



ADDIS ABABA UNIVERSITY



COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE

**STUDY ON BOVINE TREMATODES AND THEIR SNAIL VECTORS IN ENDERTA
DISTRICT AND MEKELE SPECIAL ZONE, TIGRAY REGIONAL STATE, ETHIOPIA**

**A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS
ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR
THE MASTERS DEGREE IN TROPICAL VETERINARY PARASITOLOGY**

BY

MEAZA NIGUS (BSc)

JUNE, 2021

BISHOFTU, ETHIOPIA

**STUDY ON BOVINE TREMATODES AND THEIR SNAIL VECTORS IN ENDERTA
DISTRICT AND MEKELE SPECIAL ZONE, TIGRAY REGIONAL STATE,
ETHIOPIA.**

BY

MEAZA NIGUS (BSc)

Academic Advisors:

Signature

Major Advisor: Dinka Ayana (DVM, MSc, Associate Professor)

Co-advisor: Assefa Kebede (DVM, MSc, Assistant Professor)

Board of External and Internal Examiners:

1. Dr. Takele Sori

2. Prof. Bersissa Kumsa

JUNE, 2021

BISHOFTU, ETHIOPIA

STATEMENT OF AUTHOR

First and foremost, I declare that this Thesis is my genuine work and that all sources of materials used for this Thesis have been properly acknowledged. It has been submitted in partial fulfillment of the MVSc degree requirements at Addis Ababa University, College of Veterinary Medicine and Agriculture, and has been deposited at the University Library to be made available to borrowers in accordance with the Library's rules. I solemnly declare that this Thesis is not being submitted to any other institution for the award of any academic degree, diploma, or certificate anywhere in the world. Brief quotations from this thesis are permitted without special permission as long as the source is properly acknowledged.

Name: Meaza Nigus Teka Signature: _____

Place: Addis Ababa University, College of Veterinary Medicine and Agriculture

Date of Submission: July 6/2021

TABLE OF CONTENTS

TABLE OF CONTENTS	I
ACKNOWLEDGMENTS	Iv
LIST OF TABLES	VII
LIST OF FIGURES	VIII
LIST OF ANNEXES.....	IX
LIST OF ABBREVIATIONS	X
ABSTRACT.....	XI
1. INTRODUCTION.....	1
1.1. Background and Justification	1
1.2. Statement of the Problem	4
1.3. Objectives.....	5
1.3.1. General objective	5
1.3.2. Specific objectives	5
1.4. Research Questions	6
2. LITERATURE REVIEW	7
2.1. Etiology.....	7
2.2. Transmission.....	7
2.3. Life Cycle	8
2.4. Morphology.....	10
2.5. Epidemiology	11
2.6. Risk Factors	12
2.6.1. Environmental and management risk factors.....	12
2.6.2. Host related risk factors.....	14

2.7. Diagnosis	15
2.7.1. Clinical Signs.....	16
2.7.2. Parasitological Techniques	17
2.7.3. Postmortem Findings.....	17
2.8. Prevention and Control	18
2.9. Treatment.....	19
2.10. Current Status of Bovine Trematodes.....	20
2.11. Economic and Public Health Significance of Trematodes.....	21
3. MATERIALS AND METHODS	7
3.1. Study Area	24
3.1.1. Enderta district	24
3.1.2. Mekelle special zone	25
3.2. Study Population	26
3.3. Study Design	27
3.4. Sample Size Determination and Sampling Techniques	27
3.5. Study Procedure	29
3.5.1. Fecal Sample Collection and Examination.....	29
3.5.2. Post-mortem Examinations	30
3.5.3. Snail Survey.....	31
3.5.4. Interview Survey.....	31
3.6. Statistical Analysis.....	32
3.7. Ethical Consideration	33
4. RESULTS	34
4.1. Coprological Findings	34
4.2. Post-mortem Findings.....	39

4.3. Snail Survey	40
4.4. Interview Survey	41
4.4.1. Demographic characteristics of the target population.....	41
4.4.2. Overall perceptions of target populations towards socio-economic impacts of the diseases in both study areas	42
5. DISCUSSION	46
6. CONCLUSION AND RECOMMENDATIONS.....	51
7. REFERENCES.....	53
8. ANNEXES	71

ACKNOWLEDGMENTS

Commendation is to God the most tactful, merciful and master. Whom all creatures need and without his nothing can be possible.

First of all I would like to express my heartfelt gratitude to my advisor Dr. Dinka Ayana for his unreserved guidance, constructive suggestions and comments from the beginning of the research proposal development to the completion of the final thesis.

Second, I would like to express my heartfelt gratitude to my co-advisor Dr. Assefa Kebede for his unreserved guidance, constructive suggestions and comments from the beginning of the research proposal development to the completion of the final thesis.

I would like to express my thanks to Addis Ababa University for providing me a chance to be part of the female scholarship package of the university and pursue my MSc program.

I would like to acknowledge for the Enderta Woreda and Mekelle special zone administration of veterinary offices for their cooperation and support during my field work.

Further, I would like to extend my appreciation and heartfelt gratitude to my mother, dad, sister and brother for their boundless financial and moral hold up during and before grounding of this manuscript.

I would like to express my thanks to Mekelle University College of Veterinary Sciences for the provision laboratory and internet access so as to work on my thesis.

My special thanks also go to Mr. Mihirat and his colleague for their kindly assistance in the laboratory works.

I extend my appreciations to all study participants and data collectors for their unreserved participation during the study period.

Lastly, but not the least, I would like to appreciate my friends who assisted me in one or the other way.

LIST OF TABLES

Table 1: Current Status of Bovine Trematodes in Ethiopia.....	21
Table 2: Prevalence of bovine trematodes in Enderta district and in and around Mekelle special zone by coprological examination	34
Table 3: Prevalence of bovine trematodes in different age groups.....	35
Table 4: Sex wise prevalence of bovine trematodes	35
Table 5: Prevalence of bovine trematodes based on body condition score	36
Table 6: Prevalence of bovine trematodes based on study areas	37
Table 7: Prevalence of bovine trematodes based on selected Kebeles of both study areas.....	37
Table 8: Prevalence of specific trematodes with respect to different risk factors	37
Table 9: Prevalence of trematodes in cattle slaughtered at Abergelle international abattoir.....	39
Table 10: Prevalence of bovine trematodes with respect to origin of animals slaughtered at Abergelle international abattoir	40
Table 11: Snails collected and identified from water sources and the swampy areas of the two study sites	40
Table 12: Respondent's demographic characteristics	41
Table 13: Results of interview survey with emphases to economic and public health impacts of trematode diseases in the two study sites based on target population perceptions.....	44

LIST OF FIGURES

Figure 1: General life cycle of trematodes.....	9
Figure 2: Unique morphological feature of mature <i>Schistosoma</i> worm female lying in the gynaecophoric canal of male	11
Figure 3: Map of the study area, showing map of Ethiopia (lower left), map of Tigray region (top left), map of Enderta Woreda and Mekelle zone (top right)	26
Figure 4: Eggs of trematodes demonstrated on fresh fecal samples (A) <i>Fasciola</i> , (B) <i>Paramphistomum</i> and (C) <i>Schistosoma</i> eggs with terminal spines.....	84
Figure 5: Morphology of adult <i>Fasciola</i> (A), <i>Paramphistomum</i> (B) and <i>Schistosoma</i> (C) from abattoir	86
Figure 6: Morphology of snails collected and identified from dams, Rivers and swampy areas of the study areas. A-D Morphology of <i>Biomphalaria</i> spp, E-G morphology of <i>Lymnaea</i> spp and H-J morphology of <i>Bulinus</i> spp	88
Figure 7: Possible sources of infection sites of bovine trematodes in both study areas	89

LIST OF ANNEXES

Annex 1: Interview format to assess the public and economic importance of bovine trematodes (in English version).....	71
Annex 2: Interview format to assess the public and economic importance of bovine trematodes (in Tigrigna version)	77
Annex 3: Morphology of trematode eggs	84
Annex 4: Morphology of adult trematodes identified from abattoir	85
Annex 5: Morphology of snails collected and identified from Rivers, dams and swampy area in the study areas.....	87
Annex 6: Sources of infection sites of the study areas.....	88

LIST OF ABBREVIATIONS

\$	Dollars
BCS	Body Condition Score
BoARD	Bureau of Agricultural and Rural Development
BS	Bovine Schistosomiasis
CSA	Central Statistics Agency
DNA	Deoxyribonucleic Acid
ETB	Ethiopian Birr
ELISA	Enzyme Linked Immunosorbent Assay
GDP	Gross Domestic Product
ILRAD	International Laboratory for Research on Animal Disease
LDFNS	Livestock Development for Food and Nutritional Security
NTD	Neglected Tropical Disease
PA	Peasant Associations
PZQ	Praziquantel
RK	Rural Kebele
SAERT	Sustainable Agricultural and Environmental Rehabilitation programme In Tigray
SCI	Schistosomiasis Control Initiative
SPP	Species
SWBs	Small Water Bodies
TCAR	Tigray Livestock Census Analysis Result
U.S.A	United State of America
WHO	World Health Organization

ABSTRACT

Trematodes are one of the economical and public health important vector born parasite helminthes in Ethiopia including Tigray. In the current study cross sectional study was conducted in Enderta district and Mekele special zone from November 2020 to May 2021 to assess the socio-economic significance of bovine trematodes and estimate their prevalence, associated risk factors and identify the snail intermediate hosts harboring the parasites in the areas. To achieve these objectives, a combined of coprological examination, post-mortem examination, snail collection and identification and interview was performed. Out of 480 fecal samples examined 10.42% were found positive for at least one genus of bovine trematodes. The specific prevalence for *Fasciola*, *Paramphistomum* and *Schistosoma* was 4.58%, 2.7% and 3.12%, respectively. Similarly, the prevalence of bovine trematodes in males (14.2%) was higher than that of females (6.44%) and the variation was statistically significant ($X^2 = 7.76$, $p = 0.012$). On the other hand, prevalence in poor body condition (25.7%) was higher than that of medium body condition (7.41%) as well as good body condition (3.9%) and the variation was statistically significant ($X^2 = 28.7$, $p = 3.73e-09$). In the other case, out 480 cattle slaughtered at Abergelle international abattoir 12.5% (n=60) were found to harbor adult trematode worms. The economic losses in Abergelle international abattoir was calculated based on liver condemnation and was 15,252 ETB losses from liver condemnation annually.

Furthermore, out of 1000 snails collected and identified 356 (35.6%) *Lymnaea* spp, 347(34.7%) *Biomphalaria* spp and 297(29.7%) *Bulinus* spp were identified. Trematodes are still major limiting factors to livestock production and productivity in the study areas. So an urgent implementation of control methods including, improving access to clean drinking water for both animals and humans and creation of awareness to cattle owners on the impact of the diseases is necessary. In addition creation of attitude to the farmers in the treating of their animals by using recommended anti-helminthic drugs rather than traditional treatments is mandatory.

Key words: *Bovine trematodes*, *coprological examination*, *Enderta Woreda*, *interview survey*, *Mekelle special zone*, *post-mortem examination*, *prevalence*, *Snails*, *risk factors*,

1. INTRODUCTION

1.1. Background and Justification

Animal production has been considered as the main component of agricultural development in most parts of sub-Saharan Africa. Like in many developing countries, domestic animals play a decisive role in Ethiopia. They provide food in the form of meat, milk and non-food items such as draft power, manure, transport services as inputs into food crop production and fuel for cooking. Livestock are also a source of cash income through sales of the above items, animal hides and skins. Furthermore, they serve as live bank of farmers, generate income to farmers, create job opportunities and ensure food security. In addition, they also contribute to talent, social, withstand maintenances, cultural and environmental values (Vercruyssen and Claerebout, 200).

In its different agro-ecological zones and suitable environmental conditions, Ethiopia is a home for many livestock species and suitable for livestock production (Tilahun and Schmidt, 2012). For that matter Ethiopia is recognized for its enormous prosperity of livestock in Africa which contain more than 38,749,320 cattle, 18,075,580 sheep, 14,858,650 goats, 456,910 camels, 5,765,170 equines and 30,868,540 chickens which contributing to the livestock ownership as source of revenue to an estimated 80% of rural population (CSA, 2009). However, the economic benefit derived from the livestock sector does not proportionate with the potential and produces unsatisfactory animal protein and other livestock products to meet the mandate of fast growing human population. This is due to number of complex and inter-related factors like widespread diseases occurrences, poor genetic potential of local breeds, malnutrition, supervision constraints and inefficiency of livestock development services are some of the others (Bekele *et al.*, 2010; Negass *et al.*, 2011).

Among many constraints that made the livestock sector contribution to national GDP negligible is the widespread of different diseases in the nation. Out of the prevalent diseases parasitism represents a major complication to the development of the sector (Malone *et al.*, 1989). Parasitic diseases in animals can inhibit health, reduce growth, cause low birth weight, cause reproductive

problems and reduce the usefulness of carcasses. In general parasite diseases are the main causes of economic losses in livestock worldwide (Borji *et al.*, 2012). Economic losses due to parasitic diseases includes mortality and morbidity but, not limited to those they also reduced milk production, quantity of meat and subject to partial or complete condemnation of organs or carcasses of animals like the liver and part of the carcass that are infested with parasites (Rodríguez *et al.*, 2017).

Among the prevailing parasitic diseases in Ethiopia, trematodes are daunting major problems in cattle and other ruminants health and disturb the economy of the country (Fromsa *et al.*, 2011).

These parasitic diseases are common in gigantic water lodged and boggy grazing field which is perfect for the proliferation and conservation of their intermediate host snails which directed to increase the prevalence of trematode infection (Solomon and Abebe, 2007).

Snails are invertebrate animals of the class Gastropoda found in freshwater, water shore, marshy areas and other aquatic habitats around the world (Pyron and Brown, 2015). Approximately 5000 species of snails inhabit in different habitats of the worldwide (Soldánová *et al.*, 2013). Freshwater snails receive considerable attention as they are intermediate hosts of several trematodes that can cause diseases in humans and animals (WHO, 2010).

The intermediate hosts having veterinary and public health importance belong to the genus *Biomphalaria*, *Bulinus*, *Oncomelania*, *Indoplanorbis*, *Planorbis*, *Radix* and there are about 350 species. Most of these snails are aquatic that live under the water and cannot usually survive elsewhere like genus *Biomphalaria*. But there are also amphibious snails adapted for living in and out of water like *Oncomelania* and *Lymnaea* (Lindbergh *et al.*, 2006).

Trematode species which are parasitic to livestock belong to the subclass Digenea (Hansen and Perry, 1994). The adult trematodes are commonly called ‘flukes’ and the families which include parasites of major veterinary importance are Fasciolidae, Dicrocoeliidae, Paramphistomatidae and Schistosomatidae (Andrews, 1999). But *Fasciola* (liver fluke), *Paramphistomum* (rumen/stomach fluke) and *Schistosoma* (blood fluke) are the most important flukes recorded from different parts of the world (Dreyfuss *et al.*, 2006).

Parasitic trematodes particularly schistosomiasis caused by *S. mansoni*, *S. haematobium* and *S. japonicum* and *Fasciola hepatica* are wide spread zoonosis affecting many people in the world (Mohammad and Waqtola, 2006). Those diseases are most common in rural communities in which humans share the water points with their animals, or consumed raw vegetables cultivated in endemic regions (Robinson and Dalton, 2009). Moreover, the disease caused by *Schistosoma* spp is known as schistosomiasis and is one of the Neglected Tropical Disease (NTD) is major profound medical (~206.4 million people requiring treatment and veterinary importance (Nathan *et al.*, 2019). It is a threat to 530 million cattle and infects over 165 million cattle in Africa and the Middle East (Al-Kennany *et al.*, 2009; Islam *et al.*, 2011).

Fascioliasis or liver fluke is a human and an animal parasitic disease caused by endoparasitic trematodes of the genus *Fasciola* which live in the bile ducts that cause hepatobiliary system infection mainly in cattle and sheep which have an influence on public health (Cwiklinski *et al.*, 2016; Hardi *et al.*, 2016). It is also an economically important disease of domestic livestock, in particular cattle, sheep and occasionally man. *F. hepatica* and *F. gigantica* are the two most common species occupied as the etiological agents of fasciolosis (Jaja *et al.*, 2017). The infection causes substantial reduction in production of milk, meat, wool and led to metabolic disease as well as mortality (Khanjari *et al.*, 2014,). In addition, to its effect on productivity, fasciolosis is a cause of substantial economic losses through liver condemnation at abattoirs and slaughter houses (Gebretsadik *et al.*, 2009; Abebe *et al.*, 2010; Abunna *et al.*, 2010).

Paramphistomosis which are caused by the genus *Paramphistomum* are conventionally viewed as having no clinical implication (Iglesias-Piñeiro *et al.*, 2016). However, in most livestock only light stomach fluke infections with either adult fluke or small numbers of immature fluke shows no signs of disease. But heavy infection with immature flukes which attach to the lining of the upper part of small intestine may cause severe disease which may even result in death, stomach may be pale and show slight fibrosis and superficial haemorrhages (Love, 2017). In addition moderate infections with the immature fluke may cause reduced weight gains, milk production and ill-thrift. The adult *Paramphistomum* are relatively non-pathogenic and at most may cause localized loss of rumen papillae. Generally the duodenum and upper ilium are most affected organs due to paramphistomosis (Khoramian *et al.*, 2014).

Paramphistomosis is accompanied by fatal diarrhea, weakness, dehydration, decreased milk yield, submaxillary edema and death. There by, causing great economic loss to the livestock industry in terms of decrease in milk and meat production, loss of weight treatment, cost of diseased animals, additional labor required for handling such animals and mortality rate particularly in young animals (Bianchin *et al.*, 2007; Javed, 2008)

Schistosomiasis is also economically important trematode disease worldwide. The disease is characterized by its chronic nature and debilitating tropical disease caused by adult blood flukes of the genus *Schistosoma* that deposit eggs in blood vessels surrounding the bladder or gut of infected mammalian hosts. Moreover, the anterior mesenteric and portal veins are important predilection sites for this parasite (McManus *et al.*, 2009). Under genus *Schistosoma* there are different species which inhabit the vascular system of final hosts (Lefevre *et al.*, 2010). As many as 10 different species of schistosomes have been reported to naturally infect cattle and out of them six have received particular attention mainly because of their documented veterinary consequence. The major species that cause animal schistosomiasis include: *S. bovis*, *S. indicum*, *S. japonicum*, *S. matthei*, *S. intercalatum*, *S. nasale* and *S. rodhoni* (Negero, 2017).

The economic loss results due to the effect of the disease on the productivity and reproduction performance of livestock, causing hepatic fibrosis (Dwight *et al.*, 2003), predisposing animals to other diseases (Habtamu and Woldemariam, 2011), through mortality and morbidity from severe infection and long standing chronic infection (Islam *et al.*, 2011; Zangana and Aziz, 2012) and particularly in calves the infection receive in the early age through water contact this is due to the passive immunity of calves which received by the colostrum in the prenatal and postnatal period (Gabriel *et al.*, 2002).

1.2. Statement of the Problem

Although there are numerous reports on the prevalence of cattle fasciolosis (Gebrie *et al.*, 2015; Tsegaye *et al.*, 2012; Fromsa *et al.*, 2011; Taye *et al.*, 2016; Telila *et al.*, 2014), on the prevalence of cattle paramphistomosis (Vanleeuwen *et al.*, 2014; Kifleyohanne *et al.*, 2015; Mariam *et al.*, 2014; Kemal and Terefe, 2013; Telila *et al.*, 2014; Yohannes *et al.*, 2013) and on

the prevalence of cattle schistosomiasis (Almaz and Solomon, 2011; Almaz *et al.*, 2013; Lulie and Guadu, 2014; Almaz, 2007; Aylate *et al.*, 2017; Mersha *et al.*, 2012; Solomon, 2008; Bista *et al.*, 2018) trematodes are still a problem. Despite bovine trematodes are one of the major constraints for livestock production in Ethiopia in general and in the study sites in particular; there is still paucity of detailed information on the epidemiology of the three trematodes simultaneously in Ethiopia as well as in the study areas. Furthermore, there are very scanty information concerning species composition and distribution of snail intermediate hosts in both the study areas and throughout the country. So the initiation of this study is to fill the gaps in this issue in the current study sites.

1.3. Objectives

1.3.1. General objective

- ❖ To assess the prevalence, associated risk factors, snail species composition and socio-economic impact of bovine trematodes in Enderta district, Mekelle special zone and at Abergelle international abattoir in Mekelle city, Tigray, Ethiopia.

1.3.2. Specific objectives

- ❖ To estimate prevalence and associated risk factors of bovine trematodes in the study areas
- ❖ To identify the genus/ species of trematode parasites and the intermediate host snails
- ❖ To assess farmers' perception towards economic and public health impacts of the diseases in the study areas.

1.4. Research Questions

- ❖ What is the magnitude of bovine trematodes in the study areas?
- ❖ What are the risk factors that contribute for the occurrence of the diseases in the study areas?
- ❖ Which genus of trematodes and snails are predominant in the study areas?
- ❖ What are the major impacts of trematodes on the livelihood of farmers in the study areas?

2. LITERATURE REVIEW

2.1. Etiology

Fasciola hepatica and *F. gigantica* are the two species most commonly associated as the etiological agents of fasciolosis (Walker *et al.*, 2008). *F. hepatica* is the most common and important liver fluke and has a cosmopolitan distribution in cooler climates however, *F. gigantica* is restricted to warmer regions (Blood and Radiostitis, 2007).

Paramphistomosis is caused by genus *Paramphistomum*. There are several spp of *Paramphistomum* like *p. cotylophoron*, *P. calicophoron*, *p. bothriophoron*, *p. orthocoelium* and *p. gigantocotyle* are the most common and widespread in domestic animals (Taylor *et al.*, 2016). But *P. cervi*, *P. epiclitum* and *P. microbothriodes* are the major causative agents of paramphistomosis (Sripalwit *et al.*, 2007).

Schistosomiasis is caused by genus *Schistosoma*. There are many species under the genus *Schistosoma*. However, the most important species of both human and animals are *S. nasale*, *S. bovis*, *S. indicum*, *S. spindale*, *S. hematobium*, *S. intercalatum*, *S. japonicum* and *S. mattheei* (Bont, 1995). *Schistosoma bovis* is the most important *Schistosoma* in animals which occurs in the portal and mesenteric veins of cattle (Soulsby, 2006).

2.2. Transmission

Trematodes are transmitted by intermediate host snails. As obligate intermediate hosts, freshwater or amphibious snails establish an essential component for the transmission of trematodes (Habtamu *et al.*, 2013). There are several snail species involved in the transmission of specific trematode species.

The transmission is possible either through penetration of the intact skin of the host or ingestion of encysted infective stages of the parasites attached to plates of grasses and through drinking water (Lindbergh *et al.*, 2006). Animals exaggerated by the diseases show different clinical signs

such as diarrhea, sometimes blood stained and containing mucus, anorexia, thirst, dehydration, dullness, weight loss or emaciation and anemia (Gutierrez, 2004).

F. hepatica and *F. gigantica* Transmitted by the snail called *Lymnaea truncatula* and *L. natalensis*, respectively. In Ethiopia both *Fasciola hepatica* and *Fasciola gigantica* have the greatest risk occurred in areas of protracted high annual rainfall associated with high soil moisture and surplus water and the risk diminishing in areas of shorter wet season or lower temperatures (Soulsby, 1982).

Schistosomiasis also appears in large permanent water bodies such as ponds, lakes and marshy pastures. A key determinant in the transmission of this infection is the relative abundance of the intermediate hosts and their ability to develop and survive in the environment. Contamination of water with *Schistosoma* eggs results when animal defecate in the water while drinking or if manure is used for feeding fish in ponds. Cattle become infected through skin penetration and the oral route. The type of watering facilities used by domestic livestock is also a vital role in the maintenance and transmission of the infection (Pruss-Ustun *et al.*, 2004). In Ethiopia the major endemic sites are small streams all over the highlands of country such as lakes like Tana, Zeway as well as irrigation systems such as sugar state Wonji (Shibru *et al.*, 1989).

Paramphistomosis similarly high risk of infection in low and easily flooded lands, rice growing areas, natural grass pastures with slow running water as well as in the area of lakes and marshlands (Rolfe *et al.*, 1991).

2.3. Life Cycle

The life cycles of flukes are indirect, involving one or two intermediate hosts before invasion of definitive hosts. The snails such as *Lymnaea truncatula* and *L. natalensis*, for *Fasciola*, *Planorbis* or *Bulinus* for *Paramphistomum* and *Bulinus contortus*, *Physopsis africana*, *P. globsa* and *P. nausta* for *Schistosoma* act as intermediate hosts for these flukes (Kahn, 2005)

The lifecycle of *Fasciola* and *Paramphistomum* is similar except the intermediate hosts of *Paramphistomum* are snails of genus *Pygmanisas* and *Fossaria* (Lopez *et al.*, 2008). Considering

for *Fasciola* as an example livestock become infected by ingesting the infective stage, the metacercaria (infective stage for both trematodes), which contaminates grass and other vegetation. These hatch in small intestine and migrate directly to liver. The immature flukes thus migrate through liver tissues, feeding and growing until they reach bile ducts (Kaplan, 2001).

Schistosomes have also an indirect life cycle, while water snail act as an intermediate host belong to the genera *Bullinus* and *planorbis* which potentially determining distribution of bovine schistosomiasis (BS) in different parts of the world (Brown, 1980; Urquhart *et al.*, 1996.). The adult females lay eggs in the capillaries of the intestinal wall. The eggs masses form abscesses that finally burst and release the eggs into the gut, which are transported outside with the host's feces. Once outside and in contact with water the eggs release small swimming larvae, the miracidia, which find an appropriate snail and penetrate in to its body. Inside the snail miracidia develop further during 1 to 4 months through two generations of sporocysts to asexually produced ozens of cercariae. Mature infective cercariae leave the snail through its respiratory hole. A single snail can release up to 3'000 cercariae (Kahn, 2011). Free-swimming cercariae actively search a final host. Their survival in the environment is limited to a few days. The infective stage for the diseases is matured cercaria after they leave the snail invade the final host through the skin or mucus membranes penetration or are ingested with contaminated water. Ingested cercariae penetrate the rumen. Once inside the host's body they get into a blood vessel and start a species-specific migration (often passively transported with the blood) through various organs until they reach their preferred final locations where they complete development to adult flukes, copulate and start producing eggs (Aiello, 1998).

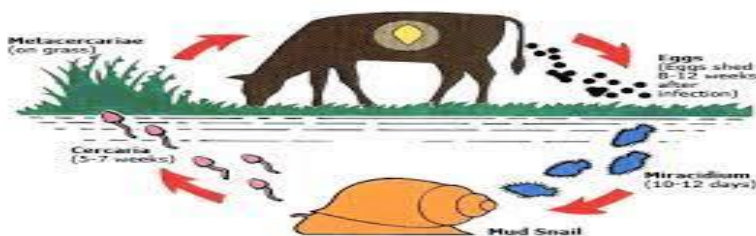


Figure 1: General life cycle of trematodes. **Source:** http://uk.merial.com/producers/dairy/fluke_facts

2.4. Morphology

Most trematodes are described as leaf shaped and they may vary substantially in size. The most characteristic of external feature is the presence of suckers. In mature trematodes the outer most body covering (integument) is no true cuticula or epidermis. The mesenchymatous tissue, which underlies the integument, fills the whole body and all viscera are situated in it. The musculature consists of circular, oblique and longitudinal fibers. The alimentary system usually lacks of definitive anus and the gut ends in a blind loop which makes an inverted figure of “Y”. There is no special respiratory system and gaseous exchange takes place through the tegument only. The excretory system consists of flame cells and has candle flame like appearance. These cells play an important role in water regulation. The nervous system in trematodes is composed of a group of paired ganglion situated dorsal to the pharynx. All trematode species are hermaphrodites, except schistosomes in which they have separate sexes (Peters and Gilles, 1989).

Members of Schistosomatidae show morphological and physiological particularities which set them apart from all other trematodes. Firstly, they are dioecious, the male bearing the female in a ventral canal, known as, gynaecophoric canal used to clap hold on the female for copulation (Lefevre *et al.*, 2010). Secondly, general members of the family live in the blood stream of warm-blooded hosts, being the only trematodes to do so (Smyth, 2005).

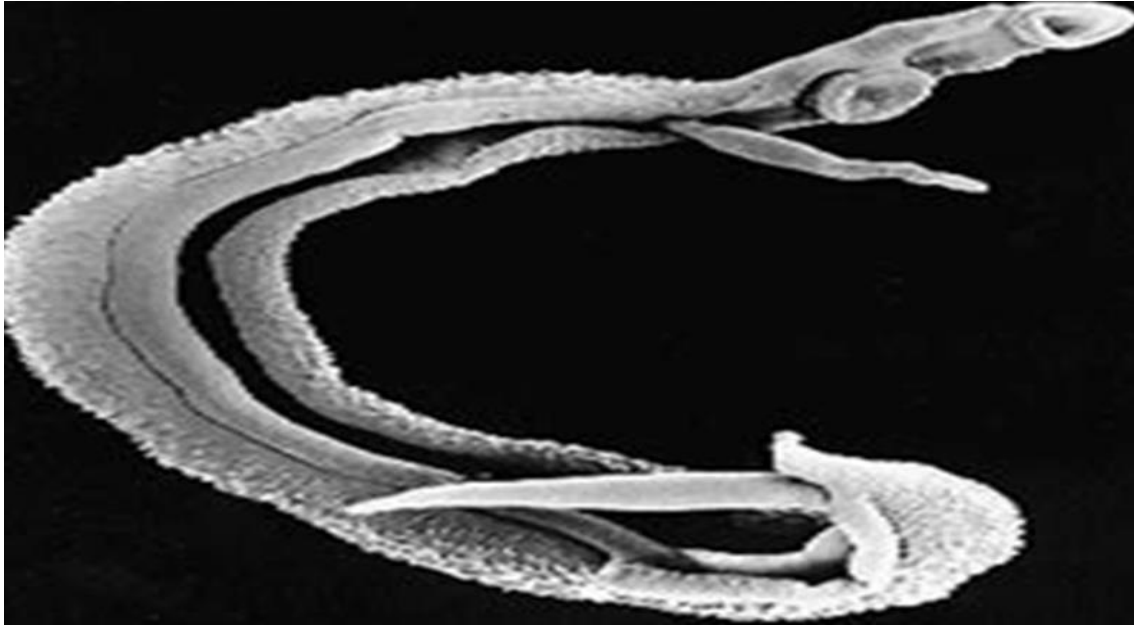


Figure 2: Unique morphological feature of mature *Schistosoma* worm female lying in the gynaecophoric canal of male

Source: (Endris and Alemneh, 2017).

2.5. Epidemiology

The epidemiological condition of trematodes is static. This is due to depending on the presence of intermediate hosts snails, their level of infection, infection rate from pastures, climatic requirement for egg hatching, development and survival of the larvae in pasture, the frequency of water contacts and climate-ecological conditions such as altitude, rainfall and temperature and livestock management system (Kahn, 2011; Kitila and Megerssa, 2015). From those situations the distribution of snail intermediate host is primarily. Both genus *Lymnaea* from land snail and *planorbis* from water snail are reported to have a worldwide distribution (Urquhart *et al.*, 1996). It is also indicated that *Bulinus* species which are important intermediate host for *S. bovis* in central, eastern and west Africa, the Mediterranean area and the Middle East, *S. mattheei* in central, southern and eastern Africa, *S. intercalatum* in central Africa, *S. japonicum* in the Far East (a species infecting humans but which may also cause schistosomiasis in ruminants and othe

r host species) and *S. nasalis* is found in the veins of the nasal mucosa of livestock in the Indian subcontinent (Urquhart *et al.*, 2003). Bovine trematodes incidence increased in consequence of global climate changes (Fairweather, 2011).

In Ethiopia, *F. hepatica* and *F. gigantica* infections occur in areas above 1800 m and below 1200 meters above sea level, respectively. This has been attributed to variations in the climatic and ecological conditions such as rainfall, altitude, and temperature and livestock management. *F. hepatica* was shown to be the most important fluke species in Ethiopian livestock with distribution over three quarter of the nation except in the arid northeast and east of the country. But *F. gigantica* was mainly localized in the western humid zone of the country that encompasses approximately one fourth of the nations (Tolossa and Tigre, 2006).

Paramphistomum is also distributed all around the world, but the highest prevalence has been reported in tropical and subtropical regions, particularly in Africa, Asia, Australia, Eastern Europe and Russia (Rolfe *et al.*, 1994)

Schistosomiasis is distributed in the tropical and sub-tropical countries. In tropics and subtropical countries the disease has significance effect (endemic) on domestic livestock production (Bont, 1995). Domestic animals in various tropical areas may be infected with *S. bovis* (cattle and sheep), *S. indium* (horses, cattle, goats and Indian buffalo), *S. matheei* (sheep, South Africa), *S. suis* (Swine and goats in India), *S. japonicum* (humans, cat and mammals in Asia) and *S. margrebowei* (horses, ruminants and elephants in Africa). In Ethiopia the disease is distributed in several parts of the country, usually at an altitude between 1200–2000 meters above sea level (Kloos *et al.*, 1988) which is found commonly in northern, eastern, southwestern and central parts of Ethiopia (Habtamu and Woldemariam, 2011).

2.6. Risk Factors

2.6.1. Environmental and management risk factors

Trematodes are narrowly dependent on their close environment such as nature of the soil, moisture, rain fall, temperature, presence of water bodies (stagnant, swampy, streams, rivers, irrigation canals, dams and marshy) and the climatic conditions for survival and multiplication of the intermediate hosts and for the survival and evolution of larval stages (miracidium, sporocyst,

redia, cercaria, and metacercaria) (Niaz *et al.*, 2010; Islam *et al.*, 2011). In addition to environmental factors management factors such as husbandry practice like grazing system, keeping animals all together or separately, feeding (contaminated pasture with larva) and drinking areas are the key factors (Mersha *et al.*, 2012) . Moreover, *Schistosoma* infection is closely associated with infested water bodies with traditional grazing and watering systems (Arshad *et al.*, 2011) and these factors tend to be conducive of enzootic schistosomiasis, which is characterized by the high prevalence and significant losses of productivity in animals.

Infection rate of trematodes was stated to be low in intensive farming system where animals are mainly stall fed. This might be due to the better management practices and sanitation (Belayneh and Tadesse, 2012). They also reported in increases the prevalence of the diseases when cattle were slaughtered through back yard system and consequently the stomach and other intestinal contents including blood and washed materials are dumped into the nearby water bodies. In the semi-intensive system of rearing where animals grazing in the fields have more risks of getting contact with water and subsequently with the infective stage of trematodes. In addition to this increasing cattle mobility through trading or rental potentially also increases the possibility of spreading the diseases or infection sources (Kahn, 2011). So that proper management practices and policy change towards urban husbandry can minimize the prevalence of trematodes.

Trematode infection rate in cattle rises during rainy season. The highest infection rate in rainy season could be due to abundance of snails and their rapid multiplication and dispersion. Furthermore, dispersion of fecal matter occurs due to rain splashes. These factors may enhance the infection of snails by miracidia and cercarial contamination to adjacent areas through water. During this time conditions on the lands are suitable for the survival of the intermediate hosts and they become heavily infected with the trematode larval stages. So, cattle are prone to get the infection of trematodes. But in dry season infection rate of the trematodes parasite is low because of harsh dry conditions and less chances of infection due to unavailability of snail intermediate hosts as the water sources are scarce in this season (Kahn, 2011).

2.6.2. Host related risk factors

2.6.2.1. Age

Infection rate increased with the increase of age and peak infection occurred at the maturity of age (Bedarkar *et al.*, 2000). This might be due to a long exposure time because older animals move long distances in search of scarce pastures and water in that way increasing their chances of infection as well as becoming infected at overcrowded watering holes. On the other hand, the very young calves do not graze extensively as the older do, so they get less infection of the infective stage of trematodes unlike adult animals. According to Kassaw, (2007) report increased contact time with trematode infested habitat increases the rate and endemicity of trematode diseases.

2.6.2.2. Sex

Differences in susceptibility to infection between sexes have been detected by various workers. The observed difference may not exclusively due to the alteration in vulnerability but may also depend on a sex-related variation in behavior that results in differences in exposure (Magona and Musisi, 2002). The reason seems to be related to social practice of keeping females under better management and feeding condition for milk production and breeding whether males are generally let lose to graze freely in pasture and frequently used for draught purpose and also more stressed. Males are also fed relatively poor diet which increases the susceptibility to parasitic infection (Houdijk and Athana, 2003).

2.6.2.3. Immunity

Cattle exist in endemic areas show a typical pattern in faecal egg counts. The faecal egg excretion usually starts between 4 and 8 months of life, counts increase rapidly to reach a maximum around the age of 6–15 months and then decrease markedly by the age of 18 months. In older animals, faecal egg counts remain low, tissue egg counts seem to follow the pattern of the faecal egg counts, while worm burden tends to increase with the age of the host (vercruysse and Gabriel, 2005). This suggests the development of an acquired immunity which, mainly acts

through a reduction of the fecundity of the female worm, expressed as reduced faecal and tissue egg counts with few effects on worm burden. However, evidence is accumulating that with increasing duration of exposure to continuous challenge cattle also become less susceptible to reinfection. Examination of naturally infected animals has shown that partial protection against reinfection also occurs and acquired resistance to trematodes is a major importance in the regulation of infection intensity in the field (Kahn, 2011). According to some authors, the strength of the immunological response of the host which results in reduced worm fecundity could be related to the intensity of the primary infection which is low levels of infection ailing to stimulate the host response (vercruysse and Gabriel, 2005).

2.7. Diagnosis

Diagnosis of trematodes contains tentative and confirmatory procedures. The tentative diagnosis of the diseases is primarily based on the history of trematodes diseases in the area and the identification of snail habitats with history of access to natural water bodies (Bedarkar *et al.*, 2000; Pawar *et al.*, 2016). It is also established that based on prior knowledge of the epidemiology of the disease in a given environment, observations of clinical signs, information on grazing history and seasonal occurrence gave valuable and supportive information for confirmatory diagnosis. The tentative diagnosis alone will not be sufficient to arrive at definitive diagnosis but, it should be used to indicate the necessity of confirmatory diagnosis (Cornelissen *et al.*, 2001; Thrusfield, 2005). The confirmatory diagnosis includes postmortem examination, hematological tests and examination of feces for trematode eggs.

Routine diagnosis of trematodes disease relies heavily on observation of clinical signs and fecal examination for eggs of the parasites. The growing interest in organic, outdoor and aquaculture farming are likely to present higher risk of infection particularly for schistosomiasis as it is a zoonotic disease affecting both humans and livestock (Chhabra and Singla, 2009).

Immunodiagnostic methods based on serology have been widely used and have greater sensitivity than parasitological methods (Doenhoff *et al.*, 2004) particularly, in areas of low endemicity. Among serological tests, ELISA assay is widely used for the diagnosis of

trematodes. But one of the difficulties in using this method is the choice of the parasite's antigen. Crude antigens may exhibit cross-reactivity with other helminthes, as well as possess low sensitivity (Alarcón *et al.*, 2000). To overcome this obstacle purified and recombinant antigens (Zhong *et al.*, 2010) have been used. Generally, trematodes can be diagnosed using:

- ✓ Clinical signs and symptoms
- ✓ History of living in an endemic area
- ✓ Serological tests
- ✓ Finding the characteristic eggs and
- ✓ Post mortem examinations

2.7.1. Clinical Signs

The pathological manifestation of fasciolosis depends upon the number of metacercaria ingested and the most damaging stage is six to eight-week-old trematode. During acute fasciolosis evidence of traumatic hepatitis and fibrinous clot on liver surface is seen and liver is mostly enlarged. Animals often decline to move and are anorexic. In case of chronic fasciolosis traumatic destruction and coagulative necrosis of liver parenchyma is seen. The most often clinical signs associated with fasciolosis are intermittent soft feces, occasional profuse diarrhea, hypo-proteinaemia, anemia, progressive loss of weight, bottle jaw and pale mucous membrane (Bowmann *et al.*, 2003).

Clinical signs of paramphistomosis consist of profuse fluid fetid diarrhea, anemia, hypoproteinaemia, edema and emaciation. Animal shows marked weakness, frequent death, thirsty and drink frequently. Severe chronic infestation by paramphistomosis in dairy cattle is associated with reduced milk yield, poor fertility and excessive weight loss. In heifer it may cause debilitation with increased incidence of metabolic and infectious disease at calving. In addition, it also shown to modulate the host's immune system so, increasing susceptibility to other infectious agents (Khoramian *et al.*, 2014).

Schistosomes are found in the portal and mesenteric blood vessels, and the principal clinical signs are associated with passage of the spined eggs through the tissue of the gut lumen, the

young parasites cause some damage during migration, but most of the lesions are due to the irritation produced by the eggs of parasites in the intestine and other organs, and blood sucking habit of the *Schistosomia* worm. The *Schistosomia* worm may also enter the vesical veins and they may cause hematuria (Soulsby, 1982)

Generally, cattle infected with *S. bovis* develop a syndrome characterized by weight loss, poor weight gain, diarrhea, loss of appetite, roughness of the skin, and pale mucous membranes. These signs are usually observed by 6-7 weeks after exposure to the infective stage, the cercaria. The severity of these signs increases between the 7th and the 9th week, where the fecal egg counts are highest. However, the clinical signs of the disease are unreliable as other trematodes parasites may produce similar clinical signs (Kahn, 2011)

2.7.2. Parasitological Techniques

Definitive diagnosis of an active trematodes infection can be made only by detecting eggs of the parasite in feces or biopsy specimen of the infected animal. The eggs are characteristics in shape and size for each species. For example for schistosomes eggs are oval (as in *S. monsoni*, *S. haematobium* and *S. japonicum*) to spindle shaped (*S. bovis* and *S. mattheei*) containing a single spined protruding from the shell (Jones and Hunt, 1997). The routine methods used for parasitological diagnosis include; fecal smear, filtration method, sedimentation method, rectal and liver biopsy and miracidial hatching test. The most commonly used method for detection of fecal egg excretion under field condition is the sedimentation method.

2.7.3. Postmortem Findings

The clinical signs and feces examination alone will not sufficient to arrive at a definite diagnosis. Because simple fecal examination in detection of trematodes eggs in chronic form has not achieved a level of reliability for use in animals. Therefore, the most direct and reliable technique for the diagnosis of trematodes is postmortem examination (Habtamu and Woldemariam, 2011). At necropsy, bovine trematodes infection can be diagnosed by finding thousands of

visible adult worms in the mesenteric vein, portal vein, liver, reticulum and rumen. Infected livers are diagnosed on the basis of the presence of macroscopic lesions of trematodes visible as white-gray foci under the liver capsule and within the substance of the liver (Hendrix and Robinson, 2006). However, in certain instances few lesions may be present and may not be detected and hence crush smears made from those livers are necessary for demonstration of eggs of trematodes to confirm the diagnosis.

Finally, the diagnosis of trematodes in animals and human beings is a key step to propose and establish a control strategy and in prescribing effective drugs because ineffectiveness of some treatments follows partly from poor diagnosis (Niaz *et al.*, 2010; Habtamu and Woldemariam, 2011). According to Martin, *et al.*, (2008) and Zhou *et al.*, (2008), determination of the target population for chemotherapy in endemic areas, assessment of morbidity and evaluation of control strategies can all be built with results of diagnostic tests.

2.8. Prevention and Control

For a rational and sustainable helminth control programme, a comprehensive knowledge of the epidemiology of parasites and their interaction with the host in a specific climate and management system is a prerequisite (Barger, 1999). Particularly in trematodes due to the complex nature of the lifecycle and epidemiology of snail intermediate host presents challenges for predictive control methods (Walker *et al.*, 2008). So identify high risk areas of fluke, fencing off watering points, attending to leaking troughs and pipes, drainage or even consider housing early and ask for abattoir feedback on any liver, rumen and reticulum rejections are main control methods (Ortiz *et al.*, 2013).

Specific habitat requirements of intermediate host snails are governed by environmental factors (Brown, 1994). The intermediate host snails need an aquatic environment and thrive even in small water bodies (SWBs), such as ponds, ditches and other humid areas consisting of open water, aquatic vegetation or inundated grass (De-Roeck *et al.*, 2014). Live snails are limited to locations with standing water or with enough moisture for survival (Clennon *et al.*, 2007) but,

they also reproduce through selfing and aestivate during the dry season. So that knowing the habitat of the intermediate host is important in the prevention and control of the diseases.

The basic preventing methods of trematodes infections include prevent contact between the animals and the parasite, by fencing of infected waters and supplying clean water and by the destruction of intermediate host snails. The destruction of the intermediate host snails population at transmission sites can be made by chemical (using molluscicides), biological and removal by mechanical barriers or snail traps (Hansen and Perry, 1994; Kahn, 2011; Mohammad and Waqtola, 2006). In addition, proper sanitary disposal of animal and human excreta to avoid water contamination, avoiding contact with fresh water infested with trematode parasites, swimming, wading, or any other aquatic activities in these water bodies that exposes the skin to possible penetration by the cercariae, Draining swamps and building sewage systems are also some preventing methods of trematodes. In cases when there is brief accidental contact with infected water, vigorous towel drying is advised to help prevent the cercariae from penetrating the skin. In using water from these fresh water sources for drinking or bathing, water must be brought to the boil for at least 1 minute to kill the parasite that may be present in the water (Centers for Disease Control and Prevention, 2014).

2.9. Treatment

Praziquantel is highly effective for the treatment of bovine and human schistosomiasis and bovine paramphistomosis (Gracia and Bruckner, 2007) but, not effective against fasciolosis. However, triclabendazole is the best drug to treat a liver fluke infection provided that is confirmed in laboratory, as this effectively kills all the liver flukes stages and their eggs (Gassenbeek *et al.*, 2001). Older drugs include antimonial preparation, tartar emetic, antimosan and stibophen, niridirozole and trichlorphon also used for treatment of the diseases. Treatment of the diseases using praziquantel helps in reversing acute or early chronic diseases, preventing complications associated with chronic infection and preventing neuro schistosomiasis. The goal of treatment is reduction of egg production via reduction of worm load and this reduces mortality and morbidity (Richer, 2003). Care has to be exercised in treating clinical cases of the diseases since the dislodgement of the damaged flukes may result in emboli being formed and subsequent

occlusion of major mesenteric and portal blood vessels and other predilection sites with fatal consequences.

Treatment and control of schistosomiasis relies solely on the World Health Organization (WHO) recommended drug, praziquantel (PZQ) since the disease is major zoonotic trematode disease (WHO, 2008.). PZQ is safe, reasonably effective, cheap to produce and administer, and quickly ameliorates morbidity (Smits, 2009). Efforts to make PZQ more widely available through increased production and expanded treatment programs (Fenwick *et al.*, 2009; Molyneux, 2014) are made by major pharmaceutical company, non-governmental organizations and philanthropic foundations.

2.10. Current Status of Bovine Trematodes

Despite huge money invested in attempts to prevent and control of trematodes in Ethiopia as well as other countries trematodes still remained a big problem in both humans and animals. Some of the evidences are: 60.42% prevalence was reported by Yeneneh, *et al.*, (2012), 61.0 % by Aragaw and Tilahun, (2019) from Ethiopia and Nzalawahe *et al.*, (2014); Bista *et al.*, (2018) from other countries. And there are report on individual parasite by Gebrie *et al.*, (2015); Tsegay *et al.*, (2012); Fromsa *et al.*, (2011); Taye *et al.*, (2016); Telila *et al.*, (2014) on *Fasciola*, Vanleeuwen *et al.*, (2014); Kifleyohanne *et al.*, (2015); Mariam *et al.*, (2014); Kemal and Terefe, (2013); Telila *et al.*, (2014); Yohannes *et al.*, (2013) on *Paramphistomum* and 18.5% by Hussen and Tilahun, (2017), 17.2% by Getachew *et al.*, (2006) in Kemissie, 37.3% by Habtamu and Woldemariam, (2011) in Bahir Dar, 43% in Bati by Getachew *et al.*, (2006), 32.4% by Kerie and Seyoum, (2014), 10.2-29% by Almaz and Solomon, (2011); Almaz *etal.*, (2013); Lulie and Guadu, (2014), 28.14% by Almaz, (2007), 27.13% in Dembia distinct by Alemseged, (2010), in Bahir Dar 3.1% by Aylate *et al.*, (2017), 13.7% by Mersha *et al.*, (2012) in Fogera and 22.06% in and around Bahir Dar by Solomon, (2008).

Table 1: Current Status of Bovine Trematodes in Ethiopia

Parasites Species	Prevalence (%)	Reported from	References
<i>Fasciola</i> spp	20.1%	Bahir dar	Aragaw, and Tilahun, (2019)
<i>Fasciola</i> spp	23.96	Andassa livestock research center	Yeneneh, <i>et al.</i> , (2012)
<i>Schistosomia</i> spp	13.7%	Fogera	Mersha <i>et al.</i> , (2012)
<i>Schistosomia</i> spp	11.5%	Dangila district	Alemayehu, and Asrat, (2015)
<i>Schistosomia</i> spp	27.13%	Dembia distinct	Alemseged, (2010)
<i>Schistosomia</i> spp	17.2%	Kemissie	Getachew <i>et al.</i> , (2006)
<i>paramphistomum</i> spp	44.2%	Jimma	Fromsa <i>et al.</i> , (2011)
<i>paramphistomum</i> spp	75%	Ashenge	Kifleyohanne <i>et al.</i> , (2015)
<i>paramphistomum</i> spp	65.3%	Hawassa town	Mariam <i>et al.</i> , 2014

2.11. Economic and Public Health Significance of Trematodes

Trematode infections are some of the most economically important helminth diseases hampering the productivity of domestic animals worldwide. The worldwide estimated loss caused by trematodes was more than \$ 2 billion/year. They cause heavy losses to livestock industry by decreasing milk and meat production, liver condemnation and cost of control. Single fluke has capacity to

suck 0.2 to 0.5 ml blood/animal/day leading to anemia and lowering of total protein contents resulting in hypoalbuminemia (Rehman *et al.*, 2013). The economic importances of trematode diseases have no adequate measurements. But can be evaluated by geographical distribution, prevalence, intensity of infection, clinical gradients, morbidity and mortality and transmission patterns which are influenced by environmental conditions, the relative efficiency of intermediate hosts and agricultural practices (Wright, 2015).

Trematode diseases affect humans, domestic animals and wild animals in tropical and subtropical countries (Zangana and Aziz, 2012). Moreover (more than 2.4 million people are infected with fasciolosis and a further 180 million at risk of the infection (Ramajot *et al.*, 2001) and schistosomiasis are snail borne diseases with public health concern. Particularly schistosomiasis which is also called bilharzia which lives in the bloodstream of humans (Adenowo *et al.*, 2015) and an economically important disease caused by several *Schistosoma* species, which inhabit the vascular system of final hosts (Lefevre *et al.*, 2010).

It is one of the neglected tropical parasitic diseases (NTDs) in the tropics and endemic in sub-Saharan Africa, the Middle East, Far East, Central America and the Caribbean (Kassahun *et al.*, 2017). When the disease is endemic, it poses significant effects on livestock production (Samrawit, 2016) and causes severe morbidity and mortality among susceptible segments of the population. It is estimated that 779 million people are at risk of schistosomiasis worldwide (Steinmann *et al.*, 2006) and 250 million people in sub-Saharan Africa (Stothard *et al.*, 2009). Schistosomiasis caused by *S. mansoni*, *S. haematobium* and *S. japonicum* is secondary only to malaria and affect approximately 200 million people in Africa, Asia, and South America (Bowman, 2003; Mohammad and Waqtola, 2006).

In Ethiopia schistosomiasis is also one of the major public health problems since temperature in Ethiopia seems to be the major factor that affects the distribution of *Schistosoma* species (WHO, 2010). The two species of schistosome causing the disease in the country are *S. mansoni* and *S. haematobium*. Infections by the parasites usually occur in agricultural communities along small streams, irrigation schemes and lakes at altitudes ranging from 1300 to 2000 meters above sea level (m.a.s.l) for *S. mansoni* and below 800 m.a.s.l for *S. haematobium* (Gashaw *et al.*, 2015). Regarding the distribution of the two schistosome species in Ethiopia, *S. mansoni* is widely

distributed and *S. haematobium* is confined to the lowland areas of the country (Kloos *et al.*, 1988)

Generally, in humans economic losses have been shown in terms of working hours and it can also cause cutaneous larva migrans often called "swimmers itch" (Cercarial dermatitis) in agricultural workers and swimmers (Aylate *et al.*, 2017). Cercarial dermatitis or swimmer's itch is a condition caused when cercariae of blood flukes that normally parasitize aquatic birds and mammals penetrate the human skin, sensitizing the areas of attack and causing pustules and an itchy rash. Since humans are not suitable definitive hosts for these flukes, the cercariae do not normally enter the blood stream and mature instead, after penetrating the skin, they are destroyed by the victim's immune response. Allergenic material released from dead and dying cercariae produce a localized inflammatory reaction. Humans may become sensitized and develop pruritic macula papular then, vesicular skin lesions at the site of penetration (Kahn, 2011).

3. MATERIALS AND METHODS

3.1. Study Area

The study was carried out from November 2020 to May 2021 in Tigray region of northern Ethiopia at Enderta district and Mekelle special zone of Tigray regional state. Geographically the region is located between 12⁰15'N-14⁰57'N, and 36⁰27'E- 39⁰59'E covering a total land area of 53,000 square kilometres. The state is divided into 6 administrative zones and 36 rural districts (locally called Woreda the second administrative level below the zone) (SAERT, 2004). The total population of the region exceeds 4.3 million and about 83.9 per cent of whom live in rural areas (CSA, 2008).

3.1.1. Enderta district

Enderta is one of the 36 Woreda's in Tigray Region of Ethiopia and far 771 Km from capital city of Ethiopia which is Addis Ababa and 12Km (the office of the district) from Mekelle which is capital city of Tigray region on the way to Addis Ababa road. It is bounded by Hintalo wajerat in the South, Samre-seharti and Degua-tembien woreda's in the West, Wukro woreda in the north and Afar Region in the east. Geographically, the Woreda is located between 13⁰-14⁰ N and at 39⁰-40⁰ E. The woreda covers a total land area of 1446.49 square kilometers. The district has a total area of 193,309 hectares, of which the total cultivated land covers 49.03%. This indicates the fields inside the land use for agriculture and degradation control. This agricultural land contains 48.48% of annual rain fed crops and 0.55% of irrigated crops (CSA, 2007)

The mean monthly maximum temperature ranged between 22.4⁰ C (December) and 27.4⁰C (June) whereas, the mean monthly minimum temperature ranged between 9.17⁰C (January) and 13.8⁰C (May). The mean annual rainfall of the area was 207.05 mm. The area has bimodal rainfall distribution characterized by prolonged wet season (main rainy season) from June to September locally known as "Kiremti" and short rainy season from April to May locally known

as “Azmera”. The driest season of the area is from December to February and it is locally called “Hagay” (Girmay *et al.*, 2013).

This is a moderately populated zone. The total human population is estimated at 114,277 of these 57,472(50.3%) are male and 56,805(49.7%) are female (CSA, 2007). Out of the total population above 80% of the population is living in rural areas. Average family size is five and population density of the Woreda is 79 people per square kilometer. It have 71,136 cattles, 11,146 sheep, 21,649 goats, 19,968 donkies, 2167 mules, 594 camels, 27,692 poultry and 2803 bee hives (CSA, 2006).

Crop and livestock production are the main economic activities in the Woreda. More than 80% of the population living in the Woreda is engaged in subsistence farming with land holding size less than one hectare. Agriculture is the most dominant source of food and income to lead their livelihoods in the Woreda (Esser and Vagen, 2002).

3.1.2. Mekelle special zone

Mekelle city is the capital city of Tigray Regional State, Ethiopia. Mekelle city is located 783 km north of Addis Ababa and it is found between 13⁰ 30.593,,N latitude and 039⁰28.849,,E longitude with altitude of 2200 m.a.s.l. The area covers 53 km², with human population of 638,297 (metro area population of Mekele, 2020) and cattle population of 2815 (BoARD and TCAR, 2004). The major occupations of the inhabitants include civil service, business, daily labor and subsistence agriculture in the sub urban villages. Water bodies including the Ilala River, Aynalem River, Gereb-Beati dam and My-Bandera River are major sources of irrigation water in suburbs of Mekelle city.

Generally seven kebeles of the study areas were selected which were four Kebles from Enderta district (Kedemay-weyane the site of Gebreabso dam, Felege-selam the site of Gredeamharay dam, Meremete the site of Haykihilat river and Meseret the site of Adcheber dam) and three from Mekelle special zone (Quiha the site of Agedbo dam, Aynalem the site of Aynalem River and Feleg-daeiro the site of Ilala River).

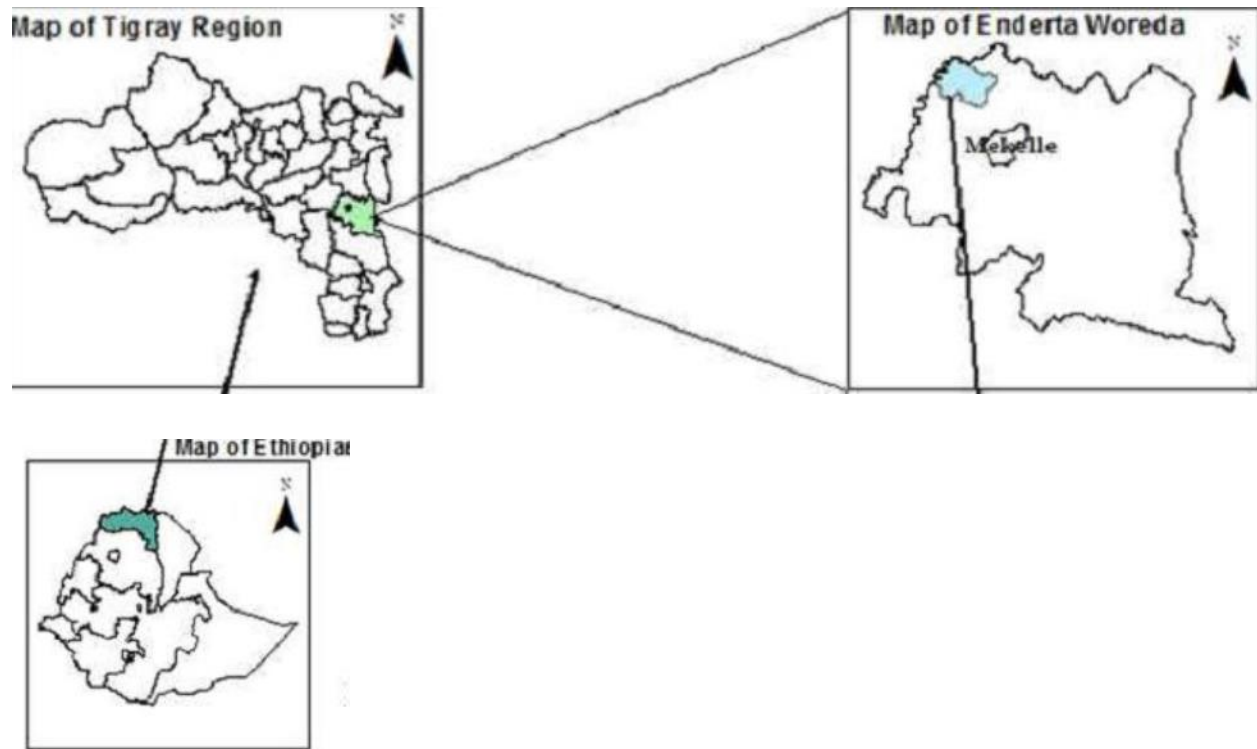


Figure 3: Map of the study area, showing map of Ethiopia (lower left), map of Tigray region (top left), map of Enderta Woreda and Mekelle zone (top right)

Source: (Girma, *et al.*, 2013)

3.2. Study Population

For coprological examination sampling units of the studied population were cattle from seven purposively selected kebeles (PA) (Aynalem, Feleg-daeiro, Quiha, Kedemay-weyane, Felege-sel am, Meremete and Meseret). A total of 480 cattle were examined for coprology. Of these animals, 247 were males whereas the remaining 233 were females. Sex, age, body condition score and study sites are the explanatory variables. Study animals include cattle of all age groups greater than or equal to one year that were be allowed/released for free grazing by owners, indigenous cattle breeds that are predominant in the region as well as in the study districts, kept under extensive management system, grazing on communally owned pasture land, crop residues and drinking and grazing in and around the dams (Agedbo, Gebreabso, Gredeamharay and

Adechebar), Rivers (Haykihilat, Ilala and Aynalem) during most months of the year. During sample collection, study animals were classified as poor, moderate and good in body condition based on anatomical parts, the flesh and fat cover at different body parts (Nicholson and Butterworth, 1986) and on subjective basis. Concurrently, their age was estimated by history and dental formula as described by De-lahunta, and Habel, (1989) principles as ($1 < 3$ year) in (Group I), (3-5 years) in (Group II) and > 5 years in (Group III) for all animals.

For post-mortem examination studied population was cattle slaughtered at Abergelle international abattoir in Mekelle city only originated from Enderta district and Mekele special zone. During snail survey the studied population was all snails found in and around the selected dams and rivers as well as all swampy areas around the selected dams and rivers until the area in which the cattle rich to graze (far until two kilometer from watering point). Finally, during interview survey the target population of our study was all households that have cattle (farmers) and their age, sex, economic status and educational status was recorded as demographic characteristics.

3.3. Study Design

Across-sectional studies were conducted from November 2020 to May 2021 to determine prevalence and to collect data on events associated with bovine trematodes in the study areas.

3.4. Sample Size Determination and Sampling Techniques

The sample size of the study was calculated according to Thrusfield, (2005) in case of coprological and post-mortem examinations and according to Arsham, (2007) for interview survey. In case of coprological and post-mortem examinations to determine the sample size, the expected prevalence of 50% was considered since there is no previous study on bovine trematodes by both coprological and post-mortem examinations in the study areas and 95% confidence interval at an absolute precision of 5%. Accordingly, the required sample size was calculated by using the following formula,

$$n = (1.96)^2 p_{exp} (1 - p_{exp}) / d^2$$

Where: n= required sample size

P_{exp}= expected prevalence= desired absolute precision

$$n = (1.96)^2 p_{exp} (1 - p_{exp}) / d^2$$

$$n = (1.96)^2 * 50\% * (1 - 50\%) / 5\%^2$$

$$n = 3.8416 * 0.5 * (1 - 0.5) / 0.0025$$

$$n = 0.9604 / 0.0025$$

$$n = 384$$

But 25% of the estimated value (96) cattle were added to minimize sampling error during sample collection during both coprological and post-mortem examinations. Therefore, the number of cattle examined in this study was calculated to be 480.

In case of interview survey the sample size was: $N = 0.25 / (SE)^2 = 100$ Where, N= sample size, SE= standard error of the proportion, with the assumption of 5% standard error. But to minimize sampling error or non-respondents 20 households were added. So a total of 120 households were considered for this study.

In case of coprological examination simple random sampling method was applied to select study animals and the study sites were purposively selected among selected kebeles of the study areas based on the disease case information obtained from the veterinary centers in the stud areas. This sample size was proportionally distributed to the selected study areas to avoid biasness and to assess the prevalence of the diseases in each selected site. However, purposive sampling method was applied to select study population in case of post mortem and interview survey that is cattle originated from Enderta district and Mekelle special zone and households that have cattle for post-mortem examination and interview survey respectively.

3.5. Study procedure

The study was undertaken by the combination of the following research approaches: coproscopic examination, post-mortem examination, snail survey and interview survey.

3.5.1. Fecal Sample Collection and Examination

Fecal samples were collected directly from the rectum of the cattle from November 2020 to February 2021. Then the collected samples were preserved in 10% formalin in a universal bottle with proper labeling of every necessary information and then were transported by using ice box to Mekelle University College of Veterinary Sciences parasitology laboratory. Simple sedimentation technique for detection of trematode eggs was used according to Bhatia, (2012). Briefly, about 3 g of faeces were taken in to centrifuge tube and 42 ml of water was added and then mixed thoroughly. The suspension was filtered through a tea strainer into other centrifuge tube and was left for 15 minutes. Thereafter, the supernatant was decanted and the sediment was re-suspended. This step was repeated 3 times until the supernatant was cleared. Then a drop of methylene blue was added and allowed to stand for 5 min. for effective staining of the debris which leaves the trematode eggs un-stained. Finally the sediment was transferred with a pipette to a clean slide and observed under low power (10x) microscope.

The slides were judged positive when oval to spindle shaped with centrally bulged and terminal spine on one side of egg was identified for *Schistosoma* from *Fasciola* and *Paramphistomum* (Jones and Hunt, 1997) and *Fasciola* eggs have a yellowish brown shell with an indistinct operculum and embryonic cells whereas *Paramphistomum* egg has transparent shell, distinct operculum with embryonic clear cells and possess a small knob at their posterior end (Urquhart *et al.*, 1996; Soulsby, 1982) (Annex 3).

3.5.2. Post-mortem Examinations

Post-mortem examination was undertaken from January 2020 to May 2021. before post-mortem examinations ante-mortem inspection was performed and each animal was given an identification number and only origins of animals were assessed and recorded because all slaughtered animals was males, have good body condition and >5 years old animals. The origins of the animals were confirmed by the livestock owners and some traders. A total of 480 cattle were examined during ante-mortem (AM) inspection and followed by postmortem (PM) examination of their respective organs at Abergelle international abattoir in Mekelle city. Each animal was visually inspected during ante-mortem (AM) examination, followed by palpation, systemic incision of organs and collection of proper samples from their predilection sites. Only animals originated from Enderta district and Mekelle special zone were selected for abattoir survey.

At postmortem examination portal vein and mesenteric vein was observed and incised to find the adult schistosomes and also the whole root of intestine was examined superficially to appreciate the presence of lesions and dead parasites at the junction of the tip of the vein and the wall, serosa and subserosa of the intestine. For both *Fasciola* and *Dicrocoelium* the liver of each animal was removed, incised along the bile duct and then followed by cutting into slices approximately 1cm thick for harvesting of adult parasite and macroscopic observance of lesion. In the case of intestinal paramphistomes, the rumen and reticulum was tied off, opened and examined for adherent trematodes according to the procedures stated by Urquhart *et al.*, (1997). Those adult worms collected from different organs and other parts of the animals were taken to veterinary parasitology laboratory of Mekelle University College of Veterinary Sciences for identification at least to the genus level. Parasites were placed on Petri dish and subjected to gross and microscopic examination according to Peters, and Gilles (1989) and Urquhart *et al.*, (1997). According to Springer (2001), key morphological features of schistosomes like presence of gynecophoric canal or schistin and the longer slender female lies folded were considered for identification of the genus.

In addition, economic loss was calculated based on condemned livers due to fasciolosis. In the study abattoir the average annual cattle slaughtered rate was estimated to be 6,200 while, mean retail price of bovine liver in Mekelle town was 60 EB. The prevalence of bovine fasciolosis at

Abergelle international abattoir was estimated as 4.1%. The estimated annual loss from organ condemnation was calculated according to mathematical computation using the formula used by Alula *et al.*, (2013):

$$ALC = CSR \times LC \times P$$

Where ALC = Annual loss from liver condemnation, CSR = mean annual cattle slaughtered at Abergelle international abattoir, LC = mean cost of one liver in Mekelle town, P = prevalence of bovine fasciolosis at Abergelle international abattoir

3.5.3. Snail Survey

Snail intermediate hosts were searched in natural, man-made water bodies, rivers, swampy areas and other watering points found in the study areas. Decaying woods, plant remains, submerged vegetation and stones were searched for snails by hand picking using gloves and forceps. Collected snails were placed in plastic buckets containing aquatic weeds or small amount of water and labeled for each collection site before transporting to Mekelle University College of Veterinary Sciences for identification. Dams like Gebreabso, Gredeamharay, Adechebar and River Haykihilat from Enderta Woreda, Rivers (Ilala and Aynalem and dam Agedbo) from Mekelle special zone and swampy areas around those watering points were searched for intermediate hosts during February and March 2021. A total of 1000 snails were collected from selected sites of the study areas for identification at least to genus level. Snails were identified using shell morphology according to Brown, (2005). After identification, snails were placed individually in shedding vials containing water and exposed to artificial light for about half an hour to induce shedding of cercariae.

3.5.4. Interview Survey

Data of socioeconomic factors were collected using face to face interview from November 2020 to January 2021. The interview was employed to 120 purposively selected members of the

community using a check list comprising major parameters that enable to determine the perception of the community towards the economic and public health impacts of the diseases in the study areas. Questionnaire was prepared in English first (Annex 1) and translated to local language Tigrigna later and administered to the farmers (Annex 2). It was pretested and revised according to the feedback got from the pretest. The economic and public health impacts of the diseases were calculated based on morbidity rate because the morbidity of animals and humans was the major impacts of the diseases in the study areas according to farmer's perceptions during fecal examination (Table 13). So it was calculated according to Anne and Angus, (2017) morbidity formula as follows:

$Ma = \text{NART}/\text{NARSA} * 100$ and $Mh = \text{NPRT}/\text{NPRSA} * 100$ Where, as

Ma = Morbidity of animals, NART = Number of Animals at Risk of Trematodes and NARSA = Number of Animals Residing at the Study Area.

Mh = morbidity of humans, NPRT = Number of Peoples at Risk of Trematodes and NPRSA = Number of Peoples Residing at the Study Area. Based on this formula the number of animals and humans at risk was estimated according to the veterinary clinics and hospitals in the study areas which was 25000 and 10000 respectively. Whereas, the total number of animals and humans was found according to metro area population of Mekele (2020). The total human populations in Mekelle special zone and Enderta district were 638,297. The total cattle found in Mekelle special zone according to the TCAR and BoARD Tigray Region, (2004) is 2815 and in Enderta district 71,136 cattle according to CSA, (2006) (total = 73951).

3.6. Statistical Analysis

The data was entered into Microsoft excel data base and analyzed using R statistical software programs version 3.6.2. A Shapiro–Wilk normality test showed that data on prevalence of trematode species show a normal distribution ($P < 0.05$) ($p\text{-value} < 2.2e\text{-}16$). Therefore, a parametric logistic regression was used to analysis the data. The overall prevalence of the disease was calculated as dividing the number of positive animals by the total number of animals examined, which is expressed in percent. Pearson's chi-square (χ^2) was used to evaluate the

association between the prevalence of the diseases with various possible risk factors. In this analysis p-value less than 0.05 at 5% level of significance was considered as statistically significant.

3.7. Ethical Consideration

Before starting the actual data collection ethical permission was obtained from Mekelle University College of Veterinary Sciences (permit number: Cvs/23913/D./2021/). Verbal consent was obtained from farmers before the interview and collecting of fecal specimens. Additionally, the importance of the study was explained to the farmers. It is also promised that at the end of the study the result of this study will be communicated back to the farmers in the form of community service in order to know the effect of the diseases.

4. RESULTS

4.1. Coprological Findings

Out of 480 fecal samples examined 50(10.42%) were found to be positive for at least one genus of trematodes. Three genera of trematodes were identified in coprological examination. In the coprological results, higher prevalence was recorded for *Fasciola* (4.6%) followed by *Schistosoma* (3.12%) and *Paramphistomum* (2.7%) (Table 2).

Table 2: Prevalence of bovine trematodes in Enderta district and in and around Mekelle special zone by coprological examination

Parasite species	Number positive	Prevalence (%)
<i>Fasciola</i>	22	4.6%
<i>Schistosoma</i>	15	3.12%
<i>Paramphistomum</i>	13	2.7%
Total	50	10.42%

The prevalence of trematodes was higher in animals with 3-5 years (group II) age group of cattle which was 17(12.1%) than >5 years (group III) age group of cattle which was 28(12%) and 1<3 years (group I) age group of cattle which was 5(4.7%). However, the prevalence of trematodes was not statistically significantly ($p>0.05$) among the different age groups (Table 3). The prevalence of *Fasciola*, *Paramphistomum* and *Schistosoma* was 5.2%, 3.0% and 3.4% respectively in >5 years cattles, 4.96%, 4.3% and 3.5% in 3-5 years cattle and 2.8%, 0% and 1.9% in 1<3 years cattle. However, the difference was not statistically significant among age groups with *Fasciola* ($\chi^2=0.97$, $p=0.25$), *paramphistomum* ($\chi^2=4.31$, $p=0.21$) and *Schistosoma* ($\chi^2=0.7$, $p=0.5$) (Table 8).

Table 3: Prevalence of bovine trematodes in different age groups

Age	Animals examined	Animals affected	Prevalence (%)	X ²	P value
1<3 (group I)	106	5	4.7%		
3-5 (group II)	141	17	12.1%	4.8	0.07
>5 (group III)	233	28	12%		
Total	480	50	28.8%		

On the other hand, higher prevalence of the trematodes was recorded in males 35(14.2%) than in females 15(6.44%) and the difference was statistically significant ($P<0.05$) (Table 4). Prevalence of *Fasciola* was higher in males (6.9%) than *Paramphistomum* (4.1%) and *Schistosoma* (3.24%). But in females the prevalence of *Schistosoma* (3.00%) was higher than *Fasciola* (2.15%) and *paramphistomum* (1.3%). In all cases the difference was not statistically significant (*Fasciola*: $\chi^2=6.15$, $p=0.131$, *Paramphistomum*: $\chi^2=3.42$, $p=0.063$ and *Schistosoma*: $\chi^2=0.021$, $p=0.883$) (Table 8).

Table 4: Sex wise prevalence of bovine trematodes

Sex	Animals examined	Animals affected	Prevalence (%)	X ²	P value
Male	247	35	14.2%		
Female	233	15	6.44%	7.76	0.012
Total	480	50	20.64%		

Similarly, prevalence of trematodes in poor body condition animals was found to be higher 29(25.7%) than medium and good body condition which was 14(7.41%) and 7(3.9%), respectively. The difference was statistically significant ($P<0.05$) (Table 5). Moreover, the specific prevalence of trematodes in poor body condition animals was 11.5%, 8.85% and 5.31% for *Fasciola*, *Schistosoma* and *Paramphistomum* spp respectively, in moderate body condition animals it was 4.2% for *Fasciola* and 1.6% for both *Paramphistomum* and *Schistosoma* and in good body condition

animals the prevalence was 2.2% for *Paramphistomum*, 1.12% for *Schistosoma* and 0.7% *Fasciola* spp. Species level prevalence among the different body conditioned animals was only statistically significant in *Fasciola* ($\chi^2=19.04$, $p=2.159e-05$) and *Schistosoma* ($\chi^2=16.6$, $p=0.0007$), however, the difference was not statistically significant for *Paramphistomum* spp ($\chi^2=3.92$, $p=0.18$) (Table 8).

Table 5: Prevalence of bovine trematodes based on body condition score

Body condition score	animals examined	animals affected	Prevalence (%)	X²	P value
Poor	113	29	25.7%	28.7	3.73e-09
Moderate	189	14	7.41%		
Good	178	7	3.9%		
Total	480	50	37.01%		

Furthermore, prevalence of bovine trematodes in Enderta district 29(11.1%) was higher than in Mekelle special zone 21(9.6%), however, the difference was not statistically significant ($P>0.05$) between the two study sites (Table 6). Moreover, the specific prevalence of trematodes in Enderta district was higher in *Fasciola* (4.59%) than *Paramphistomum* (3.45%) and *Schistosoma* (3.1%) spp and in Mekelle special zone the prevalence was higher in *Fasciola* (4.56%) than *Schistosoma* (3.2%) and *Paramphistomum* (1.83%) spp. In all cases the difference was not statistically significant (*Fasciola*: $\chi^2=0.0003$, $p=0.97$, *Paramphistomum*: $\chi^2=1.2$, $p=0.27$ and *Schistosoma*: $\chi^2=0.04$, $p=0.95$) (Table 8).

Table 6: Prevalence of bovine trematodes based on study areas

Study areas	animals examined	animals affected	Prevalence (%)	X ²	P value
Enderta district	261	29	11.1%	0.3	0.811
Mekelle zone	219	21	9.6%		
Total	480	50	20.7%		

In addition, the prevalence of bovine trematodes at Kebele level was found to be highest in Meremete 16(22.9%) followed by Feleg-daeiro 9(13.4%), Quiha 7(11.5%), Meseret 5(7.6%), Kedemay-weyane 4(6.7%), Felege-selam 4(6.2%) and least prevalence was observed in Aynalem 5(5.5%). However, the difference in prevalence of trematodes among the different Kebeles was not statistically significant ($P>0.05$) (Table 7). The specific prevalence of trematodes was 2.98%, 4.5%, and 5.97% in Feleg-daeiro, 4.4%, 0% and 1.1% in Aynalem, 6.6%, 1.5% and 3.3% in Quiha, 3.33%, 0% and 3.33%, in Kedemay-weyane, 1.54%, 3.1% and 1.54% in Felege-selam, 8.6%, 7.14% and 7.14% in Meremete and 4.54%, 3.03% and 0% in Meseret for *Fasciola*, *Paramphistomum* and *Schistosoma* spp respectively. However, the prevalence of *Paramphistomum* and *Schistosoma* was not observed significant difference (*Paramphistomes* $\chi^2=10.7$, $p=0.21$ and *Schistosoma* $\chi^2=9.8$, $p=0.64$) among the study sites but there was a significant difference among study sites on the prevalence of *Fasciola* ($\chi^2=5.12$ $p=0.052$) (Table 8).

Table 7: Prevalence of bovine trematodes based on selected Kebeles of both study areas

Kebeles	animals examined	animals affected	Prevalence (%)	X ²	P value
Feleg-daeiro	67	9	13.4%		
Aynalem	91	5	5.5%		
Quiha	61	7	11.5%		
Kedemay- weyane	60	4	6.7%	17.9	0.75
Felege-selam	65	4	6.2%		
Meremete	70	16	22.9%		
Meseret	66	5	7.6%		
Total	480	50	73.8%		

Table 8: Prevalence of specific trematodes with respect to different risk factors

Variables	<i>Fasciola</i>			<i>Paramphistomum</i>			<i>Schistosoma</i>		
	Prevalence	X ²	P value	prevalence	X ²	P value	prevalence	X ²	P value
Sex									
Male	6.9%	6.15	0.131	4.1%	3.42	0.063	3.24%	0.021	0.883
Female	2.15%			1.3%			3.00%		
Age									
1<3(group I)	2.8%			0%			1.9%		
3-5(group II)	4.96%	0.97	0.25	4.3%	4.31	0.21	3.5%	0.7	0.5
>5(group III)	5.2%			3.00%			3.4%		
BCS									
Poor	11.5%			5.31%			8.85%		
Moderate	4.2%	19.04	2.159e-	1.6%	3.92	0.18	1.6%	16.6	0.0007
Good	0.7%		05	2.24%			1.12%		
Study Areas									
Mekelle	4.56%	0.0003	0.97	1.83%	1.2	0.27	3.2%	0.04	0.95
Enderta	4.59%			3.45%			3.1%		
Study Kebles									
Feleg-daeiro	2.98%			4.5%			5.97%		
Aynalem	4.4%			0%			1.1%		
Quiha	6.6%			1.5%			3.3%		
Kedemay- weyane	3.33%	5.12	0.052	0%	10.7	0.21	3.33%	9.8	0.64
Felege-selam	1.54%			3.1%			1.54%		
Meremete	8.6%			7.14%			7.14%		
Meseret	4.54%			3.03%			0%		

4.2. Post-mortem Findings

Post-mortem examination of liver, portal vein, mesenteric vein, rumen and reticulum was undertaken in each animal to harvesting adult trematodes and examination of macroscopic lesion. Out of 480 cattle examined which was slaughtered at Abergelle international abattoir in Mekelle city 60(12.5%) harbored at least one genus of adult trematodes (Annex 4). Detailed, examination and identification confirmed that 20(4.1%) *Fasciola* spp, 7(1.5%) *Paramphistomum*, 10(2.1%) *Schistosoma*, 8(1.7%) cattle were harboring the three parasites genera, 7(1.5%) both *Fasciola* and *Schistosoma*, 5(1%) *Fasciola* and *Paramphistomum* and 3(0.6%) *Paramphistomum* and *Schistosoma* (Table 9). Gross lesions due to the diseases were not apparent in all predilection sites. The prevalence of trematodes was higher in cattles originated from Enderta district than Mekelle special zone. But the difference was not statistically significant ($p>0.05$) (Table 10). Furthermore, economic lose due to liver condemnation was 15,252 ETB loses from liver condemnation annually.

Table 9: Prevalence of trematodes in cattle slaughtered at Abergelle international abattoir originated from Enderta district and Mekelle special zone

Parasite species	Number of positive animals	Prevalence (%)
<i>Fasciola</i>	20	4.1
<i>Paramphistomum</i>	7	1.5
<i>Schistosoma</i>	10	2.1
<i>Fasciola</i> , <i>Paramphistomum</i> and <i>Schistosoma</i>	8	1.7
<i>Fasciola</i> and <i>Schistosoma</i>	7	1.5
<i>Fasciola</i> and <i>Paramphistomum</i>	5	1
<i>Paramphistomum</i> and <i>Schistosoma</i>	3	0.6
Total	60	12.5

Table 10: Prevalence of bovine trematodes with respect to origin of animals slaughtered Abergelle international abattoir

Origin of animals	Number of examined	Prevalence (%)	X ²	P value
Enderta district	245	10.2%		
Mekelle special zone	235	14.7%	2.22	0.12
Total	480	24.9%		

4.3. Snail Survey

In the current study, a total of 1000 snails were collected and identified. Accordingly, 356 (35.6 %) *Lymnaea* spp, 347(34.7%) *Biomphalaria* spp and 297(29.7%) *Bulinus* spp were identified. Furthermore, 142 (14.2%) of them were identified from Agedbo, 133(13.3%) from Gebreabso, 155(15.5%) from Haykihilat, 136(13.6%) from Gredeamharay, 138(13.8%) from Adicheber, 143(14.3%) from Aynalem and 153(15.3%) from Ilala (Table 11). Detailed experimentation to recover for cercariae from the total collected 1000 snails confirmed negative.

Table 11: Snails collected and identified from water sources and swampy areas of the two study sites.

Variables	Water bodies / swampy areas							
	Agedbo	Gebreabso	Adcheber	Gredeamharay	Haykihilat	Ilala	Aynalem	Total
Snail spp								
<i>Lymnaea</i> spp	51	45	44	48	55	56	54	35.6%
<i>Biomphalaria</i> spp	49	45	51	45	54	59	46	34.7%
<i>Bulinus</i> spp	42	43	43	43	46	38	43	29.7%
Total (%)	14.2%	13.3%	13.8%	13.6%	15.5%	14.3%	15.3%	100%

4.4. Interview Survey

4.4.1. Demographic characteristics of the target population

In this study, 120 purposively selected and willing to be interviewed farmers were subjected to Face to face interview. Out of the total surveyed households, 75% of the sampled respondents were males and 25% of them were females. The age of households was >20 and cataloged 21-30, 30-60 and >60 years and higher percentage of households were 30-60(66.7%) years age than 20-30(20.8%) and >60 (12.5) years. The educational level of the households was illiterates, read and write and elementary school. In addition, economic status of the households was moderate, poor and rich.

Table 12: Respondent's demographic characteristics

Variables	Number of respondents
Sex	
Male	90 (75%)
Female	30 (25%)
Age	
21-30	25 (20.8%)
30-60	80 (66.7%)
>60	155(12.5%)
Educational status	
Illiterate	105 (87.5%)
Read and write	9 (7.5%)
Elementary school	6 (5%)
Economic status	
Poor	50(41.7%)
Moderate	57(47.5%)
Rich	13(10.8%)

4.4.2. Overall perceptions of target populations towards socio-economic impacts of the diseases in both study areas

According to the interview result trematodes were economically important diseases in the study areas and locally known as “Desalagn” particularly for schistosomiasis. The common clinical signs of the diseases listed by interviewee were diarrhea, loss of appetite, loss of weight gain, blood in the faces and itching in humans respectively (Table 13). It was also recorded that drinking water in snails, harboring water bodies and grazing on grazing land inhabited with snail in animals and swimming habit in humans were the main risk factors in the areas. The local name of the intermediate host snail is “Arena” and this indicates the significant of the parasites and their intermediate hosts in the areas.

Economic losses caused by cattle parasites/trematodes have a significant effect on the productivity of bovine populations in both study areas. Fasciolosis, schistosomiasis and paramphistomosis were the major trematode diseases that have more economic impacts on the farmer’s economy respectively (Table 13). Consideration was given to the condemnation of liver at abattoir, production loss due to morbidity of animals, production loss due to mortality of animals (but less impact of trematodes in the mortality of animals in the study areas), lack of draft power, milk production loss, weight gain loss in beef cattle, effect on man work hour and cost of treatment, prevention and control. As the information obtained from farmers at least one farmer in one year one animal was at risk of the diseases/trematodes and this was a significant effect on the farmer’s economy whether by reduction of production or by death of the animal. Female cattle produce milk only once per day and this was scant in amount. In addition the male cattle were not used for farming as they went because of the declines in energy of the animal and this led to reduction of crop production. As obtained from the farmers the preventative chemotherapy and the anti-helminthic drugs are costly.

In addition, the veterinary clinics and pharmacies were distantly from the Enderta district farmer’s home and the poor farmers were not able to cover the treatment cost. Most of farmers have not any information about the advantage of treating parasitic diseases /trematodes using anti-helminthic drug unless using traditional medication as well as they don’t have detailed knowledge about the diseases. From the 120 farmers only about 30 (20%) farmers (Table 13)

were informed about the advantage of modern treatment of the diseases the rest was not have any knowledge. So when their animals were sick they simply given food and treat by using traditional medicines with unknown doses.

Those diseases were not only affecting the economy of the farmers also affect their health. As obtained from Enderta district farmers most of peoples particularly the animal attendants were drinking water in the dams or rivers together with their animals. So most of the peoples are acquiring the zoonotic trematodes like schistosomiasis (Table 13). Not only by drinking the water they also were swimming at the river and dam in which their animals were drank. As the information obtained from the swimmers the child's or adults show signs of itching of the body so the peoples were at risk of the disease and the diseases locally called "desalagn" for trematodes/ schistosomiasis.

Generally, trematodes have significant effect on both economic and public health in both study areas. Lastly, avoiding communally grazing lands followed by control of snails, providing animals with adequate water, and treatment of sick animals by using traditional treatment and rare modern anti-helminthics were the main control methods of the disease in the study areas. But the shortage of clean water for both animals and humans and the unaffordable cost of drugs were the major problems in the study areas. According to farmer's prescription the economic and public losses due to trematodes were estimated based on morbidity of animals and humans because morbidity of animals and humans was major economic impacts in the study area according to farmer's prescription during fecal examination.

$M_a = 25000/73951 * 100 = 33.8\%$ of the total cattle populations were at risk of trematodes diseases annually.

$M_h = 10000/50546 * 100 = 19.8\%$ of the total farmers were at risk of trematodes diseases annually.

Table 13: Results of interview survey with emphases to economic and public health impacts of trematode diseases in the two study sites based on target population perceptions.

Variables	Positive response (%)	Negative response (%)
Households that have detailed knowledge about the diseases.	70 (58.3%)	50 (41.7%)
Major clinical signs and symptoms		
A/ diarrhea	30 (25%)	90 (75%)
B/ loss of appetite	25 (20.8%)	95 (79.2%)
C/ loss of weight gain	23 (19.2%)	97 (80.8%)
D/ blood in the faces	22 (18.3%)	98 (81.7%)
E/ itching in humans	20 (16.7%)	100 (83.3%)
Main transmission methods.		
A/ snails	40 (33.3%)	80 (66.7%)
B/ contaminated water	35 (29.2%)	85 (70.8%)
C/ contaminated grazing land	25 (20.8%)	95 (79.2%)
D/ swimming in humans	20 (16.7%)	100 (83.3)
Main impacts of the diseases in the areas.		
A/ production loss due to morbidity of animals	55 (45.8%)	65 (54.2%)
B/ production loss due to mortality of animals	5 (4.2%)	115 (95.8%)
C/ lack of draft power	17 (14.2%)	103 (85.8%)
D/ loss in work hours of the farmers	24 (20%)	96 (80%)
E/ cost of prevention, control and treatments of the diseases. The average of cost for prevention, control and treatment was about 2000 birr per year for one animal	19 (15.8%)	101 (84.2%)
Order of trematode in respect to their economic impact		

A/ fasciolosis	55 (45.8%)	65 (54.2%)
B/ schistosomiasis	40 (33.3%)	80 (67.7%)
C/ paramphistomosis	25 (20.83%)	95 (79.2%)
zoonotic nature of the parasites	55 (45.8%)	65 (54.2%)
A/ fasciolosis	10 (18.2%)	45 (81.8%)
B/ schistosomiasis	45 (81.8%)	10 (18.2%)
C/ paramphistomosis	0 (0%)	0 (0%)
Main control measures of the diseases.		
A/ treatment of sick animals	8 (6.7%)	112 (93.3%)
B/ control of snails	50 (41.7%)	70 (58.3%)
C/providing animals with adequate water	10 (8.3%)	110 (91.7%)
D/ avoiding communally grazing lands	52 (43.3%)	68 (56.7%)
Way of treating their animals.		
A/ using anti-helminthic drug	30 (25%)	90 (75%)
B/ using traditional medications	90 (75%)	30 (25%)

5. DISCUSSION

In the current study, the overall prevalence of bovine trematodes in coprological examination was found to be 10.4%. This was in close agreement with 15.00% by Smith, (2009) from other countries but, lower than other study like 61% in and around Bahir Dar by Aragaw and Tilahun, (2019), 60.42% by Yeneneh *et al.*, (2012), 47.10% by Melaku, (2010), from Ethiopia and Nzalawahe *et al.*, (2014) and Bista *et al.*, (2018) from other countries. The variations observed among studies in trematode prevalence in general may be attributed to differences in climato-ecological conditions among study areas, difference in rainfall between study years, differences in study seasons, difference in amount and safeness of water body for multiplication and survival of intermediate host snails and difference in animal management practices.

The pattern of occurrence of the three trematodes in the present study was *Fasciola* followed by *schistosoma* and *paramphistomum* means that the highest prevalence was recorded for *Fasciola* (4.6%) followed by *Schistosoma* (3.12%) and *paramphistomum* (2.7%). This result was disagree with occurrence where *Paramphistomum* top the prevalence followed by *Fasciola* and *Schistosoma*, respectively has been reported different parts of Ethiopia like Yeneneh *et al.*, (2012) and Aragaw and Tilahun, (2019) and else-where in Africa like Nzalawahe, *et al.*, (2014) reported consistently higher prevalence of paramphistomes than *Fasciola* in cattle managed under different conditions. The differences among the prevalence of fluke infection might be attributed due to biology of the intermediate host, ecological and climate conditions of the study areas. The higher prevalence of *Fasciola* infection in our study may due to no major permanent water bodies in our study areas. Because of the snail intermediate hosts of *Fasciola* are amphibious (Andrews, 1999) and hence do not necessarily need aquatic environment for survival and proliferation.

The prevalence of *Fasciola* spp (4.6%) observed in our study was in close agreement with reports Fufa *et al.*, (2009) who reported 4.95 at sodd and kombolcha clinics but lower than to the 15.9% reported by Tilahun, *et al.*, (2014), 19.5% reported by Mulat *et al.*, (2011) 24% prevalence reported by Yeneneh *et al.*, (2012) and prevalence reported by Taye *et al.*, (2016) and Telila *et al.*, (2014). It was also very lower compared to other recent reports from areas adjoining Lake Tana such as Gebrie *et al.*, (2015), Tsegaye *et al.*, (2012), Biniam *et al.*, (2012), Behabtom, (2018) and reports from other parts of the country like Fromsa *et al.*, (2011). The

difference in prevalence may be due to difference in the amount of rainfall, other climatic conditions over the years in the areas, differences in climate-ecological conditions among the study areas, sampling periods and epidemiological factors (availability of stagnant water body, marshy area and drainage system for irrigation practice which favours the development and multiplication of snail intermediate hosts) (Yilma and Mesfin, 2000).

Prevalence of *Schistosoma* observed in our study was (3.13%) and it was lower than from Aragaw and Tilahun, (2019) reported 16.5%, reported 13.7% in an area adjacent to Lake Tana Fromsa *et al.*, (2011) reported 13.5% and also lower than other reports like Habtamu and Wolde mariam, (2011), Habtamu *et al.*, (2013), Yeneneh *et al.*, (2012) and. The lower prevalence of *schistosoma* in our study was due to the amount of water in our study area was scant (not permanent water bodies) and the animals was not used in the selected rivers and dams throughout the year.

The prevalence of *paramphistomum* (2.7%) recorded in the present study was lower than to previous report like Mariam, *et al.*, (2014), Kemal and Terefe, (2013), Telila *et al.*, (2014), Yo hannes *et al.*, (2013), Yeneneh *et al.*, (2012), Fromsa *et al.*, (2011) and Vanleeuwen *et al.*, (2014) which is characterized by a humid tropical climate of heavy annual rainfall. Also so lower in Studies conducted near a large marshy area traversed by a river like 65.3% by Kifleyohannes *et al.*, (2015) demonstrated higher prevalence of *paramphistomes*. The lower prevalence of *paramphistomes* in our study was might be due to our study was conducted in no major permanent water bodies because paramphistomes require aquatic snails. So that our result was opposed to some of the other studies which were conducted in permanent water bodies.

On the other hand, prevalence of bovine trematodes in our study was higher in males (14.2%) than in females (6.44%) and there was a significant difference among the sexes. Our finding was agree with previous reports like male 6.9% and in female 4.5% by Kebede, (2018), 29.61% in male and 19.54% in female by Solomon, (2008) in and around Bahir Dar and 30.70% in male and 23.30% in female by Alemseged, (2010) in Dembia district on bovine schistosomiasis. And disagree with previous reports which was reported the prevalence of trematodes were higher in females than males like Aragaw and Tilahun, (2019) and Yeneneh *et al.*, (2012) on the three trematodes and Belayneh and Tadesse, (2012); Hussen and Tilahun, (2017) Getachew *et al.*, (2006), Habtamu and Woldemariam, (2011) on schistosomiasis and Yassin *et al.*, (2017) on bovine fasciolosis. The reason seems to be related to social practice of keeping females under

better management and feeding condition for milk production and breeding whereas males are generally let lose to graze freely in pasture and frequently used for draught purpose and also more stressed in our study areas. Males are also fed relatively poor diet which increases the susceptibility to parasitic infection in our study areas and this was supported to the idea of Houdijk and Athana, (2003). Differences in susceptibility to infection between sexes may not solely due to difference in susceptibility but may also depend on a sex-related variation in behavior that results in differences in exposure (Magona and Musisi, 2002).

Prevalence of trematode infection in animals with different body condition score was statistically significant. Higher prevalence of trematodes was observed in poor (25.7%) than moderate (7.41%) and good (3.9%) body condition animals. The current finding supports the previous reports which associated fasciolosis (Fromsa *et al.*, 2011; Meshesha and Tesfaye, 2017), paramphistomosis (Fromsa *et al.*, 2011; Mariam *et al.*, 2014; Melaku and Addis, 2012), schistosomiasis (Fromsa *et al.*, 2011; Lulie and Guadu, 2014) and Aragaw and Tilahun, (2019) on the three trematodes. Because heavy infection with trematodes in cattle especially in young stock, may result in severe disease characterized by anemia, hypoalbuminemia (edema), ill thrift, weight loss, decreased appetite and listlessness. Even with moderate infections and immature trematodes (Love, 2017). In our study area the cause of animals to trematodes that led to poor body condition was due to malnutrition and lack of clean drinking water.

The effect of the specific genera of trematodes on body condition in our study was on both poor and moderate body condition animals the prevalence of *Fasciola* was higher than *Schistosoma* and *Paramphistomum* and a significant difference in both *Fasciola* and *Schistosomia* on body condition was observed. But in good body condition animals higher prevalence was observed in *paramphistomum* than *Schistosomia* and *Fasciola* and the effect of *paramphistomum* on body condition was not statistically significant. Our finding supports to the report of Bista *et al.*, 2018 who said no clinical signs and symptoms related to parasitic infestation was observed on paramphistomosis but, contradicted to report of Aragaw and Tilahun, (2019) who said it is difficult to separate the effects of the different genera of trematodes on body condition as they tend to occur together. The non-significance of paramphistomosis on body condition in our study may be due to the adult *paramphistomum* is considered non-pathogenic even though large numbers may present and at most may cause localized loss of rumen papillae (Kahn, 2010). Essentially adult *Paramphistom*

um having no clinical significance unless in heavy infection as stated by Iglesias Piñeiro *et al.*, (2016).

Furthermore, the overall prevalence of bovine trematodes in post-mortem examination was found to be 12.5% in Enderta district and Mekelle special zone. This was in close agreement with the report 14% at Wolaita Soddo abattoir by Abunna *et al.*, (2010) and higher than 8.53% and 5.43% at Hirna municipal abattoir by Nebi *et al.*, (2018) on bovine fasciolosis and bovine paramphistomosis respectively. Detailed post-mortem examination of specific predilection site of trematodes confirmed that high prevalence for bovine fasciolosis (4.1%) than for schistosomiasis (2.1%) and paramphistomosis (1.5%).

Prevalence of bovine fasciolosis in the current study was (4.1%). This finding was lower than previous reports like 24.4% at Haramaya municipal abattoir by Yusuf *et al.*, (2016), 24.3% at Mekelle municipal abattoir by Gebretsadik *et al.*, (2009), 25.2% at Dessie municipal abattoir by Ephrem *et al.*, (2012), 39.9% at Mekelle municipal abattoir by Ashenaf, *et al.*, (2016), 19% at Nekeunte municipal abattoir by Gudeta and Biyansa, (2019), 20.3% at Addis Abeba abattoir by Aragaw *et al.*, (2012), 22.14% at Dangila municipal abattoir by Alamu and Mekonnen, (2013) and 40.62% at Angacha municipal abattoir by Eyob *et al.*, (2017)

Prevalence of bovine schistosomiasis (2.1%) in the current study also lower than previous reports like 28.14% by Almaz, (2007), 22% by Belayneh and Tadesse, (2012), 27% by Solomon, (2008) and 30% by Alemseged, (2010) and the prevalence of bovine paramphistomosis (1.5%) was also lower than previous reports like 57.52% at Jimma abattoir by Abebe *et al.*, (2011), 41.5% at Nekeunte municipal abattoir by Gudeta and Biyansa, (2019) and 40.1% at Debrezeit by Sintayehu and Mekonnen, (2012).

Moreover, there were also mixed infections of all the three parasites species (1.7%), *Fasciola* and *Schistosomia* (1.5%), *Fasciola* and *Paramphistomum* (1%) and *Paramphistomum* and *Schistosomia* (0.6%). This finding also agrees with the finding of Aragaw and Tilahun, (2019) which reported mixed infection of trematodes. Generally, the difference may be due to climatic changes such as repeated draught leading to drying of natural habitats of the intermediate host snails and the larval stages of the parasites may not be reached by infective stages and may decrease their population leading to decrease in the prevalence of the diseases in our study area.

Eventhough, different samples (cattle drank and grazing in and around rivers, damp and swampy areas and cattle slaughtered at Abergelle international abattoir) were undertaken in our study for coprological examination and post-mortem examination respectively, but, the prevalence was higher in post-mortem examination. This is due to the fact that limited accuracy of coprological examination and post mortem examination may be related to the reality that adult parasites established in their predilection sites and stage of infection may determine fecal egg output. As described by De Bont and Vercruysse, (1998) immunity did not act primarily by absolute prevention of maturation of challenge infection, but mainly by suppression of worm fecundity. Thus post mortem examination is more sensitive in detecting trematode infection than coproscopic examination.

In the present study three genera of snails (*Lymnaea* species, *Biomphalaria* species and *Bulinus* species) were collected and this finding was agree with the countrywide snail survey made in Ethiopia showed that planorbid (*Biomphalaria* spp.), bulinid and lymnaeid snails of medical and veterinary importance have a wide geographical distribution (Yusuf *et al.*, 2017). Our study areas were rich in *Lymnaea* species followed by *Biomphalaria* species and *Bulinus* species and this was contradicts with previous reports which reported *Bulinus* species was the most abundant snail species followed by *Lymnaea* species and *Biomphalaria* species (Kebede *et al.*, 2020). This was due to the areas we searched was not major permanent water body. So higher number of *Lymnaea* species which is the intermediate host for *Fasciola* was collected and this support to the coprological prevalence of *Fasciola* which was high in our study this may be due to raised lymnaeid snail which is intermediate host for *Fasciola* (Kahn, 2005).

Finally, in the face to face interview the perception of the farmers was taken towards socio-economic impacts. The general perception of farmers towards trematodes was scant. They don't know separately the specific genera of trematode and the word "desalagn" mostly the local name of schistosomiasis. Generally the farmers were in need of awareness towards trematodes unless trematodes become the major factor to their livelihoods.

6. CONCLUSION AND RECOMMENDATIONS

Despite, several years of intervention in these study areas, the prevalence of bovine trematode still remained moderate. The major trematode genera identified in coprological and postmortem examination were *Fasciola*, *Schistosoma* and *Paramphistomum* however, mixed infection also observed during post mortem examination. Generally the present study demonstrates the occurrence of trematodes infection with the overall prevalence of 10.42%, 12.5% by coprological and post-mortem examinations respectively and the overall snail survey was 1000 snails which was *Lymnaea* species, *Biomphalaria* species and *Bulinus* species. They associated with risk factors such as age, sex, body condition and epidemiological area that favorable for the development and multiplication of intermediate hosts. But a significant association was observed among sexes and body condition score. Even though moderate prevalence of trematodes in the current study there is considerable economic loss due to trematode infections through reduced production efficiency of cattle and reduction of work hours in farmers in the study areas. In addition, 15, 252 ETB losses from liver condemnation annually in the Abergelle international abattoir. The prevalence of *Fasciola* spp and *Schistosoma* spp particularly the *Schistosoma* also show the risk to public health. The major feed resources at both study areas are almost natural pasture in the form of grazing land particularly in Enderta district lack of clean piped water to animals as well as for humans increasing the chance of exposure to fluke infection. The lack of proper knowledge of farmers about the risk factor, transmissions, dosing and frequency of anti-helminth was one of predisposing factors for high rate of incidence.

Based on this conclusion, the following recommendations are forwarded:

- ❖ Farmers should in need of awareness about the risk factors and its transmission at least to tell them not to graze their cattle freely in swampy areas and to supply dry feeds sometimes.
- ❖ Implementation of appropriate control measures for the intermediate host should be encouraged and Farmers should be advised and educated about the control of the diseases and its intermediate host vector.
- ❖ Strategic use of anti-helminthics should be practiced to reduce pasture contamination with fluke eggs and strategic application of fluckicide and provision of worm safe pasture

and clean water provide better considerable success in the prevention/control of fluke infection in the study areas.

- ❖ Proper grazing management should be practiced to avoid grazing around marshy area in which snail population is high.
- ❖ Empirical diagnosis and treatment of cattle, especially showing diarrhoea, loss of appetite and poor growth or weight loss in the study areas should take trematodes into consideration and animals should be treated by anti-helminthic drugs rather than traditional treatment.
- ❖ Human being after swimming must be washed their body with soap and dry with clean towel since the farmers particularly chillds were at risk of schistosomiasis in the study areas.

7. REFERENCES

- Abebe, F., Behabtom, M., and Berhanu, M. (2011): Major Trematods of Cattle Slaughtered at Jimma Municipality Abattoir and their Intermediate Host in Selected Water Bodies of the Zone. *J. Anim. Vet. Adv.*, **10(12)**:1592-1597.
- Abebe, R., Abunna, F., Berhane, M., Mekuria, S., Megersa, B., and Regassa, A. (2010): Fasciolosis Prevalence, Financial Losses due to Liver Condemnation and Evaluation of a Simple Sedimentation Diagnostic Technique in Cattle Slaughtered at Hawassa Municipal Abattoir, Southern Ethiopia. *Ethiop. Vet. J.*, **14(1)**: 39–52.
- Abunna, F., Asfaw, L., Megersa, B., and Regassa, A. (2010): Bovine Fasciolosis: Coprological, Abattoir Survey and its Economic Impact due to Liver Condemnation at Soddo Municipal Abattoir, Southern Ethiopia. *Trop. Anim. Health. Pro.*, **42**: 289–292.
- Adenowo, A., Oyinloye, B., Ogunyinka, B., and Kappo, A. (2015): Impact of Human Schistosomiasis in Sub-Saharan Africa. *Braz. j. Infect. Dis.*, **19(2)**: 196–205.
- Aiello, S., and Mays, A. (1998): The Merck Veterinary Manual. 8th Ed. Merck and co. Inc. U.S. A Whitehouse Station, N.J., **Pp.** 29 -31.
- Alarcón, N., Colmenares, C., Lanz, H., Caracciolo, M., Losada, S., and Noya, O. (2000): *Schistosoma Mansoni* Immunodiagnosis is Improved by Sodium Metaperiodate which Reduces Cross-Reactivity due to Glycosylated Epitopes of Soluble Egg Antigen. *Exp. Parasitol.*, **95**: 106–112.
- Alemseged, G. (2010): Prevalence of Bovine Schistosomosis in Denbia District, North Western Ethiopia. DVM Thesis, Faculty of Veterinary Medicine, Gondar Ethiopia. **Pp**, 20
- Alemu, F., and Mekonnen, A. (2013): An Abattoir Survey on the Prevalence and Monetary Loss of Fasciolosis among Cattle, Slaughtered at Dangila Municipal Abattoir, Ethiopia. *J.vet. Med. Anim. Health.*, **6**: 309-316.
- Al-Kennany, E., Al-Hamoo, R., and Al-Alaaf, E. (2009): Pathological Study on Sheep Infected with *Schistosoma Bovis*. *J. Vet. Sci.*, **2 (2)**: 82-87.

- Almaz, H. (2007): Pathology of Naturally Occurring Schistosoma Infection in Cattle Slaughtered at Bahir Dar Municipal Abattoir, Northwest Ethiopia. MSc Thesis, Faculty of Veterinary Medicine, Addis Ababa University. **Pp**, 15.
- Almaz, H., and Solomon W. (2011): Repeated Simple Sedimentation Technique and Prevalence of Bovine Schistosomiasis in Selected Sites of Bahir- Dar Woreda, Bahir-Dar, Ethiopia. *Ethiop. Vet. J.*, **15 (1)**: 49-57.
- Almaz, H., Tamiru, N., Asegedech, S., and Mersha, C. (2013): Pathology of Natural Infections of Schistosoma Bovis in Cattle in Ethiopia, Bahir-Dar, Ethiopia. *Glob. Vet.*, **11 (2)**: 243-247.
- Alula, P., Addisu, K., and Amanuel, W. (2013): Prevalence and Economic Significance of Bovine Fasciolosis in Nekemte Municipal Abattoir. **5(8)**: 202-205.
- Anne, C., and Angus, D. (2017): Measures of Morbidity and Mortality Used in Epidemiology.
- Aragaw, K., and Tilahun, H. (2019): Coprological Study of Trematode Infections and Associated Host Risk Factors in Cattle during the Dry Season in and Around Bahir Dar, Northwest Ethiopia. *Vet. Anim. Sci.*, **7**: **Pp**, 20.
- Aragaw, K., Negus, Y., Denbarga, Y., and Shifaraw, D. (2012): Fasciolosis in Slaughtered Cattle in Addis Ababa Abattoir, Ethiopia. School of Veterinary Medicine, Hawassa University, Ethiopia. **Pp**, 115-118.
- Arshad, G., Maqbool, A., Qamar, M., *et al.*, (2011): Epidemiology of Schistosomiasis in Buffaloes under Different Managemental Condition in Four Districts of Punjab, Pakistan. *J. Anim. Plnt. Sci.*, **21(4)**: 841-843.
- Arsham, H. (2007): Questionnaire Design and Surveys Sampling.
- Ashenafi, K., Alemu, A., Hagos, A., Biniam, T., and Aklilu, F. (2016): The Prevalence and Economic Impact of Bovine Fasciolosis in Mekelle Municipal Abattoir. *J.vet. Sci. Res*, **Pp**, **1**: 4.

- Aylate, A., Hussen, M., Tilahun, A., and Kiros, A. (2017): A cross-sectional Study on Bovine Schistosomiasis in and around Kemissie, Dawa Cheffa District, **9**: 72–77.
- Barger, I. (1999): The Role of Epidemiological Knowledge and Grazing Management for Helminth Control in Small Ruminants. *Int. J. Parasitol.*, **29**:41–47.
- Bedarkar, S., Narladkar, B., and Deshpande, P. (2000): Seasonal Prevalence of Snail Fluke Infections in Ruminants of Marathwada Region. *J.vet. Parasitol*, **14 (1)**: 51-54.
- Behabtom, M. (2018): Prevalence of Bovine Fasciolosis and Economic Significance in and Around Chora Wereda, Western Ethiopia. *Acta. Parasitol. Glob.*, **9 (3)**: 107-111
- Bekele, J., Asmare, K., Abebe, G., Ayelet, G., and Esayas, G. (2010): Evaluation Deltamethrin Applications in the Control of Tsetse and Trypanosomosis in Southern Rift Valley Areas of Ethiopia. *Vet. Parasitol.*, **168**:177-184.
- Belayneh, L. and Tadesse, G. (2012): Bovine Schistosomiasis a Threat in Public Health Perspective in Bahir-Dar Town, Northwest Ethiopia. *Acta. Parasitol. Glob.*, **5 (1)**: 1-6.
- Bhatia, B. (2012): Textbook of Veterinary Parasitology. **Pp**, 20.
- Bianchin, C., Kichel, T., and Honer, R. (2007): The Effect of the Control of Endo and Ecto Parasites on Weight Gains in Cross Breed Cattle in the Central Region of Brazil. *Trop. Anim. Health. Pro.*, **39(4)**:287-296.
- Biniam, T., Hanna, A., and Sisay, G. (2012): Study on Coprological Prevalence of Bovine Fasciolosis in and around Woreta, Northwestern Ethiopia. *J. Vet. Med. Anim. Health.*, **4(7)**: 89-92.
- Bista, S., Lamichhane, U., Singh, D., And Regmi, S. (2018): Overview of Seasonal Prevalence of Liver Fluke and Rumens Fluke Infestation in Cattle and Buffalo of Western Chitwan, Nepal, **35**: 235–241.
- Blood, DC., and Radiostitis, (2007): Veterinary Medicine A Textbook of Disease of Cattle, Horse, Sheep, Pigs and Goat, 10th Ed. Edinburg London, New York, Oxford Philadelphia Stlou Sydney Toronto. **Pp**, 2.

- BoARD Tigray Region and TCAR. (2004): Regional Annual Report. Mekelle, Tigray.
- Bont, J. (1995): Cattle Schistosomosis Host-parasitic Interactions. PhD. Thesis, University of Gent. **Pp**, 23.
- Borji, H., Naghibi, H., Nasiri, R., and Ahmadi, A. (2012): Identification of Dactylogyrus Spp. and other Parasites of Common Carp in Northeast of Iran. *J. Para. Dis.*, **36(2)**: 234–238.
- Bowman, D., Lynn, C., Eberhard, L., Alcaraz, A. (2003): Geoge’s Parasitology for Veterinary. 8rd Ed. **Pp**, 339-347.
- Bowman, D., Randy, C., Eberhard, L., and Ann, A. (2003): Parasitology for Veterinarian. 3rd Ed. USA, Sounders. **Pp**, 121-122.
- Brown, D. (1980 and 1994): Freshwater Snails of Africa and their Medical Importance, London, Taylor and Francis. **Pp**, 3.
- Brown, D. (2005): Freshwater Snails of Africa and their Medical Importance, 2nd Ed. London, Taylor and Francis Limited. **Pp**, 21
- Centers for Disease Control and Prevention. (2014): Parasites Schistosomiasis Available from <http://www.cdc.gov/Parasites/Schistosomiasis/>. Accessed April 10, 2021.
- Central Statistics Agency (CSA), (2008): Summary and Statistical Report of the 2007 Population and Housing Census, Addis Ababa, Federal Democratic Republic of Ethiopia, Population Census Commission. **Pp**, 6
- Central Statistics Agency (CSA), (2007): Population and Housing Census of Ethiopia, Statistical Report. **Pp**, 1
- Central Statistical Agency (CSA), (2006): Ethiopian Sample Survey Enumeration. Addis Ababa Ethiopia. **Pp**, 12-14.
- Central Statistical Authority (CSA), (2009): Federal Democratic Republic of Ethiopia, Central Statistical Authority, Agricultural Sample Survey Report on Livestock and Livestock Characteristics, Addis Ababa. **Pp**, 120.

- Chhabra, M., and Singla, L. (2009): Food-borne Parasitic Zoonoses in India. Review of Recent Reports of Human Infections. *J. Vet. Parasitol.*, **23(2)**:103-110.
- Clennon, J., King, C., Muchiri, E., and Kitron, U. (2007): Hydrological Modeling of Snail Dispersal Patterns in Msambweni, Kenya and Potential Resurgence of *Schistosoma Haematobium* Transmission. *Parasitol.*, **134(5)**:683-693.
- Cornelissen, B., Gaasenbeek, P., Borgsteede, W., Harmsen, M., and Boerrisma. (2001): Early Immune Diagnosis of Fasciolosis in Ruminants Using Recombinant *F. Hepatica* cathepsin L like Protease. *Int. J. Parasitol.*, **31**: 728-737.
- Cwiklinski, K., Neill, S., Donnelly, S., and Dalton, J. (2016): A Prospective View of Animal and Human Fasciolosis. *Para. Immunol.*, **38(9)**: 558
- De-Bont, J., and Vercruysse, J. (1998): Schistosomiasis in Cattle. *Adv. Parasitol.*, **41**: 285–364.
- De-Lahunta, A., and Habel, R. (1986): Teeth Applied Veterinary Anatomy, U.S.A. Saunders Company. **Pp**, 4-16.
- De-Roeck, E., Van Coillie, F., De Wulf, R., Soenen, K., Charlier, J., Vercruysse, J., *et al.*, (2014): Fine-scale Mapping of Vector Habitats Using Very High Resolution Satellite Imagery: A Liver Fluke Case-study. *Geo. Health.*, **8(3)**:671–683.
- Doenhoff, M., Chiodini, P., and Hamilton, J. (2004): Specific and Sensitive Diagnosis of *Schistosoma* Infection. *Tre. Parasitol.*, **20**: 35–39.
- Dreyfuss, G., Alarion, N., Vignoles, P., and Rondelaud, D. (2006): A retrospective Study on the Metacercarial Production of *Fasciola Hepatica* from Experimentally Infected *Galba Truncatula* in Central France. *Parasitol. Res.*, **98(2)**: 162–166.
- Dwight, D., Bowman, G., and Georgis, M. (2003): Parasitological for Veterinarians. Elsevier (USA). **Pp**, 129-133.
- Endris, M., and Alemneh, T. (2017): Bovine Schistosomiasis Mini Review. *Sci. Fed. Virol. Res. J.*, **Pp**, 3.

- Ephrem, B., Wassie, M., and Abadi, A. (2012): Prevalence and Economic Losses of Bovine Fasciolosis in Dessie Municipal Abattoir, South Wollo Zone, Ethiopia. *Euro. J. Biol. Sci.*, **4** (2): 53-59
- Esser, K., Gumar, V., Yibabe, T., and Mitiku, H. (2002): Soil Conservation in Tigray, Ethiopia. Noragic, Centre for International Environment and Development Studies Agricultural University of Norway. **Pp**, 4
- Eyob, E., Naod, T., Addisu, A., Amenu, G., and Berhanu, B. (2017): Study on the Prevalence of Bovine Fasciolosis and Estimated Financial Losses Due to Liver Condemnation in Case of Angacha Woreda, Kambata Tembaro Zone, Southern Ethiopia. *J. Biol. Agri. Health.*, **7:2**
- Fairweather, I. (2011): Reducing the Future Threat from Liver Fluke. Realistic Prospect or Quixotic Fantasy. *Vet. Parasitol.*, **Pp**, 133-143.
- Fenwick, A., Webster, J., Bosque-Oliva, E., Blair, L., Fleming, F., Zhang, Y. *et al.*, (2009): The Schistosomiasis Control Initiative (SCI), Rationale, Development and Implementation. *Parasitol.*, **136(13)**:1719–1730.
- Fromsa, A., Meharenet, B., and Mekibib, B. (2011): Major Trematode Infections of Cattle Slaughtered at Jimma Municipality Abattoir and the Occurrence of the Intermediate Hosts in Selected Water Bodies of the Zone. *J. Anim. Vet. Adv.*, **10(12)**:1592-1597.
- Fufa, A., Asfaw, Y., Megersa, B., and Regassa, A. (2009): Bovine Fasciolosis Coprological Abattoir Survey and Its Economic Impact due to Liver Condemnation at Soddo Municipal Abattoir, Southern Ethiopia. *Trop. Health. Pro.*, **10**: 1009-1019.
- Gaasenbeek, C., Moll, L., Cornelissen, J., Vellema, P., and Borgsteede, F. (2001): An Experimental Study on Triclabendazole Resistance of *Fasciola Hepatica* in Cattle. *Vet. Parasitol. J.*, **95**: 37-43
- Gabriel, S., De-Bont, I., Phiri, M., Masuku, G., Riveau, A., Schacht, A., Deelder, G., Van-Dam and Vercruyse. (2002): Transplacental Transfer of Schistosomal Circulating Antigenic Antigens in Calves. *Para. Immunol.*, **24**: 521-525

- Gashaw, F., Aemero, M., Legesse, M., Petros, B., Teklehaimanot, T., Medhin, G. *et al.*, (2015): Prevalence of Intestinal Helminth Infection among School Children in Maksegnit and Enfranz towns, Northwestern Ethiopia, with Emphasis on *Schistosoma Mansoni* Infection. *Para.Vec.*, **8**: 567.
- Gebretsadik, B., Kassahun. B., and Gebrehiwot, T. (2009): Prevalence and Economic Significance of Fasciolosis in Cattle in Mekelle Area of Ethiopia. *Trop. Anim. Health. Pro.*, **41(7)**:1503-1504.
- Gebrie, Y., Gebreyohannes, M., and Tesfaye, A. (2015): Prevalence of Bovine Fasciolosis in and around Bahir Dar, North West Ethiopia. *J. Parasitol. Vec.Biol.*, **7(4)**: 74–79.
- Getachew, T., Tesfu, K., Berhanu, E., Legesse, W., Ahmed, A., Nega, B., and Girmay, M. (2006): Pilot Control of Fasciolosis and Related Animal Fluke Infections by the use of Endod and Reduced Morbidity, Pre- intervention Studies. *Ethiop. Vet. J.*, **10(1)**:67-70
- Girmay, T., Teshome, Z., and Mahari, M. (2013): Knowledge, Attitude and Practices of Peasants towards Hyraxes in two Selected Church Forests in Tigray, **7(5)**: 299–307.
- Gracia, L., Bruckner, D. (2007): Diagnostic Medical Parasitology. Elsevier Science New York, U.S.A. **Pp**, 5.
- Gudeta, T., and Biyansa, A. (2019): Prevalence of Major Bovine Trematodes (*Fasciola* and *Paramphistomum*) in Cattle Slaughtered at Nekemte Municipal Abattoir, East Wollega, Oromia Regional State, Ethiopia. *J. Biol. Agri. Health.*, **9**: 7.
- Gutierrez, Y. (2004): Diagnostic Pathology of Parasitic Infections with Clinical Correlation. **Pp**, 2.
- Habtamu, A., and Woldemariam, S. (2011): Repeated Simple Sedimentation Technique and Prevalence of Bovine Schistosomosis in Selected Sites of Bahir Dar Woreda. *Ethiop. Vet. J.*, **15 (1)**: 4
- Habtamu, A., Negash, T., Sirak, A., and Chanie, M. (2013): Pathology of Natural Infections of *Schistosoma Bovis* in Cattle in Ethiopia. *Glob. Vet.*, **11(2)**: 243–247.

- Hansen, J., and Perry, B. (1994): The Epidemiology, Diagnosis and Control of Helminthes Parasite of Ruminants. A Hand Book of Animal Production, International Laboratory for Research on Animal Disease (ILRAD). *Parasitol. Immunol.*, **26**:167-175.
- Hardi, F., Zana, M., and Hawsar, O. (2016): Liver Fluke (Fascioliasis). *Int. J. App. Res.*, **2**: 265-271.
- Hendrix, M., and Robinson, D. (2006): Diagnostic Parasitology for Veterinary Technicians, 3rd Ed, New York, Academic press. **Pp**, 13
- Houdijk, J., and Athana, S. (2003): Direct and Indirect Effects of Host Nutrition on Ruminants Gastrointestinal Parasites in Proceedings of the sixth International Symposium on the Nutrition of Herbivores, Merida Mexico. **Pp**, 3
- Hussen, M., and Tilahun, A. (2017): A cross-sectional Study on Bovine Schistosomiasis in and around Kemissie, Dawa Cheffa District. **Pp**, 7
- Iglesias-Piñeiro, J., González-Warleta, M., Castro-Hermida, J., Córdoba, M., González-Lanza, C., Manga-González, Y., and Mezo, M. (2016): Transmission of Calicophoron Daubneyi and *Fasciola Hepatica* in Galicia (Spain), Temporal Follow-up in the Intermediate and Definitive Hosts. *Parasitol. Vec.*, **9**: 610
- Islam, M., Begum, N., Alam, M., *et al.*, (2011): Epidemiology of Intestinal Schistosomiasis in Ruminants of Bangladesh. *J. Bangl. Agri. Uni.*, **9(2)**: 221-228.
- Jaja, I., Mushonga, B., Green, E., and Muchenje, V. (2017): Seasonal prevalence, Body Condition Score and Risk Factors of Bovine Fasciolosis in South Africa. *Vet. Anim. Sci.*, **4**: 1–7.
- Javed, U. (2008): Epidemiology, Economic Importance and Therapy of Paramphistomosis in Cattle and Buffaloes in Pakistan. **Pp**, 3
- Jones, T., Hunt, R., and Kink, N. (1997): Veterinary Pathology. 6th Ed, U.S.A, Lippincott Williams and Wilkins. **Pp**, 664-667.
- Kahn, C. (2011): The Merck Veterinary Manual. 10th Ed. White-House Station, NJ: Merck and Co., Inc. **Pp**, 273–1036.

- Kahn, C., (2010): The Merck Veterinary Manual. 10th Ed. New Jersey, USA: Merck and Co. Inc., Whitehouse Station. **Pp**, 115-392.
- Kahn, C. (2005): The Merck Veterinary Manual. 10th Ed. White- House Station, NJ: Merck. Co., Inc. **Pp**, 273-1036.
- Kaplan, R. (2001). *Fasciola Hepatica: A Review of the Economic Impact in Cattle and Considerations for Control. Vet. Therap.*, **2(1)**: 12.
- Kassahun, G., Tayelgn, S., and Addisu, M. (2017): Prevalence and Associated Risk Factors of Bovine Schistosomiasis in Northwestern Ethiopia. *World. Vet. J.*, **7**: 1-4.
- Kassew, A. (2007): Major Animal Health Problems of Marketing Oriented Livestock Development in Fogera Woreda, DVM Thesis, Addis Ababa University, Faculty of Veterinary Medicine, Debrezeit, Ethiopia. **Pp**, 4.
- Kebede, A., Dugassa, J., Haile, G., and Wakjira, B. (2018): Prevalence of Bovine of Schistosomiasis in and around Nekemte, East Wollega Zone, Western Ethiopia. **Pp**, 5
- Kebede, B., Boets, P., Tiku, S., Yeshigeta, M., Muleta, G., Ambelu, A., and Peter, L. (2020): Environmental and Biotic Factors Affecting Freshwater Snail Intermediate Hosts in the Ethiopian Rift Valley Region, **13**: 292.
- Kemal, J., and Terefe, Y. (2013): Prevalence of Gastrointestinal Parasitism of Cattle in Gedebano Gutazer Wolene District, Ethiopia. *J. Vet. Med. Anim. Health.*, **5(12)**: 365–370.
- Kerie, Y., and Seyoum, Z. (2014): Original Article Bovine and Ovine Schistosomiasis Prevalence and Associated Host Factors in Selected Sites of South Achefer District, Northwest Ethiopia, **46(4)**: 561–567.
- Khanjari, A., Bahonar, A., Fallah, S., Bagheri, M., Alizadeh, A. Fallah, M., and Khanjari, Z. (2014): Prevalence of Fasciolosis and Dicrocoeliosis in Slaughtered Sheep and Goats in Amol Abattoir, Mazandaran, Northern Iran. **Pp**, 4

- Khoramian, H., Arbabi, M., Osqoi, M., Delavari, M., Hooshyar, H., and Asgari, M. (2014): Prevalence of Ruminants' Fascioliasis and their Economic Effects in Kashan, Center of Iran. *Asi. Paci. J. Trop. Biomed.*, **4(11)**: 918–922.
- Kifleyohannes, T., Kebede, E., Hagos, Y., Weldu, K., and Michael, M. (2015): Prevalence of Paramphistomosis in Ruminants in Ashenge, Tigray Ethiopia. *Acta. Parasitol. Glob.*, **6(2)**: 83–86.
- Kitila, D., and Megerssa, Y. (2015): Pathological and Serum Biochemical Study of Liver Fluke Infection in Ruminants Slaughtered at Elfora Export Abattoir, Bishoftu, Ethiopia. *Glob. J. Med. Res.*, **Pp**, 2.
- Kloos, H., Lo, C., Birrie, H., Ayele, T., Tedla, S., and Tsegay, F. (1988): Schistosomiasis in Ethiopia. *Soc. Sci. Med.*, **26**:803–827.
- Lefevre, C., Blancou, J., Chermette, R. *et al.*, (2010): Infectious Disease of Livestock. 1st Ed. Paris. Lavoizer, **2**:1699- 1703.
- Lindbergh, R., Johansen, M., Nitsson, C., and Nansen, P. (2006): An Immunohistological Study of Phenotypic Characteristics of Cells of the Inflammatory Response in the Intestine of *Schistosoma Bovis* Infected Goats. *Parasitol.*, **118(1)**:91-99.
- Lopez, L., Romero, J., and Velasquez, L. (2008): Aislamiento De Paramphistomidae en vacas De leche en el Hospedador intermedio (*Lymnaea Truncatula* y *Lymnaea Columella*) En una Granja Del Tropic Alto En El Occidente de Colombia. *Revista Colombiana De Ciencias Pecuarias*, **21(1)**: 9–18.
- Love, S., (2017): A review on liver fluke. **Pp**, 6.
- Lulie, B., and Guadu, T. (2014): Bovine Schistosomiasis: A Threat in Public Health Perspective in Bahir Dar Town, Northwest, Ethiopia. *Acta. Parasitol. Glob.*, **5 (1)**: 1-6.
- Magona, J., and Musisi, G., (2002): Influence of Age, Grazing System, Season and Agro Climatic Zone on the Prevalence and Intensity of Gastrointestinal Strongylosis in Ugandan Goats. *Small Rumi. Res.*, **44**: 187-192.

- Malone, J., Gomes, R., and Hannen, J. *et al.*, (1989): Geographical Information System on The Potential Distribution and Abundance of *Fasciola Hepatica* and *Fasciola Gigantica* in East Africa Based on Food and Agriculture Organization Data Base. *Vet. Parasitol.*, **78**: 87-101.
- Mariam, G., Mohamed, T., Ibrahim, N., and Baye, D. (2014): Prevalence of Fasciolosis and Paramphistomosis in Dairy Farm and House Hold in Hawassa Town. *Euro. J. Biol. Sci.*, **6(2)**: 54–58.
- Martin, J., Anna, C., Cristian, L. *et al.*, (2008): A combined Strategy to Improve the Control Schistosomiasis in Areas of Low Prevalence in Brazil. *Anim. J. Trop. Med. Hyg.*, **78 (1)**: 14-146.
- McManus, D., Li, Y., Gray, D., and Ross, A. (2009): Conquering Snail Fever, Schistosomiasis and Its Control in China. *Exp. Rev. Antiinf. There.*, **7(4)**: 473-485.
- Melaku, A. (2010): Study on Prevalence and Economic Importance of Bovine Fasciolosis in three Districts of Northeast Amhara Region. DVM Thesis, Faculty of Veterinary Medicine, University of Gondar, Gondar, Ethiopia. **Pp**, 2
- Melaku, S., and Addis, M. (2012): Prevalence and Intensity of Paramphistomum in Ruminants Slaughtered at Debrezeit Industrial Abattoir, Ethiopia. *Glob. Vet.*, **8(3)**: 315–319.
- Mersha, C., Belay, D., and Tewodros, F. (2012): Prevalence of Cattle Schistosomiasis and Associated Risk Factors in Fogera Cattle, South Gondar Zone, Amhara National Regional State, Ethiopia. *J. Adv. Vet. Res.*, **2**: 53-56.
- Meshesha, M. and Tesfaye, W. (2017): Prevalence of Fasciolosis in Cattle Slaughtered at Hosanna Municipal Abattoir, Southern Ethiopia. *Int. J. Adv Res. Biol. Sci.*, **4(2)**: 40–46.
- Metro area population of Mekele, (2020): Summary and Statistical Report of the 2020 Population and Housing Census Mekele, Ethiopia Metro Area Population. **Pp**, 1950-2021.
- Mohammad, A., and Waqtola, C. (2006): Medical Parasitology Jimma University, Ethiopia. **Pp**, 284-300.

- Molyneux, D. (2014): Neglected Tropical Diseases, Now More Than Just Other Diseases. *Int. Health.*, **6**: 172–180.
- Mulat, N., Basaznew, B., Mersha, C., Achenef, M., and Tewodros, F. (2011): Comparison of Coprological and Post-mortem Examinations Techniques for the Determination of Prevalence and Economic Significance of Bovine Fasciolosis, **2**: 18-23.
- Nathan, Y., Tian, T., Webster, B., *et al.*, (2019): Molecular Characterization and Distribution of *Schistosoma Cercariae* Collected from Naturally Infected Bulinid Snails in Northern and Central Côte d' Ivoire', *Para. Vec. BioMed.*, **Pp**, 1–10.
- Nebi, H., Solomon, M., and Berhanu, M. (2018): Major Trematodes of Cattle Slaughtered at Hirna Municipal Abattoir Prevalence, Associated Risk Factors and Test Agreement of Sedimentation Technique in Ethiopia, Ministry of Livestock Development and Fisheries, Ethiopia School of Veterinary Medicine, Hawassa University, **10(4)**: 51-57
- Negassa, A., Rashid, S., and Gebremedhin, B. (2011): Livestock Production and Marketing, Addis Ababa, Ethiopia: International Food Policy Research Institute/Ethiopia Strategy Support Program II. **Pp**, 5.
- Negero, J. (2017): Review on Bovine Schistosomiasis with Due Emphasis on Its Epidemiology. *J. Biol. Agri. Health.*, **7(3)**: 33–43.
- Niaz, S., Tanveer, A., and Qureshi, A. (2010): Prevalence of Schistosomiasis in Cows and Buffaloes at Different Sites of Punjab, Pakistan and Its Relation to Temperature, Relative Humidity, Rainfall and Pan Evaporation. *Pak. J. Sci.*, **62 (4)**: 242-249.
- Nicholson, M., and Butterworth, M. (1986): A guide to Body Condition Scoring of Zebu Cattle, International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia, **Pp**, 45-48.
- Nzalawahe, J., Kassuku, A., Stothard, J., Coles, G., and Eisler, M. (2014): Trematode infections in cattle in Arumeru District, Tanzania associated with irrigation. *Para. Vec.*, **7**: 107.
- Ortiz, P., Scarcella, S., Cerna, C., Rosales, C., Cabrera, M., Guzm, M., Lamenza, P., and Solana, H. (2013): Resistance of *Fasciola Hepatica* against Triclabendazole in Cattle in Cajamar

- ca (Peru), a Clinical Trial and an in Vivo Efficacy Test in Sheep. *Vet. Parasitol.*, **195**:118-121.
- Pawar, P., Singla, L., Kaur, P., and Bal, M. (2016): Caprine Schistosomiasis Prevalence and Associated Host Factors in Barnala District of Punjab State. **Pp**, 4
- Peters, W., and Gilles, H. (1989): A colour Atlas of Tropical Medicine and Parasitology. 3th Ed. London. **Pp**, 240.
- Phiri, A., Phiri, I., Sikasunge, C., and Monrad, J. (2005): Prevalence of Fasciolosis in Zambian Cattle Observed at Selected Abattoirs with Emphasis on Age, Sex and Origin. *J. Vet. Med.*, **52**:414-416.
- Pruss-Ustun, A., Kay, D., Fewtrell, L., and Bartram, J. (2004): Unsafe Water Sanitation and Hygiene. Comparative Quantification of Health Risks. Geneva, World Health Organization. **Pp**, 2
- Pyron, M., and Brown K. (2015): Introduction to Mollusca and the Class Gastropoda Invertebrates, Cambridge. **Pp**, 383–421.
- Ramajo, V., Oleaga, A., Casanueva, P., Hillyer, G., and Mum, A. (2001): Vaccination of Cattle against *Fasciola Hepatica* with Homologous Fatty Acid Binding Proteins. *Vet. Parasitol.*, **97**: 35-46.
- Rehman, T., Khan, M., Sajid, M., and Javed, M. (2013): Slaughter House Based Epidemiology and Estimation of Economic Losses of Bovine Fascioliasis in Tehsil Sargodha. *Pakis. J. Sci.*, **Pp**, 65.
- Richer, R. (2003): The Impact of Chemotherapy on Morbidity due to Schistosomiasis. *Acta Trop.*, **86 (2-3)**: 161.
- Robinson, M., and Dalton J. (2009): Zoonotic Helminthes Infections with Particular Emphasis on Fasciolosis and other Trematodiasis, *Philosophical Transactions of the Royal Society*, **364**: 2763-2776.

- Rodríguez-Vivas, R., Grisi, L., *et al.*, (2017): Potential Economic Impact Assessment for Cattle Parasites in Mexico. Review, *Revista Mexicana De Ciencias Pecuarias*, **8(1)**: 61–74.
- Rolfe, P., Boray, J., Nichols, P., and Collins, G. (1991): Epidemiology of Paramphistomosis in Cattle. *Aust. Vet. J.*, **21**: 813-819.
- Rolfe, F., Boray, C., and Collins, H. (1994): Pathology of Infection with *Paramphistomum Ichikawai* in Sheep, *Int. J. Parasitol.*, **24**: 995-1004.
- SAERT, (2004): Sustainable Agricultural and Environmental Rehabilitation programme In Tigray (SAERT): Statistical Master-Book of Tigray, **1**: 2
- Samrawit, M. (2016): Study on Prevalence and Associated Risk Factors of Bovine and Human Schistosomiasis in Bahir Dar and Its Surrounding Areas. *J. Anim. Res.*, **6**: 967-975.
- Shibru, T., Getachew, T., and Hailu, B. (1989): *Schistosoma* Bovis Infection in Bahir Ddar Area and North Central Ethiopia. DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University. **Pp**, 18-26.
- Sintayehu, M., and Mekonnen, A. (2012): Prevalence and Intensity of Paramphistomum in Ruminants Slaughtered at Debrezeit Industrial Abattoir, Ethiopia. *Glob. Vet.*, **8(3)**: 315-319.
- Smits, H. (2009): Prospects for the Control of Neglected Tropical Diseases by Mass Drug Administration. *Exp. Rev. Anti-inf. Thera.*, **7(1)**:10.
- Smyth, J. (2005): *Animal Parasitology*. Cambridge University Press. 3rd Ed. London. **Pp**, 236.
- Smith, P. (2009): *Large Animal Internal Medicine*. 4th Ed. St. Louis: Mosby Elsevier. **Pp**, 905-910.
- Soldánová, M., Selbach, C., Kalbe, M., Kostadinova, A., and Sures, B. (2013): Swimmer's Itch Etiology, Impact, and Risk Factors of Schistosomiasis in Europe. *Tre. Parasitol.*, **29**:65–74.
- Solomon, O. (2008): Observations on the Prevalence of *Schistosoma* Bovis Infection in Bahir Dar Area, North Central Ethiopia. DVM Thesis, Faculty of Veterinary Medicine, Mekele University, Ethiopia. **Pp**, 2.

- Solomon, W., and Abebe, W. (2007): Effects of A strategy Antehelmtic Treatment Intervention Bovine Fasciolosis in Endemic Area in North Western Ethiopia. *Vet. J.*, **11(2)**:59-68.
- Soulsby, E. (1982): Helminthes, Arthropods and Protozoa of Domesticated Animals. London. Bailliere Tindal. **Pp**, 136-160.
- Soulsby, E., (2006): Helminths, Arthropods, and Protozoas of Domestic Animals. 7th Ed. London . **Pp**, 72.
- Springer, V. (2001): Taxonomic Ranks under Review. Available at: <http://parasite.org.au/parasite/text/schistosoma-text.html>. **Pp**, 2
- Sripalwit, P., Wongsawad, C., Wongsawad, P., and Anuntalabhochai, S. (2007): High Annealing Temperature Random Amplified Polymorphic DNA Analysis of three Paramphistome Flukes from Thailand. *Exp. Parasitol.*, **115(1)**: 99-102.
- Steinmann, P., Keiser, J., Bos, R., Tanner, M., and Utzinger, J. (2009): Schistosomiasis and Water Resources Development: Systematic Review, Meta-analysis, and Estimates of People at Risk. *Lan. Infe. Dis.*, **6**:411–425.
- Stothard, J., Chitsulo, L., Kristensen, T., and Utzinger, J. (2009): Control of Schistosomiasis in Sub-Saharan Africa: Progress made new Opportunities and Remaining Challenges. *Parasitol.*, **136**:1665–1675.
- Taye, M., Jagema, T., Tadese, A., Mulatu, E., and Lelisa, K. (2016): Study of Ruminant Fasciolosis in Selected Districts in Upper Awash River Basin, South Western Shoa, Ethiopia. *J. Vet. Sci. Technol.*, **7(5)**: 1.
- Taylor, M., Coop, R., and Wall, R. (2016): Veterinary Parasitology 4th Ed. West Sussex, UK: Wiley Blackwell. **Pp**, 390–393.
- Telila, C., Abera, B., Lemma, D., and Eticha, E. (2014): Prevalence of Gastrointestinal Parasitosis of Cattle in East Showa Zone, Oromia Regional State, Central Ethiopia. *J. Vet. Med. Anim. Health.*, **6(2)**: 54–62.

- Thrusfield, M. (2005): Survey in Veterinary Epidemiology 2nd Ed. Cambridge: Blackwell Science
Spatial Analysis of Livestock Production Patterns in Ethiopia. Addis Ababa, Ethiopia:
International Food Policy Research Institute/Ethiopia Strategy Support Program II. **Pp**,
182-189.
- Tilahun, H., and Schmidt, E. (2012): Spatial Analysis of Livestock Production Patterns in
Ethiopia. Addis Ababa, Ethiopia: International Food Policy Research Institute/Ethiopia
Strategy Support Program II. **Pp**, 2.
- Tilahun, Z., Nemomsa, A., Haimanot, D., and Girma, K. (2014): Study on Prevalence of Bovine
Fasciolosis at Nekemte Veterinary Clinic, East Wollega Zone, Oromia, Ethiopia, *Euro.
J. Biol. Sci.*, **6 (2)**: 40-45,
- Tolosa, T., and Tigre, W. (2007): The Prevalence and Economic Significance of Bovine Fasciolo
sis at Jimma Abattoir, Ethiopia. *Int. J. Vet. Med.*, **3(2)**: 2.
- Tsegaye, B., Abebaw, H., and Girma, S. (2012): Study on Coprological Prevalence of Bovine Fa
sciolosis in and around Woreta, Northwestern Ethiopia. *J. Vet. Med. Anim. Health.*, **4(7)**:
89–92.
- Urquhart, G., Armour, J., Duncan, J., Dunn, A., and Jennings, F. (1996): Veterinary Parasitology
2nd Ed. Harlow, UK: Black well science. **Pp**, 102–120.
- Urquhart, G., Armour, J., Duncan, J., Dunn, A., and Jennings, F. (1997): Veterinary Helmintholo
gy, Veterinary Parasitology. New York: Churchill Livingstone Inc. **Pp**, 114-116.
- Urquhart, G., Armour, J., Duncan, J., Dunn, A., and Jennings, F. (2003): Veterinary Parasitology
. 2nd Ed. Scotland, Black well science, **277**: 117-120.
- Vanleeuwen, J., Tolosa, T., Sirak, A., Nemera, M., and Belaineh. (2014): Seroprevalence of Myc
obacterium Avium Ssp Paratuberculosis Infection in Ethiopian Dairy Farms. *Bulletin.
Anim. Health. Pro. Afri.*, **62**: 95–100.
- Vercruyse, J., and Claerebout, E. (2001): Treatment vs Non-treatment of Helminth Infections in
Cattle: Defining the Threshold. *Vet. Parasitol.*, **98(1)**:195-214

- Vercruyse, J., and Gabriel, S. (2005): *Parasite Immunology*, **27**: 289–295
- Walker, S., Makundi, F., Namuba, A., Kassuku, J., Keyyu, E., Hoey, P., Prodohl, J., Stothard and Trudgett, A. (2008): The Distribution of *Fasciola Hepatica* and *Fasciola Gigantic* with in Southern Tanzania Constraints Associated with the Intermediate host. *Parasitol.*, **135**: 495-503.
- WHO, (2010): Prevention and Control of Schistosomiasis and Soil-Transmitted Helminthiasis, WHO Technical Report Series, Geneva. Pp, 6
- WHO, (2010): Working to overcome the Global Impact of Neglected Tropical Diseases. The first WHO Report on Neglected Tropical Diseases, Geneva. **Pp**, 2.
- WHO, (2008): Drug Development and Evaluation for Helminths and other Neglected Tropical Diseases in Geneva. **Pp**, 4.
- Wright, W., (2015): A Consideration of the Economic Impact of Schistosomiasis. *Bull World Health.* **Pp**, 3.
- Yassin, M., Abera, B., and Berhanu, B. (2017): The Prevalence of Bovine Fasciolosis and Its Associated Risk Factor in Tullo District, West Hararghe Zone, Oromia Regional State, Eastern Ethiopia. *Acta. Parasitol. Glob.*, **8 (3)**: 124-129.
- Yeneneh, A., Kebede, H., Fentahun, T., and Chanie, M. (2012): Prevalence of Cattle Flukes Infection at Andassa Livestock Research Center in North-West of Ethiopia. *Vet. Res. Forum.*, **3(2)**: 85–89.
- Yohannes, M., Birasa, D., Damena, D., Tasew, S., and Degefu, H. (2013): Bovine Trypanosomosis and Gastrointestinal Helminthosis in Settlement Villages of Bedele District, South-Western Ethiopia. *Ethiop. Vet. J.*, **17(1)**: 41–45.
- Yusuf, M., Ibrahim, N., Tafese, W., And Deneke, Y. (2016): Prevalence of Bovine Fasciolosis in Municipal Abattoir of Haramaya, Ethiopia, Jimma University, School of Veterinary Medicine, **48**: 2224-6088.

- Yusuf, Z., Dagne, K., Erko, B., and Siemuri, O. (2017): Polyploidy in Bulinid Snails, with Emphasis on *Bulinus Truncatus/Tropicus* Complex (Planorbidae: Pulmonate Mollusks) From Various Localities in Ethiopia. *World. J. Cell Biol Gen.*, **3**:11–20.
- Zangana, I., and Aziz, K. (2012): Prevalence and Pathological Study of Schistosomiasis in Sheep in Akra/Dohuk Province, Northern Iraq. *J. Vet. Sci.*, **26**: 125-130.
- Zhong, Z., Zhou, H., Li, X., Luo, Q., Song, X., Wang, W. *et al.*, (2010): Serological Proteome-Oriented Screening and Application of Antigens for the Diagnosis of Schistosomiasis Japonica. *Acta. Trop.*, **116**: 1–8.
- Zhou, X., Guo, J., Kun, Y. *et al.*, (2008): Potential Impact of Climate Change on Schistosomiasis Transmission in China. *Trop. Med. Hyg.*, **78 (2)**: 188-194.

8. ANNEXES

Annex 1: Interview format to assess the public and economic importance of bovine trematodes (in English version)

A/ Socio-demographic characteristic

Name of farmer _____

District/woreda _____

Rural Kebele _____

Name of river or dam _____

Respondent
descriptions _____

B/ Farming system and Livestock management in the area

1. For how long have you been living in this area?

A/ less than 1 year _____ B/ 1 to 5 years _____

C/ for 5 to 10 years _____ D/ greater than 10 years _____

2. On which type of farming does your livelihood depend?

A/ crop production only _____

B/ livestock rearing only _____

C/ both livestock rearing and crop production _____

D/ others /specify/ _____

3. When did you start farming in the area? Specify _____

4. Which livestock species are you rearing currently?

A/ Cattle _____ B/ Sheep and goat _____

C/ Equine _____ D/ Others /specify _____

5. What are the major types of crops you are producing currently?

A/ Maize _____ B/ sorgum _____

C/ Teff _____ D/ ground nut _____

E/ pea _____ F/ others/ specify/ _____

6. What inputs do you need for your agricultural activity?

A/ land _____ B/ livestock _____

C/ seed _____ D/Fertilizers _____

E/ others/specify/ _____

7. Which species of livestock do you use for agricultural activity?

A/ cattle _____ B/ donkey _____

C/ others _____

8. What is the management system of livestock especially cattle?

A/ Communal and free grazing _____ B/ Private and free grazing _____

C/ Zero grazing _____ D/ others _____

If the answer for question number 8 above is A so should be answered the following questions ,

9. Where is the grazing and watering point?

A/ near and around the dam or river _____

B/ far away from the dam or river _____

10. When does water scarcity occurs?

A/ shortly after rainy season _____ B/ during dry season _____

C/ during the rainy season _____ D/ throughout the year _____

C/ Major Constraints of livestock and agricultural activities

1. What are challenges of agricultural activity in your locality?

A/ lack of arable land _____ B/ lack of draft power _____

C/ drought _____ C/ others _____

2. What are the major constrains of livestock production in your locality?

A/ livestock diseases _____ B/ lack of grazing land _____

C/ lack of drinking water _____ . D/ others _____

3. List some of the most common diseases affecting your livestock in your area?

A/ _____

B/ _____

C/ _____

4. Are there bovine trematodes in your locality/area?

A/ Yes _____ B/ No _____

5. If the answer for question number four is yes what are the common clinical signs of bovine trematodes?

6. What is the local name of the diseases/ bovine trematodes? _____

7. Which species of livestock is most affected by the diseases/bovine trematodes?

A/ Cattle _____ B/ goats _____

C/ sheep _____ D/ Others _____

8. If the answer for number seven is cattle how many cattle did you lose last year?

9. How many of the cattle do you think is due to trematodes? _____

10. At which time the diseases most frequent?

A/ shortly after rainy season _____ B/ during dry season _____

C/ during the rainy season _____ D/ similar throughout the year _____

11. What are the possible sources of bovine trematodes?

A/ Watering point _____ B/ Grazing point _____

C/ new introduction of animals _____ D/ marketing _____

12. What do you think the current status of bovine trematodes?

A/ decreasing _____ B/ increasing _____

C/ no change _____

13. What do you think the transmitter of trematodes?

A/ snails _____ B/contaminated water _____

C/ contaminated grazing land _____ D/ others _____

E/ unknown _____

If the answer for question number 13 is A,

14. What is the local name of snails? _____

15. When do you think these snails most abundant?

A/ shortly after rainy season _____ D/ during dry season _____

C/ during the rainy season _____ E/ similar throughout the year _____

16. What do you think about the impact of the diseases?

A/ production loss due to morbidity of animals _____ B/ loss due to mortality of animals _____

C/ lack of draft power _____

D/ cost of treatment of sick animal _____

E/ cost of chemicals to prevent/control the snails _____

F/ others _____

17. Are trematodes transmitted to humans (zoonosis)?

A/ yes _____ B/ no _____

If the answer for question number 17 is A so answer the following questions.

18. How many peoples were sick by bovine trematodes? _____

19. Are there any people dead due to bovine trematodes?

A/ yes _____ B/ no _____

20. If yes how many peoples died last year? _____

21. Frequency of treating animals annually?

A/ once a year _____ B/ twice a year _____

C/ thrice a year _____ D/ four times a year _____

E/ more than four times a year _____

22. How much do you pay to treat your animal at a time on average? _____

23. How much do you pay in birr for treating your animals annually? _____

24. Main control measures of the diseases in your locality?

A/ treatment of sick animals _____

B/ control of snails _____

C/ providing animals with adequate water _____

D/ others _____

25. Estimated annual cost in birr for chemicals to prevent/control the disease? _____

26. Where do you treat your animals?

A/ government veterinary clinics _____

B/ private veterinary clinic _____

C/ others _____

27. Who are giving treatment for your animals?

A/ Veterinarians _____ B/ Animal health assistant _____

C/ Experienced villager _____ D/ yourself _____

E/ others _____

28. What is the name of the drugs most commonly used in the area? _____

29. Is the treatment effective against the disease? A/ yes _____ B/ no _____

If the answer for question number 29 is no so answer question number 30.

30. What do you think is the reason behind this? _____

31. Where do you get the drugs?

A/ veterinary Pharmacy _____ B/ government veterinary clinic _____

C/ others/ specify _____

32. Is there any traditional method to control and prevent the diseases?

A/ yes _____ b/ no _____

30. If the answer for question number 32 is yes, mention some of the methods

A/ _____

B/ _____

Thank you so much!

Name of the RK _____ Name of interviewer _____

Signature _____ Date _____

Annex 2: Interview format to assess the public and economic importance of bovine trematodes (in Tigrigna version)

1. ከባቢያዊ መግለጻዊ

ናይ ሓረስታይ ስም _____

ወረዳ _____

ጣብያ _____

ቁጽጽ _____

ናይ ቆላይ ወይ ፍባ ስም _____

ናይ ተጠያቂ

መግለጻዊ _____

2. ሕርሻን እንስሳትን አታላሕዛ መንገድታት

1. ንክንደይ ዓመታት ኣብዝይ ከባቢ ነቢሮም?

ሀ/ ትሕቲ ሓደ ዓመት

ሐ/ ከብ ሓሙሽተ ክሳብ ዓሰርተ ዓመታት

ለ/ ከብ ሓደ ክሳብ ሓሙሽተ ዓመታት

መ/ ልዕሊ ዓሰርተ ዓመት

2. መናባብሮኩም ኣብ እንታይ ዓይነት ሕርሻ ዝተደረከ እዩ?

ሀ/ ኣብ ዝራእቲ

ሐ/ ኣብ ክልቲኡ

ለ/ ኣብ ምርባሕ እንስሳት

መ/ ኣብ ካሊእ

3. ናይ ሕርሻ ስራሕቲ ኣብዚ ከባቢ እዚ መዓዝ ጀሚርኩምዎ? _____

4. ኣብዚ ሓዚ እዋን ኣየናይ ናይ እንስሳት ዘርኢ ትንከባከቡ?

ሀ/ ከኣብቲ

ሐ/ ካሊእ _____

ለ/ ኣእዱግ

5. ኣብዚ ሓዚ እዋን እንታይ ዓይነት ዘራእቲ ተምርቱ?

ሀ/ ስገም

ሐ/ መሸለ

ለ/ ጣፍ

መ/ ካሊእ

6. ንግብርና ስራሕቲ ኣየናይ ግብኣት ትጥቀሙ?

ሀ/ ግራት

ሐ/ ከብቲ

ለ/ መዳበርያ

መ/ ካሊእ

7. ኣብዚ ሓዚ እዋን ኣየናይ ናይ እንስሳት ዘርኢ ንግብርና ስራሕቲ ትጥቀሙ?

U/ ከአብቲ

ሐ/ ካሊእ_____

ለ/ አእዱግ

8. ን ከብቲ እንታይ ዓይነት ኣታሓላለልዎ ትጥቀሙ?

U/ ስዲ ምግሃፅ

ሐ/ ሓበራዊ ምግሃፅ

ለ/ ግላዊ

መ/ ሀን ሐ

እንድሕር መልሲ ናይ ቁፅረ 8 መ ኢልኩም እዞም ዝስዕቡ ሕቶታት መልሱ

9. ኣበይ ኣከባቢ ይግህፁን ማይ ይሰትዩን?

U/ ኣብ ጥቃ ቃላይ ወይ ፍባ

ለ/ከብ ቃላይ ወይ ፍባ ብምርሓቕ

10. ማይ ሕፅረት መዓዝ የጋጥም?

U/ ድሕሪ ክረምቲ ኣብ ሓፅር ግዜ

ሐ/ ኣብ እዋን ሓጋይ

ለ/ ኣብ እዋን ክረምቲ

መ/ ኩሉ ግዜ

3. ግብርና ስራሕቲ ንምስራሕ ዘጋጥሙ ዋና ፀገማት

1. ኣብ ከባቢኩም ግብርና ስራሕቲ ንምስራሕ ዘጋጥሙ ፅዕንቶታት ኣየኖት እዮም?

U/ ፅበኣት መሬት

ሐ/ ካሊእ

ለ/ ሕፅረኣት እንስሳት

መ/ ድርቁ

2. ኣብ ከባቢኩም ንምርባሕ ከብቲ ዘጋጥሙ ዋና ፀገማት ኣየኖት እዮም?

U/ ናይ ከብቲ ሕማም

ሐ/ ሕፅረት ዝስተ ማይ

ለ/ ሕፅረት ዝግሃፅ መሬት

መ/ ካልእ

3. ኣብ ከባቢኩም ን ከብቲ ዘጥቅዑ ዋና ሕማማት ዘርዝሩ?

U/ _____

ለ/ _____

ሐ/ _____

4. አብ ከባቢኩም “trematodes” ዝበሃሉ ናይ ከብቲ ሕማማት ኣለዉ ዶ?

U/ ኣሎ

ለ/ የለኣን

እንድሕር መልሲ ናይ ቁፅረ 4 ኣሎ ኢልኩም እዞም ዝስዕቡ ሕቶታት መልሱ?

5. ልሙዳት ምልክታት እቶም ሕማማት እንታይ እዮም?

6. ብከባቢኩም እቶም ሕማማት እንታይ ተባሂሎም ይፍለጡ?

7. እቶም ሕማማት ብበዝሒ ን መን የጥቅዑ?

U/ ን ከብቲ

ሐ/ ን ኣጣሊ

ለ/ ን ኣባጊዕ

መ/ ን ካልኣት

8. እንድሕር መልሲ ናይ ቁፅረ 7 U ኢልኩም ክንደይ ዝኣክላ ከብቲ ኣብ ዝሓለፈ ዓመት መይተን /ቶም?

9. እቶም ሕማማት ብበዝሒ መዓዝ የጋጥሙ?

U/ ድሕሪ ክረምቲ ኣብ ሓፀር ግዜ

ሐ/ ኣብ እዋን ሓጋይ

ለ/ ኣብ እዋን ክረምቲ

መ/ ኩሉ ግዜ

10. መንቀሊ ናይ እቶም ሕማማት እንታይ እዩ?

U/ ዝስተ ማይ

ሐ/ ምእታው ሓደሽቲ እንስሳት

ለ/ ዝግሃፅ መሬት

መ/ ዕዳጋ

11. አብሂ ሐዚ እዋን እቶም ሕማማት ከመይ ኣለዉ?

ሀ/ እናወሰከ

ሐ/ ለውጢ የብሉን

ለ/ እናቀነሰ

12. እቶም ሕማማት ብምንታይ ይመሓለሉ?

ሀ/ “snails”

ሐ/ ዝተበላሸወ ዝግሃፅ መሬት

ለ/ ዝተበላሸወ ማይ

መ/ ካሊእ

እንድሕር መልሲ ናይ ቁፅረ 12 ሀ ኢልኩም እዞም ዝስዕቡ ሕቶታት መልሱ

13. ብከባቢኩም “snail” እንታይ ተባሂሉ ይፅዋዕ? _____

14. እቲ “snail” ብበዝሒ መዓዝ የጋጥም?

ሀ/ ድሕሪ ክረምቲ ኣብ ሓፀር ግዜ

ሐ/ ኣብ እዋን ሓጋይ

ለ/ ኣብ እዋን ክረምቲ

መ/ ኩሉ ግዜ

15. እቶም ሕማማት ዘምፅእዎ ፅዕንቶ እንታይ እዩ?

ሀ/ ምቅናስ እቶት ብምክንያት ምሕማም እንስሳት

ሐ/ እንስሳት ንምሕካም እነውፅኡ ወፃኢ

ለ/ ምቅናስ እቶት ብምክንያት ምማት እንስሳት

መ/ መከላከሊ መድሓኒት ንምዕዳግ

እነውፅኡ ወፃኢ

ረ/

ካሊእ _____

16. እቶም ሕማማት ካብ እንስሳት ናብ ሰብ ይመሓለሉ ዶ?

ሀ/ ይመሓለሉ

ለ/ ኣይመሓለሉን

እንድሕር መልሲ ናይ ቁፅረ 16 ሀ ኢልኩም እዞም ዝስዕቡ ሕቶታት መልሱ

17. ክንደይ ዝኣክሉ ሰባት በቶም ሕማማት ተታሒዞም? _____

18. ብምክንያት እዞም ሕማማት ዝመቱ ሰባት ኣለዉ ዶ?

ሀ/ እዉ

ለ/ የለዉን

19. እንድሕር መልሲ ናይ ቁፅረ 16 ሀ ኢልኩም ክንደይ ዝኣክሉ ሰባት ኣብዝሓለፈ ዓመት ሞይቶም? _____

20. እንስሳትኩም ኣብ ዓመት ክንደይ ግዜ ተሓክምዎም?

ሀ/ ሓደ ግዜ ኣብ ዓመት

ሐ/ ሰለስተ ግዜ ኣብ ዓመት

ለ/ ክልተ ግዜ ኣብ ዓመት

መ/ ልዕሊ ሰለስተ ግዜ ኣብ ዓመት

21. ኣብ ሓደ ግዜ እንስሳትኩም ንምሕካም ክንደይ ወፃኢ ተውፅኡ? _____

22. ኣብ ዓመት እንስሳትኩም ንምሕካም ክንደይ ወፃኢ ተውፅኡ? _____

23. ኣብ ከባቢኩም ዋና መከላከሊ መንገድታት እቶም ሕማማት እንታይ እዩ?

ሀ/ ምሕካም ዝሓመሙ እንስሳት

ሐ/ ምውሃብ ፅፍይ ዝስተ ማይ

ለ/ ምክልካል “snails”

መ/ ካሊእ

24. ኣብ ዓመት ክንደይ ዝኣክል ቅርሺ ንመዓደጊ መከላከሊ መድሓኒታት እቶም ሕማማት ተውፅኡ?

25. እንስሳትኩም ኣበይ ተሓክምዎም?

ሀ/ ኣብ መንግስታዊ ናይ እንስሳት ጥዕና ጣብያ

ሐ/ ካሊእ _____

ለ/ ኣብ ግላዊ ናይ እንስሳት ጥዕና ጣብያ

26. እንስሳትኩም መን ይሕክመልኩም?

ሀ/ ናይ እንስሳት ጥዕና ብዓል ሞያ

ሐ/ በዓልኩም

ለ/ ብ ልምዱ ዘለዎ ሰብ

መ/ ካሊእ

27. ኣብ ከባቢኩም እቶም ሕማማት ንምሕካም እትጥቀምሉ መድሓኒት እንታይ ይበሃል? _____

28. እቲ መድሓኒት ነቶም ሕማማት ብትክክል የድሕኖም ዶ?

ሀ/ እወ

ለ/ ኣየድሕኖን

29. እንድሕር መልሲ ናይ ቁፅሪ 28 ለ ኢልኩም ምክንያቱ እንታይ ይከውን ኢልኩም ትሓስቡ?

30. ባህላዊ መከላከሊ መንገድታት እቶም ሕማማት ኣለዉ ዶ?

ሀ/ እወ

ለ/ የለን

31. እንድሕር መልሲ ናይ ቁፅሪ 30 ለ ኢልኩም ዝተወሰኑ ዘርዝሩ?

ክብረት ይሃበለይ!!!!

ናይ ቁሽት ስም _____ ናይ ሓታቲ ስም _____

ፍርማ _____

ዕለት _____

Annex 3: Morphology of trematodes egg

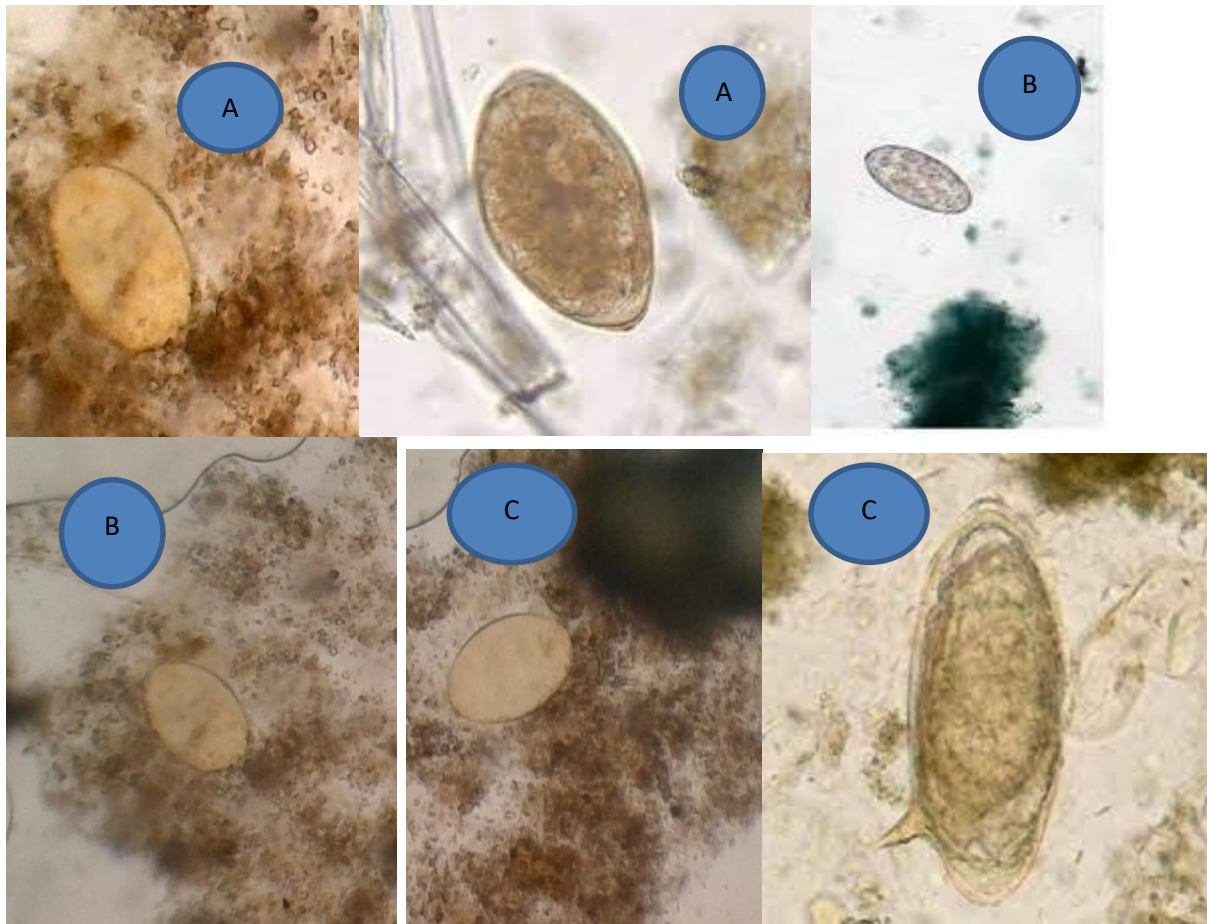


Figure 4: Eggs of trematodes demonstrated on fresh fecal samples (A) *Fasciola*, (B) *Paramphistomum* and (C) *Schistosoma* eggs with terminal spines.

Annex 4: Morphology of adult trematodes from abattoir

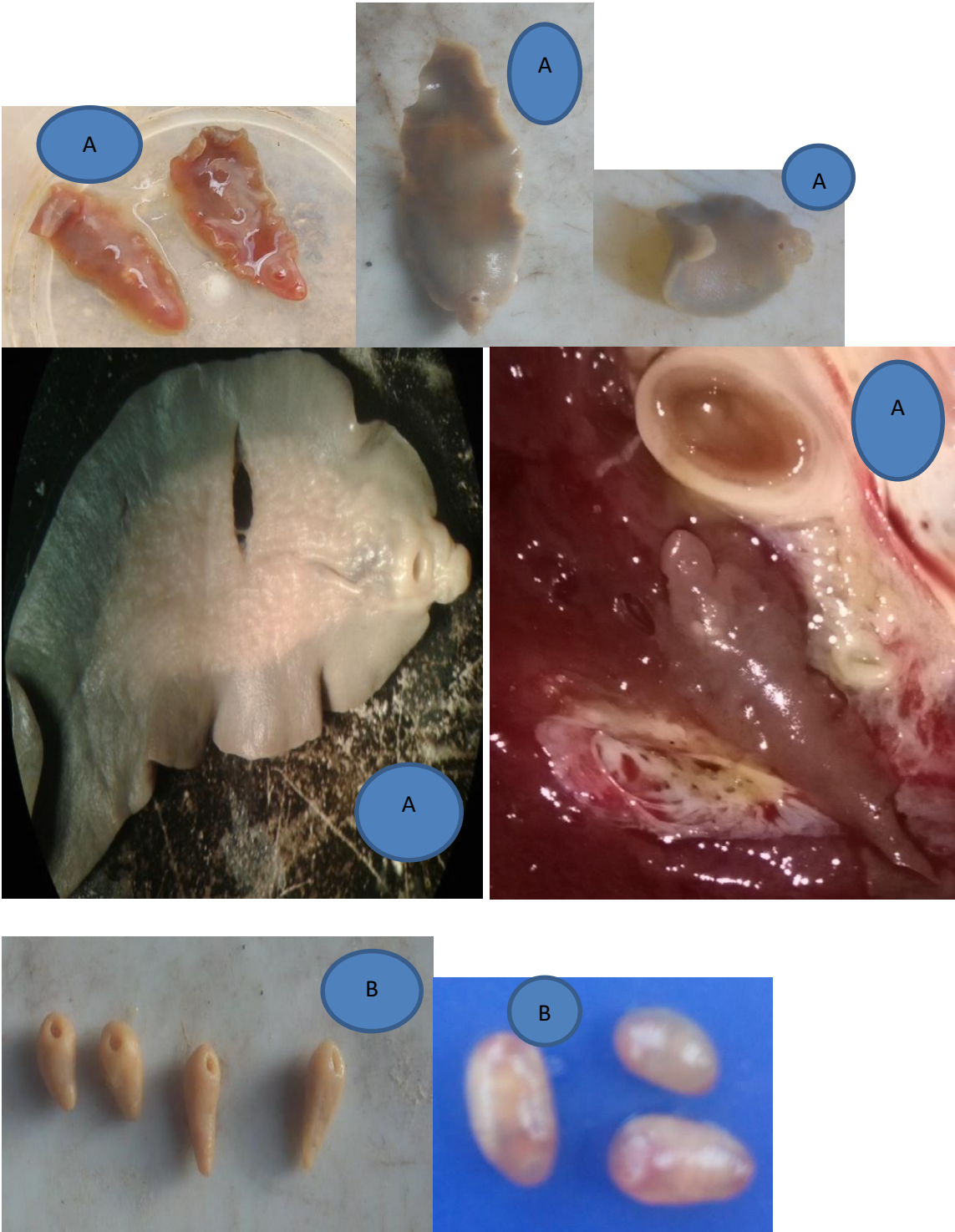
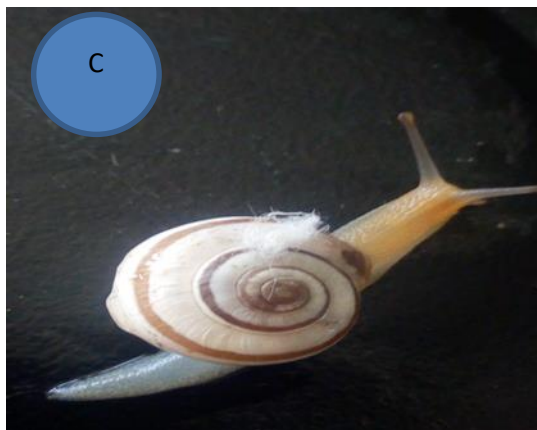
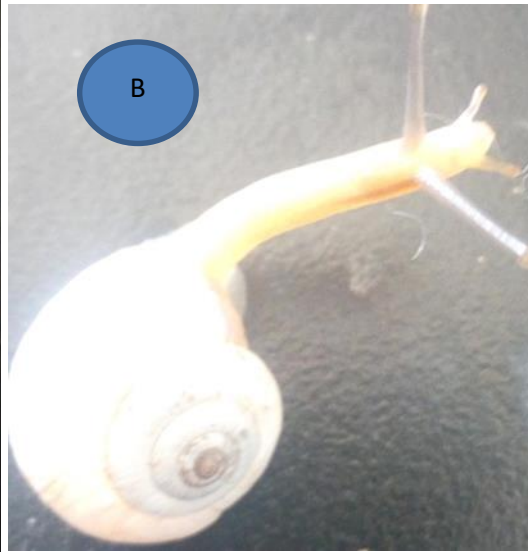




Figure 5: Morphology of adult *Fasciola* (A), *Paramphistomum* (B) and *Schistosoma* (C) from abattoir

Annex 5: Morphology of snails collected from Rivers, dams and swampy areas of the study areas.



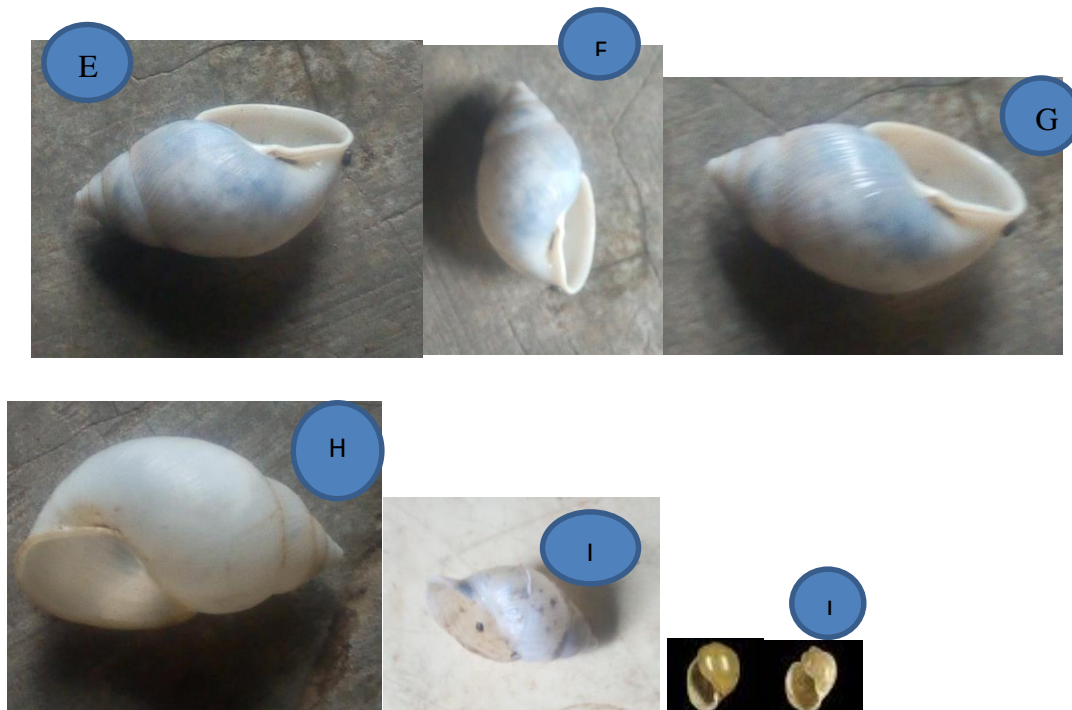


Figure 6: Morphology of snails collected and identified from dams, Rivers and swampy areas of the study areas. A-D Morphology of *Biomphalaria* spp, E-G morphology of *Lymnaea* spp and H-J morphology of *Bulinus* spp

Annex 6: Sources of infection sites of the study areas





Figure 7: Possible sources of infection sites of bovine trematodes in both study areas