



Prevalence, Cysts Distributions, Associated Risk Factors and Economic Importance of *Cysticercus Tenuicollis* in Small Ruminant Slaughtered at Jigjiga Municipal Abattoir, Somali Regional state, Ethiopia

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Authors' contributions

This work was carried out in collaboration among all authors. Author AAH, designed the study, did part of the fieldwork, laboratory works. Author MAA, analyzed part of the data, wrote the manuscript and participated in the write-up. Author AAH, analyzed the data, supervised the study. Author SAM, enriched the manuscript. All authors have read and approved the final manuscript.

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ABSTRACT

A cross-sectional study was done between November 2019 and April 2020 with the goal of identifying the prevalence of *Cysticercus tenuicollis* in small ruminants, evaluating possible risk factors associated with it, and estimating the amount of the direct economic losses associated with condemned organs. A total of 545 small ruminants slaughtered at Jigjiga municipal abattoir were randomly selected and managed through ante-mortem and post-mortem examinations. From the total inspected shoats, 98 (17.9%) were recorded to be affected with *C. tenuicollis*. From the 349 inspected goats, *C. tenuicollis* was found in 71 (20.3%), and from the 196 inspected sheep, 27 (13.8%). The prevalence of *C. tenuicollis* according to their sex was higher in male sheep 16 (14.9%) and goats 51 (22.6%) than female sheep 11 (12.35%) and goat 20 (16.12%). The infection rate of *C. tenuicollis* in regards to age group revealed that a higher incidence was recorded in adult goats 60 (22%) and sheep 20 (14.3%) than young goats 11 (14.4%) and sheep 7 (12.2%). Goats 27 (26.2%) and sheep 8 (20.5%), originated from Babile were more infected compared to goats and sheep from Jigjiga (23.7%, 17.3%) and Kebribayah (10.8%, 7.3%) respectively, with a statistically significant variations ($P < 0.05$) among goats coming from various areas. Related to body condition scores and the disease, higher prevalence was noted in poor body condition of sheep and goat (18.6%, 27%) than medium (13.7%, 19.6%) and good (10.6%, 14%) body scores respectively, with significant difference in goat ($P < 0.05$). Anatomical distribution of Metacestode revealed the highest proportions of *C. tenuicollis* in omentum followed by liver than any other organs. During the active abattoir investigation, a total of about 385,621.236 ETB (10,810.8 USD\$) were lost due to organ condemnation. The findings imply that *C. tenuicollis* is widespread, may cause health Problems for shoats, and may lead to economic loss for the country. This indicates that the problem must be controlled by reducing the number of stray dogs, deworming dogs, avoiding backyard executions, and properly disposing of infected viscera.

Keywords: Jigjiga; financial losses; *C. tenuicollis*; prevalence; sheep and goats.

1. INTRODUCTION

With an estimated 57.83 million cattle, 28.89 million sheep, 60.51 million poultry, and 29.7 million goats, excluding nomadic areas, Ethiopia is thought to have Africa's largest livestock population [1]. Approximately 30% of the country's GDP and 45% of the agricultural GDP are contributed by the subsector [2]. Additionally, it accounts for 15% of export revenue [3].

Sheep and goats play a significant role in the livestock subsector because they account for more than 30% of the meat consumed locally and are a crucial revenue generator for the nation's small-scale farmers [4]. Even though they only make up 7% of the typical total investment of capital in livestock in the mixed crop-livestock production system, they generate 40% of the earnings in cash and 19% of the overall worth of the food produced for subsistence on a yearly basis [5].

Although sheep and goats have enormous potential, their advantages don't yet match their huge potential. Veterinary care, a lack of

government attention, and widely prevalent endemic diseases have caused significant losses in the animal industry each year, which are thought to be a bottleneck for the growth of this industry [6,7,8 and 9].

The larval stage of the taeniid cestode Taenia hydatigena is known as Cysticercus tenuicollis. Canine animals like dogs and foxes have adult worms in their small intestines, but both domestic and wild intermediate ruminant hosts have metacestodes [10].

Mostly the disease is perpetual and asymptomatic which cannot be detected until slaughter [11]. The migrating larvae in live small ruminants could result hepatitis, burrowing canal, granular degeneration, deposition of serofibrinous exudates and in lungs it causes pneumonia [12,13], And in very heavy infections, it may result in eosinophilic infiltration and severe inflammation that may prove to be fatal [14].

The incidence of the *C. tenuicollis* infestation varies geographically and is typically higher in nations with less stringent sanitary regulations and an unrestrained wild carnivore population [15]. The prevalence of 37.03% and 27.29%

have been noted in sheep and in goats, respectively in India [16]. In Nigeria, a prevalence of 21.4% in sheep and 34.2% in goats has been found by [17]. In Iran, a prevalence of 12.84% in sheep and 18.04% in goats was obtained by [18]. In Ethiopia a prevalence of 40.0% and 46.6% in sheep and goat was reported by [19], respectively, at Addis Ababa abattoir.

The parasite *Cysticercus tenuicollis* in small ruminants caused significant organ condemnation in Ethiopia's abattoir sector, resulting in significant economic loss [20]. In spite of the fact that various studies have been carried out to identify the prevalence of parasitic diseases leading to organ condemnation in Ethiopia [21]. In most cases, they did not pay much attention to the study of *C. tenuicollis*. however, the purpose of this study were to identify the prevalence and associated risk factors and economic losses of organ condemnation of *C. tenuicollis* in small ruminants slaughtered in Jigjiga municipal abattoir,

2. MATERIALS AND METHODS

2.1 Descriptions of Study Area

The study was done in Jigjiga municipal abattoir. Jigjiga, the capital of Ethiopia's Somali Regional State (SRS), is 630 kilometers from Addis Ababa in the country's Eastern region. Jigjiga is situated at roughly 90200 North latitude and 450560 East longitudes, or an altitude of between 1,660 and 1,710 meters above sea level.

2.2 Study Population

A total of 545 shoats brought from Jigjiga, Babile, and Kebribeyah districts to the abattoir for slaughter purposes were randomly selected and identified by species, sex, origin, body condition, and age. Animals were grouped into two species (sheep and goats), two sexes (male and female), and two age groups (young and adult) based on the dentition standard given by [22]. Based on the manual provided by the Ethiopian Small Ruminants Productivity Improvement Program [5], body condition scoring was done.

2.3 Study Design

In order to study *C. tenuicollis*, its risk factors, and determine its direct financial losses on shoats slaughtered at Jigjiga Municipal Abattoir,

a cross-sectional study was intended to be done from November 2019 to April 2020.

2.4 Sampling Method and Sample Size Determination

In this study, shoats were chosen in the livestock market by using a simple random sampling method. The randomly selected animals were recorded, marked, and followed up through the entire slaughtering procedure in the abattoir. The formula provided by [23] was used to identify the required sample size for each species in this study. with a desired absolute precision of 5%, and a confidence interval of 95%.

$$n = \frac{1.96^2 P_{exp}(1-P_{exp})}{d^2}$$

Where,

n = required sample size
P_{exp}= expected prevalence and
d= desired absolute precision

According to the above formula, with previously studied prevalence of 15% and 35% of sheep and goat respectively [24]. the calculated sample was 545.

2.5 Study Methodology

2.5.1 Ante-mortem inspection

Sheep and goat were examined in the lairage prior to slaughter by grouping the animals according to species, age, body scores, and place of origin. Both before and after the animals entered the lairage in large groups, ante mortem inspections were carried out on each individual animal. At rest and in motion, the animals' entire sides were examined. Additionally, the animals' general behavior, nutritional status, cleanliness, and any signs of diseases or abnormality of any kind were recorded in accordance with the required ante-mortem inspection procedures by [25]. Animals fit for human consumption were approved for slaughter in accordance with the decision made by [26].

2.5.2 Post-mortem examination

Each visceral organ, in particular the lungs, kidneys, liver, spleen, heart, omentum, and mesentery, was thoroughly examined post-mortem for the existence of *C. tenuicollis* through thorough visual inspection, palpation,

and systemic incision [27,9]. Based on their morphological foundation and predilection sites, cysts were identified.

2.6 Financial Loss Assessment

Only the direct financial loss caused by the condemnation of the liver was taken into account when calculating the economic losses. The analysis was conducted using the abattoir's annual slaughter capacity while taking market demand, the average market price on the global market, and the liver rejection rate into account. The formula in [28] was then used to mathematically calculate the financial loss. for liver rejection as the following:

$$EL = \Sigma Srx * Coy * Roz$$

Where

EL stands for Estimated Annual financial Loss brought on by Organ and Carcass Rejection from Domestic or International Market.

Srx = the abattoir's annual sheep/goat slaughter rate.

Coy = Average Price of Each Liver, Lung, Heart, Kidney, Brain, and Carcass of Sheep or Goat.

Roz = the condemnation rates for the liver, kidney, heart, lung, and carcass of sheep and goats.

2.7 Analyzing and Managing Data

All data were coded, put into the Microsoft Excel 2013 program, and analyzed using STATA 20.0 version. To assess the degree of association between the various variables, Pearson's chi-

square (χ^2) was employed. All analyses were deemed significant if the P-value was less than 0.05 (at the 5% level of significance).

3. RESULTS

3.1 Overall Prevalence

Out of 545 sheep and goat slaughtered and examined at Jigjiga municipal abattoir, 98 (17.9%) of them were positive for *Cysticercus tenuicollis*. The prevalence of *C. tenuicollis* was higher in goats 71 (20.3%) than in sheep 27 (13.8%) but there were no statistically significant variations ($P > 0.05$) (Table 1).

3.2 Risk Factors of *C. tenuicollis* in Small Ruminants

3.2.1 The prevalence of *C. tenuicollis* among the species' varies sexes

Cysticercus tenuicollis with respect to sex revealed higher prevalence in male and lower prevalence in female of both species but statically no significant variation ($P > 0.05$) (Table 2).

3.2.2 The prevalence of *C. tenuicollis* within age groups of sheep and goats

Regarding the age of animals higher prevalence of *C. tenuicollis* was showed in adult sheep and goats 20 (14.3%), 60 (22%) as compared to the young ones 7 (12.2%), 11 (14.4%), respectively, There was no statistically significant variations between age categories and the disease ($P > 0.05$) (Table 3).

Table 1. Prevalence of *C. tenuicollis* in slaughtered shoats

Species	Examined number	Prevalence (%)	χ^2	P-value
Ovine	196	27(13.8)	3.672	0.063
Caprine	349	71(20.3)		

Table 2. The prevalence of *C. tenuicollis* with respect to sex

Species	Sex	Examined number	Prevalence	χ^2	p-value
Ovine	Male	107	16(14.9)	0.275	0.680
	Female	89	11(12.35)		
Caprine	Male	225	51(22.6)	2.108	0.166
	Female	124	20(16.12)		

Table 3. The prevalence of *C. tenuicollis* in regards to age

Species	No. examined	Age	Prevalence (%)	χ^2	p-value
Ovine	196	Young (57)	7(12.2)	0.151	0.821
		Adult (139)	20(14.3)		
Caprine	349	Young (76)	11(14.4)	2.066	0.197
		Adult (273)	60(22)		

Table 4. Prevalence of *C. tenuicollis* in goats and sheep in relation to origin

Species	No. examined	Origin	Prevalence (%)	χ^2	P-value
Ovine	196	Jigjiga(75)	13(17.3)	5.169	0.081
		Babile(39)	8(20.5)		
		Kebribayah(82)	6(7.3)		
Caprine	349	Jigjiga(135)	32(23.7)	9.158	0.010
		Babile(103)	27(26.2)		
		Kebribayah(111)	12(10.8)		

Table 5. Link between *C. tenuicollis* prevalence and body condition in small ruminants

Species	Examined	Body condition	Prevalence (%)	χ^2	p-value
Ovine	196	Good(66)	7(10.6)	1.402	0.511
		Medium(87)	12(13.7)		
		Poor(43)	8(18.6)		
Caprine	349	Good(115)	16(14)	6.354	0.042
		Medium(112)	22(19.6)		
		Poor(122)	33(27)		

Table 6. The differences between prevalence of specific organs and species

Visceral organs	Caprine		Ovine		χ^2	P-value
	Positive	Prevalence	Positive	Prevalence		
Liver	57	(16.3%)	21	(10.7%)	3.230	0.076
Omentum	62	(17.7%)	25	(12.7%)	2.348	0.144
Peritoneum	33	(9.45%)	12	(6.1%)	1.841	0.197
Mesentery	48	(13.7%)	18	(9.1%)	2.463	0.133
Lung	12	(3.4%)	4	(2%)	0.860	0.436

3.2.3 The prevalence of *C. tenuicollis* in small ruminants with different origin

Furthermore, sheep and goat coming from Babile (20.5%, 26.2%) followed by Jigjiga (17.3%, 23.7%) respectively, were highly infected by *C. tenuicollis* but the least prevalence was recorded in animals coming from Kebribayah district. The difference in prevalence among goats coming from different districts was statistically significant (P<0.05) (Table 4).

3.2.4 Body condition score and prevalence of *C. tenuicollis*

In terms of body condition, poor body condition scores had the highest prevalence, followed by medium and good scores. Body condition score

and *C. tenuicollis* prevalence in goats showed a statistically significant difference (P <0.05) (Table 5).

3.2.5 Cyst distribution in organs of *C. tenuicollis* and prevalence in shoats

Omentum followed by liver were the most common infected organs in both species, with a prevalence of goat (17.7% omentum and 16.3% Liver) and sheep (12.7% omentum &10.7% Liver). In both goats and sheep, only a few cysts were found to be connected to the lung's surface (Table 6).

3.3 Estimation of Direct Financial Losses

The average mean annual shoats slaughter rate was approximately 25200 heads, average liver

condemnation rate of the current study was 78(14.3%) and the average international recent market cost of single liver was 3USD. Thus, by replacing all the values in the following formula,

$$\begin{aligned} EL &= \Sigma Srx * Coy * Roz \\ EL &= (25200 * 3 * 0.143) \\ EL &= 10810.8 \text{ USD} \end{aligned}$$

Total loss = 385621.236 ETB.

The estimated annual financial loss as a result of liver condemnation was 10,810.8 USD\$, or roughly 385621.236 ETB (1USD=35.67 ETB).

4. DISCUSSION

In the current study, out of 545 small ruminants inspected, 98 were infected for *C. tenuicollis* with an overall prevalence of 17.9%. This result is considered relatively higher than the findings of 15.7% [18]. In Iran, 14.6% [29]. In [30]. Who reported 4.22% from north India. It was lower than the findings of 64.6% by [31] In Bishoftu Elfora Export Abattoir, 39% by [32] In Addis ababa abattoir, and [33] In three export abattoirs (Elfora, Helmex and Luna), [34,35] In Dire Dawa municipal abattoir, who reported 25.8%, 37.1%, 32.7% and 24.6%; respectively. The main explanations for differences in the prevalence are primarily attributed to management systems dominant in the local areas and the grazing behavior, and the essential factor leading to the perseverance of the disease is the existence of stray dogs in pastures and beside abattoirs [36].

The current finding, higher prevalence of *Cysticercus tenuicollis* in goats (20.3%) as in contrast to sheep (13.8%). But this variation was not found to be statistically significant. This outcome is higher than the results of [37], Who noted a prevalence of 8.4% in goats and 5% in sheep at Debrezeit, HELMEX Abattoir, and report of [38], Who found a prevalence of 15.8% in goats and 7.81% in sheep at Addis ababa.. The present report was lower than the findings of [39] With prevalence of 53.9% in goats and 45% in sheep at Bishoftu, Elfora Export Abattoir, reports were recorded by [40] with the results of goats 61.1% and sheep 42.2% in Tanzania, by [41] with results of goats 34.2% and sheep 21.4% in India and [42] with the prevalence of 17.52% in sheep and 55.05% in goats in Fars, Southern Iran. The low prevalence of sheep compared to goats may be caused by the fact that sheep typically develop protective immunity sooner than

goats, whose immunity develops more slowly [43].

According to this study's analysis of the distribution of *C. tenuicollis* infections among slaughtered sheep, more male sheep and goats (14.9% and 22.6%, respectively) than female sheep and goats (11.35 and 16.12%) were infected. This result is inline with the reports of [14], Who recorded a prevalence of 13.66% in males and 11.54% in females and [35], Who showed that the highest prevalence was noted in male animals (25.5%) compared to females (23.6%). This result disagreed with [10], which revealed a higher prevalence of 17% in female sheep and 21% in female goats than 7% in male sheep and 13% in male goats. Moreover, [44] also found a higher prevalence of 6.54% in female sheep and 6.47% in female goats than 2.27% in male sheep and 3.15% in male goats. The variations in prevalence rate might be due to physiological and hormonal effects [45].

In this finding, high prevalence was found in adult sheep (14.3%) and adult goats (22%); whereas, the lowest prevalence was noted in younger sheep (12.2%) and younger goats (14.4%). This result inlines with the findings of [46], who found higher infection rates in adult sheep (38%) and goats (47.2%) contrasted to young sheep (34.6%) and goats (32.9%), [47], who showed a prevalence of 41.66% and 37.5% in adult goats, and sheep, and 29.16%, and 27.5% in young goats and sheep, respectively, and [48], who found a higher prevalence of *C. tenuicollis* in adult sheep and goat (6.36% and 23%) than in young sheep and goat (6% and 11.6%) respectively. It is possible that older animals have lower immunity than younger ones, which would explain why they have a higher infection rate [49].

According to animal origin, the prevalence of *C. tenuicollis* in this study was relatively higher in goats (26.2%) and sheep (20.5%) that were sourced from Babile than in goats and sheep that were sourced from Jigjiga (23.7%, 17.3) and kebribayah (10.8%, 7.3%), respectively. There were statistically significant differences in goats ($P < 0.05$) coming from different areas while among sheep were non-significant ($P > 0.05$). This was in line with the results of [50], Who found higher prevalence of sheep and goats (60.07% and 68.06%) brought from highland than those from lowland (53.47%, 59.725), respectively, and Similarly, [19], who reported an infection rate of (58.1%) in goats and (46.5%) in sheep from

highland areas contrasted to goats (35.2%) and sheep (33.8%) from lowland areas. The variations in prevalence of different places in this study may be due to distinctions in management practice, environmental factors, and the presence of stray dogs, and uncontrolled movement of wildlife.

In regards to the body conditions, in this study *C. tenuicollis* prevalence was noted in poor body conditions of sheep and goat (18.6%, 27%) compared to medium (13.7%, 19.6%) and good (10.6%, 14%) body scores respectively, with significant difference in goat ($P < 0.05$). This result is in line with the findings of [43,51 and 52], which were conducted in Northern Jordan, Turkey and Central Ethiopia respectively. This might be because animals' immune systems are weakened by gastrointestinal internal parasite infections and nutritional deficiency or scarcity. Therefore, it is possible that this explains why the cyst is more common in animals with poor body conditioning [35].

Among the predilection sites noted during this study, the omentum, followed by liver, were shown to be the most common sites for *C. tenuicollis*. This agreed with the observations of [53,54 and 55], Who found that omentum is the common predilection site for *C. tenuicollis*. While this result disagreed with the findings of [44 and 56], who found that the cysts were significantly more present in the liver than any other organ. Omentum preference by *C. tenuicollis* is because it may favor omentum because it covers a larger surface area in the peritoneal cavity than other tissues. *C. tenuicollis*' preference for liver, could be due to the large amount of protein, carbohydrates, and other essential elements that the parasite absorbs [57].

The estimated financial losses incurred during this study as a result of the rejection or condemnation of organs from sheep and goats infected with *C. tenuicollis* were: 10,810.8 USD, or roughly 385,621.236 ETB. This finding was lower than the results of [30], with an estimated financial loss of 1836100 ETB, and [51], Who estimated an economic loss of 1,044317.79 ETB from condemned liver.

5. CONCLUSIONS

Cysticercus tenuicollis is the larval stage of adult worm *T. hydatigena* that infects canines like dogs as final host and a number of ruminants as intermediate host. Besides its animal health risk,

this metacestode is attributed to meaningful financial losses from organ condemnation. The abattoir survey data of the current study found that the disease is prevalent in the study area with an overall prevalence of 17.9%, and this resulted in extensive financial losses of about 385,621.236 ETB. However, the prevalence in these results was lower as compared to previous studies performed in other parts of Ethiopia. Lack of awareness about the disease, the existence of stray dogs that roam freely on grazing land, the deep rooted habit of feeding dogs with sheep and goats offal, backyard slaughtering of animals, and inappropriate disposal of abattoir materials were potential causing factors that played a role to the persistence of the disease in the study area.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This research was approved by the Research Ethics Review Committee of college of veterinary medicine, Jigjiga University. The study was conducted in compliance with the ARRIVE 2.0 guidelines. All methods were carried out in accordance with relevant guidelines and regulations. Before conducting the study, the objectives, expected results, and benefits of the study were explained to the abattoir workers and the required permission was obtained from Jigjiga city municipality.

AVAILABILITY OF DATA AND MATERIALS

The datasets during the current study are available from the corresponding author on reasonable request.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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