

## Prevalence, Financial Losses and Risk Factors of Bovine Cysticercosis and Human Taeniasis in Selected Districts of Northwest Ethiopia

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### Abstract

Bovine cysticercosis, caused by the larval stage of the tapeworm, is a global zoonotic disease that affects cattle. *Taenia saginata* is the adult parasite that causes taeniasis in humans. To look into the prevalence and monetary costs of cysticercosis, a total of 384 cattle were recruited at three selected abattoirs; 180 questionnaires were distributed; and financial loss record sheets were seen. The overall prevalence of bovine cysticercosis was found to be 10.42%. 82.8% of the respondents encountered human taeniasis at least once in their lives. Bovine cysticercosis had resulted in ETB 294,217.33 losses from organ condemnation. About ETB 248,983.90 expenses were recorded to buy 83,741 doses of taeniocidal drugs. In conclusion, bovine cysticercosis and human taeniasis were prevalent in the study areas and resulted in significant financial losses. Thus, integrated control systems should be adopted to control the burden.

**Keywords:** Bovine Cysticercosis, Human Taeniasis. Prevalence, Associated Risk Factors, Financial Significances, Northwest Ethiopia.

### Introduction

Taeniasis is the intestinal infection of humans by the adult stages of cestode parasites under the genus *Taenia*. *Taenia solium*, *Taenia saginata*, and *Taenia asiatica* are the principal cestode species important to cause taeniasis in human. Human acquires the adult stage and acts as a definitive host of the parasite through different risk factors. Outback human defecation and eating of raw or undercooked beef and/or pork are the primaries exposing factors [1]. Intermediate hosts of tapeworms could get cysticercosis, a disease caused by tissue infection of tapeworms, by ingestion of *Taenia* eggs. Cattle serve as an intermediate host for *T.saginata* and the cysticerci develop only in beef. *T.solium* and *T. asiatica* can preferably develop in pig visceral organs [2].

Bovine cysticercosis is caused by the larval stage of *T.saginata*. The eggs of those tapeworms (out or within the proglottids) are excreted with the feces of the infected final hosts to the external environment. Upon ingestion of these infective eggs, the intermediate hosts become infected and develop metacystode larval stages (also called cysticerci) in their muscles, resulting in bovine cysticercosis. People acquire taeniasis following ingestion of undercooked beef meat containing viable

cysticerci [3].

Taeniasis and cysticercosis are highly prevalent in countries like Ethiopia, where poor hygienic conditions are coupled with poor cattle management practice and lack of strict meat inspection. National Hygiene and Sanitation Strategy Program reported that about 60% of the disease burden was related to poor hygiene and sanitation in Ethiopia [7]. The common habit of backyard slaughtering is also the key predisposing factor of taeniasis and bovine cysticercosis [4,5]. Around the globe 50 to 77 million cases of taenia infection are recorded annually of which 50,000 people are dying of it [6].

Cysticercosis causes significant economic impact in many parts of the world, particularly in developing countries especially by hindering the export of live animal and animal products. A high (50%) prevalence was recorded under large-scale management conditions [8] most probably because of direct exposure to proglottids shed from farm workers and sewage-contaminated feed or forage [9]. Hence, bovine cysticercosis is an important public health problem causing huge amount of economic losses [10]. *Taeniasis* is a well-known disease in Ethiopia with prevalence ranging from 10% to 70% [11]. However, information about bovine cysticercosis in Ethiopia

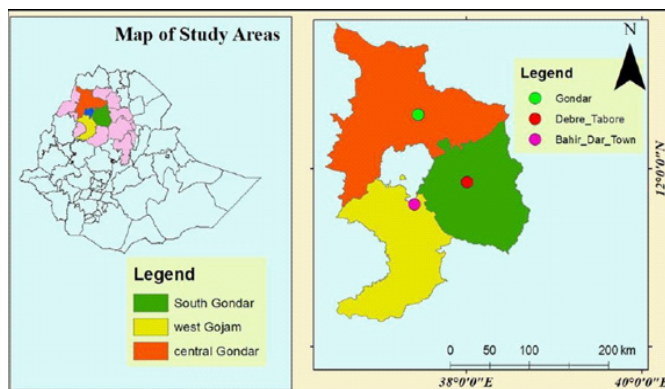
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is very limited. There is no study which is well documented to clearly show the status of taeniasis in humans and animals in parallel. The economic significances of *Taenia* infection and the number of losses due to *Cysticercus bovis* had not been well studied. Consequently, this study was conducted to give relevant information about the prevalence and financial losses of bovine cysticercosis and human taeniasis in the selected study areas; (Gondar, Bahir Dar, and Debre Tabor of northwest Ethiopia).

## Materials/Methods

### Study Areas

The study was conducted in Gondar, Debre Tabor, and Bahir Dar towns of Amhara National Regional State Ethiopia (Figure 1).



**Figure 1:** Locations of Study area (Gondar city, Debre Tabor city, and Bahir Dar city) (source: GIS data of Amhara Regional State Finance and Economics Bureau).

### Study Design

A cross-sectional study was employed from November 2018 to May 2019 on cattle presented to Gondar, Debre Tabor, and Bahir Dar municipal abattoirs for slaughtering to estimate the prevalence of bovine cysticercosis; to see the distribution of these cysts among different organs of the animals and to characterize whether they were viable or degenerated. A retrospective study was employed to assess the trends of human taeniasis using record books from Gondar, Debre Tabor, and Bahir Dar referral hospitals. Prescriptions and drug sell documents in the respective hospitals' drug shops were seen for the last 6 years (2014-2019) to assess costs lost for human taeniasis treatment. The taeniocidal drug cost supplied at each study hospitals' shop was estimated using yearly adult taeniocidal drug doses. Documents in each studied municipal abattoirs were also visited to estimate the financial losses of *C. bovis* through organ condemnation. Losses associated with organ condemnations were made on abattoir records from 2014 to 2019. Moreover, a questionnaire survey was also conducted to assess the perception, experience, and knowledge of respondents about human taeniasis.

### Sample Collection Technique

Before sampling, each selected animal was given an identification number at its initial get by writing a code with waterproof

ink on its head. Starting from animals' inlet of the abattoir; body condition, age, and breed of the animals were recorded on previously prepared data recording format. Temperature and feeding activity in the exercising place were intensively followed and recorded too. Animals brought for slaughter were categorized based on their age that 2-5 years as an adult and >5 years as old using their dentition as described by Ron et al. [15]. Body condition scoring was made based on the guideline provided by Klopčič et al., [16].

During the post-mortem inspection different predilection sites (liver, tongue, masseter muscle, heart, shoulder muscle, diaphragm, and intercostals muscle and thigh muscles) of the parasite were examined. Meat inspection was made according to Ethiopian Meat Inspection Regulations guideline and WHO meat hygiene keeping guideline in developing countries [17,18].

Sterile hypodermic needles were used to evacuate the pressure of cysts during the cyst fertility test. *Cysticercus* is characterized by its bladder-like transparent vesicle having two main parts: the vesicular wall and the scolex [19,20]. The presence of protoscolices in the cyst fluid was considered suggestive of fertility. *Cysticerci* of *T. saginata* were carefully removed using sterile scalpel blade and transported to laboratories near the abattoir. Cysts were then incubated at 37°C for 2 hours in a solution prepared from ox bile and normal saline at a proportion of 30:70. Size of *cysticerci*, presence of rostellum, and absence of hooks on the rostellum of the evaginated cyst were used to differentiate whether the cyst was *T. saginata* or another metacestode cyst [21]. Fertile cysts were subjected to a viability test. A drop of the sediment containing the protoscolices was placed on the microscopic slides and covered with cover slips and observed for amoeboid-like movements at 40X binocular microscope objective lens magnification. A drop of 0.1% aqueous eosin solution which was equal volume to the sediment containing protoscolices was added to create a clear vision. The technique differentiates the dead (red-stained) and alive (unstained) protoscolices with the principle that viable protoscolices should completely or partially exclude the dye while the dead ones take it up [22].

A questionnaire survey was conducted on 180 volunteer respondents. Data were also retrieved from hospitals' record books and daily laboratory reports of stool examination of suspected patients. Similarly, an inventory of pharmaceutical shops of the studied hospitals was also considered to estimate the economic importance of taeniasis. Annual adult taeniocidal drug dose dispenses for patients and its worth was collected from record books to estimate human taeniasis associated with annual financial losses. Financial losses due to organ condemnation were computed using retrospective data obtained from the study abattoirs. Accordingly, the total direct financial loss was calculated by the formula given by Ogunrinade, A. and Ogunrinade, BI [23]:  $DAL = \sum AC \times AP \times CR$ ; Where DAL = direct annual financial loss due to organs condemnation, AC = annual cattle slaughter rate of the abattoir, AP = average cost of each liver /heart/ tongue and CR = condemnation rates of

liver/ heart/tongue).

### Ethical Consideration

Ethical clearance was obtained from the Research and Ethical Committee of the University of Gondar, College of Veterinary Medicine and Animal Sciences, and Permission approval was also requested from each studied abattoir and hospitals. After getting permission, individual written consent was taken from each participant before administering the questionnaire.

## Results

### Cyst Prevalence, Distribution and Viability Test

From the 384 cattle, 10.42% were infected with at least one cysticercus bovis in their organs or muscles. Abattoir wise prevalence of cysticercosis was 13.3% in Gondar, 11.7% in Debre Tabor, and 6.25% in Bahir Dar. In this survey, body condition score has shown a significant association ( $P < 0.05$ ) with the prevalence of bovine cysticercosis (**Table 1**).

**Table 1:** Association of different risk factors with *C. bovis* infection in selected abattoirs.

Risk factor	Category	Number of examined animals	Number of infected animals	Prevalence (%)	$\chi^2$ , P-value
Abattoirs	Gondar	128	17	13.3	3.74, 0.154
	Debre Tabor	128	15	11.7	
	Bahir Dar	128	8	6.2	
Age	Adult	372	38	10.22	0.519, 0.361
	Older	12	2	16.67	
Breed	Local	365	37	10.1	0.618, 0.433
	Cross	19	3	15.8	
BCS	Poor	18	7	38.9	17.96, 0.001
	Moderate	349	33	9.5	
	Good	17	0	0	

From 40 animals infected by *C. bovis*, 594 cysts were collected. The number of cysts recorded per organ or muscle ranged from 1 to 7. The tongue was constituted a higher number of cysts (25.08%) than the other organs /muscles. However, a relatively lower mean distribution of the cysts was recorded in the diaphragm ( $1.45 \pm 0.69$ ). Out of the 594 cysts, 75.93% were found to be viable. The highest proportion of viable cysts (92.3%) was recorded from the shoulder muscle (**Table 2**).

**Table 2:** Mean $\pm$ SD distribution of *C. bovis* cysts per infected organs.

Organs examined	Organs infected	Total cyst counts	Mean $\pm$ SD	%
Tongue	40	149	3.72 $\pm$ 1.59	25.08
Masseter m/s	40	106	2.65 $\pm$ 1.33	17.85
Heart	37	103	2.78 $\pm$ 1.86	17.34
Intercostal m/s	17	27	1.59 $\pm$ 0.62	4.55
Diaphragm m/s	20	29	1.45 $\pm$ 0.69	4.88
Thigh muscles	28	85	1.73 $\pm$ 0.59	14.31
Shoulder m/s	15	26	3.04 $\pm$ 1.77	4.38
Liver	25	69	2.76 $\pm$ 1.92	11.62

**Status of Human Taeniasis**

82.8% of the respondents encountered *T. saginata* infection at least once in their life. The majority of the respondents (68.3%) had noted that they had an experience of raw and undercooked meat consumption and also confirmed that they knew taeniasis as an important meat-borne zoonotic disease. Only 52.7% of the participants have often accessed abattoirs service while others (47.2%) get meat from local butchers who supplied non inspected meat. 71% and 95% of the respondents who accessed meat from abattoir and local butchers respectively got *T. saginata* infection. Infected respondents have stated that they had experienced various symptoms including tapeworm segment expulsion (65.1%), abdominal discomfort (17.5%), abdominal bloating (14.8%), and not remember the signs they encountered (2.7%). Most infected participants (80%) have stated that taeniasis has resulted in treatment cost. *Taenia* infected respondents also confirmed that they

use modern medicine (87%) and herbal medicine (12%) as their treatment options while others (1%) described that they had not treated the infection.

**Financial Loss Estimations**

A total of 5,410 and 5,417 respective dosages of 200 and 400mg albendazole were used as human taeniasis treatment in the last six years in the study hospitals which worth ETB 51,535.38. Mebendazole shared a total of 23,866 dosages (for 100 mg) and 376 doses (for oral suspension), that worth about ETB 38,534.20. Praziquantel and niclosamide together had constituted to share a total dose of 48,672 doses with a worth of ETB 158, 205.64. In general, the inventory analysis showed that drug shops had sold about 83,365 doses and 376 suspensions in those areas for the last 6 years with worthies of ETB 248, 983.90 (Table 3).

**Table 3:** Annual taeniacidal drugs sold during 2014 to 2019 at 3 Hospitals pharmaceutical shops visited.

Location	Drugs	Costs per year in Ethiopian birr (ETB)						Total cost in ETB
		2014	2015	2016	2017	2018	2019	
Gondar	Albendazole	910	275.2	3884.8	-	-	3232.68	8302.68
	Mebendazole	1303.5	2524.7	2013.67	2584.8	1158	756	10340.67
	Praziquantel	8743.32	3481.68	21121.8	14227.2	41381.76	15087.1	104042.9
	Niclosamide	157	137.76	-	-	-	-	294.76
Bahir Dar	Albendazole	6436.08	6129.4	2771.56	5427.5	4494.96	6916.8	32176.3
	Mebendazole	735.46	1520.89	1056.6	1126.84	702.28	511.8	5653.868
	Praziquantel	14120.6	1172.88	1355.33	2671.56	3583.8	12316	35220.14
	Niclosamide	-	-	-	-	-	-	-
Debre Tabor	Albendazole	1281.6	1108.8	494	6422	1750	-	11056.4
	Mebendazole	5645.78	4558.6	3316.76	4819.28	4199.24	-	22539.66
	Praziquantel	300.4	2253	7660.2	5719	3010	-	18942.6
	Niclosamide	414	-	-	-	-	-	414
Total cost in ETB		<b>40,047.7</b>	<b>23,162.9</b>	<b>43,674.7</b>	<b>42,998.1</b>	<b>60,280.04</b>	<b>38,820.4</b>	<b>24,8983.9</b>

From 2014 to 2019 organ condemnation accounted about ETB 294,217.33 with the corresponding average organs cost of (liver ETB 47.5, heart ETB 57.33, and other main edible organs and muscles like thigh, and shoulder muscles ETB 186.67) (Table 4).

**Table 4:** Cost of organ condemned (in ETB) from abattoirs during 2014 to 2019.

Direct Economic loss Estimation Parameters	Years of Investigation (Retrospective Data Recorded)					
	2014	2015	2016	2017	2018	2019
Annual Cattle Slaughter	6155	6351	6740	6626	6829	7168
Condemned edible organs (liver/ heart/tongue)	69	58	74	25	15	25
Annual Condemnation Rate	0.0112	0.0091	0.0110	0.0038	0.0022	0.0035
Annual cattle slaughter Rate	2051.7	2117.0	2246.7	2208.7	2276.3	2389.3
Average cost of each organ in ETB	401.7	470.7	538.3	635.0	770	993.3
DAL/year	9238.3	9099.6	13278.9	5291.7	3850	8277.8
DAL=∑(AC X AP X CR)	55,430.0	54,597.3	79,673.3	31,750.0	23,100	49,666.7
<b>Overall DAL=∑(AC X AP X CR)</b>						<b>294,217.33</b>

## Discussion

### Bovine cysticercosis

In this study, the overall prevalence of bovine cysticercosis was found to be 10.42% (95% CI 7.6-13.8). It is comparable to the reports of Ashewani and Gebretsadik [24], Kebede *et al.* [25] and Regassa *et al.*, [26] who reported an overall prevalence of 13.8%, 8.29%, 13.3% and 11.3%, respectively. However, a relatively lower prevalence of bovine cysticercosis had been reported in Ethiopia by Wondimagegn and Belete [27], and Tamerate *et al.* [28] with a prevalence of 4.64% and 4.2%, respectively. The variations between the present finding and the aforementioned reports might be associated with the performance of the meat inspector, sensitivity of the inspection procedures that can be affected by carcass type and incision method, abattoir facilities, the willingness of the owner, breed of the animal, environmental factors (climate), culture and socio-economic related activities of the communities (habit of raw meat consumption, personal and environmental hygiene).

Body condition score has a significant association with the prevalence of bovine cysticercosis. A higher infection rate was recorded in poor body condition scored cattle. This is in line with reports across the world [29]. *C. bovis* prevalence variation among different body condition scored animals might be related to the immune status of animals: animals with good body condition score can influence the establishment of cyst formation on muscles or organs by *C. bovis*.

*C. bovis* had been recorded in tongue, masseter muscle, heart, shoulder muscles, liver, diaphragm, intercostal muscle and thigh muscle with respective prevalence value of 10.42%, 10.42%, 9.4%, 7.3%, 6.51%, 4.95%, 4.17%, and 3.65%. It was in agreement with several previous reports [6,30,31,32]. Similar to Yacob *et al.* [34] and Tesfay and Assefa [35], the tongue and heart were the most commonly affected organs with bovine cysticercosis. A report from Iran [36] has shown that the most common preferred sites for the cysts were shoulder muscles followed by masseter muscles. Thigh, intercostals and diaphragm muscles were the least infected sites in this study. It was in agreement with the previous findings [32,33,37]. The activity of the muscles, the status of blood flow to the specific tissue, geographical location of the areas and the parasite features (strain) may determine the predilection sites of *C. bovis* in cattle [21,38].

Out of 594 cysts of *C. bovis* examined for viability test, 76% were viable while 24.07% have degenerated cysts. This report is higher as compared to previous reports by Abunna *et al.* [39] and Emiru *et al.* [40], who found 44.2% and 66.6% viable cysts respectively. The variations in the cyst viability in different localities might be associated with the difference in immunological response by infected individual cattle to the cyst and also the difference in cattle management activities by the producers [41]. The current study revealed that cysts from shoulder muscle were almost viable (92.31%) followed by the intercostal muscle (88.9%), diaphragm (86.2%), liver (84.1%) thigh muscles (82.4%), heart (68.9%), masseter muscle (69.8%), tongue muscle (70.47%). This is supported by a previous report by Harrison *et al.* [42]. This viability variation among predilection sites might be since the variation in metabolic reactions in each of the body organs.

### Status of Human Taeniasis Using Questionnaire Survey

The 82.8% prevalence of taeniasis in a human was in line with different previous reports [33,34,37,43]. But it was relatively higher than the findings by Regassa *et al.* [26], Endris and Negussie [44], and Tegegne *et al.* [45]. This discrepancy might be associated with the level of community awareness about taeniasis, the differences of cysticercosis occurrence in cattle, the status of raw meat consumption, and the meat inspection procedures used. Similarly, studies have shown that the status of human taeniasis could be influenced by age, sex, religion, marital status, geographical location, educational status, and income of an individual [31,32,37,44]. This is true that in this survey religion, marital status, location, and household position of the respondents were declared as an important factor for the occurrence of human taeniasis.

The majority of the respondents (68.3%) in this assessment noted an experience of raw and undercooked meat consumption and also confirmed that taeniasis is an important public health problem in their areas. This supports the previous studies report that showed a strong association of *T. saginata* infection with the consumption of raw or undercooked beef [43,44]. The experience of human taeniasis was higher in Gondar (90%) followed by Debretabor (89.7%) and Bahirdar (69.4%). The variation across localities might be ascribed to the altitude that results in climate variation which influences the survival of the parasite in a contaminated environment, raw meat consumption habit, and hygienic status of the community.

Moreover, in this survey, beef and raw meat consumption, carcass source (from local butcher), and frequency of meat consumption had been recorded as the risk factor to influence the status of human taeniasis. This is supported by the reports of Terefe *et al.* [43] who stated that having uninspected meat from local butcher shops exposes the consumers more frequently than abattoir-originated meat. This author also declared that having raw or semi-cooked beef meat is a risk for public health concerns.

### Retrospective assessment of human taeniasis

Out of 88,878 suspected patients, 903 (1.02%) were found to be infected by *T. saginata* in the last six years. In agreement with this report, comparable findings had been documented by Sah *et al.*, (46) and Martinez-Maya *et al.*, [47].

### Economic loss estimations

A six years record from three hospitals' pharmaceutical shops indicated that taeniocidal drugs worth 248,983.90 ETB for treatment purposes. The financial losses associated with bovine cysticercosis were accounted about 294,217.33 ETB with the corresponding average cost of organs (liver 47.5 ETB, heart 57.33 ETB, and other main edible organs and muscles like thigh, and shoulder muscles 186.67 ETB) based on the information given by the abattoir's animal health control unit. In general, the direct economic losses due to the cost of the drug to human taeniasis and organ condemnation were estimated to be 543,201.23 ETB/ annum which equivalent to 18,731.07 USD. It was similar to a report by Tamirat *et al.* [28] and Van De [53].

## Conclusion and Recommendations

10.42% of the total examined animals (384) were found to be positive for *Cysticercus bovis* cyst. The body condition of the slaughtered animals has a relationship with the prevalence of *C. bovis* that poor body condition of the animal was prevalent for of *C. bovis* infection. The anatomical distribution of Cysts was investigated and the result indicated that the proportion of viable cysts was higher than non-viable cysts. Among visceral organs examined; the tongue was with a high number of *Cysticercus bovis*. In interviewed respondents, the maximum infestation frequency by *T. saginata* was two times per year. Prevalence of taeniasis was associated with raw and undercooked beef consumption, presence of backyard slaughtering practices, open defecation, low level of public awareness and poor waste disposal. Household position; raw and semi-cooked meat consumption; religion and source of the carcass (local butchers and communal slaughtering) have a significant association with the occurrence of taeniasis. On the other hand, six years of retrospective data showed that 903/88,778 of those patients were stool positive for *T. saginata* egg. Inventories assessment indicated that 259,817 doses of taeniocidal drugs were used for medication with a worth of 543,201.23 ETB/ annum which equivalent to 18,731.07 USD.

Based on the above conclusion remarks, the following recommendations were forwarded:

- Sustainable community-based control strategies against zoonotic *C. bovis* (e.g. avoiding raw and undercooked meat consumption) should be designed and implemented.
- Strict measurements should be developed and practiced in abattoir meat inspection
- Back yard slaughtering should be controlled strictly.
- Experts and professionals in human medicine and veterinary science need to work in integration and collaboration about the causes and preventive mechanisms of *C. bovis* and human taeniasis.

Further studies on the prevalence and economic importance of *C. bovis* and human taeniasis should be conducted in different zones of the regions.

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