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PREVALENCE OF CYSTIC ECHINOCOCCOSIS AND ITS ECONOMIC SIGNIFICANCE IN SLAUGHTERED LIVESTOCK IN KISUMU EAST/WEST AND ISIOLO DISTRICTS OF KENYA

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Abstract

Cystic Echinococcosis (CE) is a zoonosis caused by the larval stage of the tapeworm *Echinococcus granulossus.* The disease has a worldwide distribution and is endemic in livestock rearing, nomadic pastoral regions of Eastern Africa such as Turkana and Masaailand in Kenya. The life cycle involves canids as definitive hosts and livestock/human as intermediate hosts. The present study aimed at assessing the prevalence of CE in slaughtered livestock and associated direct economic impact resulting from organ condemnation during meat inspection and suggests sustainable control measures to reduce the economic losses. A five year retrospective data review of annual meat inspection reports and slaughter house surveys were conducted in Kisumu East/West and Isiolo districts to assess the prevalence of CE in slaughtered livestock. The data were analyzed using Ms excel spreadsheet computer program. Cystic Echinococcosis was found in cattle, sheep, goats, camels and pigs and the hydatid cysts were common in the liver and lungs. The prevalence's were; Kisumu East and West districts cattle (4.24%), sheep (4.52%), goats (2.02%), pigs (0.05%), Isiolo district cattle (6%), sheep (1.33%), goats (1%), camels (25.3%). The pigs had the least infection rate. Direct CE associated losses per year through organ condemnation were estimated, Kisumu East/West districts (US$ 4,976) and Isiolo district (US$ 4,054). This study was the first in Kenya. The study suggested sustainable CE control measures to reduce losses, regular deworming of dogs, reduction of dog population, proper and professional meat inspection/hygiene and disposal of condemned animal organs and public health education.

Keywords: Cystic Echinococcosis, *Echinococcus granulosus,* Prevalence, Direct Economic Loss, Slaughtered Livestock, Kenya.

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INTRODUCTION

Cystic Echinococcosis (CE), caused by the metacestode of *Echinococcus granulosus*, is a common zoonotic diseases associated with economic losses and great public health significance worldwide (Romig *et al.,* 2011). Estimated global annual overall losses from the burden of human CE and livestock-associated losses were reported to be $1,918,318,955 and $2,190,132,464, respectively (Budke *et al.,* 2006). Dogs and other canids are the definitive hosts for this parasite, with cattle, sheep, goats, camels and pigs as intermediate hosts. Humans are aberrant intermediate hosts and a dead link in the transmission cycle. The outcome of infection in livestock and humans is cyst development in the liver, lungs, or other organ systems (Pawloski *et al.,* 2001).

The adult tapeworm in the definitive dog host is asymptomatic unlike the hydatid cyst in the intermediate host animals that is responsible for immense economic and medical importance in infected hosts (Azlaf and Dakkak, 2006, Battelli, 2009, Ibrahim, 2010). Food animals such as sheep, goats, cattle, camels, buffaloes, and pigs acquire the infection by ingestion of infective eggs with contaminated grass and water (Fakhar and Sadjjadi, 2007). The disease is of major public health importance in sheep rearing areas worldwide (Eckert and Deplazes, 2004) due to its morbidity that causes economic impact and animal production associated losses; the affected viscera are condemned at the slaughterhouses/slabs. The parasite is cosmopolitan and possesses the second rank in consideration of helminthic diseases significance (Muller, 2002,

Toggerson and Budke, 2003, Sarioskan and Yalcin, 2009). Infections with E. granulossus cysts in the livestock intermediate hosts are typically asymptomatic, except a few cases of long-standing and heavy infections (Eckert and Deplazes, 2004). There are no reliable methods for routine diagnosis of the infection in living animals (Sadjjadi, 2006). The major economic impacts caused by CE in livestock are losses in productivity such as reductions in carcass weight, milk production, fleece and wool value, fertility, hide value, birth rate and fecundity, delayed performance and growth. Condemnation of organs especially liver and lungs, costs for destruction of infected viscera, and dead animals (Eckert *et al.,* 2001) (Ibrahim, 2011).

The previous studies on CE in Kenya only pointed out on the epidemiological aspects of the zoonosis (French, 1980, Macpherson, 1983, Magambo *et al.,* 1996, Magambo *et al.,* 2006, Addy *et al.,* 2012, Kagendo *et al.,* 2014). The economic burden of the infection in livestock intermediate host is not well established in most regions in Kenya. This is the first study of this kind in Kenya and it is conservative as only retrospective slaughterhouse data from two selected regions were considered for the cost factors. The present study was conducted to determine the prevalence of CE and its direct economic losses from condemned organs in selected regions in Kenya. Furthermore the study suggested sustainable cost effective control measures to reduce the economic impact of CE within the study areas.

MATERIALS AND METHODS

Study Areas

Kisumu East/West districts

The districts are located on the western parts of Kenya near Lake Victoria. They experience an annual relief rainfall of 1200-1300mm with a mean annual temperature of 23^0C and ranges between 20^0C and 35^0C. During the period under review, cattle (54,377), goats (38,210), sheep (17,295) and pigs (2,199) were slaughtered. The animals slaughtered in the two districts were sourced from other places (Homabay, Migori, Kuria, Kericho, Turkana) according to the movement permit reports kept at the district veterinary office.

Isiolo district

Isiolo district is located in the upper eastern region of Kenya. The climate of the district include an average temperature range of 12^0C-28^0C, rainfall of 150-650mm per annum typical of arid and semi-arid lands in Kenya. The main economic activity is pastoralism. During the period under review, cattle (7,204), goats (18,509), sheep (4,145) and camels (3,204) were slaughtered. The animals slaughtered in the district were sourced from within the district and other neighbouring districts (Meru, Marsabit, and Garrisa).

Study design

The data was collected through a retrospective data review over a specified period of five years in Kisumu East and West districts from 2005 to 2009 and Isiolo district from 2006 to 2010.

Direct slaughter house surveys was also conducted in the 2 study areas, Mamboleo (Kisumu East) and Isiolo central (Isiolo) slaughter houses for a period of one week to confirm the retrospective data.

Methodology

A five year retrospective review of the annual meat inspection was conducted in the two study sites was conducted. The data included the livestock species and total number slaughtered per year; number of hydatid cysts noted in various body organs, the disposal method of infected organs, average weight and price per kilogram of edible organs.Slaughter house surveys involved actual meat inspection, visualization, palpation and incision of the organs to locate the cysts. Any cyst(s) noted in the liver, lungs and other organs were recorded and this formed the basis of condemnation of the organ hence the lost revenue.

Any organ with a single hydatid cyst or suspect hydatid cyst calcification was condemned at meat inspection and disposed accordingly. Any cyst that was found in the liver, lungs and any other organ from the annual meat inspection reports was assumed to represent one infected animal. This assumption was significant in the calculation of the CE prevalence in slaughtered livestock in the study areas.

RESULTS

Prevalence of CE in Slaughtered Animals in Kisumu East and West Districts

Table 1 shows the prevalence of CE in slaughtered animals in Kisumu East and West districts. The infection was shown to be highly prevalent in cattle and sheep and least prevalent in pigs. The liver and lungs were the most affected organs and condemned at meat inspection according to the records.

Prevalence of CE in Slaughtered Animals in Isiolo District

Table 2 shows the prevalence of CE in slaughtered animals in Isiolo district. The infection was shown to be highly prevalent in camels and cattle and least prevalent in the small ruminants. The liver and lungs were the most affected organs and condemned at meat inspection according to the records.

Estimation of Direct Economic Loss from Cystic Organ Condemnation at Meat Inspection

Table 3 shows the animal species slaughtered in the study areas, the average weight of the normal body organs and their average market prices. The total price of each normal organ was calculated using the product of the average weight of a normal organ and average market price per kilogram of a normal organ, [TPNO = AWNO x MP/KG].

TPNO = AWNO x MP/KG

TPNO - Total price of a normal organ
AWNO – Average weight of a normal organ
MP/KG – Average market price per kilogram of a normal organ

Table 1. Cystic Echinococcosis prevalence in slaughtered animals in Kisumu East and West districts

Year	Animal species	Total slaughter numbers	Total No. infected	% infection	Total No. of liver infected	% liver infected	Total No. of lungs infected	% lungs infected
2005	Cattle	9822	456	4.6	197	2.0	259	2.6
	Goats	7231	165	2.3	73	1.0	92	1.3
	Sheep	3326	192	5.8	92	2.8	100	3.0
	Pigs	662	1	0.2	1	0.2	0	0
2006	Cattle	11037	539	4.9	182	1.6	357	3.2
	Goats	8801	180	2.0	60	0.7	120	1.4
	Sheep	5233	212	4.1	77	1.5	135	2.6
	Pigs	630	0	0	0	0	0	0
2007	Cattle	11377	364	3.2	151	1.3	211	1.9
	Goats	8604	149	1.7	50	0.6	99	1.2
	Sheep	3631	157	4.3	52	1.4	105	2.9
	Pigs	151	0	0	0	0	0	0
2008	Cattle	10555	372	3.5	163	1.5	209	2.0
	Goats	6899	121	1.8	63	0.9	58	0.8
	Sheep	2473	103	4.2	43	1.7	60	2.4
	Pigs	154	0	0	0	0	0	0
2009	Cattle	11586	573	4.9	237	2.0	336	2.9
	Goats	6675	160	2.4	81	1.2	79	1.2
	Sheep	2632	118	4.5	38	1.4	80	3.0
	Pigs	602	0	0	0	0	0	0

Table 2. Cystic Echinococcosis prevalence in slaughtered animals in Isiolo district

Year	Animal species	Total slaughter numbers	Total No. infected	% infection	Total No. of liver infected	% liver infected	Total No. of lungs infected	% lungs infected
2006	Cattle	1194	48	4	9	19	39	81
	Goats	2915	4	0	2	50	2	50
	Sheep	1048	0	0	0	0	0	0
	camels	447	106	24	53	50	53	50
2007	Cattle	1725	38	2	2	5.3	36	95
	Goats	3471	17	0.5	6	35	11	31
	Sheep	966	12	1	9	75	3	25
	camels	644	115	18	57	49	58	50
2008	Cattle	1637	112	7	46	41	66	59
	Goats	3772	17	0.5	3	18	14	82
	Sheep	730	5	0.7	3	60	2	40
	camels	650	184	28	109	59	75	41
2009	Cattle	1607	89	6	24	27	65	73
	Goats	4011	20	0.5	2	10	18	90
	Sheep	562	0	0	0	0	0	0
	camels	650	165	25	92	56	73	44
2010	Cattle	1341	160	12	58	36	102	64
	Goats	4340	83	2	12	14	71	86
	Sheep	839	38	5	14	37	24	63
	camels	813	240	30	111	46	129	54

Table 3. Estimated average weight of normal organs and market price for the respective slaughter animal

Animal Species	Organ	Average Weight (KG)	Market Price Per KG (US$)	Total Price/Organ (US$)
CATTLE	LIVER	5.0	4.0	20.0
	LUNGS	2.0	2.0	4.0
	SPLEEN	1.5	4.0	6.0
	HEART	1.5	4.0	6.0
SHEEP/GOATS	LIVER	1.0	2.0	2.0
	LUNGS	0.25	1.0	0.3
	HEART	0.25	2.0	0.6
CAMELS	LIVER	7.0	4.0	31.0
	LUNGS	3.0	2.0	7.0
	HEART	2.5	4.0	11.0
	SPLEEN	2.5	4.0	11.0
PIGS	LIVER	1.5	0	0
	LUNGS	1.0	0	0
	HEART	0.25	0	0
	SPLEEN	0.25	0	0

[Exchange rate: 1 US$ = Ksh 89]

Therefore, each organ condemned would be equivalent to the total cost of a normal organ as CE associated direct monetary loss to the livestock traders.

The total direct CE associated monetary loss per species per organ per year (TDML) was calculated by the product of the

market price of a normal organ (MPNO) and the total number of each cystic organ per species per year (TNCO/S/YR).

Total Direct Monetary Loss (Tdml) = MPNO x TNCO/S/YR

TPNO - Total price of a normal organ
TNCO/S/YR- Total number of each cystic organ per species per year

Direct Economic Loss Due to Ce in Slaughtered Livestock in Kisumu East and West Districts

Table 4 show the animal species slaughtered in the study area, the total number of cysts found in the liver and lungs per species per year, weight of the cystic organs and the revenue lost per organ per year. The calculations were based on the data in Table 3.

Number of Condemned Organs Due to Hydatid Cyst (S) in Kisumu East and West Districts

Figure 1 represents the number of cystic organs per animal species per year that was condemned in Kisumu East and West districts. Lung cysts were more frequent compared to the liver cysts. In the four animal species slaughtered in the study area, organs from cattle had the highest number of cysts while organs from pigs had an isolated case of a single cyst in the liver.

Direct Economic Loss Due to Ce in Slaughtered Livestock in Isiolo District

Table 5 show the animal species slaughtered in the study area, the total number of cysts found in the liver and lungs per species per year, weight of the cystic organs and the revenue lost per organ per year. The calculations were based on the data in Table 3.

Number of Condemned Organs Due to Hydatid Cyst (S) In Isiolo District

Figure 2 shows the number of organs condemned due to CE per species per year. In the four animal species slaughtered in Isiolo district, camels and cattle had the highest number of hydatid cysts in the liver and lungs compared to sheep and goats. The CE associated direct monetary loss in the study area was highest in the camels and cattle.

Hydatid Cysts

Plate 1 and 2 show the hydatid cysts found in the lungs of a camel and cattle in Isiolo and Kisumu East districts respectively during slaughter house surveys. Such organs were condemned at meat inspection and disposed in the condemnation pits to avoid the perpetuation of the parasite in the environment.

Table 4. Direct economic loss due to CE in livestock in Kisumu East and West Districts

Year	Animal species	No. of cystic liver	Wt. of cystic livers (kg)	Revenue lost from liver (US$)	No. of cystic lungs	Wt. of cystic lungs (kg)	Revenue lost from lungs (US$)	Total revenue lost from liver & lungs (US$)
2005	Cattle	197	985	3,940	259	518	115	5,091
	Goats	73	73	162	92	23	26	188
	Sheep	92	92	204	100	25	28	232
	pigs	1	1.5	0	0	0	0	0
2006	Cattle	182	910	3,640	357	714	1,587	5,227
	Goats	60	60	133	120	40	44	178
	Sheep	77	77	171	135	33.75	38	208
	pigs	0	0	0	0	0	0	0
2007	Cattle	151	755	3,020	213	426	947	3,967
	Goats	50	50	111	90	22.5	25	136
	Sheep	52	52	25	105	26.25	29	54
	Pigs	0	0	0	0	0	0	0
2008	Cattle	163	815	3,260	209	418	929	4,189
	Goats	63	63	140	58	14.5	16	156
	Sheep	43	43	96	60	15	17	112
	pigs	0	0	0	0	0	0	0
2009	Cattle	237	1185	4,740	326	81.5	91	4,831
	Goat	81	81	180	79	19.75	22	202
	Sheep	38	38	84	80	20	22	107
	pigs	0	0	0	0	0	0	0
TOTAL REVENUE LOSS DUE TO CONDEMNATION OF LIVER AND LUNGS								24,878

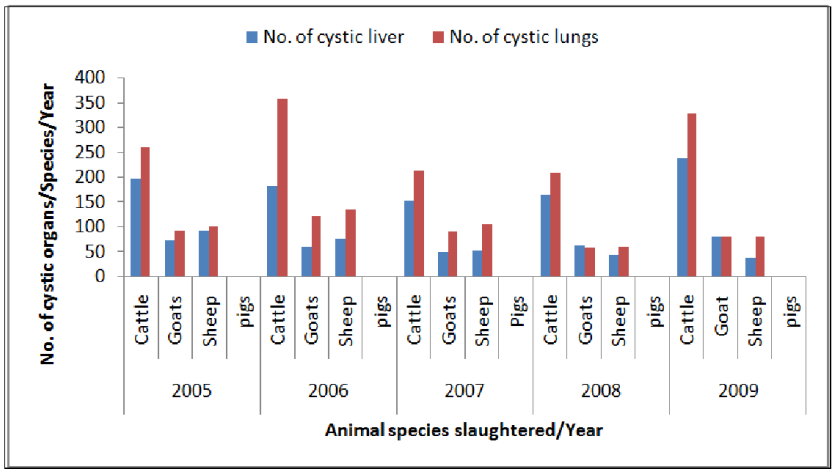

Figure 1. Number of condemned liver and lungs per animal species per year in Kisumu East and West Districts

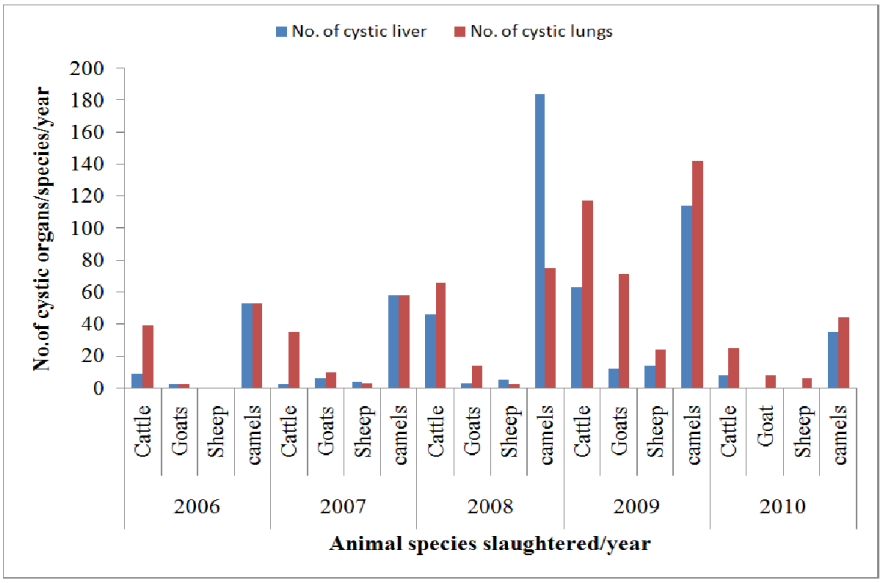

Figure 2. Number of condemned Liver and Lungs per animal species per year in Isiolo

Table 5. Direct economic loss due to CE in livestock in Isiolo District

Year	Animal species	No. of infected liver	Wt. of infected liver (kg)	Revenue lost from liver (US$)	No. of infected lungs	Wt. of Infected lungs (kg)	Revenue lost from lungs (US$)	Total revenue lost from liver & lungs (US$)
2006	Cattle	9	45	180	39	78	173	353
	Goats	2	2	4	2	0.5	0.6	5
	Sheep	0	0	0	0	0	0	0
	camels	53	371	1,649	53	159	353	2,002
2007	Cattle	2	10	40	35	70	156	196
	Goats	6	6	13	10	2.5	3	16
	Sheep	4	4	9	3	0.75	0.8	10
	camels	58	406	1,804	58	174	382	2,191
2008	Cattle	46	230	920	66	132	293	1,213
	Goats	3	3	7	14	3.5	4	11
	Sheep	5	5	11	2	0.5	0.6	12
	camels	184	1288	5,724	75	225	500	6,224
2009	Cattle	63	315	1,260	117	234	520	1,780
	Goats	12	12	27	71	17.75	20	46
	Sheep	14	14	31	24	6	7	38
	camels	114	798	3,549	142	426	947	4,496
2010	Cattle	8	40	178	25	50	111	289
	Goat	0	0	0	8	2	4	4
	Sheep	0	0	0	6	1.5	3	3
	camels	35	245	1,089	44	132	293	1,382
TOTAL REVENUE LOSS DUE TO CONDEMNATION OF LIVER AND LUNGS								20,272

Plate 1: Hydatid cyst from a camel lung in Isiolo district, Isiolo central slaughter house.

Plate 2: Hydatid cyst from cattle lung in Kisumu East district, Mambo Leo slaughter house

DISCUSSION

In the livestock intermediate host, the infection is asymptomatic (Eckert and Deplazes, 2004) and diagnosis of the disease is normally done at meat inspection or at post-mortem, ante mortem diagnosis is practically impossible (Sadjjadi, 2006). Previous studies indicate the disease to be endemic in Turkana (North West) and Masaai land (South) (Wachira *et al.,* 1993) but recent studies show a wider distribution of the disease in Kenya (Kagendo *et al.,* 2014). Prevalence of CE in the slaughtered livestock intermediate host in Kisumu East & West districts, cattle was 4.24% (2,304/54,377), sheep 4.52% (782/17,295), goats 2.02% (775/38,210) and pigs 0.05% (1/2,199).

In Isiolo district prevalence of CE +was 6% (447/7,504) in cattle, 1.33% (55/4,145) in sheep, 1% (141/14,737) in goats and 25.3% (810/3,204) in camels. These results indicate that among the species of animals slaughtered, cattle and sheep had the highest and pigs had the lowest prevalence of CE in Kisumu East & West districts. In Isiolo district, camels and cattle had the highest, and small ruminants had the lowest CE prevalence. The high prevalence of CE in slaughtered animals in the two study areas confirms that the zoonosis is spreading outside its known endemic areas in Kenya.

The cysts were common in the liver and lungs in the livestock slaughtered in the two study areas, the condemnation of these edible organs constituted the direct CE associated monetary loss to the livestock traders, (Plates 1 and 2). This finding concurs with the results of a similar study in Hawassa Municipal abattoir, Ethiopia (Regassa *et al.,* 2010). This is the first study on the assessment of the economic impact of CE in livestock in Kenya. The direct CE associated monetary loss in slaughtered livestock in the two study areas during the five years under review were, Kisumu East &West districts (US$ 24,878 average US$ 4,976) and Isiolo district (US$ 20,272 average US$ 4,054). The results from this study concur with similar studies in Ethiopia on hydatidosis associated direct economic loss from organ condemnation (Getaw *et al.,* 2010, Zewdu *et al.,* 2011, Kebede *et al.,* 2011).

The direct CE associated economic loss and the prevalence of the infection in slaughtered animals in the two study areas are very important epidemiological parameters for public health policy makers both at the county and national level to consider instituting sustainable and cost effective control measures to reduce the CE prevalence and its economic impact in these counties.

Conclusion and Recommendation

From the results of this study, cattle, camels and sheep are the main intermediate hosts harbouring the larval stage of the *E. granulossus* in the two study areas basing on the high prevalence of the infection noted in the animals. The liver and lungs were the most affected organs harbouring the hydatid cysts and therefore contributed to the monetary loss due to condemnation at meat inspection. The high hydatidosis associated direct monetary loss also confirms that the zoonosis is a parasitic disease of major public health importance in the study areas.

The study recommends proper and professional meat inspection/hygiene of slaughtered animals and disposal of condemned organs; this will control the disease at the livestock intermediate host, the definitive host (dogs) will not access the infected condemned organs.

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