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Co-infection of fasciolosis and hydatidosis and their financial loss in cattle slaughtered at Wolaita Sodo municipal abattoir, southern Ethiopia

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Abstract

Fasciolosis and hydatidosis are the world's most common zoonotic major parasitic ailments of domesticated animals with financial and public health implications. A cross-sectional study was conducted on 384 randomly selected cattle slaughtered at Wolaita Sodo municipal abattoir to estimate the prevalence and associated risk factors for co-infection of hydatidosis and fasciolosis using the ante- and postmortem examination techniques. Of the 384 examined cattle, 4.17% were found to harbor co-infections of hydatidosis and fasciolosis. Similarly, the prevalence of concurrent fasciolosis and hydatidosis infections was 76.56% and 23.44% in local and crossbred animals, respectively. The current study took into account risk factors such as age, breed, origin, and body condition score; however, there is a statistically insignificant association between the risk factors and the prevalence of concurrent fasciolosis and hydatidosis infection. In this study, overall fasciolosis was recorded at a rate of 9.38%, with the highest prevalence of *F. hepatica* at 8.59%, followed by unidentified flukes at 4.17% and *F. gigantica* at 0.78%. Likewise, the single prevalence of hydatidosis was recorded at 10.94%. Of the 142 examined cysts, the liver alone harbors 54 cysts, and the lung alone harbors 88 cysts, with a total of 43 calcified, 21 sterile, 56 viable, 9 nonviable, and 13 mixed cysts. The predicted yearly financial loss from organ condemnation was 15,436,142.00 ETB Birr. This study demonstrated that hydatidosis and fasciolosis are two relatively widespread parasite diseases of cattle in Ethiopia, causing significant economic loss attributable to organ rejection and indirect weight loss. Thus, awareness of the impact of the disease on the community could disrupt the parasite's life cycle, and its economic significance was forwarded to other points.

Keywords: Cattle, Concurrent Infections, Economic Loss, Fasciolosis, Hydatidosis

Main text

The production of cattle is hindered by parasitic diseases such as fasciolosis, which is widespread in tropical and subtropical regions, and *Fasciola hepatica* and *F. gigantica* are the two liver flukes, and responsible for fasciolosis in ruminants (Keyyu et al. 2005). Worldwide, the geographic distribution of Fasciola species depends on the geographic range of intermediate hosts, such as *Lymnaea natalensis* and *Lymnae truncatula* snails, and is frequently linked to herds and flocks grazing wet, marshy land areas (Ashrafi et al. 2006). Additionally, numerous researchers have noted the prevalence and economic importance of fasciolosis caused by *F. hepatica* and *F. gigantica* in Ethiopia (Abunna et al. 2010; Bekele et al. 2010; Petros et al. 2013). Snail intermediate hosts can find suitable habitats all year long in Ethiopia's highlands' isolated pockets of marshy vegetation (Legesse et al. 2015).

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Infection with the metacestode stage of the Echinococcus species (*Echinococcus granulosus* (cystic echinococcosis, CE), and *E. multilocularis* (alveolar echinococcosis, AE) known as hydatidosis occurs in both humans and animals (Parija and Sahu 2005). The parasite's primary hosts are dogs and other canids, while livestock serves as an intermediate host. A bizarre intermediate host is a man. Infected animals and humans develop hydatid cysts in their lungs, livers or other organs. Humans who have hydatid cysts suffer from severe illness and eventually pass away, as well as suffer financial losses from the associated medical expenses and decreased annual livestock production (Brunetti 2010). One of the most crucial aspects of the disease's epidemiology is the fertility of the hydatid cysts that develop in different intermediate host species (Otero-Abad and Torgerson 2013). Hydatid cyst fertility varies geographically and according to intermediate host species (Saeed et al. 2000).

Public health issues are also associated with hydatidosis and fasciolosis, which can infect people when they unintentionally consume parasite eggs or larvae that have been released into the environment with the feces of permanent hosts (Ashrafi et al. 2006) and (Belina et al. 2012). Thus, productivity loss caused by helminth infections can be significantly decreased by implementing efficient disease control strategies, which necessitate an understanding of the epidemiology and ecology of parasites and parasitic infections under local conditions, the effective utilization of the vast country's herd of cattle, and protection of the general populace from zoonotic parasite infection (Kerala et al. 2021).

Several independent studies carried out in various regions of Ethiopia revealed that hydatidosis and fasciolosis are extremely common and pose financial losses. The Wolaita zone in southern Ethiopia is home to cattle that are infected with hydatidosis and fasciolosis simultaneously. However, little is known about this situation. So, the purpose of this study was to estimate the prevalence of hydatidosis and fasciolosis co-infections as well as the risk factors linked to these infections in cattle slaughtered at the Wolaita Sodo Municipal Abattoir in southern Ethiopia.

Table 1 Frequency of co-infections of fasciolosis and hydatidosis in cattle slaughtered at Wolaita Sodo Municipal abattoir

Variables	Categories	N^O^	NPA	Prevalence (%)
Origin	Lowland	310	72	23.23
	Highland	74	22	29.73
Age	Young	166	41	24.70
	Adult	218	53	24.31
Breed	Local	294	75	25.51
	Cross	90	19	21.11
Body condition score	Good	84	19	22.62
	Moderate	258	64	24.81
	Poor	42	11	26.19

*N^O^* number of animals inspected, *NPA* number of positive animals

Prevalence of co-infection of fasciolosis and hydatidosis

During the study period, 384 cattle were slaughtered and examined at the Wolaita Sodo Municipal abattoir. Totally 16/384 of the animals tested positive for hydatidosis and fasciolosis at the same time. Similarly, the proportion of animals infected with Fasciola alone (36/384) was roughly equivalent to the proportion of animals infected with hydatidosis alone (42/384).

Local breeds had a higher prevalence of fasciolosis and hydatidosis coinfections than crossbreds. The prevalence of fasciolosis and hydatidosis in cattle was determined based on the animal's age, breed, origin and body condition (Table 1).

The effect of different risk factors on the prevalence of concurrent infection was investigated using univariate logistic regression analysis, and the results showed that different risk factors had statistically insignificant ($p > 0.05$) effects on the occurrence of hydatidosis and fasciolosis concurrent infection in cattle, as shown in Table 2.

Hydatid cyst fertility

According to the cyst fertility assessment, the liver and lung contained 54 and 88 cysts of various characteristics, respectively, out of the 142 examined cysts (Table 3).

Over all flukes prevalence

Of a total of 52 (13.54%) liver fluke-infected animals, *F. hepatica* (8.59%) had the highest prevalence, followed by unidentified immature infection (4.17%) and *F. gigantica* (0.78) (Table 4).

Estimation of economic loss

Direct loss

The direct yearly economic loss for fasciolosis and hydatidosis was calculated as yearly economic loss = (PI1 ×TKC1) + (PI2×TK×C2), where PI1 denotes the percentage of lung involvement out of the total examined, PI2 denotes the percentage of liver involvement out of the total examined, C1 denotes the average market price of the liver, C2 denotes the average market price of the lung, and TK denotes the average annual slaughter of ruminants (Toffik Kebede 2014). To obtain TK, if 60 cattle are slaughtered per week on average, 240 cattle are slaughtered per month and 2880 cattle are slaughtered per year, i.e., 60×4×12 = 2880) (Table 5). Annual economics loss = (14.06×310×2880) + (22.92×40×2880) = 15,193,452.

Table 2 The output of a univariable logistic regression of risk factors and their odds of exposure

Variables	Categories	N^O	NPA	*p*-value	χ2	OR	95% CI
Origin	Highland	74	22	0.242	1.367	1.399	0.796–2.458
	Lowland	310	72			Ref	
Age	Young	166	41	0.930	0.0076	1.021	0.639–1.633
	Adult	218	53			Ref	
Breed	Local	294	75	0.396	0.721	1.280	0.724–2.263
	Cross	90	19			Ref	
Body condition score	Moderate	258	64	0.685	0.2387	1.129	0.629–2.024
	Poor	42	11	0.658		1.214	0.5152–2.860
	Good	84	19			Ref	

N^O number of animals inspected, *NPA* number of positive animals, *CI* confidence interval, *OR* odds ratio

Table 3 Distribution of cysts in the lung and liver based on their fertility status in cattle

Organ	Types of cysts					Total
	Viable	Non-Viable	Mixed	Sterile cyst	Calcified cyst	
Liver	26	0	7	10	11	54
Lung	30	9	6	11	32	88
Heart	0	0	0	0	0	0
Kidney	0	0	0	0	0	0
Total	56	9	13	21	43	142

Table 4 Occurrence of fasciola species in cattle slaughtered at Wolaita Sodo Municipal abattoir

Variables	Frequency	Percentage
Fasciolosis		
Positive	52	13.54
Negative	332	86.46
Species of fasciola		
F. gigantica	3	0.78
F. hepatica	33	8.59
Immature (unidentified)	16	4.17

Table 5 Direct financial loss due to co-infection of hydatidosis and fasciolosis

Species	No of slaughtered animals	Organ type	Total examined organs	No of positive organs	Percent involvement of organ	Average unit price	Total loss (ETB)
Bovine	384	Liver	384	54	14.06	310	12,552,768
		Lung	384	88	22.92	40	2,640,384
Total	384		384	142	36.98	350	15,193,152

Indirect loss

The indirect yearly economic losses due to carcass weight loss will be calculated as annual economic losses due to carcass weight loss = Ns × Ci × Pa. where Ns = total number of animals slaughtered and positive for hydatidosis and fasciolosis; Ci = carcass weight lost in individual animals; Pa = Average market price of a kg of mutton in Wolaita Sodo. For bovine, the average carcass weight loss is 5%. The price of meat is 550 Ethiopian birr per Kg. Thus, indirect financial loss due to co-infection of hydatidosis and fasciolosis is up to 242,990 Ethiopian birr in this area. Annual economic losses will be calculated by adding both direct and indirect losses.

Meat inspection plays an important role in disease monitoring by providing feedback information to the veterinary service to control or eradicate diseases, produce safe products, and protect the public from zoonotic hazards (Vimiso et al. 2013). The prevalence of concurrent hydatidosis and fasciolosis infection in cattle slaughtered at the Wolaita Sodo Municipal abattoir was found to be 4.17% in the current study. This finding is lower than the 8% prevalence found in a similar study in cattle slaughtered at the Mekelle municipal abattoir (Berhe et al. 2011). The current finding, however, were roughly consistent with those of Kerala's report, which were recorded at 3.93% at Butajira Municipal Abattoir in southern Ethiopia (Kerala et al. 2021). The similar origins of animals may have contributed to the agreement.

Several studies have been conducted to determine the prevalence of most widespread zoonotic diseases: hydatidosis or fasciolosis. Furthermore, the majority of the disease is found in abattoir surveys, particularly in intermediate hosts (cattle). As a result, the abattoir study was the only certain place for diagnosis. As a consequence, liver and lung lesions are mostly visible and distinct to the naked eye. It states that infected organs are removed (Fasihi Harandi et al. 2012).

This study showed that the sole prevalence of hydatidosis was recorded at 10.94%. Furthermore, the frequency of hydatid cysts in cattle was lower than the prevalence reported in the dire Dawa municipal abattoir at 20.05% (Mulatu et al. 2013); in Shire Municipal Abattoir at 32% (Afera 2014); in Libya at 15% (Otero-Abad and Torgerson 2013); and elsewhere at 18.61% (Assefa 2014), 35.15% (Fromsa and Jobre 2011), 46.8% (Bekele et al. 2010), and 32.11% (Berhe et al. 2011). These variations in disease prevalence could partly be owed to differences in environmental and other features, differences in way of life, social experience, husbandry systems, garden slaughtering of domesticated animals, the absence of proper offal landfilling, and perceptions towards certain stray dogs (Kebede et al. 2009). Furthermore, the presence of adult worms in dogs and larval stages in ruminants contributes to the disease's widespread geographical distribution, which may be attributed to the worldwide availability of susceptible hosts, increased harm to the environment, and diversity in animal origin, mode of pastureland, and other environmental factors (Elmahdi et al. 2004).

The present finding reveals that the occurrence of fasciolosis in cattle was 9.38%. These results were approximately in line with the report from Kenya at 8% (Kithuka et al. 2002). However, this finding was lower than the prevalence of fasciolosis, which was 24.32% at the Mekelle municipal abattoir (Berhe et al. 2011), 20.18% at the Dessie municipal abattoir (Yalew et al. 2016), 24.29% at the Butajira Municipal Abattoir (Kerala et al. 2021), and 23.41% from the Zaria abattoir (Raji et al. 2010). This difference could be attributed to variations in animal sources. Furthermore, these differences in infection rates could be due to differences in sample size, study periods, and animal origins. Besides that, the availability of suitable habitats for the vectors is one of the most important factors influencing the occurrence of fasciolosis in an area (Bekele et al. 2010).

Concerning the percentage of Fasciola species identified, the current study established that 8.59% *F. hepatica*, 0.78% *F. gigantica*, and 4.17% mixed infection were obtained. These results disagreed with the report of Bekele (Bekele et al. 2010), who recorded the three flukes as 13.9% *F. hepatica*, 7.7% *F. gigantica*, and 4.7% immature flukes. *F. hepatica* has been identified as the dominant species responsible for fasciolosis (Bekele et al. 2010; Tolosa and Tigre 2012). This was linked to the presence of favorable ecological conditions for *L. truncatula* (the study area's intermediate host for *F. hepatica*), such as swampy areas, small irrigation, marshy areas in the low-lying plain area, and temporary shallow ponds (Bekele et al. 2010).

In this study, hydatid cysts were found primarily in the lungs and liver, accounting for 88 and 54 cysts, respectively. Other research indicates that hydatid cysts are most commonly found in the lungs and livers of ungulates (Taylor et al. 2001), which is consistent with previous findings (Bekele and Butako 2011; Eckert and Deplazes 2004), that show that lung and liver are the most common sites of hydatid cysts in domestic animals. This could be explained by the fact that these organs have larger capillary fields, allowing these organs to filter ingested oncospheres from the blood more efficiently. Before other organs are invaded, liver performs primary filtration of blood from portal veins, which is followed by pulmonary filtering actions. Only blood-transferring oncospheres reach the systemic circulation and other tissues (Eckert and Deplazes 2004).

In this research, 88 lungs and 54 livers were condemned due to fasciolosis and hydatidosis, resulting in a total economic loss of 12,552,768 and 2,640,384 ETB, respectively. This was computed using the average market price of cattle liver (310 birrs) and cattle lung (40 birrs). The direct annual economic loss, on the other hand, was calculated by taking into account the annual slaughter rate of cattle as well as the prevalence of fasciolosis and hydatidosis per liver and lung. It is estimated to be 15,193,152.00 ETB per year. Furthermore, the indirect economic loss was estimated using a 5% carcass weight loss due to hydatidosis and fasciolosis (Zewdu, Teshome and Makwoya, no date). As a result, the calculated result showed an indirect loss of 242,990.00 ETB per year. As a result, the total estimated economic loss in cattle at the Wolaita Sodo municipality abattoir due to hydatidosis and fasciolosis was 15,436,142.00 ETB or 308,722.84 USD at the ETB 50 to the USD exchange rate. The current finding is significantly higher than the results reported by (Petros et al. 2013), who reported a total economic loss of 63,072 ETB ($1,182,600) in cattle at the Nekemte municipal abattoir annually.

Conclusion

This study revealed that the higher rate of co-infection of hydatidosis and fasciolosis were recorded in local breeds than crossbreeds, lowland than highland, and moderate than poor body conditions. Lung had a higher prevalence of hydatid cysts than the liver. The majority of the flukes found were caused by *F. hepatica*. In conclusion, feeding contaminated offal to pets and stray dogs should be avoided. Domestic ruminant deworming with appropriate flukicide, the establishment of standard metropolitan processing plants, and appropriate meat examination should all be established. Supervision and prevention of home slaughtering practices should be conducted.

Methods

Study animals and study design

The study was conducted at the Wolaita Sodo Municipal Abattoir in Wolaita Sodo and cattle brought to the Wolaita Sodo Municipal Abattoir for slaughter were the study animals. A cross-sectional study was carried out from November 2021 to June 2022 to determine the concurrent prevalence and financial loss of hydatidosis and fasciolosis in cattle slaughtered at Wolaita Sodo Municipal Abattoir, Wolaita Zone, southern Ethiopia. Animals were estimated based on owners information and dentition pattern and grouped into young (<6 years) and adult (6 years) age groups (Wakeman and Pace 1983). The body condition score of cattle was given according to Nicholson and Butterworth (1986) with a scale of 1.0 to 9.0 and categorized into good (7 was classified as good/fat), medium (4, 5, 6, were medium), and poor (2, 3 were categorized as poor/lean) body conditions. The distance above sea level is defined as altitude. Areas are sometimes referred to as "highland" if they reach at least 1000 m in elevation, whereas those below 1000 m are referred to as "lowland" (Berhe et al. 2011).

Sample size determination and sampling technique

The sample size was determined using the Thrusfield, (Thrusfield 2018) formula. Since there was no study in the area, we use a 50% of the expected prevalence and a 5% margin of error.

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

where n = sample size, p = expected prevalence, d = desired level of precision (5%). Thus, a total of 384 large ruminants (cattle) were included in the study.

The study used a randomly selected, systematic sampling method based on the lairage entrance and code numbers inked on the subjects' bodies. The Wolaita Sodo Municipal abattoir was visited regularly (2 days a week) to conduct antemortem and postmortem examinations, per the schedule.

Antemortem examination

Following the selection of the study animals at the lairage entrance, an antemortem examination was carried out based on risk factors. Young (less than 5 years) and adult (more than 5 years) animals were separated into two age groups (Yusuf et al. 2016). The body condition of animals is also divided into three categories: poor, medium and good (Bekele et al. 2010).

Postmortem examination

A hydatid cyst was checked for during the postmortem examination of the abdominal and thoracic cavities' organs, specifically the liver, lung, heart, kidney, spleen, and other organs and muscles. Additionally, using the standard meat inspection procedure, the liver was examined for the presence of *Fasciola* spp. The liver and associated bile duct were meticulously examined postmortem by visualization and palpation of the entire organ, followed by a transverse incision of the lobes and making a deep cut with several small subcuts to confirm the presence of the parasites (World Health Organization 2003). One or more samples of the worms were taken from condemned livers with an active infection to determine the species of Fasciola. Recovered Fasciola was divided into three categories: *F. hepatica*, *F. gigantica* and immature liver flukes based on their morphological characteristics (Bekele et al. 2010).

Examination of cysts and viability of protoscolices

Each organ's cysts were counted and inspected. Individual cysts were grossly examined for signs of degeneration or calcification before being transported to the Wolaita Sodo University, College of Veterinary Medicine laboratory using an ice box for fertility and viability tests. Protoscolices in the hydatid fluid was checked for under a microscope. According to the method described (Saeed et al. 2000), cysts were identified and classified as fertile or infertile, and cysts lacking protoscolices were categorized as infertile cysts (Daryani et al. 2007).

A viability test that involves an eosin exclusion test for cell death was also applied to fertile cysts. By staining the protoscolices with 0.1% aqueous eosin solution and examining them under a microscope, the viability of the organisms was determined (40×). The dye was taken up by the dead protoscolices but not the living ones (Saeed et al. 2000). A calcified cyst had a gritty sound on palpation and incision, while a sterile cyst was distinguished by its smooth inner lining, typically with a slight amount of turbid fluid in its contents (Borji and Parandeh 2010).

Fasciola species identification

Flukes were collected in universal bottles after systematic incisions on the bile ducts and liver parenchyma and morphologically identified under a stereomicroscope using standard methods described by previous reports (Mwabonimana et al. 2010; Bekele et al. 2010).

Estimation of economic loss of concurrent fasciolosis and hydatidosis infection

The study assessed both direct and indirect economic losses caused by fasciolosis and hydatidosis in cattle slaughtered at the Wolaita Sodo Municipal abattoir. The direct losses were calculated using condemned organs (lung and liver), and the indirect losses were calculated using live weight loss due to fasciolosis and hydatidosis. To manipulate the cost of condemned edible organs and carcass weight loss, ten different meat sellers, two meat inspectors, and ten meat consumers were randomly interviewed to determine the price per unit organ and the collective price of lung and liver. From that data, the average price was calculated, and this price index was used to calculate the meat loss in Ethiopian birr (ETB) (Denbarga et al. 2011).

Data analysis

Microsoft Office Excel spreadsheet was used to enter and analyzed using STATA 14 to calculate the prevalence of hydatidosis and fasciolosis. The effect of different risk factors (age, breed, origin of animals, and body condition) on the outcome variable of coinfection status was also investigated using logistic regression analysis and $p < 0.05$ was considered statistically significant.

Abbreviations

AE: Alveolar Echinococcosis; BOFED: Bureau of Finance and Economic Development; CAT: Card Agglutination Test; CFT: Complement Fixation Test; CFSPH: Center for Food Security and Public Health; CE: Cystic Echinococcosis; ELISA: Enzyme-Linked Immuno-Sorbent Assay; ICSP: International Committee on Systematics of Prokaryotes; LPDB: Livestock and Pastoralist Development Bureau; NVI: National Veterinary Institute; OIE: *Office International des Epizooties*; RBPT: Rose Bengal Plate Test; SRBC: Sensitized Sheep Red Blood Cells; SRS: Somali Regional State; WHO: World Health Organization.

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Authors' contributions

HF and IA contributed to data collection, study design, and interpretation, manuscript draft, and writing, HF: the conception of the research idea, study design, data analysis, writing, revising and editing, the design of the study, and data interpretation; IA: reference search, and manuscript writing and editing and all authors have approved the submission of the final manuscript.

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Availability of data and materials

All the datasets generated or analyzed during this study are included in this manuscript.

Declarations

Ethics approval and consent to participate

Ethical consent was obtained from Wolaita Sodo University, Research Review Committee (with the reference number WSU 41/22/2342/2022). to collect research and conduct the research, and the committee approved this research work. The purpose of the study was well explained to the abattoir officials before taking the samples, and informed consent was obtained to take the appropriate sample through verbal consent.

Consent for publication

Not applicable.

Competing interests

All authors have nothing to disclose in this work.

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