Prevalence, Cyst Distribution in Visceral Organs and Economic Loss of *Cysticercus tenuicollis* in Small Ruminants Slaughtered at Bishoftu, Elfora Export Abattoir

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**Abstract:** A cross-sectional study was conducted on *Cysticercus tenuicollis* (*C. tenuicollis*) in sheep and goats slaughtered at Bishoftu, Elfora Export abattoir from November, 2014 to March, 2015. The aim of this study was to determine the prevalence, organ preference and associated risk factors and to estimate direct economic losses attributed to the condemned organs from sheep and goats slaughtered in the abattoir. Ante-mortem inspection was carried out on arrival in the lairage; temporal identification numbers were given for individual animals and abnormalities encountered were recorded. Then after, post-mortem examination was performed in each organ and carcass of individual animals along their identification number to detect gross abnormalities and aesthetic reasons that rendered each organ to be rejected from local and international market. During the study, a total of 280 goats and 262 sheep visceral organs were inspected. Of this *C. tenuicollis* was found in 151 goats (53.9%) and 118 sheep (45.0%). The prevalence of *C. tenuicollis* was higher in goats than in sheep with statistically significant difference (*p*=0.04). Adult goats 94 (59.9%) and sheep 75 (54.3%) were more infected than young goats 57 (46.3%) and young sheep 43 (34.7%). Goats 84 (60.9%) and sheep 78 (52.0%) from highland areas were more infected than goats 67 (47.2%) and sheep 40 (35.7%) from lowland areas (*p*=0.000). *C. tenuicollis* had a tendency to be located more in the omentum than other organs and this difference between infections rate of omentum and other organs was significantly associated (*p*<0.05). The liver lesions are unsightly and affect the texture of the tissue, making it unsuitable for human consumption and as a result extensive financial loss of the country associated with condemnation of liver occurred. The annual loss due to the rejection of liver from the shoats’ slaughtered in the export abattoir was estimated at approximately 77220 USD i.e. approximately 1582237.8 ETB. So as to reduce these losses, further comprehensive studies that include all the representative export and local slaughter houses should be done as to introduce appropriate preventive and control strategies that avoid the unnecessary financial losses.

**Key words:** Bishoftu · Elfora Export Abattoir · *C. tenuicollis* · Prevalence · Sheep and Goats

**INTRODUCTION**

Ethiopia has the largest livestock population in Africa, which plays an important role in the lives of its people. Small ruminants are important domestic animals in tropical animal production system including Ethiopia [1]. The country owns about 26.1 million sheep and 21.7 million goats [2]. Small ruminants (sheep and goats) contribute more than 30% of local meat and generate income from export of meat, live animals and skins [3]. Unlike the large potential of small ruminants in the country, their productivity is low. The major constraints that greatly affect the economy of sheep and goat production in Ethiopia are diseases [4]. Parasitic diseases in the tropics are responsible for great losses in the meat industry than any other infectious or metabolic disease [5]. Some of the economic losses are organ or carcass condemnation in slaughter houses and abattoirs for the presence of larval stage of some *Taenia* species with or without public health importance [6]. According to the...
report by Jacob [7]; significant amount of organs and carcasses of sheep and goats were condemned somewhere in Ethiopia due to various diseases and pathological abnormalities every year and more than 900 million USD losses are estimated annually. The major causes of huge economic losses in small ruminants in Ethiopia are parasitic diseases such as liver fluke, hydatid cyst and C. tenuicollis. Out of these, C. tenuicollis was reported to be the leading cause of liver condemnation in goats in Addis Ababa abattoir enterprise [8].

The effect of the parasite in live small ruminants is insignificant unless it is complicated by the presence of concurrent infections. However, the presence of C. tenuicollis in ruminants is an indicator of the incidence of T. hydatigena among wild and domestic carnivores. Furthermore, during its life cycle in the intermediate hosts like sheep and goats, C. tenuicollis causes fibrosis and scar along the migration sites of visceral organs like liver. Despite the liver lesions are unsightly; they affect the texture of the tissue, making it unsuitable for human consumption; however, the parasite doesn’t have human health hazard [9, 10].

C. tenuicollis is quite common in the world [11]. However, the prevalence of the parasite varies from one area to another. Generally, there is higher incidence in countries with lower degree of sanitary and uncontrolled wild carnivore population [12]. According to the study conducted by Pathak and Gaur [11] in India, the prevalence of the parasite in sheep, goats and swine was reported to be 37.03, 27.29 and 8.3%, respectively. Other reports include: 16.7% in sheep from Germany [13], 33.3% in goats from Nigeria [14], 28.0% in sheep and 27.9% in goats from Ankara province [15]. According to Woinshet and Girma [16]; the prevalence of C. tenuicollis in visceral organs of slaughtered sheep and goats at Addis Ababa abattoir was 40.0% and 46.6% in sheep and goat respectively. Yehualashet et al., [8] had also reported a prevalence of 7.81% in sheep and 15.8% in goats in Addis Ababa abattoir enterprise.

Various investigations have been conducted to determine the prevalence and economic importance of organs condemned in Ethiopia [17]. Fasciola, hydatid cyst and C. tenuicollis were the major parasites responsible for condemnation of organs and carcass in sheep and goats [18]. Despite the above investigations, there is scanty of information related to this parasite and its economic losses in Ethiopia.

Therefore, the aims of this study were:

- To determine the prevalence, cyst distribution and associated risk factors of C. tenuicollis in animals slaughtered in Debre-zeit Elföra export abattoir
- To assess the economic impact of the parasite

MATERIALS AND METHODS

Descriptions of Study Area: most of the animals were originated from Hararghe, Arsi, Bale, Borana, Afar, Konso and Jenka which represent the lowland and highland areas of the country. Areas above 1,500m above sea level were considered as highland, whereas areas below 1,500m sea level were regarded as lowland [16].

Fig. 1: Map showing study area and live animal supply chains to elföra export abattoir, Source: [19]
Study Population: The study population was all male local breeds of sheep and goats coming from lowland and highland areas of the country such as Hararghe, Arsi, Bale, Borana, Afar, Konso and Jenka and slaughtered at Debre Zeit Elfora export abattoir. In this study, small ruminants were categorized into different body conditions (poor, moderate and good) according to the guidelines set by Abebe [20] (Annex 1); two age groups, young and adult; and two species, sheep and goats. Sheep and goats with the first pair of permanent incisor teeth were considered as young and those with two and more pair of permanent incisors were regarded as adults [21, 22] (Annex 2).

Study Design: A cross sectional study was conducted from November, 2014 to March, 2015 by collecting data on events associated with C. tenuicollis in sheep and goats slaughtered at Debrezeit Elfora export abattoir.

Sampling Method and Sample Size Determination: The study animals were selected from the slaughter line using systematic random sampling technique. Sample size required to study this parasite was determined according to the [23] formula.

\[ n = \frac{1.96^2 \cdot \hat{p} (1-\hat{p})}{d^2} \]

where
\[ n = \text{Required sample size} \]
\[ \hat{p} = \text{Expected prevalence and} \]
\[ d = \text{Desired absolute precision} \]

Here, 95% level of confidence interval, 0.05 absolute precision and 37.9% expected prevalence [24] were used. By substitution all the values; 362 animals were calculated; however, to increase precision a total of 542 animals were sampled.

Study Methodology
Ante-Mortem Inspection: Pre-slaughter examinations were conducted in the lairage in order to determine the species, age, body condition and origin of animals. Identification number was given for each animal to examine after evisceration. During ante-mortem examination animals were clinically examined for any sign of illness while standing and moving according to [10] and followed the judgments passed by FAO [25]. Animal detained during ante-mortem examination were excluded from sampling.

Post-Mortem Examination: During post mortem examination, visceral organs were thoroughly inspected by applying the routine meat inspection procedures (visualization, palpation and systemic incisions) for the presence of parasites and other abnormalities, paying attention to the visceral organs and tissues in abdominal, thoracic and pelvic cavities [26].

Assessment of Financial Loss: An attempt was made in order to estimate economic significance C. tenuicollis in small ruminant due to the cost of condemned liver. To calculate the economic loss, the following parameters were taken into consideration: The market demand, mean market price, the rejection rates of liver and annual slaughter capacity of the abattoirs. The economic loss due to liver condemnation was estimated by the formula set by [27] as follows:

\[ EL = \sum S_r x \cdot Coy \cdot Roz \]

where
\[ EL = \text{Annual economic loss estimated due to liver condemnation from international market.} \]
\[ S_r x = \text{Annual sheep/goats slaughter rate of the abattoir} \]
\[ Coy = \text{Average cost of each sheep or goats liver.} \]
\[ Roz = \text{Condemnation rates of sheep/goats liver.} \]

Data Management and Analysis: All data were coded and entered in to Microsoft excel 2013 program and analyzed using STATA 20.0 version. Pearson’s chi-square (\( \chi^2 \)) was used to evaluate the association present among the different variables. P-value less than 0.05 (at 5% level of significance) were considered as significant in all analysis.

RESULTS

Over all Prevalence: Out of 542 small ruminants examined by post-mortem examination 269(49.3%) of them were harbor C. tenuicollis in one or more of their organs. The prevalence of C. tenuicollis was relatively higher in goats 151(53.9%) than in sheep 118 (45.0%) and there was statistical significant difference (P=0.04). The prevalence of C. tenuicollis was higher in adult goats and sheep 169(57.3%) than in the young goats and sheep 100 (40.5%), with a statistically significant difference of (P=0.000). There was no significant difference revealed between body condition scores with regard to cyst detection (P>0.05). From 288 goats and sheep brought from highland areas, the parasite was only detected in 162
(56.2%) goats and sheep. In the other case, out of 254 goats and sheep brought from lowland areas of the country, only 107(42.1%) goats and sheep were positive. In general, in this particular study the prevalence of C. tenuicollis was higher in goats and sheep originated from highland parts of the country than lowlands. There was statistically significant difference between these two origin of animals (P<0.05) (Table 1).

**Risk Factors and Prevalence of C. tenuicollis in Small Ruminants**

**The Prevalence of C. tenuicollis with in Age Groups of Animals:** In the current study, the prevalence of C. tenuicollis was higher in adult animals than in young. Accordingly, the prevalence in adult goats was 94(59.9%) and in adult sheep 75(54.3%); whereas, the prevalence of the parasite in young goats and young sheep was 57(46.3), 43(34.7); respectively (Table 2). There was statistically significant difference between age groups (P<0.05).

**Age Level Prevalence of C. Tenuicollis in Goats and Sheep with Different Agro-ecological Origin:** According to the present study, 60.9% of goats and 52% of sheep came from highlands and 47.2% of goats and 35.7% sheep from lowlands were found to harbour the parasite in one or more of their organs. The difference in prevalence was statistically significant (P<0.05) (Table 3).

**Body Condition Score and Prevalence:** According to this study, the prevalence of C. tenuicollis is slightly higher in animals with poor BCS. However, the difference was statistically insignificant (p>0.05) (Table 4).
Table 5: Distribution of *C. tenuicollis* in the visceral organs of infested animals

<table>
<thead>
<tr>
<th>Visceral Organs</th>
<th>Sheep</th>
<th>Goats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>51</td>
<td>76</td>
</tr>
<tr>
<td>peritoneum</td>
<td>28</td>
<td>34</td>
</tr>
<tr>
<td>Omentum</td>
<td>66</td>
<td>85</td>
</tr>
<tr>
<td>mesentery</td>
<td>45</td>
<td>48</td>
</tr>
<tr>
<td>Omentum, mesentery, liver</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Omentum, liver</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Omentum, mesentery</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>Omentum, peritoneum</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Liver, peritoneum, mesentery</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Liver, mesentery</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Liver, peritoneum</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Mesentery, peritoneum</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 6: The variation between infestation rates of specific organs and species

<table>
<thead>
<tr>
<th>Species</th>
<th>Organs</th>
<th>Positive</th>
<th>Prevalence (%)</th>
<th>$\chi^2$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovine</td>
<td>Omentum</td>
<td>66</td>
<td>25.2</td>
<td>1.797</td>
<td>0.180</td>
</tr>
<tr>
<td></td>
<td>Liver</td>
<td>51</td>
<td>19.5</td>
<td>4.446</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>Mesentery</td>
<td>45</td>
<td>17.2</td>
<td>0.000</td>
<td>0.992</td>
</tr>
<tr>
<td></td>
<td>Peritoneum</td>
<td>28</td>
<td>10.7</td>
<td>0.283</td>
<td>0.595</td>
</tr>
<tr>
<td>Caprine</td>
<td>Omentum</td>
<td>85</td>
<td>30.4</td>
<td>1.797</td>
<td>0.180</td>
</tr>
<tr>
<td></td>
<td>Liver</td>
<td>76</td>
<td>27.1</td>
<td>4.446</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>Mesentery</td>
<td>48</td>
<td>17.5</td>
<td>0.000</td>
<td>0.992</td>
</tr>
<tr>
<td></td>
<td>Peritoneum</td>
<td>34</td>
<td>12.1</td>
<td>0.283</td>
<td>0.595</td>
</tr>
</tbody>
</table>

Table 7: The variation between infestation rates of specific organs and age

<table>
<thead>
<tr>
<th>Organs</th>
<th>Age</th>
<th>Ovine (n=262)</th>
<th>Positive (%)</th>
<th>$\chi^2$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Omentum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>19(15.3)</td>
<td>11.65</td>
<td>0.001</td>
<td>28(22.8)</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>47(34.1)</td>
<td></td>
<td></td>
<td>57(36.3)</td>
</tr>
<tr>
<td></td>
<td>Liver</td>
<td>17(13.7)</td>
<td>4.975</td>
<td>0.026</td>
<td>23(18.7)</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>34(24.6)</td>
<td></td>
<td></td>
<td>53(33.8)</td>
</tr>
<tr>
<td></td>
<td>Mesentery</td>
<td>13(10.5)</td>
<td>7.410</td>
<td>0.006</td>
<td>23(18.7)</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>32(23.2)</td>
<td></td>
<td></td>
<td>25(33.8)</td>
</tr>
<tr>
<td></td>
<td>Peritoneum</td>
<td>12(9.7)</td>
<td>0.251</td>
<td>0.616</td>
<td>12(9.8)</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>16(11.6)</td>
<td></td>
<td></td>
<td>22(14.0)</td>
</tr>
</tbody>
</table>

**Organ Involvement and Distribution of Cysts:** When the data on distribution of cysts in different organs/viscera of infected animals were analyzed and summarized, the majority of the *C. tenuicollis* cysts showed to have tendency to be located in omentum (25.2% and 30.4%), liver (19.4% and 27.1%), mesentery (17.2% and 17.1%) and peritoneum (10.7% and 12.1%) of sheep and goats respectively (Table 5). Most of the positive animals were found to carry the parasite in their omentum. Out of 151 positive goats, 30.4% and 118 positive sheep, 22.1% of them were found to harbor the parasite in their omentum.

The Variation Between Infestation Rates of Specific Organs and Animals Species: In the current study, it was found that the parasite has more preference to omentum of goats (30.4%) than sheep (25.2%) and the difference was statistically significant (p<0.05) (Table 6). Only few cysts were observed to be attached to the surface of the peritoneum of both goats and sheep. Chi-square analysis of the result showed that there is significant difference in cysts burden between the liver and omentum (P<0.05). The highest cyst burden was encountered in omentum and lower percentage was found in mesentery and peritoneum.

The Variation Between Infestation Rates of Specific Organs and Age: The variation between infestation rates of different organs in the different age groups was indicated higher in the omentum of adult sheep (34.1%) than the omentum of young sheep (15.3%). Similarly, the infestation rate *C. tenuicollis* was higher in the omentum of adult goats (36.3%) than young ones (22.8%) with a statistically significant difference (p< 0.05) (Table 7).
Estimation of Direct Economic Losses: The average mean annual small ruminants slaughter rate was estimated to be 220,000 heads, average rejection rate of the abattoir was 12% (23.4%) and the average international recent market price of single liver was 1.5 USD. Therefore, by substituting all the values in the following formula,

\[ EL = \sum S \times C \times R \]

\[ EL = (220,000 \times 1.5 \times 0.234) \]

\[ EL = 77,220 \text{ USD} \]

Total loss = 158,223.8 ETB.

Therefore, the annual direct economic loss from international market of liver condemned at the export abattoir due to *C. tenuicollis* was estimated to be 77,220 USD i.e., approximately 158,223.8 ETB (1 USD = 20.49 ETB).

**DISCUSSION**

In the present study, the overall prevalence of *C. Tenuicollis* in small ruminant slaughtered in Debre-zeit Elfora export abattoir was found to be 49.3%. This was in line with the finding of Yilikal[28] who had reported to be 46.1% in Dessie. However, it was relatively higher when compared to the finding of Muktar[29] in Wolayta, Tekleye[30] in Addis Ababa abattoir, Adem[31] in three export abattoirs (Elfora, Helmes and Luna) and Endale and Mekuria[32] in Dire Dawa municipal abattoir and Tadesse et al.,[24] in HashimNur’s meat export abattoir, Debre-Zeit who reported 25.8%, 37.1%, 32.7%, 24.6% and 34.57%; respectively. It was also higher than the reports from other countries; for instance, 37.03% in India abattoir [11], 15.7% [33] and 4.21% [34] in Iran. Furthermore, it was lower than the findings of Wondimu et al.,[35] who reported 60.3% from Debezeit. This difference in prevalence of *C. tenuicollis* in the different locations could be due to the variations in temperature, agroecology, the degree of pasture contamination, the difference in culture of handling dog among different societies and the way of rearing and grazing of these animals which may favor the transmission of the parasite between ruminants, dogs and other wild canids.

The overall prevalence was higher in goats (53.9%) as compared to sheep (45%). Similar finding was reported by Sisay et al.,[36] who have reported prevalence of 38, 30, 32 and 35% in goats and 14, 12 and 15% in sheep from Haramaya, Harar, Dire Dawa and Jijiga abattoirs; respectively. Additionally, similar reports were recorded from other countries like 34.2% in goats and 21.4% in sheep in Nigeria [14], 34.2% in goats and 21.4% in sheep in Iran [37]. According to Torgerson *et al.*, [38]; under condition of high infestation of *C. tenuicollis* most sheep develop protective immunity early in life and this immunity regulate the parasite population, whereas goats develop the immunity more slowly. This considerable degree of immunity against *C. tenuicollis* infection in sheep may be the reason for low prevalence of the parasite in comparison to goats.

According to the present study, the overall *C. tenuicollis* prevalence was higher in adults (57.3%) than in young (40.5%) sheep and goats. The prevalence by age revealed that higher infestation rates were recorded in adult sheep (54.3%) and in adult goats (59.9%); whereas, the lowest prevalence was recorded in younger sheep (43%) and in younger goats (57%). This was agreed with findings of Adem[31] who reported a prevalence of 47.2% and 37.8% in adult goats and sheep and 33.3% and 33.7% in young sheep and goats, respectively. Similar finding was reported by Woinshet[39] who recorded the prevalence of 51.8% in adult goats and 47.4% in adult sheep and 41.4 and 35.8% in young goats and sheep; respectively. This may be due to cestode parasites produce significant quantities of antigens in adults than in young, these further protect adult small ruminants from infection [40]. Furthermore, this difference in infection rates between young and adult may be due to the fact that the adult animals (sheep and goats) lived longer and picked larger number of eggs during grazing as compared to the young ones which only lived for a shorter period of time in a given environment and mostly kept indoors.

In this particular study, the prevalence of *C. tenuicollis* based on animal origin was relatively higher for highland originated goats (60.9%) and sheep (52%) than their correspondents in lowlands (47.2%) of goats and (35.7%) sheep. This was in agreement with the findings of Woinshet and Girma[16] who has reported prevalence of 58.1% in goats and (46.5%) in sheep from highland areas in compared to goats (35.2%) and sheep (33.8%) from lowland areas. The difference in prevalence in this study in agro-ecological may be associated with the presence of high dog population in highlands due to presence of high human population in such areas of the country and the presence of stray dogs and uncontrolled movement of wildlife. In contrast, the low prevalence recorded in goats and sheep came from lowland areas of the country might be attributed to environmental conditions such as high temperature and low humidity (adverse conditions for the survival of the eggs of *T. hydatigena*).
In the current study, there was no an association between the presence of the disease and the body condition of the animals, 55.3%, 48.0% and 42.3% in poor, medium and good; respectively. This contradicts with the findings of Endale and Mekuria[32] who reported that body conditions of sheep was the only risk factor which contributed for the high prevalence in poor body conditioned animals (39.8%) in compared to medium (21.8%) and good (14.5%) body conditioned animals. The reason why current finding insignificant among body condition, might be either due to loss of weight cannot only be attributed by the C. tenuicollis infection alone but also inappropriate management and other helminth infection may occur.

In the current study, the major sites from where C. tenuicollis was reported were: omentum, liver, peritoneum and mesentery respectively. However, most of the positive animals were found to carry the parasite in their omentum. For example; out of 151 positive goats, 30.4% and 118 positive sheep, 22.5% of them were found to harbor the parasite in their omentum. This agreed with the observation of Samuel and Zewde[42], Senlik[43], El-Azazy and Fayek [44] who reported that omentum is the predominant predilection sites for C. tenuicollis. The results were also in agreement with the findings of Radfar et al., [33] who reported high cysticerci in omentum of sheep (84.85%) and goats (82.14%). This may be due to the fact that omentum covers larger surface area in the peritoneal cavity than other tissues.

The variation between infestation rates of different organs in different age groups of both goats and sheep were indicated to be higher in the omentum of adult sheep (34.1%) and goats (36.3%); then in omentum of young sheep (15.3%) and goats (22.8). These results agree with results of Wondimu et al.,[35] who reported that C. tenuicollis infestation was higher in the omentum of adult goats (67.4%) than the young ones (57.9%).

Lastly, in the current study; overall annual economic losses of the country due to a single organ condemnation (liver) from sheep and goats infested by C. tenuicollis was estimated to be: 77220USD$ i.e. approximately 1582237.8 ETB (Current currency: $1=20.5 ETB). This result is higher than the report of Wondimu et al., [35] (2011) who estimated an economic loss of 65,269.89 USD or 1,044317.79 ETB from condemned liver. The economic loss in the abattoir was relatively high because of its export standard in which any liver with single cyst or calcified liver with cyst was disposed from international market. Such loses are particular importance in Ethiopia, which has low economic output where sheep and goat production are the major livestock industries.

**Conclusions and Recommendations:** Abattoirs play a major role in providing and serving as a source of information and a references centre for diseases prevalence to control or eradicate diseases and to produce wholesome products and to protect the public from zoonotic hazards. C. tenuicollis was the predominant metacestode causing organ disposal with consequent approximately 77220 USD economic losses in a single abattoir. Furthermore, high prevalence of C. tenuicollis was recorded in slaughtered sheep and goats. Inappropriate infected offal disposal by being practiced by some of the abattoirs can enhance the continuation of the life cycle between the intermediate host and final hosts. Based on the results of the present study, the following recommendations are forwarded:

- Awareness creation programs should be launched for the butchers, abattoirs workers, meat sellers and dog owners about transmission, prevention and control strategies of -C. tenuicollis between dogs and farm animal.
- Disposal of affected offal freely for dogs and wild canids (the usual practice in the community) should be prohibited and all the condemned organs should be either buried or incinerated.
- Backyard and road side slaughtering practices should be prevented by putting the law and regulation of meat inspection into action.
- Thorough meat inspection should be practiced in every abattoirs of the nation.
- Sale of contaminated offal’s and organs of sheep and goats should be restricted by law.
- Dogs deworming strategy should be designed and implemented throughout the country
- Destruction of stray dogs should be supported by law.

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REFERENCES


**ANNEXES**

Annex 1: Rank of body condition score

**Body Condition:** Every sampled sheep and goats were recorded and fall in any of the three scores (poor, medium and good) where the criteria for scores are the following:

**Poor:** when individual spinous process were sharp to touch and easily distinguished, in addition, the bony structure of sheep were easily noticeable. The eye muscles are moderate depth.
Medium: When spinous process was examined with very firm pressure, they were round rather than sharp. The eye muscles are full with moderate fat cover.

Good: When the top and side back bone in lion area immediately behind th last rib and above the kidney were covered with muscles, their eye muscles were full and have a thick fat cover.

Source: (Abebe, 2007).

Annex 2: Determination of age of sheep

Estimated age for sheep and goats were estimated by looking at different numbers of erupted permanent incisors and registered as follows:-

<table>
<thead>
<tr>
<th>No. of permanent incisors</th>
<th>Estimated age range</th>
<th>No. of permanent incisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep</td>
<td></td>
<td>Goat</td>
</tr>
<tr>
<td>0 pair</td>
<td>Less than 1 year</td>
<td>Under 1 year</td>
</tr>
<tr>
<td>1 pair</td>
<td>1-1½ years</td>
<td>1-2 years</td>
</tr>
<tr>
<td>2 pairs</td>
<td>1½-2 years</td>
<td>2-3 years</td>
</tr>
<tr>
<td>3 pairs</td>
<td>2½-3 years</td>
<td>3-4 years</td>
</tr>
<tr>
<td>4 pairs</td>
<td>More than three years.</td>
<td>More than four years</td>
</tr>
<tr>
<td>Broken mouth</td>
<td>Aged</td>
<td>Aged</td>
</tr>
</tbody>
</table>

Source: (Getanby, 1991; Steel, 1996).

Annex 3: Abattoir data collection format

<table>
<thead>
<tr>
<th>Species</th>
<th>Age</th>
<th>Origin</th>
<th>Bodyconditions</th>
<th>post-mortem examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Id. No</td>
<td>sheep</td>
<td>Goat</td>
<td>Adult</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Annex 4: lation of cyst in different visceral organs of sheep and goats

Fig: *cystercus tenuicollis* on the liver
Fig: cysticercus tenuicollis on the omentum