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**EFFECTS OF A STRATEGIC ANTHELMINTIC TREATMENT
INTERVENTION ON RUMINANT FASCIOSIS IN UPPER BLUE
NILE BASIN, NORTHWESTERN ETHIOPIA**

By

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DEBRE ZEIT, ETHIOPIA

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ABBREVIATIONS

AAU	Addis Ababa University
Ab-ELISA	Antibody-Enzyme Linked Immuno Sorbent Assay
Ag- ELISA	Antigen-Enzyme Linked Immuno Sorbent Assay
ANOVA	Analysis of variance
ANRS	Amhara National Regional State
Apt	Appetite
As	Abattoir survey
AST	Aspartate Amino Transferase
BoA	Bureau of Agriculture
BCS	Body Condition Score
BCT	Buffy Coat Technique
BJ	Bottle jaw
BW	Body weight
Ce	Coprosopic examination
CI	Confidence Interval
CPSZ	Crop Production System Zone
Diar	Diarrhoea
DN	Data not available
Epg	Egg per gram
ET	Ethiopia
FAO	Food and Agricultural Organization
FEX	Faecal Examination
Fig	Figure
Gm(s)	Gram(s)
GIS	Geographical Information System
ILRI	International Livestock Research Institution
Kg	Kilo gram
LW	Live weight
m.a.s.l	Meter above sea level
Mg	Milligram

Mm	Millimeter
NR	Not Recommended
O	Oral
PA	Peasant Association
PCV	Packed cell volume
Pp	Pages
SC	Subcutaneous
SD	Standard Deviation
SE	Standard Error
Spp	Species
SPSS	Statistical Package for Social Science
STATA	Statistics/data Analysis

ABSTRACT

This study was conducted from December 2004 to March 2005 in two selected woredas in northwestern Ethiopia, with the objective of assessing the impact of a strategic treatment intervention on ruminant fasciolosis. The study was conducted using questionnaire survey, cross sectional prevalence study and experimental study involving naturally infected animals with *Fasciola spp.* and treatment with triclabendazole at a dose rate of 10mg/kg bodyweight orally. A total of 384 cattle from Fogera woreda and 368 sheep from Mecha wereda were involved in cross section prevalence study. 167 animals (80 cattle and 87 sheep) were selected from the study population and grouped into three (group I, one- time treated group, group II two-times treated group and group III, positive control) to serve as experimental animals. Out of the 752 faecal samples collected from cattle and sheep for cross sectional study, 283 (37.6%) were found positive for fasciolosis with a specific prevalence of 37.2% in cattle and 38% in sheep. Analysis of the findings among different age groups indicated the existence of a significant difference in prevalence of fasciolosis both in cattle and sheep ($P<0.05$). Sheep with poor body condition are more affected with fasciolosis than sheep of good body condition ($P<0.05$), while no significant difference was noted in cattle. The experimental study in its turn indicated a significant reduction in the prevalence of fasciolosis both in group I and group II animals following the October treatment and the overall prevalence of infection was reduced significantly after the end of the experiment in group II ($P<0.05$). Statistically, there was a significant difference ($P<0.05$) in infection rate between the three groups. The results of PCV in sheep showed that group II animals had the highest PCV (36.28 ± 5.54) followed by group I (27.18 ± 4.15) and group III (26.46 ± 3.17). The progress of PCV value in group II was significantly greater ($P<0.05$) than those of group I and III from December to March. Analysis of live weight change between the three groups of sheep showed significant differences ($P<0.05$) whereby group II had better weight gain (28.84 ± 4.64) than group III (21.53 ± 6.55) and group I (19.92 ± 4.98). Mean total weight gain per animal after the end of trial for group I, group II and group III was -2.11kg , 5.09kg and -3.11kg , respectively. In cattle, the mean body condition score for group I, group II and group III was 2.29 ± 0.71 , 3.7 ± 0.7 and 1.97 ± 0.69 at the end of the trial, respectively. Analysis of variance indicated that there was a significant difference in body condition score ($P<0.05$) between group II and group III while no difference ($P>0.05$) was observed between groups I and III at the end of the experimental trial indicating improvement in animals' body condition in twice treated cattle. At the start of the experiment (October) there were no significant differences in enzyme

concentration level of aspartate aminotransferase (AST) among the 3 groups of sheep. Thereafter (March), the enzyme level in all experimental groups has increased, however, group III had higher AST values than group II and I indicating the comparatively more liver tissue damage in untreated control groups ($P < 0.05$). This study has found the previously recommended *Fasciola* control methods and treatment intervention schedules appropriate to the Ethiopian northwestern highland areas. Nonetheless, the study indicated that the time span between the recommended intervention periods appears to be long enough so that fasciolosis buys time to highly prevail in the form of re-infestation in the study areas. Hence, additional treatment intervention in mid-dry season (December-January) has important impact in the reduction of the prevalence of liver fluke in the study areas.

Key words: Fasciolosis, Strategic treatment, Prevalence, Cattle, Sheep, Northwestern Ethiopia.

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DEDICATION

I dedicate this paper to my respectable mother, W/o Etagegnehu Teka Wolde, who passed away at the middle of the study period, December 2005. Etagegnehu had been very caring, accommodating, protective, and above all affectionate mother.

1. INTRODUCTION

Fasciolosis is a disease mainly of domestic ruminants and occasionally other domestic animals and man caused by liver fluke parasites *Fasciola hepatica* and *Fasciola gigantica*. The presence of fasciolosis in Ethiopia has a long history and is responsible for causing considerable losses in livestock production. Its prevalence and economic significance has been reported by several workers; Bergeon (1968), Graber (1978, 1975), Goll and Scott (1979) and Bahiru and Ephrem (1979), Getu (1987), Abebe (1988), Abera (1990), Zewdu (1991), Abdul (1992), Desie (1992), Genetu (1992), Mulugeta (1993), Yohannes (1994), Abduljebar (1994), Daghe (1994), Daniel (1995), Takele (1995), Mesfin (1999) and others (Annex 1) .

It is generally accepted that acute infection with fasciolosis can cause severe clinical disease and a high mortality rate in grazing sheep, but the economic impact due to chronic infection may be of considerable importance to sheep production. The subclinical form of the disease generally remains undetected and hence may significantly reduce production without the producer's knowledge (Hope-Cawdery, 1976). In sheep, infection with liver fluke reduces production, including wool growth and wool quality, lambing percentages and growth rate of lambs. For several years, severe losses of sheep were encountered at the Debre Berhan Sheep Ranch and most of this loss, which occurred in the months of December and January, had been attributed to fluke infection. Conventional treatment with fasciolicide was implemented and reduction of losses resulted (Goll and Scott, 1978). Moreover, over 45% mortality rate ascribed to fasciolosis in adult sheep was reported at Debre Berhan, Ethiopia (Njau *et al.*, 1988).

The measures required to prevent the indirect loss, which are of greater importance, have been considered uneconomic and impractical (Sauvage, 1974). A rough estimate of the economic loss due to decreased productivity cause by bovine fasciolosis is about 350 million Birr (Bahiru and Ephrem, 1979).

According to Yilma and Malone (1998) varying degrees of *F. hepatica* risk, occur in all areas of Ethiopia except in the arid northeast and eastern part of the country. The highest risk areas were localized in the western humid zone. *Fasciola gigantica* endemic-areas occur in entire

western zone of the country with localized foci in south and east. High risk of *F. gigantica* infection was indicated only at a small focus along the Blue Nile River.

Fasciolosis is the priority disease in the highland as well as in lowland areas of Amhara Region (northwestern Ethiopia). Generally the disease is found in vast water lodged and marshy grazing field, a condition anticipated to be ideal for the propagation and maintenance of high prevalence of fasciolosis. In areas along the Blue Nile River Basin such as Mecha and Fogera plain of Amhara Region are generally considered as one of the most affected and endemic areas of fasciolosis, veterinary practitioners and livestock owners complain of huge annual losses from the disease.

It is true that seasonal strategic application of effective anthelmintic specific for trematodes as well as timely prophylactic and curative treatments play an important role in the control of liver fluke infections. Strategic treatments have been developed for several regions of the world based on meteorological data (Hansen and Brian 1994).

On the basis of the study on regional monthly forecasts and transmission patterns in Ethiopia, two treatments (preventive and preventive-curative) per year for all four regions such as Western Ethiopia, South Ethiopia, North-central Ethiopia and central Ethiopia have been recommended, plus an optional curative treatment for western and southern regions (Yilma & Malone, 1998). Application of strategic treatments in the control of ruminant fasciolosis requires a conceptual understanding of the epidemiology of the disease, factors affecting the occurrence of the diseases and the type of control options specific for an area.

Fragmentary works have been done on the prevalence and economic importance of fasciolosis in northwestern Ethiopia; however there are no studies that have been conducted on the strategic control of fasciolosis in the area. This study is basically designed to implement experimental trials at farm level and analyze the effect of the strategic treatment of fasciolosis based on the previous recommendations.

The specific objectives of the project are:

- To determine the specific prevalence of bovine and ovine fasciolosis in selected sites of Amhara region.
- To assess the impact of a strategic anthelmintic treatment on parasitological and production parameters.

2. LITERATURE REVIEW

2.1. Description of the parasite

Fasciolosis is an economically important parasitic disease, which is caused by fasciolidae trematodes of the genus *Fasciola*, which migrate in the hepatic parenchyma, and establish and develop in the bile ducts (Troncy, 1989; Urquhart *et al.*, 1996).

There are two most important causes of hepatic fasciolosis, *Fasciola hepatica* and *F. gigantica*. *Fasciola hepatica* is commonly found in the temperate areas and in cooler areas of high altitude in tropical Africa (highlands of Kenya and Ethiopia), where it incurs economic losses in sheep and cattle (Yilma and Malone, 1998). It also infects all domestic animals and many wild life species; where as *F. gigantica* is predominantly found in tropical areas and is more common in Africa and India (Soulsby *et al.*, 1994).

Fasciola hepatica is characteristically leaf-shaped, broader anteriorly than posteriorly with anterior cone-shaped perception, which is followed by a pair of broad “shoulder” reaching a size of 30x13 mm. It is grayish brown in color changing to grey when preserved. The ventral sucker is situated at the level of the shoulders and is about as large as the oral. *F. gigantica*, on the other hand, resembles *F. hepatica* but it readily recognized by its large size, begin 25 to 75 mm in length and up the 12 mm in width. The anterior cone is smaller than *F. hepatica* and the shoulder not so prominent and the body is more transparent. The egg is oval, operculated, yellow and large which is about twice the size of a trichostrongyle egg; however, the egg of *F. gigantica* is larger than *F. hepatica* egg, 190x100 µm and 150x90 µm respectively (Soulsby, 1982).

2.2. Life cycle

Fasciola parasites pass their life cycle in two different hosts, intermediate host (Lymnae snail) and final host, which are generally mammals, the domestic ruminants being the primary definitive hosts (Soulsby, 1982; Urquhart *et al*, 1996).

The adult liver fluke lives in the bile duct of the final host; each fluke is hermaphrodite and prolific egg layer laying 5000-20000 eggs per day per fluke. The parasite reproduces by depositing ova in the biliary passages, through which they reach the intestine with bile and are expelled together with the faeces. Each ovum produces ciliated larval stages called miracidium, (Olsen, 1974; Georgi 1985). This larval stage does not feed and further development occurs after it penetrates in a snail. Following penetration, the ciliated coat is lost and becomes a sporocyst- an undifferentiated mass of cells. This will in turn differentiate to become rediae, from which cercaria is formed and the cercaria leaves the snail and swims to the nearest herbage where it encysts to form a metacercaria.

The final host is infected by ingestion of metacercaria together with herbage materials and undergoes excystation in the duodenum. After excystation, it penetrates the intestinal wall and migrates to the liver eventually developing to maturity in the biliary passage (Soulsby, 1982; Urquhart *et al.*, 1996).

The minimum prepatent period of *Fasciola* is about 8 weeks and minimum of 5 months is required for the complete life cycle (Dunn, 1987). The mature liver fluke can live in the final host as long as 11 years (Read, 1960).

2.3. Pathology

Pathogenesis of fasciolosis varies according to the phase of parasitic development in the liver and species of host involved, essentially the pathogenesis is two fold; the first phase occurs during migration in the liver parenchyma and is associated with liver damage and haemorrhage. The second phase occurs when the parasite is in the bile ducts, and results from the haematophagic activity of the adult flukes and from the damage to the mucosa, by their cuticular spines (Urquhart *et al.*, 1996).

In acute hepatic fasciolosis sufficient parenchyma may be destroyed to cause acute hepatic insufficiency. Hemorrhage into the peritoneal cavity may have an aggravating effect. Early in infection, during fluke migration, there is hyperproteinemia, hyperglobulinemia and hypoalbuminemia (Reid, 1973). The hypoalbuminemia is associated with plasma volume expansion caused by liver damage and reduced albumin synthesis. The latter probably resulting from the preferential use of amino acids for globulin synthesis and from damage to the liver parenchyma. Immature flukes are tissue feeders but may accidentally ingest some blood and the minor degree of anaemia that develops in the first 4 to 5 weeks of infection probably reflects the loss of blood into the migratory tract of the young fluke. At necropsy, the liver is enlarged, haemorrhagic and honeycombed with the tracts of migrating flukes. The surface, particularly over the ventral lobe, is frequently covered with fibrinous exudates. Subcapsular haemorrhages are common and these may rupture so that a quantity of bloodstained fluid is often present in the abdominal cavity (Urquhart *et al.*, 1996).

In chronic fasciolosis, which is by far the most common in bovine species, the principal pathogenic effects are anaemia and hypoalbuminaemia. The blood sucking activity of the flukes, in which more than 0.5 ml blood per fluke can be lost into the bile ducts each day and the continuous drain on iron reserves that this imposes can cause the anaemia seen in chronic fasciolosis. But recent works supports that a substance produced by the worm, possibly proline, which may possess erythrolytic effect, may contribute to the development of anaemia (Radostits *et al.*, 1994).

Hypoalbuminaemia is more marked in the chronic disease and is due mainly to increased loss of plasma proteins occurs by leakage through the hyperplastic biliary mucosa. In addition, the activities of the adult fluke in the bile ducts cause cholangitis, biliary obstruction, destruction of hepatic tissue and fibrosis (Urquhart *et al.*, 1996).

The pathogenesis in bovine has the added features of calcification of the bile ducts and enlargement of the gallbladder. Aberrant migration of the fluke is more common in cattle and encapsulated parasites are often seen in the lung (Urquhart *et al.*, 1996).

Migration of the young *Fasciola* through hepatic tissue containing quiescent spores of *Clostridium novyi* may cause the development of infectious necrotic hepatitis (black disease) in sheep and cattle. This migration has also been thought to sporadically stimulate the development of bacillary haemoglobinuria in cattle (Radostits *et al.*, 1994).

2.4. Diagnosis

Diagnosis of fasciolosis is based on clinical sign, grazing history, seasonal occurrence and examination of feces by laboratory tests.

Acute fasciolosis is common in sheep and is manifested by a sudden death of animals. Confirmation is by postmortem examination, when small fluke can be express from the liver parenchyma (Blood *et al.*, 1994).

Chronic fasciolosis is diagnosed by finding the eggs in the faeces using sedimentation technique. However, they must be distinguished from the eggs of other flukes, especially the large eggs of paramphistomes. The *Fasciola* egg has a yellow shell with an indistinct operculum, and the embryonic cells are indistinct. The paramphistome eggs have transparent shell and distinct operculum, their embryonic cells are clear and have a small knob at the posterior pole, and the eggs are larger than those of the liver fluke (Soulsby, 1982).

Numbers of eggs in faecal sample is not an accurate indication of the number of parasites in the liver, nor of the amount of damage being done to the host (Hansen and Brain, 1994).

Serological tests such as ELISA and passive haemagglutination tests are being the most reliable for routine diagnosis of fasciolosis in cattle and sheep (Urquhart *et al.*, 1996).

2.5. Treatment

Treatment of fasciolosis has long relied on derivatives of halogenated hydrocarbons, such as carbon tetrachloride, hexachloroethane, and hexachlorophene. These drugs are fairly toxic and are only active on mature flukes. Hexachlorophene is still used sometimes because of its low cost. It should be used carefully since it is unsuitable for cattle and sheep the margin between a therapeutic and a toxic dose is very narrow (Soulsby, 1982).

Other trematodocides such as niclofolan may still be found on the market. They are generally not very effective. Certain benzimidazole compounds have shown fasciolicidal activity. This is true of albendazole as well as oxfendazole and fenbendazole (both at high dose). A new salicylanilide derivative, closantel, has shown excellent activity against mature (over four weeks) and immature (over one week) *Fasciola* and against certain nematodes and arthropods. Triclabendazole has effective against immature (one week) fluke (Table 1). As in the case of gastrointestinal strongylosis, supportive treatment based on tonics and anti-anaemic should be given, at least for valuable animals (Mira and Say, 1989).

Table 1. Anthelmintics for the treatment of liver flukes

Generic name	Administration		Minimum age of fluke in weeks efficiency		
	Route	Dose (mg/kg)	rate $\geq 90\%$		
			Sheep	Cattle	
Hexachlorophene*	O	15	20	12	>20
Hexachloroethane	O	25-300	300	12	12
Tribromsalan	O	20	20	12	>12
Bithionol*	O	75	30	>12	>12
Hexachloroparaxylene	O	150	130	12	12
Bromphenophos	O	16	12	12	>12
Clixanide*	O	20	NR	12	NR
Oxyclozanide*	O	15	13-16	12	>14
Niclofolan*	O	4	3	12	>12
	SC	NR	0.8	NR	<12
Nitroxylin	SC	10	10	8	10
Brotianide*	O	5.6	NR	12	NR
Rafoxanide*	O	7.5	7.5	6	12
	SC	NR	3	NR	12
Closantel	O	7.5-10	NR	8-6	NR
	SC	NR	3	NR	>12
Diamphenetide	O	80-120	100	1 day - 6 weeks	1 day - 7 weeks
Albendazole	O	4.75	10	>12	>12
Triclabendazole	O	10	12	1	1
Clorsulon	O	-	7	-	8
	SC	-	2	-	>12

Source: Hansen and Brain, 1994. * = Also effective against paramphistomes.

2.6. Distribution and economic significance of ruminant fasciolosis

One of the most widespread diseases that has resulted enormous direct and indirect economic losses in livestock production is fasciolosis. It may affect all domestic animals and man but its economic importance is considerable only in sheep and cattle (Blood and Radostitis, 1994). Fasciolosis accounts for serious economic losses in Africa, Asia and other parts of the world due to condemnation of livers as unsuitable for human consumption, losses through death, reduction in productivity (meat, milk and wool), inhibited reproduction (fertility), retarded growth rate, lowered resistance to other diseases (Khallaayoune *et al.*, 1991).

Many workers have studied the importance of fasciolosis in different parts of the world. In dairy cows, reduction in milk yield has been shown to be related to the number of adult flukes. Robertson (1976) has reported 10% carcass weight loss because of liver fluke infection.

Every year the Kenya meat industry loses at least £7 million through a combination of poor productivity, death of stock, condemnation of infected liver and reduction in carcass quality (Harrison, 1996). In Nepal it has been estimated that farmers lose over US\$ 20 million worth production because of poor animal health, low reproduction and deaths from fasciolosis. Damage, sometimes fatal, is caused in the host animal by the parasite migration through the body to the liver. This organ is often subsequently condemned in abattoir and cannot be sold for human consumption (Hughes *et al.*, 1978).

In Ethiopia, Getachew (1987), Yilma (1983) and other workers reported the prevalence rate of fasciolosis and losses due to liver condemnation in different parts of Ethiopia (Annex 1 and 2). Annual losses due to liver condemnation and reduced carcass weight at different abattoirs range from 67,667.47 to 631,320.00 Birr (Annex 2).

2.7. Factors influencing the occurrence of fasciolosis

There are three most important factors that influence the occurrence of fasciolosis in area:

2.7.1. Availability of suitable snail habitats

The spread of fasciolosis is largely dependent on the ecology of the snail intermediate host. The snails of the genus *Lymnaea* are mainly involved as intermediate hosts in the life cycle of fasciolosis. *L. natalensis*, aquatic snail, is an important host of *F. gigantica* in Africa. They can, however, adapt to an amphibious existence in adverse condition (Hansen and Brain, 1994). *L. truncatula*, amphibious snail with a wide distribution throughout the world, is the most common intermediate host of *F. hepatica* (Hall, 1986; Soulsby, 1982; Urquhart *et al.*, 1996).

The important *Lymnaea* species of snails involved in the transmission of fasciolosis vary in their geographical distribution with world. The habitat requirements of the intermediate hosts of the two important liver flukes differ slightly.

Fasciola hepatica is found in an area above 1800 m.a.s.l. While it's tropical counter part, *F. gigantica*, occurs below 1200 m.a.s.l. In between these altitude limits, both species coexists where the ecology is conducive for both snail hosts, and mixed infections prevailed (Graber, 1975; Yilma and Malone, 1998).

2.7.2. Temperature

A mean day/night temperature of 10⁰C or above is necessary both for snails to breed and for the development of *F. hepatica* within the snail, and all activity ceases at 5⁰C. This also the minimum ranges for the development and hatching of *F. hepatica* eggs. However, it is only when temperatures rise to 15⁰C and are maintained above that level, that a significant multiplication of snails and fluke larval stages ensues (Urquhart *et al.*, 1996).

2.7.3. Moisture

The ideal moisture conditions for snail breeding and the development of *F. hepatica* within snails are provided when rainfall exceeds transpiration, and field saturation is attained. Such conditions are also essential for the development of fluke eggs, for miracidia searching for snails and for the dispersal of cercaria being shed from the snails (Urquhart *et al.*, 1996). It has been shown experimentally that all stages - eggs, young and adults of *L. truncatula* can withstand desiccation for considerable periods, the adult for periods of a year or more, provided that they are favorably covered with mud (Smyth, 1976).

Moisture is the critical factor determining the presence and extent of snail habitats, which serve as transmission foci for liver flukes. The interaction between moisture and temperature determines the survival and reproduction rate of the snails and the parasites (Dunn, 1987).

The liver flukes have a versatile survival strategy; certain stages of the parasites and their intermediate hosts have a relatively well-developed ability to persist through adverse weather conditions such as drought and freezing. Thus, persistence of infection from one season to the next may occur by several mechanisms; as adult fluke in mammalian hosts, as eggs on pasture, as larvae developing in snails and as metacercaria encysted on herbage (Hansen and Brian, 1994).

2.8. Forecasting the occurrence of fasciolosis

Geographic information system (GIS) can be used to define the epidemiology and distribution of fasciolosis. As compared to more ephemeral vectors such as mosquitoes, snails tend to be present year after year in same habitat and population generation time is relatively long. The unique biology and life cycle strategy of *Fasciola* make it amenable to effective use of GIS control model in several respects. High environmental sensitivity and the focal nature of transmission typically result in animals in fluke enzootic region (Ollernshaw, 1966).

Climate forecast models developed in Europe, the United States and elsewhere indicate that a 100-fold difference in *F. hepatica* burdens can occur in different years owing to the effect of climatic variation alone on snail host population, intermolluscan asexual multiplication, and survival of fluke eggs and persistence of metacercariae on pasture (Malone *et al.*, 1987).

The GIS forecast model developed in Ethiopia revealed that there are distinct regional differences in *F. hepatica* seasonal cercariae-shedding, fluke transmission pattern. In the western humid region, conditions are shown to be suitable for up to 6 months of transmission per year (May-November). Western sites like Gore and Jimma were considered to be high *F. hepatica* risk areas where transmission of the tropical species, *F. gigantica*, may also occur in August-September. In southern Ethiopia, *F. hepatica* transmission is bi-modal, resembling the regional rain pattern. In the north-central and central high lands *F. hepatica* transmission is confined to the heavy summer rain months (Yilma and Malone, 1998).

2.9. Control of fasciolosis

Efficient control programmes cannot be designed without a thorough knowledge of the epidemiology of the disease based on weather data analysis and seasonal surveying of hosts. In addition, the seasonal collection of snails from each farm, area, country or region and their examination for *Fasciola* larvae may be useful in establishing the distribution of the infection. The general approaches to be adopted in the control of this disease are outlined herein below:

2.9.1. Application of strategic treatment

Prophylaxis by drugs consists of eliminating flukes by regular treatments. Since local climatic conditions influence infection, they should be considered when determining the time of treatment.

It is evident that the control strategies for liver flukes infection vary according to the region and management practices. Some of the proposed control strategies in tropical climate particularly Africa include that of Fisher (1989) for Sahel region and Yilma and Malone

(1998) and FAO (1994) for Ethiopia. Thus, Fischer (1989) wrote that two treatments are usually recommended per year for the Sahel region. The first is given at the end of rainy season (October- November) to eliminate the adult parasites so that the animals pass the dry season in good condition, and to avoid contamination from the dry season water holes. The second treatment should be planned for the end of the dry season (March, April or May rarely later) when the immature flukes migrate through the hepatic parenchyma. For the second treatment, only drugs, which are active against immature flukes, should be used.

On the basis of regional monthly forecasts and transmission patterns of the disease in Ethiopia, two treatments (preventive and preventive-curative) per year for all four regions such as Western Ethiopia, South Ethiopia, North-central Ethiopia and central Ethiopia have been recommended, plus an optional curative treatment for western and southern regions. The first treatment is prophylactic and is administered toward the end of the dry season (February or April) when development of free-living stages and intralymneid phase of *Fasciola* are retarded and reproduction and activity of snail is minimum (Yilma & Malone, 1998). An optional summer curative treatment is recommended in high-risk years and when outbreaks of disease occur. The September-October treatment removes bile duct flukes prior to the commencement of the dry season. For economic reasons or otherwise, if only one treatment can be given, the September – October strategic treatment is the best choice in all areas (Yilma & Malone, 1998).

2.9.2. Control of snail population

2.9.2.1. Chemical control of snails

The use of molluscicides for the control of snail intermediate hosts is a potential tool for the control of fluke infections. Before considering chemical control of snails, it should be noted that many habitats are topographically unsuitable for the use of molluscicides and it is often very difficult to apply them effectively. They are toxic to the environment, cooperation between neighboring properties is required for effective cover, and regular (at least yearly) application is required because rapid repopulation of snails may occur. They are not species-

specific and may destroy edible snails highly valued as food in some communities. They are expensive (Hansen & Brian, 1994).

2.9.2.2. Biological methods of snail control

Reports from several parts of the world indicate that a number of plants have molluscicidal properties. Planting of these trees and shrubs along streams and irrigation channels can reduce the number of snails in a population. The discovery of molluscicidal properties of Endod (*Phytolacca dodecandra*) led to extensive subsequent studies, which revealed endod to be the best plant derived molluscicide out of 1000 species so far tested (Legesse Weldeyohanis *et al.*, 1987). The main factors that make endod very promising in the control of snail-borne diseases are its high molluscicidal potency, low mammalian toxicity, rapid biodegradability, stability under different environmental conditions, the potential for large scale cultivation and the adaptability of the plant to different agroecology (Aklilu Lemma and Yau, 1974; Legesse Weldeyohanis *et al.*, 1987). However, the efficacy of this method for control of flukes has not yet been assessed.

The introduction of large numbers of ducks into rice fields after harvest has been used to reduce the snail population. It is reported that snails infected with duck flukes will not become infected with flukes of livestock.

The introduction of edible snail species unsuitable as intermediate hosts into the habitat of the host snails may prevent the flukes from completing their life cycle (Hansen & Brian, 1994).

2.9.2.3. Management of snail habitat

(a) Good drainage and the building of dams at appropriate sites in marshy and low-lying areas may reduce the snail problem. Water holes should be managed, wherever possible, to prevent both fouling of the water with excrement from infected animals and the development of *Lymnae natalensis*. For this purpose, all pools or backwaters should be filled in and

replaced by well or tanks. This is only possible in well-developed units such as ranches or breeding farms. Troughs near well should be raised and kept clean.

(b) Keep livestock away from pastures contaminated with metacercariae. This may only be possible when the number of animals involved is small. When watering at a perennial pool cannot be avoided, those areas where the animals customarily come to drink should be cemented (Mira and Say, 1989).

(c) Establish proper watering facilities to prevent animals from drinking from lakes, ponds and streams (Hansen & Brian, 1994). The animals should be distributed over a large number of water holes, so that fewer fluke eggs are passed at each hole, thus reducing the probability of infection. Any concentration of herds around a water hole is conducive to heavy contamination.

2.10. Increasing the immunity of animals

The ability of cattle to develop protection against reinfection with *F. hepatica* suggests that immunization might be feasible. Nansen, (1975) was able to immunize calves with irradiated metacercariae of *F. hepatica*. Calves, which are 6-7 months old, were immunized with three doses of irradiated metacercariae and showed a marked decrease in faecal egg count after grazing on infected pasture. A 71% reduction in the number of flukes recovered from immunized calves was observed as compared to unimmunized animals.

Sanhoury *et al.*, (1987) demonstrated that irradiated metacercariae of *F. gigantica* are capable of stimulating resistance against homologous challenge in goats with out causing great hepatic damage. This experiment also indicated immunization of goats with irradiated cercariae of *Scistosoma bovis* failed to stimulate resistance against heterologous challenge with *F. gigantica*. Previously it was described that only unirradiated cercariae of *Scistosoma bovis* in

cattle conferred heterologous resistance against *F. gigantica* although irradiated carcariae stimulate resistance against homologous parasite. Alternatively, Nansen, (1975) suggested that stage specific adult worm antigens, which aren't expressed by irradiated infections, might stimulate heterologous resistance.

Campbell *et al.*, (1986) demonstrated that the infection of sheep with *Taenia hydatigena* 12 weeks to 9 months before infection with *F. hepatica* resulted in protection against infection with *F. hepatica*. Conversely, Hughes *et al.*, (1978) were able to demonstrate development of cross protection. Despite the number of attempts to immunize animals, its application on a wide scale farm level requires further research and refinement of the work and therefore remains as one of the future alternative option to control fasciolosis.

3. MATERIALS AND METHODS

3.1. Description of the study area

The study was conducted from October 2004 to March 2005 in Fogera and Mecha woredas (districts) in Northwestern Ethiopia. The two woredas are located along the Upper Blue Nile River Basin, Amhara region, bordered with Lake Tana and having an altitude ranging from 1600-1800 m.a.s.l.(Fig 1 and 2). The Amhara National Regional State (ANRS) covers an area of 161, 828.4 sq km located approximately $920^{\circ}14'$ North latitude, $36^{\circ}20'40''$ East longitudes. The region has common boundary with Tigray, Oromia, and Afar National Regional States at North, South and Eastern parts respectively, as well as with Benshangul Gumze National State and the Sudan Republic at northwestern part. There are 16,792,335 million inhabitants in the region of where 89% are rural population.

Based on the altitude, three main traditional agro climatic regions can be identified. These are the “Dega” (25%), “Woinadega” (44%), and “Kola” (31%) areas. There are three main river basins namely the Abay (Blue Nile), the Tekeze and the Awash river basins. The Blue Nile river forms a natural boundary with the neighboring regions of Amhara and Oromia.

The livestock population of the Amhara region comprises about 10.6 million cattle, 5.7 million sheep, 4 million goats, 2.1 million equines and 17.4 thousand camels. Smallholder mixed farming dominates (80%) and livestock is an integral part of the farming system (BoA, 2000).

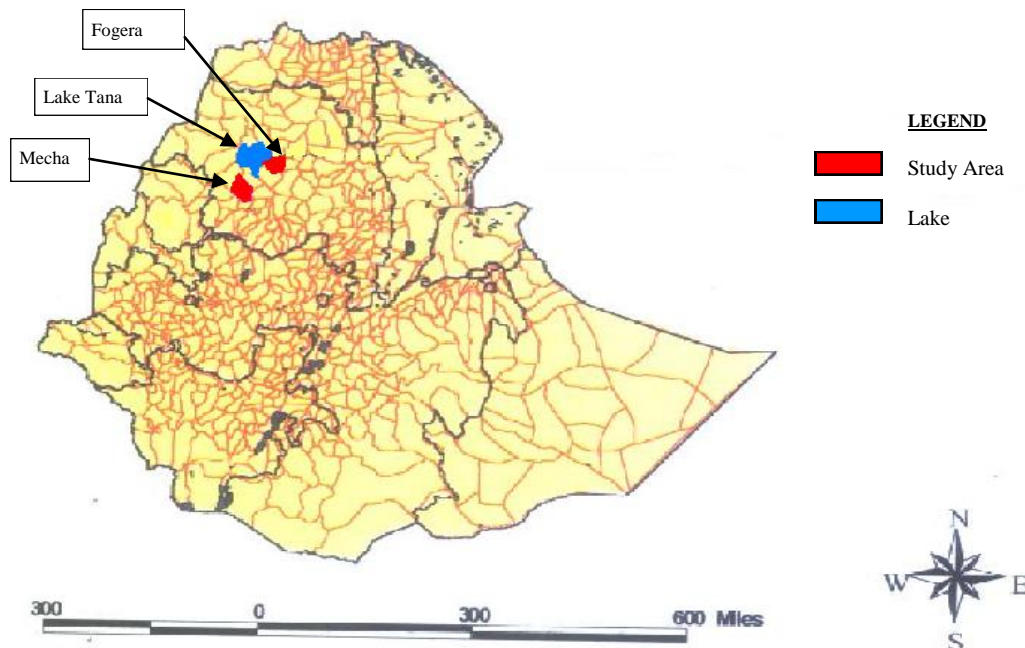


Figure 1. Political Map of Ethiopia.

Generally, most part of the specific study woredas are plains (locally termed as the “Fogera plain areas”) and is favourable for livestock raising with similar tropical / subtropical climatic condition. There are two distinct seasons, the rainy season from June to September and the dry season from October to May. The mean annual ambient temperature varies from 15-20⁰C and mean annual rainfall ranges from 1000-1600mm. The area has poor drainage and there is annual over flooding of this area during the rainy season leaving a pocket of water bodies and swampy areas for long periods during the dry season. The soil type in most parts of the low-lying plain areas is heavy dark brown clay soil that has a high capacity of water retention.

Cattle are the major livestock unit kept and one of Ethiopia’s cattle breed/type known by the name “Fogera” cattle is raised in this woreda. In the study woredas, agriculture is the basis of the economy and is typically a sedentary smallholder crop-livestock marking an important feature for the traditional husbandry livestock production system of the area.

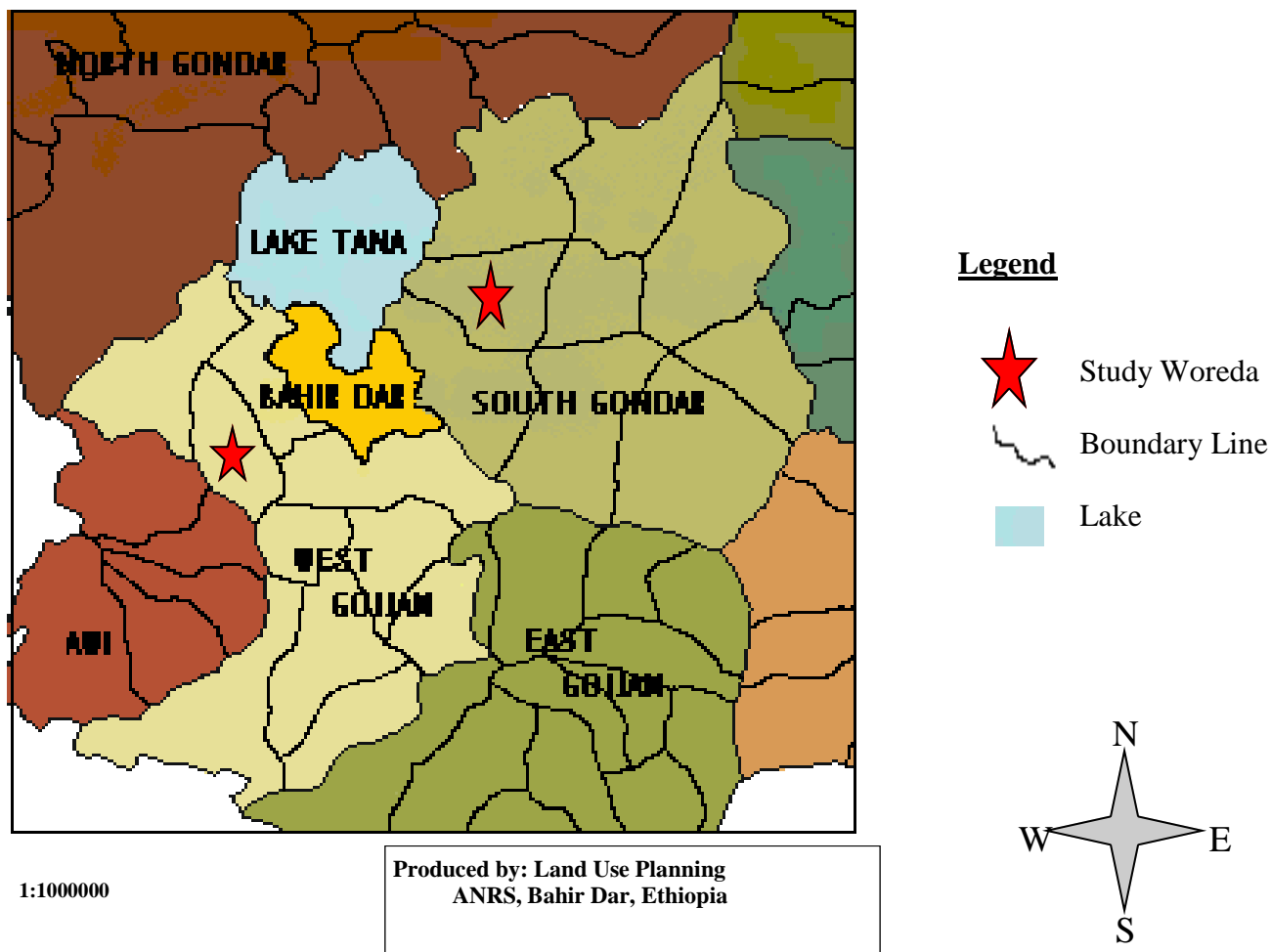


Figure 2. Map of the study areas

3.2. Meteorological data

The distribution of rainfall and the range of monthly temperature (maximum and minimum) were normal for the areas except that in April and November there were significant increases in the amount of rainfall recorded. Mean relative humidity varied from 64-75% in the wet months and 42-55% in the dry months (July/October and December/May). Figure 2 and 3 show the total monthly rainfall, mean relative humidity and mean monthly temperatures (maximum and minimum) during the period of January 2004 to March 2005 (National Meteorological Service Agency, Bahir Dar, Ethiopia).

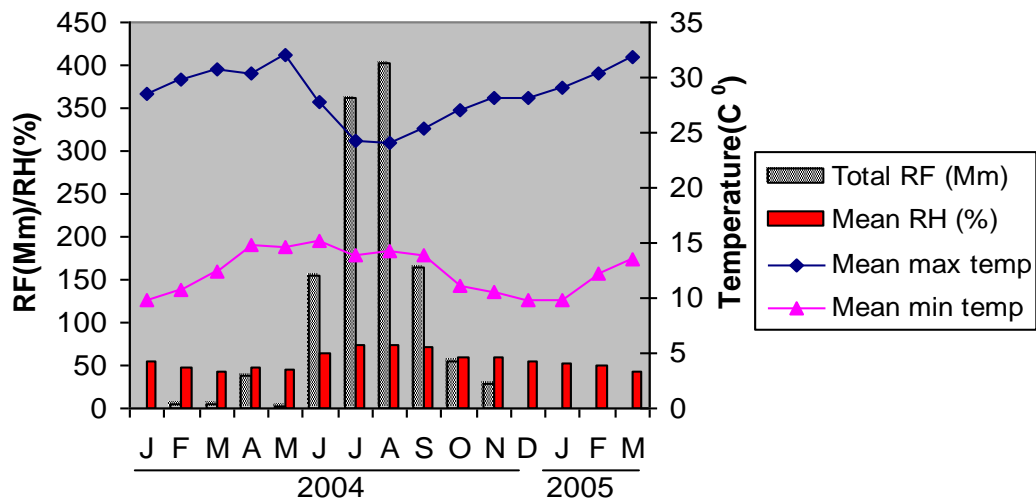


Figure 3.Total monthly rainfall, relative humidity and mean temperature at Fogera woreda.

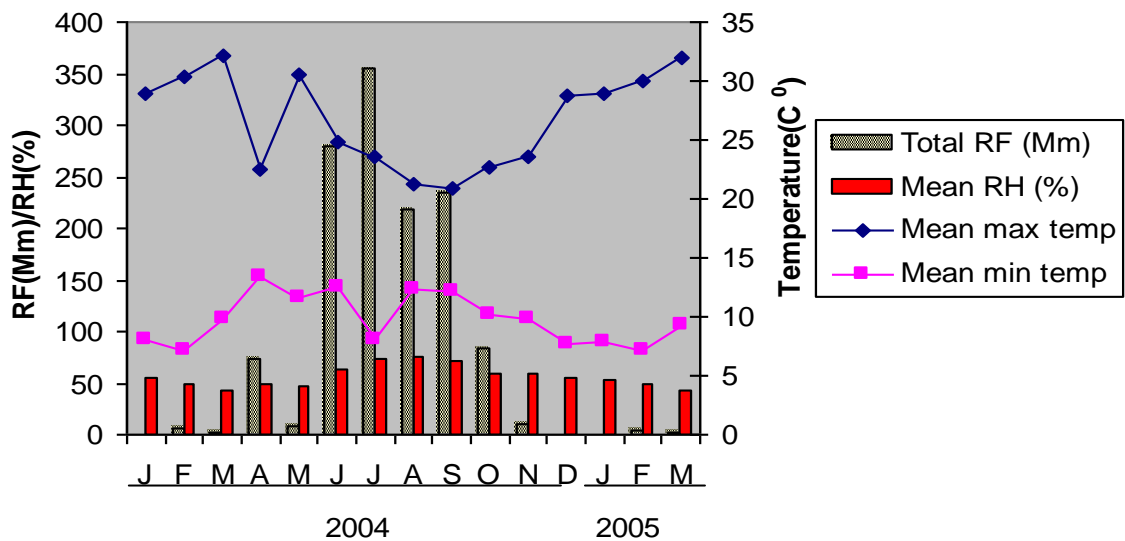


Figure 4.Total monthly rainfall, relative humidity and mean temperature at Mecha woreda.

3.3. Study population

The study population includes local breeds of cattle and sheep under extensive grazing system. The main local breed of cattle known as the “Fogera “ breed is concentrated in the Fogera woreda especially between Gumara and Rib rivers as well as on the main road from Bahir Dar to Gondar. In addition to the “Fogera” cattle type, there are other types such as the “Simada”, “Worie” and “Agew” cattle types in the area.

Until the early 90's, the Fogera cattle from marshy areas used to be trekked to the uplands (out of their territory) during the wet season, from July to October, depending on the rainfall pattern and distribution. This is mainly due to severe flooding problem that occurs in the wet season. During the dry season both Fogera and other cattle types are moved back to the Fogera plains.

The sheep raised in the area are indigenous locally known by their name “Washera” breed/type and they are characterized by a medium size (mature ewes range from 21-30 kg) with fat-tailed inverted at the tip and mainly reddish brown in color with black and white spots on head and legs. They graze freely without constant shepherding in communal grazing lands.

Table 2. Livestock population of the study woredas.

Geographic area	Livestock population					
	Cattle	Sheep	Goats	Horses	Asses	Mules
Fogera	157128	7607	27867	DN	13187	339
Mecha	2221841	19311	18854	DN	DN	DN

Note: DN = Data not available

*Source: CACC (2003)

3.4. Type of study and sample size determination

3.4.1. Questionnaire survey

Field survey supported by questionnaire (Annex 3) was undertaken to obtain general information about disease status, herd structure, large and small ruminant husbandry practices and usage of anthelmintic drugs of the area. Both open-ended and closed type questionnaires were applied to interview individual farmers or in groups. The questionnaires were tested in the field before administrating to the study population. The format was coded for computer database entry and analyzed.

3.4.2. Cross sectional study

3.4.2.1. Site selection and prevalence of infection

A combination of stratified, multistage and purposive sampling methods were applied according to Toma *et al.* (1999) and Putt *et al.* (1988). First the two discrete study woredas were selected from the two zones of the ANRS (first stage) to represent areas along the Upper Blue Nile River basin. Then a list of peasant associations (PAs) within woredas were gathered from documents obtained from the woreda's agricultural office (second stage) and sampling PAs were selected based on representation of the respective woredas and accessibility. Villages were selected in collaboration with the respective woreda's animal health workers, selected by purposive sampling on the basis of prior information on the problem, farmers' cooperation, logistics, share of communal grazing land and accessibility (third stage). Selected villages and herds grazing within the same grazing land were considered as strata. Within each stratum, sampling was performed irrespective of the other strata.

To determine the sample size, a fasciolosis prevalence of 53% and 60% (average prevalence for cattle and sheep in northwestern Ethiopia respectively) was taken into consideration. The desired sample size for the study was calculated using the formula given by Thrusfield, M. (1995) with 95% confidence interval and at 5% absolute precision. Therefore, a sample size of 752 (384 cattle and 368 sheep) was considered for this study (Table 3). It was also considered both sexes, young (for sheep <2 years, for cattle <4 years) and adult animals (for sheep \geq 2 years, for cattle \geq 4 years).

Table 3. Faecal sample collection date with respect to study woredas, species, age and sex.

Date	Woreda	Species	Age and Sex				Subtotal
			Male	Male	Female	Female	
			Young	Adult	Young	Adult	
Oct 2, 2004	Fogera	Cattle	65	95	67	157	384
Oct 6, 2004	Mecha	Sheep	67	6	156	139	368
Subtotal			132	101	223	296	752

3.4.3. Longitudinal study

3.4.3.1. Experimental design

PAs or Kebeles with high fasciolosis risk were purposively selected from the study woredas. Two hundred forty two animals (114 cattle and 128 sheep) that belong to individual farmers were selected from the study population to serve as experimental animals. All experimental animals were naturally infected with *Fasciola* parasite. The animals were randomly assigned to three groups; Group I (one-time treatment) and group II (two-times treatment) and group III was acting as controls. Numbers of experimental animals are shown in (Table 4 & 5). Each experimental animal was ear-tagged for permanent identification. However, during the trial some cattle and sheep were moved to other villages or were sold or slaughtered and some were too difficult to handle. Data from these animals were therefore discarded and only data from 167 animals were analysed. All experimental animals grazed together in communal grazing lands. The age of each animal was estimated using the dentition pattern of the animals as described in Williamson and Payne, 1959. The number of experimental animals used by group, age, sex and species is illustrated in Annex 4,5 and 6.

Table 4. Numerical changes in the experimental groupings.

Host spp	Number of experimental animals							
	At the start of the experiment				At the end of the experiment			
	Group I	Group II	Group III	Total	Group I	Group II	Group III	Total
Cattle	38	43	33	114	28	33	19	80
Sheep	38	52	38	128	27	32	28	87
Total	76	95	71	242	55	65	47	167

Table 5. Specific causes of withdrawals of experimental animals during the study period.

Host spp	Fluke related death			Sold			Unknown		
	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Cattle	1	1	3	3	2	3	6	7	8
Sheep	2	0	5	3	7	2	6	13	3
Total	3	1	8	6	9	5	12	20	11

As showed in Table 5, eight animals (3 cattle and 5 sheep) had died of fasciolosis. This assessment of the cause of death was based on the information received from the livestock owners.

3.4.3.2. Anthelmintic treatment

First strategic anthelmintic treatment intervention was performed in October (day₀) in all animals of Group I and II with triclabendazole at a dose rate of 10mg/kg and 12mg/kg body weight orally for sheep and cattle, respectively as per the recommendation of Yilma and Malone (1998) and FAO (1994). The second strategic anthelmintic treatment intervention was conducted in December (day₆₀) to only animals' in-group II. Animals' in-group III remained untreated during the study period.

3.4.3.3. Clinical parameters

3.4.3.3.1. Coproscopy

Faecal samples for longitudinal studies were collected from all groups of animals on the day₀ of the study and then after every 4 weeks. Whereas for cross sectional study, samples were taken at the beginning of the study. The faecal samples were collected directly from the rectum of each animal in the early morning on a monthly basis. The time of collection of faecal samples was uniformly maintained throughout the experimental trials to avoid possible diurnal variations in fluke egg out put (Roy and Sunkhla, 1971).

The samples were collected with clean universal bottle and labelled for pre and post treatment fluke egg detection. Each sample was examined for four times under microscope to avoid missing of *Fasciola* eggs during detection. Using the modification of standard sedimentation technique (Annex 11) the faecal egg out put of each animal was recorded (Antónia *et al.*, 2002).

3.4.3.3.2. Estimation of PCV

Blood from a punctured ear vein was drawn into a heparinized, microhaematocrit capillary tube; the tube was sealed and centrifuged for five minutes at 12000 revolutions per minute. PCV was measured with a microhaematocrit reader (Murray *et al.*, 1983). Attempts were made to rule out a concurrent trypanosome and fasciola infections in experimental animals in Fogera woreda during the study period. Thus, buffy coat examination was undertaken to detect the presence or absence of trypanosome infection in the area.

3.4.3.3.3. Live weight determination

Body weight for experimental groups of lambs and/or adult sheep was recorded using a spring scale. Each sheep was put on a sack attached to the hook of the scale and then weighed. Live weight was recorded at four weeks interval during the study period (Annex 9). Changes in live weight were not determined in cattle due to unavailability of cattle scale in the study areas during the study period.

3.4.3.3.4. Body condition score

Before and after receiving anthelmintic treatment, condition scoring of individual animal (cattle) was recorded using technique recommended by Nicholson and Butterwoth (1986). Thus, nine scores were used in which the three main conditions- (fat [F], medium [M] and lean [L]) - are subdivided into three categories. Each scoring was given a number from 1 (L-) to 9 (F+). In a borderline case a half point was added to the lower score, so that an animal described as M-/L+ was score as 3.5. Body condition scoring of sheep was recorded according to Thompson and Meyer (1992); thus, scoring was made on feeling the level of

muscling and fat deposition over and around the vertebrae in the loin region. In addition to this, feeling of spinous and transverse processes of loin vertebrae were used to assess an individual body condition score. For an appropriate purpose of this study, the standard body condition scoring of cattle (Nicholson and Butterworth, 1986) and sheep (Thompson and Meyer, 1992) for cross sectional study had been categorized in such a way to distinctly picture the animals condition in the study areas. This categorization is shown in (Annex 7 & 8).

3.4.3.3.5. Liver function test

3.4.3.3.5.1. Determination of Serum Aspartate Amino Transferase (AST)

Before and after anthelmintic treatment intervention, serum samples from 48 sheep that were selected randomly from experimental animals (group I =16; group II= 16; group = 16) were collected and analyzed for AST at Bahir Dar Regional Health Research Laboratory. Samples that were not processed within 2 hours from collection were stored in a refrigerator at 4⁰C. All serum samples were analyzed colorimetrically using Auto lab Chemistry Analyzer.

3.5. Statistical analysis

All raw data that were recorded from this study were entered into Microsoft Excel database system and referenced with geographical location of the study sites. Using SPSS computer programme, data were summarized and analyzed. Difference between treatment groups for body weight, body condition score and PCV were tested over time using a one-way factorial analysis of variance (ANOVA). Variation of serum concentration level of AST (GOT) within group was analyzed statistically using t-test. Chi Square (χ^2) test was used to determine the variation in infection prevalence between age, sex and species. A 5% significant level was used to determine whether there are significant differences between the parameters measured between the treatment groups.

4. RESULT

4.1. Questionnaire survey outputs

Result obtained from questionnaire survey showed that in Fogera woreda the main feed sources for cattle are communally owned pastureland and to some extent crop by products of teff, vetch, finger millet, chickpea, maize and noug. Hay making is not well established and practiced in the area. Animals are watered at a nearby stream and/or unprotected springs. During dry season they are penned at night without shelter.

Cattle are kept in this woreda for multipurpose functions. These include traction power (traction), milk production, and source of income, manure, reproduction and meat production. However, due to the prevalent of various animal diseases in the area, farmers could not fully exploit from animal production. The most widely spreading diseases in the area are fasciolosis locally named as (*Berer, Yegubet til*), schistosomiasis (*Yewuhatil*), trypanosomosis (*Gendi, Gechitta*), anthrax (*Kuriba, Abasenga*), blackleg (*Abagorba, Mich*), pasteuerellosis (*Enkit*), foot and mouth disease (*Aftegir*) and respiratory diseases complex. Biting flies are a heavy burden to cattle grazing in the marshes between October and November. Thus, at times of serious bites by the flies, animals are kept in the house and only allowed to graze in the morning and late in the afternoon.

The most common breeding system in the study area is pure breeding. However, especially in towns, crossbreeding between indigenous and exotic Holstein-Friesian is practiced to improve milk production. Mating in almost all cases is natural and uncontrolled and hence usually associated with year-round calving.

The main source of feeding of sheep is predominantly derived from unimproved pasture and fallow land grazing, crop residues and non-conventional foodstuffs. However, only 52.7% of the respondents reply that they supplement their animals with crop residues during the wet season. During the dry season, they depend mainly on crop residues.

The most common sheep diseases of the area mentioned by farmers are fasciolosis locally named as (*Berer*), tapeworm (*Kosso*), coughing and sneezing (*Gunfan*), foot rot (*Choke*), diarrhea (*Tekmatti*), emaciation and sudden death. Almost all farmers knew the disease called fasciolosis (*Berer*) however, 85/127 (66.9%) individuals do not have awareness about its transmission and seasonal occurrence of the disease.

Regarding the utilization of anthelmintic drugs in the area, all farmers use different anthelmintics over the last one-year for the treatment of their animals. The following brand name of drugs was recorded: Teraclozan-2400, Duxamintic-600, Albendazole-300, Tetramizole-600, Alzole, Tetramizole, and Teraclozan-C. Private veterinary drug shops are the main source of drugs for treatment of animals (57.4%) followed by government veterinary clinics (26.1%) and the illegal drug dealers (16.5%).

Though there was no indication about the existence of drug resistance to liver fluke in the area, a retrospective casebooks investigation has revealed that Albendazole-300 is widely used since in 80s. Triclabendazole is the drug now only available in government veterinary clinics for treatment of acute and chronic fasciolosis of sheep.

4.2. Results of the cross sectional study

4.2.1. Prevalence of infection

Out of the 752 faecal samples examined, 283 (37.6%) were found positive for fasciolosis. The prevalence in cattle and sheep were 37.2% and 38.0 %, respectively (Table 6 & 7). In addition, the highest prevalence of bovine fasciolosis 35 (58.3%) was recorded in Awanakokit PA of Fogera woreda and 50 (56.8%) of ovine fasciolosis in Enguti PA of Mecha woreda (Table 6 & 7). In both cattle and sheep there was a statistically significant difference ($P < 0.05$) in prevalence of fasciolosis among the different PAs. Statistical analyses of results revealed that there are no significant differences in infection between cattle and sheep ($P > 0.05$). In

cattle, prevalence of fasciolosis was noted to decrease in older animals. The prevalence of fasciolosis in cattle was highest in age groups between three and five years, and the lowest was recorded in age group over five years. However, in sheep as the age of the animal increases the prevalence of the disease also increases. Statistical analyses among different age groups both in cattle and sheep were found to vary significantly ($P<0.05$) (Table 9). Body condition scoring result of sheep indicated that very lean animals were found to be positive for fasciolosis ($P<0.05$). In cattle, there is no statistically significant difference ($P>0.05$) in infection rate among different groups of animals categorized by their body condition (Table 10). Moreover, the cross sectional study has revealed the prevalence of certain parasitic infections other than fasciolosis (Annex 10).

Table 6. Prevalence of bovine fasciolosis in different PAs of Fogera Wereda.

Kebele (PA)	Sample size	Prevalence	95% CL
*Koharmichael	53	30(56.6%)	0.50-0.62
Koharabo	105	22(20.9%)	0.13-0.28
Wojji	65	26(40%)	0.28-0.52
Workmeda	48	23(47.9%)	0.33-0.61
Addisbete	53	7(13.2%)	0.04-0.22
*Awanakokit	60	35(58.3%)	0.46-0.70
	384	143(37.2%)	0.25-0.49

*Actual sites where the longitudinal study (field experiment) was undertaken.

Table 7. Prevalence of ovine fasciolosis in different PAs of Mecha Wereda.

Kebele (PA)	Sample size	Prevalence	95% CL
Ambomesk	101	32 (31.6%)	0.15-0.47
*Engutti	88	50 (56.8%)	0.43-0.69
*Enashenfalen	94	35 (37.2%)	0.21-0.53
Enamrit	85	23 (27.0%)	0.09-0.45
	368	140 (38.0%)	0.34-0.42

*Actual sites where the longitudinal study (field experiment) was undertaken.

Table 8. Prevalence of ruminant fasciolosis on sex basis.

Spp.	Sex	Number of samples	Positive (%)	95%CL
Cattle	Male	161	59 (36.6)	0.24-0.48
	Female	223	84 (37.6)	0.31-0.43
	Subtotal	384	143 (37.2)*	0.30-0.44
Sheep	Male	71	14 (19.7)	0.10-0.28
	Female	297	126 (42.4)	0.18-0.66
	Subtotal	368	140 (38.0)*	0.30-0.46
Total		752	283 (37.6)	0.32-0.46

* No significant variation in prevalence between sex group (P>0.05)

Table 9. Prevalence of ruminant fasciolosis on age basis.

Species	Age (year)	Number of samples	Positive (%)	95%CL
Cattle	1-3	53	18(33.9)	0.21-0.45
	3-5	79	37 (46.8)	0.35-0.57
	>5	252	88 (34.9)	0.29-0.39
	Subtotal	384	143 (37.2)	0.33-0.41
Sheep	0.2-1	91	19 (20.8)	0.12-0.28
	1-3	139	50 (35.9)	0.31-0.39
	>3	138	71 (51.4)	0.43-0.59
	Subtotal	368	140 (38.0)	0.34-0.42
Total		752	283 (37.6)	0.34-0.40

Significant variation in prevalence among age groups (P<0.05)

Table 10. Prevalence of fasciolosis based on the type of body condition.

Species	Body condition score	No of samples	of <i>Fasciola</i> infection	
			Positive (%)	95%CL
Cattle	Poor	201	71 (35.32) _a	0.29-0.41
	Good	183	72 (39.34) _a	0.32-0.46
	Subtotal	384	143 (37.2)	0.33-0.41
Sheep	Poor	283	122 (43.10) _a	0.38-0.48
	Good	85	18 (21.17) _b	0.13-0.29
	Subtotal	368	140 (38.04)	0.34-0.42
Table		752	283 (37.63)	0.34-0.40

Values without a common subscript within the same host species are significantly different ($P < 0.05$)

4.3. Results of the longitudinal study

4.3.1. Effects of strategic treatment on body weight, PCV and BCS.

Results of the effects of anthelmintic treatment on live weight, PCV and body condition score of cattle and sheep involved in the treatment trial is presented in Table 11.

Table 11. Results of mean \pm SD of live weight, PCV and BCS of the 3 groups.

Spp	Group	No. Examined	Prevalence (%)	Live weight (kg)	PCV (%)	BCS
Cattle	I	28	10 (35.71)	ND	26.76 \pm 3.45 ^a	2.29 \pm 0.71 ^a
	II	33	2 (6.06)	ND	31.09 \pm 2.47 ^b	3.74 \pm 0.78 ^b
	III	19	12 (63.15)	ND	24.84 \pm 3.45 ^c	1.97 \pm 0.9 ^a
	Total	80	24 (30.00)	ND	28.10 \pm 4.02	2.81 \pm 1.07
Sheep	I	27	20 (74.07)	19.93 \pm 4.98 ^a	27.19 \pm 4.15 ^a	1.11 \pm 0.59 ^a
	II	32	5 (15.62)	28.84 \pm 4.64 ^b	36.28 \pm 5.54 ^b	2.21 \pm 0.76 ^b
	III	28	25 (89.28)	21.54 \pm 6.55 ^a	26.46 \pm 3.18 ^a	0.89 \pm 0.47 ^a
	Total	87	50 (57.47)	23.72 \pm 6.67	30.30 \pm 6.37	1.44 \pm 0.86

Values without a common superscript letter within a column are significantly different ($P < 0.05$). ND=Not done

4.3.2. Result of coproscopy in cattle

Significant reduction in the prevalence of fasciolosis was observed in group I and group II animals following the October treatment. Moreover, the overall prevalence of infection in group II was reduced after the end of the experiment. Statistically, there was a significant difference ($P < 0.05$) in infection rate between the three groups. Figure 5 shows the prevalence of fasciolosis of cattle during the experiment trial months.

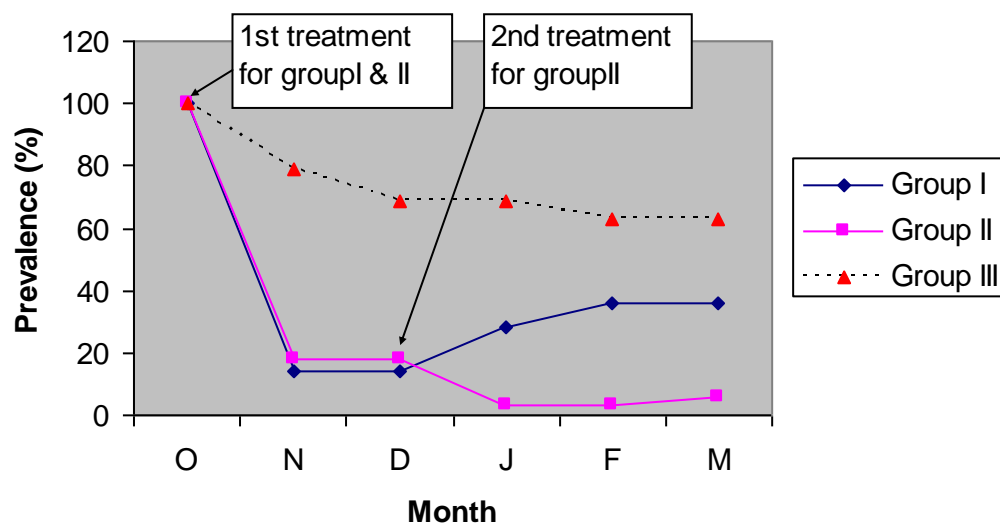


Figure 5. Prevalence of fasciolosis in 3 groups of cattle.

4.3.3. Result of coproscopy in sheep

Detection of *Fasciola* eggs was significantly reduced in group II animals as compared to those animals in group I and III. The result showed that there were significant differences ($P < 0.05$) in infection rate between the three groups. Figure 6 shows the infection rate between experimental groups during the six-month observational period.

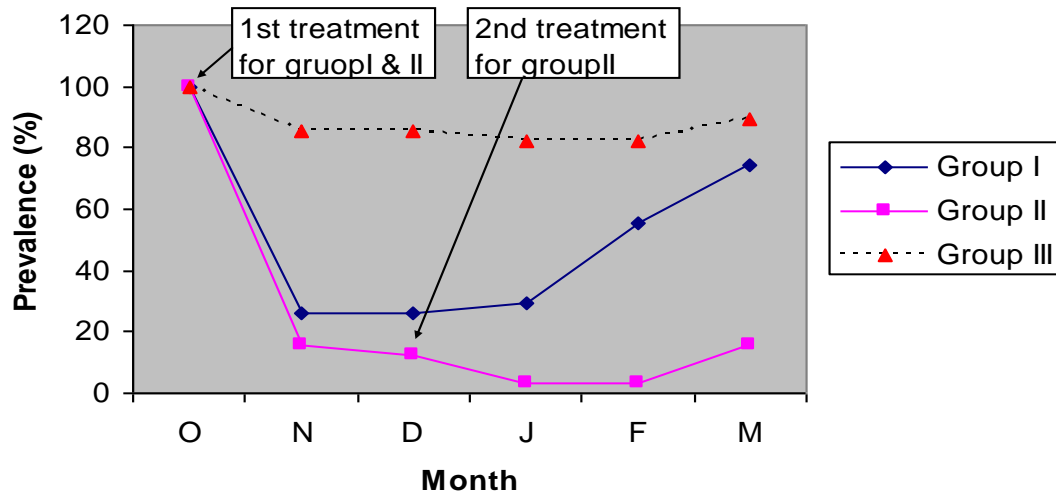


Figure 6. Prevalence of fasciolosis in 3 groups of sheep.

4.3.4. Effects of treatment on haematocrit value

4.3.4.1. Cattle

The result showed that group II had a higher PCV value (31.09 ± 2.47) compared with group I, (26.78 ± 3.45) and control group III (24.84 ± 3.45). The improvement of mean PCV value in group II was significantly ($P < 0.05$) higher than the two groups (I and III) particularly from the month of December till the end of the experimental month (Figure 7).

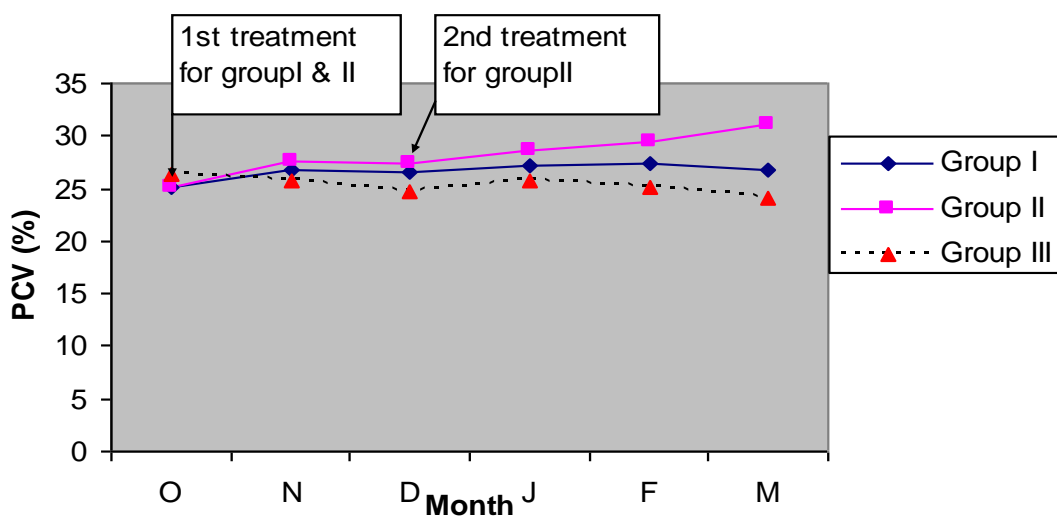


Figure 7. Mean monthly PCV value of cattle in 3 groups from October to March.

4.3.4.2. Sheep

The PCV value in experimental sheep showed that group II animals demonstrated the highest PCV (36.28 ± 5.54) followed by group I (27.18 ± 4.15) and then group III (26.46 ± 3.17). The progress of PCV value in group II was significantly greater ($P < 0.05$) than those of the group I and III from December to March (Figure 8).

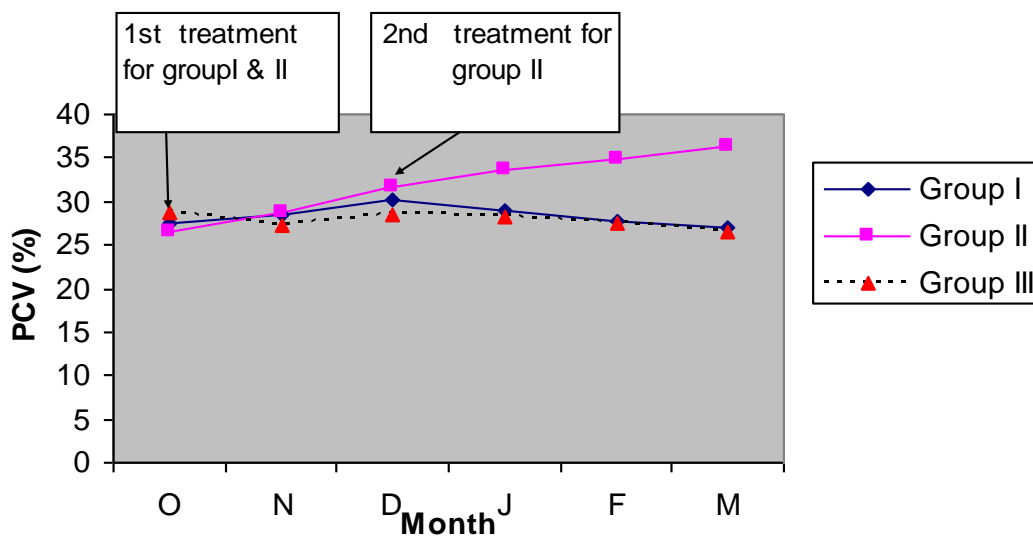


Figure 8. Mean monthly PCV value of sheep in 3 groups from October to March.

4.3.5. Live body weight changes

4.3.5.1. Sheep

Result of ANOVA of live weight change between the three groups showed that group II had better weight gain (28.84 ± 4.64) than group III (21.53 ± 6.55) and group I (19.92 ± 4.98). The average body weight changes of the sheep are shown in Figure 9.

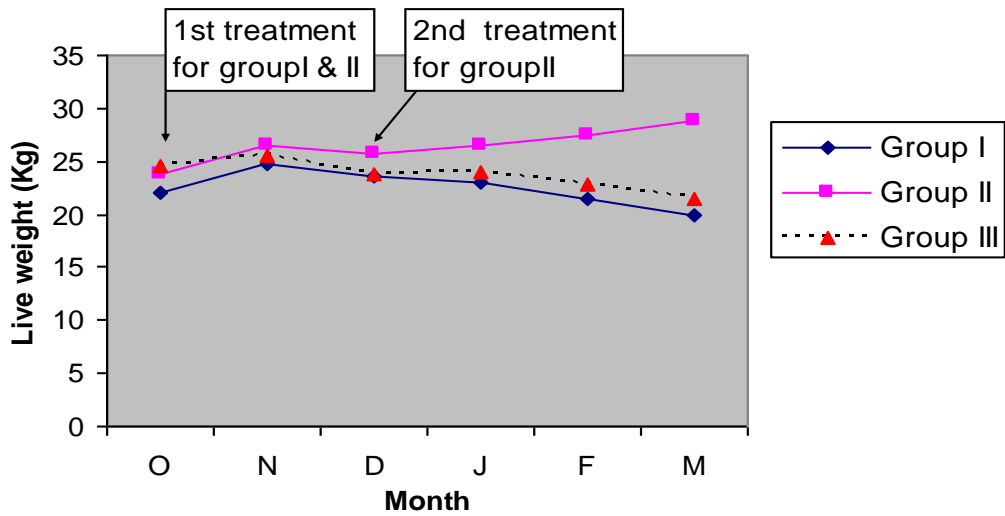


Figure 9. Mean monthly weights of sheep in 3 groups from October to March.

4.3.6. Body condition score

4.3.6.1. Cattle

The result showed that the mean body condition score for group I, group II and group III was 2.29 ± 0.71 , 3.7 ± 0.7 and 1.97 ± 0.69 at the end of the trial respectively. Analysis of variance indicated that there was a significant difference ($P < 0.05$) between group II and group III while no difference ($P > 0.05$) was observed between group I and group III at the end of the experimental trial. Figure 10 shows changes in body condition scores during the study period.

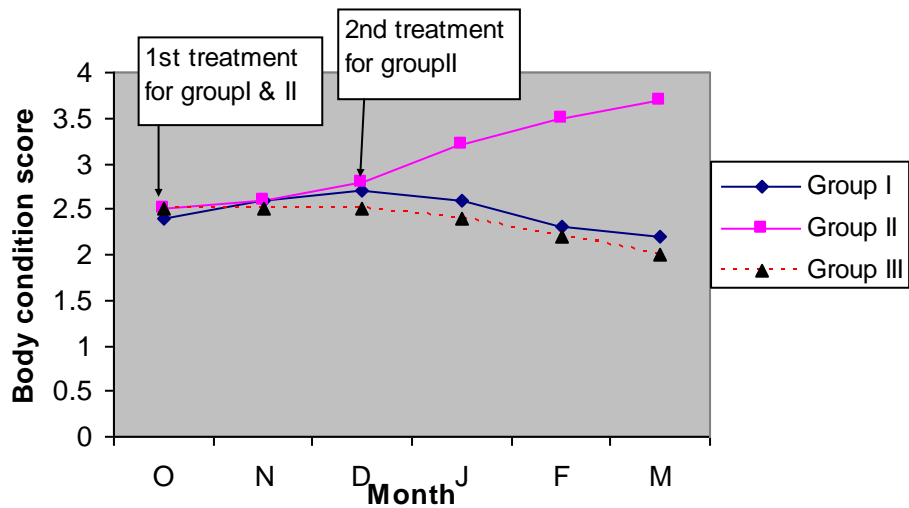


Figure 10. Mean monthly BSC of cattle in 3 groups from October to March.

4.3.6.2. Sheep

The mean body condition score for group I, group II and group III was 1.11 ± 0.59 , 2.21 ± 0.76 , and 0.89 ± 0.47 at the end of the experiment, respectively. The effect of the treatments was analyzed using a one-way analysis of variance and revealed that there were significant differences ($P < 0.05$) in body condition score between the three groups (Figure 11).

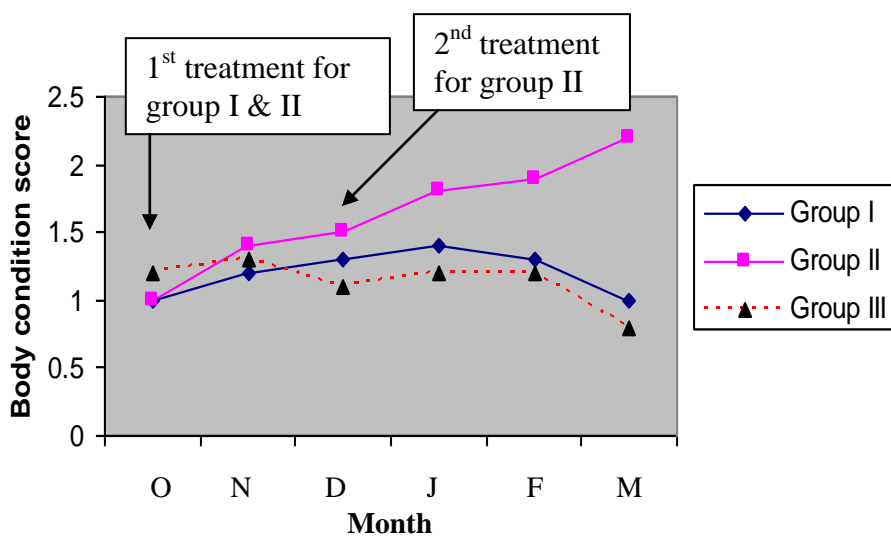


Figure 11. Mean monthly BSC of sheep in 3 groups from October to March.

4.3.7. Determination of serum enzyme concentration of AST

4.3.7.1. Sheep

At the start of the experiment (October) there were no significant differences in enzyme concentration level of aspartate aminotransferase (AST) among the 3 groups. Thereafter (March), the enzyme level in all experimental groups increased, however, group III had higher AST values than the group I and II. This difference was statistically significant ($P < 0.05$). Figure 12 shows changes in serum AST concentration of the three experimental groups of sheep during October (pre-treatment) and March (post-treatment).

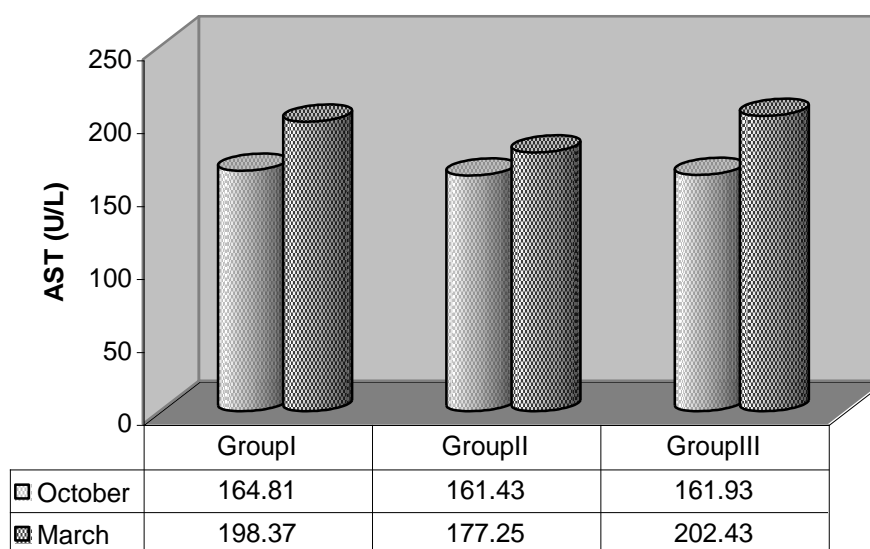


Figure 12. A comparison profile of mean AST concentration of sheep in 3 groups.

4.3.8. Cost-benefit analysis of the strategic treatment

Cost-benefit analysis as seen from bird's eye view of the strategic anthelmintic treatment intervention on live weight change was tried to be performed based on the group body weight mean with the average weight estimates of sheep (23kg) sold in the study woreda. Labour costs were omitted from the analysis because the opportunity costs were negligible under this trial. It was estimated that a sheep weighing 23kg is sold 160 birr in a market of Merawi town. The treatment cost of an average-sized sheep (10mg triclabendazole per kg body weight) is 0.75 birr per treatment. It was also considered that the total number of days taken to finish this experiment was 180 days (6 months) following the first treatment. Mean total weight gain per animal after the end of trial for group I, group II and group III was -2.11kg, 5.09kg and -3.11kg, respectively. Based on these conditions the economic benefit from sell of an individual sheep at the local market is estimated and is shown in the table below.

Table 12.Cost-benefit analysis of the 3 groups of sheep.

Group	Initial mean BW (kg)	Final mean BW (kg)	Mean gain (kg)	Value 1kg BW (Birr)	Benefit (Birr)	Treatment cost (Birr)	Net benefit (Birr)
Group I	22.03±5.42	19.92±4.98	-2.11	6.90	Nil	0.75	Nil
Group II	23.75±5.43	28.84±4.64	5.09	6.90	35.12	1.50	33.62
Group III	24.64±7.00	21.53±6.55	-3.11	6.90	Nil	NT	Nil

NB: BW= Body weight; NT= No treatment

5. DISCUSSION

The result of the present survey has revealed a relatively lower prevalence (37.6%) of fasciolosis (37.2 % in cattle and 38.0 % in sheep) than values reported by previous workers such as Muluaem (1998) noting a prevalence of 84.8% of cattle in this same survey woreda during his fieldwork. This wide gap may be due to the decrease of most of marshy and/ or waterlogged areas which are anticipated to be ideal for the propagation and maintenance of high prevalence of fasciolosis and have recently been shifted to rice production plot. Consequently, these contaminated pasture areas are limited to plots with subsequent less chance for animals to acquire the infection. It may also be asserted that the regional concerned veterinary offices and private drug shops interventions after the previous studies might have greatly contributed to the minimization of prevalence added up to the reduction of the pasture land through intensity of rice production.

This survey reveals that there is no significant difference ($P>0.05$) in prevalence of fasciolosis between cattle and sheep in the study areas. The likely explanation may be that cattle and sheep in the study areas graze in the same communal grazing lands with similar agro-ecological condition so that the chance of acquiring the disease or becoming of infected is therefore similar.

Analysis results revealed variations in prevalence of fasciolosis between the different localities (Table 6 & 7). This disparity may be associated with variation in the local climatic factors, the density of cattle population and certain specific ecological niches favouring the development of intermediate hosts and the transmission of the disease.

In this survey, the lowest prevalence of the disease in Wojji, Kohar Abo and Addisbete PAs may be explained as a result of a limited animal-water contact, which is brought about from unavailability of enough water and pastureland in the areas. The topography of these localities is also featured by the presence of hilly and sloppy sites and the utilization of the remaining plain for crop farming. The highest prevalence of bovine fasciolosis was registered in Awanakokit PA followed by Kohar Michael and the lowest in Addisbete. Likewise highest prevalence of ovine fasciolosis was recorded in Engutti PA, and the lowest in Enamrit PA.

This is probably because of the presence of many low-lying marshy and water logged plains in grazing circuits of Fogera plains available to cattle and sheep as well as the existence of small ponds and dams that might have served as good biotype in this area for the intermediate host. Generally, the difference in the prevalence of fasciolosis is strongly related to the variation in the type of soil, geomorphology and the biotype suitability for the development of the intermediate host. Schillhorn Van Veen (1980) believed that field-dried condition can account for lower prevalence of fasciolosis. Occurrence of flood plains in grazing circuits of animals also increases the risk of acquisition of infection.

In this study, significant variation ($P < 0.05$) in the prevalence of cattle and sheep of various age groups was observed (Table 9), a finding that agrees with works of Dwinger *et al.*, (1982). In the case of cattle, low prevalence of fasciolosis dominates in the younger group (1-3 years of age). This might be attributed to the fact that calves are not often driven with older age groups to grazing and watering points. They are kept at a nearby village where the source of feeding is much limited. This practice naturally reduces the chance of exposure in this age class. In different parts of Ethiopia, similar results indicating inverse correlation of prevalence and age of cattle were reported by Fekadu (1988), Rahmeto (1992), Daghe (1994) and Beyazn (1995). As the age increase to reach the adult stage, i.e. second group (3-5 years of age), so also the magnitude of the infection rate expands to a higher level. The likely explanation to this condition is that the more the age of the young increases, the possibility of moving towards new environment happens, which is an exposure to *Fasciola* contaminated pasture lands and water points. On the other hand, low prevalence of fasciolosis was observed in older cattle group (5 and above years old). This could be as a result of frequent attack by the parasite during the adult stage, which in turn helped the group to develop acquired resistance for the diseases. The feature of the resistance is related to higher level of liver tissue reaction characterized by fibrosis, creation of bile duct stenosis and calcification, which are causes (factors) for impediment of passage immature fluke. Moreover, adult parasites in the bile duct could assume unfavourable site and consequently fastens their expulsion.

The study revealed that unlike in age groups of cattle, prevalence of fasciolosis becomes high following the increment of age in sheep. In other words, the younger the age the lower the prevalence and the older the age the higher it will be (Table 9). This is certainly because the life span of sheep is too short compared to cattle so as to develop acquired resistance manifested in the form of high level liver tissue reaction.

Sex, as variable, had shown no specialized features against specific variation seen on age basis (Table 8). This might be due to grazing of both sex groups in similar *Fasciola* contaminated pastureland. Moreover, it might also be that fasciolosis is not a disease directly related to animal reproductive system.

In cattle, there is no significant difference ($P>0.05$) on prevalence of fasciolosis whether the animal is in poor or good body condition. This is because body condition deterioration in cattle is manifested when fasciolosis reaches at its chronic stage. In sheep, unlike in cattle, *Fasciola* infection has shown significant difference ($P<0.05$) in body condition of the sheep. Poor body conditioned sheep is highly vulnerable to or infected by *Fasciola* parasite, whereas in good body conditioned sheep prevalence is low. This could be associated to less resistance as a result of malnutrition, prevalence of other infections (parasitic or non-parasitic) as well.

Trematodes and nematode parasites were common in the study areas during the study period (Annex 10). Their existence along with fasciolosis might have impact on body condition and body weight of the animals particularly in sheep.

Result of field experiment showed that in cattle after the first (October) anthelmintic treatment intervention the number of positive experimental animals in group I and II decreased dramatically. The November-December prevalence of fasciolosis remained stagnant showing no progressive change. Whereas in group III, prevalence of infection up to December dropped gently which might be due to better dietary condition of the season.

December till February, the number of animals with *Fasciola* eggs in their faeces rose in group I then after to show no change till the end of the trial. This indicates that reinfection occurs between the months of December and February, which is mid-dry season of the area. On the contrary, animals in group II showed low detection of *Fasciola* eggs after the second treatment (December), which resulted in the reduction of infection rate of 6.0% unlike group I, 35.7%, at end of the trial (Figure 5).

Cattle in group III (control) had received no treatment though there was gradual drop of infection that was indicated during detection of *Fasciola* eggs through until March (Figure 5). The likely explanation may be cattle have acquired resistance. Spontaneous

recovery does occur in chronically infected cattle and previously infected animals can partially resist re-infection. This resistance is maintained by the presence of chronic fibrotic changes in the liver (Ross, 1966; FAO, 1994). The development resistance of cattle to *Fasciola* infection results in decline of egg production and eventual elimination of the infection (FAO, 1994).

The same scenario had happened in the experimental sheep. But the difference between sheep and cattle was that in sheep there were sharp rise of reinfection in group I starting from January till March. Moreover, control group (group III) in sheep as in the case of cattle showed gradual decline of infection between October and November (Figure 6), but remained constant until February. These strange factors could be the treatment of some of the animals within the groups by livestock owners or it could be due to the intermittent shedding of the parasite eggs, which is influenced by digestion of food that hinders to give definitive diagnosis of fasciolosis during faecal examination. Moreover, number of adult parasites established in the liver, level of host immunity, age of the host, stage of infection and consistency of the faeces also be additive factors for difficulty to the actual diagnosis of fasciolosis.

Khallaayoune *et al.*, (1991) revealed that Timahdit breed of sheep are able to self-regulate fluke burden seasonally, perhaps dependent upon the dietary status. He also notified that the period of fluke burden coincided with the season of maximum nutritional stress in the study areas, which may have potentiated the severity of the fluke infections, and resulted in the high mortality rate (10%). Similar results have also shown in the present study where sheep in group I and group III indicated maximum numbers of infected animals at the time of poor nutritional period (March) (Figure 6). It is well known that dietary quality considerably influences the pathogenesis of parasitic infection in domestic animals. Animals maintained on high plane of nutrition may be more resistant to infection (Boray, 1969).

After the second (December) anthelmintic treatment in group II animals, 1 cow and 2 sheep with *Fasciola* eggs in their faeces had been encountered. This may be associated with inappropriate administration of the drug and/or the liver may perhaps severely be damaged by the parasites and unable to metabolize the drug (triclabendazole) to the active compound to kill the flukes (O'Brien and Scully, 2002).

In the present study, high PCV values in group II was recorded at end of the trial (Figure 7). This implies that the infection rate of *Fasciola* in this group of cattle was low as a result of two-times treatment of anthelmintic drug. On the contrary, the PCV value of group III (control group) was low. In studies where blood-sucking parasites are important, packed cell volume (PCV) has been used as an indicator of the degree of anaemia. The effect of fasciolosis on the blood parameters has already been studied. Artificial infection of sheep with viable metacercariae of *F. gigantica* in gelatin capsules has been reported to result in rapid reduction of PCV and RBC counts nine weeks after infection (Waweru *et al.*, 1999). Anaemia is a common effect caused by sucking activity of the fluke, in which more than 0.5ml blood per fluke can be lost into the bile ducts each day and the continuous drain on iron reserves that this imposes (Radostitis *et al.*, 1994). The adult fluke ingests blood, which causes anaemia and chronic inflammation, enlargement of the bile ducts and fibrosis of the liver tissue (Ross, 1966; FAO, 1994). Immature flukes are tissue feeders but may accidentally ingest some blood and the minor degree of anaemia that develops in the first 4 to 5 weeks of infections probably reflects the loss of blood into the migratory tract of the young (Urquhart *et al.*, 1996).

Similarly, the same pattern of PCV value had been observed in the experimental sheep (Figure 8). However, the effect of treatment intervention and even the effect of reinfection were rather faster in this species. This indicated that experimental sheep in group I were reinfected after the initial treatment. Whereas no significant infection occurred in group II. Thus, one-time treatment is not enough to maintain the optimal values of PCV under this circumstance.

In the experimental groups of sheep, the comparison of live weight changes of group II with those groups I and III showed live weight gain by the former at the end of the study (Figure 9). The gain varied across the observational months. Absence of homogeneity of the experimental groups of sheep, variations in initial body weight and differences in pregnancy status might be considered to impact on the condition of live weight. Group II showed progressive changes in body weight after December. This was due to the effect of the second strategic treatment of fasciolosis, which resulted in the improvement of animals' condition. The weight gain was, however, not immediate. Group II animals gained weight faster after the second treatment. Also as shown in Figure 9, all groups of animals lost body weight between

November and December. The cause of this might be associated with the lambing season in the study area that influenced the body weight of the ewes after parturition. The depression in weight gain was also aggravated in group I and group III at the time of dry months (January-March) when there was scarcity of feeding of grazing lands. Khallaayoune *et al.*, (1992) revealed that the effects of fluke infection might be exacerbated when animals are nutritionally stressed. Generally these results confirm in part, the importance of *Fasciola* parasite as a cause of poor productivity of sheep and the beneficial effect of strategic approach to the control of subclinical fasciolosis under field conditions.

In this trial the changes in body condition score of cattle, i.e. the differences between the initial and final mean body condition score, were -0.16, 1.16 and -0.57 for group I, II and III respectively. According to the analysis made by Nicholson and Sayers (1987) with *Bos indicus* cattle, a change of one condition score was equivalent to about 24kg. Therefore, the changes in live weight corresponding to these condition score changes should be -3.84, 27.84 and -13.68 kg, respectively. Thus, twice anthelmintic treatment improves the animals' body condition. However, it has been reviewed that apparent changes in condition score could happen due to changes in physiological state such as pregnancy and lactation or gull fill or even the state of hydration of the animal. Moreover age variation of animals can affect body condition score. Osuji and Capper (1992) revealed that the effect of age on mean final body condition score had a significant quadratic effect, showing that 7 to 8 years old animals had significant better final body condition than the 4 to 5 and 10-11 year old animals.

Serum enzyme concentration of aspartate aminotransferase (AST) had been tried to determine its level on randomly selected 16 sheep from each experimental groups. A clear response to treatment is reflected in serum enzyme levels such as AST, which is a valuable aid in the diagnosis of liver disease. This experimental trial showed that two-times treated group of sheep has lower mean AST value than those animals in group I and III. Generally, aspartate aminotransferase in all groups had elevated at higher level at the end of the experiment though the highest value had been seen in group III (control) which was statistically significant ($t = -3.74$, $df = 15$, $P\text{-value} = 0.002$). This indicated that liver cells were damaged by the *Fasciola* parasites, as displayed by the large quantities of AST enzymes in the blood.

Although elevated serum AST is not specific for liver disease, it is used primarily to diagnose and monitor the course of liver disease (in combination with other enzymes such as ALT,

ALP and bilirubin) (Smith, 2005). According to Smith (2005), AST is found in the heart, liver, skeletal muscle, kidney, pancreas, spleen, lung, red blood cells, and brain tissue. When disease or injury affects these tissues, the cells are destroyed and AST is released into the blood stream. The amount of AST is directly related to the number of cells affected by the disease or injury, but the level of elevation depends on the length of the time that the blood is tested after injury. Serum AST levels become elevated 8 hours after cell injury, peak at 24-36 hours, and return to normal in 3 to 7 days. If the cellular injury is chronic (ongoing), AST levels will remain elevated. This has become a fact of this study.

Increases of AST and GLDH plasma levels appear in sheep by 3-4 weeks post infection and are related to the inflammatory state of the liver and to tissue destruction provoked by the parenchymal migration of juvenile flukes during the state of fasciolosis (Ferre *et al.*, 1995). And interpretation of liver function tests must be viewed in terms of short-term intervals because of the rapid regenerative ability of the liver. Lower values for serum AST had been recorded in twice treated group of animals during post treatment. This does not mean that the values became lower from the initial pre-treatment AST concentration level. Rather the post treatment test for group II was a bit higher from its initial value. This might have happened as a result of the long duration interval of the test. Moreover the likely explanation may be associated with the reason that during dry season (at the end of the experiment) there was scarcity of feed and a number of animals may possibly be starved and lost their body mass. Increased AST level has been reported during malnourishment and at the time of muscle degeneration. As for the remaining two groups the test showed progressive increment of AST concentration level. It, therefore, indicates that it was the effect of the December treatment of fasciolosis, which resulted the changes in serum enzyme level of animals' health condition.

6. CONCLUSION AND RECOMMENDATIONS

This study has found the previously recommended *Fasciola* control methods and treatment intervention schedules appropriate to the Ethiopian northwestern highland areas. Nonetheless, the study indicated that the time span between the recommended intervention periods appears to be long enough so that fasciolosis has time to highly prevail in the form of reinfestation in the specified areas of the study, Fogera and Mecha woredas. Hence, additional treatment intervention in mid-dry season (December-January) has important impact in the reduction of the prevalence of liver fluke in the study areas.

The presence of other helminth parasites side by side with liver fluke has exacerbated the deterioration of the productivity of the animals particularly that of sheep. The study has indicated the simultaneous treatment of fasciolosis and the other helminth parasites is much more relevant to alleviate deterioration of the productivity of the animals.

Hence, the following recommendations are forwarded.

- In addition to the previously recommended strategic treatment (September-October and April) of fasciolosis in sheep and cattle, an additional treatment in mid dry season (December-January) is required for a better control and reduction of fasciolosis in the study area.
- Application of zero-grazing method during high outbreak months (September, October and November).
- Modernization of traditional management practices through raising the awareness of livestock owners on the close follow-up of the conditions of the animals, feeding system and characteristic of the disease.
- Consideration of further study on *Fasciola* resistant breeds as a means of control of the diseases.

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8. ANNEXES

Annex 1. Prevalence of bovine fasciolosis in different regions of Ethiopia determined on the basis of faecal and abattoir survey.

Administrative region	Prevalence(%)		References
	Faecal	Abattoir	
Wolaita	28	18	Getu (1987)
Nekemte	17.14; 32	22.7; 29.8	Abebe (1988) and Wassie (1995)
Jimma	-	47.5; 57.58	Zewdu(1991) and Moges (2003)
Kombolcha	51.13	53.5	Mulugeta (1993)
Kalu	15.77	-	Girmay (1988)
Bahirdar	60.2	61.97; 84.7	Fekadu (1988) and Yohannes (1994)
Gondar	-	33.4; 50	Roman (1987) and Mesfin (1999)
Debre Birhan	87	88.57	Daghe (1994) and Tsegaye (1995)
Eastern Gojjam	50.56	-	Bayazn (1995)
Soddo	-	47	Abdul (1992)
Awassa	-	30.43	Hailu (1995)
Dembidollo	-	77.8	Abera (1990)
Arsi	53.72	41.3	Wondwosen (1990)
Asela	20.2; 24.5	-	Yosef (1993) and Dinku (1996)
Wolliso	34	-	Rahmeto (1992)
Chillalo	26.2	-	Zerfu (1991)
Bale	34.6	49	Abduljebar (1994)
Zeway	32.7	-	Adem (1994)
Westen Shoa	82.5	-	Yadeta (1994)
Easten Hararge	42.9	12.1	Hymanot (1990)
Tigray	-	26	Takele (1995)
Buno province	11.5	8.1	Seyoum (1987)

Annex 2. Economic losses due to liver condemnation and meat reduction in production at different abattoirs in Ethiopia.

Annual (Eth. Birr)	Economic losses	Place of Abattoir	References
266,741.37		Kombolcha	Mulugeta (1993)
142,128		Soddo	Abdul (1992)
78,311.60		Wolliso	Rahmeto (1992)
480,789.00		Jimma	Zewdu (1991)
100,707.00-246,000.00		Nekemte	Abera (1988) and Wassie (1995)
223,604.82		Gondar	Roman (1987)
376,019.70		Dire Dawa	Daniel (1995)
122,775.54		Awassa	Hailu (1995)
180,942.48		Bahir Dar	Yohanes (1994)
109,601.24		Robe	Abduljebar (1994)
178,933.36		Debre Birhan	Tsefaye (1995)
631,320.00		Addis Ababa	Getachew (1984)
560,678.58		Debre Zeit	Yilma (1983)

Annex 3. Format for recording of general information of the study areas.

1. Date of interview -----
2. Region -----
3. Zone-----
4. Woreda -----
5. PA / Village-----
6. Topography (%)
 - Swampy
 - Flood plains
 - Plain
 - Undulating
 - Mountainous
 - Other (specify)
7. Annual rainfall (mm) mean-----min-----max-----
8. Beginning of rain – (early, mid, late)
(Mark period in months also)
9. End of rain – (early, mid, late)
(Mark period in months also)
10. Temperature (c⁰) mean-----min-----max-----
11. Relative humidity (%)mean-----min-----max-----
12. Any distinctive feature of the cattle type in the area: -----

Type of production system:

- Agricultural (Major crops)
- Pastoral
- Agro pastoral
- Sedentary
- Semi-sedentary

Section A. Cattle Husbandry Practices

1. Do you purchase any supplementary feeds?
1=Yes 2= No
2. Do you cut and carry any fodder?
1=Yes 2= No
3. What system of animal rearing / grazing system?
1= communal grazing 2= fenced farm 3= zero grazing 4= other
4. Feeding:
 - Native pasture
 - Fallow (back yard with season)
 - Crop residue
 - Others (specify)
5. Water sources: What are the main water sources for your animals?
 - River
 - Lake
 - Protected spring / well
 - Unprotected spring / well
6. Is this water source reliable throughout the year, or what is the alternative in case it dries up?
 - Protected spring / well
 - Unprotected spring / well
 - River
 - Lake
 - Others (specify)
7. Mineral supplement? (With season)

8. Housing:

- Open camp
- Penned at night without shelter
- House at night
- House at night and part of day
- Housed day and night

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

1. ----- 5. -----
2. ----- 6. -----
3. ----- 7. -----
4. ----- 8. -----

10. Please list the different treatments the cattle have received during the past one-year.

Disease	Treatment	No. Sheep	Frequency	No. Doses	Treated by	Source of drugs

Section B. Sheep Husbandry Practices

11. Do you purchase any supplementary feeds?

1=Yes 2= No

12. Do you cut and carry any fodder?

1=Yes 2= No

13. What system of animal rearing / grazing system?

1= communal grazing 2= fenced farm 3= zero grazing 4= other

14. Feeding:

- Native pasture
- Fallow (back yard with season)
- Crop residue
- Others (specify)

15. Water sources: What are the main water sources for your animals?

- Protected spring / well
- Unprotected spring / well
- River
- Lake
- Others (specify)

16. Mineral supplement? (With season)

17. Housing:

- Open camp
- Penned at night without shelter
- House at night
- House at night and part of day
- Housed day and night

18. Major uses of sheep (prioritized = 1 = First)

- Meat ▪Skin ▪Others (specify)
- Milk ▪Manure
- Cash ▪Social value

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

- | | |
|----------|----------|
| 1. ----- | 5. ----- |
| 2. ----- | 6. ----- |
| 3. ----- | 7. ----- |

20. Please list the different treatments the sheep have received during the past one-year.

Disease	Treatment	No. Sheep	Frequency	No. Doses	Treated by	Source of drugs

21. Any other fact.

- Lamb mortality of previous year (age and reason)
- Adult mortality of previous year (age and reason)

About Fasciolosis/Liver fluke/ “ Berer”

22. Have you heard of a livestock disease called fasciolosis “ Berer”?

1= Yes 0= No

23. If yes, what causes the disease?

1= correct response 2= Incorrect response 3= Don’t know

24. How is fasciolosis transmitted to animals?

1= correct response 2= Incorrect response 3= Don’t know

25. In which season/month most often do livestock get the disease (fasciolosis)?

26. In which season or month are snails most abundant?

27. Is fasciolosis a major problem for you on this farm?

1= Yes 0= No

28. Have you had any cases of fasciolosis on your farm during the past one-year?

1= Yes 0= No

29. If yes Q. 28. How did you determine (diagnose) that they were cases of fasciolosis?

1= previous experience 2= vet diagnosed it 3= neighbour/ friend diagnosed it

4= other

30. Which of your animals did you take most care in protecting from fasciolosis?

1= All animals 2= only calves 3= only adults 4=other (describe)

31. If you used fasciolicides over the last one year, please complete the following table.

Brand name of drug	Source	Type of animal treated	No. of animals treated	Animal treated by whom?	Frequency of treatment	Price paid (Birr per treatment)

Annex 4. The number of cattle by experimental group and age.

Experimental group	Age		Total (%)
	Young (<4years) (%)	Adult (\geq 4 years) (%)	
I	8 (28.5)	20 (71.4)	28 (100)
II	12 (36.3)	21 (63.6)	33 (100)
III	11 (57.8)	8 (42.1)	19 (100)
Total	31 (35.6)	49 (56.3)	80 (100)

Annex 5. The number of sheep by experimental group and age.

Experimental group	Age		Total (%)
	Young (<2years) (%)	Adult (\geq 2 years) (%)	
I	11 (40.7)	16 (59.2)	27 (100)
II	11 (34.3)	21 (65.6)	32 (100)
III	9 (32.1)	19 (67.8)	28 (100)
total	31 (35.6)	56 (64.3)	87 (100)

Annex 6. The number of experimental animals by species, group and sex

Species	Group	Sex		Total (%)
		Male (%)	Female (%)	
Cattle	I	15 (53.5)	13 (46.4)	28 (100)
	II	17 (51.5)	16 (48.4)	33 (100)
	III	13 (68.4)	6 (31.5)	19 (100)
	Subtotal	45 (56.2)	35 (43.7)	80 (100)
Sheep	I	6 (22.2)	21 (77.7)	27 (100)
	II	5 (15.6)	27 (84.3)	32 (100)
	III	3 (10.7)	25 (89.2)	28 (100)
	Subtotal	14 (16.0)	73 (83.9)	87 (100)
Total		59 (35.3)	108 (64.6)	167 (100)

Annex 7. Body condition scoring (BCS) of sheep

Rank	Condition score type	Description	Grouping
Condition Score 1	Very thin	Spine prominent and sharp	Poor
Condition Score 2	Thin	Spine prominent and smooth	
Condition Score 3	Average	Spine smooth and rounded	Good
Condition Score 4	Fat	Spine only detected as a line	Very good
Condition Score 5	Very fat	Spine not detectable; fat dimple over spine	

Adapted from Thompson and Meyer, 1992.

Annex 8. Body condition scoring (BCS) of cattle

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

Adapted from Nicholson and Butterworth, 1986.

Annex 10. Prevalence of parasitic infections other than fasciolosis in the study areas during the period of October 4, 2004 to October 8, 2004.

No	Parasites	Host species and total number of animals examined	
		Cattle n=384	Sheep n=368
1.	Trypanosome	0 (0%)	0 (0%)
1.	Trematodes		
	1.2 <i>Paramphistomum</i>	292 (76.0%)	156 (42.3%)
	1.3 <i>Schistosoma</i>	12 (3.1%)	0 (%)
2.	Cestodes		
	2.1 <i>Monezia</i>	0 (0%)	9 (0.2%)
3.	Nematodes		
	3.1 <i>Toxocara</i>	14 (3.6%)	0 (0%)
	3.2 <i>Strongyloides</i>	7 (1.8%)	50 (13.5%)
	3.3 <i>Trychostrongyle</i> group	17 (4.4%)	316 (85.8%)
	3.4 <i>Trichuris</i>	0 (0%)	32 (8.6%)

Annex 11. Sedimentation Technique (modified McMaster)

1. Twenty gram of faeces were put in a jar and mixed with 200ml tap water and stirred well with a stirring rod (faeces from sheep were thoroughly broken up using a mortal pistil).
2. The sample was strained through a tea strainer , washed copiously and fill up with tap water.
3. The sample was allowed to stand for 15-20 min and then the supernatant discarded and re-suspend the sedimentation in tap water. The sedimentation process was done four times.
4. After the last sedimentation and decantation the sediment was recovered into a test tube and fill up to 50ml volume with tap water.
5. Agitate the tube to re-suspend the sediment. Transfer the sediment to a microslide. Cover with a coverslid and detect the presence of *Fasciola* eggs under microscope.

9. CURRICULUM VITAE

Personal information:

Name: Solomon Wolde Mariam

Sex: Male

Age: 45

Date of birth: October 20, 1960

Place of birth: Addis Ababa

Nationality: Ethiopian

Marital status: Married

Number of children: Two, age 7 and 3

Religion: Christian of the Orthodox Church

Contact address: Bahir Dar Vet Laboratory

P.O.Box 70, Tel (08)200017

Bahir Dar, Ethiopia

Educational background

Elementary school (1967-1972)

- Finished at Fit. Lakeh Adgeh local school in Addis Ababa

Junior Secondary School (1973-1974)

- Finished at the same local school in Addis Ababa

Secondary School (1975-1978)

- Finished at Nifas Silk Comprehensive School in Addis Ababa

Collage (1980-1981)

- Studied a diploma courses in veterinary at Debrezeit Animal health School and qualified as assistant veterinarian.

University (1984-1989)

- Joined the Ukraine Agricultural Academy and qualified as a doctor in veterinary science I (former) USSR.

Work experience

Assistant veterinarian (1982-1983)

- Worked at (former) Metekel and Agew Midir Awraja in Gojjam Ad. Zone

Veterinarian (1990-1992)

- Worked at Libo (Addis Zemen) and Farta (Debretabour) Awraja in South Gondar Ad. Zone.

Zonal Department Head (1993-1994)

- Worked in South Gondar Zonal Agricultural Office

Regional veterinary officer (1994-1995)

- Worked in Agricultural Bureau of ANRS Bahir-Dar

Research officer (1996-2001)

- Worked at Bahir-Dar Vet Lab in the Department of Parasitology Bahir-Dar

Department Head (Since Jan. 2002)

- Working at Bahir- Dar Vet Lab in Department of parasitology- Bahir-Dar

Credentials

Tsetse Management, Monitoring and Control (14th-24th Dec., 1995)- ICIPE (International Centre of Insect Physiology and Ecology) at Awasa

FITCA Regional Database and GIS Training (21May 2001to 15 June 2001)- ILRI-Nairobi, Kenya.

Research works

Prevalence and distribution of parasites of domestic animals in North Gondar Administrative Zone (2001); Ethiopia (presented at a workshop held in Bahir-Dar, ANRS January 2002).

Baseline Study on Vectors of Trypanosomosis(1998). Published in the Proceeding of the Workshop held at ESTC (Ethiopian Science and Technology Commission) Addis Ababa, May 2000.

Baseline Survey on Ixodid ticks of domestic animals at Ebinat and Bure Woredas (1997). A paper presented at workshop held in Bahir-Dar. ANRS February 1998.

Prophylaxis and preventive measurements of bovine tuberculosis (1989). (DVM thesis Ukraine Agricultural Academy, Kiev, June 1989)

10. SIGNED DECLARATION SHEET

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

Name Solomon Wolde Mariam Habte

Signature _____

Date of submission June 15, 2005

This thesis has been submitted for examination with my approval as an academic advisor.

Dr Abebe Wossene _____