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Review on Fasciolosis in domestic animals: prevalence, Epidemiology, economic and public health implications in Ethiopia

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Abstract

Fasciolosis is economically important livestock disease in Ethiopia. Besides its economic impact, it has been a public health concern around world including Ethiopia. In this review, different published research articles regarding fasciolosis in animal and its economic impact in Ethiopia have been collected. Articles focusing on the epidemiology and public health impact of the infection were also assessed with the objective of assessing and enumerating the current status of the disease in domestic animals (in terms of magnitude), its economic impacts, public health issues and epidemiological facts. The infection prevalence based on abattoir post mortem survey and coprological sedimentation among domestic animals in Ethiopia is reported. The overall prevalence ranges from 5% to 70% in different regions of the country. The epidemiological aspects of the disease particularly in relation to animal biological factors and agro-ecology which are associated with variation in the infection rate in domestic animals have been discussed in detail. Annual economic loss varies from 57,960 to 106, 400 ETB in bovine species in the year between 2009 and 2015 due to only liver condemnation. This loss assessment associated with the infection in livestock underestimate the true impact. Information is lacking on the economic loss assessment in other domestic animals in Ethiopia. Finally, in terms of public health perspective, few sporadic reports on human infection have been recorded in Northwestern region of the country. Therefore, veterinary public health unit must collaborate to investigate the magnitude of human fasciolosis in the community where livestock rearing is a livelihood in order to advocate control strategies.

Keywords: Economic loss, Epidemiology, Post mortem, Prevalence, Public health

Introduction

Ethiopia has tremendous number of livestock population. Still it is believed that the contribution of livestock from home consumption to national economy level is high, but much lower than its tremendous potential. The prevailing disease is one of among many constraints for underutilization and production of those animals. Of these, parasitism thought to significantly reduces the production and productivity in general (Asmare et al., 2016). Fasciolosis is an important parasitic disease which is caused by digenean trematodes of the genus *Fasciola* commonly referred to as liver fluke. The two species most commonly implicated as the etiological agents of fasciolosis in both animals and humans are *Fasciola hepatica (F. hepatica)* and *Fasciola gigantica* (*F. gigantica)* (Sissay et al., 2007).

The prevalence and global burden of the disease in many countries with different agro ecology was systematically reviewed by Khan and others (Khan et al., 2013). In Ethiopia, there have been reports on the prevalence of both animal (Abunna et al., 2010; Berhe et al., 2009; Sissay et al., 2007; Zeleke et al., 2013) and sporadic human (Bayu et al., 2005) infections in different areas. In animals, the infection burden is often reported in terms of coprological and post mortem examination. Despite some variation exists in the prevalence between these two methods, the sensitivity test conducted by a few scholars indicates that substantial agreement exists among the methods(Abebe et al., 2010; Abunna et al., 2010). In suspected human cases, examination of stool sample coupled with differential leucocytes count, imaging and serology are useful diagnostic methods (Bayu et al., 2005; Greter et al., 2017).

From epidemiological point of view, infections occur in a wide range of hosts including ruminants, equines and humans. The most common *Fasciola* species known to cause infection in animals and humans are *F. hepatica and F. gigantica* (Fentie et al., 2013). Both species of *Fasciola* are occurring at different agro ecology or sometimes they are found together in comparable manner in the same agro-ecology. Indeed, their prevalence is highly associated with the presence of intermediate hosts in which they undergo some development to complete their life cycle (Malone et al., 1998).

Fasciolosis is an important disease from both economic and public health perspective. According to available research findings, the economic impacts of animal fasciolosis are attributed to loss of production due to mortality and morbidity, reduced growth rate, condemnation of liver, loss of minerals and vitamins from liver and the expense of treatment and control measures (Berhe et al., 2009; Chanie and Begashaw, 2012; Khoramian et al., 2014; Legesse et al., 2015; Mazeri et al., 2017). The impacts of *fasciola* infection are not just on livestock industry but, also on public health. Despite it is known to be the major livestock diseases, the recent increased reports of human infections from the region(El-Tahawy et al., 2017; Fentie et al., 2013) where livestock fasciolosis is endemic reveals its zoonotic potential. Therefore, the objectives of this review are: i) to highlight the magnitude of fasciolosis among animal species confirmed by the routine diagnostic methods ii) to enumerate its epidemiological facts iii) to deal with the economic and public health impacts posed by the infection iii) to suggest future research area based on currently available data.

Prevalence of Fasciolosis in Ethiopia

In Ethiopia, a number of studies have been undertaken with regard to abattoir and sometimes farm or field based prevalence in ruminants including cattle, sheep and goats. The prevalence reports among the studies significantly vary. One reason for this variation might be due to the difference in the methods employed to detect the infection (French et al., 2016). Almost all of the reports are based on post mortem findings, coprological sedimentation and combination of these two methods. Abattoir based post mortem reports at different regions of the country for *bovine*, *ovine* and *caprine* ranges from 14-32.3%, 19.8-74.6% and 10-10.6% respectively. The overall coprological sedimentation test reports across the country either at abattoir or farms among respective animal species ranges from 4.9-60.4%, 14.5-70.2% and 10-37.9% (Table 1). From these reports, one can easily infer that ovine species has the highest infection burden in both detection methods, except one report in which infection in *caprine* appear to be higher than *ovine* (Bedada et al., 2017). Another scenario that can be contented from this review is that the diagnostic methods are influencing the true prevalence of the infection. Though there are many diagnostic techniques for *fasciola* infections in live animals with different sensitivity (Se) and specificity (Sp), diagnosis relay only on the coprological examination in resource poor countries. Among the detection methods, post mortem examination is perfect in Sp (100%) and has higher Se (Mazeri et al., 2017) compared to sedimentation technique. As a result, the prevalence of infection in live animals using coprological sedimentation test often under report the infection which is probably attributed to pre patent infection. To address this condition, some authors employ the combination of both methods to determine Se of sedimentation test and compare the agreement of tests using kappa index statistics by taking post mortem findings as gold standard test (Abebe et al., 2010; Abunna et al., 2010). Several scholars (Abebe et al., 2010; Abunna et al., 2010; Berhe et al., 2017; Chanie and Begashaw, 2012; Mazeri et al., 2017) have determined that sedimentation test has substantial agreement with post mortem examination which clearly implies fecal sedimentation still remains a very useful test during periods when infection is expected to be mainly chronic.

Fasciolosis also appears to have been infecting equines and camels in the endemic area according to some research evidence. In Ireland, Quigley and his colleagues (Quigley et al., 2016) showed that among 200 examined horses, 9.5%, 6% and 3% of *F. hepatica* infection was detected by serology, post mortem and sedimentation respectively in the same examined horses. In Ethiopia, there is only one report regarding to the prevalence and epidemiology of fasciolosis in working donkeys that represented three agro ecology (highland, lowland and mid-lowland) of the central Ethiopia (Getachew et al., 2010). According to these authors, the prevalence reports based on both sedimentation and post mortem examinations are high and comparable. A few sporadic infection might also occurs in camels as it has been reported from Egypt and Iraq (Haridy and Morsy, 2000; Karawan, 2017). This suggests that *fasciola* appears to have infected a wide range of hosts in the country where livestock species are abundant including Ethiopia. In Ethiopia, study about fasciolosis conducted in cattle, sheep and goats alone has resulted in biased report as if the disease affects only ruminants. Absence of reports in other domestic animals doesn't necessary means they are resistance to infections. The baseline information about donkeys' fasciolosis in one study in Ethiopia, horses' and camel infection elsewhere warrants future studies on the epidemiological aspects of the disease in all domestic animals at large scale.

Table 1: Summary of prevalence of fasciolosis in domestic animals from 2009-2017 in Ethiopia

S. No.	Prevalence (%)	Study site	Method of detection	Animal species	Reference
1	14.5	Abattoir	Coprological	Ovine	(Berhe et al., 2017)
	10	Abattoir	Coprological	Caprine	
	19.8	Abattoir	Post mortem	Ovine	
	10	Abattoir	Post mortem	Caprine	
		Abattoir			
2	25.6	Field/Farm	Coprological	Ovine	(Bedada et al., 2017)
	37.6	Field/Farm	Coprological	Caprine	
3	25.3	Field/Farm	Coprological	Bovine	(Legesse et al., 2015)
	35.7	Field/Farm	Coprological	Ovine	
	11.4	Field/Farm	Coprological	Caprine	
4	27.9	Abattoir	Post mortem	Ovine	(Tesfaye et al., 2015)
	10.6	Abattoir	Post mortem	Caprine	
5	30.5	Abattoir	Post mortem	Bovine	(Chakiso et al., 2014)
	34.9	Farm	Coprological	Bovine	
6	20.3	Abattoir	Post mortem	Bovine	(Aragaw et al., 2012)
7	60.4	Farm	Coprological	Bovine	(Yeneneh et al., 2012)

8	14.6 8.8	Field Field	Coprological Coprological	Ovine Caprine	(Mulatu and Addis, 2011)
9	32.3	Abattoir	Post mortem	Bovine	(Bekele et al., 2010)
10	24.7 28.6	Abattoir Abattoir	Coprological Post mortem	Bovine Bovine	(Abebe et al., 2010)
11	4.9 14	Abattoir Abattoir	Coprological Post mortem	Bovine Bovine	(Abunna et al., 2010)
12	44.4 41.9	Felid Clinics	Coprological Post mortem	Equine(donkeys) Donkeys	(Getachew et al., 2010)
13	24.3	Abattoir	Post mortem	Bovine	(Berhe et al., 2009)

Epidemiology of Fasciolosis in Ethiopia

Host Spectrum

Fasciola appears to infect wide range of domestic animals. There has never been clear report regarding which species of domestic animals are spared from the infection. However, depending on the contribution of pasture contamination and degree of shedding eggs on pasture, ruminants (cattle, sheep and goats) are considered the major host. Equines that graze with ruminants on the same pasture in endemic area can be infected and contaminants as the same as ruminants (Getachew et al., 2010; Quigley et al., 2016). Similarly, camels (Haridy and Morsy, 2000; Karawan, 2017), pigs (Valero and Mas-Coma, 2000) and wild ungulates (French et al., 2016) appear to have been infected by *fasciola* species elsewhere and are considered as minor reservoir host. The maintenance and transmission of *fasciola* between domestic and wild ungulates at wild-domestic animal interface has been recent topic of discussion. In Ethiopia, the epidemiological investigations about the disease in domestic ruminants focus on the presence or absence of intermediate host with respect to their specific agro-ecology (Yilma and Malone, 1998; Zeleke et al., 2013). While this investigation still remains crucial, the role of wild and non- ruminant domestic animals including equines, pigs and camels in the epidemiology of the *fasciola* infection should also be elucidated in the future research in Ethiopia where wide range of domestic animals graze together at communal land and close contact between wild and domestic animals appears to occur.

The extent of susceptibility and resistance of ruminants to *fasciolosis* has not been well elucidated yet. In several research findings (Berhe et al., 2017; Legesse et al., 2015; Mulatu and Addis, 2011; Tesfaye et al., 2015), *ovine* species appear to be the most susceptible one, whereas *caprine* is relatively resistant species, probably because of higher detection rate in *ovine* than *caprine* during diagnosis. The possible explanation for the higher infection rate in *ovine* might be associated with their grazing behavior unlike whose feeding behavior is browsing. Contrary to this, other report (Bedada et al., 2017) shows higher infection rate in *caprine* compared to *ovine* in lowland pastoralist area during dry seasons where agricultural irrigation often undertaken.

This could be attributed to scarcity of leaves of trees and shrubs in dry season which force *caprine* to graze with *ovine* on common pasture grasses grown by the irrigation (Malone et al., 1998) that favors the existence of snails.

Furthermore, in other epidemiological study on ruminants' infection conducted in Southwest region of Ethiopia, bovine appears to have the highest infection burden relative to both small ruminants (Zeleke et al., 2013) during rainy season. This condition might be associated with management practices of farmers to keep small ruminants indoor while allowing *bovine* to graze on pasture during rainy and flood season when *fasciola* intermediate host burden and shedding of *cercaria* become significant.

Many scholars attempted to investigate the association of additional animal related biological factors such as sex, breed, age and body conditions with fasciolosis (Bedada et al., 2017; Chanie and Begashaw, 2012; Mulatu and Addis, 2011; Tesfaye et al., 2015; Yeneneh et al., 2012). This review has identified strong evidence to conclude that infection rate is significantly higher in animals that have poor body conditions as compared to animals which have good body condition (Ahmed et al., 2007; Bedada et al., 2017; Chakiso et al., 2014; Mulatu and Addis, 2011; Tesfaye et al., 2015). This could be due to either the effect of parasite or increased susceptibility of animals with poor body condition to metacercaria as explained by several scholars.

Sex of animal is not significantly associated according to various research outputs referenced above. This fact is attributed to the same feeding habits of both male and female which provides equal chance of being exposed to metacercaria on pasture by both sexes when they are allowed to graze on the risk area, however, management practices of farmers to keep female animals indoor might protect them from acquiring the infection (Chanie and Begashaw, 2012).

Regarding to the age of animals, younger appear to be protected from the fasciolosis, probably because maternal immunity or they are not allowed to graze on pasture together with older animals as identified in many literatures (Ahmed et al., 2007; Berhe et al., 2009; Tesfaye et al., 2015). On other hand, one study demonstrated that infection was higher in younger animals as compared to older ones (Chakiso et al., 2014) which might be explained in terms of acquired immunity developed by old animals. Among biological animal factors, breed has not been well investigated yet in terms of its association of *fasciola* infection in domestic animals. Although very few studies attempt to explain the associations of local indigenous cattle breed and crossbred or pure exotic breed with the infection rate in active abattoir survey, the scanty number of crossbred or exotic breed presenting to abattoir makes the comparison difficult and probably results in invalid conclusion. The association would have been appropriate and valid if different breeds of animals with all constant other biological parameters were exposed to the same natural challenge and then comparable size of each breed were examined. Generally, the susceptibility of animals to infection in terms of biological intrinsic factors has never been elucidated, the infection rate variation is rather explained by the husbandry management, environmental condition and feeding behavior of animal.

Environment and Pathogen Factors

In Ethiopia, fasciolosis is widespread and encompassing the major productive highland plateaus where large number of human and livestock inhabit. The disease occurs in all types of agro-ecology in the country however, there are some known ecological factors including rainfall, agricultural practices, temperature and altitude of the grazing area which affects multiplication of the intermediate host. There are about different unique intermediate host species that require specific agro ecology for both *F. hepatica* and *F. gigantica* (Malone et al., 1998). The optimal base temperatures of 10°C and 16°C are necessary for the vectors of *F. hepatica and F. gigantica*, respectively, and for their development within the snails (Abunna et al., 2010). In Ethiopia, there have been reports on the occurrence of both species of *fasciola* in abattoir (Abebe et al., 2010; Abunna et al., 2010; Berhe et al., 2009; Legesse et al., 2015; Mulatu and Addis, 2011). *F. hepatica* usually circulates in the area with an altitude ranging 1200 - 2560 meters above sea level (masl) while *F. gigantica* is found at an altitude below 1800masl. And it is often considered as a lowland species where as *F. hepatica* is a known species in temperate climate and highlands of tropical and subtropical area. However, it should be noted that the presence of both *fasciola* species in the same affected animal reveals the presence of suitable agro-ecology which favors their respective intermediate host to live and multiply in the same area.

The presence of two species had been confirmed in areas of extended high annual rainfall associated with high soil moisture and surplus water or flood (Zeleke et al., 2013) and in arid lowland ecology where agricultural irrigation is being undertaken (Bedada et al., 2017; Malone et al., 1998). Therefore, it is important to carry out a comprehensive epidemiological investigation with respect to the existence of *fasciola* species and their respective snail hosts in different Ethiopian agro ecology. Moreover, many reports about the detection of *fasciola* species in Ethiopia were conducted at either local or export abattoirs where the true origin of animals and its pathway is not determined which would be valuable information for epidemiological study. Due to this fact, abattoir based reports that attempt to associate the prevalence of *fasciola* species and origin of animal will have little value unless animal are traceable for their past history.

Control and Prevention

The epidemiological characterization of the disease at regional levels requires knowledge of husbandry practices in addition to the specific factors favoring the transmission of the disease. Specifically in the area where seasonal dynamics of infection occurs as reported by many authors (Abebe et al., 2010; Legesse et al., 2015; Zeleke et al., 2013) the control scheme should focus on the grazing management. As explained by Yilma and Malone (Yilma and Malone, 1998) metacercariae can survive up to 3 months after harvesting in hay from endemic highland areas that are consumed by livestock in arid and lowland areas, particularly during the dry season when suitable grazing pastures are scarce. Hence, farmers should be aware of treating or drying such type of feed on the sun for longer period before they feed animals.

Irrigation would have major effects on transmission particularly in arid lowland climate where rainfall is scarce (Bedada et al., 2017). In this type of area during dry season, the irrigated land has high abundant pasture that attracts domestic animals to graze on. Unfortunately, areas like this favor multiplication of vectors of *fasciola* and might harbor huge number of metacercaria. Therefore, preventing animals from grazing during that particular time and seeking for alternative husbandary methods would lessen the problem.

In the area where fasciolosis is endemic throughout the year, Yilma and Malone (Yilma and Malone, 1998) recommend two treatments (preventive and preventive or and curative) per year for all endemic regions studied. It is anticipated that the recommended scheme will effectively control the disease caused by either fluke species. The first treatment is prophylactic and is administered toward the end of the dry season when development of free-living stages and intra- lymneid phases of *Fasciola* are retarded and reproduction and activity of snails is minimal. An optional summer curative treatment is recommended in high risk years and when outbreaks of disease occur. The September-October treatment removes bile duct flukes prior to the commencement of the dry season. For economic reasons or otherwise, if only one treatment can be given, the September-October strategic treatment is the best choice in all areas.

Economic impact

The economic impact of fasciolosis can be explained in a variety of ways. The impacts are generally caused by loss of production, reduced growth rate, condemnation of liver, loss of valuable mineral and vitamins from liver and the expense of treatment and control measures. In Ethiopia, the annual losses associated with bovine fasciolosis ranges from 57,960 to 106, 400 ETB (Ethiopian Birr) from the year 2009 to 2015 due to only liver condemnation (Abebe et al., 2010; Abunna et al., 2010; Bekele et al., 2010; Berhe et al., 2009; Chakiso et al., 2014). The loss related with small ruminants' fasciolosis attributed only to liver condemnation has not been well determined yet. It seems that the economic assessment reports by many scholars in Ethiopia appear to have underestimate the loss caused by ruminants' fasciolosis. The reason for this underestimation originates from estimation only based on liver condemnation criteria.

In addition to liver condemnation parameter, economic impact assessment have been conducted on other parameters including production loss, retarded growth, loss of minerals and vitamins from liver, reduced carcass weight and treatment cost (El-Tahawy et al., 2017; Khoramian et al., 2014; Mazeri et al., 2017). Only few reports (Berhe et al., 2009; Legesse et al., 2015; Ngategize et al., 1993) have shown estimation of economic loss on the basis of carcass weight loss, mortality and production loss associated with the *fasciola* infection. To wind up this economic discussion, the loss estimation would have been much higher than the previous reports caused by fasciolosis if other estimation parameters were considered in the studies. Therefore, parameters such as growth rate, minerals and vitamins loss from liver, drought power, milk production and treatment and control should be considered in the future research in the country.

Public health impact

Fasciolosis, an important zoonosis, is classified by World Health Organization (WHO) as a neglected tropical disease with an estimated 17 million people infected and a further 180 million people at risk of infection. It is food-borne zoonoses and known to occur worldwide, particularly among livestock rearing community. The disease burden in livestock keeping society indicates its veterinary public health concern (Marcos et al., 2006). According to the review article by (Nyindo and Lukambagire, 2015), human infections are predominantly found in Bolivia, Peru, Cuba, China, Spain, Nile Delta in Egypt, central areas of Vietnam and Northern Iran. The authors also contented from the global review that hyperendemicity of human fasciolosis has been noted in the Middle East and North African region particularly in Egypt, Ethiopia, Iran, Iraq, Syria and Saudi Arabia. In recent days sporadic reports (Ai et al., 2017) and outbreaks (Chen et al., 2013) of human cases have been evolved in China. The disease is also reported from Chad in pastoral and agro-pastoral community (Greter et al., 2017). In Ethiopia, where livestock fasciolosis is hyperendemic, human infection reports are generally lacking. Only one case report (Bayu et al., 2005) and one cross sectional study (Fentie et al., 2013) in Northwestern part Ethiopia have been identified. Lack of information regarding to human infection in the region where livestock fasciolosis is endemic is probably attributed to physicians may not be fully informed about human fasciolosis, they may mistake fasciolosis for other diseases with similar clinical picture (Nyindo and Lukambagire, 2015).

The infections in man occur following ingestion of contaminated edible aquatic salad vegetation, typically found near *fasciola* infected animals, such as watercress or through the consumption of metacercariae-contaminated water (Cwiklinski et al., 2016). The ingested metacercariae excyst in the duodenum and migrate into the peritoneal cavity and finally reach the liver. They bore through the liver capsule and in about 12weeks enter the bile ducts where they start to lay eggs. Infected persons develop hyperplasia of the bile ducts. Clinically, patients lose appetite and have nausea and diarrhea. Urticaria, acute epigastric pain, jaundice, eosinophilia, and hepatomegaly are common findings (Bayu et al., 2005; Nyindo and Lukambagire, 2015).

According to (Fentie et al., 2013), the risk of *fasciola* infection in human is associated with raw vegetable consumption, use of unsafe drinking water, irrigation practice and animal ownership. Factors noted to contribute to increased human transmission of fasciolosis include (i) high density of both human and animal populations living in close proximity, (ii) the presence of abattoirs and wet markets operating with rudimentary hygiene, limited cold chain for distribution, and low levels of meat inspection and biosafety measures, (iii) widespread consumption of raw/undercooked blood, meat, organ tissues, and offals and consumption of raw leaf vegetables, and (iv) the use untreated water sources for household use and/or use of untreated wastewater (Marcos et al., 2006) and sewage for agriculture (Nyindo and Lukambagire, 2015).

Control programs should first consider rigorous awareness campaigns and sensitization on both the magnitude and impact of fasciolosis in humans and animals. A typical complicating infection control scenario of zoonotic infections including fasciolosis in sub-Saharan Africa includes: (a) global warming and civil unrest (b) close proximity to domestic animals (c) rural-urban migration with poor personal, water, and food hygiene (d) lax biosafety and surveillance systems. Therefore, control programs of human fasciolosis should have an integrated approach whereby all factors that contribute to the presence of the disease are considered.

Conclusion and Recommendations

In conclusion, fasciolosis is neglected tropical disease which has both economic and public health importance. In Ethiopia, ruminants' fasciolosis has been reported from various regions with a wide range of disease burden. This review has found that the disease appear to have infected multiple domestic animals in addition to ruminants. There has never been concrete evidence to justify the susceptibility variations to the infection among the biological factors of animals. The abattoir post mortem diagnosis that many investigators relay on, where slaughter processes are quick and not giving enough time for detailed examination and the drawback of sedimentation to detect pre patent infection are thought to underestimate the true disease burden. The economic loss assessment due to the disease in many studies in the country underestimate, as all of the reports focuses on liver condemnation and ignores the loss based on other parameters. Furthermore, it's surprising that lack of adequate information on human fasciolosis in the country where livestock fasciolosis is hyper endemic. Based on the conclusive remarks, the following points are suggested.

- The infection magnitude should be enumerated in all domestic animals as this information would be crucial to determine the epidemiology of the disease

- A wide range of diagnostic tests such as serology and molecular techniques should be adopted in addition to currently existing ones

- The susceptibility to the infection in terms of animal related biological factors such as age, sex, breed and species should be investigated in controlled experiment so as to discriminate which category is susceptible and which is spared from infection

- The economic impact assessment due to fasciolosis in animals should be advanced to include other assessment parameters rather than just liver condemnation

Veterinary public health unit must collaborate to investigate the magnitude of human fasciolosis in the community where livestock rearing is a livelihood in order to advocate control strategies

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