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Prevalence and monetary loss due to cystic Echinococcosis in slaughter house livestock: A case study of Migori County, Kenya

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ABSTRACT

Cystic Echinococcosis (CE/Hydatidosis) is a parasitic zoonosis of public health importance that causes considerable economic loss worldwide. The aim of this study was to assess prevalence and monetary loss of CE in livestock slaughtered in Migori County, Kenya. The study was conducted by retrieving and analyzing secondary data over a ten year period (2007–2016) from annual meat inspection reports from sub-county veterinary offices within Migori County. The data included species/number of slaughtered animals and number of organs condemned due to presence of hydatid cyst(s) recorded. The results showed CE prevalence was highest in cattle (5.3%) followed by goats (2.0%), least affected were sheep (0.1%). The overall direct monetary loss was $152,003/year. The study results confirm occurrence of CE in Migori County and demonstrate an emerging new CE focus in Kenya with a significant direct monetary loss, a phenomenon that require serious attention to control the spread of CE in Kenya.

1. Introduction

Livestock diseases impact negatively on livestock production systems and adversely affect human food security and supply chain. A number of these diseases are zoonotic in nature and can infect humans via several routes following contact with animals, consumption of their products or from environmental exposure. Parasitic zoonoses continue to pose serious concerns at the human-animal interface in many developing countries (Abdulhameed et al., 2018), Kenya included. Cystic Echinococcosis, a chronic zoonotic disease caused by the larval form of the tapeworm *Echinococcus granulosus* is one of the most important helminth-associated zoonoses globally (Moro and Schantz, 2009).

The domestic life cycle of *E. granulosus* involves livestock and dogs as the intermediate and definitive hosts respectively. Livestock such as sheep, cattle, goats, camels and pigs can acquire the infection indirectly from grass and water contaminated by the eggs of *E. granulosus*, which are excreted with feces of infected dogs (Harandi et al., 2012; Deplazes et al., 2017). Humans can also act as aberrant intermediate hosts if they ingest infective parasite eggs either through contaminated food or directly from an infected canid. Eventually a cystic larval form gradually develops, most commonly in the liver or lungs of the intermediate hosts (Harandi et al., 2012).

Human CE has a number of important economic impacts such as diagnosis and treatment costs, losses in income during illness/convalescent period and lost income due to CE related mortality of a bread winner (Dakkak, 2010). The monetary loss

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due to CE can be divided into direct CE associated monetary loss, mainly the loss of revenue through the condemnation of offal at meat inspection and indirect livestock production CE associated monetary losses such reduced yield and quality of meat, milk and wool, reduced hide value, reduced birth rate and fecundity, delayed performance and growth of affected livestock which occur at the farm level (Abdulhameed et al., 2018).

Cystic Echinococcosis has an extensive distribution with a broad range of hosts worldwide, it is highly endemic in the continents of Southern America, Africa, Asia and Australia (Cardona and Carmena, 2013; Roostaei et al., 2017). The infection represents a serious human and animal health concern in many rural, grazing areas of North, East and sub-Saharan Africa (Magambo et al., 2006; Romig et al., 2011). The CE distribution, prevalence, economic and public health impact is higher in rural communities of developing countries such as Kenya where there is a close contact between dogs, livestock intermediate host species, and human (Ibrahim, 2010; Romig et al., 2011).

In Kenya, CE occurs in most parts of the country but available data are mostly from Turkana and Maasai communities in the North western and Southern regions respectively where the disease is endemic. Both communities are nomadic pastoralists rearing large numbers of livestock including sheep, goats, cattle, donkeys and camels (Wahlers et al., 2012). However, there is recent evidence of emerging new CE foci in Kenya (Mbaya et al., 2014; Odero et al., 2015) outside the known two endemic regions signaling the spreading trend of CE in other regions of Kenya which poses a serious public health problem from the veterinary and human public health perspective. This is the first study to evaluate the CE prevalence and estimate its economic significance inslaughter house livestock in Migori County, Kenya. Cystic Echinococcosis is an important zoonosis among the Maasai and Turkana pastoral communities in Kenya where it's endemic however epidemiological information and economic burden of the disease in humans and livestock has not been well documented in most regions of Kenya including Migori County. The main purpose of this study was to provide important epidemiological information of the status of occurrence of *E. granulosus* and the economic significance associated with CE in slaughterhouse livestock in Migori County, Kenya. The latter is an area suspected to be an emerging focus for CE in Kenya.

2. Materials and methods

2.1. Study area

A retrogressive study was conducted in seven out of the eight sub counties in Migori County, Kenya; Rongo, Awendo, Uriri, Suna East, Suna West, Kuria East and Kuria West (Fig. 1). The county is located in Southwestern Kenya, approximately 368 Km from Nairobi city and borders Homabay County to the North, Kisii County to the North East, Narok County to the East and South East, Tanzania to the South and South West and Lake Victoria to the West. Its geographical coordinates are 1° 4′ 0″ South and 34° 28′ 0″ East. The county has a total human population of 917,170 (KNBS, 2009) with a population density of 353 people per km^2, an annual growth rate of 2.38% and covers an area of 2597 km^2.

2.2. Study design

The study utilized retrospective data that relied entirely on archived information from the county annual meat inspection reports available at the sub county veterinary offices in Migori County, Kenya. The slaughtered livestock originated mainly from Tanzania through Mabera livestock auction market in Kuria west Sub County in Migori County and Narok County (Ogwedhi livestock market) at the border of Transmara and Suna East sub counties in Narok and Migori counties respectively, according to the movement permits at the sub county veterinary department offices. The slaughterhouse livestock considered for this study included cattle, sheep and goats where the total number of each species slaughtered during the period under review (2007–2016), type and number of animal organ(s) condemned at meat inspection due to presence of hydatid cyst (s), average weight and cost of normal edible livestock organs (liver, lungs) were recorded. The number of animals affected by CE was based on the assumption that an organ recorded condemned due to the presence of hydatid cyst(s) at meat inspection represented one specific animal species (Odero et al., 2015).

The prevalence of CE in slaughterhouse livestock in Migori County, Kenya was based on the reported number of hydatid cyst infested animal organ (s) identified and condemned during meat inspection at the slaughter houses/slabs within the study area. The direct annual monetary loss to livestock traders due to condemnation of edible livestock organs (liver, lungs) during meat inspection as a result of hydatid cyst infestation was computed using the formulae by Degefu and Damet (2013) as described below:

$$\text{Direct annual monetary loss due to CE} = (PI_1 \times Tk \times C_1) + (PI_2 \times Tk \times C_2)$$

The organs targeted were the liver and lungs which were coded (1) and (2) respectively.

Where: PI_1 = Percent involvement of liver out of the total examined; PI_2 = Percent involvement of lungs out of the total examined; C_1 = Average market price of liver; C_2 = Average market price of lungs; Tk = Average annual kill of cattle, sheep and goats.

The average cost of livestock organs in Migori County, Kenya were:

i. Cattle liver- Ksh 400.00/kg
ii. Cattle lungs- Ksh 200.00/piece

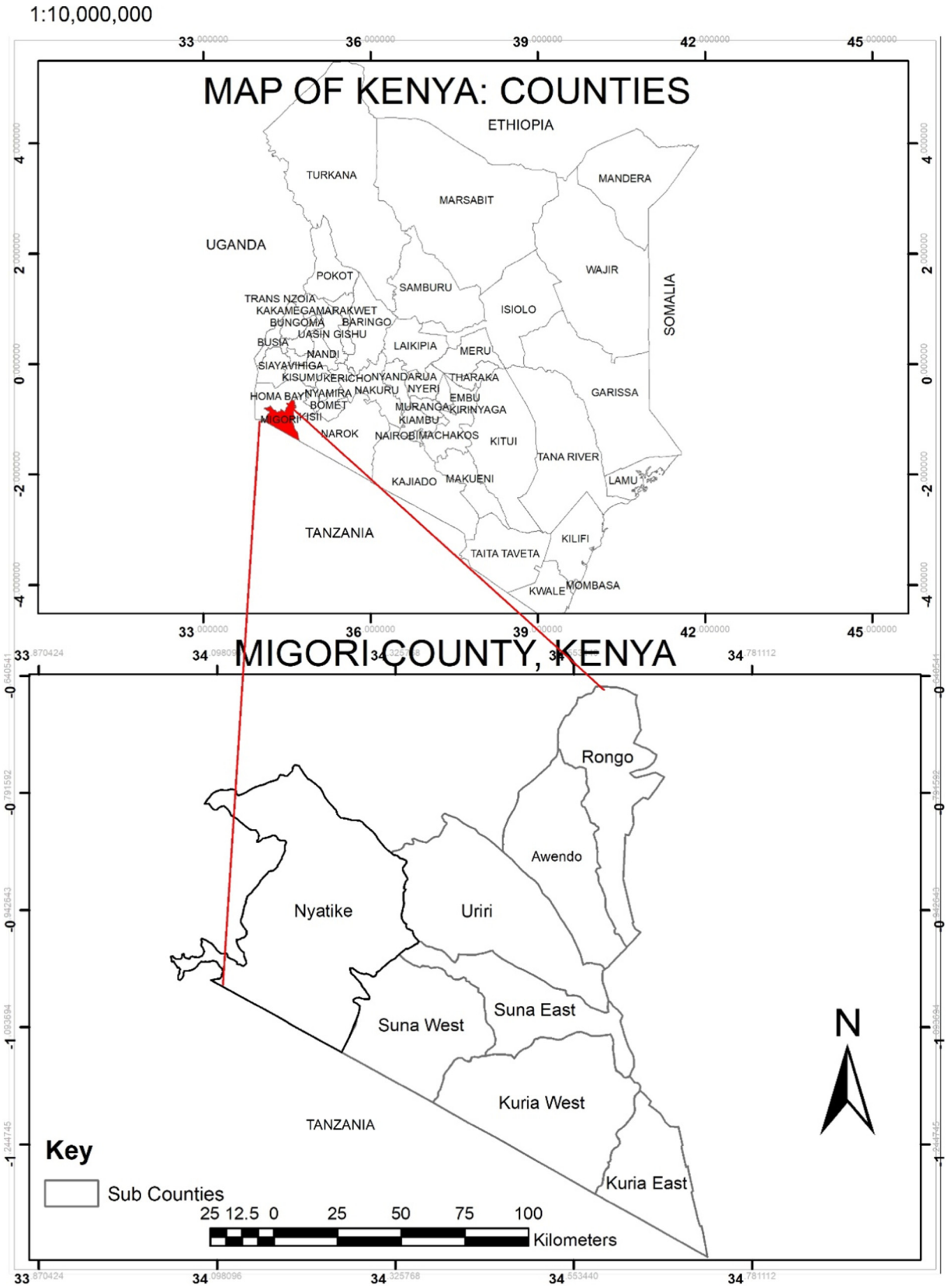

Fig. 1. Migori County map showing the eight sub counties forming the study segments.

iii. Sheep/goat liver- 0.5 kg × Ksh 480.00/kg (Ksh 240.00)
iv. Sheep/goat lungs- Ksh 50.00/piece

The average weight of a normal cattle liver was 5 kg and therefore the average cost of a single normal cattle liver was Ksh. 2000.00.

The US dollar exchange rate used for this study was Ksh. 100.70 to $1.00 (Central bank of Kenya).

2.3. Data management and analysis

The secondary data were entered in Microsoft excel spread sheet and exported to Statistical Software Package for Social Sciences® (SPSS) Version 15 for analysis. The aim was to determine the CE prevalence rate in the slaughter house livestock for this study. Descriptive statistics such as mean, standard error, standard deviation and percentages were used to determine the CE prevalence rate at 95% confidence interval. The variation of CE infection in different slaughter house livestock and infected organs were compared using the *t*-test.

3. Results

The results in Table 1 show a higher CE prevalence in cattle than sheep and goats in all the Sub Counties in Migori County, Kenya. The prevalence in goats was reported in four out of the seven Sub Counties reviewed (Kuria East/West, Suna East/West) while that of sheep was reported in two Sub Counties (Suna East/West). In all the slaughter animals, the liver and lungs were the common organs condemned at meat inspection due to presence of hydatid cysts, the highest number of infestation (s) were found in the lungs.

Fig. 2 shows the overall livestock slaughter numbers, number of each species with hydatid cyst(s) infested organ(s) and the percentage infection in the slaughter animals. The overall CE prevalence in livestock slaughtered in Migori County, Kenya in Fig. 2 show a higher prevalence in cattle (5.3%), goats (2.0%) and least in sheep (0.1%).

The direct monetary loss due to CE in livestock slaughtered in Migori County, Kenya was as a result of condemnation of hydatid cyst infested livestock organs (liver, lungs) during meat inspection shown in Table 2. A monetary loss of $152,003 per year by livestock traders due to CE was reported in Migori County, Kenya.

4. Discussion

Cystic Echinococcosis in the livestock intermediate host is usually asymptomatic and the most reliable diagnostic technique remains the demonstration of hydatid cyst(s) at meat inspection or post-mortem (Eckert et al., 2001) hence the meat inspection reports, cause of organ condemnation from livestock slaughter houses are important tools in the epidemiological survey of CE in slaughter house livestock.

The current study revealed the prevalence of CE in slaughterhouse livestock in Migori County, Kenya as follows: cattle (5.3%), sheep (0.1%) and goats (2.0%). The lungs and liver were the commonly affected organs in the animals slaughtered, with the prevalence standing at cattle (3.4%, 1.9%), goats (1.3%, 0.9%) and sheep (0.1%, 0%) respectively. This can be explained by the fact that

Table 1
Prevalence of cystic Echinococcosis in livestock slaughtered in Migori County, Kenya by Sub County (2007–2016).

Sub County	Animal spp	Total slaughter No.	Total No. of animals infected	% infection	Total No. of liver infected	% liver infected	Total No. of lungs infected	% lungs infected
Rongo	Cattle	5530	90	1.6	36	0.7	54	1.0
	Sheep	2	0	0	0	0	0	0
	Goats	4105	0	0	0	0	0	0
Awendo	Cattle	4647	130	2.8	47	1.0	83	1.8
	Sheep	179	0	0	0	0	0	0
	Goats	327	0	0	0	0	0	0
Uriri	Cattle	5166	347	6.7	181	3.5	166	3.2
	Sheep	0	0	0	0	0	0	0
	Goats	0	0	0	0	0	0	0
Kuria East	Cattle	3251	657	20	186	5.7	471	14.5
	Sheep	0	0	0	0	0	0	0
	Goats	1070	240	22.4	98	9.2	142	13.1
Kuria West	Cattle	12,094	389	3.2	117	1.0	272	2.2
	Sheep	1068	0	0	0	0	0	0
	Goats	8581	28	0.3	15	0.2	13	0.2
Suna East & West	Cattle	2727	155	5.7	59	2.2	96	3.5
	Sheep	345	2	0.6	0	0	2	0.6
	Goats	1547	52	3.4	7	0.5	45	2.9

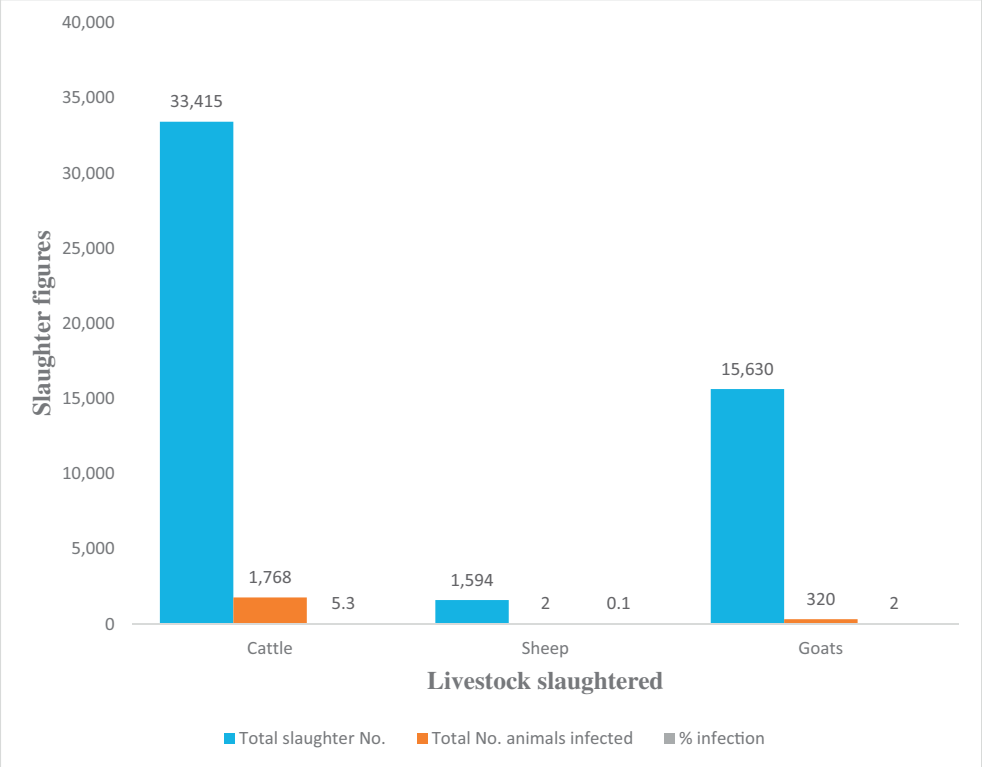

Fig. 2. Overall prevalence of cystic Echinococcosis in livestock slaughtered in Migori County, Kenya (2007–2016).

the lungs and liver possess the first great capillary sites encountered by the migrating Echinococcus oncosphere which adopt the portal vein route and primarily negotiate hepatic and pulmonary filtering system sequentially before any other peripheral organ is involved (Asfaw and Afera, 2014).

Table 2
Direct monetary loss due to cystic Echinococcosis in livestock slaughtered in Migori County, Kenya (2007–2016).

Sub county	Animal Spp.	Economic loss ($)/organ		Total loss ($)
		Liver	Lungs	
Rongo	Cattle	76,882.00	10,893.00	87,865.00
	Sheep	0	0	0
	Goats	0	0	0
Sub total				87,865.00
Awendo	Cattle	92,294.00	16,613.00	108,907.00
	Sheep	0	0	0
	Goats	0	0	0
Sub total				108,907.00
Uriri	Cattle	359,106.00	32,833.00	391,939.00
	Sheep	0	0	0
	Goats	0	0	0
Sub total				391,939.00
Kuria East	Cattle	368,038.00	92,587.00	460,625.00
	Sheep	0	0	0
	Goats	23,461.00	6960.00	30,421.00
Sub total				491,046.00
Kuria West	Cattle	240,199.00	293,044.00	293,043.00
	Sheep	0	0	0
	Goats	4090.00	852.00	4942.00
Sub total				297,985
Suna East/West	Cattle	119,154.00	18,956.00	138,110.00
	Sheep	0	103.00	103.00
	Goats	1843.00	2228.00	4071.00
Sub total				142,284.00
Overall economic loss				1,520,026.00
Overall economic loss/year				152,003.00

However in comparison, pulmonary CE was more prevalent than hepatic CE in all the study animals within the study area, a trend different from other studies in Kenya reported by Addy et al. (2012) and Odongo et al. (2018) which recorded a higher hepatic CE in their study animals. Some studies in Ethiopia suggested that a high lung hydatid cyst(s) infestation could be due to the softer consistancy of the lung tissue compared to other animal organs which favour the development and fertility of within the *E. granulosus* intermediate hosts (Getaw et al., 2010; Negash et al., 2013). The lungs also posses intensive capillary networks which are the frequent destination of the 6 hooked larvae cycled in with the blood from the intestines to contune with their development cycle (Qingling et al., 2014). Kuria East Sub County recorded the highest CE prevalence in cattle (20%) and goats (22.4%) compared to other sub counties within the study area, the difference could be due to a possibility in strain differences of *E. granulosus* in different geographical situations (Taha and Hassen, 2018). The different geographical situations in this study refers to the different sources of slaughter animals in the study area.

The prevalence of CE increases markedly with an increase in age of the study animals; as the animals advances in age the number of Protoscolices within a single cyst, hydatid cyst sizes and numbers per organ increases due to the longer period of time of cyst exposure compared to younger animals (Torgerson et al., 2009; Marshet et al., 2011). The highest CE prevalence in cattle (20%) and goats (22.4%) recorded in Kuria East sub county could also be associated with the advanced age at the time of slaughter of cattle in that particular sub county within the study area. cattle are usually slaughtered at an older age when their productivity potential inerms of milk production or draught power energy start to decrease (Taha and Hassen, 2018) unlike sheep and goats hence the highest overall CE prevalence recorded in cattle {cattle (5.3%), goats (2.0%) and sheep (0.1%) in the study area. The unusual higher prevalence of CE in goats (2.0%) than sheep (0.1%) in the study area even though goats are brouwsers and sheep are grazers, implying that sheep are more exposed to *E. granulosus* eggs than goats within the same environment. this unusual occurence may be associated with the existance of a higher leve of G7 genotype of *E. granulosus* which have a greater affinity for the goat intermediate host compared to the sheep (Varcasia et al., 2007). The CE prevalence in this current study was lower compared to other studies reported by Addy et al. (2012) in Maasailand, cattle (25.8%), sheep (16.5%) and goats (10.8%) and Njoroge et al. (2002) in Turkana, cattle (19.4%) sheep (3.6%) and goats (4.5%). The high prevalence in endemic areas can be explained by the existance of favourable factors in the environment for the propagation and maintenance of E. granulosus lifecycle. (Wahlers et al., 2012). In other CE non-endemic regions in Kenya as reported by Mbaya et al. (2014) in Central Kenya (Meru and Isiolo regions); cattle (1.92%), camels (6.94%), goats (0.37%) and sheep (4.62%) and Odero et al. (2015) in Kisumu region; cattle (4.24%), sheep (4.52%), goats (2.02%), pigs (0.05%), the CE prevalence in the current study was higher in cattle but lower in sheep, in the goats the prevalence was higher than that in Central Kenya. The variation in prevalence levels in different countries and regions of a particular country could be due to differences in the sources of slaughter livestock and possibly strain differences in *E. granulosus* that exist in different geographical situation (McManus et al., 2003; Taha and Hassen, 2018). The occurrence of CE in slaughtered livestock intermediate hosts in non-endemic areas of Kenya including Migori County confirm the spreading phenomenon of the parasites' propagation factors in Kenya. This situation pose serious public health problem in Kenya necessitating urgent concerted control and preventive measures to curb the spread of the zoonosis.

The CE prevalence in livestock slaughtered in Migori County from this current study can be associated with the origin of livestock for slaughter, most of which are from the neighboring country of Tanzania which boarders Kenya in particular Migori County to the South and South west through Mabera livestock auction market in Kuria West sub county and Narok County to the East and South East, Ogwedhi livestock market in the border of Transmara and Suna East sub counties in Narok and Migori counties respectively. This is contained in the movement permits issued by the veterinary department whenever livestock are transported for either breeding or slaughter between sub counties or impotred to Kenya from other countries upon confirmation through a No objection form that there is no outbreak of any notifiable disease in the destination of the livestock to be transported.

Ngorongoro district in Tanzania according to studies by Ernest et al. (2009) recorded a CE prevalence of cattle (48.7%), sheep (63.8%) and goats (34.7%) while Narok County (Maasai land) which is contiguous to Migori County has a known CE prevalence in cattle (25.8%), sheep (16.5%) and goats (10.8%) as reported by Addy et al. (2012). Maasai Mara game reserve is also located in Narok County where various genotypes of *E. granulosus* have been confirmed in wild canid definitive hosts of *E. granulosus* reported by Kagendo et al. (2014); lion (*E. felidis* & G1) and spotted hyena (G1). These wild canids maintains the sylvatic life cycle of *E. granulosus* and also serve as a reservoir of the parasite to the livestock intermediate hosts grazing in the game reserve.

The main sources of livestock for slaughter in Migori County, Kenya (Tanzania, Narok County) show high CE prevalence levels in livestock intermediate hosts and occurrence of *E. granulosus* strains in the wild definitive hosts. This therefore makes the study area an emerging CE focus in Kenya due to livestock trade for slaughter between the two countries (Kenya & Tanzania) and counties (Migori & Narok).

The current study shows a significant annual direct monetary loss of $152,003 by the livestock traders due to condemnation of hydatid cyst(s) infested viscera at meat inspection. The loss is higher than what is reported in studies in Ethiopia and Jordan. Different regions of Ethiopia reported significant direct economic losses in slaughter house livestock due to CE on abattoir basis. The economic losses were 52,828 ETB ($5869.8) in slaughtered ruminants (*Getaw* et al., 2010) and 19,190 ETB ($ 942.5) in slaughtered sheep and goats (Bersissa and Ahmedin, 2012) and 287,179.99 ETB ($63,211) in slaughtered sheep and goats (Zemen et al., 2015) while it was $92,294 for goats in Jordan (Torgerson et al., 2001). However, the loss was lower than that reported in other regions of the world, the annual direct economic loss due to condemned liver was estimated to be $561,112 in Wales (Torgerson and Dowling, 2001), $472,200 in Uruguay (Torgerson et al., 2000) and $266,286 for sheep and $92,294 for goats in Jordan (Torgerson et al., 2001). This shows that there are differences in economic losses by location which is associated with the livestock species and respective economic value.

In addition the variation could be due to differences in the number of slaughter animals utilized in computing the direct monetary losses in each study and the variations in the dollar exchange rates depending on inflation fluctuations unique to each country (Umur and Kaaden, 2003). The variations in CE prevalence in different countries or regions in a country affect direct CE associated economic loss greatly (Zemen et al., 2015).

This direct CE associated monetary loss is important in any epidemiological study and it shows the level of revenue and edible proteins lost due to condemnation of hydatid cyst infested livestock organs, a clear indication of a contribution to reduced food security in the study area.

5. Conclusion

The current study results confirms occurrence of CE in slaughtered livestock (cattle, sheep and goats) with a significant direct monetary loss to livestock traders in Migori County, Kenya. Migori County is an emerging CE focus in Kenya due to the high prevalence in slaughtered livestock intermediate hosts. The study recommends further detailed CE epidemiological research within the study area to provide sustainable prevention and control guidelines for this important neglected tropical disease in Migori County, Kenya.

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