LION ATTACKS ON HUMANS IN SOUTHEASTERN TANZANIA: RISK FACTORS AND PERCEPTIONS

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Dedication

This dissertation is dedicated to both my grandmothers, Gila Kushnir and Esperance Asher, whose high school educations were cut short by war and resettlement. It is because of their strength and sacrifice that I was able to obtain the education they were never able to receive.

This dissertation is also dedicated to the many victims of lion attacks in Tanzania whose stories I will never forget. It is my hope that this research will in some way help to prevent future attacks.

Table of Contents

List of Tables

CHAPTER 1:

CHAPTER 2:

CHAPTER 3:

List of Figures

CHAPTER 1:

CHAPTER 2:

CHAPTER 3:

Introduction to the Dissertation

Lions attacked over 1000 people in Tanzania between 1990 and 2007, killing at least two-thirds of the victims. This extreme form of human-wildlife conflict has a major impact on the lives and livelihoods of local communities and threatens lion conservation in Tanzania, home to the largest lion population in Africa. Working in the two districts with the highest number of lion attacks, Rufiji and Lindi, my research examines the problem from both ecological and human perspectives at multiple scales. Overall, I aimed to: (1) identify human, ecological, and landscape-level risk factors for lion attacks, (2) determine how people currently react to attacks and what methods they believe could help mitigate attacks, and (3) understand how people perceive attacks and how these perceptions align with reality.

Chapter 1, "Using Landscape Characteristics to Predict Risk of Lion Attacks in Southeastern Tanzania," examines the problem at the attack level across both districts. Using knowledge of attack locations, land cover, and important landscape features, I was able to model attack probability and then map the modeled probability in Rufiji and Lindi districts. I also extended the model to other areas in southeastern Tanzania to determine how well the model predicts high-risk areas beyond the study districts. Such a technique has potential to predict high-risk areas for future conflict in order to pinpoint prevention efforts.

Chapter 2, "Human and Ecological Risk Factors for Unprovoked Lion Attacks on Humans in Southeastern Tanzania," compares human activity patterns during attacks

between the two districts and examines risk at the village level in the areas with the highest concentration of attacks in Rufiji and Lindi districts. Human activity patterns during attacks differ significantly between the two districts and in each district they match with the details of daily life the area. By comparing villages with attacks to neighboring villages without attacks, I was able to identify a number of important risk factors related to wildlife presence and daily activities. Additionally, I examined the local response to lion attacks and views on appropriate measures to prevent attacks. Knowledge about local risk factors and response to attacks, and local views on prevention measures are all critical components of formulating methods to prevent future attacks.

Chapter 3, "Reality vs. Perception: How Rural Tanzanians View Risks from Man-Eating Lions," examines human-lion conflict at the level of the individual by determining how people perceive the risk of lion attacks and how well these perceptions match reality. My findings indicate that even though people tend to exaggerate their overall risk, they correctly perceive specifics related to risk. This supports the need for using multiple methodologies to assess risk perceptions because only determining overall perceptions limits findings and under-represents local knowledge.

The three chapters each provide different yet important perspectives on the problem that will be useful in formulating and implementing methods to reduce lion attacks on people in southeastern Tanzania. The unique combination of methodologies and scales of investigation also provide a useful framework for studies that investigate human-wildlife conflict worldwide.

CHAPTER 1: Using Landscape Characteristics to Predict Risk of Lion Attacks in Southeastern Tanzania*

* With Erik Olson, Thomas Juntunen, Dennis Ikanda, Craig Packer

A global challenge in conservation is human-carnivore conflict because of its impact on both carnivore populations and the lives and livelihoods of rural communities. In Tanzania, over 1000 people have been attacked by African lions (*Panthera leo*) in the last twenty years. We develop a logistic regression model that predicts the probability of lion attacks based on landscape characteristics, creating a risk map for the two study districts as well as for a larger area across southeastern Tanzania. Results of the model indicate that proximity to villages, other attacks, and fresh water increase the probability of attack. Attack probabilities increase in areas with a large proportion of open woodland/bushland, habitats with scattered crops, and bare areas, whereas attack probabilities decrease in urban areas. Changes in grassland, open woodland/bushland, closed woodland/bushland/forest, grassland with scattered crops, and urban areas also influence the risk of attack. The model successfully predicted attacks at the ward level (administrative unit below district) in four of five districts we tested in southeastern Tanzania, as the predicted number of attacks was correlated to the actual attacks per ward. Thus, the technique has potential to help identify underlying landscape-related causes of human-wildlife conflict, map risk of attacks, and predict future high-risk areas. The method could be adjusted to test how different landscape change scenarios will affect the location of conflict, helping researchers pinpoint efforts to prevent future attacks.

Introduction

Carnivores face increasing pressure worldwide as the human population expands (Woodroffe 2000; Fascione et al. 2004; Woodroffe & Frank 2005), primarily from habitat conversion and destruction, prey depletion, commercial exploitation, and disease outbreaks (Patterson et al. 2004; Nyhus & Tilson 2004; Kolowski & Holekamp 2006). There is an emerging consensus, however, that the single largest threat to carnivore conservation may be direct persecution in response to conflict (Woodroffe & Ginsberg 1998; Woodroffe 2000, 2001; Kolowski & Holekamp 2006; Michalski et al. 2006), much like the systematic extirpation of wolves in the United States due to conflicts with ranchers (Meine 2009). The future of successful carnivore conservation relies heavily on understanding and preventing human-carnivore conflict around the world. Novel approaches to identifying underlying causes of conflict and predicting hotspots will be critical to reducing conflict and conserving carnivores because it will allow researchers and managers to pinpoint mitigation and prevention efforts.

Research currently focused on understanding human-carnivore conflict can be broadly classified into two groups: (1) studies that characterize ecological and temporal factors related to conflict, and (2) studies that model spatial landscape patterns of conflict. Ecological studies have examined offending species or individuals (Butler 2000; Ogada et al. 2003; Wydeven et al. 2004; Wang & Macdonald 2006; Gurung et al. 2008; Sangay & Vernes 2008; Kissui 2008; Dar et al. 2009), type of livestock or people targeted (Madhusudan 2003; Nyhus & Tilson 2004; Patterson et al. 2004; Wydeven et al.

2004; Packer et al. 2005; Kolowski & Holekamp 2006; Holmern et al. 2007; Gurung et al. 2008; Sangay & Vernes 2008; Ikanda & Packer 2008; Dar et al. 2009), seasonal or climatic trends (Patterson et al. 2004; Packer et al. 2005; Kolowski & Holekamp 2006; Gurung et al. 2008; Sangay & Vernes 2008; Dar et al. 2009), relationship to prey availability (Saberwal et al. 1994; Meriggi & Lovari 1996; Stahl et al. 2001; Patterson et al. 2004; Packer et al. 2005; Woodroffe et al. 2005a; Kolowski & Holekamp 2006; Odden et al. 2008), or associated landscape features (Saberwal et al. 1994; Vijayan & Pati 2002; Nyhus & Tilson 2004; Wydeven et al. 2004; Gurung et al. 2008; Sangay & Vernes 2008).

Studies that model spatial patterns of human-carnivore conflict largely come from research on bears in the Unites States (Nielsen et al. 2004; Wilson et al. 2005; Wilson et al. 2006; Kretser 2008; Kretser et al. 2008), although additional examples come from studies of wolves in the United States (Treves et al. 2004; Treves et al. unpublished manuscript) and large felids in Brazil (Michalski et al. 2006). These spatial studies have examined the location of housing, roads, pastures, and agriculture (Nielsen et al. 2004; Treves et al. 2004; Wilson et al. 2005; Wilson et al. 2006; Kretser 2008; Kretser et al. 2008), terrain (Nielsen et al. 2004), vegetation and land cover (Nielsen et al. 2004; Treves et al. 2004; Wilson et al. 2005; Michalski et al. 2006; Wilson et al. 2006; Kretser 2008), and wild and domestic prey availability (Treves et al. 2004; Michalski et al. 2006). But only Treves et al. 2004 and Treves et al. unpublished manuscript have attempted to predict hotspots for conflict over a large area beyond their primary study area.

Tanzania is home to 25-50% of the remaining African lions (Chardonnet, 2002; Bauer & Van Der Merwe, 2004) and to four of the six lion populations over 1000 individuals on the continent (Packer et al. in review). The large lion population generates high levels of human-lion conflict, not only in the form of livestock depredation but also in direct attacks on humans. Since 1990, lions in Tanzania have attacked over 1000 people (Kushnir et al. 2010). The majority of these cases are incidents where lions enter villages and agricultural areas in search of humans as prey (Baldus 2004; Packer et al. 2005; Kushnir et al. 2010). With approximately two thirds of these cases being fatal, human-lion conflict in Tanzania has far-reaching implications for both human welfare and lion conservation.

Despite the magnitude of the conflict, little is known about the landscape factors that lead to attacks. We therefore aimed to determine if factors such as distance to human habitation, water, roads, and protected areas, as well as land cover will significantly affect the location of lion attacks on people. Our objectives are to identify specific landscape characteristics associated with lion attacks in two well-studied areas and to use these relationships to create a risk map for lion attacks across southeastern Tanzania. Because human-carnivore conflicts occur over vast geographical areas, and resources for protecting people and livestock are limited, predicting high-risk areas is important in setting management priorities. We show how detailed scientific survey data in one area can be used to predict conflict across a larger region.

Methods

Study Area

Over 50% of known lion attacks in Tanzania have occurred in seven districts on the southern coast. We worked in two districts with the highest number of lion attacks in the country, Rufiji and Lindi (Figure 1-1). Rufiji is located near Selous Game Reserve, a source of lions and wild lion prey, whereas Lindi is not located near any major protected area and thus has fewer lions and fewer prey. Both districts experienced repeated outbreaks of lion attacks between 1990-2007, with 99 unprovoked attacks in Rufiji and 175 unprovoked attacks in Lindi (Kushnir et al. 2010).

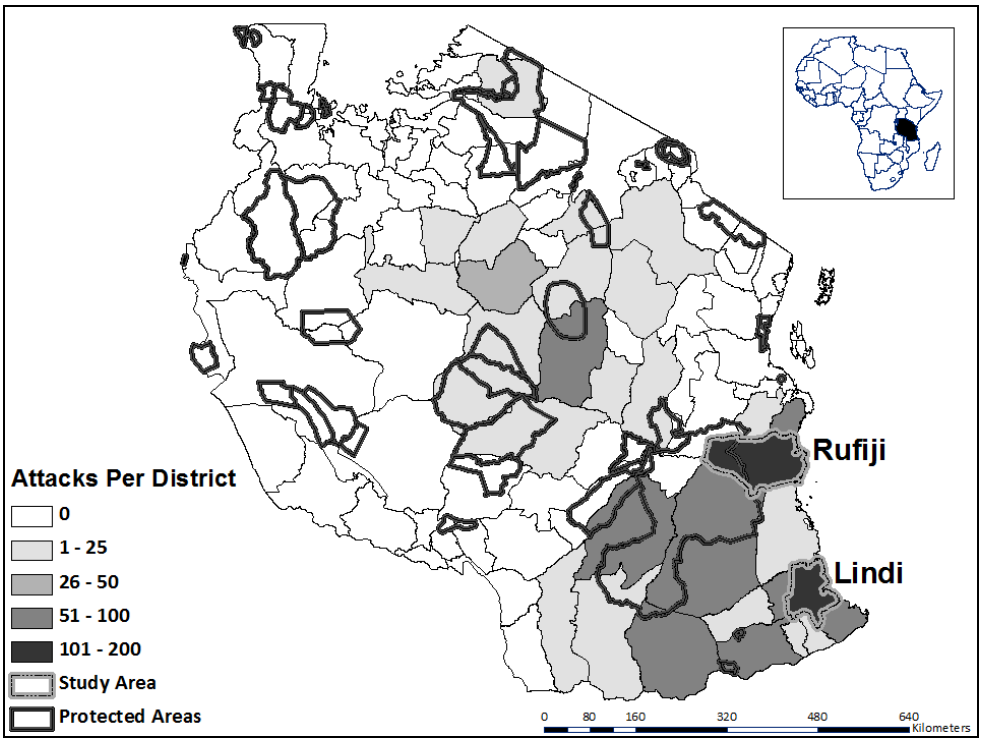

Figure 1-1: Map of Tanzania with the number of attacks per district coded. Rufiji and Lindi districts are in bold.

Data Collection

We used Global Positioning System (GPS) readings translated into Universal Transverse Mercator coordinates to map the location of lion attacks obtained from District Game Office records. Records provide the village, year, and name of the victim. Using these lists, we traced back each incident by visiting each attack location and conducting short interviews with survivors, victims' family members, or village leaders. In total, we mapped 95 out of 99 attacks in Rufiji and 143 out of 175 attacks in Lindi. The cases we were unable to map were scattered throughout the study area randomly and could not be mapped mainly because people were unsure of the location or the location was inaccessible.

We obtained village locations through two methods. As no village maps existed in Rufiji, we mapped the center of each village using GPS. For Lindi, we obtained maps from the Geographic Information Systems (GIS) Information Centre at the Naliendele Agricultural Research Institute in Mtwara, Tanzania. We created road and water body maps for both districts by combining United Nations Food and Agricultural Organization Africover data with data from Naliendele Agricultural Research Institute. The Tanzania Wildlife Research Institute provided the boundaries of protected areas. Thirty-meter resolution land cover data for 1990 and 2000 came from the Geographic Information for Sustainable Development Initiative based on imagery from Landsat Thematic Mapper (TM) and Landsat Enhanced Thematic Mapper Plus (ETM+) sensors (Wang et al. 2005).

Data Analysis

In order to compare attack locations to areas without attacks, we used ESRI's ArcGIS software version 9.2 (ArcGIS) to generate a random sample of 2000 points within a 20km radius of all villages in each district. We selected a 20km radius because this encompasses a large enough area to account for human activity around villages without limiting points to within district boundaries. We then used ArcGIS to calculate land cover characteristics for attack and non-attack points. There are two broad categories of landscape characteristics in our models: distance variables and land cover variables. Distance variables include: distance to nearest neighboring attack, nearest village, nearest road, nearest water body, and nearest protected area. In keeping with common practice when analyzing spatial distance data, we log-transformed all distance variables and included both log-transformed distances and the square of the log-transformed distance to nearest village and nearest water body. For land cover variables, we re-classified the original 21 classes into 10 categories: grassland, open woodland/bushland, closed woodland/bushland/forest, grassland with scattered crops, woodland/bushland with scattered crops, cultivated agriculture, cultivated trees/forest plantations, water/wetlands, urban areas, and bare areas. We then calculated the proportion of each land cover class within a 2.5-kilometer radius of each point. Lions move an average of 3-5km a day (Mosser & Packer 2009; Henry Brink pers. comm.), and we tested alternative radii, ranging from 0.5km to 8km, but found that 2.5km provided the best model fit. In order to integrate land cover change into the model, we also used calculated percent difference in

each land cover class within the 2.5km radius by subtracting the proportion of each class in 1990 from the proportion of each class in 2000, thereby accounting for change in the 2.5km radius around each point.

We used backwards stepwise logistic regression in SPSS to create the best model (Model 1). Using this model, we calculated attack probabilities for points on a 0.5km grid across both Rufiji and Lindi. We then removed the variable for distance to attack (Model 2) and re-ran the model to calculate attack probability for a 0.5km grid of points across Rufiji, Lindi and three additional districts, Kilwa, Ruangwa, and Mtwara, for which all necessary data, except distance to attack, were available. Once we calculated attack probability for each point in the 0.5km grid, we converted the values into a raster grid and mapped it in ArcGIS.

We conducted two tests to determine how well the models performed in relation to actual attacks. In Rufiji and Lindi, we calculated the mean probability values for 1km buffers around actual attack points using the Zonal Statistic function in Hawth's Analysis Tools add-on for ArcGIS (Beyer 2004), which sums the probabilities of all grids in the 1km buffer and divides the value by the number of grids. We then used ANOVA to compare the mean of these values to the mean of the probability values of 1km buffers around a new random sample of points across both districts. To test how well Model 2 performed in districts where we only have knowledge of attacks at the ward level (the next administrative unit below district), we calculated the sum of the probabilities in each ward as predicted by the model multiplied by a scaling variable to convert relative

probability to predicted number of attacks. We calculated the scaling variable separately for each district by dividing the number of attacks per district by the sum of the probability values for the entire district, thus converting the scale of probability values to a similar scale as attacks. The objective of this calculation was to determine how well the model predicted high-risk areas within each district. We graphed the predicted number of attacks per ward versus actual number of attacks per ward and used a correlation matrix to compare these values. First, we found the Pearson correlation value across all wards in the five districts combined. Second, we calculated correlation values across wards for each district separately.

Results

Figure 1-2 and Figure 1-3 show the location of attacks in Rufiji and Lindi districts respectively. It is evident that attacks are concentrated in certain areas within each district and that not all villages have attacks. Because lions are found across both districts, it is not the absence of lions that defines the absence of attacks. Attacks also occur in the same area over a number of different years.

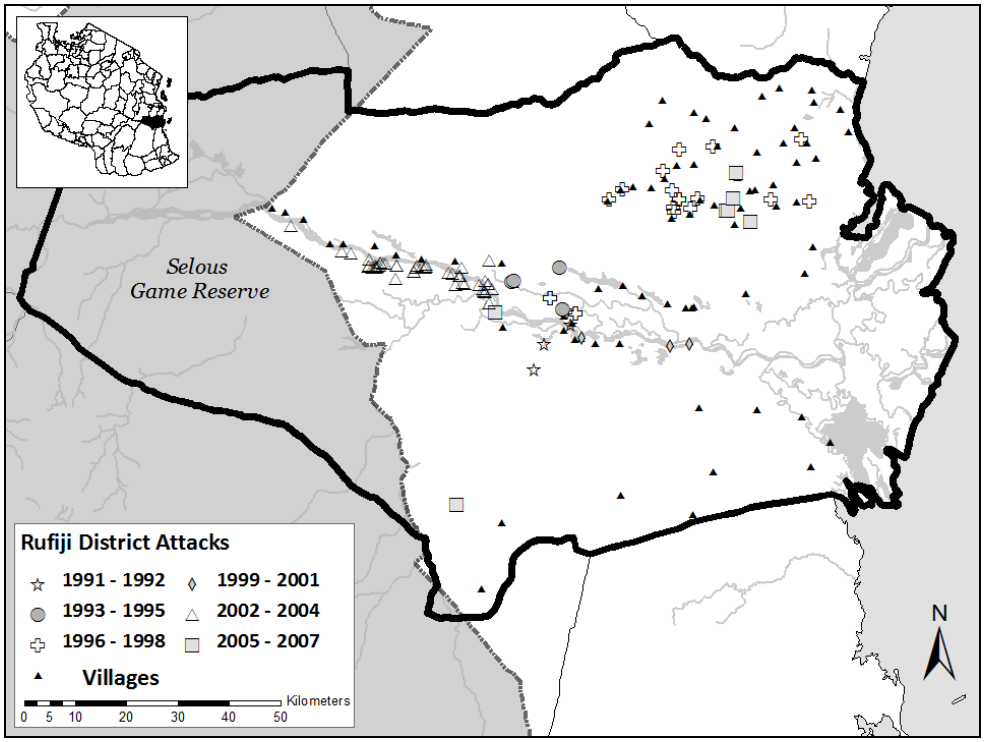

Figure 1-2: Map of Rufiji district with attacks coded by years.

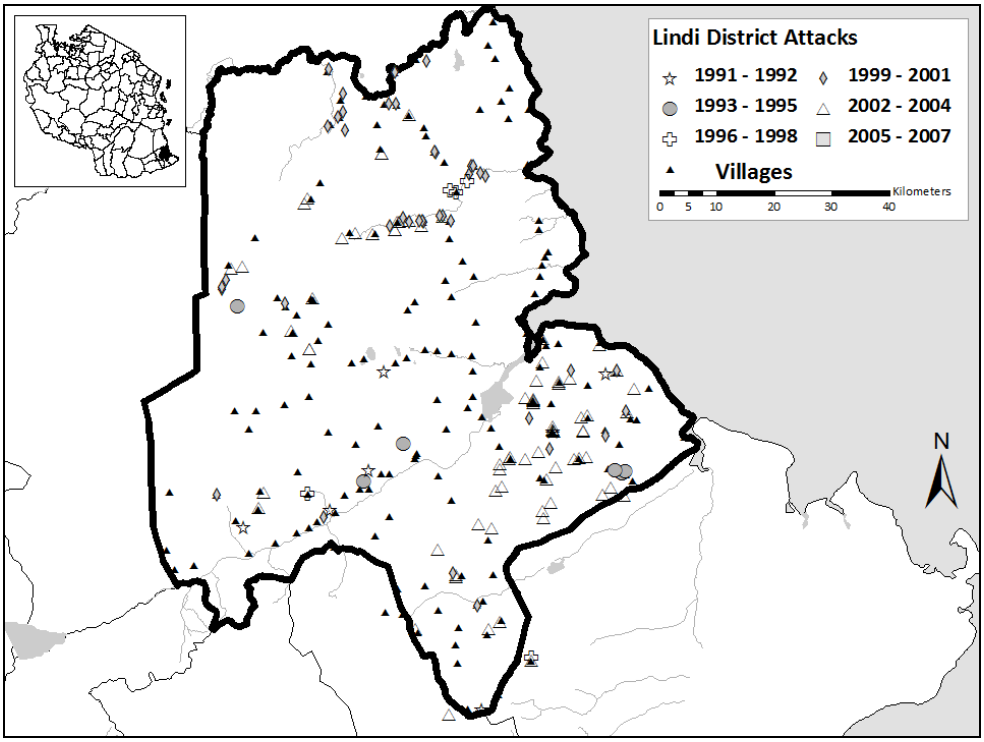

Figure 1-3: Map of Lindi district with attacks coded by years.

Table 1-1 shows the final logistic regression model for Rufiji and Lindi districts (Model 1). This model predicts 62.2% of the attack points correctly and 93.3% of all points (both attack and non-attack points) correctly. The model considers a point to be an attack point if the probability is 50% or greater. Attack probability is negatively correlated to distance to nearest attack, distance to nearest village, and distance to nearest water body and positively correlated to the squared terms for distance to nearest village and the nearest water body. High proportions of four land cover variables increase the overall probability of an attack: open woodland/bushland, grassland with scattered crops, woodland/bushland with scattered crops, and bare areas. A larger proportion of urban area decreases the overall probability of attack. Changes in land cover were also significant. Positive changes in four cover types increase the probability of attack: increases in grassland, open woodland/bushland, closed woodland/bushland/forest, and grassland with scattered crops. A high percent increase in urban areas decreases the overall probability of attack. When we removed distance to nearest prior attack from the model (Model 2, Table 1-2), all of the other variables from Model 1 continue to affect the overall probability of an attack. However, without distance to nearest prior attack, Model 2 correctly predicts a lower percentage of points: 38.3% of attack points and 90.5% of attack and non-attacks points. It is important to note that spatial autocorrelation could be an issue in both models, but we attempted to account for this by incorporating most of the important spatial variables.

Table 1-1: Results of logistic regression for Rufiji & Lindi districts (Model 1)

Variable	Estimated Coefficient	Estimated Standard Error	*p*-value	Odds Ratio
Log_{10} Distance to Nearest Prior Attack	-5.682	.488	.000	.003
Log_{10} Distance to Nearest Village	-12.581	1.741	.000	.000
Log_{10} Distance to Nearest Village Squared	8.457	1.463	.000	4707.78
Log_{10} Distance to Nearest Waterbody	-2.508	1.364	.066	.081
Log_{10} Distance to Nearest Waterbody Squared	2.221	.883	.012	9.221
Percent Open Woodland/Bushland	.010	.005	.049	1.010
Percent Grassland with Scattered Crops	.016	.008	.033	1.016
Percent Woodland/Bushland with Scattered Crops	.013	.005	.005	1.013
Percent Urban	-.213	.118	.071	.808
Percent Bare Areas	.085	.034	.012	1.089
Percent Difference in Grassland	.029	.010	.003	1.029
Percent Difference in Open Woodland/Bushland	.013	.007	.041	1.014
Percent Difference in Closed Woodland/ Bushland/Forest	.016	.008	.033	1.017
Percent Difference in Grassland with Scattered Crops	.023	.014	.096	1.023
Percent Difference in Urban	-.289	.149	.052	.749
Constant	4.770	.744	.000	117.869

Table 1-2: Results of logistic regression for all five district (Model 2)

Variable	Estimated Coefficient	Estimated Standard Error	*p*-value	Odds Ratio
Log_{10} Distance to Nearest Village	-7.833	1.225	.000	.000
Log_{10} Distance to Nearest Village Squared	2.282	1.036	.028	9.798
Log_{10} Distance to Nearest Waterbody	-1.715	.987	.082	.180
Log_{10} Distance to Nearest Waterbody Squared	1.588	.658	.016	4.892
Percent Open Woodland/Bushland	.009	.004	.023	1.009
Percent Grassland with Scattered Crops	.023	.006	.000	1.023
Percent Woodland/Bushland with Scattered Crops	.009	.004	.010	1.009
Percent Urban	-.203	.097	.036	.816
Percent Bare Areas	.112	.022	.000	1.118
Percent Difference in Grassland	.056	.009	.000	1.058
Percent Difference in Open Woodland/Bushland	.017	.006	.004	1.017
Percent Difference in Closed Woodland/ Bushland/Forest	.031	.007	.000	1.032
Percent Difference in Grassland with Scattered Crops	.064	.011	.000	1.067
Percent Difference in Urban	-.242	.119	.042	.785
Constant	.760	.510	.136	2.139

Figure 1-4 and Figure 1-5 show attack probabilities mapped across Rufiji and Lindi district as predicted by Model 1. Overlaid on the probabilities are the actual attack points. The predicted probabilities at attack points are significantly higher than the random sample of points for both Model 1 ($F=1843$, $df=2107$, $p<0.01$) and Model 2 ($F=485$, $df=2107$, $p<0.01$). At the ward level, the predicted number of attacks is significantly correlated to the actual attacks per ward (Pearson=0.554, $n=97$, $p<0.01$) (See Appendix 1 for table of actual versus predicted attacks per ward). For each separate district, predicted attacks and actual attack values were significantly correlated in Rufiji, Lindi and Mtwara districts (Pearson=0.577, $n=15$, $p<0.05$; Pearson=0.455, $n=29$, $p<0.05$; Pearson=0.475, $n=19$, $p<0.05$). In Ruangwa, results approached statistical significance

(Pearson=0.502, n=15, p=0.057), and the results from Kilwa showed almost no correlation (Pearson=-0.012, n=19, p=0.961). Figure 1-6 shows actual attacks per ward plotted against predicted attacks per ward for the three non-study districts. There is a positive relationship between actual and predicted attacks for Mtwara and Ruangwa but not for Kilwa.

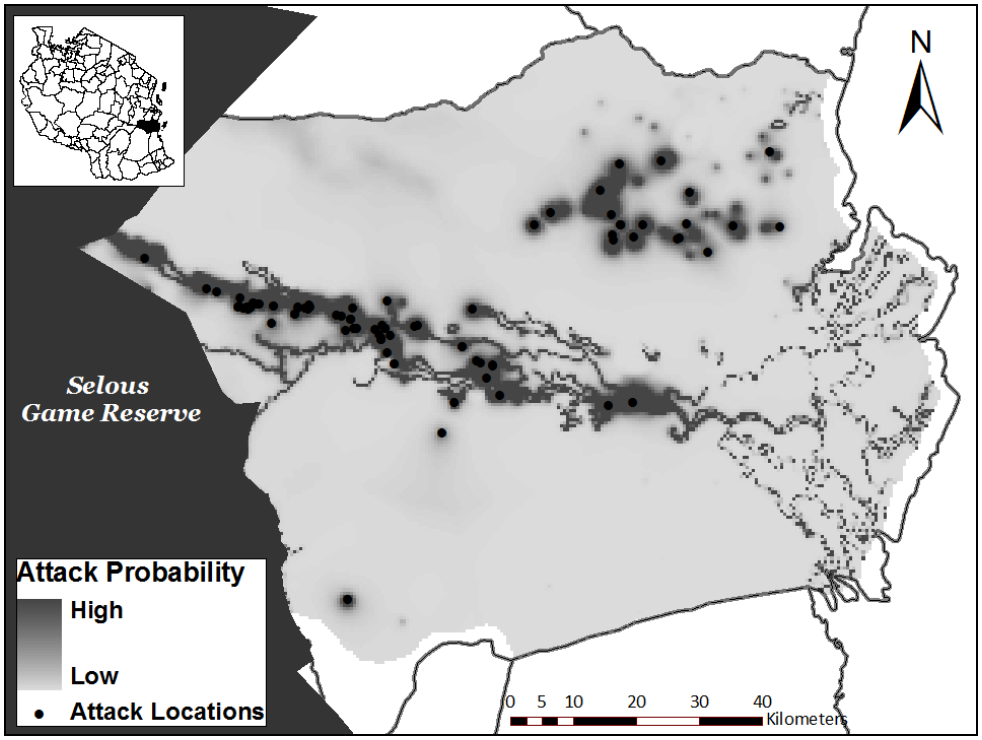

Figure 1-4: Map of Rufiji district showing the attack probability as predicted by Model 1

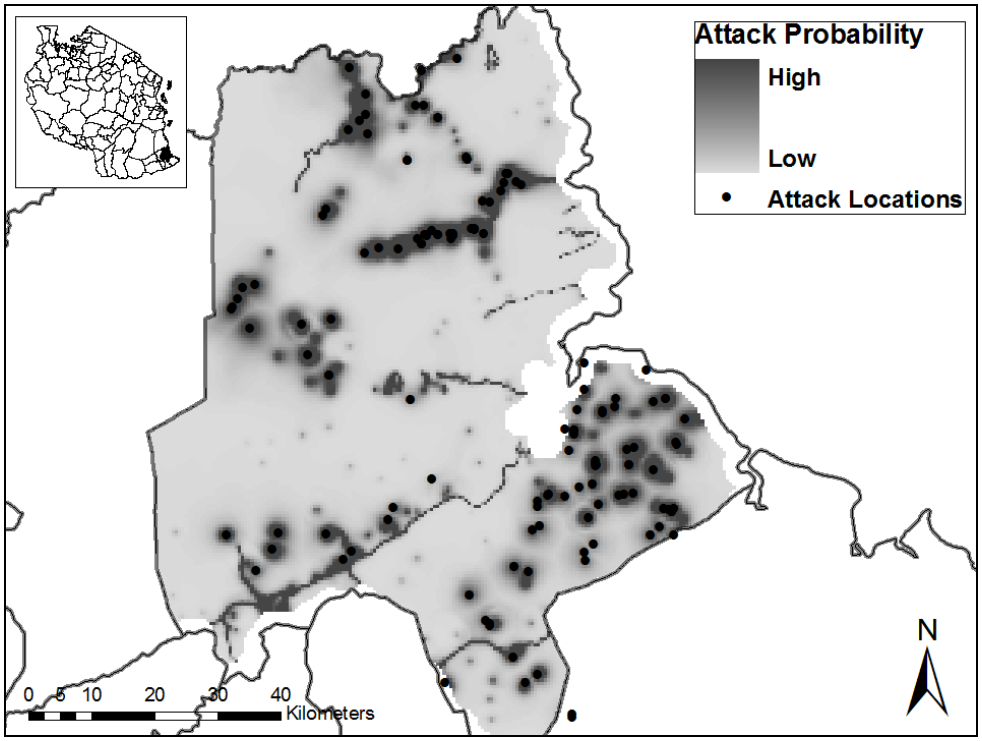

Figure 1-5: Map of Lindi district showing the attack probability as predicted by Model 1.

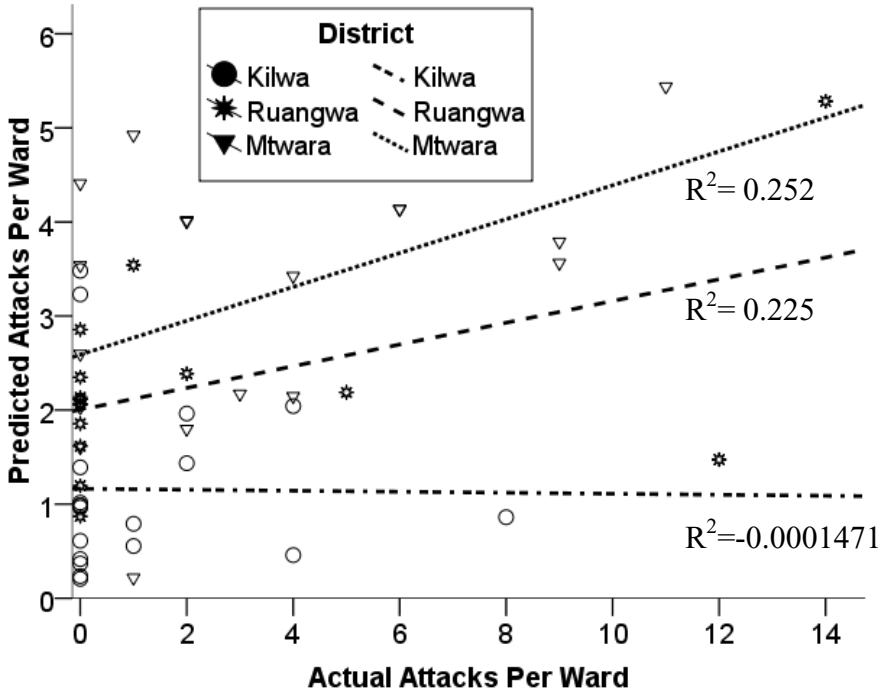

Figure 1-6: Actual versus predicted attacks for Kilwa, Ruangwa, and Mtwara districts.

Discussion

Characteristics that Influence the Likelihood of Attack

The results of Model 1 identify a number of factors that increase the probability of an attack at a given location. Probability increases as distance to the nearest attack decreases, showing that attacks tend to be clustered. Attack risk declines steadily until about 5.5km from a village, where the probability bottoms out and remains low, showing that attacks occur in areas near human habitation. Distance to water exhibits a similar effect with probabilities being high near water and declining to a constant plateau at about 3.7km. A number of studies have shown that lions prefer areas near rivers and lakes for access to water, prey, hunting cover, and den sites (Schaller 1972; Spong 2002; Ogutu & Dublin 2004; Hopcraft et al. 2005; Mosser et al. 2009). Surprisingly, distances to nearest protected area and to roads were not significant in the model. We had expected to see a protected-area effect with attacks either being higher near sources of wildlife or higher in areas where lion prey is scarce[§]. It is possible that resident lion populations in the agricultural areas are responsible for most incidents of man-eating, resulting in no clear link to protected areas. Lions are known to use roads and paths while moving through an area, and many attacks occur along roads. It is possible that our map of roads was not detailed enough to catch smaller dirt roads used by lions. The road map also did not capture footpaths used by most people.

[§] District, distance to nearest protected area, and an interaction term for district by distance to nearest protected area were all tested but none were significant or remained in the model. We also constructed a model for Rufiji district only and distance to protected area was still not significant.

A high proportion of four cover types are linked to an increase in attack probability: open woodland/bushland, both grassland and woodland/bushland with scattered crops, and bare areas. Open woodland and bushland are ideal habitats for lions, providing habitat for both grazing and browsing prey and hunting cover for lions. In a fine-scale landscape analysis of lion predation in the Serengeti National Park, Hopcraft et al. (2005) showed that lions prefer areas with hunting cover where prey are easier to catch rather than areas where prey abundance is high. Grassland and woodland//bushland with scattered crops encompass areas of small-scale agriculture occupied by both people and wildlife. The patchy nature of the landscape allows wildlife to live in close proximity to humans. In addition, people tend to live in temporary structures and stay outside to protect crops since these areas contain a high abundance of bush pigs, a common nocturnal crop pest that lure lions into agricultural areas (Packer et al. 2005; Kushnir et. al. 2010). Areas with a high proportion of bare area also have an increased likelihood of attack. These areas are mostly sandy beaches along rivers. Sand bars are cultivated during the dry season and experience high human use. Urban areas with high human population density cannot support wildlife, thus urbanization decreases attack probability.

We can group landscape changes that lead to an increase in attack probabilities into two categories: changes that lead to a loss in prey and changes that attract lions to an area. Two types of change identified by the model cause a loss in lion prey: increase in closed woodland/bushland/forest, and an increase in urban areas. Each of these changes affects the probability of attack in a different way. Conversion of land to closed

woodland/bushland/forest may increase the probability of attacks in a location by reducing the likelihood that lions can catch wild prey as grazers are forced out of the area. Spong (2002) found that lions in Selous Game Reserve show significant avoidance of woodland areas, supporting the idea than an increase in densely wooded habitat adversely affects lions. An increase in urban areas has the opposite effect: urban areas not only cause a loss in lion prey but also are environmentally unsuitable for lions. The second category of change is change that attracts lions to an area. These changes include conversion of land to grassland with scattered crops, grassland, or open woodland/bushland areas. Conversion of land to small-scale agriculture not only disrupts the ecosystem and leads to an increase in bush pigs but also makes people increasingly vulnerable, since they are in areas where they are in regular contact with wildlife. Both grassland and open woodland and bushland are preferred habitats for lions (Spong 2002; Hopcraft et al. 2005), thus an increase in this habitat near an area would increase the chance of people encountering lions, and therefore increase the chance of attack.

Extrapolating Results beyond Rufiji & Lindi

Although we were able to construct a model that identified the high-risk areas in both Rufiji and Lindi (Model 1) given attack locations, the larger question is whether we can identify high risk-areas in places where fine-scale attack data are not available. Model 2 successfully predicted attacks per ward in Rufiji, Lindi and two additional districts: Mtwara & Ruangwa. In these districts, attacks per ward were positively correlated to predicted attacks per ward. Model 2, however, failed to identify high-risk

wards in Kilwa, where actual and predicted attacks were not correlated. In Kilwa, the model under-predicted attacks in some of the wards with the most attacks and over-predicted attacks in several wards with no attacks. Kilwa district is situated between Rufiji and Lindi and experiences many fewer attacks then any of the neighboring districts. Kilwa is close to Selous Game Reserve and lions range throughout the entire district, yet Kilwa only had 22 attacks from 1990-2007. Kilwa has a population density of 12.8 people per km^2, compared to the other districts where the population densities are 38.2 (Lindi), 79.0 (Mtwara), 21.1 (Rufiji), and 45.5 (Ruangwa). It is possible, that with low human populations, much of the landscape is undisturbed, allowing lions sufficient space and prey to stay away from human settlement.

Conclusion

Techniques that identify spatial landscape characteristics predisposing areas to carnivore conflict can help to elucidate underlying causes and predict future conflicts. By modeling conflict risk in two districts with highly detailed data, we were able to predict risk in two out of three additional districts. This approach allows for the optimal implementation of conflict mitigation programs based on model predictions. For example, the identification of high-risk areas allows wildlife managers to pinpoint locations for interventions such as training local game scouts to assist in controlling man-eaters or helping villagers improve their safety. By identifying characteristics of high-risk locations, village land-use planners could encourage villagers to farm in areas that do not contain the optimal conditions for lion attacks or to maintain low-risk land cover types

near their villages. Since human-carnivore conflict greatly affects both local communities and carnivore populations, conservation biologists must identify areas most at risk in order to implement prevention measures before conflict occurs.

CHAPTER 2: Human and Ecological Risk Factors for Unprovoked Lion Attacks on Humans in Southeastern Tanzania[**]

[**] Kushnir H., H. Leitner, D. Ikanda, and C. Packer. 2010. Human and ecological risk factors for unprovoked lion attacks on humans in southeastern Tanzania. Human Dimensions of Wildlife. **15**(5). In press.

Lions (*Panthera leo*) have attacked over 1000 people in Tanzania since 1990. We worked in the two districts with the highest number of attacks, Rufiji and Lindi, and conducted interviews in two villages with high attack numbers and two neighboring villages with no attacks. Logistic regression analysis of 128 questionnaires revealed the following risk factors: ownership of fewer assets, poorly constructed houses/huts, longer walking distances to resources, more nights sleeping outdoors, increased sightings of bush pigs (*Potamochoerus porcus)*, and lower wild prey diversity. A comparative analysis revealed significant differences between the two districts: while high bush pig and low prey numbers affected both districts, hut construction was only significant in Rufiji, and walking distances, asset ownership, sleeping outdoors, and house construction were only significant in Lindi. Such information will help relevant authorities develop site-specific methods to prevent lion attacks and can inform similar research to help prevent human-carnivore conflict worldwide.

Introduction

An increase in human population and the resulting ecological impacts have led to an increase in human-wildlife conflict throughout the world (Fall & Jackson 2002), making it one of the foremost issues facing wildlife conservation today (Woodroffe et al. 2005b). This is particularly true for carnivores. Human population growth has led to encroachment into wildlife areas, alteration of carnivore habitat, and depletion of prey populations, while successful conservation has allowed for the recovery of several carnivore populations (Treves & Karanth 2003a; Quigley & Herrero 2005; Bagchi & Mishra 2006). Carnivores have the potential to cause serious economic damage and even harm humans, diminishing public support for wildlife conservation and motivating the extermination of problem animal species (Treves & Karanth 2003b; Loe & Roskaft 2004). Persecution by people in response to conflict – real or perceived – is one of the main factors in carnivore population declines around the world (Woodroffe 2001; Woodroffe & Frank 2005).

A severe example of direct human-carnivore conflict recently occurred in Tanzania where lions have attacked over 1000 people between 1990 and 2007 (updated from Packer et al. 2005). The situation is unusual in that most attacks involved lions entering settlements and agricultural areas, apparently in search of humans (Baldus 2004; Packer et al. 2005). Tanzania is home to 25-50% of all African lions, making it a critical country for lion conservation (Chardonnet 2002; Bauer & Van Der Merwe 2004). Not only are lions important top predators to the natural ecosystem, but they are also of great

economic importance to Tanzania, where nature-based tourism, including trophy hunting and photographic tourism, is the second largest source of foreign revenue (Wade et al. 2001).

Until recently, there have been few published studies of lion attacks on humans. The studies that do exist take a case-study approach, view the issue from a natural history perspective, or examine lion health as a cause of the problem (Yamazaki & Bwalya 1999; Peterhans & Gnoske 2001; Patterson et al. 2003; Baldus 2004, 2006). In 2005, Packer et al. published a study of 231 attacks across Tanzania, which broadly identifies important risk factors and patterns in human activities during attacks. The study found that lion attacks tend to be highest in districts with high abundances of bush pigs and low abundances of other natural prey. Most attacks occur when people are tending crops in their agricultural fields, and concurrently, 39% of the surveyed cases occur during harvest time (March-May). Bush pigs are a major risk factor, as people sleep in their fields in makeshift huts to protect their crops from this nocturnal agricultural pest. Farmers also report seeing lions enter their fields in pursuit of bush pigs. Along with tending and protecting crops, other common activities during attacks include walking alone in the early morning and evening hours, using the outhouse at night, and participating in retaliatory lion hunts.

Although the Packer et al. (2005) study identifies activities that put people at risk and broad-scale risk factors related to lion prey and bush pigs, it does not examine variations in human activities linked to risk. Our study examines human and ecological

risk factors in greater detail and at both the district- and village-level. We consider wildlife presence as well as human factors, including: asset ownership, distances to key resources, amount of time sleeping in agricultural fields/outdoors, and house/hut construction. We conducted the study in the two districts with the highest number of attacks reported in the Packer et al. (2005) study: Rufiji and Lindi. Within each district, certain areas experience a high number of attacks while others were free of conflict despite being in close proximity to attack hotspots, indicating that local variation in ecology and/or human activities may influence the probability of an attack. Examining variations in human activities and wildlife presence at the village- and district-levels will therefore provide a more nuanced view of the risk factors for lion attacks.

Methods

Selection of Study Areas

This study focuses on the two districts with the highest number of lion attacks since 1990, as identified in the Packer et al. (2005) study (Figure 2-1). Rufiji district had 101 attacks between 1990 and 2007 while Lindi district had 190 attacks in the same period (updated from Packer et al. 2005). Rufiji's human population totals just over 200,000 in ~98 villages; Lindi is home to just over 250,000 in ~129 villages. However, Lindi, with an area of 6,732 km^2 is more densely populated (37 people/km^2) than Rufiji (21 people/km^2), whose habitable area covers 9,645 km^2. Rufiji contains part of a major protected area, the Selous Game Reserve, which is also a source of wild lions, whereas Lindi is not near any major protected areas. Thus, Rufiji has a large number of lions, bush

pigs, and other natural prey, whereas Lindi has fewer lions, bush pigs, and other natural prey (Kushnir & Ikanda, personal observation, 2005).

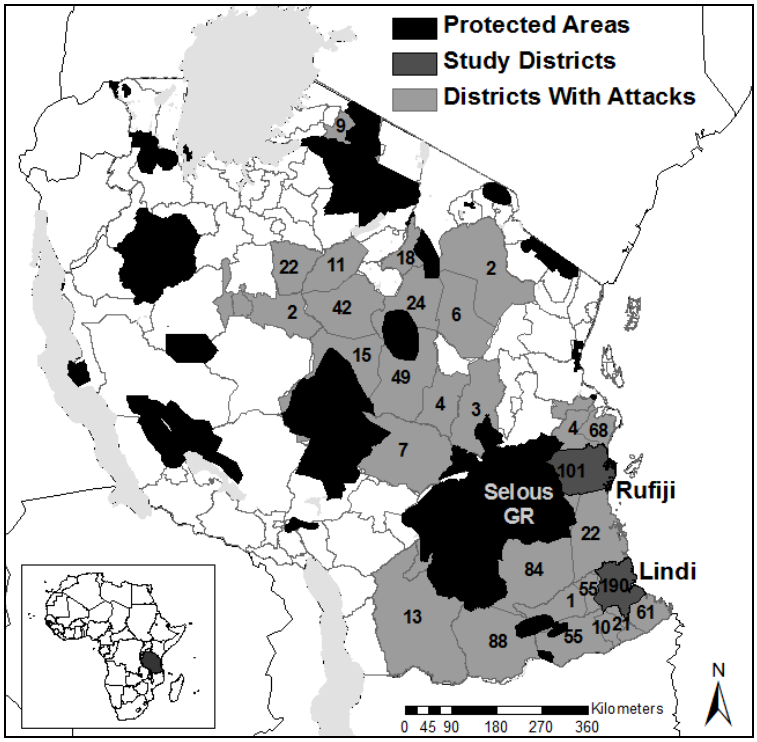

Figure 2-1: Number of attacks per district across Tanzania from 1990-2007.

Within each district, we chose areas that had the highest concentration of attacks according to government records. Figure 2-2 shows the Rufiji study area, the Rufiji River Valley, which encompasses two wards just east of the Selous Game Reserve. Figure 2-3 shows the Lindi study area, termed the Sudi-Mingoyo Area, which encompasses three wards in the southeastern portion of the district. Both areas experienced an outbreak of lion attacks that began between 2001 and 2002 and ended in 2004. In each study area, we selected two villages with a high number of attacks and two villages with no attacks in

close proximity to attack villages and with similar land cover types. An "attack village" is one that experienced an attack on humans within the boundary of the village, including the land used for cultivation by its villagers. We made site visits to verify that villages selected as "non-attack villages" were attack free from1990-2007. By selecting villages in this manner, we are able to compare human activities and wildlife presence in villages with different attack histories while controlling for environmental conditions. In addition, all villages have similar livelihood strategies (small-scale agriculture), wealth status, and religion (primarily Islam). We confirmed the presence of lions in all villages so that differences in attacks were not due to the absence of lions.

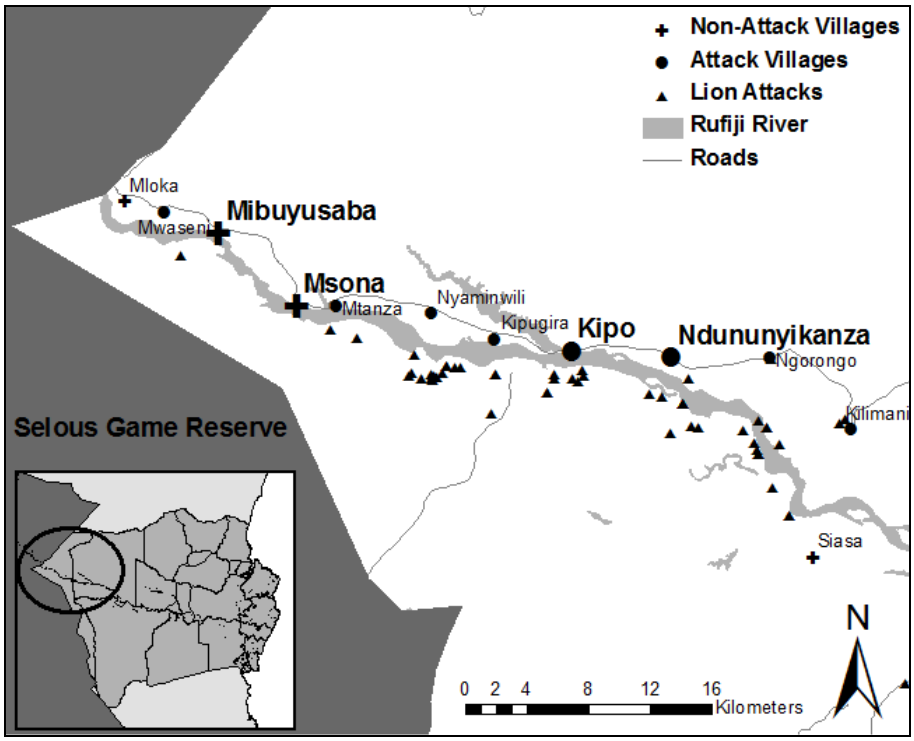

Figure 2-2: Rufiji River Valley study area, Rufiji district. Study villages are in bold with larger symbols.

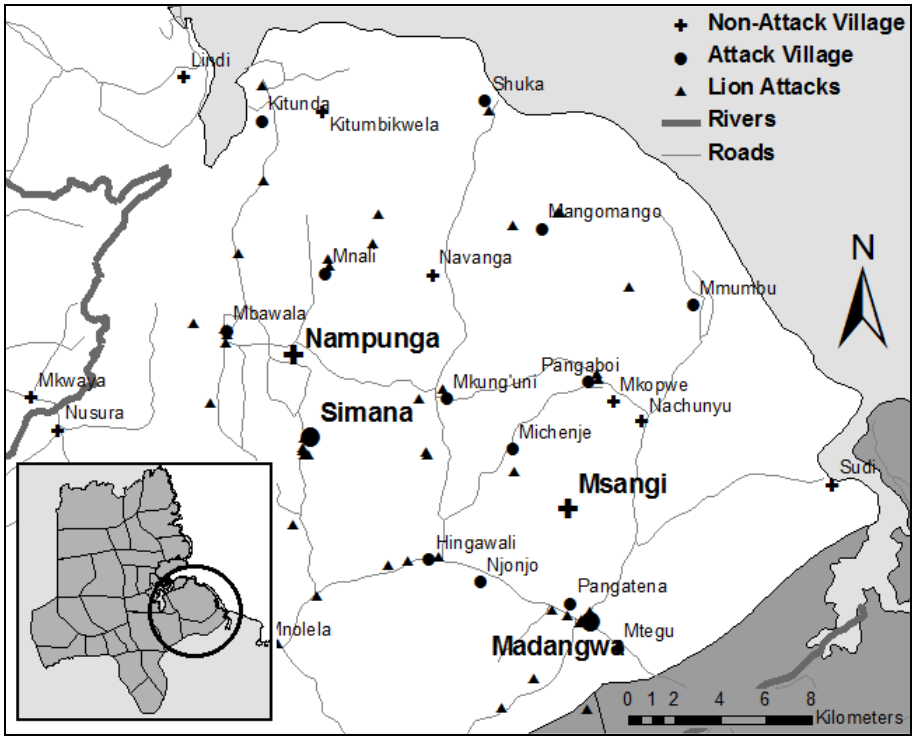

Figure 2-3: Sudi-Mingoyo study area, Lindi district. Study villages are in bold with larger symbols.

Data Collection

We collected two types of data: human activity patterns during lion attacks, and human activities and wildlife presence in attack and non-attack villages. We began by cross checking Packer et al. (2005) data with district records and obtaining information on more recent attacks. We then traveled from village to village inquiring about all attacks that occurred from 1990-2007. We uncovered a number of unreported cases by inquiring directly in each village; any remaining unreported cases are likely to be randomly distributed and of equal proportion in both districts. We focused solely on "unprovoked" attacks, which included any attack that did not occur during a lion hunt (discounting 17 attacks). We collected data on human activities during lion attacks

through interviews with village leaders, survivors, or family members. The district records generally provide the date, name, age and sex of the victim, and we collected additional data such as the time and location of the attack and what the victim was doing at the time of attack. Whenever possible, we obtained accounts from witnesses or people who visited the scene shortly after an attack to avoid bias from non-witness statements.

To compare villages with and without a history of attacks, we collected data on socioeconomics, daily activities, personal safety, wildlife presence, and attack prevention through questionnaire-based interviews (see Appendix 2 for questionnaire). With the assistance of an interpreter, we conducted sixteen interviews in each of the eight study villages, for a total of 128 interviews. Households were selected at random through village registers, and male and female heads of household were selected alternately to assure an even gender ratio. Although some of the questions were household level questions, most of the questionnaire focused on individual-level data.

Data Analysis

We used chi-square analysis to compare human activity patterns during lion attacks between the two districts. To identify risk factors, we conducted a series of backwards linear stepwise logistic regressions. Logistic regressions compared human activities and wildlife presence between villages with and without attacks by treating the study like a case-control design, where people in villages with attacks were assigned 1 and people in non-attack villages assigned 0. Three regression analyses were conducted: one with data from both Rufiji and Lindi and one each for Rufiji and Lindi separately.

For the regressions, we consider variables significant if they had a *p*-value of less than 0.05, but considered any variable with $p < 0.10$ as worthy of discussion. Table 2-1 provides a description of each variable in the model.

Table 2-1: Description of variables in logistic regression models

Variable*	Description
Main home located on agricultural field	According to interviewee & assessment of interviewer
Number of assets owned	Count of prompted list of eight assets
Number of problem species reported	Count of unprompted list of animals specified by interviewee as crop pests
Walking distance to firewood (minutes) Walking distance to water (minutes) Walking distance to neighbors (minutes)	Walking distance in minutes from home as reported by interviewee, we averaged times if interviewee had more than one home (i.e. in village center & agricultural field)
Days walked to agricultural field per year	We determined which months people go to agricultural fields, then how many days per week in each month, and calculated the total
Nights slept in agricultural field per year	We determined which months people sleep in their agricultural field, then how many days per week each month, and calculated the total
Nights slept outdoors per year	We identified what traditional activities caused each individual to sleep outdoors, then asked how many nights per year they sleep outdoors for each activity, and calculated the total
Days per year bush pigs sighted in village center Days per year bush pigs sighted in agricultural field	If interviewee specified that they see bush pigs in their village or agricultural fields, we determined which months, then how many times per week in each month, and calculated the total
Number of lions prey types sighted	Interviewees pointed to and named animals from a page of pictures of common lion prey, none of the animals were the same as crop pests mentioned.

House safety - Level 1: Elevated & non-elevated thatch hut - Level 2: Mud/brick house, thatch roof - Level 3: Mud/brick house, metal/wood roof	Interviews were always conducted at the main home of the interviewee. We observed and recorded information on each aspect of house construction (walls, roof, door, & floor). Note that coding was slightly different in the Lindi model because there were no thatch houses in Lindi.
Hut safety - Level 1: Elevated thatch & pole hut - Level 2: Non-elevated thatch & pole hut - Level 3: Mud/mud brick house - Level 4: Does not sleep in agricultural field	We considered huts to be any structure in which people temporarily reside in an agricultural field. We questioned interviewees on each aspect of hut construction (walls, roof, door, & floor). Note that coding was slightly different in the Rufiji model because mud/mud brick huts were rare.

*These represent only the variables that remained in the models after the backwards stepwise logistic regression. A number of additional variables were included in the original models but were not significant: number of livestock owned, walking distance to agricultural field (minutes), sighting of lions in village centers and in agricultural fields, sighting of lion signs in village centers and in agricultural fields.

Results

Variations in Human Activity Patterns during Lion Attacks between Districts

A number of human activity patterns varied significantly between districts. Most notable were the location and activity of victims during attacks, and the time of day when the attack occurred. In Rufiji, the majority of attacks occurred inside structures in agricultural fields (45%), whereas in Lindi, cases largely occurred outside structures in agricultural fields (39%), outside homes in the village center (31%), as well as on roads or paths in areas peripheral to the village center (19%) ($X^2 = 104.02$, $p < 0.01$) (Figure 2-4). Although both districts experienced a large proportion of attacks in agricultural fields, site visits revealed that significantly more of the Lindi attacks (39%) occurred inside village centers as compared to Rufiji (11%) ($X^2 = 23.25$, $p < 0.01$). The victims' activities during attacks also differed substantially between districts ($X^2 = 87.66$, $p <$

0.01) (Figure 2-5). In Rufiji, 43% of attacks occurred when individuals were resting, sitting, or sleeping inside their home. In Lindi, attacks were more common when people were walking (36%), using the outhouse or bathing (27%), or resting outside their homes (18%). In Rufiji, most victims were accompanied by other people at the time of the attack (59%), but in Lindi, most victims were alone (65%) ($X^2 = 9.27$, $p < 0.05$). In Rufiji, the majority of cases occurred at night (62%), while most cases in Lindi occurred in the late evening (45%) ($X^2 = 22.39$, $p < 0.01$) (Figure 2-6).

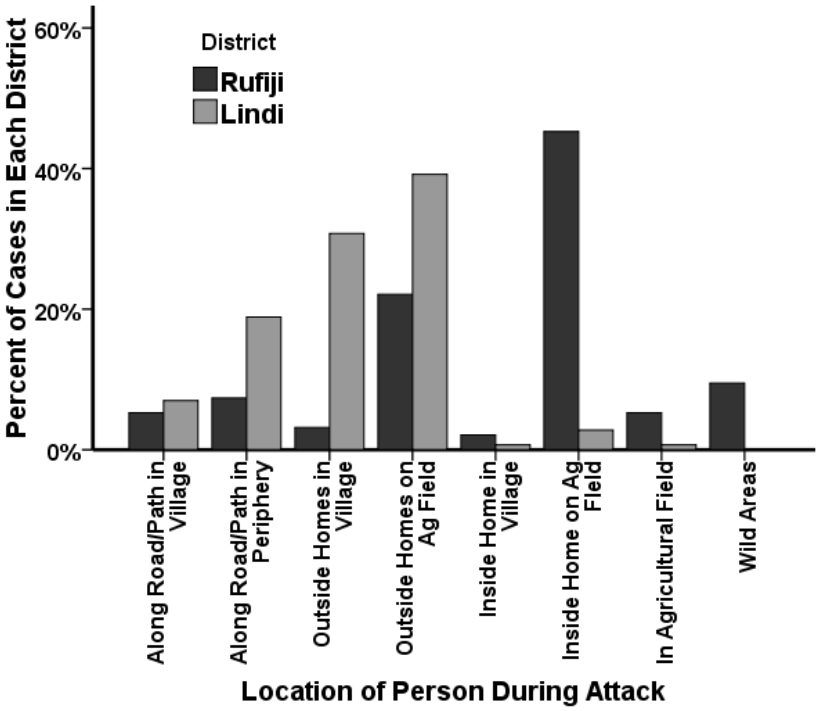

Figure 2-4: Percent of lion attacks at each location in Rufiji and Lindi districts.

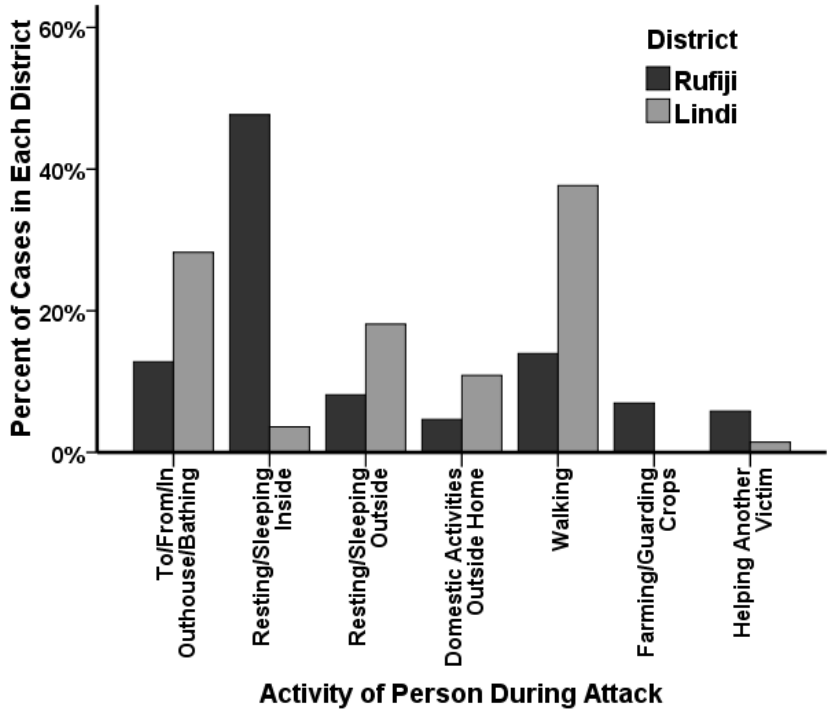

Figure 2-5: Percentage of attacks in each activity category for Rufiji and Lindi.

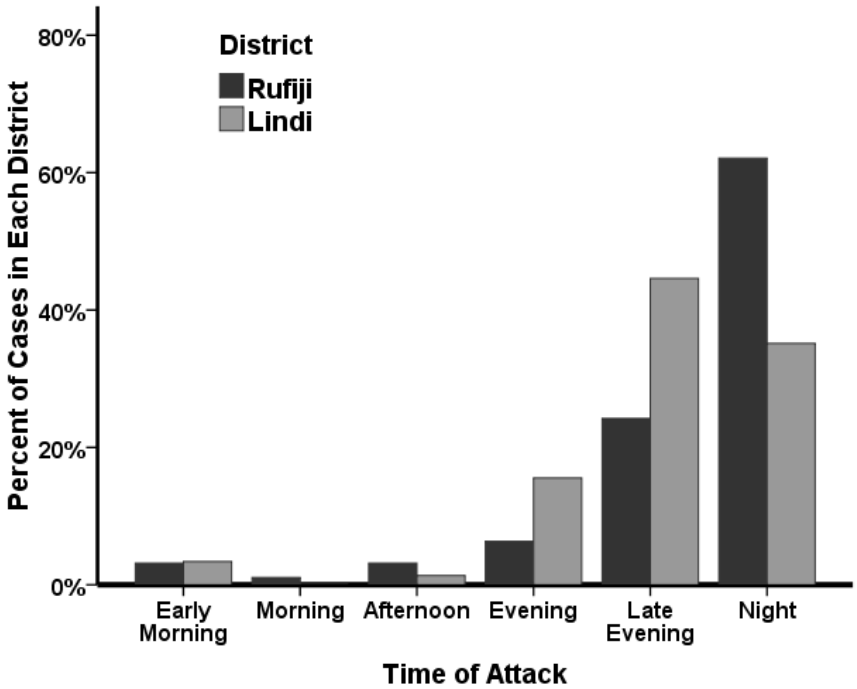

Figure 2-6: Percent of attacks at each time category for Rufiji and Lindi.

Variations in Risk Factors between Village Types and Districts

Results from the logistic regression using data from both districts identify factors that differentiate attack and non-attack villages. Compared to villages without attacks, people in attack villages walk longer distances to water, firewood, and neighbors, see bush pigs more frequently in agricultural fields, see fewer types of problem species and lion prey, spend fewer nights sleeping in agricultural fields, spend more nights sleeping outside for traditional ceremonies, such as funerals and weddings, own fewer assets, and live in weaker structures in village centers and agricultural fields (Table 2-2).

Table 2-2: Results of combined logistic regression model for both districts showing risk factors for lion attacks

Variable	B	SE	Wald	df	*P*
Gender[a]	-1.65	0.786	4.39	1	0.036
Age[a]	-0.06	0.032	2.96	1	0.086
Main home located on agricultural field[a]	-1.78	2.166	0.67	1	0.411
District[a]	2.38	1.937	1.51	1	0.220
Number of assets owned***	-1.43	0.450	10.16	1	0.001
Number of problem species reported**	-1.01	0.452	5.04	1	0.025
Walking distance to firewood (min)*	0.02	0.013	3.10	1	0.078
Walking distance to water (min)***	0.04	0.015	9.04	1	0.003
Walking distance to neighbors (min)**	0.28	0.109	6.50	1	0.011
Nights slept in agricultural field per year*	-0.02	0.009	3.21	1	0.073
Nights slept outdoors per year**	0.03	0.015	3.97	1	0.046
Days per year pigs sighted in village center	0.01	0.005	2.31	1	0.129
Days per year pigs sighted in agricultural field***	0.03	0.008	10.26	1	0.001
Number of lions prey types sighted***	-0.83	0.270	9.43	1	0.002
House safety level 1 (thatch hut)			5.87	2	0.053
House safety level 2 (mud/brick house, thatch roof)**	-3.57	1.719	4.31	1	0.038
House safety level 3 (mud/brick house, metal/wood roof)**	-4.86	2.011	5.83	1	0.016
Hut safety level 1 (elevated thatch hut)			8.68	3	0.034
Hut safety level 2 (ground level thatch hut)	-2.04	1.819	1.26	1	0.262
Hut safety level 3 (mud/mud brick house)**	-6.18	2.431	6.45	1	0.011
Hut safety level 4 (does not sleep in agricultural field)***	-6.80	2.462	7.62	1	0.006
Constant	13.07	4.126	10.03	1	0.002

[a] These variables were controlled for and therefore never dropped from the model
Significance ***$p<0.01$, **$p<0.05$, *$p<0.10$

Results from the logistic regressions for each individual district identify district-specific risk factors. The logistic regression for Rufiji revealed four main factors that distinguished attack from non-attack villages (Table 2-3): people in attack villages see more bush pigs in agricultural fields and village centers, see fewer problem species and fewer lion prey types, and build weaker structures in agricultural fields than people in

non-attack villages. Seven factors that distinguish attack villages in Lindi were identified by the logistic regression model (Table 2-4): people in attack villages own fewer assets, walk farther to firewood and water, spend more nights sleeping outdoors for traditional ceremonies, see bush pigs more frequently in agricultural fields, see fewer types of lion prey, walk to their agricultural fields on fewer days a year, and built weaker houses.

Table 2-3: Results from logistic regression model for Rufiji district showing district specific risk factors

Variable	B	SE	Wald	df	*P*
Gender[a]	-0.08	0.976	0.01	1	0.933
Age[a]	-0.01	0.034	0.02	1	0.880
Main home located on agricultural field[a]	-0.64	0.876	0.53	1	0.467
Number of problem species reported*	-0.84	0.453	3.40	1	0.065
Days per year pigs sighted in village center*	0.01	0.005	3.66	1	0.056
Days per year pigs sighted in agricultural field**	0.01	0.005	6.00	1	0.014
Number of lions prey types sighted**	-0.43	0.191	4.96	1	0.026
Hut safety (elevated thatch hut)			6.09	2	0.047
Hut safety (ground level thatch/mud/mud brick structure)**	-4.26	1.743	5.97	1	0.015
Hut safety (does not sleep in agricultural field)	0.17	1.508	0.01	1	0.911
Constant	3.78	2.595	2.12	1	0.145

[a] These variables were controlled for and therefore never dropped from the model
Significance ***$p<0.01$, **$p<0.05$, *$p<0.10$

Table 2-4: Results from logistic regression model for Lindi district showing district specific risk factors

Variable	B	SE	Wald	df	*P*
Gender[a]	-2.47	1.457	2.88	1	0.090
Age[a]	-0.03	0.052	0.29	1	0.587
Number of assets owned**	-2.01	0.884	5.19	1	0.023
Walking distance to firewood (min)**	0.08	0.032	5.90	1	0.015
Walking distance to water (min)**	0.09	0.034	7.40	1	0.007
Days walked to agricultural field per year*	-0.02	0.012	3.72	1	0.054
Nights slept outdoors per year**	0.10	0.045	4.63	1	0.031
Days per year bush pigs sighted in agricultural field**	0.05	0.023	4.85	1	0.028
Number of lions prey types sighted**	-1.84	0.801	5.29	1	0.021
House safety (mud/brick/cement house, metal/wood roof & door)			7.51	2	0.023
House safety (mud/brick house, thatch roof, metal/wood door)**	3.78	1.793	4.45	1	0.035
House safety (mud/brick house, thatch roof, thatch/pole door)	-1.40	1.723	0.66	1	0.418
Constant	5.19	4.466	1.35	1	0.245

[a] These variables were controlled for and therefore never dropped from the model
Significance ***p<0.01, **p<0.05, *p<0.10

Variations in Attack Prevention between Village Types and Districts

The two districts showed significant differences in the precautions people took to protect themselves against lion attacks ($X^2 = 17.34$, $p < 0.05$) (Figure 2-7). Although in both Rufiji and Lindi people frequently stated that they stay inside after dark, the proportion in Rufiji (55%) was lower than in Lindi (79%). In addition, in Rufiji, a larger proportion of people construct stronger homes and fences (17%), and become more vigilant (13%). In Lindi, a higher proportion of people reported that they avoided moving around unnecessarily during the day (11%). Despite these differences between districts,

there was no significant difference in precaution responses between attack and non-attack villages within each district.

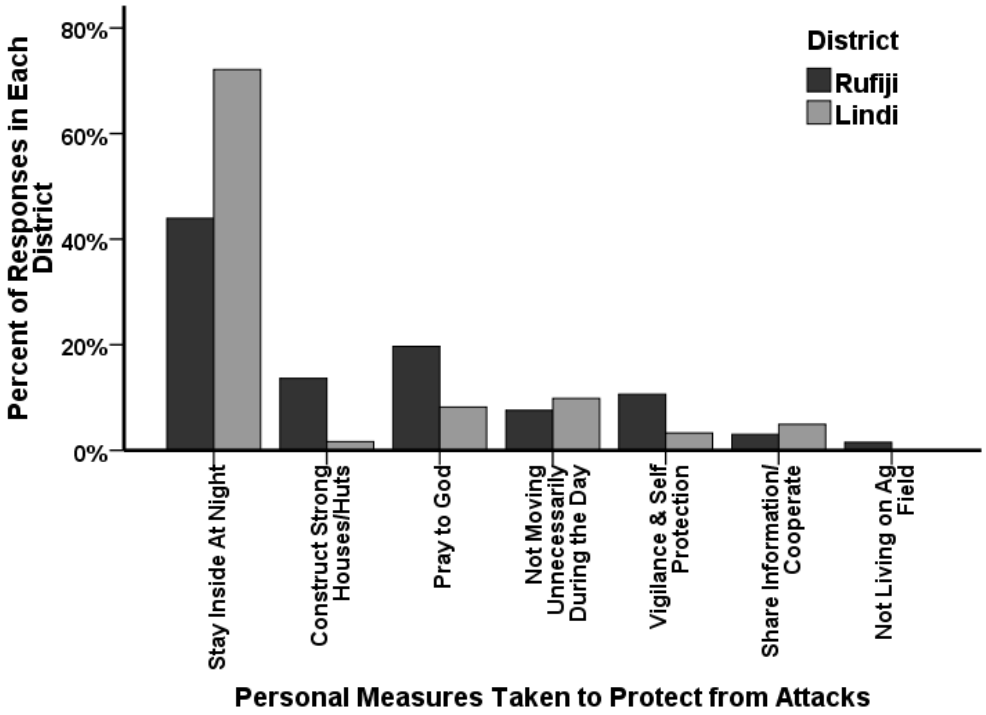

Figure 2-7: Measures people take to protect themselves from attacks.

We asked respondents about the effectiveness of measures to prevent attacks by lions on humans (Figure 2-8). In all of the measures but bush pig control, results from Rufiji and Lindi were not significantly different. Overall, people thought it would be effective to build safer structures in agricultural fields (60%), build safer homes (62%), walk in larger groups (52%), cut tall grass near homes (61%), and erect fences around their yard to enclose outhouses and cooking areas (66%). People thought it would be ineffective to avoid sleeping in agricultural fields (44%), change the location of

agricultural fields (22%), and cut high grass along commonly used paths (45%). As for bush pig control, a slight majority (52%) in Rufiji said yes, or yes with stipulations, while in Lindi, 70% of people said bush pig control would not help prevent attacks ($X^2 = 6.02$, $p < 0.05$). In some cases, people stipulated how a particular measure might become more effective. For example, 19% of interviewees said yard fences would help as long as the fences were strong or tall.

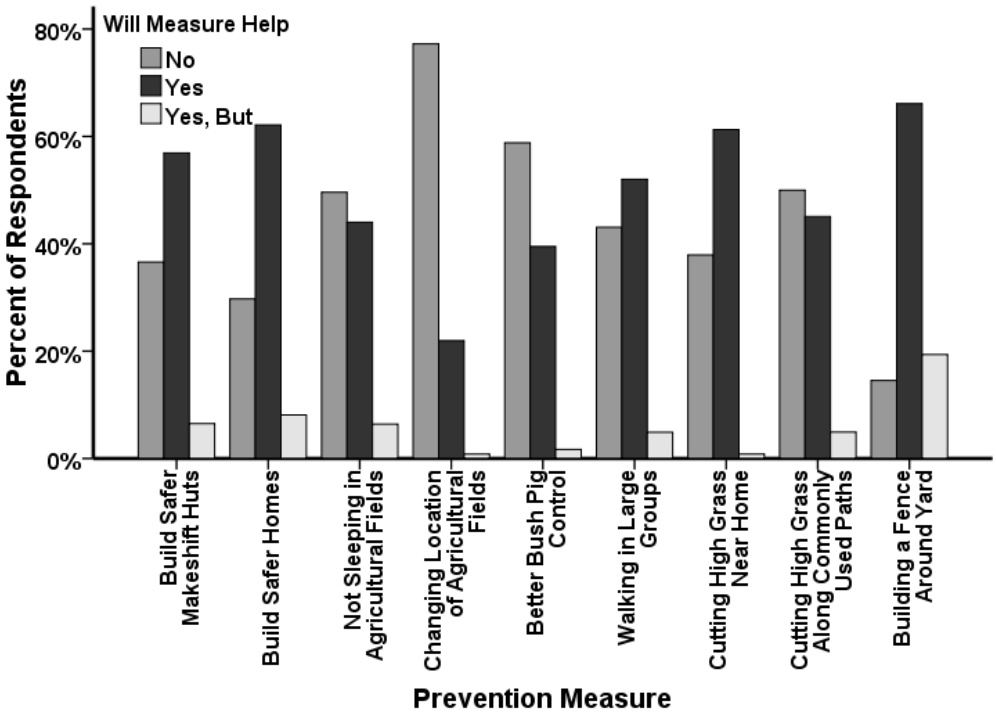

Figure 2-8: Responses of interviewees when asked if they thought specific actions would help prevent lion attacks.

We stratified responses about effective prevention measures by village type within each district. In Rufiji, people in attack villages were more likely to think that lion attacks could be prevented by building safer huts ($X^2 = 5.43$, $p < 0.05$), not sleeping in

agricultural fields ($X^2 = 4.52$, $p < 0.05$), shifting the location of agricultural fields ($X^2 = 3.95$, $p < 0.05$), and cutting grass around homes ($X^2 = 3.92$, $p < 0.05$). In Lindi, people in attack villages were more likely to think that walking in larger groups would help prevent attacks ($X^2 = 4.36$, $p < 0.05$).

Villagers in both districts and in both village types gave statistically similar responses when questioned on what should be done to reduce lion attacks. Government assistance was the most common response (42%), which includes providing security, hunting offending lions, and providing resources to respond to attacks. Only 18% mentioned killing lions, and 14% mentioned the need for village game scouts to respond to attacks. Less than 10% of respondents mentioned measures like providing villagers with guns, more cooperation between villages, personal precautions such as building stronger homes, advice about conflict mitigation from researchers, and clearing bushes.

Discussion

Qualitative Differences between Districts

Differences in both ecology and culture provide a framework for understanding risk factors for lion attacks. The villages in Rufiji lie along the Rufiji River, on which the villagers are dependent for water and food. Although the village centers lie on the north side of the river, the fertile areas are to the south. This means that people need to cross the river daily or live in their agricultural fields to tend and protect their crops. Since the primary livelihood is subsistence agriculture, villagers spend considerable time on the south side of the river. At the same time, the village centers – schools, shops, people's

homes - and the main road lie to the north of the river, requiring villagers to travel between the village centers and the agricultural fields. Since most people have a home at the village center, they build temporary structures on the south side of the river, where they spend most of their time during harvest seasons for upwards of seven to ten months per year. The harvest season is a critical time to sleep in agricultural fields, as pests like bush pigs, warthogs (*Phacochoerus africanus*), vervet and blue monkeys (*Allenopithecus nigroviridis, Cercopithecus mitis*), yellow baboons (*Papio cynocephalus*), and even elephants (*Loxodonta africana*), come regularly to raid crops. Anecdotal evidence from villagers suggests that lions are predominantly found on the south side of the river and are at least partially blocked from moving into the villages by the river.

Much like in the Rufiji River Valley, people in the Sudi-Mingoyo Area of Lindi district subsist mainly on small-scale agriculture, but unlike in Rufiji, they have no clear physical feature that defines the location of agricultural fields. Thus, agricultural fields can be anywhere from a five minute walk to a two and a half hour walk each way from village centers, but overall they tend to be closer to village centers on average than in Rufiji. In addition, people rarely choose to sleep in their agricultural fields, but rather spend most of the year in their homes in the village centers. This is most likely because the main crop pests in Lindi, monkeys, are diurnal and do not require people to protect crops at night, whereas in Rufiji, one of the main crop pests are bush pigs, a nocturnal species. Another difference between Rufiji and Lindi is the location of water. Unlike in Rufiji, people in Lindi do not fetch water from a river; instead, they use water pumps in

the village or travel to wells. The distance traveled each way to wells can be as long as an hour, and even when there are water pumps in the village, they may be dry, causing people to walk to neighboring villages.

District-Level Variations in Human Activity Patterns during Lion Attacks

Along with an awareness of the ecological and cultural difference between the districts, data on human activity patterns during lion attacks provides further information for understanding key differences between Rufiji and Lindi districts. In Rufiji, the majority of attacks occurred at night, inside structures located in agricultural fields while people were sitting, resting, or sleeping inside. Victims in Rufiji therefore tended to be accompanied by other people during the attacks. In Lindi, attacks mostly occurred outside homes in either the village center or agricultural fields, while people were conducting various domestic activities or walking along roads and paths outside the village center. The attacks in Lindi predominantly occurred in the late evening, while individuals were alone, walking home or preparing to retire for the night.

District-specific conditions explain these results. In Rufiji, the separation created by the river causes attacks to be located primarily in agricultural fields, where more lions are present and where people often sleep in unsafe structures. In Lindi, there are no barriers between agricultural fields and village centers, therefore lions move freely and attack people in both locations. Since most people in Lindi do not sleep in their agricultural fields, and since walking distances to resources are quite variable, people are more susceptible to attack while walking along paths and roads. In addition, since village

homes are stronger than structures on agricultural fields, most attacks occur outside homes.

Village-Level Variation of Risk Factors

It is clear from the analysis of the questionnaire data that human activities and wildlife presence varies between villages with and without a history of attacks. Since we chose villages with similar ecological surroundings, these differences should help clarify the factors that increase the risk of lion attacks. Due to the small number of study villages, statistical differences could have resulted from chance or unmeasured variables, however, most of the significant factors relate to obvious risk factors. Additionally, differences do not come from lion absence, as all villagers reported lions roaming through their village during the 2001-2004 outbreaks and lion presence was not a significant variable in any logistic regression models.

Six key determinants emerge from the logistic regression of village-level variation that combines both districts: distance walked to resources, bush pig presence, wild prey diversity, sleeping outdoors, socioeconomic variables, and home safety. People in attack villages walk longer distances to firewood, water, and neighbors than people in villages without attacks. On average, people will walk 52 min per day for firewood with some people traveling two hours each way, not including the time spent collecting firewood in unsafe areas. People usually retrieve water two to three times a day and walk an average of 20 min each way with some traveling up to two hours to arrive at water. People also spend time visiting neighbors, traveling an average of about five minutes, though

occasionally walking as long as 30 min, often in the evening hours. With no electricity and lions roaming freely, even a short walk to a neighbor's house after dark can pose a significant risk. Distance to agricultural fields was surprisingly not a significant variable in the model.

People see bush pigs more frequently in attack villages as compared with non-attack villages. Bush pigs increase the risk of attack in two ways. First, bush pigs are major nocturnal crop pests that force people to sleep in their agricultural fields and even leave their huts in the middle of the night to chase bush pigs away. Secondly, bush pigs are a key lion prey species in places depleted of other prey, drawing lions into human-dominated areas. To compound things further, the human population of Rufiji and Lindi is predominantly Muslim, so people will not eat and rarely kill any type of pig. This ensures that bush pigs thrive in agricultural areas, despite being a major pest. Similar examples of the relationship between large cats and wild pigs are documented in Sumatra, another largely Muslim society, where wild pigs (*Sus scrofa*) draw tigers (*Panthera tigris*) into oil palm plantations. Much like with lions, pigs allow tigers to live in highly disturbed human dominated areas because they thrive as crop pests in the same areas (Maddox et al. 2003).

People in attack villages see fewer types of other crop pests and lion prey than people in non-attack villages. Other crop pests include warthogs, monkeys, baboons, rodents, and elephants. Lion prey includes giraffe (*Giraffa camelopardis*), Grant's gazelles (*Gazella granti*), impala (*Aepyceros melampus*), bushbuck (*Tragelaphus*

scriptus), duiker (*Cephalophus spp.*), and dikdik (*Rhynchotragus kirki*). Both categories of animals indicate levels of wildlife diversity and abundance. These results support earlier findings that lion attacks occur in areas where lions have a harder time finding food (Packer et al. 2005).

Another difference identified by the model is that people in attack villages spend more nights sleeping outdoors for weddings, funerals, memorial services, cultural festivals, and religious events. On these occasions, people will travel to other villages or homes within their village and often spend a few nights sleeping outside. For example, at funeral ceremonies, visitors sleep outside the home of the deceased for two to three nights. Lions have been known to attack individuals in large groups of sleeping people (unpublished data), further supporting this finding.

Results show that villages with wealthier individuals are less likely to be attacked than poorer villages, presumably because of greater resources for more solidly built homes and other protective measures such as fences. Indeed people in villages without attacks tend to live in more solidly built homes, while people in attack villages are more likely to live in homes built from thatch and grass. People in attack villages are also more likely to live in grass and thatch structures in their agricultural field, whereas people in non-attack villages either build mud structures or do not sleep in their agricultural fields. One noteworthy result warranting further investigation is that people in non-attack villages sleep in agricultural fields more nights a year then people in attack villages ($p < 0.10$). This may be because more people in non-attack villages live full-time in their

agricultural field and invest in safer structures. Our data on hut safety show that sleeping in a secure structure made of mud or mud brick in an agricultural field is as safe as sleeping away from the field altogether. By sleeping in a secure structure, people can remain safe even in agricultural fields where attack risk is high.

Given the different environmental contexts discussed above, we can identify location-specific risk factors. In Rufiji, most attacks occur in agricultural fields, and risk is associated with bush pig sightings, decreased lion prey diversity, and poor agricultural hut construction. Although risks in Lindi are also associated with bush pigs, prey diversity, and weaker home construction, there are no barriers to lion movement and attacks are not confined to agricultural fields. Thus, attacks in Lindi are also associated with longer walking distances to resources, and more nights spent sleeping outdoors for traditional ceremonies. Although only significant at $p<0.10$, our data suggests that people in attack villages in Lindi may walk to agricultural fields fewer days a year than people in non-attack villages, suggesting that walking to agricultural fields is not a risk factor. This is further supported by the fact that distance to agricultural field was not significant in any of the three regression models.

Attack Prevention

In order to formulate methods to prevent future attacks and to understand how people perceive risk, it is important to determine how people react to lion attacks, what kinds of precautions they take, and what they think should be done to reduce attacks. Villagers in Rufiji and Lindi respond to location-specific risk factors. The most common

personal safety measure in both districts is to stay indoors after dark. Yet in Rufiji, people also build stronger homes and fences and show greater vigilance. In Lindi, where attacks occur just outside homes or while walking in peripheral areas, people mainly stay indoors at night or reduce unnecessary movement during the day.

The same location-specific pattern emerges when analyzing individuals' responses about recommended preventive measures. People from both districts generally agree on the utility of each method except for bush pig control. Bush pigs are the primary reason why people reside in agricultural fields in Rufiji – the same place where most lion attacks occur. Thus, it follows that people in Rufiji recognize a direct link between bush pigs and lion attacks and are more likely to consider controlling bush pigs as a means to reduce attacks.

Aside from bush pig control, people in both districts agreed on which measures would help prevent attacks. Since all of the methods we recommended could conceivably reduce attacks, the measures considered helpful by the majority of villagers were actually the tactics people thought they themselves could undertake. These responses do not necessarily identify measures that could best prevent attacks but instead identify measures that people believe are feasible and effective at the village level. Building safer structures and fences, walking in larger groups, and cutting grass around homes are all measures people can accomplish, even with limited resources. However, not sleeping in agricultural fields, shifting agricultural fields, controlling bush pigs, and cutting grass along all commonly used paths are all measures that are hard for people to accomplish, or

may lead to repercussions they cannot afford such as a limited crop harvest. Any project aimed at reducing attacks needs to be cognizant of such local-scale feasibility.

Villagers' views on strategies to reduce lion attacks offer insight into who they feel is or should be responsible for addressing the problem. The most common response was that government should provide assistance by removing lions and providing guns, game scouts, and security. Villagers also mentioned government assistance in vague terms with no specifications on the form of assistance and looked towards researchers to provide assistance. Only a small number of responses accepted full personal responsibility for dealing with lion attacks (personal protection measures, intra- and inter-village cooperation), although some responses such as hunting and killing lions, and clearing bushes suggested partial personal responsibility. The response to this question suggests that people feel somewhat detached from solutions; although lion attacks directly affect them, they do not feel like they have the ability to prevent future attacks.

One noteworthy finding is that people do not immediately suggest the eradication of lions. Even those who advocate lion control rarely state that all lions should be eliminated, instead, they say that the offending lion(s) should be hunted. This shows a surprising level of tolerance for lions given the high number of attacks in both districts. Of course, it is possible that our identity as lion researchers influenced responses to these questions. However, having spent many months talking to village leaders, relatives of victims, and survivors of attacks, we have found that lion attacks are a very emotional topic, and people generally do not hold back when discussing their fear, lack of control,

or anger over the slow response from wildlife managers. If they are open about these issues, we believe that they are also being honest about not wanting to eliminate lions.

Conclusion

Our study identified distinct district- and village-scale risk factors for lion attacks. Our results support current knowledge by linking villages with lion attacks to low prey diversity and a high abundance of bush pigs, and identify additional risk factors linked to human activities. We show the need to investigate local-scale variations when developing tools to prevent human-carnivore conflict. Solutions tailored for Rufiji would not always be relevant in Lindi, but certain factors, like bush pigs, lion prey, and home/hut construction, are more universal. Our results also show that local responses to conflict often mirror the main risk factors, but that measures suggested by researchers may not always be locally feasible. Local knowledge is critical to developing feasible solutions to human-wildlife conflict. Thus, conflict-prevention strategies should be cognizant of local conditions and be tailored to site-specific human and environmental factors.

CHAPTER 3: Reality vs. Perception: How Rural Tanzanians View Risks from Man-Eating Lions

Perceptions of risk are an important component of human-wildlife conflict research, as perceptions greatly affect peoples' attitudes and behaviors towards wildlife. Lions (*Panthera leo*) have attacked over 1000 people in Tanzania since 1990, providing a unique opportunity to examine risk perceptions in an extreme situation. I conducted questionnaire surveys in the two districts with the highest number of attacks to identify: (1) overall risk perceptions, (2) factors that influence risk perceptions, (3) aspects of risk that are correctly perceived, and (4) how risk perceptions of lions compares to other risks. Overall, people tend to overestimate their risk from lions; 53% of respondents think they are very likely to be attacked while over an average lifespan people only have 0.19% chance of being attacked. Although risk perceptions are correlated to gender, age, education, acres of land cultivated, and number of livestock owned, previous experience with attacks (attack in village or family) and sighting of lions or lion signs are not correlated to perceptions. People perceived risky locations, times, and activities significantly differently in the two districts and these differences match with differences in attack context between the two districts. Overall, people were very aware of who was at risk, and when and where risk was greatest. People believe risk from lions is greater than from mega-herbivores and about the same as from other predatory species. Although most perceive non-wildlife risks to be greater, many believe risks such as famine and malaria are equal to the risk of attack by a lion, emphasizing the tendency for people to overestimate risks that are rare but elicit strong fears. This study highlights the importance of using multiple methods to gauge risk perceptions and local knowledge,

identifies important management implications, and demonstrates that studies of risk perceptions are important when formulating methods to prevent human-wildlife conflict.

Introduction

In Tanzania, lions have attacked over 1000 people since 1990 (Kushnir et al. 2010). The overwhelming majority of these cases were unprovoked, where lions entered human-dominated areas specifically to prey on people (Baldus 2004; Packer et al. 2005; Kushnir et al. 2010). In order to develop and implement appropriate prevention measures, it is important not only to understand why conflict is occurring but also how people perceive the risk of lion attack. Public perceptions provide important insights into how people view risky situations (Slovic 1987, 1997). Perceptions tell how society and individuals view and respond to hazards and can identify widely held popular beliefs (Tate et al. 2003). Most importantly, peoples' perceptions – whether empirically correct or incorrect – affect attitudes and behaviors, so perceptions should be considered as carefully as actual risk (Stout et al. 1993; Naughton-Treves 1998; West & Parkhurst 2002; Conforti et al. 2003; Naughton-Treves & Treves 2005; Gore et al. 2005, 2006; Baird et al. 2009; Thornton & Quinn 2010). Perceptions also greatly influence support for conservation and the likelihood of retaliation towards offending species (Conforti et al 2003), and are therefore critical for informing management and prevention efforts (Henderson et al. 2000; Kretser et al. 2009).

Numerous studies have examined perceptions and attitudes towards protected areas or wildlife (Manfredo et al. 1998; Kuriyan 2002; Bauer 2003; Gadd 2005;

Lucherini & Merino 2008). The goals of these studies were not to assess risk, but rather to determine how communities view conservation and wildlife. Other studies have examined perceptions of problem animals or perception of damage from problem animals (Mcivor & Conover 1994; Conover 1994; West & Parkhurst 2002; Marker et al. 2003; Henderson et al. 2000; Kretser et al. 2009), and several have compared actual losses from wildlife to perceived losses (Naughton-Treves 1997, 1998; Gillingham & Lee 2003; Linkie et al. 2007). Less common are studies that look specifically at perceived risk of living in close proximity to protected areas (Baird et al. 2009), or perceptions of danger to humans from wild animals (Zinn & Pierce 2002; Conforti et al. 2003; Kleiven et al. 2004; Gore et al. 2006; Kaltenborn et al. 2006; Thornton & Quinn 2010). These previous studies have shown that perceptions of wildlife are affected by: ethnicity (Naughton-Treves 1997), age (Kleiven et al. 2004; Kaltenborn et al. 2006; Kretser et al. 2009; Thornton & Quinn 2010), gender (Naughton-Treves 1997; Zinn & Pierce 2002; Kleiven et al. 2004; Kaltenborn et al. 2006; Thornton & Quinn 2010), socioeconomics (Naughton-Treves 1997; Kleiven et al. 2004; Kretser et al. 2009), previous experience or economic loss (Stout et al. 1993; West & Parkhurst 2002; Kleiven et al. 2004; Kretser et al. 2009, Thornton & Quinn 2010), education (Kleiven et al. 2004; Kaltenborn et al. 2006), and location (Naughton-Treves 1997; Kleiven et al. 2004; Naughton-Treves & Treves 2005; Kaltenborn et al. 2006; Kretser et al. 2009; Thornton & Quinn 2010).

The situation in Tanzania provides a unique opportunity to examine perception of risk from lions in an area where danger to humans is serious and widespread. My

objectives are to: (1) determine how people perceive their overall risk of attack by a lion, (2) determine how past experience, demographics, socioeconomics, and location affects perceptions, (3) compare perceived risk to actual risk to determine when people perceive risks correctly, and (4) determine how people compare the risk of lion attacks to other wildlife and non-wildlife risks.

Methods

Study Area

I worked in the two Tanzanian districts with the highest number of attacks: Rufiji and Lindi (Kushnir et al. 2010). The districts differ in two distinct ways: abundance of wildlife and human activity patterns during lion attacks. Rufiji is near Selous Game Reserve and thus home to larger lion and lion prey populations than Lindi, which is not near any major protected areas (Kushnir et al. 2010). In Rufiji, the majority of attacks occur at night, in agricultural fields, while victims are sleeping indoors. In Lindi, the majority of attacks occur in the late evening, both in villages and agricultural fields, while victims are walking or conducting activities just outside their homes (Kushnir et al. 2010). Despite these major differences, both districts experienced a major outbreak of lion attacks from 2001 to 2004 (Kushnir et al. 2010). The seasonality of attacks, outcome, and victim demographics were similar between districts. Most attacks in Lindi and Rufiji occurred during the wet season, which corresponds to the harvest season, and the months with the highest attack numbers were December, January, March, April, and May (Kushnir, unpublished data). Sixty-six percent of attacks in Rufiji and Lindi led to death,

58% of victims were male, and 74% of victims were adults (Kushnir, unpublished data).

In each district, I conducted village surveys in the area with the highest recorded concentration of attacks. In Rufiji, this area lies just east of Selous Game Reserve along the Rufiji River; in Lindi, it is the southeastern portion of the district (Figure 3-1). Using data on attack locations obtained from district records and the Packer et al. 2005 study, I selected four villages in each study area: two with a history of attacks and two neighboring villages with no attacks. An "attack village" is a village that had attacks within its boundaries, which includes agricultural areas within its jurisdiction. A "non-attack village" is a village with no attacks from 1990-2007 as verified by both district records and site visits (see Kushnir et al. 2010 for additional information of site selection).

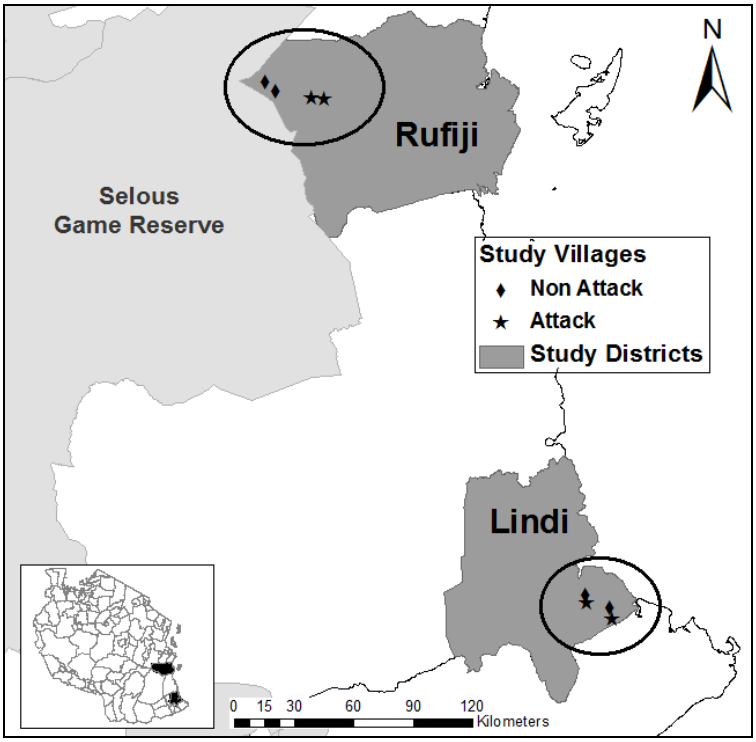

Figure 3-1: Map of southeastern Tanzania with study districts in gray and circles around area with the highest concentration of attacks.

Data Collection & Analysis

I conducted 128 questionnaire-based interviews with the help of a translator in the eight study villages by randomly selecting 16 households from village registers and alternately selecting female and male household heads to ensure an even gender ratio. Questionnaires included questions on demographics, socioeconomics, education, attack history in family, and sighting of lions and lion signs (see Appendix 2 for questionnaire). I asked three prompted questions to gauge the individual's perception of risk:

(1) How likely do you think you are to be attacked by a lion (not at all, somewhat, very)?

(2) Are you worried about being attacked by a lion (not at all, a little, worried, very)?

(3) Are you afraid of being attacked by a lion (not at all, a little, afraid, very)?

Because of low responses for some categories for questions 2 and 3, I grouped "not at all" and "a little" together and "worried"/"very" and "afraid"/"very" together for analysis. I also asked a number of questions about attack specifics:

- Have the number of attacks increased or decreased over your lifetime in this village (unprompted)?
- In what particular years were attacks worse (unprompted)?
- What activities do you engage in that make you feel most at risk (unprompted)?
- Do you think the following activity puts people at risk for lion attacks, if so how much risk (prompted – list of eleven activities)?
- Where do you feel most at risk (prompted – village center, agricultural field, both, other)?
- During which times of day do you feel most at risk (unprompted)?
- Who in your village do you think is most at risk of lion attacks (unprompted)?

Additionally, I asked respondents which threat poses the greatest risk: another wildlife species or non-wildlife risk, a lion, or both (comparison of risks). The additional wildlife included elephants (*Loxodonta Africana*), hippopotamus (*Hippopotamus amphibius*), buffalo (*Syncerus caffer*), crocodile (*Crocodylus niloticus*), leopard (*Panthera pardus*), and snake. Non-wildlife risks included drought, famine, malaria, and AIDS. I only questioned respondents about the respective animal species that were present in the study

area, so I did not question people in Lindi about hippopotamus and crocodile. In a very small number of cases, people would indicate that the animals were not present and thus could not know about its level of risk (this only occurred for buffalo and elephant).

Data were analyzed using SPSS 16.0. I used the chi-square goodness-of-fit test and analysis of variance (ANOVA) to compare perceptions to demographic data and perceptions between districts. I used a multivariate ordinal regression to determine the variables that influence perceived likelihood of attack. The dependent variable in the ordinal regression model was the response to Question 1 on likelihood of attack, ranked from 1-3: (1) Not at all likely, (2) Somewhat likely, and (3) Very likely. To compare perceptions of risk involving locations, times, activities, and people at risk, I plotted the percent of responses in each category versus the percent of attack cases in each category for each district. Activity categories of perceptions did not always match activities during attacks, so I re-coded these categories to match. I could not match five perceived risky activities with actual attack activities because attack activities are not categorized with the same specificity. These were left out of the graph (collecting firewood, getting water, collecting building materials, fishing, and collecting wild tubers). In addition, I combined farming/guarding crops with sleeping inside in agricultural fields because the main reason people sleep in their agricultural fields is to farm or guard crops. To compare years that people remembered as being bad years to actual bad years, I plotted the percent of responses for a given year against the number of attacks per year. I used chi-square tests for non-parametric data to determine if differences between responses in the

comparison of risks question were significant.

Results

Overall Risk & Factors that Affect Risk Perceptions

Overall, 96.5% of respondents are afraid of being attacked, 69.0% are worried about being attacked, and 53.2% think they are very likely to be attacked. Given that there are an average of 15.5 attacks per year in Rufiji and Lindi, that approximately 450,000 people live in both districts, and that the average lifespan in Tanzania is 55.9 years, people have a 0.19% chance of being attacked over their lifetime. There are no significant differences in response to the three perceptions questions listed above (fear, worry, likelihood) between people living in an attack or non-attack village or between people with or without an attack in their family. There is also no significant difference in perceptions (fear, worry, likelihood) based on proximity to protected areas or sightings of lions or lion signs in villages or agricultural fields, with one exception: people who see lion signs in their village are more likely to be worried/very worried about attacks as compared with those that don't ($X^2 = 5.529$, $p < 0.05$). Both males and females are equally afraid and worried about attacks, but females are more likely than males to think that they are not at all likely to be attacked ($X^2 = 10.123$, $p < 0.01$). People with more education (having completed Standard 5-7) were more afraid ($X^2 = 13.124a$, $p < 0.01$) and worried ($X^2 = 9.978$, $p < 0.01$) about attacks and thought they were more likely to be attacked ($X^2 = 12.703$, $p < 0.05$) than those with less education (Standard 1-4) or no education at all. Although age does not have a significant effect on risk perceptions (fear,

worry, likelihood), people who thought attacks had increased were younger on average than those who thought that attacks had decreased ($F = 7.052$, $p < 0.01$).

Results of the multivariate ordinal regression show there are five variables that are related to a person's perceived likelihood of attack (Table 3-1): age, acres of land cultivated, number of livestock owned, gender, and education. An increase in one's age and number of livestock owned decreases perceived likelihood of attack, while an increase in acres of land cultivated and level of education increases perceived likelihood of attack. In addition, men perceive their likelihood of attack to be higher than do women. Note that having an attack in the village or family and sighting of lion signs are not significant.

Table 3-1: Results of multivariate ordinal regression assessing perceived likelihood of being attacked

	Estimated Coefficient	Estimated Standard Error	*p*-value	95% CI Lower Bound	95% CI Upper Bound
Threshold					
Somewhat likely	-3.883	1.231	.002	-6.296	-1.469
Very likely	-2.288	1.180	.053	-4.601	.025
Location					
Age**	-.056	.021	.007	-.096	-.015
Number of assets owned	-.310	.202	.125	-.706	.087
Acres of land cultivated*	.369	.147	.012	.081	.658
Number of livestock owned*	-.049	.024	.043	-.096	-.001
Male (compared to female)*	1.024	.515	.047	.014	2.034
No education * (compared to S5-7)	-1.392	.556	.012	-2.483	-.302
Standard 1-4 (compared to S5-7)	-.343	.713	.631	-1.740	1.055
No attack in village	.256	.478	.592	-.680	1.193
No lion attack in family	-.812	.620	.191	-2.028	.404
Never seen a lion in village	-.248	.473	.601	-1.176	.680
Never seen a lion in agricultural field	.543	.562	.334	-.559	1.644
Never seen lion signs in village	.223	.630	.724	-1.012	1.457
Never seen lion signs in agricultural field	-.674	.651	.301	-1.951	.602
Rufiji (compared to Lindi)	.529	.537	.325	-.524	1.581

Significance **$p<0.01$, *$p<0.05$
Pseudo r-squared values: Cox & Snell = 0.258, Nagelkerke = 0.297, McFadden = 0.148

When asked about risky locations, times, and activities there were significant differences between the two districts. The majority of people in Rufiji thought that agricultural fields were the most risky (59.1%), while in Lindi, the majority felt that both villages and agricultural fields were most risky (75.0%) ($X^2 = 36.778$, $p < 0.01$). In Rufiji, 66.1% of people thought nighttime was most risky, while responses in Lindi were more evenly distributed with 22.7% saying morning, 29.5% saying afternoon/evening, 31.8% saying nighttime, and 15.9% saying all the time ($X^2 = 27.466$, $p < 0.01$). Activities

that made respondents feel at risk also differed significantly across districts ($X^2 = 39.465$, $p < 0.01$) (Figure 3-2). Farming was the most common response in Rufiji (25.9%) followed by guarding crops (17.3%), collecting building material (16.0%), and collecting firewood (16.0%). Farming was also the most common response (39.2%) in Lindi, followed by collecting firewood (10.3%), getting water (10.3%), using the toilet/bathing at night (7.2%), walking to/from agricultural fields (7.2%), and walking to/from/between villages (7.2%). Being outside around the house (5.2%) was mentioned only in Lindi.

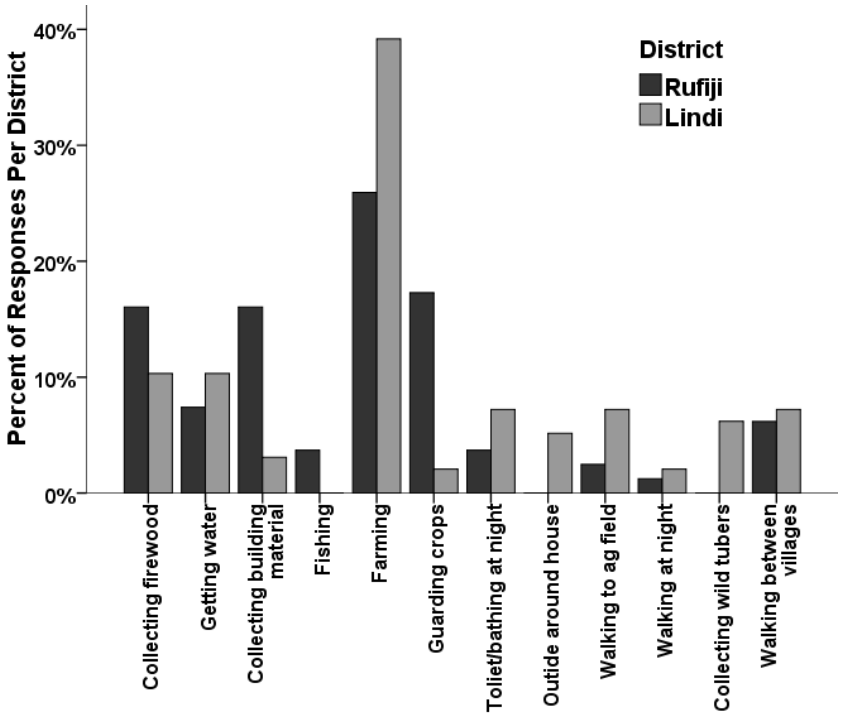

Figure 3-2: Activities that make people feel most at risk for a lion attack.

Even though the majority of people in both districts thought the following activities were risky, people in Rufiji were more likely to say that they were only of

medium/low/no risk: collecting firewood ($X^2 = 10.852$, $p < 0.05$), getting water ($X^2 = 34.226$, $p < 0.01$), collecting timber ($X^2 = 9.156$, $p < 0.05$), walking alone after dark ($X^2 = 10.775$, $p < 0.05$), going to the toilet after dark ($X^2 = 8.965$, $p < 0.05$), and sitting/resting outside after dark ($X^2 = 13.102$, $p < 0.01$). There were no differences between districts over the level of risk from fishing, walking during the day, guarding crops, and sleeping in agricultural fields; the majority of people in both districts thought these activities were risky. When questioned about cooking outside after dark, people in Rufiji were more likely to say this was not risky ($X^2 = 4.753$, $p < 0.05$).

There was no difference between districts on which sex or age groups people thought were most at risk. People viewed men and women as equally at risk, with 50.9% of respondents stating male and 49.1% stating female. Respondents mentioned adults 55.7% of the time, adolescents 27.9%, elderly 9.8%, and children 6.6% of the time.

Perceived Risk versus Actual Risk

Figure 3-3 and Figure 3-4 show perceived risk versus actual risk in Rufiji and Lindi districts respectively. The closer points are to the diagonal line, the more closely actual risks and perceptions align. Points below the line show an underestimation of risk and points above the line show an overestimation of risk. In Rufiji, perceptions and actual risk align well as most points are close to the diagonal line. People perceive risky locations quite well, although they slightly overestimate the risk at the village center and underestimate the risk in agricultural fields. With time of day, they slightly overestimate nighttime and underestimate evening. With age groups and sex, they overestimate risks

for women and children and underestimate risks for men and adults. For activities, they underestimate the risk of helping victims, conducting activities directly outside the house, using the bathroom or bathing, and farming/guarding crops. In Lindi, people are less accurate at correctly perceiving risk than in Rufiji, as there are more points further away from the diagonal line, but overall, many of the perceptions align quite well with actual risk. With risky locations, people in Lindi tend to overestimate risk in the village center and underestimate risk in wild areas. With time of day, they overestimate risk in the early morning and underestimate risk at night. They also overestimate risk to adults and women and underestimate risk to children and men. Perceptions in Lindi diverge most from actual risk when looking at risky activities. People overestimate their risk from farming and guarding crops and underestimate their risk from walking, using the bathroom and bathing, and conducting activities just outside the house.

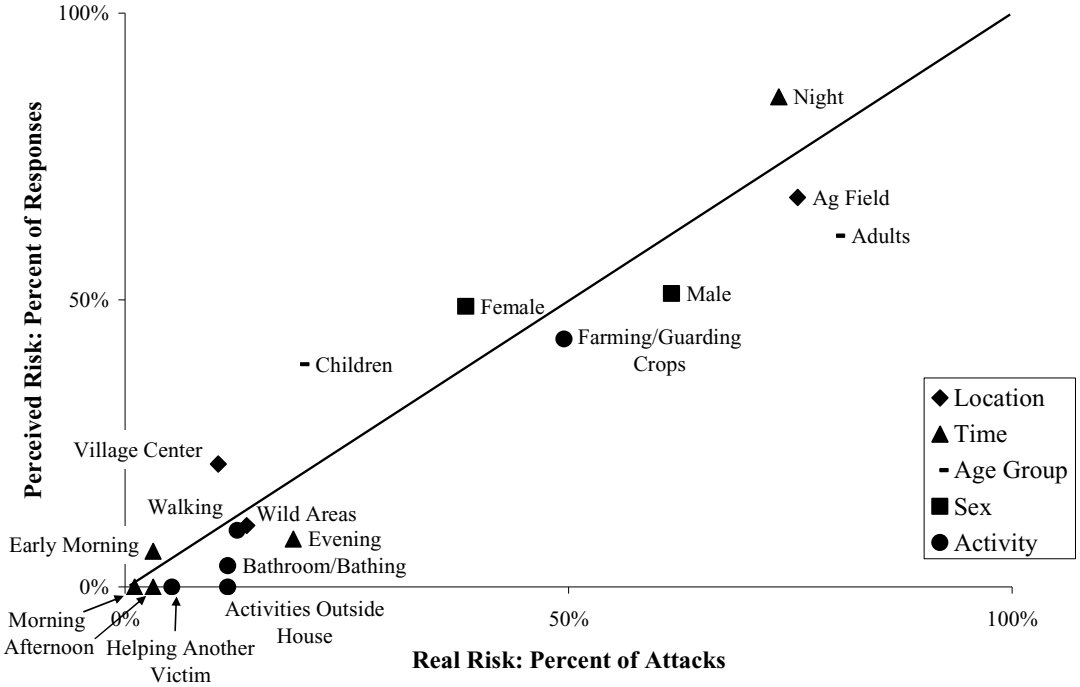

Figure 3-3: Comparison of real versus perceived risk in Rufiji district.

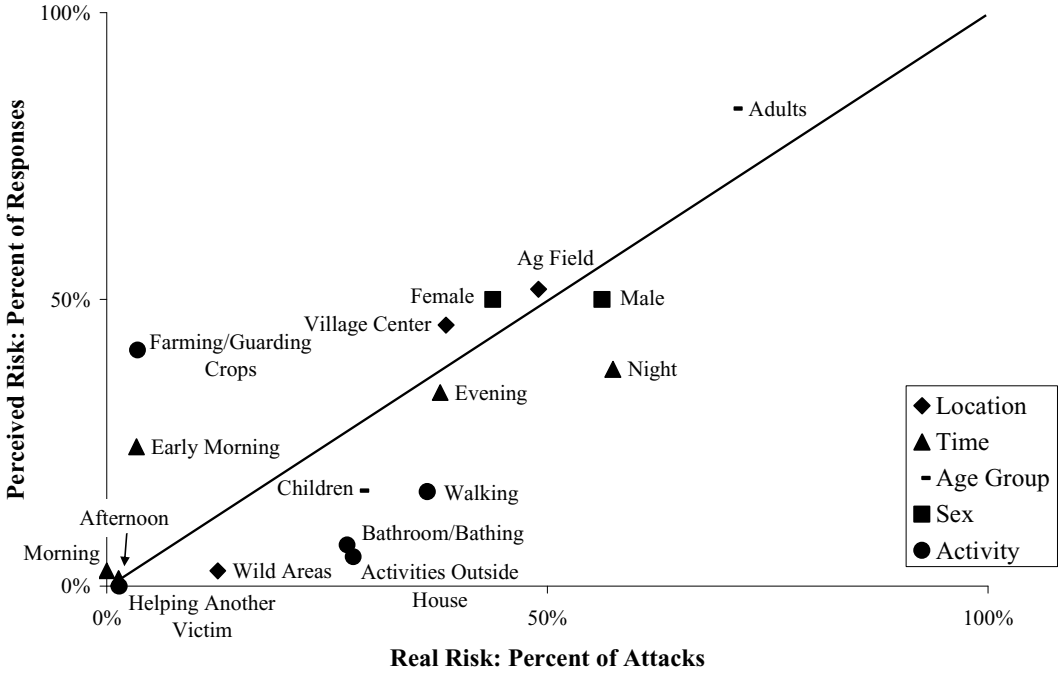

Figure 3-4: Comparison of real versus perceived risk in Lindi district.

The accuracy of peoples' memory in perceiving the years that were bad for lion attacks did not differ significantly between districts. Figure 3-5 shows the percent of responses mentioning each year plotted by the actual number of attacks per year. Although people tend to overestimate 2005 as a bad year, they did quite well at correctly identifying 2000-2004 and 2006-2007. Before 2000, people were worse at identifying bad years, underestimating 1990-1992 and 1997-1999.

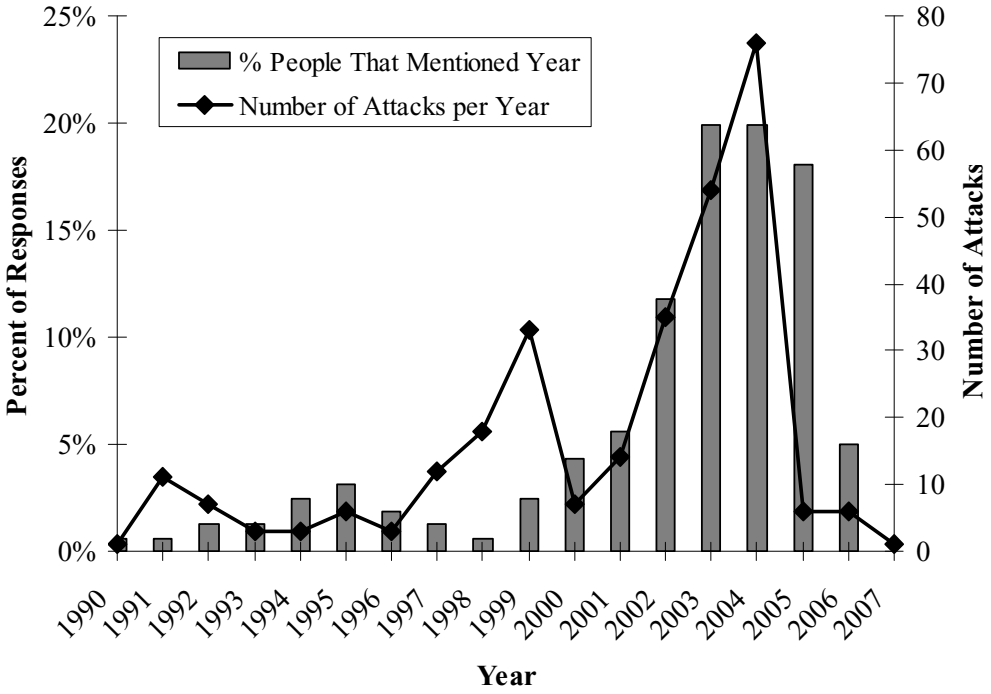

Figure 3-5: Comparison of years people perceive as being bad versus actual attacks per year.

Comparison of Risks

Overall, the majority of people think that lions are more dangerous than elephants, hippopotamus, and buffalo and that crocodiles, leopards, and snakes are equally as

dangerous as lions (Figure 3-6). The highest proportion of people say that risks from drought, famine, malaria, or AIDS are higher than risks from lions, but a large proportion of villagers also view these risks as equal to the risk from lions (Figure 3-7). There are significant differences between the three responses (lion, other, both equally) for all wildlife and non-wildlife risks except drought (Table 3-2). When comparing only those people who responded "lion" versus "other" as being more dangerous, the differences are significant for all comparisons except with crocodiles (Table 3-2). There are no significant differences in responses comparing risk from lions to other wildlife or non-wildlife risks between districts, between attack- versus non-attack villages, or between persons who have or have not had attacks in their family.

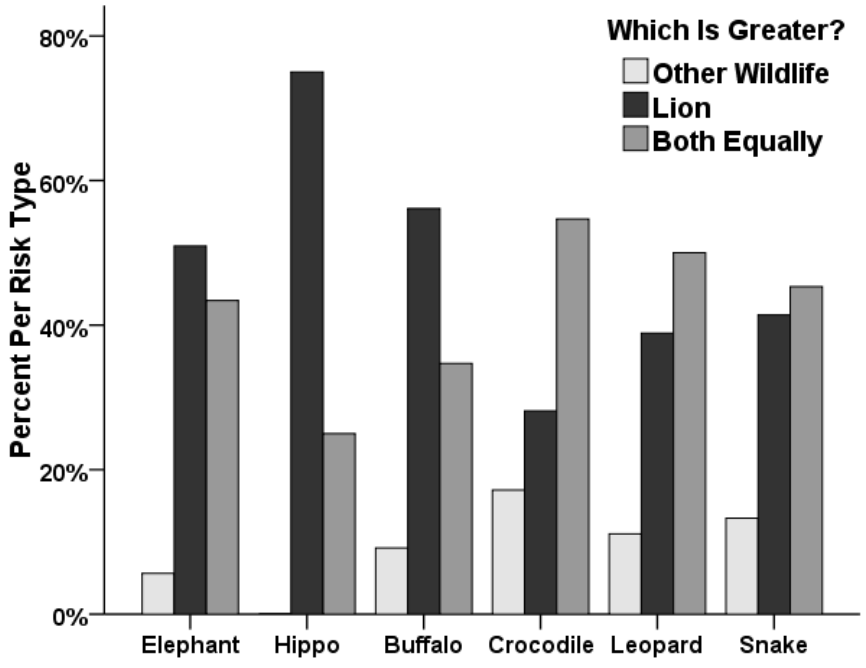

Figure 3-6: Comparison of risk between lions and other wildlife.

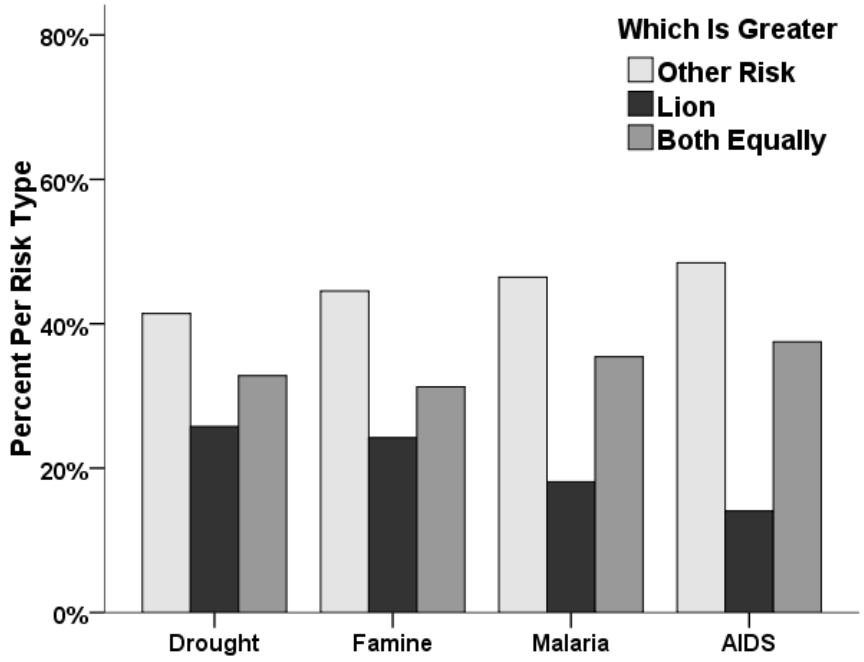

Figure 3-7: Comparison of risk between lions and non-wildlife risks.

Table 3-2: Chi-square statistics for comparing risk from lions to other wildlife and non-wildlife risks

Risk	Comparing Lion, Other & Both Equal		Comparing Lion versus Other	
	Chi-Square Statistic	*p*-value	Chi-Square Statistic	*p*-value
Elephant	37.434	.000**	38.400	.000**
Hippo	16.000	.000**	No one said hippo only	
Buffalo	32.469	.000**	33.063	.000**
Crocodile	14.281	.001**	1.690	.194
Leopard	30.333	.000**	19.444	.000**
Snake	23.453	.000**	18.514	.000**
Drought	4.703	.095	4.651	.031*
Famine	8.172	.017*	7.682	.006**
Malaria	15.559	.000**	15.805	.000**
AIDS	23.688	.000**	24.200	.000**

Significance **$p<0.01$, *$p<0.05$

Discussion

Perception of Overall Risk

An overwhelming majority of individuals, even in villages that have never experienced attacks, felt afraid and worried about lion attacks. The majority also felt that it was likely that a lion would attack them. Considering that over the course of an average lifespan people in Rufiji and Lindi districts only have a 0.19% chance of being attacked, people have a grossly exaggerated perception of their risk from lion attacks. An examination of the psychological literature on risk perceptions provides a framework for understanding why people are overly concerned about lion attacks. Numerous studies have discussed how emotions and feelings relate to risk perceptions and have shown that people often judge risk on feelings rather than on rational thoughts (Fischhoff et al. 1993; Loewenstein et al. 2001; Slovic et al. 2005; Slovic & Peters 2006; Slovic et al. 2007). Studies have shown that people have an inflated perception of risk for involuntary and uncertain situations over which they have little control. The more sensational or vivid the consequences and the more feeling of dread associated with the risk, the higher people perceive their risk to be (Slovic 1987, 1997, 2001; Johnson & Tversky 1983; Fischhoff et al. 1993; Stout et al. 1993; Loewenstein et al. 2001; Slovic 2001; Tate et al. 2003; Slovic et al. 2005, 2007). One example is the tendency for people to overestimate their risk from terrorism; people focus so much on the outcome and nature of the event that they do not consider that it is unlikely to occur (Slovic & Peters 2006). The majority of people also rationally know driving in a car is more dangerous than flying, yet people often perceive

the risk from flying to be greater (Loewenstein et al. 2001). Lion attacks mirror risks like terrorism or airplane crashes because even though attacks are unlikely, the consequences are high, the situations are terrifying, and attacks are completely out of peoples' control.

Specific Factors that Affect Risk Perceptions

There is no relationship between an individual's previous experience with attacks, proximity of village to protected areas, and awareness of evidence of lion presence in villages and agricultural fields and perceptions of risk when examined in univariate or multivariate tests. The only exception is that people who see lions in their village are more worried about attacks. My findings are counterintuitive and contrary to findings in many studies that found that those that suffered more economic loss, experienced previous damage, or had more contact with wildlife were more likely to have negative perceptions or high levels of fear (West & Parkhurst 2002; Kleiven et al. 2004; Kretser et al. 2009; Thornton & Quinn 2010). Results also do not align with studies that have shown that individuals that live further from animals or are more disconnected from wildlife have perceptions that are more positive and experience less fear (Mcivor & Conover 1994; Kaltenborn et al. 2006). In the case of lion attacks, the disconnection between experience and risk perceptions is likely due to the extreme and uncontrollable nature of attacks (as discussed above), as well as the social amplification of risk, whereby discussion of attacks within the community may inflate concerns over the risk (Gore et al. 2005). There is a similar example from a study in south Brazil where researchers found no relationship between perceptions and predation history by jaguars (Conforti et al.

2003). Surprisingly, the majority of people viewed jaguars as posing a risk to humans but expressed less fear towards pumas, even though there were no reported cases of jaguar attacks and pumas have attacked humans. Conforti et al. (2003) suggest that this is because jaguars are the more visible species and thus the focus of public awareness.

A number of demographic variables relate to people's perceptions of risk. Both univariate and multivariate tests showed that women, older individuals, and people with less education perceive less risk from lion attacks. My finding that women think they are less likely to be attacked than men contradicts the majority of similar perceptions studies (Zinn & Pierce 2002; Kleiven et al. 2004; Kaltenborn et al. 2006; Thornton & Quinn 2010). This is probably because women are aware that men put themselves more at risk; overall men are more likely to be attacked or to be away from home conducting dangerous activities like walking at night. Previous studies have shown contrasting results on the connection between perceptions and age; some show that older individuals perceive greater risk because of greater vulnerability (Kleiven et al. 2004; Kretser et al. 2009) and others show that younger individuals perceive greater risk because of less experience (Kaltenborn et al. 2006). My finding that increased age decreases risk perceptions is most likely because older individuals have more experience and perhaps are more focused on other concerns and thus less fearful of attacks regardless of their vulnerability. Studies also show contrasting results for education, with more education increasing perceptions of risk (Kaltenborn et al. 2006) or decreasing perceptions of risk (Kleiven et al. 2004) with my results supporting the former.

Two variables related to socioeconomics in the multivariate ordinal regression may further help explain peoples' perceptions: owning more livestock decreases perceived likelihood of attacks, while cultivating more land increases perceived likelihood of attacks. Livestock ownership, which in Rufiji and Lindi is mostly chicken and goats, most likely reflects socioeconomics and thus reflects ability to protect from attacks. People with greater means are better able to construct stronger homes and fences and are less affected by loss of crops during outbreaks. People who cultivate more land, however, are more susceptible to attacks because they spend more time where attacks are common and are potentially less able to withstand loss of crops during outbreaks because their efforts are focused on agriculture. Kretser et al. (2009) found that people with lower incomes were more likely to negatively perceive wildlife. Similarly, Naughton-Treves (1997) discusses how risk perceptions are amplified by peoples' inability to cope with economic loss. My findings support the idea that ability to increase protection and cope with economic loss may decrease risk perceptions of lion attacks.

Although I identified numerous factors linked to risk perceptions, it is important to note that the multivariate model has a low pseudo r-squared. This suggests that although some factors explain perceived likelihood of attack, no combination of variables does a very good job explaining perceptions of attack likelihood. This is likely due to the fact that emotions and fear play a major role in the way people perceive risk and thus perceptions cannot be captured by examining demographic and socioeconomic variables alone.

Comparison of High-Risk Situations between Districts

The significant differences in responses by district to questions about risky locations, times, and activities show that perceptions reflect actual history of risk and that people are attuned to the place-specific environmental conditions that put them at risk. In Rufiji, where people are mostly attacked indoors in agricultural fields at night, people believe that agricultural fields and nighttime are riskiest. In Lindi, where most people are attacked outdoors in both villages and agricultural fields in the evening, people believe that agricultural fields and villages are equally as risky and that they are at risk throughout the day. There are also differences in activities that people think are risky, with people in Rufiji mostly stating farming, guarding crops, and collecting building material/firewood and people in Lindi mentioning additional activities like getting water, using the toilet/bathing at night, and walking (common contexts of attacks in Lindi). Interestingly, people in Rufiji do not mention activities outside the house; this is a common context for attack in Lindi but not Rufiji. People in Lindi are also more likely to think activities like collecting firewood, getting water, collecting timber, walking alone after dark, going to the toilet after dark, and sitting/resting outside after dark are of high risk than do people in Rufiji. These activities outside the home are indeed more risky in Lindi than in Rufiji (Kushnir et al. 2010). Overall, people in Lindi are less accurate at perceiving risk than in Rufiji. This is probably because high-risk situations in Lindi are much less predictable than in Rufiji. Attacks in Rufiji mostly occur in agricultural fields in and around homes, whereas in Lindi attacks occur in multiple locations and while

people are engaged in a variety of activities (Kushnir et al. 2010).

Perceived Risk versus Actual Risk

People have a tendency to be overly fearful and worried about attacks as well as to overestimate their likelihood of being attacked. This is not unusual, as many studies that compare perceived wildlife damage to actual wildlife damage have shown that perceptions do not match reality and that people perceive loss to be worse than actual loss (Naughton-Treves 1997, 1998; Gillingham & Lee 2003). A number of explanations may account for this. People have a broader concept of risk than "experts" [e.g. actuaries, psychologists, etc.] often realize. "Experts" consider risk in terms of death or injury, but the general public has a more nuanced view that may include outcomes such as psychological stress or loss in productivity (Slovic 1987). In addition, any attempt to measure or define risk is inherently subjective (Fischhoff et al. 1993; Slovic 1997, 2001). Perceptions may be amplified by peoples' inability to cope or lack of control over the situation (Naughton-Treves 1997; Gillingham & Lee 2003) or other factors may inflate risk perceptions. For example, when it comes to crop damage, people may not just be responding about crop loss but also the indirect cost of abandoning a field (Naughton-Treves & Treves 2005). Additionally, there is always bias introduced by the questionnaire itself. Studies have shown that the context, mood of the individual, and preceding questions can have a great impact on the response (Johnson & Tversky 1983; Windschitl 2002). Thus, it may be incorrect to use such studies to judge if people are sensitive to the likelihood of an event (Windschitl 2002). It is true that people do not have

a 53% chance of being attacked by a lion, but the emotional response to the question combined with the disruption in daily life and potential economic impact of attacks also affect the response to this question.

People appear to be good at identifying relative risk but have a hard time judging extent of risk without comparisons (Fischhoff et al. 1993; Slovic et al. 2007). Asking respondents about people at risk and risky locations, activities, and times is a way to determine if people perceive risk correctly and to identify which aspects of risk they are best able to recognize. People in Rufiji and Lindi generally do a good job assessing their relative risk in specific locations, activities, and times. They also have a good sense of who in their community is at risk. The most noteworthy differences between real and perceived risks are in activities. Both people in Rufiji and Lindi tend to underestimate their risk when conducting activities around the house and using the bathroom or bathing. In Lindi, people also underestimate their risk from walking and overestimate their risk from farming and guarding crops. A certain amount of error comes from the way I measured and compared risk. For example, people did indicate that collecting firewood and water were dangerous activities, but I did not account for such specifics in my attack categories and thus left them out of the risk comparison. People are attacked walking to and from areas where they gather wood or get water, but I only categorized the activity as walking, which might explain the underestimate for walking. Even with errors due to categorization, it is striking that people most underestimate the risk around their home. This may indicate a false belief about safety near homes that would reduce vigilance in

these situations. It may also be an example of people underestimating risk from mundane activities, much like the tendency to underestimate the risk from driving while overestimating the risk from flying (Johnson & Tversky 1983; Slovic 2001). When looking at the years people think were bad for attacks compared to actual bad years, it is evident that people have a good memory for recent outbreaks but that these memories start to fade five to seven years after attacks occur.

Comparison of Risks

Comparing the risk of lion attacks to other dangers is a useful way to identify flawed perceptions and to determine reasons behind these misperceptions since relative standings are less faulty than an absolute scale (Windschitl 2002). People generally believe that lions are more dangerous than elephants, buffalo, and hippopotamus and that lions are equally as dangerous as crocodiles, leopards, and snakes. Detailed data on human injury and death from wildlife do not exist for Tanzania but two studies have tried to quantify and compare risk from various species. Baldus (2004) estimated deaths from dangerous animals throughout Tanzania using a systematic survey of newspaper records and claimed that most deaths are caused by crocodile, hippopotamus, and lion followed by elephant, leopard, buffalo and hyena, with lions causing a quarter to a third of all deaths. Ikanda (In prep) surveyed district records in six districts in southeastern Tanzania and found that lions are responsible for 55% of all deaths and injuries followed by crocodiles (13%), leopards (12%), hyenas (7%), elephant (6%), hippopotamus (5%), and buffalo (2%). These data show that people assess their risk from the mega-herbivores

correctly, as elephants, hippopotamus, and buffalo do kill less people than lions. However, peoples' tendency to equate the risk of lions as equal to that of leopards and crocodiles illustrates the tendency to overestimate risk from situations that elicit dread and fear. The fear that arises when people think about being hunted by a predator creates a perception that all predators are equally dangerous. Much like the response to questions about fear and concern over attacks, people may not be responding to actual objective risk of death or injury but to the fear associated with predatory species. Death from snakes is harder to quantify than death from larger animals because people often die before seeking medical attention and cases are not reported to the districts. It is likely that people are overestimating their risk from snakes as compared to lions because snakes elicit the same type of dead and fear as predators.

Most people view the danger from drought, famine, malaria, and AIDS to be greater than that from lions. However, a large number of people also view these risks to be the same as those posed by lions. This shows that although some people rationally consider these day-to-day risks to be greater than the danger from lions, many still exaggerate their risk from lions. According to the United Nations World Food Programme (2009), 58% of Tanzania's population lives on less than $1 a day, 44% are undernourished, and 38% of children under five are malnourished. The country is also plagued with irregular rainfall and 1.4 million people (3.4% of the total population) are living with HIV/AIDS (World Food Programme 2009). Considering these statistics, it is remarkable that almost 40% of the interviewees perceive the risk from lion attacks to be

the same as drought, famine, malaria, and AIDS. This again highlights peoples' tendency to overestimate infrequent dramatic causes of death while underestimating more mundane common risks (Johnson & Tversky 1983). Similarly, numerous studies on perceived versus actual crop damage have found that people perceive more visible and extreme damage to be worse than continuous damage (Conover 1994; Naughton-Treves 1997; Gillingham & Lee 2003; Naughton-Treves & Treves 2005; Linkie et al. 2007). An example is that people perceive elephants to be the worst crop pests even though monkeys, pigs, and even livestock cause more economic loss (Naughton-Treves 1997).

Conclusion

People in Rufiji and Lindi districts overestimate their risk from lion attacks, which is consistent with literature on risk perceptions of other spectacular though rare events. It is not that people are irrational but rather that they are responding to the unique and terrifying nature of such events. In fact, when questioned about specifics of risk, people are very aware of where and when they are at risk. This study highlights the importance of using multiple types of questions to uncover risk perceptions, because a narrow survey might only capture the overall level of fear and not identify people's ability to accurately asses risk and the high level of local knowledge about such events.

The findings of this study also have management implications. Since the majority of the population is concerned about attacks, management officials will be able to implement prevention efforts just as easily in communities with a history of attacks as those without attacks. This is necessary because all rural residents of high-risk areas

should take precautions because attacks could occur in new areas due to changes in the landscape or human activity patterns. Details about the specific locations and activities that people incorrectly estimate also point to areas to focus community education and prevention. For example, people in both districts underestimate their attack risk near their homes. Although such attacks are not as common as those in agricultural fields or walking in the village periphery, people need to understand their risks and be encouraged to build fences that enclose their cooking area and outdoor toilet. Such details highlight the importance of considering local perceptions when developing management strategies to reduce human-wildlife conflict.

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APPENDIX 1: Predicted Attacks versus Actual Attacks per Ward

District	Ward	Predicted Attacks	Actual Attacks
Kilwa	Chumo	1.02	0
Kilwa	Kandawale	0.46	4
Kilwa	Kijumbi	0.96	0
Kilwa	Kikole	1.39	0
Kilwa	Kipatimu	1.96	2
Kilwa	Kiranjeranje	0.86	8
Kilwa	Kivinje Singino	0.98	0
Kilwa	Lihimalyao	0.23	0
Kilwa	Likawage	1.43	2
Kilwa	Mandawa	2.04	4
Kilwa	Masoko	0.21	0
Kilwa	Miguruwe	3.23	0
Kilwa	Mingumbi	0.61	0
Kilwa	Miteja	0.42	0
Kilwa	Mitole	0.99	0
Kilwa	Nanjirinji	3.48	0
Kilwa	Njinjo	0.79	1
Kilwa	Pande	0.56	1
Kilwa	Tingi	0.37	0
Lindi	Chiponda	2.29	0
Lindi	Chlkonji	3.14	0
Lindi	Kilolambwani	5.86	0
Lindi	Kitomanga	3.20	8
Lindi	Kiwalala	3.07	1
Lindi	Kiwawa	4.35	7
Lindi	Lindi Urban	4.97	3
Lindi	Mandwanga	2.69	5
Lindi	Matimba	5.47	9
Lindi	Mbanja	4.41	0
Lindi	Mchinga	14.62	10
Lindi	Milola	10.85	7
Lindi	Mingoyo	2.13	1
Lindi	Mipingo	19.52	13
Lindi	Mnara	6.08	1
Lindi	Mnolela	8.41	27
Lindi	Mtama	5.03	4
Lindi	Mtua	1.83	3
Lindi	Nachunyu	13.10	18

Lindi	Nahukahuka	4.03	2
Lindi	Namupa	3.93	1
Lindi	Nangaru	9.78	25
Lindi	Ng'apa	3.78	0
Lindi	Nyangamara	5.74	12
Lindi	Nyangao	17.76	3
Lindi	Nyengedi	3.11	4
Lindi	Rutamba	8.08	7
Lindi	Sudi	6.40	17
Lindi	Tandangongoro	6.36	2
Mtwara	Chawi	3.56	9
Mtwara	Dihimba	4.92	1
Mtwara	Kiromba	5.44	11
Mtwara	Kitaya	1.80	2
Mtwara	Kitere	4.14	6
Mtwara	Madimba	2.60	0
Mtwara	Mahurunga	3.42	4
Mtwara	Mayanga	2.07	0
Mtwara	Mnima	4.00	2
Mtwara	Mtiniko	3.79	9
Mtwara	Mtwara Urban	2.15	4
Mtwara	Namtumbuka	2.17	3
Mtwara	Nanguruwe	4.41	0
Mtwara	Nanyamba	2.03	0
Mtwara	Naumbu	0.22	1
Mtwara	Ndumbwe	4.14	6
Mtwara	Nitekela	1.60	0
Mtwara	Njengwa	4.02	2
Mtwara	Ziwani	3.54	0
Ruangwa	Chienjere	2.07	0
Ruangwa	Chunyu	1.86	0
Ruangwa	Likunja	2.06	0
Ruangwa	Luchelegwa	2.35	0
Ruangwa	Makanjiro	1.20	0
Ruangwa	Malolo	2.13	0
Ruangwa	Mandarawe	1.62	0
Ruangwa	Mandawa	5.28	14
Ruangwa	Mbekenyera	2.39	2
Ruangwa	Mnacho	2.86	0
Ruangwa	Nambilanje	1.47	12
Ruangwa	Namichiga	2.19	5
Ruangwa	Narung'ombe	3.54	1
Ruangwa	Nkowe	2.12	0
Ruangwa	Ruangwa	0.87	0

Rufiji	Bungu	5.32	1
Rufiji	Chumbi	14.18	0
Rufiji	Kibiti	7.16	11
Rufiji	lkwiriri	2.99	1
Rufiji	Mahege	3.88	1
Rufiji	Mbwara	4.75	1
Rufiji	Mchukwi	1.31	2
Rufiji	Mgomba	1.38	0
Rufiji	Mkongo	10.76	11
Rufiji	Mtunda	0.06	1
Rufiji	Mwaseni	8.69	5
Rufiji	Ngorongo	15.52	52
Rufiji	Ruaruke	5.30	8
Rufiji	Umwe	10.44	0
Rufiji	Utete	8.24	6

APPENDIX 2: Questionnaire

Questionnaire # _____

Date _____Village _____Sub-Village_____

Ward _____ District _____

Interviewee's Name _____

GPS Location_____

Interviewer's Name_____Interpreter's Name_____

Interview Start Time_____ End Time _____

Level of cooperation: 1 2 3 4 5 (low to high)

Level of understanding: 1 2 3 4 5

Comments:

Section A: Demographic Information

1. Gender: __Male(00) __Female(01)
2. Age or year born: _____
3. Tribe:_____
4. Religion: __Muslim(00) __Christian(01) __Other specify(99) _____
5. Position in household: __Husband(01) __Wife(02) __Female Head(03) __Male Head(04)
6. Marital status: __Married(01) __Widowed(02) __Divorced/Separated(03) __Single(04) __Engaged(05)
7. Level of education completed_____
8. Main occupation of household head _____
9. Total number of people living in the household ____ a. Number of adults____ b. Number of children ____

Section B: Home & Assets

10. Do you own or rent your home? __Own(00) __Rent(01) __Owned by Family Member(02)

11. Does your household own any of the following assets *(prompt)*? If so, how many?

#	Assets	Number
01	Generator	
02	Water tank	
03	Sewing machine	
04	Radio	
05	Cell phone	
06	Bicycle	
07	Motorcycle	
08	Canoe (Rufiji Only)	
09	Farm land cultivated and fallow (list amount in acres) – Farm 1	
09	Farm land cultivated and fallow (list amount in acres) – Farm 2	
10	Fence around your back yard enclosing your toilet and cooking area	
	If yes, why?	

Section C: Livestock & Agriculture

12. What livestock does your household own *(prompt)*? Where are they kept?

#	Type	Number	Where are they kept? Village(00), Shamba(01), Both(03) Other specify(99)
01	Cattle		
02	Goats		
03	Sheep		
04	Chickens/Chicks		
05	Dogs		
06	Ducks		
07	Donkey		
99	Other specify		

13. In the last 12 months, how much land did your household cultivate?

Farm1____ Acres, Farm 2____ Acres

14. In the last 12 months, what crops did your household plant *(do not prompt)*? In what months where they planted and harvested? And, how many sacks were harvested?

#	Crop	Months Planted	Months Harvested	Number of Sacks Harvested
01	Maize			
02	Cassava			
03	Sorghum			
04	Millet			
05	Beans			
06	Sweat potatoes			
07	Coconut			
08	Cashew			
09	Groundnuts			
10	Tobacco			
11	Cotton			
12	Vegetables			
13	Fruit			
14	Rice			
15	Sesame			
99	Other specify			

15. Does your household have problems with crop pests? __No(00) __Yes(01)
16. What crop pests are a problem *(do not prompt)*? During which months do the problems occur? Have their numbers increased or decreased? Have the problems with them changed in the last 10 years?

#	Pest	Months	Frequency- Daily (01), Weekly(02), Monthly(03)	Change - Increase(01), Decrease(02), No Change (03), Don't Know(04) *Animals*	*Problems*
01	Bush pigs				
02	Warthog				
03	Baboons				
04	Monkeys				
05	Elephants				
06	Birds				
07	Rodents				
99	Other specify				

Section D: Shamba Activities

17. Is your main house located in the village center? __No(00) __Yes(01)
18. If yes, how far is your shamba from your house in the village?

    Farm 1 _____Min, Farm 2 _____Min
19. If no, how far is your shamba from the village center?

    Farm 1 _____Min – Farm 2 _____Min
20. If you own more than one shamba, how far apart are they? _____Min
21. Do you ever sleep in your shamba? __No(00) __Yes(01)
22. Which months do you sleep in your shamba and for how many days during each months?

Month	1	2	3	4	5	6	7	8	9	10	11	12
Tick if you sleep in your field												
How many days that month												

23. What are the main reasons for sleeping in your shamba (do not prompt)? __Tending crops(01) __Protecting Crops(02) __Main home(03) __Walking distance(04) __Other specify(99)_____
24. Which months do you walk to our shamba and for how many days each month?

Month	1	2	3	4	5	6	7	8	9	10	11	12
Tick if you walk to your field												
How many days that month												

25. When sleeping in your shamba do you sleep in any sort of structure or hut? __No(00) __Yes(01)

26. If you sleep in a stricture or hut, what materials were used to build it *(do not prompt, tick only one each)*?

Materials	Hut 1	Hut 2	Hut 3	Hut 4
a. Walls				
01 Palm and poles				
02 Mud and poles				
03 Mud bricks				
04 Grass and poles				
99 Other specify				
b. Floor				
01 Earth/Clay				
02 Cement				
03 Poles and mats				
99 Other specify				
c. Roof				
01 Palm and poles				
02 Corrugated metal				
03 Grass and poles				
04 None				
99 Other specify				
d. Door				
01 Palm and poles				
02 Tarp/Cloth/Mat				
03 Corrugated Metal				
04 Grass and poles				
05 Wood				
06 Poles				
07 None				
99 Other Specify				
e. Elevated? 00 No if Yes note how high (m)				

27. Do you have an outdoor toilet near your hut in your shamba? __No(00) __Yes(01)

    a. If no, how far from your hut to you go to relieve yourself _____Meters

28. If you have an outdoor toilet, what materials were used to build your toilet *(do not prompt, tick only one)*?

Materials	Toilet 1	Toilet 2	Toilet 3	Toilet 4
a. Walls				
01 Palm and poles				
02 Mud and poles				
03 Mud bricks				
04 Grass and poles				
99 Other specify				
b. Floor				
01 Earth/Clay				
02 Cement				
03 Poles and mats				
99 Other specify				
c. Roof				
01 Palm and poles				
02 Corrugated metal				
03 Grass and poles				
04 None				
99 Other specify				
d. Door				
01 Palm and poles				
02 Tarp/Cloth/Mat				
03 Corrugated Metal				
04 Grass and poles				
05 Wood				
06 Poles				
07 None				
99 Other Specify				
e. Corresponding hut # from above				
f. Distance from corresponding hut				

Section E: Daily Activities

29. When you are staying in your shamba, do you ever do the following *(prompt)*? If so, what time of day do you usually do it? How often do you do it? And, how far do you go to do it?

#	Activity	N(00) Y(01)	Time of day	# Times a week	How far (km)	Travel time (min)	Notes
01	Collect firewood						
02	Get water						
04	Visit a neighbor						
05	Go to town						
99	Go to other Shamba						
99	Other specify						
99	Other specify						

30. When you are staying in your main house, do you ever do the following *(prompt)*? If so, what time of day do you usually do it? How often do you do it? And, how far do you go to do it?

#	Activity	N(00) Y(01)	Time of day	# Times a week	How far (km)	Travel time (min)	Notes
01	Collect firewood						
02	Get water						
04	Visit a neighbor						
05	Go to town						
99	Go to other Shamba						
99	Other specify						
99	Other specify						

31. Which of the following activities do your children do on a daily basis *(prompt)*?)? If they do the activity, what time of day do they usually do it? How often do they do it? And, how far do they go to do it?

#	Activity	N(00) Y(01)	Time of day	# Times a week	How far (km)	Travel time (min)	Notes
01	Collect firewood						
02	Get water						
03	Go to the shop						
07	Go to shamba						
08	Herd livestock						
09	Play outside						
10	Go to school						
99	Other specify						
99	Other specify						

32. Which of the following activities the elderly in your family do on a regular basis *(prompt)*? If they do the activity, what time of day do they usually do it? How often do they do it? And, how far do they go to do it?

#	Activity	N(00) Y(01)	Time of day	# Times a week	How far (km)	Travel time (min)	Notes
01	Collect firewood						
02	Get water						
03	Go to the shop						
04	Visit neighbors						
07	Go to shamba						
08	Herd livestock						
99	Other specify						

Section F: Being Outside While Dark

33. Do you do the following activities outdoors after sundown *(prompt)*? Until what time? Are there any other reasons why you are outside after dark?

	Activity	**Main Home (00)**		**Shamba (01)**	
#		*N(00) Y(01)*	*Until what time*	*N(00) Y(01)*	*Until what time*
01	Bathing				
02	Cooking/Eating				
03	Sitting/Resting				
99	Other specify				

34. Do you do any activities outdoors between 5AM and 7AM *(prompt)*? If so, when?

	Activity	**Main Home (00)**	**Shamba (01)**
#		*Starting at what time*	*Starting at what time*
99			
99			
99			

35. Do you use the outdoor toilet/or relieve yourself after dark? __No(00) __Yes(01)
    a. If so, how many times after dark do you go? _____
36. Are there any occasions when you sleep outdoors at night? __No(00) __Yes(01)
37. If you sleep outdoors at night, on what occasions (*do not prompt*)? (*Tick all that apply*)

#	**Activity**	**Tick**	**How many nights a year?**
01	Traditional Ceremonies		
02	Weddings		
03	Funerals		
04	Fishing		
05	Hunting		
06	Collecting Timber		
99	Other specify		

Section G: Wildlife

38. Have you seen lions in the village? __No(00) __Yes(01) *(Actual lions, not just evidence of them)*
39. Have you seen lions in the shambas? __No(00) __Yes(01) *(Actual lions, not just evidence of them)*
40. If you have seen lions in your village or shamba, when did you see them? (*list each sighting)*

Number of lions	**When?** Month/Season & Year	**Location** Village(00), Shamba(01), Other specify(99)

41. Have you seen signs of lions in the village? __No(00) __Yes(01) *(Foot prints or roaring)*
42. Have you seen sign of lions in the shambas? __No(00) __Yes(01) *(Foot prints or roaring)*
43. How often do you see signs of lions in your village or shamba during each season?

Season	**Times a Month?**	
	a. In Village (00)	*b. In Shamba (01)*
00 Wet Season		
01 Dry Season		

44. Do you think the number of lions have increased or decreased in this village during your lifetime?
    __Increase(01) __Decrease(02) __Same(03) __Don't Know(04) a. Why? _____
    _____
45. What types of animals do the lions that live in the area eat? _____
    _____

46. Have you seen bush pigs in the village? __No(00) __Yes(01)
47. If yes, during which months and how many days in each month do you see bush pigs in your village?

Month	1	2	3	4	5	6	7	8	9	10	11	12
Tick if you see bush pigs												
How many days each month												

a. How many times a week during above mentioned months do you see them

48. Have you seen bush pigs in the shambas? __No(00) __Yes(01)
49. If yes, during which months and how many days in each month do you see bush pigs in your shamba?

Month	1	2	3	4	5	6	7	8	9	10	11	12
Tick if you see bush pigs												
How many days each month												

a. How many times a week during above mentioned months do you see them

50. Do you think the number of bush pigs have increased or decreased in this village during your lifetime?
__Increase(01) __Decrease(02) __Same(03) __Don't Know(04) a. Why? _____
_____
51. How do you protect your crops against bush pigs? _____
_____
52. If you trap bush pigs, about how many times a year do you do so? _____ a. How effective is the trapping *(prompt)*? __Very Effective(01) __Somewhat Effective(02) __Not Effective(03) __Don't know(04)

53. What other types of wildlife do you see *(prompt, use pictures)*? When are they most common? And, do you think their numbers have increased or decreased in the last ten years?

Animal Name & Code From Picture	**Months Most Common/Season**	**Change -** Increasing (01), Decreasing (02), No Change (03), Don't Know (04)

54. What other animals you see that are not in the pictures? _____

Section H: Perceptions of Risk

55. Have you or anyone in your family been attacked by a lion? __No(00) __Yes(01)
    a. If yes, what is their relation to you? _____
56. How likely do you think you are to be attacked by a lion? *(prompt)*
    __Very likely(01) __Somewhat likely(02) __Not at all(03) __Don't know(04)
57. Are you worried about being attacked by a lion? *(prompt)*__Very Worried(01) __Worried(02) __A little Worried(03) __Not at All(04) __Don't Know (05)
58. Are you afraid of being attacked by a lion? *(prompt)*__Very Afraid(01) __Afraid(02) __A little Afraid(03) __Not at All(04) __Don't Know (05)
59. In your opinion, have the number of attacks increased or decreased in this village during your lifetime? __Increase(01) __Decrease(02) __Same(03) __Don't Know(04) a. Why? _____
    _____
60. Are there any particular years when attacks were worse? _____
61. What activities do you engage in that make you feel most at risk? _____

62. Where do you feel most at risk *(prompt)*? __Village center(01) __Shamba(02) __Both(03) __Don't Know (04) __Other specify(99)_____

63. During which times of day do you feel most at risk *(do not prompt, tick all)*?__Early morning(01) __Morning(02) __Afternoon(03) __Evening(04) __Night(05) __All the time(06) __Don't Know(07)

64. Who in your village do you think is most at risk of lion attacks *(do not prompt, tick all that apply)*? __Children(01) __Young Men(02) __Young Women(03) __Adult Men(04) __Adult Women(05) __Old Men(06) __Old Women(07) __All at risk(08) __Don't Know (09) __Other specify(99)_____

    a. Why? _____

65. Do you think the following activities put people at risk of lion attacks *(prompt)*? If yes, how high of a risk?

#	**Activity**	**N(00) Y(01) Don't Know(02) Not Applicable(03)**	**Amount of Risk** High(01), Medium(02), Low Risk(03), Don't Know(04)
01	Collecting firewood		
02	Getting water		
03	Collecting timber		
04	Fishing		
05	Walking alone during the day		
06	Walking alone when dark		
07	Guarding crops		
08	Sleeping in shamba		
09	Going to the toilet when dark		
10	Cooking outside after dark		
11	Sitting/resting outside after dark		

66. In what ecological surroundings or landscape features do you feel most at risk and why? For example, in an open field, in the forest, in bushland, near a river. _____

_____

67. Which of the following poses the greatest risk? *(prompt first two columns and tick)*

01	00 Elephant	01 Lion	02 Both	03 Don't Know	04 Not Applicable
02	00 Hippo	01 Lion	02 Both	03 Don't Know	04 Not Applicable
03	00 Buffalo	01 Lion	02 Both	03 Don't Know	04 Not Applicable
04	00 Crocodile	01 Lion	02 Both	03 Don't Know	04 Not Applicable
05	00 Leopard	01 Lion	02 Both	03 Don't Know	04 Not Applicable
06	00 Snake	01 Lion	02 Both	03 Don't Know	04 Not Applicable
07	00 Drought	01 Lion	02 Both	03 Don't Know	04 Not Applicable
08	00 Famine	01 Lion	02 Both	03 Don't Know	04 Not Applicable
09	00 Malaria	01 Lion	02 Both	03 Don't Know	04 Not Applicable
10	00 AIDS	01 Lion	02 Both	03 Don't Know	04 Not Applicable
11	00 Other Diseases	01 Lion	02 Both	03 Don't Know	04 Not Applicable

Section H: Mitigation Methods

68. What measures are taken by village leadership when a lion is seen in your villages *(do not prompt)*? __Poison(01) __Trap(02) __Hunt(03) __Report Problem(04) __No Action(05) __Don't Know(06 __Other specify(99) ___

69. What measures do you take to protect yourself from lion attacks? _____

_____

70. What do you think can be done to reduce the problem of lion attacks? _____

_____

71. Do you think doing the following things would reduce the risk of lion attacks (*prompt*)?

#	**Activity**	**N(00)** **Y(01)** **Don't Know(02)**	**Reason**
01	Build different, safer makeshift huts		
02	Build safer houses		
03	Not sleeping in shamba		
04	Changing location of shambas		
05	Better bush pig control		
06	Walking in large groups		
07	Cutting high grass near home		
08	Cutting high grass along commonly used paths		
09	Building a fence around your home that encloses your outdoor toilet and cooking area		

Section I: Observation

72. What materials were used to build the house and toilet at the interview location (*Tick only one each)*?

Materials	House (00)	Toilet (01)
a. Walls		
01 Palm and poles		
02 Mud and poles		
03 Mud bricks		
04 Grass and poles		
99 Other specify		
b. Floor		
01 Earth/Clay		
02 Cement		
03 Poles and mats		
99 Other specify		
c. Roof		
01 Palm and poles		
02 Corrugated metal		
03 Grass and poles		
04 None		
99 Other specify		
d. Door		
01 Palm and poles		
02 Tarp/Cloth/Mat		
03 Corrugated Metal		
04 Grass and poles		
05 Wood		
06 Poles		
07 None		
99 Other Specify		

73. How far is the outdoor toilet from the home? ___Meters

74. Is there a fence around the backyard that encloses the cooking area and toilet?

__No(00) __Yes(01)

a. If yes, what materials were used to build it (*check only one*)? __Poles(01) __Poles & Palm(02) __Poles & Grass(03) __Corrugated metal(04) __Timber(05) __Other specify(99) _____