

Short Communication

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Parasitic infections as major cause of abattoir condemnations in cattle slaughtered at an Ethiopian abattoir: 10-year retrospective study

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Abstract

Abattoirs are vital for gathering information on animal diseases and protecting the public from consuming infected or unhygienic meat. To assess the major reasons for organ and carcass condemnations and their financial implications, we reviewed 10-year abattoir records of slaughtered bovines between January 2005 and December 2014 at Kombolcha ELFORA abattoir, north-east Ethiopia. Of the 46,913 cattle slaughtered during that period, 17,963 (38.3%) had at least one disease condition. Lungs (10.67%) and liver (25%) were the most affected and condemned organs, followed by heart (1.53%), head (0.56%), tongue (0.17%) and kidney (0.32%). The major conditions responsible for condemnation were fasciolosis (49.89%), hydatid cyst (55.55%), pericarditis (78.2%), hydronephrosis (35.8%), abscess (71.7%) and abscess (43.9%), in liver, lung, heart, kidneys, head and tongue, respectively. The direct financial losses incurred from organ and carcass condemnation over the 10-year period amounted to ETB 1,219,399 (USD 61,946.9), with parasitic diseases such as fascioliasis and hydatidosis accounting for ETB 256,837.5 (USD 13,047.64) and ETB 170,827.5 (USD 8678.23) in losses, respectively. This study describes a significant loss of cheap and reliable sources of protein due to non-utilization of infected organs or carcasses, emphasizing the need to implement integrated approaches in disease surveillance and control programmes.

Introduction

Human populations are increasing faster than the rate of livestock production, especially in developing and underdeveloped countries (Steinfeld *et al.*, 2006). Undernourishment is highest in sub-Saharan African countries, where around half the population live on USD 1.90 a day or less. In Ethiopia, cattle, numbering 53.99 million, are the major source of red meat (CSA, 2013). Livestock accounts for 20% of the Ethiopian economy but could contribute more; however, livestock diseases are an important constraint on this resource (Biffa *et al.*, 2006). Diseases cause significant economic losses through mortality, reduced growth or weight gain, and rejection of edible organs and carcasses at slaughterhouses (Jobre *et al.*, 1996). Also, some zoonotic diseases can be transmitted to humans by direct contact, indirectly from the infected farm environment, or through the consumption of infected raw or undercooked meat and milk (Swai and Schoonman, 2012).

Abattoirs are vital in the detection and surveillance of animal diseases. Abattoir records can help in tracing an infected carcass back to the farm from which it originated. Abattoirs also aid in diagnosing chronic or subclinical infections during post-mortem examination, which may have gone unnoticed during ante-mortem examination. Epidemiological findings based on abattoir records are useful in assessing the risk of human exposure to zoonotic diseases. In recent years, abattoir records have been recognized as a valuable syndromic surveillance tool for the detection of emerging diseases (Dupuy *et al.*, 2013).

There is a need for detailed documentation of various causes of food (meat) wastage, especially in drought-affected and poverty-stricken countries such as Ethiopia. Surveys of food wastage have been reported for several parts of Ethiopia (Alembrhan and Haylegebriel, 2013; Assefa and Tesfay, 2013; Regassa *et al.*, 2013). However, disease incidence varies with geographical area, and most of these surveys were short-term studies and focused only on parasitic diseases. Additionally, these studies did not assess abattoir losses due to partially condemned organs. Kombolcha ELFORA abattoir is the major abattoir in South Wollo, Amhara regional state, Ethiopia. This study determined the various causes of bovine carcass and organ condemnation at this abattoir, and estimated the associated economic losses, using 10-year abattoir record data to increase the precision of findings and minimize the effect of climate or other environmental variables.

Materials and methods

Study area

This retrospective study was based on 10-year (January 2005–December 2014) record data from Kombolcha ELFORA abattoir, located in the town of Kombolcha, Amhara, Ethiopia. Kombolcha is located 376 km north-east of Addis Ababa, 11°84'N and 0.39° 46' E, at an elevation of 1840 m above sea level; it has an average annual rainfall of 1248 mm and an average annual temperature of 15.9°C. The farming sector has grown substantially because of the suitable topography and agro-climatic conditions, and the availability of a large water reservoir associated with the Borkena River. According to CSA (2006), the animal population of the study area comprises 90,664 cattle, 43,010 poultry, 31,043 goats, 12,975 sheep, 7,758 donkeys, 866 camels and 489 horses.

The Kombolcha ELFORA abattoir was established by the Italian investor MR Sopral in 1957. It is privately owned and is the major source of inspected beef in Kombolcha city. A portion of this meat is supplied to the Kombolcha meat processing factory for canning. The size, hygiene and quality standard of the abattoir is comparable to other abattoirs in Ethiopia. Currently, one veterinarian and two meat inspectors work in the abattoir. Approximately 50–150 cattle are slaughtered per day, and slaughtering is usually done on alternate days. Tissue samples from the abattoir that require further laboratory testing are submitted to the adjoining Kombolcha Regional Veterinary Laboratory.

Study design

To assess the proportion of organs or carcasses condemned, along with the causes and associated financial implications, retrospective data were collected from the record book of Kombolcha ELFORA abattoir on 46,913 apparently healthy cattle slaughtered between January 2005 and December 2014. Data related to age, origin and body condition score for slaughtered cattle were not available, nor were data on sex or breed; however, as per the veterinarian and meat inspectors, most of the cattle brought to the abattoir are male and of indigenous zebu breeds.

Ante-mortem examination of animals is routinely carried out before slaughter, and only apparently healthy animals are passed for slaughtering. Routine meat inspection at the abattoir is carried out by the qualified veterinarian or by meat inspectors under the supervision of a veterinarian following the guidelines of the Ministry of Agriculture (Hailemariam, 1975). Decisions for total approval, partial approval, conditional approval and total condemnation are made only after thorough meat inspection. However, heart, head and tongue are totally condemned even if only minor abnormalities are observed. Total condemnation of a carcass was not practised in the abattoir for economic reasons. All pathological lesions responsible for organ or carcass condemnation are recorded on a daily basis on a standardized data sheet. Data records with missing or ambiguous information on diagnosis, date of slaughter and condemnation were excluded from the study.

Direct financial losses

Direct financial losses were estimated by multiplying the average price (per organ or per kg of carcass) and the sum of condemned organs (either partially or totally) and carcasses (in kg). Based on information from local butchers and customers in May 2015, the average cost of bovine lung, liver, heart, kidney, head, tongue and

carcass (per kg) was ETB 30, 45, 25, 25, 75, 25 and 100, respectively. The value of a partially condemned organ was considered, on average, to be half the price of the whole organ.

Data analysis

Data collected from the abattoir record books were entered into a Microsoft Excel spreadsheet, then descriptive statistics were used to calculate the percentage of organs (partial or full) and carcasses (partial) rejected for human consumption. The associated economic losses over the 10-year study period were determined by taking into consideration the market prices of organs and carcasses, and by assuming a currency exchange rate of USD 1 = ETB 19.6846.

Results

Of the 46,913 cattle slaughtered during the study period, 38.49% ($n = 18,056$) had one or more abnormalities leading to partial or total condemnation of organs or carcasses (only partial). Organ-specific condemnations were as follows: 11,731 livers (25%), 5001 lungs (10.7%) and 720 hearts (1.53%) (table 1). The least affected organs were the head (0.56%), kidney (0.32%) and tongue (0.17%). Approximately 0.23% (109/46,913) carcasses were affected with one or more pathological conditions, resulting in condemnation of 5030 kg of meat.

The main causes of liver condemnation were fascioliasis (49.89%), cirrhosis (22.13%), hydatidosis (16.66%), hepatitis (5.25%) and peritonitis (4.61%). In contrast, hydatid cysts (55.55%) were the leading cause of lung condemnation, followed by pneumonia (31%) and pleurisy (12.84%). Pericarditis (78.19%), hydatidosis (17.15%), *Cysticercus bovis* (2.64%) and abscess (1.67%) were the major causes for condemnation of hearts (table 1). Similarly, hydronephrosis (35.8%), hydatidosis (32.43%), congenital cyst (12.2%), nephritis (12.2%) and infarction (7.4%) were major causes of condemnation of kidneys, whereas the main causes for heads were abscess (71.7%), *C. bovis* (20%) and actinomycosis (8.3%). Abscess (36, 43.9%), ulcer (28, 34.15%) and *C. bovis* (18, 21.95%) were the major reasons for wastage of 82 tongues (table 1). Of the 109 (0.23%) partially condemned carcasses, bruise, abscess, haematoma and *C. bovis* were responsible for condemnation of 38.5%, 26.6%, 9.17% and 20.2%, respectively (table 1). The remaining portions of partially condemned carcasses were allowed for consumption after providing special treatment (e.g. chilling) if necessary.

Monetary losses related to wastage of organs or carcasses from the 10-year record data were estimated to be ETB 1,219,399 (USD 61,946.9) (fig. 1). This included financial losses associated with organ wastage, which were calculated as USD 36,307.57, and carcass weight losses amounting to USD 25,639.33. A smaller percentage (3.57%) of these organs received partial condemnation. The main condemned organ was liver, responsible for losses of up to ETB 593,596.396 (USD 30,155.37), of which ETB 256,837.5 (USD 13,047.64) was associated with fascioliasis only (table 2). Year-wise distribution showed an overall decline of losses from 2005 to 2014, with highest losses of ETB 202,447.5 (USD 10,284.56) observed in 2007, and with the lowest values in 2014 (ETB 58,555 or USD 2975.36) (fig. 2).

Discussion

Abattoirs gather information on animal diseases (especially chronic or subclinical disease), protect the public from consumption of

Table 1. Causes of condemnations with respect to organs and carcasses in Kombolcha ELFORA abattoir in north-east Ethiopia between January 2005 and December 20014 (n = 46,913). N is the number of cattle slaughtered.

Organ	Cause	Number of animals slaughtered and organs condemned (percentage) over the period 2005–2014										A	B	C
		2005 N = 5032	2006 N = 4098	2007 N = 6634	2008 N = 5116	2009 N = 3631	2010 N = 4031	2011 N = 4031	2012 N = 4525	2013 N = 3506	2014 N = 5534			
Lung	Pneumonia	210(4.17)	192 (4.69)	185 (2.79)	245(4.79)	158(4.35)	132(3.27)	108(2.68)	102(2.25)	109(3.11)	110(1.99)	1551(8.59%)	5001(10.7%)	31.01%
	Abscess	1(0.02)	6(0.15)	4(0.06)	2(0.04)	0(0)	0(0)	1(0.02)	4(0.09)	3(0.09)	0(0)	21(0.12)		0.42%
	Pleuritis	98(1.95)	32(0.78)	116(1.75)	35(0.68)	12(0.33)	45(1.12)	65(1.61)	120(2.65)	49(1.40)	70(1.26)	642 (3.56%)		12.84%
	Hydatid cyst	532(10.57)	121(2.95)	1046 (15.77)	594(11.61)	20(0.55)	123(3.05)	78(1.94)	143(3.16)	31(0.88)	90(1.63)	2778(15.39%)		55.55%
	<i>C. bovis</i>	0(0)	0(0)	1(0.02)	0(0)	1(0.03)	3(0.07)	2(0.05)	0(0)	0(0)	0(0)	7(0.04%)		0.14%
	Emphysema	0(0)	0(0)	0(0)	1(0.02)	0(0)	1(0.02)	0(0)	0(0)	0(0)	0(0)	2(0.01%)		0.04%
Liver	Abscess	19(0.38)	25 (0.61)	33(0.50)	13(0.25)	17(0.47)	5(0.12)	0(0)	3(0.07)	2(0.06)	2(0.04)	119(0.66%)	11731 (25%)	1.01%
	Fasciolosis	951(18.90)	832(20.30)	963(14.52)	853(16.67)	617(16.99)	405(10.05)	543(13.47)	432(9.55)	123(3.51)	134(2.42)	5853(32.41%)		49.89%
	Hydatid cysts	149(2.96)	358(8.74)	448(6.75)	155(3.03)	192(5.29)	98(2.43)	120(2.98)	113(2.50)	108(0.08)	213(3.85)	1954(10.82%)		16.66%
	Cirrhosis	310(6.16)	271(6.61)	380(5.73)	255(4.98)	265(7.30)	211(5.23)	243(6.03)	209(4.62)	120(3.42)	332(5.60)	2596(14.38%)		22.13%
	Haemangioma	1(0.02)	3 (0.07)	2(0.03)	2(0.04)	0(0)	1(0.02)	0(0)	0(0)	0(0)	0(0)	9(0.05%)		0.08%
	Calcification	11(0.22)	2(0.05)	4 (0.06)	0(0)	0(0)	4(0.10)	6(0.15)	3(0.07)	2(0.06)	5(0.09)	37(0.21%)		0.32%
	Necrosis	2(0.04)	0 (0)	0(0)	1(0.02)	0(0)	0(0)	0(0)	2(0.04)	1(0.03)	0(0)	6(0.03%)		0.05%
	Hepatitis	97(1.93)	62(1.51)	134 (2.02)	70(1.37)	58(1.60)	12(0.30)	8(0.20)	43(0.95)	9(0.26)	123(2.22)	616(3.41%)		5.25%
	Peritonitis	23(0.46)	98(2.39)	13(0.20)	98(1.92)	18(0.50)	87(2.16)	88(2.18)	15(0.33)	69(1.97)	32(0.58)	541 (3.0%)		4.61%
	Heart	Hydatid cyst	6 (0.12)	13(0.32)	10(0.15)	5(0.10)	9(0.25)	6(0.15)	33(0.82)	12(0.27)	10(0.29)	22(0.40)		126 (0.7%)
Pericarditis		60(1.19)	32(0.78)	75(1.13)	62(1.21)	49(1.35)	54(1.34)	43(1.07)	61(1.35)	43(1.23)	84(1.52)	563(3.12%)	78.19%	
Abscess		0(0)	0(0)	1(0.02)	4(0.08)	0(0)	2(0.05)	3(0.07)	0(0)	0(0)	2(0.04)	12(0.07%)	1.67%	
<i>C. bovis</i>		0(0)	0(0)	0(0)	1(0.02)	0(0)	1(0.02)	4(0.10)	1(0.02)	0(0)	12(0.22)	19(0.11%)	2.64%	
Kidney	Hydro-nephrosis	2(0.04)	5(0.12)	6(0.09)	6(0.12)	5(0.14)	6(0.15)	9(0.22)	10(0.22)	3(0.09)	1(0.02)	53(0.29%)	148(0.32%)	35.81%
	Infarction	4(0.08)	2(0.05)	4(0.06)	0(0)	0(0)	0(0)	0(0)	1(0.02)	0(0)	0(0)	11(0.06%)		7.43%
	Hydatid cyst	8(0.16)	9(0.22)	4(0.06)	3(0.06)	7(0.19)	0(0)	4(0.10)	2(0.04)	5(0.14)	6(0.11)	48(0.27%)		32.43%
	Congenital cyst	2 (0.04)	4(0.10)	3(0.05)	1(0.02)	0(0)	1(0.02)	0(0)	4(0.09)	2(0.06)	1(0.02)	18(0.1%)		12.16%
	Nephritis	0 (0)	0 (0)	2(0.03)	2(0.04)	0(0)	0(0)	0(0)	6(0.13)	0(0)	8(0.14)	18(0.1%)		12.16%
Head	Abscess	22 (0.48)	5(0.12)	34(0.51)	20(0.39)	7(0.19)	12(0.30)	23(0.57)	32(0.71)	21(0.60)	14(0.25)	190(1.05%)	265(0.56%)	71.70%
	Actinomycosis	0 (0)	6(0.15)	0(0)	1(0.02)	0(0)	1(0.02)	8(0.20)	0(0)	6(0.17)	0(0)	22(0.12%)		8.30%
	<i>C. bovis</i>	10 (0.20)	20(0.49)	4(0.06)	0(0)	5(0.14)	0(0)	2(0.05)	12(0.27)	0(0)	0(0)	53(0.29%)		20%
Tongue	Abscess	1 (0.02)	5 (0.12)	3(0.05)	7(0.14)	8(0.22)	0(0)	4(0.10)	3(0.07)	3(0.09)	2(0.04)	36(0.2%)	82(0.17%)	43.9%
	<i>C. bovis</i>	4(0.08)	0 (0)	3(0.05)	1(0.02)	0(0)	2(0.05)	5(0.12)	0(0)	3(0.09)	0(0)	18(0.1%)		21.95%
	Ulcer	2(0.04)	1 (0.02)	6(0.09)	4(0.08)	8(0.22)	3(0.07)	0(0)	2(0.04)	1(0.03)	1(0.02)	28(0.16%)		34.15%

(Continued)

Table 1. (Continued.)

Organ	Cause	Number of animals slaughtered and organs condemned (percentage) over the period 2005–2014										Total		
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014			
Carcass	Bruising	2(0.04)	10(0.24)	7(0.11)	8(0.16)	3(0.08)	4(0.10)	1(0.02)	5(0.11)	2(0.06)	0(0)	42(0.23%)	109(0.23%)	38.53%
	<i>C. bovis</i>	2(0.04)	6(0.15)	4(0.06)	1(0.02)	2(0.06)	2(0.05)	1(0.02)	2(0.04)	2(0.06)	0(0)	22(0.12%)		20.183%
	Abscess	6(0.12)	1(0.02)	4(0.06)	3(0.06)	2(0.06)	1(0.02)	5(0.12)	4(0.09)	1(0.03)	2(0.04)	29(0.16%)		26.6%
	Haematoma	2(0.04)	2(0.05)	0(0)	1(0.02)	0(0)	2(0.05)	3(0.07)	0(0)	0(0)	0(0)	10(0.06%)		9.17%
	Oedema	1(0.02)	1(0.02)	0(0)	2(0.04)	0(0)	1(0.02)	0(0)	1(0.02)	0(0)	0(0)	6(0.03%)		5.5%
	Total	2538	2124	3499	2456	1463	1225	1410	1347	728	1266	18,056 (100%)	18,056 (100%)	

A: Number of specific organs condemned with a particular disease condition (percentage of the particular disease condition in total number of animals slaughtered)

B: Total number of specific organ condemned (percentage of specific organ condemned in total number of slaughtered animals)

C: Percentage of a particular disease condition in a specific organ causing its condemnation (B/A)

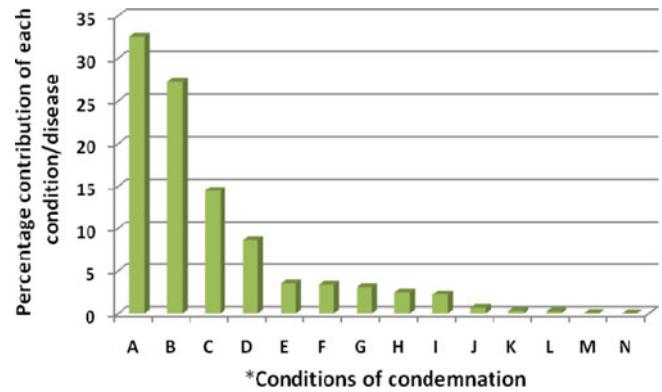


Fig. 1. Graph depicting the trends of contributions of major reasons for wastage of organs/carcass in Kombolcha ELFORA abattoir in north-east Ethiopia. *A: fascioliasis; B: hydatidosis; C: cirrhosis; D: pneumonia; E: pleuritic; F: hepatitis; G: pericarditis; H: peritonitis; I: abscesses; J: *C. bovis*; K: hydronephrosis; L: carcass bruising; M: liver haemangioma; N: emphysema.

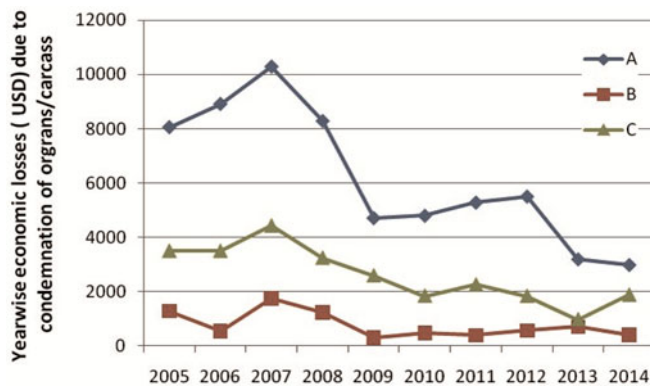
infected and unhygienic meat, and are vital in improving overall management of animals, helping to reduce pre-slaughter problems (Jibat *et al.*, 2008). The present study revealed that several different conditions resulted in the wastage of a large number of organs and carcasses, thereby reducing the availability of a cheap source of nutrients (including protein, vitamins and minerals), and depriving farmers and cattle traders of valuable income. Although similar work has been done on this abattoir in the past (Sheferaw and Abdu, 2017), yearly trends of various conditions responsible and associated financial losses were not described and the economic losses due to partial condemnation of organs such as liver and lung were not included. Moreover, this study covers data from 10 years to minimize the influence of environmental variables on the overall findings.

Similar to our findings, liver and lung were reported to be major condemned organs in cattle in the same abattoir (Sheferaw and Abdu, 2017), in slaughterhouses of other parts of Ethiopia (Alembrihan and Haylegebriel, 2013; Regassa *et al.*, 2013) and in other countries, including Tanzania (Mellau *et al.*, 2011) and Nigeria (Alawa *et al.*, 2011). The most common causes of lung and liver condemnation were parasitic diseases, i.e. hydatidosis and fascioliasis, respectively. These organs are the first large capillary beds encountered by the blood-borne *Echinococcus* oncospheres (Kebede *et al.*, 2009). The higher prevalence of hydatid cysts in lungs could be attributed to the larger capillary network in this organ compared to the liver (Getaw *et al.*, 2010). Similarly, the liver is the first organ encountered by infective larval stages of fasciola and other pathogens that gain entry through the oral route. Similar findings of parasitic infections being major causes of liver and lung condemnations have been reported in Ethiopia (Borji *et al.*, 2012; Nurit *et al.*, 2012; Terefe *et al.*, 2012; Yibar *et al.*, 2015); Ahwaz, Iran (Borji *et al.*, 2012); Bursa province, Turkey (Yibar *et al.*, 2015); and Arusha, Tanzania (Mellau *et al.*, 2011). The higher occurrence of fascioliasis (5853/46,913 or 12.5%) in the present study than in earlier reports in Ethiopia (9.26% by Assefa and Tesfay, 2013) and Turkey (2.8% by Yibar *et al.*, 2015) may be due to favourable local environmental conditions (higher humidity and temperate temperature), unavailability of effective control strategies and development of resistance to the routine lines of treatment in the study area. Although fascioliasis rarely causes mortalities in cattle, it affects meat production and results

Table 2. Proportion of cattle infected with different parasitic diseases and associated estimated economic losses due condemnation of organs at Kombolcha ELFORA abattoir during the study period (n = 46,913).

Parasitic disease	Number of infected cattle	Percent of infected cattle	Total losses (USD)*	Mean losses per infected animal (USD)	Losses per slaughtered animal (USD)
Fascioliasis	5853	12.5	13,047.64	2.229	0.278
Hydatidosis	3526	7.52	8678.23	2.461	0.185
Cysticercosis	76	0.16	4687.47	61.677	0.1
Total losses			26,413.34		

*Includes losses due to both total condemnation and partial condemnation of organs

**Fig. 2.** Annual trend of financial losses due to wastage of (A) all organs and carcasses, (B) livers only, and (C) lungs only, at Kombolcha ELFORA abattoir, Ethiopia, from 2005 to 2014.

in liver condemnation during post-mortem examination in slaughterhouses (Kambarage *et al.*, 1995).

In the present study, more than one quarter (27.8%) of condemned organs were lungs, possibly due to the anatomical and histological structure suitable for the growth of pathogens and parasites. Hydatid cysts were the most common abnormality encountered in bovine lungs (5.2%) (table 2). This finding accords with Assefa and Tesfay (2013) and Borji *et al.* (2012), who reported the occurrence of hydatidosis in lungs of slaughtered cattle as 5.1% and 3.8% in northern Ethiopia and south-western Iran, respectively. However, Efrem *et al.* (2015), Tenaw *et al.* (2015) and Sheferaw and Abdu (2017) reported higher prevalence of hydatidosis in western Ethiopia (12.17%), central Ethiopia (16.62%) and in the same abattoir (9.6%), respectively. This variation in prevalence of hydatidosis may be associated with factors such as control measures adopted, level of awareness, education and economic status of the local population, the presence of specific strains of *E. granulosus*, and agroclimatic conditions in the study area (Ibrahim, 2010).

In addition to livers and lungs, 720 hearts, 148 kidneys, 265 heads and 82 tongues were completely condemned during the 10-year period. The main cause of heart and kidney condemnation was found to be pericarditis and hydatid cysts, respectively. The primary agents that cause pericarditis in cattle include viruses, bacteria and mycoplasma, which mostly arise through the hematogenous route as in septicemic conditions or through perforation of the pericardial sac by an infected foreign body via the reticulum, or from direct extension of pathogens from nearby structures (FAO, 2007). Mesele *et al.* (2012) also reported pericarditis and hydatidosis as the predominant reasons for condemnation of heart and kidney, respectively, in cattle slaughtered

in Gondar, north-west Ethiopia, and Mellau *et al.* (2011) and Sheferaw and Abdu (2017) reported pericarditis as the leading cause of heart condemnation in the Arusha region, Tanzania, and Kombolcha ELFORA, Ethiopia. Abscess was the major reason for head and tongue condemnation, similar to the findings of Mummied and Webb (2015).

The proportion of carcasses affected with one or more pathological conditions was 0.23% (108/46,913), resulting in 5030 kg of meat loss by partial condemnation only. Bruises in cattle are usually associated with inappropriate handling or improper transportation during pre-slaughter stages (Edwards *et al.*, 1999). A bruise rate of 0.089% (42/46,913) in carcasses observed in the present study was lower than the 17.05% and 21.71% reported by Mummied and Webb (2015) and Negero and Ferede (2017), respectively. This could be related to the negligence of meat inspectors in recording minor trimmed portions of carcass, which are usually associated with bruising. Similarly, abscesses were recorded to be prevalent in 0.059% (28/46,913) of carcasses, probably linked to injuries during transportation or improper injections, facilitating growth of bacteria. Most of the abscesses were located at injection sites (neck and gluteal region), indicating that the cause was probably the use of unsterilized needles or syringes or struggling of animals due to improper restraining, as indicated by the presence of broken needles in muscles of two carcasses. In contrast to our findings, Sheferaw and Abdu (2017) reported tuberculosis and tuberculosis-like lesions as the major cause of carcass condemnation in the same abattoir. This may be due to the fact that tuberculosis cases were excluded from our study because of insufficient or ambiguous information on diagnosis.

The total economic losses incurred were ETB 1,219,399 (USD 61,946.9), with average annual losses of USD 6,194.69 reported due to wastage of organs and carcasses from the slaughtered cattle during the study period. Highest losses (ETB 202,447.5 or USD 10,284.56) were recorded during 2007, which may be associated with the highest number of animals slaughtered (6634) during that year (fig. 2). The total annual financial losses due to the rejection of organs and carcasses showed an overall decline from 2005 to 2014 (fig. 2). For instance, the prevalence of fascioliasis declined from 18.9% in 2005 to 2.42% in 2014, while prevalence of hydatidosis was reduced by almost half (11.5% in 2005 to 5% in 2014). This suggests a steady improvement in veterinary delivery services, including anthelmintic treatment, greater awareness amongst farmers and the use of better control measures. Also, several livestock disease control measures were initiated by the government and NGOs in this decade to control parasitic infections. This disparity could partly be attributed to variability of climatic conditions such as humidity, rainfall and temperature, which are known to influence the development and survival of pre-parasitic stages of helminth parasites (Andersen *et al.*, 1970;


Soulsby, 1982; Hansen and Perry, 1994). During this survey of 10-year records, fascioliasis, hydatidosis and cysticercosis were responsible for direct economic losses of ETB 256,837.5 (USD 13,047.64), ETB 170,827.5 (USD 8678.23) and ETB 92,271 (USD 4687.47), respectively. As *C. bovis* and hydatid cysts infect multiple organs, economic losses per infected animal were higher for cysticercosis (61.68%), and hydatidosis (2.46%) than fascioliasis (2.23%) (table 2). Higher overall prevalence of fascioliasis led to higher financial losses per slaughtered cattle compared to other parasitic diseases (table 2).

Overall, parasitic diseases were the predominant cause of offal condemnation and were responsible for 42.64% (ETB 519,936 or USD 26,413.33) of the total losses due to the condemnation of organs and carcass. Several authors (Alawa et al., 2011; Assefa and Tesfay, 2013; Regassa et al., 2013; Tenaw et al., 2015; Yiber et al., 2015; Assefa et al., 2017; Sheferaw and Abdu, 2017) have reported parasites being the major cause of condemnation of organs or carcasses. Higher incidence of these parasitic infections in the current study indicates lack of effective control strategies, insufficient coverage of anthelmintic use and lack of awareness among the residents. Therefore, appropriate control measures involving awareness creation among residents about proper drainage of marshy areas, clearing of aquatic vegetation, proper disposal of condemned offal or meat, minimizing pasture contamination, and regular treatment of animals with broad-spectrum anthelmintics should be implemented. Moreover, the two major parasitic infections found in the present study (i.e. hydatidosis and fascioliasis) are of zoonotic importance. For instance, hydatidosis has been ranked second (after rabies) among 43 prioritized zoonotic diseases in Ethiopia (Pieracci et al., 2016). Similarly, several fascioliasis cases have been reported in humans in Ethiopia (Bayu et al., 2005; Aregahagn and Asrat, 2018). Therefore, effective implementation of control programmes for such zoonotic diseases requires a “One Health” approach involving interdisciplinary collaboration among veterinary and human health workers and environmentalists.

The recorded magnitude of different diseases and abnormalities in this abattoir in the present study may not depict the true situation. A number of abnormalities and lesions might remain undetected due to potentially inadequate meat inspection, the limited time available for inspection of each organ, the influence of butchers or owners on judgements made by meat inspectors, and substandard training of inspectors (Cadmus and Adesokan, 2009). Another limitation of this study was that indirect losses related to the reduced growth rate (weight) due to diseases, the treatment losses and losses due to public health implications were not taken into account for estimating financial losses. Future research incorporating these aspects is warranted.

In conclusion, this 10-year retrospective study showed that parasitic infections, especially hydatidosis and fascioliasis, in cattle still remain a major challenge, as they were responsible for nearly half (43.7%) of all condemnations of organs in apparently healthy cattle slaughtered at Kombolcha ELFORA abattoir; this may also reflect the scenario in other slaughterhouses in Ethiopia. Moreover, the data showed that 38.3% of slaughtered cattle had one or more abnormalities, resulting in total losses of USD 61,946.9 (or annual average losses of USD 6194.69) due to various diseases in cattle. These losses are particularly a matter of concern for farmers and those associated with the livestock chain in sub-Saharan countries such as Ethiopia, which is struggling to cope with food insecurity due to El Niño and has low economic output and per capita income of USD 1 per day. Therefore, there is a need for countrywide implementation of appropriate

control, prevention and treatment methods for diseases in cattle, especially the parasitic diseases identified in the present study.

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