

**ADDIS ABABA UNIVERSITY
COLLEGE OF HEALTH SCIENCES
SCHOOL OF VETERINARY MEDICINE**

**EFFECT OF TSETSE AND TRYPANOSOMOSIS CONTROL ON
GROWTH AND MORTALITY OF CALVES IN ARBAMINCH
DISTRICT IN THE SOUTHERN RIFT VALLEY, ETHIOPIA**

**BY
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A thesis submitted to the school of Graduate Studies of Addis Ababa University in partial fulfillment of the requirement for the degree Master of Science in Tropical Animal Production and Health

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LIST OF ABBREVIATIONS

AW-IPM	Area Wide Insect Pest Management
BCS	Body condition score
BLM	Body length measurement
BWM	Body weight measurement
CIRDES	Centre International des Recherche Développement sur l'Elevage en zone Subhumide
CSA	Central Statistical Authority
DFID	Department for International Development
HGM	heart girth measurement
HHM	Hip height measurement
FAO	Food and Agricultural Organization of the United Nations
FDRE	Federal Democratic Republic of Ethiopia
IAEA	International Atomic Energy Agency
IBAR	Inter Africa Bureau for Animal Resource
IIRR	International Institute of Rural Reconstruction
ILRI	International Livestock Research Institute
PA	Peasant Associations
PAAT	Programme against African Trypanosomosis
PATTEC	Pan African Tsetse and Trypanosomosis Eradication Campaign
SAT	Sequential Aerosol Technique
SIT	Sterile insect technique
SNNPR	Southern Nation Nationality and People's Regional State
SPSS	Statistical Package for Social Science
SRVL	Soddo Regional Veterinary Laboratory
STEP	Southern Tsetse Eradication Project
TCS	Trypanosomosis Control Service

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ABSTRACT

A study was conducted to assess the effect of tsetse/trypanosomosis control on growth and mortality of calves in tsetse controlled and tsetse uncontrolled blocks of southern tsetse eradication project (STEP), at Arba Minch Zuria district of southern region. A total of 182 farmers were interviewed with structured formal questionnaire from the two blocks. They were mainly interviewed on socioeconomic and farming system characteristics, livestock herd size and composition, cattle herd size and composition, the objectives of cattle keeping, cow housing, feeding and culling, major animal health problems and calf management. 180 clusters (house hold heads) herds from two blocks were established to collect blood samples in wet and dry seasons. From each household an average of calves three (total 1080) were examined to determine the prevalence of bovine trypanosomosis using dark ground/ Buffy coat examination technique. To assess tsetse and biting fly population in both blocks 240 NGU traps were deployed from October 2009 to March 2010 (40 traps every month). A case control study of 40 calves, (20) from each blocks were performed for consecutive six months to determine the body weight gain, hip height increment, body length measurement and body condition score.

The questionnaire survey indicated that Mean livestock herd size and composition in tsetse controlled block were 6.05 ± 0.31 cattle, 0.48 ± 0.12 sheep, 1.56 ± 0.22 goats, 0.37 ± 0.07 donkey and 4.66 ± 0.47 poultry, were as in tsetse uncontrolled block were 11.26 ± 1.18 cattle, 0.93 ± 0.22 sheep, 0.93 ± 0.21 goats and 2.38 ± 0.48 poultry. No donkey was found in tsetse uncontrolled block. Mean livestock herd size and composition was smaller in tsetse controlled block than tsetse uncontrolled block. All cattle owned by the sampled households were indigenous. Mean cattle herd size and composition in tsetse controlled block was cows 2.14 ± 1.18 , heifers 0.77 ± 0.08 , bulls 0.98 ± 0.83 , male calves 0.74 ± 0.08 , female calves 0.66 ± 0.07 and steers 0.77 ± 0.07 . In tsetse uncontrolled block were cows 3.41 ± 0.43 , heifers 1.45 ± 0.24 , bulls 1.77 ± 0.23 , male calves 1.26 ± 0.20 , female calves 1.04 ± 0.16 , and steers 1.13 ± 0.15 . Mean cattle herd size was smaller in tsetse controlled block than tsetse uncontrolled block

Results of parasitological study revealed that the prevalence of trypanosome positive calves in dry and wet seasons were higher in tsetse uncontrolled block ($p < 0.05$). It was 5(1.85%) in wet

season and 3(1.1%) in dry season, while in tsetse controlled block no positive cases detected in both seasons. *Trypanosoma congolense* 75% and *trypanosoma vivax* 25% was responsible for trypanosome infection of calves. Mean PCV value of $30.48 \pm 0.42\%$ was recorded in tsetse controlled block, while in tsetse uncontrolled block it was $28.37 \pm 0.37\%$. The difference in the level of anemia between the two blocks and between parasitaemic and aparasitaemic animals was significant ($P < 0.05$).

The entomological survey showed that the apparent density (fly/trap/day) in tsetse controlled block were 0.12 for tsetse fly, 1.67 for *Tabanus* and 0.76 for *Stomoxys*, while in tsetse uncontrolled block, 32.16 for tsetse fly, 2.41 for *tabanus* and 1.26 for *stomoxys*. Mean catch (average $\pm$ SE) of tsetse and biting flies varied significantly between the two blocks ($P < 0.05$).

The case control study of calves after six months revealed that the mean ($\pm$ SE) body weight of calves in tsetse controlled and tsetse uncontrolled blocks were 40.23 ± 0.70 kg and 34.74 ± 0.68 kg, respectively, which were statistically different ($P < 0.05$). The above findings strongly suggest that trypanosomosis is a disease of economic importance in the area and control programs being implemented by the STEP project is registering a significant improvement in livestock production in the areas it has intervened.

Key words: calves, birth, controlled, disease, growth, health, herd, mortality, trypanosomosis, tsetse, STEP, uncontrolled, weaning

1. INTRODUCTION

Ethiopia has the largest livestock population in Africa estimated to be 49.3 million cattle, 25.02 million sheep, 21.88 million goats, 1.79 million horses, 5.42 million donkeys, 335 thousand mules, 1(one) million camels, 38.13 million chicken and 4.7 million beehives (CSA, 2008). The livestock sub sector plays a vital role as source of food, income, services and foreign exchange to the Ethiopian economy, and contributes to 12 and 33% of the total and agricultural GDP, respectively, and accounts for 12–15% of the total export earnings, second in order of importance. Livestock contribute to the livelihoods of 60-70% of the population (Ayele *et al.*, 2003). It is eminent that livestock products and by-products in the form of meat, milk, honey, eggs, cheese, and butter supply the needed animal protein that contribute to the improvement of the nutritional status of the people(CSA, 2008). However, the future development of any livestock production relies, among other things, on successful programmes of raising calves and heifers for replacement (Bath *et al.*, 1985). In addition, the health management practices of replacement animals are important components of the total herd productivity. Poor health management has negative impact on growth of calves, limits opportunity for genetic selection due to high mortality of replacement animals and reduce milk yield from these animals that experience chronic illness during growth of calves to adult cows and increased veterinary costs (Rahmato, 2005). Diseases that most commonly affect calves in the early age are: calf scours caused by bacteria, viruses and coccidian etc. In the later stages when calves are more and more exposed to infections during grazing practices, are a wide variety of parasitic (direct and vector born) and other contagious diseases. One of the most important parasitic vector born diseases threatening the lives of both calves and adult cattle is trypanosomosis.

Trypanosome transmission is cyclic in most of the cases and begins when blood from a trypanosome infected animal is ingested by tsetse fly. Tsetse flies infest about 10 million km² of fertile land and spread across 37 countries on the African continent, from Senegal in the North to South Africa in the south. Many areas that are infested with tsetse flies are the most suitable areas for livestock and crop production (PATTEC, 2001). Tsetse flies are the main vectors of African animal trypanosomosis (AAT) caused mainly by *Trypanosoma congolense*, *T. vivax* and *T.brucei*. It is estimated that some 46 million cattle are at risk of contracting AAT in Sub-Saharan Africa (Kristjanson *et al.*, 1999; FAO, 2000). The disease is

characterized by intermittent fever, anemia, lymphadenopathy, splenomegally and cachexia often followed by death in untreated cases (Mulligan, 1970). Besides the direct pathological impacts of trypanosomosis on livestock, the indirect negative effects include inability to use more productive exotic and cross breed cattle, depression of growth and distribution of livestock population, reduced opportunities for livestock and crop production integration, and impacts on human settlements (Shaw, 2004). In Ethiopia, 14 million cattle are exposed to trypanosomosis and 20,000 heads die every year. Inter Africa Bureau for Animal Resource (IBAR, 1989) and (Slingenbergh, 1992) reported that at least 6 million of the 45 million heads of cattle that are raised under trypanosomosis risk in Africa are now found in west and south west Ethiopia.

In the absence of vaccines, trypanosomosis control relies heavily on vector control and chemotherapy. The benefits of tsetse/trypanosomosis control are: reduced disease prevalence or even disease elimination, reduced mortality rates, less treatment expenses and improved health and agricultural productivity. These would result in an increase in the amount of milk and meat, lower price to consumers and increased traction power and manure production. Reports showed that cattle in tsetse-free areas produced 83% more milk and 97% more meat per unit land area than those in tsetse-infested areas (Kristjanson *et al*, 1999). There are different ways of controlling tsetse and trypanosomosis. These include chemotherapy and chemoprophylaxis, vector control, the use of trypanotolerant breeds of livestock and integrated approaches. Complete dependence on drugs, in many situations, has now become very risky in many areas because of drug resistance and foreign exchange problems. In countries with few monetary and foreign exchange resources, community-managed traps and screens for killing tsetse flies, insecticide application on the animals, and the use of trypanotolerant livestock are to be favored. Control should be flexible and integrated involving all available methods which are suitable in a particular situation (Uilenburg, 1998).

In Ethiopia, successful control of tsetse and trypanosomosis in the Ghibe Valley appears to have accelerated conversion of wooded grassland into cropland and fragmented wild life habitat (Cathleen *et al.*, 1996) making the area suitable for livestock rearing. Despite such successes in pockets of trypanosomosis affected areas, the disease and its cyclical vector are still prevalent in many parts of Ethiopia causing reduced productivity and affecting the livelihood of animal breeders. One of the many effects of trypanosomosis in animal

production is calf morbidity and mortality (Rowlands *et al.*, 1994) and tsetse control in the Ghibe valley has reduced calf mortality (Rowlands *et al.*, 1999). However, the impacts of the disease on a one the hand and tsetse and trypanosomosis control programs on the other hand on calf production (morbidity, mortality and growth) have never been studied at Arba Minch Zuria District around the Southern Tsetse Eradication Project site in southern rift valley of Ethiopia.

The objectives of this study were therefore:

- To assess the impacts of trypanosomosis control on the growth of calves in the study areas
- To assess the status of calf morbidity and mortality due to trypanosomosis in the study areas

2. LITERATURE REVIEW

2.1. Calf rearing and its importance

Calf refers to group of young cattle from birth to six or nine months of age after which in natural circumstances, it might be expected to be self-sufficient (Webster, 1984; West, 1995). The term calf, in less intensive system of production, may generally include cattle older than the age indicated in the above definition. The population of calves wean before six months of age increase from less intensive to more intensive system of production (ILRI, 1996). Calves have some special features in their body system that have relevance in diseases occurrence and accordingly require special attention in management. Those that are of particular importance are the poorly developed defense mechanism and a dynamic digestive system that has to evolve from milk digestion to solid feed digestion. This make calves particularly susceptible to disease (Wudu, 2004).

Maintaining healthy calves is the product of good nutritional and housing management in addition to planned disease prevention and control measures. Target growth rates cannot be achieved without an effective health management Programme (Crown, 2006). The future of any dairy production depends, among other things on successful program of raising calves and heifers for replacement (Bath *et al*, 1985). On the other hand, the health and management of replacement animals are important components of total herd profitability. The productivity of the herd can be negatively impacted by retarded growth of calves, decreased milk production of animals that experienced chronic illness as baby calves, spread of infectious diseases from calves to adult cows, increased veterinary costs and the limited opportunity for genetic selection due to high mortality of replacement animals. Among all animals present on dairy farms, the highest mortality rates generally occur in baby calves prior to weaning (Rahmato, 2005).

Raising replacement dairy heifers presents a challenge in building for the future. Records show that about 25 to 35% of milking cows must be replaced annually, and therefore, to maintain herd size and improve genetic material for high milk production, quality heifer replacement must be continuously available (Waltner-Toews *et al*, 1986). But calf morbidity and mortality are perennial problems in all countries where cattle are raised. The mortality rates vary from 2% to as high as 20%, with mortality on individual farms varying from 0% to

above 60%, although in well managed dairy herds of developed countries, average mortality is usually between 2 to 4%. In developing countries, under poor management and major disease problems, especially in sub-Saharan Africa, the usual average mortality is 7 to 25%. Most of the illness and deaths occur during the first few weeks of life, because of the effects of infectious pressure and mismanagement of both the calf and its environment (Heinrichs and Radostits, 2001).

A high rate of pre-weaning mortality in calves is one of the main causes of low off-take for slaughter in pastoralist herds. Animals that are small for their age and breed at weaning will take longer to reach slaughter weight and consume more feed than are well grown at this stage. When calves are young, they use metabolisable energy for growth more efficiently than when they are older. Calf management strategies should therefore aim to maximize pre-weaning survival and promote an optimal growth rate for the production system (Smith, 2006). Livestock represent the majority of pastoralist's wealth. Pastoralists sell animals when they need cash, barter them for grain, or slaughter them for meat. The herd is like a bank account: the size of herd represents the owner's wealth; the calves that are born are the 'interests'. However, disasters such as severe drought, disease epidemics, cattle raids or war may decimate a herd. Rebuilding an economically viable herd may be impossible for people who have lost most or all of their animals; such people may become destitute (IIRR, 2002).

The optimum weight of a calf at birth is one close to the mean for the breed since both very large and very small birth weight calves have lower survival rates from birth to weaning. The death of very large calves usually occurs during or shortly after birth and is connected to dystocia. Indigenous tropical breeds tend to produce relatively small calves and dystocia is rare. Mortality associated with low birth weight occurs throughout the pre weaning period, for example the cumulative mortality of N'Dama calves in the Gambia increased progressively with age from birth to 120 days. In addition, as weight at birth declines below 0.9 of the mean, the cumulative mortality to all ages increased substantially (Table 1) (Smith, 2006).

Table 1. Pre-weaning mortality amongst N'Dama calves in traditionally managed herds

Body weight growth at birth	Body weight at birth (kg)	Cumulative calf mortality			
		Day 30	Day 60	Day 90	Day 120
Low	<14.1	3.6	7.0	10.7	13.8
Average	14.1-7.3	0.9	2.7	4.6	6.3
High	> 17.3	0.3	1.4	2.6	5.0

Source: Agyemang (1992)

2.2. Calf management

2.1.1. Calf feeding and nutrition

The early nutritional status of calves has a marked influence on their later productivity. Colostrum feeding management has an important influence on the health and welfare of calves. Colostrum is the milk produced by the cow prior to and during the first few days after calving. Colostrum obtained from the first milking after calving contains more protein, particularly immunoglobulins, fat, minerals, and vitamins than milk produced later. For approximately 4-6 weeks after birth, calves depend on these immunoglobulins absorbed from colostrum for protection from infectious agents in their environment (Arana *et al*, 1998). The timing of first colostrum is particularly important since calves' ability to absorb colostrum is substantially reduced six to eight hours after birth. Newborn calves consume milk only, but as they grow increase their intake of solid feed. Consumption of both milk and solid feed (usually grass) influences the rate of calf growth. Water is an essential nutrient. It is necessary for various metabolic activities such as digestion, hydrolysis of carbohydrates and proteins, excretion of waste products, nutrient transport, lubrication of joints, electrolyte balance, body temperature control, and development of rumen function. All calves should have access to clean, fresh water. The amount of water consumed depends on the calf's age, the amount and type of feed consumed, ambient temperature, amount of exercise, and water cleanliness and temperature (Arana *et al*, 1998).

2.1.2. Housing

Calves must have a shed and bedding that provides comfort, insulation, warmth, dryness and traction. Bare concrete is not acceptable as a resting surface. Housing must allow calves to easily stand up, lie down, turn around, adopt normal resting postures, and have visual contact with other calves. The bedded area for group-housed calves must be large enough to allow all calves to rest comfortably at the same time (Kees *et al*, 2009). Individual pens separate calves and reduce the spread of communicable diseases and make it easier to observe behavior, feed consumption, and fecal and urine production.

2.1.3. Weaning

In traditionally managed herds, calves are usually weaned naturally when the cow dries up at end of her normal lactation period (7-12 months after calving). In commercial herds, calves are normally weaned earlier. They can be weaned early and still achieve a good mature weight, if they are given a diet containing at least 13% roughage and 70% concentrates (Smith, 2006). Weaning can be a stressful time for the calf and if not carried out properly can set back progress within the rearing programme. Calves may be weaned as early as six weeks of age, although it is commonplace for calves to be weaned between 8-12 weeks of age depending on the availability of milk due to the quota situation on the farm. Making a decision about what stage to wean calves should not be based solely on the age of the animals but also on body weight, intake and healthy (Crown, 2006).

2.1.4. Health care

Disease affecting the pre-weaned calf may compromise its ability to mature and produce milk. A calf treatment protocol should be established, and calf personnel trained to recognize disease early and to promptly initiate treatment. Well managed calf operations can keep death loss prior to weaning below 5%. Death losses greater than 5% indicate management should be improved. Failure in any of the following areas can contribute to increased calf illness and death: colostrum management, facility, design, sanitation, disease recognition and treatment, preventive health care, and quality nutritional programs (Arana *et al*, 1998). Diseases that most commonly affect calves in the early age are: calf scours caused by bacteria, viruses and coccidian etc. In the later stages when calves are more and more exposed to infections during grazing practices, are a wide variety of parasitic (direct and vector born) and other contagious diseases. One of the most important parasitic diseases threatening the lives of both calves and adult cattle is trypanosomosis. Although trypanosomosis is an important cause of calf growth and mortality, studies done to quantify the magnitude of the problem, and to determine the underlining causes are scant and scarce. Attempts to quantify the impact of diseases have taken into account the direct (mortality, fertility, milk production, animal traction and weight) and indirect effects on key productivity measures. This disease will be described in detail in the following subtopic.

2.2. Trypanosomosis and its impact on calf production

2.2.1. Trypanosomosis

Trypanosomosis is one of the most important diseases of livestock and man. It is a protozoan disease caused by the genus *Trypanosoma*, transmitted cyclically by the tsetse fly (*Glossina* species) and mechanically by biting flies. Species of economic and public health significance are *Trypanosoma congolense*, *T. brucei brucei* and *T. vivax* in animals and *T. brucei gambiense* and *T. b. rhodesiense* in man (Seifert, 1996). The disease is characterized by intermittent fever, anemia, lymphadenopathy, splenomegally and cachexia often followed by death in untreated cases (Mulligan, 1970). The pathogenesis of African trypanosomosis differs according to the species causing the infection. *T. vivax* and *T. congolense* appear to be strictly parasites of the blood plasma and produce tissue injury through the development of anemia. *T. brucei* is more widely distributed in the host affecting the intercellular fluids of

the body cavities (Robertson, 1976). Here also anemia occur but is considered to be of secondary importance to extensive degenerative, necrotic and inflammatory changes. The pathogenesis also includes chancre, lymphadenopathy, and tissue damage (Mulligan, 1970). Chancre develops when the tsetse fly injects infective metacyclic trypanosomes into the skin of the host and here local inflammatory reaction and swelling occur probably due to the bite of tsetse and the multiplication of the parasite. The metatrypanosomes divide and multiply in the chancre and give rise to the typical blood forms which invade the lymphatic and lymph nodes and then the blood stream (Uilenburg, 1998).

African animal trypanosomosis is arguably still the main constraint to livestock production on the continent, preventing full utilization of land to feed rapidly increasing human population (Murray *et al*, 1983). Tsetse transmitted trypanosomosis affect 37 sub-Saharan countries. An estimate of 160 million cattle and 200 million sheep and goats (Table 2) are kept in this area of risk extending over 10 million Km² of land (Erkelens *et al.*, 2000).

Table 2. Tsetse transmitted animal trypanosomes in the world

Trypanosoma species	Animals affected	Geographic distribution
<i>T. congolense</i>	Cattle, sheep, goats, pigs, camel, horses, most wild animals	Tsetse regions of Africa
<i>T. vivax</i>	Cattle, sheep, goats, camels, horses, various wild animals	Africa and South America west Indies*
<i>T. brucei brucei</i> .	All domestic animals various wild animals, most severe in dogs, horses, cats,	Tsetse region of Africa
<i>T. simiae</i>	Domestic and wild pigs	Tsetse region of Africa

* In non tsetse infested areas transmission is by biting flies

Source: Cynthia (2005)

There are five economically important animal trypanosome species in Ethiopia: *T. congolense*, *T. vivax*, *T. b. brucei*, *T. b. evansi* (Langridge, 1976) and *T. equiperdium* (Hagos, 2005) Geographic distributions of pathogenic trypanosomes in Ethiopia are indicated in Figure 1.

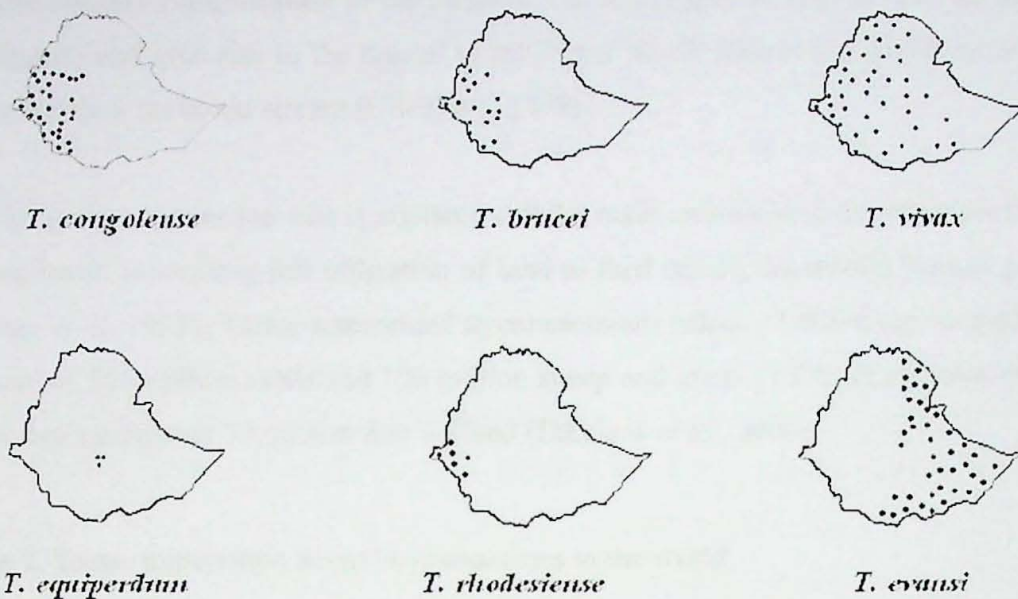


Figure 1. Geographic distributions of pathogenic trypanosomes in Ethiopia
(Source: Abebe, 2005)

A report by Abebe and Jobre (1996) indicated an infection rate of 8.5% for *T. congolense*, 31.27% for *T. vivax* and 3.5% for *T. brucei* in cattle in tsetse infested areas of southern Ethiopia. They also indicated that 8.71% trypanosome prevalence rate was recorded in the highlands (tsetse free areas) of which 99% was due to *T. vivax*. In countries such as Ethiopia, where livestock is an important part of the agricultural sector, trypanosomosis contributes to direct economic losses in mixed crop-livestock production systems (Miruk, 2007). The prevalence of trypanosomosis in different species of livestock in different parts of Ethiopia is depicted in Table 3.

Table 3. Prevalence of trypanosomosis in different species of livestock in Ethiopia

Host	Study site	Prevalence (%)	Major causes	Reference
Cattle	Arba Minch	32	<i>T. congolense</i> <i>T. vivax</i>	Argaw and Abebe, 1998
	Southwest Ethiopia	17.7	<i>T. congolense</i> <i>T. vivax</i>	Abebe and Jobre, 1996
	Metekel	17.2	<i>T. congolense</i> <i>T. vivax</i>	Afewerk <i>et al.</i> , 2000
	Didessa	21.3	<i>T. congolense</i> <i>T. vivax</i>	Tewelde <i>et al.</i> 2004
Sheep	Didessa/Ghibe	7.65	<i>T. congolense</i> <i>T. vivax</i>	Dinka and Abebe, 2005
Goats	Didessa/Ghibe	3.56	<i>T. congolense</i> <i>T. vivax</i>	
Donkeys	North Omo	18.2	<i>T. congolense</i> <i>T. vivax</i>	Assefa and Abebe, 2000
Camel	Borena	10.9	<i>T. evansi</i>	Tekle and Abebe, 2001

2.2.2. Transmission

In animals, trypanosomes are either transmitted cyclically by tsetse flies (Genus: *Glossina*) or mechanically by haematophagous flies of the genus *Tabanus*, *Stomoxys* etc (Seifert, 1996). The most important trypanosomes in terms of economic losses in livestock are the tsetse transmitted species: *T. congolense*, *T. vivax* and *T. brucei* (Mulligan, 1970). However, *T. vivax* has been found outside the zone of *Glossina* infestation, where it is transmitted non-cyclically by other species of biting flies (Abebe and Jobre, 1996). *T. evansi* is also acyclically transmitted by biting flies of the genus *Tabanus* and *Stomoxys*. *T. equiperdum* on the other hand is transmitted sexually, from host to host (Molyneux and Ashford, 1983).

The cyclical transmitters of trypanosomes, tsetse flies, belong to the family Glossinidae that consists of single genus *Glossina*. They are confined to tropical Africa, extending from the southern Sahara in the North to Zimbabwe and Mozambique in the south (Urquhart *et al.*, 2001). Approximately 10-11 million km² of land or 37 African countries are infested by 22 species and 8 subspecies of tsetse, divided into three groups with contrasting ecological and behavioral characteristics (Cynthia, 2005). The Morsitans group of tsetse is found mainly in savannah woodlands across sub-Saharan Africa. These species are highly mobile and use a combination of visual and olfactory stimuli to locate their hosts. The group includes *G. pallidipes*, *G. morsitans*, *G. longipalpis* and *G. austeni*. The palpalis group comprises species found mainly in riverine woodland of west and central Africa. Species from this group are generally less mobile, being confined to their riverine habitats, and use visual senses, rather than olfactory ones to locate their hosts. The group includes important vectors of human sleeping sickness such as *G. fuscipes* and *G. palpalis*. The Fusca group comprises species typically found in humid forests. Species from this group are generally considered to be less important as a vector, largely because their natural habitat is less used by livestock and people. Nonetheless, some species (eg, *G. brevipalpis*) have been implicated as significant vectors of animal trypanosomosis (Leak, 1999).

Trypanosome transmission is cyclic in most of the cases and begins when blood from a trypanosome infected animal is ingested by the fly. The trypanosome loses its surface coat and multiplies in the fly. Then it re-acquires a surface coat and becomes infective (Cynthia, 2005). This process takes 5-13 days for *T. vivax*, 15-23 days for *T. congolense* and 12-23 days for *T. brucei*. Infection rates in tsetse populations are generally low; however, these rates vary according to factors such as the local climate, the species, age and physiological status of the flies and the availability of infected hosts (Holmes, 2008).

Trypanosomosis is also mechanically transmitted by tsetse and other biting flies through the transfer of blood from one animal to another during interrupted feeding. The most important mechanical vectors are flies of the genus *Tabanus*, but *Haematopota*, *Liperosia*, *Stomoxys*, and *Chrysops* flies have also been implicated. In Africa, both *T. vivax* and *T. b. evansi* have spread beyond the "tsetse fly belts", where transmission is principally by tabanid and hippoboscids (Maré, 1998).

2.2.3. Tsetse distribution in Ethiopia

There are five species of tsetse in the southern and south western part of the country, which is believed to be fertile and suitable for crop cultivation. The infested area is estimated to be from 50,000-220,000 km² and about 10-14 million heads of cattle and equivalent numbers of small ruminants are under serious risk of the disease (STEP, 2002). The tsetse belts extend from the southern part of the Rift Valley around the southwestern lowlands to the larger river valley of the Abay/Didessa, Baro/Akobo, and Ghibee/Omo (FAO/IAEA, 1995). Further eastward spread is restricted by the cold limit imposed by the highlands and the semi-desert conditions along the southern border east of the Rift Valley (TCS, 1980). The *Glossina* species found in Ethiopia are *G. morsitans morsitans*, *G. pallidipes*, *G. longipennis*, *G. fuscipes* and *G. tachinoides*. *G. morsitans morsitans*, *G. pallidipes* and *G. fuscipes* in the southwest Ethiopia, *G. tachinoides* in west and southwest Ethiopia and *G. longipennis* in southern Ethiopia in semi desert area (Langridge, 1976) (Figure 2).

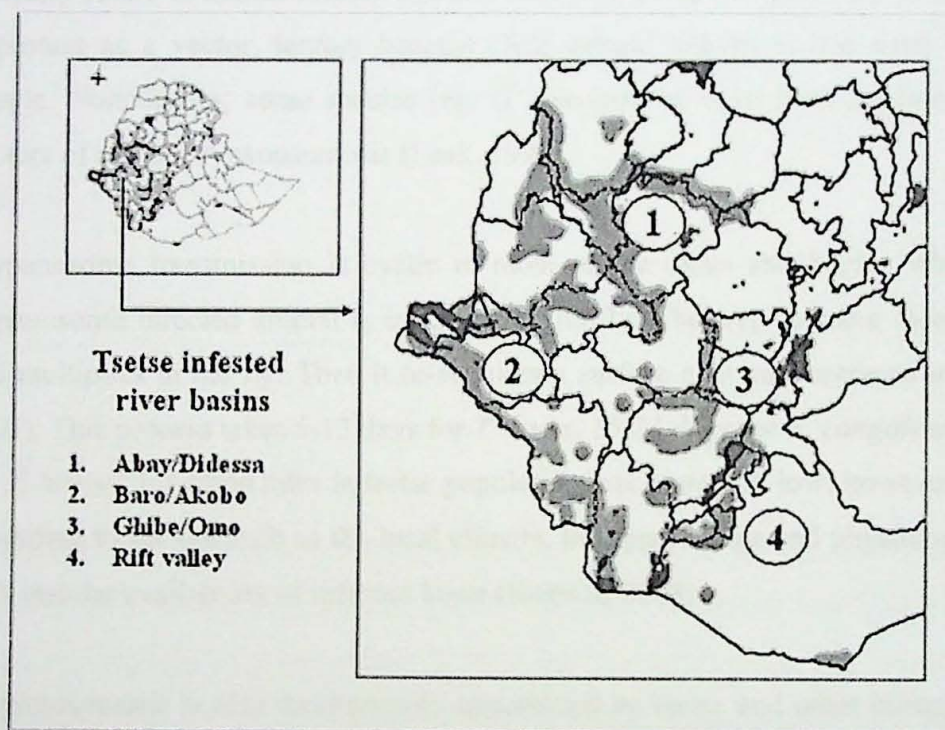


Figure 2. Tsetse infested river basins in Ethiopia

(Source: Abebe, 2005)

2.2.4. Impact of trypanosomosis

Tsetse flies infest approximately 10 million km² or about 40 percent of Africa. The *Glossina* species are the vectors of trypanosomosis, which hinders agricultural development and causes poor weight gain, stunted growth, lowered milk production and reproductive disorders in livestock. Besides losses of meat and milk, trypanosomosis limits land utilization in infested areas and may lead to overgrazing in non-infested areas. African's tsetse infested savannas are the region's only remaining land source with good physical and biological potential, representing the best watered and most fertile land on the continent (Wilson, 2007).

The impact of trypanosomes in African agriculture is most obviously seen in the birth and mortality rate of young animals (Erkelens *et al*, 2000). In susceptible cattle breeds, the disease reduces calving by up to 20% and causes the death of another 20% of young stock. Similarly, livestock kept under trypanosomosis challenge have 6-20 percentage point higher annual calf mortality, 6-19 percentage point lower calving rate and a 20% decrease in milk yield (Shaw, 2004). Weight loss and a reduction in work efficiency of oxen used to cultivate the land (up to 38%) are additional direct effects of the disease (Shaw, 2004). Even so-called "trypanotolerant" animals are affected; studies in the Gambia indicate that trypanosomosis reduces milk off take by up to 26%, and reduces lambing and kidding rates by as much as 37% (PAAT, 1999). The Food and Agriculture Organization (1992) of the United Nations has estimated that, every year, Africa loses over 3 million cattle and other domestic livestock through deaths caused by trypanosomosis. Approximately 35 million doses of trypanocidal drugs (worth about USD 35 million) are bought every year in futile efforts to maintain livestock free of the disease (PATTEC, 2000). The annual loss directly attributed to trypanosomosis, in terms of reduced meat and milk production and in terms of cost related to treating the disease or controlling the vector, has been estimated at USD1.2 billion. This figure rises to over USD 4.5 billion per year, if losses in potential crop and livestock production attributable to the disease are considered. In Ethiopia, some 10-14 million heads of cattle and an equivalent number of equine, goat and sheep are exposed to the risk of acquiring trypanosomosis. Morbidity and mortality losses from ruminant livestock alone are estimated to be USD 200 million (IAEA, 1996).

In southern rift valley low lands, the livestock management system can lead calves to trypanosomosis at early ages. Except cows and calves, the herds pass their night in the barn,

which has no shelter to prevent harsh environments. The calves let out after two months of age and graze grasses at their vicinity. This condition may expose them to direct contact with tsetse flies and consequently to trypanosomosis infection. However, very little attempts have been made to quantify the impact of trypanosomosis in calves in this area.

2.2.5. Tsetse and trypanosomosis control

Control of trypanosomosis currently focuses both on the parasite by medication using trypanocidal drugs, and on its vectors (especially cyclical vectors) by using insecticides, traps and insecticide impregnated targets (Abebe, 2005). Over most of sub-Saharan Africa, bovine trypanosomosis continues to be controlled primarily by trypanocides. Only three compounds-isometamidium chiloride, homidium (bromide and chloride) and diminazene aceturate are practically available and all other drugs have been on the market for over 40 years (Holmes *et al*, 2004). However, chemotherapy alone doesn't have any permanent effect on the cycle of the disease, because if the treatment is relaxed, the incidence of the disease soon returns to permanent levels. Moreover, because of the repeated utilization of the same types of drugs for many years, the effectiveness of all trypanocidal drugs have dangerously declined with the emergence of more and more drug resistant trypanosome strains (CIRDES, 2000). Treatment is effective in well-fed and rested animal, in which the immune system is not adversely affected by stress and lack of food (PAAT, 1999).

In the absence of vaccines and effective and affordable drugs, trypanosomosis control relies heavily on vector control. Attempts to control tsetse flies in Africa have been continuing since the early 1900's. Some control methods such as bush clearing and game elimination were widely practiced in the past. Over the last 30 years, tsetse control and eradication attempts have largely involved the use of either selective ground spraying or sequential aerial application of insecticides. However, because of high cost and environmental consideration, the use of insecticide becomes no more a method of choice to carry out (SRVL, 1998).

Currently, several different control approaches are used with eventual impacts ranging from reduction of fly populations to total eradication. Targets and traps have been effective in

controlling populations locally and have been used extensively in agricultural settings (Vale, 1988) and considerable success has been achieved by directly applying insecticides on animals (pour-on) (Rowlands *et al*, 2000). Tsetse is visually attracted to specially designed traps or targets. This attraction may be augmented by the use of olfactory attractants (Calvin and Gibson, 1992). Insecticide treated cattle as pour-on offer numerous advantages over-baited traps and targets. Cattle are used as moving targets and hence no cost on odor baits, besides cattle can be moved to spray races or dips rather than staff traveling to widely dispersed traps/ targets. The technique was field tested and found successful in a number of African countries including Ethiopia (Rowlands *et al*, 2000; Hailemariam, 2003).

An alternative approach that is area-wide in nature is the sterile insect technique (SIT), which has been successfully applied in the control of several important pests including the screwworm fly in the USA and the Mediterranean fruit fly (Rogers and Randolph, 1990). The technique was applied in large scale tsetse eradication programs in some parts of Africa including Burkina Faso (Clair *et al*, 1990), Northern Nigeria (Jordan, 1986), Tanzania, and Zanzibar. In Ethiopia, a major SIT project is being coordinated by the Ethiopian Science and Technology Ministry and implemented by the Agricultural Bureau of the Southern Nations, Nationalities, and Peoples Administrative Region in the southern Rift valley, which is aimed at the establishment of sterile insect production plant and the actual field operation of the fly eradication process (Abebe *et al*, 2004).

The Southern Tsetse Eradication Project was established in 1997 with approval and commitment from the Government of the Federal Democratic Republic of Ethiopia, The Southern Nations, Nationalities and Peoples Regional State (SNNPR), and the International Atomic Energy Agency (IAEA). The project area is located in the southern rift valley of Ethiopia, mainly in SNNP Regional State (70%), and Oromia Regional State (30%). It consists of an estimated area of about 25,000km² (Figure 3). The major activities of the project are baseline data collection, fly population suppression, fly rearing and irradiation and sterile male releasing and eradication of tsetse flies from the targeted areas (STEP, 2000). The project has collected so far information on tsetse fly diversity, distribution and abundance, at different altitudes, and vegetation. As part of the entomological surveys, a total of 7,733 traps have been deployed at different altitude and vegetation classification in 63 grids. A total of 12,298 tsetse flies (*G. pallidipes*) were caught at preliminary surveys. The highest apparent

density was 68.6 flies/trap/day while the least apparent density was 0.013 fly/trap/day. The altitude at which tsetse were trapped varies from 786 to 1,992 meters above sea level (STEP, 2000). The results of the parasitological survey indicated that *T. vivax*, *T. congolense* and *T. brucei* are the most common parasites in the project site. Overall disease prevalence rates of 7.66% and 1.20% have been found during the first and second surveys, respectively. Preliminary analysis of the result of two rounds parasitological survey and four cycles of entomological survey showed that there is a very good overlap between the vector and the parasite distribution in the project area (STEP, 2000).

Following base line data collection and based on the analysis of the results, fly population suppression was commenced in the project area using conventional technologies such as traps, targets and pour-on application. The technologies that were applied during this period were proven to be efficient and cost effective (STEP, 2008). However, the impact of the control program on the productivity of livestock, and specifically, on calf mortality and performance in the area is not studied particularly at Arba Minch Zuria District.

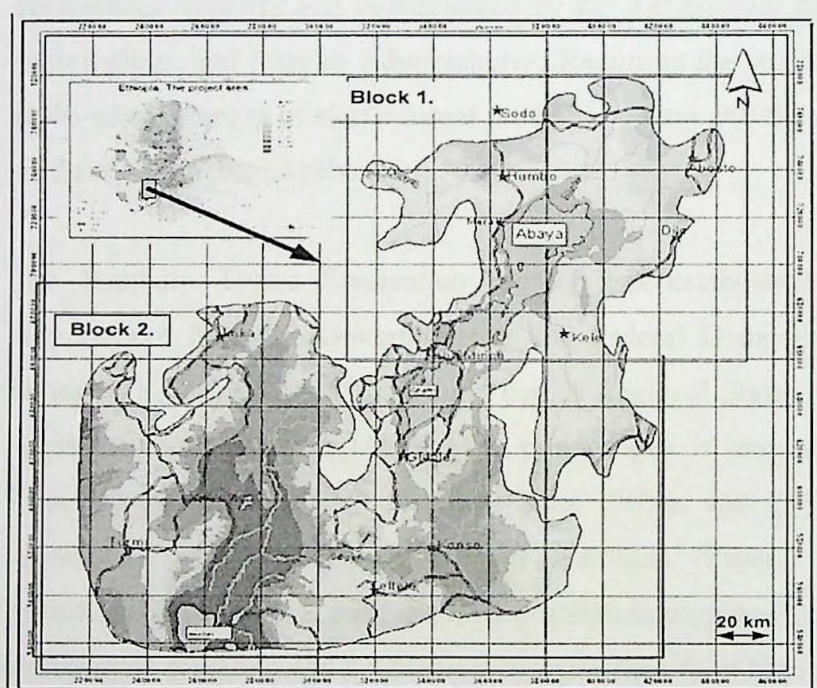


Figure 3. Southern Tsetse Eradication Project (STEP) project work area

3. MATERIALS AND METHODS

3.1 Study area

Arba Minch Zuria District was the study area which is located within the Southern Rift Valley area in Gamo Gofa Zone of SNNPR, about 500 km south from Addis Ababa, at $5^{\circ} 70''$ - $6^{\circ} 18''$ north, latitude and $37^{\circ} 31''$ - $37^{\circ} 81''$ east longitude. It is bordered at southeast by Chamo Lake (551 km^2) and Nech Sar Park (514 km^2), at northeast by the largest rift valley lake of Abaya (1160 km^2), and at the west by Ganta chain of mountains. The District is entirely organized into 29 PA's. From these 5 PA's were under the STEP activities while 3 are not yet included in the activity. The total area of the District is about 1638.30 km^2 of which about 901.80 km^2 is used for cultivation and about 163.20 km^2 is used for grazing. The rest portion of the area is covered by lakes, parks, bush, rivers and thin forests. The District lies within the range of 1000 to 2500 meters above sea level. The area has an average minimum and maximum annual temperature of 15.1°C and 25°C , respectively. The mean annual rainfall ranges between 801 and 1600mm. The agro-climatic condition of the area includes 14% highland 53% midland and 33% lowland. There are two rainy seasons, the short rainy season occurs during February to April, followed by the long rainy season, from June to September. The total human population of the District is estimated to be 164,235 of which 83,993 are males and 80,242 are females. The total livestock population is estimated to be 90,956 cattle, 19,837 goats, 17,818 sheep, 3,129 equine and 55,889 poultry. The predominant farming system of the district is mixed crop-livestock farming system (SNNPR, 2006/07). The Southern Tsetse Eradication Project site located at $4^{\circ} 45''$ and $7^{\circ} 15''$ North, $36^{\circ} 40''$ and $38^{\circ} 20''$ East within the Southern Rift Valley of Ethiopia. The project covers an area of 25000 km^2 . Four PA's were selected purposely from Arba Minch Zuria District: Kola Shara and Chano Mille from tsetse control program areas, which are located at about 15 km on the northern wing of Arba Minch town and Ganta Kanchama and Elgo from uncontrolled sites located at about 25 km on the southern wing of the town. These PA's have similar ecological conditions, production system and the same cattle breeds are found in the study area.

3.2. Study population

The study population comprised calves of different age and sex groups. A calf is defined as cattle up to six months of age after which under natural circumstances; it might be expected to be self-sufficient (Webster, 1984). Households keeping calves in the study areas represented the study population.

3.3. Study design

A longitudinal type of study was conducted to estimate the prevalence of trypanosomosis in wet and dry seasons, the monthly fly density and calf growth parameters. There was also a retrospective type of study to collect data on calf growth parameters and calf management practices.

3.4 Sampling procedure and sample size determination

The sampling method used was a one stage cluster type of sampling. Herds were considered as cluster and the sample size determination formula recommended by Thrusfield (2005) was used to calculate the sample size:

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

Where: g=number of clusters sampled

P exp = expected prevalence

d = desired absolute precision

n = number of animals per cluster

vc = between cluster variance

As data derived from previous cluster samples, were not available, the between cluster-variance component (vc) was estimated (Thrusfield, 2005). Considering 3 calves in a cluster (herd), a between cluster variance of 0.035, a desired absolute precision of 5% at confidence level of 95% and expected prevalence of 7.66% (STEP, 2000), a total of 90 households were sampled from each block, which made a total of 180 households. Thus, a total of 540 calves were included in this study.

3.5 Data Collection

3.5.1. Prevalence study of trypanosomosis

Blood samples were collected aseptically from the ear vein of 540 calves (twice during the study period: 1080 samples in total) heparinized haematocrit capillary tube. The Buffy-coat dark ground technique was used for parasitological examination. The blood filled haematocrit tubes were centrifuged at 12,000 rpm for 5 minutes after which the capillary tubes were cut with a diamond tipped pencil, 1 mm below the Buffy coat, to include the top layer of RBC. The Buffy coat and the upper most layer of RBC were extruded on to clean microscopic slides, covered with a cover-slip and examined based on the type of movement in the microscope field (Murray *et al.*, 1977). Confirmations of trypanosome species by morphological characteristics was done after staining the blood smear with Giemsa and examination with oil immersion microscopy.

3.5.2. Packed cell volume (PCV) determination

Blood samples collected and processed for Buffy coat examination were used for PCV determination. Before cutting, the capillary tubes were loaded on a microhematocrit reader and the percentage of PCV in relation to the total volume of blood in the tube was determined (Delespaux *et al.*, 2005).

3.5.3. Tsetse apparent density

To assess the apparent densities, distribution and species of tsetse flies and other biting flies in different vegetation pattern, 40 NGU traps (Bright *et al.*, 1991) were deployed for six consequent months in each selected site considered to be a suitable habitat for tsetse flies. Every trap was odor-baited with acetone and cow urine, as odor attractants for tsetse flies. The underneath of each trap pole was smeared with grease in order to prevent ants climbing up the pole towards the collecting cage that could damage the tsetse flies. The deployment time was 72 hours. Then, the flies captured in the collecting cage were sexed, species identified and sites recorded. A hand lens was used for the identification of tsetse fly species. Other biting

flies were also identified and recorded. The species of tsetse flies was identified based on morphological characteristics (Langridge, 1976; Leak *et al*, 1999).

3.5.4. Measure of growth parameters

Body length, heart girth and body weight

Case control study of calf growth parameters was undertaken on 40 randomly selected (an average one month of age) calves twice each month for six months. The following measurements were undertaken:

- Body length: measures the length from the point-of-shoulder (A) to the point-of-rump or pin bone (B).
- Heart girth: measures the circumference from a point slightly behind the shoulder blade, down the fore-ribs and under the body behind the elbow all the way around.

After these measurements are made in inches, the following formulas were used to calculate the body weight of selected animals:

Weight in pounds= (Heart girth X heart girth X body length) ÷ 300 (Winter 2007)

The body weight values in pound were converted into kilograms by dividing the pound values by 2.2.

Body condition scoring

Body condition scoring was done using the recommendations (1-9 scores) by Smith (2006) and animals were grouped in one of the following categories:

1= Animal is emaciated.

2= Spine (dorsal processes) prominent and transverse processes feel sharp to the touch, with no detectable fat cover.

3= Individual dorsal spines are pointed to the touch. Hooks, pins, tail head and ribs are

prominent. Transverse processes are visible, usually individually.

4= Ribs, hooks and pins are clearly visible. Muscle mass between hooks and pins slightly concave. Slightly more flesh over transverse processes than in point 3 above.

5= Rib usually visible; little fat cover; dorsal spines barely visible.

6= Animal smooth and well covered; dorsal spines cannot be seen but are easily felt.

7= Animal smooth and well covered; fat deposits are not marked. Dorsal spines can be firm pressure, but are rounded rather than sharp.

8= Fat cover in critical areas (tail head, dewlap and codpiece; ribs, hooks and pins) can be felt easily; transverse processes cannot be seen or felt.

9= Heavy deposit of fat clearly visible on tail head, dewlap and codpiece; ribs, hooks and pins fully covered and cannot be felt even with firm pressure.

Body height

The height measurements for the calculation of frame score are taken at the hip directly over the hook bones. Height measurements were collected through the use of hip height measuring sticks marketed specifically for that purpose. Such height sticks are constructed with a sliding arm containing a bubble level on a pole scaled in height increments. To make a measurement, the pole is held vertically alongside the animal's hip with the sliding arm positioned level and directly over the hook bones and a measurement read from the pole where the arm attaches. For accurate height measurements it is necessary for the animal to have its legs set squarely and head in a normal position (John, 1995).

3.5.5. Questionnaire survey

A structured questionnaire format was developed and administered to randomly selected household heads to obtain information on management practices, herd composition, the major livestock health problems, calf management, main roles of animals, socioeconomic activities, impact of trypanosomosis on livestock production with particular reference to growth rate, morbidity and mortality.

3.6. Data analysis

Data collected through questionnaire survey, measure of growth parameters, tsetse apparent density and prevalence study of trypanosomosis were entered in to MS-Excel spread sheet (Microsoft excel 2003). The data was analyzed using SPSS (SPSS release version 11.5, 2002). Descriptive statistics was used to summarize data and independent t-test, ANOVA, Chi-square and Mann-Whitney test were used to compare means of continuous variables and scores, respectively.

4. RESULTS

4.1. Questionnaire survey

4.1.1. Household characteristics

Out of the total interviewed farmers ($N = 182$), 96.70% were male and the rest 3.30% were female. The overall average age (Mean $\pm$ SE) of respondents in the studied households was 42.80 ± 1.3 , while it was 45.66 ± 1.3 in tsetse controlled areas and 39.93 ± 1.3 years in tsetse uncontrolled areas. The overall mean family size (Mean $\pm$ SE) in the studied household was 8.05 ± 0.32 persons. Higher value for family size was found in tsetse controlled area (8.43 ± 0.32 persons) than in uncontrolled areas (7.67 ± 0.32 persons) (Table 4).

Table 4. Mean and standard error of household characteristics

Variable	Unit	Controlled area		Uncontrolled area		Overall		t-value	P-value
		Mean	SE	Mean	SE	Mean	SE		
Family size		8.43	0.32	7.67	0.32	8.05	0.32	-1.66	0.099
Land holding (crop)	ha	1.09	0.05	1.50	0.08	1.3	0.07	4.53	0.000
Landholding (pasture)	ha	0.07	0.01	0.08	0.02	0.08	0.02	0.86	0.389
Land holding (total)	ha	1.15	0.06	1.59	0.08	1.37	0.07	4.25	0.000
Livestock herd size									
Cattle herd size		6.05	0.31	11.26	1.18	8.66	0.63	3.3	0.001
Sheep flock size		0.48	0.12	0.93	0.22	0.71	0.13	1.76	0.081
Goat flock size		1.56	0.22	0.93	0.21	1.25	0.15	-2.05	0.042
Donkeys		0.37	0.07	0.00	0.00	0.19	0.04	-5.14	0.000
Poultry		4.66	0.47	2.38	0.48	3.52	0.35	-3.39	0.001

With respect to educational status of the respondent household heads, the overall proportion of illiterate farmers, those who completed elementary school and secondary school was 35.2%, 36.8% and 28.0%, respectively. In tsetse controlled area 28.6%, 40.7%, and 30.8% of the respondents were not educated, completed elementary school and secondary school while, in tsetse uncontrolled area 41.8%, 33.0% and 25.2% of the respondents were not educated, completed elementary school and secondary school, respectively.

The overall (Mean $\pm$ SE) land holding in the study areas was 1.37 ± 0.07 ha. The total land holding was higher in the uncontrolled areas (1.59 ± 0.07) than the controlled areas (1.15 ± 0.08). The same thing holds true for crop land holding. In both areas (controlled and uncontrolled) more land was allocated for crop production (93.1% in the controlled area and 94.2% in the uncontrolled area) than pasture. The difference in total land holding and crop land holding between the controlled and uncontrolled areas was statistically different ($p<0.05$).

The livestock herd size and compositions in the two areas is shown in (Table 7). The livestock herd size was dominated by cattle in both the controlled and the uncontrolled areas. There were more cattle and sheep in the uncontrolled areas than the controlled areas while the number of goats, donkeys and poultry was higher in the controlled areas. The difference between the controlled and the uncontrolled areas was statistically significant for cattle, goat, donkeys and poultry ($p<0.05$)

4.1.2. Cattle herd size and composition

All cattle owned by the sampled households in both controlled and uncontrolled areas were indigenous. In both controlled and uncontrolled areas the cattle herd was dominated by cows from which lactating cows constituted the highest proportion in both study areas. The proportion of lactating pregnant and dry pregnant cows was higher in the controlled area than in the uncontrolled. On the other hand the proportion of dry non-pregnant cows was higher in the uncontrolled area than in the controlled. Regarding absolute number, there were more pregnant non-lactating, lactating non-pregnant and dry non-lactating cows in the uncontrolled areas than the controlled area while the reverse was true for lactating pregnant and dry pregnant cows. There were more cows, heifers, bulls, calves of both sex and steers in the uncontrolled area than the controlled area. The differences between the study areas (controlled and uncontrolled) was statistically significant for the number of cows, heifers, bulls, male calves, female calves and steers ($p<0.05$) (Table 5).

Table 5. Means and standard errors of mean of cattle herd size and composition by production blocks

Cattle type	Tsetse controlled (N = 551)		Tsetse uncontrolled (N= 917)		Overall (N = 1468)		t - value	p- value
	Means (SE)	%	Means (SE)	%	Means (SE)	%		
Cows	2.14(1.18)	35.39	3.41(0.43)	33.90	2.78(0.23)	34.36	-2.825	0.006
Pregnant non lactating	0.45(0.07)	21.03	0.55(0.10)	16.08	0.50(0.06)	17.98	0.807	0.421
Lactating non pregnant	0.67(0.08)	31.28	1.14(0.14)	33.44	0.91(0.08)	32.61	2.928	0.004
Lactating pregnant	0.45(0.07)	21.03	0.32(0.07)	9.32	0.38(0.05)	13.83	-1.385	0.168
Dry pregnant	0.44(0.07)	20.51	0.31(0.08)	9.01	0.37(0.05)	13.44	-1.259	0.210
Dry non pregnant	0.13(0.42)	6.15	1.10(0.18)	32.15	0.62(0.10)	22.14	5.225	0.000
Heifer	0.77(0.08)	12.70	1.45(0.24)	14.41	1.11(0.13)	13.72	-2.702	0.008
Bull	0.98(0.83)	16.16	1.77(0.23)	17.59	1.40(0.13)	17.31	-3.075	0.003
Male Calves	0.74(0.08)	12.16	1.26(0.20)	12.53	1.00(0.11)	12.36	2.485	0.014
Female Calves	0.66(0.07)	10.89	1.04(0.16)	10.34	0.85(0.09)	10.51	2.255	0.026
Steers	0.77(0.07)	12.70	1.13(0.15)	11.23	0.95(0.09)	11.74	2.041	0.043

N =number of observations, SE = standard error

4.1.3. Cow Management

The majority (83.5%) of the respondents house their Cows in mixed corals, while a small proportion (16.5%) used separate coral. The most important feed resource in the study area is grazing on marginal lands and shores of lakes in the area. All the farmers in both study areas supplemented their animals with horticulture byproducts and green grass. All the respondents cull their cattle for different reasons. The main reasons for culling of animals were old age (71.4%), poor milk production (17.6%), susceptibility to disease (6.6%), and behavioral problems (4.4%).

In both the study areas farmers allowed new born calves to suckle their mother for more than 15 days without milking for human consumption. After day seven, the calves were

supplemented with starter feed like green grasses. Then after 15 days, calves are allowed to suckle for shorter time prior to milking to stimulate the dam and then are allowed to suckle at the end of milking. All the respondents feed colostrum to new born calves for two to four days. In tsetse controlled area, 92 % of respondents rear all females born to reach puberty, for cow replacement, while in tsetse uncontrolled area only 63 % of respondents rear all females born to reach puberty.

On the other hand, 87 % of the respondents in tsetse controlled area and 50% of them in tsetse uncontrolled areas keep all males to reach puberty for draught use. In both tsetse controlled and uncontrolled areas, calves are weaned at 6 to 9 months of age. The overall average weaning age of calves were 7.36 ± 0.105 months with very little variation between the study areas 7.55 ± 0.089 months in tsetse controlled area and 7.18 ± 1.055 in tsetse uncontrolled area. All of the respondents in both areas provide their calves with separate housing.

4.1.4. Major animal health problems

To assess the significance of animal diseases in the study area, the questionnaire survey has allowed gathering important information with particular reference to trypanosomosis. In both study areas, 94% of the respondents suggested that bovine trypanosomosis ranks first as the major animal health problem. Internal parasites, anthrax, blackleg, and pasteurellosis were also considered as the second, third and fourth most important animal health problems respectively. Sixty four percent of the respondents use veterinary service to manage cattle health problems while 35.16 % of the respondents resort for both local veterinary service and traditional healers. All the respondents give vaccines against anthrax, blackleg and pasteurellosis. Deworming was practiced by most of the selected households (73.5%) in tsetse controlled and 84.6% in tsetse uncontrolled areas.

The majority of the respondents (62.09 %) observed that the wet season of the year is the peak period for occurrence of trypanosomosis, while 17.58% of them replied that trypanosomosis occurred all the time. Eighty two percent of respondents in tsetse uncontrolled block agreed that the occurrence of trypanosomosis has increased for the last five years, while all respondents in tsetse controlled block agreed that trypanosomosis situation has been decreasing in the last five years. The interviewees characterized the disease trypanosomosis

by signs like emaciation, rough hair coat, milk loss, lacrimation, cough and death when untreated. All the respondents know that tsetse flies are the transmitters of the disease (trypanosomosis) in both blocks.

4.1.5. Animal mortality

Since the last 12 months (six months before and six months after the start of this study), respectively, 26.37% and 16.48% of the respondents have lost adult and young cattle in tsetse uncontrolled block, while in tsetse controlled block 0.00% of the respondents have lost their livestock (Figure 4). The difference between the two study areas is statistically significant ($P<0.05$).

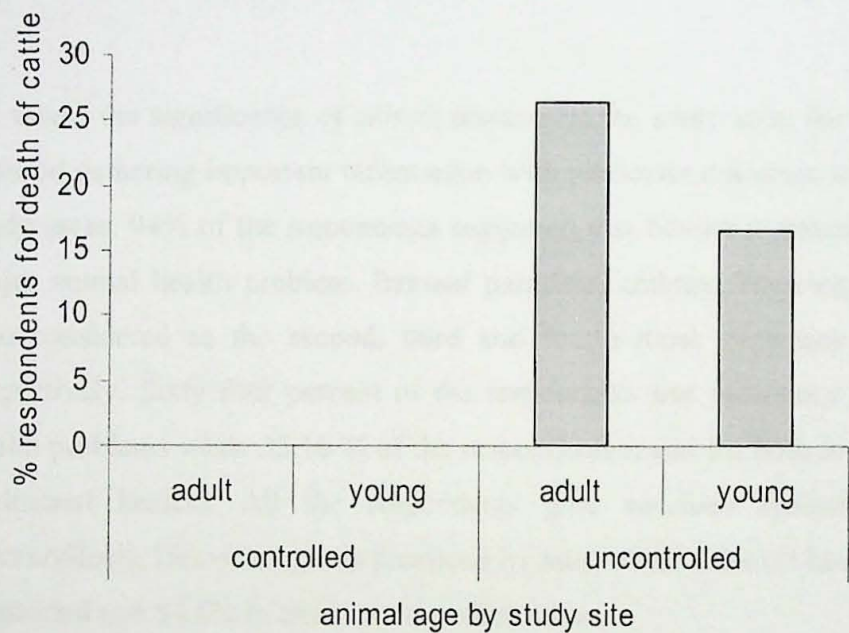


Figure 4. Proportion of respondent households confirming the death of among their adult and young cattle since six months before the start of the study until the end of the study period in the two study sites

4.2. Vector and parasitological study results

4.2.1. Tsetse and biting flies' survey

Fly catches in both study sites have revealed that only *Glossina pallidipes* is prevalent among the cyclical transmitters of trypanosomes. A total of 11,620 *Glossina pallidipes* (8,334 females and 3,286 males) and 2,171 biting flies (1,469 tabanus and 702 stomoxys) were captured in the survey areas between October-2009 and March-2010. In tsetse controlled block 44 *Glossina pallidipes* (31 females and 13 males) and 877 biting flies (602 tabanus and 275 stomoxys) were captured, while in tsetse uncontrolled area 11,576 *Glossina pallidipes* (8,303 females and 3,273 males) and 1294 biting flies (867 tabanus and 427 stomoxys) were captured. The overall mean catches (fly/trap/day) of tsetse flies in controlled and uncontrolled areas were 0.12 and 32.16, respectively. For tabanus the mean catches were 1.67 and 2.41, respectively while for stomoxys they were 0.76 and 1.26, respectively (Table 6). Mean catches of *Glossina*, *Tabanus* and *Stomoxys* were significantly higher at uncontrolled site than at tsetse-controlled site ($p < 0.05$).

Table 6. Summary of fly survey results between October 2009 and March 2010

Month	Number of traps deployed		Number of tsetse and biting flies caught			
	Controlled	Uncontrolled	Controlled		Uncontrolled	
			Tsetse flies	Biting flies	Tsetse flies	Biting flies
October-2009	20	20	1	155	2256	352
November-2009	20	20	4	142	2166	291
December-2009	20	20	11	174	1958	226
January- 2010	20	20	11	157	1792	201
February- 2010	20	20	7	141	1670	149
March- 2010	20	20	10	108	1734	122
Total	120	120	44	877	11576	1294

4.2.2. Trypanosome survey

A total of 1080 blood samples were examined from 540 calves during two seasons (540 in wet and 540 in dry seasons) in tsetse controlled (n=270) and tsetse uncontrolled areas (n=270) to detect trypanosomosis infection. In both sampling periods no trypanosomes were detected from calves in controlled areas. The prevalence of trypanosome in calves in the uncontrolled area was 1.1% (3/270) in the dry season and 1.85% (5/270) in the wet season. The difference in prevalence between the two study areas was statistically significant ($p < 0.05$). The difference between seasons was not statistically significant. The trypanosomosis detected in tsetse uncontrolled area was due to *Trypanosoma congolense* (75%) and *Trypanosoma vivax* (25%) infections.

4.3. Hematological results

The mean values of PCVs of calves in tsetse controlled and uncontrolled areas irrespective of trypanosome status were 30.5 ± 0.30 and 28.4 ± 0.27 , respectively (Table 7). There was statistically significant difference in PCV value between the two areas ($p < 0.05$). The mean PCV values of parasitaemic animals were significantly lower than those of aparasitaemic calves ($p < 0.05$). In both wet and dry seasons, the mean PCV value of calves tsetse controlled areas were significantly higher than those of calves from the uncontrolled area ($p < 0.05$).

Table 7. Summary of factors affecting PCV of calves

Factors	Category	N	Mean PCV value (SE)	95% CI of means	P-value
Study areas	Tsetse controlled	540	30.5 (0.30)	29.9-31.1	0.000
	Tsetse uncontrolled	540	28.4 (0.27)	27.8-28.9	
Parasitological status	Parasitaemic	8	22.63 (1.51)	19.1-26.2	0.004
	Aparasitaemic	1072	29.47 (0.20)	29.1-29.9	
Season	Wet season-controlled	270	31.25 (0.45)	30.36-32.13	0.015
	Wet season-uncontrolled	270	29.82 (0.38)	29.07-30.57	
	Dry season-controlled	270	29.71 (0.40)	28.93-30.49	
	Dry season-uncontrolled	270	26.91 (0.36)	26.21-27.62	

4.4. Growth parameters in calves

The results of independent t-test and Mann Whitney tests at the beginning of the study showed that there was no statistically significant difference between the tsetse controlled and uncontrolled areas in calf heart girth, body length, body weight, hip height and body condition measurements (Table 8). However, calves in the tsetse control program areas have registered significantly higher body weight gain, heart girth increment, body length increment and hip height increment than those in uncontrolled areas (Table 9) after six months of the study ($p < 0.05$). Calves in the tsetse controlled area gained an average of 40.23 ± 0.70 kg and increased their heart girth, body length and hip height by 23.62 ± 0.3 , 22.48 ± 0.2 , and 21.03 ± 0.3 centimeter, respectively. On the other hand calves in tsetse uncontrolled area gained an average of 34.74 ± 0.68 kg, and increased their heart girth, body length and hip height by 21.84 ± 0.2 , 18.67 ± 0.2 , and 17.15 ± 0.3 centimeter, respectively. The average improvement in body condition score in the controlled and uncontrolled areas was not significantly different.

Table 8. Mean values of calf growth parameters at the beginning of the study

Variable	Mean Values at the Beginning of the Study		t-value or MW value	p-value
	Tsetse controlled	Tsetse uncontrolled		
Heart girth (cm)	70.99(0.24)	70.84(0.24)	0.297	0.769
Body length (cm)	59.95(0.19)	60.45(0.19)	-0.737	0.466
Body weight (kg)	28.08(0.65)	28.00(0.65)	0.080	0.937
Hip height (cm)	70.36(0.26)	70.10(0.26)	0.273	0.786
Body condition score (1-9)	3.40(0.152)	3.35(0.182)	0.211	0.834

Table 9. Mean increment of calve growth parameters after six months of study period

Variable	Mean increments/gains after		t-value or MW value	p-value
	6 months			
	Tsetse controlled	Tsetse uncontrolled		
Heart girth (cm)	23.62(0.26)	21.84(0.21)	2.08	0.006
Body length (cm)	22.48(0.20)	18.67(0.24)	4.80	0.001
Body weight (kg)	40.23(0.70)	34.74(0.68)	5.61	0.000
Hip height (cm)	21.08(0.25)	17.15(0.30)	3.97	0.000
Body condition score (1-9)	0.65(0.18)	0.20(0.23)	1.56	0.128

5. DISCUSSION

Household characteristics

The overall mean family size (Mean $\pm$ SE) in the studied household was 8.05 ± 0.32 persons. This value is higher than the one reported by Rutebuka, (2006) in the Southern Rift Valley of Ethiopia (5 people). With respect to educational status of the household head, the overall proportion of illiterate farmers was 35.2%. Higher value of illiteracy was also reported by Rutebuka, (2006) 95.5% for Southern Rift Valley of Ethiopia suggesting un improvement in the literacy status of the population since then. The average (Mean $\pm$ SE) land holding per household in tsetse controlled area was 1.15 ± 0.06 ha while it was 1.59 ± 0.08 ha in tsetse uncontrolled area. The difference was statistically significant. Similar result was reported by Mesele (2008) in the Southern Rift Valley, where the average land holding per house hold was lower in STEP tsetse controlled area (1.42 ha) than in the uncontrolled area (2.16 ha). Tizazu (2007) reported similar result in Dawuro Zone. This indicates that land is relatively more abundant in tsetse challenged areas since people are not encouraged to cultivate land in tsetse challenged areas for fear of trypanosomosis.

The overall cattle herd size and composition was dominated by cows (2.78 ± 0.23) followed by bulls (1.40 ± 0.13), heifer (1.11 ± 0.13), male calves (1.00 ± 0.11), steer (0.95 ± 0.09) and female calves (0.85 ± 0.09). This result is in agreement with the reports of Rutebuka (2006) in Southern Rift Valley of Ethiopia. She reported that cows comprised the highest proportion of the cattle herd (30%). The number of non pregnant dry cows was significantly lower in tsetse controlled area than tsetse uncontrolled are in this study ($p < 0.05$). This result was similar with the report of Mesele (2008) in Southern Rift Valley of Ethiopia. Sekoni *et al* (2007) reported that the chronic disease either due to *T. vivax* or *T. congolense* could be an important cause of infertility or sterility in crosses of Zebu and Friesians.

Cow management

Overall, in both study areas, majority (83.52%) of the respondents house their cows in mixed coral, while the small proportion (16.48%) house their cows in separate coral with comparable results in the tsetse controlled and uncontrolled areas. Ojuni (2009) reported that most households (72.5%) in the mixed crop–livestock system of Gambella Region kept their cattle within separately built barn, while considerable proportions (27%) used corrals or barns to keep all species of livestock together. His report was not in agreement with the results of the current study.

Feed resources commonly used by cattle keepers in the study areas were natural pasture, hay, crop residue and green feed (cut and carry). In tsetse controlled block, animal are supplemented with wastes and leaves of banana and mango fruit while in tsetse uncontrolled area the most common supplemental feeds were banana and mango by-products and green grasses to some extent. Similarly, Rutebuka (2006) found out that pasture and hay/stalk are the main fodder types used during the dry season and they constitute 35% and 37% of the fodder, respectively, at Southern Rift Valley, Ethiopia.

All of the respondents in the current study in both study areas (100%) cull their cattle for different reasons. Ojuni (2009) reported similar result in Gambella Region, where 93.8% of the farmers practiced culling. And the most important reasons of culling in both study areas was old age, which agrees again with the report of Ojuni (2009).

In both study areas, farmers allowed their calves to suckle their mother for more than 15 days without milking the dam for human consumption. After day seven, the calves were supplemented with starter feed like soft grasses. A slightly different practice was reported by Ojuni (2009) in Gambella region in that all cattle producers in the mixed crop–livestock system practiced partial suckling prior to milking, and colostrums are given freely. Also the majority (60.2%) of households provided supplementary feed (on top of milk) to calves between 15 and 30 days after birth.

Major animal health problems

Almost all the respondents ranked trypanosomosis as the most important cattle health problem in the current study. Similar findings were reported by Tewelde (2001) in Bedelle District, West Ethiopia (100%), Mesele (2008) in tsetse challenged area in the Southern Rift Valley (100%), Tizazu (2007) in tsetse challenged areas of Dawuro District (99%) and Perry *et al*, (2002) in a global context. Moreover, Rutebuka (2006) reported that from 5314 cattle deaths, trypanosomosis was responsible for 4660 (87.6%) in the Southern rift Valley of Ethiopia. More than 79% of the respondents believed that cattle are the mostly affected species of livestock by trypanosomosis followed by equines and small ruminants. In the current study in tsetse uncontrolled block 26.37% and 16.48% of the respondents lost their adult cattle and young cattle, respectively, since the last 12 months, while in tsetse controlled block none of the respondents has lost their livestock. The report of Kamuanga *et al*, (2001) in southern Burkina Faso demonstrated a reduction of cattle mortality from 63.1% to 7.1% following tsetse control measures. Ahmedine and Hugh (1995) also stated that in South Western Ethiopia, cattle in high tsetse challenge area had higher mortality rate by 14% than low tsetse challenge area. Kamuanga *et al*, (2001) also reported that over 60% of calves died due to trypanosomosis in Burkina Faso. The report of Mesele (2008) indicated that the mortality of calves was higher in tsetse challenged area by 15 fold than tsetse controlled areas in the Southern Rift Valley. Swallow (2000) estimated an annual cattle mortality rate due to trypanosomosis ranging from 0-20%. In Ethiopia, the report of Tizazu (2007) indicates that mortality of cattle was reduced by about 72% in areas where tsetse control measures were applied. Therefore, it is possible that tsetse control program has contributed to the reduction of calf mortality in the controlled area although the role other diseases could not be undermined.

No trypanosome infected calves have been detected in the tsetse controlled area during the study period, while positive calves were found in both dry and wet seasons in uncontrolled area. All calf management practices being similar in the two areas, it appears that the tsetse and trypanosomosis control program has significantly reduced the prevalence of the disease. This is in agreement with the result reported by Okiria *et al*, (2002) in Masaba Sub-county, Uganda, where the prevalence of trypanosomosis dropped from 37.7% to 3% after the onset of treatment of all cattle with deltamethrin. The significant reduction indicates that the control measures taken have had an effect.

Hematological findings

Trypanosomosis is known to cause mild to severe anaemia characterized mainly by significant reduction in PCV. In this study, the mean PCV of calves in tsetse controlled area was higher than that of calves in uncontrolled area. This could be attributed to the presence of parasitaemic animals in the latter area and/or the cumulative effect of the prevalence of the disease in the population of cattle. In northern Côte d'Ivoire Rowlands *et al*. (1996) revealed that an average of 13.6% reduction in mean trypanosome prevalence in calves between 1987 and 1988/1989 was associated with an increase of $1.3 \pm 0.3\%$ unit increase in PCV value. This report agrees with the findings of the current study. Parasitaemic animals had experienced significant reduction in PCV values compared to aparasitaemic animals in the tsetse uncontrolled block. This is in agreement with the results reported by Feyisa (2004) who registered PCV of parasitaemic and aparasitaemic calves as 21.65% and 25.54% respectively in Southwest Ethiopia, and Sori (2006) who registered 20.22% and 27.23%, respectively, in West Ethiopia.

Tsetse density

The current study revealed that 44 *Glossina pallidipes* and 877 biting flies were captured in tsetse controlled area while in tsetse uncontrolled area, 11,576 *Glossina pallidipes* and 1,294 biting flies were captured. The result revealed that integrated control of tsetse fly reduced tsetse density in controlled area. The average fly density in Masaba Sub-country-Busia

District in Uganda before treatment 5.9 (FTD). However, following treatment of all cattle for 6 months with deltamethrin, the fly density dropped to 0.1 FTD; a 98.24% reduction (Okiria, *et al.*, 2002). Deltamethrin impregnated traps & treated cattle (live targets) have been successfully used to control tsetse flies, achieving population reductions of 80.98% as reported by Diate *et al.* (1991). Similarly, community-based tsetse fly control in Konso Special Woreda using deltamethrin treatment resulted in dramatic drops of tsetse fly numbers from 3.05 to 0.32 flies per day per trap as reported by Pound and Jonfa (2006).

Case control study

The mean growth parameters (body weight, heart girth, body length and hip height) increment of calves in tsetse controlled area was higher than those recorded in the tsetse uncontrolled areas. The current study agree with the report from Northern Côte d'Ivoire by Rowlands *et al.* (1996), where an average 13.6% unit reductions in mean trypanosome prevalence in calves between 1987 and 1988/1989 was associated with an increase of 12.2 ± 3.6 kg in calf live weight gain. Overall mean body condition score of 480 calves studied was 3.66 ± 0.684 (SD). The minimum body condition score was 2 and maximum body condition score was 5. The mean body condition score of calves was 0.20(0.23) in tsetse uncontrolled area and 0.65(0.81) in tsetse controlled area. There was no statistically significant difference in body condition score of calves between the two study areas ($p > 0.05$). This result is contrary to the reports of Pound and Jonfa (2006), who found that community-based tsetse fly control in Konso Special Woreda using Deltamethrin resulted in the increment of the body condition score of treated animals by 46%.

6. CONCLUSION AND RECOMMENDATION

The current study revealed that cattle production in both study areas is a traditional type of production based on natural pasture grazing with little supplementation of leftovers of locally available perennial plants. Calf management was very poor in both tsetse controlled and uncontrolled areas. Trypanosomosis was ranked as the first most important disease in both the study areas. There was higher prevalence of trypanosomosis in calves in tsetse uncontrolled area than the controlled area which resulted in lower PCV value of calves in the uncontrolled area. The fly catch rate was also higher in tsetse uncontrolled area. Calves in the tsetse controlled area had higher values of increment of growth parameter (heart girth, body length, body weight and hip height) in 6 months time than those in the uncontrolled area. These collectively suggest that trypanosomosis has a deleterious impact on calf production and the tsetse and trypanosomosis control program being implemented in the area has significantly improved the situation.

Based on the above conclusions the following are recommended:

- The readiness of the livestock owners (community based) to make commitment towards tsetse and trypanosomosis control should be given due consideration;
- Government and donor agencies should start integrated and sustainable tsetse control program in other areas where tsetse is found and little control programs are attempted;
- Finally, further studies should be carried out to interpret the effects of trypanosomosis on growth of calves and herd composition into economic terms.

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8. ANNEXES

Annex 1. Structured questionnaire to interview individual farmer

I. General information of farmer's identity, location

I. Survey site (Location)

Region: _____ Zone _____ Woreda _____ Kebele _____

Altitude (m a.s.l.) _____

II. Socioeconomic and farming system characteristics

1. Name of farm owner: _____

2. Age of farm owner: _____

3. Sex of farm owner: _____

4. Educational status: _____

5. Family size: _____

6. Land holdings (ha)

Crop _____, Pasture _____, Fallow _____, Forest _____, Others _____,

7. Livestock herd size and composition

Livestock species	Herd size	What is the trend in the last ten years (increase or decrease)	Reason for the change in the trend
Cattle			
Sheep			
Goats			
Donkey			
Horse			
Mule			
Camel			
Poultry			

8. Cattle herd size and composition

Cattle type	Status	Number			
		Indigenous	Crossbred	Exotic	Total
Cows	Pregnant non-lactating				
	Lactating non-pregnant				
	Lactating pregnant				
	Dry pregnant				
	Dry non-pregnant				
Heifers					
Bulls					
Male calves					
Female calves					
Steers					
Total					

9. What are the objectives of cattle keeping?

Milk _____ Meat _____ Draught _____ Other (s): _____

10. When did you start keeping cows in your farm?

Breed of cows % of exotic blood	Year of establishment

11. How do you house your cows?

- a) Separately in corral b) Mixed in corral c) Mixed in barn
d) Separately in barn e) In the farmer's house mixed with people
f) Other (specify)

12. What type of feeding do you practice for cows?

- a) Based on only grazing
b) Based on only stall feeding (concentrate + hay and/or crop residue+ agro-

industrial byproducts + cut and carry) please underline the combinations

c) Based on grazing and stall feeding (concentrate + hay and/or crop residue+ agro- industrial byproducts + cut and carry) please underline the combinations

d) Any other system (specify)

14. Do you practice culling of cows?

a) Yes

b) No

if yes, why

III. Cattle health

1. What are the major health problems of cattle that are of economic importance in the area?

List in the order of importance

2. Do you see any difference in susceptibility to disease problems among the different breeds of cattle you own?

If yes, which ones are highly susceptible?

3. How do you manage cattle health problems?

a) Taking to local veterinary clinic

b) Taking to a traditional healer

c) Any other way (specify)

4. Do you give vaccines to your cattle?

If yes, against which diseases?

5. Do you practice deworming of your cattle?

If yes, how frequent per year and when?

6. Is trypanosomosis one of the problems to your animals? Yes /No?

7. If yes, which species does it mostly affect? A) Cattle b) goats c) sheep d) equine e) all

8. During which season (months) does it mostly occur? a) Wet season b) Dry season c) All the time;

9. Was there an increase or decrease in its occurrence since the last five years?

10. What are the major clinical signs that an animal affected by trypanosomosis shows?

11. Do you know that tsetse flies transmit the disease?

12. How many animals have you lost since the last 12 months from trypanosomosis?

A) cattle: adults____; young____; b) sheep____; c) goat____; d) equine____;

13. What are the major impacts of tsetse and trypanosomosis on calves?

IV. Calf management

1. Do you feed new born calves with colostrum? If yes, for how long?

2. For how long new born calf stay with their mother?

Local _____ Cross _____ Exotic _____

3. For how long new born calf stay at house until they start grazing?

Local _____ Cross _____ Exotic _____

4. Do you provide supplementary feed to newborn calf till they start grazing?

a) Yes

b) No

5. If yes, mention the type of feed and form of feeding?

	Type of feeds	Form of feeding
Local	_____	_____
Cross	_____	_____
Exotic	_____	_____

6. Do you rear all females born to reach puberty?

a) Yes , explain reason _____

b) No , explain reason _____

6. Do you rear all males born to reach puberty?

a) Yes , explain reason _____

b) No , explain reason _____

7. When and how do you wean your calves?

When

How

8. Do you rear all female calves to puberty? If not, why or what is the basis of selection to rear them to puberty?

9. Are you providing your calves with separate housing?

If yes, is it protecting the calves from extremes of temperature and humidity?

Annex 2. Calf body measurement format

PA_____

Week_____

Date_____

ID	Owner's Name	Color	Sex	Age	HGM	BLM	B/W	HHM	BCS

HGM = heart girth measurement BLM = body length measurement

B/W= body weight HHM = hip height measurement BCS = body condition score

Annex 3. Entomological Survey position

A. Tsetse controlled block

Trap ID	Latitude	Longitude	Altitude	Veg	Start Date	End Date	Tsetse species	Males	Females	Total	Tabanus	Stomoxes
KS1	6.11609	37.56439	1284	BUL								
KS2	6.11509	37.56314	1286	BUL								
KS3	6.11383	37.56166	1278	BUL								
KS4	6.10771	37.55846	1299	BUL								
KS5	6.10612	37.55741	1285	BUL								
KS6	6.10471	37.55649	1291	BUL								
KS7	6.10214	37.55593	1317	BUL								
KS8	6.10029	37.55435	1324	BUL								
KS9	6.10013	37.55251	1357	BUL								
KS10	6.09801	37.55309	1342	BUL								
CM1	6.12463	37.61915	1157	BUL								
CM2	6.12603	37.61773	1239	BUL								
CM3	6.12609	37.61591	1228	BUL								
CM4	6.12506	37.62035	1202	BUL								
CM5	6.12571	37.62232	1211	BUL								
CM6	6.12476	37.62381	1214	BUL								
CM7	6.12267	37.62137	1201	BUL								
CM8	6.12173	37.62087	1198	BUL								
CM9	6.12128	37.62005	1198	BUL								
CM10	6.12132	37.61873	1201	BUL								

KS = Kola Shara CM = Chano Mile

B. Tsetse uncontrolled block

Trap ID	Latitude	Longitude	Altitude	Veg	Start Date	End Date	Tsetse species	Males	Females	Total	Tabanus	Stomoxes
K1	5.94032	37.53779	1116	BUL								
K2	5.94269	37.5378	1135	BUL								
K3	5.94496	37.53784	1135	BUL								
K4	5.94691	37.53822	1135	BUL								
K5	5.94902	37.53839	1148	BUL								
K6	5.95112	37.53861	1153	BUL								
K7	5.95423	37.53926	1151	BUL								
K8	5.95695	37.53926	1156	BUL								
K9	5.95971	37.53966	1157	BUL								
K10	5.96279	37.54038	1170	BUL								
E1	5.78136	37.44609	1135	BUL								
E2	5.77968	37.44549	1139	BUL								
E3	5.78475	37.44724	1131	BUL								
E4	5.78675	37.44797	1126	BUL								
E5	5.78751	37.44724	1121	BUL								
E6	5.78606	37.44826	1122	BUL								
E7	5.78821	37.44587	1122	BUL								
E8	5.78662	37.44453	1130	BUL								
E9	5.78503	37.44465	1130	BUL								
E10	5.78179	37.44466	1137	BUL								

K = Kanchama E = Elgo

Annex 4. Parasitological Survey format

Woreda _____

Location; Latitude _____

PA _____

Longitude _____

Season _____

Date _____

Id No	Owner' Name	Age	Sex	Color	Results				
					Tc	Tv	Tb	Mixed	Total

Tc = Trypanosoma congolense Tv = Trypanosoma vivax Tb = Trypanosoma brucei

Annex 5. Parasitological Survey Positions

Elgo	Kola Shara
N. 05.84102	06.08950
E. 037.46194	037.56693
Altitude; 1134	1196
Kanchama	Chano Mille
N. 05.90787	06.10992
E. 037.50413	037.59515
Altitude; 1125	1121

9. SIGNED DECLARATION

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

Name _____

Signature _____

Date of submission _____

This thesis has been submitted for examination with our approval as university advisors.

Dr. Kelay Belihu (DVM, PhD, Associate Professor) _____

Dr. Getachew Terefe (DVM, PhD, Associate Professor) _____