

Factors Contributing to Transmission of Domestic and Sylvatic Lifecycles of *Echinococcus* Species in Samburu and Maasai Mara, Kenya

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Abstract

Cystic echinococcosis (CE), caused by different species of the *Echinococcus granulosus* sensu lato (s.l), is an important global zoonotic disease with a particular impact on pastoralist communities. Depending on the species, the lifecycles can be domestic, peri-domestic or wildlife-based. Previous studies have established existence of both domestic and peri-domestic cycles in Kenya. However, factors related to the interaction and hence transmission of both cycles are unknown. To investigate factors, leading to interaction and transmission of CE within pastoral communities living near wildlife conservation areas, 740 residents (356 from Maasai Mara, and 384 Samburu) were interviewed. An open-ended questionnaire was administered seeking information on practices, behaviors and activities involving possible interaction between wild life and humans living within the study areas. Data collected identified the associated risk factors as; livestock herding in the wildlife conservation areas, dogs accompanying herders into the conservation areas, frequent uninspected home slaughter and feeding of raw offal to dogs. Additionally, poor personal hygiene due to lack of enough water, environmental contamination with faecal matter from dogs and wild carnivores, and the wild carnivores preying on livestock contributed majorly to Cystic echinococcosis transmission risk. Further, in Samburu community, cultural practices such as humans not eating lungs and therefore feeding to dogs posed an important risk for the disease transmission. transmitting Cystic Echinococcosis. The study concludes that illegal encroachment of human and livestock into the wildlife conservation areas and the free roaming and preying of wild carnivores on livestock in human settlements favor the existence of both domestic and wildlife *Echinococcosis* life cycles. The study recommends enforcement of meat control act, community education programs as well as conducting more prevalence studies in a view to map out the disease situation in Kenya.

Key Words: *Transmission, Taeniid eggs, Domestic, Wildlife, Cycle*

Introduction

Cystic echinococcosis (CE) is a neglected disease of public health importance. However, National and international research funds have been directed to diseases such as Malaria and Tuberculosis. Cystic Echinococcosis adversely affects the health of human and animals (Odel *et al.*, 2015). Continued growth of hydatid cyst and its presence and expansion may cause discomfort and tremendous pressure on the infected organs (Addy *et al.*, 2012; Mutwiri *et al.*, 2013).

Several organs and tissues such as the lungs and heart have been known to harbor hydatid cysts which often result in breathing problems due to increase in cyst size. In man, *E. granulosus* infection in the lungs may be related with increased body temperature and troubled breathing (Wachira *et al.*, 1993). *E. granulosus* cysts may also develop in other organs including the brain and lead to increased difficulties since the normal tissue is pressurized (Wachira *et al.*, 1993).

It is a typical affliction of rural pastoralist cultures with little access to health facilities, and whose economic losses are rarely considered and are difficult to quantify (Budke *et al.*, 2006; Odero *et al.*, 2015). Control of CE in domestic settings is very complex due to varied challenging factors in endemic regions (Magambo *et al.*, 1998).

Increasing species diversity and wide range of hosts for Echinococcus parasite have posed a bigger challenge preventing and controlling its transmission. In Africa, CE control has only been partially achieved despite long-term control programs. In Kenya, the disease is endemic in livestock rearing areas and pastoralist communities. Highest prevalence worldwide has been reported in Turkana community of Kenya, with a prevalence ranging from 3.1% - 5.6% (Wachira *et al.*, 1990; Mutwiri *et al.*, 2013).

Once infected, sure cure is surgical removal of the cyst. Strain diversity dictates pathogenicity and transmission of the disease in different set ups (Thompsons *et al.*, 2002). The situation on distribution in human in different set ups and the genetic diversity of Echinococcus species in domestic and wild-life cycles in Kenya has for many decades not been well documented. However, recent studies have reported existence of Echinococcus species in areas other than the Turkana and these were in Maasai land (proportions more than 25% in cattle and 0.8% in people), the Isiolo-Samburu (15% in cattle, 1.2% in people), as well as in the wildlife sanctuaries (2.4%) (Addy *et al.*, 2012; Kagendo *et al.*, 2014; Mbaya *et al.*, 2014).

It is however not known if the wildlife and the domestic cycles are dependent or

independent of each other. This study endeavored to shed more light on transmission factors associated with the disease transmission in both domestic, peri-domestic and wildlife cycles in the two pastoralist communities of Kenya.

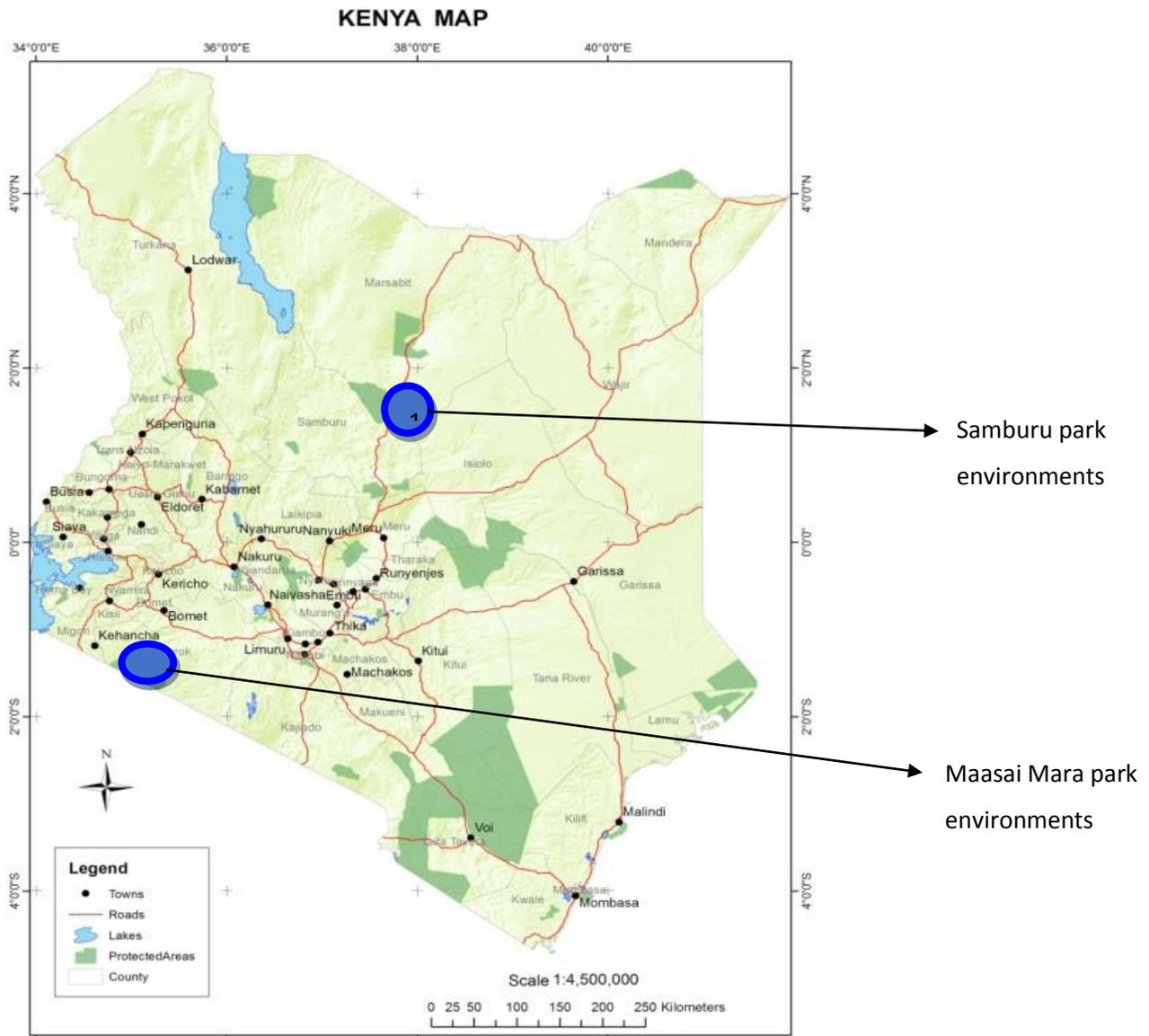
Materials and Methods

Study area

This study was done in two CE endemic areas of, Maasai Mara and Samburu Game Parks and their immediate environs and this was between April 2016 and April 2017. The two areas were selected due to its common characteristics with Turkana which is a pastoralist community with long standing of high prevalence of cystic echinococcosis in the world (3-5.6% across different villages). An earlier study reported prevalence >25% in cattle in Maasai Mara. (Addy *et al.*, 2012).

Maasai Mara Game Park occupies 1,500 km², situated at the northern part of the Serengeti-Mara National Park. The park setting has suitable vegetation and climatic conditions for wild animals including herbivores and carnivores, livestock and human.

Samburu Game Park covers about 165 km². Human, livestock and wild animals in this area primarily depend on river Ewaso Nyiro. In Samburu Game Park, manyattas are found surrounding the unfenced park, morans and herds men move freely in and out of the conserved areas. Human-wildlife interactions and conflicts are therefore a common phenomenon, with wild carnivores often preying on livestock and human killing the predators in return.



Study design and Study population

The study employed a cross-sectional survey of study participants living close to the park lines of the game reserves or individuals who frequented the Game Park areas for herding of livestock. Families are encroached in a traditional household setting called a ‘Manyatta’, and this was evident in both study areas. A structured questionnaire was

administered to all adults over 18 years of age who consented to participation in the study either by appending their signatures or by thumbprints.

Inclusion

Adults, 18 years and above who had lived in the study area for at least six months. Those who gave consent to participate in the study

either by appending their signatures or by thumb print.

Sample size calculation

Both Samburu and Maasai Communities live in Manyattas (Several households together encroached in one fence). Most times the Manyattas are temporally set ups because of the nomadic nature of the pastoralist communities. Census method was used whereby all those who met the inclusion criteria within the Manyattas were interviewed. This method was utilized because of the low population density around the park environments and the nomadic nature of the communities.

Data analysis and presentation

Statistical package for social sciences (SPSS) version 20 was used to analyze data into frequencies and proportions.

Ethical consideration

Permission to conduct the research was granted by Meru University of Science and Technology Institutional Research Ethics Review committee (MIREC-035-2017). To enable collection of data in wildlife

encroachment areas, permission was given by the Kenya wildlife service (permit number KWS/BRM/5001). Participants were assured of data confidentiality and consent was signed appending a signature or by thumbprint.

Results

Respondents by gender in Maasai Mara and Samburu Park Environments

To investigate factors leading to transmission of CE within pastoral communities living near wildlife conservation areas, 740 herds men and women (356 respondents from Maasai Mara (181males and 175 females) and 384 respondents of Samburu (182 males and 202 females) were interviewed (Table 1). This was done using an open-ended questionnaire, which was administered to every adult in the study population. Questions included thematic areas such as practices, behaviors and activities involving possible interaction between wild life, livestock, domestic dogs and humans living within the study areas.

Table 1: Respondents in Maasai Mara and Samburu Park environments

Study area	Gender	Frequency	Percent
Maasai Mara	Male	181	50.8
	Female	175	49.2
	Total	356	100.0
Samburu	Male	182	47.4
	Female	202	52.6
	Total	384	100.0

Park visits per week

Park visits in Maasai Mara park environments

In Maasai Mara where 356 individuals were interviewed on the number of times they visited wildlife conservation and restricted areas, 37.9% visited Maasai Mara park areas

four times a week. 40.2% of them visited the area to herd cattle, 36.4% visited to collect firewood while 3.8% of them entered park on game drive. Only 5 elderly men did not visit park environments, these said they heard their cattle within their home compounds.

Table 2: Visits and activities in Maasai Mara park environments

Number of Times per week	Herd cattle	Collect fire wood	Game drive	None	Total
Once	40	19	3	0	62 (17.4%)
Twice	24	36	11	0	71(19.9%)
Thrice	47	36	0	0	83 (23.3%)
Four	75	52	8	0	135 (37.9%)
None	0	0	0	5	5 (1.4%)
Total	186 (52.2%)	143(40.2%)	22(6.2%)	5 (1.4%)	356 (100%)

Visits and activities in Samburu Park environments

In 384 Samburu respondents, 206 visited park environments to herd cattle, and this was either once (61), twice (19), thrice (39) whilst majority of the cattle herders (107 respondents) visited Samburu park area four times a week. Other activities that made respondents visit the park areas included collect firewood (153 respondents) and game drive 5 respondents who visited the park varied times as detailed in Table 3

Table 3: No of times respondents visited Samburu park environments

Times per week	ACTIVITY			Total
	Herd cattle	Collect fire wood	Game drive	
Once	61	25	2	88
Twice	19	28	2	49
Thrice	39	42	0	81
Four	107	58	1	166
Total	226	153	5	384

Domestic dogs per household

Maasai Mara domestic dog ownership

In Maasai Mara domestic dog ownership varied from individual family to the other, and only 3% respondents did not own any dog. Majority of the respondents (54.8%) owned 5 or more dogs, whereas 10.9 % and 17.9% individuals owned up to 3 and 4 dogs respectively. Those who owned only two dogs accounted for (7.9%) with lowest number of dog owners being 5.3%.

Samburu domestic dog ownership

Majority of respondents in Samburu owned more than five domestic dogs. Those who owned three and four domestic dogs per household in the area were 11.5% while respondents who owned 2 dogs per households in the area were 9.9%. Lowest numbers were recorded among individuals who owned only one dog per household.

Domestic dog feeding

Feeding of domestic dogs with condemned offal from slaughter houses and home slaughter was evident and was reported by 91% of the respondents in Maasai Mara National Reserve. Others in the area fed their dogs on game meat and these were 8.4%. Similarly, in Samburu where 384 individuals were interviewed, 95.6% fed their dogs with condemned meat from slaughterhouse while 3.9% fed their dogs on game meat. In both

areas, dogs defecated nonspecifically within home compound.

Slaughter practice

In Maasai area, only 7.6% of the respondents slaughtered their animals in slaughter slabs. Majority of the people 92.4% practiced home slaughter. Among them 87.6% of these respondents said they often discovered fluid filled cysts in the organs of slaughtered animals. Over three quarters of them said they often removed the cyst materials and directly give their waiting dogs.

The trends were not any different from Samburu where out of the 384 respondents, 95.6% practiced home slaughter and among them 90.8% often saw fluid filled as well as calcified cysts in organs. Similar to Maasai Mara, these organs were directly fed to waiting domestic dogs. In both areas animals often slaughtered at home included sheep, (84.8%) Maasai Mara and (53.6%) in Samburu, Goats 13.5% in Maasai Mara and 31.5% in Samburu, cattle included 1.7% in Maasai Mara and 13.5% in Samburu. Others included 1.3% camels in Samburu.

The respondents indicated that the larger animals (cattle and camels) were only slaughtered during celebrations, i.e. during circumcisions and Marriage ceremonies. From the responses, it was clear that small stock was slaughtered by women whilst

slaughtering of large stock was mainly the work of older men, and this was in both Maasai Mara and Samburu.

Proportion of cysts per organ infected in Maasai Mara

Respondents reported having seen cysts on either one organ or multiple organs in most of the animals. In Maasai Mara, liver harbored

the highest number of CE cysts, and these were 64.3% followed by intestine 10.9%,

while 8.9% observed cysts in both liver and Kidney, an indication of Multiple organ infestation. Only 2.5% of the respondents indicated having discovered cysts in the lungs as they carried out their home slaughter as detailed in table 4.

Table 4: Proportions of number of cysts per organ infected in Maasai Mara

	Frequency	Percent	Cumulative Percent
Intestines	39	11.0	11.8
Intestine liver	6	1.7	13.5
Kidney, lungs, liver	2	.6	14.1
Liver	229	64.3	78.4
Liver, spine	2	.6	78.9
Liver, spleen	3	.8	79.8
Liver, spleen, intestine	2	.6	80.3
Liver/kidney	32	9.0	89.3
Liver/lungs	19	5.3	94.7
Liver/lungs/kidney	2	.6	95.2
Lungs only	9	2.5	97.8
Lungs, kidney, liver	2	.6	98.3
Lungs and kidney	4	1.1	99.4
Stomach	2	.6	100.0
Total	356	100.0	

In Samburu majority of cysts were reported to be in the liver (74.2%), lungs (18.7%) and intestines (8.1%). Other organs infested included the kidney, the spleen and the heart to a less extent.

Wild carnivore encroachment into human settlements

Maasai Mara marauding wild carnivores

In this area majority of the respondents had seen lions (10.1%), hyena (85.4%), and leopards 5.3% within their home compounds. They also indicated having seen hyena faeces within home compound and open fields where they often herd their cattle.

Samburu Marauding wild carnivores

In Samburu a total of 89.3% persons indicated not only seeing the hyena at night within home compounds but also hyena faeces within the compound. Those who said they had seen lions were 3.6%.

Shared water sources

Majority of respondents (59.6%) in Maasai Mara and (73%) in Samburu often use River water for their daily consumption and use. It was evident that these sources are shared among human, domestic animals as well as wild animals. Those who owned boreholes were 19.4% in Maasai Mara and (18.7%) in Samburu. Other respondents (21.1% Maasai Mara and 8.1% in Samburu) indicated using

water from Natural wells which were at times also shared between people and animals.

Discussion

Direct Transmission routes

Human Encroachment into wildlife conservation areas.

Human encroachment into wildlife areas has since been reported as a major risk in transmission of many Zoonotic diseases, Echinococcosis included (Shyamapada & Manisha., 2012). Pastoralism is the main source of living for communities in arid areas of Kenya.

This is the case with the communities living near wildlife conservations in Samburu and Maasai Mara where it was reported that 45% of the population visited the parks for herding purposes with 46% of them herding up to four times a week. Similarly, collecting firewood was the second common activity that led 40% of the population into the parks with 36% of them visiting up to four times a week. This creates a window for interface between wildlife and human and a possible route for Echinococcosis transmission (Kagendo *et al*, 2014). Only 5.9% of the population went to the park for game drive which is solely a tourist activity.

Dog man contact

Just like most nomadic communities, majority of the people (54.8%) in the study sites owned more than five dogs. Dogs are

usually reared to provide protection during herding and collecting firewood as well as keeping away marauding wild animals at night. Humans and dogs in these communities have a close interaction which poses a transmission risk for Taeniid eggs. In addition, oral fecal transmission of Taeniid eggs is enhanced by handling of dog fecal matter without protective equipment especially by women while conducting cleaning chores in the homestead. (Odero *et al.*, 2014; Mulinge *et al.*, 2018). It was observed that domestic dog contact was common among owners in both communities. Children and adults were often seen playing and stroking the fur of their dogs which they regarded as close pets.

It was observed that domestic dogs often accompanied women during their house chores, in close proximity to nursing mothers, during water fetching trips, during herding or even collecting fire hood, and sometimes in wildlife restricted areas. Higher proximity to domestic dogs was also observed in Morocco where it was reported that women handled dogs twice as much (52.9%) compared to men (21.9%) and children (25.2%) (Berbri *et al.*, 2015).

Slaughter Practices

Previous studies indicate that the highest influence of dog tape worm (*Echinococcus granulosus*) is through feeding dogs with condemned meat either from home slaughter or slaughter slabs (Mbaya *et al.*, 2014, Addy

et al., 2012). It was further observed that dogs were always present during home slaughter, normally a duty of women, and always received their share of infected offal. As reported by Wachira *et al.*, 1993, men are rarely involved in slaughter except during ceremonies. The current study concurs with these reports. Over 92% of the respondents in both communities slaughtered their animals at home while the rest used slaughter slabs. Moreover, 87% of the respondents witnessed fluid filled cysts in the organs with majority being sequestered in the liver, intestines and lungs.

Customarily, in Samburu community lungs are not consumed by people and are obviously food for dogs. It was noted that 8.4% and 3.9% of the population fed their dogs with game meat in Maasai Mara and Samburu respectively. Other studies have advocated introduction of meat inspection services in more areas of the country to combat cystic echinococcosis by ensuring that infected carcasses are properly disposed (Acha *et al.*, 2003; Addy *et al.*, 2012).

Indirect Transmission Routes

Sharing water sources

The study area is arid with minimal water sources. The few sources available are shared between domestic and wild animals as well as humans. This creates an enabling triad for oral fecal transmission of Taeniid eggs from the host, agent and the environment. In Samburu for example, wild animals,

livestock and humans all share river Ewaso Ngiro, which poses a great risk, not only to existence of wildlife, but also disease exchange between human and animals and vice versa.

Marauding wild carnivores

Occasional visits in the homestead by hyena, lion and leopard was reported by the participants. This could be as a result of non-fenced demarcation between the two inhabitants, wild animals and domestic life. It was noted that these wild carnivores usually left behind fecal matter. These faeces have a higher likelihood of being fed by livestock during grazing (Magambo *et al.*, 1998).

They could as well be accidentally picked by human, children as well as adults included during their dairy chores, posing a great health risk, either due to Echinococcosis and other also helminthic diseases. This eventually drains the country's economy by the country, either through expensive surgical treatments or /and through animal loses to diseases. This agrees with recent studies which found out the country's monetary loses due Echinococcus for instance stands at relatively high levels. (Odero *et al.*, 2015).

Conclusion

The study concludes that illegal encroachment of human and livestock into the wildlife conservation areas and the free roaming and preying of wild carnivores on

livestock in human settlements favor the existence of both domestic and wildlife *Echinococcosis* life cycles. The study emphasized on the mechanisms of Echinococcus infection from wild to human and vice versa. The study identified certain aspects such as human movement into wild life areas, animal movement into households and Manyattas as well as poor cultural processes and practices are the major causes of transmission of Echinococcosis in Kenya.

It was evident that dog-man contact and poor slaughter practices may in a big way augment transmission of zoonotic diseases of public health concern, such as Echinococcosis. Due to lack of enough grazing land and fodder, pastoral communities have found their way into wildlife conservation areas, posing an environmental risk, as well as endangering the country's economy due to human interference with nature.

Recommendations

The study recommends enforcement of meat and control act to prevent and reduce transmission of zoonotic diseases during animal and meat handling. More so wildlife conservation programs and community education programs on control and prevention of zoonotic diseases during encroachment activities is Key. Further recommendations include carrying out prevalence studies in a view to map out the disease situation in Kenya.

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