing the need for targeted protection strategies that address species vulnerabilities and the unique risks faced by smaller or weaker animals.

The social impact and incidents of human and livestock attacks have led to economic losses. These losses were attributed to several factors, including reduced working time due to fear of hyena attacks, the need to escort children to and from school, livestock losses, and hospital bills resulting from human injury. The average household monthly income in the study area is estimated at TZS 150,000 (USD 43), based on the number of livestock owned, crop yields and wages. This amount is lower than the average income of families engaged in agriculture across Tanzania, which stands at TZS 274,293 (USD 98) [87]. However, in both cases, the income is insufficient to cover daily living expenses, as the average living income for rural Tanzania is TZS 458,092 (USD 200) per month [87]. Additionally, farmers expressed concerns over delays, insufficient amounts, and, at times, a complete lack of consolation funds for losses due to wildlife conflicts, further straining their livelihoods. These challenges, combined with restrictions on working time due to fear of hyena attacks and potential livestock loss, continue to reduce household income and exacerbate financial hardships. Addressing these challenges through improved livestock husbandry will be essential for enhancing the livelihoods of these households. The economic impact of reduced working time was particularly pronounced in Bukungu village, where villagers faced challenges working early in the morning or late in the evening due to frequent human attacks, as previously explained. These losses are particularly impactful for rural communities that are heavily reliant on farming and livestock production as their primary sources of livelihood. This finding is consistent with previous studies that have shown financial losses due to predators attacking livestock [88, 89].

The findings of this study demonstrate that sustainable management of hyena conflicts requires addressing both the protection of human livelihoods and the conservation of hyenas. Loss of livestock directly impacts household income and food security, particularly in rural areas where people heavily rely on livestock for their livelihood. Additionally, the fear of hyena attacks restricts people's movements, affecting their daily activities and overall quality of life, leading to psychological stress and reduced community well-being.

Conclusion

Compared to other studies in Africa, the social impacts and economic losses reported in this study are among the highest and thus need urgent attention. The conflicts can lead to retaliatory killings of hyenas by villagers, negatively impacting their populations. Our findings highlight the necessity of educating the local community in the Nyang'whale district on how to avoid hyena

attacks, especially by safeguarding children during the evening and early morning, when most attacks occur. Additionally, improving livestock husbandry practices is crucial, as most livestock attacks happen at night. The study also shows that human attacks were high in villages with fewer livestock, indicating limited food resources for the hyenas. Therefore, this study recommends further research on the hyena population in the district and the availability of natural food resources for hyenas. This may include faeces analysis to determine prey preferences and the foraging strategies of spotted hyenas in the district.

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Authors' contributions

All authors designed the study. N.S.H. collected data. R.P.M. and N.S.H. analysed the data. N.S.H. wrote the manuscript. R.P.M. and D.J.M. commented on the previous version of the manuscript. All authors reviewed the final version of the manuscript.

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Data availability

The datasets used in this study can be obtained from the corresponding author upon request.

Declarations

Ethics approval and consent to participate

There was voluntary participation by respondents in this study, and a consent was obtained before the interviews. Ethical clearance for conducting the study was provided by the Institutional Research Review Ethics Committee (IRREC) of the University of Dodoma.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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