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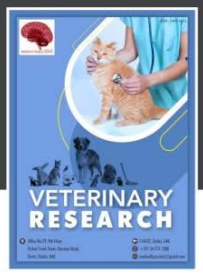

Aabattoir Study on the Economic Loss of Ruminant Fasciolosis in Two Municipal and Three Export Abattoirs of Ethiopia

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Key words: Prevalence, economic loss, fasciola, sheep, goat, cattle, Ethiopia

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Abstract: A cross-sectional abattoir study was conducted to determine the prevalence of bovine and ovine fasciolosis and the associated economic loss due to liver condemnation in three local and two export abattoirs in Ethiopia. A total of 5427 randomly selected animals comprising cattle (2257), sheep (1189) and goats (1070) managed under extensive traditional system and brought to two export and three municipal abattoirs were exposed to antmortem and postmortem inspection. Individual flatworms were identified to species level according to existing keys and descriptions using their morphologic characters. Fluke counts and subsequently the lesion score (severity) were made based on fluke burden and damage to the liver. All fluke infected livers were considered as condemned and included in the calculations for the associated economic losses. A univariable logistic regression followed by multivariable logistic regression model was used to investigate the relation and statistical significance between positivity for liver examination and the factors considered. A total of 2530 (46.6%±0.059) livers examined in abattoirs were positive for fasciolosis. The total number of livers observed in export abattoirs (Elfora and Helimix) were 2330 (48.4%) while the remaining 3097 were (51.6%) from municipal abattoirs (Addis Ababa, DebreBerhan and Bahrdar). The overall prevalence of fasciolosis observed in ruminants slaughtered in export abattoirs was 34.6% (877/2530) whereas it was significantly higher in ruminants slaughtered at municipal abattoirs 65.2% (1653/2530) as the whole. The mean annual financial loss recorded altogether in export and municipal abattoirs was 7,049,638 ETB/335, 697.1 USD. However, the overall mean financial loss observed in three municipal abattoirs (5,260,596 ETB/250,504.6 USD) was significantly higher

than the combined loss incurred in two export abattoirs (1,789,043ETB/85,192.5 USD). The present findings on ruminants at abattoirs had shown higher prevalence of fasciolosis (46.6%±0.059) with significant annual financial loss (1,789,043ETB/85,192.5 USD). This indicated the economic loss is more significant, since, animals had shown prevalence above 25%. The high prevalence of fasciolosis in ruminants coupled with relatively higher mean annual financial loss observed in both export and municipal abattoirs clearly indicated the effect of the liver flukes in ruminant production and its impact to the Ethiopian economy.

INTRODUCTION

Ruminant livestock production in Ethiopia has been significantly affected by economically important parasitic diseases including the one caused by the liver flukes[1] Ethiopia's huge numbers of ruminants (the largest in Africa) are reared mostly by small holder farmers and pastoral and agro pastoral producers with extremely variable agroecological condition[2].

Although, the majority of Ethiopia's livestock is found in the highlands, 95% of the livestock for export is supplied by the pastoral and the agropastoral areas of Afar, Somali and Borana[3]. Thus, far, significant numbers of beef cattle supplied for domestic consumption and fated into municipal abattoirs are from highlands[4, 5]. Nearly all of the meat exported from Ethiopia comes from lowland sheep and goats (20% sheep and 80% goats) due in large part to the preferences of the international market for these animals that have developed over the years[5].

Fasciolosis still remains as one of the hindrances for the marginal utilization of this available large ruminant livestock resource[6, 7]. The poor performance of livestock production and productivity due to this parasitic disease among others (shortage of forage, poor livestock management and diseases) is reflected on agriculture based economy of the country and subsequently the national annual food insufficiency. The direct and indirect economic losses of fasciolosis due to morbidity, the associated mortality and the condemnation of the liver were largely underestimated and/or unaccounted[8].

Ethiopia has possessed favorable climatic and ecological conditions for the development and spread of fasciolosis in various areas. The two species most commonly concerned as the etiological agents of fasciolosis in Ethiopia are *F. hepatica* and *F. gigantica* with their distribution and prevalence associated with the presence of the snail intermediate host[9-11]. The study of liver flukes in live animals depends on the use of faecal egg examination. Information collected at abattoirs can be used for cross-sectional studies to compare animal management and performance with enumeration of parasites and other indices of infection. Moreover, abattoir-based studies have been used as a component of the study of the liver fluke and to describe various aspects of liver fluke infection.

Attempt was made to establish the prevalence of ruminant (sheep, goats and cattle) fasciolosis in Ethiopian. Comparative abattoir study (two export abattoirs and three municipal abattoirs) and the associated risk factors were determined. The origins of animals representing the major agroecological zones (geographical area) were also included. The comparison of the intensity of the liver infections and liver lesions and the associated economic loss due to liver condemnation was revealed.

MATERIALS AND METHODS

The study area: The study was conducted from November 2012 to April 2013 in two export abattoirs (Helimix and Elfora) situated in the town of Debrezit, 50 km away from the national capital (Addis Ababa) and three municipal abattoirs (Bahrdar, Debreberhan and Addis Ababa municipal abattoirs). Helimix has production capacity up to 2000 sheep/goat and 150 cattle per day and currently exports chilled meat to UAE, Saudi Arabia, Yemen and frozen meat to Egypt. The Elfora export abattoir has branches in Metehara, MelgeWondo, Diredawa, Kombolcha and Gondar and it has similar export destination and meat production capacity as that of Helimix with possible potential to expand production[12]. The municipal abattoirs used are located at Addis Ababa, Bahrdar (758 km Northwest of Addis Ababa) and Debreberhan towns (125 km North of Addis Ababa). The laboratory works were carried out at college of veterinary medicine and agriculture, the veterinary clinics residing in the respective cities (Bahr Dar, Debre Berhan, Addis Ababa).

Study design and sample size: A cross-sectional study of ruminants (cattle, sheep and goats) in three local and two export abattoirs was conducted using Antmortem (AME) and Postmortem Examinations (PME). During the AME, several risk factors were identified and scored for consistency. The fasciola specimens were collected for dry seasons only (November to April). Sampled animals were marked and identified from slaughter to evisceration (PMI) for the purpose of liver inspection. Animals were selected in different age groups as young (calves and heifers or lambs and weaned lambs) and adults. Age estimation was done by inspection of the incisor teeth according to a method by Yeates and Schmidt[11] which is based on incisor teeth temporary teeth replacement and the degree of wear of permanent teeth. In addition sex of animals and their body condition status (poor and good) were recorded. The body conditions were estimated based on descriptions of Nicolson and Butterworth[13] for zebu cattle and Thompson and Meyer[14] for sheep. The sample size was determined according to the formula

given by Thrusfield[15] with expected prevalence of 50 and 5% margin of error with confidence level of 95%. Nonetheless, to increase the precision the sample size was made to 2257 cattle, 1189 sheep and 1070 goats in total in three local and two export abattoirs.

Study animals: Local zebu cattle and their crosses with the Holestien-Freiesian cattle as well as local sheep and goats with their crosses were used for the abattoir study. However, the significant numbers of animals used in this study were the local breed cattle, sheep and goats managed extensively.

Postmortem examination: Adult fasciola parasites specimens were collected from condemned livers and associated gallbladder of cattle and sheep in Debre Berhan Municipal abattoir. Each liver was placed in a large basin and all the flukes in the gall bladder and the major bile ducts were collected into a small plastic container for subsequent counting. After visual observation and palpation of the liver, sharp incisions were made on the surface, through the major bile ducts into the parenchyma. The liver was then sliced into strips of about 1 cm in thickness and soaked in normal saline for about 5 h and washed extensively (incubated in physiological saline, 0.9% NaCl) in order to regurgitate the intestinal contents. Flukes emerging from the cut bile ducts were put into the same jar and each sliced strip was thoroughly squeezed from end to end, washed in saline and discarded. The contents of the basin were sieved put into a petridish and the adult, immature and cut pieces of flukes were added to the container.

Fluke identification: Individual flatworms were identified to species level according to existing keys and descriptions using their morphologic, morphoanatomic characters and morphometeric measurements[16, 17]. Accordingly, they were classified as adult *F. hepatica*, *F. gigantica*, mixed and immature flukes. Adult *F. hepatica* are smaller than *F. gigantica* and have well developed 'shoulders' distal to the oral sucker whereas, the shape of *F. gigantica* is more streamlined without 'shoulders'[16]. Counts of the heads of cut flukes was made and added to the appropriate count of adult flukes.

Estimation of economic loss due to liver condemnation: The estimation of the economic loss due to the condemnation of fluke affected livers was done by considering all livers affected with fasciola as condemned. The annual loss from liver condemnation was assessed by considering the overall annually slaughtered animals in the abattoir and retail market price of an average ruminant liver. The annual loss from the liver condemnation was assessed by using the formula set by Ogunrinade and Adegoke[18]:

$$ALC = CSR \times LC \times P$$

Where:

ALC = Annual loss from liver condemnation
CSR = Mean annual cattle slaughtered at abattoirs
LC = Mean cost of one liver
P = Prevalence of fasciolosis at the abattoir

Statistical analysis: The data was entered into Excel spreadsheet for data management. The descriptive statistics was used to describe the overall prevalence of fasciolosis and the associated risk factors (age, sex, body condition, species, season and PA). A univariable logistic regression followed by multivariable logistic regression model was used to investigate the relation and statistical significance between positivity for liver examination and the factors considered. Data analysis was undertaken for the prevalence with species, breed, season, sex, body condition and age as independent variables. Fluke infection and egg detection with positive samples was considered as dependent variable. The results were analyzed for statistical significance by using STATA Version 11 (STATA, Stata corp. LP, 4905, Lakeway drive, College Station, Texas, USA). A p-value of less than 0.05 was considered as significant.

RESULTS AND DISCUSSION

Postmortem examinations

Prevalence of fasciolosis in different abattoirs: From a total of 5427 ruminant livers examined in five abattoirs, 2530 (46.6%±0.059) were indicated the presence of liver flukes. The total number of livers observed in export abattoirs (Elfora and Helimix) were 2330 (48.4%) while the remaining 3097 were (51.6%) from municipal abattoirs (Addis Ababa, DebreBerhan and Bahrdar). The overall prevalence of fasciolosis observed among the abattoirs had shown highly significance difference ($p<0.05$). Hence, the overall prevalence of fasciolosis observed in ruminants slaughtered in export abattoirs was 34.6% (877/2530) whereas it was significantly higher in ruminants slaughtered at municipal abattoirs 65.2% (1653/2530) as the whole. Comparison of the prevalence of fasciola positive ruminants in each of the four different abattoirs with respect to the prevalence observed at HELIMIX (44.9%±0.087) indicated significantly higher prevalence at Debre Berhan (80.1%±0.95) than the rest of the abattoirs (Table 1).

Prevalence of fasciolosis in different geographical origin: The difference in the overall prevalence of fasciolosis based on their geographical origin was significant ($p<0.05$). The overall prevalence of liver fluke infection was higher in ruminants from North Shoa (42.4%±0.2) followed by Arsi (18.4±0.21%), Hararghe (8%±0.2) and Gojjam (7.8±0.2%), respectively. However, the overall abattoir prevalence of fasciolosis in ruminants from the rest of the origins (<5%) considered in this study were much lower (Table 1).

Table 1: The prevalence of fasciolosis in different abattoirs, origin, altitude of slaughtered ruminants

Risk factors	SE	No. examined	No. positive	Overall prev. (%)	Prev. (%)	Sig.	Exp (B)	CI 95 (%) LB	CI 95 (%) UB
Abattoir									
AA	0.059	987	322	12.7	32.6	0.000	1.681	1.411	2.004
BD	0.090	797	278	11	35	0.000	1.520	1.263	1.829
DB	0.095	1313	1053	41.6	80.1	0.000	0.201	0.168	0.240
ELFORA	0.091	1149	349	13.3	30.3	0.000	1.882	1.587	2.231
Helimix	0.087	1181	530	20.9	44.9	-	-	-	-
Origin									
Afar	-	338	84	3.3	24.9	0.119	1.389	0.919	2.100
Arsi	0.211	1151	462	18.4	40.1	0.035	0.685	0.482	0.974
Bale	0.180	239	91	3.6	38.1	0.176	0.747	0.490	1.140
Borana	0.215	524	118	4.7	22.5	0.021	1.581	1.071	2.334
Gojjam	0.199	559	199	7.8	35.6	0.333	0.831	0.572	1.208
Gondar	0.208	326	122	4.8	37.4	0.197	0.768	0.515	1.146
Hararghe	0.223	387	203	8	52.4	0.000	0.416	0.283	0.613
North Sh.	0.197	1352	1073	42.4	79.4	0.000	0.119	0.084	0.171
Somali	0.188	287	86	3.4	30	0.738	1.074	0.708	1.629
Wolaita	0.213	102	41	1.6	40.2	0.149	0.684	0.408	1.146
Wollo*	0.263	162	51	2	31.9	0.000	-	-	-
Altitude									
Highland	0.052	2331	1358	53.7	58.3	0.000	0.497	0.438	0.562
Lowland	0.070	1276	427	16.8	33.4	0.000	1.378	1.187	1.600
Midland*	0.081	1820	745	29.5	40.9	-	-	-	-

*Significant values

The overall number of slaughtered ruminants brought to the abattoirs had shown that the majority had their origin from North Shoa (1352/24.9%) followed by Arsi (1150/21.2%) and Borana (524/9.7%), respectively. However, the greater part of ruminants brought to the abattoirs from North Shoa (79.4%) and Hararghe (52.4%) were found positive for liver fluke infection whereas significant number of ruminants from Gondar (41.8%), Wolaita (40.2%) and Arsi (40.1%) were found to harbor fasciola species (Table 1).

Prevalence of fasciolosis in different altitude ranges: There have been significant differences ($p<0.05$) on the overall prevalence of fasciolosis among the slaughtered ruminants from various agroecological areas (altitude difference). Accordingly, it had significantly higher prevalence among ruminants from highlands (53.7%±0.52) followed by midlands (29.5%±0.81) and lowlands (16.8%±0.07), respectively (Table 1).

The majority of the ruminants slaughtered at abattoirs were from the highlands (43%/2331) and the midlands (33.5%/1820) followed by the lowlands (24%/1276). Altogether, midlands and highlands had contributed more than three fourth (76.5%/4151) of the total slaughtered ruminants in the abattoirs. Furthermore, the numbers of small ruminants (984/) from the lowlands were lower in contrary to the relatively higher number of small ruminants supplied to the abattoirs from the highlands (57.6%/1343) and midlands (46.3%/843). However, substantial number of cattle (42.4%/988) and sheep (24.1%/564) had their origin from the highlands and midlands, respectively. On the other hand, more than half (51.6%/552/1070) of goats slaughtered in the abattoirs were from the lowlands (Fig. 1).

The present study indicated that the numbers of small ruminants supplied to the two export abattoirs from the different agroecological zones were lower than those supplied to the sum of the three municipal abattoirs and the different was not significant ($p>0.05$). However, those supplied to Debreberhan abattoir (only sheep) from the highlands was substantial (38.8%/510). Similarly large numbers of ruminants supplied to Bahrdar (50%/401) and Addis Ababa (37%/361) municipal abattoirs were from the midlands. Meanwhile, sheep and cattle (68%/3686) slaughtered in municipal abattoirs were mainly from the highlands and midlands as a whole. The supply of goats to the export abattoir is mainly from the lowlands. The present study revealed that goats were never encountered at Bahrdar and Debreberhan municipal abattoirs (Fig. 1).

The prevalence of fasciolosis in different species and age: From the overall prevalence of fasciolosis (46.6%±0.06) reported in ruminants, the overall prevalence encountered in sheep (23.8%±0.109) was significantly lower than that of cattle (45.3%±0.059) but it was significantly higher than the overall prevalence observed in goats (5.4%±0.72). Nonetheless, out of a total of 2257 cattle, 1189 sheep and 1070 goat livers examined, the prevalence was 50.8, 58 and 12.2%, respectively (Table 2):

*BC = Body Condition

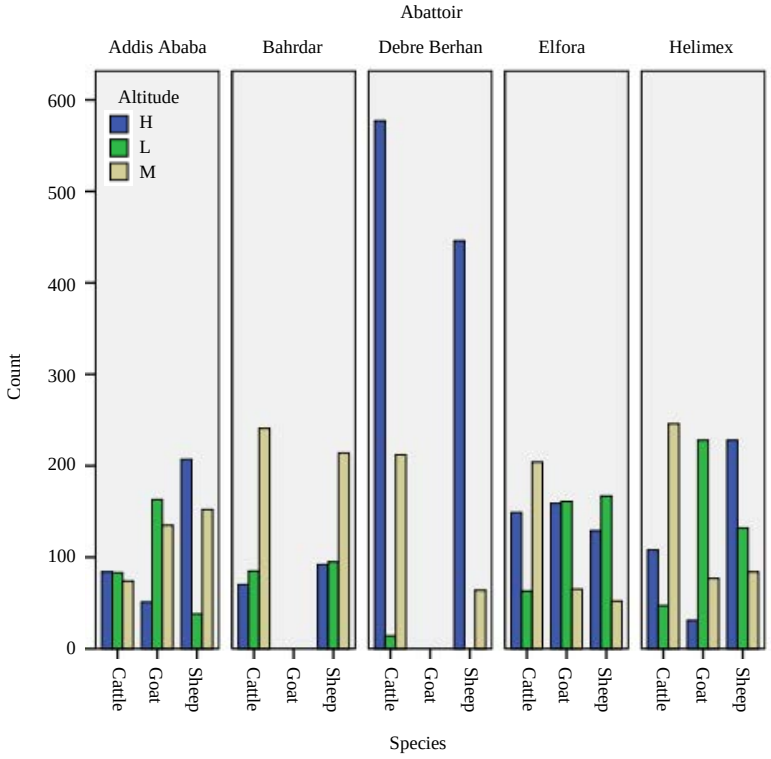

Fig. 1: The supply of ruminants to the export and municipal abattoirs from different agroecological zones

Table 2: The abattoir prevalence of ruminant fasciolosis OR (95% CI) with respect to different factors assessed (Sex, age, breed, body condition)

Risk factors	SE	No. examined	No. positive	Overall prev. (%)	Prev. (%)	p-value	OR (95%) CI
Species							
Cattle	0.061	2257	1147	45.3	50.8	0.000	1.4 [1.3 1.6]
Goats	0.102	1070	137	5.4	12.8	0.000	9.9 [8.1 12.1]
Sheep	-	2100	1246	23.8	59.3	-	-
Sex							
Female	0.061	1514	744	29.4	49.1	0.021	0.87 [0.77 0.98]
Male	-	3913	1786	70.6	45.6	-	-
Age							
Adult	0.055	2792	1320	52.3	47.3	0.269	1.1 [0.95 1.2]
Young	-	2234	1083	42.8	48.5	-	-
Breed							
Cross	0.066	1198	685	27.1	57.2	0.000	0.58 [0.51 0.66]
Local	-	4229	1845	72.9	43.6	-	-
***BC**							
Good	0.061	1951	801	43.2	41	0.002	1.2 [1.1 1.4]
Poor	0.040	2565	1173	56.8	59.4	0.000	-
Fasciola							
FH		1974	1399	70.9			
FG		1974	424	21.5			
Mixed		1974	135	6.8			
Immature		1974	192	9.7			

The total numbers of adult ruminants (52.4%/2792) slaughtered were relatively higher than the young animals (42.6%/2234). However, the prevalence of fasciolosis was relatively lower in adult (47.3%±0.57) animals than the young (48.5%±0.42) ruminants and the difference was not significant (Table 2). In both export (42.9%/2330) and municipal (57.1%/3097) abattoirs the slaughtered ruminates were predominantly adults. In all abattoirs, irrespective of the origins the large numbers of the slaughtered ruminants were adults. Nonetheless, most of those that had their origin from North Shoa (79.4%), Gondar (52.4%) and Hararghe (37.4%) were young ruminants (Fig. 2 and 3).

The species analysis had shown that most of the total slaughtered cattle (53.3%/1024), goats (55.6%/595) and sheep (59.2%/1243) were adult. Similarly, irrespective of

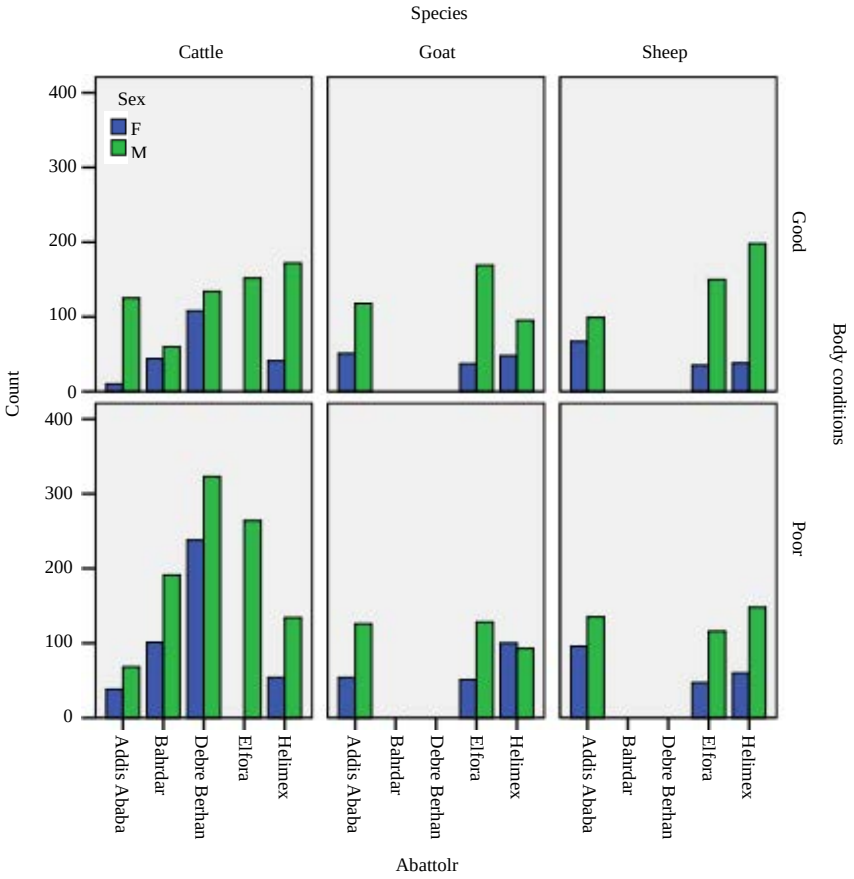

Fig. 2: The sex of slaughtered ruminants with respect to the species, the abattoirs and body condition

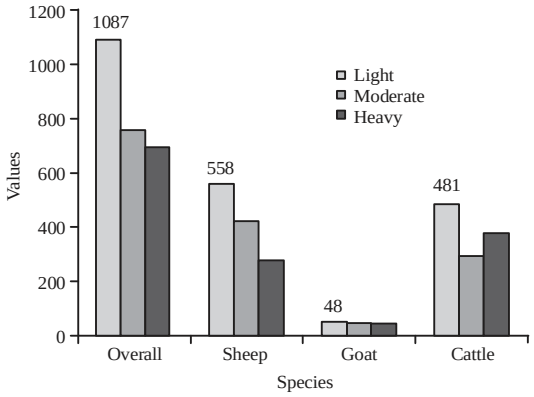

Fig. 3: The severity of liver lesions in ruminant species

the agroecological zones (highland (54.7%), midland (54.5%) and lowland (56.3%)) most of the slaughtered ruminants were adults.

The prevalence of fasciolosis in different sex and breed: The slaughtered ruminants were predominantly male (71%/3913). On the other hand, out of the total slaughtered ruminants, female animals account for about one third (29%/1514) only. The difference in the overall prevalence between the sex groups was significant. The overall prevalence in male (71%) was significantly higher than the female (18.1%) ruminants, however, out of 1979 fluke positive animals, 52.4% were male and 22.8% were females (Table 2). In addition, out of 3913 male and 1514 female animals slaughtered, the prevalence was 45.6% and 49.1%, respectively. Hence, the female appears to show higher prevalence despite the overall lower number of female animals slaughtered (Table 2).

Relatively large numbers of male animals were slaughtered in export abattoirs than the municipal abattoirs. Accordingly, 979 and 840 male animals were examined for fluke infection in Elfora and Helimix export abattoirs, respectively. Meanwhile, the proportion of male ruminants were still significant than the female in all the remaining municipal abattoirs including those in Addis Ababa (671/987), Debreberhan (457/803) and Bahrdar (251/396) abattoirs. The number of male animals was also significant than the female animals with respect to the origin, species and agroecological zones (altitude differences) and body conditions considered (Table 2 and Fig. 2).

The local breed of ruminants represented more than three fourth (78%/4229) of those entirely slaughtered at the abattoirs. Hence, the overall prevalence of fasciolosis was significantly higher in local breed (72.9%±0.66) of ruminants than the cross breed (27.1%±0.66) animals. However, out of 1198 cross bred and 4229 local bred ruminants slaughtered, 685 (57.2%) and 1845 (43.6%) were found to harbor liver flukes, respectively. Despite the lower number of cross breed ruminants slaughtered, this result indicated the significantly higher prevalence of fasciolosis along with cross breed (57.2%) ruminants than the locals (43.6%) (Table 2). The trend in the number of ruminant slaughtered (cross and local breeds) was similar irrespective of the differences in origin, agro ecology (altitude), species and abattoirs considered.

The prevalence in different body condition: More than half of the slaughtered ruminants (56.8%) in poor body condition were positive for the liver fluke infection compared to the lower overall prevalence (43.3%) observed by ruminants in good body condition status. From a total of fasciola positive ruminants, the prevalence of liver flukes in poor body condition animals were 59.4% (Table 2).

However, the prevalence observed in ruminants with good body condition status was only 41%. About 53.4% (1370/2565) of the ruminants slaughtered at municipal abattoirs were predominantly not in good body condition. Altogether, the prevalence of poor conditioned ruminants slaughtered at export abattoirs were 46.6%. On the other hand the prevalence of fasciolosis in ruminants with good body condition at export and municipal abattoirs was 58.2 and 41.8%, respectively.

Significant numbers of slaughtered cattle (62.5%/ 1411) were in poor condition compared to the relatively lower number in goats (52%/552) and sheep (51%/602). Meanwhile, the difference in fasciola prevalence among the body condition status (good and poor) of cattle, sheep and goats was significant.

Similar trends have been observed for the prevalence of fasciolosis in body conditioned status of ruminants with their respective origins and agroecological zones. Hence, the poor body conditions and the higher prevalence of fasciolosis were positively related irrespective of their geographic origin (r = 0.58) or altitudinal (r = 0.69). Young, male and local ruminants represented significantly higher number of poor body conditioned animals in both export and municipal abattoirs than ruminants with good condition.

The different prevalence of fasciola species: In general, *Fasciola hepatica* (70.9%) was a dominant *fasciola* species identified followed by *Fasciola gigantica* (21.5%), mixed infections (6.8%) and immature flukes (9.7%). *F. hepatica* and *F. gigantica* had been identified from all the slaughtered ruminants (cattle, sheep and goats) and in both the export and municipal abattoirs. However, *F. hepatica* was the only species identified from ruminants that had their origin from the highlands. Both *F. hepatica* and *F. hepatica* were identified from the midland ruminants. *F. gigantica* was the only diagnosed species from ruminants originated from the lowlands. Mixed infections were observed in ruminants from midlands and all the abattoirs included in the present study. The result indicated that, immature flukes were found in ruminants slaughtered in all of the abattoirs irrespective of the origin of the ruminants and altitudinal variations and other factors considered.

Severity of the liver lesions: The lesions of fluke infections were clearly observed in the livers of all the three species of ruminants slaughtered in the export and municipal abattoirs, irrespective of their geographical origin and agroecological variations. The overall lesion observation had shown that most of the fluke infected livers examined were affected lightly (20%/1087). The numbers of moderately (13.8%/752) affected livers were slightly higher than those heavily infected livers (12.8%/ 692). However, the difference in the number of ruminants with light liver lesion was significant ($p>0.05$) than that of either the moderately or heavily infected ruminants. But the difference in overall count of moderately and heavily affected livers was not significant (Fig. 3).

About 22.1% (558/2530) and 19% (481/2530) of lightely affected livers in sheep and cattle were outnumbered either the livers with moderate (417 and 287/2530) liver fluke infection or the heavely (271 and 379/2530) infected ones, respectively. In cattle alone significant number livers were heavely (15%) infected compared to the lower count of moderately (11.3%) infected livers. The severity of the diffrences in the number of fluke infected liver of goats were not significant in either light, moderate or the heavly infected groups (Fig. 4).

Irrespective of the lesion types, fluke induced lesions were abundent in Debereberhan municipal abattoir followed by Helimix export abattoir. In all the abattoirs the predominant lesions encounterd were light type except the slightly higher count of heavy lesions observed at Bahrdar abattoir (Fig. 4).

Irrespective of the orgin of the ruminants, fluke infected livers were predominantly lightly affected and the subsequently observed lesions were moderate type. However, observation of fluke infected ruminant livers from North Shoa had shown that most of the livers were lightly affected followed by heavly infected livers instead of the moderate types observed elsewhere.

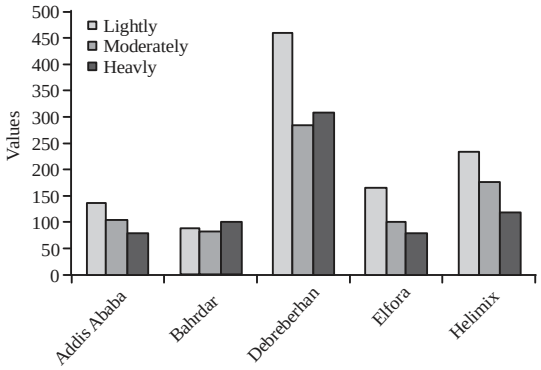

Fig. 4: The severity of the lesions of fluke infected livers in different abattoirs

The light type of lesion was predominant on ruminants from the highlands and followed by those from the midlands and lowlands, respectively. Similarly, moderate lesion type outnumber in highlands and midlands respectively. However, the heavily infected livers were more pronounced in ruminants from the lowlands with successive light type lesions. However, ruminants with heavy infection of fluke infeceted livers were niticeably the lowest in the midlands.

The predominant lesion types in both the local and cross breed ruminants were light type and successively encountered lesion was the moderate type. The difference in the number of lesions types between cross and local breed animals was not significant, although, the light (283) types slightly outnumber the moderate (200) and the heavily (200) infected ones. However, in local breed animals the light type (804) lesions significantly higher than the lesions categorized as moderate (551) and heavily (442) infected ones (Fig. 4).

The overall count of fluke infected liver lesions with respect to breeds of ruminants: The liver lesions were more pronounced in male and adult ruminants than the female and the young ones. The observation of fluke infected livers indicated the predominance of light type lesions. However, in male and young ruminants the moderate type of lesions was abundant. This is not the case in female and adult ruminants where the high count of the light types of lesion was succeeded by the relatively high number of heavily infected livers.

The overall mean number of flukes recovered from sheep and cattle were 65.5±5.6 and this was ranged from 16-175. However, the mean number (74.5±0.7) recovered from the cattle was relatively high in comparison to the lower count obtained from sheep (57.6±0.6) and goats (35.6±0.8).

Economic losses incurred at abattoirs: The retail price of the liver of cattle at export abattoirs was 30 ETB/1.43 USD while that of small ruminants was 12 ETB/0.57 USD only. However, this had shown variation among municipal abattoirs (25-48 ETB for liver of beef cattle and 12-22 ETB for shoats). The mean annual financial loss recorded altogether in export and municipal abattoirs was 7,049,638 ETB/335, 697.1 USD. However, the overall mean financial loss observed in three municipal abattoirs (5,260,596 ETB/250,504.6 USD) was significantly higher than the combined loss incurred in two export abattoirs (1,789,043 ETB/85,192.5 USD).

Comparison of the loss incurred in two export abattoirs for beef cattle had shown slightly lower loss at Helimex (474,682.5 ETB/22,603.9 USD) than the Elfora (499,320/23,777) export abattoir. Similar pattern of rejection of fluke infected liver for human consumption and the associated loss of the wholesale price was observed for sheep at Helmix (257,040 ETB/12,240 USD) and Elfora export abattoirs (294,000 ETB/14,000 USD) (Table 1 and 3). The mean loss incurred in meat goats was relatively lower at Helimix (112,800 ETB/5,371.5 USD) than at Elfora (151,200 ETB/7,200 USD) export abattoir. The order of substantial economic loss due to liver condemnation was observed for beef cattle followed by sheep and goats, respectively (Table 3).

Comparison of the financial loss observed for slaughtered animals at three municipal abattoirs had shown that, it was significantly higher at Addis Ababa (4,843,837 ETB) municipal abattoir followed by Debreberhan (375,153.4 ETB) and Bahrdar (41,605.2 ETB). The loss for bovine fasciolosis was significantly higher in both Addis Ababa and Debre Berhan abattoirs than the loss incurred in small ruminants (Table 4):

*DB = Debre Berhan

At present there are seven large scale meat processing abattoirs that have been established in Ethiopia in response to the emerging meat export opportunities to the Middle East and North African Countries. There are also several meat export abattoirs under construction and more are planned to be established in the near future in different regions of the country[4, 12]. However, the large majority are Municipal abattoirs and slaughterer slabs. The export abattoirs are competing for the domestic supply of live cattle and shoats with the demand for live animals for domestic consumption and for formal and informal trade[4, 12].

Fasciolosis has direct and indirect impact on Ethiopian economy affecting animal production and productivity[1, 19-21]. The economic loss is more significant when animals show prevalence above 25% with evident clinical signs. It is estimated that >300 million cattle and 250 million sheep in the world that are grazing in areas

Table 3: The annual economic loss due to ruminants liver condemnation in two export abattoirs

Species	Abattoir name	Location (town)	Annual slaughter capacity	Prevalence (%)	Retail price (ETB/USD)	Total price (ETB/USD)
Bovine	ELFORA (export)	DebreZeit	54,750	28.90	30	474,682.5/22,603.9
Bovine	Helimix (export)	DebreZeit	54,750	30.40	30	499,320/23,777
Ovine	ELFORA (export)	DebreZeit	100,000	24.50	12	294,000/14,000
Caprine	ELFORA (export)	DebreZeit	100,000	12.60	12	151,200/7200
Ovine	Helimix (export)	Debre-Zeit	100,000	21.42	12	257,040/12,240
Caprine	Helimix (export)	Debre-Zeit	100,000	9.40	12	112,800/5371.5
Total						730,440/34,782.9

Table 4: The annual economic loss due to ruminants liver condemnation in three municipal abattoirs

Species	Abattoir name	Location (town)	Annual slaughter capacity	Prevalence (%)	Retail price (ETB/USD)	Total price (ETB/USD)
Bovine	DB (municipal)	DB	7392	77.8	48	288223.5/13724.9
Bovine	Bahrdar (municipal)	DB	4368	38.1	25	41605.2/1981.2
Bovine	AA (municipal)	AA	177,781	48.8	35	4311189/205294.7
Ovine	DB (municipal)	DB	4,704	84	22	86929.92/4139.5
Ovine	AA (municipal)	AA	117,780	30.3	12	428248.1/20392.8
Caprine	AA (municipal)	AA	60,000	14.5	12	104400/4971.4
Total						805391.3/38352

where infective forms of the parasite present, represent annual losses of more than, USD 3 billion[21-22]. Moderate to heavy fasciola infections (over 40 flukes) result in production losses in the major cow calf operations in the United States.

From a total of 5427 ruminant livers examined in five abattoirs, 2530 (46.6%±0.059) were indicated the presence of liver flukes. The overall prevalence of fasciolosis observed among the abattoirs had shown highly significance difference. Hence, the overall prevalence of fasciolosis observed in ruminants slaughtered in export abattoirs was 34.6%, whereas this was significantly lower in ruminants slaughtered at municipal abattoirs 65.2% as the whole. Comparison of the prevalence of fasciola positive ruminants in each of the four different abattoirs with respect to the prevalence observed at Helimix (44.9%±0.087) indicated significantly higher prevalence at Debreberhan (80.1%±0.95) than the rest of the abattoirs.

There have been significant differences on the overall prevalence of fasciolosis among the slaughtered ruminants from various agroecological areas with altitude differences. Accordingly, it had significantly shown higher prevalence among ruminants from highlands followed by midlands and lowlands, respectively. Altogether, midlands and highlands had contributed more than three fourth of the total slaughtered ruminants in the abattoirs. The higher fasciola prevalence in municipal abattoirs (Debre Berhan) may be related to the supply of slaughter animals from the highlands and midlands with abundant of snail intermediate host in contrary to the relatively large number of slaughter animals supplied to the export abattoirs from the lowlands.

From the overall prevalence of fasciolosis reported in ruminants, the overall prevalence encountered in sheep was significantly lower than that of cattle but it was significantly higher than the overall prevalence observed in goats. Nonetheless, out of a total of 2257 cattle, 1189 sheep and 1070 goat livers examined, the prevalence was 50.8, 58 and 12.2%, respectively. The slaughtered ruminants were predominantly male (71%). The difference in the overall prevalence between the sex groups was significant. The female appears to show higher prevalence despite the overall lower number of female animals slaughtered.

Despite the lower number of cross breed ruminants slaughtered, this result indicated the significantly higher prevalence of fasciolosis along with cross breed (57.2%) ruminants than the locals (43.6%). Altogether, the prevalence of poor conditioned ruminants slaughtered at export abattoirs were 46.6%. On the other hand the prevalence of fasciolosis in ruminants with good body condition at export and municipal abattoirs was 58.2% and 41.8%, respectively.

In general, *Fasciola hepatica* (70.9%) was a dominant fasciola species identified followed by *Fasciola gigantica* (21.5%), mixed infections (6.8%) and immature flukes (9.7%). *F. hepatica* and *F. gigantica* had been identified from all the slaughtered ruminants (cattle, sheep and goats) and in both the export and municipal abattoirs. The lesions of fluke infections were clearly observed in the livers of all the three species of ruminants slaughtered in the export and municipal abattoirs, irrespective of their geographical origin and agroecological variations. The overall lesion observation had shown that most of the fluke infected livers examined were affected lightly (20%). Irrespective of the lesion types, fluke induced lesions were abundent in Debereberhan municipal abattoir followed by Helimix export abattoir. In all the abattoirs the predominant lesions encounterd were light type except the slightly higher count of heavy lesions observed at Bahrdar abattoir. The predominant lesion types in both the local and cross breed ruminants were light type and successively encountered lesion was the moderate type.

The overall mean number of flukes recovered from sheep and cattle were 65.5±5.6 and this was ranged from 16-175. However, the mean number (74.5±0.7) recovered from the cattle was relatively high in comparison to the lower count obtained from sheep (57.6±0.6) and goats (35.6±0.8).

In Ethiopia, various authors reported the wide distribution and occurrence of fasciolosis with significance economic loss associated with the rejection of fluke infected liver at abattoirs. The overall financial loss observed in the present study (7,049,638 ETB/335,697.1USD) was significantly higher than the work of other researchers elsewhere in the country. Abebe *et al*.[23] reported a loss of 8312 USD at Hawassa abattoir whereas Tolosa and Tigre[24] and Abuna *et al*.[25] reported a financial loss of 6300 USD and 4000 USD at Jimma and Wolaita Soddo municipal abattoirs, respectively.

The relatively higher fluke prevalence at Elfora (28.9%) and Helmix (30.4%) export abattoirs coupled with higher annual slaughter rate (54,700 cattle/annum) were responsible for higher overall financial loss incurred due to condemnation of fluke infected bovine liver. Similarly the prevalence and annual number of animals slaughtered had significant effect on the higher overall financial loss incurred in small ruminants (Helimix, sheep (24.5%); Elfora, sheep (21.42%); Helimix, goats (9.4%) and Elfora, goats (12.6%) with annual slaughter capacity of 100,000 each)[12] (for slaughter capacity).

The Addis Ababa municipal abattoir has also high production capacity (177,781) compared to the other municipal abattoirs with much lower number of slaughtered animals per annum (Hawassa, 20,000; Jimma, 14,000; WoliataSoddo, 5678, Bahrdar 4368, Debreberhan, 7728 and Gondar, 7392). Comparison of the loss that incurred for beef cattle at Debreberhan abattoir (288, 223 ETB/13,724 USD) was significantly higher than the report of other workers[23-25]. However, at Bahrdar (41,605.2ETB/1981.2 USD) it was much lower compared to the previous reports of the same authors.

Despite the low annual slaughter rate, the retail price of the liver of beef cattle at Debreberhan (48 ETB) was relatively higher than the price at Addis Ababa (35 ETB). Furthermore, the prevalence of bovine (77.7%) and ovine (81%) fasciolosis was significantly higher at Debreberhan than that of Addis Ababa (48.8, 30.3 and 14.5 for cattle, sheep and goats, respectively).

In general, the high fasciola prevalence reports in the abattoirs of the present study was responsible for clear observed differences in the economic loss incurred as a result of the rejection of fluke infected liver. The retail price of the liver of cattle at export abattoirs was only 30 ETB/1.43USD while that of small ruminants was 12/0.57USD. However, these had shown variation among municipal abattoirs (25-48 ETB) for liver of beef cattle and 12-22 ETB for shoats. The variation of the retail price of the liver had significant effect on the observed financial loss due to fluke infected liver. The retail price differs with the demand of the liver in different towns, as it is clear that the price is affected by the demand and supply for uninfected healthy liver to the market. Thus, there was relatively high price tag for liver of cattle at Addis Ababa (35 ETB) and Deberberhan (48 ETB) towns compared to the lower prices observed at Bahrdar (25 ETB) and DebreZeit (30 ETB). The present findings plainly indicated that, the retail price of the liver of sheep (22 ETB) was relatively higher at Debreberhan town than the other towns (12 ETB).

The combined mean financial loss recorded in both export and municipal abattoirs was 7,049638 ETB/335, 697.1 USD. However, the overall mean financial loss observed in three municipal abattoirs altogether (5,260, 596 ETB/250504.6 USD) was significantly higher than the sum of combined loss incurred in two export abattoirs (1,789,043 ETB/85,192.5USD). Comparison of the financial loss observed for slaughtered animals at three municipal abattoirs had shown significantly higher loss at Addis Ababa (4,843,837ETB) municipal abattoir followed by Debreberhan (375,153.4ETB) and Bahrdar (41,605.2 ETB).

The financial loss observed due to fluke infected liver of bovine was significantly higher in Addis Ababa (4,311,189ETB/205,294 USD) abattoirs than on the whole loss incurred in small ruminants at municipal abattoirs (549, 978 ETB/26,189.43USD). However, the loss in small ruminants was almost twice the loss observed in rejection of fluke infected liver at Debreberhan (288, 223.5 ETB/13724.9) for cattle alone.

CONCLUSION

The overall mean fluke count (M±SE) indicated that moderately affected sheep and goats liver had relatively higher fluke counts compared to the severely affected ones. However, in cattle, fluke counts in heavily affected livers exceeded that obtained from moderately affected ones. The worm burden in lightly affected sheep liver had relatively higher fluke counts compared to the severely affected liver. The less worm burden in severely affected livers of sheep may be associated with the severe fibrosis that impedes the passage of immature flukes and acquired resistance that resulted in the expulsion of flukes from the bile ducts[26].

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