ADDIS ABABA UNIVERSITY
FACULTY OF VETERINARY MEDICINE

ASSESSEMENT OF THE TSETSE AND TRYPANOSOMOSIS CONTROL PROGRAM IN CHEWAKA SETTELEMENT STATION , ILLUBABOUR ZONE , SOUTHWEST ETHIOPIA

MSC THESIS
BY
MANYAZEWAL ANBERBER

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DEBRE ZEIT, ETHIOPIA

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A thesis submitted to the School of Graduate Studies of Addis Ababa University
in partial fulfillments for the requirements for the Degree of

Master of Science in Tropical Veterinary Epidemiology

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LIST OF ABBREVIATIONS

AAT:	African Animal Trypanosomosis
CFT:	Complement Fixation Test
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
ICIPE:	International Centre for Insect Physiology and Ecology
ILCA:	International Livestock Centre for Africa
ILRAD:	International Laboratory for Research on Animal Diseases
ISCTRC:	International Scientific Council for Trypanosomosis Research & Control
MOA:	Ministry of Agriculture
NTTICC:	National Tsetse & Trypanosomosis Investigation & Control Centre
OAU/IBAR:	Organization of African Unity/ Inter-African Bureau for Animal Resources
PCV:	Packed Cell Volume
PCR:	Polymerase Chain Reaction
SIT:	Sterile Insect Technique
USD:	United States Dollar

ABSTRACT

The impact of tsetse and trypanosomosis control program conducted in Chewaka settlement station during 2005/6 was assessed through retrospective and cross sectional studies by comparing the prevalence of trypanosomosis and density of tsetse before and after the intervention within Chewaka settlement area, and the current situation at Bikiltu Didessa, where there is no tsetse control activity. A total of 830 cattle, 160 biconical traps and 160 heads of households were used for the cross sectional survey and the Buffy coat, apparent density of tsetse (fly/trap/day) and questionnaire format interview methods were employed to determine the prevalence of trypanosomosis, tsetse population density and socioeconomic status of farmers, respectively. The overall tsetse fly density in Chewaka settlement area prior to the control, 13.96 FTD, was dropped by 98.6 % to 0.2 FTD at the end of the control period. The drop in the overall mean FTD was statistically highly significant (P=0.000). The spatial distribution of tsetse had also diminished significantly; tsetse was not trapped at four sites and in the remaining three sites it exists in very low densities ranging from 0.03 to 1.10 FTDs. The mean tsetse fly density in the controlled study area, 0.2 FTD, was significantly lower (P=0.000) than the mean density in the uncontrolled stud area, 2.28 FTD. There was no difference in fly density among the six sites of Chewaka showing the uniformity of the control operation at all sites of the settlement station. The decline in the mean prevalence of bovine trypanosomosis in Chewaka from 37.5% (prior to control) to 3.1% (post control) was statistically highly significant (P=0.001). During this period the mean herd PCV had increased significantly (p=0.000) from 19.4% to 26.5 % with a slope of -0.21 and a significant negative linear correlation with prevalence of trypanosomosis (r=-1.000). The prevalence of trypanosomosis in Bikiltu, 15%, was significantly higher (P=0.000) than the prevalence in Chewaka, 3%. Animals in Bikiltu had an OR of 4.935 (2.714-8.976) Positivity as compared to animals in Chewaka implying the chance of positivity for animals in Bikiltu was about five times the chance of positivity for animals in Chewaka. There was no statistically significant difference in prevalence of trypanosomosis among the six sites of Chewaka study area and no difference was also observed (P>0.05) OR=0.614 (95%CI 0.373-1.010) among the three age groups, calves, young and adults, and between male and female animals in Bikiltu and Chewaka study areas The mean herd PCV in Chewaka, 26.5% (95% CI =26.1-27), was

significantly higher (p=0.000) than the mean herd PCV in Bikiltu, 24.4% (23.9-24.8). The mean herd PCV of sites with high prevalence of trypanosomosis in Bikiltu (Chalalaki-1, Chalalaki-2 and Burka) were significantly lower ($p<0.05$) than sites with low prevalence of the disease (Kolu and Loko). Sixty six percent of the respondents in Chewaka and only 24% of them in Bikiltu sold animals during a year period (Dec.96/Dec.97) and a significant difference (P=0.000) was obtained in animal sell between the two study areas indicating better family income due to animal sell in Chewaka than in Bikiltu. Out of the total respondents 85% (68/80) in Chewaka, and 36% (29/80) in Bikiltu purchased animals during this period and the average number of cattle bought /hh/yr in Chewaka, 1.15 head, was significantly higher (P=0.000) than the average number of cattle bought in Bikiltu, 0.55 head/hh/yr. The chance of cattle and oxen mortality in Bikiltu was 10 and 6 times more likely than in Chewaka (OR= 6.5 and 10.2) and 51% of the total mortality in Bikiltu was attributed to deaths of draught oxen which resulted in significant decline of crop production. During 2005/07, the overall livestock and cattle population in Chewaka had increased by 116% and 1038.9 %, respectively, and expansion of cultivated land by 46.8%/year resulted in growth of grain production by 31.6 %/year. In Bikiltu, the high mortality of cattle despite frequent treatment scheme and the high recurrence of trypanosomosis in recently treated animals suggest the existence of drug resistance problem in the area.

It was concluded that the tsetse and trypanosomosis control operation conducted in the newly established Chewaka settlement station had resulted in satisfactory achievements on the prevalence of the disease, density of tsetse fly and livelihood of the human population in the area. Findings of this study are discussed and recommendations forwarded.

1. INTRODUCTION

African trypanosomes exert significant morbidity and mortality in man and his livestock. *Trypanosoma brucei* and *T. congolense* are the causative agents of sleeping sickness in humans and Nagana in cattle, respectively. The protozoan parasites live extracellularly in blood and tissue fluids of mammals and are transmitted by the bite of infected tsetse flies *(Glossina species*). Approximately, 30% of the total cattle populations in Africa, 46 million head, are exposed to the risk of contracting Nagana, and 3 million die every year. The disease costs an estimated 1340 million USD per year (Kristjanson *et al*., 1999). Over 60 million people living in 36 sub-Saharan countries are threatened with sleeping sickness (WHO, 2001) and 48,000 deaths were reported in 2002 (WHO, 2004).

About 10 million km^2 land of sub-Saharan Africa, representing 37% of the continent, is underutilized for crop production due to tsetse fly infestation; on top of this, improved breeds of cattle can not be introduced in to the tsetse infested areas as they are highly susceptible to the disease. Affected animals become chronically unproductive in terms of meat, milk, manure and traction power. Animal losses in terms of meat production alone are estimated at 5 billion USD and seven million km^2 of land could be suitable for mixed agriculture if trypanosomosis could be controlled ((ILRAD, 1990 and 1993).

Several intervention methods are used currently in the fight against bovine trypanosomosis. Programs to control tsetse flies and trypanosomosis outlaid farmers, governments and aid agencies a large sum of money through out the last century. Chemotherapy of African trypanosomosis still relies on drugs developed decades ago and some of these display serious toxic side effects (Croft, 1997, Fairlamb, 2003). In addition, drug resistance in African trypanosomes is increasing (Ross and Sutherland, 1997; Matovu, *et al.*, 2001).

At present, self-sufficiency in food production is a pressing task for most of the developing countries of the world since the rate of growth in food production lags behind the rate of population growth. The human population of Africa is growing at the rate of 3% a year, while

food production growth rate is only 2% per annum Among many other problems responsible for this disproportionate growth between food production and population growth, the presence of tsetse and trypanosomosis ranks first.

Ethiopia's economy is largely dependent on agriculture, and, this in turn, is strongly influenced by livestock, which provide more than 90% draught power required for crop production. The causes of food deficiency in the country could be numerous and it is difficult to separate one from the other, however, some livestock and human diseases have obvious influences on the country's self-reliance in food production (Ethiopian Agricultural Research Organization (EARO), 1999). Amongst such problems tsetse borne trypanosomosis is the most important one, which has negative influence on agricultural production. Trypanosomosis has existed in Ethiopia since time immemorial, and was first recorded in a report by Donaldson Smith in 1894-1895 (Langridge, 1976). However, it started emerging as a serious problem to livestock only since 1960's with the steady increase in human population and the need for expanding agricultural land to the lowland areas of the southwestern region (Farming In Tsetse Controlled Area (FITCA), 1999). Tsetse flies have progressively invaded productive agricultural areas of the country and severely affected sound agricultural production. Recent findings indicate that tsetse had extended to an altitude of 2000m (National Tsetse and Trypanosomosis Investigation and Control Center (NTTICC), 1996).

The over all prevalence of bovine trypanosomosis in tsetse infested and tsetse free areas were reported to be 17.67% and 8.71%, respectively (Abebe and Jobre, 1996). Moreover, chemotherapy and chemoprophylaxis are losing their potency, which they used to have earlier, and the evolving trypanosome drug resistance is an ever-increasing challenge in various parts of the country. Trypanosomosis causes a multitude of problems, which are, in many cases, difficult to clearly separate from other development problems. Tikubet, (1999) invested the major and well-recognized menaces brought about by trypanosomosis in Ethiopia as:

- some 10-14 million head of cattle and an equivalent number of equine, goats and sheep are exposed to the risk of acquiring trypanosomosis at any time. Morbidity and mortality losses from ruminant livestock alone are estimated at some USD 200 million/year; 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 Southwestern parts of the country; human and livestock populations are concentrated in tsetse and trypanosomosis free but ecologically fragile highlands with the resultant effect of overgrazing 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 trypanocidal drugs every year and the problem is still serious and some unofficial estimates from the Ministry of Agriculture (MOA) put the overall trypanosomosis related losses as between 1,408 and 1,540 million USD per annum excluding animal traction power and manure values.

While most livestock deadly diseases have been under reasonable control either through immunization or chemotherapy, trypanosomosis could not be dealt with effectively and the problem is becoming even greater than before as tsetse flies are steadily advancing in to new areas. Although some efforts had been made to control tsetse and trypanosomosis during the past few decades (NTTICC, 1996; FITCA, 1999), much has to be done to overcome the ever-increasing problem posed by tsetse and trypanosomosis in the country. Control programs should meet at least three criteria: 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 (Slingenbergh, 1999).

The utilization of tsetse-infested areas with high agricultural potential remained the major priority of the Ethiopian government during the last few decades. Currently the government had launched an extensive national resettlement Program in the rural areas of the country in order to attain its goal on food self-sufficiency and poverty reduction program. The main objective of the resettlement program is to transfer rural populations from the densely populated low productive highland areas to the fertile, virgin and uncultivated low land areas found at different locations of the country. Amongst such areas is part of western Oromia Region, an estimated 50,000 km^2 of tsetse infested land which has not been utilized for agricultural development hitherto.

Chewaka settlement station is one of the 50 settlement stations established in western part of Oromia Region in 2004. Tsetse and trypanosomosis survey and control program was commenced

during the initial year of the establishment of the settlement station by Oromia Rural and Agricultural Development Bureau in collaboration with NTTICC. Since then, an extensive and integrated control operation comprising targets, live baits and chemotherapy has been carried out which is supposed to have significant outcome for agricultural development in the area.

The impact of tsetse control on agriculture and livestock production can be assessed by comparing changes before and after the implementation of a control intervention or, alternatively, by cross-sectional comparison of fly and disease magnitude of similar agricultural areas under different level of trypanosomosis challenge or both.

The objectives of the study are:

1. To assess the achievements of the tsetse and trypanosomosis control program conducted in Chewaka settlement station (SS) during 2005-2006.

2. To compare the prevalence of trypanosomosis and density of tsetse fly in the tsetse-controlled, Chewaka, study area with tsetse-uncontrolled, Bikiltu Didessa Farmers' Association (FA), found in similar agro ecological zone.

3. To compare the socioeconomic status of the human population in Chewaka settlement station with that of Bikiltu Didessa study area in respect to the tsetse control out put.

2. LITERATURE REVIEW

2.1. The trypanosomes

Trypanosomes are animal parasites ,specifically protozoa of the genus *Trypanosoma* approximately the size of red blood cells, in the vertebrate hosts; microscopic examination makes it possible to recognize the major groups (sub-genera) of trypanosomes due to their morphological characteristics. One can thus easily distinguish *T. brucei* (Trypanozoon sub-genus) from *T.vivax* (Duttonella sub-genus) and from *T. congolense* (Nannomonas sub-genus).

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 the 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 characteristics and its 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 in vivo (Molyneux and Ashfrod, 1983).

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

Trypanosoma vivax has an average length of 20-26 µm, 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 forms** (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;.(c) i**ntermediate 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).

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

The total length of *Trypanosoma suis* has a range from 13-19 µm (average 16 µm) 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. The tsetse fly (vectors of trypanosomosis)

2.2.1. Classification of tsetse

Tsetse flies belong to the sub-order Cyclorrhapha, and form, along with the families Hippoboscidae, Streblidae and Nycteribiidae, the superfamily Hippoboscoidea. They are now placed within their own family the Glossinidae, with a single genus the Glossina. The word

‘tsetse ’ is believed to originate from the Tswana language in Botswana, meaning ‘fly that kills livestock (Kuzoe. and. Schofield, 2004)

There are 31 members in the genus Glossina, 23 species and 8 sub-species. The proboscis of tsetse flies project straight out from the head and is simple in structure consisting of only labrum, hypopharynx and labium. These structures are ensheathed by the equally long palps. Tsetse flies are extremely important vectors of African trypanosomosis, causing nagana in livestock, a fatal disease of horses and cattle, and sleeping sickness in humans. Apart from two localities in the Arabian Peninsula tsetse flies are found only in sub-Saharan Africa. The 31 members of the Glossinidae are divided further into three sub-genera, the *Glossina*, *Nemorhina* and *Austenina.* The sub-genera are also called *morsitans*, *palpalis*, and *fusca*, respectively, and refer to the commonest species in each of the sub-genera. (Kuzoe and Schofield, 2004).

The subgenus *Glossina* contains a total of seven species and sub-species. Those of major economic importance are *G. morsitans* and *G. pallidipes* with *G. swynnertoni* and *G. austeni* being important in specific regions. The species of the *Glossina* sub-genus are called the savannah flies due to their preference for this environment. It is this fact that makes them the most important vectors as the African savannah is a vast area and the flies come into contact with both man, his animals and wild game animals. Flies of this sub-genus are totally dependent on wild animals for their blood meals. These animals act as a reservoir of trypanosomes; with time, wild animals developed immunity to trypanosomosis, but domestic livestock have not.

The sub-genus *Fusca* or *Austenina* group is also referred to as forest flies. The 15 species and sub-species which comprise this group are mainly of no medical or veterinary importance. These larger and also more primitive flies feed on small mammals in forested areas. The main exceptions are *G.longipennis* and *G.brevipalpis* which do not live in the dense equatorial forest but *G.longipennis* in more arid areas and *G.brevipalpis* in secondary forest. They have very little contact with man and his livestock due to their habitat. None of this group is vectors of sleeping sickness (Kuzoe. and. Schofield 2004).

The sub-genus *Nemorhina* or *Palpalis* group are often called the riverine flies. There are 9 species and sub-species in this group, which are found in close association with local patches of dense vegetation along the banks of rivers and lakes in arid country, and in dense, wet, heavily forested equatorial rain forest. Species of this group occur throughout much of western Africa. The principal hosts of these flies are reptiles, especially monitor lizards and crocodiles. They will also bite ungulates (hoofed animals). *G. palpalis* is the commonest and all species are vectors of trypanosomosis.

2.2.2. Morphological features of tsetse

Tsetse flies range in size from 6-14 mm and are robust in form, they are yellowish to brown in color and the abdomen may be uniformly colored or transversed by stripes according to species. Two visually distinctive characters that are apparent to the eye are the forward projecting proboscis and the unusual hatchet shaped cell formed by the wing venation. A closer examination also reveals that the arista arising from the third antennal segment (a characteristic of Cylorrhapha) has branched setae which is not seen on any other fly (Rogers, 1990).

The hatchet cell is found in the center of each wing, in between veins 4 and 5. The resting position of the wings is also unusual although not unique in that they are folded across the abdomen-laying one over the other. Both sexes have dichoptic eyes and it is olfaction that plays the main part in host location. In male tsetse flies, the folded terminalia forms a button like structure, which is used to sex the flies. This structure is called the hypogyium and when extended reveals a pair of sexual claspers used in copulation. Tsetse are unique amongst medically important vectors, with a series of biological and demographic characteristics that make them very vulnerable to available control techniques. Their life cycle is particularly unusual since they do not lay eggs. Instead, an inseminated female develops the egg and young larva within her uterus, laying the mature (3^{rd} instar) larva into shaded soil. The larva quickly burrows under the soil surface and pupates and the teneral fly emerges 20-45 days later depending on temperature (pupal development does not succeed below 17 °C and above 32 °C). Thus, each female produces only one offspring at a time, and can produce up to 12 offsprings at intervals of 9-10 days during her typical adult lifespan of 2-3 months. As a result, the intrinsic rate of tsetse

population growth tends to be low, with the maximum rate of population increase estimated to be no more than 10-15 times per year (Rogers, 1990).

On emergence, the teneral fly is unable to fly immediately and has to wait until the wings are expanded. It takes a further ten or so days until the complete endocuticle is secreted and the exocuticle hardens. Having emerged both sexes will seek a host to gain a blood meal. In the females this provides energy and material to build flight muscle mass and rear her larva. In males feeding also develops muscle mass and energy for spermatogenesis. Males are not fully fertile until several days after emergence whilst females are able to mate two to three days after emergence. Tsetse feed every two to three days and the first larval offspring is deposited about 9-12 days after the female emerged. Due to the length of development tsetse flies are relatively long lived, up to 14 weeks for females, with males having shorter lives of around 6 weeks. Hence the rate of reproduction is extremely slow compared to other diptera, like the prodigiously prolific house-fly.

2.3. Epidemiology of trypanosomoses

Livestock exposed to trypanosomosis risk differ in their responses depending on genetic factors such as species, breeds and even individual characters and on many environmental factors including trypanosome and tsetse characters all contributing to the epidemiology of the disease. The factors affecting susceptibility to trypanosomosis must be well understood if effective measures to control the disease are to be developed (D'iteren, *et al*., 2000).

2.3.1 The parasite

In animals, trypanosomes are either transmitted acyclically by haematophagus flies of the genus *Tabanus* and *Stomoxys* or cyclically by the tsetse flies. 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: (a) The tsetse fly got infected with the trypomastigote blood form which loses its

surface coat in the goiter of the fly, and, which remains there for at least one hour, restructuring its mitochondria. (b) The trypanosomes enter the mid gut where they transform through length wise division into the epimastigote form in the cardia. (c) 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 trypomastigote form which has now got its surface coat; the trypanosomes are haploid. (d) After the vertebrate host has been infected by tsetse fly, syngamy takes place; the trypanosomes become diploid and multiply through length wise division.

Because of the complicated development of trypanosomes within the tsetse fly, only about 0.1-0.4 % of the flies are infected and thus are potential vectors of trypanosomosis. The length of time taken for trypanosomes to complete development in tsetse is quite variable (Leak, 1999). The risk of infection to which cattle are exposed is closely related to the density and the species of tsetse fly present. In the tsetse infested zones, *Trypanosoma congolense*, *T. vivax* and *T. brucei brucei* are the main pathogenic species encountered. In field investigations, mixed infections are often observed both in wildlife and domestic livestock. Although variations in virulence between different trypanosome stocks and clones belonging to the same species is known to occur, *T. congolense* and *T. vivax* are generally considered to be more pathogenic to domestic ruminants, as assessed by their capacity to induce anaemia, depress live weight and, eventually, cause death, than T. b. brucei (Mattioli, *et al*., 1998).

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. Mechanical transmission of African animal trypanosomoses may be important in some localities. *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 of *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 highland areas unsuitable for the survival of tsetse flies. *T. congolense* is confined to tsetse belt areas and is the dominant species in this region affecting a wide range of hosts. *T. brucei* is also restricted to tsetse infested localities with wide host range, but mainly restricted to cattle (Uilenberg, 1998).

2.3.2. The vector

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). Adult tsetse, male and female, feed exclusively on vertebrate blood; the immature stages do not feed. Teneral flies can become infected with trypanosomes while taking a blood meal from an infected host, once the infection is established; the flies appear to remain infected for life. In the cyclical development, the establishment and development of trypanosomes in the tsetse vectors, is a complex process, involving a series of vector and parasite defense and counter-defense mechanisms (Wellburn and Maudlin, 1999), and there is evidence that tsetse become harder to infect as they mature. Often therefore, natural populations of tsetse show relatively low infection rates generally less than 0.1% in the case of human-infective forms, but often as high as 10-15% in the case of cattle-infective forms.

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 whatever 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 (Clausen *et al.*, 1998). Species of the fusca group typically occur in lowland rain forests of West and Central Africa (exceptions being *G. longipennis* and *G. brevipalpis* in the drier regions of eastern Africa). Species of the palpalis group are more usually associated with riverine vegetation, but some also extend into savannah regions between river systems; while species of the morsitans group are primarily associated with drier savannahs. These groupings coincide broadly with epidemiological significance (Patterson and Schofield, 2004).

2.3.3. The host

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

The risk to susceptible ruminants living in comparatively free areas surrounded by tsetse-infested regions, or at the edge of tsetse belts, varies from year to year. Generally, tsetse fly population 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 host to transmit trypanosomes to vectors has only been studied in detail in the past few years. Wildlife surveys have shown that some favored hosts of tsetse such as bushbuck are major reservoirs of trypanosomes with high prevalence rates of infections. However, there are clear examples of favored hosts with only modest level of patent infection (buffalo and warthog). Despite little preferences by tsetse flies to feed on, many savannah species such as wildebeest and zebra and waterbuck harbor high level of trypanosome infection. (Clausen *et al*, 1998)

2.4. Clinical signs of trypanosomosis

Clinical signs of tsetse-transmitted trypanosomosis may include intermittent fever, oedema, abortion, and emaciation. Anaemia usually develops in affected animals and is followed by loss of body condition, reduced productivity and often mortality. When the tsetse fly injects infective metacyclic trypanosomes into the skin of the host there is a phase of local inflammation and swelling, chancre, develops. The metatrypanosomes divide and multiply in the chancre and give

rise to the typical blood forms, which invade the lymphatics, lymph nodes and 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 erythrophagocytosis, 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 and 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. Hence, following treatment; PCV either recovers slowly or remains at low level (Murray and Dexter, 1988).

The acute phase of the disease in cattle is shown by 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 becomes increasingly emaciated and anemic and in the terminal stages, the animal is recumbent and some times comatose. Pregnant animals suffering from chronic trypanosomosis are liable to abort. Certain strains of *T. vivax*, mainly in East Africa, causes hemorrhagic syndrome in cattle associated with high parasitaemia, in which haemorrhage, particularly of the gastro-intestinal tract and high mortality occur (Gradiner and Wilson, 1987). The acute form of *T. vivax* infection with sever hemorrhagic syndrome in cattle had also been reported in Ethiopia (Wellde *et al.,* 1983).

Postmortem signs may include emaciation, enlarged lymph nodes, enlarged liver and spleen, excessive fluid in the body cavities, and petechial haemorrhages. In animals that died during the chronic phase of the disease, severe myocarditis is a common finding and the lymphoid organs are not usually enlarged.

2.5. Diagnosis of trypanosomosis

2.5.1. Clinical diagnosis

In regions where the disease is endemic clinical signs and postmortem lesions are important indications, especially in combination with the history of the disease and the region in which it occurs. However, neither clinical nor post-mortem signs of tsetse-transmitted trypanosomosis are pathognomonic. Therefore, diagnosis must rely on direct techniques that confirm the presence of trypanosomes either by microscopic visualization or by indirect serological techniques or by polymerase chain reaction (PCR) (Luckins, 2004).

2.5.2. Parasitological diagnosis

Parasite detection techniques are highly specific, but their sensitivity is relatively low (i.e. the proportion of false-negative results recorded is high). Sensitivity is especially low when results are considered at the individual animal level rather than the herd level. Due to this low sensitivity, the apparent parasitological prevalence of trypanosomosis is generally lower than the true parasitological prevalence. The low diagnostic sensitivity also makes it difficult to detect trypanosomosis when present at low parasitological prevalence and it is impossible to establish the absence of the disease with a high degree of confidence. Moreover, in areas where trypanocidal drugs are used extensively, parasites may not be detected. Several parasite detection techniques are available, each with varying sensitivity. (Luckins, 2004).

Direct examination techniques

The simplest techniques are examination of wet, thick or thin films of fresh blood, usually obtained from the ear vein, jugular vein or the tail. Amongst the direct examination techniques, stained thin blood films are generally regarded as more specific but less sensitive than the other two. The actual specificity and sensitivity of these techniques is directly dependent on the volume of blood actually examined and the skill and experience of the technician (Luckins, 2004).

Wet blood films

These are made by placing a drop of blood (about 2 µl) on a clean microscope slide and covering with a cover slip (22 x 22 mm). The blood is examined microscopically using 400x total magnification with condenser aperture, phase-contrast or interference contrast and approximately 50-100 fields are examined. Trypanosomes are recognized by their movement among the red blood cells (RBCs). A presumptive diagnosis can be made of the trypanosome species depending on their size and movements although final confirmation of the species is made by examination of the stained preparation (Luckins, 2004).The method is simple, inexpensive and gives immediate results but its diagnostic sensitivity is generally low and depends on the examiner's experience and the level of parasitaemia. Sensitivity can be improved significantly by lysing the RBCs before examination using a hemolytic agent such as sodium dodecyl sulfate (SDS) ((Luckins, 2004).

Thick blood films

These are made by placing a drop of blood (5-10 µl) on a clean microscope slide and spreading it over an area of approximately 2 cm in diameter using the corner of another slide. The thickness of the resultant film should be such that, when dry, the figures on a wristwatch dial can just be read through it. The film is dried thoroughly by rapidly waving in the air and, without fixation, is dehaemoglobinised by immersion in distilled water for a few seconds and dried before staining. The smear should be kept dry and protected from dust, heat, flies and other insects and is stained for 30 minutes with 4% diluted Giemsa stain in phosphate buffered saline, pH 7.2. The stained smear is then washed with buffered water and examined at x500 to x1000 total magnifications.
Trypanosomes are easily recognized by their general morphology, but may be damaged during the staining process making it difficult to identify the species. The method is simple and relatively inexpensive, but results are delayed because of the staining process. (Luckins, 2004)

Thin blood films

Thin blood smears are made by placing a small drop of blood (about 5 µl), for example from a microhaematocrit capillary tube, on a clean microscope slide approximately 20 mm from one end (allowing for space to apply the thick smear) and spreading with the edge of another slide placed at an angle of approximately 30° to the first slide and drawn back to make contact with the blood droplet. The blood is allowed to run along the edge of the spreader and pushed to the other end of the slide in a fairly rapid but smooth motion. Ideally, thin films should be prepared so that the RBCs are fairly close to each other but not overlapping. The slide is dried quickly by waving in the air and fixed for 3 minutes in methanol, and stained as for thick blood smears. After staining, the slide is washed gently under tap water and allowed to dry.

A variation of this method is to fix in methanol for 2 minutes, apply May-Grünwald stain for 2 minutes, then add an equal volume of buffered water, pH 7.2, and leave for a further 8 minutes and drain off. Approximately, 50-100 fields of the stained thin smear are examined, with a x50 or x100 oil-immersion objective lens, before the specimen is considered negative. Even after a trypanosome has been detected, approximately 20 extra fields have to be investigated to determine if more than one species is present. This technique can also be used for biopsy samples of lymph obtained from punctured lymph nodes. Usually, both thin and thick smears are made from the same sample, thick smears contain more blood than thin smears and, hence, have a higher diagnostic sensitivity, thin smears on the other hand allow *Trypanosoma* species identification (Luckins, 2004).

Parasite concentration techniques

The probability of detecting trypanosomes in a sample from an infected animal depends largely on the amount of blood examined and the level of parasitaemia. The amount of blood examined with direct examination techniques is low and parasites are often very scanty in the blood of an infected animal. Both of these factors contribute to the low sensitivity of direct examination techniques. Sensitivity can be improved by increasing the volume of blood to be examined and by concentrating the trypanosomes (Luckins, 2004).

The microhematocrit centrifugation technique (Woo method)

The microhematocrit centrifugation technique, or the Woo method (Woo, 1970), is widely used for the diagnosis of animal trypanosomoses. It is based on the separation of the different components of the blood sample depending on their specific gravity. The microhematocrit centrifugation technique is more sensitive than the direct examination techniques (Kratzer and Ondiek, 1989). In the case of *T. vivax* infections, the sensitivity of the Woo methods approaches 100% when the parasitaemia is greater than 700 trypanosomes/ml blood. Sensitivity decreases to 50% when parasitaemia varies between 60 and 300 trypanosomes/ml blood. Trypanosomes become very difficult to detect when the parasitaemia is lower than 60-trypanosomes/ml blood (Desquesnes. and Tresse, 1996). Identification of trypanosome species is difficult. As the specific gravity of *T. congolense* is similar to that of RBCs, parasites are often found below the buffy coat in the RBC layer. To improve the separation of RBCs and parasites, and increase the sensitivity for *T. congolense*, the specific gravity of RBCs can be increased by the addition of glycerol (Murray *et al.*, 1977).

Dark-ground/phase-contrast buffy coat technique

The buffy coat technique or Murray method (Murray *et al.*, 1977) represents an improved technique for the detection of trypanosomes and is widely used. It is carried out following steps 1-5 above, after which the capillary tube is cut, with a diamond tipped pencil, 1 mm below the buffy coat, to include the top layer of RBCs. The buffy coat and the uppermost layer RBCs are extruded on to a clean microscope slide and covered with a cover-slip (22 x 22 mm). Approximately, 200 fields of the preparation are examined for the presence of motile trypanosomes with a dark-ground or a phase-contrast microscope with a x40 objective lens.

As with the microhaematocrit centrifugation technique, the buffy coat technique is more sensitive than the direct examination techniques and when compared with the microhaematocrit centrifugation technique, the buffy coat technique has the added advantage that preparations can be fixed and stained for more accurate identification of species and for retention as a permanent record. The sensitivity of the buffy coat method can be improved by using the buffy coat double-

centrifugation technique (Kratzer and Ondiek, 1989). A total amount of 1500-2000 µl of blood is centrifuged, after which the buffy coat is aspired into a microhaematocrit capillary tube and centrifuged again.

Both the microhematocrit centrifugation and buffy coat techniques give direct results and can be used for screening large numbers of animals. They require specialized equipment and an electricity supply making the test more expensive than the wet blood film. However, this is compensated by increased sensitivity. Both parasite concentration techniques rely on the detection of motile, live, trypanosomes because trypanosomes can lose their vigour and die rather quickly. Once the blood sample is drawn, samples collected in capillary tubes should be cooled immediately and not allowed to overheat in the microhaematocrit centrifuge or on the microscope stage. Samples should be examined as soon as possible after collection, preferably within a couple of hours.

The microhaematocrit centrifugation and buffy coat techniques are particularly useful in that the packed cell volume (PCV) can be assessed at the same time. Measuring the PCV is useful to determine the degree of anaemia. Anaemia can be caused by factors other than tsetse-transmitted trypanosomosis however, it remains, one of the most important indicators of trypanosomosis in cattle (Luckins, 2004). To determine the PCV after centrifugation, the microhaematocrit capillary tube (containing ear vein or jugular vein blood) is placed in a haematocrit reader. The length of the packed RBC column is expressed as a percentage of the total volume of blood. As trypanosomosis is a herd problem, the PCV-profile of a herd is influenced by the number of trypanosome-infected animals and can be used to indicate differences in disease challenge. The average PCV is also influenced by the age and level of genetic susceptibility of cattle (Luckins, 2004).

2.5.3. Animal inoculation

The sub-inoculation of blood into rodents, usually mice or rats, is particularly useful in revealing sub-patent infections. The laboratory animals are injected intraperitoneally with 0.2-5 ml (depending on the size of the rodent) of freshly collected blood. Artificial immunosuppression of

recipient animals by irradiation or drug treatment will greatly increase the chances of isolating the parasite. They are bled three times a week for at least 2 months. Collected blood is examined using the wet film method. Animal inoculation is more sensitive than direct examination of the wet blood film. Nevertheless, the method is not practical; it is expensive and diagnosis is not immediate. The method is highly sensitive in detecting *T. b. brucei* infections. However, some *T. congolense* strains are not easily transmitted and *T. vivax* rarely infects laboratory rodents. Animal inoculation should be avoided as it raises serious animal welfare concerns (Luckins, 2004).

2.5.4. DNA amplification tests

A PCR method has been developed as a tool for the diagnosis of infections with African trypanosomes in humans and animals, as well as tsetse flies. Specific repetitive nuclear DNA sequences can be amplified for *T. vivax* and three types of *T. congolense* (Masiga *et al.*, 1992; Desquesnes and Davila, 2002). The procedure is extremely sensitive, but false-positive results may occur as a result of contamination of samples with other DNA and False-negative results may occur when the parasitaemia is very low (<1 trypanosome/ml of blood), which occurs frequently in chronic infections. Sample collection has been simplified by adapting the test using blood or buffy coat spotted on to filter paper (Geysen and Geerts, 2003), thus, large number of samples can be processed at one time, making it potentially suitable for large-scale surveys. However, the test requires specialized equipment and highly trained personnel, so it is not suitable for use in many laboratories and the cost of PCR analyses is prohibitive for the routine use of the test.

2.5.5. Serological tests

Several antibody detection techniques with variable sensitivity and specificity have been developed for the diagnosis of animal trypanosomosis. The methods of choice are the indirect fluorescent antibody test (IFAT) (Katende *et al*., 1987) and the trypanosomal antibody-detection ELISA (Hopkins *et al.*, 1998). The identification of major antigens of trypanosomes, and their production as recombinant molecules or synthetic peptides, is leading to the current development

and validation of new tests based on the use defined molecules. Thus, in the near future, it may be possible to improve the specificity of serological tests to allow the detection of species-specific antibodies, and to reach a high level of standardization that is currently not achieved by the use of total parasite extracts (Luckins, 2004).

Antibody-detection enzyme-linked immunosorbent assay

The standard antigen for trypanosomosis antibody tests is derived from bloodstream-forms of trypanosomes. Antigens are prepared as a soluble fraction of trypanosomes purified by DEAE anion-exchange chromatography of parasites from whole blood of infected rats, with lysis using seven freeze-thaw cycles and centrifugation at 10,000 ***g*** for 30 minutes. Antigens obtained from *in-vitro* propagated procyclic trypanosome forms can also be used (Greiner *et al.*, 1997). Both the IFAT and antibody-detection ELISA have been adapted for the analysis of blood samples collected on filter paper and have high sensitivity and specificity. Their species specificity is generally low. They detect immune responses to current and past infections and can, therefore, only provide a presumptive diagnosis of active infection. Immunodiagnosis needs expensive, sophisticated equipment and expertise, which is not always available. It has to be performed in specialized laboratories and there is a substantial delay between the actual sampling and the availability of the results.

Indirect fluorescent antibody test

The original method for this test has been replaced by a new technique for the preparation of trypanosomal antigens ((Katende *et al*., 1987), which involves fixation of live trypanosomes using a mixture of 80% cold acetone and 0.25% formalin in normal saline.

2.6. Control of trypanosomoses

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

2.6.1. 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. Treatment and prevention of animal trypanosomosis relies essentially on three drugs, namely: Homidium (Homidium chloride-Novidium □ and Homidium bromide-Ethidium□), diminazene aceturate (Berenil□) and isometamidium chloride (Samorin□,Trypamidium□). Isometamidium, Diminazine 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). Trypanosomes are usually not resistant to both diminazene and Isometamidium at the same time Thus, these two compounds have been termed as sanative pair (Whiteside, 1960), and in instances of resistance to one drug the application of the other one will usually control the disease. However, experimental studies have demonstrated the occurrence of resistance in trypanosomes to both diminazene and isometamidium (Clausen *et al*., 1992). Resistance has also been confirmed in studies conducted in Ethiopia, (Codjia *et al.,* 1993; Peregrine *et al.,* 1995; Ademe and Abebe, 2000; Afework, *et al*., 2000).

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 in resistant trypanosomes. Whatever 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 be avoided (Guy d'Ieteren, 1999).

So far, all attempts made at developing a vaccine against trypanosomosis have failed. This situation has been stranded by the unlimited ability of trypanosomes in the host to change their surface antigen frequently, until the host immune system becomes exhausted. In addition, 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 (Uilenbereg, 1998).

2.6.2. Vector control

A wide variety of tsetse control techniques have been developed and have undergone trial. From this extensive experience, it would seem possible to tailor a package of intervention measures that could give satisfactory control of tsetse within any given target region (Kuzoe and Schofield, 2004). The control techniques include:

Bush and game clearance

Early attempts to control tsetse included extensive bush clearance (designed to eliminate the shaded places where tsetse rest and lays their larvae) and extensive shooting of wild game animals (designed to eliminate the wild blood sources used by the tsetse). Although widely effective, such methods can no longer be recommended.

Insecticides

Ground spraying:- Trial**s** with insecticides against tsetse started in 1945, when DDT and BHC (HCH) were the only synthetic compounds available. The application of residual deposits of persistent insecticides to tsetse resting sites was very widely used, but is now discouraged due to concerns about effects on non-target organisms.

Traps and targets

In the early 1900s, sticky traps worn by plantation workers were successfully deployed on the Island of Principe to eradicate *G. palpalis.* Since then, trapping techniques have been greatly enhanced by development of designs that mimic the fly's perception of vertebrate hosts. These generally use blue and black cloth in a shape that attracts the flies and then funnels them upwards into a netting trap usually in the form of a monoconical (pyramidal) or biconical shape. For tsetse

control, a simpler and cheaper device involves a suspended screen of blue and black cloth (often known as a tsetse target) impregnated with a biodegradable pyrethroid insecticide such as deltamethrin. Flies are attracted by the blue segments and land on the black segment, quickly succumbing to the insecticide. The effectiveness of traps and targets can be greatly enhanced by addition of an appropriate odour-bait. Such odour-baits are usually short-chain aromatic compounds such as acetone or octenol (Kuzoe and Schofield, 2004).

Live bait techniques

Similar to the concept of traps and targets, the live bait technique involves treating cattle with appropriate insecticide formulations, usually by means of cattle dips, or as pour-on, spot-on, or spray-on veterinary formulations. These are highly effective against tsetse, and have the additional advantage of controlling other flies and cattle ticks (Kuzoe and Schofield, 2004).

Sterile insect technique (SIT).

SIT exploits the particular mating biology of tsetse, whereby female flies rarely mate more than once. Male flies are therefore mass reared in the laboratory, sterilized by irradiation, and released to mate with wild females. Females mated with sterile males are unable to produce offspring. Unlike all other tsetse control techniques, SIT has no effect on non-target organisms. Also unlike other techniques, SIT becomes more efficient at lower fly densities, and is ideally suited to the final phase of local tsetse eradication (Kuzoe, and Schofield, 2004).

2.6.3. Trypanotolerant breeds

The term `trypanotolerance' means reduced susceptibility to trypanosomosis and denotes an inherited biological property allowing animals to live, breed, grow and survive in a naturally infected environment without exhibiting clinical signs of trypanosomosis after harboring pathogenic trypanosomes. In regions where eradication of the vector is not possible with present methods, genetic improvement of trypanotolerant breeds should be attempted. Attention has recently focused on genetic resistance and various selection programs are being discussed to

select trypanotolerant animals. Such programs could involve selection of trypanotolerant animals under natural challenge or selection of marker traits (e.g., aspects of the immune response). Selection could also act on polymorphic loci that may affect trypanotolerance, and may be closely linked to genes acting upon tolerance via marker loci. Trypanotolerance is found not only in cattle (all dwarf semi -achondroplastic West and Central African types) but also in sheep, goats, and in some rare pony types, such as the Kotokoli of the Ivory Coast. The N´Dama (Hamitic Longhorn of the *Bos taurus* type as well as those breeds of the West African Shorthorn) is a West African breed (e.g., Gambian cattle) noted for its small size and its trypanotolerance.

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 trypanpanosomes 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).

2.6.4. Integrated control program

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). 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.

2.6.5. 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 purposes. It is widely felt that successful control operation using traps and targets should involve the local community, beneficiaries of the control program, for sustainability and economic reasons (Leak, 1999; Catley et al., 2001). One of the major components of sustainability of these methods is the active participation of the majority of the community contributing to a relevant production system in a given environment or region.

Recent experiences with community-based tsetse control in Africa have indicated that greater community involvement in project design might help to avoid inappropriate and non-sustainable interventions. Specifically, the high level of collective and sustained action that is often expected of communities in tsetse control projects needs to be compared with the methods that people are already using to control trypanosomosis. This comparison of options is particularly relevant when private, individual action to control the disease is well established (Catley et al., 2001). Opinions of what constitutes community participation vary, ranging from simple awareness of the community about the tsetse control activity in their area to contribution of money and labor towards the implementation of the control operation, or community ownership of the project, (Leak, 1999).

Community participation can be best answered through process of participatory research and planning that consider the knowledge, believes and incentives of the local people and the social, economic and cultural structure of the local community (Catley et al., 2002a). 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. A community based tsetse control program is more likely to succeed where the community understands the role tsetse flies play as vectors of trypanosomosis. Little is known

regarding the awareness of the community about the disease despite several epidemiological investigations conducted in most tsetse-controlled areas. Community awareness, mobilization and utilization are currently seen as prerequisites for tsetse control activities to enable the beneficiaries to sustain the control program. (Catley et al., 2001).

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).

2.6.6. Eradication of the disease

The technical approach of eradication of trypanosomosis involves the use of traps, targets, and/or sequential ultra-low-volume (ULV) aerial spraying (SAT) to reduce tsetse populations to very low levels, followed by sterile insect release (SIT) to eliminate any last remaining flies. A pilot program to test the principle of this approach was successfully implemented in Zanzibar (1994-1997), from where *Glossina austeni* now seems to have been eliminated. More recently, a similar approach was applied in the Okavango delta region of Botswana, and, this programme is now being extended through PATTEC into western Zambia, and through the Caprivi strip of Namibia into southern Angola (Vreysen *et al*, 2000).

2.7. Impact of tsetse control on farming system

The effect of trypanosomosis on livestock not only reduces the availability of meat and dairy produce, but also most particularly denies the use of cattle and horses for transport and traction. For agricultural communities, this means that only small areas can be tilled by hand, leaving the communities vulnerable to food shortages, starvation, and famine. Studies indicate that if draught animals were available, a family currently dependent on manual labour alone could increase its

income from agricultural work by 45% per unit of land, and 143% per unit of labour (FAO, 2000). From initial estimates by Steelman (1976), FAO (1994) estimated that for the whole of Africa, overall agricultural losses attributable to trypanosomosis would total more than US$4 billion annually. Agricultural benefits accruing to tsetse elimination could reach 4.5 billion US $ per year. Tsetse has been termed 'the poverty insects' in WHO//FAO communiqués.

Comprehensive studies to quantify the economic importance of African trypanosomosis, have been attempted rarely, 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, infertility and the costs of implementing and running trypanosomosis control operations. Indirect losses are due to the risk of the disease; which 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 done so far in Ethiopia on impacts of tsetse control on livestock productivity and agriculture:-

- It has been shown that where oxen are available for cultivation, maize production has 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 farmers to abandon the fertile area for higher ground (Slingenbergh,1992).

- A consultancy report on assessment of disease situation and socio-economic impact of tsetse control on farming systems in the Upper Didessa valley showed a decline in the apparent density of tsetse flies and prevalence of trypanosomosis to a minimum level, an increment in total cultivated land per farmer, an increment in labor-intensive crop products like teff and an increment in number of households and human population as well as diversification of crop production (Bedane, 1998).

- Efforts to control tsetse flies using targets and insecticides pour-on in Ghibe valley in 1991, resulted in drop of tsetse fly densities by 95%, decline of trypanosomes prevalence by 63% ,decline of drug treatment by 52%, drop of still births and calf mortality by 57%, rising of the ratio of under 12 month calves to over 36 month cows by 49%, and increased body weights of adult males by 8%, within one year of the control program (Leak *et al.*, 1995).

- A pilot community based tsetse fly control study model conducted in Damot Woyde Woreda and Gurage Zone during 1995-1997 showed an increased average milk production per cow from 4.10 kg (±2.60 se) to 8.71kg (±0.526 se), a significant reduction in the overall mean percent of livestock mortality, a reduction by 23% of the mean age of females to reach fertility, a decreased livestock abortion and an increased calving rate (Tikubet, 1999).

3. MATERIALS AND METHODS

3.1. Study area

This study was conducted in Chewaka settlement station and Bikiltu Didessa Farmers' association found in high tsetse infested and similar agro ecological zone in south-west Ethiopia.

3.1.1. Chewaka settlement station

Chewaka settlement station is the largest of the 50 settlement stations established in western Oromia Regional State during 2004, and is the only settlement station structured as a district on its own owing to its large landmass of 542 sq km and human population 80,000 settlers contained in 12,000 households. The settlement station is found in Illubabour Administrative Zone, 570 kms southwest of Addis Ababa and is located between latitudes of 08^{o} 35' 23"and 08^{o} 41' 21" North and longitudes of 036^{o} 01' 27" and 036^{o} 07' 06".

The area lies in the bottom of a deep valley and is surrounded by mountains in the east and south and by Dabena and Didessa Rivers in its western and northern sides respectively. Most of the settlement station is plane savannah grassland with scattered trees while some part of it, towards the mountainous escarpment and along the two major rivers, is a sloppy land covered with dense forests of tall trees. The settlement station is organized in to seven sites comprised of 26 villages and altitude of the area varies from 1100-1768 Masl. Prior to 2004, there were neither livestock nor human population residing in the area due to its high infestation with tsetse flies, however, since 2004 it has been inhabited by settlers and an extensive tsetse and trypanosomosis control had been conducted during the past two years (2005 and 2006).

3.1.2. Bikiltu Didessa Farmers' Association

Bikiltu Didessa Farmers' Association is found in western Oromia Regional State, Illubabour Zone, at a distance of 510 kms southwest of Addis Ababa. It is located between latitudes of 08^{0},

40', 51" and 08^0, 42', 25" North and longitudes of 036^0, 21', 12" and 036^0, 23', 58" East, and covers an area of 40 sq km of land with altitudinal range of 1200 to 1600 Masl.

Bikiltu Didessa is an adjacent site to Chewaka settlement station and lies in a valley floor surrounded by mountains in the south, west and north and by a savannah plane of scattered bamboos and Didessa River in the east. Like Chewaka, Bikiltu Didessa is also a settlement station established some 25 years back in the tsetse infested similar agro ecological zone of southwest Ethiopia. Since then, there has not been any tsetse control operation carried out in this site, yet, significant number of livestock are being reared with the aid of trypanocidal drugs to control trypanosomosis.

Vegetation of both study areas is mainly scrub woodland and open grassland used for extensive grazing and fuel wood collection (Slingenberg, 1992). Mixed crop-livestock production characterizes the farming system of the region, livestock playing a vital role in agricultural production. Oxen power is the only source of draught energy and is crucial for crop production. Cattle management differ between the two study areas, in Bikiltu, cattle are kept under traditional communal grazing management, whereas, in Chewaka, cattle are usually tied and fed through cut and carry system. Calves below six months of age are always tied up around homesteads at both study areas.

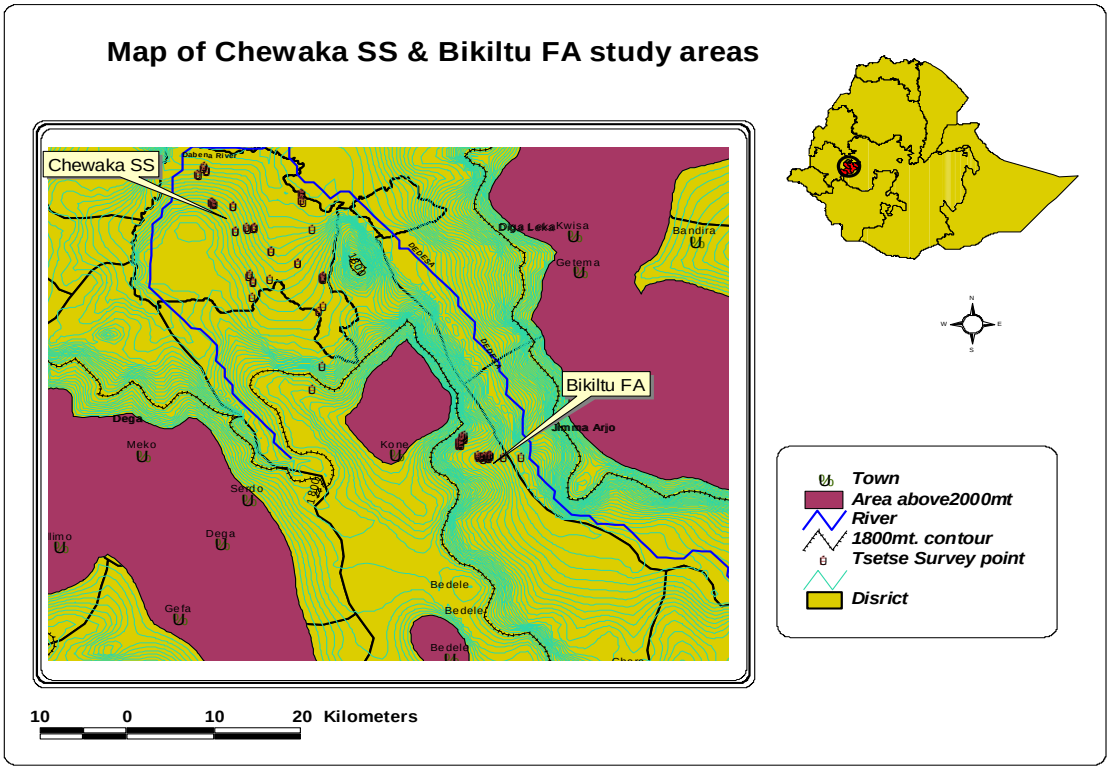

Figure 1: Map of the study areas: Chewaka SS and Bikiltu FA

3.2. Study design

The study design includes retrospective and cross-sectional studies to determine prevalence of trypanosomosis and tsetse fly density before, during and after the control operation in Chewaka settlement station and to estimate the current status of the disease and tsetse fly density in Bikiltu Didessa farmers' association.

3.2.1. Retrospective study

Tsetse survey data prior to the commencement of the control program in Chewaka, data on inputs utilized for the control operation during 2005-2006 as well as data on tsetse and trypanosomosis surveys during the control program were gathered from Bedelle Regional Veterinary Laboratory and NTTICC. Data on settled human population, animal population, cultivated land and crop production of Chewaka settlement station were collected from the Rural and Agricultural

Development Office of Chewaka settlement district. Similar data of Bikiltu Didessa farmers association were collected from records of the Development Agent Office on the site and the Rural and Agricultural Development offices of Bedelle and Dabo districts.

3.2.2. Cross-sectional study

Disease prevalence

Detailed village and household counts were made at both Bikiltu and Chewaka and animals were selected using the three-stage multistage random sampling method in which Villages and households were selected by simple randomly sampling at step 1 and 2, respectively, and animals owned by the selected households were listed and the sampling animals selected at step 3 using the same method The sample size for the study was determined using the formula by Thrusfield, (1995); at a precision level of 5%, confidence interval of 95% and an estimated disease prevalence of 16 % (previous reports in the area).

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

Where:

n = required sample size

P_{exp} = expected prevalence

d = desired absolute precision

Accordingly, the calculated sample size for estimating prevalence in simple random sampling was 207. In order to adjust the sample size required for the present multistage random sampling method and to make a prevalence estimate more precise, the sample size was inflated two times than in simple random sampling and was set to 415 for each study area. Hence, a total of 830 cattle were sampled at both study areas for the surveillance of bovine trypanosomosis.

The buffy coat, stained thick and thin smears were used as parasitological diagnostic tests (Paris *et al*., 1982). Blood was collected from an ear vein into heparinized microhaematocrit centrifuge

capillary tubes and onto glass slides, as thick and thin blood smears. The capillary tubes were sealed with 'Cristaseal' (Hawksley) and centrifuged immediately in a microhaematocrit centrifuge for 5 minutes at 9000 rpm. After centrifugation, the packed cell volume (PCV) was determined .and the buffy coat and the uppermost layer of red blood cells of each specimen were extruded onto a microscope slide and examined with a phase-contrast microscope, 40x objective, for the presence of motile trypanosomes. Giemsa-stained thick and thin blood smears were examined with the 100x oil immersion objective lens for identification of trypanosome species.

Tsetse survey

A total of 180 biconical traps were deployed 100-200 mts apart along the established tsetse controlled localities of Chewaka and known tsetse habitats of Bikiltu to estimate the tsetse apparent density at each study area. Traps were placed at suitable intervals depending on the ecology of the target species. Savannah tsetse can detect odors from about 50-100 mts; so traps were spaced at about 200 mts, riverine tsetse are fairly sedentary and mostly do not react to the odor baits that are currently available; hence, shorter spacing was used for this group. Traps were baited with cow urine, octenol and acetone and universal bottles filled with these odor attractants were placed under the traps in which filter papers were inserted to decrease the evaporation rate of the odor baits for high catch of tsetse. urine collected from local cows was "aged" three weeks at ambient temperature (25º-30º) prior to use The traps were deployed for 72 hours and tsetse flies caught during this period were collected, identified and grouped according to their species and sex categories. Flies caught by each trap were then counted and recorded to calculate the fly/trap/day (FTD) values. Other biting flies collected during this process were also identified in to genera level, counted and recorded.

For all tsetse trapping sites mentioned above, an accurate on site 3D GPS location, latitude – longitude and altitude coordinates were taken using GPS 76, GARMIN device to specifically indicate the respective trapping sites. The GIS databases were developed using Arc View 3.2 GIS (ESRI, Redlands, CA) and ERDAS imagine 8.3.1 (ERDAS, Atlanta, GA) software. The GPS locations of all study sites included in the GIS were transformed to geographic, latitude-

longitude, decimal degree format using the ESRI Digital Chart of the World (DCW) as a base map standard for GIS construction.

Questionnaire survey

A two- stage multistage random sampling was used for the questionnaire survey where by villages were selected first and households were selected later using the simple random sampling method. The questionnaire survey was conducted through interviews made with eighty heads of households at each study area to collect data on socio-economic impact assessment of bovine trypanosomosis. The questionnaire covers issues on trypanosomosis, animal production and crop production and includes parameters such as grain production, livestock population, animal sell, animal purchase, abortion and mortality of animals that were used to compare the study areas on the socio-economic impact of tsetse control (Annex 1).

3.3 Data analysis

Based on the objectives of the study, collected data were assessed to determine whether the tsetse and trypanosomosis control program conducted during 2005-2006 had brought a significant change on tsetse population density, prevalence of trypanosomosis, and socio-economic status of the settled human population in Chewaka as compared to the neighboring non tsetse controlled area. The data and statistical methods employed were as follows: -

3.3.1. Data on bovine trypanosomosis

Prevalence of trypanosomosis was calculated as the number of parasitological positive animals divided by the total number of animals investigated at that particular time (Murray *et al.*, 1977). The PCV of all animals sampled at each site was averaged and is referred as the herd average PCV. The general linear model univariate pairwise comparison and One-way ANOVA Post Hoc Test: were used to compare the prevalence of trypanosomosis before and after the control program. The Pearson's correlation coefficient was used to measure the association between the herd average prevalence and herd average PCV. The effects of explanatory variables: area of

sampling, sex, age, duration of stay and treatment on the herd average prevalence were investigated by logistic regression models. The exponentiated estimates of the coefficients of the models were interpreted as odds ratio (OR).

The effects of sampling area, sex and age on the herd average PCV were investigated by analysis of variance using data obtained from the two study areas. The student's t-test was utilized to compare the mean PCV of parasitaemic and aparasitemic cattle both within and between the study areas.

3.3.2. Data on tsetse fly survey

Apparent density of tsetse was used to estimate the tsetse population density, when traps are used; apparent density is defined as the number of flies/trap/day (F/T/D) (FAO, 2000). Data on species, sexes and density of tsetse flies were compared using descriptive statistics such as ratios and percentages. Data on tsetse density before and after the control program were compared using the One-way ANOVA Post Hoc Test.

3.3.3. Socio-economic data

Questionnaire survey Data was summarized using descriptive statistics and percentages. Parameters on crop production, such as total land cultivated, annual crop production and parameters on livestock production like total cattle population, animal sell /household/year, and animal purchase /hh/yr, were compared using descriptive statistics like percentages and ratios. Comparisons of data between the two study areas were made by use of the General linear model univariate analysis. Data on abortion of cows /hh/yr and mortality /hh/yr were computed by the logistic regression model, Odds Ratio. All analyses were performed using the statistical package SPSS (SPSS Inc.).

4. RESULTS

4.1. Retrospective study

4.1.1. The tsetse and trypanosomosis control program

Control of tsetse and trypanosomosis was carried out during 2005 and 2006 using the insecticide-impregnated target method which was further strengthened through application of spot-on and pour-on chemicals on animals' back and administration of curative and prophylactic trypanocidal drugs as the need arises. Community based approach was used to deploy targets over a wide area of land whereby 400 tsetse control teams, comprising 4000 farmers, coordinated the community to accomplish the activities. Members of the teams were trained by staffs of Bedelle Regional Veterinary laboratory and NTTICC on different aspects of target management such as construction and deployment, spraying and maintenance, follow-up care and re-spraying of targets at field conditions.

Prior to introduction of government purchased oxen into the settlement station during 2005, preventive measures against trypanosomosis, internal parasites and prevalent infectious diseases were taken which includes: administration of two doses of curative and prophylactic trypanosomal drugs (diminazene aceturate and isomethamidium chloride) at weekly intervals, deworming with broad spectrum anthelmintics and vaccination against prevalent diseases in the area. Once animals had been introduced in to the settlement station only clinically sick ones were used to be treated with curative trypanosomal drugs so as to avoid the interference of prophylactic drugs on the ongoing control program. The overall data on inputs utilized during the two control years are summarized under Fig. 2.

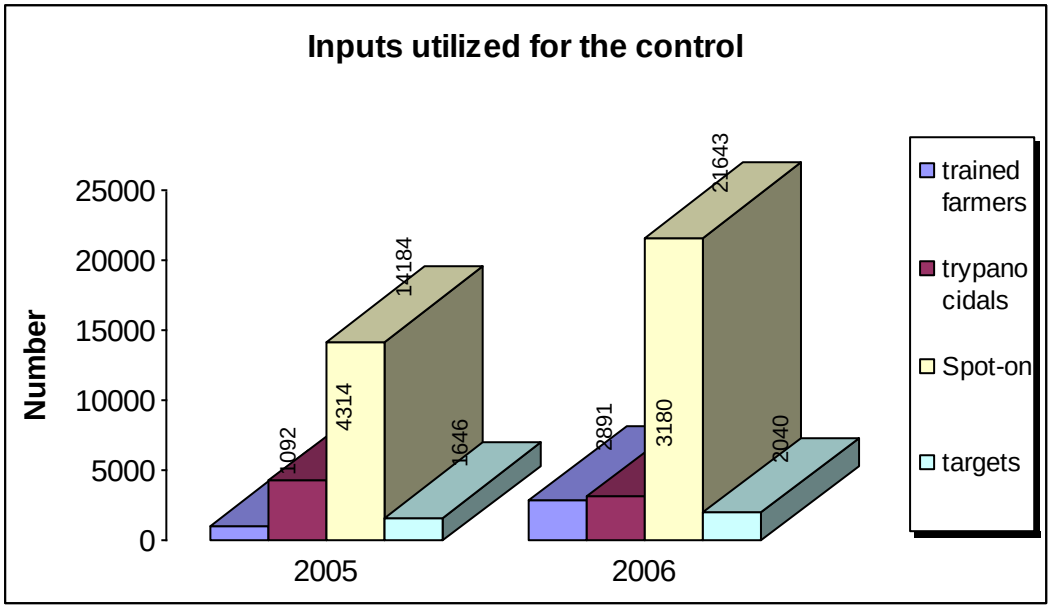

Figure 2: Inputs utilized for the tsetse control program of Chewaka SS (2005-06)

4.1.2. Initial tsetse fly survey

Initial survey on tsetse density and distribution was carried out during May 2004, prior to the commencement of the tsetse and trypanosomosis control program in 2005. Results of the survey showed the existence of two species of tsetse flies in the area namely: *Glossina morsitans morsitans* and *Glossina tachinoides*. *Glossina morsitans morsitans* was reported to be widely distributed in the savannah plains of the settlement station while *Glossina tachinoides* was mainly distributed along the two major rivers (Didessa and Dabena Rivers) and their tributaries in the area (Table 1).

Table 1: Distribution and density of tsetse fly in Chewaka SS during 2004

site	month	Altitude	No of traps	Tsetse species				Total fly	FTD
				G.morsitans		*G.tachinoides*			
				Male	Female	Male	Female		
1	May	1262-1768	13	92	116	-	-	208	8
4	May	1250-1259	5	4	12	-	-	16	1.6
5	May	1260-1286	4	47	61	-	-	108	13.5
7	May	1146-1256	11	4	7	24	23	58	2.6
R	May	1146-1768	5	50	47	341	233	671	67.1
overall			**38**	**197**	**243**	**365**	**256**	**1061**	**14**

R=River (Dabena) FTD= fly/trap/day

4.1.3. Tsetse fly surveys during 2005

A total of 150 traps were deployed at all the seven sites of Chewaka settlement station during the surveys carried out from march-June 2005. The traps were distributed through out the sites in such a way that all localities within them are included in the surveys. A total of 784 tsetse flies were caught of which 17% (131/784) were *G. tachinoides* and 83% (653/784) were *G. morsitans*. The proportion of female flies exceeds that of males, 42% (327/784) were males while 58% (457/784) were females. The density of flies vary from site to site, higher FTD values, 6.6 and 5.6, were in sites 6 and 2, respectively, whereas lower FTDs of 0.68 and 0.25 were recorded in sites 1 and 5, respectively. The overall FTD for the surveys conducted during 2005 was 2.61 (Table 2).

Table 2: Distribution and density of tsetse at different sites of Chewaka SS during 2005

site	month	altitude	No of traps	tsetse species				Total	FTD
				G.m.morsitans		*G.tachinoides*			
				male	female	male	female		
1	Mar.	1270-1280	22	11	19	-	-	30	0.68
4	Mar.	1231-1314	35	60	27	31	26	144	2.06
5	Mar.	1273-1293	4	1	1	-	-	2	0.25
2	Apr.	1262-1273	8	39	48	1	1	89	5.56
3	Apr.	1263-1283	13	8	11	-	-	19	0.73
6	Apr	1200-1260	20	88	176	-	-	264	6.6
7	Apr.	1135-1240	22	10	13	30	42	95	2.16
2	June	-1200-1285	26	48	93	-	0	141	2.71
Total			**150**	**265**	**388**	**62**	**69**	**784**	**2.61**

4.1.4. Tsetse fly surveys during 2006

A total of 234 traps were deployed in order to monitor the ongoing tsetse and trypanosomosis control operation in Chewaka settlement station during February to April 2006. All sites and localities within them had been reached and investigated in these extensive surveys and a total of 471 tsetse and numerous other biting flies were collected and identified. The overall mean FTD obtained was 1.01, *G. morsitans* constitutes 83% (392/471) of the total tsetse catch and *G. tachinoides* shared the remaining 17% (79/471). Female flies were higher in numbers than males sharing 64% (303/471) of the total catch whereas male flies comprised 36% (168/471). Except in site 2 where the highest mean FTD, 6.25, was reported, the density of tsetse in the seven surveyed sites was in the range of 0-2 FTD.and no fly was caught with the 36 traps deployed at various tsetse habitats of site 1 during this survey. This site is far away from the two big rivers in the area (Dabena and Didessa Rivers) and lies on the escarpment of the valley, at a relatively higher altitude (1300-1700 masl) than the other sites in the settlement station (Table 3).

Table 3: Density of tsetse at different sites of Chewaka SS during 2006

site	month	altitude	No of traps	tsetse species				total	FTD
				G.m.morsitans		*G.tachinoides*			
				male	female	male	female		
4	Feb.	1060-1400	34	40	44	16	21	121	1.78
6	Feb.	1300-1400	30	12	45	-	-	57	0.95
7	Feb.	1190-1220	19	-	2	2	21	25	0.66
1	Mar.	1400-1800	31	-	-	-	-	0	0.00
2	Mar.	1100-1400	16	10	22	-	-	32	1.00
5	Mar.	800-1200	23	-	1	-	-	1	0.02
1	Apr.	1400-1800	35	13	10	-	-	23	0.33
2	Apr.	1110-1180	12	40	110	-	-	150	6.25
3	Apr.	1150-1240	11	4	8	-	-	12	0.55
6	Apr.	1300-1400	8	11	5	-	-	16	1.00
7	Apr.	1190-1220	15	12	3	8	11	34	1.13
total			**234**	**142**	**250**	**26**	**53**	**471**	**1.01**

4.1.5. Initial survey of trypanosomosis

During the initial year of the settlement program in 2004 there were no animals residing at all sites of Chewaka SS, hence, prevalence of trypanosomosis in cattle of a neighbouring farmers' association found south east of the settlement station, on top of the escarpment of the valley, Chamen FA, and a small village situated at the south-western edge of the settlement station was taken as an initial data for the control program. Results of the survey showed a prevalence rate ranging from 34.1-75% with an average prevalence of 37.5% (Table 4).

Table 4: Prevalence of trypanosomosis in Chewaka SS during 2004

site	No examined	species of trypanosomes				Prevalence%	PCV %
		T. c	T.v	mix	Total		
5	4	-	2	1	3	75	20.5
Chamen FA	44	2	11	2	15	34.1	18.3
Total	**48**	**2**	**13**	**3**	**18**	**37.5**	**19.4**

Tc=Trypanosoma conglonse. Tv=Trypanosoma vivax, mix=Tc+Tv, PCV=packed cell volume

4.1.6. Trypanosomosis surveys during 2005

A number of surveys were conducted at six of the seven sites of the settlement station during 2005 through which 341 blood specimen were randomly collected from oxen and examined. Laboratory analysis of these samples showed the presence of two species of trypanosomes, *T. congolense* and *T. vivax*, with a proportion of 53.8% and 40.7%, respectively, and mixed infections by the two species was 5.5% of the total infections. The range of prevalence was 14.6 - 37.5% and the average herd prevalence was 25.2%. High infection rates were seen at sites 1, 6 and 3 with prevalences of 37.5%, 33% and 31.7%, respectively (Table 5).

Table 5: Prevalence of trypanosomosis at different sites of Chewaka SS during 2005

site	month	No examined	species of trypanosomes				prevalence %	PCV %
			Tc	Tv	Tc+Tv	Total		
2	Mar.	79	15	7	3	25	31.7	24.6
3	Mar.	84	11	7	-	18	21.4	25.2
4	Mar.	24	3	2	-	5	20.8	25.4
6&7	Mar.	82	15	12	-	27	33	-
1	Jul.	24	1	7	1	9	37.5	23.9
2	Jul.	48	4	2	1	7	14.6	26.9
total		**341**	**49**	**37**	**5**	**91**	**26.69**	**24.15**

4.1.7. Trypanosomosis surveys during 2006

Surveys on bovine trypanosomosis were conducted at all of the seven sites of Chewaka settlement station to assess the progress of the ongoing tsetse and trypanosomosis control program in 2006. A total of 1577 cattle were sampled and examined, of which, 17.3%, were found positive for trypanosome parasites. The range of prevalence obtained during these surveys was between 2.8 and 39.4%, the highest prevalence, 39.4%, was in site 1 and the lowest prevalence, 2.8%, was in site 2. Infections with *Trypanosoma vivax* were found in higher proportions, 65%, than *Trypanosoma congolense*, 35%, (Table 6).

Table 6: Prevalence of trypanosomosis in Chewaka SS during 2006

Site	Month	No examined	species of trypanosomes				prevalence	PCV
			Tc	Tv	Tc+Tv	Total		
1	Feb.	216	25	60	-	85	39.4	21.2
2	Feb.	120	3	11	-	14	11.7	22
5	Feb.	36	3	5	-	8	22.2	26.8
6	Feb.	120	2	24	-	26	21.7	24.5
7	Feb.	157	4	2	-	6	3.8	23
2	Mar.	258	18	23	1	42	16.3	24
3	Mar.	146	19	11	-	30	20.6	25
4	Mar.	284	19	11	-	30	10.6	29.5
1	Apr.	64	-	21	-	21	32.8	21
2	Apr.	72	-	2	-	2	2.8	26
6	Apr.	32	-	3	-	3	9.4	25
7	Apr.	72	-	5	-	5	7	25
overall		**1577**	**93**	**178**	**1**	**272**	**17.25**	**24.71**

4.2. Cross sectional study

4.2.1. Tsetse fly survey

A cross-sectional survey was conducted to determine the distribution and density of tsetse fly species in Chewaka settlement station (tsetse controlled study area) and Bikiltu Didessa farmers association (tsetse uncontrolled study area) during Dec/06-Jan/07. A total of 160 traps, 80 traps/study area, were deployed at six sites of Chewaka (site 2-7) and four known tsetse habitat sites of Bikiltu namely:- Kerkeha, Loko river, East-Chalalaki and West-Chalalaki. The traps were erected for 72 hours and tsetse flies caught during this period were identified, counted and the FTD calculated through dividing the total number of flies caught by each trap by three.

Tsetse were caught at 3 of the six surveyed sites in Chewaka settlement station namely: sites 2, 6 and 7 and at all of the four trapping sites in Bikiltu (Fig.3). No fly was caught at 3 sites of Chewaka (sites 3, 4 and 5). The mean FTD value in the tsetse controlled study area (Chewaka), 0.2, was significantly lower (p=0.000, OR=4.32, 95% CI=2.27-8.22), than the mean FTD, 2.28, in the tsetse uncontrolled study area (Fig.4). The mean number of tsetse catch in Bikiltu, 1.95, was also significantly higher (p=0.002, OR=1.63, 95% CI=1.3-2.01), than the mean tsetse catch, 0.04, in Chewaka. There was no significant difference in fly density among the six sites of Chewaka, whereas, in Bikiltu study area, the mean tsetse fly density in east-Chalalaki, 3.63, was significantly higher than Loko ,0.77, and west-Chalalaki ,1.3, ($P<0.05$) but it was not statistically different (p=0.797) from the fly density in Kerkeha , 3.43. The chance of catching tsetse at Bikiltu was more than 4 times the chance of catching tsetse at chewaka. A total of 47 and 548 tsetse flies were caught, out of which, 94% and 72% were *Glossina m. morsitanse*, 6% and 28 % were *Glossina tachinoides,* 79% and 67.5%, were females, and 21% and 32.5% were males, in Chewaka and Bikiltu respectively (Figs 5 and 6). Out of the total *G.morsitans* and *G.tachinoides* caught at both study areas, 90 and 10 %, and 98 and .02 %, were in Bikiltu and Chewaka, respectively (fig.7).

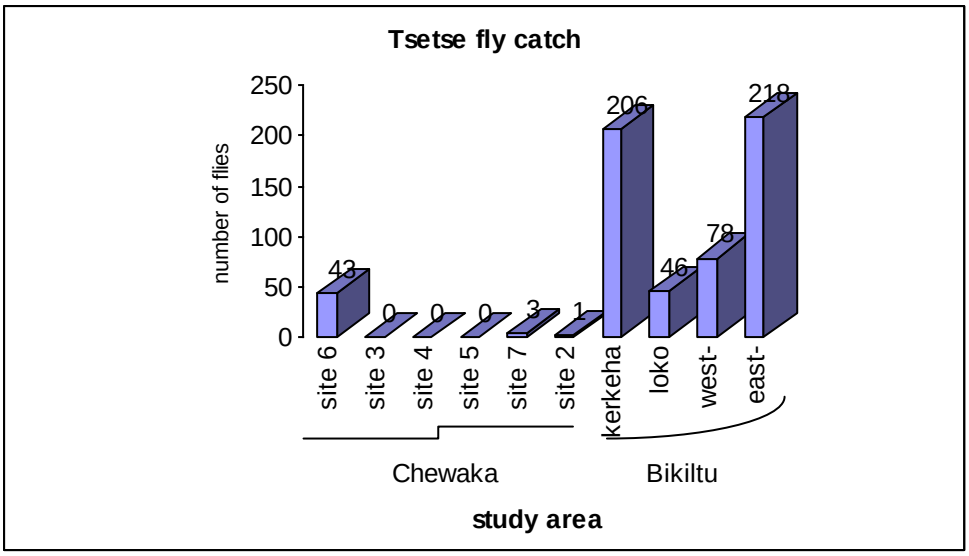

Figure 3: Tsetse fly catch in Chewaka and Bikiltu study areas (Dec/06-Jan/07)

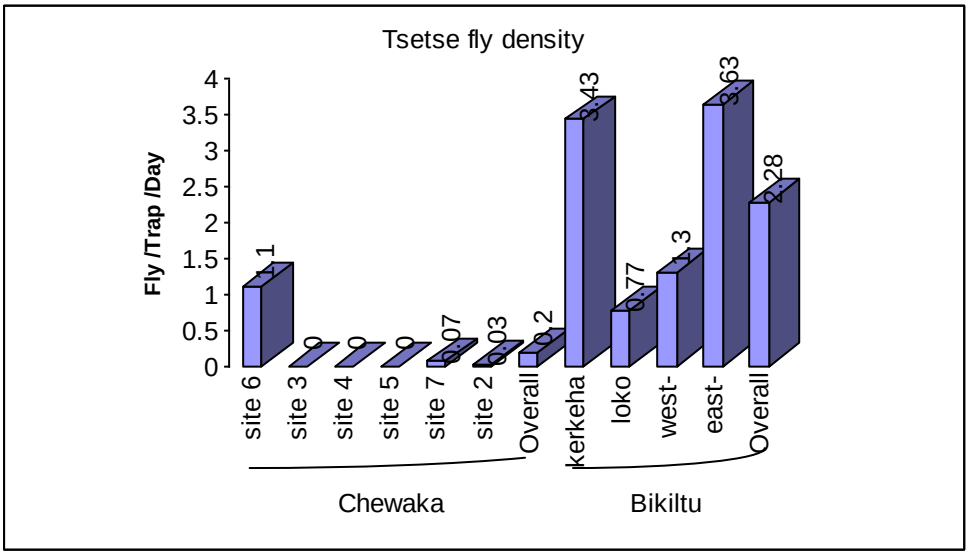

Figure 4: Tsetse fly density in Chewaka and Bikiltu study areas (Dec/06-Jan/07)

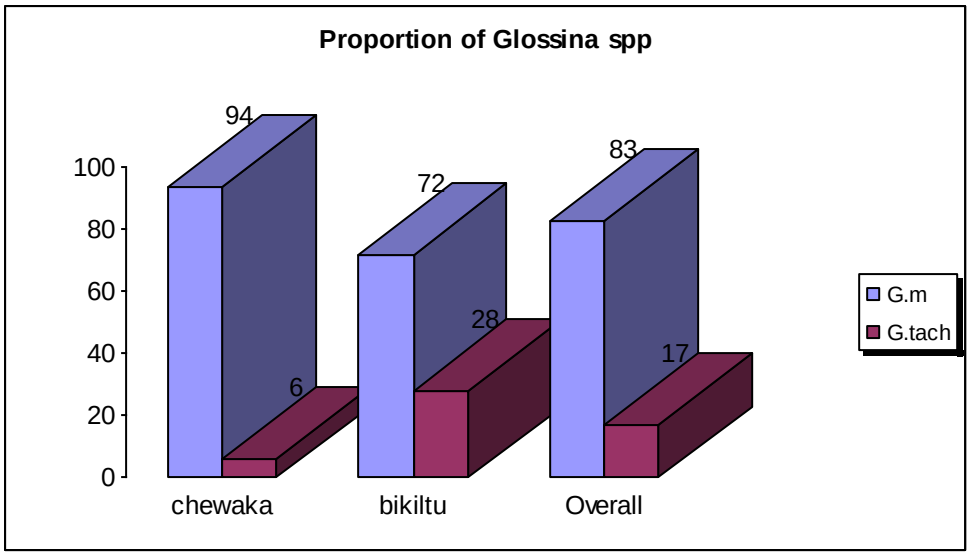

Figure 5: Proportion of *G .morsitans* and *G. tachinoides* at each study area (Dec/96-Jan./97)

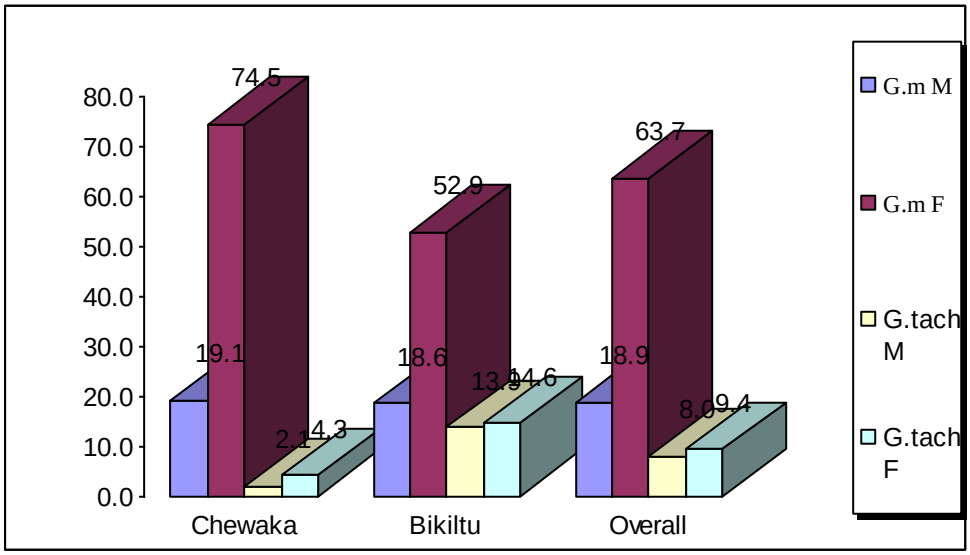

Figure 6: Proportion of tsetse species by sex in Chewaka and Bikiltu study areas (Dec/96-Jan./97)

M=male F= female

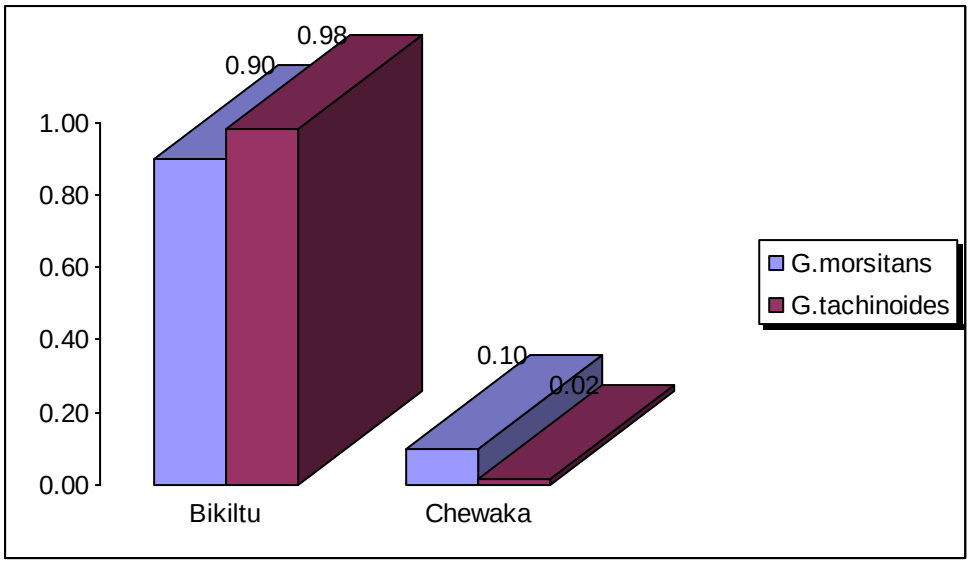

Figure 7: Proportion of tsetse species out of total catch at both study areas

4.2.2. Trypanosomosis survey

A cross-sectional survey of bovine trypanosomosis was carried out in Chewaka settlement station and Bikiltu Didessa farmers' association (FA) during Dec/06- January/07. A total of 830 cattle, 415 at each study area, were randomly selected from a total of 8000 cattle residing at eleven sites of both study areas. Blood samples collected from the ear veins of animals were subjected to the buffy coat, thick and thin blood smear methods of parasitological examinations, the buffy coat samples were examined on the spot for detection of motile trypanosomes, while the thick and fixed thin slide smears were conveyed to Bedelle Regional Veterinary Laboratory for identification of trypanosome species.

Trypanosomes were detected at five of the six surveyed sites in chewaka and at all of the five surveyed sites in Bikiltu with a prevalence range of 0-4.8 % and 4.1-23.4 % in Chewaka and Bikiltu, respectively (Fig.8). The mean prevalence of trypanosomosis in Bikiltu FA, 15%, was significantly higher (P=0.000) than the 3% prevalence in Chewaka Animals in Bikiltu had an OR of 4.935 (95% CI=2.714-8.976) positivity as compared to animals in Chewaka (Table 9). The chance of positivity for animals in Bikiltu was about five times the chance of positivity for animals in Chewaka. There was no statistically significant difference in prevalence of

trypanosomosis among the six sites of Chewaka study area (p=0.791) (Table 10). Whereas in Bikiltu study area, the highest prevalence of trypanosomosis obtained in Chalalaki-1, 22%, was significantly higher (p= 0.001) than Loko, 11% and Kolu, 4%, but was not different from the prevalence obtained in Chalalaki-2, 20%, and Burka, 18%, (Table 11).

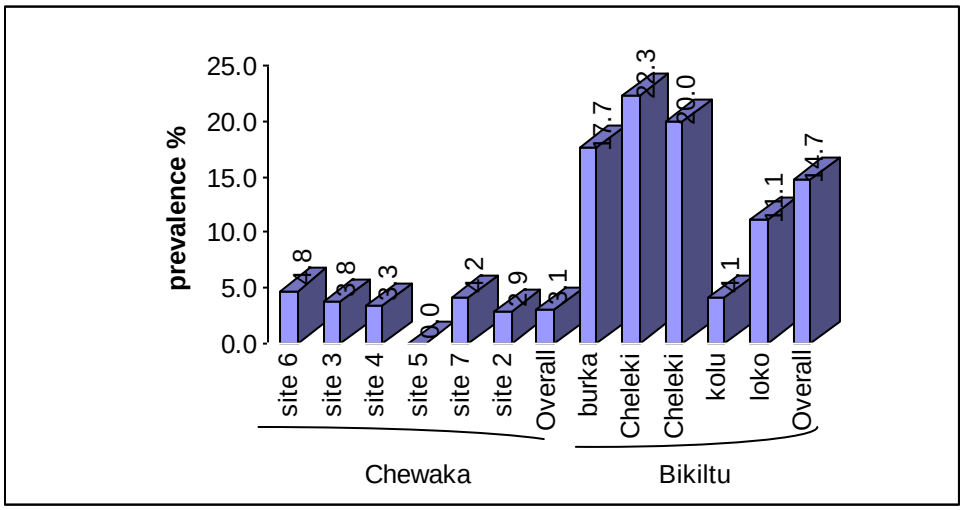

Figure 8: Prevalence of trypanosomosis in Chewaka and Bikiltu study areas (Dec/06-Jan./07)

Trypanosoma congolense and *T. vivax* were the two species detected in blood samples of examined cattle causing bovine trypanosomosis either as a single or mixed infection in the area. In Chewaka, almost all infections were due to single species, while in Bikiltu; mixed infections were commonly encountered sharing 18% of the total infections. *T. congolense* was the most abundant species involving 63.6% and 75.4% of the total infections in Chewaka and Bikiltu, respectively. *T. vivax* infections were encountered in higher proportions in Chewaka, 27.3 %, than in Bikiltu, 6.6% (figs. 9 and 10). Of the total positive cases obtained at both study areas the proportion of *T.congolense*, *T. vivax*, and mixed infections were 85.2, 50 and 91.7% and 14.8, 50 and 8.3% for Bikiltu and Chewaka respectively (Fig.11).

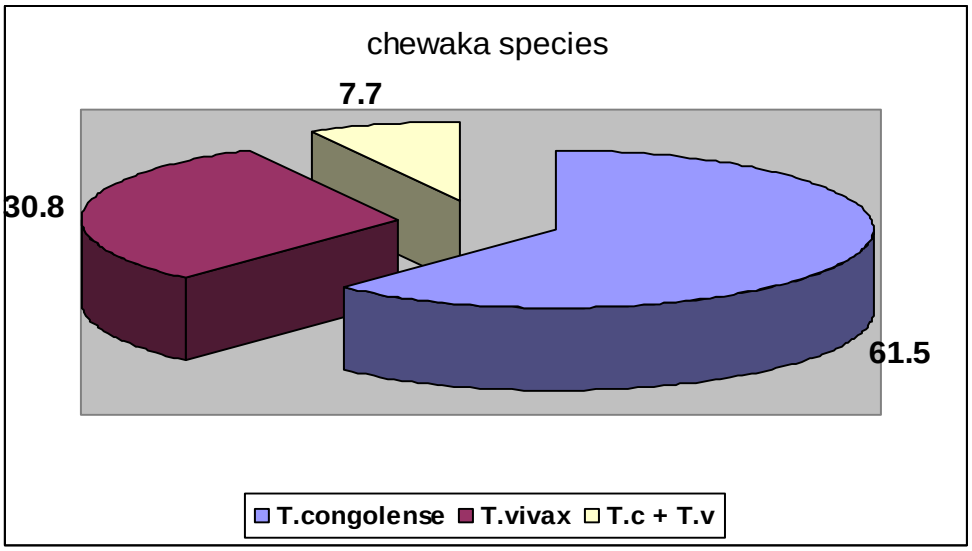

Figure 9: Proportion of trypanosome species infection in Chewaka study area (Dec/06-Jan./07)

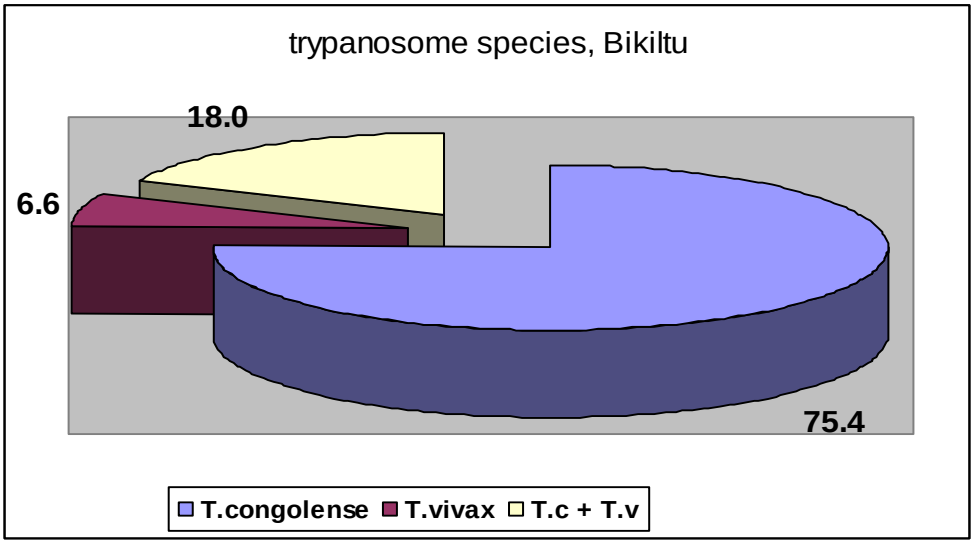

Figure 10: Proportion of trypanosome species infection in Bikiltu study area (Dec/06-Jan./07)

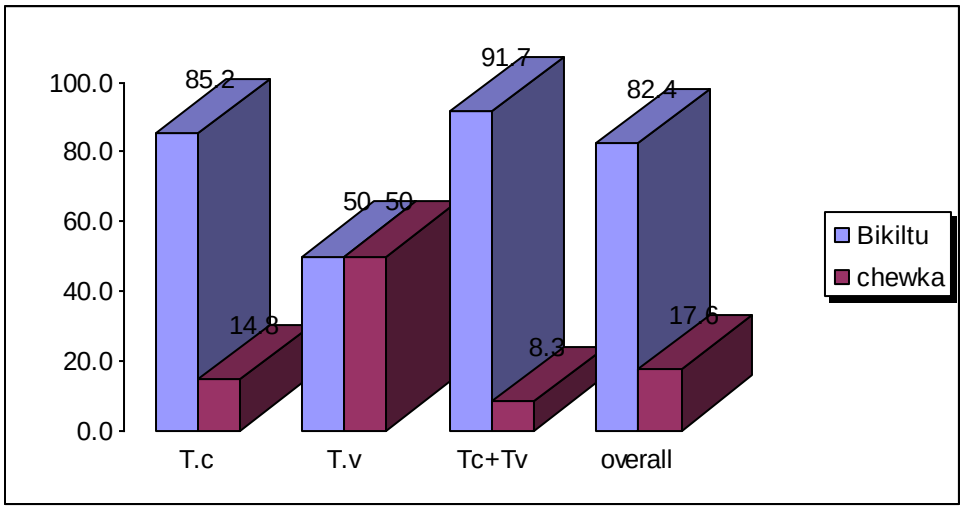

Figure 11: Proportion of trypanosome species infections from the total infections at both study areas (Dec/06-Jan/07)

Prevalence of trypanosomosis was not different among the three age groups: calves (less than 2 years), young animals (between 2 and 5 years) and adult animals (greater than 5 years) at both Chewaka and Bikiltu ($p>0.05$) and there was no difference in prevalence of trypanosomosis between male and female animals at both study areas ($p>0.05$) (Tables 7, 9, 10, 11,). Animals were also categorized into five (age x sex) groups: oxen, cows, bulls, heifers and calves and no difference was observed among these groups at both study areas ($p=0.824$, OR=0.920 95% CI=0.439-1.926) (Tables 9, 10, 11,).

Based on their history of last trypanocidal drug treatment date, animals were categorized into three groups: - none treated, treated within 3 months of the sampling (<3month) and treated before three months of the sampling (>3months). Non-treated group were not found in the tsetse uncontrolled Bikiltu study area, while in the tsetse controlled Chewaka study area, 71.6% (316/415) of the examined animals were not treated and showed a prevalence of 3%. The highest prevalence, 19%, was in animals treated before 3 months in Bikiltu followed by animals treated within 3 months of the sampling in the same study area, 14%. However, the difference in prevalence of trypanosomosis among these groups was not statistically significant at both Bikiltu and Chewaka ($p=0.440$, OR=0.791, 95% CI=0.435-1.436) (Tables 8, 9, 10, 11).

Since animal return is very high in tsetse infested areas it was tried to look for differences in prevalence of the disease among animals stayed for longer periods (greater than 1 year) and shorter period (less than 1 year) . Only 28% of the examined animals in Chewaka and 96.1% in Bikiltu had stayed for more than one year in their respective area, while 72 and 3.9% of them in Chewaka and Bikiltu, respectively, stayed for less than one year. The highest prevalence, 15%, was in animals stayed for longer than 1 year in Bikiltu followed by 6% prevalence in animals stayed for less than one year in the same area. Cattle stayed for greater than 1 year and less than 1 year in Chewaka showed prevalences of 5 and 3%, respectively (Table 8). Regression analysis showed that animals stayed for greater than one year acquired more infections as compared to animals stayed for less than one year at both study areas (p=0.000, OR=4.943, 95% CI=2.453-10.178) (table 9), however, this difference was not found to be significant (p>0.05) when computed separately at each study area (Tables 10 and 11).

Table 7: Prevalence of trypanosomosis by factors in Chewaka and Bikiltu (Dec/96-Jan/97

factors		study area	mean prevalence (%)	95% CI for mean	
				lower	upper
sex	male	Bikiltu	16.5	13.2	19.8
		Chewaka	3.8	0.94	6.7
	female	Bikiltu	11.0	6.3	15.8
		Chewaka	0.0	0.0	0.0
age	adult	Bikiltu	13.1	9.5	16.6
		Chewaka	3.8	-6.9	14.7
	calves	Bikiltu	12.5	4.5	20.5
		chewaka	2.0	-7.6	7.7
	young	Bikiltu	18.9	13.9	23.9
		Chewaka	3.9	0.8	6.9

Table 8: Prevalence of trypanosomosis by factors in Chewaka and Bikiltu study area (Dec/96-Jan/97)

factors		study area	mean prevalence (%)	95% CI for mean	
				Lower	Upper.
last	<3 months	Bikiltu	13.7	10.6	16.7
treatment		Chewaka	4.3	-2.3	11.0
	>3 months	Bikiltu	18.8	12.8	24.8
		Chewaka	3.3	-6.8	13.4
	non treated	Bikiltu	0.0	0.0	0.0
		Chewaka	3.2	5.0	6.3
years	<1 year	Bikiltu	6.3	-7.6	20.1
stayed		Chewaka	2.7	-0.5	5.9
	>1 year	Bikiltu	15.0	12.3	17.8
		Chewaka	5.2	4.5	10.3

Table 9: Odds ratio comparisons in the prevalence of trypanosomosis by major risk factors, at both study areas

factors	P value	OR	95% CI.for OR	
			Lower	Upper
Study area	0.000	4.935	2.714	8.976
Sex	0.636	0.867	0.480	1.566
Age	0.055	0.614	0.373	1.010
Animal type	0.824	0.920	0.439	1.926
Last drug	0.440	0.791	0.435	1.436
Year of stay	0.000	4.997	2.453	10.178

Table 10: Odds ratio comparisons in the prevalence of trypanosomosis by major risk factors, in Chewaka study area

Factors	P value	OR	95% CI.for OR	
			Lower	Upper
Site	0.791	0.812	0.175	3.781
Sex	0.769	0.001	0.000	1.420
Age	0..998	1.003	0.126	7.983
Animal type	0.071	0.644	0.400	1.038
Last drug	0.624	0.719	0.193	2.684
Year of stay	0.214	0.504	0.171	1.486

Table 11: Odds ratio comparisons in the prevalence of trypanosomosis by major risk factors, in Bikiltu study area

Factors	P value.	OR	95.% CI .for OR	
			Lower	Upper
Site	0.001	0.171	0.060	0.489
Sex	0.143	0.628	0.337	1.170
Age	0.325	1.626	.618	4.283
Animal type	0.431	0.735	0.342	1.580
Last drug	0.804	0.035	0.000	10.547
Year of stay	0.350	0.378	0.049	2.906

The mean herd PCV in Chewaka, 26.5 %,(95% CI =26.1-27), was significantly higher (p=0.000) than the mean herd PCV in Bikiltu, 24.4% (95% CI =23.9-24.8). The mean PCV value of trypanosome positive animals, 22.1 % and 21%, was significantly lower (p=0.000) than the mean PCV value of trypanosome negative animals, 26.7% and 25 %, in Chewaka and Bikiltu study areas, respectively (Fig.12).Out of the total examined animals 62.9% in Bikiltu and 41.7% in

Chewaka showed PCV values less than 26%. The mean prevalence of trypanosomosis in animals with normal PCV values (PCV>26%) in Bikiltu, 3%, (95% CI=2-9%) was significantly lower (P=0.000) than the mean prevalence of trypanosomosis, 21.5%, (95% CI=17.3-25.6%) in animals with low PCV values (PCV<26%), the same was true in Chewaka where the mean prevalence of trypanosomosis in animals with normal PCV values, 0.08%, was significantly lower (p=0.001) than the mean prevalence of trypanosomosis, in animals with low PCV values, 6.9% (Fig. 13).

There was no significant difference (p=0.972) in mean PCV value between male, 26.5% (95% CI=26-27), and female animals, 26.5% (95% CI=25.1-27.9), in Chewaka and also no difference was observed (p=0.905) between male, 24.4 %, (23.8-24.9) and female animals , 24.4%, (23.6-25.2) in Bikiltu FA. The mean PCV value of calves, adult and young animals in Bikiltu and Chewaka study areas, 25, 24.4 and 24.1 % and 25.5, 25.6 and 26.8% respectively, were not found to have statistically significantly difference (p>0.05).

Analysis of the herd prevalence of the six surveyed sites in Chewaka showed that the mean herd PCV value of site seven , 28.1% (95% CI 27-29.3%), was significantly higher (p=0.010) than the other five sites, In Bikiltu study area, the mean herd PCV in Chalalaki-1 was significantly lower (p<0.05) than Kolu, Loko and Burka sites with mean herd PCV of 25.4, 26.2 and 23.9% (95% CI=24.5-26.3%, 25.1-27.2%, and 23-28%) respectively, but doesn't differ (p=0.08) from Chalalaki 2. The PCV results match with the high prevalence in Chalalaki-1 and Chalalaki-2 sites as compared to the other three sites. The linear association between the mean prevalence and the mean herd PCV in Chewaka and Bikiltu study areas were seen to have negative correlation, r=-0.306 and -0.173 respectively, at the 0.01 level.

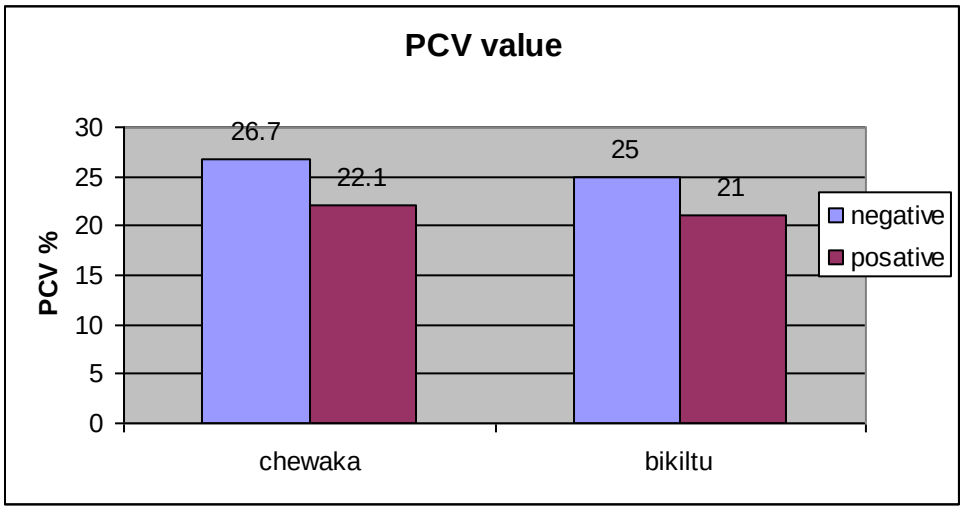

Figure 12: PCV of trypanosome positive and negative animals in Chewaka and Bikiltu study areas (Dec/96-Jan/97)

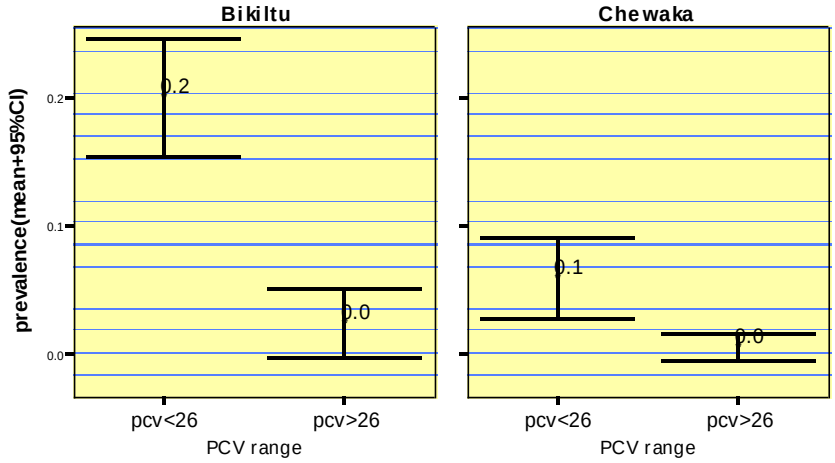

Figure 13: Prevalence of trypanosomosis in animals with PCV less than 26 and greater than 26 in chewaka and Bikiltu study area (Dec./06-Jan/07)

4.2.3. Questionnaire survey

Livestock population

Questionnaire survey results show that the mean number of total cattle and oxen owned by a household in Chewaka, 1.44 and 1.23 head are significantly lower (p=0.000) than the mean number owned by a household in Bikiltu, 5.01 and 2.15 head, respectively. The mean number of small ruminants (Shoats)/ household in Chewaka, 3 head, is significantly higher (p=0.000) than the mean number in Bikiltu, 1.39. There was no significant difference between Chewaka and Bikiltu households in the average number of equines they posses (p=0.279) (Table 12).

Table. 12: Questionnaire survey results on average number of livestock species owned/hh in Chewaka and Bikiltu study areas

study area		no of oxen	no of cows	no of bulls	no of heifers	total cattle	no of shoats	no of equine	crop..land (hectares)
Bikiltu	Sum	172	92	21	53	401	111	10	186.3
	% of TS	63.7%	95.8%	100.0%	80.3%	77.7%	31.6%	40.0%	60.2%
	Mean	2.15	1.15	.26	.66	5.01	1.39	.12	2.328
Chewaka	Sum	98	4	0	13	115	240	15	123.1
	% of TS	36.3%	4.2%	.0%	19.7%	22.3%	68.4%	60.0%	39.8%
	Mean	1.23	.05	.00	.16	1.44	3.00	.19	1.539

TS=total sum

Livestock Management

Questionnaire survey results show that Cattle management greatly differ in the two study area, In chewaka, animals are usually tied under tree shades around farm areas and hand fed with chopped sugar beet, grass and farm by-products during the day and night time. They pass the night in warm barn rooms with comfortable beddings and are not exposed to rain and cold. Settlers of Chewaka study area are descendents from the eastern part of the country (Oromia

Regional State, Hararghe Zones) where the tradition of animal feeding housing, oxen fattening as well as preservation and storage of crop by products had been developed. In Bikiltu study area, cattle pass the day time grazing in savannah grassland, bushes and open grazing fields and are not provided with any type of additive feeds either during the day or the night time, they are not protected from rain and cold of the night since they are confined in open and non comfortable bedding barns. The tradition of preservation and storage of crop by-products had not been developed and, hence, animals are solely dependant on their day time grazing for maintenance and production.

In Chewaka, animals pass most months of the year tied under tree shades around farm areas and hence, the animal-tsetse contact is very low, however, during the dry months of the year (February-May) cattle are released freely and wonder in bushy areas for search of grass, it is during this season that the animal-tsetse contact is higher and animals get infected with trypanosomosis. In Bikiltu, animals acquire trypanosomosis throughout the year since they are continuously in contact with flies at grazing areas, infection of cattle reaches maximal in the late rainy months (July–October.) during which flies are excessively found in the area.

Animal sell and purchase

Out of the eighty interviewed farmers at each study area, 66%, (53/80) in Chewaka and 24% (19/80) in Bikiltu sold a total of 64 and 29 animals, respectively, during a year period, Dec/05-Dec/06. An average of 0.85 (95% CI=0.691-1.0) head of cattle were sold/hh/yr in Chewaka and only 0.34 (95% CI=182-.493) head/hh/yr were sold in Bikiltu (tab.14). Analysis of data showed a significant difference (p=0.000) in animal sell between the two study areas, indicating the family income due to animal sell in Chewaka was 60% greater than the family income in Bikiltu (Table 15). The purpose of animal sell differ between the two study areas in that the respondents in Chewaka reported that 98% of the sell were fattened oxen sold for slaughter houses while the respondents in Bikiltu stated that 59% of the total sell were oxen, most of which were, sold due to repeated attacks of trypanosomosis, and the rest, 41%, were breeding cows and young stocks. Farmers in Bikiltu Didessa reported that they are frequently obliged to sell small ruminants so as to purchase trypanosomal drugs for their cattle.

Animal purchase is one of the factors to estimate the status of trypanosomosis and economic potential of farmers in tsetse infested areas. Results of the questionnaire survey on animal purchase showed that 85% (68/80) of the respondents in Chewaka and 36%, (29/80) in Bikiltu bought a total of 89 and 44 animals, respectively, during the year period. There was a significant difference in animal purchase (p=0.000) between the two study areas, on average a household in Chewaka bought 1.15 animals which were double that of Bikiltu, 0.55 animals/hh/yr. Farmers in Chewaka bought 0.99 (95% CI=0.87-1.08) head of bulls/hh/yr which was significantly higher (p=0.000) than the average number of bulls purchased by farmers in Bikiltu, 0.11 (95% CI=0.05-0.231), head/hh/yr. The average number of oxen purchased /hh/yr in Bikiltu 0.28 (95% CI=0.192-0.358) was significantly higher (p=0.000) than the average number of oxen bought/hh/yr in Chewaka (Table 14). No significant difference was observed between the two study areas in purchase of cows (P=0.832) and heifers (P=0.238). The purpose of animal purchase also varies between the two study areas in that, the majority of the animals bought in Chewaka, 99%, were young animals (bulls) for draught, growing and breeding purposes while most of the animals bought in Bikiltu, 52%, were adult animals (oxen) aimed for draught power purposes to replace oxen died of trypanosomosis.

Mortality of cattle

Results of the questionnaire survey showed that only 9% (7/80) of the total respondents in Chewaka and 81% (65/80) in Bikiltu asserted deaths of 7 and 233 head of cattle during the year period in Chewaka and Bikiltu, respectively (tab.14). The average cattle mortality /hh/yr in Bikiltu, 3, head (95% CI=2.6-3.4), was significantly higher (p=0.000) than the mean loss/hh/yr in Chewaka, 0.09 head (95% CI=0.309-0.486). |Overall cattle and oxen in Bikiltu had an OR of 10.199 (95% CI=4.458-23.333) and 6.556 (95% CI=3.196-13.448) mortality as compared to overall cattle and oxen in Chewaka (Table-15). Thus the chance of mortality of overall cattle and oxen in Bikiltu was 10 and 6 times more likely than the chance of mortality of cattle and oxen in Chewaka. Oxen were the most affected group in Bikiltu comprising 51% of the total mortality during the year and, on average, a house hold had lost 1.48 head of oxen/yr.

Abortion of cows

Results of the questionnaire survey show that out of the total respondents 2.5% (2/80) in Chewaka and 30 % (24/80) in Bikiltu reported abortion of 2 and 40 cows in Chewaka and Bikiltu, respectively. The average number of aborted cows /hh/yr in Chewaka, 0.03, was significantly lower (p=0.000) than the average number in Bikiltu, 0.5 /hh/yr. Cows in Bikiltu had an OR of 10.792 (95% CI=2.567-45.370) abortion rate as compared to cows in Chewaka indicating that the chance of abortion was more than 10 times in Bikiltu as compared to Chewaka (Table.15). More than eighty percent of the respondents stated that abortions were mostly related to clinical cases of trypanosomosis and, therefore, cows showing symptoms of trypanosomosis may abort at any period of gestation.

Trypanocidal treatment frequency

Questionnaire survey results show that all farmers in Chewaka had never handled trypanocidal drugs and their animals are solely treated by veterinary personnel, on the other hand, almost all farmers in Bikiltu Didessa have their own syringes and trypanocidal drugs and know the different types of trypanocidal drugs on market. More than 90% of the respondents in Bikiltu stated that the frequency of animal treatment may not exceed a maximum of 6 weeks; some animals may even be treated twice a month. Dosages of drugs are not well known the by the respondents in Bikiltu and both prophylactic and curative drugs are given repeatedly until animals show improvement of condition. In Bikiltu, 85% of the farmers prefer diminazene aceturate to isomethamidium chloride for its fast action in revival of cattle. It was stated that trypanocidal drug shortages may occur at times but farmers are curious in search of drugs even from far distances, the usual sources of trypanocidal drugs are the nearby veterinary and human drug shops or drug smugglers in the area.

Although veterinary clinics exist at a nearby distance of both study areas there was a shortage of transportation facility for the vet personnel to reach the widely dispersed villages as soon as the need arises, hence, farmers have to move sick animals for an average of two-three hours to reach to veterinary clinics.

Table 13: Questionnaire survey results on number of animals sold, purchased, died and aborted in Chewaka and Bikiltu study area (Dec/05-Dec/06)

study area	statistics	oxen sold	total sold	oxen died	total died	bulls purchased	total purchased	aborted cows
Bikiltu	Sum	17	27	118	242	9	44	40
	% of TS	20.5%	28.7%	94.4%	97.2%	10.3%	32.4%	95.2%
	Mean	.21	.34	1.48	3.03	.11	.55	.50
Chewaka	Sum	66	67	7	7	78	92	2
	% of TS	79.5%	71.3%	5.6%	2.8%	89.7%	67.6%	4.8%
	Mean	.82	.84	.09	.09	.97	1.15	.03

TS= total sum

Table 14: Odds ratio comparisons on mortality of animals and abortion of cows /hh/yr in Chewaka and Bikiltu study area (Dec/95-Dec/96).

parameters	P value	OR	95% CI. for OR	
			Lower	Upper
Oxen died	.000	6.556	3.196	13.448
Total cattle died	.000	10.199	4.458	23.333
Cows aborted	.001	10.792	2.567	45.370
Oxen sold	.000	.174	.092	.331
Total sold	.000	.354	.213	.589
Bulls purchased	.000	.046	.019	.109
Oxen purchased	.644	.445	.000	26.000

4.3. Changes before and after the control program in Chewaka SS

Results of the tsetse and trypanosomosis surveys conducted during 2004-2006 and results of the cross sectional tsetse and trypanosomosis survey conducted at the beginning of 2007 in Chewaka settlement station showed a dramatic drop in tsetse population density and prevalence of trypanosomosis in the area.

4.3.1. Changes in tsetse distribution and density

The tsetse fly relative density recorded in 2004, 14 FTD, declined to 2.61 in 2005 and further reduced to 1.01 and 0.2 in 2006 and 2007, respectively (Fig.14). The drop in the overall mean FTD from 14 to 0.2 between 2004 and 2007 was statistically highly significant (p=0.000). During this period the decline in tsetse fly density at each of the seven sites of the settlement station were also highly significant (p>0.05) (Fig 14).

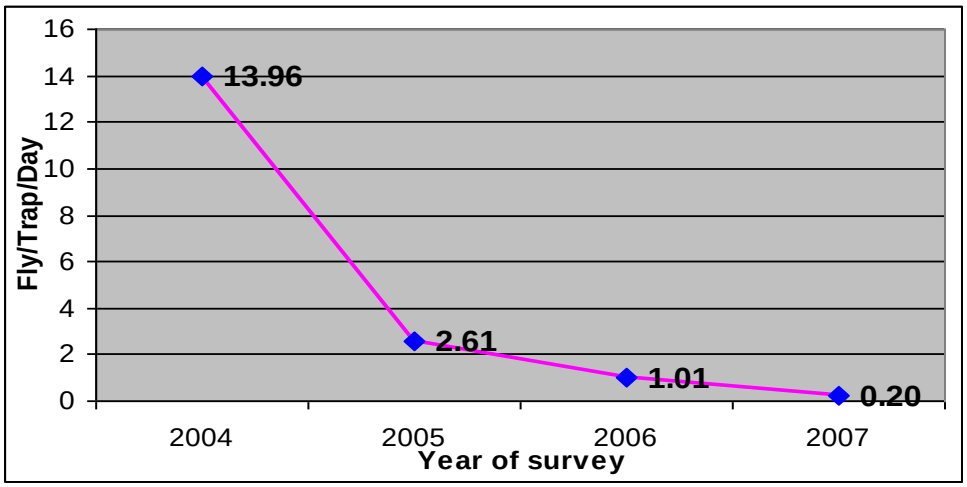

Figure 14: Overall decline in tsetse fly density (FTD) in chewaka SS (2004-07)

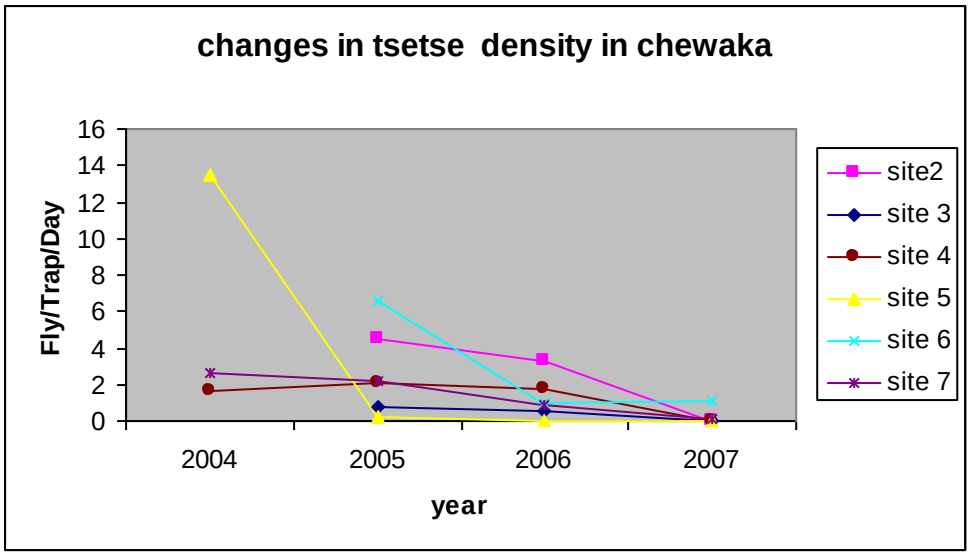

Figure 15: Decline in tsetse density at different sites of Chewaka (2004-07)

4.3.2. Changes in prevalence of trypanosomosis

Between 2004 and 2007 the prevalence of trypanosomosis had declined from, 37.5 to 3.1%, and correspondingly, the herd PCV had increased from 19.4 to 26.5% (Fig 15). The changes in the overall prevalence of trypanosomosis and herd PCV as well as the decline in prevalence and the increment in herd PCV at each of the six surveyed sites during this period were highly significant. (Table 15; Figs. 16, 17 and 18).

Table 15: Comparisons of mean prevalence mean fly/trap/day and mean herd PCV in Chewaka SS 2004 and 2007

variables	mean		P value	95% CI for difference	
	2004	2007		lower	upper
Prevalence (%)	37.5	3.1	0.000	33.12	69.62
fly/trap/day	14	0.2	0.009	5.040	31.694
PCV %	19.4	26.5	0.000	-10.350	-3.917

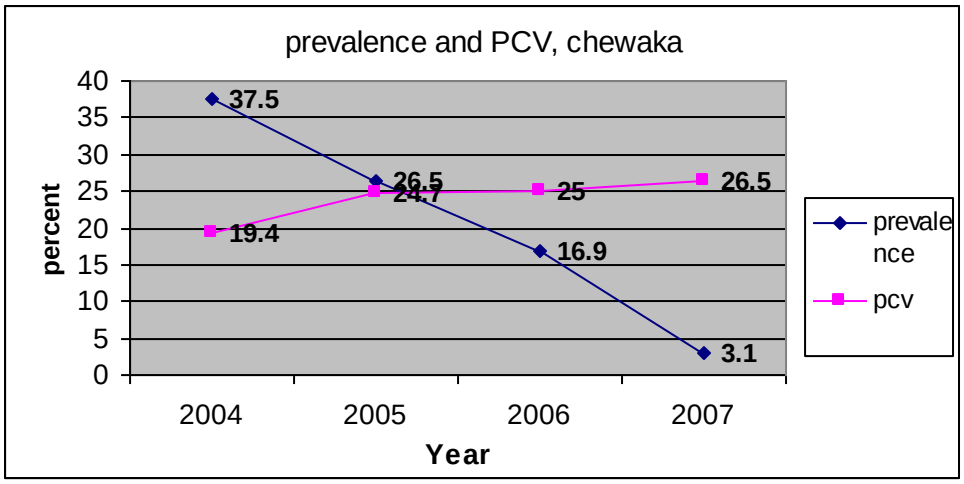

Figure 16: Overall changes in prevalence of trypanosomosis and herd PCV in Chewaka SS during 04-07

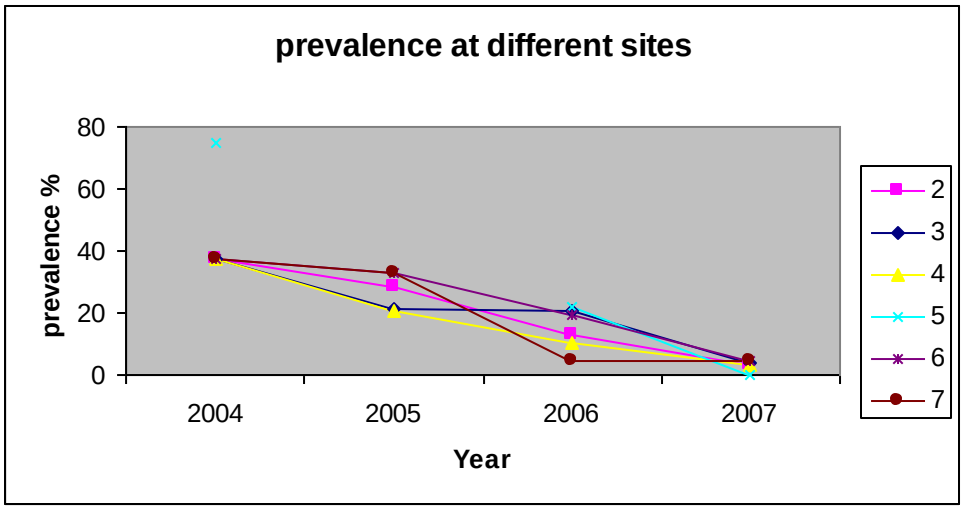

Figure 17: Declines in prevalence of trypanosomosis at different sites of Chewaka SS (04-07)

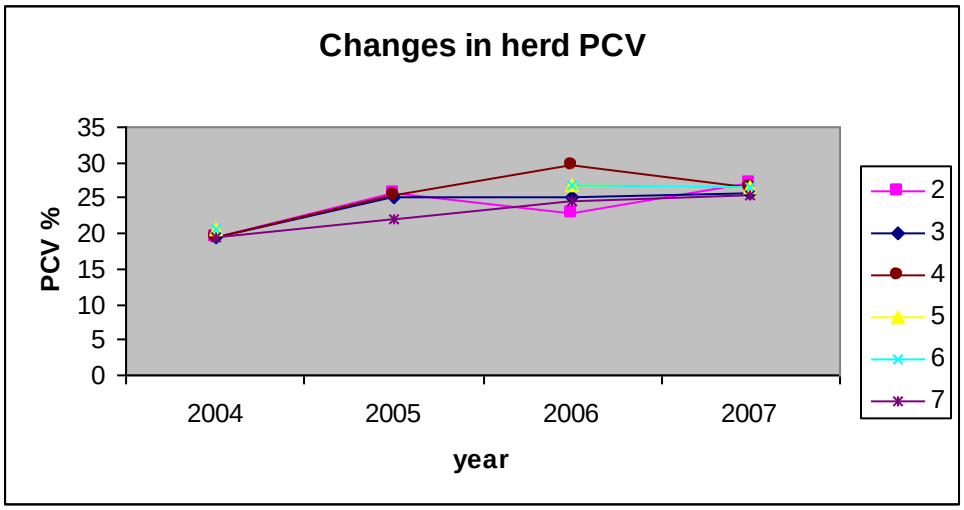

Figure 18: Increment in herd PCV at different sites of Chewaka SS (2004-07)

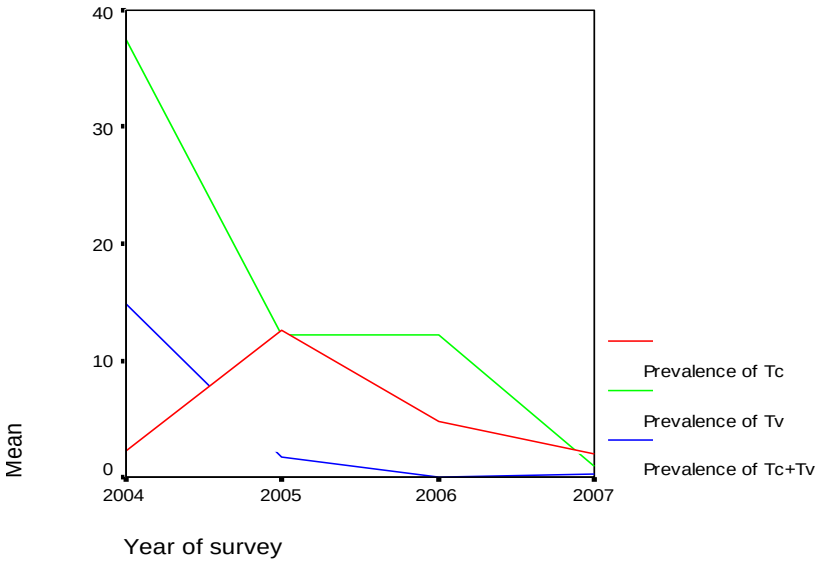

Figure 19: Changes in prevalence of trypanosome species in Chewaka study area during 04-07

4.3.3. Socioeconomic changes

Changes in livestock population

Goats were the first livestock species introduced in to Chewaka settlement station in 2004 followed by small number of donkeys and sheep in the same year, whereas, oxen were introduced during 2005 after extensive tsetse control measures had been conducted in the area. Recorded data shows an increment in total livestock population in Chewaka SS during 2005-2007 (Fig 19). However, during the same period, the total livestock population in Bikiltu Didessa had declined significantly, cattle population dropped by 47.5%, sheep population by 26.5% and goat population by 47.3%.Equine was the only species that had shown an increment in population size (Fig. 20).

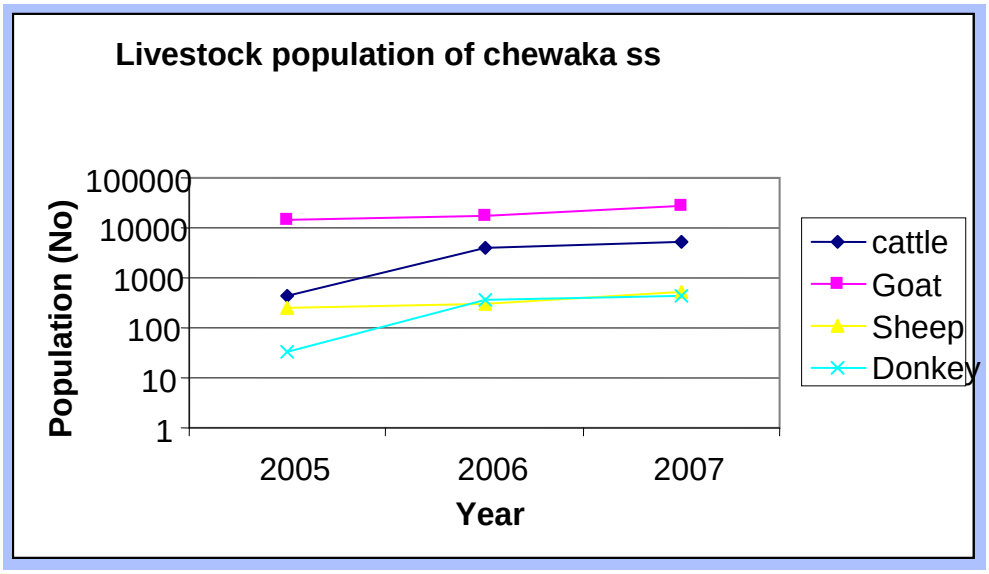

Figure 20: Increment in livestock population of Chewaka SS (2005-2007)

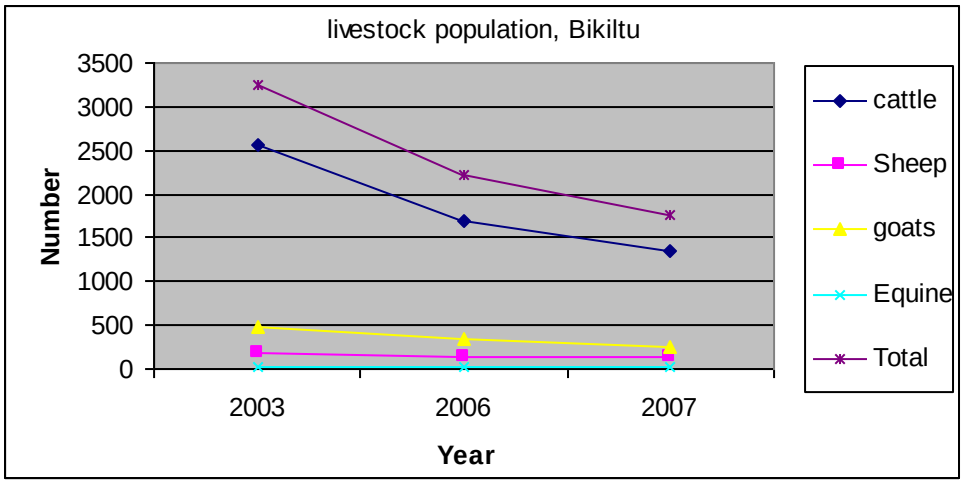

Figure 21: Livestock population of Bikiltu Didessa FA (04-07)

Changes in cultivated land and Crop production

Recorded data show that four types of crop:- maize, sorghum, sesame and soybean, were commonly cultivated at both study areas and a total of 581.3 tones of grain was produced in Chewaka during the three production years, 2005-2007. The increment in total cultivated land in Chewaka was 63.7% and 18.3% for 2006 and 2007, respectively, with an average growth rate of 46.8%/year. The increment in farm land dimension resulted in boost of grain yield by 39.5% and 17% during 2006 and 2007, respectively, with an average production growth rate/year of 31.6%. (Figs 21 and 22)

During 2006 and 2007 maize production had increased by 7.9 and 35.2 %, and sorghum production increased by 33.3 and 44.3%, respectively. Although there was a partial shift in crop production from oil seed crops to food crops during this period, the total production growth remained unaffected. In Bikiltu Didessa, the total cultivated land had increased by 22.6% between 2005 and 2007; however, the total grain produce had declined by 46.5% (fig 23). Analysis of the questionnaire survey show that, on average, farmers in Chewaka own , 1.54 hr of land which is significantly lower ($p=0.000$) than the average number of hectares owned by Bikiltu farmers, 2.3 hectares.

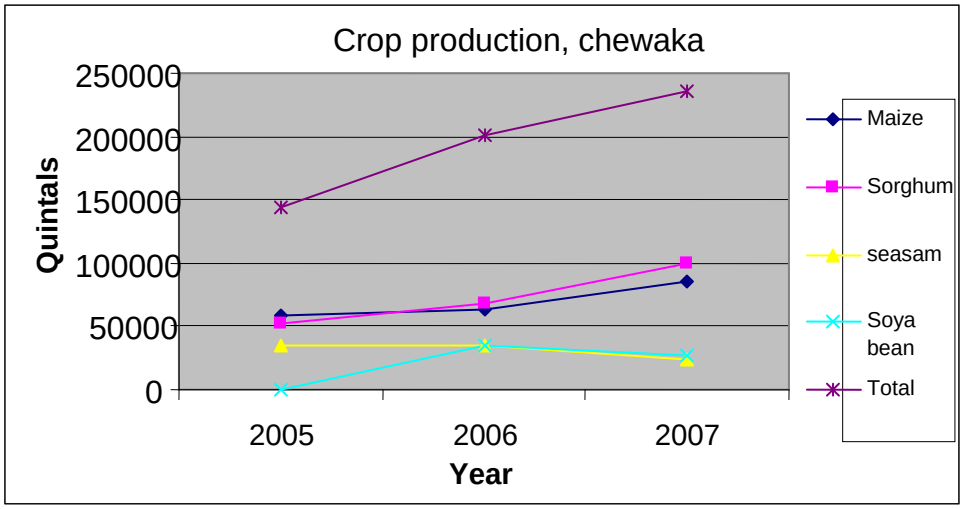

Figure 22: Increment in crop production in Chewaka SS during 2005-07

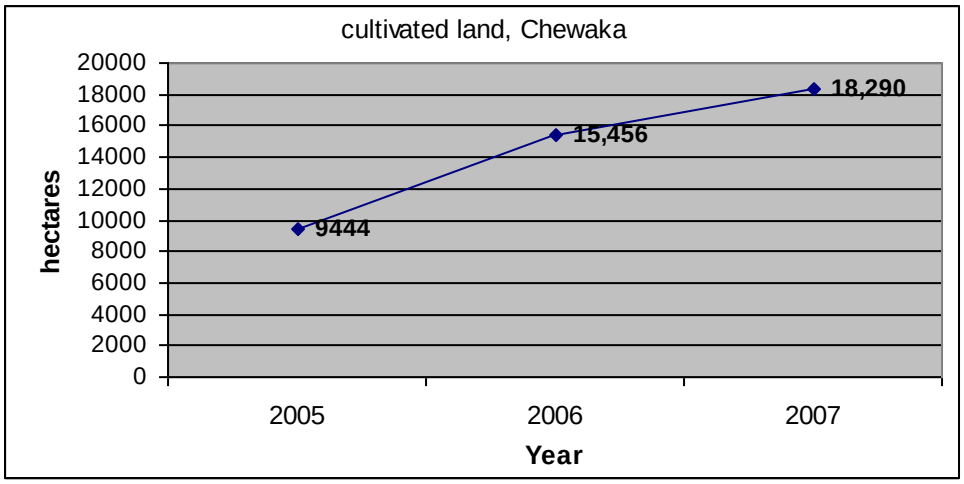

Figure 23: Growth in cultivated land in Chewaka SS (2005-2007)

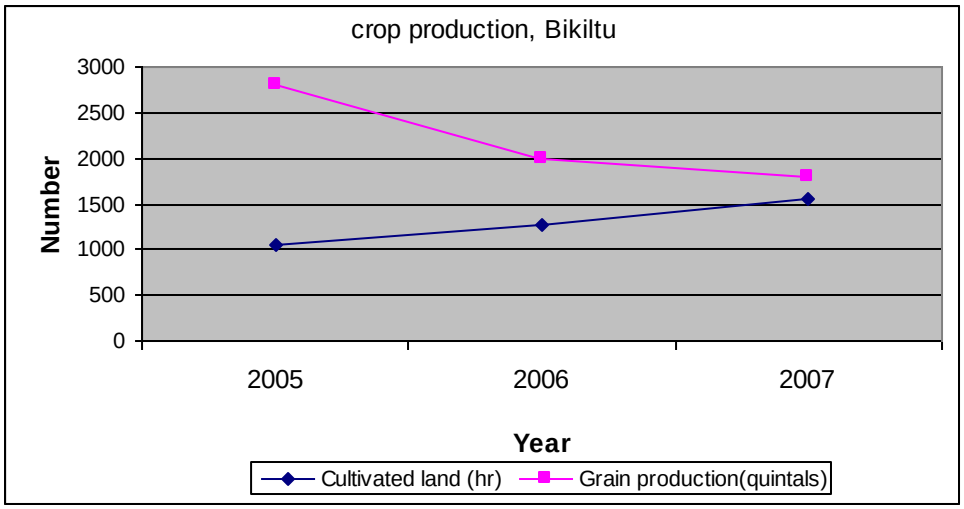

Figure 24: Cultivated land and grain production in Bikiltu FA (05-07)

5. DISCUSSION

An integrated community based tsetse and trypanosomosis control program comprising targets, live baits and treatment of animals was conducted in the newly established Chewaka settlement station during 2005-2006. The overall density of tsetse fly recorded before the commencement of the tsetse control operation in 2004, 13.96 FTD, was dropped by 98.6 % to 0.2 FTD in 2007. The highest drop in the density of tsetse was during the initial year of the control program in which a drop of fly density by 81.3 % was achieved. The drop in the overall mean FTD between 2004 and 2007 was in agreement with reports from Chello tsetse controlled area of upper Didessa valley in which a relative tsetse density of 25 FTD was dropped to zero (FITCA, 1999).

The spatial distribution of tsetse had also diminished significantly, no fly was caught at sites 1, 3, 4 and 5 and in those sites where tsetse were caught during 2007, they exist in very low densities ranging from 0.03 to 1.10 FTDs. Tsetse remained at few pockets of sites 2, 6, 7 and river side vegetations of Didessa and Dabena Rivers.

Only two species of tsetse fly, *G. morsitans* and *G. tachinoides,* were encountered throughout the surveys at both study areas; *G. morsitans* was distributed throughout the savannah and is the dominant species in the area, while *G.tachinoides* was restricted along the vegetations of the two major rivers. The present finding is in agreement with earlier reports in the Didessa river valley (Langridge, 1976; NTTICC, 1996; FITCA, 1999; Feyisa, 2004). In almost all cases, the proportion of female flies was greater than males which might be due to the female flies' dynamism for search of blood meal as compared to the male flies.

There was no difference in fly density among the six sites of Chewaka showing the uniformity of the tsetse control operation at all sites of the settlement station whereas, a significant difference was obtained among the four sites of Bikiltu study area. The mean tsetse density obtained at Bikiltu in this study, 2.28 FTD, was lower than that of previous reports in the area, 3.56 FTD (Feyisa, 2004), because the major river in the area, Didessa, was not included in this survey.

Farmers of chewaka study area affirmed that animal-tsetse fly contact is higher during the dry months of the year (February.-May) since freely released animals move to forest and river side vegetations in search of palatable grass and make contact with tsetse, while, during the wet months (May-October), grass is available all over the farming and homestead areas, and so, animal-tsetse contact is negligible. On the other hand, during the wet season, the entire area is invaded by large number of biting flies which would compel animals to escape from grazing fields. In the presence of trypanosome parasites in blood of wild or domestic animals of the area, these mechanical transmitters are able to spread and boost up the magnitude of trypanosomosis in cattle. The existence and abundance of *Tabanus* and *Stomoxys* species had been described in this and previous surveys.

Although the findings of this study in regard to the achievements on the prevalence of trypanosomosis in Chewaka is similar to previous reports in the tsetse controlled upper Didessa and Gibe valleys where by a pre-intervention prevalence of 56 and 37.6% had declined to 3% and 9.8%, respectively, (FITCA, 1999; Leak, 1995) .The high achievements of the control program in Chewaka might be due to the high inputs and extensive involvement of the community.

There was no statistically significant difference in prevalence of trypanosomosis among the six sites of Chewaka study area showing the uniform effect of the tsetse control operation and the advancement of the control program at each site. The changes in the percentage composition of *T. congolense* and *T. vivax* infections during 2005 and 2006 shows the escalating importance of *T vivax* infection which might be due to increased transmission of *T. vivax* infection via mechanical way concomitantly with falling down of tsetse density in the area .or introduction of the infection through animals purchased from the surrounding highland areas where T.vivax but not T.congolense is commonly encountered.

The prevalence of trypanosomosis in Bikiltu obtained in the present study,15%, is in agreement with an earlier report of 15% in Village 1 settlement and slightly less than that of the 21.3% in Kone and the 27.2% in Didessa tsetse infested area (Feyisa, 2004,Tewolde *.et a.l*, 2004).

Infection of cattle with trypanosomes depends on their contact with tsetse and the tsetse density in an area and it is known that the higher the tsetse density, the higher the infection rate in the hosts (Rogers, 1979).The difference in the prevalence of trypanosomosis among herds of Bikiltu villages might be associated with the density of tsetse at their grazing sites, Chalalaki-1, Chalalaki-2 and Burka herds graze in the high fly density savannah of east-Chalalaki and Kerkeha sites, whereas, loko and Kolu herds commonly graze in the low fly density pasture of loko site.

Data analysis prove that animals stayed for longer period in the tsetse uncontrolled Bikiltu study area showed higher prevalence rates than those stayed for shorter period, nevertheless, no difference was observed between the above groups in Chewaka. This illustrate that, in tsetse controlled area duration of stay may not affect infection rate of animals, while in tsetse infested area, the longer the duration of stay, the higher the animal-tsetse contact and the more likely that animals acquire infections, and vise versa. In the tsetse uncontrolled Bikiltu study area 45% of the total positive animals were known to have been treated with Isomethamidium chloride within 3 month of the sampling period, the recurrence of infection in such short period might be attributable to the existence of trypanocidal drug resistance problem in the area.

The relationship between the prevalence of trypanosomal infections and herd average PCV could be a useful tool in the management of trypanosomosis and planning of its control. (Rowlands, *et al.,* 2001). Bovine trypanosomosis control aims at reducing the prevalence of infection with a concomitant increase in the herd average PCV (Bauer *et al*., 1999). Therefore, knowledge on the relationship between the prevalence of trypanosomal infections and herd average PCV could be a useful tool in the preliminary assessment of the expected impact of a control intervention. A study on the impact of utilizing biconical traps for the control of trypanosomal infections in cattle in Coˆ te d'Ivoire revealed a reduction in prevalence from 12.6 to 2.8% and increment of herd PCV from 29.8 to 32.2% (Rowlands *et al*., 1996). The corresponding slope,-0.24, is similar with the slope calculated in this study,-0.21 **(**19.4-26.5/37.5-3.2**).** In a study on the effect of a tsetse control intervention in Ethiopia using an insecticidal pour-on applied to village zebu cattle, the changes on average herd trypanosome prevalence and herd PCV percentage before and during a tsetse control were 39.1 to 14.6%, and 24.3 to 25.9%, respectively (Rowlands *et al.*, 1999).

Similar study to assess the changes made on disease prevalence and herd PCV before and after a tsetse intervention program in the upper Didessa valley illustrated a reduction of infection rate from 33.4 % to 7.9 % and improvement of herd PCV from 23.4 to 25 %.(Feyisa, 2004). Although the findings of this study in Chewaka, with a decline of prevalence from 37.5% to 3.2%, and increment of herd PCV from 19.4 to 26.5%, are similar with the above studies, a relatively wider area of coverage and shorter period of time were involved in chewaka, on account of the extensive involvement of the community, integrated method of approach, and high inputs utilized.

The development of anaemia is one of the most typical signs of trypanosomosis caused by T. congolense in susceptible cattle breeds (Murray and Dexter, 1988). The level of anaemia or the PCV usually gives a reliable indication of the disease status and productive performance of an infected animal (Trail *et al*., 1993). The mean herd PCV in Chewaka, 26.5% was significantly higher than the mean herd PCV in Bikiltu, 24.4% and the proportion of animals with PCV less than 26% were 41.7% in Chewaka as compared to the 63% in Bikiltu These findings show that the high prevalence of trypanosomosis in Bikiltu resulted in a significant decline of the herd PCV and, hence, productivity of animals as compared to Chewaka study area.

The mean herd PCV of sites with high prevalence of trypanosomosis in Bikiltu (Chalalaki-1, Chalalaki-2 and Burka) was significantly lower than sites with low prevalence of the disease (Kolu and Loko). At all surveyed sites, regression analyses show that the herd average PCV decreases with increasing prevalence of trypanosomal infections. The mean herd PCV of Bikiltu Didessa cattle reported by Feyisa (2004), 22.83%, was lower than the mean herd PCV obtained in this study, 24.4%, which harmonizes with the differences in prevalence of the disease between the two studies, 27.2 and 15%, respectively. However, the herd average PCV is affected by factors other than trypanosomosis (Connor, 1994). These confounding factors are not always easily identifiable but they are likely to affect both trypanosomosis positive and negative animals. Hence, the average PCV of trypanosomosis-free herds are a good indicator of the levels of anaemia in the absence of trypanosomosis and could form the baseline for comparison between areas.

During 2005 and 2007, the overall livestock and cattle population had increased by 116% and 1038.9% in Chewaka and decreased by 45.7% and 47.5% in Bikiltu, respectively, the difference, in growth rate of livestock population between the two study areas, clearly shows the effect of tsetse control on animal production. The average growth rate of cultivated land per year in Chewaka between 2005 and 2007, 46.8%, resulted in average grain production growth rate/year of 31.6%, whereas in Bikiltu Didessa, although the total crop land had increased by 22.6%, the total grain produce declined by 46.5%. The controversy between growth of farm land and decline of grain production in Bikiltu might be due to losses of oxen as a result of trypanosomosis. The difference in animal management between the two study areas certainly has an effect on animal-tsetse contact and could have possibly contributed to the difference in the prevalence of trypanosomosis between the two areas.

Mortality of cattle was more common in Bikiltu study area than in Chewaka, only 9% of the respondents in Chewaka as compared to the 81 % in Bikiltu reported deaths of their animals during a year period and, mortality of cattle in Bikiltu was 10 times higher than in Chewaka signifying the severe outcome of trypanosomosis in tsetse uncontrolled, Bikiltu, as compared to the tsetse controlled study area. Furthermore, 51% of the total mortality in Bikiltu was attributed to deaths of draught oxen which undoubtedly resulted in the decline of crop production.

The significant difference in animal sell between the two study areas show better efficiency of animals and better family income in the tsetse controlled Chewaka as compared to the uncontrolled Bikiltu study area. Animal purchase is one of the factors to estimate the status of trypanosomosis and economic potential of farmers in endemic areas of tsetse-born trypanosomosis. The difference in bull purchase amounting to 39.3%, was accredited to the disparity between the two study areas in tsetse control, and comparatively show, the superior economic status and encouragement of Chewaka farmers to purchase animals as compared to Bikiltu farmers. Currently, the reduction in the calamity of trypanosomosis in Chewaka is going real by the activity of farmers in the area; they are enthusiastically engaged in small scale fattening which enabled them to have attractive livestock value in their locality, for the reason of which, more than 500 fattened oxen were sold to the capitals' market within three months of 2006

Farmers in Bikiltu commonly use trypanocidal drugs to treat their animals, however lack of knowledge on drug dilution and dosages as well as inconsideration of body weight estimation, were observed during the questionnaire survey. High mortality of animals in spite of high treatment frequency as well as high recurrence of parasitaemia in recently treated animals suggest the presence of drug resistance problem in Bikiltu study area. This insight had been reported by previous workers in the area and in the south western part of the country (Mulugeta, *et al*., 1997; Ademe and Getachew, 2000; Afework, *et al.*, 2000; Asefa and Abebe, 2001; Nega, *et al.*, 2004).

6. CONCLUSION AND RECOMMENDATIONS

The changes made in chewaka settlement station, as observed during the two years control period and a year after it, were satisfactory in that, the overall tsetse density had declined to extremely low level, tsetse was nearly cleared from four of the seven sites and remained in only few pocket areas of the remaining three sites, prevalence of bovine trypanosomoses had diminished to negligible position and the average herd PCV had increased significantly.

The prevalence of bovine trypanosomosis and density of tsetse fly in Chewaka tsetse controlled area was much lower than in the tsetse uncontrolled Bikiltu study area

The socioeconomic status of farmers in chewaka settlement station was much better than farmers in Bikiltu farmers' association. The improvements made on the general livelihood of the human population in chewaka, in terms of, growth in animal population, crop production, income from animal sell and animal purchasing power are promising.

However, as disease control programs have been decentralized and decision-making is left to district/regional level, these initiatives would face difficulty of sustainability and unless implemented over a wide geographic range and supported by more advanced technologies like the SIT , their effectiveness will be compromised in the long-run. Further research is recommended on the seasonal dynamics of tsetse population, prevalence of trypanosomosis in different livestock species and on an area wide application of SIT in the south western region of the country.

whilst the level of tsetse density and prevalence of trypanosomosis become minimized in an area, certainly, there will be an increasing pressure on the fallow and forest land as a consequence of increased human and livestock population as well as additional demand for crop land, therefore, attention should be given to maintain the ecological balance of the area through land use planning, principally, to look after the forest and the wildlife fauna within it.

Farmers of chewaka settlement station had perceived the benefit of the two years control program in terms of changes in their livelihood, nevertheless, as the achievements gained within this short period might lead to overconfidence and reluctance towards future control operations further motivation of the community to sustain and strengthen the achievements gained by the previous control program and to avoid the risk of tsetse re-invasion is highly mandatory.

The experience gained from the control program in chewaka settlement station could be a good example for the neighboring Bikiltu Didessa farmers' association and the rest farmer communities in the tsetse belt region of the country. Motivation of such highly distressed community towards tsetse control operation would be valuable not only for the beneficiaries but also for the national campaign against tsetse and trypanosomosis and to manage the ever expanding trypanocidal drug resistance problem in southwestern Ethiopia.

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8. 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

6. In which season of the year is livestock feed least available?

_____

C) Livestock diseases

1. Name the 5 most common diseases affecting your livestock

a) _____

b) _____

c) _____

d) _____

e) _____

2. Does trypanosomosis occur in your area?

Yes_____ No_____

3. If yes, would you rank trypanosomosis with regard to cattle loses compared to other Diseases?

a)_____

b) _____

c) _____

d)_____

e)_____

4. Which livestock does trypanosomosis most affect?

□ Cattle □ Equine

□ Small ruminant

5. Do you know the signs of trypanosomosis?

□ Yes □ No

6. In which season or months do livestock most often get the disease (trypanosomosis)

□ Wet season

□ Dry season

7. 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

8. Do you know that flies transmit trypanosomosis?

□ Yes □ No

9. If yes, to question No. 7, which flies do you think to transmit trypanosomosis?

□ Tsetse flies □ I do not know

□ other biting flies

10. In which season are tsetse flies abundant?

□ Dry season □ All the year

□ Wet season

11. 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. Which disease control method(s) do you know?

□ Tsetse trapping □ Trypanocides

□ Pour-on application □ others

6. Which disease control method(s) do you prefer for effectiveness?

□ Tsetse trapping □ Trypanocides

□ Pour-on applications □ others

7. Have you participated in tsetse control?

□ Yes □ No

8. How do you participate in the future?

□ Money □ Buy and use of trypanocides

□ Labour □ I do not want

9. 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. Cultivated land (hectares)

a) Maize _____ b) Sorghum _____ c) Teff_____

d) Coffee _____ e) Others _____

5. Milk production (average in liters) of an individual cow

_____ Per day _____average days of lactation

6. Draught oxen-work out put

_____Hours per day _____Work days per year

7. Sale price (Birr)

Female calf _____ Bull calf _____ Heifer_____ Cow_____

Oxen _____ Milk per liter_____ Labour value of oxen/day_____

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

Animal category	Sold	Slaughtered	Died(Crude mortality)	Sick (trypanosomosis)		Introduced into herd(born,purchased ,etc)
				Treated	Died	
Oxen						
Cows						
Female calf						
Male calf						
Heifer						
Bull ox						

10. 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 _____

9. CURRICULUM VITAE

Personal Information

Name**: Manyazewal Anberber Zeleke**

Nationality: Ethiopian

Sex: Male

Place of birth: Gursum, E. Harerge

Date of birth: 10 june 1963

Marital status: Married

Academic qualification: Doctor of Veterinary Medicine (DVM)

Scientific Membership: Member of the Ethiopian Veterinary Association (EVA)

Educational Background

1972-1977: Grade 1- 8. Number 1 elementary and junior secondary school (Gursum).

- 1979-1982: Grade 9-12. Harar Junior secondary school (Harar). Award:
- Ethiopian School Leaving Certificate Examination (ESLCE)
- 1981-1989: Addis Ababa University, Faculty of Veterinary Medicine, Debre Zeit. Award: DVM degree
- 2005 to the present: Addis Ababa University, Faculty of Veterinary Medicine, Debre Zeit. Postgraduate MSc Student in Tropical Veterinary Epidemiology

Work Experience

- 1989__ 1995: Veterinary officer in various districts of JImma zone.
- 1995__ 1998 Veterinary team leader of Jimma zone.
- 1998 to the present: Bedelle Regional Veterinary Laboratory

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References

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10. SIGNED DECLARATION SHEET

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

Name: _____

Signature: _____

Date of submission: _____

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

Advisors: ----------
