

Status of small ruminant fasciolosis and diagnostic test evaluation at Haramaya town municipal abattoir, East Harrarghe Zone, Ethiopia

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Abstract

A cross-sectional study to estimate the prevalence of fasciolosis and associated risk factors at Haramaya Municipal Abattoir was conducted from November 2017 to April 2018. Moreover, the direct financial loss due to liver condemnation and evaluation of the sensitivity of direct sedimentation technique for detection of *Fasciola* eggs were performed. A total of 384 small ruminants comprising of 235 sheep and 149 goats were subjected to coprological and post-mortem examination. An overall prevalence of 12.8% was found. Forty-four animals were positive for eggs of *Fasciola* with an overall prevalence of 11.5%. However, it was 14.1% (54/384) in the examination of the same animals exposed to postmortem examinations of fluke-infected livers. The prevalence of fasciolosis based on body condition score was 62.2%, 12.4%, and 4.1% in that order, in poor, medium, and good body condition groups and the difference was statistically significant ($p < 0.05$). Other factors considered like, the monthly prevalence, species, age, and sex of the animals did not show significant differences ($p > 0.05$). The prevalence of fasciolosis was highest in Haramaya (19.0%) followed by Awaday (14.9%), Kersa (10.3%), Midhaga (8.1%), and the lowest prevalence was observed in Babile (5.8%), however, the difference in prevalence across the origin of the animals was not significant ($p > 0.05$). *F. hepatica* was a dominant 63.0% (34/54) species identified followed by *F. gigantica* 20.4% (11/54) and 5.6% (3/54) and 11.1% (6/54) were due to mixed and immature flukes, respectively. Taking liver examination as the gold standard for diagnosis of fasciolosis, the sensitivity of the direct sedimentation technique was found to be 81.5% and the specificity 100% with almost perfect agreement ($k = 0.89$) between the two methods. The direct financial loss due to liver condemnation was estimated to be 46,318.5 (965 USD) Ethiopian birr per annum. In conclusion, *Fasciola* spp are important parasites affecting small ruminants in the study area. Control strategies targeted to the parasite and the inter-

mediate hosts (snail) with particular emphasis on mature poorly conditioned animals is recommended.

Keywords: Abattoir; Coprology; Fasciolosis; Prevalence; Risk factor; Small ruminants.

Introduction

Despite having the world's tenth biggest livestock population, Ethiopia contributes less than 1% of global meat production. Thus far, small ruminants play a very important role in human nutrition and they have the potential of serving as tools for poverty reduction through the provision of meat, milk, household income, manure, and skin. Sheep and goats are one of the most important livestock species in Ethiopia's ruminant production next to cattle. Nevertheless, the productivity per animal is still low; several constraints remain on sheep and goats' productivity. Fasciolosis causes serious economic losses, particularly in the humid and sub-humid zones, and is responsible for several economic losses in a variety of ways. In terms of numbers, the population is estimated at 42.9 million sheep and 52.5 million goats making Ethiopia the country in front lines of the small ruminant population in Africa (Jobre and Malone, 1998; Taylor *et al.*, 2007; Alemu and Merkel, 2009; CSA, 2021; Tadesse *et al.*, 2019a, b).

The importance of fasciola infections is magnified in poor countries like Ethiopia, where more than 84 percent of the population lives in rural areas and relies on livestock for income, and parasitism is a severe concern for the livestock economy (Jobre and Malone, 1998; Jobre and Ali, 2000; ; CSA, 2021; Biffa *et al.*, 2006; Dina and Henok, 2018; Tadesse *et al.*, 2019a, b). Acute fasciolosis can cause massive economic losses (Chick *et al.*, 2008; Spithill *et al.*, 1997) in terms of anemia due to its ability to suck 0.2–0.5 ml of blood per day per animal (Urquhart *et al.*, 1996) and a decrease in total proteins, specifically hypoalbuminemia (Soulsby, 1982). Whereas chronic fasciolosis can reduce growth rate, feed conversion rate, and wool production (Taylor *et al.*, 2007).

It is a well-known fact that fasciolosis is an economically important parasitic disease, which is caused by digenean trematodes of the genus *Fasciola*, commonly referred to as liver fluke that migrates in the hepatic parenchyma and establishes in the bile ducts. *F. hepatica*, which is found in temperate areas and cooler places of high altitude in the tropics and subtropics, and *F. gigantica*, which is found in tropical locations including Ethiopia, are the two species

most usually implicated as the etiological agents of fasciolosis (Troncy, 1989; Jobre and Malone, 1998; Jobre and Ali, 2000; Biffa *et al.*, 2006; Tadesse and colleagues, 2019a, b).

The disease remains as one of the hindrances for the marginal utility of this available small ruminant livestock resource (Tekelye *et al.*, 1992a, b; Mas-Coma, 2005; Tadesse *et al.*, 2019b). The worldwide loss in animal productivity due to fasciolosis was estimated over US \$ 3 billion per annum (FAO, 1994). In many parts of Ethiopia, small ruminant fasciolosis due to *F. hepatica* and *F. gigantica* has been reported as endemic and economically important (Tekelye *et al.*, 1992a, b; Sirajudin *et al.*, 2012; Dina and Henok, 2018; Tadesse *et al.*, 2019a, b). The study on Ethiopian ruminant livestock (cattle, sheep, and goats) in three municipal (Addis Ababa, Debre Berhan, and Bahrdar) and two export abattoirs (ELFORA and HELMIX) indicated an estimated annual loss of 7,049,638 ETB / 335, 697.1 USD due to liver condemnation alone (Tadesse *et al.*, 2019b).

In Ethiopia, the epidemiology of fasciolosis is dependent on the ecology of the intermediate host. The snails of the *genus Lymnaea* are mainly involved as an intermediate host in the life cycle of fasciolosis (Graber and Daynes, 1974; Jobre and Malone, 1998; Tadesse *et al.*, 2019a, b).

Lymnaea truncatula is the most common intermediate host for *F. hepatica* in different parts of the country, whereas *Lymnaea natalensis* is common the most important intermediate host of *F. gigantica* (Njau and Scholtens, 1991; Urquhart *et al.*, 1996; Jobre and Malone, 1998; Jobre and Ali, 2000; Tadesse and colleagues, 2019a, b). In Ethiopia, *F. hepatica* and *F. gigantica* infections occur in areas above 1800 m and below 1200 m above sea level respectively; which has been attributed to variations in the climatic and ecological conditions such as rainfall, altitude, temperature, and livestock management system. In between these altitude limits, both species coexists where ecology is conducive for both snail hosts, and mixed infections prevail (Jobre and Malones, 1998; Taylor *et al.*, 2007).

The presence of fasciolosis due to *F. hepatica* and *F. gigantica* or mixed (*F. hepatica* and *F. gigantica*) infections at abattoir surveys in some parts of the country has long been known and its prevalence and economic significance have been reported by several workers. More recently Tadesse *et al.* (2019b) reported 294, 000 (6125 USD) and 257, 040 ETB (5355 USD) in ovine and 151,

200 (3150 USD) and 112, 800 ETB (2350 USD) in caprine fasciolosis in Elfora and Helimix export abattoirs per annum, respectively. Nevertheless, there is still a gap for many prospective sites of the country to review the countrywide prevalence and economic significance. Therefore, the objectives of this study were to estimate the coprological and abattoir prevalence and associated risk factors of small ruminant fasciolosis, to estimate the financial losses due to fasciolosis as the cause of liver condemnation, and to evaluate the specificity and sensitivity of fecal examination at Haramaya municipal abattoir.

Materials and methods

Study area

The study was conducted at Haramaya municipal abattoir in the Eastern Hararghe zone of the Oromia region, Southeastern Ethiopia. The area is located, 14 km from west of Harar city and 511 km east of Addis Ababa. The estimated animal population in the area was about 63,723 cattle, 13,612 sheep, 20,350 goats, 15,978 donkeys, and 42,035 chickens (HADB, 2010). The production system of the district was a mixed type. Topographically, it is situated at an altitude of 1600 to 2100 meters above sea level with the mean annual temperature and relative humidity of 18°C and 65%, respectively. There are four seasons; a short rain season (from March to mid-May), a short dry season (from the end of May to end of June), a long wet season (early July to mid-October), and a long dry season (end of October to end of February). The Haramaya area receives an average annual rainfall of approximately 900 mm, with a bimodal distribution pattern, peaking in mid-April and mid-August. The vegetation that constitutes the available pasture lands in this area is predominantly native grasses and legumes inter dispersed with open acacia shrubland (HADB, 2010).

Study population

The study populations all ages and sex groups of indigenous breeds of sheep and goats which were brought from mainly Haramaya and its surrounding district to Haramaya municipal abattoir for slaughter and kept under traditional extensive husbandry systems with communal grazing practice.

Study design

A cross-sectional type of study was conducted from November 2017 to April 2018. It involved categorization of the study population according to their spe-

cific geographic origin (district), body condition score (BCS), sex, species of animal, and age to estimate the prevalence of fasciolosis and assess the associated potential risk factors and used to determine the sensitivity and specificity of sedimentation technique as compared to postmortem findings. The origins of the animals were determined by interviewing animal owners. To assess whether other factors usually have a significant effect on the prevalence of fasciolosis, a monthly difference in the prevalence of fasciolosis during the dry season (November to April) was conducted.

Sampling method and sample size determination:

Sampling method

The animals were selected using systematic random sampling and marked at the regular weekly interval to study the prevalence and species of *Fasciola* involved in small ruminants both by fecal examination before slaughter and postmortem examination. On every slaughter, day (three days per week) fecal samples were collected from these systematically and randomly selected animals before they were subjected to detailed postmortem examination for liver inspection.

Sample size determination

The sample size for the study was calculated using the formula given by Thrusfield (2007). For calculating the required sample size, a 95% confidence interval (CI) and 5% absolute level of precision were used. However, to increase the precision, the sample size was made to 384 sheep and 384 goats.

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

Where, n= Sample size

P_{exp}= expected prevalence (50%)

d= desired level of precision (5%)

Therefore, $n = \frac{1.96205(1-0.5)}{0.0025} = 384$ sheep and goats

Study methodology

Antemortem examination

During the antemortem examination, identification numbers were given to the study animals, and information regarding the origin, species, sex, age, and body condition of the study animals were recorded during the antemortem examination. Body condition score was grouped into five and animals score 0-2, 3, and 4-5 are classified as poor, medium, and good conditions, respectively according to MoARD (2008). Age estimation was carried out by examination of the teeth eruption using the approach of Steele (1996). Those animals were recorded as young while their age was estimated at one year and adults for above. Then, before the selected animals were slaughtered, a fresh fecal sample was collected directly from the rectum using disposable plastic gloves and placed in a clean screw-capped universal sampling bottle, and preserved by 10% formalin after labeling. Then the sample was transported to Haramaya University Veterinary Parasitology Laboratory.

Coprological examination

A total of 384 fecal samples were examined in the laboratory to determine the prevalence of the disease. Fecal samples for parasitological examination were collected directly from the rectum of each animal before slaughter using disposable plastic gloves and placed in a clean screw-capped universal sampling bottle. Then each fecal sample was labeled with the animal identification numbers (origin, age, sex, and species) and date of collection. Samples were preserved with a 10% formalin solution to avoid eggs developing and hatching. The collected fecal samples were taken to the parasitology laboratory of the School of Veterinary Medicine of Haramaya University and examined using standard sedimentation technique (Hansen and Perry, 1994; Zajac and Conboy, 2012).

To differentiate between eggs of *Paramphistomum* species and *Fasciola* species a drop of methylene blue solution was added to the sediment. Eggs of *Fasciola* show yellowish color while eggs of *Paramphistomum* species were stained by methylene blue (Hansen and Perry, 1994; Zajac and Conboy, 2012).

Postmortem examination of fresh liver

All animals from which fecal samples were taken were followed for postmortem examination to correlate the coprology and postmortem examination of each animal. During the postmortem examination, livers were examined visually and palpation of the entire organ. Visual inspections followed by multi-incisions of 1 cm of liver were made to examine the species of *Fasciola* and severity of the liver lesion. The liver was sliced into 1cm thick slices and placed in a metal trough filled with warm water to allow mature flukes caught in smaller bile ducts to escape. To screen for adult flukes, the gall bladder was removed and cleaned. Identification of the fluke species involved was carried out based on the morphological features of the agent and classified into *F. hepatica*, *F. gigantica*, mixed and unidentified or immature forms of liver fluke (Soulsby *et al.*, 1982; Urquart *et al.*, 1996).

The pathological lesion categorization of the affected livers was undertaken based on the intensity of the lesions. Hence, affected livers were grouped into three categories as per the criteria previously described by Ogunrinade and Adegoke (1980). *Lightly affected*: a quarter of the organ is affected and only one bile duct is prominently enlarged on the visceral surface of the liver; *moderately affected*: half of the organ is affected and two or more bile ducts are hyperplastic, and *severely affected*: almost the entire organ is involved, the liver is cirrhotic and triangular in outline as the right lobe is often atrophied.

Sensitivity and specificity of the fecal examination method

One of the objectives of this study was to evaluate the sensitivity of the direct sedimentation method, which was used to examine the presence of *Fasciola* species eggs in feces. For this test, fecal samples were taken from the rectum of 384 small ruminants (149 goats and 235 sheep) randomly selected from those brought for slaughter and subjected to liver inspection. The collected samples were taken to the laboratory in tightly closed universal bottles. In the laboratory, the samples were processed by the sedimentation technique as described by Hansen and Perry (1994).

The sensitivity and specificity of the method were computed by taking liver inspection at postmortem as the gold standard for the diagnosis of fasciolosis. Kappa coefficient was used to determine the agreement of the tests (sedimen-

tation and postmortem examination). Cohen's Kappa is a measure of agreement between the two individuals when two binary variables are attempted by two individuals to measure the same thing and Kappa of 1 indicates perfect agreement, whereas a kappa of 0 indicates agreement equivalent to chance. Kappa value was interpreted as: agreement by chance ($k < 0$), slight agreement ($k < 0.2$); fair agreement ($k = 0.2 - 0.4$); moderate agreement ($k = 0.4 - 0.6$); substantial agreement ($k = 0.6$ to 0.8); and almost perfect agreement ($k > 0.8$) (Thrusfield, 2007).

Estimation of financial loss due to liver condemnation

The total annual financial loss incurred due to liver condemnation at the Abattoir was computed by multiplying the average number of sheep and goats slaughtered annually in the Abattoir by the prevalence of fasciolosis obtained from the present survey and the mean price of the liver in the Haramaya city. Then the mean annual slaughter rates were estimated from previous data recorded in the past two years.

Financial losses were then computed mathematically by adapting the formula of Ogunrinade and Ogunrinade (1980) as follows:

$$EL = \Sigma S_{rx} * Coy * Roz$$

Where,

EL=Estimated Annual Economic Loss due to organ condemnation

S_{rx}=Annual sheep/goats slaughter rate of the abattoir=7300 (4015 sheep and 3285 goats)

Coy=Average cost of liver=45ETB

Roz=Average rejection rate of the liver due to fasciolosis = 14.1%

All affected livers were considered as condemned since partial approval was not practiced in the Abattoirs. The retail market price of the liver was collected from different butcher shops of the study areas and the average price of one liver was 45 birr used for calculation.

Data management and analysis

Data collected from abattoir survey and fecal examination were entered into a Microsoft Excel spreadsheet and analyzed with STATA 13 statistical software. The prevalence of fasciolosis was calculated as the number of infected individuals divided by the number of individuals sampled x 100. Origin, species, sex, age, months, and body condition score of the small ruminants were the major independent variables. The association of these variables with the prevalence of fasciolosis was assessed by Chi-square test and logistic regression based on results of postmortem examination. The sensitivity of the direct sedimentation technique was calculated by taking postmortem inspection of the liver as the gold standard. Kappa coefficient was used to compare the agreement between coprology and necropsy examination for the diagnosis of fasciolosis. In the analysis, p values <0.05 were considered significant at a 95% confidence interval.

Results

Prevalence

From the 384 sheep and goats livers tested, the overall prevalence of fasciolosis was 14.1 % (54/384). However, based on coprological examination this was only 11.5% (44/384) and a prevalence of 8.1% (12/149) in goats and 13.6% (32/235) in sheep. On postmortem examination of the liver, the prevalence of 16.6% (39/235) and 10.1% (15/149) were recorded in sheep and goats, respectively. Out of the total 54 livers found positive for fasciola during the study period; 34 (63%), 11 (20.4%), 3 (5.6%), and 6 (11.1%) were due to *F. hepatica*, *F. gigantica*, mixed infection, and immature flukes, respectively (Table 1).

Table 1. Prevalence of fasciolosis in small ruminants and its associated risk factors.

Risk factors		No. of examined	No. positive	Prevalence (%)	X ²	P_Value
Species	Ovine	235	39	16.6%	3.34	0.076
	Caprine	149	15	10.1%		
	Total	384	54	14.1%		
Sex	Male	198	24	12.1%	1.28	0.260
	Female	186	30	16.1%		
	Total	384	54	14.1%		
Age	Young ≤1year	112	15	13.4%	0.06	0.809
	Adult >1year	272	39	14.3%		
	Total	384	54	14.1%		
BCS	Poor	45	28	62.2%	73.42	≤0.001
	Medium	145	18	12.4%		
	Good	194	8	4.1%		
	Total	384	54	14.1%		
Origin	Haramaya	163	31	19.0%	3.47	0.07
	Kersa	58	6	10.3%		
	Babile	52	3	5.8%		
	Awaday	74	11	14.9%		
	Midhaga	37	3	8.1%		
	Total	384	54	14.1%		

BCS: body condition score

Risk factor assessment

The prevalence of *Fasciola* infection was found significantly higher in small ruminants with poor body conditions as compared with medium and good body conditions as described in Table 1. Differences in prevalence among species, sexes, ages, and origins were also observed. However, these differences were not statistically significant (Table 1).

The following figure shows the results of the liver examination monthly. From the 384 small ruminants slaughtered at Haramaya Municipal abattoir, 54 animals (14.1%) were found to be infected with *Fasciola* species. Statistically insignificant ($\chi^2 = 1.06$; $p=0.306$) variation in prevalence of fasciolosis

among study months was found. The highest prevalence was seen in November (20.0%) while the lowest was in March (10.4%). The prevalence observed during December, January, February, and April were 18%, 12.6%, 11.1%, and 17.5%, in that order.

Concerning the intensity of pathological lesions produced in the liver by the *Fasciola* species, infection of mixed (*F. gigantica* and *F. hepatica*) resulted in the highest severity. The variation in the intensity of pathological lesions produced in the liver by the *Fasciola* species was statistically ($p < 0.05$) significant (Table 2).

Table 2. The intensity of pathological lesions produced in the liver by *Fasciola* species

Species of <i>Fasciola</i>	The intensity of pathological lesions	No. (% Prevalence)	X ²	P-value
<i>Fasciola hepatica</i>	Light	5(14.7)	-	-
	Moderate	12(35.3)	37.42	0.042
	Severe	17(50.0)	57.62	0.035
	Total	34(63.0)		
<i>Fasciola gigantica</i>	Light	1(9.1)	-	-
	Moderate	4(36.4)	3.62%	0.67
	Severe	6(54.5)	11.74%	0.52
	Total	11(20.4)		
Mixed	Light	0(0)	-	-
	Moderate	1(12.5)	1.74	3.67
	Severe	3(37.5)	263.29	≤ 0.001
	Total	4(50.0)		
Immature	Light	3(67.7)	-	-
	Moderate	0(0)	1.74	≤ 0.001
	Severe	2(33.3)	128.9	
	Total	2(33.3)		

According to age and sex, the intensity of pathological lesions produced in the liver was higher in adults than in young ($p > 0.05$) animals and the same holds in females than in males (Table 3). However, the difference in the prevalence of fasciolosis between both sex and age were not statistically significant ($p > 0.05$). Based on the body condition of the animals, the intensity of pathological lesions

produced in the liver was the highest in those animals with poor body conditions and lowest in good body conditions. The variation between the prevalence of body condition scores and the severity of pathological lesions produced in the liver was statistically significant ($p < 0.05$).

Table 3. The intensity of pathological lesion based on host-related risk factors

Risk factors	No. examined	Light	Moderate	Severe	X ²	P- value
Age						
Young ≤ 1 year	112	3 (2.7%)	5 (4.5%)	7 (6.2%)		
Adult > 1 year	272	8 (2.9%)	12 (4.9%)	19 (7.0%)	0.06	0.809
Total	384	11 (2.9%)	17 (4.4%)	26 (6.8%)		
Sex						
Male	119	5 (2.5%)	8 (4.0%)	11 (5.6%)		
Female	186	6 (3.2%)	9 (4.8%)	15 (8.1%)	1.2	0.260
Total	384	11 (2.9%)	17 (4.4%)	26 (6.8%)		
Body condition						
poor	45	2 (4.4%)	17 (37.8%)			
Medium	145	5 (3.4%)	8 (5.5%)	73.42	0.000	
Good	194	4 (2.1%)	1 (5%)			
Total	384	11 (2.9%)	26 (6.8%)			

The sensitivity and specificity of the faecal examination technique

Table 4. Sensitivity and specificity test for sedimentation technique

Faecal examination	Post mortem examination			kappa
	Fluke (+)	Fluke (-)	Total	
Eggs present (+)	44	0	44	0.89
Eggs absent (-)	10	330	340	
Sensitivity = 81.5%,		Specificity = 100%		

The sensitivity and specificity of the direct sedimentation technique were calculated from the results in the above table which sets out the numbers of positive and negative tests in animals with and without flukes in their livers (Smith, 1995). Out of the 384 sheep and goats subjected to both fecal and

liver examination, 54 had flukes in their livers but only 44 showed *Fasciola* eggs in their feces. Accordingly, the sensitivity of coprological examination by sedimentation method was 81.5% and specificity was 100% for the study period with an almost perfect agreement between the two methods (Kappa=0.89) (Table 4).

Financial loss due to liver condemnation

Based on the prevalence of fasciolosis determined by this study, the annual slaughter rate of Haramaya municipal abattoir, and the current market price of sheep and goat liver in Haramaya town, the direct financial loss due to liver condemnation was estimated. The direct financial losses were computed mathematically by adapting the formula of Ogurinate and Ogunrinade (1980) as follows:

EL= 7300 direct (4015 sheep and 3285 the goats) $\times 45 \times 14.1\%$ = 46,318.5 ETB (965 USD).

Discussion

Fasciolosis is a widespread ruminant health problem and causes significant economic losses due to liver condemnation. The occurrence of small ruminant fasciolosis in many parts of Ethiopia, due to *F. hepatica* and *F. gigantica* has been reported as endemic and economically important (Tekelye *et al.*, 1992a, b; Sirajudin *et al.*, 2012; Dina and Henok, 2018; Tadesse *et al.*, 2019a, b).

The present study on the overall prevalence of fasciolosis was 14.1% and it was 16.6% (39/235) in sheep and 10.1% (15/149) in goats. This current overall prevalence of small ruminant fasciolosis was comparable with a more recent overall 14.6% prevalence report by Tadesse *et al.* (2019b) in three municipalities (Addis Ababa, Debre Berhan, and Bahrdar) and two export abattoirs (ELFORA and HELMIX) in Ethiopia. However, the overall prevalence of ovine fasciolosis report disclosed by the same authors (Tadesse *et al.*, 2019b) was 23.8%. In Debre Berhan alone a similar but different study released by Tadesse *et al.* (2019a) also indicated significant higher overall coprologic, herd, and abattoir prevalence of 65.2%, 59.4%, and 84% in sheep, in that order. Tadesse *et al.* (2019b) and were also disclosed 24.5% and 21.42 % in ovine and

12.6% and 9.4% in caprine fasciolosis in ELFORA and HELIMIX export abattoirs, respectively.

The current overall prevalence of fasciolosis was lower than the previously disclosed overall 21.3% prevalence of fasciolosis at Hashim Nur's Ethiopian Livestock and Meat Export abattoir (HELMEX) by Melkam, (2008). Another report unveiled at HELMEX in 2012 by Abdulhakim and Addis, at Addis Ababa Abattoir Enterprise by Birhanu *et al.* (2015) at Dessie municipal abattoir by Berhe *et al.* (2017) indicated a higher overall prevalence of 17%, 19%, 18.8% of small ruminant fasciolosis, respectively.

However, the current overall prevalence of liver flukes in small ruminants was higher than the 3.2% report from Modjo Modern Export Abattoir, Ethiopia (Dawit and Adem, 2011), 10.5% report from Addis Ababa Abattoir Enterprise, Ethiopia (Yehualash *et al.*, 2013), 8.2% reports from HELMEX (Mensur *et al.*, 2016). These differences in prevalence may be due to the presence of favorable environments for the existence, multiplication, and spread of intermediate host snails or the parasite, the season of the study, the difference in ecology of the study area, implementations of control strategies over the periods, sample size differences, the shift of most of the marshy or waterlogged areas for crop production, improvement in veterinary services, and the ability of the inspector to detect the infection may play a part. These could be the reason for the differences in the prevalence of fasciolosis from different parts of Ethiopia.

In this study, the prevalence of fasciolosis was higher in sheep (16.6%) as compared to that of goats (10.1%). The difference in infection by *Fasciola* was not statistically significant between sheep and goats although sheep were affected at higher than goats. Similar results were reported at Dessie Municipal Abattoir 19.8 % and 10% in sheep and goats, respectively by Berhe *et al.* (2017) and 12% in sheep and 7.5% in goats in Hawassa Zuria and Dale Districts, Sidama Zone, Southern Ethiopia by Rahmeto *et al.* (2014). Naturally, goats depend on browsing plants for their nutrition, and thus, they are less exposed to the infective larval stages of parasites including *Fasciola* spp. However, nowadays in most parts of Ethiopia goats had changed their feeding behavior from browsing to grazing on the same pasture along with sheep because of the shortage of browsing plants associated with bush clearing for expansion of crop agriculture and human settlement. This had resulted in equal exposure of goats

to infective larval stages of *Fasciola* species to a similar level of infection as in sheep (Marquard *et al.*, 2000).

This result did not agree with previous results reported, 5.6% in sheep and 0.8% in goats at Modjo Modern Export Abattoir, Ethiopia (Dawit and Adem, 2011), 25.9% in sheep, and 10.6% in goats at Addis Ababa Abattoir Enterprise, Ethiopia (Birhanu *et al.*, 2015) and 11.9% in sheep and 4.2% in goats at HELMEX (Mensur *et al.*, 2016) they reported that statistically significant difference in the prevalence of fasciolosis between sheep and goats being high in sheep. This might be due to the area where the animals come.

The prevalence of fasciolosis in the current study is 12.1% in males' and 16.1% in females. However, there is no statistically significant difference in the prevalence of fasciolosis between the two sex groups. In contrary to the present findings, Tadesse *et al.* (2019a) revealed a significant difference in the overall prevalence of ovine fasciolosis in male (55.1%) and female (71.9%) animals slaughtered at Debre Berhan abattoir. Similarly, Jarso *et al.* (2016) reported a statistically significant difference in the prevalence of fasciolosis between the females (73.05%) and males (26.95%) in Debra Berhan.

However, this result was in agreement with previous results reported in the North Gondar zone, 7.07% in females and 6.97% in males (Dagnachew *et al.*, 2011), 10.1% in males, and 14.5% in females at Bahir Dar town (Amsalu, 2017) and 11.3% females and 8.0% in males in Hawassa Zuria and Dale Districts, Sidama Zone, Southern Ethiopia (Rahmeto *et al.*, 2014). This might be because both sexes were grazing in similar pastureland having equal access for the infection or similar management was given regardless of the sex of small ruminants.

In the present study, age had no significant effect on the prevalence (13.4% in young and 14.3% in adults) of small ruminant fasciolosis. This might be because in the present time adults were not separated from their young as in previous times for grazing because of lack of grazing lands. Due to these reasons, most young and adults small ruminants were tethered at homesteads, which might have reduced the chance of adults to exposure to *Fasciola* infective stages (encysted metacercariae). This means both ages have an equal chance of exposure to *Fasciola* infection or due to appropriate management and improvement in veterinary service. This result was in agreement with

previous results on the reported prevalence of 55.6% in young sheep and 72.3% in adults (Tadesse *et al.* 2019a). Similarly, lower 14.4% prevalence in young and 21% in adults was reported by Birhanu *et al.* (2015), 67.7% and 32.21% in adults and young respectively by Jarso *et al.* (2016), 44.67% in adults and 39.29% young by Ibrahim *et al.* (2017) and 32.43% in young and 34.75% in adults by Chekol and Girma (2018).

The results of this study indicated that the infection in poor body conditioned (62.2%) animals was significantly higher than that of the medium (12.4%) and good body conditioned (4.1%) animals. The result was in agreement with the findings of several authors elsewhere (Tadesse *et al.*, 2019a; Molalegn *et al.*, 2010; Yemisrach and Mekonnen, 2011; Mulatu and Addis, 2011; Desta *et al.* 2013; Mathewos *et al.*, 2014; Birhanu *et al.*, 2015). This might be because *Fasciola* worms are known to suck blood and tissue fluid and even damage the parenchyma of the liver due to the migrating immature worms or due to increased susceptibility of animals with poor body conditions to fasciolosis and other infections than animals with medium and good body condition (Marquard *et al.*, 2000; Taylor *et al.*, 2007). Although poor body condition can happen due to several reasons, such as nutritional deficiency, many other diseases, and helminth infections; the chronic wasting of infected animals caused by fasciola infection is undoubtedly well documented (Taylor *et al.*, 2007).

The monthly prevalence of fasciolosis recorded was 20%, 18%, 12.6%, 11.1%, 10.4%, and 17.5% in November, December, January, February, March, and April respectively. The difference in monthly prevalence was not statistically significant. This might be due to fact that the study was carried out in the dry season when most of the snail habitats were dried up, change in the feeding system of the animals, the shift of most of the marshy or waterlogged areas for crop production and improvement in veterinary services. This result was not in agreement with another previous result reported in the district of south Gonder administrative zone bordering Lake Tana (Mulualem, 1998) and in and Around Debre Berhan (Jarso *et al.*, 2016).

Based on origin, there was no significant difference among animals from different origins. This was in agreement with the report of Ahmed *et al.* (2007) in the Middle Awash River Basin, Ethiopia, Mohammed (2010) in and around Kombolcha, Alula *et al.* (2012) in Nekemte Municipal abattoir and Birhanu *et al.* (2015) at Addis Ababa Abattoir Enterprise. This could be due to the conversion of most marshy or waterlogged areas to crop production, the drying up

of natural lakes (e.g. Haramaya lake), improvements in veterinary service, animal feeding systems (e.g. in Hararrghe, most animals were tethered at homesteads), which may have reduced the risk of exposure to *Fasciola* infective stage (encysted metacercariae) due to a lack of grazing land, and the lack of significant altitudinal variation between the districts or animals brought nearly from the same agroecological zone.

F. hepatica was identified as the most predominant species infecting small ruminants in the study area. This might be associated with the agroecology of animal origin which is favorable for the intermediate host, snail. For instance, Haramaya town and surrounding areas have altitudes ranging from 1600-2100 meters above sea level, which is favorable for *L. truncatula*, the main intermediate host for *F. hepatica*. In Ethiopia, *F. hepatica* is a widely spread species in an area with an altitude above 1200-2000 meter above sea level whereas *F. gigantica* appears to be the most common species in an altitude below 1200 meter above sea level which maintain *L. natalensis*, an intermediate host for *F. gigantica* and both species as co-existing in an area with altitude ranging between 1200 to 1800 meter above sea levels (Jobre and Malone, 2011). This finding is in agreement with the reports of Tadesse *et al.* (2019a, b), Mensur *et al.* (2016), and Berhe *et al.* (2017).

Although *F. hepatica* was the predominant species infecting small ruminants in the study area, mixed and *F. gigantica* had a higher prevalence of severity of small ruminant livers in the study area. The difference between the prevalence of severity of *Fasciola* species to small ruminant livers was statistically significant ($p < 0.05$). This is due to the fact that *F. gigantica* to be less infective but more pathogenic than *F. hepatica* (Massoud and Vedadi, 1983). This was in agreement with the previous result reported by Amsalu (2017).

In the current study, the sensitivity of coprological examination of feces by sedimentation technique was determined using postmortem examination (liver examination) as the golden standard. The sensitivity of the sedimentation technique was found to be 81.5% concerning the results of the liver examination and almost perfect agreement ($\kappa = 0.89$) was observed between the two tests. However, this test suggests that about 18.5% of infected animals may pass undetected with the examination of feces by sedimentation technique. The decrease in sensitivity sedimentation method might be attributed partly to the fact that *Fasciola* eggs only appear in feces 8-15 weeks post-infection (Happich and Boray, 2008). Furthermore, detection of *Fasciola* eggs is

not reliable during the prepatent period as eggs are expelled intermittently depending on the evacuation of the gall bladder (Briskey, 1998). In another report that was a similar study with the current, but lower sensitivity than the present study finding reported 75% at Dessie municipal abattoir (Berhe *et al.*, 2017), 68% at Addis Ababa Abattoir Enterprise, Ethiopia (Birhanu *et al.*, 2015), and 67.13% at Hawassa Municipal abattoir, southern Ethiopia (Rahmeto *et al.*, 2010).

The economic importance of ovine and caprine fasciolosis has been the concern of several workers in Ethiopia. Fasciolosis had resulted in economic loss due to decline in production and reproduction, death, loss of carcass weight, predisposition to other diseases, condemnation of liver, and treatment cost. In the present study, the direct economic loss due to rejection of liver was estimated to be 46,318.5 Ethiopian birr per annum/965USD from the local market. The economic loss in the abattoir was relatively low when compared with the findings of the previous workers. Tadesse *et al.* (2019b) disclosed losses of 86,930 ETB (1749 USD), 428,248 ETB (8922 USD), 294, 000 ETB (6125 USD), 257, 040 ETB (5355 USD) per annum at Debre Berhan, Addis Ababa, ELFORA, and HELIMIX abattoir due to ovine fasciolosis alone, respectively. The same authors have also revealed losses of 104, 400 ETB (2175 USD), 151, 200 ETB (3150 USD) and 112, 800 ETB (2350 USD) per annum due to caprine fasciolosis at Addis Ababa, ELFORA, and HELIMIX abattoirs, in that order. Berbersa *et al.* (2016) reported a financial loss of about 110,361 Ethiopian birrs (2299 USD) per annum on small ruminants slaughtered at Luna export abattoir during the active abattoir survey. The difference in the financial loss estimated in various abattoirs may be due to the variation in the prevalence of the disease and the mean annual number of animals slaughtered in the different abattoirs.

Conclusions

This study has revealed the overall prevalence of fasciolosis in sheep and goats at Haramaya municipal abattoir to be about 14.1%. The prevalence of fasciolosis by sedimentation was 13.6% in sheep and 8.1% in goats while 16.6% in sheep and 10.1% in goats based on post mortem examination. This indicated that some of the animals were negative for coprological examination by simple sedimentation technique even though they were found positive by post-mortem examination of the livers. Therefore, the coprological examination had some degree of perfection (81.5% sensitivity and 100% specificity almost perfect agreement, $k = 0.89$) in detecting the presence of *Fasciola* infection when

compared with post mortem examination. Age, sex, species, origin, and months did not show a significant difference in the prevalence of small ruminant fasciolosis, while sheep and goats with poor body conditions were significantly affected by fasciolosis. Between the two species of *Fasciola*, *F. hepatica* was the predominant in the study area. Concerning the intensity of pathological lesions, mixed (*F. gigantica* and *F. hepatica*) were found to be more paramount. The financial loss incurred due to liver condemnation was very high. Therefore, these factors should be taken into account whenever a control intervention is launched in the area.

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