

## Bovine cysticercosis and human taeniasis: Animal–human health and economic approach with treatment trends in Kombolcha Town, Wollo, Ethiopia

Aragaw Tegegne<sup>1</sup>, Adem Hiko<sup>1</sup> and Kemal Kedir Elemo<sup>2</sup>

1. Department of Veterinary Public Health, College of Veterinary Medicine, Haramaya University, Po. Box. 138 Dire Dawa, Ethiopia; 2. Department of Animal Sciences, School of Agriculture and Natural Resources, Animal and Range Sciences, Madda Walabu University, Po. Box. 274 Bale-Robe, Ethiopia.

**Corresponding author:** Adem Hiko, e-mail: [adex.2010ph@gmail.com](mailto:adex.2010ph@gmail.com)

**Co-authors:** AT: [aragaw792@gmail.com](mailto:aragaw792@gmail.com), KKE: [kkedir8@gmail.com](mailto:kkedir8@gmail.com)

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### Abstract

**Background and Aim:** Bovine cysticercosis and human taeniasis accounted for parasitic zoonotic implications with economic losses from organ contamination and treatment cost. The disease is common where hygienic conditions are poor and the inhabitants traditionally eat raw or insufficiently cooked meat under inadequate community awareness on the associated risk factors for the occurrences of infections in developing countries such as Ethiopia. The aim of this study was to assess bovine cysticercosis and *Taenia saginata* human taeniasis considering animal–human health and economic approach with treatment trends in Kombolcha Town, Wollo, Ethiopia.

**Materials and Methods:** A cross-sectional study was conducted in cattle slaughtered at Kombolcha ELFORA abattoir from November 2016 to April 2017. A questionnaire survey was applied for community awareness, exposure risk, and treatment trends for taeniasis assessment in Kombolcha Town with economic losses from organ condemnation, and drug cost for taeniasis treatments were estimated.

**Results:** Of the 234 examined carcasses, 21 (8.97%) were found infected with bovine cysticercosis. Organ distribution of the cysts showed highest proportions in liver 40 (29.2%), followed by heart 26 (18.9%), tongue 22 (16.1%), masseter muscle 20 (14.6%), triceps 15 (10.9%), diaphragm 9 (6.7%), and lung 5 (3.6%). Both male, i.e., 15 (6.4%), and female, i.e., 6 (12.8%), were infected. Regardless of sample size, *Cysticercus bovis* infection was found 8 (21.62%) in adults and 13 (6.60%) older aged. Of 110 interviewed individuals, about 31.8% aware of taeniasis and they also have exposure risk for taeniasis with no differences ( $p>0.05$ ) within studied demography. The majorities (54.3%) of exposed groups use pharmaceutical drugs, while 28.6% use herbal medicine, but 17.2% use both for treatment. Of 31,469 clinical cases in Kombolcha Town, 22 (0.07%) were positive for taeniasis over the year 2016. An inventory of pharmaceutical shops revealed the supply of 6998 adult taeniacidal drug doses for a cost of 19,621.00 Ethiopian Birr (ETB) where mebendazole and albendazole were the most frequent. A total annual economic loss of 1,841,311.00 ETB (73,652.44 USD) consisting of 1,831,890.00 ETB from organ condemnation and 19,421.00 ETB from taeniacidal drug cost was estimated.

**Conclusion:** The present finding indicates the need for community awareness creation regarding the disease condition, associated risk factors, and application of environmental hygiene which could bring a paramount reduction of diseases in human and beef industry which prevent the associated economic loss.

**Keywords:** abattoir, *Cysticercus bovis*, economic loss, Ethiopia, Kombolcha, taeniasis.

### Introduction

Cysticercosis, caused by *Taenia saginata*, is among the diseases affecting food safety [1]. The bovine cysticercosis is a the metacestode stage in cattle where the adult is parasitic zoonosis in human intestinal, *T. saginata* [2]. In developed countries, low prevalence of cysticercosis (<1%) in carcasses [3] but high and very common occurrences in African countries reaching

a level of 30-36% in Kenya, 20% in Guinea, 18% in Sierra Leone, and 20% in Cameroon [4] were reported. Florova [5] reported a prevalence of 100% which is the highest in Africa and also in the world. The World Health Organization [6] included cysticercosis as a part of the neglected zoonoses subgroup in tropical diseases. In Ethiopia, the prevalence of *Cysticercus bovis* has been reported with 3.65% [7] and 26.3% [8] based on abattoir survey while *T. saginata* with 64.44% [7] and 64.2% [8] based on questionnaire survey. As a result, human health, the esthetic value of meat, and trading of meat and offal are compromised [9]. In some parts of Ethiopia, habit of raw or undercooked beef consumption is the source of *T. saginata* infection in human [10]. Tembo [11] reported the prevalence of 89.41% in different agroclimate zones associating this high prevalence

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with the habit or culture of raw or undercooked beef consumption in Ethiopia.

Besides, considerable amount of economic losses approaching 30% due to bovine cysticercosis from carcass weight loss and the cost of freezing for the infected meat [12], investigation, grade of the infected animals from markets, and treatment costs for detained carcass [13] accounted huge in Africa. Moreover, medical costs for taeniasis treatment of infected human [14, 15] and cost of taenicial drugs are also reported. In Ethiopia, treatment cost of 4,937,583.21 ETB (225,036.97 USD) has been estimated [16].

Bovine cysticercosis is widely distributed in Ethiopia with a prevalence of 9.7% in Bishoftu [17], 21% in Nekemte [18], 6.4% in Kombolcha [19], 4.9% in Assele [20], and 3.2% in Ethiopian different agro-climatic zones [11]. However, community awareness, exposure risk, and treatment trends for taeniasis in Kombolcha Town were not yet assessed. This study was aimed to assess animal–human health and economic loss aspects with treatment trends of bovine cysticercosis and taeniasis in Kombolcha Town, Wollo, Ethiopia.

## Materials and Methods

### Ethical approval

Examination of animal and interview of human beings were made in this study. Thus, ethical clearance was obtained from College of Veterinary Medicine, Haramaya University Ethical Committee. Informed consent was obtained from the participants.

### Study area

The study was conducted from November 2016 to April 2017 at Kombolcha Town, northeast part of Ethiopia at a distance of about 377 km from the capital city (Addis Ababa), located at 11° 08' N and 39° 74' E, and has an elevation of 1883 m above the sea level. The area receives 1500-1840 mm rainfall annually with the minimum and maximum temperature of 11.7°C and 23.9°C, respectively [21].

### Study population

The study population was local zebu cattle (*Bos indicus*) from Dessie Zuria, Kemissie, Kombolcha, South Tigray, West Afar, and South Gondar woredas and slaughtered at Kombolcha ELFORA abattoir. The average minimum and maximum numbers of animals slaughtered per day were 50 and 70, respectively. The study population also consists of randomly selected human inhabitant population in Kombolcha Town interviewed for the questionnaire survey.

### Study design

A cross-sectional study was conducted to determine the prevalence and economic hurt associated with bovine cysticercosis in cattle slaughtered at Kombolcha ELFORA abattoir. Similarly, a questionnaire survey was applied to randomly selected individuals to assess community awareness, exposure

risk, and treatment trends for taeniasis in Kombolcha Town. One-year retrospective drug shop inventory was also applied to estimate the economic losses due to taeniasis treatments in human cases.

### Sample size determination

The desired sample size was calculated using the formula recommended by Thrusfield [22] with 95% confidence level, 6.4% expected prevalence [19], desired absolute precision, and expected prevalence. Therefore, the required sample size for animals was calculated as follows:

$$N = \frac{1.96^2 \times P \exp(1 - P \exp)}{d^2}$$

where N = required sample size, P<sub>exp</sub> = expected prevalence, d = desired absolute precision (usually 0.05), and 1.96 = Z-value for 95% confidence level.

Accordingly, the sample size becomes 93 animals which was increased up to 234 animals.

For questionnaire survey, the sample size was calculated using the formula given by Arsham [23] which is as follows:

$$N = 0.25/SE^2,$$

where N = sample size and SE (standard error) = 5%.

Thus, the sample size required for the questionnaire survey was 100, but 110 volunteers were included with proportion distribution according to demographic and other study factors.

### Study methodology

#### Abattoir survey

Abattoir survey was conducted using detailed meat inspection on randomly selected cattle antemortem inspection according to the FAO [24] and slaughtered at Kombolcha ELFORA abattoir. Factors such as animal origin, breed, age, sex, and body condition scores were recorded before slaughtering. Postmortem examination was conducted by visualization, inspection, palpation, and systematic incision of each of visceral organs such as liver, lung, heart, and tongue and muscles such as masseters, diaphragm, and triceps for the presence of parasites and other abnormalities [25]. The presence or absence as well as the anatomical distribution of the cysts count by organ or muscle was registered.

#### Community awareness, exposure risk, and treatment trends for taeniasis

Community awareness on the use of latrine availability, meat consumption habit, meat source, knowledge of taeniasis, source of information on the diseases, use of drug for treatment, aware of the route of transmission, and knowledge on prevention mechanism was incorporated in the questionnaire. Exposure risk to taeniasis was assessed using demographics

such as gender, age categories, occupation, educational status, residence location, and marital status of the respondent. Taeniasis treatment trends of community were assessed whether an individual used pharmaceutical drug, herbal medicine, or both.

#### Retrospective assessment of 1-year data

Retrospective clinical cases reported of human taeniasis was assessed. Records from two selected private clinics and three public health centers found in Kombolcha Town were assessed. Similarly, for the year 2016, taeniocidal drugs frequently supplied by the local pharmacy in the area were assessed in four private pharmacies and three health center drug stores.

#### Estimation of economic loss

The total financial loss due to organ condemnation was computed based on the condemnation rate of each type of examined organs, average number of animals slaughtered in the abattoir per year from retrospective data, and condemnation rate of each organ. Accordingly, the total direct financial loss was calculated by the formula given by Ogunrinade and Ogunrinade [26] as  $DAL = \sum AC \times AP \times CR$  (where DAL = direct annual financial loss due to organs condemnation, AC = annual cattle slaughter rate of the abattoir, AP = average cost of each liver/lung/heart/tongue, and CR = condemnation rates of liver/lung/heart/tongue).

The taeniocidal drugs supplied during the year 2016 inventory was conducted at drug shops. The cost was estimated using yearly adult taeniocidal drug doses. The cost incharge of pharmacies from the records (prescription papers and patient complaints) was collected. The total cost of taeniocidal drug doses was calculated and estimated at annual cost.

#### Data management and analysis

The abattoir survey, questionnaire, clinical case reports, and drug shop inventory data were recorded and entered into Microsoft Excel 2013<sup>®</sup> and analyzed using STATA software version 11.0 (Stata Corp, 2009). From the abattoir data, percentage and Chi-square ( $\chi^2$ ) were calculated. Anatomical distribution of metacystodes (*C. bovis*) was tabulated and described by proportional distribution of the cyst. Questionnaire data were categorized into demographic and other study factors for the occurrence of taeniasis among different respondents groups. Inventory data of pharmaceutical shops were described using frequency. Economic losses from animal organ contamination and human treatment drugs were calculated both in Ethiopian Birr (ETB) and USD. A level of significance of  $p < 0.05$  was used to assess the differences.

## Results

#### Prevalence and organ distribution of bovine cysticercosis

As shown in Table-1, an overall prevalence of bovine cysticercosis was 21 (8.97%), indicating no

significant difference among animal origin as well as between animal sex groups ( $p > 0.05$ ). Regardless of number of animal examined, *Cysticercus bovis* was 21.6% in adult and 6.6% in old age animals.

A total of 137 cysts were detected from 21 cysticercosis-positive animals during the study period. Using organ and tissue distribution, the prevalence of *C. bovis* was ranged from 5.6% in the liver to 0.9% in the lung in positive animals (Table-2). The proportion counted cyst was higher in the liver (29.2%), heart (19.10%), tongue (16.0%), masseter muscles (14.6%), triceps muscle (11.0%), and the lungs (3.6%) in descending order.

#### Economic losses associated with bovine cysticercosis

Direct annual financial loss of the abattoir from slaughtered cattle in 2016 accounted 5257.00 ETB with the corresponding average cost of organs (liver - 45 ETB, heart - 30 ETB, lung - 20 ETB, and tongue - 55 ETB), based on information given by the abattoir's health control and marketing director.

**Table-1:** Prevalence of *Cysticercus bovis* by the studied risk factors.

Risk factors	Number of examined	Number of positive (%)	$\chi^2$	p value
Origin				
Dessie Zuria	28	3 (10.71)	1.96	0.854
Kombolcha	43	4 (9.30)		
Kemissie	35	1 (2.86)		
South	39	4 (10.26)		
Tigray				
South	32	3 (9.38)		
Gondar				
West afar	57	6 (10.53)		
Sex				
Female	47	6 (12.77)	1.04	0.309
Male	187	15 (8.02)		
Age				
Adult	37	8 (21.62)	8.61	0.003
Old	197	13 (6.60)		
BCS				
Poor	218	15 (6.88)	*	*
Medium	14	6 (42.86)		
Good	2	0 (0.00)		
Total	234	21 (8.97)		

\*Not calculated due to zero cell

**Table 2:** Organ distribution of *Cysticercus bovis* among positive animals.

Tissues and organ prevalence	Cyst count and proportion	
Organs inspected (N=234)	Number (%) of positive	Number (%) proportion of cysts (N=137)
Liver	13 (5.6)	40 (29.2)
Heart	11 (4.7)	26 (19.0)
Masseters	11 (4.7)	20 (14.6)
Triceps	10 (4.2)	15 (11.0)
Tongue	9 (3.8)	22 (16.0)
Diaphragm	5 (2.1)	9 (6.6)
Lung	2 (0.9)	5 (3.6)

**Table 3:** Community awareness/knowledge about association of studied factors with risk of *Taenia saginata* contraction.

Studied factors	Number of interviewed	Presence of awareness on taeniasis N (%)	$\chi^2$	p value
Latrine availability				
Present	98	33 (33.67)	1.43	0.233
Absent	12	2 (16.67)		
Meat consumption habit			1.16	0.762
Raw meat	19	6 (31.58)		
Partially cooked	5	1 (20.00)		
Raw and partially cooked	14	6 (42.86)		
Well cooked	72	22 (30.56)		
Meat source			0.33	0.848
Local butcher	77	25 (32.47)		
Abattoir	11	4 (36.36)		
Own slaughter	22	6 (27.27)		
Heard of taeniasis			*	*
Yes	72	35 (48.61)		
No	38	0 (0.00)		
Source of information			2.7639	0.429
Social media	13	8 (61.54)		
Health center	15	5 (33.33)		
Veterinarian	12	7 (58.33)		
Social interaction	32	15 (46.88)		
Drug use			*	*
Yes	35	35 (100)		
No	75	0 (0)		
Rout of transmission			*	*
Contact	13	10 (76.92)		
Raw meat	59	25 (42.37)		
I don't know	38	0 (0.0)		
Knowledge about prevention			*	*
Hygiene keeping	18	6 (33.33)		
Cooked meat	31	14 (45.16)		
Meat from abattoirs	11	5 (45.45)		
All	11	10 (90.91)		
Not know	39	0 (0.00)		
Total	110	35 (31.82)		

\*Not calculated due to zero cell

Annual organ rejection rate for inspected organs costs 1,831,890.00 ETB which is equivalent to 76,328.75 USD in Kombolcha abattoir.

#### Human taeniasis

Of the total 110 voluntary respondents interviewed, 31.8% of them was knowledgeable on considered risk factors for infections with taeniasis (*T. saginata*). Out of 110 volunteers interviewed, 76.9% and 42.4% of respondents were aware that the source of infection is raw or undercooked meat, respectively (Table-3).

The respondents were confirmed with human taeniasis (*T. saginata*), witnessing that they observed proglottids in their feces. Accordingly, the prevalence was 36.6% in male but 23.1% in female. Similar and about 32% prevalence was found in both the rural and urban areas inhabitant individuals (Table-4).

#### Frequently used drugs and treatment trends of human taeniasis

Of taeniasis patients, gastrointestinal syndromes characterized by nausea (40.0%) and abdominal pain (37.1%) were frequent. Most of the exposed individuals to taeniasis (54.3%) used modern pharmacy,

while 28.6% used herbal medicine, and the remaining 17.2% used both (Table-5).

Of 31,469 clinical cases, human taeniasis accounted, 22 (0.07%). It was 0.1% in males but 0.04% in female (Table-6).

A total of 6998 taeniocidal drug dose with highest for mebendazole (4942) and albendazole (1625) were supplied by pharmacies in the studied area (Table-7). A total cost for 1-year taeniocidal drugs accounted for 19,421.00 ETB in the area.

#### Discussion

Bovine cysticercosis is reported in various countries including Ethiopia, as a major parasite disease contributing to low meat productivity, role in organ condemnation, and public health risk [3-5,27,28]. The present 8.97% bovine cysticercosis indicated the risk in Kombolcha and the surrounding, which is comparable with 8.6% in Halaba municipal abattoir [29], 7.5% in Addis Ababa abattoir [30], 11.3% in Wolita Sodo [28], 6.7% in Kombolcha [31], and 6.4% in Kombolcha [19]. However, the present finding

**Table-4:** Community exposure risk to taeniasis in respective of the demography of participants in Kombolcha Town, Wollo, Ethiopia.

Demography of studied participants	Number of interviewed	Exposure risk to taeniasis N (%)	$\chi^2$	p value
Gender				
Female	39	9 (23.08)	2.12	0.145
Male	71	26 (36.62)		
Age (years)				
15-24	12	2 (16.67)	2.17	0.538
25-34	47	14 (29.79)		
35-45	31	11 (35.48)		
>45	20	8 (40.00)		
Occupation				
Gov. employee	16	4 (25.00)	2.29	0.681
Private employee	41	12 (29.27)		
Student	30	9 (30.00)		
Farmer	10	4 (50.00)		
Merchant	13	5 (38.46)		
Educational status				
Primary school	24	7 (29.17)	1.4	0.712
College and above	45	13 (28.89)		
Secondary and prep	24	10 (41.67)		
Illiterate	17	5 (29.41)		
Resident				
Rural	18	6 (33.33)	0.02	0.880
Urban	92	29 (31.52)		
Marital status				
Married	65	25 (38.46)	3.23	0.072
Single	45	10 (22.22)		
Meat consumption habit				
Cooked meat	31	14 (45.16)	*	
Raw meat from abattoirs	11	5 (45.45)		
All	11	10 (90.91)		
Not know	39	0 (0.00)		
Total	110	35 (31.82)		

\*Not calculated due to zero cell

**Table-5:** Symptom encountered for exposed respondent and treatment trends in Kombolcha Town, Wollo, Ethiopia.

Community skill on symptom	Number (%) of exposed respondent (N=35)	Treatment drug source N (%)		
		Pharmacy	Herbal	Both
Nausea	14 (40.0)	8 (57.1)	3 (21.4)	3 (21.4)
Abdominal pain	13 (37.1)	9 (69.2)	3 (23.1)	1 (7.7)
Diarrhea	2 (5.7)	0	1 (50.0)	1 (50.0)
Head ache	1 (2.9)	1 (100)	0	0
All signs listed	5 (14.3)	1 (20.0)	3 (60.0)	1 (20.0)
Total	35 (100)	19 (54.3)	10 (28.6)	6 (17.2)

**Table-6:** Retrospective clinical case reported human taeniasis in studied area.

Sex	Number of examined	Number of positive cases	Prevalence (%)
Male	15,048	15	0.10
Female	16,421	7	0.04
Total	31,469	22	0.07

was lower than the findings 21% at Nekemt [18], 26.25% at Hawassa abattoir [8], 18.49% in North west Ethiopia [32], and 17.5% in East Shoa [33] all from Ethiopia. The differences could be due to variation geographic area associated with statues of personal hygiene, frequencies of raw meat consumption, and

**Table-7:** Taeniocidal drugs frequently supplied in the area and the annual cost over the year 2016.

Name of modern drug used	Total number of dose supplied*	Total worth in ETB**
Praziquantel	316	2,326.00
Niclosamide	115	690.00
Mebendazole	4,942	12,155.00
Albendazole	1,625	4,450.00
Total	6,998	19,621.00

\*Dose is the amount of drug used to treat one adult human taeniasis case. \*\*1 ETB=0.04 USD during the study period

epidemiology of the diseases. Conversely, this finding was higher than 2.6% at Batu, Ethiopia [34], 0.11% in

Croatia [35], 0.2% in South Africa [36], 0.9% in Cuba [37], and 0.48-1.08% in Germany [38]. This could be associated with control measure and personnel hygiene application in those developed countries than in Ethiopia. Distribution of *C. bovis* in various organs and tissues of the infected animal was also observed with the more number of cyst in the liver than other organs inspected during the study. Elemo *et al.* [20] also reported cysts count of 28.6%-3.2% in different organs and tissue of the positive cattle in Arsi, Asella, Ethiopia. These could be due to accesses of the ingested egg via circulatory systems to specific predilection site and development into *C. bovis*. A number of *C. bovis* were collected from mesenteric and portal veins residing in the liver [39]. The cost associated with condemnation of the infected organs resulted in the high economic loss which was lower than the reports of Fufa [16] from other parts of Ethiopia.

About 31.8% of studied respondent are both knowledgeable on considered risk factors for infections with taeniasis (*T. saginata*) and have also been exposed to the disease. With the majority, 76.9% and 42.4% of respondents were aware that the source of infection is raw or undercooked meat, respectively. The present 31.8% exposure risk human taeniasis in the area is similar with 44% in Hawassa Town [40], 44.44% in Shire Indasilassie district [41], and 19% in and around Halaba Kulito Town [29] but lower than 64% in Bishoftu [42], 62.5% in Wolaittasoddo [43], 58% in Jimma [44], 70% in Yirgalem [45], 56.7% in Zeway [46], 64.2% in Awassa town [8], 59% in and around Batu [34], and 56.7% in Jimma town [47], all from Ethiopia showing wide distribution and public health risk of the diseases where Desta [48] also reported the uses of herbal medication in Ethiopia. However, the present finding was lower than the 0.2-12.0% taeniasis in Vietnam [49].

One-year (2016) taeniasis case record of laboratory showed that more than 3-fold of patients were male but female accounted low, showing concomitant prevalence with exposure risk from this study. This could be due to the fact that males consume frequently raw beef at outdoor than females in Ethiopia with higher exposure risk to *C. bovis*. Clinical symptoms ranging from nausea, abdominal pain, diarrhea, and headache to the pathognomonic sign of observing proglottids in the feces of exposed groups were observed in Ethiopia. Similar clinical symptoms and pathognomonic sign of taeniasis in infected individuals in Vietnam were reported by Van De [49]. However, unlike the present finding, Van De *et al.* [49] reported subcutaneous nodules, epileptic seizures, impaired vision, and memory loss in Vietnam. Pharmaceutical taenicidal drugs such as praziquantel, niclosamide, albendazole, and mebendazole [49] were supplied in studied as effective medicine. However, 28.6% of the exposed individuals use herbal medicine and 17.2% use both the pharmaceutical and herbal drugs. Desta [48] has also been studied and listed frequently used taenicidal herbal plants in

Ethiopia with its LD<sub>50</sub> indicating a long history of the use of such treatment trend in the country.

## Conclusion

The present finding indicates the prevalence of *C. bovis* and human taeniasis in the area with an evidence of exposure risk and clinical cases in the area. Animal organ distribution of the cyst incurred an economic loss and health risk from a public health point of view. Variable knowledge of community about the associated risk also shows the need for community education as awareness creation regarding the disease condition, associated risk factors, and application of environmental hygiene. Detailed meat inspection with proper cooking before consumption could also bring a paramount reduction of the diseases in human and beef industry which reduces the associated economic loss.

## Authors' Contributions

AT: Study conduction, data collection, analysis, reference search, and manuscript writing; AH: Study conduction, data analysis, reference search, manuscript writing, and editing; KKE: Data analysis, reference search, manuscript writing, and editing. All authors have read and approved the final manuscript.

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## Computing Interests

The authors declare that they have no competing interests.

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