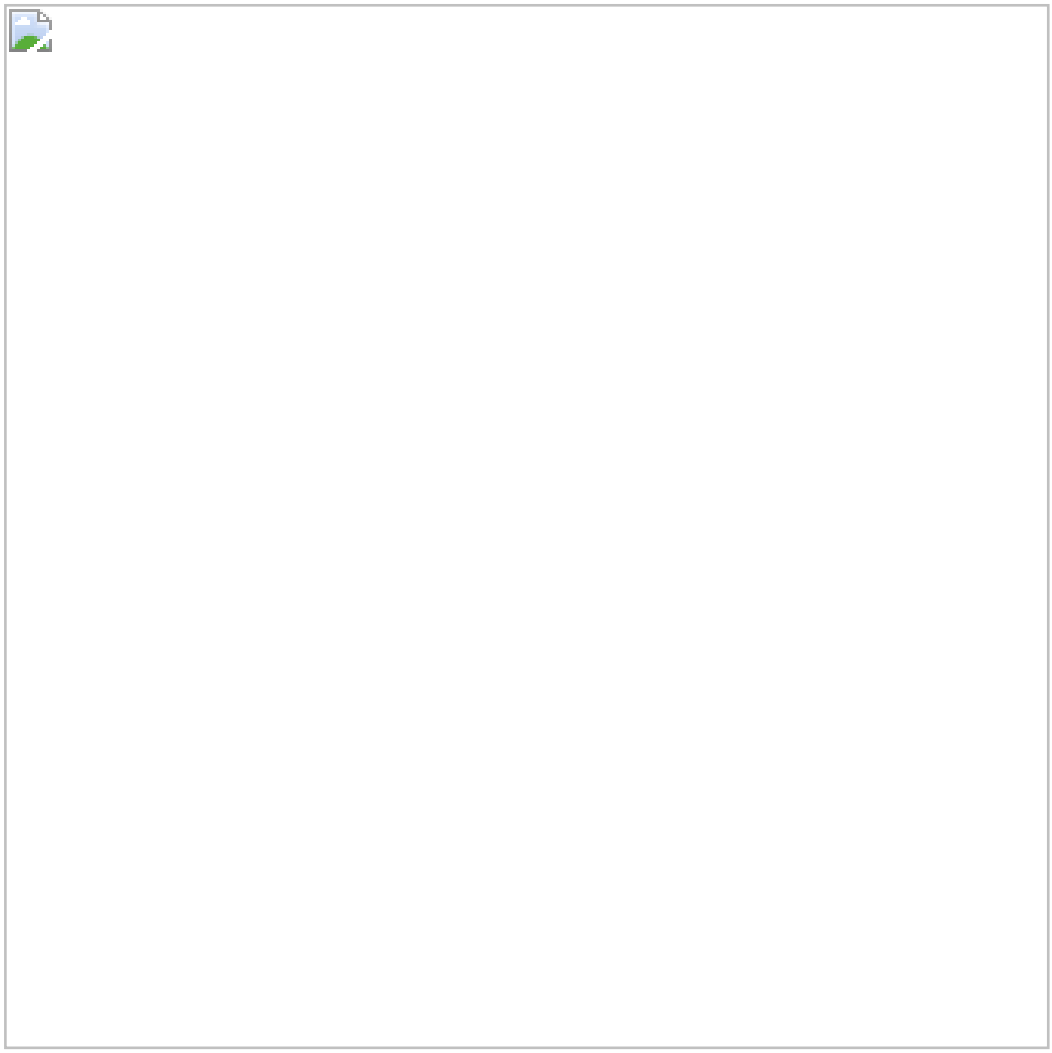

Prevalence and Associated Risk Factors of Cysticercosis bovis in Bishoftu Municipal Abattoir, Central Ethiopia

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Prevalence and Associated Risk Factors of *Cysticercosis bovis* in Bishoftu Municipal Abattoir, Central Ethiopia

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ABSTRACT

BACKGROUND: *Cysticercus bovis* has zoonotic implications with economic losses from organ contamination and treatment costs. In developing countries such as Ethiopia, where hygienic standards are low and residents customarily eat raw or undercooked meat, the disease is prevalent.

METHODS: A cross-sectional study was carried out from December 2021 to June 2022 to determine the prevalence of *Cysticercus bovis* in cattle slaughtered at the Bishoftu municipal abattoir, in central Ethiopia. Study populations for the active abattoir survey were cattle presented to the abattoir for slaughtering and routine meat inspection conditions. The organ namely the tongue, masseter muscle, liver, and triceps muscle were inspected for the presence of *C. bovis*.

RESULTS: From a total of 330 cattle, 14 were found to be positive for *C. bovis*, with an overall prevalence of 4.24%. Based on the origin of the animals, the highest prevalence was recorded at Adama (7.27%), followed by Bishoftu (5.45%), Mojo (5.45%), Borana (3.63%), Dukem (3.63%), and Kaliti (0.00%). Similarly, out of 111 adults and 219 old-aged cattle slaughtered and examined at the abattoir, 4.5%, and 4.11% were positive for *C. bovis*, respectively. Among tested independent variables, sex, body condition score, age, and origin of animals had no relationships with the prevalence of *C. bovis*. From the detected organ, the tongue ranks first for the highest number of cysts, followed by the masseter muscle, liver, and triceps muscle, with total cysts of 6, 4, 3, and 1, respectively.

CONCLUSION: *C. bovis* is a prevalent zoonotic parasite disease that causes carcass condemnation; an enhanced understanding of the health consequences of teniasis is required to protect the community.

KEYWORDS: *Cysticercus bovis*, Bishoftu municipal abattoir, Ethiopia, prevalence

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Introduction

Ethiopia has the largest livestock population in Africa, with an estimated 56 706 389 cattle, 29 332 382 sheep, and 29 112 963 goats.[1] However, national income and livestock populations were not comparable due to different factors. Consequently, livestock productivity is decreasing due to major constraints such as diseases, the low genetic potential of indigenous cattle, poor reproductive performance, scarcity of nutrition, and a lack of good husbandry practices.[2]

Among its constraints, livestock diseases cause extensive financial waste as a result of direct and indirect economic losses, which is a major concern for the livestock industry.[3] Among highly prevalent diseases, *Cysticercus bovis* is the most common, resulting in economic losses and public health problems.[4] It is a parasitic infection of cattle caused by the larval stage (Cysticercus) of the cestode *Taenia saginata*. This larva is meat-borne, and human infection occurs when raw or undercooked beef is consumed. *Cysticercus bovis* is a disease that affects the musculature of cattle and is caused by the metacestode stage of the human intestinal cestode and *Taenia saginata*.[3]

Taenia saginata is known as the "beef tapeworm" because beef is the main source of infection, it has a cosmopolitan distribution, and it causes anorexia, weight loss, abdominal pain, and digestive upset.[5] *T. saginata* has 2 different stages in its life cycle, the intermediate host (cattle) and the final host (human). The larval stage (*Cysticercus bovis*) occurs in the heart and skeletal muscles of the intermediate host, and the adult worm is located in the intestine of the final host. Cattle are infected when they ingest water or feed on pastures or fodder containing the *T. saginata* eggs expelled in human feces. Cysticercosis in cattle often has no clinical features, but a heavy infection may cause myocarditis. Human infection occurs by consuming infected raw or semicooked beef.[6]

The infection is a problem in developed countries where considerably rare (ie, undercooked) beefsteak is consumed and is more widespread in developing countries where hygienic conditions are poor and where the inhabitants traditionally eat raw or insufficiently cooked meat. It is important to note that eggs have been demonstrated to survive almost all stages of sewage treatment.[7] Cysticercosis is an important zoonotic disease in Africa, with a high reported incidence when compared with other continents of the world. The parasite is found in both developed and underdeveloped countries.[8]

Cysticercosis in cattle, caused by *C. bovis*, is a major cause of economic loss in the beef meat business due to the rejection of infected meat. The distribution of infection differs from that of

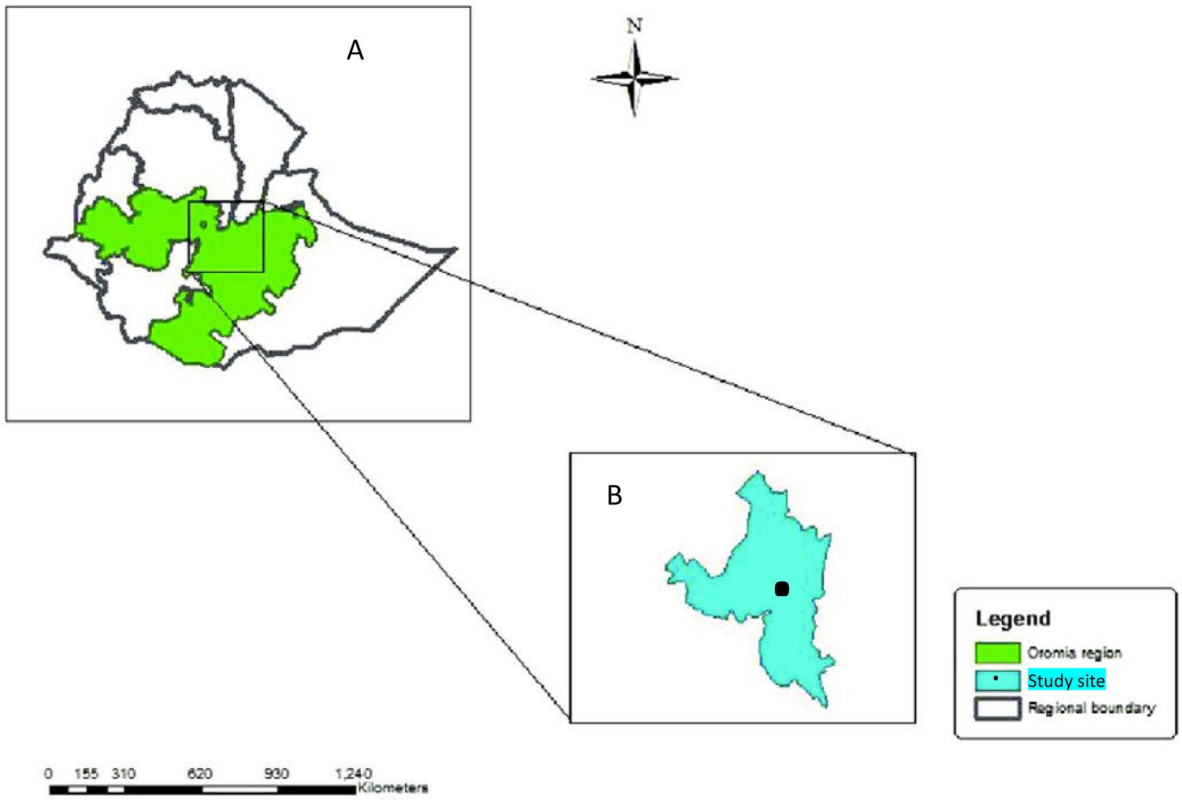

Figure 1. Map of Ethiopia and Oromia region (A) and study area with slaughterhouse location (B).
Source: Duresa et al.[25]

teniasis in humans. Africa accounted for approximately 40% of the 77 million documented cases of bovine teniasis worldwide. In Ethiopia, several authors have reported its seroprevalence or infection prevalence in a wide range of 2.5% to 89.41% and 3.11% to 27.6%, in humans and cattle, respectively.[8]

The most effective method of diagnosing *Cysticercus bovis* is postmortem examination. The primary method of detecting *Cysticercus bovis* in slaughterhouses is a visual inspection of cut muscles at specific predilection sites, such as the external and internal masseter pterygoid muscles, heart, tongue, diaphragm, and esophagus. Therefore, meat inspection is the main public health measure for the prevention of the transmission of *T. saginata*. The relative public health importance of this parasite, especially to humans and cattle, has necessitated this study to determine the prevalence of *C. bovis* in cattle slaughtered at the Bishoftu municipal abattoir. It is believed that the cultural habit of eating raw meat in the form of "Kurt"-meat cubes and "Kitfo"-minced meat in Ethiopia has favored the spread of this disease.[9] Even though different authors have reported its prevalence in different areas at different times, a recently updated report is very important to ensure the surveillance as well as the public health and economic importance of the disease. Therefore, this study aims to determine the prevalence and risk factors of *C. bovis* in cattle slaughtered at the Bishoftu municipal abattoir.

Materials and Methods

Study area

The study was conducted in Bishoftu, central Ethiopia (Figure 1). Bishoftu is located approximately 45 km southeast of Addis Ababa, just on the escarpment of the Great Rift Valley, and the geography of the area is marked by creator lakes. It is found at 9°N latitude and 40°E longitude at an altitude of 1850 m above sea level in the central highlands of Ethiopia. It has a human population of approximately 95 000. It has a bimodal rainfall pattern, with the major rainy season lasting from June to September (with an estimated 84% of rain) and from March to May having a short wet season with an average annual rainfall of 800 mm. The mean annual minimum and maximum temperatures are 12.3°C and 27.7°C, respectively, with an overall average of 18.7°C. The mean relative humidity is 61.3%.[10] The Bishoftu municipal abattoir are specialized in slaughtering cattle.

Study design

A cross-sectional study was carried out from December 2021 to June 2022 to determine the prevalence of *Cysticercus bovis* in the Bishoftu municipal abattoir in central Ethiopia. Information regarding the age, sex, origin, and body condition score of the animals was recorded during preslaughter.

Study population

The study populations were cattle presented to the abattoir for slaughtering and routine meat inspection conditions. The study animals were brought from surrounding Bishoftu and other districts by traders for slaughter. Depending on where the animals were collected, they were carried to the abattoir by truck or on foot.

Sampling method and sample size determination

Sampling was conducted using multistage random sampling methods. The sample size of the active abattoir survey was determined using the expected prevalence of *Cysticercus bovis* in the Bishoftu municipal abattoir at 7.8% reported by Geinoro and Beredo,[11] with a 95% confidence interval at a desired absolute precision of 5% according to the formula given by Thrusfield.[12] Therefore,

$$n = \frac{1.96^2 \times Pexp(1\text{-}Pexp)}{d^2}$$

where *n* is the required sample size, *P*exp is the expected prevalence, and d is the desired absolute precision, usually $d = 0.05$ at a 95% confidence level.

Thus, the required sample size was 110, but 330 cattle were sampled to increase the level of accuracy (triple fold samples) used in determining the updated prevalence.

Abattoir survey

Antemortem and postmortem examinations were carried out for every sampled animal. Before slaughter, 330 cattle were selected using a multistage sampling method for antemortem investigation for the presence of disease or abnormality. Animals were first grouped according to their sex. Then, they were grouped according to their region of origin, followed by their age. The number of animals brought to the slaughterhouse during the study period was taken into consideration when choosing the animals from each age group. Finally, each study animal was chosen at random from a group of animals classified by age (⩽5 years: adult; >5 years: old). Thus, 111 adult and 219 old animals were chosen from each area using multistage sampling. The regions where the animals were brought for slaughter (which are regarded as the animals' places of origin) were Adama, Bishoftu, Borana, Dukem, Kaliti, and Mojo, and according to their body condition score, they were divided into poor, medium, and good categories.

During the antemortem examination, the study animal was given an identification number. After being slaughtered, the carcasses were examined for *C. bovis*. The post-mortem examination was carried out in accordance with the Ministry of Agriculture's[13] guidelines. It includes visualization, palpation, and incisions. In addition, the examination included a longitudinal incision of the heart from base to apex, 2 longitudinal ventral incisions of the tongue from tip to root, 1 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, 3 parallel incisions into the long axes of the neck muscles on both sides, and 1 extensive incision. The results were recorded according to the organs examined.

Data management and analysis

All data collected from the slaughtered cattle were entered into a Microsoft Excel worksheet in 2016 and were analyzed by Pearson Chi-square, or Fisher Exact test where appropriate (STATA-14, Stata Corporation, Texas, USA, 2014). Descriptive statistics, such as percentages, were used to determine the level of organ condemnation. The associations between the various potential risk factors, such as age, origin, sex, and body condition score, of animals were assessed by Pearson Chi-square (X^2) or Fisher Exact test, and a *P*-value $<.05$ was considered significant.

Results

Prevalence of C. bovis

In the current study, out of 330 inspected cattle, the overall prevalence of cysticercosis was 4.24% (95% CI; 2.52, 7.05).

Role of risk factors for C. bovis

Among 311 males and 19 females slaughtered and examined cattle at Bishoftu municipal abattoir (n = 330), 4.18% of males and 5.26% of females were positive for *C. bovis*. Similarly, out of 111 adults and 219 old-aged cattle slaughtered and examined at the abattoir, 4.5%, and 4.11% were positive for *C. bovis*, respectively. Moreover, the prevalence of *C. bovis* according to origin and body condition score is presented in Table 1. However, the present study revealed that there was no statistical association ($P > .05$) between the sex, body condition score, origin, and age of animals and the prevalence of *Cysticercus bovis*.

The tongue with 42.9% cysts ranks first for the highest number of cysts, followed by the masseter muscle at 28.6%, the liver at 21.42%, and the triceps muscle at 7.14%. The abattoir survey analysis indicated that there was a significant variation in the anatomical distribution of *C. bovis* in the inspected organs of slaughtered animals (Table 2).

As indicated in table 3, the univariable analysis revealed that there was no statistically significant association ($P > 0.05$) between sex, age, body condition score, and origin and prevalence of C. bovis.

Discussion

In livestock production, *Cysticercus bovis* is a significant problem. It causes severe economic loss in the meat industry due to

Table 1. Prevalence of *Cysticercus bovis* based on risk factors (n = 330).

VARIABLES	CATEGORIES	NO. OF ANIMALS EXAMINED	NO. OF POSITIVE ANIMALS	PREVALENCE (%)	CHI-SQUARE/FISHER EXACT TEST VALUE	*P*-VALUE
Sex	Male	311	13	4.18	0.572	.820
	Female	19	1	5.26		
Age	Adult	111	5	4.50	0.028	.866
	Old	219	9	4.11		
Body condition score	Good	298	11	3.69	0.173	.316
	Medium	21	2	9.52		
	Poor	11	1	9.09		
Origin	Adama	55	4	7.27	0.473	.524
	Bishoftu	55	3	5.45		
	Borana	55	2	3.63		
	Dukem	55	2	3.63		
	Kaliti	55	0	.0		
	Mojo	55	3	5.45		

Table 2. Anatomical distribution of cysts among inspected organs and their degree of association.

VARIABLE	CATEGORIES	POSITIVE	PREVALENCE (%)	FISHER EXACT	*P*-VALUE
Organs	Tongue	6	42.9	0.000	.0001
	Masseter muscle	4	28.6		
	Liver	3	21.42		
	Triceps muscle	1	7.14		

meat condemnation or carcass downgrading.[14] The present study revealed that the overall prevalence of *C. bovis* from the carcasses inspected at the Bishoftu municipal abattoir was 4.24%. This finding agreed with the prevalence rate of 2.59% in Wolaita Sodo,[15] 3.6% in Addis Ababa Municipal Abattoir,[16] 2.93% in Jimma municipal abattoir,[17] and 6.4% in Kombolcha Elfora.[18]

However, the present study lowers the prevalence of *C. bovis* obtained to 26.25% in the Awassa abattoir,[8] 18.49% in northwestern Ethiopia,[19] 7.5% in the Addis Ababa abattoir,[20] and 22.9% in the Hawassa municipal abattoir.[21] On the other hand, the current *C. bovis* prevalence was higher than the report of Swai and Schoonman[22] 1.49% in the Tang city abattoir, Tanzania. This variation between previous prevalence and current prevalence might be due to differences in agroclimatic conditions, animal size sampled, people living or management systems, and the area from which animals came. In addition, in the routine inspection of beef carcasses, many infestations remain undetected due to the fact that there is a practical limitation to the degree of incision permissible because a grossly visible incision lowers the marketability of the carcass.

The present study has revealed that there was no significant difference between the sex of animals with the prevalence of *Cysticercus bovis*, and it was lower in males (4.18%) than in females (5.26%). This finding agrees with Teklemariam and Debash[9] in and around Batu, Ethiopia. However, this finding disagreed with Ibrahim and Zerihun[16] in the Addis Ababa municipal abattoir, where they explained that there was a significant difference ($P < .05$) in the occurrence of *Cysticercus bovis* between the sexes of animals. This result could be due to the equal susceptibility of cattle to *Cysticercus bovis* irrespective of sex. Moreover, the possible reason for this variation of significance among different studies might be the sample size variation between female cattle slaughtered at different municipal abattoirs and females kept in the herd for breeding and milk production and thus rarely sent to slaughter.[16]

In the current study, the prevalence of *Cysticercus bovis* was higher in adult-aged animals (4.5%) than in old-aged animals (4.11%). This finding agreed with the report of Engdaw et al[18] in the Kombolcha Elfora Abattoir but contrary to the report of Teklemariam and Debash[9]. However, the current study showed that there was no significant difference between the ages of

Table 3. Univariable logistic regression output of risk factors and their odds of exposure.

VARIABLES	CATEGORIES	NO	NPA	OR	95% CI	*P*-VALUE
Sex	Male	311	13	Ref.		
	Female	19	1	1.27	0.16-10.28	.821
Age	Old	219	9	Ref.		
	Adult	111	5	1.10	0.36-3.37	.866
Body condition score	Poor	11	1	Ref.		
	Good	298	11	0.38	0.05-3.26	.380
	Medium	21	2	1.05	0.08-13.08	.968
Origin	Adama	55	4	1.36	0.29-6.38	.697
	Bishoftu	55	3	Ref.		
	Borana	55	2	0.65	0.10-4.08	.649
	Dukem	55	2	0.65	0.10-4.08	.649
	Kaliti	55	0	1		
	Mojo	55	3	1	0.19-5.18	1.00

Abbreviations: CI, confidence interval; No, number of animals examined; NPA, number of positive animals; OR, odds ratio; Ref, reference cell.

animals with the prevalence of *Cysticercus bovis*. One possible explanation for this variation might be that any age group of animals has similar susceptibility to *T. saginata* eggs, and most of the animals slaughtered in this abattoir were adults and old and had similar management systems.

In the present study, the prevalence of *Cysticercus bovis* was higher in medium (9.52%) than in good (3.69%) and poor body-conditioned animals (9.09%). This finding was lower than the report of Netsanet et al[3] with medium (14.2%) and good body condition (11.8%). The majority of the animals slaughtered in the abattoir were brought from the fattening systems of the individual farmer. And also the animals from such farms were less exposed to eggs of *T. saginata* as they grazed on relatively clean defined pasture land, tying the system to the pegs and intensive feeding system in the house for fattening purposes, and used anthelminthic drugs.[3] This study showed that there was no significant difference between the body condition of animals and the prevalence of *Cysticercus bovis*. However, this result disagreed with the report of Netsanet et al[3] in Dessie, which showed that there were statistically significant body conditions of the animals with the prevalence of *Cysticercus bovis*.

Based on the origin of the animals, the highest prevalence was recorded at Adama (7.27%), followed by Bishoftu (5.45%), Mojo (5.45%), Borana (3.63%), Dukem (3.63%), and Kaliti (0.00%). The reason for the overlap rate occurrences in Bishoftu and Mojo as well as in Borana and Dukem might be due to equal sampled cattle and similarity in management systems. The statistical analysis showed that there was no statistical association between the origin of animals and the prevalence of *C. bovis*. This finding agreed with the reports of Teklemariam and Debash[9] in Batu, Ethiopia, who reported no statistical association between the origin of animals and the prevalence of *C. bovis*. This variation in prevalence could be associated with geographical differences, habits of society toward raw meat consumption, the presence or absence of sanitary problems, and likely associated with the number of animals brought to the abattoir.[3]

Anatomical distribution of cysts

An active abattoir survey found that the anatomical distributions of *C. bovis* in the examined cattle organs varied. The most frequently affected organ was the tongue, with the highest number of cysts (6, 42.9%), followed by the masseter muscle (4, 28.6%), the liver (3, 21.42%), and the triceps muscle (1, 7.14%). These organ-specific figures agree with Teklemariam and Debash[9] and Tesfaye et al,[23] who reported tongues with the highest number of cysts. However, this organ-specific prevalence disagreed with Netsanet et al,[3] who reported the liver with the highest cyst number, and Belachew and Ibrahim[21] at Hawassa Municipal Abattoir, Mohamed et al[24] at Addis Ababa enterprise abattoir, who reported the triceps muscle to be the first to harbor *C. bovis*. The abattoir survey analysis indicated that there was a significant variation in the anatomical distribution of *C. bovis* in the inspected organs of slaughtered animals. This demonstrated that the tongue was the first ranked to confirm *C. bovis* at abattoirs. This variation might be due to the ability of the meat inspector to identify the cases, sample size, method of meat inspection, and several cuts.

Conclusion and Recommendations

Cysticercus bovis is an important zoonotic disease. It is strongly associated with raw or undercooked beef consumption and occupation. The present study revealed that *Cysticercus bovis* is slightly prevalent in the Bishoftu municipal abattoir. Among the risk factors, sex, body condition score, and age of the animals were not significantly associated with the prevalence of Cysticercosis bovis. This implies that all animals without their status of sex, age, and origin were equally infected by *C. bovis*. Based on the above conclusions, the following recommendations are forwarded: An all-inclusive approach focused on improving sanitary conditions and strengthening meat inspection and reporting systems among abattoirs should be improved; a routine meat inspection procedure should be applied.

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Author Contributions

All authors contributed to the study design, data gathering, data analysis, manuscript write-up, and editing of the manuscript. All authors have approved the submission of the manuscript.

Consent for Publication

Not applicable.

Data Availability Statement

The data will be provided upon the request of the corresponding author.

Ethics Approval and Consent to Participate

Ethical clearance was obtained from the University Review Board. The purpose of the study was well explained to the cattle owners before taking the samples, and informed consent was obtained to take the appropriate sample through verbal consent.

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