ADDIS ABABA UNIVERSITY

FACULTY OF VETERINARY MEDICINE

CURRENT EPIDEMIOLOGICAL SITUATION OF BOVINE TRYPANOSOMOSIS IN LIMU SHAY TSETSE CONTROLLED AREA OF UPPER DIDESSA VALLEY

By

FEYESA REGASSA

JUNE, 2004

DEBRE ZEIT, ETHIOPIA

ADDIS ABABA UNIVERSITY

FACULTY OF VETERINARY MEDICINE

CURRENT EPIDEMIOLOGICAL SITUATION OF BOVINE TRYPANOSOMOSIS IN LIMU SHAY TSETSE CONTROLLED AREA OF UPPER DIDESSA VALLEY

A Thesis submitted to the Faculty of Veterinary Medicine, Addis Ababa University in partial fulfillment of the requirements for the Degree of Master of Science in Tropical Veterinary Epidemiology

By

FEYESA REGASSA

JUNE 2004

DEBRE ZEIT, ETHIOPIA

CURRENT EPIDEMIOLOGICAL SITUATION OF BOVINE TRYPANOSOMOSIS IN LIMU SHAY TSETSE CONTROLLED AREA OF UPPER DIDESSA VALLEY

BY

FEYESA REGASSA

Board of Examiners:	Signature
1. Pro. Ph. Dorchies	
2. Prof. Feseha Gebreab	
3. Dr Wondwossen Abebe	
4. Dr Giles Innocent	
5. Dr Andy Catley	
6. Dr David Barrett	

Academic Advisors:

1. Prof. Getachew Abebe

2. Dr. Arun K. Sangwan

DEDICATION:

This thesis paper is dedicated to my beloved wife Abinet Assefa, my daughter Ilili Feyesa and my son Samuel Feyesa.

CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF ANNEXES

LIST OF ABBREVIATIONS

AAT	African Animal Trypanosomosis
CFT	Complement Fixation Test
CI	Confidence Interval
DNA	Deoxyribo Nucleic Acid
EARO	Ethiopian Agricultural Research Organization
ELISA	Enzyme Linked Immuno-Sorbent Assay
FAO	Food and Agricultural Organization of the United Nations
FITCA	Farming in Tsetse Control Area
FLDP	Fourth Live stock Development Project
FTD	Fly per Trap per Day
ICIPE	International Centre for Insect Physiology and Ecology
ILCA	International Livestock Centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
ILRI	International Livestock Research Institute
ISCTRC	International Scientific Council for Trypanosomosis Research and control
Km^2	Square kilometer
NLDP	National Livestock Development Project
MOA	Ministry of Agriculture
MSc	Master of Science
NGO	Non Governmental Organization
NTTICC	National Tsetse & Trypanosomosis Investigation & Control Centre
OAU/IBAR	Organization of African Unity/ Inter-African Bureau for Animal Resources
OBAD	Oromia Bureau of Agricultural Development
PCV	Packed Cell Volume
PCR	Polymerase Chain Reaction
SIT	Sterile Insect Technique
Spp	Species
USD	United States Dollar

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my advisor Prof. Getachew Abebe for his unwavering guidance, advice and invaluable comments during my research work.

I would like also to express my grateful thanks to my second advisor Dr. A. K. Sangwan for the advice and comments he has given me in the process of my research work.

I am also grateful to Dr. Bayleyegn Molla, Associate Dean for Research and Graduate Studies for his invaluable assistance coordinating and guiding the MSc research work.

I would like to extend my gratitude to Dr. Miressa Keno FITCA National project Coordinator and Dr. Debebe Argago head of the NTTICC, Dr. Adugna Tadesse head of Bedelle zonal laboratory for providing the required facilities and manpower. I would like also to acknowledge the technical staff of the NTTICC for their hospitality and technical support in the field and laboratory during my research work. I would like also to note and thank for the contributions made by senior staff of Bedelle Regional laboratory.

My sincere gratitude is to Oromia Bureau of Agricultural Development for allowing and facilitating my MSc study.

My special thanks go my colleague Dr. Manyazewal Anberber and his family for his incredible help and friendship during my research work.

Iwould like also to thank Dr. Nesiru Hussen, Ato Girma Teshome, Ato Tadesse Sori, Ato Moti Cheru, Dr. Zenebech Fite and Dr. Birhanu Xilahun and Dr. Aster Tadesse for the technical help and encouragement they have given me.

The advice and encouragement given by my friend Dr. Getachew Gari is also acknowledged.

My appreciation and heart felt thanks go to my beloved wife Abinet Assefa mother of Ilili and Samuel, for her prayer, encouragement and advice given to me during my research work.

I would like also to thank organizations, institutions and individuals who directly or indirectly helped me in my MSc research study with out which this research work would have not been possible

Above all, thanks go to the almighty God, who helps me always.

ABSTRACT

Trypanosomosis is one of the most devastating diseases, which afflict both people and animals in Africa. The Ethiopian government is placing a great emphasis on tsetse control activities. The control program must fit into the rural development policy of the country and monitoring and impact assessment of the control programs is equally important. The main objective of the study was to assess the prevalence of bovine trypanosomosis with regards to changes in tsetse density and to assess the socio-economic impact of tsetse control in Limu Shay tsetse controlled area of the upper Didessa valley. The impact of tsetse control in Limu Shay was assessed by comparison with the tsetse infested (Didessa) area. The study was carried out from October 2003 to March 2004 and comprised of cross sectional study on the disease and its vector tsetse fly, questionnaire and collection of the recorded data for socio-economic impact assessment. The prevalence study was carried out on 810 randomly selected cattle using the dark ground/ phase contrast buffy coat technique (BCT). A total of 180 monoconical traps were deployed along the identified localities and suitable tsetse habitats (1300-1525 meters above sea level) to determine the mean catch and tsetse apparent densities. A total of 180 family heads were interviewed by using standard questionnaire, particularly with questions covering issues on livestock and crop production and together with the socio economic data from secondary sources were used to assess the socio-economic impact of tsetse control. Survey results in the tsetse controlled area showed 7.9% prevalence of trypanosome infection in cattle with average packed red cell volume (PCV) of 25%. In the tsetse infested area the prevalence and average PCV were 27.16% and 22.85% respectively. Similarly, comparison of the tsetse infested area with the tsetse infested area showed 71% reduction in trypanosome prevalence and 9.51% increase in PCV values. The observed differences were statistically significant for prevalence (95% CI= 0.1490- 0.202; $P < 0.001$) and PCV (%) (95% CI= 23.623- 24.2387; $P < 0.001$). Tsetse fly mean catch between the tsetse controlled (mean=4.03) and the tsetse infested (mean=10.68) areas differed significantly ($P < 0.05$) with 62.4% reduction in the tsetse apparent density in the controlled area. No *G. m. submorsitans* was found in the tsetse controlled area but the apparent density (1.34 fly per trap per day in the controlled area 2.05 fly per trap per day in the infested area) was reduced by 35% for *G. tachinoides*. The questionnaire survey result indicated that the calving rate was increased by 35.3%. The average age at first calving (42 months), the average calving interval (20.04 months) and abortion rate (16.1%) were also reduced by

11.5% (5.5 months), 13.6% (3 months) and 39% respectively in the controlled area as compared to the tsetse infested area. Mortality rate in the herds of controlled (7.9%) area showed 72% reduction as compared to the infested (29.1%) area. The differences observed between the two areas were statistically significant. Likewise, analysis of the data revealed an increase by 80% in average daily milk yield per cow (1.67liters), an increase by 120% in average lactation yield (350 kg) and decrease in the average use of trypanocidal drugs treatments of per animal per year from 7.16 treatment in the infested area to 0.19 in the tsetse controlled area. Conversely, there was a reduction by 40% and 90%, for the productive offtake rate (sale and slaughter rate) and purchase rate respectively, in the controlled area as compared to the infested area. By comparison with the infested area oxen in the controlled area were 40% and 31% more efficient in the average work hour per day and in the average area cultivated per ox respectively. Analysis of the secondary source data showed that the number of cattle and draught oxen has increased by 323% and by 260% respectively over 15 years between 1988 and 2003. The increase in animal traction has in turn brought about changes in cultivation practices with subsequent increase in average area ploughed under animal traction by almost 800% increase and an average area cultivated per household by 400%.The average cultivated land per house hold increased by 145% as compared to the infested area. Besides, the population growth in the controlled area between 1988 and 2003 was found to be rapid at 7.2% annual growth rate. Based on the results of the present study it was concluded that a reduction in trypanosome prevalence in cattle associated with reduction in tsetse densities and the disappearance of *G. m. submorsitans* as a result of tsetse control improved the socio-economic activities of the people in the study area.

Keywords: Bovine, Trypanosomosis, Prevalence, Tsetse fly, Apparent density, Socio economic, Upper Didessa valley.

1. INTRODUCTIOIN

1.1. Tsetse and Trypanosomosis in Africa

Trypanosomosis is a protozoan disease of both man and animals caused by different species of the genus *Trypanosoma.* In Africa, the most important trypanosomes interms of economic loss in livestock are the tsetse transmitted species: *Trypanosoma congolense*, *T. vivax*, and *T. brucei* (Mulligan, 1970). Tsetse transmitted African animal trypanosomosis is an important constraint to livestock productivity in sub-Saharan Africa (Leak *et al.*, 1988).

.

At present, self-sufficiency in food production is a pressing task for most of the developing world. The rate of growth in food production lags behind the rate of growth of the human population. This gap must be closed. Among many other problems responsible for this disproportionate growth between food production and population growth, the presence of tsetse and trypanosomosis rank high in the list in sub-Saharan Africa, where some 10 million km^2 of land, representing 37% of the continent is not exploited. The human population of Africa is growing at the high rate of 3% a year, while food production lags behind in growth rate at 2% (Masiga, 1995)

Bovine trypanosomosis is a major factor in restricting livestock production and land development. About 50 million cattle, approximately 30% of the total population in Africa are exposed to the risk of infection with trypanosomes and 3 million die every year (Tikubet, 1993). In addition to the mortality and morbidity caused by bovine trypanosomosis the disease also affects land use. Because of tsetse challenge a large proportion of the fertile and potentially productive land of Africa is underutilized for grazing. Improved breeds of cattle can not be introduced into the tsetse infested areas as they are highly susceptible to the disease. Draught animals are also susceptible to the disease and therefore can not be used for ploughing and other purposes. It has to be done manually, as the majority of the peasant farmers can not afford costly machinery. The end result is that only a small fraction of potential agricultural land is cultivated for crop production (Tikubet, 1999).

There are several intervention methods used currently in the fight against bovine trypanosomosis. Programs to control tsetse fly populations and bovine trypanosomosis have cost farmers, governments and aid agencies large sums of money throughout this century. The direct annual costs are estimated to be 1.54 billion USD and African farmers spends 35 million USD per year on trypanocidal drugs to protect cattle (Greets and Holmes, 1998). Affected animals become chronically unproductive in terms of milk, meat, manure and traction. Losses in terms of meat production alone are estimated at 5 billion USD (ILRAD, 1990). Seven million km^2 of tsetse-infested Africa could be suitable for livestock and mixed agriculture if trypanosomosis could be controlled (ILRAD, 1993)

1.2. Tsetse and trypanosomosis in Ethiopia

Ethiopia's economy is largely dependent on agriculture, and this in turn, is strongly influenced by livestock which provide more than 90% draught energy required for crop production. The causes of food deficiency in the country could be numerous and it is difficult to separate them all. However, some livestock and human diseases have obvious influences on the country's self-reliance in food production (EARO, 1999)

Amongst such diseases and related problems trypanosomosis and particularly tsetse borne trypanosomosis is the single most important disease, which has negatively influenced agricultural production. Trypanosomosis has been existed in Ethiopia since time immemorial, but was first recorded in a report by Donaldson Smith in 1894-1895 (Langridge, 1976) while exploring in the southern Ethiopia in which his pack animals died of the same disease. However, it started emerging as a serious problem to livestock (and also humans) only since 1960's with the steady increase of human population and the need of expanding agricultural production into the unexploited lowland areas, in the south-west (FITCA,1999). Tsetse flies have progressively invaded productive agricultural areas of the country and excluded from sound agricultural production. Resent findings indicate that tsetse in some areas extend to an altitude of 2000 m (NTTICC, 1996)

Trypanosomosis causes a multitude of problems which are, in many cases, difficult to clearly separate from other development problems. However, the following are some of the major and well recognized menaces brought about by trypanosomosis in Ethiopia (Tikubet, 1999)

- Some 10-14 million heads of cattle and an equivalent number of equine, goats and sheep are exposed to the risk of acquiring trypanosomosis at any time. Morbidity losses and mortality losses from ruminant livestock alone are estimated at some USD 200 million

- Livestock and particularly cattle would not be introduced and used for agricultural production in to some 200,000 km^2 of fertile valleys in the west and south-west parts of Ethiopia.

- Human and livestock populations are concentrated in tsetse and trypanosomosis free but ecologically fragile highlands with the resultant effect of over grazing, over ploughing, soil erosion, land degradation, loss of resources and poverty. Food security attempts have been stifled due to unbalanced land use and access exclusion from otherwise available land resources.

- The government is obliged to spend a substantial amount of scarce resources annually in order to curb the effects of trypanosomosis and related problems. About 1 million USD is spent for typanocidal drugs every year and the problem is still serious. Estimates from the MOA put the overall trypanosomosis related losses at between 1,408 and 1,540 million USD per annum excluding animal traction power and manure values.

While most livestock pestilence have been under reasonable control either through immunization or by chemotherapy, trypanosomosis could not be dealt with effectively and the problem is becoming even greater than before as tsetse flies are steadily advancing into new areas. The overall prevalence of bovine trypanosomosis in tsetse infested and tsetse free areas is 17.67% and 8.71% respectively (Abebe and Jobre, 1996). Moreover, chemotherapy and chemoprophylaxis are losing the potency which they used to have earlier, and evolving trypanosome drug resistance is an ever increasing challenge in the various parts of the country.

The utilization of tsetse infested areas with high potential for agricultural production has been a major priority of the government of Ethiopia. Recognizing the impact of tsetse and trypanosomosis as a limiting factor in the exploitation of the most fertile land the government has made various efforts targeting the control of both the disease and the vector. The followings are considered the main activities in this area:

-The most comprehensive survey conducted with the assistance of the British Ministry of Overseas Development by Langridge (1976) where 5 species of tsetse and 6 species of trypanosome were identified.

-Survey and control proposed by Ford, *et al*., (1976)
-The establishment of the trypanosomosis control service (TCS) in 1971 and its successor the NTTICC at Bedelle in (1985) with the assistance of FAO.

-A pilot tsetse control program in the Upper Didessa valley initiated in 1986, which ran in different phases up to 1990 with the assistance of FAO (Slingenbergh, 1992) and continued up to 1994 with funds provided under the Fourth livestock Development Project (FLDP).

Currently, an Eastern African-Regional Program "Farming in Tsetse Control Areas (FITCA)" project is operating over a total of 4500 km^2 of the Upper Didessa valley to control tsetse flies and rehabilitate mixed farming practices. Apart from this, operation is under way to eradicate tsetse flies from an area of 25,000 km^2 in southern rift valley of Ethiopia using the Sterile Insect Technique (FITCA, 1999). A tsetse control program in the Upper Didessa valley commenced in late 1988 with the objective of rehabilitating mixed farming practices.

Although these efforts are not negligible, much has still to be done to overcome the ever-increasing problem posed by tsetse and trypanosomosis in the country. Control programs should have to meet at least three criteria (Slingenbergh, 1999). First they should be economically sound and sustainable. Second, their direct and indirect effects on the environment should be negligible. Third, and most important, they should fit in to the rural development policy of a country. The monitoring and impact assessment is a key issue for success of any control program. The impact of tsetse control on the agriculture and livestock production can be best assessed by comparing changes before and after the implementation of a control intervention or alternatively by cross-sectional comparison of similar agricultural areas under different level of trypanosomosis challenge or both (Doran and van den Bosche, 1999).

1.3. Objectives

The objectives of the study are:

- To assess the prevalence of bovine trypanosomosis with regards to changes in tsetse density in Limu Shay tsetse controlled area of the upper Didessa Valley.
- To assess the socio-economic impact of tsetse control in Limu Shay tsetse controlled area.

2. LITERATURE REVIEW

2.1. Morphology of trypanosomes

2.1.1. *Trypanosoma* (Nannomonas) *congolense* Borden, 1904

The trypanosomes of this sub genus have a range in total length of 8-24μm. There is no free flagellum at any stage in the life cycle, which is an unusual characteristic. The flagellum, thus, terminates at anterior end of the parasite. The posterior end of the body is usually rounded but can be slightly pointed in longer parasites. The medium- sized kinetoplast is usually in a marginal and sub terminal position. *T. congolense* is one of the smallest trypanosomes with an average length of 12-17μm. *T. simae*, the porcine trypanosome, is more pleomorphic in its characteristics and the average length is 15-19μm slightly longer than *T. congolense.* Nannomonas trypanosomes are very active in fresh blood films but do not tend to move far across the microscope field. They also demonstrate agglutinating properties by tending to adhere to host tissue invivo (Molyneux and Ashfrod, 1983).

2.1.2. *Trypanosoma* (Duttonella) *vivax* Ziemannn, 1905

Trypanosoma (duttonella) *vivax* Zimann, 1905, has an average length of 20-26μm, a long free flagellum and a large terminally placed kinetoplast, distinguishing it from the other pathogenic Salivarian trypanosomes. *Trypanosoma vivax* is a very mobile and "lively" parasite. It crosses the field of a microscope rapidly, which makes difficult to follow its movements.

2.1.3. *Trypanosoma* (Trypanozoon) *brucei* Plimmer and Bradford, 1899

The blood forms of *T. brucei* measures from 11-39 μm in total length. They are typically poleomorphic, being represented by three forms. (a) slender forms (average lengths 14-39μm) possessing a long free flagellum and a well developed undulating membrane, elongated nucleus, sub terminal kinetoplast and narrow posterior end drawn out to a blunt point or some times truncated; (b) stumpy trypanosomes (average length 16.6-20 μm) which are stout and usually with out a free flagellum, undulating membrane well developed, nucleus rounded (displaced to the posterior end in posterior-nuclear forms), kinetoplast near broadly rounded or obtusely pointed posterior end; and (c) Intermediate forms (average length 14-390 µm) in which the flagellum is shorter, the posterior end blunter and the kinetoplast nearer to the extremity than in the slender forms. The kinetoplast in trypanozoon is smaller than in any of the other Salivarian trypanosomes. Animal and human infective *T. brucei* are morphologically indistinguishable (Mulligan, 1970).

2.1.4. *Trypanosoma* (pycnomonas) *suis* Ochmann, 1905

The total length of *Tyrpanosoma suis* has a range from 13-19µm (average 16µm) with a normal distribution, indicating that this species is monomorphic. A free flagellum is typically present. Its body is very broad and short; the posterior end usually terminates in a short point, but some times it is rounded. The small kinetoplast is usually situated near the posterior end and in the majority of cases occupies a marginal position, while the voluminous nucleus lies in the anterior part of the body and the undulating membrane is conspicuous (Mulligan, 1970).

2.2. Epidemiology of Trypanosomosis

2.2.1. The parasite

Trypanosomes are blood parasites (haemoparasites), from the word haem (blood), which in the vertebrate host occur in the blood and tissue fluid and with in that group are known as haemo-flagellates, as they progress actively by the movement of thread-like filament called flagellum (Uilenberg, 1998)

In animals, trypanosomes are either transmitted acyclically by haematophagus flies of the genus *Tabanus* or cyclically by the tsetse flies. Mechanical transmission of African animal trypanosomosis may be important in some localities. Acyclically, however, the pathogen can only be carried over a short distance since it will survive only for a short time on and in the proboscis of tabanidae. In contrast, the transmission by tsetse flies is a complex mechanism in which the tsetse fly remains a life long carrier. Seifert (1996) summarized the transmission interchange of hosts of African trypanosome which is transmitted by tsetse flies as follows:

- The tsetse fly got infected with the trypamastigote blood form which loses its surface coat in the goiter of the fly, and, which remains there for at least one hour, restructures its mitochondria.

- The trypanosomes enter the mid gut where they transform through length wise division into the epimastigote form in the cardia.

- The trypanosomes penetrate the haemocoel via the peritroph membrane and mid gut epithelium and move from there to the salivary glands of the tsetse fly where they develop into the metacyclic infectious trypamastigote form which has now go t its surface coat. Because the complicated development of trypanosomes with in the tsetse fly, only about 0.1-0.4 % of the flies are infected and thus are potential vectors of trypanosomosis.

- After the vertebrate host has been infected by tsetse fly, syngamy takes place; the trypanosomes become haploid and multiply though length wise division.

The length of time taken for trypanosomes to complete development in tsetse is quite variable and also development up on the maintenance temperature of adult tsetse (Leak, 1999)

The distribution of tsetse transmitted African trypanosomes is governed by that of their vectors, i.e roughly between 15°N and 29°S latitude in tropical Africa. Apart from cyclical transmission through *Glossina* species, *T. vivax* has the capacity to be transmitted mechanically by other blood sucking diptera such as horse-flies (Tabanidae) and stable flies *(Stomoxys).* Mechanical transmission explains the occurrence of *T. vivax* infections out side Africa; and it has been reported from the island of Mauritius, the Caribbean islands of Guadeloupe and the south American and in cases *T. vivax* infection in Africa in areas out side tsetse belt. Thus spread in distribution is by movement of infected cattle and the ability of *T. vivax* to be transmitted by biting insects other than tsetse (Hoare, 1972

In Ethiopia *T. vivax* is commonly found in high lands too cold for tsetse survival. *T. congolense* is encountered in tsetse areas and is dominant species with in tsetse belts occurring in a wide rage of hosts. *T. brucei* is also restricted to tsetse infested localities with wide host range, but mainly restricted to cattle (Uilenberg, 1998).

2.2.2. The vector

Insects are usually involved in the natural transmission of the African pathogenic trypanosomes. Transmission by insects may be cyclical (*Glossina* species) or mechanically by other biting flies. Nevertheless, the distribution of nagana in Africa largely coincides with that of its cyclical vector, the tsetse flies, and the disease tends to die out in their absence. At present 23 different species of the genus *Glossina* are recognized, belonging to three groups.

The different groups of tsetse flies exploit ecologically different habitats as savannah group (i.e. the morsitans group), the riverine group (i.e. the palpalis group) and the forest group (i.e. the fusca group). In some situations species of the various groups overlap and co-exist in different parts of the same ecosystem (Uilenberg, 1998).

The general distribution of tsetse flies is determined principally by climate and influenced by altitude, vegetation and the presence of suitable host animals (Leak, 1999).

The different species of tsetse have preferred hosts, with most species feeding on sub set of bovids or suids available in many localities. Riverine species also utilize reptiles, and odd hosts such as hippos. However, many tsetse species will feed opportunistically and hence will adapt to what ever hosts are available. In the absence of suitable wild life, tsetse will feed almost exclusively on livestock and humans, and therefore establish peri-domestic disease cycles with often very high infection rate in animals (Angus, *et al.,* 1995)

2.2.3. The host

Species and breed susceptibility are of course of great importance in the epidemiology of the disease. In the areas trypanosomosis is very obvious problem in susceptible livestock. It may remain practically inapparent where trypanotolerant breads (such as N'Dama) are concerned (Uilenberg, 1998). In cattle, the rate and type of infection is affected by the species of tsetse to which they are exposed, the influence of chemotherapy drugs, potential reservoir hosts for trypanosomes and host immune responses, which can be determined by breed (Leak, 1999).

The risk to susceptible ruminants living in comparatively free areas surrounded by tsetse infested regions, or at the age of tsetse belts, varies from year to year. Generally tsetse fly populations during wet years will increase, spread out and persist during the season in areas from where they disappear in dry years. Herd management, daily activity patterns of tsetse species involved and the grazing patterns of the herds are of great influence on the transmission of the disease between tsetse flies and domestic ruminants (Uilenberg, 1998).

The ability of wild hosts to transmit trypanosomes to the vector has only been studied in detail in the past few years. The wild life survey has shown that some favored hosts of tsetse such as bush buck are major reservoirs of trypanosomes, with many animals infected. However, there are clear examples of favored hosts with only modest level of patent infection (example, buffalo, and warthog), buffalo transmits trypanosomes to various species of *Glossina*. Many savannah species such as wild beast and zebra also harbor trypanosomes, despite little overlap with tsetse distribution and/or feeding habits. A similar puzzle is the high level of infection in waterbuck, rarely shows up in tsetse blood meals (Angus, *et al.,* 1995).

2.3. Clinical signs of Trypanosomosis

The disease shows varieties of clinical manifestations which are also common to other diseases. The fact that the disease may run an acute, chronic or sub clinical course further complicates the diagnosis of trypanosome infection on the basis of clinical signs. The clinical manifestations are dependent on the pathogenesis of trypanosomosis which are characterized by chancre, anemia, lymhyadenopathy and tissue damage (Abebe, 1991).

When the tsetse fly injects infective metacyclic trypanosomes into the skin of the host there is a phase of local inflammation and swelling, the so called chancre, develops. The metatrypanosomes divide and multiply in the chancre and give rise to the typical blood forms which invade the lymphatics and lymph nodes, then the blood stream (Uilenberg, 1998).

One of the major effects of infection with pathogenic trypanosomes is anemia. In acute infections, packed cell volume (PCV) falls rapidly due to erythropagocytosis, but an equally rapid recovery takes place following trypanocidal drug treatment. Measurement of anemia gives a reliable indication of disease status and productive performance, although its severity is affected by virulence of the infecting trypanosome species as host factors such as age, nutritional status and breed. In chronic infection, the bone marrow function become impaired and haemopoiesis can no longer compensate for erythrophagocytosis. Following treatment, PCV either recovers slowly or remains at low level (Murray and Dexter, 1988).

As regards to trypanosomes, *T. congolense* and *T. vivax* are the most important and despite the acute hemorrhagic infection due to *T. vivax,* most infections are clinically indistinguishable. The clinical signs of the disease in cattle include acute phase with elevated body temperature and death within a few weeks. The chronic stage which is more typical with indigenous African cattle can persist for months or even years. At this stage, the animal become increasingly emaciated and anemic and in the terminal stages, the animal is recumbent and some times comatose. Pregnant animals suffer from chronic trypanosomosis are liable to abort. Certain strains of *T. vivax*, mainly in East Africa, cause hemorrhagic syndrome in cattle associated with high parasitaemia, in which hemorrhage, particularly of the gastro-intestinal tract, occur. This can result in a high level of mortality (Gradiner and Wilson, 1987) and there are several reports of an extremely acute form of *T. vivax*, infection in Ethiopia causing hemorrhagic syndrome in cattle (Wellde *et al.,* 1983).

2.4. Diagnosis of Trypanosomosis

2.4.1. Clinical diagnosis

In regions where the disease is known to occur, clinical symptoms and post mortem lesions are important indications, especially in combination with the history of the disease and the region in which it occurs. However, symptoms and lesions of trypanosomosis are never pathognomic, and suspicion has to be confirmed by other means. In general, fever, anemia and body conditions are important parameters which are routinely used for the tentative diagnosis of trypanosomosis in areas where this disease is endemic and laboratory services are not available (Uilenberg, 1998). Definitive diagnosis of the disease is ultimately dependent on the detection of the trypanosome in blood samples from infected animals.

2.4.2 Parasitological diagnosis

Parasitological diagnosis is the direct demonstration of the parasites in blood or less frequently in other body fluids (using a microscope). The scarcity of parasites and the fluctuating nature of the parasitaemia limit the use of laboratory tests based on demonstration of trypanosomes in accessible body tissues such as the peripheral blood (Doyle, 1997). Therefore, several techniques for the concentration of blood trypanosomes have been developed, which increase the chance of trypanosome detection.

(a) Haematocrit centrifugation technique (HCT, WOO, 1970, modified by Mehlitz, 1978)

A microhaematocrit capillary tube containing 70μl of blood is centrifuged for 5 minutes at 12000 rpm as for measurement of PCV. Two rectangular pieces of glass from a standard microscope slide (1.2 mm thick) are fixed 1.5mm apart on a microscope slide. The prepared capillary tube is then placed on the slot and a few drops of immersion oil are put on top of the capillary tube. The oil fills the space between the capillary tube and the two pieces of glass thus reducing the effect of light diffraction. By slowly rotating the tube the Buffy coat plasma junction is examined using a long working distance (6.7mm) objective which allows considerable depth of focus through the capillary unlike the standard objective where the average working is approximately 0.5mm. Depending on the trypanosome species the analytic sensitivity for this method is $1\text{-}5\times10^2$ trypanosome/ml of blood.

(b) Dark ground/phase contrast Buffy coat technique (Murray *et al., 1977)*

The Buffy coat zone prepared in a microhaematocrit capillary tube filled with 70μl of blood and centrifuged for 5 minutes at 12,000 rpm is examined for trypanosome by cutting the capillary tube to include 1 mm of erythrocytes and 1cm of the plasma. The Buffy coat is poured on a slide and covered with a 22×22mm cover slip. The preparation is examined using a microscope with a phase contrast and dark ground illumination. The use of 10× eye piece in combination with a 25× objectives gives optimal viewing, by allowing large visual fields and sufficient magnification for ready identification of trypanosomes. This technique is the most sensitive of the parasitological tests for the detection of *T. congolense* and *T. vivax,* detecting trypanosomes to an estimated level of just over 10^2 parasites/ml. In addition, species identification on the basis of size and movement is easier to assess.

2.4.3. Other diagnostic methods

Indirect methods involving biochemical tests including the mercuric chloride test, thymol turbidity test and formol gel test depends on an increase in serum euglobulins as a result of infection (Pegram and Scott, 1976). Serological tests are used to detect specific humoral antibody and circulating antigens. The tests employed include the Immunosorbent assay (Antigen ELISA, Antibody ELISA), the Complement Fixation Test (CFT) and the passive haemaglutination test.

The molecular tests include DNA-probes (Nucleic acid probes) and PCR (Polymerase chain reaction). The principles of molecular tests are demonstration of the occurrence of nucleotides, which are specific for a trypanosome sub genus, species or even type or strain. They can only be carried out reliably in well-equipped laboratories by specifically trained staff, and are still mainly research tools (Uilenberg, 1998).

2.5. Disease control

Methods used to control trypanosomosis include, parasite control, vector control and exploitations of trypanotolerant livestock (Uilenberg, 1998).

2.5.1. Parasite control

The method most commonly used to control animal as well as human trypanosomosis is drug treatment, which is administered both to prevent and to treat the disease. Isometamidium, Diminazene and Homidium salts have been in use for more than 35 years and it is estimated that 35 million doses per year are currently used in Africa (Greets and Holmes, 1998).

Trypanocidal drugs remain the principal methods of animal trypanosomosis control in most African countries. However, there is growing concern that their future effectiveness may be severely curtailed by widespread drug resistance (Greets and Holmes, 1998).

The potential for the development of drug resistance in wild populations of trypanosomes is exacerbated by the small numbers of compounds used against the parasite, the long and wide spread use of the compounds and the similar chemical structures of the drugs. The latter means that a mechanism that evolves to tolerate one drug may well be effective against others. This complicates the use of sanative pair strategy. An equally important problem is that drugs administrated in the field are often adulterated or given in insufficient doses; this exposes trypanosomes of tolerant parasite populations (Peregrine, *et al.,* 1995).

So far, resistance to one or more of the three trypanocidal drugs used in cattle has been reported in at least 13 African countries in sub-Saharan Africa including Ethiopia. In Ethiopia the emergence of drug resistance has seriously hampered the control of animal trypanosomosis. Multiple trypanocidal drug resistance have been reported in the Abay Didessa tsetse belt in Metekel (Afework, *et al*., 2000), in the Ghibe/Omo tsetse belt adjacent to the upper Didessa river valley (Codjia, *et al*., 1993, Mulugeta, *et al*., 1997, Ademe and Abebe, 2000) and in North Omo (Assefa and Abebe, 2001).

The exact mechanism of drug resistance is insufficiently known and this is not surprising when one remembers that the precise mode of action of trypanocides is also unclear. It is possible that some times penetration of the drugs into the trypanosomes is decreased because of changes in the surface of the parasite cell or that the enzyme process disrupted by the drug in susceptible trypanosomes remains unaffected to the action of the drug. What ever the mechanisms involved, the fundamental fact of extreme importance is that drug resistance in trypanosomes often arises or is accelerated as a result of their exposure to a sub-lethal level of the compound used. It is therefore clear that such an event, so often the result of carelessness use of drugs, must avoided (Guy d'Ieteren, 1999).

So far all attempts made at developing a vaccine against trypanosomosis are failed. This situation has been stranded by the almost unlimited ability of trypanosomes in the host to change their surface antigen frequently, until the host immune system becomes exhausted. Also the antigen repertoire is different between different strains, types and subspecies of same trypanosome species. Moreover often a mixed infection of two or even three different species is possible (Uilenberg, 1998).

2.5.2. Vector control

There has recently been renewed interest in methods used to reduce tsetse numbers or to eradicate populations. This is due to improvement in tsetse control techniques and in part to increasing reports of the development of parasite resistance to the few available drugs that prevent and cure trypanosomosis (ILRAD, 1993).

Vector control has traditionally based on specialized large-scale operations. Recently, there has been a tendency towards smaller scale methods, which can be applied by farmers themselves (Uilenberg, 1998).

Eliminating the wild hosts of tsetse and bush clearing was widely used in some African countries. Both of these early methods however, involve the destruction of valuable resources (ILRAD 1993).

Both ground and aerial insecticide spraying have been used successfully against tsetse, but most attempts to apply this approach in more suitable tsetse habitats have failed, largely because flies from neighboring areas have reinvaded the target area soon after the spraying. Furthermore, the high running costs and expertise needed for these control methods make them problematical in most African countries. Current opinion holds that aerial spraying should be used only to eradicate an isolated tsetse population.

Tsetse traps, targets and pour-on insecticides are used to impose a small but steady mortality on a fly population sufficient to keep fly numbers down to an acceptable low level. While eradication may be both feasible and desirable in some places, tsetse populations are highly resilient and will often recover from very low number once control measures are relaxed. Furthermore barriers against re-invasion of cleared areas need to be about eight to ten kilometers wide to be effective. Demands for cheap and simple tsetse control methods have driven much of the effort behind modern trap design (ILRAD, 1993).

In some situations targets are more effective against tsetse than traps. However like most traps, targets require imported insecticide and, because they do not catch flies they cannot be used to monitor the progress of control operations. Another approach is to turn cattle into mobile targets. The animals are dipped or sprayed with insecticide or the compound is poured on them. The effectiveness of this strategy depends on cattle density, grazing pattern and fly distributions. The strategy works best where livestock are the main host of tsetse (ILRAD, 1993).

Sterile Insect Technique (SIT) is a highly effective and environmentally benign method of insect pest suppression and eradication. It would lend credibility to the efficiency of SIT if sterile mating frequencies were estimated in challenged population and correlated with target population densities (Krasfur, 1998). The success of the program depends on the fact that the emerging male fly is as virile as its untreated counterpart in inseminating the female and that the sterile sperm is competitive with untreated sperm (Mramba, 1992).

2.5.3. Trypanotolerant breeds

Genetically determined innate resistance to trypanosomosis occurs in taurine breeds now mainly confined to west Africa, form Senegal to Nigeria, but they used to occur as far to the east as the central Sudan (Nuba Mountains) and even western Ethiopia. N'Dama cattle (which originate from Guinea) have rather long horns, while breeds with short horns comprise for example, the Baoule (Burkina Faso and Northern Cotedivoire) and the Muturu (Nigeria). They are"dwarf" cattle (although a N'Dama cow can weigh as much as 200 kg similar to the size of many of the smaller Zebu breeds). Past ILRAD research has shown that these 'trypanotolerant' animals unlike the African Zebu and European dairy cattle, which are susceptible to trypanosomosis, are able both to control the number of parasite in their blood and to stop the development of anemia. A main characteristic of trypanotolerant N'dama cattle is superior to the relatively large and humped Boran (*Bos indicus*) cattle, which are susceptible to trypanosomosis (Uilenberg, 1998).

There have been attempts to introduce west African trypanotolerant cattle, but with limited success. Livestock owners, who are used to larger cattle, are not readily attracted to the smaller trypanotolerant breeds. There are also limits to their trypanotolerance and where challenge is high even such animals may show clinical trypanosomosis. Their resistance is particularly effective in the face of riverine species of tsetse, which usually occur in lesser number and have a lower infection rate with pathogenic trypanosomes than the savannah species. Apart from this they are small in number, poor in productivity, and highly susceptible to other diseases compared with other breeds of cattle (Uilenberg, 1998). Although, not supported with hard evidence, there are some fragmentary reports and perceptions that the Sheko and the Abigar cattle breeds of Ethiopia are relatively resistant to trypanosomosis than the other breeds found in the country (EARO, 1999).

2.5.4. Integrated approach

Combining different control methods against a parasitic disease is called integrated control or integrated disease management and is generally not intended to achieve eradication of the parasite in question. Such a cost-effective combination of techniques, adapted to each particular set of circumstances, is very relevant for the control of African Animal Trypanosomosis (Uilenberg, 1998).

While the eradication of trypanosomosis is unrealistic goal for most of Africa, considerable effort has been invested in control of this disease by the use of trypanocidal drugs, management of the vectors and exploitation of the genetic resistance exhibited by indigenous breeds, such as N'dama cattle.

There are situations where trypanosomes are resistant to all commercially available drugs, including diminazene aceturate, homidium and isometamidium. In such a case of multiple drug resistance, trypanocides cannot offer a solution and other measures should be considered. The use of integrated control should help to prevent such situations from occurring in the first place (Uilenberg, 1998).

The Ethiopian Government is attempting to control trypanosomosis with imported trypanocidal drugs inorder to introduce draught oxen and other livestock into tsetse infested areas that have been selected for development. The high recurrent costs of these drugs, the continuing high level of livestock losses and the fact that therapy is essentially a palliative and not a long-term solution to trypanosomosis problem have resulted the government placing a greater emphasis on tsetse control activities (FITCA, 1999).

In areas of south-western Ethiopia, for example, where high level of trypanosome resistance to several drugs were found, staff members of ILRAD, ILCA and the Ethiopian government introduced experimental tsetse control to complement chemotherapeutic treatment and this has had beneficial effects. The tsetse control program had reduced the relative density of this by over 90%, and reduced trypanosome prevalence in cattle by 70 % (ILRAD, 1993).

The alternative tsetse control measures include method such as aerial and ground spraying with insecticides and deployment of targets, traps and screens (ILRAD, 1993). A particular concern with large-scale insecticide application is the pollution it may cause, as most insecticides are harmful to aquatic and terrestrial animals. If live bait animals are used without any other form of tsetse control, difficulties arise with persistence of flies in areas where the treated animals do not go. In case of sterile male technique, the effect on the population only becomes apparent after a period and a substantial fly suppression has to precede the application of SIT. Traps and screens may be stolen for cloth they contain and during rainy season the rapidly growing vegetation may camouflage the trap or screen, which thus loses its visual activities for the flies (Uilenberg, 1998).

Trypanotolerant cattle that stand up to challenge in a particular region may suffer from disease when introduced into another area, and so far, all attempts at developing a vaccine against trypanosomosis have failed (Uilenberg, 1998).

In general, all of the available methods have advantages and disadvantages and the various techniques act in a complementary way; an advantage of one may off set a disadvantage of another. The economic and feasibilities of employing various control methods must be compared for any given tsetse infested area. In many African countries, reducing the risk of trypanosomosis by employing more effective control methods may well increase both livestock and crop production (ILRAD, 1993).

One of the major components of sustainability of these methods is the active participation of the majorities of the communities contributing to a relevant production system in a given environment or region. Successful strategies for controlling animal trypanosomosis must be based on accurate appraisals of the impacts of the disease constraints on village farming system and the development of cost-effective sustainable disease control packages which can be adapted by producers.

2. 6. Impacts of tsetse control on farming system

Among the factors influencing the productivity and profitability of livestock, animal diseases deserve special attention because they diminish the capacity of the animal to achieve its inherent potential level of production, for any given feeding and management regimen. It is well established that animal trypanosomosis depress livestock productivity, crop yields, and farmers' income across a wide swathe of Africa (Swallow, 1997).

A comprehensive quantification of the economic importance of African trypanosomosis, however, has never been attempted, mainly due to a paucity of reliable data on such important factors as the distribution and numbers of human, animal and insect vector populations; insufficient knowledge of the effects of the disease on livestock production; and the difficulty in quantifying the values of livestock and their products in pastoral and mixed crop/livestock subsistence production systems. Donor agents, African policy makers and disease control workers have long needed more accurate estimations of the costs of trypanosomosis and the economics of alternative control strategies employed under different livestock production systems so as to better judge the degree of the disease problems in given areas and to apply optimal control strategies (ILRAD,1993).

Direct losses caused by trypanosomosis are due to the presence of the disease in livestock populations; they include production and reproduction losses resulting from mortality, morbidity and mortality and infertility and the costs of implementing and running trypanosomosis control operations. Indirect losses are due to the risk of the disease; they include the exclusion of ruminant livestock production levels due to restricted grazing, and reduced crop production due to exclusion or limitation of draught power. Three types of information are needed to quantify direct losses in given areas (ILRAD 1993):

(1) The livestock production system employed, including the breed, type and number of animals at risk from trypanosomosis; the milk, meat, manure and draught output of the livestock; and the prices of these livestock product;
(2) The impact of trypanosomosis, including estimates of the prevalence and incidence of infections and disease and their effect on key livestock production parameter, such as mortality, fertility, milk yield and draught power; and
(3) The degree of human population pressure for access land, which influences the type and intensity of land use following successful trypanosomosis control.

Success of any modern tsetse and trypanosomosis control program requires information not only on the disease and vector prevalence but also their circumstantial socio-economic profiles. Usually the distribution and prevalence of the disease is well established but its impact on the production is, on the other hand, less well known and assessments of its socio-economic impact are often based on assumptions. The socio-economic impact of trypanosomosis and the expected impact of control are important criteria used in the identification of priority areas for control interventions. The impact of bovine trypanosomosis on animal production and faming practices is probably best assessed by comparing herd performance parameters and other agricultural indicators before and after the implementation of a control intervention in a particular area. However, time series analysis of socio- economic studies of this kind is often fraught with problems and sufficient amount of time is required to make valid comparisons. Alternatively, the impact of trypanosomosis on animal production can be compared by cross-sectional comparisons of similar agricultural areas under different levels of trypanosomosis challenge. To minimize differences in production performance caused by factors other than trypanosomosis, two ecologically similar and adjacent areas are compared (Doran and van den Bosche 1999).

Below are indicated, some of the studies so far done in Ethiopia, on the impacts of tsetse control on livestock productivity and agriculture:

- It has been shown that where oxen are available for cultivation, maize production is increased 4 or 5 fold and when the number of oxen was halved due to trypanosomosis, production of cereals fell accordingly and further loss of oxen caused the cultivators to abandon the fertile area for higher ground (Slingenbergh, 1992).
- The information generated from the consultancy report on disease situation and socio-economic data collection study to quantify the impact of tsetse control on farming systems in Upper Didessa valley (Bedane, 1998) addressed that the apparent density of tsetse flies declined to a minimum level but is not yet eradicated from the area. Trypanosomosis prevalence is also reduced to a minimum level, and the low level of infection still observed might be attributed to the very few *G. m. sub morsitans* still present, or more to the *G. tachinoides* associated with riverine vegetation. Total cultivated land per farmer has increased in tsetse control areas. In areas like Limu Shay, farmers were able to diversify their crop production after the control program and increased teff production which is known to be labor intensive. Human population and the number of households in the area have changed positively over the period.
- Tsetse transmitted trypanosomes effectively exclude livestock from vast areas of land in south western Ethiopia. Efforts to control tsetse flies using targets and insecticides pour-ons in Ghibe valley caused a decline of 93% in the apparent density of *G. pallidipes,* and a reduction of 83% in the apparent density of *G. m. submorsitans,* associated with a

reduction in trypanosome prevalence in cattle of over 74% and drug treatment by 52% despite high level of drug resistance. Still births and calf mortality dropped by 57%, the ratio of live calves under 12 months to cows over 36 months rose by 49%, and body weights of adult males-key providers of traction throughout this part of Ethiopia increased by 8% (Leak *et al.,* 1995).

- Evaluating the effects of trypanosomosis incidence on the productivity of oxen used for traction conducted by ILRI in the Ghibe valley of Ethiopia indicated the difference in the tsetse infested and tsetse controlled area. Households in the infested area were able to cultivate 0.5 additional hectares for each ox that they owned. Whereas households in the controlled area, for each additional ox that they owned, they were able to cultivate an additional 0.8 hectares of land. Comparison of the two slopes provides the measure of the relative inefficiency of oxen in the infested area: oxen in the high risk area were 38% less efficient than oxen in the low risk area (Rowlands, *et al*., 1993).
- A pilot study model field project comprising community based tsetse fly control; trap-technology-up take and sustainability were conducted in Damot Woyde woreda from 1995 to 1997 and Gurage zone. The project was executed within the context of a holistic rural development package. The socio-economic survey showed that average milk production per cow before tsetse fly operation was 4.10 kg (±2.60 se). After suppression of tsetse flies there was a significant improvement to 8.71kg (±0.526 se) during the survey time. The overall mean percent in livestock mortality before and after suppression was also reduced significantly. The mean age of female livestock to reach fertility after tsetse fly suppression was reduced by 23%. Furthermore, the survey showed that the fly control operation decreased livestock abortion and increased calving rate (Tikubet, 1999).

In Ethiopia the huge cattle resources plays an important role in food security, cash income and as capital asset to face risks. However, the contribution of cattle towards food supply and other needs is unable to meet the demand, as local cows are less productive. Offtake from the national herds is estimated at 8% for cattle and about 82% for "unofficial" (Private or household) slaughter. At the level of the animal, first parturition in cattle does not generally take place until four years of age, calving intervals average two years and growth is slow. Carcass weights are estimated to produce only 110 kg of beef and milk production from native cows is low at about 210 kg in a short lactation of 150-200 days. Draught oxen work about 600 hours per year made up of 120 days of 5 hours each (NLDP, 1998).

There is a fairly general agreement on the levels of fertility normally to be expected in dairy cattle; heifers should calf between 2 and 3 years of age; the conception rate to first service should be between 60 and 70 percent; a ratio of services to conception should average between 1.4 and 1.6; the calving internal for the herd should average between 12 and 13 months and the annual percentage of cows which abort should not exceed 3 (FAO, 1982). Radostits (2001) suggested performance targets for dairy cattle including mean interval time to conception of 85-125 days; mean age at first calving of 22-24 months; abortion rate (%/year) of less than 2 and mean length of lactation 305 days. Morrow (1986) suggested a calving interval of 12 months.

2.7. Community participation

While the technical means of controlling tsetse flies are available, the main difficulty lies in sustaining control over a long period. This is especially the case when using traps and targets for control as opposed to aerial or ground-spraying operations. The reasons for this are, that aerial or ground spraying of insecticides are usually being intensive campaigns carried over a long period which require central direction and a fairly large amount of capital. On the other hand, targets and trapping techniques are long-term operations, requiring some initial organization and direction followed by a long maintenance phase. It is widely felt that successful control using traps and targets should involve the local community. It is believed that if the communities which are the intended beneficiaries of the control are involved in the exercise, the operation will be much more economical and sustainable (Leak, 1999).

Opinions of what constitutes community participation vary, ranging from simply awareness by the community of tsetse control activities being carried out in their area, and passive participation in which the community is persuaded to leave targets or traps alone, to contribution of money and labor towards the implementation of control activities, or community ownership of the project, which some people see as the only way of ensuring sustainability (Leak, 1999).

Community participation can be best answered through process of participatory research and planning that consider the knowledge, believes and incentives of local people and the social, economic and cultural structure of the local community (Kamara, *et al.,* 1995). Furthermore, there are some examples of traps and target-based tsetse control programs that have failed to garner the minimal level of local support needed to prevent people from vandalizing and or removing tsetse traps and targets (Swallow and Mulatu, 1994) A community based tsetse control program is more likely to succeed where the community understands the role the tsetse flies play as vectors of trypanosomosis. Little is known regarding the awareness by the community, of the disease despite several epidemiological investigations conducted in most tsetse control areas. Community awareness, mobilization and utilization are currently seen as a prerequisite for tsetse control activities to enable the beneficiaries to sustain the control program (Kamuanga *et al.,* 1995).

Trials in which traps and targets have been used with substantial local participation have been under taken in Uganda, Congo and Kenya. Studies on community willingness to contribute either money or labor and their perceptions of trypanosomosis and tsetse control have been conducted in Ethiopia (Swallow and Mulatu, 1994). In this study in Ethiopia, only 4% of local residents were unwilling to provide either cash or labor; 58% of the respondents offered cash and labor, 20% offered only labor and 12% offered only money. Several household factors affected decision on contributions to tsetse control (ILCA, 1993/94).

A pilot study and model field project comprising community based tsetse fly control in southern Ethiopia (Damot Woyde Woreda and Gurage Zone) in which 230 farmers participated endorsed community based integrated vector control as one of the best option for the future. In the survey area, as a result of tsetse suppression animal productivity increased and the vast majority of the households willingly responded regarding the presence of tsetse flies and was aware of the problems associated with it (Tikubet, 1999). In the Upper Didessa valley, in the past operations, the farmers helped the tsetse control teams, to deploy the traps and targets and they also learnt how to replenish the acetone, octenol and urine odor attractants. They also learnt how to respray the traps and targets (FITCA, 1999).

3. MATERIALS AND METHODS

3.1. Study area

3.1.1. Description of the area

The study was conducted in the Upper Didessa valley, of south western Ethiopia. The Didessa river flows down from Setema Woreda running first to east and then to north west directions to join Abay (Blue Nile) river. The area from the valley floor up to the escarpment shoulder and at the head waters of this river is known as the Upper Didessa valley. More specifically, it is the valley of the river between the Bedelle-Arjo road bridge and the Jimma-Bedelle bridge (about 400 km away from Addis Ababa). Upper Didessa valley is part of a lengthy valley, ranging from 4 to 15 km in width, formed by the erosive action of the Didessa River and its tributaries. The narrow valley has steep side slopes with sharp changes in altitude from the floor to the escarpment shoulder, which makes access and communication between the high land and the low land extremely difficult (Ford, *et al.,* 1976).

The surface area of the Upper Didessa valley is estimated to be 5500 km^2 (Slingenbergh, 1992). Administratively, the Didessa valley is part of the Oromia Regional State adjoining or serving as a corridor between Jimma, Illubabor and East Wollega zones. The valley comprises areas from Goma, Limu Kosa and Limu Seka woredas of Jimma zone; Bedelle Dabo, Didessa and Gechi Borecha woredas of Illubabr zone; and Jimma-Arjo and Nunu Kumba of the East Wollega zone as indicated in Fig.1. Tsetse control activities have commenced in Upper Didessa valley in 1986.

Figure 1: Map Showing tsetse controlled sites and the Didessa tsetse infested area in the Upper Didessa valley.

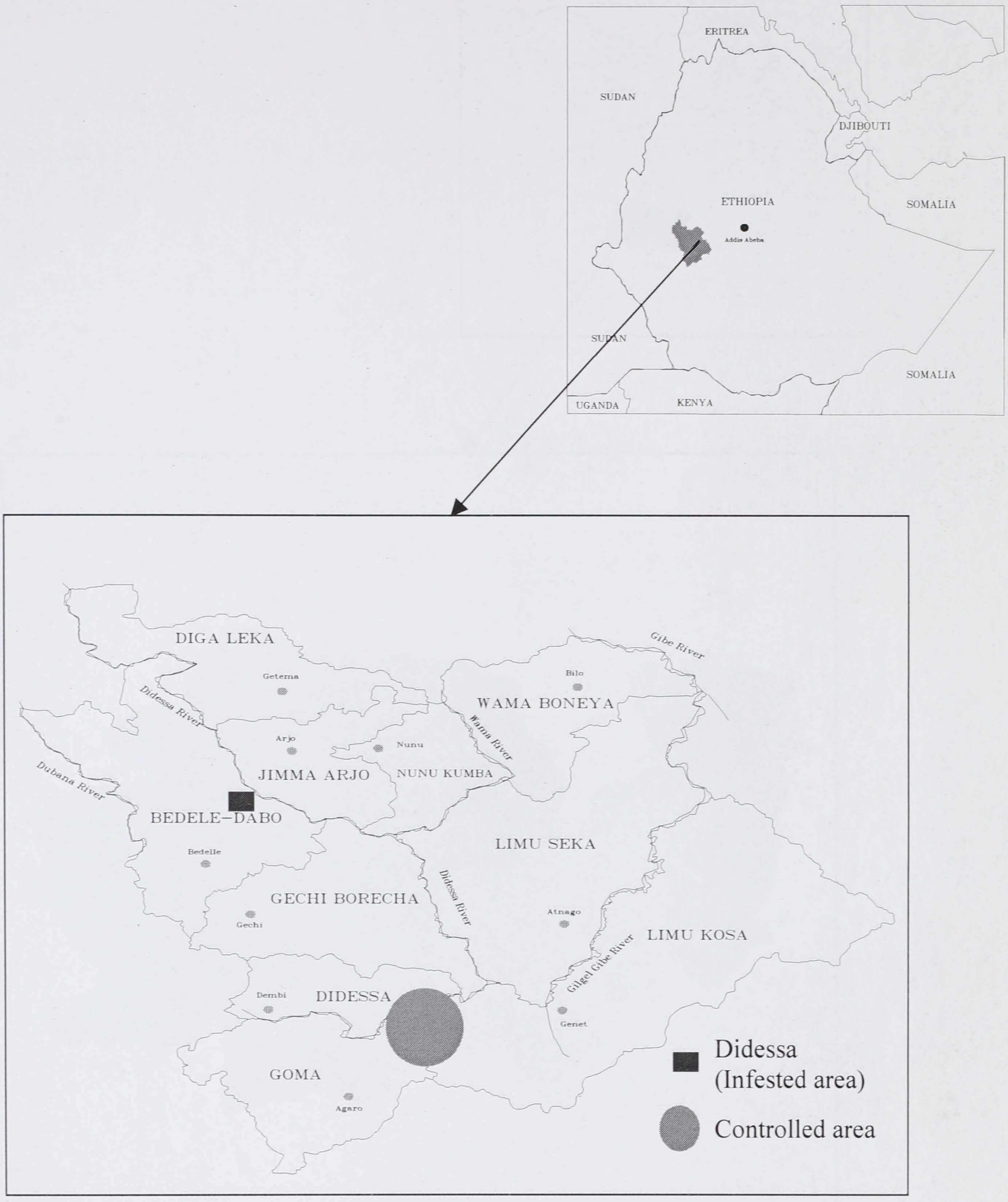
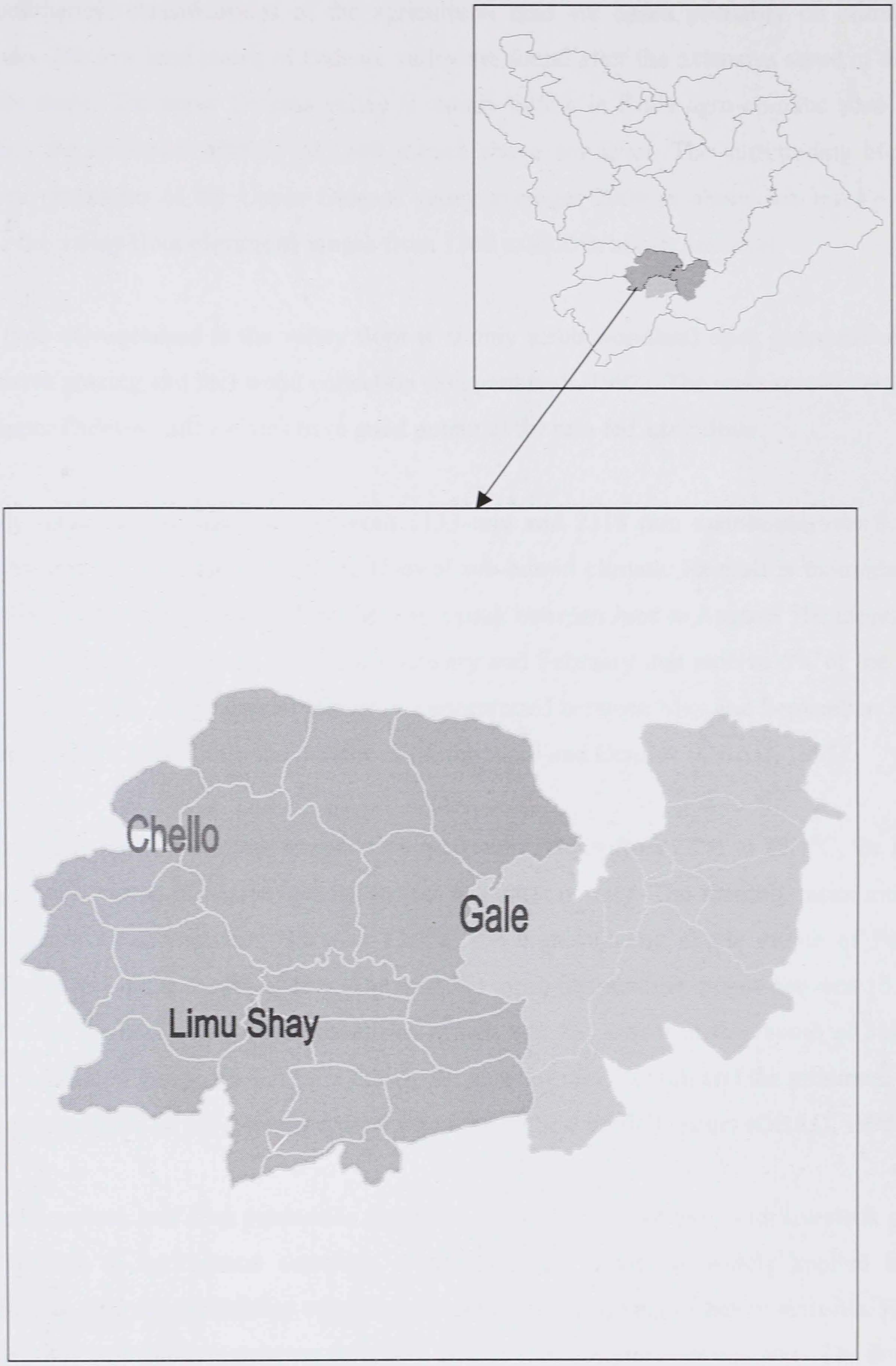


Figure 2: Location of Tsetse control sites in Upper Didessa valley.



3.1.2. Agro-climatic and farming system

Agroclimatical classifications of the agricultural land are based primarily on climate and altitude. The low land plains of Didessa valley are found after the extensive slope of the hilly or side slope. The upper Didessa valley is mainly falling in Kolla agro-climatic zone, which reaches the minimum altitude of 1300 meters above sea level. The surrounding high land plateau elevations of the Upper Didessa valley averages 2000 m above sea level or more, while the valley floor elevations ranges from 1300 to1500 m above sea level.

The type of vegetation at the valley floor is mainly scrub woodland open grassland used for extensive grazing and fuel wood collection (Slingenbergh, 1992). The wide spread vertisols of the upper Didessa valley plains have good potential for rain fed agriculture.

Yearly mean rainfall oscillates between 1133 mm and 2118 mm distributed over 8 humid months, and the area falls within the tropical sub-humid climate. Rainfall is unimodal, with monthly rainfall rising steadily from May to a peak between June to August. The months with least rainfall are November, December, January and February that receive 5% of the annual total. Nearly 75% of the annual rainfall is concentrated between May and September, and the remaining 20% falls within the months of March April and October (OBAD, 1995).

The monthly mean maximum temperature in the area ranges from 22°C to 27.7°C, the highest being in the month of March and the lowest in month of July. The monthly mean minimum temperature ranges between 9.5°c to 12.8°c, the highest being in the month of February and the lowest in the month of July. The monthly mean temperature ranges between 15.75°cto 20.6°c, the highest being in the month of March and the lowest in the month of July. The mean maximum temperature occurs during the onset of rainy season and the minimum occurs during the middle of the growing season when the highest rainfall occurs (OBAD, 1995).

Mixed livestock and crop production characterize the farming system, with livestock playing a vital role in agricultural activities. Animal draught power is widely applied in crop production, and the availability of oxen is essential for ploughing of heavy vertisols. Farmers in the study area apply manure on their own land to increase yield per unit area. The dominant crops grown in the area are teff, maize, sorghum, finger millet, wheat and barley, and the main crops in the lowland (kolla) areas are maize, sorghum finger millet and teff.

The livestock commonly found are cattle, sheep, goats and equines. The total number of livestock for the woredas around the Upper Didessa valley is about 503,500 consisting of 400,000 cattle, 58,500 sheep, 31,500 goats and 13,000 equines. Wild animals such as wart hog, bushbuck and monkeys are known to exist in area.

Crude population density for rural area is 74 persons/km^2. Population density per cultivated area is 1.65 persons per hectare. Average family size in the study area ranges from 3.7 to 5.6 the average being 4.7 members.

3.1.3. Distribution of tsetse and trypanosomosis

The invasion of the Upper Didessa valley by tsetse flies is believed to have taken place since 1930's. By the 1940's people were actively moving out of the area (Barrette, 1992). The two species of tsetse found during Langridge's survey conducted between 1971and 1976 in Didessa and Anger valleys were *G. m. submorsitans* and *G. tachinoides* (Erkelens, 1999). In the later years these species were found in Upper Didessa valley, the first occupying the wood land on the floor and sides of the valley and the second, occupying the vegetation on the drainage lines (Slingenbergh, 1992). Tsetse and trypanosomosis became a serious problem to the area around the pilot control program in the early 1980 (Barette, 1992). The problems pushed the rural communities out from around the waters of the Didessa river. Moreover, they made new advances upstream and to the south to the Ghibe tributaries, where a previous survey did not reveal the presence of any *Glossina* species. This new spread across the watershed into the adjacent drainage systems called for a lasting operation to prevent further tsetse advances (Slingenbergh, 1992). Ford *et al.* (1976) found in a three days an average apparent density of 245 flies pre-control. The NTTICC annual report (1992) and the FITCA document (1999) suggest a rough figure 30% trypanosomosis prevalence rate for the pre-operation period. The species of trypanosome involved in livestock infection in Upper Didessa valley remain essentially *T. congolense* and *T. vivax,* in this order of importance. However, monitoring activity revealed that, some amount of *T. brucei* was also present in all the sites. An overall picture shows that *T. congolense* is responsible for 74% of all the infections followed by *T. vivax* which account for some 22% (Bedane, 1998).

3.1.4. Tsetse control programs

FAO's assistance in tsetse and trypanosomosis control in the Upper Didessa valley commenced in 1983 with a preparatory assistance mission. This was followed by a one-year (1986) Tsetse Control Project (TCP) with the objective of assisting the NTTICC to conduct a pilot tsetse control trial in the Chello area using an odor-baited, insecticide-treated targets to eradicate *G. m. submorsitans*. FAO's assistance continued to consolidate the previous achievements under a new project: Emergency Assistance to control Tsetse and Trypanosomosis infection. This project encompassed more villages of the Chello area and operated from May 1987 to April 1988. They used odor-baited insecticide traps and targets in Bedelle, Dembi/Toba, and Limu Shay areas (Barrette, 1992)

Tsetse Control and related area Development Project in the Upper Didessa valley was the subsequent project with the objectives of strengthening the NTTICC and increasing tsetse eradication program to the Limu Shay area. FAO together with the FLDP (Fourth Live stock Development Project) financed the farming system development survey for a detailed assessment of tsetse advance on livestock and crop production in the Upper Didessa valley. In 1990, FAO's assistance came to an end and FLDP continued funding the operation up to December, 1994, and after that the NTTICC had to rely on limited government finance (FITCA, 1999)

Due to these control efforts, tsetse suppression activities, mainly targeting *G. m. submorsitans* were under taken in about 1000km² of the Upper Didessa valley (NTTICC, 1999). Subsequently in tsetse controlled areas, the apparent density of tsetse flies (25-32 FTD) and the prevalence of trypanosome infection (average 30%) have declined to about 0.05 FTD and 7% respectively (Bedane, 1998).

An extension of the previous activities, an Eastern Africa-Regional Program "Farming in Tsetse Control Areas (FITCA)" project is presently operating over a total area of 4500 km² of the Upper Didessa valley to control tsetse flies and rehabilitate mixed farming practices.

3.2. Study design

3.2.1. Study sites

Two sites, one from tsetse controlled area and one from tsetse infested area were selected for the study. Limu Shay and Didessa were selected as tsetse controlled and tsetse infested areas respectively. Limu Shay is in Goma Woreda of Jima zone and is an area in the Upper Didessa valley where tsetse control program had been implemented (Fig. 2). It is a rural community composed of 9 PA's. Tsetse control operations began at the end of 1988, when some 600 targets were sited over an area of about 150 km^2.Abarrier zones of about 25 targets per km: over a distance of 2 km has been constructed between the cold highlands and the Didessa river. Since 1996 there has not been any tsetse control activity in Limu Shay, and the area is being considered as tsetse controlled area in the Upper Didessa valley. The most interesting feature of the Limu Shay area is that, before commencement of control operations, there was generally, low tsetse density (1-4 FTD), while the prevalence of trypanosomes in cattle was as high as 60% in some villages. The mosaic cultivated land, coffee bushes, much open grass land, relatively small areas of wood land are features that provide an adequate environment for *G. m. submorsitans* to cause a major trypanosomosis problem.

Didessa is tsetse infested area in the Upper Didessa valley, purposively selected on the basis of its similar agro-climate with the Limu Shay (tsetse controlled), for the comparison to be made. The study was conducted on cattle, and the total number of cattle in both areas was approximately 26500, consists of 24000 and 2500 heads of cattle in the controlled and the infested areas respectively. Likewise, the total number of house holds in both areas was 5295, consists of 4395 and 900 in the controlled and infested areas respectively. Accordingly, the entire households and cattle populations in both of the areas were the study population.

3.2.2. Disease prevalence

Sample size:

A total of 810 cattle were sampled for bovine trypanosomosis prevalence study. Detailed village counts were made in both tsetse controlled and uncontrolled areas. Then cattle herds were sampled using a two-stage cluster sampling technique. A herd is taken as a group of cattle owned by a family or a household. The approximate sample size required to detect a difference between two proportions was determined with an estimated disease prevalence rate of 20% and 30% for both the tsetse controlled and tsetse infested areas respectively; at a precision level and the probability that we fail to detect the difference of 5% and 95% confidence interval using the following formula (Thrusfield, 1995).

$$n = \frac{\{M_1\sqrt{2P(1-P)} + M_2\sqrt{P_1(1-P_1) + P_2(1-P_2)}\}^2}{(P_1 - P_2)^2}$$

n = sample size for each population

P_1 = true proportion in population1

P_2 = true proportion in population 2

$P = ½(p_1 + p_2)$

M_1= multipliers associated with the required significance level (α.).

M_2 = multiplier associated with the probability that we fail to detect the difference (β).

Accordingly, the calculated sample sizes required in each control and infested areas was 405 cattle.

Diagnostic method

Dark ground/ phase contrast buffy coat method (Murray *et al.,* 1977) was employed to study the prevalence rate of trypanosome infections. Two capillary tubes were filled for each blood sample. Blood to be examined was added to the capillary tubes by capillary attraction until the tubes were filled ¾ ways. Each capillary tube was sealed at one end using plasticin. After centrifugation at 12,000 rpm for 5 minutes, the capillary tube was cut to include 1 mm of erythrocytes and 1cm of the plasma and the buffy coat was expressed on microscope slides and examined using a microscope with × 40 objectives. Thin blood smears stained with Giemsa was used to confirm the species of trypanosomes in case of parasitaemia. Consequently, the PCV of each sample was estimated using a microhaematocrit reader.

3.2.3. Tsetse survey:

A total of 180 monoconical traps were deployed along the established tsetse control localities categorized at five altitudinal levels between 1300 to 1550 meters above sea level at 50 meters interval in order to minimize the altitudinal variation between the tsetse controlled and tsetse infested areas for the estimation of tsetse apparent densities. Traps were not equally distributed over the different localities. They were distributed over the established localities in the Limu Shay (controlled) area, and along the selected suitable tsetse habitats in the Didessa (infested) area. The traps were deployed during the end of rainy reason in 90 trapping sites in each area. 44 (24.44%) of the traps were deployed in altitude up to 1350 meters above sea level, 52 (28.89%) between 1351and 1400 meters above sea level, 38 (21.11%) between 1401 and 1450 meters above sea level, 26 (14.44%) between 1451 and 1500 meters above level and 20 (11.11%) of the traps were deployed in an altitude 1500 and 1550 meters above sea level. About 80 % the traps were deployed in the savannah and the rest 20 % were deployed along the Didessa river and its tributaries in both survey areas. Traps were placed at suitable intervals depending on the ecology of the target species. Savannah tsetse can (*G. m. submorsitans*) detect odors from about 50-100 meters; so it is best to space traps at about 200 meters. Riverine tsetse (*G. tachinoides*) are fairly sedentary and mostly do not react to the odor baits that are currently available. Hence, shorter spacing can be used for this group. Traps were baited with cow urine from local zebu cows which was "aged" three weeks at ambient temperature (25°-30°) prior to use and acetone. The odor attractants were dispensed from standard dispensers placed under traps which were sited in shade with good visibility. Filter papers were also introduced in the bottle in order to increase evaporation rate of the odor for the high catch of tsetse flies. The traps were deployed in places, which were considered to be the habitat of tsetse flies for 72 hours. The total number of flies caught, sex, species and apparent densities were recorded. When traps are used, apparent density is defined as the number of flies/trap/day (FTD) (FAO, 2000).

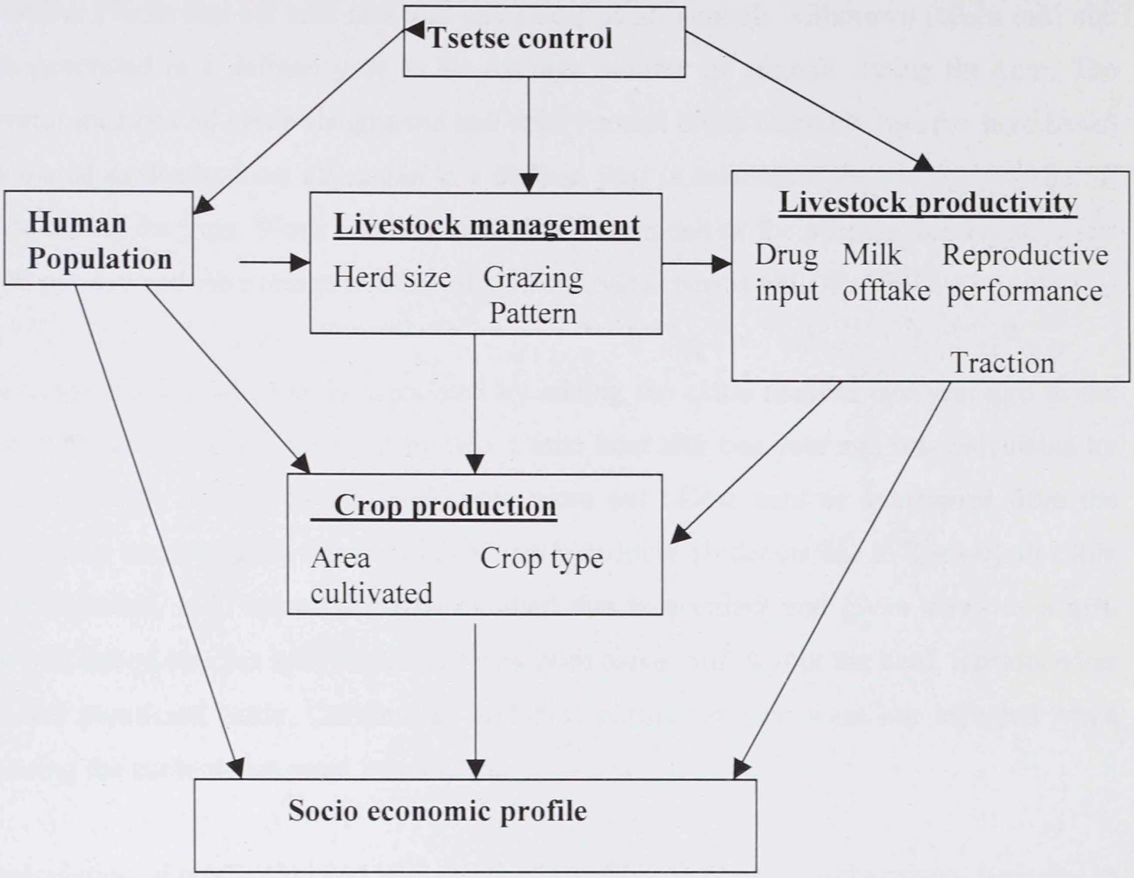
3.2.4. Questionnaire survey and retrospective data collection:

For the questionnaire survey a two- stage cluster sampling was used. By using a simple random sampling technique, first, the villages were selected, and then, the households. The questionnaire survey was conducted in the controlled (Limu Shay) and infected areas

(Didessa) to provide data for the socio-economic impact assessment of bovine trypanosomosis. A total of 180 households (90 in each area) were interviewed. The questionnaire (Annex 1) covered issues on the disease and animal production required to compare both controlled and infested areas on the socio-economic impact of tsetse control. At each household, respondents (head of household) were asked about the trypanosomosis, tsetse and its control, and their impacts on cattle performance parameters, and inputs (use of trypanocidal drugs), with the perceived tsetse challenge and trypanosomosis risk in the area. This approach was necessary with the absence of scientific monitoring and measurements such as done under health and productivity studies, or when these studies are not organized at the on set of field experiments to characterize the pre-intervention situation.

The organizing framework used in this study generally adopts the distinction between the direct and indirect impacts suggested by Putt *et al.*, (1980). The direct impacts were aggregated into impacts on animal productivity, livestock management and human population. The direct impacts on livestock management were concerned particularly on number of livestock kept by farmers and the way that livestock are grazed. The indirect impacts focused on crop production. Questionnaire survey was designed to provide data mainly on the direct impacts, whereas, the secondary source data (retrospective) were used mainly to assess the indirect impacts on crop agriculture

Figure 3: Conceptual framework of the socio economic impacts of tsetse control



The different parameters used to assess tsetse control impact on animal productivity included: cow reproductive performance parameters (age at first calving, calving interval, calving rate and abortion rate), lactation offtake (yield in liter per day and lactation days), crude annual mortality rate, animal traction or draught oxen productivity (work hour per day and work day per year) and trypanocidal drug inputs (treatment/animal/year). Tsetse control impact on livestock management that included grazing management, animal number, purchases and productive offtake (sale and slaughter rate) was also assessed from the questionnaire data.

Respondents were asked to estimate the average values for each parameters. The reproductive performance parameters were calculated using the methodology of the

International Livestock Center for Africa (Bourzat et al., 1988). The age at first calving was defined as the date of animal's first calving and calving interval as the interval between two calvings. Calving rate is defined as the percentage of calves born to the average number of breeding females in a defined year. Abortion rate is the percentage of pregnant females ended in abortion. Productive off take rate was calculated as all animals withdrawn (taken out) and values generated in a defined year to the average number of animals during the year. The numerator includes all cattle slaughtered and sold. Annual crude mortality rate (on herd basis) is calculated as deaths from all causes in a defined year in relation to the average number of animals during the year. Work oxen out put were determined as the average number of hours worked per day and the average number of land cultivated per ox (FLDP, 1994).

The average number of cattle is calculated by adding the cattle number one year ago to the current number and then dividing it by two. Cattle herd size one year ago was calculated by considering cattle introduced into and cattle taken out of the herd as questioned from the farmer. Cattle number taken out were calculated by adding all deaths due to disease, all cattle sold, slaughtered, lost, eaten by predators, died due to accident and given away as a gift. Cattle introduced into the herd include all new born calves still within the herd, introduced as a gift and purchased cattle. Calves born and died during the year were not included when calculating the cattle which went into a herd.

The calculation of production and reproduction variables was based on the annual holy day in this particular study, the Ethiopian Epiphany *timket beal.* Thus, a one year is the period from one *timket beal* to the other. Data necessary for annual epidemiological rates calculation, were compiled by considering events which had occurred form the previous *timket beal* to the current *timket beal*.

Didessa valley is one of the tsetse belt areas where a number of studies have been conducted. In addition, the National Tsetse and Trypanosomosis Investigation and Control Center (NTTICC) is located there. Likewise, there are literatures and recorded data on tsetse and trypanosomosis activities in the area. The precontrol data and the current socio-economic data on agricultural and livestock performance parameters and data on tsetse population and trypanosomosis prevalence, and human population were collected from NTTICC, MOA, Oromia Bureau of Agriculture Development, and Bedelle Dabo and Goma Woredas agricultural offices, and other relevant sources. The recorded data together with the questionnaire survey were used to assess the socio- economic impact of tsetse control on farming systems in Limu Shay tsetse controlled area. Annual growth rate and average family size were used to assess the impacts on human population. Parameters on animal traction, area cultivated and households were used to assess impacts on crop agriculture.

3.3. Data analysis

Based on the objective of the study, data was collected to assess whether the control program in the Limu Shay has brought a significant effect on; tsetse population, trypanosomosis prevalence, and the socio-economic activities of the target population. Data analyzed include:

Data on bovine trypanosomosis:

Data collected on prevalence, species of trypanosomes identified and PCV were analyzed. The prevalence rate of trypanosome infection was calculated as the number of parasitologically positive animals as examined by dark ground/phase contrast Buffy coat method (Murray, *et al.*, 1977) divided by the total number of animals investigated at that particular time. Confidence interval (95%) and chi-square test were used to compare the prevalence rates of trypanosome infection in different villages and between tsetse controlled and the infested areas. Student t-test was utilized to compare the mean PCV of the parasitaemic cattle with that of the aparasitaemic cattle both within and between the controlled and uncontrolled areas.

Data on tsetse fly survey:

Data on density, species and sexes of tsetse flies were compared using descriptive statistics such as percentage reduction in tsetse densities due to control operations. Apparent density was utilized to estimate the tsetse population (density) in both controlled and infested areas. Chi^2 test was used to test the percentage of traps that caught *Glossina,* regression analysis and ANOVA were used to test the relationships and differences in fly catch by the altitudinal levels and t test was also used to test the difference in the mean fly catch between tsetse controlled and tsetse infested area.

Socio-economic data:

Parameters on crop production, such as total land cultivated, land cultivated per crop per house hold, and parameters on livestock production like total cattle population, draught-oxen work out put per year, milk yield per day and milk offtake per lactation were compared for both tsetse controlled and uncontrolled areas and before or after the control operations using descriptive statistics like percentages and ratios. Where data were suitable for statistical analysis parameters means and proportions were examined for associations and significance using a one tailed t-test and chi-square.

The statistical packages used for the analysis were Intercooled stata 7.0 for windows and SPSS 11.5 for windows.

4. RESULTS

4.1. Disease prevalence

4.1.1. Parasitological findings

In order to assess the current epidemiological situation of bovine trypanosomosis , a total of 405 cattle in 6 villages of Limu Shay (controlled) and 405 cattle in 5 villages of Didessa tsetse (infested) areas were examined for the presence of trypanosome infection to determine the disease prevalence rate during the months of October to December 2003.

4.1.1.1. Tsetse controlled (Limu Shay) area

The prevalence rate of trypanosome infection in cattle in Limu Shay tsetse controlled area of the upper Didessa valley investigated was found to be 7.9% (CI= 0.0526-0.1054). Highest trypanosomes prevalence rate of 14.3% was recorded in Meti village followed by village 3&5 (12.9%). The parasitological results are presented in Table1. Fifty percent of the over all infections were due to *T.vivax,* 43.75% due to *T. congolense* and 6.25% due to *T. brucei.*

Table 1: Parasitological result in the 6 villages of the Limu Shay tsetse controlled area.

Villages	Animals			Trypanosome species			95% CI
	Examined	Infected	%	TV	TC	TB	
Balto Warabu	63	4	6.3	2	2	0	0.0016-0.1254
BaltoAbulu	68	6	8.8	2	3	1	0.0191- 0.1574
Koticha	60	4	6.7	1	3	0	0.0017- 0.1316
Meti	64	9	14.1	5	3	1	0.0532- 0.2281
Village 3 & 5	70	9	12.9	6	3	0	0.0818- 0.2089
Sokoru	80	0	0	0	0	0	
Total	405	32	7.9	16	14	2	0.05226- 0.1054

Note: TV= *T. vivax*; TC= *T. congolense*; TB= *T. brucei*.

4.1.1.2. Tsetse infested (Didessa) area

The prevalence rate of trypanosome infection in Didessa tsetse infested area of the Upper Didessa valley investigated was found to be 27.16% (CI= 0.2281- 0.3151). The highest prevalence rate was recorded in Burka village (41.2 %) and the lowest in Temo village (8.96%). The prevalence rates of trypanosomosis infection in different villages are as shown on the Table 2. About 78.2% of the overall infections were due to *T. congolense*, 17.3% due to *T. vivax*, 0.9% due to *T .brucei* and 3.6% were mixed infection (*T. congolense* and *T. vivax)*. Except for Temo there was no apparent difference between villages as regards the most prevalent trypanosome species. In Temo village 50% of the parasitaemia was due to *T. vivax* while 33.3% of the parasitaemia accounts for *T. congolense*, the otherwise predominant trypanosome in the area.

Table 2: Parasitological results in 5 the villages of the Didessa (tsetse infested) area.

	Animals			Trypanosome species.				
Village	Examined	Infected	%	TV	TC	TB	Mixed	95% CI
Chelelek	94	27	28.72	3	24	-	-	0.1941-0.3804
Burka	85	35	41.18	9	25	-	1	0.3050- 0.5185
Loko	90	28	30.0	1	24	1	2	0.2136- 0.4086
Kolu	69	14	20.29	3	11	-	-	0.1056- 0.3002
Temo	67	6	8.96	3	2	-	1	0.0194- 0.1597
Total	405	110	27.16	19	86	1	4	0.2281- 0.3151

Note: TV= *T. vivax*; TC= *T. congolense*; TB= *T. brucei*.

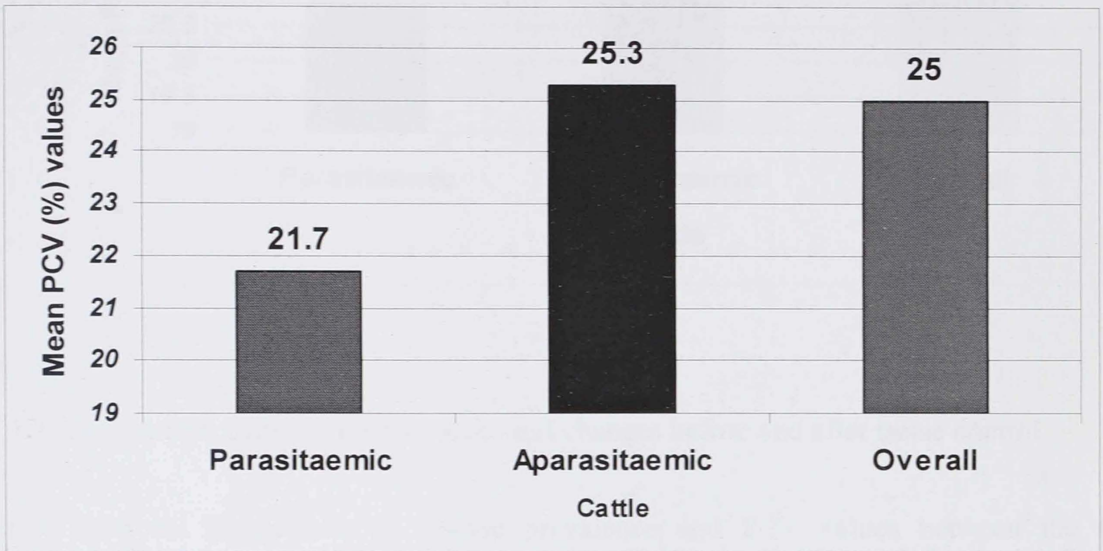
4.1.2. Hematological findings.

4.1.2.1. Tsetse controlled area (Limu Shay).

Results of the hematological findings are presented in Figure 4 (see also Annex 2). The mean packed red cell volume PCV (%) value of the total number of cattle tested was 25.0%. Cattle herds found in village3&5 had the lowest mean PCV values (22.46 %) compared with the other areas. There was statistically significant difference (P<0.001; CI=24.1909- 25.7557) between the mean PCV values of cattle found at Sokoru and village 3&5. On the other hand, over 42% of the PCV values of cattle examined were greater than or equal to 26%. About

19% of the parasitaemic and 44% of the aparasitaemic cattle had PCV greater than 26%. The mean PCV value of parasitaemic cattle (21.66; CI= 20.0371- 23.2734) was significantly lower than the mean PCV value of the aparasitaemic cattle (25.29; CI= 24.8567- 25.7224; P< 0.001).

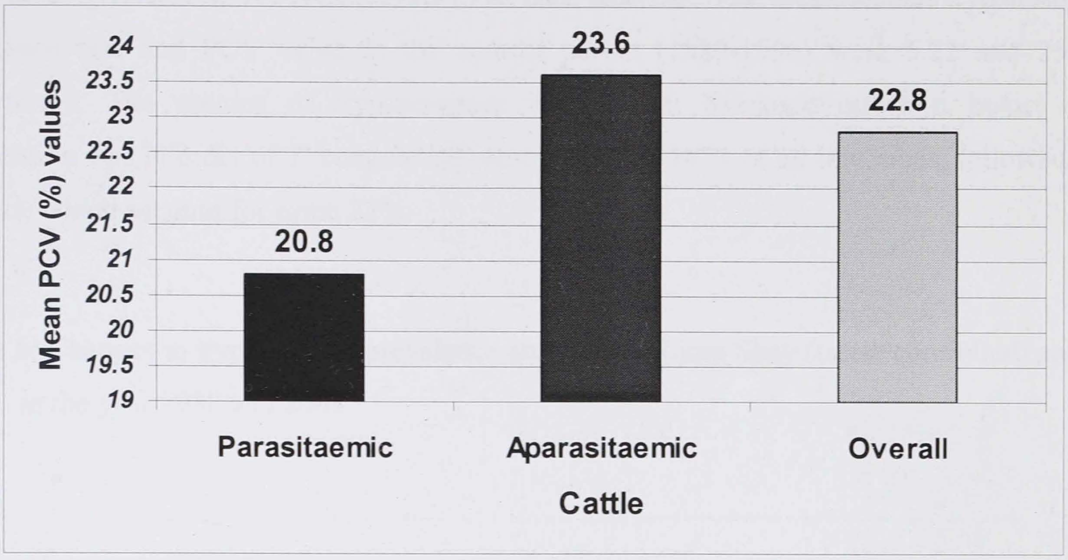
Figure 4: The mean PCV values of parasitaemic and aparasitaemic cattle in Limu Shay (tsetse controlled) area.



4.1.2.2. Tsetse infested (Didessa) area

Results of the hematological findings are presented in Figure 5 (Annex 3). The mean PCV value of the total number of cattle tested was 22.83. The mean PCV values of parasitaemic cattle (mean=20.8; CI = 20.1126- 21.5602) was statistically lower (P< 0.001) than the mean PCV values of aparasitaemic cattle (mean=23.6; CI=23.1303- 24.0968). About10 % of the parasitaemic and 31.0 % of the aparasitaemic cattle had PCV values greater than or equal to 26%, and 25.45% of the animals had average PCV value greater than 26%.

Figure 5: The PCV values of parasitaemic and aparasitaemic cattle in the tsetse infested (Didessa) area.



4.1.3. Comparison between the two areas and changes before and after tsetse control

Cross sectional comparison of disease prevalence and PCV values between the tsetse controlled (Limu Shay) area and the tsetse infested (Didessa) area has shown 71% reduction in trypanosome prevalence (Chi^2= 51.95; 95% CI = 0.1490- 0.202; $P< 0.001$) and 9.51% increase in PCV values (t= 7.035; 95% CI = 23.623- 24.2387; $P< 0.001$) at Limu Shay (controlled) area which was statistically highly significant. The results are presented on Table 3 below.

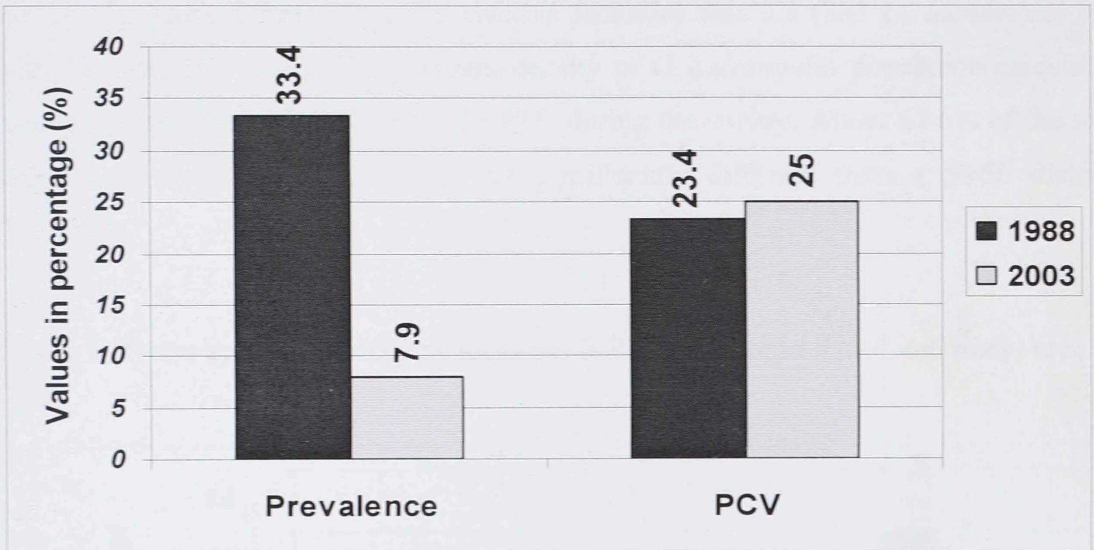
Table 3: Comparative disease prevalence and PCV values between Limu Shay (controlled) and Didessa (infested) areas.

Area	No of cattle examined	Trypanosome prevalence ± SE	Mean PCV (%) ± SE
Tsetse controlled	405	$0.079^{a}\pm0.013$	$25.00^{a}\pm0.217$
Tsetse infested	405	$0.2716^{b}\pm0.022$	$22.85^{b}\pm0.213$
Overall	810	0.1778±0.0133	23.93±0.157

Note: a ,b, means followed by different superscripts differ significantly.

Data Analysis for changes in disease prevalence and PCV values (Figure 6) before (1988) the intervention and the present finding (2003) has shown that, infection rate in cattle reduced from 33.4 % (mean prevalence rate) to 7.9 % and that PCV mean values increased from 23.42 to 25 (Annex 4: NTTICC, 1988-1996 data records). The mean annual trypanosome prevalence rate and PCV value in the control period (1889-1996) were 5.22 and 25.11 respectively. The species of trypanosomes involved in livestock infection before the intervention was in order of *T.* congolense responsible for 74 % of all infections, followed by *T. vivax*, which account for some 22%.

Figure 6: Changes in trypanosome prevalence and PCV at Limu Shay (tsetse controlled) area in the year 1988 and 2003.



4.2. Tsetse fly survey

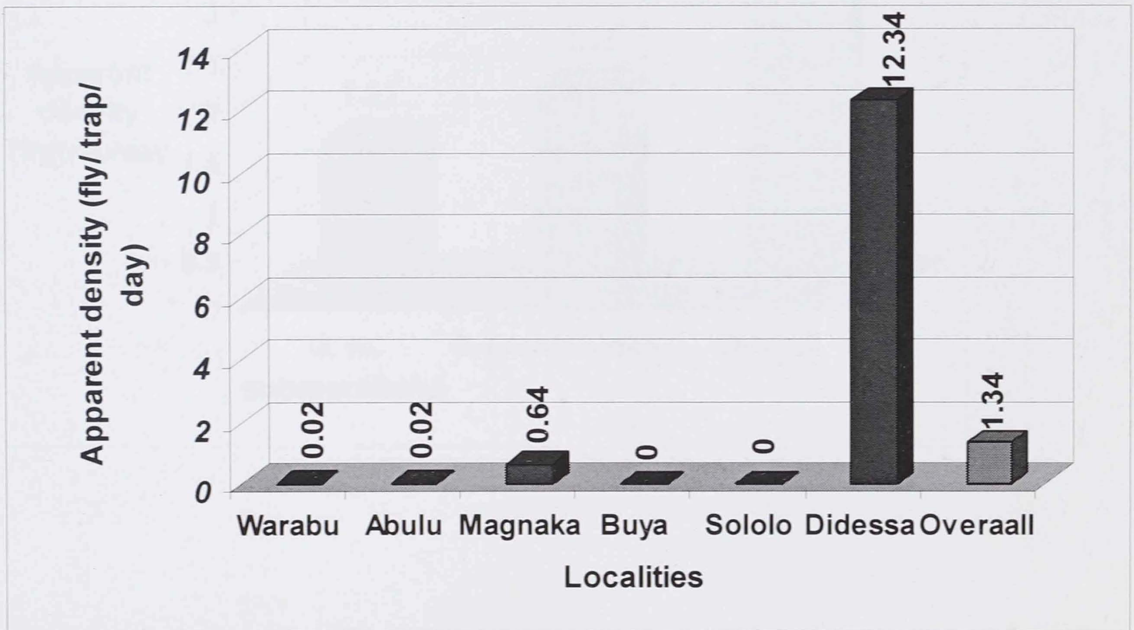
The main objective of tsetse fly survey was to assess changes in tsetse fly densities. For this purpose 90 traps in Limu Shay (controlled) and 90 traps in Didessa (infested) areas were deployed at the end of rainy season from October to December, 2003 (Annex 5).

4.2.1. Tsetse controlled (Limu Shay) area.

Following the official declaration of *G. m. submorsitans* control in Limu Shay in 1996, this study has been the first intensive entomological and parasitological survey set up to confirm particularly the status of control of *G. m. submorsitans* in the area. During the study period, no *G. m. submortans* was trapped, despite the deployment of 90 monoconical traps in the previously highest tsetse density localities, and which are the locations where the fly populations are most likely to be encountered.

During the survey only one *Glossina* species was caught in the study area as shown in Figure 7. *Glossina tachinoides* was trapped in 4 out of the 6 localities surveyed (66.67 % the area) along the drainage lines in Didessa river and its tributaries (Annex 6). A total of 363 *G. tachinoides* with apparent density of 1.34 fly per trap per day (FTD) were caught during the survey. Apparent density along the riverine localities was 5.5 (363 *G. tachinoides* trapped with 22 traps in 3 days). The apparent density of *G. tachinoides* population calculated per localities, varied from 0 FTD to 12.37 FTD during the survey. About 63.6% of the total fly samples were female flies, which was significantly different from a 50/50 distribution ($P<0.001$).

Figure 7: Tsetse apparent density by localities in the tsetse controlled (Limu Shay) area..



4.2.2. Tsetse infested (Didessa) area

During the survey, two *Glossina* species were caught in the study area. *G. m. submortans* was trapped in 5 out of the 6 localities surveyed (83.3% of the area) in the savannah woodland. Like wise, *G. tachinoides* was trapped in 2 out of the 6 localities surveyed (33.33%) in the areas along the drainage lines, Didessa and its tributaries. A total of 409 *G. m. submorsitans* and 553 *G. tachinoides* were caught during the survey (Annex 7). Figure 8 shows the apparent densities of *G. m. submorsitans* and *G. tachinoides* in the infested area and Figure 9 shows the apparent densities according to species of tsetse in the different localities. Apparent densities of *G. m. submorsitans* (1.5 FTD) population calculated per localities, varied from 1.26 to 2.91 FTD, and from 5.08 to 23.9 FTD for *G. tachinoides* (2.05 FTD).

About 56 % and 58.05% of the total flay catch were females for *G .m sub morsitans* and *G. tachinoides* respectively.

Figure 8: Apparent densities of *G. m. submorsitans* and *tachinoides* in tsetse infested (Didessa) area.

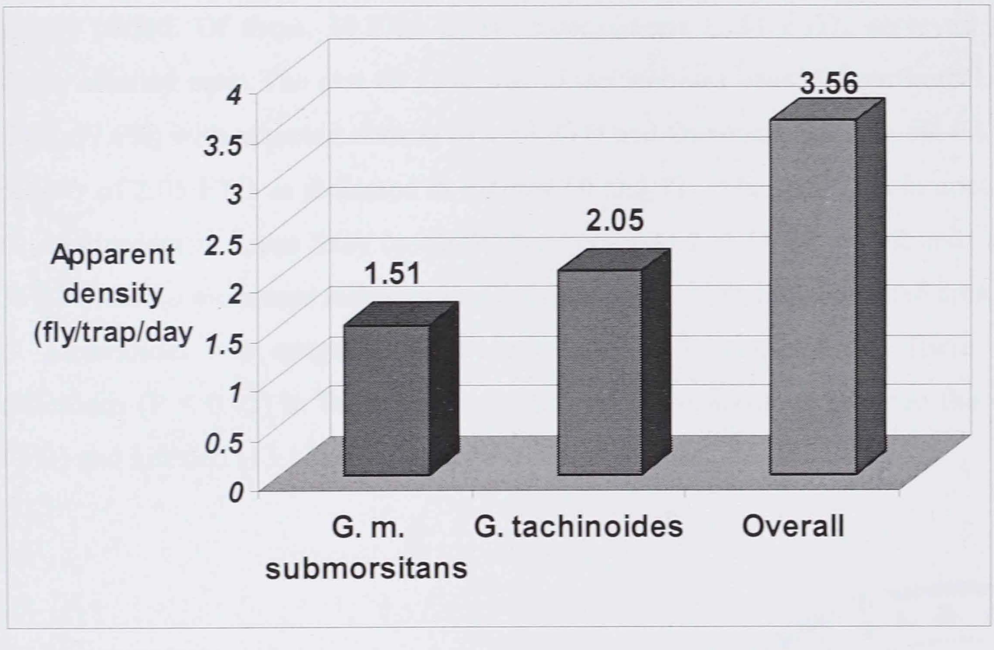
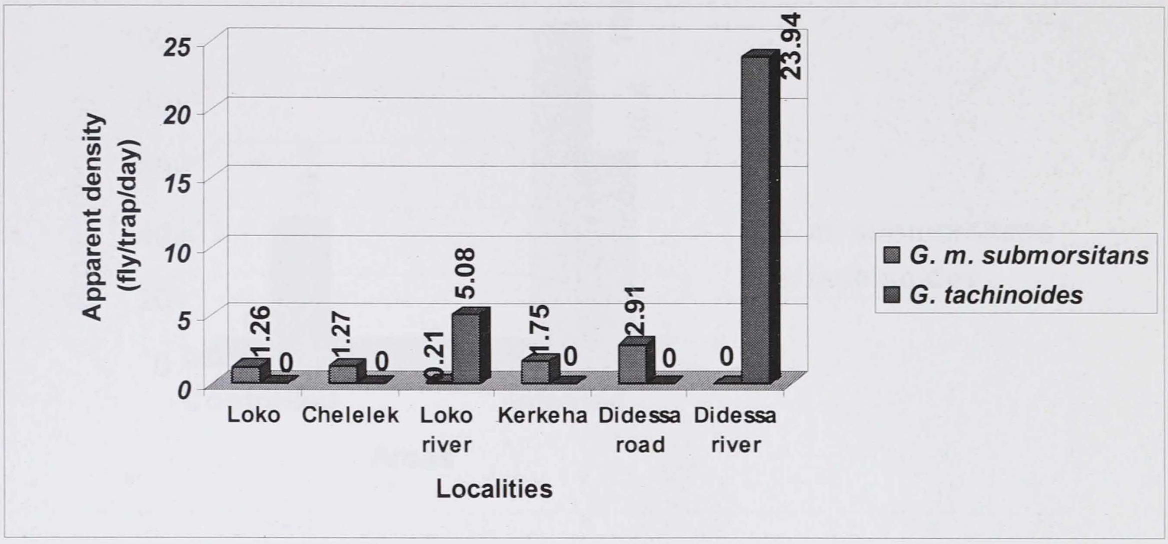


Figure 9: Apparent densities of *G. m. submorsitans* and *G. tachinoides* by localities in tsetse infested (Didessa) area.



4.2.3. Comparison between the two areas and changes before and after tsetse control.

A total of 1325 tsetse flies (*G. m. submortans* and *G.tachinoides*) were caught during the survey period. Of these, 30.87% *G. m. submorsitans* (1.51 FTD) surveyed in the Didessa tsetse infested area. The rest 69.13% was *G. tachinoides* caught from both Limu Shay area (363, 39.6%) with apparent density of 1.34 FTD and Didessa area (553, 60.4%) with apparent density of 2.05 FTD as indicated in Figures 10 and 11. The reduction in apparent density of *G. tachinoides* in Limu Shay (controlled) as compared to Didessa (infested) area was about 35%. *Glossina morsitans submorsitans* was not detected in the controlled area. In both areas, *G. tachinoides* was caught along Didessa river and its tributaries. There was a marked difference ($P < 0.05$) in the apparent density of *G. tachinoides* between the controlled (5.5 FTD) and infested (13.17) areas along the drainage lines.

Figure 10: Proportion of flies according to species in Limu Shay (controlled) and Didessa (infested) areas.

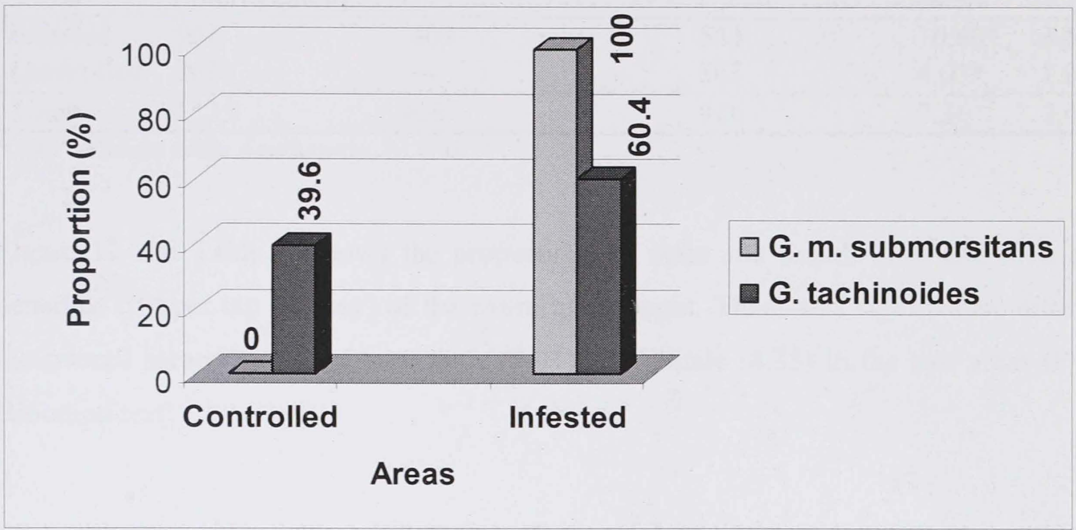


Figure 11: *G. tachinoides* apparent density in the controlled and infested areas.

Table 4 shows the total catches with its mean and apparent density calculations. The overall (pooled data) catches were 27.4% (Mean=4.033; 95% CI= 0.4734- 7.5932) in the controlled area and 72.6 % (Mean= 10.69; 95% CI= 5.19475- 16.18302) in the tsetse infested area. The mean catches of tsetse flies in the Limu Shay tsetse controlled area were significantly different ($p<0.05$) as compared to the Didessa tsetse infested area. Overall tsetse apparent density was reduced by 62.4% in the controlled (1.34 FTD) as compared to the infested (3.56 FTD) area.

Table 4: Tsetse apparent density (fly per trap per day) in the controlled and infested areas.

Area	Total catch (3 days catch)	*G .m. submorsitans*	*G. tachinoides*	Mean catch	FTD
Infested	962	409	553	10.69*	3.56
Controlled	363	---	363	4.03*	1.34
Total	1325	409	916	7.36	2.45

Note: * = means differ significantly, P< 0.05.

Figure 12 and Table 5, shows the proportions of male and female flies and their apparent densities (fly per tap per day) of the overall fly caught. There was significance difference in the overall mean catches of both male (3.01) and female (4.35) in the two areas (P< 0.001, Binomial test).

Figure 12: Proportion of male and female flies in both Limu Shay (controlled) and Didessa (infested) areas.

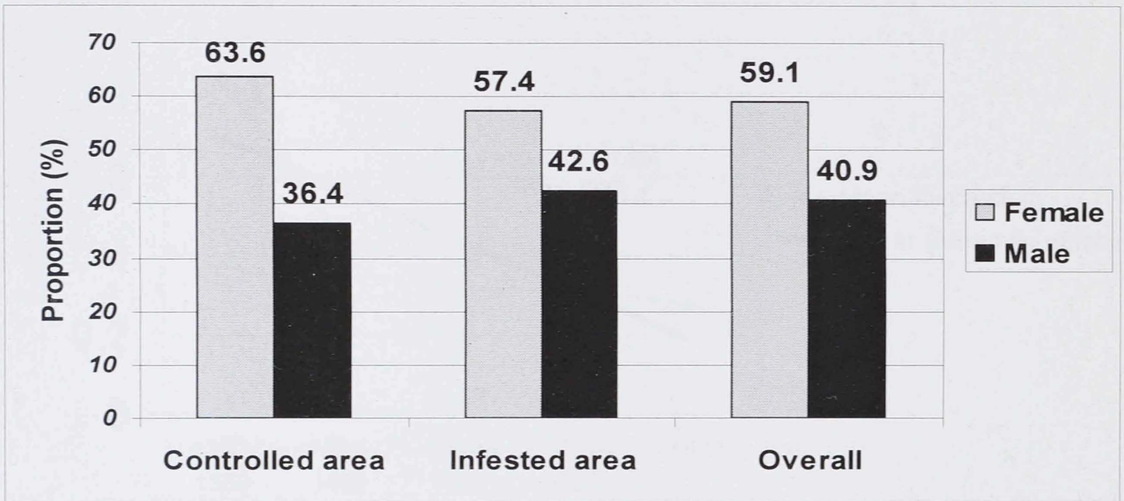


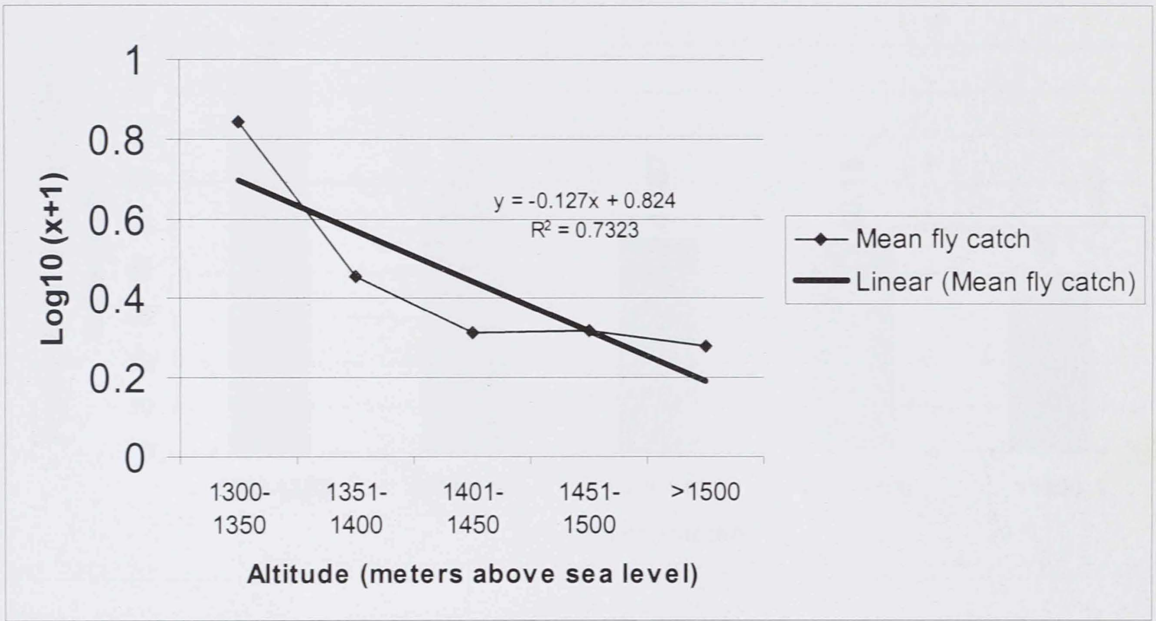
Table 5: Comparison of Male and female apparent densities, (fly per trap day).

Sex	*G. m. submorsitans*		*G. tachinoides*		Overall	
	3 days catch	FTD	3 days catch	FTD	3 days catch	FTD
Male	178	0.33	364	0.67	542	1.00
Female	231	0.43	552	1.02	783	1.45

In the analysis of the pooled data, 69.3% (918 flies, mean= 20.86; CI= 8.2985- 33.4287) of the total *G. m. submorsitans* and *G. tachinoides* were at an altitude below 1350 meters above sea level. It was only 2.79% (37 flies, mean= 1.86; CI= 0.5152- 3.1848) in altitude level above 1500 meters (1501-1525 meters above sea level).

Statistically significant difference was observed (F= 6.04, P < 0.001) in the tsetse fly catch within altitudinal categories. A linear regression analysis for the Log10 (x+1) transformed mean fly catch was performed to see if there was a correlation between tsetse fly distribution and altitude as shown in Figure 13. Accordingly, as altitude increase there was a decrease in the tsetse fly catch which indicates that there was a negative relationship between altitude and tsetse fly distribution.

Figure 13: Relationship between the density and altitudinal distribution of tsetse flies

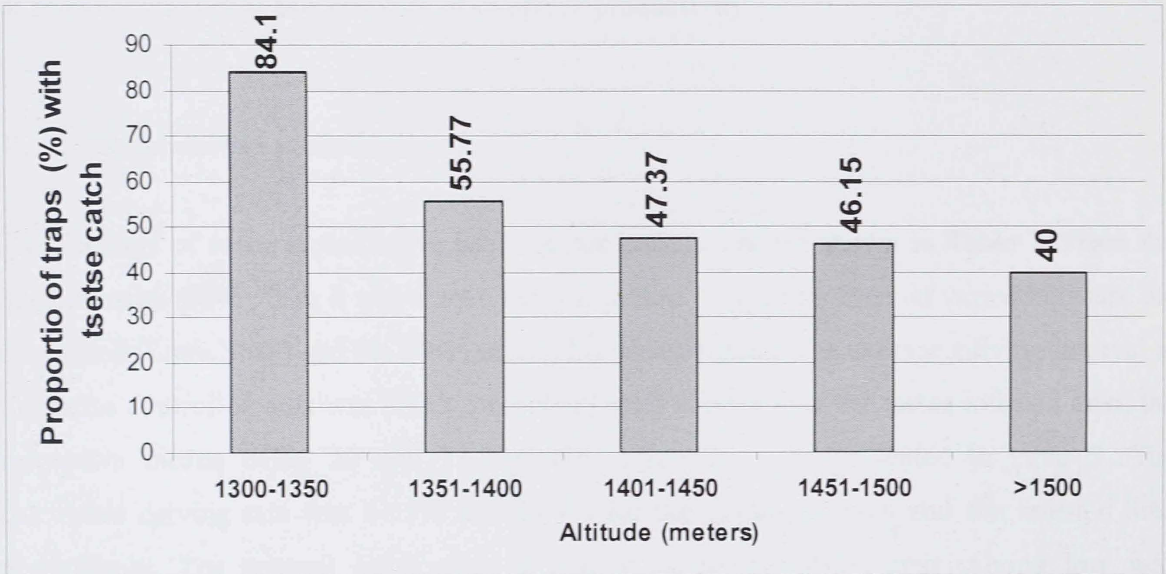


As indicated in Table 6 and Figure 14 only 57.78% of the overall traps in both areas caught tsetse flies (Chi^2= 87.54; 95% CI= 0.5049- 0.6506). Analysis of the data shows a statistically significant difference (P< 0.001) between the two areas. About 23% (21) and 92% (83) of the total traps caught flies in the controlled and infested areas respectively.

Table 6: Percentage of traps that caught tsetse flies in Limu Shay (controlled) and Didessa (infested) area.

Altitude (meters)	Controlled area		Infested area	
	Number of traps	Number of traps with *Glossina* (%)	Number of traps	Number of traps with *Glossina* (%)
1300-1350	22	15 (68.2)	22	22 (100)
1351-1400	26	4 (15.4)	26	25 (96.2)
1401-1450	19	0	19	18 (94.7)
1451-1500	13	1 (7.7)	13	11 (84.6)
>1500	10	1 (10)	10	7 (70)
Total	90	21 (23.3)	90	83 (92.2)

Figure 14: Overall (poled data) showing Percentage of traps that caught tsetse flies in each altitudinal level.



Recorded data (Slingenbergh, 1992) has shown that, the population of flies in the Limu Shay prior to the intervention was 1 to 4 FTD for *G. m. submorsitans*. At the end of 1988 tsetse control program was started at Limu Shay over an area of some 150 km^2. The last trapped *G .m. submorsitans* fly (2 female flies) in Limu Shay was found in 1992 but monitoring traps maintained over the entire area until the end of the control program in 1996 failed to catch any wild flies. Nevertheless along the course of the Didessa river and its tributaries adjacent to the controlled area are permanently infested with *G. tachinoides*.

4.3. Questionnaire and retrospective data findings

Data collected in February/March, 2004 from a random sample of 180 households and existing data records were assessed to determine how tsetse control has affected livestock productivity and crop agriculture in the study area.

4.3.1. Impacts on Animal productivity

The Parasitaemic status and PCV value as a measure of livestock productivity has been presented on the disease prevalence section. Here it is shown, reproductive performance, lactation offtake, mortality, animal traction and inputs of preventive and curative treatments of trypanocidal drugs as a measure of livestock productivity.

4.3.1.1. Reproductive performance

The findings of cattle reproductive performance parameters are shown in Table 7. From the questionnaire survey data it was shown that the means for calving interval varied between the controlled (Limu Shay) and the tsetse infested (Didessa) areas. The average calving interval at the tsetse controlled area was about 3 months (14%) shorter than the tsetse infested area, the respective means being 20 and 23.2 months respectively as presented in table 7. The calculated calving rate was 61.1% and 47.4% for the controlled area and the infested area respectively. The general implication is that in tsetse controlled area calving rate was increased by 35.3%.

Analysis of the data also gave the average mean of the estimated age at first calving to be 42 and 47.4 months in the areas of the tsetse controlled and the tsetse infested respectively. In the tsetse controlled area, associated with the reduction in the prevalence of bovine trypanosome infection was also a significant reduction of about 39.7% in average abortion rate. The abortion rate was 16.1% and 26.7% in controlled and infested areas respectively.

Table 7: Reproductive performance of cows at Limu Shay (controlled) and Didessa (infested) areas.

Parameters	Controlled area			Infested area		
	Obs	Mean	SE	Obs	Mean	SE
Calving interval (months)	89*	20.04[a] (2.67)	0.284	65*	23.20[b] (2.99)	0.372
Age at 1st calving (months)	89*	42.00[a] (4.45)	0.472	65*	47.45[b] (3.63)	0.450
Calving rate	329**	0.641[a] (0.49)	0.026	116**	0.474[b] (0.48)	0,047
Abortion rate	329**	0.161[a] (0.37)	0.203	116**	0.267[b] (0.44)	0.411

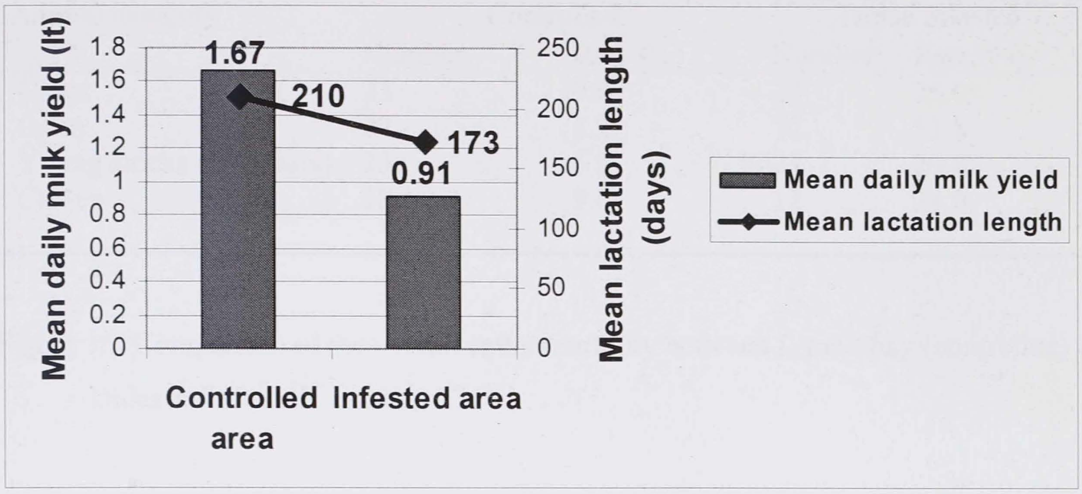
Note: Figures followed by different superscripts (a, b) differ significantly (P< 0.001); Standard deviations in parentheses; Obs= observations (* = Number of respondents, ** = average number of breeding females).

4.3.1.2. Lactation Offtake

Respondents in both tsetse controlled and tsetse infested areas were asked to estimate the daily milk offtake per cow for human consumption at the time of survey.

As indicated on Figure 15, analysis of the household survey has shown that, the estimated average means for daily milk offtake between the Limu Shay (1.67 liters per day) tsetse controlled and Didessa tsetse infested (0.91 liters per day) areas were significantly different (P< 0.001). The estimated average mean for lactation yield per cow from the tsetse controlled area was high at 350.7 kg in a lactation of 210 days. The corresponding result for the tsetse infested area was 157 kg and 173 days respectively for the lactation yield and lactation length respectively. The result has shown that; mean lactation yield was increased by 122.8% in the tsetse controlled area as compared to the infested area in the valley.

Figure 15: Estimated means for lactation length and mean daily milk yield per cow in Limu Shay (controlled) and Didessa (infested) areas.



4.3.1.3. Mortality

In cattle, trypanosomosis causes production losses and eventually death. Farmers perceived that the most important livestock trait affected by trypanosomosis was cattle mortality. Farmers were asked how much overall cattle losses they attribute to trypanosomosis irrespective of age-sex groups. About 99 % of the owners in the tsetse infested area and only 52 % of the owners in the tsetse controlled area ranks trypanosomosis top. Table 8 and Figure 16 show cattle mortalities in both areas. The estimated crude annual mortality rate in both tsetse controlled (out of the 1148 average number of cattle kept in the preceding year) and tsetse infested areas (average number of cattle 481) were 7.93 % and 29.1 % respectively. Overall the population of cattle dying of trypanosomosis consequence was reduced by 72.7 % in the tsetse controlled area as compared to the infested area with the largest reduction noted in the categories of oxen (>4 years) and young animals (1-4 years). The difference in the overall mortality between the two areas was statistically significant ($P< 0.001$).

Table 8: Estimated cattle mortalities in age and sex category at Limu Shay (controlled) area and Didessa (infested) area.

Animal category	Controlled		Tsetse infested	
	Number	Rate (%)	Number	Rate (%)
Cows	23	7.0	29	25.0
Oxen	27	8.2	72	33.8
Young stocks (1-4 years)	23	5.8	27	20.8
Calves	18	9.0	12	24.0

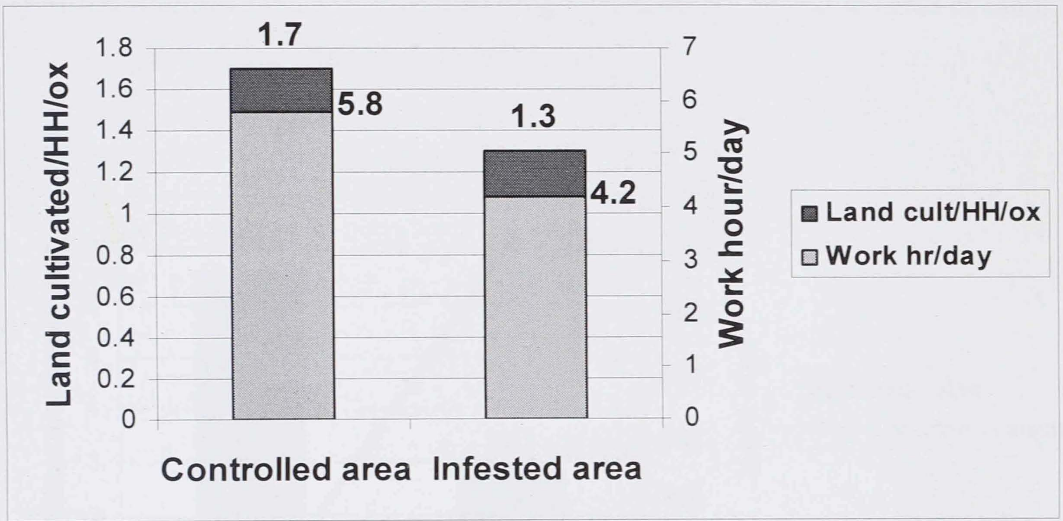
Figure 16: Comparison of the overall cattle mortality between Limu Shay (controlled) and Didessa (infested) areas.

4.3.1.4. Animal traction

Oxen and plough are used to till the land where livestock can be kept; in other areas handhold hoes are used. In the upper Didessa valley animal draught is widely applied in crop production and the health and availability of oxen is essential for ploughing of heavy vertisols. During the survey the effect of trypanosomosis incidence on the productivity of oxen used for traction was evaluated as presented in Figure 17. The household survey has shown that in the tsetse controlled area draught oxen work about 789 hours per year made up of 136 days of 5.8 hours each. The corresponding calculated result for the tsetse infested area was 202 work hours per year made up of 48 days of 4.2 hours each.

The recorded socio-economic data collected during the survey from both areas was evaluated and average area cultivated per household was plotted against the number of oxen owned per household. In the tsetse controlled area, for each additional ox each household was able to cultivate an additional of 1.7 hectares of land. For household in the infested area the corresponding figure was 1.3 additional hectares that could be cultivated for each ox that they owned. Comparison of the two slopes provides a measure of the relative inefficiency of oxen in the tsetse infested area. An ox in the tsetse controlled area was 30 % more efficient than oxen in the tsetse infested area.

Figure 17: Draught oxen performance according to work hour per day and land cultivated per house hold per ox in Limu Shay (controlled) and Didessa (infested) areas.



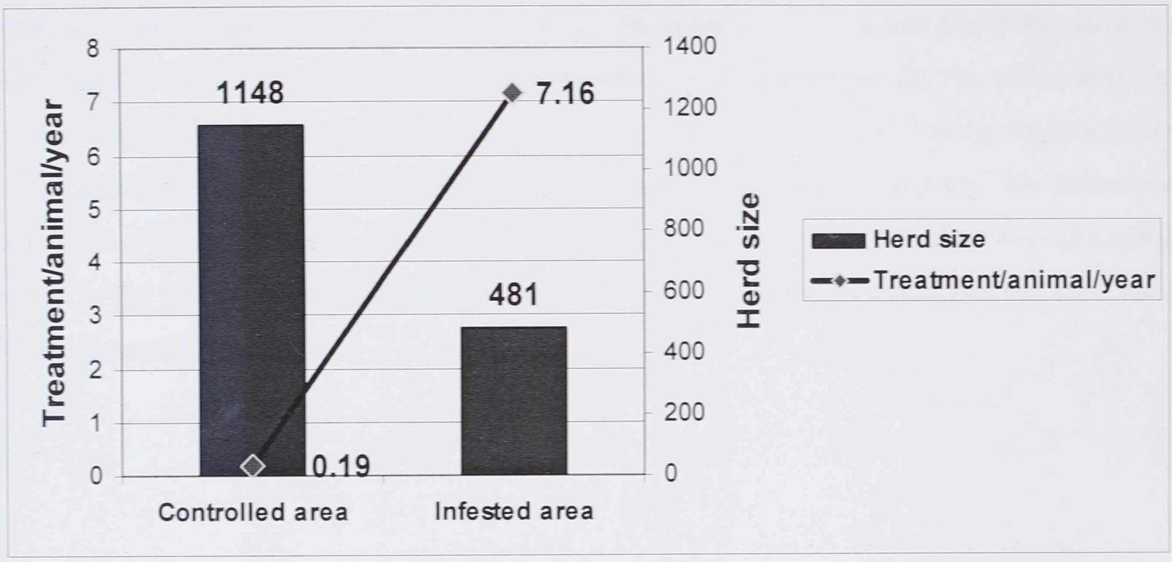
Note: Cult = Cultivated; HH = Household; hr = Hour

4.3.1.5. Trypanocidal drugs input

Analysis of questionnaire survey for farmers' trypanocidal drugs usage showed that chemotherapy was a common approach to trypanosomosis control. Where as chemoprophylactic measures, although practiced were less obvious. Investigation on the use of trypanocides in the survey areas showed that most cattle owners, 98% in tsetse infested area and 72% in the tsetse controlled area use trypanocidal drugs to treat their cattle herds.

There was no Government veterinary clinic in both areas and the treatments in all the cases in the tsetse controlled area and 71.1% of the cases in tsetse infested area were farmer treatments applied either by them selves or by the drug smugglers. The trypanocides diminazene aceturate (Berenil R) and isometamidium (samorin R) were used in the study areas. Analysis of the respondents' preference for trypanocides indicates that in 41% of the cases there was a preference for isometamidium in tsetse infested area. In tsetse controlled area almost in all the cases (99%) the preference was for the diminazene aceturate. As indicated in Figure 18 (see Annex 8) the mean number of treatments per animal per annum in the tsetse controlled and tsetse infested areas was 0.19 and 7.16 respectively. In both areas in almost all the cases they prefer to treat sick animals. The implication was that framers in the controlled area reduced trypanocidal drug inputs by 97% as compared to the infested area.

Figure 18: Average annual trypanocidal drug treatments per animal in herds of Limu Shay (controlled) and Didessa (infested) areas.



4.3.2. Impacts on livestock management

4.3.2.1. Grazing management

The findings from the household survey suggested that almost in all the cases cattle were grazing as collective village herds, with animals housed in corrals at each household at night, then brought together into collective herds each morning. Grazing pattern changed as the intensity of land use increased with tsetse control resulted in successful reduction of trypanosomosis risk in the tsetse controlled area. In the tsetse controlled area over 86% of the respondents said that the current grazing area was near river valley and gallery forests around Didessa river. In the tsetse infested area all the respondents suggested that cattle's grazing was generally focused on village grazing fields, particularly during morning and late afternoon, and in the savannah during the midday. This kind of grazing movement is used as a traditional grazing movement of animals that are used to minimize tsetse contact.

4.3.2.2. Impacts on animal numbers, purchases and sales

Cattle density in the tsetse controlled area and tsetse infested area were compared based on the current socio-economic recorded data collected from Goma and Bedelle Dabo Woredas, respectively, for the two areas. Data analysis has shown that, cattle owned per household are higher in the tsetse controlled area (94%) than the tsetse infested area as shown in Table 9. The number of cattle per owner in the tsetse controlled area is twice that of the tsetse infested area, with an average of 5.5 cattle per owner in the tsetse controlled area and 2.84 cattle per owner in the tsetse infested area. Herd structures also differed between the two areas, with the proportion (29.51%) of draught animals (males >4 years) in the total herd being slightly lower in the tsetse controlled area than the tsetse infested area (31.94%). Relatively, the difference was higher in the proportion of cows' between the controlled (31%) and infested (18.63%) areas. In the tsetse controlled area the Oxen: Cow ratio was 0.9:1 compared to the 1.7:1 ratio in the tsetse-infested area.

Table 9: Relationship between level of trypanosomosis risk and average number of cattle owned.

Animal category	Controlled area		Infested area		All areas relatives	Relative difference (A/B) (%)
	Number/ house hold	Proportion (%)	Number/ household	Proportion (%)		
Calves	0.66	12.00	0.34	12.05	0.61	+94
Young stocks (1-4 years)	1.51	27.49	1.06	37.38	1.43	+43
Cows	1.71	31.00	0.53	18.63	1.51	+223
Oxen	1.62	29.51	0.91	31.94	1.50	+78
Cattle overall	5.5	100	2.84	100	5.05	+94

Livestock production parameters selected for monitoring changes in the tsetse control sites of the Upper Didessa valley included the number per species types. Analysis of the data recorded from NTTICC (1988- 1996) and Goma woreda (1997- 2003) for Limu Shay tsetse controlled area (Annex 9 and 10) indicated that the average increase in number of animals owned by each household over a period of 15 year (1988-2003) had been 323% for cattle 363% for sheep, 950 % for goats and 450% for equines, as presented on Table 10. The population of oxen has been raised by 558 %. The ratio of oxen per household was calculated and the result showed that there was an increase in parameter by 260%. The increase in total livestock population in Limu Shay recorded for the period 1988 and 2003 was 364 %.

Table 10: Changes in average livestock growth in Limu Shay tsetse controlled area.

Livestock	Before intervention (1988)		After intervention (2003)		Relative increase in number /household (%)
	Number	Number /household	Number	Number /household	
Cattle	3133	1.30	24190	5.50	+323
Oxen	1085	0.45	7140	1.62	+260
Sheep	266	0.11	2265	0.51	+363
Goats	204	0.08	3700	0.84	+950
Equine	137	0.06	1448	0.33	+459
Overall	3740	1.55	31603	7.19	+364

Table 11 shows sales and slaughter rates. However, the household survey has shown that the productive offtake rates (sale and slaughter rates) were 6.5% and 10.8% for the controlled and infested areas respectively. Likewise, the purchase rates were 1.5% and 17.6% for controlled and infested areas respectively. Productive offtake rates were lower (by 39.5%) for the tsetse controlled area than the tsetse infested area. In the tsetse controlled area, about 41% of cattle purchases were breeding animals. In the tsetse infested area, on the other hand, about 63.1% of all purchases were adult males purchased for draft purposes. Sales and slaughter rates were not increased after control operations become effective.

Table 11: Offtake rate and purchase rate in Limu Shay (controlled) and Didessa (infested) areas.

Parameters	Controlled area		Infested area		Overall	
	No	Mean± SE	No	Mean±SE	No	Mean±SE
Sale and slaughter	75	$0.065^{a} \pm 0.007$	52	$0.108^{b} \pm 0.0142$	127	0.078±0.007
Purchases	17	$0.0148^{a} \pm 0.003$	84	$0.176^{b} \pm 0.173$	101	0.620±0.0125

Figures followed by different superscripts (a, b) differ significantly (Chi^2= 8.63 a, b, P< 0.01 for sale and slaughter and Chi^2=148.89, P< 0.001for purchase rate)

4.3.3. Impacts on human population

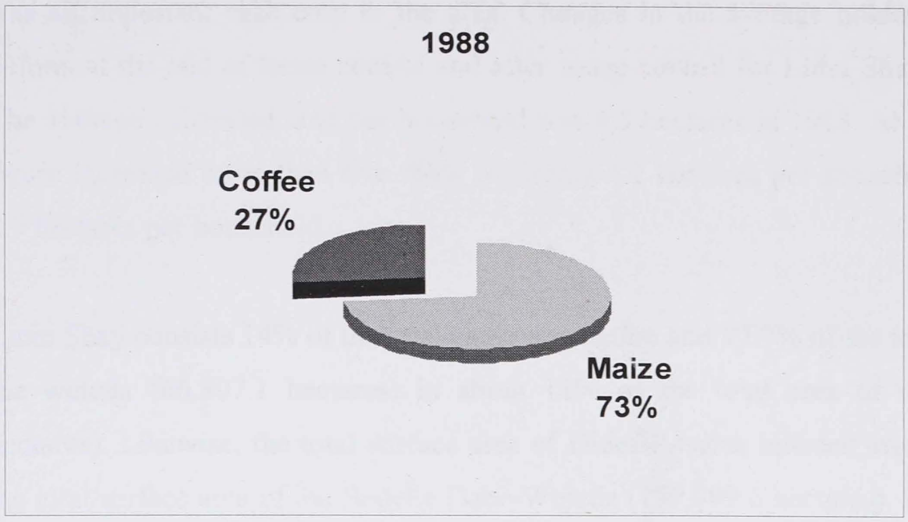
In both study areas, over 60% of the households reported that they or their parents moved to the area. In Limu Shay, movement to the area was highest during the period of active tsetse control (1988-1996). More recent migrants settled nearer to the river and further from the roads than less recent migrants. NTTICC socio economic data records (1988- 2003) showed that the recorded number of households and total population in 1988 were 2416 and 9292. The corresponding figure for the year 2003 was 4395 and 19415 for number of households and total population respectively. As a result the number of households and total population in the area increased by 81.9% and 108.9% respectively, between 1988 and 2003 with an average annual growth rate of 5% in the number of households and 7.2% in the number of total population. Likewise, analysis of the 2003 recorded socio economic data revealed that the average family size for Limu Shay tsetse controlled and Didessa tsetse infested (Annex 11) were 4.4 and 2.9 persons respectively. The number of households and total population in 2003 for Didessa was 900 and 2640 respectively. Tsetse control has changed the spatial pattern of settlement and human population in Limu Shay as compared to Didessa tsetse infested area.

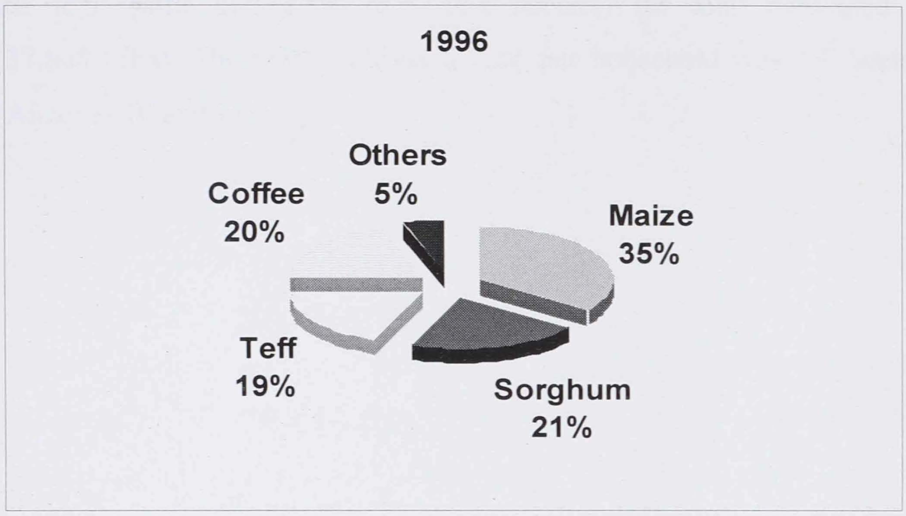
4.3.4. Impacts on crop agriculture and land use

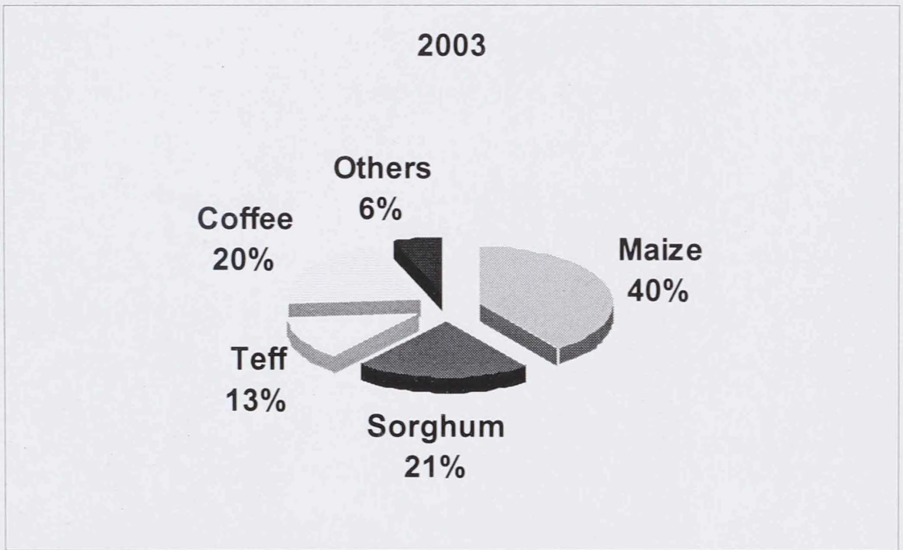
Nearly all respondents link recent increase in the use of animal traction and use of pack animals in Limu Shay area to the reduction in tsetse challenge and the consequent improvement in animal health, which has resulted in expansion of cultivable land due to improved access to previously infested zones.

Analysis of data records (Annex 9 and 10) from NTTICC (1988-1996) and Goma Wereda (1997-2003) has shown that, the number of draught animals (Oxen and bulls) per household between 1988 and 2003 increased from 0.56 to 2.4 in Limu Shay tsetse controlled area. The increase in animal traction use from 1988 and 2003 has inturn brought about changes in cultivation practices with subsequent increase in average area ploughed under animal traction from 1277.1 hectares to 11825 hectares. Here the increment recorded in 2003 reached 826 % as compared to that of 1988, with an average annual increase of 55.1%. Figure 20 shows the changes made to the proportion of cultivated crops in Limu Shay. A very interesting result was observed regarding the proportion of land put under different crops prior to the control activities; only maize (73%) and coffee (27%) were produced in Limu Shay. As the trypanosomosis situation improved, diversification of crop production started in Limu Shay. By 1992, farmers in the area grew almost all types of crops. Figure 19: shows the proportion of land cultivated per crop type before the tsetse control (1988), at the end of the control program (1996) and 7 years after the end of the control program (2003).

Figure 19: Proportion of land cultivated /crop type in Limu Shay tsetse controlled area.







As can be seen, by the end of 1996, crop production in Limu Shay was diversified and the proportion of land cultivated for teff, frequently neglected because of being labor intensive, was an important cash crop in the area. Changes in the average holding of cultivated land before, at the end of tsetse control and after tsetse control for Limu Shay was also analyzed. The average cultivated land per household was 0.5 hectares in 1988. At the end of 1996, this figure increased more than five folds becoming 3.2 hectares per household. By 2003, it was 2.7 hectares per household.

Limu Shay consists 14% of the total cattle population and 17.7% of the total cultivated land of the wereda (66,807.1 hectares) in about 11% of the total area of the wereda (134,912 hectares). Likewise, the total surface area of Didessa tsetse infested area is almost 8.37% of the total surface area of the Bedelle Dabo Wereda (199,099.6 hectares). It consists of 3.2% of the total cattle and 2.8% of (1,054 hectare) the total cultivated land of the wereda (37,648.15ha). The mean cultivated land per household was 1.1 hectares for Didessa area (Annexes 10 and 11).

5. DISCUSSION

The predominant farming system in Ethiopia is characterized by mixed livestock and crop production, with livestock playing a vital role in agricultural activities. Animal draught power is widely applied in crop production and the availability of oxen is essential for ploughing. Large proportion of the fertile and potentially productive land of Africa is uninhabitable mainly because of tsetse/trypanosomosis problem consequences and it has not been feasible or cost effective to maintain cattle in areas of high tsetse infestation.

Tsetse infested lowlands in the western part of Ethiopia have the best potential for agriculture provided that the tsetse and trypanosomosis constraints are over come (FAO, 1987). Recognizing the impact of tsetse and trypanosomosis as a limiting factor to exploit the most fertile land, the government of Ethiopia has made various efforts to control both the disease and the vector. However tsetse control operation is limited in scope in Ethiopia. It covers only 14% of the total tsetse infested area of the country (NTTICC, 1996). Tsetse control program was being carried out in Limu Shay area of upper Didessa valley, and this site is situated at the upper limit of the Didessa valley. Advancement of *G. m. submorsitans* in these areas occurred since 1940`s (Barrett, 1992) and at that time farmers lost about 80% of their domestic animals due to trypanosomosis. The disease prevalence rate in the remaining stock was varied from 30% to 60%. At the end of 1988, tsetse control was initiated at Limu Shay over an area of 150 km^2 using targets baited with a combination of acetone, octenol and cow urine sprayed with deltamethrin (0.1%) and deployed along drainage lines, on the foot of hills and inside woodland patches. Though the control program lies within the framework of area development in the highly affected areas, its success requires information on the disease, the vector and socio-economic profile. The main objectives of the study were to assess the impacts of the tsetse control on the prevalence of bovine trypanosomosis and on the socio-economic activities of people in the area. To achieve the objectives, disease survey, tsetse fly survey, questionnaire survey and collection of data form secondary sources were conducted in Limu Shay tsetse controlled and Didessa tsetse infested area of the Upper Didessa valley.

The prevalence study conducted at Limu Shay tsetse controlled area of the upper Didessa valley, during the months of October to December 2003, has determined the bovine trypanosome prevalence rate to be 7.9% with mean PCV of 25%. The result has shown a remarkable reduction of about 71% in disease prevalence and an increase of 9.5% in PCV values by comparing with the Didessa tsetse infested area. Similar results were also obtained through the longitudinal comparison for changes in disease prevalence and PCV values between 1988 (pre-intervention) and 2003 (the present study). It has shown that infection rate in cattle was reduced by 76% and that mean PCV values increased by 7%. Tewelde *et al.*, (2004) had conducted a similar study in the tsetse infested area of the Upper Didessa valley and reported the prevalence rate up to 21.3% and PCV values of about 21.5%, which was slightly less than the prevalence rate (27.16%) and the PCV (22.83%) recorded during the present study in Didessa tsetse infested area. NTTICC (2002) reported prevalence rates of 17% in tsetse controlled (Limu Shay) and 29% in tsetse infested areas of the Upper Didessa valley. The observed difference could be of time factor and/ or place (areas closer to river were expected of higher disease incidence in tsetse controlled areas).

Trypanosoma vivax was the most dominant (50%) trypanosome in the controlled area. However *T. congolense* (78.2%) has remained the dominant species in the tsetse infested area, similar to the results of past studies. Langridge (1976) reported that *T. vivax* is the sole cause for outbreaks of trypanosomosis outside from tsetse belt to be transmitted mechanically by biting flies and *T. congolsnse* in the tsetse infested areas uses tsetse flies as a biological vector. In the present finding the proportion of *T. vivax* was higher than that ones reported by Bedane (1998) in Upper Didessa valley of western Ethiopia (22%) and lower than that reported by Langridge (1976) from areas where livestock are not in contact with tsetse (85%). As far as *T. congolense* is concerned the present finding was higher than the reports of Abebe and Jobre (1996) for tsetse infested areas of the country (58.5%), Afework *et al.*, (2001) in northwest Ethiopia (47.6%), Rowland *et al.*, (1993) in southwest Ethiopia (37%), and Langridge (1976) where tsetse is present in Ethiopia (60%). But it was similar with the findings of Tewelde (2001) in western Ethiopia, (77%). Therefore mechanical transmission by biting flies as a vector of *T. vivax* still infecting the cattle in Limu Shay tsetse controlled area needs to be considered.

In the present finding an animal with a PCV value less than 26% was considered anemic (Coles, 1986). The mean PCV values of cattle herds between the tsetse controlled and tsetse infested areas and the mean PCV values of parasitaemic and aprasitaemic cattle herds in both areas differ significantly. In Limu Shay about 19% of the parasitaemic and 44% of the aparasitaemic animals PCV values was greater than or equal to 26%. The corresponding result for the Didessa tsetse infested area was 10% and 31% for the parasitaemic and aparasitaemic respectively. The present values are lower than those reported by Yohannes (1997) in north west Ethiopia, that 10% of the parasitaemic and 90% of the aparasitaemic cattle had PCV greater than 27%, and Rowlands (2000) in Ghibe, south west Ethiopia reported that few animals were detected parasitaemic when PCV values was greater than or equal to 26%. In the present finding, generally the investigated PCV values in both controlled and infested areas were low. Infact, there are a number of factors which can affect PCV. Leak (1995) reported that haemoparasites, such as Babesia spp., and blood sucking insects such as Haemonchus spp. could also have a significant effect. Nevertheless, the mean PCV values of infected cattle in Limu Shay (21.66%) differ significantly from those cattle, which were not infected (25.29%). Likewise, the mean PCV values of parasitaemic cattle in Didessa (20.8%) differ significantly from the mean PCV values of aparasitaemic (23.56%) cattle.

It is likely, therefore that the significant reduction in trypanosome prevalence in cattle, and an increase in mean PCV value in the Limu Shay (controlled) area was associated with the control of tsetse fly. This was brought about by the disappearance of *G. m. submorsitans*, the most important vector of animal trypanosomosis in tsetse infested areas of African continent, and the reduction in the apparent density (62%) of population of the vectors of trypanosomes to cattle as the trypanosomosis risk depends mainly upon the density of tsetse, the species of tsetse and the pathogenesity of the trypanosomes (Leak, 1999). Langridge (1976) had reported the presence of *G. m. submorsitans* in the area, and that it is the most efficient in the transmission of *T. congolense* (the most dominant trypanosome parasite in the area) before the intervention period.

The results are in agreement with the study conducted in the Ghibe valley, southwest Ethiopia. Leak (1995) reported that tsetse control had resulted in a decline of 93% in the apparent density of *G. pallidipes* and a reduction of 83% in the apparent density of *G. m. submorsitans,* associated with a reduction in trypanosome prevalence in cattle of over 74%.

Tsetse mean catch and apparent density were significantly different between the two areas. The most important difference was the disappearance of *G. m. submorsitans* in the controlled area. The tsetse control started in late 1988 caused the decline of G. *m. submorsitans*. The last trapped *G. m. submorsitans* fly (2 female flies) in Limu Shay was in 1992 (Slingenbergh,

1992) and monitoring traps maintained over the entire area until the end of the control program 1996, and as it happened during the present survey (2003) failed to catch any wild flies. Recorded data (NTTICC, 1992) has shown that before the intervention the apparent density of *G. m. submorsitans* in the Limu Shay ranges 1 to 4 FTD. However, in the different areas of the Upper Didessa valley Ford *et al.* (1976) and Slingenbergh (1992) found an apparent densities of tsetse fly up to of 245 and 25-35 FTD respectively, irrespective the species of *Glossina* species. Therefore it is evident that the present findings of 3.56 FTD in the tsetse infested area was much lower as compared to the fly density prior to the intervention. However, the present finding in the infested area was in accordance with the result obtained by NTTICC (1996). The survey conducted in 4 woredas of the upper Didessa valley where there was no tsetse control revealed an apparent density ranging from 0.00 in Sibu Sire and Wama Boneya woredas to 13.02 FTD in Jima Arjo woredas. It seems that tsetse population is decreasing even in the surrounding tsetse infested areas as compared to the pre-intervention period.

Nevertheless, in the present study, 43% (1.5 FTD) of the total fly caught in Didessa tsetse infested area was *G. m. submorsitans*. Likewise, in both areas, along the course of the Didessa river and its tributaries are permanently infested with *G. tachinoides*. About 70% of the total fly catch was *G. tachinoides* caught from both tsetse controlled (39.6%) and tsetse infested (60.4%) areas.

Therefore, only one species of tsetse fly (*G. tachinoides*) was caught in Limu Shay tsetse controlled area during the survey. *Glossina tachinoides* was caught entirely along the drainage lines of Didessa river and its tributaries with lower apparent density (1.34 FTD) in the controlled area than the infested area (2.05 FTD) and reduction by about 35%. The difference could be mainly due to the tsetse control and the subsequent changes in the vegetation cover in the controlled area. The favorable savannah vegetation type has already been shifted to cultivated crops. Tsetse density is influenced by the effectiveness of deliberate control program and the vegetation that is vital for providing shade and suitable microclimate for tsetse as well as their hosts (Leak, 1999).

As an effect of tsetse control the mean trypanosome prevalence rate in cattle decreased from 33.4% in the pre-intervention period (1988) to 7.14% end of the control period (1996) and to 7.9% of the present finding (2003). In spite of the disappearance of *G. m. submorsitans,* the fact that the trypanosome prevalence did not decline further following the control of *G. m.*

submorsitans may be mainly due to the existence of *G. tachinoides* in the area. The following factors forwarded by Sahel *et al.*, (1999) are also important while considering the epidemiological situation of trypanosomosis.

i) Incomplete knowledge of tsetse fly distribution and the dynamics of the different species of tsetse flies are very difficult to detect at low fly population densities.
ii) Understanding of the mobility of certain species of tsetse flies
iii) Insufficient knowledge of or underestimation of the epidemiological relevance of the movement of infected livestock.
iv) Recrudescence of parasitaemia in chronically infected animals and
v) Underestimation of drug resistant trypanosome population
vi) Mechanical transmission by biting flies.

Glossina tachinoides and biting flies could play an important role in areas like Limu Shay where cattle are abundant. De La Rocque *et al.* (1999) have explained in the places with few human settlements, the *G. tachinoides* feeds on reptiles and are infected with non-pathogenic trypanosomes. On the other hand, in the sites regularly used by domestic animals the majority of the vectors feed on these animals and transmits pathogenic trypanosomes. Thus various epidemiological situations occur on a few kilometer squares scale, and transmission risk depends on the intensity of contact between the hosts and the Glossina than on the density of the insects.

There was significant variation in the 50/50 distribution of the overall male and female flies caught in the two areas. For *G .m. submorsitans* in the infested area, the ratio of male to female was 0.77: 1. For *G. tachinoides,* which existed in both areas, the ratio of male to female was 0.66: 1. Leak (1999) described that female would comprise between 70% and 80% of an average populations. The higher proportion of female may be attributed to the fact that they live longer (mean female fly span being 8 weeks, than males about 4 weeks), so that more females could be caught.

Tsetse fly distributions in both areas were also analyzed in relation to altitude which is one of the main factors that could affect the abundance and distribution of tsetse flies (Leak, 199). It was mainly to observe the spatial relationship between fly and altitude in the lowlands of the

Upper Didessa valley. The present findings indicated that, the tsetse fly (*G. tachinoides* in both areas and *G. m. submorsitans* in the Didessa tsetse infested area*)* distribution along the five-altitudinal level was significantly different from one another irrespective of the areas. About 87% of the total catches were in the lower altitude level (upto1400 meters) and only about 3% were in the higher altitude (>1500 meters) indicating that the catch was decreasing with increasing altitude. This was in agreement with the previous works done in Ethiopia by Verysen *et al* (1998) who found a significant high catch (over 93%) in altitude between 1100 and 1400 meters above sea level in the southern rift valley of Ethiopia. Analysis of the pooled data revealed that there was a statistically significant difference ($F= 6.04$, $P< 0.001$) in the fly catch within the altitudinal categories. The Linear regression line for the Log10 (x+1) transformed mean fly catch line indicates the negative relationship. In general, the distribution of the fly in the study area showed that it was also affected by altitude, which influences the climate. The altitude also affects the vegetation cover, the temperature and humidity that are very critical for the survival of tsetse fly (Leak, 1998).

Tsetse transmitted trypanosomosis is one of the most ubiquitous and important constraints to agricultural development in the sub-humid and humid zones of Africa. Swallow (1999) reported, compared to animals kept in trypanosomosis free areas, animals kept in areas of moderate risk of trypanosomosis have lower calving rates, lower milk yields, higher rates of calf mortality and require more frequent treatment with preventive and curative doses of trypanocidal drugs. At the herd level, trypanosomosis reduces milk offtake, live animal offtake and work efficiency of oxen used for cultivation. Trypanosomosis also affects where people live, the way they manage their livestock and the number of animals that they keep.

The present study assessed the socio-economic changes resulted due to changes in trypanosomosis prevalence rate and tsetse fly densities brought about by the introduction of tsetse control program in the Upper Didessa valley of Limu Shay area. Analysis of the questionnaire survey and the recorded data were used to assess the socio-economic changes in the area.

The estimation of cattle performance parameters was an important part of the questionnaire survey. While we recognize that there may be confounding factors associated with what respondents may identify, nevertheless, we believe that the large sample conducted based on well-structured questionnaires administered by well trained and professional enumerators provided reasonable measurements of mean tendencies and minimum and maximum values of productivity gains. Everything else was also considered equal in both areas except the tsetse control intervention.

The actual impacts of trypanosomosis on reproductive performance was estimated by comparing the productivity of cattle herds kept in the near by areas of the tsetse controlled (Limu Shay) and the tsetse infested (Didessa) areas of the Upper Didessa valley.

The results of the present study showed that the average calving rate was increased by 35.3% in tsetse controlled area as compared to the tsetse infested area. Likewise, the average age at first calving, the average calving interval, and abortion rate were reduced by 11.5% (5.5 months), 13.6% (3 months) and 39.7%, respectively, in the controlled area as compared to the infested area. The differences observed in the reproductive performance parameters between the tsetse controlled (Limu Shay) and tsetse infested (Didessa) area were statistically significant and the smaller the standard deviations associated with the results in each area indicated a consistency of opinion in a collective perception that the changes in the reproductive performances was about the same magnitude.

In the present study, the results presented on reproductive performance supported the standard hypothesis about the impacts of tsetse and trypanosomosis control. That is, successful tsetse and trypanosomosis control will lead to more rapid increase in the total cattle population (improved health, increase in live births, and reduction in mortalities, abortion and still births).

In the present study the increase in calving rate in the controlled area as compared to the infested area was, similar to those studies reported by Jemal and Hugh-Jones (1995) and Slingenbergh (1992) in the Upper Didessa valley of Ethiopia (33.3%). Also the present finding on the calving rate was consistent with other studies done in Zambia and Malawi as reported by Doran and van den Bossche (1999). The average calving rate along tsetse infested edge of Malawi was 37% and in the tsetse controlled area average calving rate was 53.7 % (45% increase). Rowlands *et al.*, (1993), on his study about the impacts of trypanosomosis, reported a reduction in calving rate by 11% (lower than the present finding) and an increase in age at first calving by 10% (similar with the present finding) in areas of southern Ethiopia. Tikubet (1999) also reported a 23% reduction in the mean age of female livestock to reach fertility after tsetse fly suppression. The observations made by other authors also confirm the result of the present findings. The implication about the impact of African trypanosomosis reviewed by Swallow (1999), was that incidence of trypanosomosis reduces calving rate by 1-12% in tolerant breeds of cattle and by 11- 20% in susceptible breeds, increases calf mortality by 0- 10% in tolerant breeds of cattle and by 10-20% in susceptible breeds of cattle.

About 99% and 52% of the owners in the controlled (Limu Shay) and infested (Didessa) areas respectively attributed cattle losses (mortality) to trypanosomosis irrespective of the age-sex groups. Analysis of mortality rate in herds of tsetse controlled and tsetse infested area showed a statistically significant difference ($P < 0.001$). There was a 72% reduction in the annual crude mortality rate in the controlled area as compared to the infested area. The largest reduction was noted in the age categories of oxen (> 4 years age, 75.9%) and young animals (1-4 years, 72.1%). However, calf mortality was increased about 3 folds in the infested area. The reduction in the annual crude mortality rate observed was similar with that of Kamuanga (1999) who reported that the overall proportion of cattle dying of trypanosomosis consequences were reduced by 78% with the largest reduction noted in the categories of young (1-2 years) animals in southern Burkina Faso. The result of the current finding on the reduction of calf mortality (62.5%) as compared to the tsetse infested area was consistent with the finding of Mulatu (1995), at Gullele area of southwest Ethiopia (50%).

Respondents were also asked to estimate the average daily milk yield per cow for human consumption and average lactation length at the time of survey. Analysis of the data revealed an increase by 80% in the average daily milk yield per cow and an increase by 120% in average lactation yield in the controlled area as compared to the infested area. Tikubet (1999) reported an increase by more than 100% in the average daily milk yield as an effect of tsetse control in southern Ethiopia. The result of the present study was similar with that one reported by Kristjanson *et al.*, (1999) who used a herd simulation model and showed that the tsetse free areas produce 83% more milk per unit land area than the tsetse infested areas. Swallow (1999) on his review of the impacts of trypanosomosis on African agriculture reported that trypanosomosis reduces milk offtake even from trypanotolerant cattle in Gambia by 10-26%.

In the present study it was also observed that, as a result of the decreased trypanosome prevalence, there was also a decrease in the average use of the antitrypanosomal compounds diminazene aceturate and isometamidium chloride from 7.16 treatments per animal per year in the tsetse infested area to 0.19 treatments per animal per year in the tsetse controlled area. Leak (1995) showed similar results with an overall decrease in the use of trypanocidal drugs before and after intervention from 0.51 treatments per animal per month to 0.12 treatments per animal per month. However, the substantial decrease in trypanosome prevalence indicates that drug treatment was associated with better ability of animals to control existing trypanosome infection when there was a reduced tsetse challenge. Investigation on the use of trypanocidal drugs have shown that most cattle owners use trypanocides and the treatments were given by themselves and the drug smugglers, since there was on Government veterinary clinic in both areas. Therefore indiscriminate use of trypanocidal drugs may be associated with drug resistance particularly in the high tsetse challenge area (Didessa). Drug resistance have been reported in Ethiopia by Afewek *et al.* (2001) in the Abay/Didessa tsetse belt, Codjia *et al.* (1993), Mulugeta, et al. (1997), Ademe and Abebe (2000) in Ghibe/Omo tsetse belt adjacent to the upper Didessa river, Assefa and Abebe (2001) in the north Omo and Tewelde, *et al.*, (2004) in the Upper Didessa valley of western Ethiopia. In both areas they prefer to treat sick animals irrespective of age- sex category. Despite the level of challenge trypanosomosis related mortality may be reduced by the use of trypanocidal drugs by the cattle owners in trypanosomosis endemic areas such as the Didessa area. Furthermore, the noted difference in the intensity of treatments between the two areas indicates the risk form trypanosomosis that forced the owner to administer trypanocidal drugs. The difference in the pattern of treatments in the use of more isometamidium (41%) as a prophylactic in the infested area and diminazene (99%) in the controlled area suggested the level of challenge and time factor. The isometamidium treatments were successful in controlling trypanosomosis at treatment level and that the majority of animals were protected from infections. Conversely, the present cost of isometamidium per dose was greater than other trypanocides and this must be viewed as a restrictive when assessing its practical application under high disease challenge. The production benefits of using isometamidium were not therefore, obvious and under circumstances this strategy cannot be considered to an economically viable option.

Both the longitudinal and cross-sectional comparison on the size of livestock for the tsetse controlled area has shown the increase in the overall and /or age-sex category of livestock. Herd size per owner differed significantly between the two areas. There was a significant difference between the number of cattle per owner in the tsetse controlled area and tsetse infested areas, with an average of 5.5 cattle per owner (94% increase) in the tsetse controlled area and 2.84 cattle per owner in the tsetse infested area. More pronounced difference was observed with the longitudinal assessment in the average number of cattle, sheep, goats and equines per owner (364% increase over 15 years).

The average number of livestock owned per household recoded in the present study was however, higher than that one reported by Bedane (1998) in the Upper Didessa valley (145.7%). Gilbert *et al.* (1999) have also predicted that without the presence of tsetse, there would be a 200% increase in actual numbers of cattle for African continent as a whole. Everything else equal, one can assume that tsetse and trypanosomosis control had a positive impact on the size of the herd in the study area.

Sale and slaughter (productive off take rate) and purchase rate were lower in the tsetse controlled area as compared to that of tsetse infested area. The present finding indicated a reduction by 40% and 90% respectively, for the productive offtake rate and purchase rate for the controlled area. Likewise, the result of the present finding is lower than off take from the National herd estimated at 8% for cattle (NLDP, 1998). The result was inconsistent with the assumption that says; offtake rates are often assumed to increase after control operations become effective and benefits of this kind is typically incorporated in economic and financial appraisals of animal disease interventions (Kamuanga, *et al.*, 1999).

However, the tsetse controlled area where the sale and purchase rates were low; they were influenced predominantly by the need to obtain cash to pay for food, school fees, dowry, clothes and inputs like drugs, fertilizers, etc. When cash needs can be met from alternative sources (like crops, off-farm and non-farm income) off take rates tends to decline. Animal disease program (tsetse control), which improve crop performance indirectly (for example, through an expansion of area cultivated) may therefore, result in reduced (not increased) sale rates and even sale levels and this can radically affect the benefits associated with tsetse and trypanosomosis control interventions. Also surplus above household needs was not invested to cattle, as there was a reduced purchase rate. In the controlled area (Limu Shay) market constraints and even herd accumulation may limit the capacity to purchase breeding stock. In the tsetse infested area (Didessa) oxen together with bulls constituted 52% of the total herd. But in the controlled area where the disease constraint (trypanosomosis) was removed emphasis was given to herd accumulation by retention of female stock. The relatively increased offtake rate and purchase rate in the tsetse infested area was markedly influenced by emergency sales or slaughters because of trypanosomosis. A reduction in mortality resulting from control may mean that offtake rates decline significantly after effective control measures have been implemented in the present study.

In the tsetse controlled area it was also observed that the grazing pattern has been changed. The findings suggested that in the study area, there had been an initial expansion of grazing areas towards the rivers due to the reduction in problems with tsetse, then reduction of grazing areas closer to villages as more and more of the land was brought into cultivation.

The present finding indicated that there has been a relationship between human population, cattle density, cultivated land, and disease prevalence and tsetse control. The population growth in the controlled (Limu Shay) area between 1988 and 2003 was rapid at 7.2% average annual growth rate. Therefore, areas cleared of tsetse became much more attractive to potential immigrants and trypanosomosis can also be an important constraint on migration and human settlement patterns, the main factor driving changes in land use and land cover.

Reid *et al*. (1997), in the Ghibe valley of Ethiopia reported about the impacts of trypanosomosis that over 70% of all family heads reported that they or their parents moved to the area. More recent migrants settled nearer to the rivers and further from roads than recent migrants. The trend is particularly worrying in the present tsetse controlled area since the riverine forests are main concentrations of biological diversity within the landscape. Swallow (1999) on his review of the impacts of Trypanosomosis on African agriculture noted the relationship between tsetse infestation and cattle density, and reported that cattle density is positively related to human population density, altitude and the presence or absence of tsetse.

The present study also investigated the advantage of tsetse control as increased use of animal traction (on average 1.62 oxen per household cultivate an average of 2.77 hectare), improved animal health in longer periods of field traction (on average, a work oxen was used for 136 days per year comprised of an average 5.8 hours of work per day) and expansion of cultivable land due to improved access to previously infested zones (an average of 2.7 hectare land cultivated per household).

Analysis of the data on work oxen performance has shown that, by comparison with the tsetse-infested area oxen in the controlled area were 40% more efficient in the average work hours per day and 31% more efficient in the average area cultivated per ox. Similar with the present finding was the one reported by Swallow (1995). He reported that oxen in the high trypanosomosis risk area were 38% less efficient than oxen in the low risk area. The present finding on the oxen work hour per day was slightly higher than the National, FLDP (1994) report on the herd health and productivity monitoring study of 3 years. The finding indicated that, on average a work oxen was used for 120 days per year each comprised of 5 hours.

Promotion of animal traction is an engine for agricultural development. Nearly all respondents link an increase in the use of animal traction in the tsetse controlled (Limu Shay) area to the reduction in tsetse challenge and the consequent improve in animal health. The number of draught animals owned has increased by 260% between 1988 and 2003. The increase in animal traction use has in turn brought about changes in cultivation practices with subsequent increase in average area ploughed under animal traction by almost 800% and average area cultivated per household by 400%. Therefore, increased use of animal traction and the capacity to work has translated into increased cropped land most notably for the tsetse controlled (Limu Shay) area. Households with access to draught power were more likely to crop larger areas of land and obtain higher levels of food production as a result. Comparing both areas, households in the tsetse controlled area grow significantly more crops than the tsetse infested area and are thus in a better position to diversify and reduce the risks associated with crop failure and/ or market price changes.

6. CONCLUSION AND RECOMMENDATIONS

The study on the current epidemiological situation of bovine trypanosomosis in Limu Shay showed a reduction in disease prevalence. It was associated with the disappearance of *G. m. submorsitans* in the specific study site and reduction of the population of *G. tachinoides* as an effect of tsetse control.

Comparison with the tsetse infested area showed a positive impact of tsetse control by increased calving rate, reduced abortion rate, age at first calving, calving interval, mortality and trypanocidal drugs inputs. This inturn, through increasing the number of cattle and the work efficiency of oxen, improved the development of integrated livestock production system in the area. People in the controlled area raise more cattle, cultivate more land and are more efficient in the use of resources.

It was concluded that tsetse control in areas of high potential for integration of crops and livestock mixed farming like Limu Shay area is, therefore, beneficial.

Based on the result of the present study the followings are recommended:

- In the tsetse controlled study area, livestock, human population and cultivated land have been increasing at faster rate. It is necessary to consider the trade-offs between development and environmental objectives. Therefore, proper land use plan has to be in place.
- The low level of infection still observed might be attributed to *G. tachinoides* of the riverine vegetation, necessitating its control and possibly the biting flies.
- The possibility of reinvasion by *G. m. submorsitans* from the near by tsetse infested areas should be considered at all levels.
- Public support in construction of veterinary clinics and integration of vector control with chemotherapy in the high-risk tsetse infested area would be needed.
- Further studies should be conducted to quantify the impacts of tsetse control in terms of monetary values.
- A cost effective way to generate more information about trypanosomosis impact would be to make impact assessment part of monitoring and evaluation of actual disease control intervention.

7. REFERENCES

Abebe, G. (1991): The Integrity of the Hypothalamic-pituitary adrenal axis in Boran (*Bos indicus*) cattle infected with *T. congolense*. PhD thesis. Brunel University.UK.

Abebe, G. and Jobre, Y. (1996): Trypanosomosis: A threat to cattle production in Ethiopia *Rev. Med. Vet.* **147,** 897-902.

Ademe, M. and Abebe, G. (2000): Field study on drug resistant trypanosomes in cattle (*Bos indicus*) in Kindo Kuyshe Wereda, Southern Ethiopia. *Bull. Anim. Hlth. Prod.* **48,** 131-138.

Afework, Y. (1998): Field investigations on the appearance of Drug resistant populations of Trypanosomes in Metekel District, north-west Ethiopia. MSc thesis, Addis Ababa University and Freie Universtat Berlin.

Afework, Y. Abebe, G., Tilahun, G., Clausen P. H. and MehlitZ, D. (2000): Multiple drug resistant *T. congolense* populations in village cattle of Metekel district, north-west Ethiopia. *Acta Trop.* ***76***, 231-238.

Angus, S. D., Githiori, J. B., Stevenson, P. G., Ndung'u, J. M., Green, C. H., Maudlin, I. and Holmes, P. H. (1995): Chemoprophylaxis of the animal reservoir-Anew approach to the control of Rhodesian sleeping sickness. In: The Meeting of 23rd International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Banjul, Gambia. Publication, No **118.** 197-209.

Anon (1996): An assessment of Global National Trypanosomosis situation and options for its control. The National work shop on policy and strategy options for the livestock sub sector. January 27, 1996. Addis Ababa Ethiopia.

Assefa, E., and Abebe, G. (2001): Drug resistant *T. congolense* in naturally infected donkeys in north Omo Zone, south Ethiopia, *Vet. Parasitol*, **99**, 261-271.

Barrett, J. C. (1992): Report of a visit to Ethiopia to evaluate a tsetse control project in the Upper Didessa valley.7-9 September 1992.

Bedane, B. (1998): Consultancy report on quantifying the impact of tsetse control on farming (FITCA): Food and Agricultural Organization of the United Nations (FAO), Addis Ababa, Ethiopia.

Bourzat, D., Zessin, K. H., Bauman, M. P. O., and Gautch, K. D. (1988): Technical report: Farming systems and small ruminant production in central Somalia. A cross sectional survey. Mogadishu, Somalia: CRDP component.

Codjia, V., Mulatu, M., Mujia, P. A. O., Leak, S. G. A., Rowlands, G. J., Authie, E., D'Ieteren, G. O.M. and Peregrine, A. S. (1993): Epidemiology of Bovine Trypanosomosis in Ghibe Valley, south-west Ethiopia. 3. Occurrence of population of *T. congolense* resistant to diminazene, isometamidium and homidium. *Acta Top*. **53**, 151-163.

Coles, E. H. (1986): Veterinary clinical pathology 4th edition. W.B. Saundesr Company. 13.

De La Rocque, S. S., Michel, J. F., Michel, V., Solano, P., De Wispelaere, G., Arnaud, M. and Cuisance, D. (1999): From pathogenic system to risk evaluation: Application on animal trypanosomosis in an area of Burkina Faso. In: Sones, K. R. (ed). Meeting of the 25th International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya. Publication No **120**, 329-333.

Doran, M. and Van den Bossche, P. (1999): An assessment of the socio-economic impact of bovine trypanosomosis and its control in southern Africa region. In: Sones, K. R. (ed). Meeting of the 25th International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya. Publication No **120**, 307-312

Doyle, J. J. (1977): Antigenic variation in Salivarian trypanosomes. In: Pino, J. Millor, L. and Mckelvey J. L. J. (eds). Blood borne parasitic disease. Plenum, New York. 31.

EARO (1999): Livestock Research Strategy of the Ethiopian Agricultural Research Organization. Part 1. Addis Ababa, Ethiopia.

Erkelens, A. M. D., Winger, R. H., Bedane, B., Slingenbergh, J. H. W. and Wint, W. (1999): Selection of priority areas for Tsetse control in Africa; a decision tool using GIS in Didessa valley as a pilot study. In: Sones, K. R. (ed). Meeting of the 25th International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya. Publication No **120,** 379-385.

FAO (1982): Reproductive efficiency in cattle: A Guide for projects in Developing countries. FAO Animal Production and Health paper. Rome, Italy. **25,** 7- 57.

FAO (2000): Training manual for tsetse control personnel. J.N. Pollock (ed). Ecology and behavior of tsetse. vol. **2.**

FITCA (1999): OAU/IBAR Regional eastern Africa program, Framing in Tsetse Control Area (FITCA): Ethiopian component, Federal Democratic Republic of Ethiopia, Ministry of Agriculture, Project proposal for EU Funding, Addis Ababa, Ethiopia.

FLDP (1994): Fourth Livestock Development Project, Animal and Fisheries Resources Development main Department Veterinary Epidemiology and Economics Unit: herd health and productivity monitoring study, final reports of findings of 3 years observations. Addis, Ethiopia.

Ford, J., Makin M. J., and Grimble R. J. (1976): Trypanosomosis control program for Ethiopia. Ministry of Overseas Development of Great Britain.

Gardiner, P. R. and Wilson, A. J. (1987): *Trypanosoma* (Dutenella) *Vivax*. *Parasitol. Today* **3**, 49-52.

Glibert, M., Jenner, C., Pender, J., Rogers, D., Slingenbergh, J. and Wint, W, (1999): "The development and use of the Program Against African Trypanosomosis Information System (PAATIS)." Paper presented at the 25th Meeting of International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya.

Greets, S. and Holmes, P. H., (1998): Drug management and parasite resistance in bovine trypanosomosis in Africa. Program Against African Trypanosomosis (PAAT). Technical and scientific series 1. Food and Agricultural Organization of the United Nations (FAO) Rome. 1-3, 25.

Guy d'Ieteren (1999): The exploitation of trypanotolerance: A dream of academic or a reality for sustainable livestock development in tsetse infested areas. In: Sones, K.R. (ed). Meeting of the 25th International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya. Publication No **120**, 265-277

Hoare, C. A. (1972): The *Salivarian*, subgenus *Duttonela,* 1918. In: The trypanosomes of mammals. A zoological monograph. Black well scientific publications, Oxford and Edinburgh. 401-429.

ILICA (1993/94): Annual report and program high Light. International Livestock Center for Africa (ILICA). Addis Ababa, Ethiopia. 31-41.

ILRAD (1990): Reports of the International Laboratory for Research on Animal Diseases (ILRAD). Nairobi, Kenya April, 1990.

ILRAD (1993): Reports of the International Laboratory for Research on Animal Diseases (ILRAD). Nairobi, Kenya. Vol. **11**, Number 2.

Jemal, A. and Hugh-Jones, M. E. (1995): "Association of Tsetse control with health and productivity of cattle in the Didessa valley, western Ethiopia." *Prev. Vet. Med*. **22**; 29-40

Kamara, D.W., Swallow, B. M., Echessaa P. N., and Curry, J. J. (1995): Combining qualitative, quantitative and participatory research methods in assessment of the prospects for community-based tsetse control in Burkina district, Kenya. In: Ndung'u, J. M. (ed). Meeting of the 23rd International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Barjul, Gambia. Publication. No **118,** 310-317.

Kamuanga, M., Kabore, I., Swallow, B., Amsler-Delafosse, S., and Bauer, B. (1995): Evaluating factors affecting implementation of community-based tsetse control in southern Burkina Faso. In: Ndung'u, J. M. (ed). In: Meeting of the 23rd International Scientific Council for Trypanosomosis Research and Control (ISCTRC). Banjul, Gambia. Publication No. **118,** 318-330.

Kamuanga, M., Antoine, C., Brasselle, A. S., Swallow, B., Guy d' Iteren and Bauer, B. (1999): Impacts of Tsetse control on Migration, Livestock production, Cropping practices and Farmer herder conflicts in the Mouhoun valley of southern Burkina Faso. In: Sones, K. R. (ed). Meeting of the 25th International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya. Publication No **120**, 239-253

Krasfur, E. S. (1998): Sterile Insect Technique (STT) for suppressing and eradicating insect population. Tsetse and trypanosomosis information quarterly. Food and Agricultural Organization of the United Nations (FAO). Vol. **25**, No 1145-11588. 120.

Kristjanson, P. M., Swallow, B. M., Rowlands, G. J., Kruska, R. L. and de leeuw, P. N. (1999): "Measuring the costs of African Animal Trypanosomosis, the potential benefits of control and returns to research." *Agricultural systems*, **59**: 79-98

Langridge, W. (1976): A Tsetse and trypanosomosis survey of Ethiopia. Ministry of Overseas Development of Britain and Ministry of Agriculture of Ethiopia. Addis Ababa, Ethiopia. 96-98.

Leak, S. G. A., (1999): Tsetse biology and ecology. Their role in the epidemiology and control of trypanosomosis. CABI publishing in association with International Livestock Rsearch Institute (ILRI). Nairobi, Kenya.

Leak, S.G. A., Mulatu, M., Rowlands, G.J. and D'Iteren, G. (1995): Atrial of a Cyperpermethrin "Pour-on insecticide to control *G. pallidipes*, *G. fusipes G. m. submorsitans* in south west Ethiopia. *Bulletin of Entomological Research*, vol. **85**, 241-251.

Leak, S. G. A., Awoume, K., Colardelle, C., Duffera, W., Feron, A., Mohamed, B., Mawuena, K., Minengu, M., Mulungo, M., Nannkodaba, G., Ordner, G., Pelo, M., Sheria, M., Tikubet, G., Toure, M. and Yangari, G. (1998): Determination of tsetse challenge and its relationship with trypanosome prevalence in Trypanotolerant Livestock Network. Livestock production in tsetse affected areas of Africa. Proceedings of a meeting held on 23-27th November 1987, ILRAD/ILICA, Nairobi, Kenya.

Masiga, W. N. (1995): Opening speech. In: Ndung'u, J. M. (ed). Meeting of the 23rd International Council for Trypanosomosis Rsearch and Control (OAU/STRC). Barjul, Gambia. Publication No **118**, 5-6.

Mehlitz, D. (1978): Untersuchungen Zur Empfa nglichkeit on Matalensis fur *Trypanosoma (Trypanozoon) brucei gambense. Tropenmed, Parasit*. **29**:101-107

Molyneux, D. H. and Ashford, R.W. (1983): Trypanosomosis. In: The Biology of *Trypanosoma* and *Leishmania*, parasites of man and domestic animals. Taylor and Francis Ltd, London. 124-144.

Morrow, D. A. (1986): Current Therapy in theriogenology, 2 nd ed. W.B. Sounders, USA. 390-394, 408-410.

Mramba, N. (1992): Tsetse control by killing preferred games, Animal diseases due to Protozoa and Rickettsia. 33-34.

Mulatu, W., Rowlands, G. J., d' Ieteren, G. D. M., Leak, S.G. A. and Nagda, S. M. (1995): Productivity of cattle treated with cypermethrin' pour-on' insecticide to control Tsetse in south west Ethiopia. . In: Ndung'u, J. M. (ed). Meeting of the 23rd International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Barjul, Gambia Publication. No **118**, 297.

Mulligan, H.W. (1970): The African trypanosomosis. George Allen and Unwin Ltd. London.

Mulugeta, W., Mulatu, M., Wilkes, J., Majiwa; P.A.O., Masake R., and Peregrine A. S., (1997): Long-term Occurrence of *T. congolense* resistant to diminazene, isometamidium and homidium in cattle at Ghibe, Ethiopia, *Acta. Trop*. **64**, 205-217.

Murray, M. and Dexter, T. M. (1988): Anemia in bovine African trypanosomosis. *Acta Trop.* **45**, 389-432.

Murray, N., Murran P.K., and McIntyre W. I. M., (1977): An Improved parasitological technique for the diagnosis of African trypanosomosis. *Trans. R. Soc. Trop. Med. Hyg.* **71**. 725-326.

NLDP (1998): National Live stock Development Program, Ethiopia. Main report. FAO, Rome. Vol.**1.**

NTTICC (1992): Annual report. Ministry of Agriculture, National Tsetse and Trypanosomosis Investigation and Control Center (NTTICC), Bedelle, Illubabor.

NTTICC (1996): Annual report. Ministry of Agriculture, National Tsetse and Trypanosomosis Investigation and Control Center (NTTICC), Bedelle, Illubabor.

NTTICC (2002): Annual report. Ministry of Agriculture, National Tsetse and Trypanosomosis Investigation and Control Center (NTTICC), Bedelle, Illubabor.

OBAD (1995): Oromia Bureau of Agricultural Development, Department of Environmental Protection and Land use planning: Land and socio-economic resources inventory for land use planning of Bedelle woreda Illubabor zone, with indicative land use planning. Addis, Ethiopia.

Pegram, R. G. and Scott, J. M. (1976): The Prevalence and diagnosis of *T. evansi* infections in camels in southern Ethiopia. *Trop. Anim. Hlth*. **8**, 20-27.

Peregrine, A. J., Kemei, S. and Ndoutame, G. (1995): Cross resistance phenotypes associated with induction of resistance to isometamedium chloride and qiunapyramine sulphate in *T. congolense.* In: Ndung'u, J. M. (ed). Meeting of the 23rd International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Banjul, Gambia. Publication. No **118**.

Radostits, O. M. (2001): Herd health: Food Animal Production Medicine, 3 rd ed. W.B. Sounders Company, USA. 211-219, 236-239, 397.

Reid, R. S., Wilson, C. J., Kruskal, R. L. and Mulatu, W. (1997): "Impacts of tsetse control and land use on vegetative structure and tree species composition in southern Ethiopia." Journal of applied ecology. **34**(3): 731-747

Rowlands, G. J. (2000): Detecting resistance of trypanosomal infections to diminazene aceturate-a possible field test. In: proceedings of the workshop on drug delivery and resistance in the context of integrated disease management, 31 May-4 June 1999, Nairobi, Kenya. Newsletter on Integrated Control of Pathogenic Trypanosomes and their vectors (ICPTV). No. **2**, 6- 12

Rowlands, G. J., Mulatu, W., Authie, E., D'Ieteren, G. D. M., Leak, S. G. A., Nagda, S. M. and Peregrine, A. S. (1993): Epidemiology of Bovine Trypanosomosis in the Ghibe valley south west Ethiopia. 2. Factors associated with variations in trypanosome prevalence, incidence of new infections and prevalence recurrent infections. *Acta Trop.* **53**, 135-150.

Saleh, K. M., Mussa, W. A., Juma, K. G. and Vreysen, M. J. B. (1999): Eradication of *Glossina austeni* from the Island of Unguja confirmed: Results of 2 years of post-eradication monitoring activities. In: Sones, K. R. (ed). Meeting of the 25th International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya. Publication No **120,** 231- 238.

Seifert, S.H.H. (1996): Tropical animal health second ed. Dordrech: Kluwer Academic publishers, 149-169.

Slingenbergh, J. H. W. (1992): Tsetse control and agricultural development in Ethiopia. *World Anim. Rev.* **70/71,** 30-36.

Slingenbergh, J. H. W. (1999): Criteria for identification of priority areas for African animal trypanosomosis control. Draft report to the Program Against African Trypanosomosis. FAO, Rome.

SPSS (2002): SPSS 11.5 for windows, Standewel Version, SPSS. INC, http://www.spss.com.

Stata-7 (1984-2001): Intercooled Stata-7 Statistical Data Analysis. Stata Corporation, College Station, Texas 77845 USA.

Swallow, M. B. and Mulatu, W. (1994): "Evaluating willingness to contribute to a local public good: Application of contingent valuation to tsetse control in Ethiopia"; *Ecological Economics,* vol. 153-161.

Swallow, M. B. (1997): "Impacts of African animal trypanosomosis on human migration, live stock and crop production" Review of paper prepared for the Program Against African Trypanosomosis (PAAT) for presentation at ISCTRC, Maputo, Mozambique.

Swallow, M. B. (1999): Impacts of Trypanosomosis on African Agriculture. International Livestock Research Institute, (ILRI). Nairobi Kenya. 6, November 1999.

Putt, S. N. H., Shaw, A. P. M., Matthewman, R.W., Bourn, D. M., Underwood, M., Jones, A. D., Hallam, M. J. and Ellis, P. R. (1980): The Social and Economic Implications of Trypanosomosis Control: A Study of its Impact on Livestock Production and Rural Development in Northern Nigeria. University of Reading.

Tewelde, N. (2001): Study on the occurrence of Drug Resistant Trypanosomes in cattle in the Farming in Tsetse Control Areas (FTICA) project in western Ethiopia. MSc thesis. Addis Ababa University and Freie Universitat Berlin.

Tewelde, N., Abebe, G., Eisler, M., McDermott, J., Greiner, M., Afework, Y., Kyule, M., Munstermann, S., Zessin, K. H. and Clausen, P. H. (2004): Application of field methods to assess isometamidium resistance of trypanosomes in cattle in western Ethiopia. Elsevier, *Acta Trop.* **90** (2004) 163-170

Thrusfield, M. (1995): Veterinary Epidemiology, 2nd edition. UK: Black well. Science Ltd. 215.

Tikubet, G. (1993): Tsetse and Trypanosomosis management in Ethiopia. In: Sustainable community-based pest management for rural development. International Center for Insect Physiology and Ecology (ICIPE). Proceedings of a conference held at Africa Hall, Addis Ababa, Ethiopia. 15-24.

Tikubet, G. (1999): Community driven and sustainable trypanosomosis management in southern Ethiopia, in the context of holistic development. In: Sones, K. R. (ed). Meeting of the 25th International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya. Publication No **120**, 379-385

Uilenberg, G. (1998): A Field guide for diagnosis, treatment and prevention of African animal trypanosomosis. Adapted from the original edition by W.P. Boyt. Food and Agriculture Organization of the United Nations (FAO), Rome. 43-135.

Verysen, M. J. B., Assefa, M., Minutet, M., Gizaw, W., Kiflom, M., Kassahun, B. and Gezahegn, (1999): The Distribution and Relative abundance of tsetse flies in the southern rift valley of Ethiopia: Preliminary survey results. In: Sones, K. R. (ed). Meeting of the 25th International Scientific Council for Trypanosomosis Research and Control (ISCTRC). OAU/STRC, Mombasa, Kenya. Publication No **120**, 202- 213.

Wellde, B. T., Chumo, O.A., Adoyo, M., Kovatch, R. M., Mwongela, G. N. and Opiyo, E. A. (1983): Hemorrhagic syndrome in cattle associated with *T. vivax* infection. *Trop. Anim. Hlth. Prod.* **15**, 95-102

9. ANNEXES

Annex 1: Questionnaire set to interviewing individual farmers

A) General information

Date———————————————
Name of Farmer -----------------------------
Age---
PA---
Village---------------------------------------

B) Livestock management

1. When you first settled in this area which livestock did you start keeping?
   □ Cattle □ Equine
   □ Small ruminants □ others

2. How you do manage cattle?
   □ Free grazing □ Stall feed
   □ Tether

3. If cattle are allocated to free grazing scheme, are they in herd? or in small groups?
   □ In herd □ In small groups

4. Where do cattle graze?
   □ In the field □ In the bush
   □ In the savannah □ Near the river valleys

5. Where is the location of watering point?
   □ Less than 3 km away □ 3-5 km away
   □ More than 5 km

C) Livestock diseases

1. Does trypanosomosis occur in your area?
   Yes________ No__________

2. If yes, would you rank trypanosomosis with regard to cattle loses compared to other Diseases?
   a)____________________________________
   b) ____________________________________
   c) ____________________________________

d)______________________________________

e)______________________________________

3. Which livestock does trypanosomosis most affect?
   - □ Cattle
   - □ Equine
   - □ Small ruminant

4. Do you know the signs of trypanosomosis?
   - □ Yes
   - □ No

5. In which season or months do livestock most often get the disease (trypanosomosis)
   - □ Wet season
   - □ Dry season

6. Is trypanosomosis getting worse better or unchanged in your area?
   - □ It is getting worse
   - □ It is unchanged
   - □ I do not know
   - □ It is getting better

7. Do you know that flies transmit trypanosomosis?
   - □ Yes □ No

8. If yes, to question No. 7, which flies do you think to transmit trypanosomosis?
   - □ Tsetse flies
   - □ I do not know
   - □ other biting flies

9. In which season are tsetse flies abundant?
   - □ Dry season
   - □ All the year
   - □ Wet season

10. Where is tsetse population high?
    - □ In areas close to river
    - □ In the bush
    - □ In the savannah
    - □ In the grazing scheme

D) Disease control

1. Where are the common treatment sources?
   - □ Vet clinic
   - □ Smugglers
   - □ Local farm
   - □ NGO

2. Who is applying the treatment?
   - □ Local farm
   - □ Smugglers
   - □ others
   - □ Veterinarians

3. Which drugs, do you think, are most effective to treat your animals?
   - □ Isometmedium chloride □ Diminazine aceturate □ Others

4. When you use trypanocidal on cattle do usually treat:
   - □ All your animals
   - □ only mature oxen
   - □ only cows in milk
   - □ only sick animals

5. Did you treat your herd last year?
□ Yes □ No

6. If yes, what is the frequency of treatment?
Frequency____ Season_____ Age group_____

7. How many cattle were treated with trypanocidal drugs last year?______

8. Which disease control method(s) do you know?
□ Tsetse trapping □ Trypanocides
□ Pour-on application □ others

9. Which disease control method(s) do you prefer for effectiveness?
□ Tsetse trapping □ Trypanocides
□ Pour-on applications □ others

10. Have you participated in tsetse control?
□ Yes □ No

11. How do you participate in the future?
□ Money □ Buy and use of trypanocides
□ Labour □ I do not want

12. Do you think that the problem of trypanosomosis is expanding to new areas?
□ Yes □ No □ I do not know

E) Socio-economic data

1. What are your main sources of income?
□ Livestock □ Crops □ Both □ Others

2. What is the importance of keeping cattle?
□ Milk production □ Meat production □ Draught power
□ Manure production □ Paying dowry □ Others

3. Total number of live stock population
a) Cattle
______Oxen ______Cows ________Female calves
______Male calves ______Heifers _________Bull calves
b) Sheep _________
c) Goat __________
d) Equine _________

4. Milk production (average in liters) of an individual cow
____________ Per day _________average days of lactation

5. Draught oxen-work out put
___________Hours per day _________Work days per year

6. How many cattle have you lost or introduced into your herd since last year?

Animal category	Cattle withdrawn				Cattle introduced		
	Sold	Slaughtered	Died	Others	Born	Purchased	Others
Oxen							
Cows							
Female calves							
Male calves							
Heifers							
Bullocks							

7. Concerning breeding females:

(a) Total number of breeding females you owned since last year____________
(b) Total aborted since last year ___________
(c) Age at 1st calving of a breeding female __________
(d) Calving interval of a breeding female ____________

Annex 2: Mean PCV value of cattle examined in 6 villages of Limu Shay (tsetse controlled) area.

Village	Number of animals and mean PCV value (%)			95 % CI
	Parasitaemic	Aparasitaemic	Total	
Balto Warabu	4 (20.8)	59 (24.4)	63 (24.2)	22.2152- 25.1976
Balto Abulu	6 (23.3)	62 (26.4)	68 (26.1)	25.1247- 26.9929
Koticha	4 (26)	56 (25.5)	60(25.5)	24.4441 - 26.6225
Meti	9 (21.7)	55 (24.5)	64 (24.2)	23.2109- 25.2577
Village 3&5	9 (19.7)	61 (22.9)	70 (22.6)	21.4457- 23.4685
Sokoru	0	80 (27.2)	80 (27.2)	26.2276- 28.1223
Combined	32 (21.7)	373 (25.3)	405 (25)	24.5749- 25.4300

Annex 3: Mean PCV value of cattle examined in 5 villages of Didessa (tsetse infested) area.

Village	Number of animals and mean PCV value (%)			95% CI
	Parasitaem ic	Aparasitaem ic	Total	
Chelelek	27 (21.7)	67 (22.8)	94 22.5)	21.8434- 23.6034
Burka	35 (20.8)	50 (23.8)	85 (22.6)	21.7138- 23.4627
Loko	28 (20.5)	62 (22.8)	90 (22.1)	21.1788- 23.0878
Kolu	14 (21.6)	55 (23.4)	69 (22.9)	21.7913- 23.9477
Temo	6 (18.5)	61 (25.2)	67 (24.6)	23.4448- 25.2715
Total	110 (20.8)	295 (23.6)	405 22.8)	22.4398- 23.2786

Annex 4: Annual mean trypanosome prevalence and PCV at Limu Shay area from (1989-1996). Source: NTTICC data records (1889- 1996).

Phase	Year	Prevalence (%)	PCV (%)
Pre control	1988	33.4	23.42
Control period (1889-1996)	1989	9.5	28.96
	1990	1.74	26.2
	1991	1.46	27.9
	1992	5.32	26.5
	1993	3.83	25.6
	1994	7.38	25.2
	1995	5.4	23.5
	1996	7.14	25.11
Mean± SE	1989-1996	5.22±0.99	26.12±0.60

Annex 5: Fly survey data - tsetse fly catch and altitude at every trapping location.

Identifications: A=area (A1Controlled: A2, Infested); L=location; T=each trapping site; Alt= altitude; 1=G. tachinoides, 2= G. m. submorsitans; 3= Total (1+2); M= Male; F= Female

Wereda	Localities	Site	Alt	Start	Finish	1		2		3
						M	F	M	F	
Goma	Magnaka	A1L1T1	1345	10/11/2003	13/11/2003	0	1	0	0	1
Goma	Magnaka	A1L1T2	1345	10/11/2003	13/11/2003	0	2	0	0	2
Goma	Magnaka	A1L1T3	1350	10/11/2003	13/11/2003	0	1	0	0	1
Goma	Magnaka	A1L1T4	1340	10/11/2003	13/11/2003	1	2	0	0	3
Goma	Magnaka	A1L1T5	1340	10/11/2003	13/11/2003	0	0	0	0	0
Goma	Magnaka	A1L1T6	1340	10/11/2003	13/11/2003	0	0	0	0	0
Goma	Magnaka	A1L1T7	1340	10/11/2003	13/11/2003	0	0	0	0	0
Goma	Magnaka	A1L1T8	1340	10/11/2003	13/11/2003	0	1	0	0	1
Goma	Magnaka	A1L1T9	1345	10/11/2003	13/11/2003	2	1	0	0	3
Goma	Magnaka	A1L1T10	1340	10/11/2003	13/11/2003	3	2	0	0	5
Goma	Magnaka	A1L1T11	1360	10/11/2003	13/11/2003	2	2	0	0	4
Goma	Magnaka	A1L1T12	1340	10/11/2003	13/11/2003	4	1	0	0	5
Goma	Magnaka	A1L1T13	1345	10/11/2003	13/11/2003	1	0	0	0	1
Goma	Magnaka	A1L1T14	1360	10/11/2003	13/11/2003	0	1	0	0	1
Goma	B/Warabu	A1L2T1	1520	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T2	1510	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T3	1510	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T4	1500	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T5	1520	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T6	1510	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T7	1505	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T8	1500	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T9	1480	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T10	1475	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T11	1470	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T12	1460	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T13	1425	14/11/2003	17/11/2003	1	0	0	0	1
Goma	B/Warabu	A1L2T14	1425	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T15	1425	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T16	1435	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T17	1430	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T18	1440	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T19	1480	14/11/2003	17/11/2003	0	0	0	0	0
Goma	B/Warabu	A1L2T20	1500	14/11/2003	17/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T1	1450	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T2	1440	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T3	1445	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T4	1430	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T5	1415	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T6	1410	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T7	1415	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T8	1410	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T9	1400	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T10	1400	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T11	1395	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T12	1390	18/11/2003	21/11/2003	0	0	0	0	0

Goma	A/Sololo	A1L3T13	1385	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T14	1380	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T15	1375	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T16	1370	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T17	1365	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T18	1360	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T19	1355	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T20	1350	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T21	1340	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T22	1340	18/11/2003	21/11/2003	0	0	0	0	0
Goma	A/Sololo	A1L3T23	1345	18/11/2003	21/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T1	1520	23/11/2003	26/11/2003	1	0	0	0	1
Goma	B/Alabu	A1L4T2	1525	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T3	1525	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T4	1510	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T5	1500	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T6	1490	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T7	1485	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T8	1480	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T9	1465	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T10	1450	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T11	1440	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T12	1420	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T13	1415	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T14	1410	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T15	1400	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T16	1395	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T17	1390	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T18	1385	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T19	1380	23/11/2003	26/11/2003	0	0	0	0	0
Goma	B/Alabu	A1L4T20	1375	23/11/2003	26/11/2003	0	0	0	0	0
Goma	Didessa	A1L5T1	1340	28/11/2003	1/12/2003	0	0	0	0	0
Goma	Didessa	A1L5T2	1360	28/11/2003	1/12/2003	4	2	0	0	6
Goma	Didessa	A1L5T3	1345	28/11/2003	1/12/2003	2	1	0	0	3
Goma	Didessa	A1L5T4	1360	28/11/2003	1/12/2003	10	17	0	0	27
Goma	Didessa	A1L5T5	1365	28/11/2003	1/12/2003	18	35	0	0	53
Goma	Didessa	A1L5T6	1325	28/11/2003	1/12/2003	36	96	0	0	132
Goma	Didessa	A1L5T7	1320	28/11/2003	1/12/2003	30	36	0	0	66
Goma	Didessa	A1L5T8	1320	28/11/2003	1/12/2003	14	27	0	0	41
Goma	Didessa	A1L5T9	1330	28/11/2003	1/12/2003	3	3	0	0	6
Goma	Buya	A1L6T1	1390	3/12/2003	6/12/2003	0	0	0	0	0
Goma	Buya	A1L6T2	1395	3/12/2003	6/12/2003	0	0	0	0	0
Goma	Buya	A1L6T3	1400	3/12/2003	6/12/2003	0	0	0	0	0
Goma	Buya	A1L6T4	1390	3/12/2003	6/12/2003	0	0	0	0	0
D/Bedele	Loko	A2L1T1	1455	17/10/2003	20/10/2003	0	0	1	1	2
D/Bedele	Loko	A2L1T2	1460	17/10/2003	20/10/2003	0	0	0	0	0
D/Bedele	Loko	A2L1T3	1430	17/10/2003	20/10/2003	0	0	1	3	4
D/Bedele	Loko	A2L1T4	1400	17/10/2003	20/10/2003	0	0	1	2	3
D/Bedele	Loko	A2L1T5	1400	17/10/2003	20/10/2003	0	0	1	4	5
D/Bedele	Loko	A2L1T6	1380	17/10/2003	20/10/2003	0	0	6	5	11

										.....Annex 5 continued
D/Bedele	Loko	A2L1T7	1385	17/10/2003	20/10/2003	0	0	2	2	4
D/Bedele	Loko	A2L1T8	1385	17/10/2003	20/10/2003	0	0	2	2	4
D/Bedele	Loko	A2L1T9	1385	17/10/2003	20/10/2003	0	0	2	3	5
D/Bedele	Loko	A2L1T10	1520	2/11/2003	5/11/2003	0	0	0	2	2
D/Bedele	Loko	A2L1T11	1510	2/11/2003	5/11/2003	0	0	0	0	0
D/Bedele	Loko	A2L1T12	1510	2/11/2003	5/11/2003	0	0	2	3	5
D/Bedele	Loko	A2L1T13	1490	2/11/2003	5/11/2003	0	0	2	2	4
D/Bedele	Chelelek	A2L2T1	1400	17/10/2003	20/10/2003	0	0	1	2	3
D/Bedele	Chelelek	A2L2T2	1400	17/10/2003	20/10/2003	0	0	2	3	5
D/Bedele	Chelelek	A2L2T3	1400	17/10/2003	20/10/2003	0	0	3	1	4
D/Bedele	Chelelek	A2L2T4	1400	17/10/2003	20/10/2003	0	0	2	1	3
D/Bedele	Chelelek	A2L2T5	1420	17/10/2003	20/10/2003	0	0	1	3	4
D/Bedele	Chelelek	A2L2T6	1420	17/10/2003	20/10/2003	0	0	1	1	2
D/Bedele	Chelelek	A2L2T7	1420	17/10/2003	20/10/2003	0	0	2	2	4
D/Bedele	Chelelek	A2L2T8	1420	17/10/2003	20/10/2003	0	0	2	4	6
D/Bedele	Chelelek	A2L2T9	1420	17/10/2003	20/10/2003	0	0	1	0	1
D/Bedele	Chelelek	A2L2T10	1400	17/10/2003	20/10/2003	0	0	2	4	6
D/Bedele	Loko river	A2L3T1	1350	24/10/2003	27/10/2003	2	2	0	0	4
D/Bedele	Loko river	A2L3T2	1340	24/10/2003	27/10/2003	4	9	0	0	13
D/Bedele	Loko river	A2L3T3	1345	24/10/2003	27/10/2003	0	1	0	0	1
D/Bedele	Loko river	A2L3T4	1350	24/10/2003	27/10/2003	8	12	0	0	20
D/Bedele	Loko river	A2L3T5	1345	24/10/2003	27/10/2003	1	1	0	0	2
D/Bedele	Loko river	A2L3T6	1340	24/10/2003	27/10/2003	1	3	0	0	4
D/Bedele	Loko river	A2L3T7	1320	2/11/2003	5/11/2003	8	10	5	0	23
D/Bedele	Loko river	A2L3T8	1320	2/11/2003	5/11/2003	23	37	0	0	60
D/Bedele	Kerkeha	A2L3T9	1350	24/10/2003	27/10/2003	0	0	1	3	4
B/Dabo	Kerkeha	A2L3T10	1350	24/10/2003	27/10/2003	0	0	19	18	37
B/Dabo	Kerkeha	A2L3T11	1385	24/10/2003	27/10/2003	0	0	0	1	1
B/Dabo	Kerkeha	A2L3T12	1365	24/10/2003	27/10/2003	0	0	3	5	8
B/Dabo	Kerkeha	A2L3T13	1510	24/10/2003	27/10/2003	0	0	0	0	0
B/Dabo	Kerkeha	A2L3T14	1520	24/10/2003	27/10/2003	0	0	3	5	8
B/Dabo	Kerkeha	A2L3T15	1370	24/10/2003	27/10/2003	0	0	2	0	2
B/Dabo	Kerkeha	A2L3T16	1390	24/10/2003	27/10/2003	0	0	5	7	12
B/Dabo	Kerkeha	A2L3T17	1370	24/10/2003	27/10/2003	0	0	7	8	15
B/Dabo	Kerkeha	A2L3T18	1420	24/10/2003	27/10/2003	0	0	1	3	4
B/Dabo	Kerkeha	A2L3T19	1375	24/10/2003	27/10/2003	0	0	1	2	3
B/Dabo	Kerkeha	A2L3T20	1390	24/10/2003	27/10/2003	0	0	2	3	5
B/Dabo	Kerkeha	A2L3T21	1410	24/10/2003	27/10/2003	0	0	1	1	2
B/Dabo	Kerkeha	A2L3T22	1380	27/10/2003	30/10/2003	0	0	0	1	1
B/Dabo	Kerkeha	A2L3T23	1390	27/10/2003	30/10/2003	0	0	1	0	1
B/Dabo	Kerkeha	A2L3T24	1345	27/10/2003	30/10/2003	0	0	1	2	3
B/Dabo	Kerkeha	A2L3T25	1380	27/10/2003	30/10/2003	0	0	2	1	3
B/Dabo	Kerkeha	A2L3T26	1375	27/10/2003	30/10/2003	0	0	3	6	9

.....*Annex 5 continued*

B/Dabo	Kerkeha	A2L3T27	1375	27/10/2003	30/10/2003	0	0	0	0	0
B/Dabo	Kerkeha	A2L3T28	1410	27/10/2003	30/10/2003	0	0	1	1	2
B/Dabo	Kerkeha	A2L3T29	1420	27/10/2003	30/10/2003	0	0	0	2	2
B/Dabo	Kerkeha	A2L3T30	1440	27/10/2003	30/10/2003	0	0	0	0	0
B/Dabo	Kerkeha	A2L3T31	1450	27/10/2003	30/10/2003	0	0	1	2	3
B/Dabo	Kerkeha	A2L3T32	1450	27/10/2003	30/10/2003	0	0	2	6	8
B/Dabo	Kerkeha	A2L3T33	1510	27/10/2003	30/10/2003	0	0	4	2	6
B/Dabo	Kerkeha	A2L3T34	1460	27/10/2003	30/10/2003	0	0	1	2	3
B/Dabo	Kerkeha	A2L3T35	1510	27/10/2003	30/10/2003	0	0	6	2	8
B/Dabo	Kerkeha	A2L3T36	1510	27/10/2003	30/10/2003	0	0	4	1	5
B/Dabo	Kerkeha	A2L3T37	1510	27/10/2003	30/10/2003	0	0	1	1	2
B/Dabo	Kerkeha	A2L3T38	1505	27/10/2003	30/10/2003	0	0	0	0	0
B/Dabo	Kerkeha	A2L3T39	1460	27/10/2003	30/10/2003	0	0	9	6	15
B/Dabo	Kerkeha	A2L3T40	1460	27/10/2003	30/10/2003	0	0	2	0	2
B/Dabo	Kerkeha	A2L3T41	1400	30/10/2003	2/11/2003	0	0	2	4	6
B/Dabo	Kerkeha	A2L3T42	1430	30/10/2003	2/11/2003	0	0	7	4	11
B/Dabo	Kerkeha	A2L3T43	1430	30/10/2003	2/11/2003	0	0	2	3	5
B/Dabo	Kerkeha	A2L3T44	1440	30/10/2003	2/11/2003	0	0	0	2	2
B/Dabo	Kerkeha	A2L3T45	1400	30/10/2003	2/11/2003	0	0	0	3	3
B/Dabo	Kerkeha	A2L3T46	1450	30/10/2003	2/11/2003	0	0	2	0	2
B/Dabo	Kerkeha	A2L3T47	1450	30/10/2003	2/11/2003	0	0	3	4	7
B/Dabo	Kerkeha	A2L3T48	1460	30/10/2003	2/11/2003	0	0	2	3	5
B/Dabo	Kerkeha	A2L3T49	1460	30/10/2003	2/11/2003	0	0	2	2	4
B/Dabo	Kerkeha	A2L3T50	1460	30/10/2003	2/11/2003	0	0	2	0	2
B/Dabo	Didessa road	A2L4T1	1480	30/10/2003	2/11/2003	0	0	7	14	21
B/Dabo	Didessa road	A2L4T2	1470	30/10/2003	2/11/2003	0	0	2	3	5
B/Dabo	Didessa road	A2L4T3	1465	30/10/2003	2/11/2003	0	0	0	0	0
B/Dabo	Didessa road	A2L4T4	1460	30/10/2003	2/11/2003	0	0	0	5	5
B/Dabo	Didessa road	A2L4T5	1400	30/10/2003	2/11/2003	0	0	2	7	9
B/Dabo	Didessa road	A2L4T6	1400	30/10/2003	2/11/2003	0	0	3	7	10
B/Dabo	Didessa road	A2L4T7	1350	30/10/2003	2/11/2003	0	0	3	10	13
B/Dabo	Didessa road	A2L4T8	1345	30/10/2003	2/11/2003	0	0	0	8	8
B/Dabo	Didessa road	A2L4T9	1350	2/11/2003	5/11/2003	0	0	7	5	12
B/Dabo	Didessa road	A2L4T10	1340	2/11/2003	5/11/2003	0	0	4	3	7
B/Dabo	Didessa road	A2L4T11	1350	2/11/2003	5/11/2003	0	0	3	3	6
B/Dabo	Didessa river	A2L4T12	1320	2/11/2003	5/11/2003	90	130	0	0	220
B/Dabo	Didessa river	A2L4T13	1310	2/11/2003	5/11/2003	20	15	0	0	35
B/Dabo	Didessa river	A2L4T14	1300	2/11/2003	5/11/2003	14	16	0	0	30
B/Dabo	Didessa river	A2L4T15	1310	2/11/2003	5/11/2003	7	10	0	0	17
B/Dabo	Didessa river	A2L4T16	1310	2/11/2003	5/11/2003	45	60	0	0	105
B/Dabo	Didessa river	A2L4T17	1320	2/11/2003	5/11/2003	9	15	0	0	24

Annex 6: Distribution and apparent densities (fly per trap per day) of tsetse flies in different localities of Limu Shay (tsetse controlled) area.

Localities	Altitude (meters)	Number of traps	*G. tachinoides*		Total	FTD
			Male	Female		
Balto Warabu	1425-1520	20	1	0	1	0.02
Balto Abulu	1400-1525	20	0	1	1	0.02
Maganka	1340-1360	14	13	14	27	0.64
Buya	1390-1400	4	0	0	0	0
Agamsa Sololo	1350-1450	23	0	0	0	0
Didessa river	1320-1365	9	117	217	334	12.37
Total	1320-1525	90	132	231	363	1.34

Annex 7: Distribution and apparent densities (fly per trap per day) of tsetse flies in different localities of Didessa (tsetse infested) area.

Locality	Altitude	Number of traps	*G. m. submorsitans*		*G. tachinoides*		Total	FTD
			Male	Female	Male	Female		
Loko	1400-1520	13	20	29	0	0	49	1.26
Chelelek	1400-1420	10	17	21	0	0	38	1.27
Loko river	1320-1380	8	5	0	47	75	127	5.29
Kerkeha	1400-1520	42	105	116	0	0	221	1.75
Didessa	1350-1480	11	31	65	0	0	96	2.91
Didessa river	1300-1320	6	0	0	185	246	431	23.94
Total	1300-1320	90	178	231	232	321	962	3.56

Annex 8: Average annual trypanocidal drug treatments in herds in Limu Shay (tsetse controlled) and Didessa (tsetse infested) areas of the upper Didessa valley, questionnaire survey February/March, 2004.

Area	Treatment			Herd size	Treatment/Per animal/ year
	No	Curative (%)	Prophylactic (%)		
Controlled	213	98.8	1.2	1148	0.19*
Infested	3444	58.9	41.1	481	7.16 *
Total	4165	69.77	30.23	1622	2.25

*=Mean differ significantly (P< 0.001)

Annex 9: Limu Shay socio economic data. Source: NTTICC, socio economic data records (1988- 1996).

Parameters	1988	1989	1990	1991	1992	1993	1994	1995	1996
Fam. head	2416	2181	2256	2240	2630	2241	2347	2511	2525
Human pop.	9292	9785	9484	8683	8616	9710	10420	11384	13227
Oxen	1085	1411	1614	1020	1437	1536	1990	3225	3826
Cow	1125	1181	1622	1657	2192	2388	2836	3687	4430
Heifers	414	685	703	742	1183	1287	1643	2071	2208
Bulls	264	370	444	391	691	924	1001	1351	1442
Calves	245	488	716	354	845	832	633	1084	1524
cattle total	3133	4135	5099	4164	6348	6967	8103	11418	13430
Sheep	260	390	669	371	651	605	452	926	1290
Goats	204	311	384	282	516	383	425	932	1399
Ovine total	470	701	1053	653	1167	988	877	1858	2689
Equine	137	128	132	95	157	128	139	283	398
Maize	934.3	1435.9	1925.2	1710	1488.3	1429.2	1511	2343	2809
Teff					950.8	756.5	610	1013	1486
Sorghum					968	1028.3	1135.4	1610	1674
Other cereals					291	146.1	208.5	276	437
Coffee	342.8	438.1	567	645.2	1178.02	1131.6	1381.5	1560	1645
Total cult. Land	1277.1	1874	2492.2	2355.2	4876.12	4491.7	4846.4	6802	8051

Note: Fam. = Family, pop= population

Annex 10: Limu Shay socio economic data. Source: Goma woreda agricultural development office data records (1997- 2003).

Parameters	1997	1998	1999	2000	2001	2002	2003
Fam. head	2908	3065	3245	3450	3639	3847	4395
Human pop.	15662	16020	16483	17757	18342	18714	19415
Oxen	4698	5005	6124	6800	6790	6970	7140
Cow	5090	5923	6062	6484	7200	7484	7500
Heifers	2012	2215	2354	2433	2600	3270	3500
Bulls	2000	2538	2680	2330	2600	3050	3150
Calves	1450	2415	2028	2600	2800	2600	2900
cattle total	15250	18096	19248	20647	21990	23374	24190
Sheep	1369	1600	1445	1490	2040	1990	2265
Goats	1460	2000	1960	1950	2315	2720	3700
Ovine total	2829	3600	3405	3440	4355	4710	5465
Equine	655	918	868	898	1021	1059	1448
Maize	2853	3064	3563	4018	3658	5045	4790
Teff	1490	1570	1575	1450	1836	1500	1560
Sorghum	1705	1730	2150	2690	2520	3450	2420
Other cereals	450	455	470	490	590	620	700
Coffee	1685	1900	2000	2120	2190	2285	2355
Total cult. Land	8183	8719	9758	10768	10794	12900	11825

Note: Fam. = Family, pop= population.

Annex 11: Didessa socio economic data. Source: Bedelle Dabo woreda data records (2003).

Parameters	2003
Fam. head	900
Human pop.	2640
Oxen	816
Cow	476
Heifers	464
Bulls	491
Calves	308
cattle total	2555
Sheep	184
Goats	474
Ovine total	658
Equine	26
Maize	250
Teff	102
Sorghum	200
Other cereals	500
Coffee	2
Total cult. Land	1054

Note: Fam. = Family, pop = population

9. CURRICULUM VITAE

Name: Feyesa Regassa Geleta

Address: East Wollega Agricultural Development Office
P.O.Box 37, Tel. 611019, Nekemte, Wollega

Nationality: Ethiopian

Date of birth: August 24, 1965

Place of birth: Kekero, Wollega

Marital status: Married

Education:

1968-1974 Elementary and Junior School Gida Ayana, Wollega
1975-1980 High school, Gida Ayana, Wollega

Qualification and training:

1982-87 University Graduate (DVM), Addis Ababa University, Faculty of Veterinary Medicine, Debre Zeit, Ethiopia

International Group Training Course on Tsetse Management, Monitoring and Control. ICIPE, Nairobi, Kenya, November 1997.

Work experience:

1998-1991, worked as Regional Animal and Fisheries Resources Development team leader (Assosa Administrative Region)

1992-1993 Regional Animal and Fisheries Resources Development team leader (Wollega Administrative Region).

1994-1996 Animal health team leader (Wollega zone).

1997- 2002 Zonal senior veterinarian (East Wollega).

1997- 1998 Teaching at Bako Agricultural Training center.

Current duties and responsibilities:

Head Agricultural Office (Sassiga Woreda)

Language skills:

Oromifa: Fluent, written and spoken.
English: Fluent, written and spoken.
Amharic: Fluent, written and spoken.

10. SIGNED DECLARATION SHEET

I the under signed, declare that the thesis is my original work and has not been presented for a degree in any university.

Name FEYESA REGASSA

Signature ------------------------------------

Date of submission July 1/2004

This thesis has been submitted for examination with our approval as University Advisors

Prof. Getachew Abebe ______________________________

Dr. Arun K. Sangwan ______________________________

Curreny epidemiological stuation of
Bovine trypanosomosis in limu shay
Tsetse controlled area of upper
Didessa Valley

Feyesa Regassa