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Fasciolosis in sheep and goats slaughtered at abattoirs in Central Ethiopia and associated financial losses

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ABSTRACT

Fasciolosis is a serious animal health problem in Ethiopia where livestock is crucial for the domestic economy. A study was conducted in two Ethiopian abattoirs to estimate the prevalence of *Fasciola* infection in goats and sheep, and the monetary losses resulting from liver condemnation. Post-mortem examination of 925 animals (424 sheep and 501 goats) were examined by incision of the liver parenchyma for presence of the liver fluke, *Fasciola*. The direct financial losses were calculated based on the estimated prevalence, the market price of the liver, and the average number of sheep and goats slaughtered annually. The overall prevalence of fasciolosis was 10.4% (20.7% sheep and 1.6% goats). Among the studied variables, species of the study animal and age in sheep showed a statistically significant association with infection ($p < 0.05$). Based on the annual average of 89,054 sheep and 76,374 goats slaughtered, the annual average economic loss due to the condemned liver was estimated at 3700 US$ (185,232 ETH Birr) for sheep and 245 US$ (12,220 ETH Birr) for goats.

This study revealed that the prevalence of fasciolosis was higher in sheep than in goats, and substantial economic losses occur for the sheep and goat industry. Hence, considering the irrigations schemes in the country, strategic control programs targeting *Fasciola* infection and intermediate hosts are warranted.

1. Introduction

Ethiopia has the largest livestock population in Africa, estimated at 60.39 million cattle, 31.3 million sheep, 32.74 million goats, 0.46 million camels, and 56.06 million poultry (Central Statistical Agency (CSA), 2018). Sheep and goats have significant socio-cultural roles, especially for farmers in Ethiopia, and contribute 25% of domestically consumed meat and 6.18% of exported meat. Moreover, there are substantial earnings from the export of live animals, edible organs, and skin (Legese and Fadiga, 2014).

Despite the high potential and existing favorable conditions, the current contribution of livestock in general and sheep and goats to the national economy is limited. Livestock diseases are one of the constraints that limit the production and productivity of animals. Among others, fasciolosis, or liver fluke infection, is the most common helminth infection reducing animal productivity. The distribution of fasciolosis is dependent on the ecology of aquatic snail intermediate hosts that inhabit both tropical and temperate climatic zones. *Fasciola hepatica*, whose intermediate host is *Lymnaea truncatula* has cosmopolitan distribution in high-altitude, temperate, and

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cooler areas in tropical and subtropical areas, while *F. gigantica*, whose intermediate host is the *Lymnaea natalensis* is distributed widely in tropical regions (Urquhart et al., 2007).

Acute fasciolosis is caused by the migration of the juvenile fluke in the liver parenchyma, which leads to liver inflammation, hemorrhage, necrosis, and fibrosis. Chronic fasciolosis develops because of the presence of adult fluke in the bile duct that causes physical damage to the liver and bile duct. Fasciolosis is usually characterized by chronic inflammation of the liver and bile ducts, often acute or subacute, accompanied by submandibular edema, anemia, anorexia, weight loss, unthriftiness, ascites, and death. Anemia and hypoproteinemia are due to blood loss in the bile. Chronic infections are rarely fatal in cattle but often fatal in sheep (Ibrahim, 2017). During postmortem examination, the liver is pale, friable and the bile ducts are enlarged and packed with adult fluke (Underwood et al., 2015).

Fasciolosis has great impact on the economy, due to its high incidence and direct effect on the animal productivity (Mas-coma, 2005). The direct loss is incurred through liver damage that leads to total liver condemnation, mortality, and cost of control (Okewole et al., 2000), while indirect loss is through decreasing productivity, lower birth weight, reduced growth rate, poor quality of wool and skin, and lower resistance to other diseases (Ngategize et al., 1993). Human fasciolosis also causes significant health problems, especially in farming communities with low incomes (Caravedo and Cabada, 2020).

In Ethiopia, the prevalence of sheep and goats fasciolosis is varying and widespread (Ahmed et al., 2007; Kedir et al., 2012). Reports from central Ethiopia show that the annual loss due to ovine fasciolosis to be 1 million US $ (48.4 million ETH Birr) from mortality, loss of productivity, and liver condemnation (Ngategize et al., 1993). The epidemiology of fasciolosis is complex that can change over the years (Mungube et al., 2006) and the economic loss also changes over the years. Hence, assessing the change in the trends of prevalence and monetary loss in Addis Ababa abattoir enterprise and Abyssinia slaughtering service house where there is a higher slaughter rate for domestic consumption and export, respectively was found necessary. Therefore, the objectives of this study were to estimate the prevalence of sheep and goats fasciolosis, assess its associated risk factors and financial loss at Addis Ababa Abattoir enterprise and Abyssinia slaughtering service house.

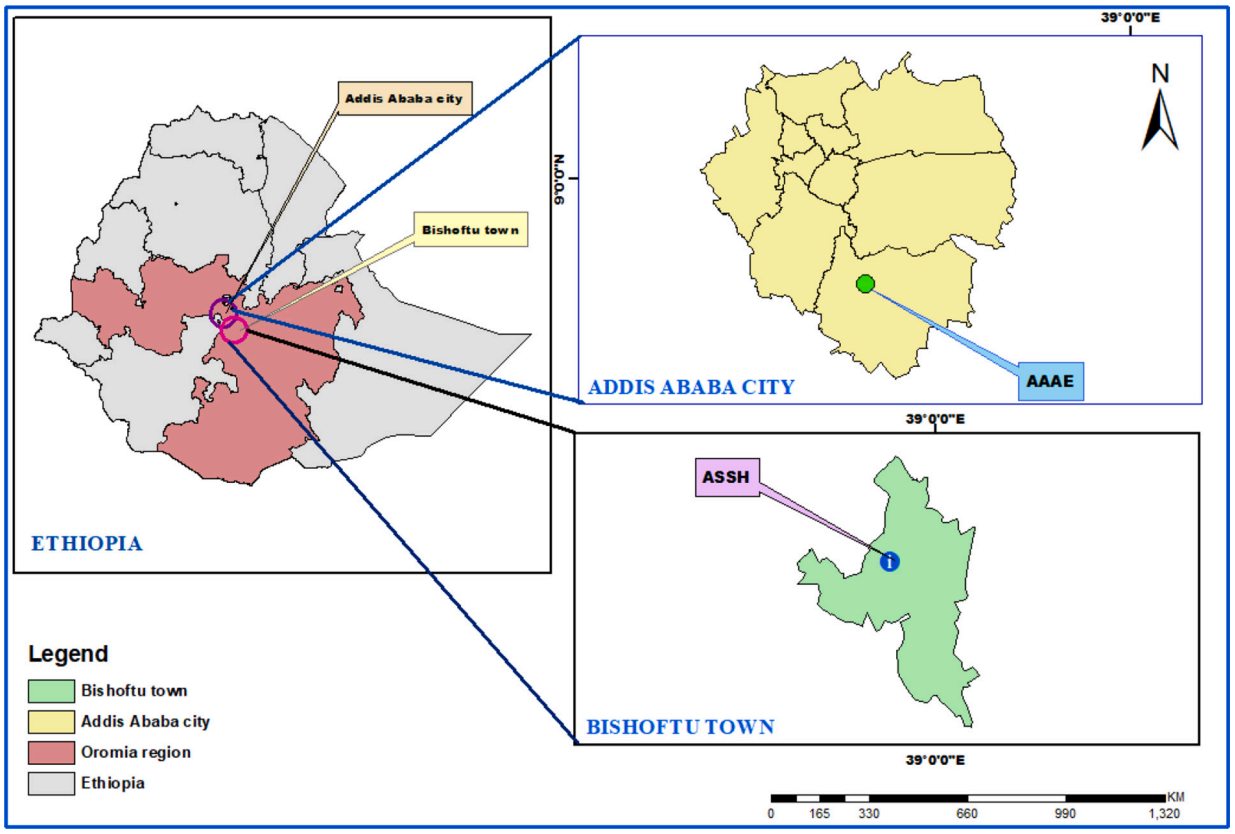

Fig. 1. Location of Addis Ababa Abattoirs enterprise (AAAE) and Abyssinia Slaughtering Service House (ASSH) in Central Ethiopia. (Source: created by Arch map 10.2).

2. Materials and methods

2.1. Study area

This study was conducted in two selected abattoirs in central Ethiopia namely, Addis Ababa Abattoir enterprise and Abyssinia slaughtering house. Addis Ababa Abattoir enterprise is the largest abattoir located in the capital city of the country. It was established in 1983 for the slaughter of cattle, sheep, goats, and swine for local consumption. The abattoir is situated at 11°1′48" N and 39°37′59.83″ E, at an altitude of 2000 m a.s.l. – 3000 m a.s.l. The total human population in the city in 2020 was estimated to be 4,793,699.

Abyssinia slaughtering service house is an export abattoir located in Bishoftu town, 45 km southeast of Addis Ababa. The town is situated at f 9°N latitude and 40°E longitude, elevation of 1788 to 1825 m.a.s.l. The annual temperature of the town is 19.5 °C. Abyssinia slaughtering service house is a private limited company established in 2007 mainly to export meat of livestock to foreign countries. Fig. 1 shows the location of the two study abattoirs.

2.2. Study population

The study population includes sheep and goats brought to Addis Ababa abattoir enterprise and Abyssinia slaughtering service house for slaughter from December 2019 to March 2020 from various parts of the country. Depending on the origin, sheep and goats were classified as lowland and highland. Sheep and goats of various age groups (young = no full permanent teeth and adult = full permanent teeth) and both sexes (male and female) were included in the study.

2.3. Study design and sampling method

A cross-sectional study design was used to estimate the prevalence of fasciolosis in sheep and goats and assess the associated risk factors and financial loss from the condemnation of infected liver. A regular abattoir visit was arranged for 5 days every month during the study period. Stratified sampling was used to select animals at the species level and a systematic random sampling method was used to sample individual animals.

2.4. Sample size determination

The sample size was determined according to Thrusfield's (2005) formula by considering 50% expected prevalence in both sheep and goats and with 5% precision to have a larger sample size. Accordingly, 768 (384 sheep and 384 goats) was the calculated sample size. However, to compensate for sample losses during sample processing, this sample size was increased to 925 (424 sheep and 501 goats) from the two selected abattoirs.

2.5. Anti-mortem examination

During the ante mortem inspection, information regarding the species, sex, body condition, and origin of the animal was recorded. The age of each animal was estimated based on the dentition formula as given by Abegaz and Awgichew (2009). The body condition score was classified into three categories: lean (1,2), medium (3), and fat (4, 5), according to Thompson and Meyer (1994).

2.6. Post-mortem examination

Examination of livers for fluke infection was performed during post-mortem examinations, following standard meat inspection procedures; where the liver of individual animals was visually inspected, palpated, and incised (Food Agriculture Organization of the United Nations (FAO), 2003).

2.7. Direct economic loss assessment

Direct economic loss was assessed by counting the number of livers affected and condemned due to fasciolosis. The annual loss from liver condemnation was calculated by considering the total annual slaughter and the average price of the sheep and goat liver in the abattoir and retail market. According to the information gathered from the butcheries in Addis Ababa and Bishoftu, an average price of sheep and goat liver costs 0.2 US$ (10 ETH birr). Based on this, the calculation for the economic loss due to the disease was carried out following the formula defined by Ogunrinade and Adegoke (1982): ALC = CSR X LC X P; Where, ALC = Annual loss from liver condemnation, CSR = Mean annual sheep and goats slaughtered at the abattoir, LC = Mean cost of one liver at Addis Ababa city and Bishoftu town, and P=Prevalence of the disease at the study abattoirs.

2.8. Data analysis

The collected data were entered into Microsoft Excel, 2010 spreadsheet for storage, and analyzed using STATA version 11.0 for Windows (Stata Corp. College Station, TX, USA). Descriptive analysis was performed to summarize the data. Prevalence was sorted by

study abattoir, sex, age, body condition, and origin. The statistical association was tested using the Chi-square test. Logistic regression analysis was used to detect predictors for fasciolosis infection in sheep and goats. The odds ratio (OR) and the 95% confidence intervals (CI) were calculated and the level of significance of $\alpha = 0.05$ was considered in all the analyses.

3. Results

3.1. Prevalence of fasciolosis in sheep and goats

Out of the total 925 sheep and goats examined at Addis Ababa abattoir enterprise and Abyssinia slaughtering service house, 96 (10.4%) of them had flukes in their liver. In Addis Ababa abattoirs enterprise out of the 308 sheep and 125 goats examined, 64(20.8%) and 3 (2.4%) had liver fluke infection, respectively. Similarly, in Abyssinia slaughtering service houses out of the examined 116 sheep and 376 goats, 24(20.7%) and 5 (1.3%) of them had flukes in their liver, respectively. The prevalence of liver flukes was significantly higher ($p < 0.05$) in sheep than in goats in both abattoirs (Table 1).

Age was the only variable which showed statistically significant association ($P < 0.05$) with prevalence of fasciolosis in sheep. Higher prevalence was recorded in young 25.8% (49/190) than in adult 16.7% (39/234) sheep slaughtered in the two abattoirs. The body condition showed marginal significance with prevalence of the infection being higher in sheep with medium and lean body conditioned than those with fat body condition. Sex, and animal origin didn't show any statistically significant association ($p > 0.05$) in sheep. None of the studied variables showed significant association with prevalence of fasciolosis in goats (Table 2).

3.2. Logistic regression analysis of risk factors of sheep and goat liver fluke infection

Results of the univariable logistic regression analysis showed that the odds of acquiring liver flukes were significantly higher in sheep (OR = 16.1, 95%CI = 7.7, 33.7; $p < 0.001$) than in goats and in female (OR = 3.1, 95%CI = 2.0, 4.8; $p < 0.001$) than in male animals. Similarly, animals with lean body conditions (OR = 6.8, 95%CI = 2.1, 22.6; $p = 0.002$) and medium body conditions (OR = 3.6, 95%CI = 1.1, 11.7; $p = 0.033$) than with fat body condition and animals from highland (OR = 4.3, 95%CI = 2.8, 6.6; $p = 0.000$) than lowland origin were more likely to acquire fasciolosis. However, no statistically significant difference was detected in the prevalence of fasciolosis between the adult and young animals (Table 3).

Based on their collinearity (<50%) and *p*-value (<0.25), all variables, except for origin of the animal were included in multivariable logistic regression analysis. The analysis revealed that species of the animals is the predictor of liver fluke infection in the study areas (Table 3).

3.3. Financial analysis of liver condemnation at the two abattoirs

The direct financial loss from liver condemnation because of fasciolosis was computed as the sum of the costs of the condemned liver in sheep and goats slaughtered annually at the two abattoirs. The sum of the average annual slaughter of sheep at two abattoirs was 89,054 (74,866 at AAAE and 14,188 at ASSH). Accordingly, considering the 0.2 US$ (10 ETH Birr) retail price of sheep liver and the 20.8% prevalence, annual losses due to condemned livers at the two abattoirs was estimated at 3700 US$ (185,232 ETH Birr). On the other hand, the sum of the average annual slaughter of goats at two abattoirs was 76,374 (30,384 at AAAE and 45,990 at ASSH). Accordingly, considering the 0.2 US$ (10 ETH Birr) retail price of goat liver and the 1.6% prevalence, annual losses due to condemned livers at two abattoirs was estimated at 245 US$ (12,220 ETH Birr).

4. Discussion

The overall prevalence of sheep and goat liver fluke infection in the current study was 10.4% (96/925), which was lower as compared to the 24.0% in Jimma, southwestern Ethiopia (Kedir et al., 2012). Higher prevalence such as 28.7% in sheep and 13.9% in goats, from Debre Zeit, central Ethiopia (Abdulhakim and Addis, 2012), and 18.8% both in sheep and goats in Dessie, northern Ethiopia (Berhe et al., 2017) were reported. Prevalence value of 39.1% in sheep and 35.0% in goats in Nigeria (Isah, 2019), 14.7% in sheep in Egypt (Amer et al., 2016), 6.6% in sheep and goat of Iran (Khanjari et al., 2014) were also reported. Generally, the moderately high prevalence reports in Ethiopia indicate the endemicity of fasciolosis in sheep and goats in various regions. However, the variation

Table 1
Prevalence of liver fluke in sheep and goats in the two Ethiopian abattoirs.

Study Abattoir	Animal species	Number examined	No. positive	Prevalence (%)	(Chi-Square)	*p*-value
AAAE	Sheep	308	64	20.8	22.96	0.000*
	Goat	125	3	2.4		
	Total	433	67	15.5		
ASSH	Sheep	116	24	20.7	59.90	0.000*
	Goat	376	5	1.3		
	Total	492	29	5.9		
Ground total		925	96	10.4		

AAAE- Addis Ababa Abattoir Enterprise, ASSH- Abyssinia Slaughtering Service House, *- statically significant value.

Table 2
Prevalence of fasciolosis based on sex, body condition, origin, and age of sheep and goats slaughtered in two abattoirs of central Ethiopia.

Risk factor	Category	Sheep			Goats		
		No. examined	No. positive (%)	Chi-square (P-value)	No. examined	No. positive (%)	-Chi-square (P-value)
Sex	Male	195	35 (17.9)	1.73 *(0.189)*	334	7 (1.6)	0.005 *(0.942)*
	Female	229	53 (23.1)		67	1 (1.5)	
Body condition	Fat	32	2 (6.2)	4.93 *(0.085)*	76	1 (1.3)	4.75 *(0.093)*
	Medium	215	50 (23.3)		363	4 (1.1)	
	Lean	177	36 (20.3)		62	3 (4.8)	
Animal origin	Lowland	164	31 (18.9)	0.56 *(0.455)*	485	7 (1.4)	2.27 (0.131)
	Highland	260	57 (21.9)		16	1 (6.2)	
Age	Adult	234	39 (16.7)	5.31 (*0.021**)	309	6 (1.9)	0.61 (0.435)
	Young	190	49 (25.8)		192	2 (1.0)	

* Statistically significant value.

Table 3
Logistic regression analysis of factors related to the occurrence of fasciolosis in sheep and goats.

Factors	Category	No. examined	No. positive (%)	Univariable		Multivariable	
				OR 95%CI	P-value	OR 95%CI	P-value
Species	Goat	501	8 (1.6)	1		1	
	Sheep	424	88 (20.7)	16.1(7.7,33.7)	0.000	13.9(6.4,30.2)	0.000*
Sex	Male	629	42 (6.7)	1		1	
	Female	296	54 (18.2)	3.1(2.0,4.8)	0.000	1.4(0.9,2.3)	1.436
Age	Adult	543	45 (8.3)	1	0.014	1	
	Young	382	51 (13.3)	1.7(1.1,2.6)		1.7(1.0,2.9)	0.066
Body condition	Fat	108	3 (2. 8)	1		1	
	Medium	578	54 (9.3)	3.6(1.1,11.7)	0.033	2.8(0.82,9.56)	0.097
	Lean	239	39 (16.4)	6.8(2.1,22.6)	0.002	1.7(0.58, 1.5)	0.406
Origin	Lowland	649	38 (5.86)	1			
	Highland	276	58 (21.01)	4.8(2.8,6.6)	0.000		

OR-odd ratio; CI-confidence interval, No.- Number.

in the prevalence among the regions and countries might be attributed to the difference in presence of a favorable environment for the intermediate host, snails. It might also be due to differences in the use of anthelmintic against the parasite in the farming community. The moderate prevalence reported in the present study compared to past reports might be due to the time of the study, where the current study was carried out in the dry season when most of the snail habitats were dried up (Yilma and Mesfin, 1998).

The prevalence of fasciolosis was considerably higher in sheep (20.75%) as compared to goats (1.59%) in the present study, which agrees with the previous reports (Kedir et al., 2012; Bayu et al., 2013). The difference in the grazing behavior of the two species could be responsible for the higher prevalence of fasciolosis in sheep than in goats. Sheep are grazers while goats are browsers, hence goats do not normally graze marshy areas where there is a great possibility of acquiring the metacercaria together with the grass (Kantzoura et al., 2011; Abdulhakim and Addis, 2012). It could also be due to differences like their immunological response to the *Fasciola* parasite, as sheep acquire low resistance (Phiri et al., 2006).

Fasciolosis affect both sexes equally as reported by Birhanu et al. (2015) from the Addis Ababa abattoir enterprise. However, in the current study, higher prevalence of fasciolosis was detected in female compared to male sheep and goats, which might be due to the disproportion in the number of examined females than male animals slaughtered during the study period. According to personal observation during the study period, male sheep and goats were brought from southern and eastern lowland areas of Ethiopia, while female animals, mainly sheep were brought from nearby highlands in central Ethiopia, where fasciolosis is more prevalent. Therefore, the effect of origin where sheep and goats were brought might have attributed to the sex-wise difference in the prevalence in the present study.

Sheep and goats with lean and medium body conditions were found to harbor *Fasciola* parasites than those animals with fat body conditions. The association of fasciolosis with lean body conditioned animals could be related to the susceptibility of such animals to parasitic infections as described by Devendra and Marca (1983). It can also be justified that *Fasciola* spp. are known to suck blood and tissue fluid with serious damage to the liver parenchyma, especially during the migratory phase of the juvenile worm (Marquardt et al., 2000).

Furthermore, chronic fasciolosis can also lead to loss of body condition due to the development of cholangitis and liver cirrhosis caused by the adult worms in the bile duct that block the bile flow to the duodenum, consequently reducing the lipid emulsification, fatty acid digestion, and lipid-soluble vitamins, and hence affect the feed conversion rate (Gargili et al., 1999). Hence, the current study supported the importance of fasciolosis as a cause of weight loss and emaciation in sheep and goats (Radiostits et al., 2007).

Although not statistically significant, the prevalence of fasciolosis was a bit higher in sheep of highland origin than those from lowland areas. This is primarily due to the more frequent distribution of the snail intermediate host, *Lymnaea truncatula* in highland areas. Generally, successful breeding of the *Lymnaea* snails and development of the larval flukes in the intermediate host require

adequate bionomic conditions. In Ethiopia, the ideal condition for the breeding of snails is during the rainy season, which is long enough in the highland areas compared to the very short rainy season in the lowland areas. In the lowland areas due to the long dry season and absence of wet and swampy areas, the distribution of *Lymnaea* spp. is limited in lowlands (Yilma and Mesfin, 1998).

Sheep and goat fasciolosis causes a significant financial loss to the farmer through loss of body condition reducing the market value, cost of treatment, condemnation of infected liver in the abattoirs, and death of the animals that impact the profits from animal agriculture and affect food security (Admassu et al., 2015). In current study, the estimated total direct monetary loss was 172,000 ETB in both abattoirs, which is higher than the 157,684 ETB loss recorded in central Ethiopia by Bayu et al. (2013). The disparity in the number of ruminants slaughtered in the abattoirs and the change in the price of the liver over time might influence the variation in the monetary loss. The estimated economic losses could be an underestimation, as the real monetary loss from fasciolosis has to consider the loss from death, therapy costs, and other indirect costs of production and reproduction. Nevertheless, it is important to interpret the estimated annual monetary loss from the condemnation of liver in this study with caution because loss is dependent on the market values of sheep and goats as organ condemnation, the prevalence of disease, and the number of animals slaughtered per year alters the amount of the financial loss.

On the other hand, currently, ranges of small-scale irrigation schemes are developing to ensure sustainable food production in several areas of Ethiopia. There are also large-scale dam constructions for the improved power supply and food production to support economic development. However, the implementation of such irrigated agriculture and dams might lead to environmental and ecological changes that might modify the distribution and density of vectors intermediate host species, resulting in the occurrence and increased incidence of tropical vector-borne diseases of both animals and humans such as the fasciolosis, malaria, schistosomiasis, and filariasis (Yewhalaw et al., 2014). Consequently, there is a need to plan intervention strategies in parallel to reduce the risk if it occurs. As a limitation, we didn't confirm the *Fasciola* species detected during the liver examination, which might help the species-specific comparison between sheep and goats s of highland and lowland origin. Secondly, the present study was conducted during the dry season, however, a longitudinal data comparing the seasonal variation of liver fluke infection in the highlands and lowlands together with its relation to the body condition of sheep and goats could improve the understanding of the seasonal variations in the prevalence of the disease.

5. Conclusions

The prevalence of fasciolosis was higher in sheep than goats, and more so in animals with lean body conditions than in medium and fat body conditions, and in highland animals than in lowland. The annual economic loss from liver condemnation due to fasciolosis is substantial. Therefore, considering the irrigations schemes in the country, strategic control programs are needed to prevent parasites in such areas and avoid pasture contamination with fecal eggs. Regular deworming of sheep and goats using Triclabendazole, as well as educating farmers regarding fasciolosis are necessary for the successful control of fasciolosis.

Declaration of Competing Interest

The authors declare no competing interests.

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