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FACULTY OF VETERINARY MEDICINE

EPIDEMIOLOGY OF BOVINE TRYPANOSOMOSIS IN SELECTED SITES OF THE NEWLY ESTABLISHED SETTLEMENT AREAS EAST WOLLEGA ZONE, WESTERN ETHIOPIA

BY

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DEBRE ZEIT, ETHIOPIA

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ABBREVIATIONS

A I	Anger I
A II	Anger II
AAU	Addis Ababa University
ARD	Agriculture and Rural Development
ARDB	Agriculture and Rural Development Bureau
BCT	Buffy Coat Technique
CI	Confidence Interval
CSA	Central Statistical Authority
Df	Degree of freedom
FAO	Food and Agriculture Organization of the United Nations
FSDPP	Food Security, Disaster Prevention and Preparedness office
FVM	Faculty of Veterinary Medicine
ILCA	International Livestock centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
ISCTRC	International Scientific Council for Trypanosomosis Research and
K	Kenaf
Km	Kilometer
m.a.s.l.	Meters above sea level
MOA	Ministry of Agriculture
MOARD	Ministry of Agriculture and Rural Development
MWFV	Mean Wing Fray Value
NTTICC	National Tsetse and Trypanosomosis Investigation and Control Centre
OAU	Organization of African Unity
OIE	Office International des Epizooties
OR	Odds Ratio
PATTEC	Pan African Tsetse and Trypanosomosis Eradication Campaign
PCV	Packed Cell Volume

SPSS	Statistical Package for Social Sciences
STRC	Scientific and Technical Research Commission
T. c.	*Trypanosoma congolense*
T. v.	*Trypanosoma vivax*
TBS	Thin Blood Smear
TCS	Trypanosomosis Control Services
US$	United States Dollar
WFP	World Food Programme
WHO	World Health Organization of the United Nations

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ABSTRACT

A study on the epidemiology of bovine trypanosomosis in selected sites of the newly established settlements of Anger I, Anger II and Kenaf areas was conducted in East Wollega Zone, Oromiya Region, Western Ethiopia. The purpose of the study was to determine the prevalence of the disease and associating risk factors and estimate the apparent densities and distributions of tsetse and other biting flies. It was also to generate baseline data that may assist in decision making for planning and implementation of the settlement programmes. Retrospective study and questionnaire survey were conducted to collect background descriptive data and cross-sectional survey to determine the prevalence and vector apparent densities and distributions in late rainy and dry seasons in 2005/06. A total of 576 cattle were sampled and the buffy coat technique was applied to diagnose the trypanosome infection and 96 mono-pyramidal traps to capture the vector fly. Differences between parameters were tested for significance at probability levels of 0.05 or less. Results of the retrospective study and questionnaire survey indicated that bovine trypanosomosis is the major constraint to cattle production in the settlement areas. The curative and preventive doses of trypanocidal drugs are commonly used to control the disease. However, many cattle owners have developed the practices of selling out their work oxen after each crop season as the coping mechanism with the disease risk to replace by new animals and generate additional incomes from sales. The entomological survey showed that only two tsetse species, *Glossina morsitans submorsitans* and *G. tachinoides* were found to exist along with other biting flies of the tabanid and muscid groups. The *G. m. submorsitans* was detected at a mean apparent density (fly/trap/day) of 0.01 and *G. tachinoides* at 0.35. The overall apparent densities (fly/trap/day) were found to be 0.36 (95% CI = 0.22 – 0.50), 1.26 (95% CI = 0.55 – 1.97) and 41.15 (95% CI = 28.8 – 53.5) for tsetse, tabanids and muscid flies respectively in the study areas. The seasonal apparent densities were 0.40 and 0.33 ($p > 0.05$), 2.18 and 0.34 ($p < 0.05$), 76.0 and 6.29 ($p < 0.05$) for tsetse, tabanids and muscid fly in late rainy and dry seasons in corresponding order. The fly apparent densities in different vegetation types were assessed but the differences were not statistically significant ($p > 0.05$) for all fly kinds. The sex ratio for tsetse fly was determined and fewer proportion of male flies detected (21/58) and (15/47) during late rainy season and the dry season, respectively. The average age for male tsetse fly sample population was estimated from wing fray analysis and observed to be 19 and 16 days for late rainy season and dry season, respectively. The overall prevalence of bovine trypanosomosis was 8.9% (95% CI = 7 – 11%) the seasonal infection rate being 14.9% (95% CI = 11 – 19%) and 2.8% (95% CI = 1 – 5%) with statistically significant difference ($p < 0.001$) between late rainy and the dry seasons respectively. In all cases the dominant trypanosome species was *Trypanosoma congolense* 56.8% (95% CI = 43 – 71%) followed by *T. vivax* 31.4% (95% 21 – 47%). The prevalence of trypanosome infection in newly introduced cattle from tsetse free areas was 12.4% (95% CI = 8 - 16%) whilst in native animals 4.3% (95% CI = 2 – 6%) with a statistically significant difference ($p < 0.01$) between the two groups. The prevalence by sex was 8.4% (95% CI = 4 – 12%) in the female and 9.1% (95% CI = 6 – 12%) in male counterpart. The infection rates in different age groups were nil, 8.0% (95% CI = 5 – 12%) and 10.0% (95% CI = 7 – 13%) in animals of less than 1, 1 – 4 and above 4 year-old, respectively. The differences in infection were not statistically significant ($p > 0.05$) between sexes and age groups. Analysis of the interaction of the assumed risk factors indicated season and origin to be the risk factors ($p < 0.01$) for trypanosome infection among the cattle population of the settlement areas. However, sex was not ($p > 0.05$) while age was signified to be risky which is largely determined by absence or presence of exposure to tsetse challenge. The risk of acquiring infection was lower in the dry season as compared to late rainy season (OR = 0.13, 95% CI = 0.06 – 0.28) and 3.36 times higher (OR = 3.36, 95% CI = 1.64 – 6.88) in the newly introduced than in the native cattle population. The mean PCV values were 27.23% (95% CI = 26.77 – 27.69%) and 20.22% (95% CI = 18.75 – 21.68%) with statistically significant difference ($p < 0.001$) for the non-parasitaemic and parasitaemic animals respectively. The mean PCV value was negatively correlated ($r = -0.35$) with the trypanosome prevalence. Bovine trypanosomosis is the major constraint in the newly established settlement areas. Introduction of susceptible cattle population to tsetse infested settlement areas would result in heavy losses especially animals coming from tsetse free areas being the high risk group when the vector challenge is high. Different epidemiological circumstances appeared to exist that would maintain the contact between tsetse and the host animal. Interiorly tsetse-infested wooded borders of many rivers and streams that traverse the areas as well as scrap of forest at the edge of settlements to which *G. tachinoides* seems well adapted would sustain their constant interactions. On the other hand moderately infested peripheries to which *G. m. submorsitans* receded that have a link with the major tsetse belt constitute a potential risk to the areas. Furthermore, the frequent movement of animals coming from or crossing the tsetse-infested areas to the major market outlet in Uke, Kenaf prefecture is the major source of infected animals. The vast potential land in the settlement areas would only be exploited if the problem of animal trypanosomosis is resolved under the present crop-livestock farming system. Therefore, community based integrated control option should be promoted with strong surveillance and monitoring activities.

Keywords: Bovine, Origin, Settlement, Season, Trypanosomosis, Trypanosome, Tsetse.

1. INTRODUCTION

Tsetse-transmitted trypanosomosis is the widespread protozoan disease complex affecting cattle and other wide range of hosts in the sub-Saharan Africa. The course of the disease may run from a chronic long lasting to an acute and rapidly fatal one depending on the vector-parasite-host interactions (Bourn, 2001). The disease is mainly characterized by intermittent fever, progressive anaemia and loss of condition of susceptible hosts which if untreated leads to heavy mortalities. The disease is caused by the pathogenic species of the trypanosomes transmitted cyclically by tsetse fly (Glossina species) and non-cyclically by other biting flies except *Trypanosoma equiperdum*, which follows another epidemiological route of transmission among the equine population in its endemic areas.

Trypanosomosis is the main constraint to the cattle production on the continent of Africa and prevents full utilization of land. Much of the best grazing land on which cattle can be raised is infested by tsetse flies which can transmit the pathogenic trypanosomes: *Trypanosoma congolense*, *T. vivax* and *T. b. brucei* (Luckins, 1992). Out of 165 million cattle found in Africa only 50 million are found within the tsetse belt. These are mainly low producing breeds that are maintained on high drug management regimen to keep trypanosomosis in check. The presence of tsetse flies and trypanosomosis forced people and livestock to crowd into partially environmentally fragile tsetse free areas leading to overgrazing and erosion (PATTEC, 2001).

In Ethiopia five species of tsetse flies are known to exist and a total of an estimated 220,000 km square of land is infested (NTTICC, 1996). Four species of tsetse-borne trypanosomes are found in the country, which are *T. congolense, T. vivax, T. b. brucei* of livestock and *T. b. rhodesiense* of humans (Langridge, 1976). Due to the fear of trypanosomosis majority of human and livestock populations are concentrated in the tsetse free areas leading to depletion of natural resources and recurrent attacks from drought and famine. All these factors being the major driving forces behind, the need is rapidly growing now to settle in the areas of river basins including the tsetse-infested fertile valleys. To this effect extensive operations have been undertaken since 2003 to resettle 2.2 million people within 3 - 5 years time (MOARD, 2005).

Most of the settlement areas are tsetse-infested which poses major constraints to the programme and livestock keepers to sustain in their new home areas. In the majority of the newly established settlement schemes of East Wollega Zone of Western Ethiopia bovine trypanosomosis is the most important disease. In the beginning year of the settlement the disease caused heavy mortalities in certain settlements reaching to the extent of complete losses of a large number of introduced work oxen.

As sufficient information was lacking on the status of the disease and in response to the complaints raised from the community, the present study was proposed to undertake addressing the problem. Using the preliminary information available at hand the study sites were selected supposedly to include the low, medium and the high tsetse challenge areas. Based on this approach a study on the epidemiology of bovine trypanosomosis in selected sites of the newly established settlements of Anger I, Anger II and Kenaf areas was conducted in East Wollega Zone, Oromiya National Regional State, Western Ethiopia from October 2005 to March 2006 which covered the field research work in late rainy and the dry seasons. The study methods involved a retrospective study and questionnaire survey and cross-sectional entomological and parasitological surveys in two different seasons.

Understanding of the epidemiology of the disease will facilitate the choice of suitable control methods and help in planning for development programmes in the areas. Therefore, the study was carried out to generate baseline data that may assist in decision making for setting up the settlement programmes and administer appropriate tsetse and trypanosomosis control with the following objectives:

- Determine the prevalence of bovine trypanosomosis.
- Estimate the potential risk factors associating with the occurrence of the disease.
- Assess the apparent densities, distributions and species of tsetse and other biting flies.

2. LITERATURE REVIEW

2.1. Biology and Distribution of Tsetse Flies

The most distinctive feature of the life history of the tsetse flies, shared with only a few other small families of Diptera, is retention of the single egg in the uterus of the female, where it hatches to a larva and nourished by the products of a pair of modified accessory glands. This method of reproduction is referred to as adenotrophic viviparity (Langley and Weidehaas, 1986; Jordan, 1993; Leak, 1999). This form of reproduction involves cyclical production of eggs, which hatch in the uterus and the insect does not feed from the time it leaves the female fly as a mature larva until the adult emerges from the pupa (Phelps and Lovemore, 1994; Leak, 1999). Females are receptive to males as soon as they start seeking food and often mate when taking their first blood meal or soon after and mate once in lifetime. Male flies may not mate soon after emergence from the pupa and they are not fully fertile until they are a few days old. Active and viable sperms can remain in the sperm thecae, nourished by a secretion of layers of cells; surrounding the cuticular lining of the lumen of each sperm theca, throughout the life of the female. The whole pregnancy cycle takes about nine days although the rate of development of each stage is temperature dependent. By the ninth day the third instar larva with its two conspicuous black polypneuptic lobes at the posterior end is deposited through the vagina (larviposition) on the ground (Jordan, 1993). The successful burrowing in the soil by the deposited larva depends on various factors, for instance, soil particle size, moisture content of the soil and possibly the soil temperature are the most important ones.

Under favourable environmental conditions (temperature and moisture of the soil) newly deposited larva is transformed, within a few hours, into a hard almost black larva and moults to form the pre pupa, but remains within the third cuticle, which then harden to form the puparium within an hour of larviposition. Thirty days later adult fly emerges from the puparium with the sex ratio of 1:1. The puparial period is highly dependent on temperature; Jordan (1993) indicated that at a minimum temperature of 20^{0} C, the duration of puparium period is about 47 days while at 30^{0} C it is about 20 days only.

At temperature below 17^0 C and above 32^0 C there are insufficient fat reserves within the puparium and development cannot be successfully completed. The optimum temperature for the puparium development is about 25^0 C (Leak, 1999) and at this temperature male emerges after 27 days (Jordan, 1993).

Both sexes of tsetse flies feed exclusively on blood of vertebrates (mainly from mammals but some species take the meal from reptiles and birds). They usually search for hosts and food when they are active. It has been noted that female flies live longer than males. As a result of this, there are always more females than males in any tsetse population. A female fly may produce about 8 - 10 offspring in her lifetime. Consequently the rate of reproduction is much lower than in any oviparous insects and in fact resembles that of small mammals (Langley and Weidehaas, 1986; Leak, 1999) that is why the sterile insect technique (SIT) control method is facilitated. Leak (1999) noted even though more precise limits of distribution, particularly in low densities, are not known the general distribution of tsetse flies is determined principally by climate and influenced by altitude, vegetation and the presence of suitable host animals.

The effect of climate on tsetse distribution is often through its effect on vegetation. Buxton (1955) discussed in detail the relationship between tsetse flies and different climatic factors and effect of temperature on the ecology of tsetse flies is through its effect on the interval and puparial duration and also the influence on the activity of the flies. In temperature below 15^0 C tsetse flies are inactive and above 35^0 C they seek refuge in rot-holes in the trees and animal burrows and deep tissues in the barks, where they remain inactive (Phelps and Lovemore, 1994). Humidity is also important factor both for pupal and adult fly development (Nagel, 1995). Cumulative effect of long rainy season or dry season is thought to influence advances and recession in tsetse population (Leak, 1999). Humidity has also an important effect in relation to the behavior of the flies. Tsetse flies use light for searching food and most of them are active during day time (Buxton, 1955). The effect of altitude on tsetse distribution is through its effect on climate, mainly temperature. As temperature falls with increasing altitude, the geographic limitations of different species may be due to their inactivity in low temperature (Vreysen *et al*., 1999).

Different species of tsetse flies require particular vegetation type that would provide an optimal condition for growth and survival and vegetation is also important that provides shelter for their hosts (Buxton, 1955; Leak, 1999). Highest catches of *G. pallidipes* were in bushes and wooded grassland in the southern Rift Valley of Ethiopia (Vreyesen *et al*., 1999). The presence of wide different types of host animals is essential component of tsetse fly distribution. The distribution and abundance of some species of tsetse flies such as *G. morsitans* and *G. pallidipes* which are often known as game tsetse flies are closely related to the number and habitats of certain wild animals. Nagel (1995) also described that the highest densities of certain tsetse fly species are reported from areas with very high densities of wild animals and low human population areas.

2.2. Morphology of Trypanosomes

2.2.1. *Trypanosoma* (Nannomonas) *congolense*

Trypanosomes of this subgenus range 8 - 24 μm in length. Free flagellum is absent at any state in the life cycle, which is an unusual characteristic. The flagellum thus terminates at anterior end of the parasite. The posterior end of the body is usually rounded but can be slightly pointed in longer parasites. The medium sized kinetoplast is usually marginal and sub-terminal in position. *Trypanosoma congolense* is one of the smallest trypanosomes with an average length of 12-17 μm. *Trypanosoma simiae*, the porcine trypanosome is mostly pleomorphic in its characteristics and the average length is 15-19 μm 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 Ashford, 1983).

2.2.2. *Trypanosoma* (Duttonella) *vivax*

Trypanosoma (Duttonella) *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 it difficult to follow its movements (Stephen, 1986).

2.2.3. *Trypanosoma* (Trypanozoon) *brucei*

The blood forms of *T. brucei* measure from 11-39 µm in length and they are typically pleomorphic represented by three forms:

a) Slender forms (average length 14-39 µm) 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 sometimes truncated.

b) Stumpy trypanosomes (average length 17-22 µm) which are stout and usually without a free flagellum, undulating membrane is well developed, nucleus rounded (displaced to the posterior end in posterior nuclear forms), kinetoplast near broadly rounded and pointed posterior end.

c) Intermediate forms (average length 20-25 µm) in which the flagellum is shorter, the posterior end blunt and 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 (Stephen, 1986).

2.2.4. *Trypanosoma (*Pycnomonas*) suis*

The total length of *T. suis* has a range from 13-19 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 sometimes 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).

2.3. Tsetse and Trypanosomosis Challenge

2.3.1. In Africa

Nearly 10 million km square of Africa is infested by tsetse flies. Part of this large area is composed of fertile land that is left uncultivated, a so-called green desert abandoned by humans and cattle. Eradicating the tsetse and with trypanosomosis, the disease it carries, would allow rural Africans to reclaim areas of their continent and greatly increase food production. The tsetse fly transmits a deadly parasite, trypanosome that attacks the blood and tissue of its victims. It causes trypanosomosis known as Nagana in livestock and sleeping sickness in humans (FAO, 2002). The genus *Glossina*, which encompasses around 30 species and sub-species members of this group of biting flies, are commonly termed tsetse flies. These flies are confined to a belt of tropical Africa extending from the Southern Sahara (Latitude 15^0 N) and in the South (Latitude $20\text{-}30^0$ S). The species are restricted to various geographical areas according to habitat. The three main groups, named after the commonest species in each group, being Fusca, Palpalis and Morsitans, found respectively in forest, riverine and savannah areas. The last two groups because of their presence in the major livestock rearing areas are the most important from the veterinary standpoint.

The disease in human (sleeping sickness) caused by *T. b. gambiense* and *T. b. rhodesiense* is always fatal if left untreated. It causes malaise and associated waves of parasitaemia in affected individual (Jordan, 1986). Tsetse keeps people poor by preventing them from producing the food they need to survive. In fact, tsetse and trypanosomosis are major impediments to the development of sustainable agricultural systems in the region, hitting the poorest of the poor rural people in the most indebted countries in Africa (FAO, 2002).

Trypanosomosis is one of the most devastating diseases in Sub-Saharan Africa, killing 80% infected victims. The World Health Organization of the United Nations (WHO) reports over 60 million people, mainly living in rural areas of Sub-Saharan Africa, are at risk of becoming infected with the disease. Out of the estimated 500,000 people already infected 25,000 die every year and the situation is rapidly deteriorating with more than 40,000 new cases being registered every year, excluding the many unreported cases from inaccessible rural areas (surveillance covering only 5-7 % people at risk).

Trypanosomosis kills 3 million livestock animals each year and reduces the productivity of sick animals. About 50 million animals are at risk from Nagana. Domestic livestock in Africa are important as sources of protein (meat and milk), animal traction and investment (social security) and measure for enhancing agricultural (crop) production (Erkelens *et al*., 2000). The Food and Agricultural Organization of the United Nation (FAO) has estimated that 35 million doses of trypanocidal drugs (worth about US $ 35 million) are bought every year in futile efforts to maintain livestock free of the disease.

The annual losses directly attributed to trypanosomosis, in terms of reduced meat and milk production and in terms of the costs related to treating the disease or controlling the vector, have been estimated at US $ 1.2 billion. This figure rises to over US $ 4.5 billion per year, if losses in potential crop and livestock production attributable to the disease are considered and excludes the losses attributable to the effects of sleeping sickness in humans.

Majority of the areas that are infested with tsetse flies are most suitable for livestock and crop production extending from Senegal in the north to South Africa in the south. These areas, however, are virtually devoid of cattle and other domestic livestock (Figure 1).

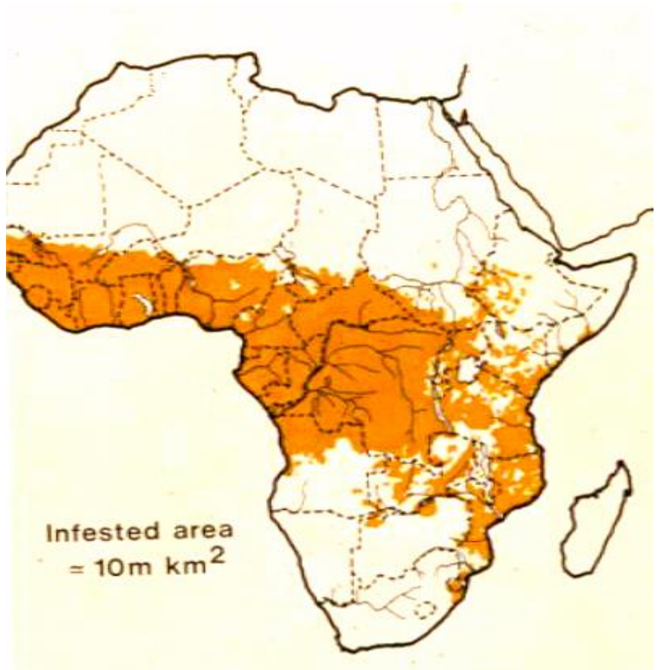


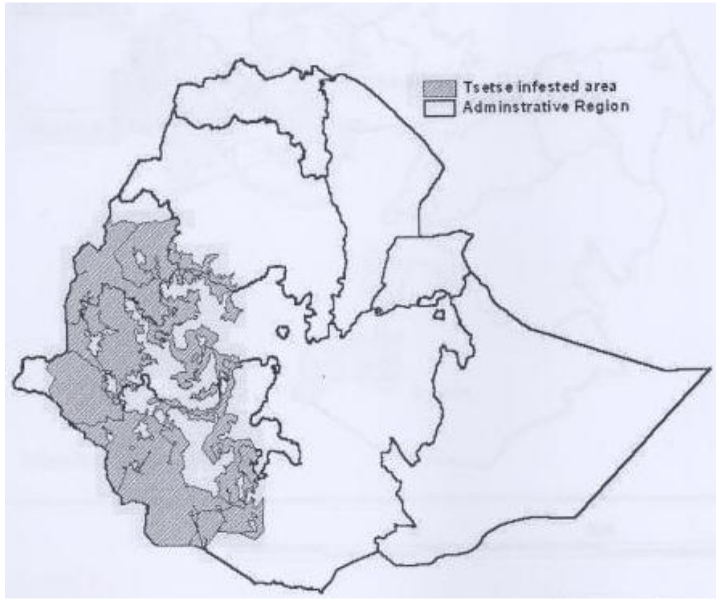
Figure 1. Distribution of tsetse flies in Africa.

Reports of reinfestation of areas that had previously been cleared of the tsetse fly are frequent. The numbers of cases recorded of the disease in man and domestic animals have reached unprecedented levels. Despite this situation, no vaccine against the disease is available and no new drugs are being developed. Some of the drugs used to treat sleeping sickness are highly toxic. All drugs currently used to treat trypanosomosis have been rendered largely ineffective by widespread drug-resistance. The future availability of drugs against trypanosomosis is uncertain since their continued production is threatened for commercial reasons. The only market is Africa where the purchasing power of the consumers affected is poor and rapidly deteriorating (PATTEC, 2001).

2.3.2. In Ethiopia

Ethiopia is located in the Horn of Africa between latitude 3^0-15^0 N and longitude 33^0 - 48^0 E is an agrarian country. The rural agricultural sector makes up 85% of the total population and accounts for 95% of all crop and livestock production (Slingenberg, 1992). Previous workers have estimated the potential area of tsetse infestation as 98,025 km square based on 1600 meters above sea level of breeding limit (Langridge, 1976). However, in more recent years tsetse flies have progressively invaded productive potential agricultural areas in the west and Southwest parts of the country. It is estimated that a total area of 220,000 km square is currently infested with different species of tsetse flies in which case livestock below 2000 meters above sea level contour are exposed to various levels of trypanosomosis risk (NTTICC, 1996).

Five species of tsetse are known to exist in the tsetse belt areas namely: *Glossina longipennis*, *G. m. submorsitans*, *G. pallidipes*, *G. fuscipes fuscipes* and *G. tachinoides*. Pertaining to their specific ecology, *G. m. submorsitans* is usually found in deciduous woodland and wooded grassland, often interspersed with evergreen vegetation. *G. pallidipes* almost invariably associated with extensive and fragmented thickets including evergreen species. *G. longipennis* inhabits in dry acacia, thorny bush and is very active after sunset and before nightfall. *G. fuscipes* and *G. tachinoides* are common to valley forests, thickets and fringing vegetation on streams, rivers and lake shores (Langridge, 1976). Tsetse infested region of the country is indicated in Figure 2.



(Source: WFP, 1998)

Figure 2. Distribution of tsetse flies in Ethiopia.

Four species of tsetse borne trypanosomes are known to exist namely: *T. congolense T. vivax, T. b. brucei* of livestock and *T. b. rhodesiense* of humans were identified and their distribution and frequency in hosts are recorded. *T. vivax* was detected in almost all regions of the country below 2,500 meters above sea level altitude limits (Lemecha, 1994). Also *T. evansi* and *T. equiperdem* are known to exist in the country. Some prevalence studies on animal trypanosomosis are indicated on Table 1.

Table 1. Some of the published papers on prevalence studies on animal Trypanosomosis.

Hosts	Study sites	Prevalence (%)	Major trypanosomes	Authors
Cattle	Arbaminch	32	*T. congolense* ***T. vivax***	Argaw and Abebe, 1988
	Southwest Ethiopia	17.7	*T. congolense* *T. vivax*	Abebe and Jobre, 1996
	Metekel	17.2	*T. congolense* *T. vivax*	Afewerk *et al*, 2000
	Didessa	21.3	T. *congolense* *T. vivax*	Tewelde *et al*, 2004
Sheep	Didessa/Ghibe	7.65	*T. congolense* *T. vivax*	Dinka and Abebe, 2005
Goats	Didessa/Ghibe	3.56	*T. congolense* *T. vivax*	Dinka and Abebe, 2005
Donkeys	North Omo	18.2	T. congolense *T. vivax*	Assefa and Abebe, 2001
Camel	Borena	10.9	*T. evansi*	Tekle and Abebe, 2001

2.4. Epidemiology of Bovine Trypanosomosis

Three elements influence the epidemiology of the disease, namely distribution of the vectors, the virulence of the parasite (trypanosome) and response of the host. Any discovery, even if it is only partial, leads not only to a better understanding of this complex group (parasite-vector-host and their multiple interactions) but also to a better control of the disease (Clair, 1987).

2.4.1. The Vector

Of the three groups of *Glossina*, the savannah and riverine are the most important as they inhabit areas suitable for grazing and watering. Although the infection rate of *Glossina* with trypanosomes is usually low, ranging from 1 to 20 % of the flies, each is infected for life. Their presence in any number makes the rearing of cattle, pigs and horses extremely difficult (Urquhart *et al*., 1996).

Apart from the tsetse, which is the main vector of trypanosomosis, other biting insects can transmit the disease (tabanidae, muscidae, hippoboscidae) through interrupted blood meals. This ″mechanical transmission″ is difficult to study and there is still little information on it. It concerns primarily *T. vivax*, which is also transmitted cyclically. This phenomenon undoubtedly plays a role in the dispersion and growth of the disease. However, in the absence or disappearance of tsetse it becomes less serious.

It is evident that disease risk depends primarily on the density of the vector. All factors influencing tsetse populations, disease risk and consequently the evolution of the disease should be considered, i.e. climatic and ecological factors, presence of trypanosomes, food sources (hosts) etc. Tsetse flies (Glossina species) are larviparous and have low reproductive rate. Both sexes are bloodsuckers and are vectors all their lives (Seifert, 1996).

The general distribution of tsetse flies is determined principally by climate and influenced by altitude, vegetation and presence of suitable host animals. Each of these factors may directly affect the birth, death or migration rates of the vector and thus the population size (Hay *et al*., 1996).

The most favourable temperature for Glossina is between 21 and 24^0 C for the adult stage while too high (> 35^0 C) or too low temperature (< 14^0 C) hinders puparia from completing their development. The condition of the soil is more important than the type. If it is hard and compacted or if it is very fine dust, the tsetse larva cannot burrow into it to pupate. Badly drained soil can become water logged and drown the pupae.

Vegetation is an important ecological component for the tsetse. It spends most of its life in woody vegetations and consequently shelter from unsuitable weather conditions is of great importance. Therefore, shrubs and trees by providing shelter are deciding factors for the distribution of tsetse species (TCS, 1980).

2.4.2. The Parasite

Trypanosomes are insect-borne and their epidemiology is determined by the ecology of their insect vector, the tsetse. Cyclical African trypanosomes are transmitted by several species of the tsetse fly *Glossina* found only in sub-Saharan Africa excluding areas of high altitude, extreme drought or cold temperatures. The flies have strict requirements of temperature and vegetation. The carrier state reservoirs of the trypanosomes are found in many wild animals and in domestic ones that are affected by the chronic disease. Tsetse flies caught in and around game reserves tend to have relatively high infection rates. For this reason, animals grazing close to a game reserve or park are at higher risk. Furthermore, the relative abundance of wild life in East Africa, as compared to West Africa may explain, at least in part, why the prevalence of the disease appears to declining more rapidly in the west. Once trypanosomes have been introduced into a herd, transmission is possible even in the absence of *Glossina* (non-cyclical). Biting flies such as Tabanidae, Stomoxyinae and Hippoboscidae are capable of mechanically transmitting trypanosomes in their mouthparts if they feed on more than one host within a short interval. This is how *T. vivax* is spread in areas outside the tsetse belt in Africa, Central and South America. Mechanical transmission can also occur through the needle during inoculations and in carnivores feeding on infected carcass. In addition, intrauterine infections occasionally occur with different species of trypanosomes (Radostits *et al*., 1994).

Since parasitaemic animals commonly survive for prolonged periods, there are ample opportunities for fly transmission, especially of *T. brucei* and *T. congolense*. In contrast some strains of *T. vivax* in cattle and *T. simiae* in domestic pigs kill their hosts within 1-2 weeks so that the chances of fly infection are more limited. Perhaps the most important aspect of trypanosomosis, which accounts for the persistent parasitaemia, is the way in which the parasite evades the immune response of the host.

Metacyclic and blood stream trypanosomes possess a glycoprotein (Variable Surface glycoprotein, VSG) coat, which is antigenic and provokes the formation of antibodies that cause opsonization, and lysis of the trypanosomes. Unfortunately by the time the antibody is produced, a proportion of the trypanosomes have altered the chemical composition of their glycoprotein coat and now, displaying a different antigenic surface, are unaffected by the antibody.

Those trypanosomes possessing this new variant antigen multiply to produce a second wave of parasitaemia; the host produces a second antibody, but again the glycoprotein coat has altered in a number of trypanosomes so that a third wave of parasitaemia occurs. This process of antigenic variation associated with waves and remissions of parasitaemia, often at weekly intervals, may continue for months, usually with a fatal outcome.

The repeated switching of the glycoprotein coat is now known to depend on a loosely ordered sequential expression of an undefined number of genes, each coding for a different glycoprotein coat. The complexity of antigens potentially involved has also defeated attempts at vaccination (Urquhart *et al*., 1996).

2.4.3. The Host

Trypanosomosis is basically an infection of wildlife in which it has achieved a mode of survival in that the animal hosts are parasitaemic for prolonged periods, but generally remain in good health. This situation is known as trypanotolerance. In contrast, rearing of domestic livestock in endemic areas has always been associated with excessive morbidity and mortality. However, there is evidence that a degree of adaptation or selection has occurred in several breeds. Precisely how trypanotolerant animals cope with antigenic variation is unknown. It is thought that the control and gradual elimination of the parasite may depend on the possession of a particularly rapid and effective antibody response, although other factors may also be involved (Urquhart *et al*., 1996).

With regard to host factors in the mammalian host, the effect of the infection varies with the host in that most wild animals and some domestic ones establish a balance with the parasite and remain as clinically normal carriers for long periods. Also some breeds of cattle indigenous to Africa can tolerate light to moderate challenge with tsetse flies by limiting the multiplication of trypanosomes in their blood. This phenomenon of trypanotolerance is both genetic and environmental in origin. The taurine breeds such as N' Dama and Baoule are more tolerant than the West African zebu. Amongst the East African zebu cattle, the Orma Boran has superior tolerance. Trypanotolerance also occurs in some indigenous breeds of small ruminants, notably the West African Dwarf sheep and goats and the East African goats.

Environmental factors: the density of tsetse fly population in the area and the level of their contact with the host will determine the level of infection that will occur. This is further influenced by the vectorial capacity of the fly and the availability of its preferred host, which is not necessarily domestic livestock. Trekking of cattle through tsetse-infested vegetation is a risk.

Agricultural and industrial developments generally lead to a lowering of tsetse density by destroying its habitat where as the establishment of game or forest reserves provides large numbers of preferred hosts or a suitable habitat for tsetse, respectively.

Pathogen factor: in cattle *T. vivax* generally produces higher level of parasitaemia than the other species. Its life cycle in the tsetse fly is also shorter. *T. vivax* is readily transmitted than the others when animals are introduced into a tsetse infested area. It can also be transmitted mechanically.

Immune mechanism: animals recovering from infection with one strain or species of trypanosome are not immune to infection with another strain or species. Animals infected with trypanosomes are more susceptible to secondary infections by other microorganisms, particularly bacteria. The mechanisms involved in the immunosuppression are not fully understood but may vary among species of animals.

Zoonotic implication: the species of trypanosomes that infect livestock are generally not transmissible to humans with the possible exception of *T. brucei*, which is morphologically indistinguishable from human pathogens, *T. rhodesiense* and *T. gambiense*. Humans contract the disease when bitten by tsetse flies, which generally abound in game parks, forest reserves and along streams. Consequently the disease is seen essentially in rural populations and in visitors to those areas (Radostits *et al*., 1994).

The epidemiology of animal trypanosomosis is extremely complicated as the wild animals constitute a range of reservoirs of the disease (Clair, 1987). The principal host animals of *G. m. submorsitans* are warthog (30 - 45% of food source) and some bovids, (25-40%), of which kudu is the most important followed by buffalo, bushbuck and eland. *G. pallidipes* obtains 80% of its food from bushbuck and the remaining chiefly from bushpig. *G. fuscipes* and *G. tachinoides* take most of their meals from reptiles (crocodiles, varanus lizard, snake) and thicket haunting bovids such as bushbuck.
These species can persist on diets of human and domestic animal blood in the absence of their favourable hosts and hence become important vectors in epidemics of sleeping sickness.

The natural hosts of *G. longipennis* are rhinoceros, elephant, giraffe and buffalo. The degree of risk for domestic animals varies based on their proximity to tsetse habitat. High risk is considered when animals are in contact or within 10 km of tsetse and where the infection rate in herds may exceed 30% (TCS, 1980).

2.5. Diagnosis

Accurate diagnosis of trypanosome infection in livestock is required for a proper understanding of the epidemiology of the in any geographical locality. Besides clinical diagnosis, direct (parasitological) and indirect (serological) diagnostic methods with varying degrees of sensitivity and specificity are available for trypanosomosis.

2.5.1. Clinical diagnosis

In general, diagnosis of trypanosome infection based on clinical signs alone is rather difficult, but hematological parameters like PCV value could be reliable indicators of the progress of the disease. In regions where the disease is known to occur; fever, anaemia and loss of body condition are important parameters used routinely for tentative diagnosis of trypanosomosis in areas where the disease is endemic and laboratory services are not available (Uilenberg, 1998). Definitive diagnosis of the disease is ultimately dependent on the detection of the trypanosome in blood samples from infected animals.

2.5.2. Parasitological diagnosis

Parasitological diagnosis is the direct demonstration of the parasite in blood or less commonly in other body fluids using a microscope. The scarcity of the parasites and the fluctuating nature of the parasitaemia limit the use of the laboratory tests based on demonstration of trypanosomes in accessible body tissues such as the peripheral blood (Doyle, 1977). Therefore, several techniques for the concentration of blood trypanosomes have been developed, which increase the chance of trypanosome detection.

2.5.2.1. Dark ground/ Phase contrast/ Buffy coat technique

The buffy coat Zone prepared in a microhaematocrit capillary filled with 70 μl of blood and centrifuged for 5 minutes at 12000 rpm is examined for trypanosomes by cutting the capillary tube to include 1 mm of erythrocytes and 1 cm of the plasma. The buffy coat is poured on a slide and covered with a 22 x 22 mm cover slip. The preparation is examined using a microscope with a phase contrast and dark ground illumination. The use of 10x eyepiece in combination with a 25x objective gives optimal viewing by allowing large visual fields and sufficient magnification for ready identification of trypanosomes. This technique is the most sensitive of the parasitological tests for the detection of *T. congolense* and *T. vivax* detecting trypanosomes to an estimated level of just over 10^2 parasites per ml (Murray *et al*., 1977).

In addition, species identification based on size and movement is easier to assess (Paris *et al*., 1982). Trypanosomes can be identified and the level of parasitaemia is estimated using a scoring system. The PCV is measured before examination of the blood for parasitaemic detection.

2.5.2.2. Haematocrit Centrifugation Technique

A microhaematocrit capillary tube containing 70 μl of blood is centrifuged for 8 minutes at 10,000 rpm to measure PCV. Two rectangular pieces of glass from a standard microscope slide (1.2 mm thick) are fixed 1.5 mm apart on a microscope slide. The prepared capillary is then placed in the slot and a drop of immersion oil put on top of capillary tube. The oil fills the space between the capillary tube and the two pieces of glass, thus reducing the effect of light diffraction. By slowly rotating the tube the buffy coat plasma junction is examined using a long working distance (6.7mm) objective that allows considerable depth of focus through the capillary unlike the standard objective where the average working distance is approximately 0.5mm. Depending on the trypanosome species the analytic sensitivity for this method is 1-5 x 10^2 trypanosome per ml of blood.

Other diagnostic methods including capillary concentration technique, biochemical tests, serological tests to detect specific humoral antibody and circulating antigens (Ab-ELISA, Ag-ELISA, CFT, Passive Haemagglutination test, etc), and the molecular tests DNA – Probes and PCR techniques could be used.

2.6. The Growing Need for more Fertile Land in the Tsetse-infested Areas

Of 165 million cattle in sub-Saharan Africa, 155 million are in tsetse free areas such as the highlands or the semi-arid Sahel Zone, leading to overgrazing by animals and overuse of land by people for food production. Breaking the cycle of poverty and hunger must therefore incorporate decisive action against trypanosomosis (FAO, 2002). The human population of Africa is growing at high rate of 3% a year, while food production lags behind in growth rate at 2% (Masiga, 1995). The livestock population of Ethiopia is estimated at 30 million heads of cattle, 21.7 million sheep, 16.7 million goats, 7.02 million equines and 1 million camels (CSA, 1998). In Ethiopia considering only the highland and lowland agro-ecological Zones, which roughly constitute 35 % and 65 % of the general composition respectively, the highland Zone is estimated to accommodate 85 % of human population, 80 % of cattle, 75 % of sheep and 90 % of equine population which subject it to high population pressure. This huge concentration of population at highland is badly hitting the ecologically fragile zone as the result of overgrazing, over ploughing, soil erosion and depletion of natural resources. Thus, the end result is being recurrent attack of drought and famine and hence poverty. Now all these prevailing bad features of the livelihoods are being the major driving forces to move the affected people to the vast fertile areas of the country, which are mainly tsetse affected.

To this effect the settlement programme planned by government is in operation since 2003 targeting to resettle 2.2 million people within 3-5 years time (MOARD, 2005: personal communication). Therefore, to break the cycle of hunger and poverty farming in the tsetse affected areas should be possible. To achieve this goal the extensive fertile valleys in the tsetse-affected areas of the country must be cleared of tsetse and trypanosomosis, which give opportunities for improving livestock productivity and the integration of livestock with cropping sector. Livestock are the integral part of the rural economy.

The direct impacts of trypanosomosis incidence are the morbidity, mortality, lower work efficiency and the costs of treatment for the animals that contract the disease. The indirect impacts of trypanosomosis incidence are the changes in human settlement, crop production and land use that occur due to the reduced productivity of existing animals raised under trypanosomosis risk (Swallow, 1997).

2.7. Tsetse and Trypanosomosis Control

Options available for controlling animal trypanosomosis in Africa are identified as following: Autonomous, anthropogenic impacts that influence and modify the extent and severity of the disease are distinguished from more purposive, managed and intentional control measures. Autonomous control includes the environmental impacts of human population growth, the expansion of agriculture, settlements and road networks, and the elimination of wild life, through hunting and habitat loss (Bourn *et al*., 2001). Purposive control measures fall into three categories: those related to animal husbandry and breeding; those directed against the trypanosomes and those targeted at tsetse.

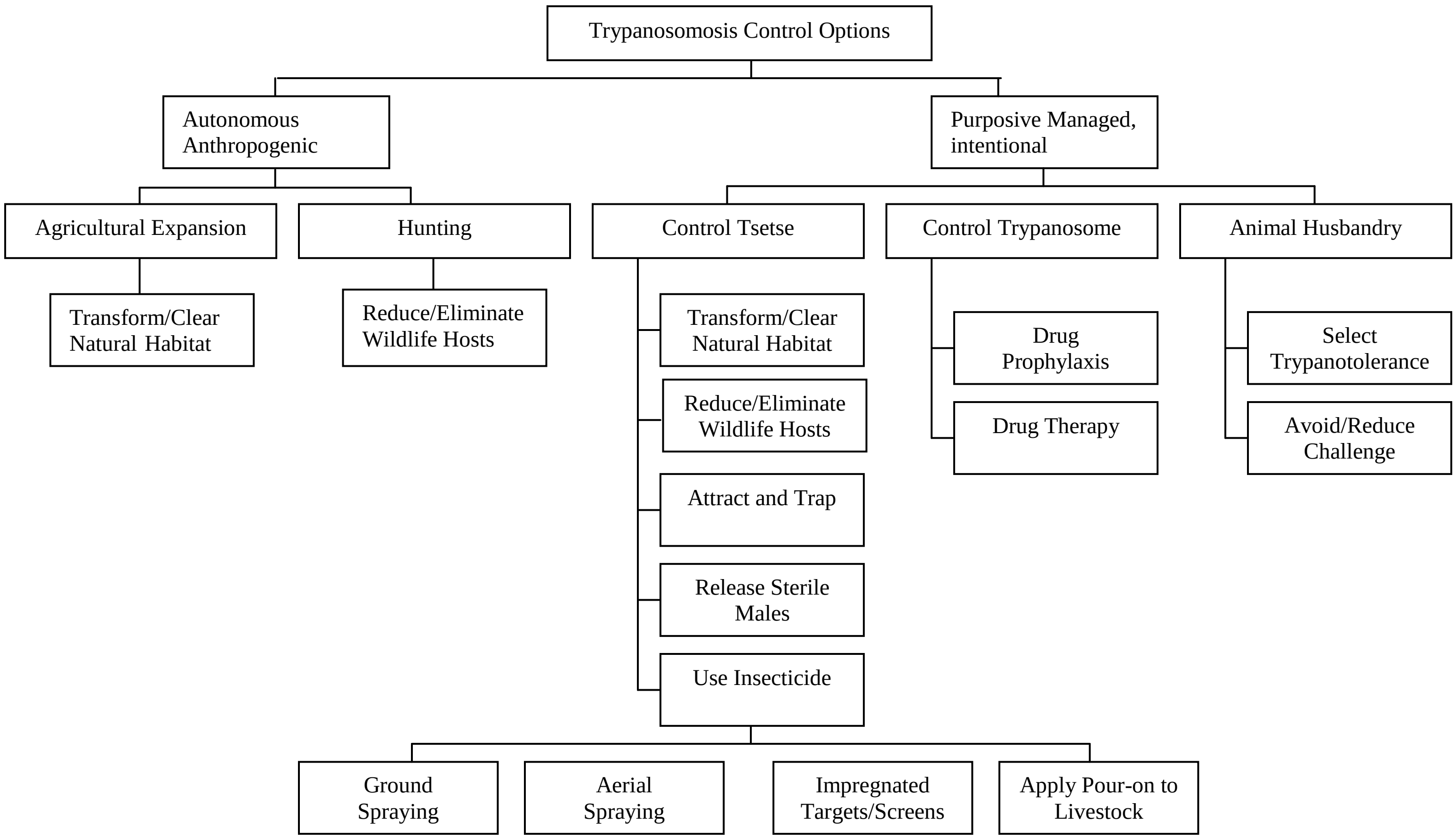
Experience has shown that no one single technology or approach will result in the eradication of tsetse flies from an area. Therefore, integrated approach and use of appropriate combinations of available technologies in the tsetse eradication effort is very important. This will include the promotion of agricultural development in suitable areas, the linking of ongoing and planned projects, the detection and treatment of trypanosomosis, the provision of support for the development and application of appropriate conventional and new technologies for fly population control, the establishment of barriers, etc. (PATTEC, 2001).

Many of the large valleys in the South and South western Ethiopia, which are at present infested with tsetse, favour luxurious growth of vegetation and are suitable for profitable cultivation. At present people are generally reluctant to utilize these fertile valleys for fear of disease such as malaria and also because they are unable to keep their cattle if tsetse flies are present there. So carefully planned control measures are necessary. Where tsetse control operations are successful, the development of a number of other activities including mixed farming may become possible and eventually lead to a permanent change in land use. Combining different control methods against a parasitic disease is called integrated control or integrated disease management. It is generally not intended to achieve eradication of the parasite in question. Such a cost - effective combination of technologies adapted to each particular set of circumstances are very relevant for the control of African animal trypanosomosis (Uilenbergh, 1998).

Successful strategies for controlling animal trypanosomosis is 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. In many circumstances, using combinations of tsetse control and chemotherapy is more effective than employing either method alone. Any control method should be integrated into overall control strategies rather than replacing existing control methods (ILCA, 1993/94). Methods used to control trypanosomosis include: vector control, parasite control and exploitation of trypanotolerant livestock (Uilenbergh, 1998).

2.7.1. Vector Control

The most common options of tsetse control activities are indicated on figure 3. In the past, control of trypanosomosis both in human and in animals depended mainly on large scale killing of game animals which act as reservoirs. It was also common to clear large areas of bush in order to destroy the habitats of the adult flies. These methods were fairly successful, but are now largely unacceptable on ecological and economic grounds (Urquhart *et al.*, 1996). These methods were effective in eradicating or controlling tsetse flies in some parts of Africa but they resulted in destroying valuable plant and animal resources and also led to soil erosion.



Source: Bourn, 2001

Figure 3 Factors involved and options available for the control of Trypanosomosis

The methods have been replaced by the use of insecticides especially DDT and endosulfan, applied strategically in the form of ground and aerial spraying over large expanses of land. As tsetse flies are very sensitive to insecticides and no resistance has developed, considerable successes have been achieved in some countries. However, the method is costly and harmful to the environment.

The costs and the environmental effects can be considerably reduced if the insecticides for example, synthetic pyrethroids are applied directly on the animal in the form of spray or pour-on formulation. The development of live bait technology for the control of tsetse flies and trypanosomosis of livestock depends upon using cattle, or other livestock as living, mobile targets with built-in natural odours mostly produced in their breath to attract tsetse flies. These flies are then killed or suffer ″knockdown″ paralysis effects as they land on cattle and attempt to feed. The killing or knock-down effects are produced by treating the animals with insecticide. The approach of turning cattle into mobile targets where animals are dipped or sprayed with insecticide or the compound is poured on them. The effectiveness of this strategy depends on cattle density, grazing pattern and fly distributions. The strategy works best where livestock are the main host of tsetse (Radostits *et al*., 1994).

Tsetse traps, targets and pour on insecticides are used to impose a small but steady mortality on a fly population sufficient to keep fly numbers down to an acceptable low level. While eradication may be both feasible and desirable in some places, tsetse populations are highly resilient and will often recover from very low number once control measures are relaxed. Furthermore barriers against re-invasion of cleared areas need to be about eight to ten kilo- meters wide to be effective. Demands for cheap and simple tsetse control methods have driven much of the efforts behind modern trap design (ILRAD, 1993). Targets impregnated with insecticides and traps that attract and catch the flies are effective, simple, cheap and could be constructed and maintained by local communities. Furthermore they do not pollute the environment, are suitable for both the small and large-scale farmer. They have been used to reduce tsetse fly population by over 97% within 7 months in a community in the Congo. However, steps must be taken to ensure that individuals do not steal traps or destroyed by wildlife (Radostits *et al.,* 1994).

Light sensory and smelling organs assist the tsetse to recognize its host from a distance. It has a special preference for dark objects. This piece of knowledge has been used to the construction of flytraps. The constructions based on the knowledge that tsetse flies are attracted by the contrast between light and shade and seek shade or dark spots. They choose resting places as well as the sites where they feed (on the under the belly) in the shade consequently traps have been constructed in such a way that the entrance is placed on the underside and made out of dark-coloured material. The tsetse fly is attracted from a distance by the blue colour and then, when approaching, by the dark colour. Several variations of the construction of the classical challier-traps have been developed. They all follow the principle but are different in design (one or two-cone, or only square cage).

Targets are also being used for tsetse fly control. They are placed on appropriate sites at determined intervals. Tsetse flies are attracted at a distance by blue and black colour when approaching. In addition, 50 ml bottles with acetone plastic bags/containers with octenol or phenol or bottles with pig or cattle urine are placed at the foot of the target as a lure. In order to kill the flies which settle on the target, it is sprayed with the pyrethroids (Deltamethrin 0.1%) at regular intervals (8 months). Four targets per km square located 1 km apart is enough to reduce the fly infestation considerably (Seifert, 1996).

In the pilot tsetse control programme in the Didessa valley, western Ethiopia, the striking differences in health (mortality rate) and productivity (calving rates and off take rates) of cattle among the four villages with different levels of trypanosomosis suggest an impact of the pilot tsetse control programme on the health and productivity of cattle in the Didessa valley (Jemal and Hugh-Jones, 1995).

In the Ghibe valley in Southwest Ethiopia, a Cypermethrin (pour-on) insecticide was applied to trypanosusceptible zebu cattle regularly treated with trypanocidal drug diminazene aceturate. The cattle at Ghibe have been monitored regularly since 1986 but the tsetse control programme started only in 1991. By December 1993, the tsetse control programme had reduced the relative density of tsetse flies by over 90% compared with mean values for 1986-90 and reduced trypanosome prevalence in cattle by 74% (ILCA, 1993/94).

With the sterile insect technique (SIT) a large number of sterile males are introduced in a ratio of about 6:1 into a population. The sterile males will thus have a greater chance than the wild males of copulation with the females. Since the females can only mate once they are unable to produce offspring. Radioactive cobalt or caesium are used for the radiation, the dose of radiation being adapted to the resistance of each species. The mating of released sterile male insects with indigenous fertile female insects causes infertility in the target population (Seifert, 1996).

2.7.2. Parasite Control

Considering consequences of widespread chemoprophylaxis, the earlier investigators observed that trypanosomes could retain their drug resistance during transmission. One of the recommendations given was the use of alternative treatments of two or more drugs of different chemical groups to delay the appearance of dug resistance. The idea of a ″sanative pair″ was then introduced later. After forty years, the same recommendation is given in a review by other workers as one of the guidance to control resistance (Murilla, 1999).

Treatment and prevention of bovine trypanosomosis rely essentially on three drugs, namely: Homidium, Diminazene and Isometamidium. However, as in many parts of Africa, in Ethiopia all of these trypanocides are gradually losing their efficacy due to drug resistance (Afewerk, *et al.*, 2000). Standard doses of Isometamidium chloride and diminazene aceturate fail to cure donkeys of *T. congolense* infection. The epidemiology of drug resistant populations of trypanosomes is dynamic; once established the incidence progressively spread within the population. For instance, the incidence of recurrent infection in the Ghibe valley of Ethiopia was 7% in 1986 and it increased to 14% in 1989 (Rowlands *et al*., 1993). Transmission by tsetse flies does not appear to affect the drug sensitivity of trypanosomes and drug resistant strains remain resistant after passage through tsetse flies (Moloo and Kutuza, 1990). The long-term occurrence of *T. congolense* resistance to diminazene, isometamidium and homidium in the Ghibe valley of Ethiopia (Mulugeta *et al*., 1997) indicated the magnitude of the problem once drug resistance is established in a herd.

The resistance trait is known to be stable for a long time and such stocks can spread to wider areas through animal movement and/or the spread of tsetse populations. Results suggest that resistant population established in an area can be disseminated in different animal hosts, for example from cattle to donkeys or vice versa, in a given locality.

2.7.3. Trypanotolerant animals

Animals that can survive and produce in tsetse-infested areas without the aid of trypanocidal drugs offer one of the most sustainable options for boosting agricultural rural development. Trypanotolerant livestock are often combined with tsetse control and trypanocidal drug in integrated trypanosomosis control strategies. According to evaluation of differences in susceptibility in East African cattle to trypanosomosis studies have indicated that the Orma Boran are less susceptible to trypanosomosis than are the Kenyan Boran. The resistance was independent of the previous exposure to the disease. The resistance thus appears to be innate rather than acquired. More extensive use of trypanotolerant livestock can open new areas to animal production and reduce farmers' dependence on using imported drugs to control both the disease and the vector (ILCA, 1993/94).

2.8. Sustainability of Control Programmes

2.8.1. Community Participation

It is easy to kill tsetse but much more difficult and very expensive to keep an area free of tsetse when the conventional methods of tsetse control are used. Therefore, full and active participation of the community should be employed to resolve the tsetse and trypanosomosis problems. The problems of tsetse and trypanosomosis should not be tackled in isolation from other constraints of integrated rural development since it is one of the major factors affecting food security and public health in many parts of Africa.

Hence, the strategy and tactic that should be employed to resolve the problem in a systematic way should take full and active participation of the community (Tikubet, 1993). The appropriateness of the available control methods should be evaluated in view of their suitability, transferability and sustainability under the particular situation of the local community (Bossche and Doran, 2001).

2.8.2. Settlement Programmes and Development of the Land Cleared of Tsetse Fly

Once a tsetse-infested area is reclaimed through an effective control method or combinations of methods applied, it is liable to reinvasion if left undeveloped. Thus, complete exclusion of the tsetse from the area could be effected through a well-planned and systematized settlement schemes. This can be realized by expanding agricultural and industrial development as well as via expansion of trade and road networks. Therefore, it is very relevant to our particular situation in line with the national policy of poverty reduction to ensure the nation's food security at household level. Tsetse control programme needs to be closely linked with land use planning in tsetse-controlled areas. Resources such as woodland and grazing areas need to be well managed by promoting sound and sustainable agricultural development in areas cleared of tsetse (Salmon and Barret, 1994).

2.8.3. Involvement of Other Stakeholders

Tsetse control and/or eradication is not merely a simple task undertaken by an individual, a group of individuals or any other body in isolation. A joint effort and participatory approaches have crucial effects. In tsetse eradication process the participation of major stakeholders, national Governments, donors, international organizations and other partners must be achieved (PATTEC, 2001).

2.9. Socio-Economic Impact of Animal Trypanosomosis

Among the factors influencing the productivity and profitability of livestock, animal diseases deserve special attention because they diminish the capacity of the animal to achieve its inherent potential level of production, for any given feeding and management regimen. It is well established that animal trypanosomosis depresses livestock productivity, crop yields and farmers' income across a wide swathe of Africa (Swallow, 1997). Owing to trypanosomosis, the use of animal draught power in agriculture and transport and the practice of mixed farming are not well developed in most of Africa. Fear of contracting sleeping sickness and exposing their animals to trypanosomosis continues to prevent people from living in tsetse-infested areas.

This renders large expanses of land uninhabitable and under-developed leading to overcrowding in the few available tsetse-free areas. The limitations imposed by the tsetse and trypanosomosis problem continue to frustrate efforts and hamper progress in crop and livestock production. This contributes to hunger, poverty and the suffering of entire communities in Africa (PATTEC, 2001).

In Ethiopia trypanosomosis is one of the most important diseases, which contribute to the direct and indirect economic losses to the livestock industry. Animals at risk of trypanosomosis are estimated at 14.8 million cattle, 6.12 million sheep and goats, 1 million camels and 1.23 million equine populations are prone to contract the disease. Non-tsetse transmitted trypanosomosis also affects a substantial amount of animal production in tsetse-free areas of the country (MOA, 1995). Animals at risk of trypanosomosis are shown in Table 2.

Table 2. Animals at risk of trypanosomosis in Ethiopia.

Category of assets	At risk	Total
Livestock (in million)	23.15	76.42
Cattle	14.80	30.0
Sheep and Goats	6.12	38.4
Equines	1.23	7.02
Camels	1	1.00
Surface area (millions km square)	0.22 (tsetse infested)	1.10

Source: MOA (1995)

In tsetse-infested regions of Ethiopia, the problem of trypanosomosis is the main cause of decline in the population of cattle and particularly draught oxen (Abebe and Jobre, 1996). Therefore, draught animals cannot be used for ploughing and other purposes where the situation forces the farmers to cultivate manually, as the majority of the peasant farmers cannot afford costly machinery. The end result is that only a small fraction of potential agricultural land is cultivated for crop production (Tikubet, 1993).

Economic losses due to trypanosomosis in tsetse-affected areas are attributed to mortality and morbidity of livestock, treatment and control costs and denied access to land resources. Thus, a total of 9,672,575 doses of different compounds of trypanocidal drugs have been imported to the country and distributed during the fiscal years of 1980 - 82. A total amount of 17,920,780.70 Ethiopian Birr was spent both for buying the drug and cost of inoculation (TCS, 1983).

According to Lemecha (1994), an indication of some US $ 1.5 million is annually spent on the importation of trypanocidal drugs. This budgetary allocation is regular every year although insufficient to make any strong impact on tsetse research and control.

The losses in livestock and overall agricultural development are estimated to exceed US $ 236 million annually (Vreysen *et al.*, 1999). The general situation in Ethiopia regarding animal trypanosomosis is therefore found to be very serious and of great national concern which requires to be adequately redressed (Lemecha, 1994).

3. MATERIALS AND METHODS

3.1. Study Areas

3.1.1. Description of the Areas

The present study on the epidemiology of bovine trypanosomosis was conducted in three selected sites of the newly established settlement areas namely Kenaf in Guto Wayu, Anger I and Anger II in Sassiga districts of East Wollega Zone, Oromiya National Regional State, Western Ethiopia. The settlement sites are located in the lowland areas of the districts within the altitude range of 1250 - 1400 meters above sea level bordering each other in the region of Abbay-Didessa river system (Fig. 4). The tsetse-infested peripheries and wooded river borders are linked with the large tsetse belt that extends to the Benshangul Gumuz region. The settlements were established to resettle drought-affected and landless farmers from East and West Hararghe Zones of Oromiya Region. Kenaf is situated about 30 km from Nekemte to the north, Anger I and Anger II are 50 km far-off Nekemte to the northwest direction. The levels of tsetse challenge were supposed to be low, medium and high in Kenaf, Anger II and Anger I, respectively.

The areas receive sufficient amount of annual rainfall of 1500 - 1600 mm during the long rainy season lasting from June to nearly the end of September and the temperature range is 15 – 32^0 C with relative humidity of 30 – 80 %. The vegetation type is mainly cultivated land and strips of riverine forests interspersed with thickets along the riverbanks with minimal wooded savannah land and bush land in the peripheries.

The areas were formerly under the possession of extensive state farm units whereby large-scale bush clearing was undertaken for crop production. However, since the last 8 years, the areas are abandoned and left fallow land until the time of recently expanding human settlements. In Anger I and Anger II previously altogether about 74 km square and in Kenaf 26 km square of land was under cultivation. The areas are tsetse-infested that extend to the great tsetse belt in the adjacent

Benshangul Gumuz Region in the Abbay-Didessa river basin having further connection with the Southern Sudan.

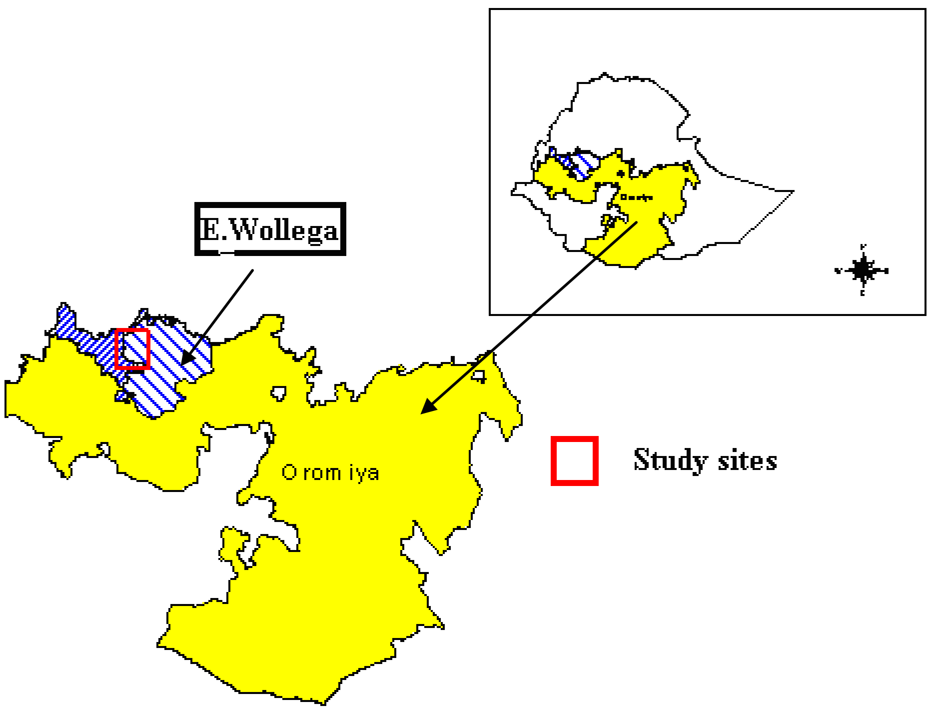


Figure 4. Map of Oromiya Region showing the Study Sites.

3.1.2. The Socio-Economic and Farming system in the Areas

The settlements were established in 2003/04 as part of the national settlement programme to resettle 2.2 million people from over populated and drought victim areas of the country within 3 - 5 years period. The settlement programme was planned as one component of the national poverty reduction strategies and hence to ensure the national food security at household levels. With this vision, altogether 13,161 people settled in Kenaf, Anger I and Anger II.

Agriculture is the mainstay of the livelihoods of the settlers with the mixed crop-livestock farming system. Livestock play an important role in the agricultural activities whose main functions are to provide meat, milk, cash income, transportation and principally source of traction power whereby draught oxen are the key animals for the production of food crops. The introduction of livestock to the areas initially began with provision of a single draught ox and a breeding goat to each family from the Government along with some agricultural hand tools and household goods.

After the subsequent crop years many families introduced some additional animals through purchase. The new home areas are being stocked with different species of livestock including cattle, goats, sheep, donkeys and poultry. Bee keeping is also another great potential in the areas.

3.1.3. Constraints to the Livestock Production in the Areas

According to the complaints from the settlers and animal health workers, losses of animals from diseases are the common problems. Previously soon after the introduction of livestock, especially the draught oxen, the disease episode was so serious killing a large number of work oxen that challenged the hope for new life in the settlement areas. Among the other prevailing endemic diseases, bovine trypanosomosis poses a major problem from losses through mortality and morbidity, reduced work efficiency, treatment and control costs. Feed shortage is also another potential threat to the livestock keepers in the areas.

3.2. Study Population

The study population constitutes 4,446 indigenous cattle managed under smallholder mixed crop-livestock farming system. They are aggregated approximately into 158 clusters according to settlement sub-villages. Cluster in this context is defined as a group of cattle owned by people living in a small village or sub-village in a very immediate neighbourhood with their animals sharing the same grazing areas and watering points. The animals comprise mainly draught oxen and introduced into the areas primarily for the purpose of providing traction power for crop production.

The study animals were categorized into two levels by origin. The animals which were born or have been kept in the herd for 6 -12 months or above were considered as native whilst others introduced to the farm since the last 6 months were taken as new ones. This 6 month-based grouping was considered mainly because majority of the animals, particularly the work oxen would be kept in the herd for an average time of 10 –12 months after which they would be sold out for meat or other purpose to replace by new ones. They were also classified into three age groups on the basis of the age composition of the source population. The first group composed of animals less than one year, the second and third groups constituting animals of one to four and above four years old, respectively.

3.3. Study Design and Methodology

3.3.1. Sampling Method and Sample Size Determination

The sampling method applied in the present study was a combination of focused selection and one-stage cluster sampling. The study sites were selected presumably based on the level of disease prevalence to include apparently the low, medium and high tsetse challenge areas. The study populations were clustered according to their respective villages or sub-villages after detailed counts were made. The representative clusters were selected randomly using a lottery system from the population clusters whereby all the animals in the selected clusters were sampled for this study, which is one-stage cluster sampling (Thrusfield, 1995).

The sample size required for trypanosomosis prevalence study was a total of 560 animals. In the present study practically 576 animals were sampled and from the local indigenous cattle in the settlement areas, 288 samples were drawn from 10 sub-villages (clusters) during each season in 2005/06 for this study purpose. The sample size was approximated by the following formula.

$$g = \frac{1.96^2 \{nVc + P_{exp} (1 - P_{exp})\}}{nd^2}$$

where:

g = number of clusters to be sampled = 11

n = predicted average number of animals per cluster = 28

Pexp = expected prevalence = 30%

d = desired absolute precision = 0.05

Vc = between cluster variance = 0.00015 (estimated)

Finally since the population of clusters from which the sample drawn was small, the estimated number of clusters was adjusted by:

$$G_{adj} = \frac{G*g}{(G + g)}$$

where: G is the total number of clusters in the study population = 158

3.3.2. Retrospective Information Source and Questionnaire Survey

Background descriptive data were collected retrospectively from zonal Agriculture and Rural Development (ARD) and Food Security, Disaster Prevention and Preparedness (FSDPP) including the district offices on the situation at the beginning of the settlement programmes. Information on the history of the settlers, introduction of livestock and the incidence of bovine trypanosomosis was gathered. The available data on the level of tsetse challenge were also obtained from the National Tsetse and Trypanosomosis Investigation and Control Centre (NTTICC) and animal health units of the districts.

To assess the status of bovine trypanosomosis general information was obtained mainly using closed type of questionnaire set to encourage the response as given in Annex 1. Information was required on the history of settlements, socio-economic aspect, farming system, livestock management and constraints and problem of bovine trypanosomosis in the settlement schemes. More information was sought from areas subject to different levels of tsetse challenge likely under different epidemiological circumstances and current disease management practices.

Ten individual farmers from each study area and further eight farmers from Didessa settlement were interviewed. The Didessa area is situated some 35 km away in the middle Didessa river valley to the southwest direction from Anger II. The area is known for its heavy tsetse challenge and thus the cattle population is nearly non-existent. However, the people were included to seek more additional comprehensive information to the questionnaire administered.

Altogether 38 family heads were included and the selection was done on random basis. All respondents were male and the questionnaire was pre-tested on some other similar farmers. This was to assess the response rate and consistency of replies as well as to monitor any source of bias in the course of interview. The information basis collected is to be used to answer the following pertinent question. Is bovine trypanosomosis a constraint to development in the areas?

3.3.3. Cross-Sectional Study

Repeated cross-sectional studies were conducted to determine the seasonal dynamic of tsetse population and other biting flies and the prevalence of bovine trypanosomosis in late rainy and dry seasons, which covered from October to November 2005 and from February to March 2006, respectively.

3.3.3.1. Entomological Survey

To assess the apparent densities, distributions and species of tsetse flies and other biting flies in different seasons and vegetation pattern the survey was ensued according to the following survey protocol. Entomological data were collected twice in late rainy and dry seasons of the year 2005/06. Mono-pyramidal traps baited with acetone, octenol and three-week-old cow urine (Brightwell *et al*., 1987) were used for assessing the fly density. Site selection was done to include suitable tsetse habitats like savannah area, river valleys, livestock grazing areas and watering points and vicinity to assumed wild game reserve areas.

In all study sites a total of 96 mono-pyramidal traps (Annex 2), 48 in each season were deployed early in the morning and maintained in position for 72 hours. To perceive the tsetse density on the peripheral zone, 4 traps 2 during each season were also placed outside the study areas some 10 km away at major bridge of Anger river where cattle routes converge. The traps were sited preferably in shade with good visibility and at suitable intervals depending on the ecology of the target species. Savannah tsetse (*Glossina morsitans submorsitans*) can detect odours from about 50 - 100 meters. So the traps were spaced at about 200m intervals. Riverine tsetse (*G. tachinoides*) is fairly sedentary and mostly do not react to the odour baits that are currently available and thus shorter spacing was used for this group.

During trapping, acetone and octenol were dispensed from open vials through an approximately O-sized hole while cow urine from open bottles. Into the open bottle of cow urine a piece of tissue paper was included to facilitate odour diffusion. All odours were placed on the ground about 30 cm upwind of the trap. The trap poles were greased to exclude insect predators like ants.

The different fly catches in each trap were counted, identified and analyzed. The species of tsetse fly was identified based on the characteristic morphology (Ford *et al.*, 1976; Langridge, 1976; Leak *et al*., 1993). Other biting flies were separated according to their morphological characteristics such as size, color, wing venation structure and proboscis at the genus level (Wall and Shearer, 1997).

Sexing was done just by observing the posterior end of the ventral aspect of the abdomen by microscopic lenses as a result male flies easily identified by enlarged hypopygium in the posterior ventral part of the abdomen. Average aging of male tsetse was done by categorizing the degree of wear of wings on scales of 1 - 6 using wing fray method described by (Jackson, 1946; Challier, 1965). Mean wing fray was calculated as the sum of each category multiplied by the corresponding factor divided by the sum of fly number for each category and find the corresponding number from wing fray tables.

The fly apparent density is the mean catch in traps deployed, expressed as the number of fly catch per trap per day (Leak *et al*., 1987). The fly catches were properly recorded along with their particular habitats and sampling season on diary format for latter analysis. Awareness was created among the local communities to raise their knowledge about the tsetse and the disease it carries which keep them poor and unable to produce sufficient food they require because of the loss of their livestock assets.

3.3.3.2. Parasitological Survey

To determine the seasonal prevalence of bovine trypanosomosis and estimate the potential risk factors associating with the disease, snapshot cross-sectional parasitological surveys were conducted. Sample collection and parasitological examination were performed according to the following working procedures:

Sample Collection

Blood samples were collected after properly securing the animal and aseptically preparing around the veins. In this study a small quantity of paired blood samples were obtained from the marginal ear vein after pricking the vein with the tip of a lancet.

Parasitological Examination

The buffy coat / phase contrast / dark ground technique:

This is the technique recommended for diagnosing low parasitaemia (Annex 2), helps to identify trypanosome species and its quantification. Paired blood samples were collected from auricular vein of each animal using two haematocrit capillary tubes that were filled 3/4 of the height and sealed with cristaseal in one end. The blood in capillary tubes centrifuged at 12,000 rpm for 5 minutes. The capillaries were also used to measure the PCV values on the haematocrit reader for the determination of anaemia and comparison of infected animals with non-infected ones.

The capillary tube was cut 1mm below the buffy coat junction to include the top layer of red cells. The content of the capillary tube was then expressed onto a clean microscope slide, mixed and covered with a 22 x 22 mm cover slip. Then the slide was examined for trypanosomes based on the type of movement in the microscopic field. Confirmation of trypanosome species by morphological characteristics was done after staining the blood smear with Giemsa and examination with oil immersion microscopy with 100x power of magnifications (Murray *et al*., 1977). Then all the relevant data (species of trypanosome detected, number and identification of the animals by settlement, village, owner, parasitaemic and non-parasitaemic animals, PCV values, age, sex and origin of the animals) were recorded for analysis. Animals found positive for trypanosomes were reported to the owner and the nearby veterinary clinic.

3.4. Data Management and Analysis

Data collected from retrospective information source and questionnaire survey, vector fly and trypanosome infection survey entered into MS excel spreadsheet programme to create database. For the analysis of data statistical software programmes: Intercooled Stata 7.0 and SPSS 11.5 for windows and Win Episcope 2.0 versions were used. Analysis of retrospective data and replies from respondents to questionnaire set, descriptive statistics was used to compute frequency of responses and percentage to summarize the data. Vector survey data were analyzed using two-sample t-test to compare seasonal mean catches and ANOVA to compare the mean catches in different vegetation types and study areas.

Data on trypanosome prevalence were analyzed by applying chi-square test to evaluate the association with different variables like area, origin, sex and season. Multivariate logistic regression model was fitted to the data to establish the interaction of different risk factors such as origin, sex, age and season. Data collected on PCV values were analyzed by two-sample t-test to compare the mean PCV values of parasitaemic and non-parasitaemic animals and correlation was run to see the relationship of PCV value with trypanosome infection rate. In all cases differences between parameters were tested for significance at probability levels of 0.05 or less.

4. RESULTS

4.1. Retrospective Information Source and Questionnaire Survey

Secondary data obtained from departments indicated that during the settlement operations 1,965 families having 13,161 people settled in Anger I, Anger II and Kenaf settlement areas. The settlers were entirely the farming communities that came from East and West Hararghe Zones of Oromiya Region (Annex 3). On average each family was provided with 2 hectares of land holding. During the planning and establishment of the settlement projects in the year 2003/04, to rehabilitate the new settlers and support their agricultural activities the Government has supplied a large number of work oxen which were purchased from various distant districts including those with less or no tsetse risk areas. Majority of households were offered with single ox and a breeding goat each along with some agricultural hand tools.

Bovine trypanosomosis is the major constraint to cattle production in the settlement schemes. The claim from zonal veterinary services department revealed that, in the early settlement years from 1,095 newly introduced work oxen 366 (33%) were died of which 85% of deaths were attributed to bovine trypanosomosis (Annex 4). At present stocking in the settlement areas is growing at faster rate and altogether about 4,446 heads of cattle are currently being reared which were introduced by settlers themselves in the subsequent years as shown in Annex 5. The animals were brought to the areas through purchase from surrounding peasant associations and parishes. They are maintained on regular treatment regimen with trypanocidal drugs as being delivered so far free of charge through public veterinary services.

According to the National Tsetse and Trypanosomosis Investigation and Control Centre (NTTICC), from the previous survey 1.6 and 1.0 tsetse apparent densities (fly/trap/day) were recorded at Anger I and Kenaf areas in early 2005, respectively. The reported disease prevalence include 29.2 % and 17.7 % in Anger I in 2003 and early 2005, respectively. In Anger II 5% and in Kenaf 4% were registered in early 2005 (Annex 6).

The responses of 38 farmers to a structured questionnaire set were assessed. About 80% of the respondents were settled in the areas in the year 2003/04 and 60 % of them came to the settlements because of the combined effect of the lack of farmland and prevailing drought condition. All interviewed people were livestock keepers in their previous home places. However, none of them brought their stock to the new areas. Nearly 95 % of them introduced new animals to their farm since their arrivals and 55 % of the respondents use free grazing and tether whilst 45% often utilize free grazing alone. About 60 % of the farmers do not trek their animals utmost more than 3km for grazing and watering.

Out of the 38 replies 95 % of the respondents judged that bovine trypanosomosis ranks first as the major animal health problem impairing agricultural development in their areas. According to the 79 % of the responses cattle are the most susceptible class of livestock to trypanosomosis whereas about 16 % were of the opinion that both cattle and goats are equally affected and yet 3 % commented donkeys to be most susceptible animals in their areas. Most of them complained that the early and late rainy seasons of the year are the most peak periods for animal trypanosomosis outbreak. About 58% of the respondents know that tsetse flies are the transmitters of the disease while 42% do not know any thing about the fly. Out of the 38 answers 95 % indicated that newly introduced cattle from the highland areas are the major victims to the disease than the native animals in the areas.

As regards 70 % of the views obtained, chemotherapy is the sole control means to manage the disease and yet many farmers are exercising to sell out their draught oxen after having treated with the trypanocidal drugs and stuffing. This last practice is becoming the major coping mechanism with the disease risk. Through this practice more than 80% of the respondents shift their cattle after every 10 – 12 months and replace by new ones. Regarding the trend of the disease, 92 % of the responses showed that it is on the decreasing line as compared to the situation at the beginning of the settlements. About 45 % of the farmers treat their animals every quarter of the year and 78 % of the answers explained recovery rate is good after treatment. About 80% of the respondents were not familiar to the disease in their previous home areas.

Almost all people replied that the main source of their income is generated from mixed crop-livestock farming although most of the Didessa area farmers are lacking draught oxen from recurrent attack of trypanosomosis. Most of the families possess on average 2 cattle, 2 goats, 3 chickens and 2 hectares of land holding per household.

4.2. Entomological Survey

4.2.1. Fly Collection

A total of 11,316 flies were captured in late rainy season out of which 0.50 % belong to tsetse, 2.8 % to tabanids and 96.7 % to muscids. The dry season catch was 1,002 of which 4.7 %, 4.9 % and 90.4 % were tsetse, tabanids and muscids, respectively for all study areas as presented in Annexes 7 and 8. During the entomological survey relatively high proportion of other biting flies were collected along with tsetse flies and in places where tsetse was not caught. The tabanid fly group comprises Tabanus, Haematopota and Chrysops while the muscid group mainly belongs to Stomoxys.

In the present vector survey only two species of tsetse were detected to exist which are *Glossina morsitans submorsitans* and *G. tachinoides*. The *G. tachinoides* has relatively wider distribution inhabiting the strip of forests and thickets along the course of many rivers and streams that traverse the settlement areas. Also the scrap of forest in the peripheral zone is infested by same species. The *G. m. submorsitans* has retreated to the marginal areas that have connection with the major tsetse belt in the Benshangul Gumuz Region where the few samples were obtained. In the present survey only 3 flies of the species were sampled in the vicinity of Anger II area at the edge of bush land in the grazing places. The apparent densities of 0.01 and 0.35 were obtained for *G. m. submorsitans* and *G. tachinoides*, respectively in the present study (Annex 9).

Tsetse apparent densities (fly/trap/day) were 0.05, 0.32 and 0.78 for Anger I, Anger II and Kenaf respectively across both seasons the overall apparent density being 0.36. For tabanid fly group 0.93, 2.85, 0.23 and for muscid fly 47.60, 60.25 and 16.25 relative densities were recorded in the areas correspondingly as summarized in Table 3.

Table 3. The fly apparent densities (fly/trap/day) by area and season in Anger I, Anger II and Kenaf settlements in 2005/06.

Group (variable)		Tsetse		Tabanids		Muscid fly	
		Apparent density	95% CI	Apparent density	95% CI	Apparent density	95% CI
Area	A I	0.05	0.01 – 0.09	0.93	0.32 – 1.50	47.60	26.6 – 68.6
	A II	0.32	0.07 – 0.57	2.85	0.67 – 5.03	60.25	31.1 – 89.4
	K	0.78	0.45 - 1.11	0.23	0.05 – 0.40	16.25	9.4 – 23.1
Season	Late rainy	0.4	0.18 – 0.62	2.18	0.83 – 3.50	76	55.7 – 96.3
	Dry	0.33	0.14 – 0.52	0.34	0.18 – 0.50	6.29	3.7 – 8.90
Overall apparent density		0.36	0.22 – 0.50	1.26	0.55 - 1.97	41.15	28.8 – 53.5

There were statistically significant differences in mean catches between areas being ($F = 10.869$, 2 df, $p < 0.001$), ($F = 4.678$, 2 df, $p < 0.05$) and ($F = 4.334$, 2 df, $p < 0.05$) for tsetse, tabanid and muscid flies, respectively.

The different fly densities were assessed per season where (0.40 and 0.33) for tsetse; (2.18 and 0.34) for tabanid flies and (76.0 and 6.29) for muscid group relative densities (fly/trap/day) were registered in late rainy and dry seasons, respectively as indicated in Table 3.

Slightly higher mean catch was obtained during late rainy season than the dry season for tsetse fly where the difference was not statistically significant ($t = 0.518$, $p > 0.05$). However, statistically significant differences were observed for other biting flies between seasons ($t = 2.640$, $p < 0.05$) and ($t = 6.6698$, $p < 0.05$) for tabanids and muscid, respectively.

Tsetse and other biting fly distributions and apparent densities were surveyed in different vegetations which are shown in Table 4. Analysis of variance indicated that there were no statistically significant differences observed in fly mean catches between vegetation types being ($F = 2.652$, 3 df, $p > 0.05$) for tsetse; ($F = 0.543$, 3 df, $p > 0.05$) for tabanids and ($F = 1.490$, 3 df, $p > 0.05$) for muscid group.

Table 4. Tsetse and other biting fly apparent densities (fly/trap/day) in different vegetation types in Anger I, Anger II and Kenaf settlements in two seasons in 2005/06.

Vegetation type	Late rainy season			Dry season		
	Tsetse	Tabanids	Muscid	Tsetse	Tabanids	Muscid
Cultivated land	-	0.13	28.93	-	0.08	1.88
Bush land	0.44	2.0	90.05	-	0.48	4.05
Riverine forest	0.50	2.63	77.75	0.52	0.29	7.03
Savannah	-	2.11	81.88	0	1.22	15.89
Total	0.40	2.18	76	0.33	0.34	6.29

Generally the tsetse apparent density recorded in the interior and immediate outskirts of the settlement areas was low as compared with the potential risk areas in the peripheral zones. With few traps deployed at the major bridge of Anger river some 10 km away from the study areas, apparent densities of 8.6 and 19.6 were recorded for *G. tachinoides* in late rainy and dry seasons, respectively.

Out of a total of 58 and 47 tsetse flies collected 21 males in late rainy and 15 males in dry seasons, were recorded, respectively. In all cases the number of female fly exceeded that of the male counterpart. Average age estimation of the male fly sample population revealed relatively more adult fly population in late rainy season than in dry season being 19 and 16 days old, respectively (Table 5).

Table 5. Estimation of average age from wing fray analysis for male tsetse fly in Anger I, Anger II and Kenaf settlements in 2005/06.

Wing fray category	Number of fly in each category x multiplier	
	Late rainy season	Dry season
1	1x9 = 9	1x8 = 8
2	2x6 =12	2x1 = 2
3	3x2 = 6	3x4 = 12
4	4.4x0 = 0	4.4x1 = 4.4
5	5.5x1 = 5.5	5.5x0 = 0
6	6.9x3 = 20.7	6.9x1 = 6.9
Mean wing fray value and estimated age	53.2/21 = 2.53 = 19 days	33.3/15 = 2.22 = 16 days

4.3. Parasitological Survey

4. 3. 1. Trypanosome Infection

In Anger I, Anger II and Kenaf study areas repeated cross-sectional surveys of trypanosome infections were conducted in two seasons. A total of 576 indigenous cattle (288 in each season) were sampled to determine the prevalence of bovine trypanosomosis and evaluate the associating assumed risk factors like season, origin, sex and age of the animal as summarized in Table 6.

Table 6. Prevalence of trypanosome infection in the cattle subpopulation by area, season, origin, sex and age in the settlement areas of Anger I, Anger II and Kenaf in 2005/06.

Group (variable)		No. of animals examined	Trypanosome species			No. infected and prevalence (%)	95% CI
			T.c.	*T.v.*	Mixed*		
Area	A I	192	6	8	2	16 (8.3)	4 – 12%
	A II	192	10	2	3	15 (7.8)	3 – 11%
	K	192	13	6	1	20 (10.4)	6 – 14%
Season	Late rainy	288	23	14	6	43 (14.9)	11 – 19%
	Dry	288	6	2	-	8 (2.8)	1 – 5%
Origin	Newly introduced	322	25	11	4	40 (12.4)	8 – 16%
	Native	254	4	5	2	11 (4.3)	2 – 6%
Sex	Female	191	8	7	1	16 (8.4)	4 - 12%
	Male	385	21	9	5	35 (9.1)	6 – 12%
Age (year)	< 1	19	-	-	-	-	-
	1 – 4	226	10	6	2	18 (8.0)	5 – 12%
	> 4	331	19	10	4	33 (10.0)	7 – 13%
Total		576	29	16	6	51 (8.9)	7 – 11%

* Mixed infection refers to *T. congolense* and *T. vivax.*

The prevalences of bovine trypanosomosis in the settlement schemes were found to be 8.3 %, 7.8 % and 10.4 % in Anger I, Anger II and Kenaf, respectively. The overall prevalence for the areas was 8.9 % across both seasons. However, there was no statistically significant difference among areas in trypanosome prevalence (Chi square = 0.904, 2 df, $P > 0.05$). Among the prevailing pathogenic trypanosome species, *T. congolense* was the dominant one accounting for 56.8 % (95% CI = 43 – 71%) followed by *T. vivax* 31.4 % (95% CI = 21 – 47%) and mixed infection due to both constituted 11.8 % (95% CI = 5 – 24%).

The seasonal prevalence of bovine trypanosomosis was found to be 14.9 % and 2.8 % in the late rainy and dry months, respectively (Table 6). There was a statistically significant difference in prevalence between the two seasons (Chi square = 26.353, 1 df, $p < 0.001$).

The trypanosome infection in newly introduced cattle into the settlement areas was 12.4% while in the native animals 4.3% (Table 6) with statistically significant difference between the two groups (Chi square =11.5, 1 df, $p < 0.01$). The *T. congolense* was the dominant species detected followed by *T. vivax* in the new group whilst in the native group *T. vivax* infection slightly predominates.

The prevalence of trypanosomosis was found to be slightly higher in male (9.1 %) than in the female animals (8.4 %) as shown in Table 6. But there was no statistically significant difference observed between the two sexes (Chi square = 0.081, 1 df, $p > 0.05$)

The prevalence of trypanosomosis in different age categories revealed nil, 8.0% and 10.0% in animals less than one, one to four and above four years old, respectively (Table 6). Nevertheless, there was no statistically significant difference among the age groups in trypanosome infection (Chi-square = 2.58, 2 df, $p > 0.05$).

The multivariate analysis performed using logistic regression model adjusted for assumed risk factors (season, origin, sex and age) for trypanosome infection is presented in Table 7. The overall model for the assumed risk factors is statistically significant ($p < 0.05$) for the occurrence of bovine trypanosomosis with the exception of sex. Age is only considerable in terms of the presence or absence of exposure to tsetse challenge since another statistical test proved that the difference was not significant among age groups with regard to trypanosome infection. The risk of trypanosomosis was lower in the dry season as compared to the wet season (OR = 0.13, 95% CI = 0.06 – 0.28) and the likelihood of contracting the disease was more than 3 times higher in the newly introduced cattle population than the native animals.

Table 7. Multivariate logistic regression estimates for the interaction of risk factors in trypanosome infection in the cattle subpopulation of the settlement areas of Anger I, Anger II and Kenaf in 2005/06.

Risk factors	Odds Ratio	Std. Err.	P	95% CI
Season	0.13	0.05	0.000	0.06 - 0.28
Origin	3.36	1.23	0.001	1.64 - 6.88
Sex	1.17	0.39	0.649	0.59 - 2.27
Age	2.08	0.65	0.018	1.13 - 3.82

4.3.2. Haematological Finding

In the present study the range of mean PCV in the parasitaemic and non-parasitaemic animals was 22% (10 – 32%) and 38% (12 – 50%), respectively. The mean PCV in non-infected cattle was 27.23% (95% CI = 26.77 – 27.69%) while that of the infected animals was observed to be 20.22% (95% CI = 18.75 – 21.68%). There was a statistically significant difference in the level of anaemia between the trypanosome infected and non-infected animals ($t = 8.91$, $p < 0.001$).

The mean PCV values for parasitaemic and non-parasitaemic animals in the late rainy season were 20.30% (95% CI = 18.87 – 21.73%) and 25.76% (95% CI = 24.33 – 25.95%) and the dry season values 19.75% (95%CI = 18.32 – 21.18%) and 28.53% (95% CI = 27.61 – 28.95%), respectively (Figures 5 and 6). There was a statistically significant difference in mean PCV values between the parasitaemic and non-parasitaemic groups in both seasons ($t = -7.31$, $p < 0.001$). Majority of the parasitaemic and non-parasitaemic animals had mean PCV values of 16 – 20 % and 26 – 30% in both seasons, respectively. The level of mean PCV value was found negatively correlated with the trypanosome prevalence ($r = -0.35$).

The mean PCV values in different age categories were 29.11% (95% CI = 28.50 – 29.72%), 26.31 (95% CI = 25.86 – 26.76%) and 26.68%(95% CI = 26.23 – 27.13%) for age groups of less than 1 year, 1 to 4 years and above 4 years old, respectively. However, the difference was not statistically significant among the different age levels ($F = 2.16$, 2 df, $p > 0.05$).

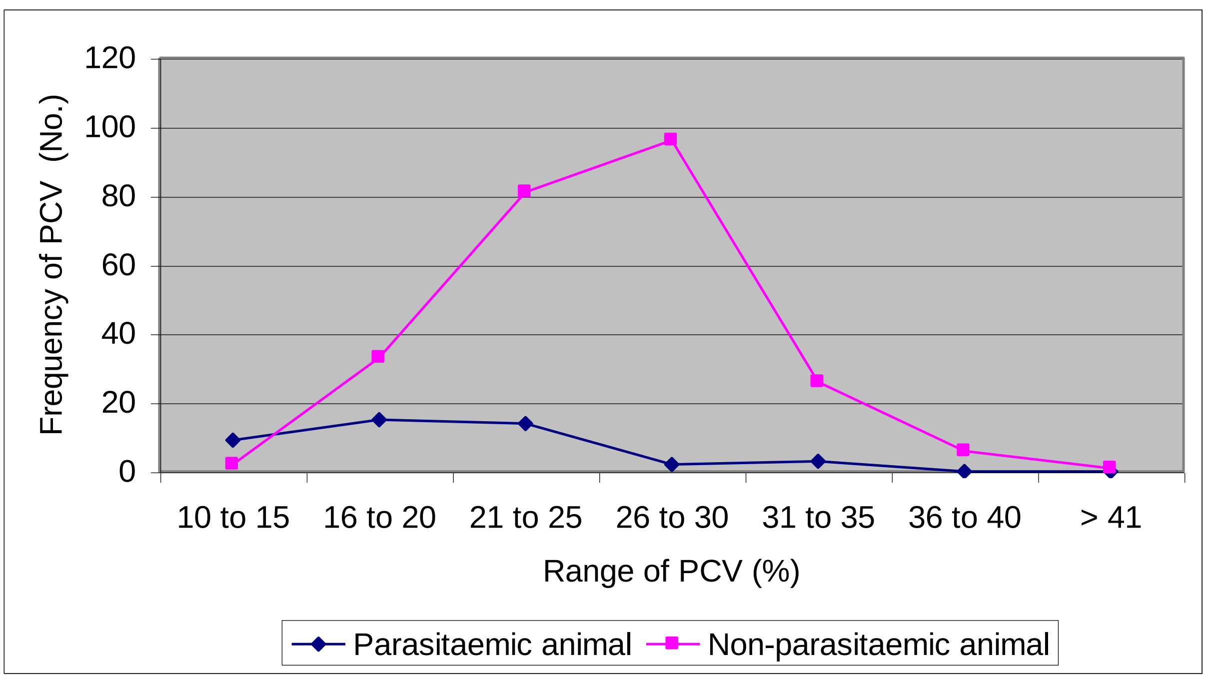


Figure 5. The frequency distribution of mean PCV values in parasitaemic and non-parasitaemic animals in Anger I, Anger II and Kenaf settlements in late rainy season in 2005/06.

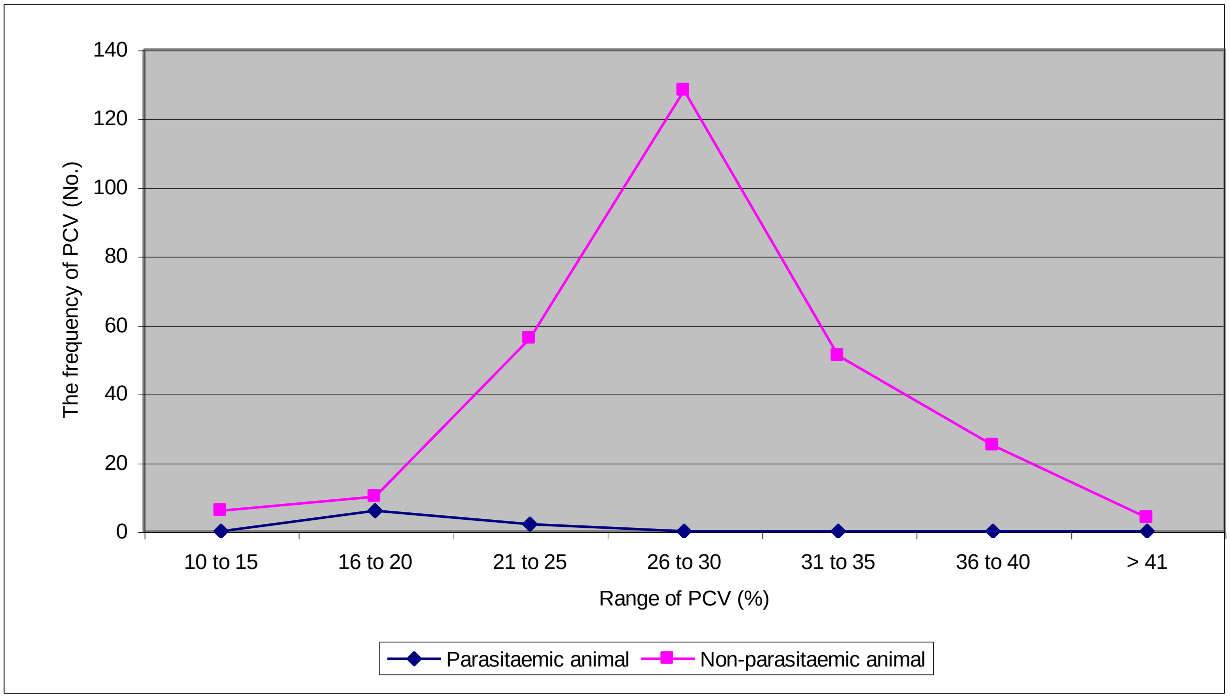


Figure 6. The frequency distribution of mean PCV values in parasitaemic and non-parasitaemic animals in Anger I, Anger II and Kenaf settlements in dry season in 2005/06.

5. DISCUSSION

Secondary data and relevant information obtained from East Wollega Zone Agriculture and Rural Development (ARD) and Food Security, Disaster Prevention and Preparedness (FSDPP) offices on the operation of the settlement programmes in 2003/04 indicated that it was an immense and urgent activity to establish many new settlement schemes in various districts to resettle the drought affected and landless farming communities from other parts of Oromiya Region.

Through the implementation of the settlement projects in Sassiga and Guto Wayu districts, among others Anger I, Anger II and Kenaf centers are the newly established settlement areas. After the fulfillment of some basic requirements and accommodations like shelters, food and water supplies, road networks and other household provisions many voluntary people came to settle. In Anger I 771 families (5,197 people), in Anger II 703 families (5,243 people) and in Kenaf 491 families (2,721 people) altogether 1,965 families (13,161 people) came to the new settlement home from East and West Hararghe Zones of Oromiya National Regional State. The new settlements were established in the low land agro-ecology of the districts with sufficient annual rainfall and vast potential agricultural land in the Anger-Didessa catchment areas.

The areas were previously under the administration of the Wollega Agricultural Development Enterprise that had been engaged to produce mainly food crops before its termination since the last 8 years. As a result large-scale bush clearing was undertaken nearly over its entire landholding of about 74 km square in Anger I and Anger II and about 26 km square in Kenaf (East Wollega Zone Investment Office, 2005). The former extensive land development in the areas paved the way for the present settlement projects so that the new settlers enjoyed the opportunities to get easy access to their farmland without any difficulties of bush clearing to prepare the land for crop production. During the establishment of the new home places in the year 2003/04, to rehabilitate the settlers and facilitate their agricultural activities a large number of work oxen were supplied. It was an immediate need to cultivate the land to produce food crops.

To meet the need for traction power a massive purchase of oxen was performed from various distant areas including those with less or no tsetse risk areas. Majority of the households were supplied with an ox and a breeding goat and on average 2 hectares of land holding each.
According to the information gathered from zonal ARD and FSDPP offices, bovine trypanosomosis was the major impairment to the cattle production in the settlement schemes soon after its inception. Serious outbreaks were encountered in many of the settlement areas where in Baqo settlement in Sibu Sire and in Didessa settlement in Diga districts the entire herds of oxen introduced were devastated. Out of a total of 1095 draught oxen introduced in Anger I, Anger II and Kenaf settlement areas 366 died, of which 85% of deaths were attributed to bovine trypanosomosis in two years period since their establishment.

Before the recently expanding new settlement schemes in Anger I, Anger II and Kenaf areas, other previous settlers are dwelling in the vicinities who are keeping livestock on their farm. However, the trypanosomosis outbreaks among their stock are not alarming. The previous bovine trypanosomosis prevalence survey of the National Tsetse and Trypanosomosis Investigation and Control Centre (NTTICC) indicated 29% and 17.7% in Anger I in 2003 and early 2005, respectively. Similarly, 5 % and 4% prevalences were reported in Anger II and Kenaf in early 2005, respectively. The higher prevalence recorded especially at Anger I clearly confirmed the serious impact of trypanosomosis posed to the newly introduced herds of cattle in the early year of the settlement.

Results of the questionnaire survey conducted among 38 family heads of the community members indicated that 80 % of the respondents were new comers and not familiar to the bovine trypanosomosis. This fact made their disease management situation worse as the result of failure to recognize the ill health in their animals. Consequently there was marked delay to report the crisis to the animal health professionals while the animals were succumbing to the disease that led to heavy losses. All the respondents replied that they are engaged in mixed crop-livestock farming system where oxen are the main source of draught power to cultivate their land. All of the interviewed farmers from the Didessa settlement area invariably complained of the serious attack of bovine trypanosomosis and depletion of farmlands thus inquiring to shift to other new places. About 95% of the responses judged that bovine trypanosomosis ranks first as the major animal health problem.

Out of 38 farmers 36 indicated newly introduced cattle from highland areas are the major victims to the disease than the native animals. This complaint was in agreement with the present parasitological survey result. Seventy nine percent (79 %) of respondents showed that cattle are the most affected whilst 16 % believed cattle and goats are equally infected and other 3% replied donkeys are most susceptible. Eighty percent (80%) of the respondents indicated that early and late rainy months were peak periods for animal trypanosomosis outbreaks. This was consistent with the present finding of higher trypanosome prevalence coinciding with the occurrence of high apparent densities of tsetse and other biting flies.

Out of 38 respondents 42 % revealed that they did not know that tsetse flies transmit animal trypanosomosis while 58 % were well informed of tsetse being the vector for the disease. Their knowledge of tsetse and the disease they carry came to existence among the community very recently through time. The improvement in the awareness of the farmers is the necessary precondition for the community to actively participate and launch a sustainable tsetse and trypanosomosis control programmes that could overcome the menace confronted in the newly established settlement schemes. Full and active participation of the community should be employed to resolve the tsetse and trypanosomosis problems (Tikubet, 1993).

Majority of the respondents indicated chemotherapy to be the only control means and the common treatment places are the public veterinary health centres. Yet many of the cattle owners have adopted the practices of selling out their work oxen after every crop season when they attain optimum live body weight. This practice has gained the confidence of the farmers in that besides generating additional income to each family; it is becoming a good means of overcoming the direct and indirect losses from chronic attack of bovine trypanosomosis. This exercise is quickly expanding among the community members and after every 10 – 12 months they replace their work oxen by new younger ones. Ninety two percent (92%) of the views obtained stated that the trend of bovine trypanosomosis is generally decreasing in their localities. This phenomenon is in agreement with parasite and vector survey result of the present study as compared with the previous result recorded by NTTICC (Annex 5).

Forty five percent (45%) of the respondents indicated on average 3 round treatments are offered per animal per year and no evidence of drug failure was suggested as 78 % of responses were in favour of good recovery after treatment. On the other hand judicious use of trypanocidal drugs was not strictly followed as instances witnessed by our observation. Farmers were supplied with the drugs from local animal health workers to do the treatment at home while they were ignorant of handling the drug as seen in Kenaf area. This abuse of drugs could undoubtedly lead to a serious consequence of overwhelming appearance of drug resistant population of trypanosome strains (Afewerk *et al*., 2000).

Season based surveys were undertaken to assess tsetse apparent density, distribution and species prevailing as well as other biting flies to the genera levels in the study areas. Mono-pyramidal traps were employed to trap the target fly. NGU traps are efficient for savannah species (Leak *et al*., 1987). However, in the study conducted in Abbay basin area of northwest Ethiopia monoconical traps were the best in sampling *Glossina m. submorsitans* over NGU and biconical traps (Shimelis, 2004). Monoconical was also very efficient to sample *G. m. submorsitanis* and *G. tachinoides* in the survey conducted in Limu Shay area and Didessa district in upper Didessa valley (Feyisa, 2004).

During the survey period *G. m. submorsitans* and *G. tachinoides* were the only two species of tsetse detected in the study areas. This result agrees with the earlier report of Langridge (1976). He reported that the Abbay river system that includes the Didessa, Anger, Dabana and Dabus rivers are infested with *G. m. ugandensis* which is now known to be *G. m .submorsitans* and *G. tachinoides* that occurs along most of the rivers in Abbay river system.

Ford *et al*., (1976) reported that 5,902 km square of the river basin of the Anger, Didessa and Wama valleys were infested by *G. m. submorsitans and G. tachinoides. The G. m. submorsitans* has a more wide spread habitat than *G. tachinoides and G. pallidipes.* It is also an efficient vector of pathogenic trypanosomes to domestic livestock.

The *G. m. submorsitans* was only caught in the vicinity of Anger II settlement area at the edge of bush land in the grazing area during the late rainy season. Throughout the survey period only three *G. m. submorsitans* flies were sampled, which was, obviously influenced by the scarcity of its suitable habitat in the survey areas. This appeared the result of extensive bush clearing and expansion of cultivated land pushing the fly front to the extreme margins to the large tsetse belt areas in the adjoining Benshangul Gumuz Region.

The *G. tachinoides* species have relatively high abundance and wider distribution along the wooded river borders and thickest. This finding agrees with the previous reports where dense peri-domestic population of these species have been described from many localities in West Africa, Central and parts of East Africa. The reason for the resilience of the palpalis group in the presence of man is based on their adaptation to changes from feeding on the large species of wild animals to the less obvious components of the wild fauna, such as reptiles as well as to man and his domestic animals.

The species are able to adapt to man-made habitats and thus, despite more people and changed habitats and hosts, the flies survive and thrive. These species are not as effective vectors of animal trypanosomosis as are species of the morsitans group. However, the implications for the persistence of the disease in such circumstances are obvious (Jordan, 1986).

In the present work the result of entomological survey revealed that tsetse apparent density (fly/trap/day) was 0.40 in the late rainy season while in dry season it was 0.33. For other biting flies the seasonal apparent densities were 2.18 and 0.34 for tabanid group and 76.0 and 6.29 for the muscid fly in late rainy season and dry season, respectively. According to Langridge (1976) some 20 km away from Kenaf settlement to the north in Anger Gutin a mean apparent density of 150 for *G. m. submorsitans* was recorded with concentrations in certain localities of up to 800. Another study in Abbay basin area of northwest Ethiopia showed apparent densities of 1.08 and 0.68 for tsetse, 6.0 and 91.0 for muscids and 0.43 and 7.0 for tabanid fly group were recorded in late rainy season and dry season respectively (Shimelis, 2004). A study in southwest Ethiopia indicated that apparent densities of 1.34 in tsetse controlled Lumu Shay and 3.56 in tsetse infested Didessa district in upper Didessa valley (Fayisa, 2004).

The apparent densities for *G. pallidipes* were 2.4 and 0.6 in wet and dry seasons; for *G. fuscipus* 0.10 and 0.06 in wet and dry seasons were reported in southern rift valley of Ethiopia (Msangi, 1999). Similarly the mean fly catches of *G. pallidipes* was 1.42 and for *G. fuscipes* 0.29 in Ghibe valley (Leak *et al*., 1993). Infestation with *G. m. submorsitans* and *G. tachinoides* was reported in Anger Gutin, Didessa state farm and other localities (TCS, 1983). The finding of the present study with regard to the prevailing tsetse species in the settlement areas in the Abbay Didessa drainage system is completely in agreement with the survey reports of earlier workers in the area.

However, when it comes to apparent density of tsetse fly, absolutely an interesting shift was observed when comparing the present result of an overall apparent density of 0.36 (fly/trap/day) with the earlier 150 mean apparent density reported in Anger Gutin in the adjacent area (Langridge, 1976). Obviously the previous apparent density recorded could not be expected under the present condition of complete change existing in tsetse natural habitat in the same area.

The same pattern of change in vegetation type and fauna is very evident in the present study areas of Anger I, Anger II and Kenaf settlements that affected the present tsetse apparent density particularly of the morsitans group. The expansion of cultivated land and fast growth in human population appeared to have played a great role to reduce the tsetse apparent density critically in the interior and immediate peripheries of the study areas.

The entomological survey showed that the apparent densities of different flies across both seasons varied significantly among the 3 settlement areas. It was 0.05, 0.32 and 0.78 for tsetse ($p < 0.001$) for Anger I, Anger II and Kenaf settlements the cumulative density being 0.36. For tabanid group 0.93, 2.85, 0.23 ($p < 0.05$) and for muscid fly 47.60, 60.25 and 16.25 ($p < 0.05$) relative densities were recorded in Anger I, Anger II and Kenaf areas in their corresponding order. The overall apparent densities of 1.26 and 41.15 were recorded for tabanids and muscid fly, respectively.

The tsetse apparent densities recorded in Anger I and Kenaf areas in the present study were less than the previous result reported by NTTICC (2005) for the areas where it was 1.6 for Anger I and 1.0 for Anger II. The likely suggestion for the apparent reduction observed is the relative expansion of cultivated land in Anger I reducing the tsetse habitat areas as compared to Kenaf area where extensive strip of riverine forests harbouring tsetse are existing. Another possible reason could be, since May 2005 insecticide impregnated targets were placed in both areas although the operation was not consistent and the materials were damaged by theft.

Pertaining to the seasonal collection of flies, the apparent densities of 0.40 and 0.33 ($p > 0.05$) for tsetse, 2.18 and 0.34 ($p < 0.05$) for tabanids and 76.0 and 6.29 ($p < 0.05$) for muscid fly were recorded during late rainy season and dry season, respectively. The seasonal tsetse apparent density for the wet season was higher than the dry season collection though it was not statistically significant. In the present finding the apparent density of tsetse population appeared to be affected by destruction of its suitable habitat in the study areas of Anger I, Anger II and Kenaf by expansion of crop farming and human settlements.

Generally the apparent densities recorded in late rainy season for different flies were higher as compared to the dry season in the present survey. Similar results were reported in previous works (Leak *et al*, 1987; Msangi, 1999 and Terzu, 2004). This could be explained by an absolute increase in the number of flies. It happens due to favourable environment such as enough moisture, vegetation growth and suitable habitat. The spread of flies from the riversides and thickets where they usually inhabit during the dry season to more open areas during the rains increases relative density in open areas (Brightwell *et al*., 1987).

Nevertheless, in the present study the narrow difference observed in tsetse fly catches between the two seasons could be explained further by the fact that because of heavy vegetation clearing, the tsetse could not spread out much into the more open areas of farmland during the wet season. The other way round also appeared to work where the existing tsetse population retreats to the riverside strip of forests and thickets that yielded high mean catches during the dry season. This instance was especially observed at Anger river bridge about 10 km in the peripheral zone from the study areas. In that specific locality with the few traps deployed along the heavy thickets of the river bank about 8 and 19 mean apparent densities were recovered for tsetse during the late rainy season and dry season, respectively.

As mentioned in the foregoing discussion, the higher density recorded for dry season was because tsetse moved back to the wooded river borders in the dry season. The other reason could be enlightened by the fact that the cattle routes converge at the major bridge of Anger river and at the same time it is the main watering point for the cattle and human users. This situation has a great bearing on the epidemiology of the disease constituting a great potential risk for the settlement areas of Anger I, Anger II and Kenaf. Animals coming from or crossing the moderately infested localities on their way to the major market centre at Uke are important sources of infected animals. Similar circumstances were explained by Radostits *et al,* 1994.

In the present study season based survey of fly distribution in different vegetation types showed that the tsetse apparent densities recorded for bush land and riverine forest zones were high as compared to the cultivated land and savannah type area where no mean catches were obtained in late rainy season. In the dry season survey, in the riverine forest area high apparent density was recorded whereas in the rest of vegetation types no mean catch of tsetse at all. Yet the differences in apparent densities among vegetation types were not statistically significant for all fly kind ($p > 0.05$).

This could be explained by the fact that the tsetse apparent density was generally low in the present study areas. For the rest biting flies of tabanid and muscid groups, although significant difference was recorded between the two seasons in mean catches, the apparent densities obtained for vegetation types did not reveal significant difference. Similar results for different vegetation types were reported in Abbay basin area of northwest Ethiopia (Shimelis, 2004).

During the study period, for the tsetse flies collected the sex ratio and average age were assessed. Higher number of females was recorded and similar results reported by other workers (Mohamed-Ahmed and Dairri, 1987; Msangi, 1999) in Somalia and Southern Ethiopia respectively. Leak (1999) reported that in unbiased sample female would comprise 70 – 80% of the mean population. The wing fray method analysis was used to estimate the average age of the male population sampled. The result revealed that relatively high proportion of adult flies was recorded during the late rainy season. This result is consistent with the finding reported in Abbay basin area of northwest Ethiopia (Shimelis, 2004).

In the newly established settlement areas of Anger I, Anger II and Kenaf a cross-sectional parasitological surveys were conducted in two seasons to determine the prevalence of bovine trypanosomosis and associating risk factors. The corresponding prevalence obtained for each area in the present finding was low the dominant pathogenic trypanosome species being *T. congolense* followed by *T. vivax* as compared with the previous prevalence reported for the areas. The National Tsetse and Trypanosomosis Investigation and Control Centre (NTTICC, 2005) field report recorded high prevalence of 29.2% (95% CI = 21.4 – 39.7%) in 2003 and 17.7%(95% CI = 11.5 – 27.3%) in early 2005 at Anger I settlement. Similarly the least rate of 4.2% (95% CI = 2.1 – 8.2%) was reported in early 2005 at Kenaf area.

The decline observed in prevalence correlated with the low tsetse relative density registered at Anger I settlement, which was 0.05 (95% CI = 0.01 – 0.09) in the present study as compared with the previous density of 1.6 reported for the same area. On the other hand in the present finding relatively the high prevalence of bovine trypanosomosis recorded at Kenaf settlement area corresponded to the high tsetse apparent density observed in the same area.

Generally the present drop in trypanosome infection rate among the cattle population in Anger I, Anger II and Kenaf areas directly related to the drop in tsetse apparent density observed in each area. This phenomenon could be the result of adverse effects occurring to tsetse. The expansion of cultivated land that pushed away the tsetse front to the extreme margins as the result of bush clearing is the major factor that could be cited. Awareness of the community to control the disease has been raised up notably and reduction of the massive purchase of cattle from tsetse-fee areas, as it used to be in the early days of settlement, have contributed to the low prevalence recorded in the present study.

The intensive use of trypanocidal drugs as curative and preventive doses has suppressed the disease prevalence in the areas. Other pilot control interventions like mass application of insecticides to live animals (pour-on) and the use of insecticide-impregnated targets to suppress the population of insect vectors were attempted in May and June 2005. The programme was commenced by Oromiya Region Agriculture and Rural Development Bureau (ARDB) that is supposed to have additional effect for the drop observed in disease prevalence and tsetse apparent density. However, the process was not consistent as the second round operation was delayed until February 2006. Yet the link that exists with the neighbouring great tsetse belt area in the Benshangul Gumuz Region and tsetse-infested thickets and strip of forests along many rivers and streams that pass through the areas constitute a great potential risk.

The relationship observed between disease prevalence and tsetse apparent densities was in agreement with some established facts. The density of tsetse fly population in the area and the level of their contact with the host will determine the level of infection that will occur. This is further influenced by the vectorial capacity of the fly and availability of its preferred host, which is not necessarily domestic livestock (Radostits *et al*., 1994).

The seasonal occurrence of the disease was also higher during the late rainy season than the dry season period. The prevalence of trypanosome infection coincided with the relatively higher vector population recorded regardless of the narrow mean catch registered for tsetse fly between the seasons. The result agrees with that reported in Kenya (Tarimo-Nesbitt *et al*., 1999).

The most prevalent trypanosome species in tsetse-infested areas of Ethiopia are *T. congolense* and *T. vivax*. Rowlands *et al*., (1993) reported a prevalence rate of 37 % for *T. congolense* in southwest Ethiopia, Abebe and Jobre (1996) reported an infection rate of 58.5 % for *T. congolense* and 31.2 % for *T. vivax* in southwest Ethiopia which agrees with the present result. A prevalence of 6.1 % was recorded for *T. vivax* in tsetse free districts bordering Lake Tana in northwest Ethiopia (Alekaw, 2004).

Different workers (Muturi, 1999; Afewerk *et al*., 2000; Tewelde *et al*., 2004) reported the disease prevalences of 17.5 %, 17.2 %, and 21.3 % in cattle populations in southern rift valley, Metekel district and upper Didessa valley of tsetse-infested areas, respectively. An overall prevalence of 17.8 % was recorded in Limu shay area and Didessa district in southwest Ethiopia (Feyisa, 2004). In all reports the dominant species were *T. congolense* followed by *T. vivax*.

Cattle recently introduced to the settlement areas especially from the high land zones were more prone to the trypanosome infection. Sudden introduction of susceptible population from tsetse free or low risk areas resulted in serious outbreaks of bovine trypanosomosis as observed in the present study. This result agrees with the following epidemiological circumstances. Largely the level of interaction between tsetse and cattle determines the epidemiology of bovine trypanosomosis and its impact on cattle production. The disease has an epidemic character with significant impacts on production in areas where cattle have been introduced recently or along the interface between the tsetse-infested game areas and tsetse-free cultivated areas. Bovine trypanosomosis has an endemic character with little impact on production, in areas where tsetse mainly feed on cattle and where the invasion of tsetse is low.

Herds of trypanosusceptible livestock can be devastated by sudden exposure to high levels of trypanosomosis risk. Options for the control of bovine trypanosomosis will vary according to the epidemiological circumstances. In particular, the control of tsetse with insecticide-treated cattle will only be effective when a large proportion of feeds are taken from cattle over a large area and when the invasion of tsetse can be reduced sufficiently (Van den Bossche, 2001). The risk of trypanosomosis also has an influence on where people decide to live, the way they manage their livestock and the number of animals that they keep (FAO, 2000).

This fact is in favour of the present finding that the farmers have developed the practices of selling out their work oxen for another function after one crop season to replace by new ones to cope with the threat of bovine trypanosomosis. This was advancement in the local knowledge of the settlers towards managing the disease risk. On the other hand the settlers prefer to keep cattle on their farm especially the draught oxen, which are the main source of traction power. They understood also that cattle are more resistant to trypanosomosis, which was indicated by responses to questionnaire survey.

According to the complaint from the farmers interviewed, work oxen are more affected by trypanosomosis than cows are. Nevertheless, in the present finding the trypanosome infection rates were 9.1% (95% CI = 6 – 12%) in males and 8.4% (95% CI = 4 – 12%) in the female counterpart. Slightly more prevalence was recorded in male animals than in female but the difference was not statistically significant ($p > 0.05$). Other researchers reported similar results where sex of the animal made no significant difference with regard to trypanosome infection rate (Muturi, 1999 and Tewelde, 2001) in North Omo Zone and upper Didessa valley of southwest Ethiopia, respectively. Even in trypanotolerant West African zebu cattle like N'Dama and Baoule due to variation with individual animal within that breed it can be overcome by heavy tsetse challenge, malnutrition or other stress factors (Radostits et *al*., 1994).

In the present study the occurrence of the disease in different age categories was assessed. In the calf group the prevalence was nil which happened to be as the result of low exposure to the vector challenge. Conversely in the older age groups of animals the prevalence of trypanosome infection was higher due to the routine contact existing with the tsetse fly in the field. The prevalence of 10% was recorded in the older animals (> 4 years old) whilst in the younger age group (1 – 4 years old) 8% was obtained. However, the difference was not statistically significant between the age groups ($p > 0.05$) which is in agreement with the result reported in northwest Ethiopia (Shimelis, 2004).

The multivariate analysis using the logistic regression model fitted to the assumed risk factors signified season, origin and age with the exception of sex to be the risk factors for the trypanosome infection in the cattle population of the settlement areas. Season was found to be a risk factor for high prevalence of trypanosome infection and increase in fly population recorded. The risk of contraction trypanosome infection was lower in the dry season as compared to the late rainy season when the tsetse challenge is high (OR = 0.13, 95% CI = 0.06 – 0.28). This result agrees with the finding reported in North Omo Zone (Muturi, 1999).

Origin of the animal was indicated to be the important risk factor for the occurrence of bovine trypanosomosis in the present study. The output of the interaction analysis showed that the risk of acquiring the disease was more than 3 times higher (OR = 3.36, 95% CI = 1.64 – 6.88) in the newly introduced cattle than it was in the native animals. On the other hand sex was not the risk factor for trypanosome infection whereas age was indicated to be. However, the age factor appears hold true in relation to the level of exposure to tsetse challenge. As observed in the present study the younger calves are usually maintained in the farmstead and do not go far for grazing and watering which minimizes the chance of exposure to tsetse fly. But the older age groups were more exposed to the tsetse risk in the field at grazing and watering places. Also for the draught oxen the likelihood of contact with tsetse fly is high while travelling long distances to the working field.

This is supported by other similar previous reports. Suckling calves would not get out with their mothers but graze at homestead until weaned off (Rowlands *et al.*, 1995). Young animals are also naturally protected to some extent by maternal antibodies. A number of other workers have reported that calves of less than one year old are more resistant than adults to the effects of trypanosomosis (Fiennes, 1970 and Murray *et al*., 1982).

In the present finding all trypanosome infected cattle had mean PCV values less than 26 % which was 20.22 % (95 % CI = 18.75 – 21.68 %) across both seasons. The mean PCV value recorded in non-parasitaemic animals was 27.23 % (95 % CI = 26.77 – 27.69 %) for both seasons. Cattle with mean PCV values less than 26% were considered anaemic (Rowlands *et al*., 2000), which is said to be the principal sign of trypanosomosis. In the present study trypanosome infection and mean PCV values registered were negatively correlated. This is in agreement with the result reported by Rowlands *et al*. (2001) at Ghibe valley in southwest Ethiopia. As the proportion of samples detected parasitaemic increased PCV values decreased. In the present finding the mean PCV values for parasitaemic cattle were considerably low during both late rainy and dry seasons. On the other hand the mean PCV values recorded for the non-parasitaemic animals were significantly high. This shows that trypanosome infection has adverse effect on the mean PCV values of the affected cattle.

The same trends of mean PCV values were reported for the trypanosome-infected and non-infected cattle by other researches. Muturi (1999) obtained the mean PCV values of 16.7 % and 28.0 % in North Omo Zone; Alekaw (2004) in districts bordering lake Tana in northwest Ethiopia reported 21.60 % and 25.40 % and Feyisa (2004) recorded 21.65 % and 25.54 % in southwest Ethiopia for the parasitaemic and non-parasitaemic cattle, respectively.

The appearance of trypanosome negative animals with mean PCV values of less than 26 % may be due to inadequacy of detection method used (Murray *et al*., 1977) or delayed recovery of anaemic situation after recent treatment with trypanocidal drugs or may be due to compound effects of poor nutrition and haematophagous helminth infection such as haemonchosis and bunostomosis (Afewerk, 2000). However, PCV values can be affected by many factors other than trypanosomosis. These factors are likely to affect both trypanosomosis positive and negative animals (Van den Bossche and Rowlands, 2001).

6. CONCLUSION AND RECOMMENDATIONS

The study conducted on the epidemiology of bovine trypanosomosis in the newly established settlements of Anger I, Anger II and Kenaf areas, East Wollega Zone, Oromiya Region, Western Ethiopia, gave some vital information on the current situation of the disease in the areas. Based on the study findings the following conclusion and recommendations are drawn. Regardless of its dynamic extent bovine trypanosomosis is the major constraint to cattle production in the newly established settlements of Anger I, Anger II and Kenaf areas. Introduction of susceptible cattle population to the tsetse-infested settlement areas would result in heavy losses which are exacerbated by virtue of animals coming from tsetse free localities to moderate tsetse challenge areas principally during the wet season of the year when the apparent densities of the vector populations are high. Different epidemiological circumstances appeared to exist in the areas that shall maintain the contact between tsetse and the cattle population. Interiorly tsetse-infested wooded borders of many rivers and streams as well as scrap of forest at the edge of settlements to which *G. tachinoides* appear well adapted would sustain their constant interactions. On the other hand moderately infested peripheries to which *G. m. submorsitans* receded that have a link with the major tsetse belt constitute a potential risk to the areas. Furthermore the frequent movement of animals coming from or crossing the tsetse-infested areas to the major market outlet in Uke, Kenaf prefecture is the major source of infected animals. The vast potential land in the settlement areas would only be exploited if the problem of animal trypanosomosis is resolved under the present crop-livestock farming system. Raising the awareness of the community of animal trypanosomosis and its vector fly would contribute much towards a thriving control of the disease in the settlement schemes. Therefore, community based integrated control option should be promoted with strong surveillance and monitoring activities.

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8. ANNEXES

Annex 1. Structured questionnaire to interview individual farmers.

A. General information

1. Date ……………………………………………………………………..…
2. District.…………………………………………………………………………
3. Settlement area (village) ……………………………………….……………
4. Name of the farmer ……………………………………….…………………

B. History of settlement

1. When did you settle in this area? …………………………………………
2. Where did you come from? ……………………………………………..
3. Why did you leave your previous home place?
   a) Draught b) Lack of farmland c) Disease epidemics d) Civil conflict e) Forced to come
   f) Other (specify)

C. Livestock management

1. Did you keep livestock in your previous place? a) Yes b) No
2. If yes to (Q1), which animal did you use to keep? a) Cattle b) Sheep c) Goats d) Equine
   e) Poultry f) All
3. Did you bring your previous animals here? a) Yes b) No c) Other (specify)
4. If yes to (Q3), how many are they? a) Cattle……b)Sheep……c) Goats…..d) Equine…………
   e) Chicken………
5. Did you introduce additional animals to your herd or flock since your arrival? a) yes b) no
6. How many animals do you privately own altogether now?
   a) Cattle ……. b) Sheep……. c) Goats…….. d) Equine……………………… e) Chicken……
7. How do you manage your animals? a) Free grazing b) Stall feeding c) Tether
8. If cattle are allowed to free grazing, are they in large herd or small group? a) In large herd
   b) In small group
9. Where do cattle graze? a) in savannah grassland b) near the wild game reserve areas c) in the

bush d) valley bottom (river valleys) e) valley top

10. How long is the grazing area from cattle barn? a) 3 km b) 3-5 km c) more than 5 km

11. How long is the watering point? a) 3 km b) 3-5 km c) more than 5 km

D. Livestock disease occurrence

1. What are the most common diseases affecting cattle? List in decreasing order of importance by their local name. a)…………b)…………c)…………d)…………..e)…………f)……………

2. Does bovine trypanosomosis occur in this area? a) yes b) no c) I do not know d) other (specify)

3. How do you call by local name? ………………………………………………………………..

4. What is the rank of the disease among others………………………………………………..?

5. Is trypanosomosis a deadly disease in your area? a) Yes b) No c) Other

6. Which animals does trypanosomosis affect most? a) Cattle b) Sheep c) Goats d) Equine

7. How many animals have you lost from trypanosomosis since you start living in this area?
   a) Cattle………………………………………………………………………………………..
   b) Sheep………………………………………………………………………………………..
   c) Goats………………………………………………………………………………………..
   d) Equine……………………………………………………………………………………….

8. Do you know the clinical signs of bovine trypanosomosis?

…………………………………………………………………………………………………….

……………………………………………………………………………………………………..

9. In which season or month do cattle get trypanosomosis most? a) Wet season b) Dry season c) all the time

10. Do you know that tsetse flies transmit the disease? a) Yes b) No c) Other (specify)

11. In which season or month are they most abundant? A) Wet season b) Dry season c) Year round

12. In which place are they most abundant? a) In cattle grazing areas b) game reserve areas b) along the river valleys d) savannah areas e) bush land f) cultivated land

13. Which wild animals are most commonly found in your area? a) Buffaloes b) wart hogs c) bush backs d) antelopes e) elands f) other arboreal animals

14. Which age group of cattle is most affected? a) Less than 1year b) 1-4 c) more than 4 year old

15. Which category of cattle are most affected by trypanosomosis? a) Newly introduced animals b) Animals native to the area c) all category are equally affected

16. Which sex is most affected? a) Cows b) draught oxen c) young bulls d) heifers

17. How many cattle died from trypanosomosis in your village?

………

18. How is the incidence of bovine trypanosomosis in your village? a) Increasing b) Decreasing c) Rarely occur d) I cannot judge.

19) How do you control bovine trypanosomosis? a) Modern treatment b) Traditional treatment c) Sufficient feed d) Resting draught oxen from working condition

20. Where is the common treatment place? a) Vet. Clinic (public, private) b) At home (self experience) c) Other specify

21. Do cattle recover after treatment from trypanosomosis? a) Yes b) No

22. Did you treat your animal last year?

23. If the answer is yes to Q22, what is the frequency of treatment? a) Fortnightly b) Monthly c) Quarterly d) Every 6 month e) annually f) other option

24. Which trypanosomosis control method do you know? a) use of trypanocidal drugs b) tsetse trapping c) pour-on application d) other means (specify)

25. Are you familiar to the disease in your previous home place? a) yes b) no c) I do not know.

E. Socio-economic data

1. What is the main source of your income? a) livestock b) crop production c) other (specify)
2. What the importance of keeping livestock? a) milk production b) meat production c) source of draught power d) paying dowry e) manure production f) religious ritual g) other use
3. What is the livestock population in your village? a) oxen…..b) cows…….c) heifer…… d) young bulls…….e) calves……..f) sheep……g) goats……h) equine…….i) chicken……..
4. What is the daily milk yield of a lactating cow in liter?......................
5. What is the draught ox work output in hours per day……………….
6. What is the problem with the breeding cows? a) abortion? b) delay in age at first calving c) long calving interval d) other (specify)

Thank you!

Name of Interviewer ………………………………………………………….

Signature …………………

Date …………………….

Annex 2. Pictures of material, study animal and parasite.

Plate 1. A mono-pyramidal trap fixed in site to capture the vector fly.

Plate 2. An advanced case of bovine trypanosomosis showing marked loss of bodily condition.

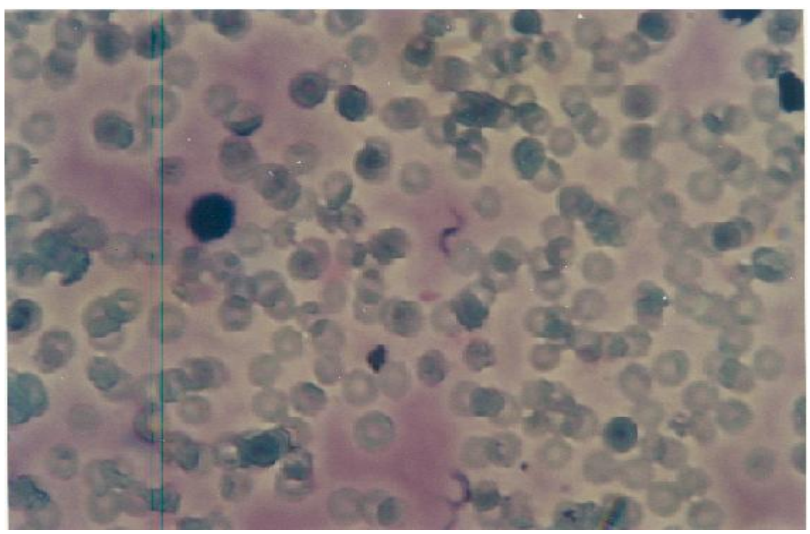

Plate 3. Picture of a parasite (*Trypanosoma vivax*) detected in the above work ox.

Annex 3. Human population in the settlement schemes of Anger I, Anger II and Kenaf in 2005/06.

Settlement	Family heads	Family members	Total	Total land holding (ha)
Anger I	771	4,426	5,197	1,932
Anger II	703	4,540	5,243	1,472
Kenaf	491	2,230	2,721	988
Total	1,965	11,196	13,161	4,392

Source: East Wollega Zone ARD and FSDPP Offices (2005)

Annex 4. Draught oxen introduced to settlement areas and crude mortality in two years of which 85% was attributed to bovine trypanosomosis (2003 - 2005).

Settlement	Purchased	Died	Crude mortality (%)	95% CI
Anger I	429	202	47	42 - 52%
Anger II	405	109	27	23 - 31%
Kenaf	261	55	21	17 - 25%
Total	1,095	366	33	30 - 36%

Source: East Wollega Zone ARD and FSDPP Offices (2005)

Annex 5. Livestock population in the study areas of Anger I, Anger II and Kenaf settlements in 2005/06.

Settlements	Classes of Livestock				
	Cattle	Goats	Sheep	Donkey	Poultry
Anger I	1,477	1,004	20	94	1,496
Anger II	1,632	1,222	40	126	826
Kenaf	1,337	408	102	11	580
Total	4,446	2,634	162	231	2,902

Source: Districts ARD Offices (2006)

Annex 6. Previous bovine trypanosomosis field survey report in the settlement areas of Anger I, Anger II and Kenaf.

Area	Year	No of animals. examined	No. Infected and Prevalence (%)	95% CI
Anger I	2003	72	21 (29.2)	21. 4 – 39. 7%
	May, 2005	96	17 (17.7)	11.5 – 27.3%
Anger II	May, 2005	96	5 (5 .2)	3.3 – 8.2 %
Kenaf	June, 2005	48	2 (4. 2)	2.1 – 8.2 %
Total		312	45 (14.4)	11.0 – 18.9 %

Source: NTTICC (2005)

Annex 7. Different fly catches in late rainy season in Anger I, Anger II and Kenaf settlements in 2005/06.

Areas and no. of trap*	Late rainy season							
	Tsetse					Tabanid	Muscid	Total
	G. m. submors.		*G. tach.*		Total			
	m	f	m	f				
Anger I (19)	0	0	0	3	3	97	5,101	5,201
Anger II (14)	2	1	9	14	26	208	4,507	4,741
Kenaf (15)	0	0	10	19	29	9	1,336	1,374
Total (48)	2	1	19	36	58	314	10,944	11,316

G. m. submors. = *Glossina morsitans submorsitans*

G. tach. = *G. tachinoides*

* Numbers in parentheses indicate the number of traps fixed per study site.

Annex 8. Different fly catches in dry season in Anger I, Anger II and Kenaf settlements in 2005/06.

Area and no. of traps*	Dry season							
	Tsetse					Tabanid	Muscid	Total
	G. m. submors.		*G. tach.*		Total			
	m	f	m	f				
Anger I (18)	0	0	0	2	2	6	177	185
Anger II (14)	0	0	1	0	1	31	554	586
Kenaf (16)	0	0	14	30	44	12	175	231
Total (48)	0	0	15	32	47	49	906	1,002

G. m. submors. = *Glossina morsitans submorsitans*

G. tach. = *G. tachinoides*

* Numbers in parentheses indicate the number of traps fixed per study site.

Annex 9. Apparent densities for different species of tsetse in Anger I, Anger II and Kenaf in two seasons in 2005/06.

Tsetse species	Total catches	Mean catch (fly/trap)	Apparent density (fly/trap/day)
G. m. submorsitans	3	0.03	0.01
G. tachinoides	102	1.06	0.35
Total	105	1.09	0.36

9. CURRICULUM VITAE

1. **Personal data**

   Name…………………………………Takele Sori Aga

   Place of Birth…………………………..**Raram**, Gidda Kiremu, East Wollega Zone.

   Date of birth……………………….. …September 10, 1955 (E. C)

   Qualification…………………………..Veterinarian (Doctor of Veterinary Medicine)

   Nationality……………………………Ethiopian

   Marital status…………………………Married

   Scientific Association…………………Member Ethiopian Veterinary Association (EVA)

2. **Educational background**

   1962 – 1966 (E. C) Primary School, Gidda Ayana, East Wollega Zone

   1967 – 1972 (E. C) Junior and Senior Secondary High School, Shambu, East Wollega Zone. Achievement: ESLCE Certificate

   19 73 – 1979 (E. C) Faculty of Veterinary Medicine, Addis Ababa University

   Achievement: Doctor of Veterinary Medicine (DVM)

3. **Work experience**

   1980 – 1985 (E. C) Field Veterinary Officer, Ministry of Agriculture

   1986 – 1994 (E. C) Team leader, Animal and Fisheries Resources Department, Zonal Agricultural Development Office, East Wollega Zone, Oromiya Region

   1995 – 1996 (E. C) Head, District Agricultural and Rural Development Office, Shambu, East Wollega Zone

4. **Research papers**

   A Study of the Incidence of Bovine Mastitis in Chilalo Awuraja, Arsi region, DVM thesis (1987), Addis Ababa University, Faculty of Veterinary Medicine (unpublished).

   Epidemiology of Bovine Trypanosomosis in Selected Sites of the Newly Established Settlement Areas, East Wollega Zone, Oromiya Region, Western Ethiopia, MSc thesis (2006), Addis Ababa University, Faculty of Veterinary Medicine.

10. SIGNED DECLARATION SHEET

The thesis is my original work, has not been presented for a degree in any other university and that all sources of material used have been duly acknowledged.

Name ____

Signature ____

Date of submission ___________________________________

The thesis has been submitted for examination with my approval as university advisor.

____