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EPIDEMIOLOGY AND ECONOMIC IMPORTANCE OF FASCIOLOSIS OF DOMESTIC RUMINANTS IN SELECTED SITES OF TIGRAY REGIONAL STATE, NORTHERN ETHIOPIA

BY

GEBRU LEGESSE

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DEBRE ZEIT, ETHIOPIA

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ABBREVIATIONS

BoARD	Bureau of Agriculture and Rural Development
BoFED	Bureau of Finance and Economic Development
CI	Confident Interval
CSA	Central Statistics Authority
ELISA	Enzyme Linked Immuno Sorbent Assay
FOA	Food and Agricultural Organization
IgG	Immunoglobulin G
IgM	Immunoglobulin M
ILCA	International Livestock Center for Africa
LSD	Lumpy Skin Disease
MoARD	Ministry of Agriculture and Rural Development

ABSTRACT

A cross sectional study was conducted to determine prevalence, assess risk factors associated with fasciolosis and evaluate economic losses in four selected areas of Tigray Regional State, during September 2007 to May 2008. A total of 1736 domestic ruminants comprising of 1015 cattle, 526 sheep, 167 goats and 28 camel were subjected to coprological investigation and 236 slaughtered animals were included for post mortem survey. Based on coprological investigation the overall prevalence of fasciolosis was 25.3%, 35.7%, 11.4% and 3.6% in cattle, sheep, goats and camels, respectively. In the slaughterhouses survey the prevalence of fasciolosis was 33.1%, 37.2%, and 17.6% in cattle, sheep and goats, respectively. High prevalence was recorded in sheep (37.2%) and lowest in goats (17.6%). Statistical significant differences was observed in prevalence among the species ($p<0.05$) using coproscopy. *Fasciola hepatica* was dominant in the highlands while the dominant species in the midland and lowland was *F. gigantica*. Differences in agroecology, season, body condition and age were shown to have associations with prevalence while no significant association was observed between sexes of animals. Species of animals, season, age and agro-ecology were known to be among important risk factors associated with fasciolosis. The direct and indirect economic loss incurred due to fasciolosis in the study area was estimated to be 268,536.21 Ethiopian Birr. Out of the total incurred losses, 86.3% was in cattle. The present study revealed that infection of domestic ruminants by *Fasciola* species was attributed by the presence of favorable environment for the abundance of intermediate host and the parasite, hence requiring immediate strategic intervention against the disease.

Key words: Ruminants, Epidemiology, Prevalence, *Fasciola* species, Coproscopy.

1. INTRODUCTION

Ethiopia has the largest livestock inventories in Africa, including more than 38.749.320 cattle, 18,075,580 sheep, 14, 858,650 goats, 456,910 camels, 5,765,170 equines and 30,868,540 chickens with livestock ownership currently contributing to the livelihoods of an estimated 80 percent of the rural population (CSA, 2006). In the arid and semi-arid extensive grazing areas in the northeastern, eastern, western as well as southern lowlands cattle, sheep, goats, and camels are managed under migratory pastoral production systems. However, the full exploitation of these huge resources was hindered due to a combination of factors such as drought, poor genetic potential of animals, traditional system of husbandry and management as well as the presence of numerous diseases (Mtenga *et al*., 1994).

In Ethiopia where farm animals kept on pasture throughout the year climatic conditions are favorable for development and survival of infective stages of helminth parasites. helminthosis rank as the major constraint to animal production causing anemia, diarrhea, and emaciation resulting in reduced weight gains, increased production cost and mortality (Tembely, 1998).

Among highly prevalent and economically important parasitic diseases is fasciolosis, which affects all domesticated animals as well as man, inducing significant morbidity, mortality and economic losses mainly in domestic animals (Dalton, 1999; Scott, 2003). Fasciolosis occurs commonly as a chronic disease and the severity often depend on the nutritional status of the host (Georgi, 1985). Meanwhile, cattle, sheep and goats are more susceptible to this parasite compared to other domestic animals (Schoenian, 2003).

Estimation of the economic losses due to fasciolosis was insufficiently notified by lack of accurate information of the disease prevalence, complexity in disaggregating and quantifying the direct and indirect effects of the disease and lack of a common methodology for assessing the economic loss (Ogunrinade and Adegoke 1982). The annual loss due to endoparasitism including fasciolosis in Ethiopia is estimated to be about 700 million Birr while decreased productivity alone due to bovine fasciolosis was estimated about 300 million Birr (Ngategize *et al*., 1993).

Many researchers have reported prevalence of fasciolosis of cattle, sheep and goats in different places of Ethiopia: in sheep 86.78% (Yilma, 1985); 77.8% (Abera, 1990) and 88.57% (Dange, 1994); in goats 40% (Gebreyesus, 1986); 30% (Getu, 1987), 12.4% (Rahmato, 1992) and in cattle 84.7% (Fekadu, 1988) and 82.5% (Yadeta, 1994). Moreover, previous preliminary study at Mekelle abattoir and its surrounding areas pointed out that the prevalence of fasciolosis was 26.13% (Takele, 1995) in domestic ruminants.

Economic importance of bovine fasciolosis has been the main concern of several workers in Ethiopia. Currently in Tigray region, it is assumed that fasciolosis in ruminants may have a tendency towards increasing prevalence because of the created favorable environment for reproduction of the snail vector. There are increased irrigated landmasses from the newly constructed microdames, ponds and the tendencies of the farmers to rear their animals in these marshy and dumpy areas that could increase risk of fasciolosis in various parts of the region (Hagos, 2007).

Studies on the epidemiology of fasciolosis in domestic ruminants such as cattle sheep. goats and camels were not so far conducted in Ofla, Atsibiwomberta, Hintalowejerat and Alamata district of Tigray regional state.

The objectives of this study hence. were the following:

- Determine field and slaughterhouses prevalence of fasciolosis of cattle, sheep. goats and camels
- Assess major risk factors associated with the disease
- Evaluate the intensity of the disease such as fluke burden and liver lesions
- Identify the *Fasciola* species affecting animals in the study area
- Determine the direct and indirect economic impacts exerted by the disease

2. LITRATURE REVIEW

2.1. The disease

Andrews (1999) pointed out that, historically Jean de Brie (1379) first cited the disease known to be "liver rot" in sheep in France with out association to a worm. Jean de Brie did not associate the cause of the disease with liver fluke but thought as the consequence of the liver being affected by toxic substances produced by certain plants. Furthermore, observations made by an Italian physician, Fanensi Gabucinus (1523), described the worms resembling pumpkin seeds in the blood vessels of liver of sheep and goats. Additional observations on liver fluke disease were recorded during the second half of the 16th century; afterward the digenetic life cycle was named.

The disease, fasciolosis, is caused by digenetic trematodes/flukes of the genus *Fasciola*, commonly referred to as liver flukes. The two species most commonly implicated are *F. hepatica* and *F. gigantica*. Meanwhile, *F. hepatica* has a worldwide distribution but predominates in temperate zones and cooler areas of high altitude in tropics and subtropics while *F. gigantica* is found in many regions of the world, mainly with wide range of distribution in tropical regions (Urquhart *et al.*, 1996; Okewole *et al.*, 2000).

Even though all ruminants are susceptible to *Fasciola* specie, frequent infection occurs in sheep, cattle and buffalo and has economic importance. Goats, camel, horses, deer and many other species of herbivore can be infected; however, the parasite is of less economic importance on a global scale in these hosts (Mira and Ralph, 1989; Torgerson and Claxton, 1999).

Fasciola hepatica is wide spread in areas with altitude range of 1800 to 2000 masl while *F. gigantica* appear to be most common in areas below 1200 masl; in between these altitude limit both species co-exist as the ecology is conducive for both snails so that mixed infection is envisaged (Urquhart *et al.*, 1996; Malone and Yilma, 1998)

F. hepatica and *F. gigantica* causes major economic losses in livestock predominantly in East Africa. *F. hepatica* was to be shown the most important fluke species in Ethiopia where it is distributed to over three quarter of the nation except in the arid-ecosystem lying in northeast and east of the country. Meanwhile the distribution of *F. gigantica* was localized mainly in the western humid zone of the country that encompasses approximately one fourth of the nation (Malone and Yilma, 1998).

The presence of fasciolosis in Ethiopia has been known a long time and is responsible for causing considerable losses in livestock production. Several researchers have reported its prevalence and economic significance such as Graber (1978), Bahru and Ephrem (1979), Yilma (1985), Abebe (1986), Abera (1990), Mulugeta (1993), Daniel (1995), Solomon (2005) and Meskerem (2006). Moreover, in recent years, small-scale irrigation and water conservations are being expanding in many parts of the country, which has created habitats for fluke spreading vector and concomitant increased occurrence.

2.2. The parasite morphology

The genus *Fasciola* is a digenean parasite of ruminants and other mammalian hosts, which undergoes sexual and asexual generation parasitizing alternative hosts. *Fasciola hepatica* is leaf shaped worm of variable size ranging from 20 to 50mm long and 1 to 15 mm wide, dark brown in color, marginal zone of vitelline is easily seen with two suckers close together at the anterior end, broader in the anterior than in the posterior and cone shaped. The cuticle is covered with backwardly directed spines that wear off with age, but are always visible microscopically in the hollow of the shoulder and on the anterior cone through which trauma of hepatic parenchyma is caused (Bowmann *et al.,* 2003). The flukes are easily recognized grossly and the only confusion likely is with *F. gigantica*. *F. gigantica* is similar with *F. hepatica* but larger in size ranging from 25 to 75 mm long and 3 to 12 mm wide, and has less prominent shoulders (Urquhart *et al.*, 1996).

The eggs of both *F. hepatica* and *F. gigantica* are similar in that both are oval, operculated and yellowish- brown in color measuring 130 to 150µm by 60 to 90µm and 156 to 197µm by 90 to 104µm, respectively, and have a thin shell containing a morular mass (Soulsby, 1986; Hendrix, 1998).

2.3. The snail intermediate host

The principal intermediate hosts of *Fasciola* species are *Lymneae truncatula* for *Fasciola hepatica* and *Lymneae natalensis* for *F. gigantica*. All require water especially for breeding but spend much of their time out side. They need high oxygen, and are never found in deep water (Radostitis *et al*., 1994; Urquhart *et al*., 1996; Bowmann *et al*., 2003). *Lymneae natalensis* is truly aquatic where as *L. truncatula* is amphibious (Troncy, 1989). The lymnaeid snails that serve as intermediate hosts require neutral soils that remain reasonably moist throughout the year and tend to flourish where winter areas are not so cold as to destroy the eggs and juvenile stages thus permitting the parasite population to survive its season of hardship in both definitive host and the environment (Bowmann *et al*., 2003).

Fasciola hepatica uses a mud for the intermediate host survival so that infection with this species is usually associated with herds and flocks grazing in the mud areas during wet season or on marshy land. On the other hand, *F. gigantica* uses water snails for its intermediate host. Therefore, infestation with this species is associated with livestock grazing in wet and irrigated lands (Spithil *et al*., 1999).

According to Urquhart *et al*. (1996) and Andrews (1999), *L. truncatula* is the most common and widely distributed snail in the world. Moreover, among important Lymneae species in different countries out side Europe are *Lymneae diaphena* in South America, *L. victor* in South America, *L. humilis* and *L. columella* in North America, *L. tomentosa* in Australia and New Zealand and *L. bulimedidae* in South USA and Caribbean. *Lamneae victor* and *L. columella* are distributed in the regions of Brazil and Uruguay (Ueno *et at*., 1982; Urquhart *et al*., 1996).

Morphologically the body of *L. truncatula* does not form the major parts of the whorls shell like in *L. natalensis,* which is known to have at least five whorls. In some other species, there are more than four whorls. Under field conditions, the specimens of snails on necked-eye are dark brown or black in color. The adults snails are rarely more than 4 to 5mm long (Reinecke *et al*., 1983, Urquhart *et al*. 1996).

Lymneae truncatula are capable of with standing summer drought or winter freezing for several months by hibernating deep in the mud. Optimal conditions includes slightly acidic pH environment and a slowly moving water medium, they feed mostly algae and the optimal temperature range for development is 15 to 22^{0}c, below 10^{0}c development ceases. *Lymneae natalensis* is aquatic and associated with permanent water channels or dams. Development with the snails is completed at the end of rainy season (Urquhart *et al*., 1996; Bowmann *et al*., 2003)

2.4. Life cycle

The life cycle of *Fasciola* species consists of five phases from egg laying up to adult worm formation in succession: passage of eggs from the final host, hatching in the environment, development in the intermediate host, encystment and ingestion of the larvae by the final host (Andrews, 1999).

The life cycle of *Fasciola hepatica* is typical of the family Fasciolidae. It is indirect where the parasite requires snails as intermediate host. The principal intermediate hosts of *Fasciola* are *Lymneae truncatula* for *F. hepatica* and *Lymneae natalensis* for *F. gigantica* in Africa (Radostitis *et al*., 1994, Urquhart *et al*., 1996).

Fasciola eggs are laid in the bile ducts, pass down into the intestine and then pass out in the faeces. They develop and hatch releasing motile ciliated miracidia. This takes nine days at optimal temperature of the 22-26 °C and little development occurs below 10 °C (Hendrix, 1998).

The mechanism of hatching is a complex process, depending on responses to several external and internal stimuli. Lights, and tonicity of the environmental fluid, are among the external factors and the miracidium itself contributes an enzyme, which acts upon the eggshell, and in particular, upon the cement sealing down the operculum which is present in trematode eggs (Radostitis *et al*., 1994).

The liberated miracidium has a short life span and must find a suitable snail within three hours for successful penetration. In infected snails, development proceeds through sporocyst and radiae stages to final stages in the intermediate host, the cercariae. The cercariae are shed from the snail as motile forms, which attach themselves to firm surfaces such as grass blades and encysted there to form the infective stage, metacecariae. It takes a minimum of 6 to 7 weeks for completion of the development from miracidium to metacercaria, although under unfavorable circumstances a period of several months is required. Infection of snail with one miracidium can produce over 4000 metacercariae. This phenomenon is called paedogenesis, which is essential point in the life cycle of trematodes. Metacercariae ingested by the final host excyst in the small intestine, migrate through the gut wall, cross the peritoneum and penetrate the liver capsule. The young flukes tunnel through the parenchyma for 6-8 weeks then enter the bile ducts where they migrate to larger ducts (Radostitis *et al*., 1994). The prepatent period for *F. hepatica* is from 10-12 weeks and for *F. gigantica* is 13 to 16 weeks. The longevity of *F. hepatica* in untreated sheep may be years, while in cattle is usually less than one year (Urquhart *et al*., 1996).

2.5. Pathogenesis and clinical Signs

Several workers described the pathology and pathogenesis of fasciolosis in detail during the 1960s; however, there are still undiscovered pathological changes in particularly to Fasciola species infection in domestic ruminants (Behm and Sangster, 1999). Adult liver flukes live in the bile ducts of the final host (Radostitis *et al*., 1994) while immature flukes are found in the liver parenchyma where it causes severe pathological lesions; however, occasionally aberrant flukes are found and become encapsulated in other organs such as lung (Urquhart *et al*., 1996).

Abrasions caused by spines and the prehensile action of the suckers appear to account for the damage caused in the liver. Death of the host is a consequence of the hemorrhage induced by this damage; however, the precise causes of the pathology are still unknown, though information on histopathology and examination of caecal contents are bases for the knowledge of pathogenesis (Behm and Sangster, 1999).

The pathogenesis of fasciolosis may vary depending upon the development of the parasite in the liver and the species of the host involved. Most commonly, the pathogenesis of fasciolosis has two phases: the first phase occurs during immature fluke migration in the liver parenchyma while the second phase occurs when the adult parasite establishes in the bile ducts. The first phase is associated with liver tissue damage and causes hemorrhage while the second phase results by the haematophagic activity of adult flukes and damage to the biliary mucosa, which causes cholangitis by their cuticular spines (Radostitis *et al.*, 1994).

Several clinical syndromes may be associated with liver fluke infection, depending on the numbers and stages of development of the parasite and on the presence or absence of bacteria: *Clostridium novyi*. The disease causes a wide range of clinical signs but none of the syndromes is pathognomonic. Depending on the number of metacercariae ingested, the disease could be manifested in acute, sub-acute or chronic forms. Acute form of the disease occurs during invasion of the liver by recently ingested metacercariae that causes trauma and is inflated by the migrants tunneling about in the liver and cause inflammatory reaction, which results in heavy fatal clinical illness (Bowmann *et al.*, 2003). It occurs 2-6 weeks after the ingestion of a large number of metacercariae, usually, over 2000, which invariably causes severe hemorrhagic trauma during of immature fluke migration in the liver parenchyma (Urquhart *et al.*, 1996).

In the subacute form of the disease 500-1500 metacercariae are ingested over longer a period of time, of which some might have reached the bile ducts, cause cholangitis, and others still migrating, cause less severe lesions. This is manifested as a rapid and severe hemorrhagic anemia with hypoalbuminemia, rapid loss of condition, submandibular oedema and ascites may be present (Radostitis *et al.*, 1994; Bowmann *et al.*, 2003).

Chronic fasciolosis is the most common form in cattle, sheep, goats and other hosts (Kauffmann, 1996). It is associated with the presence of adult flukes in the bile ducts and is characterized by the classical clinical signs: gradual losses of condition, progressive weakness, anemia and hypoproteinemia with development of edematous subcutaneous swelling, especially in the intramandibular space and over the abdomen (Bowmann *et al.*, 2003).

2.6. Epidemiology of the disease in domestic ruminants

Fasciolosis is principally cosmopolitan endemic infection and of greatest economic importance in ruminants while in human occurs by chance and focal in distribution (Dalton, 1999).

In developed countries, the incidence of fasciolosis can reach up to 77%. However, in tropical regions, it is considered the single most important helminth infection of cattle with prevalence 30% to 90% in Africa, 25% to 100% in India and 25% to 90% in Indonesia (Spithill, *et. al.*, 1999). The incidence in Ethiopia is known to be relatively high (Graber, 1975; Bahru *et al.*, 1979).

Factors that substantially influence its occurrence, dissemination and epidemiology of *Fasciola* species are the host, parasite and environmental risk factors or their combination. Availability of suitable definitive host, snails intermediate host, altitude, temperature and soil types are important factors for *Fasciola* species existence (Bowmann *et al.*, 2003).

2.6.1. Host factor

The genus *Fasciola* has adapted to alternative hosts in which susceptibility of various species and breeds of animals to the parasite vary and are genetically determined (Urquhart *et al.*, 1996). Evidence suggests that sheep and cattle may be considered the main host species, pigs and donkeys being secondary (Mas-Coma *et. al.*, 1999). However, cattle, sheep and goats are more susceptible to internal parasites than other types of farm livestock (Schoenian, 2003); some ruminants show resistance against establishment of *Fasciola* species. For example, *Bos indicus* cattle appear to be more resistant than *B. taurus* to infection with *F. hepatica* (Torgerson and Claxton, 1999). The Indonesian Thin Tail Sheep have high resistance against *Fasciola gigantica* but not against *F. hepatica* (Roberts *et al*, 1997). Khallaayoune *et al.*, (1991) reported particularly marked infection variations in the Timahdin breed in sheep in Morocco. It was indicated that the major mechanism of resistance was manifested against immature parasites while Merino Sheep did not acquire resistance against *F. hepatica* (Radostitis *et al.*, 1994; Urquhart *et al.*, 1996).

Infection depends on several factors related to the vectors, biology and management of the flocks and herds. In Europe, the molluscs population reaches maximum denşity between November and March and start decreasing beginning April. During the rainy season, from June to October only few snails remain to ensure survival of the species (Mira and Ralph, 1989).

The low incidence of fasciolosis in goats could relate to their grazing behavior. Goats naturally are browsers and usually prefer to feed on higher plants than grazing grasses (Devendra and Marca, 1983; Georgi, 1985; Payne, 1990). The epidemiology of the disease is also influence by the grazing habit of the animals. Animals grazing in wet marshy areas, favored by the fluke's snails are more likely to become infected.

Adult flukes can survive for as long as 6 months up to 2 years in the livers of infected cattle but sheep can live for longer period. The egg production figures for *F. hepatica* are impressively high; in light infection in sheep (up to 50 flukes), each fluke produces an average of 25.000 eggs per day over a long period. Eggs production is responsible for high degrees of pasture contamination and thus greatly influences the epidemiology of the disease (Fairweather *et al.*, 1999).

2.6.2. Climate and environmental factors

Parasite distribution in the environment is extremely variable (Hanson and Perry, 1994). However, despite the variability, for *Fasciola* species to complete their life cycle the environment must provide a consistent set of suitable conditions of moisture and temperature for the development of the larval stages and the development of the intermediate host itself (Torgerson and Claxton, 1999). Generally, *F. hepatica* is found at an altitude of above 2000 meters above sea level (masl) while *F.gigantica* found below 1200 masl (Radostitis *et al.*, 1994; Malone and Yilma, 1998). Media with slightly acidic PH are considered optimal for the development of Lymnaedae (Urquhart *et al.*, 1996).

In many parts of the tropics as well as in temperate areas the numbers of larval stages of parasitic helminths found on the pasture follow seasonal fluctuations. Investigations carried out on

Fasciola larvae ecology in parts of sub-Saharan Africa, the rate of development and the longevity of eggs and larvae vary with temperature, rainfall and humidity in different geo-ecological regions and may have an influence on the seasonal availability and abundance of the free-living stages of *Fasciola* parasites. The survival of *F. hepatica* infection on tropical pasture is variable depending on the climate and degree of shade, but the infective larvae are relatively resistant for 1-3 months on pasture (Hanson and Perry, 1994). On the other hand, European temperate climate is unfavorable for the survival of *Fasciola gigantica*, while *Fasciola hepatica* prefers cool climate (Urquhart *et al.*, 1996).

Effect of temperature on snail, intermediate host, is important to consider as epidemiological factor. When temperature rises above 10^0C and is maintained above that level, a significant multiplication of snails and fluke larval stage occurs. Maximum growth of snails occurs at 18-27 ^{0}C. *L. trancatula* can grow to sexual maturity in 3 to 4 weeks, depending on the amount of food available and the number of parasites in the snail. It is stated that *L trancatula*, the mud snail, may undergo a prolonged state of aestivation, if the environment dries out, during which transmission of the parasite is suspended but when the rains return, there can be rapid recolonization of the environment (Torgerson and Claxton, 1999). The minimum temperature for the development of *L. Natalensis*, intermediate host for *F.gigantica*, is greater than that required for the intermediate host of *F.hepatica*. Development of cercariae does not occur below 12^0C, but grows in 73 days at 15^0C and 25 days at 30^0C (Al Habbib and Al Zako, 1981).

The optimal moisture condition for snail breeding and the development of *F. hepatica* with snails are provided when rainfall exceeds transpiration and field saturation is attained. Such conditions are also essential for the development of fluke eggs, miracidia, searching for snails and dispersal of cercarial being shed from the snails. Typically, long wet seasons are associated with a higher rate of infection. However, large number of cysts more likely infects sheep during dry periods, following a wet season. Due to a reduction in availability of pasture, animals are forced to graze in swampy areas or in areas where the water has receded, there by contaminating the vegetation resulting in heavy infection with metacercariae in *Fasciola* species (Hanson and Perry, 1994; Torgerson and Claxton, 1999).

Metacercariae have been shown to survive for more than one year in the laboratory but under pasture condition, it is likely that high level of infection does not persist for such long period (Soulsby, 1986); however; both *F. hepatica* eggs and metacercariae can survive over the winter and play on important role in the epidemiology (Urquhart *et al.*, 1996). At 12-14^{0}C, up to 100% of metacercariae can survive for 6 months while only 5% survive for 10 months in pasture lands and up to 3 months in harvested hay in endemic highland areas. Metacercarial survival is reduced in hot condition (Torgerson and Claxton, 1999; Njau and Scholtens, 1991).

Moreover, discovering the multiple causation of the disease might be predicted through Geographical Information System (GIS) and satellite sensor technology emerging new tool for epidemiological studies on human and animal cases, especially vector-borne diseases with strong environmental determinants. The new tool was applied in Ethiopian condition to predict prevalence of fasciolosis because of presence of suitable information on the disease and natural habitats in a defined ecosystem (Malone and Yilma, 1998).

In Ethiopia, the general pattern is that the low- lying areas in the highland have poor drainage and the soil seems to be acidic and there is suitable temperature, moisture and snails intermediate host. This condition favors the development of fasciolosis. Various researchers recorded the epidemiology of fasciolosis in different areas in Ethiopia. The following table summarizes prevalence of fasciolosis in different parts of Ethiopia (Table 1).

Table 1. Prevalence of fasciolosis in different parts of Ethiopia

Area	Prevalence (%)		Animal species	Authors
	faecal	abattoir		
Mekelle		32.8		Hagos (2007)
Addis Ababa		22.75	ovine	Berhanu (2006)
ELFORA	1.14	1.14	ovine	Meskerm (2006)
Debre Berhan	64.23	83.6	bovine	Zerihun (2006)
	54.17		ovine	
Upper Blue Nile	37.2		bovine	Solomon (2005)
	38.6		ovine	
Jimma		57.58	bovine	Moges (2003)
Gondar		43.1	bovine	Mezgebu (2003)
		40.6	ovine	
Assela	32.9	31.8	bovine	Dinka (1995)
Awassa		30.43	bovine	Hailu (1995)
E. Gojjam	50.56		bovine	Beyazn (1995)
Tigray		26.13	bovine	Takele (995)
Nekemte	18.99	22.72	bovine	Wassie (1994)
	12.42	15.56	ovine	
Debre Berhan	80.0	88.57	bovine	Dange (1994)
Bale	34.6	49	bovine	Abduljebar (1994)
Zeway		56.6	bovine	Adem (1994)
		38.9	ovine	
W.Shoa	26.22	81.6	bovine	Yadeta (1994)
		84	ovine	
Kombolcha	45.26	53.5	bovine	Mulugeta (1993)
Wolliso		27.1	bovine	Rahmato (1992)
Soddo	15.77	47	bovine	Abdul (1992)
Chillalo	60.2		bovine	Zerfu (1991)
Assela	32.0	53.72	bovine	Wondowosson (1990)
Dembidollo	-	77.8	bovine	Abera (1990)
Kallu	15.77		bovine	Girmay (1988)
Bahre Dar	60.2		bovine	Fekadu (1988)
Gondar		75.1	bovine	Roman (1987)
Nekemte	32.0		bovine	Abebe (1986)
Gondar	40.6		bovine	Gebreyesus (1986)
Hollota	82.78		bovine	Yilma (1985)

2.7. Economic significance of the disease in domestic ruminants

Fasciolosis causes important economic losses in most regions of the world where cattle and sheep are raised. In areas where ruminants are raising, infection is principally endemic (Radostitis, *et al*., 1994; Hanson and Perry, 1994).

F. hepatica has a cosmopolitan distribution but the distribution of *F. gigantica* is more limited, being restricted to tropical areas and have been recorded in Africa, the Middle East, Eastern Europe and South and Eastern Asia (Torgerson and Claxton, 1999). About 250 million sheep and 350 million cattle are at fasciolosis risk worldwide (Ramajo, *et. al.,* 2001). In many countries about a quarter of the sheep and cattle, populations are exposed to infection causing severe economic losses (Chen and Mott, 1990).

Economic effects of the disease in livestock can range from sudden death because of massive infection to subclinical infections, which produce marked economic losses. Several authors have estimated the economic losses due to reduction in the live weight gain and milk production.

The direct impacts of fasciolosis are liver lesions, reduction in feed utilization efficiency, depravation of the animals of ingested nutrients, and reduced feed intake through loss of appetite and discomfort leading to reduced feeding time (Radostitis *et al.,* 1994; Urquhart *et al*., 1996). The economic implications; however, are assessed best at the output and input levels. The effects include growth rates, reduced production of meat, milk, and wool, reduced reproductive efficiency and mortality.

Fasciolosis can also lead to total carcass condemnation when it is associated with jaundice and severe emaciation. Moreover, it has been found that 2% mortality rate may occur in the case of acute fasciolosis (Fabiyi and Adepeye, 1982; Gracey *et al*., 1999; Soulsby, 1986).

In West Germany, the economic loss in the form of reduced meat and milk production was estimated to be 5 dollars per animal per year (Gracey *et al*., 1999). It was estimated that fasciolosis account for an annual loss of about 50 million dollars in milk and meat production in the United Kingdom (Ogunrinade *et al*., 1980). In general, infection of domestic ruminants with liver fluke causes significant economic loss estimated at over US$ 200 million per annum to the agricultural sector worldwide(Ramajo, *et. al.*, 2001).

Swell (1966), cited by Dakkak (1991), estimated that about 0.198 kilogram of body weight per fluke is lost annually because of fasciolosis in cattle. In sheep and cattle, the reduction of weight gain and other adverse effects depends on the parasite burden. Infection has also serious effect on milk quantity and quality; it causes lower fertility rates in cattle and sheep (Machanicka, 2000),

Cowdery (1984) also estimated a loss of between 8 to 28% in body weight in-group of animals exposed to light heavy fluke worm burden in six-month period (Fabiyi and Adepeye, 1982; Campbell and Rewe, 1986). Other workers (Henderson and Blood, 1974; Fabiyi and Adepeye, 1982) recorded an estimated loss of 10% carcass weight loss due to bovine fasciolosis.

The economic loss due to reduced milk yield resulting from fasciolosis is also immense. Ross (1977) estimated even in low level of infection with 100 flukes can lead to 8% reduction in milk production. A 16% reduction rate in cattle infected with 250-300 flukes and 20% reduction rate in animals infected by 500 or more flukes is reported. This parasite may reduce beef production by 10%, milk production by 16% and the loss of flesh in affected sheep by 25% as indicated by Thornton and Gracey. (1978); Yagoub and El-Khawad, 1980).

Various reports indicated that fasciolosis is a serous problem of livestock production in Ethiopia causing considerable economic losses. The annual loss due to endoparasitism including fasciolosis in Ethiopia is estimated to be at 700 million Birr (Mulugeta *et al.*, 1989). The economic impact of fasciolosis is huge because of decrease in production and productivity of animals. A rough estimate of economic losses because of a decreased productivity alone due to bovine fasciolosis is estimated at 300 million Birr (Bahru and Ephrem, 1978).

It brings death, loss of carcass weight, reduced milk yield, condemnation of affected livers, decline in reproductive performance, predispose animals to other diseases and additional cost due to treatment (Olsen, 1974; Radostitis *et al.*, 1994).

It is likely that fasciolosis is considered one of the major constraint to sheep production in the Ethiopian highland (ILCA, 1991). It causes huge direct and indirect loss. Financial losses due to ovine fasciolosis was estimated at 48.8 million Birr per year of which 46.5%, 48.8% and 4.7 % were due to mortality, productivity and liver condemnation, respectively. Reduced reproductive efficiency manifests it self through reduced potential development, extended lambing intervals, reduced weight and number of weaned offspring per ewe and subsequent effect on the age and sex structure, and genetic impediment of the flock (Ngategize *et al.*, 1993).

Preliminary surveys were carried out on the prevalence and economic losses in different parts of Ethiopia. Bahru *et al.*, (1979) has reported prevalence of bovine fasciolosis in eight of the 14 administrative regions namely Kaffa, Illibabur, Sidamo, Showa, Wollega, Wollo, Gondar and Arsi. In this study, the mean *Fasciola* species infection level was 61% with highest incidence in Kaffa (86%) and lowest in Sidamo (42%). Similarly, different studies indicated that prevalence of fasciolosis was 38.6% Solomon (2005) in Upper Blue Nile, 22.75% in Addis Ababa(Berhanu, 2006), 75.1% in Gondar (Roman, 1987), 53.72% in Arsi (Wondowosson, 1990), 31.8 % in Assela (Dinka, 1996) and 32.8% in Mekelle (Hagos, 2007) abattoirs.

Some of the annual losses recorded were 350 million Ethiopian Birr in eight administrative regions (Bahru *et al.*, 1979); 497,752.56 Ethiopian Birr at Gondar abattoir (Roman, 1987); 119,704.15 Ethiopian Birr in Arsi administrative region (Wondowosson, 1990) and 1.026.951.12 Birr at Mekelle abattoir (Hagos, 2007).

Further, more various researchers with substantial information variations reported on economic losses due to fasciolosis in different parts of Ethiopia. Detail reports are summarized on table 2.

Table 2. Financial losses due to fasciolosis in different parts of Ethiopia

Annual losses in (Eth.Birr)	Place (Abattoir)	Authors
1,026,951.12	Mekelle	Hagos (2007)
178,933.36	Debre Berhan	Tesfaye (1995)
376,019.70	Dire Dawa	Daniel (1995)
112,775.54	Awassa	Hailu (1995)
100,707.00	Nekemte	Wassie (1995)
109,601.24	Robe	Abduljebar (1994)
180,942.48	Bahir Dar	Yohannes (1994)
266,741.37	Kombolcha	Mulugeta (1993)
142,128.00	Soddo	Abdul (1992)
488,789.00	Jimma	Zewdu(1991)
119,704.15	Assela	Wondowosson (1990)
92,153.60	Bahir Dar	Fekadu (1988)
497,752.56	Gondar	Roman (1987)
67,667.40	Nekemte	Abebe (1986)
631,320.00	Addis Ababa	Getachew (1984)

2.8. Public health importance

Human infection by *F. hepatica* has not been gives it due attention; however, it is a disease of public health importance. Reports estimate that as many as 2.4 to 17 million people are infected and 180 million people are at risk worldwide (Mas-Coma *et al.*, 1999). It is worth mentioning that the numbers of reported clinical cases and of infected people identified during epidemiological surveys have been increasing since 1980 (WHO, 1995).

The WHO review (Chene and Motti, 1990, cited by Dalton, 1999) was the first paper to highlight the importance of human cases; however, human infection by *F. hepatica* was considered a disease of secondary importance. Human fasciolosis infection is high in areas where extensive sheep and cattle raising occur.

In humans, fasciolosis (caused by *Fasciola hepatica)* is focal in distribution and sporadic cases occur throughout the world while in ruminants the infection is principally endemic and of greatest economic importance. In Europe, cases are associated with the eating of watercress contaminated with metacercariae (Soulsby, 1986).

Fasciola hepatica may be acquired by man, but not directly from animals. Human infections may occur by chance in endemic areas depending on people's eating habits, most commonly because of eating infected vegetations and is becoming a serious condition to date. The vertebrate hosts acquire infection by ingesting the metacercariae with water plant (Chene and Motti, 1990, cited by Dalton, 1999).

The degree of pathogenecity of *F. hepatica* to man depends on many factors, particularly the number of worms present and the organs infected. Mechanical and toxic effects are characteristics (Elmer and Glenn, 1982). *F. gigantica* rarely infects human. Reported cases are usually from Africa.

2.9. Treatment and control measures of the disease

2.9.1. Treatment strategies

A number of agents may be used to treat *Fasciola* species infected animal. Carbon tetrachloride and other old drugs have been used for more than 50 years. Because of its inconvenient side effects, this drug is no more in use for treatment.

However, efficient drugs are now available, the ones of choice are diamphenethide, and triclabendazole, which removes the developing stages over one week old. Two other drugs, rafoxanide and nitroxynil, which at increased dosage rates will remove flukes over four weeks old are in common use (Hanson and Perry, 1994).

A single dose of diamphenethide accompanied with movement of cattle to fluke free or well drained or pasture recently cultivated field should be adequate treatment. However, with rafoxanide (cattle and sheep 7.5mg/kg BW) or nitroxynil (cattle and sheep 10mg/kg BW) a second treatment may be needed 2-3 weeks later (Mira and Ralpha, 1989). Out breaks of fasciolosis can be treated with any of these drugs and following treatment the anemia usually regresses within 2-5 weeks. Albendazole is also effective against adult flukes (Urquhart *et al*., 1996).

For bovine fasciolosis, the only one drug, which could remove the early parenchyma stages of flukes, is triclabendazole (cattle 10mg/kg BW, sheep 12mg/kg BW). Albendazole (cattle 15mg/kg BW, sheep 7.5mg/kg BW) is also effective at an increased dosage rate. In lactating cows, where the milk is used for human consumption, the above drugs either are banned or have extended withdrawal periods in most countries. An exception is oxyclozanide (cattle 10-15mg/kg bw, sheep 15-20mg/kg bw), which is licensed for use in lactating animals in many countries and has milk with holding time of up to 3 days (Urquhart *et al*., 1996).

2.9.2. Control measures

Effective control of internal parasite problems requires prevention of life cycle from completion, by use of anthelmintics, use of "safe pasture" after treatment, use of other animal species and managing animals and pasture effectively. Control of *Fasciola* species infection is based on strategically applied chemotherapy (Hanson and Perry, 1994).

Eradication of the parasitic infections of fasciolosis is rarely a practical option and of course needs to aim at the reduction of disease to allow economic livestock production. Specific aim of the control programme may be to prevent build up of parasites in the environment, reduce chance of contact between intermediate and final host and to avoid areas of heavy contamination of pasture. Reduction of pasture contamination may be obtained through use of anthelmintics, management regulation, use of molluscicides and biological competition as components of integrity control program (Radostitis *et al*., 1994; Dalton, 1999). In addition, the use of resistant animals to reduce impact of infection may have potential, especially where treatment cost is relatively high (Urquhart *et al*., 1996; Roberts *et al*., 1997).

Host treatment with anthelmintics is the principal method employed to control fasciolosis. Strategic mass treatment are generally carried out using anthelmintic drugs, notably specific narrow spectrum drugs at predetermined intervals based on the perceived duration of prophylaxis. All animals in a herd or flock may be treated or treatment may be targeted at a particular group of valuable animal of risk at a peak of the fluke season. When routine treatment with triclabendazole is practiced, it is recommended that two treatments be administered with an interval of 5-6 weeks to an individual animal (Hanson and Perry, 1994).

Regular treatment of at 12-13 weeks intervals with flukicides effective against both mature and immature fluke will reduce the intensity of infection in a flock or herd over time. This should be effective regardless of the climate provided there are no significant wildlife reservoirs of infection or infected irrigation or watercourse that could reconstitute the pasture. Once the prevalence of fasciolosis has been reduced to a low proportion, it may be possible to reduce treatment intervals or dispense with treatment completely for a number of years, though reinfection appear to occur eventually (Torgerson and Claxton, 1999) .

Molluscicides: Molluscicides have been used both successfully and cost effectively to control snails populations (Urquhart *et al.*, 1996), however, this approach has been not achieved wide acceptance. Risk of environmental contamination may be unacceptable, particularly when molluscicide kills utility species such as fish and crabs. Because of the snails' high biotic potential, pasture can quickly become re-infected. The most important compounds, which can be applied to control snails, are niclosamide, sodium pentachlorophenate and N-tritylmorpholine. Niclosamide is highly toxic to snails and eggs at 0.1 to 0.2 ppm and has low toxicity to mammals. Sodium pentachlorophenate is also effective when applied at 0.4 to 10 g per m^2 on snail habitat may be used. Like niclosamide, it is highly toxic to fish (Torgerson and Claxton, 1999; Bowmann *et al.*, 2003).

Because of the disadvantages of anthelmintic chemotherapy and chemical control of snail population, include residues in both the host species and the environment and the development of anthelmintic resistance, there is increasing interest in developing more environmentally friendly approach to fasciolosis control. These include natural molluscicides, vaccination, management and biological control and the use of resistant livestock (Torgerson and Claxton, 1999).

Hanson and Perry (1994) and Malone and Craig (1990) thought that seasonal strategic application of effective anthelmintics specific for fasciolosis as well timed prophylactic and curative treatment play important role in the control of liver fluke infection. Option of strategic chemotherapy could be indicative at the end of a period when larval development in the fluke eggs or in the snails has been retarded and when the reproductive rate of snails is low or their activity is impaired. Curative treatment was recommended to conduct about one to two months after the expected peak infection of the host aimed to remove the residual fluke burden acquired from metacercariae on the herbage. Occasionally tactical treatment may be required when the seasonal climatic condition are favorable for the parasites and snail development or in areas where metacercarial intake often occurs as a result of restricted gazing of wet areas during dry season(Hanson and Perry,1994).

However, Torgerson and Claxton (1999) suggested that strategic control programme using anthelmintics for different climatic zones could be modified in light of local knowledge of the infection.

In Europe, most transmission of fasciolosis infection to cattle occurs in the autumn. A single treatment in the winter, effective against all stages, will minimize pasture contamination in the spring. In regions with mild winters, significant number of over wintering metacercarial or fluke-infected snails may survive. In this case, additional treatment active against juveniles may be necessary during the transmission season. Torgerson and Claxton(1999) suggested that twice-yearly treatment provides a more effective long-term control of fluke infection in cattle than once yearly treatment; however, in Gulf coast states of United States, local recommendations are based on the facts that, transmission ceases during the hot, dry summer (Kaplan *et al.*,1994). In addition, because of high summer temperatures, which are often combined with drought, flukes normally, survive within fluke-infected cattle. In this case, a single treatment against adult fluke should virtually destroy the entire population of viable flukes, but in high-risk years, additional treatments with a flukicide that kills both juveniles and adults may be necessary in spring.

Malone and Craig (1990) suggested that clinical infections where prevalence in a herd is less than 25% and the mean egg count less than 0.5 eggs per gram of faeces, the herd burden is considered low and there is low probability of economic loss. Areas where prevalence is 25-75% and the mean egg count 1-5 eggs per gram of faeces infection is moderate, and economic loss is possible: where prevalence is more than 75% and mean egg count are greater than 5 eggs per gram of faeces then the burden of disease is high with concomitant economic loss.

Hence, the type of control program that can be recommended will depend on local husbandry and climatic conditions together with socio-economic factors relating to the livestock owner. These factors will vary between temperate and tropical climates as well as between farmers and industrial companies to lesser developed countries. A range of modules that predict the likely infection of fasciolosis in particular years, based on climatic data, contamination rate of livers and the local epidemiology of infection, have been produced in many specific ecosystems (Radostitis, *et al.*,1994; Torgerson and Claxton,1999).

2.10. Diagnosis

Diagnosis of fasciolosis both in animals and in man may involve considerations of various aspects such as history, clinical findings and general epidemiology of the disease. Confirmation in all cases can be made by either faecal examination or recovery of the worms at postmortem examination. Currently serological and molecular techniques are developing by various researchers. Analysis of the enzyme and haematological profiles are also known to give important clues as to the presence or absence of fasciolosis in animals (Hendrix, 1998; Martinez-Moreno *et al.*, 1999).

2.10.1. History and clinical manifestations

Infection with *F. hepatica* is usually associated with herds and flocks grazing in wet, marshy lands. On the other hand, *F. gigantica* uses water snails as intermediate host. There fore, infection with this species is associated with livestock grazing around the snail-infected watering places. which may be seasonally inundated (Spithil *et al.*, 1999; Payne, 1990).

Within infested group, different degrees of clinical severity are usually apparent; typically, some animals are mildly affected while others are moderately or severely affected. The clinical manifestation of parasitic diseases, including fasciolosis depends on the severity of infestation and localization of the parasite in the host. Clinically presumptive diagnosis of fasciolosis can be therefore made. However, most parasitic diseases have similar clinical pictures the observed signs should be supported by further laboratory and postmortem findings (Urquhart *et al.*, 1996: Hendrix, 1998; Bowmann *et al.*, 2003).

2.10.2. Laboratory diagnosis

Laboratory diagnosis of fasciolosis is mainly based on faecal and postmortem examinations (Hanson and Perry, 1994; Hendrix, 1998) as well as liver enzymes determination (Zheng *et al.*, 1990; Galtier *et al.*, 1994).

Qualitative faecal examination: is used to know the presence or absence of a parasite or whether an animal is infected or not. Under field condition, the methods most commonly used are sedimentation and floatation (Hanson and Perry, 1994; Hendrix, 1998; Antonia *et al.*, 2002).

Sedimentation procedure concentrates both faeces and eggs at the bottom of a liquid medium, usually water, and detects most parasite eggs or cysts that have high or specific gravity, like trematode (fluke) eggs (Hendrix, 1998; Antonia *et al.*, 2002).

The floatation method is based on difference in specific gravity of parasite eggs and that of the faecal debris. Trematode parasites' eggs have a specific gravity between 1.30 and 1.35. To make the egg float saturated salts such as zinc chloride, magnesium sulphate and potassium iodomercurate solutions with a higher specific gravity than the eggs must be used. Commonly used flotation procedures open the operculum and sink the fluke eggs rather than flotation it for surface determination (Hendrix, 1998).

Serological method: in recent years, serological diagnosis of parasitic infection has been further extended for the detection of antigen of parasitic infections, which is circulating in the serum or blood. It is used for the early detection of infections such as fasciolosis (Zheng *et al.*, 1990). Furthermore, liver enzyme determination is used in the diagnosis of fasciolosis that changes in serum enzymes are indicators of hepatic metabolism impairment (Galtier *et al.*. 1994).

It is assumed that certain liver tissue cells contain characteristic enzymes, the presence of which in the blood indicates the probable site of tissue damage by immature or adult *Fasciola* species. A rise in the level of serum hepatic enzyme gamma glutamyl trasnspeptidase (GGT) and glutamate dehydrogenase (GLDH) were shown to be indicative of liver damage due to obstruction of the biliary tract and liver damage by parasites (Martinez-Moreno *et al.*, 1999). The test for antibodies (ELISA) is highly specific and sensitive but remains positive for five months after treatment with or without the presence of flukes. The test can be particularly useful for the early detection of *F hepatica* infection (Zheng *et al.*, 1990). Hence, estimation of serum levels of enzyme released by damaged liver cells is used as supplement to faecal examination to justify the presence of infection with fasciolosis (Urquhart *et al.*. 1996).

Serum activities of GLDH and GGT are used as markers of the different stages of *Fasciola* infection in sheep, indicating the presence of cell necrosis caused by juvenile migrating flukes and bile duct lesions associated with mature helminths, respectively (Ferre *et al.*, 1997).

2.10.3. Postmortem examination

Post mortem parasite count provides a more precise assessment of parasite burden than parasite egg count. It is used for the detection and identification of the adult and immature forms of parasites. This method is more suitable for differential parasite count under field condition or laboratory conditions using simple, easily obtainable inexpensive equipments (Hendrix, 1998). Liver is examined for the assessment of worm burden, particularly *Fasciola* species and *Dicrocoelium* species (Theodoridis *et al.*, 1991). Lesions related to fasciolosis are specific, which is localized in the liver forming chronic cholangitis (Zheng *et al.*, 1990).

3. MATERIALS AND METHODS

3.1. Study area

The present study was conducted in Tigray Regional State, Northern Ethiopia. The region has common boundaries with Afar and Amhara Regional States at the Eastern and Southern parts, respectively, and international boundaries with Sudan and Eritrea at the Western and Northern parts, respectively. The region covers an area of is 54,548.32km^2. The livestock resource of the region consists of 3,596,649 cattle, 1,646,752 goats, 1,064,501 sheep, 364,940 equines, 13,661 camels and 2,570,833 poultry, representing nearly 10% of the livestock population of the country (Tigray BoFED, 2008). In the study area, agriculture is the main occupation and source of economy of the rural people who stay sedentarily, where smallholding with traditional crop-livestock farming system is dominant. Indigenous breeds of cattle, sheep and goats are the major livestock kept in the study areas. Based on the altitude, three main traditional agro climatic zones can be identified: 15% highland, 40% midland) and 45% lowland areas. There are two main river basins, namely the Tekeze and Mereb basins. The Mereb River forms boundary with Eritrea, while the Tekeze River delimits with Amhara Regional State, the Sudan and part of Eritrea (Tigray BoARD, Woody Biomass, 2002).

The districts selected in this study represent the typical agroecology of the region, comprising highland (Atsibi-womberta and Ofla), midland (Hintalowejerat) and lowland (Alamata), located at 851km, 617 km, 717 km and 851km, respectively, from Addis Ababa, North of Ethiopia. Most parts of the study areas are characterized with undulating hillsides: however, the climate and topography is favorable for livestock rearing with similar tropical and subtropical conditions.

There are two distinct seasons: wet and dry seasons. The wet season extends from June to September while the dry season is from November to May. The mean ambient temperature varies from 13.75°C to 21.25°C and the mean annual rainfall from 500 to 900 mm (Tigray BoARD, Woody Biomass, 2002). Two of the study districts, Ofla and Atsibiwomberta have poor drainage and there is a long period of over flooding and after rainy seasons leave a pocket of water lodge and swampy areas expanding up to the mid dry seasons, however in all areas there is an intensive microdams construction intended to increase potable water, irrigable land and groundwater level.

The soil type in the highland areas is moderately light dark brown clay soil that has a significant capacity of holding water. The study area, in the lowland create few pockets of water lodge areas which most parts stay only during the rainy and shortly after rainy seasons (Tigray BoARD, Woody Biomass, 2002). The vegetation of the study areas is based on the respective agroecological zones. In the highlands eucalyptus, tickets, coniferous trees and intensively cropped fields with teff, barley and wheat crops are common. Crop residues are important source of animal feed. The midland and lowland areas are characterized with acacia trees, bushes and grasslands. Furthermore, few varieties of wild animals are known to exist in the study areas, hyena and foxes being dominant (Tigray BoARD, Woody Biomass, 2002; Tigray BoARD, 2007).

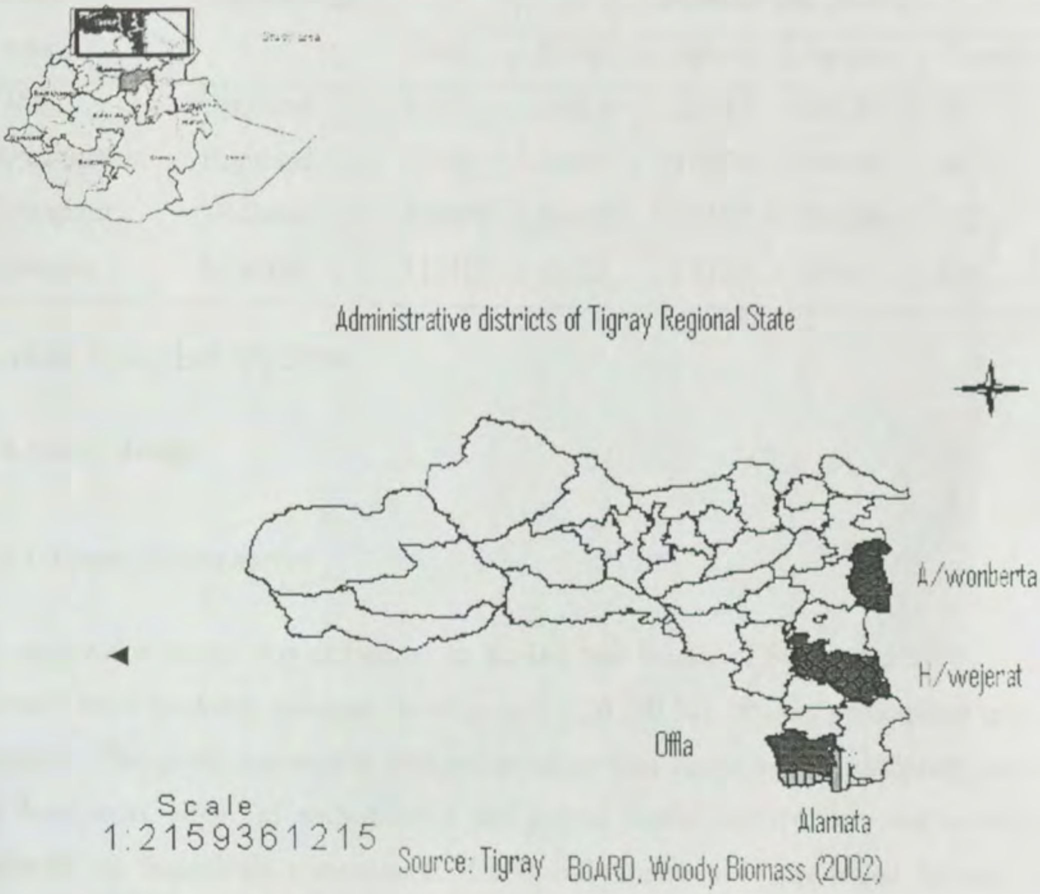

Figure 1. Map of study area

3.2. Study animals

For coprological investigation study animals consisted of indigenous breeds of cattle, sheep and goats kept under traditional extensive husbandry systems with communal grazing while animals of the same species but those slaughtered in three slaughterhouses in the study site were subjected to postmortem examination. Table three shows the livestock population of the selected study sites.

Table 3. Livestock population of the study areas

Study area	Agroecology	Livestock population					
		Cattle	Sheep	Goats	Equine	Camels	Poultry
Ofla	Highland	99147	59904	22489	19725	14	38065
A/womberta	Highland	52097	74608	12376	10800	62	48085
H/wejerat	Midland	117078	16039	18597	20558	373	41536
Alamata	Lowland	112418	13013	17715	8399	834	50228

Source: Tigray BoFED, 2008)

3.3. Study design

3.3.1. Questionnaire survey

Questionnaire survey was carried out in the last two weeks of September 2007. A total of 150 farmers were randomly selected; however, only 120 (80 %) farmers participated in all the study districts. The questionnaire was intended to collect data about animal husbandry, major diseases in their areas, usage of anthelmintics and animal health service in place, evaluate farmers' aptitude on fasciolosis transmission. The questionnaire was pre-tested in the field before administrated to the study population. The questionnaire was administered to individual farmers. The format was coded for computer database entry and analysis.

3.3.2. Cross sectional survey

According to Thrusfield (2005) a combination of multistage, random and purposive sampling methods were applied to select study areas and population.

For coprological survey, four districts were purposively selected based on agroecological differences, prior information on the disease problem and accessibility (first stage).

To select peasant associations (PAs) and villages a multistage random sampling method was used. Twelve peasant associations (three from each district, then one village from each peasant association) were randomly selected in collaboration with the respective district's animal health offices (second stage). Then 460 households (from each district 115 households of animal owners) were selected from the list at the development agent office. In each village, individual animals were selected randomly from the households (third stage). Proportional animal holding size was considered to determine the number of farmers included in the study.

The sample size for the cross sectional study was determined using the formula given by Thrusfied (2005).

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

Where

n = sample size to sampled;

P_{exp} = expected prevalence based on previous surveys;

d = desired absolute precision;

1.96 is to indicate 95% confident interval.

Accordingly, a precision level of 5%, 95% confident interval with estimated disease prevalence of 26.13%, for the three selected agro-ecological sites the sample size was 1015 cattle, 526 sheep, 167 goats and 28 camel including animals of all age and sex group. In all study areas, the dominant species of animals were indigenous breeds of cattle, sheep and goats with proportion ratio of 0.62, 0.27 and 0.11, respectively. Accordingly, the sample size was based on the livestock population proportion of the study district, hence proportionally distributed among the four study sites were 434 animals for Atsibiwomberta; 418 for Ofla; 459 for Alamata and 425 animals for Hintalowejerat study sites (Table 3).

In every stage, a random sampling technique was applied and parameters like species, age, and sex, observation of body condition and previous history of recent treatment were recoded.

In order to determine the prevalence of fasciolosis a cross sectional study type was carried out in two seasons: late rainy season, conducted during the last two weeks of September 2007 to mid October 2007 and dry season, conducted from January to February 2008.

Post mortem investigation was conducted to evaluate the fluke burden, severity of liver lesions, identify *Fasciola* species and determine prevalence. A total of 215 slaughtered animals were included for abattoir survey in the three selected slaughterhouses namely, Korem (Ofla), Alamata and Atsibi-edaselasie (Atsibiwomberta). Furthermore, 21 sheep liver were examined on samples obtained from restaurants (Adigudom/Hintalowejerat).

During the study period, *Fasciola* infected livers were collected and further examined for fluke burden and severity. Each slaughtered animal was identified and referred for its origin from the documents.

Parasitological examination procedures

Coprological examination

The faecal samples were collected from the study animals directly from the rectum into a clean universal bottle. The collected sample was preserved in 10% formalin when examination is delayed in the laboratory. Examination of the faecal samples for *Fasciola* species was made according to the methodology described by Hansen and Perry (1994) (Annex. 1).

The faecal samples thus collected subjected to qualitative (sedimentation) and quantitative techniques (Annex 1). Each negative sample was examined at least three times under a microscope to avoid any missing *Fasciola* eggs. Among the eggs, three to four eggs were measured using micrometer for *Fasciola* species identification. According to Soulsby (1986), an egg size 130-150μm in length by 60-90 μm width is *F. hepatica* and 156 -197 μm lengths by 90-104 μm width is *F. gigantica*. Size overlapping was avoided by taking the larger measurement from each microscopic field.

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

Fluke burden and species identification

Fasciola species identification and worm burden determination was carried out during the study period. Liver samples were obtained by systematic random sampling method from cattle, sheep and goats, which were slaughtered in three rural towns (Korem, Atsibi-endasilasie and Alamata slaughterhouses and restaurants in Adigudom).

A day before slaughtering ante-mortem investigation was performed and origin, age, sex, and general health condition of the animals recorded. Using the post mortem inspection, the liver of each animal was removed and kept under cold condition until examination. Observation of gross pathological lesions of the liver and the bile ducts and the gallbladder was made according Hendrix (1998). The affected liver was incised, sliced and soaked in saturated salt solution (Annex 2).

Identification of the *Fasciola* species involved was carried out using size parameter described by Soulsby (1986). Categorization of the pathological lesions observed in the affected livers was based on the work of Ogunrinade *et al.* (1980) as follows: a) lightly affected if small portion of the organ is affected and only one bile duct is enlarged on the visceral surface of the liver. b) moderately affected if half of the organ is affected and two or more bile ducts are enlarged. C) severely affected if the most of the organ is involved and the liver is cirrhotic.

3.3.3. Retrospective study

To assess liver condemnation and economic losses a retrospective study was conducted in selected slaughterhouses in the study areas.

3.5. Estimation of age and body condition scoring

Ages of cattle, sheep and goats were recorded according to the methodologies described by Nicholson and Butterworth (1986), Gatenby (1991) and Mike (1996), respectively (Annexes 3A, 3B, 3 C and 3D).

Before taking faecal sample body scoring of individual animals was recorded, using techniques recommended by Nicholson and Butterworth (1986), and body scoring in sheep and goats was recorded according to Gatenby (1991) and Mike (1996), respectively (Annexes 6, 7 and 8). The body condition scoring was made by feeling the level of muscling and fat deposition over and around the vertebrae of the loin region. In addition to this, feeling the spinous and transverse processes of loin vertebrae were used to assess individual body condition score. For this study, body condition score was categorized in three main groups: poor, medium and good.

3.6. Assessment of economic significance

Economic loss due to fasciolosis was estimated by computing direct loss (condemned liver) and indirect loss (carcass weight loss).

3.7.1. Direct loss

Investigation of annual liver condemnation was assessed considering the overall prevalence of the disease as a function of the total number of animals slaughtered annually.

Annual animal slaughter was determined from the retrospective slaughterhouse records of the last five years, including the study period. The retail market prices of an average size zebu liver and that of local breed sheep and goats was determined from interviews made with local butchers and restaurants in the study areas: Korem, Alamata and Atsibi-edaselasie slaughter houses, and restaurants in Adigudom.

Information obtained from the butchers and restaurants were then mathematically computed using the formula set by Ogunrinade *et al.* (1980).

ALC= CSR x Lc x P

Where ALC= annual loss from liver condemnations

CSR= mean annual slaughter in study areas

Lc = mean cost of one liver in the slaughter areas

P= mean prevalence of the disease

3.7.2. Indirect losses due to carcass weight loss

Henderson (1974) and Thornton and Gracey (1978) reported a 10% and 25 % carcass weight loss due to fasciolosis in cattle and sheep, respectively.

Average carcass weight of an Ethiopian zebu is taken as 126kg (ILCA. 1991). Live weight of tropical sheep and goat ranges between 40kg and 55kg. while dressing percentage ranges between 40% and 50 % (Payne, 1990; Mike, 1996). In Ethiopia. dressing percentage of sheep and goats ranges between 37% and 43 % (Galal and Kassahun, 1981: Solomon *et al.*, 1996).

The annual carcass weight loss due to bovine fasciolosis was then assessed using the following formula set out by Ogunrinade *et al.* (1980).

ACW= CSR x CL x BC x P;

Where ACW = annual loss from carcass weight

CSR= average number of cattle slaughtered per year in the study area

CL= carcass weight loss in individual cattle due to fasciolosis

BC = average market price of beef in the study areas

P= prevalence rate of fasciolosis in the study area

The total economic loss due to fasciolosis in the study area was estimated from the summation of ALC+ ACW

Similar methodology was followed to estimate direct and indirect economic losses in sheep and goats.

3.7. Data analyses

All raw data obtained from field on coproscopy results, post mortem and questionnaire surveys were coded and entered in MS Excel database system. Descriptive statistics and graphic results were generated in SPSS (version, 15.0) and MS Excel windows. The data were summarized and analyzed in reference to area and agroecology. Logistic regression using SPSS was applied to investigate the relationship between presences or absence of faecal eggs in individual study animals and study population independent variables such as sex, age (less than 2 year, 2-3 years and more than 3 years), body condition, locality, season (late rainy and mid dry) and agroecology as factors.

Dependent variable such as number of slaughtered animals, condemned liver and parasite burden were statistically analyzed and compared using the ANOVA. A 5 % significance level was used to determine whether there is statistical significant difference between the parameters used to measure the infection.

4. RESULTS

4.1. Questionnaire survey

Farming system: All farmers included in the study practice mixed farming where crop and livestock production being the major source of income. The farmers are sedentary and have different animal holding sizes with an average of four, three and two, for cattle, sheep and goats, respectively. Camels were very limited in number and found scattered in the lowland and midland areas only.

Animal management: In all study areas, communal land is used for free grazing purpose and in dry seasons animals are supplemented with crop residues in the morning and evening periods. Most cattle, sheep, goats and equines graze together in groups or herds (Annex 11). Livestock feed was better available during the rainy season (July to November) than the dry season (January to May). A small number (15%) and about half (45%) of the farmers used to move their animals for as long as 5 to 10 km in highland and midland, respectively, and the majority (95%) of the farmers move 15 km or more in lowland areas for grazing and watering purposes during the dry season. In the highlands, the grazing areas are close to livestock watering points.

Livestock diseases: The questionnaire survey indicated that among diseases affecting livestock in the area, bacterial (anthrax, blackleg and pasteurollosis), viral (FMD, LSD and sheep pox), gastrointestinal helminthosis and external parasites were the most important diseases. During the survey the majority (85 %) of the interviewed farmers in the highland areas considered fasciolosis as major disease, but in the midland and the lowland areas 73.3% and 90%, respectively, of the interviewed farmers considered the disease as less important. Fasciolosis is termed locally as "*EFel disease*" or "*Haseke tselim kebdi*". Farmers' observation on seasonality of the disease indicated that infection occurs during both the wet and early dry seasons. Farmers claimed that fasciolosis causes reduced appetite, diarrhea, emaciation, weakness, bottle jaw and reduction in milk yield of their lactating animals and reduction in the working power of their ploughing oxen. The majority of the interviewed farmers (89.2 %) do not know *Fasciola* and the role of snails as intermediate host (Annex 5).

Anthelmintic drug usage: More than half of the animal owners in the highlands (60.0%) use anthelmintic drugs at least once in a year, but a less number in the midland (30.0%) and lowland (10.0%) areas uses anthelmintics. Of the farmers used, their type of drug preference with specific against fasciolosis was albendazole in cattle and sheep. Anthelmintic users in the highland (60%) areas were higher as compared to midland (30%) and lowland (10%) area (Annex 5).

4.2. Cross sectional study

4.2.1. Parasitological coproscopy findings

Out of 1736 faecal samples examined 465 (26.8%) were found positive for fasciolosis. The overall prevalence in cattle, sheep, goats and camels was 25.3%, 35.7%, 11.4% and 3.6%, respectively. Coproscopy result detected that highest prevalence of the disease was in sheep (35.7%) and lowest in camels (3.6%) as indicated in Table 4.

The prevalence of fasciolosis varied among the four districts. The highest prevalence of fasciolosis was recorded in Ofla (41.9%) followed by Atsibiwomberta (34.8%) and lowest in Alamata district (11.5%). Statistical analysis of results revealed that there was significant difference ($p<0.05$) in infections among species and areas (Table 4).

Table 4. Prevalence of fasciolosis in the study areas on the basis of coprological analysis

Study area	Animal specie	Sample size	Prevalence (%)	95%CI
Ofla	Cattle	233	45.0	39.0 - 51.0
	Sheep	150	43.3	35.3- 51.3
	Goats	35	2.0	-3.0- 7.0
	Camels	0	0.0	
	Total	418	41.9	36.9 - 46.9
A/womberta	Cattle	175	25.7	19.7 - 31.0
	Sheep	211	46.0	39.0 - 53.0
	Goats	48	18.7	7.7 - 29.7
	Camels	0	0.0	
	Subtotal	434	34.8	30.8 - 38.8
H/wejerat	Cattle	308	22.1	17.1 - 27.1
	Sheep	83	20.5	12.5 - 28.5
	Goats	22	0.0	
	Camels	12	8.3	-6.7 - 23.3
	Subtotal	425	20.2	16.2 - 24.2
Alamata	Cattle	299	13.0	9.0 - 17.0
	Sheep	82	13.4	6.4 - 20.4
	Goats	62	4.8	-02 - 9.8
	Camels	16	0.0	
	Subtotal	459	11.5	8.5 - 14.5
Overall	Cattle	1015	25.3	22.3 – 28.3
	Sheep	526	35.7	31.7 -39.7
	Goats	167	11.4	6.4 – 16.4
	Camels	28	3.6	-3.4 – 10.6
	G/total	1736	26.8	24.8 – 28.8

During the study period, the distribution of *Fasciola* species varied among the different agro-ecological zones. In highland areas *F. hepatica* was commonly (61.07%) while *F. gigantica* was detected commonly in midland (8.4%) and lowland areas (11.4%). Significant difference ($p<0.05$) in *Fasciola* species distribution was observed among the three agro-ecologies (Table 5).

Table 5. Distribution of *Fasciola* species based on coprological result survey

Agroecological zones	*Fasciola* species		Total
	F. hepatica	*F. gigantica*	
High land	284(61.07%)	32(6.9%)	316(67.9%)
Midland	42(9.03%)	39(8.4%)	81(17.4)
Lowland	14(3%)	54(11.6%)	67(14.4%)
Total	340(73.1 %)	125 (26.9%	465(100%)
95% CI (of total)	69.1% - 77.1%	22.9% - 30.9%	

F. hepatica was widespread in Ofla (31.4%) and Atsibiwomberta (29.85%) districts while *F. gigantica* was more common in Alamata (11.6%) district. The highest percentage of *Fasciola* species was observed in Ofla (35.7%) district while the lowest in Alamata (14.6%) district Figure2)

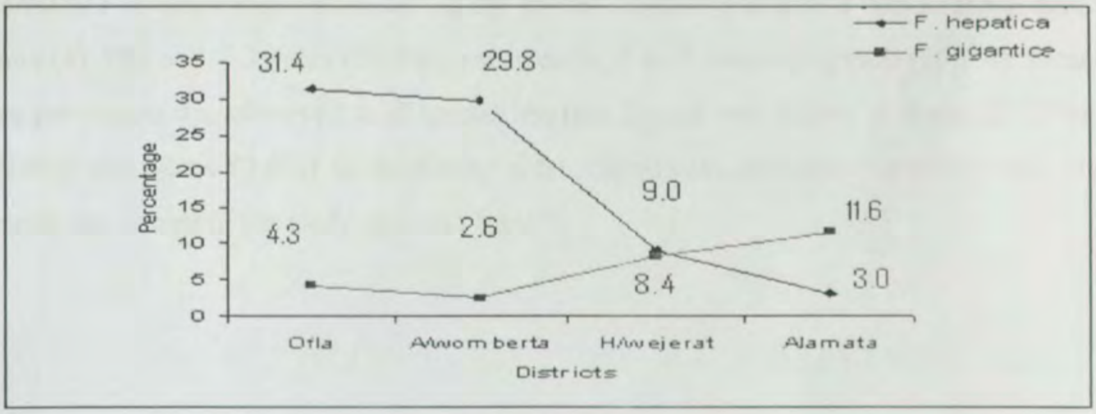

Figure 2. Distributions of *Fasciola* species based on coprological result by study district

The prevalence of fasciolosis in late and dry seasons was 31.8% and 21.7%, respectively, and prevalence in female and males was 27.4% and 26%, respectively. The highest prevalence was in the highland (38.2%) and lowest in the lowland (11.5%) areas. Significant difference (p<0.05) of prevalence was observed between the three agroecological zones and seasons; however, no significant difference (p= 0.514) was observed between sexes (Table 6).

Table 6. Coprological analysis results based on season, sex and agroecology in the study sites

Description		Sample size	Prevalence (%)	95 % CI	P-value
Season	Late rainy season	877	31.8	28.8 –34.8	0.000
	Dry season	859	21.7	19.0 - 24.4	
Sex	Female	967	27.4	24.6 – 30.2	0.514
	Male	769	26.0	23.0 – 29.0	
Agro-	High land	852	38.3	34.0 – 4.0	0.000
ecology	Midland	425	20.2	16.0 – 24.0	
	Lowland	459	11.5	0.08 - 1.53	
Total		1736	26.8	24.8 – 28.8	

Prevalence of fasciolosis varied among age groups. Highest prevalence was in sheep aged 2 to 3 years (41.5%) and > 3 years (38.6%); and in cattle, 2 to 3 years age group (36.7%). Meanwhile, low prevalence was observed in all species less than 2 years with value, in sheep (25.75%), cattle (22.4%) and goats (9.6%) in decreasing order. Significant difference (p<0.05) was observed among age groups in the study animals (Table 7).

Table 7. Coprological analysis results based on age group in the study sites

Animal species	Age group	Sample size	Prevalence (%)	95 % CI	P-value
Cattle	< 2 years	308	22.4	17.8 – 27.0	0.000
	2 -3 years	340	36.7	31.7 – 41.7	
	> 3 years	367	23.7	19.7 – 27.7	
Sheep	< 2 years	152	25.7	19.7 – 31.7	0.000
	2 -3 years	159	41.5	34.5 – 48.5	
	> 3 years	215	38.6	32.6 – 44.6	
Goats	< 2 years	52	9.6	1.6 – 17.6	0.000
	2-3 years	61	13.1	5.1 - 21.1	
	> 3 years	54	11.1	3.1 – 19.1	
Camels	> 2 years	28	3.6	-3.4 – 10.6	
	Total	1736	26.8	25.0 – 29.0	

Prevalence of fasciolosis based on poor body condition in sheep, cattle and goats was 47.4%, 31.7% 12.9%, respectively; however, animals with good body condition showed prevalence of 24%, 16.9% and 7.5% in sheep, cattle and goats, respectively. Significant difference ($p<0.05$) in prevalence was observed among body condition of the study animals (Table 8).

Table 8. Coprological analysis results based on body condition of study the animals

Animal species	Body condition	Sample size	Prevalence (%)	95 % CI	P-value
Cattle	Poor	341	31.7	27.9 – 35.7	0.000
	Medium	378	26.2	22.2 – 30.2	
	Good	296	16.9	12.9 – 20.9	
Sheep	Poor	192	47.4	40.4 – 54.4	0.000
	Medium	180	33.3	27.3 – 39.3	
	Good	154	24.0	18.0 – 32.0	
Goats	Poor	54	12.9	4.9 – 20.9	0.000
	Medium	60	13.3	5.3 – 21.3	
	Good	53	7.5	0.5 – 14.5	
Camel		28	3.6	-3.4 – 10.6	
Total		1736	26.8	25.0 –29.0	

Among the assessed faecal samples, apart from the Fasciola egg, infection with multiple parasites was evident in the study areas. Other trematodes: Paramphistomum egg and nematodes: Strongyle egg type, Trichostrongylus egg, Moniezia, Toxoascaris vitullorum. Their existence along with fasciolosis might have impact on the clinical manifestation and body condition of the animals.

4.2.2. Post mortem survey results in survey areas during the study period

During the cross sectional study period, out of 236 inspected livers 32.6 % were condemned due to fasciolosis. The highest liver condemned was observed in sheep (37.2%) and lowest in goats (17.6%); however, there was no record in camels (Figure 3).

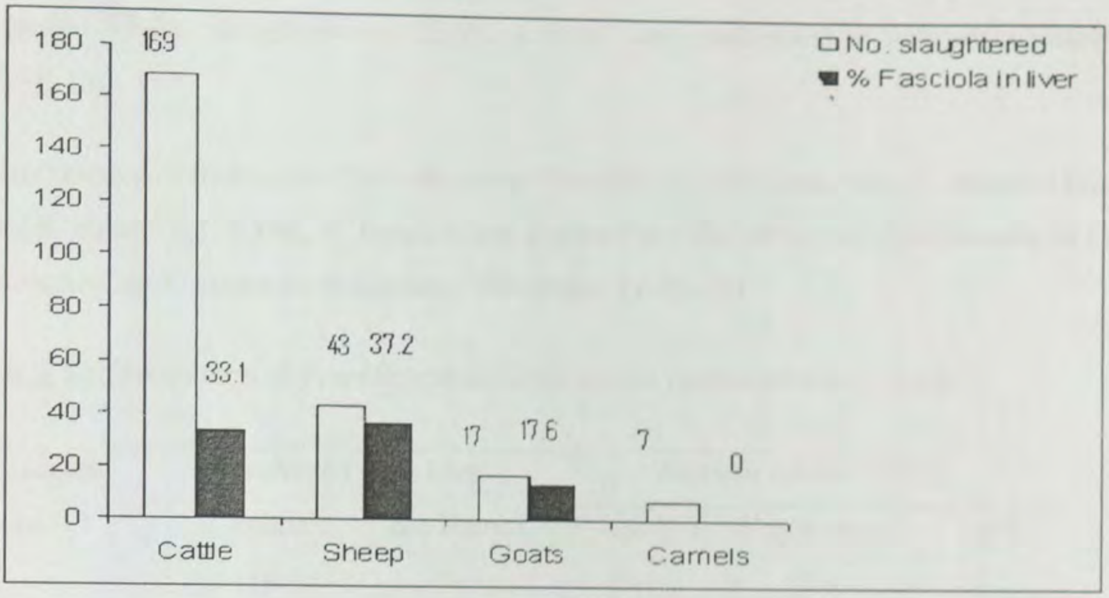

Figure 3. Intensity of liver infection in study animals

The mean adult fluke burden in liver was 73.47 ± 7.30. The parasite burden in severe, medium and light liver lesions were 99.56 = 13.96; 63.38 ± 8.88 and 53.36 ± 13.02, respectively. The highest mean fluke burden was reordered at Atsibi-edaselasie (85.36 ± 19.62) and lowest at Adigudom (23.40 ± 3.47) (Table 9).

Table 9. Fluke burden and liver lesion during the study period

Lesion	No	Fluke burden	95% CI Mean	
		Mean ± SE	Lower boundary	Upper boundary
Severely	27	99.56 ± 13.96	70.86	128.25
Medium	26	63.38 ± 8.88	45.08	81.69
Lightly	22	53.36 ± 13.02	26.28	80.45
Total	75	73.47 ± 7.30	58.90	88.03

During the cross sectional study period liver condemned at Korem, Atsibi-endasilasie, and Alamata slaughterhouses was 48.3%, 48.3% and 13.4%, respectively. The highest liver condemnation was observed in Korem (48.3%) and Atsibi-endasilasie (48.3%) and the lowest in

Alamata (13.4%) slaughterhouse. 23.8% of livers were condemned in Adigudom restaurants (Table 10)

Liver inspection findings of *Fasciola* species identified in study areas were *F. hepatica* (62.7%) *and F. gigantica* (37.3%). *F. hepatica* was dominant at Ofla (48%) and Atsibiwomberta (12%) districts while *F. gigantica* at Alamata (16%) district (Table 10).

Table 10. Distribution of *Fasciola* species based on post mortem results in 2008

Slaughter site	Slaughtered Animals (no)	Liver condemned (%)	*Fasciola* species (*n*=75)		
			F. hepatica (%)	*F. gigantica* (%)	Total
Korem	97	48.3	48.0	9.3	57.3
A/endasilasie	89	48.3	12.0	6.7	18.7
Alamata	29	13.4	1.3	16.0	17.3
Adigudom	21	23.8	1.3	5.3	6.7
Total	236	31.8	62.7	37.3	100.0

Results of logistic regression of risk factors associated with fasciolosis infection in the study areas

Logistic regression model analysis indicated that the effect of agroecology, animal species, body condition, and seasonal variation had significant impact on coproscopy positive result for fasciolosis ($p< 0.05$). The risk estimated in highland vs. lowland was more than 4 times (OR= 4.77) higher, highland vs. midland (OR= 2.44) and midland vs. lowland (OR=1.9) was almost 2 times higher. Risk estimated in sheep vs. goats (4.33) was higher than sheep vs. cattle (OR=1.64), and cattle vs. goats (OR=1.8). The risk estimated in poor body condition of vs. good (OR=2.5) was higher than poor vs. medium (OR= 1.45) and medium vs. good (OR=1.7). Animals located in highlands those having poor body conditions in late rainy seasons were significantly ($p<0.001$) associated with increased risk of *Fasciola* species infection (Table 11).

Table 11. Logistic regression analysis results of risk factor associated with fasciolosis occurrence in the study areas

Variables		ß	P-value	OR	95.0% CI for OR
Agroeco.	HL* vs. LL	1.60	0.000	4.77	3.44-6.52
	HL vs. ML	0.90	0.000	2.44	1.85-3.20
	constant	0.48	0.000	1.60	
	ML* vs. LL	0.70	0.000	1.90	1.3-2.80
	constant	1.40	0.000	3.90	
Animal	sheep* vs. cattle	0.50	0.000	1.64	1.30-2.06
	sheep vs. goats	1.50	0.000	4.33	2.60-7.21
	constant	0.60	0.000	1.80	
	cattle* vs. goats	0.70	0.000	2.90	1.6-4.35
	constant	1.08	0.000	2.90	
Body con.	poor* vs. good	0.90	0.000	2.50	1.9-3.20
	poor vs. medium	0.40	0.03	1.45	1.33-1.85
	constant	0.60	0.000	1.90	
	medium*vs. good	0.50	0.000	1.70	1.3-2.30
	constant	0.90	2.70		
Season	late rainy* vs. dry	0.524	0.000	1.70	1.4-.09
	constant	0.239	0.000	1.30	

*Reference variables, **OR** = coefficient regression ratio for 95% CI (or parameter risk estimates)
ß = coefficient regression

4.3. Retrospective study results in slaughterhouses

4.3.1. Retrospective post mortem survey results

Out of 11966 inspected livers, 22.62% were condemned due to fasciolosis in five years period. The rate of liver condemnation due to fasciolosis in cattle, sheep and goats was 23.76%. 34.04%, and 10.89%, respectively. The highest liver condemned was in sheep (34%) and lowest in goats (10.9%). There was no record of liver condemnation due to fasciolosis in camels.

Retrospective study of five years period revealed that the highest liver was condemned in Korem (35%) and the lowest in Alamata slaughterhouse (10%). Furthermore, liver condemnation was highest in sheep (61%) in Korem and lowest in goats (4.74%) in Alamata (Table 12).

Table 12. Livers condemnation due to fasciolosis in three slaughterhouses in years July 2004 to April 2008

Slaughterhouse site	Animal species	Number slaughtered	Liver condemned
Korem	Cattle	1854	619(33.4%)
	Sheep	1088	615(61.0%)
	Goats	1220	221(18.11%)
	Camels	0	0
	Subtotal	4162	1455(35.0%)
Alamata	Cattle	3132	394(12.58%)
	Sheep	1015	101(9.95%)
	Goats	1434	68(4.74%)
	Camels	47	0
	Subtotal	5628	563(10.0%)
A/endasilasie	Cattle	2176	689(26.15%)
Overall of the sites	Cattle	7162	1702(23.72%)
	Sheep	2103	716 (34.0%)
	Goats	2654	289 (10.9%)
	Camels	47	0 (0%)
	G total	11966	2707(22.62%)

During July 2004 to April 2008, the study revealed that mean number liver condemned due fasciolosis in Korem slaughterhouse was 123.8 in cattle, 123.0 in sheep and 44.2 in goat; while in Alamata slaughterhouse was 78.8; 20.2 and 13.6, respectively; however, there was no record in camels (Table 13).

Table 13. Mean annual number slaughtered animals and condemned livers due to fasciolosis in years July 2004 to April 2008

Slaughterhouse site	Animal type	Mean annual	
		Slaughtered animal	Liver condemn
Korem	Cattle	370.8	123.8
	Sheep	217.6	123.0
	Goats	244.0	44.2
Atsibi-edaselasie	Cattle	435.2	137.8
Alamata	Cattle	626.4	78.8
	Sheep	203.0	20.2
	Goats	268.0	13.6
	Camel	9.4	0.0
Total		2393.2	540.4

Results of mean slaughtered animals and mean liver condemned were 351.94 ± 42.71 and 93.34 ± 10.32, respectively. The highest liver condemnation was in 2006 and lowest in 2008 (Table 14).

Table 14. Retrospective data of yearly mean slaughtered animals and condemned liver due to fasciolosis in years July 2004 to April 2008

Year	Mean slaughtered animals	Mean condemned livers
	M ± SE	M ± SE
2004	411.75 ± 107.77	96.29 ± 26.27
2005	394.38 ± 78.14	105.00 ± 27.24
2006	390.17 ± 134.78	110.00 ± 19.80
2007	331.33 ± 85.91	96.80 ± 11.56
2008	189.00 ± 48.24	52.80 ± 16.14
Total	351.94 ± 42.71	93.34 ± 10.32

4.3.2. Analysis of economic losses

The over all direct and indirect financial loss incurred due to fasciolosis in cattle, sheep and goats in the study areas was 268,536.21 Ethiopian Birr. A loss at Korem (Ofla district) was highest as compared to Atsibiwomberta and Alamata districts. Out of the total incurred losses, 86.3% was in cattle and only 8% of the losses were due to liver condemned by fasciolosis in cattle, sheep and goats (Table 15).

Table 15. Annual average direct and indirect losses due to fasciolosis in years July 2004 to May 2008

Slaughterhouse site	Animal species	Annual average slaughter animal	Average annul losses		
			direct losses (Birr)	indirect loss (Birr)	Total (Birr)
Korem	Cattle	370.8	5,731.08	81,238.12	86,969.20
	Sheep	217.6	1,576.51	19,547.17	21,123.68
	Goats	203.0	1,767.78	19,483.29	21,251.07
	Subtotal		9,075.37	120,268.58	129,343.95
Alamata	Cattle	626.8	2,686.00	38,074.09	40,760.09
	Sheep	244.0	408.03	5,059.16	5,467.19
	Goats	286.8	576.47	6,353.44	6,929.91
	Subtotal		3,670.50	49,486.69	53,157.19
A/endasilasie	Cattle	435.2	8,687.63	95,347.44	104,035.07
	G/total		21,433.50	265,102.71	268,536.21

Average cost of one liver = 32.00 Birr, average cost of one kilogram meat = 36.00 Birr, mean prevalence in Korem and Atsibiwomberta = 48.3%, in Alamata = 13.4%

5. DISCUSSION

The present study was designed to determine prevalence, assess risk factors associated with fasciolosis and evaluate economic losses in four selected districts of Tigray Regional State.

The current study revealed that half of the respondents ranked fasciolosis the most important among parasites causing considerable direct and indirect losses Tigray Regional State. Fasciolosis is termed locally as "*EFel disease*" or "*Haseke tselim kebdi*" (Annex1 0). Farmers claimed fasciolosis to cause reduced appetite, diarrhea, emaciation, weakness, bottle jaw and reduction in milk yield of their lactating animals and reduction in the working power of their ploughing oxen; even if, the majorities do not know the parasite and its role intermediate host. Poor awareness of the livestock owners might greatly attribute for high prevalence of the parasite in the study areas, because of low skills on economic analysis at farmer's level, which usually leads tendencies to refuse treatment interventions. On the other hand, low awareness of the livestock owners might be due to poor extension service intervention; however, farmers are highly dependent on livestock raising for crop production (traction power) and income from animal resources (Zerbini and Alemu, 1996).

The present study revealed that overall prevalence of fasciolosis based on coprological investigation and post mortem results was 26.8 % and 31.8%, respectively. This finding agrees with previous studies observed at Mekelle abattoir by Takele (1995) and Hagos (2007). However, it was much lower when compared with results of Brook *et al.* (1985) in Debre Berhan (88.6 %), Yilma (1985) in Hollota (82.78 %), Roman (1987) in Gondar (75.1 %) and 53.72 % Wondowosson (1990) in through abattoir surveys, and Bahru *et al.*, 1979 (86 %) in Kaffa who came to this result through faecal examination. This might be due to differences in climate and agroecology for the development of the snail intermediate hosts, seasonal and nutritional level variation in the study periods. The difference in prevalence and severity of the disease syndrome are evident in various geographical regions depending on the local climatic conditions, availability of permanent water and system of management (Urquhart *et al.*, 1996).

The difference might also be due to breed resistance and concurrent infection with other parasites (Urquhart *et al.*, 1996; Torgerson and Claxton, 1999). Resistance of animals to infection by

Fasciola species following an initial exposure also account for the differences observed. This resistance reduces the number of mature and immature flukes, which would have developed (Cox, 2001).

Intensity of *Fasciola* species identified was not in agreement with the previous reports by Takele (1995) and Hagos (2006) in the same region. The reason might be due to the differences in temperature, moisture, humidity and soil that might favor multiplication of intermediate host, snails. Marshy areas, particularly at Lake Hashenge areas of Ofla and the high annual rainfall at Ofla and Atsibiwomberta districts combined with the construction of multiple microdams in Hintalowejerat and Atsibiwomberta districts might be other important factors for the perpetuation of the intermediate host. On the other hand, at Alamata district due to long dry season and hot climatic condition reputation of the disease was low as compare to in Hintalowejerat and Ofla districts (Tigray BoARD, 2002). Moreover, most of the Ethiopian, highlands contain pockets of waterlogged marshy areas, which provide suitable habitats year round for the snail intermediate hosts (Argaw, 1998).

Yilma and Malone (1998) suggested that distribution of *F. hepatica* and *F. gigantica* is limited to extreme highland (>1800m) and lowland <1200m) elevations, respectively. Mixed infections are present at intermediate altitude zone (1200 -1800m). However, lowland and midlands areas are considered low risk for *F. hepatica* infection due to the arid or semi- arid ecology. *F. hepatica* is the most important fluke species in Ethiopian livestock, which is distributed over three quarters of the nation. *F. hepatica* risk occurs in all areas of Ethiopian except in the arid. Northeast and Eastern part of the country.

This study detected that the higher the altitude, the abundant *F. hepatica* and the lower the altitude the more *F. gigantica*. but the existence of *Fasciola* species irrespective to their ecology might indicate the existence of snails away from the expected agroecology due to flooding to lower areas and, hence, capable of surviving in harsh environmental condition. The reason for variation might be also due to differences in climatic and animal management that could influence the development of the snails and intermediate host (Andrews, 1999). Analysis results revealed variation in prevalence of fasciolosis between different geographical areas. This disparity might be associated with variations in local climatic and temperature conditions, the density of livestock population, availability of specific ecological niches that might favor the development of intermediate host and the presence of the disease (Torgerson and Claxton, 1999). The highland areas, Ofla and Atsibiwomberta districts, which showed higher prevalence, are conducive for the development of intermediate hosts of *Fasciola* species.

A high prevalence noted in sheep and cattle might denote their frequency and grazing behavior on the pasture land as well as susceptibility differences (Torgerson and Claxton, 1999). Because, goats and camels are thought to be browsers (Devendra and Marca, 1983; Payne, 1990), prevalence of fasciolosis was low. Regardless of grazing behavior, fasciolosis was observed in camels (3.6%) at Hintalowejerat district. The reason might be due to the presence of poor vegetations, camels might graze around the watering points and microdams in the area. More over, camels have frequent mobility for browsing from lowland to midland or from midland to highland and vise versa.

The effect of sex difference was recorded in this study. Sex as a variable had shown no difference against variation in agroecology, area and age. On the contrary, Cowdery (1984) reported that cows and bulls have higher condemnation rate of livers than younger bullock and heifers.

The prevalence observed in this study with respect to age agrees with reports of Dwinger *et al.*, (1982) and Solomon (2005). High prevalence of fasciolosis was recorded between two and three years of age. Age variations prevalence of fasciolosis in cattle provides evidence for an incomplete protective immune response (Torgerson and Claxton, 1999). However, reason for age differences might be attributed because calves are not often driven with older age group to watering and grazing points because of extended lactation period and fairly due care provided to young animals. Young animals are kept at near their homestead where the source of feeding is much limited for snail contamination due to intensive cultivation. This traditional practice might have effect to reduce the chance of exposure in the young age category while older animals graze frequently in pasture lands.

In different parts of Ethiopia, similar results indicated inverse correlation of fasciolosis incidences and age of cattle (Girmay, 1988; Dagne, 1994; Beyazn,.1995; Dinka, 1996). This study showed that as the age increases to reach the second age group (2-3 years) the magnitude of infection increased. This indicates that the more the age of the young increases, the possibility of moving towards new environment happens, which leads to is an exposure to fluke-infected snail pasturelands and water points. On the contrary other authors reported that as the age of cattle increases the incidence decreases due to resistance development (Dalton, 1999; Solomon, 2005).

Furthermore, this study revealed that prevalence of fasciolosis was higher in sheep with on increase of age. In other words, the younger the age the lower the prevalence, and the older the age the higher. The reason might be due to that young sheep have less exposure to the parasite while older animals are left to graze frequently in pasture lands. On the other hand, due to short life span, as compared with cattle, sheep do not develop acquired resistance (Torgerson and Claxton, 1999).

Evaluation of adult *Fasciola* species in different degrees of liver lesions was recorded in this study. Even though precise causes of the pathology due to *Fasciola* species are still unknown, information on pathology is the basis for the knowledge of pathogenesis (Behm and Sangster, 1999). Effects of the parasite on liver tissues require investigation; however. Coles *et al.* (2001) suggested that feature of the resistance is related with higher level of liver tissue reaction characterized by fibrosis, creation of bile ducts stenosis and calcification. which are causes for impediment of passage of immature fluke. During the study period. chronic fasciolosis. characterized by enlarged and thickened bile ducts. standing out as whitish. firm branching cords with extended segments or in localized areas with fibrosis and calcified lesions of the hepatic parenchyma were commonly observed. Mature flukes were readily detectable in the larger bile ducts.

Even though. an accurate description of seasonal occurrence requires long-term epidemiological investigation over several years. the following season's variation may be expected. The peak of the snail (*Lymnaea* species) population is high at the onset of spring and shortly after the heavy rains. During the dry season. when there is a reduction in moisture in the habitat, the snails aestivate. As a result, snails resume their activity. In most cases December to May are the dry months in the study areas with some short rainy periods in Ofla and Atsibiwomberta from January to March which might have significant role for the development of snails in the latter areas. However, it is suggested that during the dry season there is a drop in the *Fasciola* species infection (Goll and Scott, 1978, cited by Lemma *et al.*, 1985). However, season of infection was an important factor in this study.

In the study districts, farmers' observation on seasonality of the disease indicated that infection occurs commonly both during wet and early dry seasons. The result was corroborated by the field survey and is in agreement with results of Daniel (1995) at Dire-Dawa.

The increase in coprological prevalence during the late rainy season might be related to the high number of metacercariae intake from the heavily contaminated pasture. As a result, temperature and moisture during late rainy season period are conducive to peak pasture contamination, so that a period for clinical manifestation and high chance of getting the eggs in faeces samples (Torgerson and Claxton 1999; Bowmann *et al.*, 2003). On the other hand, dry season is characterized by low ambient temperature and had less significant association with the snails' intermediate host (Andrews, 1999).

Contrary to the findings this study other authors reported that in cattle no significant difference was detected with respect to body condition score, with the fact that deterioration due to fasciolosis occurs at its chronic stage (Cole *et al.*, 2001; Solomon, 2005). The reason might be associated with scarcity of feed resources. Sheep of poor body condition are vulnerable for parasitic diseases (Devendra and Marca, 1983).

Fasciolosis influences directly or indirectly the economic development of livestock production. The economic loss due to the disease is considered on the amount of liver condemned based and reduced production in meat and milk. Based on five years average current retail price of liver and one kilogram of beef in the study areas, a total annual mean loss of 268,536.21 Ethiopian Birr per year has been incurred. The average annual loss is much lower as compared with other reports. The economic impact caused by the disease was enormous in the study area. The difference of the results on economic losses due to this disease might be due to the variation in the prevalence of the disease, mean annual slaughtered animals in different slaughterhouses and variation in retailer as well consumers. The cultural, socio-economic, agricultural and educational status of farmers might have influenced high infection with fasciolosis in the study areas. The high prevalence and significant economic losses due to this parasite does not only occur in the study areas, but it is also at regional as well at national problem and in most African countries. Consideration is usually also given to mortality and cost of treatment, reduced reproductive performance and decreased host resistance (Fabiyi and Adepeye 1982). Nevertheless. in this study loss was calculated from liver condemned and reduction in carcass weight only. The loss in body weight gain of infected cattle is directly related to the number of adult flukes found in liver (Henderson and Blood, 1974). To save the direct and indirect losses incurred due to fasciolosis in Ethiopian climatic condition, it is advisable to treat infected animals twice a year before and after the rainy season (Solomon, 2005). Similarly, in high risk temperate zone treatment usually is suggested in autumn and spring. In dry period snails undergo prolonged aestivation and transmission of the parasite is suspended, infection only remains within fluke-infected animals. Hence, treatment intervention successfully reduces the successive snail infection (Zukowski *et al.,* 1991; Torgerson and Claxton, 1999).

In this study loss due to condemned liver and reduction in carcass weight points a need to improve the Ethiopian animal health services.

6. CONCLUSION AND RECOMMENDATIONS

The result of the present study indicate that fasciolosis is one of the major problems to livestock productivity as well as economically important disease in the study area. However, it is increasingly evident that a proper evaluation of the epidemiology and economic losses due to fasciolosis is lacking. Assessment of losses due to the disease is of great economic importance for Ethiopian livestock including many other tropical countries.

The two *Fasciola* species, *F. hepatica* and *F. gigantica*, were detected indicating the existence of favorable environment in the study areas for the development of the intermediate host. Different domestic ruminants such as cattle, sheep, goats and camels of all age and sex group were found to be affected by the parasite.

The relatively high prevalence reported in this study has clearly indicated lack of strategic control measures against the disease as well as poor veterinary services. This high prevalence found in the study area could be also due to the promotion of water conservation program which increased irrigated land masses from the currently constructed microdams and ponds at Hintalowejerat, Alamata and Atsibiwomberta districts, and farmers' tendency to graze their animals in these areas because of feed scarcity.

Reduction in the seasonal prevalence of the disease was observed in proceeding order of late rainy to dry season, which might indicate importance of the study to be done year round including the short and long rainy season, so as to precisely predict the occurrence of the diseases as to implement proper strategic control program in all agro-ecological zones.

The overall survey results on fasciolosis disclosed that fasciolosis prevalence and economic significance was evident, and the losses calls for to improve the health service of the Ethiopian ruminants.

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8. ANNEXES

Annex 1. Sedimentation techniques

•Two grams of faeces will be put in a jar and mixed with 200ml tap water and stirred well with a string rod (faeces from ruminants) will be thought broken up using a mortar pistil.

•The sample will be strained through a tea strainer, washed copiously and fill up with tap water.

•The sample will be allowed to start for 15-20min and the supernatant will be discarded and re-suspended the sediment in tap water. This sedimentation process will be done four times.

•After the last sedimentation and decantation the sediment will be recovered into a test tube and fill up to 50ml value with water.

•Agitate the tube to re-suspend the sediment. Transfer the sediment to a microscope. Cover with a cover slide and detect the presence of *Fasciola* eggs under microscope.

Annex 2. Examination of liver for the presence of *Fasciola* species (Hendrix, 1998)

1. Before the liver is removed from the carcass the common bile duct will be ligated to prevent the escape of flukes.
2. The gall bladder is removed, transferred to a bowl containing normal saline and cut open.
3. The bile duct and any haematomas are opened and the liver, which may have to be cut into two to three portions for this purpose is washed in the bowl of saline. Any flukes seen adhering to the liver are detached with forceps.
4. The liver is cut into slices 1cm thick and these are squeezed and thoroughly washed in the saline.
5. The slices are cut up into small pieces approximately 1x5cm. the squeezing and washing is repeated and the pieces of liver are discarded.
6. The saline is now passed through the wire mesh screen with an aperture of 0.5cm and the flukes. which are retained by the screen. are recovered in a small volume of saline for counting and examination. Some of the flukes will have been cut into several pieces. When the whole flukes have been counted and removed the number represented by the pieces is

assessed by counting heads / tails. If no adults, the bile may be examined for the presence of fluke eggs. The bile is poured through a wire mesh screen with an aperture of 0.015mm by which any eggs are retained.

Annex 3. Body condition scoring

3. A) Body condition scoring of cattle (Nicholson and Butterworth, 1986)

Score	Condition	Future	Grouping
1	L-	Marked emaciation	
2	L	Transverse process project prominently, neutral spines appear sharply	
3	L+	Individual dorsal spines are pointed to the touch, hips, pins, tails-head and ribs are prominent, transverse process visible, usually individually	Poor
4	M-	Ribs, hips and pins are clearly visible. Muscle mass between hooks and pins slightly concave. Slightly more flesh above the transverse processes than in L+.	
5	M	Ribs usually visible. little fat cover, dorsal spines barely visible	Good
6	M+	Animals smooth and well covered; dorsal spines cannot be seen. but are easily felt	
7	F-	Animals smooth and well covered, but fat deposit are not marked. Dorsal spines can be felt with firm pressure, but feel rounded rather than sharp	Very good
8	F	Fat covered in critical areas can be easily seen or felt	
9	F+	Heavy deposit of fat clearly visible on tail-head and cod. dorsal spines ribs hooks and pins fully covered and cannot be felt even with firm pressure	

3. B). Body condition scoring of sheep (Gatenby, 1991)

Scoring	Condition	Description
Starving	0	Extremely emaciated and on points of death, not possible to detect any muscle or fatty tissue between skin and the bone
Very thin	1	SP are prominent and sharp. TP are also sharp, the fingers pass easily under the end, and it is possible to feel between each process. The eye muscle areas are shallow and no fat cover
Thin 2	2	SP feel prominent but smooth and the individual process can be felt only at fine corrugations. TP is smooth and rounded and it is possible to pass the fingers under the end with a little pressure. Eye muscle areas are full, and have a moderate depth, but have a little fat cover.
Moderate	3	SP are detected only as small elevation; they are smooth and rounded, and individual bones can be felt only with pressure. The TP are smooth and required to feel over the ends. Eye muscle areas are full, and have a moderate degree of fat cover.
Fat	4	The SP can just be detected with pressure as a hard line between the fat covered eye muscle areas. The ends of TP cannot be felt. The eye muscle areas are full and have a thick covering of fat.
Very fat	5	The SP cannot be detected even with firm pressure and there is a depression between the layers of fat in position where the SP would normally be felt. The TP cannot be detected; the eye muscle areas are very full with thick fat cover. There may be large deposits of fat over the rump and tail.

3. C). Body condition scoring of the goats (Mike Steel, 1996)

Score	Body condition
0	Extremely thin, nearly dead, no muscle between skin and bone
1	SP sharp and stick up. TP are sharp and your fingers easily pushed under thin ends. There is hollow between the ends of each processes, loin muscle are shallow.
2	SP Feel less sharp, your fingers can be pushed under the TP with the little pressure, loin muscles are of moderate depth.
3	SP only sticks up very slightly; they are smooth and rounded. Firm pressure is needed to detect each one separately. TP are smooth and well covered; firm pressure is required to push your fingers under the ends; loin muscles are full
4	SP can just be felt with firm pressure as a hard line and level with the flesh on either side. The ends of the TP cannot be felt; loin muscles are full.
5	SP cannot be felt at all, TP can be felt; loin muscles are very fully developed.

SP – Spinous processes; **TP**-Transverse processes; Eye muscle is the muscle along the side of the backbone.

Annex 4. Estimation of the age of different animals

4.A). Estimation of the age of the cattle (Dyce *et al*., 1987)

Permanent incisors	Age of the cattle
None	Less than 18 -24 months
1 pair	18-24 months
2 pairs	24- 30 months
3 pairs	36-42 months
4 pairs	42-48 months

4. B). Estimation of age of the sheep (Gatenby, 1991)

Permanent incisors	Age of the sheep
None	Less than 1 year and 3 months
1 pair	1 year, 3 months up to 1 year and 10 months
2 pairs	1 year, 10 months up to 2 year and 4 months
3 pairs	2 year, 4 months up to 3 years
4 pairs	More than 3 years

4.C). Estimation age of the goats (Mike Steel, 1996)

Age group	Teeth condition
lambs under 1 year	Eight sharp incisors
Yearling (1-2 years)	Central pair of baby teeth replaced by permanent ones
Young adults (3-4 years)	4 permanent teeth
Adults (4-5 years)	8 permanent teeth
Older adults > 5 years	Worn teeth and some missing

Annex 5. Questionnaire survey result of livestock owners' observation, their response and flukicide users

Description	Highland areas n=60	Midland areas n=30	Lowland areas n=30	Total n=120
Rank of fasciolosis (%)				
major	85.0	26.7	10.0	51.7
minor	15.0	73.3	90.0	48.3
Farmers observed flukes in liver (%)	81.7	96.7	96.3	89.2
Farmers with idea of fluke transmission (%)	18.3	3.3	3.3	10.8
Anthelmintic (flukicide) drug users (%)	60.0	30.0	10.0	40.0
Purchase of anthelmintic illegally (%)	40.0	33.3	33.3	36.7

Annex 6. Photographs

Photo 1. Animals grazing together at Hashenge pasture land (Ofla woreda)

Photo 2. Animals grazing together at Hashenge pasture land (Ofla woreda)

Photo 3. Cattle grazing at Timuga PA pasture lands (Alamata district)

Photo 4.Cattle grazing at Timuga PA pasture lands (Alamata district)

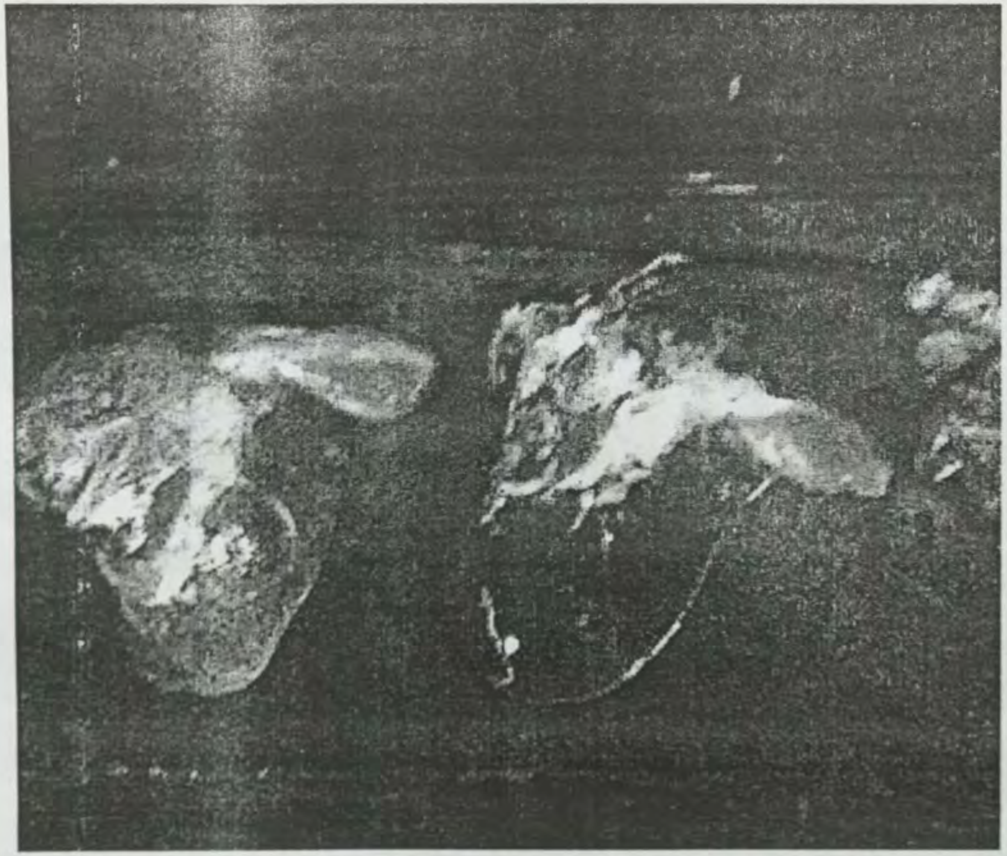

Photo 5: Liver affected by *Fasciola* species before incision

Photo 6: Liver affected by *Fasciola* species after incisio

Annex 7. Questionnaire survey format

Section A. general information at woreda/PA level (References)

1. Date of interview--
2. Name of the interviewed--
3. Region-------------zone---------- district (woreda)-----------------PA----------
4. Total area: grazing--------------; cropland-------------; forest ------------;other-------

5. Topography (%): Swampy------------------ Undulating---------

Mountainous--------- Others (specify)-----

Plain---------------------

6. Livestock population: cattle-------------------, sheep-----------------goats----------

equines-------------------poultry--------------------------------

7. Average holding size of livestock population per household:

cattle-------------------, sheep-----------------, goats-------------

equines-------------------, poultry---------------------------------

9. Annual rainfall (mm): min-----------------max---------------------mean----------

10. Beginning of rainfall (months): early---------------, mid-----------------, late------

11. End of rainfall (months): early------------------, mid--------------------, late---------

12. Temperature (0c): min--------------------max----------------------=-mean-----------

13. Relative humidity (%): min-----------------max----------------------mean----------

14. Altitude (masl): low------------------------------, high--------------------------------

15. Location: longitude-------------------latitude----------------------of district center

16. Type of production system (%)

-Agricultural (major crops)--------- Pastoral------------------

-Agro-pastoral----------- Sedentary------------

-Semi-sedentary---------

17. Any special remarks ---

Section B. Animal husbandry practices

Please tick (✓) the appropriate answer in the box or give short answers in the space provided.

1. Name of the owner--

2. Sex: M ☐ F ☐

3. Are you permanent residence of this PA? 1= yes ☐ 2= no ☐

4. What is your major farming activity? 1=livestoc☐ 2=crop ☐ 3= mixed ☐

5. Component of your livestock? 1= cattle ☐ 2= sheep☐ 3= goats ☐ 4=camels ☐ 5-equine

6. If Q5 has component limitations, no, why? 1=disease problem☐ 2=no grazing☐
   3 = shepherd's problem ☐ 4=predators ☐

8. Do your animals share shelter each other? 1= y☐ ☐ 2= no ☐

9. Did you get any training on aspects of health, husbandry and market by the extension service? 1= yes ☐ 2= no ☐

10. What was your first challenge to continue your farm?
   1= disease probl☐ 2=no grazi☐ 3= shepherd's probl☐ predat☐

11. Do you have any thing that you fear to increase your herd/flock size? 1= yes 2= no

12. Do you practice rotational grazing? 1= yes ☐ 2= no ☐

13. Do you provide supplementary feed for your flock? 1= yes ☐ 2= no ☐

14. Do your small ruminants graze together with large animals? 1= yes ☐ 2= no ☐

15. What system of animal grazing do you use?
   1=communal grazing ☐ 2= fenced farm ☐ 3= zero grazing ☐ 4=other ☐

16. Feeding practices

Native pasture (natural) grazing ☐ semi-zero grazing ☐

Crop residue feeding ☐ stall feeding ☐ other (specify) ☐

17. Water sources: -River Lake Pond: Protected springs/well; unprotected springs

18. Housing: Open enclosure ☐ Housed at corral ☐ Penned at night with shelter ☐

19. Do you want to improve your herd/flock breed? 1= yes ☐ 2= no ☐

20. If Q28 no, why?
   1=disease problem ☐ 2=no grazing ☐ 3= shepherd's problem ☐ 4 =knowledge ☐

21. Any other facts--

Section C. Disease of animals and health services

1. Is veterinary service problem in your district? 1= yes ☐ 2= no ☐
2. How often do your animals get health services?
   1=frequently ☐ 2=rarely ☐ 3=very rarely ☐
3. Do you have Vet. clinic in your PA? 1= yes ☐ 2= no ☐
4. If Q3 no, where do you use health service?
   1=district center ☐ 2= neighboring PA ☐ 3= nothing ☐
5. Who performs treatment of your animals in your areas?
   1=vet. Personnel ☐ 2 =CAHW ☐ 3 = private practitioners ☐ 4= all ☐
6. What is the reason for early culling of your animals?
   1 =disease ☐ 2 =feed ☐ 3 =problem of shepherds ☐
7. Which disease the reason for early culling of your animals?
   1 =worm 2 = infectious 3 = non-infectious
8. What do you call a disease caused by a worm? (Refer Q B 7)
9. Do you know an animal disease called "internal parasitism" /"Wishitawi-tsigetenga or Haseka tselim kebd"? 1 = yes ☐ 2 = no ☐
10. For Q 8, what do you call it in your area? --------------------------------
11. What are the clinical signs of the worm you mentioned?
    1=correctly answered ☐ 2=incorrectly answered ☐
12. What causes the disease of Q10?
    1 =correctly answered ☐ 2 = incorrectly answered ☐ 3 =do not know ☐
13. Is the disease present in your flock at this time? 1= yes ☐ 2= no ☐
14. How frequent does the disease occur in your herd/flock?
    1=all round the year ☐ 2= wet season ☐ 3= dry season ☐
15. How is the disease transmitted?
    1=correctly answered ☐ 2=incorrectly answered ☐ 3 =do not know ☐
16. In which season/months often do animals get the disease?
    1=late wet ☐ 2=early dry ☐ 3=late dry ☐ 4=early wet ☐
17. Is the disease a major problem to your farm? 1= yes ☐ 2= no ☐
18. Have you had any cases of internal parasite disease on your farm during the past one-year?
    1= yes ☐ 2= no ☐

19. If Q17 is yes, how did you determined/diagnosed whether the disease was internal parasite or not? 1 =previous experience ☐ 2=Vet. diagnosed☐ 3= neighbor /friend diagnosed it☐
4 =others ☐

20. What are the major cattle diseases in order of importance?

1------------------2------------------3-----------------

4------------- ------5------------------6------------------

21. What are the major sheep diseases in order of importance?

1---------------------2------------------3-----------------

4-- ---------- ------5------------------6------------------

22. What are the major goat diseases in order of importance?

1-------------------2------------------3-----------------

4------------- ------5------------------6------------------

23. What are the major camel diseases in order of importance?

1------------------2------------------3-----------------

4------------- ------5------------------6------------------

24. Do you protect your animals from the disease? 1= yes☐ 2= no ☐

25. How do you protect your animals from the disease?

1=drug from vet clinic ☐ 2= drugs from the other holders ☐ 3=herbal (specify) ☐

26. Which of your animals do you take most care in protecting from the disease?

1 = all animals ☐ 2=calves kids and lambs☐ 3 =only adults ☐ 4=ox/cow☐

Section D. Recording sheet for post mortem finding at slaughterhouse

Site__________________; No. Ante-mortem exam.__________;No postmortem exam.__________

1. Records during the study (organ condemnation records) period

1.1. Ante mortem and judgments recording sheet

Date	Animal species	Origin	Affected organ	Reasons for condemnations	Judgments Fff /Pc/Tc	Unit price	Total cost

1.2. Conditions: classification of liver lesions light (L); moderate (M) and heavy (H) due to fasciolosis (Un-fit for human consumptions)

Date	Animal species	Status of liver lesions			Total (no)
		L (no)	M (no)	H (no)	
	Cattle				
	Sheep				
	Goats				
	Camels				
	Cattle				
	Sheep				
	Goats				
	Camels				
	Cattle				
	Sheep				
	Goats				
	Camels				

1.3. Fluke count sheet on daily working calendar bases

Date	Animal species	Fluke type	Fluke counts (no)	Remarks
	Cattle			
	Sheep			
	Goats			
	Camels			
	Cattle			
	Sheep			
	Goats			
	Camels			
	Cattle			
	Sheep			
	Goats			
	Camels			

2. Pathological lesion observation remarks:--

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3. Previous data recordings (organ condemnation records)

Site________________; No. Ante-mortem exam.__________; No postmortem exam.__________

Year	Animal species	Origin	Affected organ	Reasons for condemnations	Judgments Fff /Pc/Tc	Unit price	Total cost

Fff - Fit for food; **Pc**- Partial condemnation; **Tc**-total condemnation

9. CURRICULUM VITAE

Personal information

Name	Gebru Legesse
Sex	Male
Date of birth	September 8, 1967
Nationality	Ethiopian
Marital status	Married
Religion	Orthodox

Educational background

Elementary and high schools		**Award**
Elementary school		
Place	Tigray	
Name of school	Maikenetal	
Attended	1975-1978	Certificate
Junior school	Maimisham Christ School	
Attended	1978-1980	Certificate
High school		
Place	Gojjam	
Name of school	Dangla	
Attended	1980-1983	Certificate

Higher education

Place	Debre Zeit	
Attended	1984-1986	Diploma
Place	Ukraine, Kiev	
Attended	1989-1993	DVM

Work experience

Place	Arsi Rural Development Unit
Responsibility	expert- animal health assistant at Arsi Rural Development Unit, Gobe cattle breeding center
Year	1986—1988
Place	Tigray Bureau of Agriculture and Rural Development, Southern Tigray Agriculture and Rural Development
Responsibility	Zonal veterinary unit coordinator
Year	1993—2003
Place	Tigray Bureau of Agriculture and Rural Development
Responsibility	PACE (Pan-African Control of Epizootic) branch office coordinator
Year	2004—2006

Research experiences

1. Livestock heath situation in central Tigray (1996). Published In: Rural exploratory of studies in Central Zone of Tigray, Northern Ethiopia. Workshop preceding of, Agricultural University of Norwegian.
2. Spatial and temporal distribution of CBPP in Southern Tigray (not published)
3. Role of Community Animal Health Service in Tigray Region (Document: Tigray Bureau of Agriculture and Rural Development Office)

Additional training

1. Privatization Promotion of Tropical Animal Health Service (Edinburgh, Scotland, CTVM, 1996)
2. Risk analysis (Royal University, London UK in collaboration with MoARD, Addis Ababa, Ethiopia, 2005)
3. ARIS-Animal Resource Information System in Africa. Oracle data analysis (2006, MoARD, Addis Ababa, Ethiopia

10. SIGNED DECLARATION SHEET

I, the under signed, declare that the thesis is my original work and has not been presented for a degree in any university and that all sources of materials used for the thesis have been dully acknowledged.

Name Gebru Legesse

Signature______________________

Date of submission______________________

This thesis has been submitted for examination with our approval as university advisors

Advisors	Signature
1. Dr Yilkal Asfaw (DVM, MSc. Assistant Professor)	______________________
2. Dr Yacob Hailu (DVM, MVSc. PhD, Assistant Professor)	______________________