Assessment of bovine fasciolosis and the analytical test evaluation at Yirgalem municipal abattoir, Ethiopia

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Abstract

A cross-sectional study was conducted from November 2021 to April 2022 to estimate the prevalence of bovine fasciolosis, assess the risk factors, and estimate the direct financial loss due to liver condemnation in cattle slaughtered at Yirgalem municipal abattoir. Furthermore, the comparison of the diagnostic efficiency of fecal and postmortem examination was evaluated. The study was based on both postmortem inspection of the liver for liver fluke infection and coprological examination using the sedimentation technique. Thus, a total of 400 cattle were sampled using systemic random sampling techniques and the prevalence was 27.0% (108/400) and 20.8% (83/400), by postmortem and coprological examination, respectively. The prevalence of *F. hepatica, F. gigantica*, mixed infections, and unidentified species were 56.5%, 19.4%, 16.7%, and 7.4%, respectively. The difference between age groups was statically significant (p<0.05). Coprological examination revealed the highest prevalence was recorded in the age group of > 7 years old (34%, adjusted odds ratio [AOR]= 4.2) followed by 4-6 years old adults (26.8%, AOR=4.2) and in young cattle of <3 years old (6.7%). Prevalence by postmortem examination was 43.0% (AOR= 4 0), 27.8% (AOR= 2.4), and 8.3%, for age groups > 7 years old, 4-6 years old adults and in young cattle of <3 years old, respectively. The body condition score result revealed a significant difference (p<0.05) as a greater magnitude of infections were detected in poor body condition animals (AOR=7.7) than in medium and good body condition (p<0.05). Considering the liver examination as a gold standard for diagnosis of fasciolosis, the sensitivity of the sedimentation technique was 76.8%, and the specificity of 100% with a very good agreement (kappa = 0.94) between the two methods. The total financial loss per annum due to the condemnation of infected liver was 945, 999 ETB (18,192.288 USD). Therefore, strategic control and prevention of the snail intermediate host should be implemented. Furthermore, upon diagnosis of fasciolosis, epide-

miological information about the disease with suggestive clinical examination should be considered even in the absence of *Fasciola* eggs during coprological examinations and also other parasitological techniques such as the FLOTAC and FLUKE FINDER methods with high sensitivity and specificity should be employed.

Keywords: Abattoir; Cattle; Economic loss; Fasciolosis; Prevalence; Yirgalem.

Introduction

Fasciola species infect mainly ruminants (especially sheep and cattle), but humans can also become infected (Mas-Coma *et al*., 2009; Tadesse *et al*., 2019a, b). The effects of fasciola infection in livestock result in profound consequences of decreased production outcomes such as reduced weight gain and body condition scores, poor carcass quality and organ condemnation, decrease in reproductive performance, and, in acute cases, sudden death in sheep has been well-documented (Dalton, 1999; Taylor *et al*., 2007; Mas-Coma *et al*., 2014; Tadesse *et al*., 2019b). Despite the significant human and animal health impacts, it remains a neglected disease, especially in developing countries (Mas-Coma *et al*., 2009; Cwiklinski *et al*., 2016).

F. hepatica infects more than 300 million cattle and 250 million sheep worldwide and, together with *F. gigantica* causes significant economic losses to global agriculture estimated at more than US$3 billion annually (Keiser and Utzinger, 2005; Torgerson and Macpherson, 2011). The study on Ethiopian ruminant livestock in five abattoirs indicated an estimated annual loss of over 7, million ETB or more than 335, 697.1 USD due to liver condemnation alone (Tadesse *et al*., 2019b).

The total cost of bovine fasciolosis in Turkey was estimated as 7.4 million US$ (6.1–8.8) for beef cattle and 35.4 million US$ (28.9–42.6) for dairy cows (Sariozkan and Yalc, 2011). This cost was estimated based on a 1.9% mean prevalence of fasciolosis to calculate the total cost of a disease. The cost will be much higher if it was estimated by the current 20.8% and 27% prevalence that were obtained in the present finding through coprological and postmortem examination at Yirgalem, respectively.

Infection with *F. hepatica* has been shown to modulate the immune system of infected hosts by causing a shift towards a T helper 2 (Th2) cell response, leaving hosts more susceptible to infection with other bacterial pathogens such as *Mycobacterium bovis* and *Bordetella pertussis* (Brady *et al*., 1999; O'Neill *et al*., 2001). This immunomodulation has also been shown to confound the outcomes of diagnostic tests for diseases, including bovine tuberculosis, due to the suppression of an effective Th1 response, increasing the rate of false-negative results (Garza-Cuartero *et al*., 2016).

The prevalence of fasciolosis is global and increasing due to a changing climate, emerging anthelmintic resistance, and adaptations in agricultural practices (Coles *et al*., 2005; Mas-Coma *et al*., 2014; Cwiklinski *et al*., 2016; Fairweather, 2020). In Ethiopia, where the majority of production systems are grassland-based with an extensive type of production system, the cost of fasciolosis to the Ethiopian livestock sector will be estimated to increase annually. In fact, in the highlands of Ethiopia, communal grasslands are critical resources that provide livestock feed to farmers and ecosystem services to a substantial sector of society (FAO, 2018; Eba and Sircely, 2021). In rural settings of traditional extensive types of livestock keeping of the country, diagnosis, and monitoring of ruminant fasciolosis are challenging. In Ethiopia, an indication of the liver fluke presence on ruminants on farms often comes from liver condemnation reports (Tadesse *et al*., 2019 a, b; Tadesse and Usman, 2022), but these are based on visual evaluations and therefore not standardized between abattoirs.

The effective characteristics of diagnostic tests are commonly evaluated in terms of diagnostic sensitivity and specificity. Sensitivity reflects the ability of a test to correctly identify those individuals that are infected and specificity is the ability of a test to correctly identify those uninfected as negative (Thrusfield, 2007). There are several antemortem fluke diagnostic tests available, but no one test can be considered as having adequately high sensitivity and specificity in the field setting (Mazeri *et al*., 2017; Rapsch *et al*., 2006). The diagnosis of acute fasciolosis is implemented by the determination of serum hepatic enzyme activities which are released from the damaged hepatic cells (Matanovic *et al*., 2007). Clinical diagnosis and positive fecal egg count along with increasing levels of gamma-glutamyl transferase (GGT) confirm the presence of chronic fasciolosis. Confirmatory diagnosis for fasciolosis is based on the demonstration of characteristics of *Fasciola* eggs through standard examination of feces in the laboratory and the presence of immature and mature flukes in the liver through postmortem examination (Khan, 2005).

Even though several researchers (Tadesse *et al.*, 2019 a, b; Tadesse and Usman, 2022) in the country have investigated many aspects of the parasite; specific studies are always needed at a particular site to update different aspects of fasciolosis; disease status and the most prevalent species on regular basis. Moreover, most of the available studies only calculated the cost of the condemned liver due to bovine fasciolosis and ignored the analytical test evaluation and important potential risk factors. To this end, the objectives of this study were to estimate the prevalence of bovine fasciolosis, assess the potential risk factors, and estimate the direct economic loss exerted by the disease at Yirgalem abattoir. Furthermore, the techniques used for the detection of *Fasciola* and the intensity of the disease such as fluke burden and liver lesions were evaluated.

Materials and methods

Study area

The study was conducted at Yirgalem municipal abattoir in Yirgalem. Yirgalem is the Dale woreda administrative town in Sidama Region and 320km far from Addis Ababa. Geographically the town lies between 6°27’00” - 6° 51’00” N latitude and 38°00’00” -38°37’00”E longitude. The altitude ranges from 1650-2800 m.a.s.l. The mean annual temperature ranges between 9.6°C and 29.2°C. The area has a bimodal rainfall pattern with the first peak from April to May and the second peak from August and October. The lowest rainfall was recorded between November and February. The mean annual rainfall at the Awada Research sub-center in Yirgalem is 1314 mm (Gelfeto, 2019). The study areas encompassed as the source of animals for slaughter were Bore, Arsi-Negele, Dimtu, and Wonshu. These are areas in close proximity to the abattoir and have variable climatic (rainfall and temperature) condition and geographical location (SRADO, 2021).

Study animals

The study animals comprised all cattle slaughtered at the Yirgalem municipality abattoir. The study population includes all cattle that were brought to the abattoir from different areas for slaughtering purposes and were managed under an extensive and semi-intensive production system. This population comprised different breeds, sex, age, body condition groups, and cattle originating in and around Yirgalem city. Sometimes it is difficult to trace the origin of the animals as they usually pass a chain of markets and due to the lack of reliable animal identification methods to relate the findings to a particular locality. Age determination was categorized based on dental characteristics into three such as young, adult, and old (Ensminger, 1992). The data were collected according to recording *preformat*: Young (1-3 years), adult (3-6 years), and old (above 6 years). Also during the survey, the sex and breed of animals were recorded.

The body condition of the study animals was scored based on the criteria set by Nicolson and Butterworth (1986). Accordingly, the body condition was grouped into three, poor, medium, and good.

Study design

A cross-sectional study was conducted from November 2021 to April 2022.

Sampling strategy

A total of 400 samples were collected during the study period from cattle slaughtered in the Yirgalem municipal abattoir by using a systematic random sampling technique.

Sample size

The animals were selected by using a systematic random sampling method where a sampling interval of 7 animals was used. To determine the sample size, an expected prevalence of 50% was taken since there was no prior research carried out in the area. The sample size was calculated using the formula given by Thrusfield (2007). The 95% confidence interval and 5% absolute precision were taken.

$n = (1.96)^2 \, pexp \, (1- p \, exp)/d^2$

Where,

n= Number of samples

d= Desired absolute precision

p = expected prevalence

$n = (1.96) \times 50\% \, (1- 50\%)/ (5\%)^2$

$= 3.8416 \times 0.5 \times 0.5)/ (0.05)^2$

$0.9604/ 0.0025 = 384$ cattle

Therefore, using a 95% confidence interval, 5% precision, and 50% expected prevalence, the number of cattle needed was 384, but to increase the precision 400 cattle were sampled.

Sampling methods

Coprological examination

Before sampling, an identification number was given to each animal presented to the abattoir for slaughter. At the time of sampling, 15-20 animals were selected in the lairage where the date of sampling, the sex, the origin, the body condition, the management system (through the interview), and the breed of the cattle were recorded for each cattle on a recording format. Faecal samples were collected directly from the rectum of each study animal, using disposable plastic gloves, and placed in a clean universal bottle and each sample was clearly labeled. Faecal samples were preserved with 10% formalin solution to avoid the eggs developing and hatching. The samples were transported to Hawassa University Veterinary Parasitology laboratory on the same day of collection and examined for *Fasciola* eggs by using sedimentation as described (Hansen and Perry, 1994). And their specificity and sensitivity were interconnected with post-mortem findings. Samples that were not processed within 24 hours were stored in a refrigerator at 4°C.

Abattoir work

Antemortem and postmortem examinations were conducted by visiting the abattoir two days a week. At the time of antemortem examination, detailed records about the species, breeds, sexes, origins, fecal consistency, and body conditions of the animals were performed. In the postmortem examination, the previously identified animals and their livers were carefully supervised and examined, to avoid mixing up the organs to be inspected with the faecal samples and to correlate the coprology and postmortem examination of each animal. The fluke recovery and count were conducted following the approach of (Taylor *et al*., 2007), as follows: the gall bladder was removed and washed to screen out mature flukes. The liver was cut into slices about 1 cm thick and put in a metal trough of warm water to allow mature flukes lodged in smaller bile ducts to escape and then the heads of the flukes were counted. Identification of the species involved was carried out using the size parameters described by (Soulsby, 1982; FAO, 2003), whereas pathological lesion categorization of the affected livers was undertaken based on the intensity of lesions. Hence, affected livers were grouped into three categories as per the criteria previously described by Ogunrinade and Adegoke (1982) as lightly, moderately, and heavily affected.

Species identification

The liver of each study animal was carefully examined for the presence of lesions suggestive of *Fasciola* infection externally followed by slicing for confirmation. Liver flukes were recovered for the differential count by cutting the infected liver into fine, approximately 1 cm slices with a sharp knife. The sample was placed in a universal bottle and transported to Hawassa University Veterinary Parasitology laboratory. Species identification and further investigation were conducted on recovered Fasciola based on morphological features of the agents and classified into *Fasciola hepatica*, *Fasciola gigantica*, mixed infection by both flukes and unidentified or immature forms of liver fluke (Urquhart *et al.,* 1996; FAO, 2003).

Assessment of direct financial loss

Several parameters were used to estimate the losses attributable to liver condemnations in slaughtered cattle to determine the direct annual financial loss. Such parameters were taken by considering the overall prevalence of the disease, the total number of animals slaughtered annually in the abattoir, and the retail market price of the liver. The annual number of animals slaughtered was estimated from retrospective abattoir records of the last three years, while the average selling price of cattle livers was established through a survey which was conducted in various meat shops in the town. The average current price of one liver in Yirgalem town was about 900 ETB. All affected livers were rejected since partial approval was not practiced in the abattoir. The collected information was subjected to mathematical computation using the formula set by (Ogunrinade and Ogunrinade, 1980).

ALC = MCS x MLC x P Where ALC=Annual loss from liver condemnation,
MCS= Mean annual cattle slaughtered at Yirgalem abattoir,
MLC= Mean cost of one liver in Yirgalem town,
P= Prevalence of the disease at the study abattoir.

Data management and data analysis

The raw data were entered and managed using a Microsoft Excel worksheet and summarized with descriptive statistics. STATA statistical software version 14 was used to determine the association between prevalence and hypothesized risk factors. Many attribute data that were imported to the database system, include information on the origin, age, sex, breed, body condition, detection of fluke eggs, and the liver fluke. In addition to these, the number of livers condemned, species of the flukes, and worm counts were entered for abattoir data analysis. Variations in infection prevalence between species, age, sex, breed, origin, and body condition were determined and evaluated by using logistic regression analysis. The output of the statistical analysis is considered significant when the p-value is less than 0.05 at a 95% confidence level.

Moreover, the sensitivity and specificity of the sedimentation method were assessed by taking a necropsy examination as a gold standard for the diagnosis of fasciolosis. Kappa statistic was used to determine the degree of agreement between the two diagnostic methods employed (fecal sedimentation technique and necropsy finding) in the study. The kappa value was interpreted as: no agreement ($k < 0.0$); slight agreement ($k = 0.1\text{-}0.2$); fair agreement ($k = 0.2$ to 0.4); moderate agreement ($k = 0.4$ to 0.6); substantial agreement ($k = 0.6$ to 0.8); and almost perfect agreement ($k > 0.8$) (Thrusfield, 2007).

The formula for Cohen's kappa is calculated as:
$k = (po - pe) / (1 - pe)$ = observed agreement−chance agreement / 1- chance agreement
where:

po: Relative observed agreement among the analytical tests

pe: Hypothetical probability of chance agreement

Results

Coprological examination

The coprological examination of 400 cattle slaughtered at the Yirgalem municipal abattoir during the six months study period detected 20.8% (83) of animals for *Fasciola* eggs. The highest prevalence of fasciolosis was observed during March (33.8%) followed by April (25.7%), November (23.2%), February (22.7%), December (14.9%), and January (9.6%). Similarly, the prevalence among young, adult, and aged revealed the prevalence of 4 (6.7%), 60 (26.8%), and 19 (34%), respectively, and the difference was statistically significant ($p<0.05$) (Table 1).

Moreover, the assessment of the breed and management system revealed significant disparity ($p<0.05$) as a greater magnitude of infections were detected in local and animals reared extensively. However, there is no significant difference between sex, origin, and altitude ($p>0.05$). Variation in prevalence was observed among poor, medium, and good body condition scores with a prevalence of 48% (12/25), 25.2% (61/242), and 7.5% (10/133), respectively and the difference was significant ($p<0.05$) (Table 1).

Table 1. Prevalence of fasciolosis and associated risk factors using the coprological examination

Variable	Category	No of examined	Number +Ve (%)	AOR	95%CI	p-value
Sex	Male	297	57(19.2)	1.1	0.6-2	0.757
	Female	103	26(25.2)			
Age	<3	60	4(6.7)	2.7	0.9	0.089
	4-6	224	60(26.8)		8.7	0.038
	>7	56	19(34.0)	4.2	1.1-16	
Breed	Local	347	80(23.0)	1.5	0.9-12	0.683
	Cross	53	3(5.7)			
Management system	Extensive	326	79(24.2)	13	2-84.6	0.008
	Semi-intensive	74	4(5.4)			
BCS	Poor	25	12(48.0)	2.4	0.8-6.9	0.113
	Medium	242	61(25.2)	7.7	2-27.7	0.003
	Good	133	10(7.5)			
Month	November	43	10(23.2)	2.8	0.92-8.5	0.07
	December	74	11(14.9)	6.4	2-21.3	0.003
	January	83	8(9.6)	1.8	0.6-5	0.293
	February	97	22(22.7)	1.3	0.38-3.3	0.82
	March	68	23(33.8)	1.4	0.4-5	0.576
	April	35	9(25.7)			
Altitude	Midland	264	60(22.7)	1.9	0.9-5.9	0.093
	Lowland	94	10(10.6)	1.2	0.3-4	0.832
	Highland	42	13(31.0)			

Variable	Category	No of examined	Number +Ve (%)	AOR	95%CI	p-value
Origin	Tulla	66	14(21.2)	3.1	0.8-12.2	0.09
	Loka abay	68	6(8.8)	1.8	0.7-4	0.201
	Arsi	31	7(22.6)	1.12	0.4-2.7	0.848
	Wonsho	73	18(26.7)	1.1	0.42-3	0.788
	Dale	91	21(23.1)	1.1	0.3- 3.2	0.892
	Bore	42	13(31)			
	Dimtu	29	4(13.8)			

BCS=Body Condition Score, +ve= Positive; AOR=Adjusted Odd Ratio; CI= Confidence Interval; p-value= Probability value

Faecal egg count based on the severity

Among 83 coprological positive animals, faecal egg count-based severity was performed and 52(62.6%), 19(22.9%), and 5(6.0%) were affected lightly, moderately, and heavily, respectively (Table 2).

Table 2. Prevalence of fasciolosis and level of egg burden

EPG	No examined	Number of +Ve (%)	Severity	Min.	Max.
0	83	7(8.4)	None	-	-
1-5	83	52(62.6)	Light infestation	100	500
6-10	83	19(22.9)	Moderate infestation	500	1000
11-13	83	5(6.0)	Heavy infestation	1000	1500

Where, Min=Minimum, Max= Maximum

Postmortem examination

Out of 400 cattle slaughtered at the abattoir and examined for fasciolosis, 27.0% (n=108) of livers were positive for *Fasciola* species. Among 108 livers having fluke infection during postmortem inspection, 56.5% (61) *F. hepatica*, 19.4% (21) *F. gigantica*, 16.7% (18) mixed infections and 5% (5) contained unidentified immature fluke (Table 3).

The highest prevalence was seen in March (41.1%) and April (40%) while the lowest was in January (14.4%). "The comparison according to the body condition score showed higher prevalence in animals with poor body condition (60.0%) compared to animals with moderate (30.6%) and good body condition (14.3%). During postmortem examination, the prevalence of fasciolosis was proved to be higher in local cattle 103 (29.7%) than cross breed 9 (12.2%) animals and the difference was significant ($p< 0.05$) (Table 3). The prevalence between the six different areas in the present study showed the presence of variability in the prevalence of bovine fasciolosis between them. The highest (42.9%) and the lowest (16.2%) prevalence of bovine fasciolosis were observed in the Bore and Loka Abay areas, respectively. Similarly, the prevalence among young, adult, and aged revealed the prevalence of 5(8.3%), 79(27.8%), and 24 (43%), respectively with significant differences ($p < 0.05$) (Table 3). Furthermore, the management system revealed a significant difference ($p < 0.05$) as a greater magnitude of infections were detected in animals reared extensively (30.3%) (Table 1). However, there was no statistically significant difference ($p > 0.05$) in the prevalence of fasciolosis between the sexes and the altitude differences (Table 3).

Table 3. Prevalence of fasciolosis in cattle using postmortem results and the associated risk factors

Variable	Category	No. examined	Number +Ve (%)	AOR	95% CI	p-value
Sex	Male	297	74(25.0)	1.05	0.6-1.9	0.855
	Female	103	34(33.0)			
Age	<3	60	5(8.3)	2.4	0.86-6.8	0.093
	4-6	284	60(27.8)	4.0	1.2-13.3	0.024
	>7	56	24(43.0)			
Breed	Local	347	103(29.7)	1.44	0.3-7.24	0.683
	Cross	53	5(9.4)			
Management system	Extensive	326	99(30.3)	4.4	1.1-20	0.36
	Semi-intensive	74	9(12.2)			
BCS	Poor	60	15(60)	3.2	1.14-9	0.027
	Medium	224	74(30.6)	6.6	1.96-25	0.002
	Good	56	19(14.3)			
Month	November	43	15(34.9)	2.5	0.91-7.14	0.075
	December	74	16(21.6)	5.0	1.7-16.6	0.003
	January	83	12(14.4)	2.0	0.76-5.2	0.157
	February	97	23(23.7)		0.41-2.93	0.845
	March	68	28(41.1)		0.4-3.6	0.780
	April	35	14(40)			
Altitude	Midland	264	71(26.9)	1.12	0.42-2.32	0.92
	Lowland	94	19(20)	1.2	0.45-2.7	0.867
	Highland	42	18(42.9)			

Origin	Tulla	66	15(22.7)	2.37	0.69-8.1	0.168
	Loka abay	68	11(16.2)	1.4	0.6-3.2	0.477
	Arsi	31	8(25.8)	1.06	0.45-2.5	0.878
	Wonsho	73	22(30.1)	1.22	0.46-3.21	0.68
	Dale	91	26(28.6)			
	Bore	42	18(42.9)			
	Dimtu	29	8(27.6)			

AOR= Adjusted Odds Ratio; +Ve = Positive; CI= Confidence Interval; p-value= probability value

Liver fluke burden and degree of pathological lesions

A total of 2414 flukes were recovered from the infected bovine livers examined. Of these, 57 (52.8%), 46 (42.6%), and 5 (4.6%) were affected lightly, moderately, and severely, respectively (Table 4).

Table 4. Categorization of livers according to the severity of lesions and their fluke burdens

Fluke count Interval	Severity of lesions	No of livers	Relative proportion (%)	Min	Max
4-20	Lightly affected	57	52.8	4	20
21-49	Moderately affected	46	42.6	21	49
50-57	Severely affected	5	4.6	50	57
	Total	108	100		

Where: Min= Minimum, Max= Maximum

Fasciola species identification

From the total of 108 infected livers, infections with *F. hepatica* and *F. gigantica* occurred with a prevalence of 56.5% (n =61) and 19.4% (n = 21), respectively, while mixed and unidentified species or immature fluke were 16.7% (n = 18) and 7.4% (n =8) (Figure 1).

Figure 1: Infected bovine liver samples. (A) Adult parasite (*arrow*) (B) Thickening of the bile duct (*arrow*)

Table 5. Prevalence of *Fasciola* species in cattle slaughtered from the total Positives

Fasciola species	No. of infected liver	Prevalence (%)
Fasciola hepatica	61	56.5
Fasciola gigantica	21	19.4
Mixed	18	16.7
Immature	8	7.4
Total	108	100

The diagnostic test evaluation

From the total of 400 cattle examined for the presence of *Fasciola*, postmortem findings revealed better results (27.0%) than coprological examination (20.8%), which showed us that the sedimentation technique used for *Fasciola* egg assessment failed to detect eggs from some faecal samples (Table 6)

Table 6. Measuring the sensitivity, specificity, and agreement level of the two tests

Fecal examination	Postmortem examination		Total	Kappa
	Positive	Negative		
Positive	83(a)	0(b)	83	0.84
Negative	25(c)	292(d)	317	
Total	108	292	400	

Sensitivity= [a/ (a+c)] ×100 = 83/108= 76.8%

Specificity= [d/ (b+d)] ×100 = 292/292= 100%

Economic loss analysis

The total economic loss due to fasciolosis in Yirgalem municipal abattoir was estimated from the summation of annual liver condemnation. Partial condemnations of the liver were not a common practice in this abattoir. The average retail price of one liver (one liver=3kg) in town was taken as 900 ETB. The average numbers of cattle slaughtered in the Yirgalem municipal abattoir were 3893 cattle per year based on 3 years of recorded data. Accordingly, the annual loss from liver condemnation at Yirgalem municipal abattoir was found to be 945,999 ETB (18,192.288 USD).

Discussion

The present result disclosed fasciolosis as an economically important disease in the study area. Therefore, the findings of this study have relevance and significance to cattle owners, veterinary personnel in the area, and livestock authorities. Accordingly, the coprological and postmortem examination revealed a prevalence of 20.8% and 27.0, respectively. Comparable results of 19.4% and 26.8% prevalence were disclosed at Wolaita Sodo municipal abattoir through coprological and postmortem studies, respectively (Assefa *et al*., 2015). Similar findings unveiled by Alemu and Mekonen (2014) at Dangila municipal abattoir revealed a prevalence of 22.1% and 30.2%, whereas a different record by Mulat *et al*. (2012) at the Gonder ELFORA abattoir revealed a similar prevalence of 19.5% and 29.8% both by coprological and postmortem examination, respectively.

This could be related to the fact that the development of *Fasciola* eggs in the feces takes eight to fifteen weeks after infection, uneven egg discharge to the duodenum, and specific groups of animals that may have had pharmacological therapy before being transported to the abattoir. Furthermore, because eggs are released intermittently depending on the evacuation of the gall bladder and the life cycle of *Fasciola*, the detection of *Fasciola* eggs and the emergence of the disease in some locations was difficult to detect during the prepatent period (Radostits *et al*., 2007; Tadesse *et al*., 2021).

A comparison of the current findings disclosed that there was a significant difference in the prevalence of fasciolosis found through coprological (20.8%) and postmortem examinations (27.8%). The current result was significantly lower than that of 50.8% coprological prevalence previously reported by Tadesse *et al*., (2019b). Tadesse *et al*. (2019a) reported significantly higher overall coprology, and abattoir prevalence of 59.2%, and 81.0% in cattle in Debre Berhan. In the present study, the overall prevalence of fasciolosis (27.8%) observed in post-mortem examination was relatively similar to 26.8% in Wolaita (Asefa and Belay, 2015), 28.63% in Hawassa (Rahmeto *et al.,* 2010) and 28% in Kombolcha (Nuraddis *et al.,* 2009). But the prevalence in this study was lower when compared to 35% in Kombolcha by George Opio (2021), 54.5% in Jimma by Abie *et al*., (2012), 45.3% in Bahir dar by Ayalew *et al*., (2013) and 56.2% in and around Chora woreda by Tadelle and Behablom (2018). On the other hand low prevalence (14.4%) has been reported from Wolaita Soddo municipal abattoir

(Adane, 2019), 20.3% in Addis Ababa (Kassaye *et al.,* 2012) and 21.3% in Bonga municipal abattoir by (Simegnew *et al*., 2016).

Variations in the origin of the samples, ecological and climatic conditions such as altitude, rainfall, and temperature; animal management systems, sample size, and the inspector's ability to detect the infection may all play a role in the difference of the prevalence of the current study among other researchers' findings across the country. The availability of suitable habitat for the snail intermediate hosts, which is necessary for the development of fluke eggs, miracidia hunting for snails, and cercariae dissemination, is one of the most important elements that influence the occurrence of fasciolosis in a given location (Urquhart *et al.,* 1996; Dalton *et al*., 1999; Taylor 2007).

The species identification on 108 *Fasciola* infected livers disclosed that 56.5% of them were positive for *F. hepatica,* whereas, *F. gigantica*, mixed infection and immature or undifferentiated were recorded to be 19.4%, 16.7%, and 7.4%, respectively. These findings are in agreement with the reported prevalence in cattle with *F. hepatica* (46.1%), *F. gigantica* (27.3%), mixed infection (18.2%), and immature (9.1%) by Alemu and Mekonen (2014), *F. hepatica* (42%), *F. gigantica* (27.6%), mixed infection (19.0%) and immature (11.2%) by Asefa and Belay (2015), *F. hepatica* (42%), *F. gigantica* (27.6%), mixed infection (19.0%) by Paulos (2021) at Addis Abeba abattoir.

However, concerning the proportion of *Fasciola* species identified, the present finding was lower than the findings of Tadele and Worku (2007) and Nuraddis *et al*. (2009). These authors demonstrated the predominant species of bovine fasciolosis in Jimma municipality and Kombolcha Industrial abattoirs as *F. hepatica* (63.89%; 24.8%) followed by *F. gigantica* (63.6%; 24.3%), respectively. The prevalence of fasciolosis and the *Fasciola* species showed variability with the locality.

In Ethiopia *F. hepatica* and *F. gigantica* infections occur in areas above 1800 m.a.s.l. and below 1200 m.a.s.l., respectively which has been attributed to variations in the climatic and ecological conditions such as altitude, rainfall, temperature, and livestock management system. The high prevalence of *F. hepatica* may be associated with the existence of favorable ecological biotopes for *L. truncatula*, the recognized intermediate host of *F. hepatica* in Ethiopia. Asefa and Belay (2015) revealed a relatively small proportion of cattle infected with *F. gigantica* alone or mixed infections by both species. This may be explained by the fact that most cattle for slaughter came from high land and middle altitude zones and therefore drainage ditches are favorable habitats to the intermediate hosts (Tadesse *et al*., 2019a; Taylor, 2007; Urquhart *et al*., 1996). Studies in other countries of Africa showed that *F. gigantica* was the predominant species encountered (Phiri *et al*., 2006; Yabe *et al*., 2008) whereas, in Europe, the Americas, and Oceania only *F. hepatica* is concerned (Mas-Coma *et al*., 2005).

The current study indicated that animals with good body conditions had less prevalence of *Fasciola* infection. There was a statistically significant association between *Fasciola* infection and the body condition of the animals. Good body-conditioned animals were 6.6 times less likely to be infected as compared to poor body conditions. Concerning the body condition of the animals, the abattoir prevalence was higher in those animals with poor body conditions (60%) than in those with medium (30.6%) and good body conditions (14.3%). In support of this finding, a study conducted in five abattoirs in Ethiopia (Tadesse *et al*., 2019a) and another study in Bahir Dar, Ethiopia (Ayalew *et al*., 2013) indicated a significant association between the prevalence of fasciolosis and body condition of the animals. Reports of Mojo *et al*.(2014) were also in line with the current finding.

The reason for this could be because *Fasciola* worms drain blood and tissue fluid and damage the parenchyma of the liver due to migrating immature worms, and decreases body condition. It indicates the significance of fasciolosis in producing weight loss, which is a symptom of the disease (Radostitis *et al*., 2007; Asefa and Belay, 2015).

The monthly variation in the prevalence of fasciolosis has been studied for six dry months in the study area. It was difficult to indicate the effect of seasonal variation on the prevalence of bovine fasciolosis since the study period was too short without incorporating wet months of the season. An accurate description of seasonal occurrence requires long-term epidemiological investigation over several years. Even though the study period is short and in the dry season, the highest prevalence was seen in March (33.8%, 41.1%) and April (25.7%, 40%), and November (23.2%, 34.9%) while the lowest was in January (9.6%, 14.4%) both in coprology and postmortem examination. There was a statistically significant variation in the prevalence of fasciolosis in the study month of January and other months.

The significant variation in these months may be due to the area has been receiving additional rainfall in October and November, and short rain in March and April, This provides a favorable environment for the snail population. Moreover, the infection was reported throughout the year due to resistance of metacercariae to desiccation, especially during the dry season, and the continued presence of shallow water, enough vegetation, and humidity for continued exposure of the animals to encysted metacercariae and no restriction on cattle grazing habits and movement between the infected and treated localities (Nazima *et al*., 2016).

In this study, a significant variation was revealed in the prevalence of *Fasciola* between different age groups. The least infection in the age group <1-3 years might be due to the possibility of fewer chances of acquiring infection due to short exposure time as compared to older animals. This might be because adults were separated from their young's for grazing in the field whereas most young's were tethered at homesteads. Due to this reason, most adults might have a high chance of exposure to infective stages (encysted metacercariae). This finding agrees with the works of Fikirtemariam *et al.*(2013) and Teklu *et al.*(2015).

This result indicated a significantly lower prevalence of fasciolosis in cross-breed (9.4%) ruminants than the locals (29.7%). This might be due to the slaughter of a lower number of cross-breed ruminants. There was a statistically significant association between fasciolosis with breeds. Our results are in agreement with a study conducted by Teklu *et al.* (2015). This difference in prevalence based on breed might be due to the management of the animals as most of the indigenous animals were reared in an extensive system of management which makes them easily exposed to the parasites. Also, the same result was found in extensive and semi-intensive management systems, with a significant association in prevalence between extensive (30.3%) and semi-intensive (9.4%) cattle in necropsy findings. This might be because animals in extensive management systems were usually kept for grazing in the field whereas those animals in semi-intensive management systems were kept at homesteads. Due to this reason, most animals in extensive management systems might have a high chance of exposure to infective stages (encysted metacercariae). The maximum and minimum fluke burden observed in this study was 4 and 57 flukes per liver (range: 4-57). According to Soulsby (1982), the presence of more than 50 flukes per liver indicates a high pathogenicity. It has also been reported that significant production losses occur in infections with 30 flukes and/or herd prevalence of 25% (Vercruysse and Claerebout, 2001).

In this study, the sensitivity of the fecal examination technique was found to be 76.8% about the results of the liver examination and a very good agreement (k = 0.84) was observed between the two tests. However, this test suggested that about 23.2% of infected animals might pass undetected with a single fecal examination technique. The present sensitivity value (76.8%) is comparable to the reports of 81.5% at Haramaya town municipal abattoir, East Harrarghe zone by Tadesse and Usman (2022) and 71.1% in Northern Ethiopia (Assefa *et al.,* 2015) and 69% in Switzerland (Rapsch *et al*., 2006). However, it is much higher than the 35% sensitivity reported by Abunna *et al*.(2010) at Welaita Sodo. The low sensitivity of the sedimentation method may be attributed partly to the fact that *Fasciola* eggs only appear in feces 8-15 weeks post-infection. Furthermore, the detection of *Fasciola* eggs is not reliable during the prepatent period as eggs are expelled intermittently, depending on the evacuation of the gall bladder (Tadesse *et al*., 2021).

In the present study, the economic significance of fasciolosis analyzed indicated the annual loss from liver condemnation to be 945,999 ETB (18,192.288 USD). The study by Tadesse *et al*. (2019b) indicated more than 7 million ETB losses in five Ethiopian abattoirs. This finding was also higher than the result reported by Asefa and Belay (2015) who revealed an economic loss of about 321,750.00 ETB per annum in cattle and by Adane *et al*. (2019) 1,505,856 ETB ($43,024.45) annual losses due to liver condemnation at Wolaita Sodo municipal abattoir. The variation of loss, due to liver condemnation in this study may be due to the current increment of the price of the liver as compared to the preceding reports.

Limitations of the study

The major limitation of the study is that it does not include other factors such as loss of carcass, milk yield, and fertility (calving intervals, additional service) to estimate the total economic loss of bovine fasciolosis. However, it relied on the economic loss estimation based on liver condemnation alone. It also lacks testing more sensitive methods such as fluke finder and flotac instead of the commonly used conventional sedimentation technique for the present analytical test evaluation.

Conclusions

Fasciolosis is an important parasitic disease of cattle caused by two liver fluke species: *Fasciola hepatica* and *F. gigantica*. The present study recorded a moderate prevalence of bovine fasciolosis in Yirgalem municipal abattoir. The dominant *Fasciola* species identified was *F. hepatica* which induces economic losses due to liver condemnation and was found economically important parasite of cattle at the Yirgalem municipal abattoir. Moreover, the current study reflected that the higher prevalence of fasciolosis was present in those animals with poor body conditions, extensively reared and aged. There was a very good agreement between coprological examination and liver inspection in the diagnosis of fasciolosis. However, the disparity still observed indicated that coprological examination for parasite eggs has significant limitations in detecting the presence or absence of fasciolosis, while examination of the liver of animals during postmortem is the most reliable method to detect fluke infection. The annual economic loss of 945,999 ETB obtained in this study, signified the severity of the problem and the need for effective control measures that should be supported through studies on the economic importance of the infection in bovine species and epidemiology of the disease. Therefore, strategic control of the snail intermediate host should be performed to interfere with the life cycle of *Fasciola* alongside strategic treatment of infected animals with Fasciolicides.

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