Greener Journal of Environment Management and Public Safety

ISSN: 2354-2276

Analysis of temporal and distribution patterns of elephant attacks on humans and elephant mortality in Transmara District, Kenya

By

Elizabeth N. Wakoli
Noah Sitati

Research Article

Analysis of temporal and distribution patterns of elephant attacks on humans and elephant mortality in Transmara District, Kenya

Elizabeth N. Wakoli[1] and Noah Sitati[2]*

[1] Moi University, Department of Wildlife Management, P.O Box 1125, Eldoret.
[2]World Wide Fund for Nature, P.O Box 62440 – 00200, Nairobi.

*Corresponding Author's Email: n_wasilwa@yahoo.com

ABSTRACT

The purpose of this study was to examine the spatial and temporal pattern of elephant attacks on people and elephant mortality in Transmara District, Kenya. The study was also aimed at assessing the impact of preventive and corrective mitigation measures employed to minimize the human-elephant conflict. Increasing human-elephant conflict is expected to exert a huge burden on Kenya's economy and health care services because the current conflict mitigation interventions are ad hoc, 'wait and see' and ineffective due to a large elephant range. Using conflict records from the Kenya Wildlife Service (KWS) and World Wide Fund for Nature (WWF) for a ten (10) year period (2000-2009), the study examined the conflict patterns in Transmara District, part of the Greater Mara ecosystem. The data was subsequently analyzed and compared using Analysis of Variance (ANOVA) and Chi square test of goodness of fit. The results showed that the number of conflict incidences varied by year, at an average of one person annually. Elephant attacks on humans, is well explained by the independent variables i.e., time of day, proximity to the forest, gender, and state of the person. An average of five dead elephants was recorded every year under different circumstances. Based on these findings, the study recommends measures to reduce conflict in Transmara Conflict. These include sensitization of the local people at times of peak conflict season especially in conflict prone days (e.g., traditional ceremonies) and seasons (e.g., Christmas) on ways to avoid attack, ensuring that community scouts are constantly trained to ensure that they are up to date with contemporary conflict mitigation strategies at all times, learning from other elephant range states with better conflict mitigation strategies and ensuring adequate and long-term funding for conflict mitigation projects. These measures, if well executed, can reduce elephant attacks on people and subsequently minimize retaliatory killing of elephants in Transmara District and Kenya in general. These findings are important for future planning of elephant range into zones with sustainable land use types and to influence policy formulation that can safeguard elephant conservation and guarantee people's security.

Key words: Transmara District, Injury, death, elephant, humans, conflict.

INTRODUCTION

Human-elephant conflict is a primary threat to elephant survival throughout the elephant range (Barnes 1996; Western 1997; Sitati et al., 2003). Elephants are mega-herbivores and commonly raid crops, causing economic losses, injury and death to people (Hoare 1995; O'Connell-Rodwell et al. 2000; Sitati et al. 2003; Ngene et al. 2009). Over the years there has been a considerable amount of research carried out on crop raiding, including the development of noble and cost effective mitigation strategies (Sitati and Walpole, 2006; King et al. 2010; FAO 2009). However, there is little information available on elephant attacks on human and elephant mortality based on long term monitoring and particularly so after project intervention. Yet elephant attack on people is ranked first among ten types of conflicts by local communities (Sitati et al., 2007), and these communities have developed a negative attitude and less tolerance towards elephants (Naughton-Treves, Rose & Treves 2000; Sitati 2003). Deaths caused by larger mammals, such as elephants and lions, incites far greater passion among people than deaths from, say, venomous snake or rabid dog bites (Sukumar 2003). The psychology underlying public outcry against elephants may be the human perception of greater vulnerability to larger animals than to small creatures. Wildlife laws that prescribe severe penalties for killing the endangered megavertebrates may also contribute to the public reaction; a poisonous snake can be killed quietly, irrespective of its legal status, without inviting any attention. This has far- reaching implications on elephant populations as they are killed or injured by the local community in revenge for conflicts that

they cause, and also due to the attitude and perception of local communities towards conservation of elephant's habitat (Hoare 2000).

India, by far, records the highest number of people either killed or injured by elephants. For instance, during 1980-2000, about 150 – 200 people on average lost their lives due to elephant attacks (Sukumar 2003). Information from Sri Lanka suggests that over 50 people are killed annually, while similar figures are also suggested for Kenya (KWS, 2001). Generally, in all incidences more men than women are killed by elephants but there is no clear annual pattern of elephant attacks on people (Sukumar 2003). Several observers in Africa and Asia note that elephant populations that have not been harassed by poachers are relatively peaceful towards humans, while affected elephant populations show aggressive or terrified behavior. These aggressive behaviors are usually passed from one generation to the next (Douglas-Hamilton and Douglas-Hamilton 1992).

The Mara ecosystem which supports over 3,000 elephants is no exceptional in this case (rephrase sentence). Unprecedented human population growth in the Mara ecosystem due to immigration and natural reproduction has led to increased conversion of natural habitat to human dominated landscapes, bringing elephants and humans into greater contact and conflict. Recent surveys by KWS (2007) have shown a declining elephant population in the Masai Mara National Reserve with increasing human settlement (Sitati *et al.* 2008). The current elephant range for Transmara District is approximately 1,200 km^2 with about 800 elephants and a density of two elephants per km^2, which is higher than the required density of one elephant per km^2 (Sitati & Walpole 2006, Sitati 2007). Notwithstanding, elephants are forced to disperse into dense human settlements. Following this, the local communities who live near the forest where elephants live have been adversely affected (Sitati et al. 2003).

In this study, the historical records of human and elephant deaths and injuries in Transmara District were examined for the possibility of the existence of any seasonal and temporal patterns between the years 2000 and 2009. Additionally, the impact of project intervention in 2003 was examined. Understanding patterns of human and elephant deaths is useful in designing effective management strategies, such as land use planning and zonation and change in human behaviour and incompatible activities. Unlike elephant attacks on humans, the temporal and spatial variations in crop raids by elephants (Tchamba, 1995; Bhima, 1998; Sitati et al., 2003) and by lions (Packer, et al., 2005) is a widely recognised phenomenon.

MATERIALS AND METHODS

Study Area

Transmara District covering 2900 km^2 is an important elephant dispersal area for the elephant population in the Mara Triangle of the Maasai Mara National Reserve. The district lies in south-western Kenya on the border with Tanzania (0^o 50′ - 1^o 50′ S, 34^o 35′ - 35^o 14′ E), and encompasses the western portion of the world famous Maasai Mara National Reserve. Approximately 2,200 km^2 of the district is unprotected of which 1,200 km^2 is the elephant range (Sitati & Walpole, 2006). The district maintains an elephant population estimated at 800 elephants (Sitati 2007). Temperatures in Transmara District are moderated by the high altitude, and range from 14.8^0 to 20.3^0 C. The mean annual temperature ranges from 15^0 C in the north to 17^0 C in the south. Long rains occur between February and June, while short rains occur between November and December. The mean annual rainfall is about 1500 mm. The region is a zone of high agricultural potential, thus, increased agricultural activity threatens the future survival of the elephants due to increased conflicts. Some of the crops cultivated include: maize, beans, bananas and sugarcane.

Research design

All cases of human and elephant deaths and injuries from 2000 to 2009 were monitored and recorded by 10 trained field enumerators supported by WWF elephant project. Any elephant attack on people, and a dead or injured elephant within an enumerator's area was visited for verification purposes and the location was recorded in Universal Transverse Mercator (UTM) coordinates using a Garmin GPS12 satellite navigation unit (Garmin Corp., Ulathe, KA). Further details of persons attacked by the elephants, such as time of incident, ethnicity, sex, state of the person (i.e. whether drunk or not), among others, were recorded from the complainants on a standardized reporting form (Sitati, 2003). Historic incidents from 1986 onwards were also extrapolated from the Kenya Wildlife Service occurrence books and through participatory rural appraisals (PRA) with local communities, as described by Sitati et al., (2003) for comparison. The UTM coordinates of each incident were imported into the Arc View GIS software package (ESRI Inc., Redlands, CA) for manipulation prior to analysis. Separate layers were created for elephant attacks on people and elephant mortality.

Data obtained were first coded in Microsoft Excel before it was transferred to SPSS (SPSS Inc. Chicago, IL) for statistical analysis whereby appropriate tests were undertaken such as frequencies, percentages and chi-square tests.

RESULTS

Spatial patterns of elephant attack on people and elephant mortality

Human-elephant conflict occurred in 14 group ranches with elephant attacks on people in 13 group ranches and elephant mortality in 11 group ranches (Table 1). Moyoi group ranch had the highest (20%, n=14) cases of elephant attacks on humans followed by Kimintet (19%, n=13) and Olonkolin (10%, n=7) group ranches (Figure 1). Isambi group ranch had no elephant attack on humans. Kerinkani, Osinon and Olalui Group ranches had the lowest cases of elephant attacks with 1.4%, 1.4% and 2.9%, respectively. There was a weak positive and significant correlation between number of elephants and the number of humans attacked ($y=0.0005x$; $r^2=0.262$; $p<0.05$).

Table 1. Spatial distribution of the number of people killed or injured by elephants and elephant mortality by group ranches in Transmara District, 2000-2009.

Group Ranch	No. of Elephants	No. of Dead / Injured Persons	%	No. of Dead / Injured Elephants	%
Isampin GR	0	0	0.0%	1	2.2%
Kerinkani GR	3	1	1.4%	1	2.2%
Kimintet GR	180	13	18.6%	6	13.3%
Masurura GR	124	4	5.7%	3	6.7%
Moita GR	204	5	7.1%	7	15.6%
Moyoi GR	44	14	20.0%	7	15.6%
Nkararu GR	180	4	5.7%	0	0.0%
Ntulele GR	150	3	4.3%	1	2.2%
Olalui GR	0	2	2.9%	8	17.8%
Oloirien GR	39	6	8.6%	7	15.6%
Olomismis GR	26	6	8.6%	2	4.4%
Olonkolin GR	316	7	10.0%	2	4.4%
Olosakwana GR	172	4	5.7%	0	0.0%
Osinoni GR	1	1	1.4%	0	0.0%

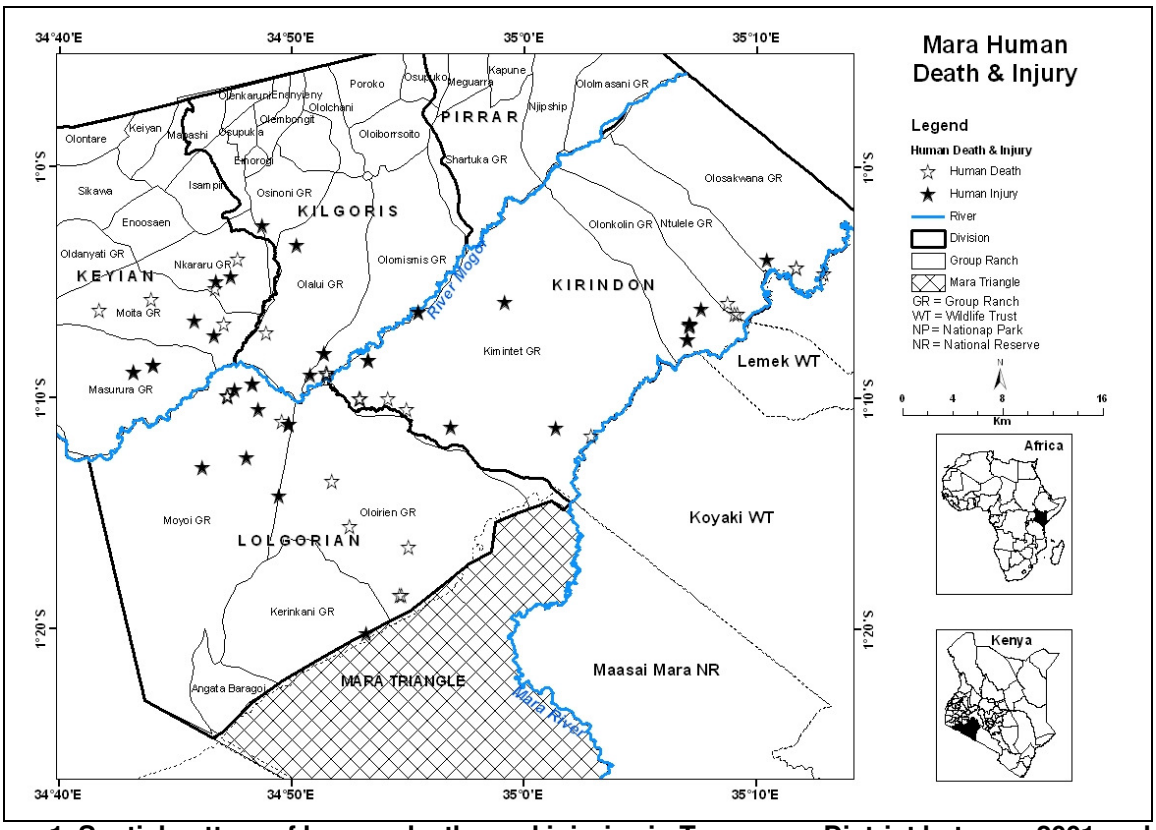

Figure 1. Spatial pattern of human deaths and injuries in Transmara District between 2001 and 2009

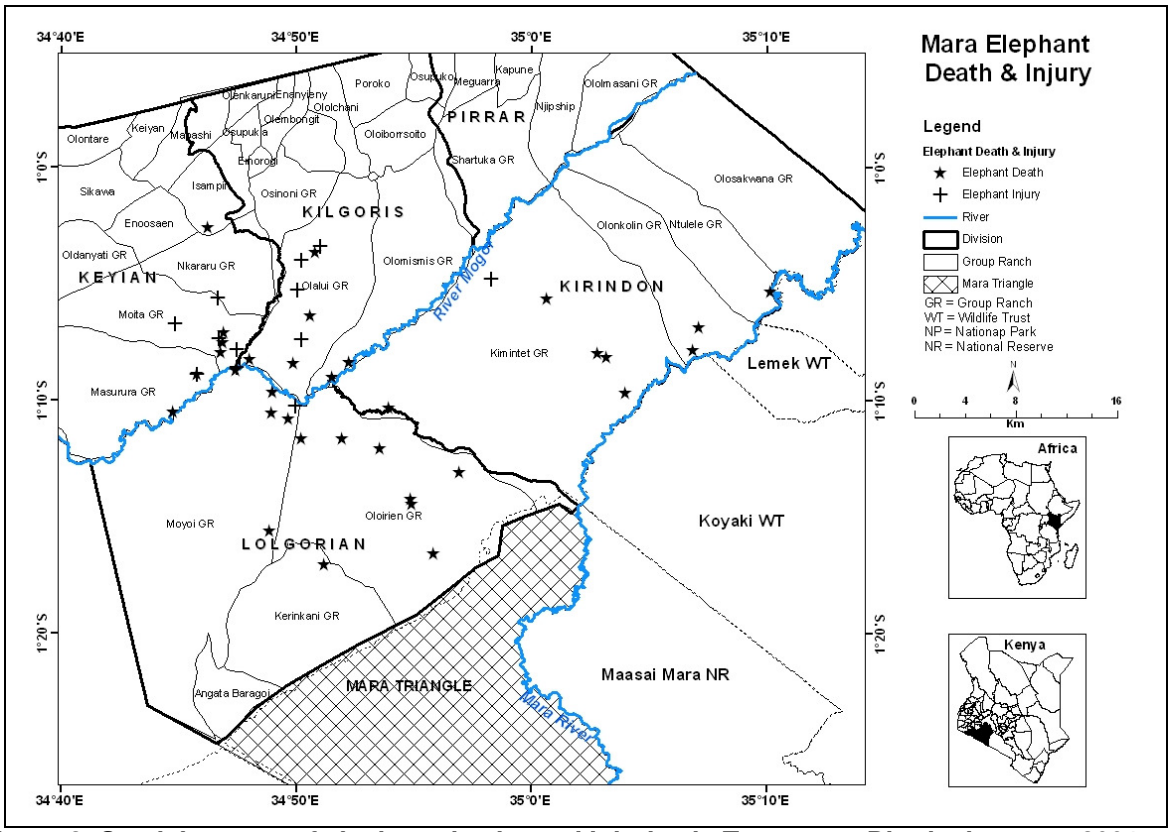

Figure 2: Spatial pattern of elephant deaths and injuries in Transmara District between 2001 and 2009

Highest incidences of elephant deaths and injuries were recorded in Olalui group ranch (17.8%, n=8) followed by Moyoi, Moita, and Oloirien group ranches each with 16% (n=7) and Kimintet group ranch with 13% (n=6). There were no elephant deaths or injuries in Nkararu, Olosakwana and Osinon group ranches while 3 group ranches had only one case each and 2 group ranches had two cases each. There was a positive and significant correlation between number of elephants and the number of elephant mortality ($y=0.004x$; $r^2=0.527$; $p<0.05$).

Annual and seasonal patterns of elephant attack on people

Elephant attacks on humans by decade shows an increase in attacks within the last three decades: 1981-90, 1991-2000, and 2001-2009 from 3 to 27 and to 65 respectively (Figure 3). However, a focus on the 2000 - 2009 periods showed a different trend after project intervention (Figure 4).

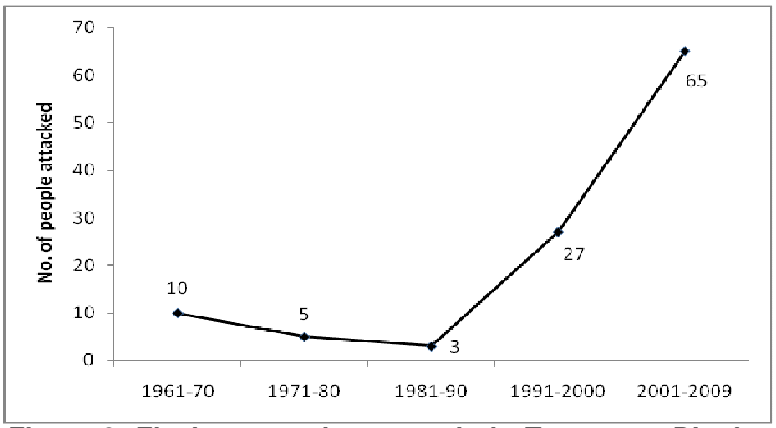

Figure 3. Elephant attack on people in Transmara District by decade, between 1961 and 2009

Elephants attacked 70 people between 2000 and 2009 in Transmara District of which 49% (n=34) died and 51% (n=36) were injured (Figure 3). A Chi-square analysis revealed no significant difference between cases of human injuries and deaths caused by elephants (χ^2 =0.057, df =1, p=0.811). There was no clear pattern of the number of people attacked, with 2003 recording the highest (19%) cases of human attacks (7 deaths and 6 injuries), followed by 2002 with 16% (n=11). The lowest number of human attack was three. Generally, incidences of elephant attack on people increased between 2000 and 2003 and declined steadily up to 2009 after project intervention in 2003. Figure 4 shows the number of people attacked elephants observed for the 10- year period. Regression models of recorded number of people attacked by elephants against the years reveal non -significant negative relationship ($P<0.05$). The fitted regression line corresponds to: $Ln(y) = -0.1705x^2+682.84$ ($R^2=0.255$; n=10; $P>0.05$).

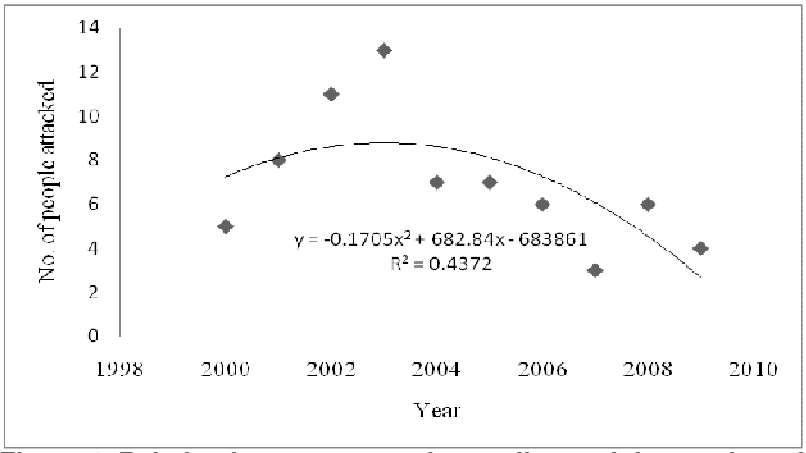

Figure 4. Relation between year of recording and the number of people attacked by elephants.

The fitted regression line corresponds to: Ln (y) = -0.1705x^2+682.84 (R^2=0.255; n=10; P>0.05).

The victims of elephant attacks who died increased substantially between 2000 and 2005 followed by a steady decline through 2009. Additionally, the number of people injured by elephants dropped tremendously between 2000 and 2009 (Figure 5). Regression models of recorded human deaths and injuries against the years reveal significant negative relationships (P<0.05) with injured people and non- significant decline in human deaths (P>0.05; Figure 5).

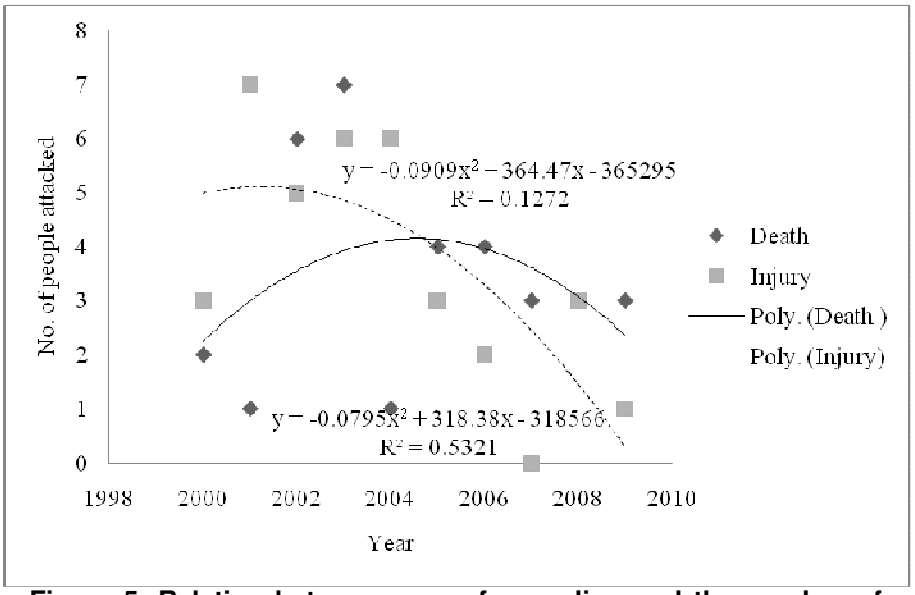

Figure 5. Relation between year of recording and the number of people either killed or injured by elephants.

The fitted regression line corresponds to: killed (R^2=0.00; n=10; P>0.05) and injured (R^2=0.463; n=10; P<0.015)

In terms of attack by gender, 30 (88%) males and 4 (12%) females were killed by elephants while 33 (92%) and 3 (8%) males and females, respectively were injured by elephants. From the results, it is evident that men risked being attacked by elephants compared to women (χ^2 =44.800, df =1, p=0.000).

The study also revealed that approximately 67% of the people attacked by the elephants were not drunk (χ^2 =8.229, df =1, p=0.004). For example, out of 34 people who were killed, 13 (38%) were drunk and 21 (62%) were not drunk. For those who were injured, 10 (28%) were drunk and 26 (72%) were not drunk.

Time of attack and the ethnicity of the victims

The time for elephant attacks was divided into four time blocks. Only 65 cases of elephant attacks had the time known (Figure 6). Most attacks (56%, n=39) occurred between 6:00 PM and 11:00 PM constituting 18 (42%) deaths and 21 (58%) injuries. This was followed by the early and late parts of the mornings (12:00 AM - 5.00 AM and 6:00 AM - 11:00 AM) comprising of 19% each, where there were 10 (29%) injuries and 3 (8%) deaths and 3 (8%) injuries and 10 (29%) deaths, respectively. The lowest (0.1%) cases of elephant attack occurred between 12:00 PM and 5:00 PM with 3 deaths and 2 injuries. Chi square analysis showed a significant difference between the times the victims were attacked by elephants (χ^2 =37.657, df =3, p=0.000; Figure 4). More Maasai's (72%) were attacked by elephants than non Maasai (28%) (χ^2 =30.229, df =1, p=0.000).

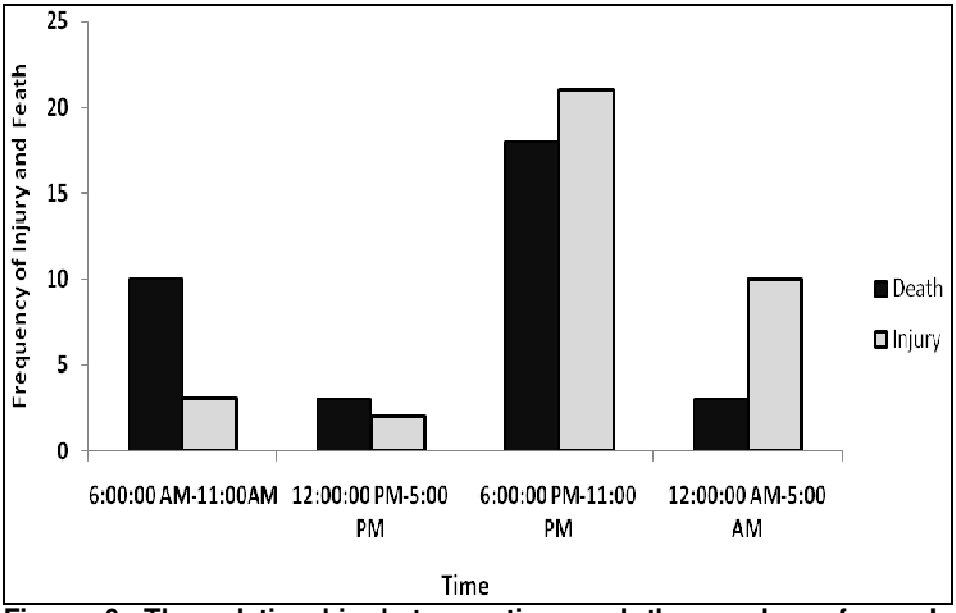

Figure 6. The relationship between time and the number of people attacked by the elephants between 2000 and 2009

Annual and seasonal patterns of elephant deaths and injury

A total of 46 elephants were found either dead (72%, n=33) or injured (28%, n=13) in Transmara District. The trend showed a slight increase between 2000 and 2005 followed by a slight decline with 2005 recording the highest number (Figure 7). The number of dead elephants was higher compared to those injured between 2000 and 2009 with 13 and 33 elephants being injured or dead, respectively. Equally, the number of dead and injured elephants varied between years with 2005 having the highest (22%, n=10) followed by 2003 with 15% (n=7). Only one injured elephant and no deaths were recorded in 2007. On the other hand, 4 injured elephants, being the highest were recorded in 2000 while 2006, 2007, 2008 and 2009 had no incidences of injured elephants. Only 27 dead elephants sex could be identified of which 16 (59%) were males and 11 (41%) were female elephants while 5 males and 4 females were injured.

Figure 7 shows combined number of dead and injured elephants observed for the 10year period. Regression models of recorded dead and injured elephants against the years reveal non-significant relationships (P>0.05).

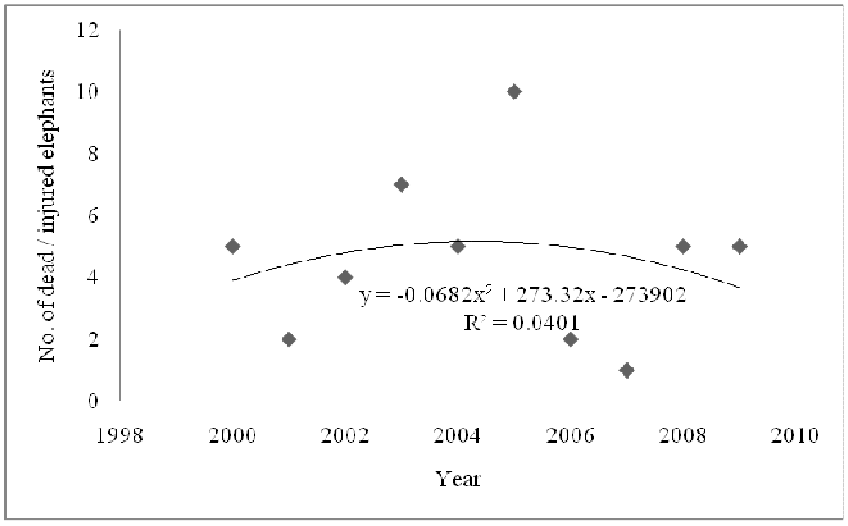

Figure 7. Relation between year of recording and elephant mortality. The fitted regression line corresponds to: R^2=0.001; n=10; P>0.05

Figure 8 shows the number of dead and injured elephants observed for the 10year period. Regression models of recorded elephant mortality and injuries against the years reveal significant negative relationships (P<0.05) with injured elephants and insignificant increase in dead elephants (Figure 7).

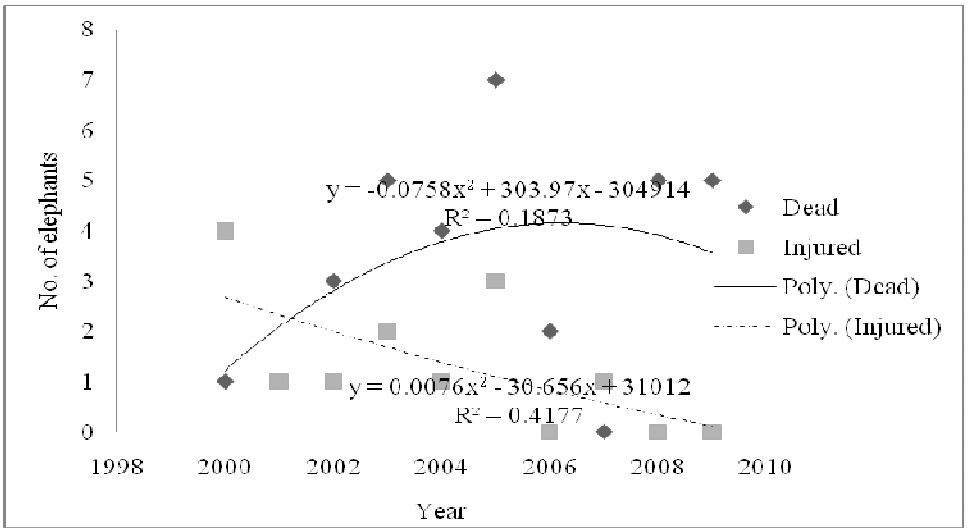

Figure 8. Relation between year of recording and elephant mortality.

The fitted regression line corresponds to: killed (R^2=0.122; n=10; P>0.05) and injured (R^2=0.523; n=10; P<0.05).

Cases of elephant deaths and injuries varied between months but the highest cases of deaths were reported in July and June with 6 and 5, respectively; while most (n=4) injured elephants were recorded in April.

Most of the elephant carcass found were still fresh (n=13) thus being able to identify sex and the cause of death among other information. The recent carcass ranged from one day to one week while recent was ranked between 1-2 weeks and old was 3-4 weeks. The 'very old' was a carcass that was difficult to identify the cause of death and sex. Recent carcasses were 8, 7 were old and 5 were very old. The chi-square results indicated that the state of the carcass did not vary (χ^2 =4.212, df =3, p=0.239).

Causes of elephant death

Poaching contributed to the highest number of elephant mortality with 11 cases followed by Problem Animal Control (PAC), control by Kenya Wildlife Service (KWS) with 7. Natural death, unknown cause and those killed during defense by the local community were 5 each. Hence the causes of elephant mortality varied significantly (χ^2 =4.212, df =4, p=0.390).

Of the 33 dead elephants, 11 (33%) had their tusks still intact, while 12 (36%) carcasses had tusks chopped off by poachers. KWS collected tusks from 9 (27%) cases while one elephant was borne without tusks. The chi-square analysis indicated that more tusks were recovered by KWS from dead elephants (χ^2 =9.061, df =3, p=0.028).

DISCUSSION

Loss of human life is the most serious form of human-elephant conflict according to the ranking by local communities (Campbell et al. 2000; Sitati & Ipara 2007). Human deaths and injuries are a major form of conflict in elephant ranges, yet these have only been simply described in most studies (Sukumar 1989; Sukumar 2003) or totally avoided. Generally hundreds of people have been killed by elephants in heavily populated areas (Sukumar 1990; KWS 1994; Sukumar 2003), while the lack of human deaths and injuries in Zaire was attributed to the low human population (Kakira 1996). However, Tchamba (1998) believes most figures are exaggerated, and loss of human life is actually rare and negligible. Today, however, elephant-caused human deaths and injuries often result in a more

vociferous public outcry than when a person is killed by other causes (Sukumar 1990), because elephants have become highly politicized species. For instance, while elephants have attacked 70 people in Transmara District over the last 10 years, lions in Tanzania have killed 563 people and injured at least 308 in 15 years (Packer et al. 2005).

Attack on humans by elephants in Transmara showed an increasing pattern, which can be attributed to an increase in human (CBS, 2010) and elephant populations (Sitati 2007) followed by reducing elephant range resulting from increasing cultivation (Sitati et al. 2003). The chances of elephants and people coming in contact are quite high especially when elephants attempt to utilize human settlement areas at night (Sitati et al. 2003) with attacks reported every year and at least every month. Most attacks on humans occurred in the traditional elephant corridors and next to forest reserves with high elephant density. Equally, they also occurred mostly during the months when crops are mature and ready for harvesting and when the local community guarded their crops against invasion by the elephants (Sitati et al. 2008). However, spatial differences in the planting and harvesting seasons in Transmara have an effect on the occurrence of HEC cases and hence conflict mitigation.

In relation to time, most cases of human deaths and injuries occurred at night when elephants had left the forested areas for crop raiding, when most people were going back home from market places and drinking places. Most men face death and injury by elephants and this could be as due to reasons studied by Sitati (2003) which include: men walking for long distances looking for and/or after cattle, women going home early to milk while men stay out late, men engaging in social activities that usually involve drinking alcohol, whereas women attend to domestic responsibilities, women being allowed to leave the *boma (homestead)* when the elephants reach the forest and Maasai women being regarded as cowards and thus kept away from elephants (Sitati 2003). In India, according to Sukumar (2003), more men than women and children are killed by elephants because men venture more often into the forest and almost exclusively guard cultivated fields at night.

The increase in cases of human deaths and injuries by elephants could be as a result of: increase in human population thus increased chance of encounters with elephants; encroachment into areas traditionally used by elephants restricting elephant access to their important areas; immigration of other tribes who practice farming and shoot elephants with arrows while protecting their farms, making elephants more aggressive towards people; and, drinking alcohol and returning home late at night. According to Sukumar (2003), the same happens in India and the victim show delayed or no reaction to the presence of an elephant. There is also a breakdown in the information flow system and traditional methods of evading elephants, where for instance the Maasai could very easily by-pass elephants unnoticed by determining the wind direction using grass or saliva, and staying down wind. The Maasai also never used to bathe with conventional soap, but instead used some plant species such as '*Olmusigiyioi'* (*Rhus natalensis*) and '*Olmarashrash'* (*Trichocladus ellipticus*) which did not produce any unusual smell that could be detected by elephants. Now, the Maasais have forgotten the traditional methods of by-passing elephants and have also started crop farming which attracts elephants to the farms. Blockage of elephant corridors by human activities has caused many human deaths by elephants. Elephants are usually attracted to human settlements especially the livestock *bomas* which grows kikuyu grass (*Pennisetum clandestenum*), pumpkin (*Curcabita maxima*), and the calabash and sometimes attack livestock. The aftermath of elephant poaching has made elephants very cautious of humans, and they may attack people. Finally, artificial water dams built for livestock attracts elephants, especially during the dry season, thus causing conflict (Sitati 2003).

Lack of benefits and incentives from tourism (Sitati & Ipara 2007) and the delayed and low compensations has led to increased revenge attacks by the local community using poisoned arrows and spears. The new wildlife policy has raised the compensation for human deaths from $ 625 to $ 2,500 and injury from $ 375 to $ 625. The government is revising the figures to $ 12,500 for deaths and $ 2,500 for injury. Elephants are also killed by KWS during PAC to appease the local community. Elephant mortality in Transmara by KWS fluctuated between 2000 and 2009. Due to poaching and encroachment, elephants have developed aggressive behaviour and other survival tactics (Kangwana 1995; Sukumar 2003).

A total of 33 elephants died and 13 injured between 2000 and 2009 with male elephants bearing the brunt compared to female elephants. The highest cases occurred in 2005 but the cases of death cases have not reduced, factors leading to their death are more less the same as those leading to human injury and death by elephants. While it was easy for fresh and undecomposed elephant carcass to determine the sex and the cause of death among other information, the opposite was true for the decomposed carcass including information such us if the tusks were removed by KWS rangers or by poachers. Some dead elephants had wounds as a result of snares and spears and arrows.

With a sign of an increase in both human and elephant death and injury compared to 1990s, the future of elephants in Transmara District remains bleak with increasing human and elephant populations while elephant range is diminishing. The ratio of human and elephant death for the last ten years is 1:1; this could indicate that most elephants are killed as a result of revenge by the local community members. The ratio of human and elephant injury is 3:1 with more people being injured than elephants. However, this is negligible considering human and elephant

populations in the district or elephant range. Recommended is land use planning, equitable benefit sharing from conservation of natural resources and increased interventions by conservation agencies, Non Governmental Organizations and local communities through sustainable and long term funding, education and awareness and sharing lessons and experiences.

ACKNOWLEDGEMENTS

We would like to thank WWF for funding this project. We also wish to express our deep gratitude to the enumerators who were involved in field work. We wish also to acknowledge MyCOE for giving additional financial support, equipment and GIS software. More so we appreciate the tireless contributions, support and encouragement by Dr. Patricia Solis, Dr. Rodrigo Sierra and Dr Matthew Koepe.

REFERENCE

Barnes, R.F.W., (1996). The conflict between humans and elephants in the Central African forests. *Mammal Review*. 26:67-80.

Bhima, R., (1998). Elephant status and conflict with humans on the western bank of Liwonde National Park, Malawi. *Pachyderm,* 25:74-80.

Campbell, D., Gichohi, H., Mwangi, A., & Chege, L., (2000). Land use conflict in Kajiado District, Kenya. *Land Use Policy*, 17:337-348.CBS (2010). National Census, Kenya. Government Printer, Nairobi.

Douglas-Hamilton, I., and Douglas-Hamilton, O., (1992). *Battle for the elephants*. Double-day,London.

FAO (2009). Human-wildlife conflict in Africa. Causes, Consequences and Management Strategies. FAO Forestry Paper 157. Italy.

Hoare, R.E. (2000). *African elephants and humans in conflict*: the outlook for coexistence. *Oryx*, 34, 34-38.

Hoare, R.E., (1995). Options for the control of elephants in conflict with the people. *Pachyderm*, 19:54-63.

Kakira, L.M., (1996). An assessment of crop damage by large mammals in the reserve de Faune a okapis – Ituri forest – Zaire, with special emphasis on African forest elephant (Loxodonta Africana). Msc. Thesis, University of Kent, UK.

Kangwana, K.I., (1995). Human-elephant conflict: the challenge ahead. *Pachyderm,* 19:11-15.

King, L., Soltis, J., Douglas-Hamilton, I., Savage, A., Vollrath, F., (2010). Bee threat elicits alarm call in African elephants. Vol. 5. Open Access.

KWS (2007). Wet and Dry Season Total Aerial Counts of elephant in the Mara ecosystem. KWS Unpublished Report. Nairobi.

KWS (2001). A preliminary analysis of human-elephant conflict in Kenya. KWS unpublished report, Nairobi

KWS (1994). Wildlife-human conflicts in Kenya. Report of the Five-Person Review Group.

Naughton-Treves, L., Rose, R., & Treves, A., (2000). *Social and Spatial Dimensions of Human-Elephant Conflict in Africa. A review of the Literature and Case Studies from Cameroon and Uganda*. IUCN Publication Series of the African Elephant Specialty Group. IUCN, Gland, Switzerland. 80 pp.

O'Connell-Rodwell, C.E., Rodwell, T., Rice, M., & Hart, L., (2000). Living with the modern conservation paradigm: Can agricultural communities co-exist with elephants? A five- year case study in East Caprivi, Namibia. *Biological Conservation*, 93:328-391.

Packer, C., Ikanda, D., Kissui, B., and Kushnir, H., (2005). Lion attacks on humans in Tanzania. *Nature,* Vol 436/18. Pp. 927-928.

Sitati, N.W., Ucakuwun, E.K., & Wishitemi, B.E.L., (2008). Spatio-temporal analysis of land use types in the Masai Mara dispersal areas, Kenya. *East African Journal of Pure and Applied Science.* vol. 4. Pp. 24-31.

Sitati, N.W., (2007). Wet and dry season elephant counts in Transmara District, Kenya. WWF Mara HEC Project. Unpublished report.

Sitati, N.W., and Ipara, H., (2007). The role of tourism development and benefit sharing in mitigating human-elephant conflict in the Mara ecosystem, Kenya: In (ed) Kloek E. M., and Rene van der Dium. Tourism and nature in Africa. Thematic proceedings of Association for Tourism and Leisure Education (ATLAS) Africa conferences, *ATLAS*, Vol. 1, Pp. 71-80.

Sitati, N.W., & Walpole, M.J., (2006). Assessing Farm-Based Measures for Mitigating Human-Elephant Conflict in Transmara District, Kenya. *Oryx*. Vol 40, No. 3, July 2006. 279-286.

Sitati N.W., (2003). Human-Elephant Conflict in Transmara District adjacent to Maasai Mara National Reserve. PhD Thesis. University of Kent, Canterbury, UK.

Sitati N.W., M.J. Walpole, R.J. Smith, N. Leader-Williams,. (2003). Predicting Spatial Aspects of Human-elephant conflict. *Journal of Applied Ecology*, (40) 667-677

Sukumar, R., (2003). The living elephants: Evolutionary ecology, behavior, and conservation. Oxford University Press, Inc.

Sukumar, R., (1990). Ecology of the Asian elephant in southern India. Feeding habits and crop raiding patterns. *Journal of Tropical Ecology*, 6:33-53.

Sukumar, R., (1989). The Asian elephant: *ecology and management*. Cambridge University Press, Cambridge.

Tchamba, M. N., (1998). Habitudes migratoires des elephants et interactions homme-elephant dans la region de Waza – Logone (Nord – Cameroon). *Pachyderm,* 25:53-66.

Tchamba, M.N., (1995). The problem elephants of Kaele: a challenge for elephant conservation in northern Cameroon. *Pachyderm*, 19:26-33.

Western, D., (1997). *In the Dust of Kilimanjaro*. Island Press, Washington, D.C.