Prevalence, Anatomical Cyst Distribution and Economic Significance of *Cysticercus bovis* in Cattle Slaughtered at Kombolcha Elfora Meat Factory, North-Eastern Ethiopia

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Abstract

Bovine cysticercosis is a parasitic disease caused by *Cysticercus bovis* that affects cattle health and causes economic loss due to organ and carcass condemnation. Therefore, the cross-sectional study was conducted from November 2017 to April 2018 to determine the prevalence of *Cysticercus bovis*, cyst distribution, and economic significance in cattle at the Kombolcha Elfora meat factory. 420 randomly selected cattle were subjected to postmortem examinations and routine meat procedures were performed. Of the 420 cattle examined, 26 confirmed positive for bovine cysticercosis, resulting in an overall prevalence rate of 6.0%. Of the 26 infected cattle, 92 cysticerci were identified. The liver exhibited the highest proportion of *Cysticercus bovis* cysts (65.2%), followed by the tongue (17.4%), masseter muscle (10.8%), and heart (6.52%). However, no significant differences in *Cysticercus bovis* prevalence were observed based on breed ($\chi2=0.32$; $p=0.857$), sex ($\chi2=0.732$; $p=0.980$), age ($\chi2=0.658$; $p=0.417$), body condition scores ($\chi2=0.609$; $p=0.705$), and origin ($\chi2=7.299$; $p=0.200$). Moreover, assessment of annual economic loss due to bovine cysticercosis at Kombolcha meat factory from organ condemnation and carcass weight loss was estimated at 294,841.89 ETB (Ethiopian Birr). In conclusion, the prevalence of *Cysticercus bovis* in the study area was slightly higher and resulted in substantial economic losses. Therefore, it is vital to increase public awareness, maintain good drainage system and implement standard routine meat inspection measures to safeguard public health and minimize economic losses.

Keywords: Bovine • *Cysticercus bovis* • Economic significance • Kombolcha • Prevalence

Introduction

Ethiopia has one of the largest portfolios in Africa with livestock and it comprises 56,706,389 cattle, 29,332,382.56 sheep, 29,112,963 goats, 7,428,037 donkeys, 2,033,115 horses, 1,164,106 camels, 400,329 mules, and 56,866,719 poultry. Livestock rearing is an integral part of agricultural production, and currently supporting and sustaining the livelihoods of an estimated 80 percent of the rural poor. The contribution of these huge livestock resources to the national income is disproportionate due to several factors. Of these factors, parasitic diseases are considered to be the major obstacle to the health and production performance of livestock [1].

Bovine cysticercosis is one of the most common parasitic diseases associated with large economic losses and great public health impact. It caused by *Cysticercus bovis*, the larval stage of *Taenia saginata*. Humans are the final host of the parasites, while cattle act as an intermediate host. Cattle acquired the infection through ingestion of *Taenia saginata* eggs with feedstuff [2]. After a certain development, *Cysticercus bovis* is located in the tongue, masseter muscles, heart muscles, triceps muscles and thigh muscles, moreover in the liver, diaphragm, and intercostal muscles of bovines.

Most of these organs and muscles were condemned and could be potential factors for economic losses in contracting cysticercosis. The economic effects of cysticercosis in cattle have been correlated with decreased production of meat and milk, downgrading of hide, reduction in growth rate, and a predisposition to other diseases. However, the economic losses in the meat industry are directly related to the severity of the infection. When it comes to widespread cysticercosis, the carcass has to be completely rejected. However, condemning the locally confined cysticercosis-affected areas, when a specific local area is affected [3].

The disease, bovine cysticercosis distributed throughout the world and is extensive in developing countries due to poor hygienic conditions, inadequate health education, low availability of treatment, and the habits of traditionally eating raw or inadequacy-cooked beef [2], particularly in Africa, Latin America, South/Central Asia and eastern Mediterranean countries. In African nations, bovine cysticercosis is a widespread and prevalent parasitic infection, mainly in Kenya (33%), Ethiopia (80%), and Sudan (8%).

In Ethiopia, bovine cysticercosis is widely spread in different parts of the country due to backyard animal slaughtering practices, the absence of standard meat inspection procedures, the lack of well-constructed toilets, and the long-standing habit of eating raw beef dishes such as Kurt and Kitffo [4]. Based on this reason, cysticercosis is the major cause of organ and carcass condemnation in most Ethiopian abattoirs and slaughterhouses. Available studies have been conducted on the prevalence of cysticercosis in different parts of Ethiopia are in Wolaita Soddo (11.3%), in Jimma (4.4%), in Mekelle (7.3%), in Bako (11.88%) [5], in Ethiopia (92.7%) and [1] in Bishftu (5.4%). While previous studies have reported on bovine cysticercosis in various regions, there is limited information specific to the Kombolcha Elfora meat factory. Thus, the current research fills this gap by providing detailed information on the prevalence, economic significance, and anatomical distribution of *Cysticercus bovis* in various organs of cattle. Therefore, the objectives of this study were to determine the prevalence of *Cysticercus bovis*, economic significance and anatomical cyst distribution in cattle at the Kombolcha Elfora meat factory.

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Methods

Study area

The study was conducted from November 2016 to April 2017 in the Kombolcha Elfora meat factory, Amhara regional state, north-eastern Ethiopia. The study area is located 375 km from Addis Ababa. It is found at a latitude of 11o4'N 39˚44'E and a longitude of 11.067∘N 39.733∘E and is elevated between 1500 and 1840 meters above sea level. The area experiences a bimodal rainfall pattern with a short rainy season from March to May (39.63 mm), and the longest rainfall was extended from June to September (750–900 mm). The remaining months are dry periods. The annual temperature ranged from 25 to 30 °C. The relative humidity of the area varies from 23.9 to 79%. The animal population of the study area comprises 90,664 cattle, 12,975 sheep, 31,043 goats, 489 horses, 7,758 donkeys, 866 camels, and 43,010 poultry. Crop-livestock farming is the main farming system in the area, and cattle are the first dominant species kept by farmers (Figure 1,2).

Study animals

The study animals were cattle slaughtered at the Kombolcha Elfora meat factory. The slaughtered cattle originated from six different localities, namely Dessie Zuriya, Raya, kemise, Kombolcha, Bati, and Shire. Different risk factors were considered like age, sex, breed, and body condition score of the cattle. The age of the animals was determined by the dentition formula according to the method described by De-Lahunta A and Teeth HR [6]. The body condition score was classified as good, medium, and poor based on Nicholson M and Butterworth A [7].

Study design

A cross-sectional study was conducted from November 2017 to April 2018 to determine the prevalence and economic significance of *Cysticercus bovis* as well as the anatomical distribution of the cyst in cattle slaughtered at the Kombolcha Elfora meat factory.

Sample size determination and sampling techniques

The desired sample size required for this study was determined based on the formula proposed by using the expected prevalence of 50%, the 5% desired absolute prevalence, and a 95% Confidence Interval (CI).

N= (1.96² Pexp(1-Pexp))/d²

Where; 1.962 is the value of z at the 95% Confidence level; n=required sample size; Pexp=expected prevalence; and d=desired absolute precision. Accordingly, a total of 384 cattle were supposed to be sampled. However, to increase the level of accuracy for prevalence determination and to maximize the chance of getting an adequate amount of cysts, the sample size was increased to 420 in the current study. Four hundred twenty cattle were selected

Figure 1. Study area map.

by using a systematic random sampling technique from cattle that came to the kombolcha Elfora meat factory abattoir.

Study methodology

Abattoir survey: The active abattoir survey for both ante-mortem and postmortem examinations was carried out during the study period. In the abattoir, regular visits were made to conduct an ante-mortem examination of cattle brought for slaughter and examined clinically both at rest and in motion before slaughter in the slaughtering house. A systematic random sampling technique was applied to those cattle that came to the meat factory. Before sampling, each selected cattle were given an identification number by writing a code on its head using a permanent marker. The first cattle were randomly selected and then every 5th cattle was considered. Cattle sex, age, body condition, breed, and origins were recorded accordingly. However, young age and exotic breed cattle were not incorporated into the study. Seven cattle were examined on each slaughter day. A total of 420 cattle carcasses presented to Kombolcha Elfora meat factory 3 days/week were examined for the presence of *Cysticercus bovis* according to the guideline described by the Ministry of Agriculture's. It includes visualization, palpation, and incisions. Moreover, the examination includes a longitudinal incision of the heart from base to apex, two longitudinal ventral incisions of the tongue from tip to root, one deep incision into both sides of the triceps muscles of the shoulder, a deep incision into the external and internal muscles of the masseter parallel to the plane of the jaw, three parallel incisions into the long axes of the neck muscles on both sides and one extensive incision. The results were recorded according to the organs examined.

Estimation of economic loss analysis: To determine the economic losses due to cysticercosis in cattle, both direct and indirect losses were considered. The calculation of the direct losses is based on condemned organs (liver, heart, head (master and tongue)) and the indirect losses were evaluated based on live weight reduction due to cysticercosis. The mean prices of the edible organs were obtained from the current local market price during the study period and this price index was later used to calculate the meat loss in terms of Ethiopian Birr (ETB). The average annual slaughter rate of cattle in the Kombolcha Elfora meat factory was determined based on a retrospective analysis of data recorded from the last 2 years. An average of 12 heads of cattle per day was slaughtered. Similarly, the annual slaughter rates were estimated at 4,380 cattle. A 5% estimated carcass weight loss due to bovine cysticercosis was taken into account to determine the carcass weight loss. The average carcass weight of an Ethiopian zebu was taken as 126 kg, as estimated by the International Livestock Center for Africa [8]. The annual economic loss produced by the condemnation of organs and carcasses weight loss was calculated using a formula proposed by Ogunrinde A and Ogunrinde BI [9].

Direct economic losses from organ condemnation are calculated as

LOC= (pI1×Tk×c1) + (pI2×Tk×c1) + (pI3×Tk×c3)

Where; loss from organs condemnation, pI1=percent involvement of liver out of total examined, pI2=percent involvement of heart out of total examined, pI3=percent involvement of the head out of total examined, c1=average market price of the liver, c2=average market price of heart, c3=average market price of the head. Tk=average annual kill of cattle).

Indirect economic losses from carcass weight loss were determined

ACW=(CSR×CL×BC×P)

Where; ACW=Annual Cost from carcass Weight loss; CSR=average slaughtered cattle per year in the abattoir; CL=carcass weight loss in the individual=(126×5%); BC=average price of 1 kg carcass at Kombolcha town, P=prevalence rate of *Cysticercus bovis* at Kombolcha Elfora meat factory.

Data management and analysis: All the collected raw data was organized, entered into the MS Excel spreadsheet computer program, and analyzed using the SPSS 20 software version. Descriptive statistics were used to summarize the relative frequency and percentages. The chi-square test ($\chi2$) was used to measure the association among risk factor and the occurrence of *Cysticercus bovis*. In all the analyses, the confidence level was set at 95%, and P<0.05 was set for significance.
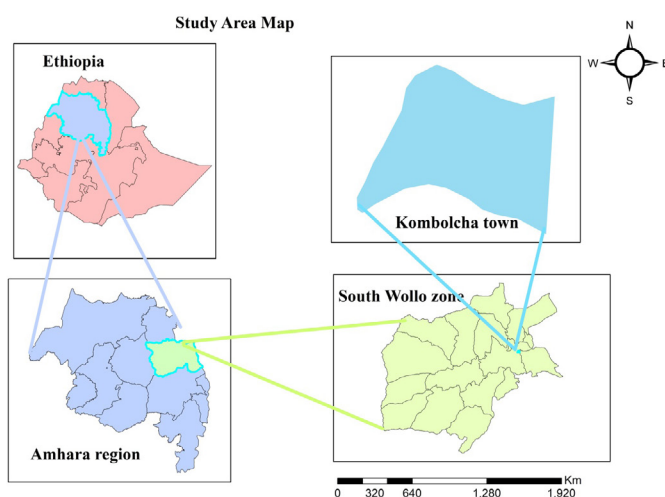
Results

Abattoir survey result

The prevalence of *Cysticercus bovis* among different associated risk factors: In the present study, of the total of 420 examined cattle slaughtered at the Kombolcha Elfora meat factory, 26 (6.01%) cattle were infected by *Cysticercus bovis*. In addition, old, female, cross breed and cattle in good body condition were noted to have a higher prevalence of *cysticercus bovis* than the adult, male, local breed and poor body condition respectively. According to the chi-square test analysis, the result showed that there was no statistical association (P> 0.05) between the sex, body condition score, origin, breed, and age of cattle and the prevalence of *Cysticercus bovis* as described in Table 1.

Anatomical distribution of cysts among inspected organs and their degree of association: An active abattoir survey analysis clearly stated there was a significant variation in the anatomical distributions of *Cysticercus bovis* in the examined organs of slaughtered cattle in the study abattoir. The highest frequency of infection was observed in the liver (65.21%), followed by the tongue (17.4%), masseter muscle (10.86%), and heart (6.52%). A total of 92 cysts of *Cysticercus bovis* were recovered from 26 cysticercosis-positive cattle during the study period as shown in Tables 2 and 3.

Economic losses of *Cysticercus bovis* in slaughtered cattle: In the current study, a total of 11 liver (2.62%), 5 heart (1.19%), and 10 Head (master and tongue) (2.38%) were condemned due to the detection of cysticercus cysts. The mean current unit prices of these organs in Komblcha are 35, 15 and 400 ETB, respectively, while the mean current price of 1 kg beef is 150 ETB. The mean number of cattle slaughtered annually at the Kombolcha Elfora meat factory was determined from the records of the last 2 years as 4380. Therefore, the annual economic loss due to organ condemnation is estimated as follows

The direct economic loss from organ condemnation was calculated as:

$$LOC= (pI1 \times Tk \times c1)+(pI2 \times Tk \times c1)+(pI3 \times Tk \times c3)$$

$$=(4380 \times 2.62\% \times 35)+(4380 \times 1.19\% \times 15)+(4380 \times 2.38\% \times 400)=46{,}495.9 \text{ ETB}$$

The indirect monetary loss from carcass weight loss was calculated as: $LCWL=4380 \times 6.01\% \times 5\% \times 150ETB \times 126kg=248{,}346$ ETB. Therefore the annual monetary losses were 294,841.89 ETB per annum. The result implies that loss due to carcass weight reduction was greater than loss due to organ condemnation.

Discussion

In the present study, the overall prevalence of bovine cysticercosis in the

Table 1. The prevalence of *Cysticercus bovis* among different associated risk factors.

	Variable	Number of Cattle Examined	Number of Positives	Prevalence %	χ^2	P-Value
Ages	Adult	267	14	5.2	0.658	0.417
	Old	153	12	7.8		
Sex	Male	352	18	5.1	0.732	0.98
	Female	68	8	11.7		
Body Condition	Poor	163	9	5.5	0.609	0.705
	Medium	211	13	6.16		
	Good	46	4	8.7		
Breed	Local	358	21	5.9	0.32	0.857
	Cross	62	5	8		
Origin	Dessie zuriya	74	4	5.4	7.299	0.2
	Kombolcha	75	3	4		
	Kemise	58	4	6.8		
	Bati	57	3	5.3		
	Raya	72	4	5.6		
	Share	84	8	9.5		
Total		420	26	6.00%		

Table 2. Anatomical distribution of *Cysticercus bovis* cyst among inspected organs.

Organs	Number Infected Organ	Number Cyst Counted	Percent (%)
Tongue	6	16	17.40%
Liver	11	60	65.21%
Masseter muscle	4	10	10.86%
Heart	5	6	6.52%
Total	26	92	100%

Table 3. Economic losses of *Cysticercus bovis* in slaughtered cattle organs based on the current price.

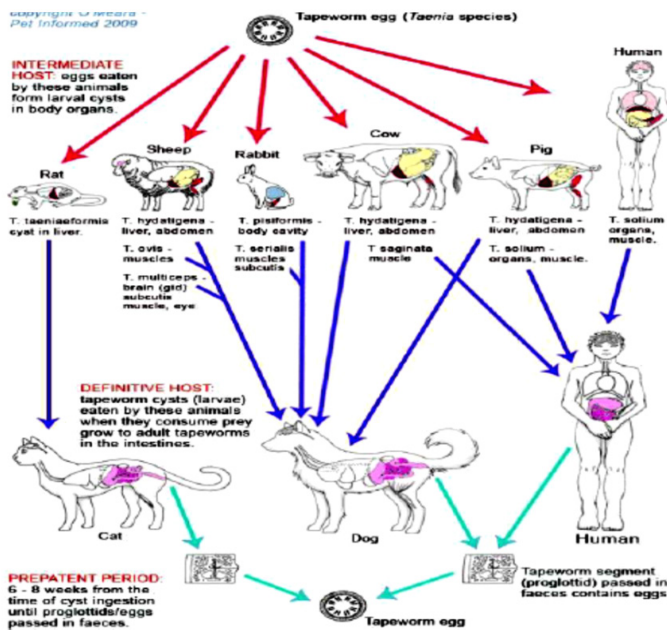| Organ	Number of Organs Condemned	Unit Price	Total
Liver	11	35	385
Heart	5	15	75
Head (masseter and tongue)	10	400	4000
Total	26	450	4460

Figure 2. The life cycle of *Taenia* tapeworm.

Kombolcha Elfora meat factory was 6.0%, which is consistent with the previous work done by in Mekelle (7.3%), in Komblcha (6.4%) and [1] in Bishftu (5.4%). However, the current study was lower than the earlier findings of in Wolaita Soddo (11.3%), in Bako (11.88%), and [5] in Ethiopia (92.7%). This study was also higher than the works in Egypt (1.6%) and in Jimma (4.4%). This variation in prevalence might be due to variations in agro-climatic conditions, sample size, management systems, and routine inspection.

Chi-square test analysis indicated that *Cysticercus bovis* was not significantly associated with age, sex, body condition, and breed of slaughtered cattle (P>0.05). The current study was consistent with the work in Addis Ababa, in Meshkinshahr, [10] in Hawassa and [4] in Addis Ababa. However, this study was inconsistent with the earlier findings in Wolaita Soddo in eastern Tigray in Rwanda and in the west Arsi zone. The possible reason for this variation of significance might be the sample size variation, immunity status, breed susceptibility, and management system. Similarly, as the statistical analysis showed that there was no statistical association between the origin of cattle and the prevalence of *Cysticercus bovis*. This finding was similar to the reports of Belachew M and Ibrahim N [10] in Hawassa and in Komblcha. Although this finding contradicted the reports in Woloaita Soddo, This variation in prevalence could be associated with geographical differences, habits of society toward raw meat consumption, sample variation and sanitary problems.

Regarding the anatomical distribution of the cyst, the current study revealed that the most frequently affected organ by *cysticercus bovis* was the liver, followed by the tongue, masseter muscle, and heart. This study was in line with the report of in Mekelle City. However, this result was not in line with the study done by Wanzala W, et al. [11] in Kenya, in Rwanda, and [2] in Iran, who reported that the heart was a highly infected organ, in Meshkinshahr, who showed that the master muscle is highly infected, and [1] in Bishoftu, who reported that the tongue was the most frequently affected organ. The variation in the anatomical distribution of cysts in the organs of slaughtered cattle might be due to the ability of the meat inspector to identify the cyst, sample size, method of meat inspection, and several cuts.

The current study indicated that the annual economic loss incurred due to organ condemnation and carcass (live) weight loss because of *Cysticercus bovis* was estimated to be 294,841.89 ETB. This finding was relatively similar to the findings of [12] in Egypt 282, 170.85 ETB, and [13] in the west shoa 289, 799.03 ETB. This study was much greater than the findings in Welaita Soddo, 40,200 ETB, and in Bko, 180,972 ETB. However, the present study was much lower than the findings of Fan PC [14] in South Africa (1 billion ETB), [15] in Adama (6,814,190 ETB) and [16] in Egypt (6,274,047 ETB), and.

The difference in economic loss analysis in various abattoirs may be due to variations in the prevalence of the disease, the mean annual number of cattle slaughtered in different abattoirs, and variations in the sales price of organs and carcass [11].

Conclusion

The present study has revealed that bovine cysticercosis exemplifies a parasitic disease of paramount significance in both the domains of animal health and economics. The findings of this particular investigation have effectively demonstrated the prevalence and anatomical distribution of cysts in various bodily organs, alongside the economic loss incurred by the condemnation of infected organs and the reduction of carcasses consequent to the presence of *Cysticercus bovis*. In this study, *Cysticercus bovis* was found to be moderately prevalent, with the liver being the organ most frequently affected, followed by the tongue, masseter muscle, and heart. Among the various risk factors examined, it was determined that sex, body condition score, age, breed, and origin of the cattle did not exhibit any significant association with the prevalence of Cysticercosis bovis. Overall, bovine cysticercosis still constitutes a serious threat to the health of both animals and humans, ultimately resulting in substantial financial losses.

Recommendations

Based on the results of the present study, the following recommendations were forwarded:

Apply standard routine meat inspection, proper disposal of infected organs and drainage system in order to break the life cycle of the Cysticercosis bovis could be helpful.

Awareness creation to the public should be implemented on general personal and environmental hygiene, means transmission and control of bovine cysticercosis.

Further study on the public health significance and molecular characterization of bovine cysticercosis should be done.

Ethical Agreement

Hereby, I declare that this manuscript entitled Prevalence, Anatomical Cyst Distribution and Economic Significance in Cattle Slaughtered at Kombolcha Elfora Meat Factory is the author's original work, which has not been previously published elsewhere and is not currently being considered for publication elsewhere. All sources used are properly revealed and correctly cited.

Availability of Data and Materials

The datasets for the current study are available from the corresponding author upon request.

Author Contributions

SK generated the study design, collected the data, performed laboratory procedures, coordinated the experiment, presented and analyzed the data, and performed and finalized the study. All authors participated in writing, reviewing, and finalizing the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

Permission to carry out this study was granted by Wollo University, the Ethical and Higher Degrees Committees of the School of Veterinary Medicine, how to use animals for the research, and all protocols or procedures in this study. The objectives of this study were well explained to all owners and meat inspectors, who all expressed their consent to participate in the research activities.

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