JIMMA UNIVERSITY
COLLEGE OF AGRICULTURE AND VETERINARY MEDICINE
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STUDY ON TRYPANOSOMOSIS IN CATTLE, SHEEP AND GOATSAND ASSESSMENT OF THE IMPACTS OF CONTROL ACTIVITIES IN DAWURO ZONE, SOUTHERN ETHIOPIA

BY
TEFERI MANDADO

NOVEMBER, 2018
JIMMA, ETHIOPIA

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BY

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M.Sc. THESIS

Submitted to the School of Veterinary Medicine, Jimma University College of Agriculture and Veterinary Medicine for the Partial Fulfillment of the Degree of Masters of Science /M.Sc. / in Veterinary Epidemiology

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DEDICATION

I dedicate this thesis to my beloved wife Alemitu Gata, girl child Merisa Teferi, my father Mandado Masana, my mother Lasore Chanbula, all my families and my friendsfor their partnership and being always in higher expectation to see my final success.

STATEMENT OF THE AUTHOR

I declare that this thesis is my actual work and all the sources of materials that were used for preparation of this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. Degree in Veterinary Epidemiology at the Jimma University and will be deposited in the Library of Jimma University that will be available to borrowers in interest under rules of the Library. I confidently declare that this thesis is not submitted to any other institution for award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

Dr. TeferiMandado was born in 1989 in Gena Bosa District, Dawuro zone, Southern Nation Nationalities and People Regional State, Ethiopia. He attended his elementary education at Ella-Bacho Elementary School in Loma District of Dawuro zone and Secondary Education in Gesa High School ofGena District in Dawuro zone. He also attended his Preparatory education in Waka High and preparatory school of Mareka District in the Dawuro zone. After the successful completion of his preparatory school education, he joined the University of Gondar Faculty of Veterinary Medicine in 2008G.C and graduated with Doctor of Veterinary Medicine (DVM) Degreein July 2012. After his graduation, he soon employed in Gena Bosa District Agricultural Office, Livestock Production and Health Core Work Process as a Coordinator and Veterinary Service Provider where he served for one year and ten months. After that in June 01/2014, he joined Dawuro zone Urban Development and Housing Department and served as a Coordinator of the Urban Abattoir Core Work Process until September 2016G.C. Then, he joined the School of Veterinary Medicine of Jimma University to pursue his M.Sc. degree in Veterinary Epidemiology. He has married and a father of single girl until the end of 2018.

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ABBREVIATIONS

AAT	African Animal Trypanosomosis
BW	Body Weight
CFSPH	Centre for Food Security and Public Health
DZFEDD	Dawuro Zone Finance and Economy Development Department
DZLFDD	Dawuro Zone Livestock and Fishery Development Department
GDP	Gross Domestic Product
HAT	Human African Trypanosomosis
ICIPE	International Centre of Insect Physiology and Ecology
IMC	Isometamidium Chloride
MCH	Mean Corpuscular Hemoglobin
MCHC	Mean Corpuscular Hemoglobin Concentration
MCV	Mean Corpuscular Volume
MHP	Mitochondrial Heat Shock Protein
MoA	Ministry of Agriculture
NICETT	National Institute for Control and Eradication of Tsetse and Trypanosomosis
PATTEC	Pan African Tsetse and Trypanosomosis Eradication and Control Center
PCV	Packed Cell Volume
RF	Riverine forest
SIT	Sterile Insect Technique
SNNPRS	Southern Nations Nationalities and People Regional State
STEP	Southern Tsetse Eradication Project
WSTTICC	Wolaita Sodo Tsetse and Trypanosomosis Investigation and Control Center
WGL	Wooded Grass Land

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ABSTRACT

African Animal Trypanosomosis is the major constraint of livestock production in tsetse infested areas of Ethiopia and is the major challenge in Dawuro zone. However, there is shortage of information on general situations and impacts of control methods. A cross-sectional study was conducted from November, 2017 to June, 2018 in the area with the aims of assessing the prevalence and risk factors of ruminants` trypanosomosis, apparent density of tsetse and impacts of the control interventions. The study was conducted in the areas with the history of application of tsetse control interventions.The hematological and parasitological techniques, trap deployment,questionnaire study were conducted. Blood sample was collected from themarginal ear vein of 302 cattle, 126 sheep and 103 goats and tested at Tarcha Veterinary Laboratory. The data was analyzed using binary logistic regression. The findings of this study showed the overall prevalence of 15.6% (95%CI: 12.5%-18.7%) and the prevalence of 23.8% (95%CI: 19%-29.6%), 4% (6%-7.4%) and 5.8% (1.3%-10.3%) in cattle, sheep and goats respectively. Therisk factors such asage (*P-value* = 0.01,OR = 3.3),coat color (OR = 2.6, *P-value* = 0.009), body conditions (*P-value* = 0.008,OR = 0.36) and forest coverage (*P-value* = 0.004, OR = 0.3) in bovine and age (*P-value* = 0.03, OR = 0.03),coat color (*P-value* = 0.005, OR = 0.17), body conditions (*P-value* = 0.005, OR = 0.07) and forest coverage (*P-value*= 0.04,OR = 0.2) in shoats were showed statistically significant association the prevalence of trypanosomosis.The apparent density of tsetse and *Stomoxys* were 5.37f/t/d and 0.39f/t/d respectively. The overall mean prevalence and vector density of pre-intervention were 4.50±7.44SD and 0.17±0.38SD while post intervention was 10.83±11.63SD and 5.50±0.51SD respectively. There is control continuouscontrol interventions applied in the area but the results show that the disease prevalence and apparent density were increasing. Therefore, comprehensive national wise evaluation of the impacts of control interventions applied to the disease so far is better to be taken.

***Keyword**: Prevalence, Tsetse density, Control interventions, Ruminants, Dawuro, Ethiopia*

1. INTRODUCTION

1.1 Background

Ethiopia is one of the top ranking countries in Africa and among the first ten in the world in terms of livestock resource (OIE, 2008) with an estimated 56.71 million cattle, 29.33 million sheep and 29.11 million goats (CSA, 2017). Ethiopia has huge and diverse livestock population that plays important roles in the economy and livelihoods of farmers and pastoralists(Tegegne *et al*., 2013).

Livestock are a 'living bank' or 'living account' for rural and urban poor farmers and livestock owners(Belay *et al.*, 2012(a). They serve as financial reserves during period of economic distress such as crop failure as well as primary cash income (Bekele *et al.*, 2010). Livestock plays vital roles in generating income to farmers, creating job opportunities, ensuring food security, providing services, contributing to asset, and social, cultural and environmental values and sustain livelihoods(Belay *et al*., 2012(b)*)*. The subsector contributes about 16.5% of the National Gross Domestic Product (GDP) and 35.6% of the agricultural GDP. It also contributes 15% of export earnings and 30% of agricultural employment. Furthermore, the livestock subsector currently supports and sustain livelihoods for 80% of all rural population (Metaferia *et al*., 2011). Among livestock, cattle are the primary resource for people and government of Ethiopia (Bekele *et al.*, 2010).

Despite the importance of livestock to the largest sector of the population and to the economy at large, the productivity of this livestock sector is lower than the potential level of the African production average(Belay *et al.*, 2012(b)). This is attributed to a multitude of problemsincluding diseases, age-old traditional management system, inferior genetic make-up coupled with under nutrition and complicated by malnutrition and the absence of well-developed market infrastructure (Behnke, 2010; Belay *et al*., 2012(a)*)*.

African Animal Trypanosomosis (AAT) is a vector born disease of livestock caused by haemo-parasites of the genus known as *Trypanosoma.*The parasite mainly found inthe blood and tissues of vertebrates including livestock, wildlife, and people. It is considered to be one of the major constraints in improving livestock and agricultural production in Sub-Saharan Africa including Ethiopia(OIE, 2009). Trypanosomosis is one of the major impediments to livestock development and agricultural production, which negatively affect the overall development in agriculture in general and to food self-reliance efforts of the nation in particular (Denbarga *et al*., 2012). It is the common diseases of livestock in Ethiopia affecting livestock's production and productivity particularly in cattle (Denbarga *et al*., 2012). According to the Food and Agriculture Organization of the United Nations (FAO, 2009), it is probably the only disease which has been profoundly affecting the settlement and economic development of a major part of the continent.

The disease occurs in 37 Sub-Saharan Africa countries covering about 9 million km^2, an area which corresponds approximately to one-third of the total area of Africa (Mattioli *et al*., 2013). An estimated 45 to 60 million cattle, 7 million equines, 1.8 million camels and about tens of millions of small ruminants are at risk of contracting trypanosomes (Gilbert *et al.*, 2002; Chadenga, 2014). FAO estimates that about three million of cattle will die each year due to AAT (FAO, 2000). The disease has been contributing to the direct and indirect economic losses to crop and livestock production in several countries of Africa including Ethiopia.In Ethiopia, trypanosomosis is widespread in domestic livestock in the Western, South and South-western lowland regions and the associated tsetse infested river basins (i.e. Abay, Ghibe, Omo, Baro/Akobo and Rift Valley) (Getachew, 2005).

The tsetse fly (genus: *Glossina*) is the vector of trypanosomosis occurs only in sub-Saharan Africa. In other parts of the world, the transmission of pathogenic trypanosomes to animals is believed to be non-cyclical or mechanical and is effected mainly by blood sucking arthropods (Denbarga *et al*., 2012). Currently about 220,000 Km^2 areas of the Western, South and South-western lowland regions are infested with five species of tsetse flies namely *G. Pallidipes*, *G. m. submorsitans*, *G. fuscipes*, *G. tachinoides* and *G. longipennis* (NICETT, 2004) and these fertile lands are excluded from agricultural activities. The most important trypanosome species affecting livestock in Ethiopia are *T. congolense*, *T. vivax* and *T. brucei* in cattle, sheep and goat, *T. evansi* in camel and *T. equiperdum* in horse (Getachew, 2005).

The direct and indirect impacts of African Animal Trypanosomosis on agriculture constitute a major constraint to the socio-economic development of tsetse fly *(Glossina)* infested areas of Africa (Swallow, 1999*)*.Estimation of the annual economic impact according to Food and Agriculture Organization (FAO, 2008) stated that, in every year, Africa loses over 3 million cattle and other domestic livestock through deaths due to trypanosomosis. Approximately 35 million doses of trypanocidal drugs (worth about US $35 million) is bought every year in futile efforts to maintain livestock free of the disease. The annual loss 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, has recently been estimated at US$1.2 billion

(FAO, 2008). 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 (PATTEC,2000*)*.

1.2. Statement of the Problem and Justification

In endemic areas, trypanosomosis reduces calving rates, milk yields and oxen work efficiency whereas calf mortality is increased (Swallow, 1999*)*. Mortality and morbidity vary widely and depend on factors such as the host species and breed, the *Trypanosoma* species, the virulence of the parasite and the innate resistance of the host (Mbahin, *et al*., 2013).According toDereje *et al*., *(*2014),the prevalence and severity of diseases varies with seasons, animal species and breed, vegetation coverage, animal husbandry system, body conditions and other related factors.In addition to the measurable economic impact on a national economy, the inability to sell their animal can bring severe hardship to a pastoral family with no other income sources of support *(*FOA, 2002*)*. The local breeds of cattle, sheep and goats are believed to be moderately susceptible to trypanosomosis. However, they are still highly affected by the diseases (Dereje *et al.,* 2014).

According to the systematic review performed by Meyer*et al*., (2016) on past and ongoing tsetse and animal trypanosomosis control operations in five African countries including Ethiopia with long history of their considerable effort on control of trypanosomosis and tsetse fly indicated that there is lack of evaluation of the impacts of control programmes, as well as a lack of a standardized methodology to conduct such evaluations. Even though, there were extensive and longtime tsetse and trypanosomosis control programmes that have been running in Ethiopia for several years, African Animal Trypanosomosis is still remained as major constraint of livestock production in tsetse infested areas of the country in general (NICETT, 2012) and this was found as the higher ranking constraints to livestock production in the study areas in particular (WSTTICC, 2017). The four common trypanosomosis control interventions that have been applied in Tarcha and Tocha areas of Dawuro zone were spot-on techniques, chemical impregnated targets and traps, chemoprophylaxis and treating of specifically known diseased animals (DZLFDD, 2017). They have been applied in the studied areas for several years but there was luck of improvement on the disease prevalence and tsetse fly density in the area (WSTTICC, 2017). Therefore, to take further control interventions of different kinds, assessment of the effects of existing trypanosomosis control interventions should be conducted to look for alternative disease control optionsin the areas (Meyer *et al*., 2016).

In addition to the luck of assessment of the impacts of the control interventions of trypanosomosis and tsetse fly, there was limited information on the current prevalence of trypanosomosis on cattle, sheep and goats and the associated risk factors in the two selected study areas of Dawuro zone.After achievement of these objectives, the data would serve as the baseline for livestock sectors, policy makers and researchers for the practitioners with the same interests in future.Therefore, this study was conducted with the following objectives;

- To determine the current prevalenceand associated risk factors of cattle, sheep and goats trypanosomosis in the study areas
- To assess the impacts of some of the applied trypanosomosis control interventions
- To assess the perception of the farmers on the impacts of control interventions

2. LITERATURE REVIEW

2.1. Trypanosomosis

African Animal Trypanosomosis is the disease of livestock caused by haemo-parasites known as *Trypanosoma*(FAO, 2002; OIE, 2009). The disease is caused by flagellated unicellular parasites named as African *Trypanosoma* that are almost exclusively transmitted by the bite of tsetse flies. Here, both male and female tsetse flies are obligatory blood feeders that able to carry and transmit trypanosomosis during their entire life span (Abbeele and Rotureau, 2013).

African Animal Trypanosomosis is also vector-borne diseases of human and their livestock, with devastating socio-economic consequences for the Sub-Saharan African countries. It is considered to be one of the major constraints to improved livestock and agricultural production in sub-Saharan Africa. AAT is also becoming increasingly prevalent beyond its traditionally defined realm and is an established threat to animal health in South America and Asia (Auty *et al*., 2015).

2.2. The Etiology

African Animal Trypanosomosis is a disease caused by the parasite species of the genus *Trypanosoma*(*T. congolense, T.b. brucei* and *T. vivax*). The disease can be transmitted cyclically by the bites of infected tsetse flies or mechanically by other biting flies (Mare, 1998). It is a complex disease caused by unicellular parasites of the genus *Trypanosoma* found in the blood and other tissues of vertebrates including cattle (livestock), wild life and people (Tesfaye, 2002). The most important *Trypanosoma* species affecting livestock in Ethiopia are *T. congolense, T. vivax* and *T. brucei* in cattle, sheep and goats, *T. evansi* in camels and *T. equiperdum* in horses (Getachew, 2005).

Recent studies based on isoenzymatic differences and molecular techniques, resulted in new subdivisions of the species of *Trypanosoma* into several types; *T. congolense* has been divided into four types *T. congolense* Savannah type, *T. congolense* Tsavo type, *T. congolense* Forest type and *T. congolense* Kilifi type. *T. godferyi* has been separated lately from *T. congolense* in Gambia on isoenzymatic and molecular bases; although it has the same morphology as *T. congolense* and causes more chronic disease in pigs (Uilenberg, 1998).

2.3. The Tsetse Fly (Vector)

The vector, tsetse fly, can be classified in the order Diptera(the two-winged flies), family *Glossinidae*, and within the genus: *Glossina*. There are about 23 species and 8 sub- species of *Glossina* identified so far (Moloo, 1993; Leak, 1999). They are medically and agriculturally important vectors that transmit African *Trypanosoma*species, the causative agents of sleeping sickness in humans, and nagana in animals. Sleeping sickness, fatal if untreated, still affects a wide range of people in sub-Saharan Africa (WHO, 2005), where more than 60 million people are at risk. Nagana is estimated to cost African agriculture US$ 4.5 billion per year (Reinhardt, 2002).

Tsetse flies in Ethiopia are confined to Southern, Southwestern and Western regions between a longitude of 33^o and 38^{o}E and latitude of 5^o and 12^{o}N (Ayana*et al.*, 2015). Tsetse infested areas lie in the lowlands and in tsetse river basin of Abbay (Blue Nile), Baro, Akobo, Didessa, Ghibe and Omo (Tekle and Mekonen, 2013). Out of the nine regions of Ethiopia, five (Oromia, SNNPR, Amhara, Beninshangul Gumuz, and Gambella) are infested with more than one species of tsetse flies. Consequently, new areas are being invaded and settled communities are being continually evicted by the advancing tsetse. Five species of *Glossina* (*G. m. submorsitans*, *G. Pallidipes*, *G. tachinoides*, *G.f. fuscipes*, and *G. longpennis*) have been recorded in Ethiopia (Getachew, 2005). According to the information provided by National Institute for Control and Eradication of Trypanosomosis and Tsetse, the tsetse transmitted animal trypanosomosis is still remain as one of the major causes of livestock production losses in Ethiopia (NICETT, 2012).

2.4. Epidemiology

African Animal Trypanosomosis is found mainly in those regions of Africa where its biological vector (tsetse fly) exists. Bovine trypanosomosis is continued to be the major constraints of livestock production in Sub-Saharan Africa, jeopardizing the lives of 55 million people (CFSPH, 2009). According to FAO (2002), the risk of infection in domestic animals and humans has greatly affected social, economic and agricultural development of communities within tsetse infested areas which roughly constitute more than a third (10 million square kilometers) of Africa between 14^{o}N and 29^{o}S of the continent.In Ethiopia, trypanosomosis is widespread in domestic livestock in the Western, South and Southwestern lowland regions and the associated river basins (MoA, 2003). According to (Afework *et al.*, 1998) and (Tewelde *et al.*, 2008) studies, farmers strongly recognized trypanosomosis as the primary problem for their livestock productivity and agricultural development in the Northwestern and Western parts of Ethiopia, respectively. Trypanosomosis in cattle locally referred, as "Gendi" is a serious constraint to livestock production in the Northern and Southwest Ethiopia at an altitude of below 2000 m.a.s.l (NICETT, 2004).

Trypanosomosis is mainly restricted to areas in which the vector, tsetse fly (*Glossina* species) can survive. The disease is also found outside the tsetse belt areas transmitted mechanically by other biting flies of the genus *Tabanus*, *Hematopota*, *Chrysops* and *Stomxys*. A number of *Trypanosoma* species are important in bovine trypanosomosis (*T. b. brucei*, *T. congolense* and *T. vivax*) that differ from those causing the human form of the disease, sleeping sickness (*T. b. gambiense*, *T. b. rhodesiense*). In Ethiopia, five species of *Trypanosoma* species are recorded and the most important *Trypanosoma* species in terms of economic loss in domestic livestock that transmitted by tsetse species includes: *T. congolense*, *T. vivax* and *T. brucei* (Getachew, 2005).

2.4.1. Host range

Trypanosomes can infect all domesticated animals; clinical cases have been described in cattle, water buffalo, sheep, goats, camels, horses, donkeys, alpacas, llamas, pigs, dogs, cats and other species. In parts of Africa, cattle are the main species affected, due to the feeding preferences of tsetse flies; in effect, they can shield other domesticated animals such as goats and pigs from the effects of trypanosomosis (OIE, 2009).

Susceptibility of cattle to trypanosomosis depends on breed, age, body conditions, behavior, previous exposure and health status (OIE, 2005). Tsetse-transmitted trypanosomosis infects various species of mammals but, from an economic point of view, it is particularly important in cattle (OIE, 2000). The indigenous zebus are trypanosuceptible and West African *Bos Taurus* breeds are trypanotolerant, i.e. they can survive and be productive without treatment under trypanosomosis risk. Exotic imported ruminants (e.g. improved dairy cattle) are more severely affected than local breeds of cattle (CFSPH, 2009). The diurnal tsetse flies are induced by breath and urine components of the host to fly upwind, near the host they orientate visually, responding more strongly to moving than stationary hosts. Colors are discriminated, blue being particularly attractive and the different species prefer different regions of the body of the host for blood sucking. Recent studies have shown that brown and fawn coloured cattle were more likely to be infected than cattle of other colors (Carty, 2002).

Wildlife including warthog, bush pig, duiker, bush buck, kudu, buffalo and monitor lizard are the natural hosts of tsetse and may acquire prolonged, symptomless *Trypanosoma* infections. Livestock exhibit a range of susceptibilities to infection, from refractory to highly vulnerable (Bounee*t al*., 2001). However, the wildlife in Africa generally tolerates infection and often serves as a reservoir for human and livestock-infective trypanosomes. Monkeys, rats, mice, guinea pigs and rabbits can also be infected by trypanosomes; ruminants, wild equidae, lions, leopards and wild pigs can serve as carriers (Taylor and Authie, 2004).

The host preferences of each *Trypanosoma* species may differ, but *T. congolense*, *T. vivax* and *T brucei* have a wide host range among domesticated animals. *T. godfreyi* and *T. Sui*occur in pigs. *T. simiae* appears to be most important in pigs, but it has also been reported by PCR in camels and horses (Janson *et al*., 1999). Animal trypanosomosis is a disease of vertebrates, including livestock, wildlife and human (Gupta *et al*., 2009 and Ayana *et al*., 2015). It has a significant negative impact on economic growth in many parts of the world (Sharma *et al*., 2013), particularly in sub-Saharan Africa (Cecchi *et al*., 2008).

2.4.2. Geographical distribution

Trypanosomosis can be found wherever the tsetse fly exists. Tsetse flies are endemic in Africa between latitude 15° N and 29° S, from the southern edge of the Sahara Desert. Animal trypanosomosis occurs in most of the tropical regions, but only in equatorial Africa, it constitutes a major obstacle to the development of animal production (Janson *et al*., 1999).

Several reports made in Ethiopia revealed that tsetse fly occupy over 66,000 km^2 area based on 1500 m.a.s.l. The tsetse fly breeding area limited in Southern and Southwestern parts of Ethiopia (Getachew, 2005).

2.4.3. Methods of transmission and source of infection

Trypanosoma evansi have multiple origins, geographical locations, hosts, and clinical features. In addition, it has multiple and complex means of transmission, which vary in terms of relative significance depending on the hosts and the geographical area. Therefore; *T. evansi* is transmitted in several ways, via biting insects, sucking insects, and vampire bats; transmission can also be vertical, horizontal, iatrogenic, and per-oral, with various epidemiological significances, depending on the season, the location, and host species. Similarly, leeches may transmit trypanosomes, and their potential for transmission of *T. evansi* should be explored, especially for buffalo leech (*Hirudinaria manillensis*) in Asia. Mechanical transmission by biting insects is the most important mode of transmission of *T. evansi* in camels, as well as in livestock and other large animals generally (OIE, 2009).

Trypanostomatidae, infecting animals are transmitted from host to host mainly by hematophagous insects and this mechanical transmission occurs by hematophagous flies of Tabanidae (mainly the genus *Tabanus*), *Culicidae*, *Muscidae*, *Hematopoba*, *Leperosia*, *Stomoxys*, and *Chrysops* (Seifert, 1996). The mechanical transmission of *T. evansi* by tabanids has been extensively studied in different countries since the turn of the century and the evidence incriminating tabanids as vectors is conclusive. *T. vivax*is the only species of tsetse transmitted *Trypanosoma* that has become permanently established outside of Africa. Tabanids have been associated with the transmission of over 35 pathogenic agents of animal and the majority of diseases associated with tabanids are mechanically transmitted and this mechanical transmission is important in the epidemiology of many agents of livestock disease (Keno, 2005).

Mechanical transmission is a non-specific process, which can take place when a biting insect initiates a blood meal on an infected host, starts to feed on infected blood, is interrupted (by defensive movements of the host), flies off from the infected host, and lands on another animal to begin its blood meal again. When the insect first attempts to feed on blood, its mouthparts can contain a small amount of blood via capillary strength, estimated at 1-12 nl in tabanids and 0.03 nl in *Stomoxys*. The residual blood may be partially inoculated into another animal during the early stage of the next attempt to bite, when the insect inoculates a small amount of saliva (necessary for its anticoagulant properties) prior to sucking the blood of the second host (Desquesnes *et al.*, 2009).

Experimental research shows that the transmission is efficient when there is a short time lapse between two interrupted blood meals, that is, less than 30 minutes (Sumba, 1998). Immediate mechanical transmission of this type can only occur in a group of animals (such as intra-herd transmission). However, it may occur between herds of the same species (camels) or of different species (camels and goats) at a water point. Transmission can also occur between wild and domestic herbivores, such as deer or capybaras when they graze with horses, cattle, or buffalo. This occurs in extensive breeding conditions in Brazil (Franke, 1994).

Other insects, such as Culicidae, Ceratopogonidaemay also have an important role in transmission in particular local conditions. Experimental transmission of *T. evansi* has been successful with *Aedes aegypti*, *Aedes Argenteus* and *Anopheles fuliginosus*. However, the epidemiological significance has not been demonstrated (Mare, 2013). It is not possible to establish an exhaustive list of the potential mechanical vectors of *T. evansi*. However, the most important are the largest and most abundant biting insects (Desquesnes *et al*., 2005). "Delayed mechanical transmission" might lead to the concept of "infective area," such as a water point, where an infected herd could infect *Stomoxys* at a given time, which in turn would infect healthy animals (4-48 hours later), in the absence of contact between infected and uninfected herds. Mechanical transmission of *T. evansi* is thought to be essentially due to tabanids and *Stomoxys*. However, Hippoboscids were previously suspected, especially in camels and horses (*Hippobosca equina* and *H. camelina*) (Rowland *et al*., 1993).

Regarding the epidemiological factors involving in mechanical transmission, the titer of infectious agent, the persistence and the infectiousness of the agent at the portal of entry are the major ones. Similarly, the number and type of insects feeding on hosts is important. The viremia or parasitaemia of the donor most often determines the number and types of vectors required to transfer infection. Information on the quantity of blood remaining on the mouth parts of insects after an interrupted meal also can provide a starting point for evaluating the importance of different insects. Certainly, the number of insects and the quantity of blood transferred between hosts is important. The distance between animals has a significant impact on the percentage of mixed feeding. The larger the tabanid, the greater the potential for transfer between two host animals is achieved. Smaller tabanids may move between hosts less frequently than larger lies and individually transport less residual blood meal. However, the differences in population density may change the relative importance of different sized tabanid or other insect vectors (Foil, 1996).

2.4.4. Mortality and morbidity

Trypanosomosis is often a chronic disease in susceptible animals. The morbidity rate is high, and many untreated animals infected with. *T. vivax*, *T. brucei* or and *T. congolens*e eventually die. In cattle infected with some strains, the mortality rate can reach 50-100% within months after exposure, particularly when poor nutrition or other factors contribute to debilitation (Janson *et al*., 1999).

Morbidity and mortality vary with the breed of the animal, as well as the strain and dose of the infecting organisms. Some breeds of African cattle and small ruminants are genetically resistant to the development of clinical trypanosomosis, a phenomenon known as trypanotolerance. Trypanotolerant breeds of cattle include West African Shorthorn also known as Muturu, Baoule, Laguna (Lagune, Namchi, Samba) Somba or Dahomey cattle) and N'Dama (CFSPH, 2009).

The impact of trypanosomosis on African agriculture is most obviously seen in the birth and mortality rates 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. Even the "trypanotolerant" animals such as the N'Dama cattle are affected. It strongly reduces milk off-take (reduction of 26%) and lambing and kidding rates (reduction of 37%) recorded in the Gambia. The disease reduces the availability and efficiency of drought animals used for ploughing land for crop production (reduction of 33%) in Ethiopia (FAO, 1998). In mixed farming systems, where trypanosomosis is most severe, it constrains the number of oxen that farmers owned, so it can reduce the average area planted per household by as much as 50% (FAO, 2000b).

2.5. Pathogenesis

The precise pathogenesis of trypanosomosis remains unclear. Four pathogenic featuresthat are common in the processes of pathogenesis: chancre, lymphadenopathy, anaemia, and tissue damages dominate the pathology of trypanosomosis (Taiwo *et al.*, 2003;Ngure *et al.*, 2008).

2.5.1. Chancre

Infection becomes established at the site of inoculation of metacyclic *Trypanosoma* in the skin, where a chancre may be formed. The chancre reaches to a maximum diameter of 100 millimeter within ten to fourteen days after an infective tsetse fly feed; its development preceding invasion of the bloodstream by trypanosomes, and is accompanied by enlargement of the draining lymph nodes which is known as lymphadenopathy. At this time the chancre begins to regress and the characteristic series of intermittent parasitaemia begins (Ntantiso, 2012).

2.5.2. Anaemia

One of the major effects of infection with pathogenic trypanosomae is anaemia (Leak, 1998). The trypanosomae species affecting human and domestic animals have been subdivided intotwogroups, the haematinic group (*T. congolense* and *T. vivax*) those remain in the plasma and the tissue invading group (that includes*T. brucei, T. evansi, T. gambiense, T. rhodesiense* and *T. equiperdum*) found in extra and intra vascular spaces (Radostits*et al.*, 2007). Anaemia is a cardinal sign of trypanosomosis in many domestic animals and the aetiology is probably similar in all species. Animals lose weight and conditions, as a result of dyshaemopoiesis, remain anaemic. The anaemia caused byanimal trypanosomosis could be associated with the decrease in Packed Cell Volume (PCV), haemoglobin and red blood cells (RBC) counts as reported by many authors in different animal species (Silva *et al.*, 1999) which may result from massive erythrophagocytosis (lysis of RBS) by an expanded and active mononuclear phagocytic system of the host. Reports also showed that anaemia with a significant reduction in PCV, total RBC count and hemoglobin concentration is a consistent finding in *Trypanosoma* infected cattle, goats, sheep, dogs and rabbits (Bisalla, 2007).

On the other hand, significant increases were reported in mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) values, whereas no significant change was observed in mean corpuscular haemoglobin concentration (MCHC) (Nadia *et al*., 2012). Total white blood cell (WBC) counts were also varied from normal range to significant reduction in animal trypanosomosis. The mechanism or pathophysiology of anaemia occurred due to trypanosomosis complex and multi-factorial in origin (Naessens *et al*., 2005).

2.5.3. Tissue damage

The pathogenesis of tissue lesions varies with the species of *Trypanosoma*. *T. congolense* and *T. vivax* are mainly intravascular parasites; they induce changes in the endothelium of capillaries, and therefore, indirectly cause damage to adjacent tissues. The severity of endothelial injury also depends on the interaction of host and parasite. Damage to endothelial cells by parasite products, immune complexes, vasoactive amines and cytokines increases vascular permeability. In *T. congolense* infections, a generalized dilatation of capillary beds, which alters the haemodynamics, is observed (Connor and Bossche, 2005).As the lesion of chancre decreases in size, increased numbers of mature plasma cells, macrophages, eosinophils, and mast cells are found, and these compositions of cells within the chancre suggest an initial immune response. This behavior largely depends on the species of trypanosomae. *T. vivax* usually multiplies rapidly in blood and is evenly dispersed throughout the cardiovascular system, whereas *T. congolense* tends to aggregate in small blood vessels and capillaries of the heart, brain and skeletal muscle from where a small proportion of parasites enter the blood circulation. *T. brucei* and rarely *T. vivax* have the added capability of passing out of the capillaries into the interstitial tissues and serous fluids of body cavities where they continue to multiply (Abebe, 1991).

2.6. Clinical Manifestations

The disease varies from acute to chronic forms. The acute form occurs soon after the infection, characterized by high parasitaemia and rapid fall of packed cell volume (PCV) due to the destruction of red blood cells (RBC) caused by foreign body proteins from the parasites in the host blood and tissues. This induces an autoimmunity or erythrophagocytosis, resulting in fever.

Death normally occurs within ten days in susceptible animals. The extent of the acute or chronic forms of the disease is determined by a number of factors; complete tolerance (no-illness) in the case of game, virulence of the trypanosomae species such as *T. congolense* and the level of parasitaemia (Bossche, 2004).

Most cases of trypanosomosis are chronic, acute disease which may be fatal within a week, can also occur. The primary sign of trypanosomosis may be localized swelling (chancre) at the site of the tsetse fly bite which usually remained unnoticed. The primary clinical signs are an intermittent fever, signs of anaemia, lymphadenopathy and weight loss. Animals lose condition and become progressively emaciated. Milk yield may be decreased in dairy animals. Neurological signs, dependent edema, cardiac lesions, diarrhea, keratitis, lacrimation, in appetence and other signs have also been reported. Effects on reproduction include abortion, premature births and perinatal losses, as well as testicular damage in males. Deaths are common among chronically infected animals, and animals that recover clinically may relapse when stressed. Sudden deaths have been reported in small ruminants infected with *T. vivax*. Trypanosomosis can cause immune suppression, and concurrent infection may complicate the disease. An acute hemorrhagic syndrome has been reported among cattle infected with *T. vivax* in Africa. Affected animals have enlarged lymph nodes and signs of severe anaemia and they develop wide spread visceral and mucosal hemorrhages, particularly in the gastrointestinal tract. In one outbreak, the main sign was bleeding from the ears. The syndrome can be rapidly fatal(CFSPH, 2009).

Animal trypanosomosis is a parasitic disease that causes serious economic losses to pastoralists (Teka *et al*., 2012); it manifests anemia, loss of condition, agalaxia and emaciation. Many are untreated cases which are fatal (Mamoudou, *et al*., 2015). It is considered that one quarter of economic losses due to animal pathologies is attributable to trypanosomosis (Hann and Bekure, 1991). The mechanism or pathophysiology of anaemia in trypanosomosis is complex and multi-factorial in origin. This product is known to lyse red blood cells in the absence of antibodies (*in-vitro*) and haemodilution (*in-vivo*). This mechanism has been adequately described in gold fish (*Carassius auratus*) infected with *T. dahilewskyi* (Islam, 1991) and in murine models infected with *T. b. rhodesiense* (Naessens *et al*., 2005).

The appearance of chancre, follow detectable parasitaemia in a few days, is accompanied by the development of fever and marked enlargement of draining lymph nodes (Luckins *et al*., 1994). The clinical manifestation of trypanosomosis in animals is influenced by the host as well as the trypanosomae species and "strain". In general, the disease is characterized by severe anaemia, weight loss, reduced productivity, infertility and abortion, with death occurring in some animals during the acute phase of the disease. Animals which survive often remain infected for several months or years, exhibiting a low level of fluctuating parasitaemia which serves as a reservoir for the disease. Occasionally, however, the infected animals may undergo spontaneous recovery (Sharma *et al*., 2013).

2.7. Diagnosis

The easiest technique for detection of trypanosomes in peripheral blood is by direct microscopic examination of blood, either by the wet film method to detect motile trypanosomes or, as stained thick and thin smears, when parasites are identified on the basis of their morphology by light microscopy.Identification of the *Trypanosoma*species was done based on morphological descriptions as well as movement in wet film preparations.Experience is required to identify the parasites to species level by noting the type of movement under the field of microscope. Examination of wet blood preparation, the hematocrits (HCT), is quick and the method is suitable for screening large numbers of animals. It is widely used in epidemiological surveys and at the same time the status of anaemia in the animal can be assessed. This method, however, is insensitive as half of the infected animals may be missed (Kemal, 2014).

Blood parameters are essential indicators of health status in animals and they are invaluable in diagnosis, treatment, or progress of many diseases. The Packed Cell volume (PCV) is most frequent test used to determine the functional state of erythrocyte. Other tests such as the red blood cell count (RBC) and concentration of Haemoglobin (Hb) gives the number of circulating erythrocytes and their oxygen carrying capacity respectively. Techniques for diagnosis of *Trypanosoma* parasites can either be direct by using the parasitological methods (Ntantiso, 2012) or indirect by the application of serological methods (Radostits*et al*., 2007).

Direct methods involve identification of the trypanosomes in thick and thin blood smears or by the buffy coat preparation by using the haematocrit centrifugation technique (HCT). Blood smears stained with conventional stains, for example, Giemsa's stain; identify the parasites by the aid of compound microscope (Tadesse and Tsegaye, 2010).

2.7.1.Hematological laboratory study

Packed Cell Volume (PCV) determination

Blood samples were collected by puncturing the ear vein with a lancet which was then transferred into heparinized capillary tubes. Using appropriate procedure in the laboratory, the tubes were centrifuged at 12,000 rpm for 5 minute. The centrifuged capillary blood was then read with a PCV reader and the reading was recorded in percentage. For cattle with PCV $<$24% were considered to be anaemic and those with PCV $\geq$24% were considered as non-anaemic (OIE, 2009). For sheepand goats with PCV $<$24% were judged as anaemic and those with PCV $\geq$24% were categorized as non-anaemic (Kemal, 2014).

2.7.2 Parasitological laboratory study

Buffy Coat Technique

The buffy coat was recovered by centrifugation of the blood collected in heparinized microhaematocrit capillary tubes at 12,000 rpm for 5 minute. Since *Trypanosomae* are found in the buffy coat layer, the capillary tube was cut 1 mm below and 3 mm above the Buffy coat. The buffy coat was then placed onto a glass slide, covered with cover slip and was examined for movement of parasite under x40 objective and x10 eye piece (OIE, 2009).

Thin blood smear

A small drop of blood collected using a microhaematocrit capillary tube was placed on a glass slide, air dried and fixed in methyl alcohol for two minute and later it was stained with Giemsa stain (1:10 solution) for 30 minute. The excess stain was washed with distilled water and the slide was air dried and examined under the oil immersion microscope (x100) objective and (x10) lens magnification (OIE, 2008).

Thick blood smear

The method is simple and relatively inexpensive, but results are delayed because of the staining process. *Trypanosoma* are easily recognized by their general morphology, but may be damaged during the staining process. This may make it difficult to identify the species (Taylor and Authie, 2004).

2.7.2. Serological diagnosis

Indirect Enzyme-Linked Immune-sorbent Assay (ELISA)

The binding of anti-*Trypanosoma* antibodies to the antigen is shown by a conjugate of anti-bovine (if the test serum is bovine) immunoglobulin's labeled with an enzyme, which can be visualized by adding an appropriate chromo-genic substrate (i.e. the interaction between enzyme and substrate will create a color). Usually solubilized antigens obtained from disrupted trypanosomes (successive freezing and thawing cycles or ultrasound) are used and the soluble antigens are coated in the wells of microtrays. Each micro tray contains usually 96 wells. This makes it possible to process many sera at the same time, using multi-channel pipettes. Only small quantities of sera and conjugate are used (Bannai *et al*., 2003).

An ELISA reading instrument will quickly give the optical density of each well (showing quantitatively the intensity of the interaction between the enzyme and the substrate), thus helping to speed up the processing of large numbers of sera (Nadia *et al*., 2012). Various ELISA systems have been constructed exploiting different reagents for detection of antibodies, but still require laboratory and field validation studies to be further assessed for their capacity to improve diagnosis of African trypanosomosis. Recently, the ability to use mitochondrial heat shock protein 70 (MHP) of *T. congolense* as a diagnostic antigen was examined (Shaw *et al*., 2014) and with encouraging results, but the technique still needs to be further validated and evaluated for natural infections in cattle (Bannai *et al*., 2003).

Indirect Fluorescent Antibody Test (IFAT)

The test is used to detect trypanosomes antibodies. It has proven to be sensitive test but it has the disadvantage in that it can only be carried out in laboratories and the procedure is rather long and complicated as well as some extent subjective (i.e. titration, but different operators may give somewhat different results) (Uilenberg, 1998).

2.7.3. Molecular diagnosis

Polymerase chain reaction (PCR)

Provides tools for sensitive and specific diagnosis based on DNA sequence recognition and amplification. PCR permits identification of parasites at levels far below the detection limit of the commonly used parasitological techniques. PCR assays for *Trypanosoma* detection have been developed using species specific DNA hybridization probes. This method requires either prior knowledge of the species to be found or the use of several probes for each sample to be tested (Ogwu*et al*., 1992).

2.8.Differential Diagnosis

Other diseases having manifestations of approximately the same clinical signs like anemia and weight loss including babesiosis, anaplasmosis, haemonchosis, theileriosis, and malnutrition or helminth infestation should be ruled out (CFSPH, 2009).

The main disease entity which resembles trypanosomosis in goats and sheep is helminthosis, especially haemonchosis. Anaemia, ill thrift, weight loss, submandibular oedema and high mortality rates are common to the two disease complexes, although diarrhoea sometimes accompanies helminthosis. A history of sudden death in a number of pigs, combined with clinical signs as described, is suggestive of *T. simiae* in areas adjacent to tsetse infestations. Other causes of sudden death that should be differentiated include African and European swine fevers and anthrax. Chronic trypanosomosis in pigs should be differentiated from helminthosis and malnutrition. Acute disease in horses and donkeys must be distinguished from African horse sickness, anthrax and babesiosis. In chronic trypanosomosis the oedema has to be differentiated from that occurring in African Horse Sickness and the anaemia from that of equine infectious anaemia. Chronic babesiosis may also produce signs similar to chronic trypanosomosis. The signs of weight loss, emaciation and oedema caused by dourine (*T. equiperdum*) infection with strongylosis, malnutrition and dental disorders that should be differentiated from those caused by salivarian *Trypanosoma* (Connor and Bosche, 2004).

2.9. Treatment

2.9.1. Curative treatment

Curative drugs aim to eliminate parasites from a sick animal. A drug could be regarded as “curative” when the dose used is able to eliminate all parasites. The most widely used curative trypanocide against surra is diminazene aceturate. However, other drugs can be used, such as isometamidium chloride (both curative and preventive), cymelars (so far, recommended only for curative treatment of camels), suramin, and quina pyramine (curative and/or preventive) (Desquesnes, 2004). Diminazene aceturate (DA) is an aromatic diamidine used to control babesia and trypanosome infection in ruminants. A curative dose of DA is administered via intramuscular injection to obtain a high concentration of the chemical in the circulating blood. The withdrawal period for the consumption of products from cattle injected with DA is seven days for meat and three days for milk (Peregrine and Mamman, 1993). However, the chemical dose in the serum actually suggests a longer withdrawal period of one month and twenty-one days for meat and milk respectively (Mdachi *et al.*, 1995).

The dose recommended for the treatment of infections due to parasites belonging to the *Trypanozoon* subgenus is 7mg/kg bodyweight of DA, via intramuscular injection. This could be for various reasons, including ignorance of the right dose or concern to save money by reducing the cost of treatment. Use of the "wrong" dose is based on the recommended dose for the treatment of infections by two other African *Trypanosoma*species: *T. vivax* and *T. congolense*. Diminazene aceturate is recommended in ruminants. Its use in horses and dogs is limited due to poor efficacy and tolerance in these species. Consequently, trypanosomes have developed chemo-resistance in most parts of the world (Desquesnes, 2004). The low dose treatment can lead to the selection of chemo-resistant strains (Tuntasuvan, 2003; Kongkaew, 2012)**.**

Isometamidium chloride (IMC) belongs to the phenanthridine family, as well as homidium chloride or bromide. However, the latter are highly toxic because they are DNA intercalating agents. Therefore, their use in the field is not recommended. It can be used for curative (0.5mg/kg BW) and preventive (1mg/kg BW) treatment of *Trypanosoma* infections in ruminants and horses, via intramuscular or subcutaneous injection. Alternate use of DA and IMC constitutes a "sanative pair," which means that once resistance develops to one of the drugs, the other drug should be used to control the infection (Desquesnes, 2004). The withdrawal period for the consumption of products in cattle injected with IMC is 23 days. However, it is obvious that the chemical can circulate in the blood for up to 4-5 months after injection (Eisler, 1996). These withdrawal periods make IMC poorly adapted to beef or dairy cattle. Horses have a limited tolerance to IMC, although it remains an alternative to DA. Melarsomine dihydrochloride (Cymelarsan) is the latest trypanocide to be developed and used to control surra in camels via deep intramuscular injection (Desquesnes, 2004).

Evaluations conducted on other host species suggested in horses, cattle and buffaloes (Desquesnes, 2009). Dogs have a satisfactory tolerance to the drug. However, in the case of nervous infections in horses and dogs, even high doses, respectively, 0.5mg/kg BW and 2mg/kg BW, failed to cure the animals. In the absence of a trypanocide capable of establishing curative treatment for dogs, this strategy aims to enhance specific and protective immunity against the parasite (Cherdchutham *et al.*, 2012). Suramin is a ureic component which was used in horses and camels by intravenous injection. It was effective against *T. evansi* infection, although it is no longer used. A more effective combination of quina pyramine sulphate and quina pyramine chloride (Triquin) can be used as a curative/preventive drug against *T. evansi* in horses and camels, administered by subcutaneous injection at a dose of 8mg/kg BW. However, the drug is quite efficient and the chemoprophylactic effect can last up to 4months. In cattle, the use of quina pyramine is not recommended because it may induce cross-resistance to both DA and IMC. Its use should be restricted to horses and camels only (Peregrine *et al*., 1995).

2.9.2. The use of Trypanocides in different host species

Buffalo, cattle, and small ruminants infected by *T. evansi* can be treated with DA (the drug of choice) at a dose of 7mg/kg BW by intramuscular injection. The withdrawal period for meat consumption should be greater than thirty days. In the case of strong clinical signs, especially when parasitaemia is high, an initial injection of 3.5mg/kg BW DA may be given to reduce the parasitaemia and a second injection of 7mg/kg BW can be given five days later to ensure that all the parasites are killed. If the treatment is ineffective, the use of IMC is recommended at a dose of 0.5 mg/kg (withdrawal period for meat should be greater than 90 days). Alternatively, the efficacy of Melarsomine hydrochloride was recently demonstrated (no nervous signs were observed), at a dose of 0.5mg/kg BW by deep intramuscular injection in cattle (Radostits *et al*., 2007, Cherdchutham *et al*., 2012).

Horses, dogs, and cats can be treated with DA or IMC despite being quite sensitive to the drugs. Given that horses have a low tolerance to DA and IMC, the normal recommended dose can also be split into two sub boosts. However, the intervals between the sub-boosts should not be too long; otherwise the curative drug concentration in the plasma will not be reached. DA treatment is not efficient in the case of nervous infection. As an alternative, the efficacy of Melarsomine dihydrochloride was evaluated in horses and dogs (Desquesnes *et al*., 2012). Another alternative is the treatment of horses with quina pyramine sulphate and chloride (curative and chemo prophylactic effect), which provides durable protection to the animals (Arjkumpa*et al*., 2012).

In camels, although a number of trypanocide have been used (DA, IMC, suramin, quina pyramine, etc.). In pigs, little information is available on the control practices used for African trypanosomes. Quina pyramine may be used, as well as DA, though the latter appears to be of limited efficacy (Tuntasuvan *et al*., 2003). IMC and Melarsomine dihydrochloride could also be used. Lower doses, such as 5mg/kg BW, resulted in relapses (Hin *et al*, 2004); while 8mg/kg BW seems to be efficient (Rodtian *et al*., 2012).

2.10. Control and Prevention

2.10.1. Control of infection

The control of trypanosomosis in enzootic countries involves control of tsetse fly population, prophylactic treatment and good husbandry of animals at risk and use of trypanotolerant animals. The earliest methods involved bush clearing and elimination of game animals on which tsetse feed. More recent methods involved the use of insecticides applied strategically in the form of ground and aerial spraying over large expanses of land (Getachew and Eley, 1993).

2.10.2. Chemical control of parasites

Attempts at trypanosomosis control have also been directed to prophylactic dosing with chemicals such as homidium bromide, homidium chloride and isometamidium (Eisler *et al*., 1998). In the absence of a vaccine, control methods must combine reduced exposure to the vectors (large scale tsetse trapping and pour-on applications) with strategic treatment of exposed animals along with use of trypanotolerant animals when feasible (Radostits *et al*., 2007).

2.10.3. Other methods to prevent infection

In situations where it is difficult to control the biting insect populations, it may be easier to control transmission, though it has no 100% efficacy. Tabanids are naturally persistent feeders and they do not leave one animal to bite another if the latter animal is more than 50 meters away. Therefore, 200m is considered to be a safe distance for mechanical transmission by biting insects. However, separating bovines from equines is highly recommended to avoid the transmission of *T. evansi* from buffalo or cattle reservoir to highly sensitive horses. To avoid any risk of transmission (even that of occasional contact with animals that have escaped), it is advisable to breed cattle and horses in completely different areas that are at least several kilometers apart (Barros and Foil, 2007).

The case of carnivores is quite unusual. Carnivores may be infected when they eat the bones, flesh, or blood of an infected animal that has only just died. Rodents, which are omnivorous, may become infected like carnivores. *T. evansi* can be transmitted via oral infection as demonstrated in a trial in which per-oral blood was given to rats and mice. To avoid such infections, the dead animals' carcasses should be eliminated as soon as possible and dogs, especially stray dogs, should be contained around slaughterhouses, as well as on livestock farms in general (Silva *et al*., 2007). In addition to per-oral contamination, dogs may also contract the infection from biting flies, especially the dog fly, *Stomoxys*, when they live in the vicinity of reservoir animals, such as cattle and horses (Vergne*et al*.,2011).

2.10.4. Use of trypanotolerant livestock

In recent years, increasing interest has been paid to exploitation of trypanotolerant traits within the number of cattle breeds, particularly the taurine breeds of West Africa such as the N`dama. However, the trypanotolerant trait is not absolute solution to trypanosomosis because trypanotolerant cattle have been known to succumb to the effects of trypanosomosis under circumstances of stress, poor nutrition, over work, inter current diseases or under heavy tsetse fly challenge. The use of trypanotolerant livestock is thus often supplemented by the use of trypanocidal drugs in areas of heavy tsetse fly challenges. Trypanotolerant cattle also appear to have higher levels of resistance to ticks, helminthes and dermatophilosis. It should also be noted that while classically considered trypanosuceptible in comparison to N`dama and other similar West African taurine breeds, the Zebu and Sanga cattle of East and Southern African are undoubtedly less susceptible to the disease than the many breeds of exotic cattle that have been imported into tsetse infested countries. The Orma Boran cattle of Kenya have been studied for their trypanotolerant (Bossche, 1998).

2.10.5.*Vaccination*

Despite extraordinary research efforts directed at the development of vaccines against trypanosomes, no vaccine has so far been developed. The studies have been undergoing to find out the vaccine still where there has been some progress in the development of an anti-disease vaccine. Here efforts had been directed towards preventing the pathogenic effects of the parasite rather than infection itself (Authie *et al*., 2001).

2*.10.6. Control of Vector*

In the case of tsetse transmitted trypanosomosis in Africa including Ethiopia, vector control is quite effective at reducing the *Trypanosoma* pressure. The cyclical vectors can be specifically targeted using insecticide impregnated screens and insect sterilization techniques can be used in a limited livestock breeding area. Conversely, the control of mechanical vectors is not easy because of the diversity of tabanid species in a given area, their high mobility and prolificacy. In addition, the larval stages of tabanids are generally spread over a wide area and different species colonize various landscapes. The ecological control of one species might help the development of another. Tabanid control using insecticide sprays was proven to be efficient in small closed deforested areas in French Guyana (Foil and Hogsette, 1994). However, even in this case, tabanid infestation re-appeared 2-3 years after the end of the control campaign (Desquesnes, 2004).

As tsetse flies are sensitive to insecticides and no resistance has been developed, considerable successes were achieved. Other effective methods involve targets impregnated with insecticides and traps that attract and catch tsetse. These are simple, cheap and can be constructed and maintained by local communities (Boulange *et al*., 2002). Another method is the sterile male technique. Since the female tsetse only mates once in a life time, this technique is theoretically able to eradicate a targeted tsetse species in areas where other methods have been used to reduce its density but it is expensive. Finally, it has been stated that use of the land for agriculture, industries, highways, etc. will effectively destroy the habitat for tsetse flies (Radostits *et al*., 2007).

The control of trypanosomosis in endemic countries involves control of tsetse fly population and use of trypanotolerant animals. Control of tsetse has successfully achieved, but re-invasion is frequent if the land is not properly utilized. The old methods of controlling the vectors involved bush clearing and elimination of game animals on which tsetse feed for their survival. More current or recent methods involved the use of insecticides applied strategically in the form of ground and aerial spraying over large expanses of land (Getachew and Eley, 1993).

In order to control tabanid populations successfully, egg development must be kept below 2%. The control of surra's vector populations can be attempted using traps and/or impregnated screens or using insecticides on livestock (Mihok, 2002). Spraying insecticides, such as Deltamethrin on cattle, is efficient for controlling mechanical vectors (Foil, 1991). However, the effect is relatively short-lived, which makes efficient control costly. One of the traditional methods for controlling biting insects is the use of smoke released by slow fire. The smoke repels the insects. However, because it only covers a limited protected area, the animals in this area reduce their food intake (Desquesnes, 2004).

2.10.7. The uses of traps and targets

Traps can be used unbaited (Okoth, 1999) or baited using cow urine and cow breath (Alsop, 1994) and also may use synthetic odour (Vale *et al.,* 1999). Baits are various natural or synthetic compounds that act as olfactory attractants to tsetse flies in the field and when applied on to traps and targets, results in significantly increased catches of tsetse flies. Tsetse control by use of traps offers some of the best realistic approaches for control of many Glossina species. Traps can be made from local materials for example cone traps made from old vehicle tires or biconical tsetse traps made from bark cloth with the upper cone made from palm reed netting. Community participation ensures effective planning, designing and implementation of tsetse control using traps, thus eliminating the disadvantages of a top down approach (Okoth, *et al*., 1999).

The community can make cheap traps themselves and take responsibility for their viability and sustainability. The government and researchers aid in creating awareness about community participation of the use of traps in controlling trypanosomosis. Communities are encouraged to elect their own leaders. Together with officials and scientists or researchers, they draw up trapping programmes. Since the community members own land, they know where the tsetse flourishes. Tsetse fly trapping activities becomes an integral part of their normal routine agricultural work (Dransfield *et al*., 1991). The use of traps has a number of advantages in that they are cheap, technologically simple, and environmentally friendly and largely target specific. They are very good for small scale operation against *G. palpalis* and *G. morsitans*, involve low initial capital investments, have no risk of resistance and incorporate community participation (Aslop, 1994).

2.10.8. Sterile Insect Technique (SIT)

This involves production of large sterilized male tsetse flies which are released to the wild. It is a cumbersome venture, involving use of skilled manpower (Alsop, 1994 and Jordan, 1998). With this method of tsetse fly control, there is a need to have regional effort. However, in an event of eradication tsetse flies, SIT can be used for mopping up low density foci of tsetse flies remaining (Jordan, 1998).

2.10.9. The baiting system

Instead of the destruction or contamination of the environment by tsetse, the systems depend on the attraction of the fly from its surroundings to some introduced object, which may be insecticidal, but which can if necessary be removed later; this may be an artifact (such as trap), or a live host, treated with insecticide. Bait systems are inherently of low environmental impact, and are relatively low-technology. It is also claimed that they are logistically less demanding than other approaches, and are capable of being adopted by local communities on self-help basis and seems increasingly likely that these techniques will form the basis for tsetse fly control in the short to medium term (Khan, 2006).

Although attempts were made to control tsetse using targets impregnated with insecticides many years ago, successful application of this technique followed by production of the second generation synthetic Pyrethroid insecticides (Deltamethrin, Cypermethrin, Cyfluthrin etc.) and the development of potent of odour attractants in the last ten to twenty years (Leak, 1999).

2.10.10. Pour-on (spot-on)

These are formulation in which the insecticide is applied to the back of the animals and spreads over the body surface.This has been successful in African countries like Kenya, Cote d'Ivoire, Zanzibar, and Burkina Faso where in the latter two, *G. austeni* and *G. palpalis* gambiense were completely eliminated from localized habitats for a time, without other control measures being applied (Lalise *et al., 2016*). Likewise, the control trials of *G. pallidipes, G.f. fuscipes, G.m. Submorsitans* and other biting flies with Cypermethrin pour-on insecticide was carried out in Ethiopia at a site with a high prevalence of multi-drug resistant trypanosomosis resulted in a reduction of 98 percent apparent density of main vector, *G. pallidipes*,and a 70 percent reduction in *Trypanosoma* prevalence in cattle. Similarly, the application of Deltamethrin spot- on appeared to effectively control *G. m. submorsitans* and *G. tachinoides* in the upper Didessa valley where reinvasion pressure was not high (STEP,2008).

2.11. Risk Factors of Domestic Livestock Trypanosomosis

The African Animal Trypanosomosis has many risk factors facilitating animals to be diseased. Some of the risk factors of cattle include altitude, animal migration and climatic conditions (Majekodunmi*et al*., 2013). The prevalence and severity of diseases varies with seasons, animal species and breed, vegetation coverage, animal husbandry system, body conditions and other related factors were recognized as the risk factors of trypanosomosis in livestock (Dereje *et al*., 2014). Other study on prevalence of small ruminants indicated that animals body conditions, anaemia and *Trypanosoma* species were the risk factors of the disease in small ruminants (Bacha *et al*., 2013).

A very recent study on prevalence of bovine trypanosomosis and associated risk factors shown that animal's body conditions and *Trypanosoma* species were the common risk factors of the disease in cattle (Walkite*et al*., 2018).The other study on theprevalence of camel trypanosomosis at Selected Districts of Bale Zone, Southern Ethiopiacome with the results that the ages of animals, the animals` living area and the *Trypanosoma* species were taken as the risk factors for the disease occurrence in camels (Abera *et al*., 2014). The study conducted on Prevalence and impact of bovine trypanosomosis determined that seasons, animal breed, body conditions and coat colors were shown significant association in prevalence of bovine trypanosomosis (Abdoulmoumini *et al*., 2015).

2.12. Economic Impacts of Livestock Trypanosomosis

According to FAO (2009), trypanosomosis is probably the only disease that has profoundly affected the settlement and economic development of a major part of SSA continent. Approximately 7-10 million km^{2}or about 40 percent of Africaof land was infested by tsetse fly, on which for about 20 million cattle are raised. Under different circumstances, this land could support more than 140 million cattle and increase meat production by 1.5 million tons (Getachew, 2005). Trypanosomosis threatens 50 million head of cattle in SSA. Every year, trypanosomosis causes about 3 million deaths in cattle while approximately 35 million doses of trypanocidal drugs are administered to enable livestock to survive in tsetse-infested areas. While the economic losses in cattle production alone are in the range of US$1.0-1.2 billion. The indirect impact imposed by the disease on the total agriculture-livestock production is estimated at US$4.5 billion per year. The overall negative impact extends to the access and availability of cultivable areas, changes in land use and exploitation of natural resources, restriction of opportunities for diversification and intensification of agricultural activity. The magnitude of the problem requires a multidisciplinary approach for effectively promoting sustainable agriculture and rural development strategies (Mattioli and Slingenbergh, 2013). Recent study estimated the direct annual cost of trypanosomosis to be about 1.34 billion USA dollar (Janson *et al*., 1999).

The disease directly affects the milk and meat productivity of animals, reduces birth rates, increases the abortion rates as well as mortality rate; all these affect the herd size and herd composition. Indirect impact of trypanosomosis mostly lies on crop production through the availability and cost of animals that provide traction power (Swallow, 1999). The disease reduces work efficiency of oxen for cultivation, reducing access to animal traction or discourages the introduction of drought animals in to crop farming (Omotainse *et al*., 2004). Evaluation on impacts of trypanosomosis incidence on the productivity of oxen used for traction showed that relative inefficiency in the high risk area was 38% less efficient than oxen in the low risk area (Swallow *et al*., 1999). The other study (Tadesse and Tsegaye, 2010)based on the economic benefits from intervening against bovine trypanosomosis reported the significant benefits especially for Ethiopia, because of its very high livestock densities and the importance of animal traction. The estimated maximum benefit per square kilometer of tsetse infested area is US$ 10,000. Consequently, the total maximum benefits from dealing with bovine trypanosomosis in Ethiopia could be as much as US$ 1 billion.

2.13.The Distribution of Livestock Trypanosomosis in Ethiopia

Trypanosomosis is the most important disease of livestock in Ethiopia. There are six pathogenic species of trypanosomes commonly affect livestock in Ethiopia, namely *T. vivax*, *T. congolense*, *T.b. brucei*, *T. evansi*, *T. equiperdum* and *T. rhodesiense*. But the most important trypanosomes in the country are *T. vivax* and *T. congolense*. Both species affect a great number of cattle which are the most important species of the domestic animals in Ethiopia. Due to its extensive distribution, *T. vivax* is more important than *T. congolense*. Most of the above listed species of trypanosomes are limited in distribution to Africa which is the home of the cyclical vector. But the mechanically and venereally transmitted *Trypanosoma* have a cosmopolitan distribution (Seyoum *et al.*,2013).

T. vivax is found in the entire country except in the highlands, which are 2,500 meters above sea level. The highlands include: the North Central and the Arsi-Bale Massifs, the Tigrean and Showan Plateaus, the South-Western and the Harar Plateaus. The wide spread of *T. vivax* is due to its adaptation to mechanical transmission by biting flies in areas outside tsetse fly belt. The distributions of *T. congolense* and *T.b. brucei* have been limited nearly to the area of the cyclical vector, the Ethiopian tsetse fly belt. This is due to the fact that both species of trypanosomes are not adapted to mechanical transmission. Therefore, the diseases caused by *T. congolense* and *T.b. brucei* are limited to southern and western administrative regions including Sidamo, Gamo Gofa, Keffa, Illubabor, Wollega, parts of Gojjam and Shoa *(*Tekle and Mekonen, 2013*)*. The distribution of tsetse transmitted trypanosomosis very common in the geographical areas of tsetse in Africa and indicated according to Cynthia, (2005) (Table 1).

Table 1.The Distribution of Tsetse Transmitted Animal Trypanosomes in the World

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

Source: Cynthia (2005)

Very recent estimate indicates that, more than 140, 000 km^2 otherwise agriculturally suitable land in the western and southwestern parts of the country is found to be potentially suitable for tsetse (Leta *et al*., 2015). The general distribution of tsetse flies is determined principally by climate and influenced by altitude, vegetation and presence of suitable host animals. To date, five species of *Glossin*a (*Glossinam. submorsitans*, *G. Pallidipes*, *G. tachinoides*, *G. f. fuscipes* and *G. longipennis*) have been recorded from Ethiopia. The distribution of tsetse transmitted livestock trypanosomosis is basically related to the geographical distribution of tsetse fly (Lalise *et al*.,2016*)*. The distribution of prevalence of domestic livestock trypanosomosis in different parts of Ethiopia is tabulated (Table 2).

Table 2.The Summary of Distribution of livestock trypanosomosis in Ethiopia

Species	Prevalence	Research area	References
Cattle	5.6%	Bullen district of Metekele	Aki and Godeso, 2016
››	27.5%	Arba Minch woreda	Abraham and Tesfaheywet, 2012
››	6.25	Chiliga, North West Ethiopia	Zewdu and Dessie, 2016
››	50%	Western Gojam	Erkihun, 2015
››	3.7%	Abaya District	Dawit *et al.*, 2016
››	9.61 %)	South western Ethiopia	Duguma and Tasew, 2012(a)
››	17.9%	Bale zone, Southern Ethiopia	Abera *et al.*, 2014
››	15.57%	Eastern Wellega	Tekle and Mekonen, 2013
››	13.3%)	Mandura, Benishangul Region	Dinede and Aki, 2017
Shoats	3.75%	Upper Didessa Valley	Samson and Frehiwot, 2010
››	2.6%	Benishangul Gumuz	Ayana*et al.*, 2015
››	2.56%	Dangur District, Benishangul	Lalise *et al.*, 2016
Camel	5	Tigrai	Hailu, 2000
››	7.7	Somali	Issa, 1998
››	10.9	Borena	Tekle and Abebe, 2001
››	31.9	Yabello	Lakew, 1993
››	12.12	Dello-Mena and Sawena	Hagos *et al*, 2009
Equine	17.785%	Bale highlands of Oromia	Hagos *et al.*, 2010
››	4.2%	South Anchefer district, Northern Ethiopia	Denbarga *et al*., 2012

2.14.The Impacts of Control Interventions of Trypanosomosis

The combination of pour-on and strategic use of trypanocidal drugs is considered as the most likely to be delivered since these control methods are largely private in nature (all benefits accrue to the person paying for the service/goods) and can be delivered by the private sector (McDermott and Coleman, 2001). The challenges associated with the delivery of the other tsetse control methods or integrated approaches could be addressed by blending them with rural development initiatives or other disease control measures (Holmes, 1997). Combining tsetse/trypanosomosis control with other rural development initiatives has, however, not been tested or used before.The effectiveness of new tsetse and trypanosomosis control technologies has traditionally been assessed using field trials. Such studies, however, need to be integrated with theoretical analyses (using simulation or mathematical models). In this system, field studies would provide data for estimating the effectiveness of a technology and at the same time, the values of parameters used in building the models. Mathematical models, in turn, provide a framework for evaluating the expected impact of a technology when used alone or in integrated versions in multiple settings (McDermott and Coleman, 1999).

According to Torr *et al.*, (2005), there are some of the limitations of the available tsetse and trypanosomosis control methods applied in different parts of Sub-Saharan Africa. The lack of adequate extension services in tsetse-infested areas further curtails the provision of professional guidance and supervision in the application of these technologies. The community-based control operations, especially deployment of traps or targets, are dependent on pooling private resources to achieve a public good. Problems inherent in any collective action, allied to a lack of technical advice and the economic constraints faced by poor communities in rural areas, mean that effective baits are seldom optimally deployed (Dransfield and Brightwell, 2004). With regard to the use of trypanocides, resistance to one or more of the three compounds currently used for the treatment of trypanosomosis in cattle (diminazene aceturate, homidium chloride/bromide and isometamidium chloride) is known to be present in at least 13 Sub-Saharan countries. These limitations necessitate: judicious application of the available technologies; development of new technologies and development of integrated control strategies (Geerts and Holmes, 1998).

The national component of the Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) is the most important tsetse control program ever implemented in Burkina Faso. The current program took advantage of lessons learned from the past and was based on a holistic approach of trypanosomosis control. Indeed, the main reason for failure of past campaigns in

Burkina Faso was the sustainability of the achievement. In past period of the study, numerous tsetse control projects were implemented in the areas. In these campaigns, beneficiary communities, farmers and public authorities did not continue the efforts after the projects ended. Consequently, the tsetse cleared areas were re-invaded rapidly by tsetse and the trypanosomosis incidence regained similar levels as before the projects implementation. The successes and failures of these projects have been discussed previously (Percoma *et al*., 2018). Some recent researchfindings shown that, the insecticide-impregnated targets appliedareas; the results of control methods showed that apparent density of tsetse flies declined from 10.73(13.27SD) to 0.43 (2.51SD) fly/trap/day from the third month of campaign onwards and remained lowthereafter. At the end of the campaign, an 83% reduction of apparent density of tsetse was observed for Glossina palpalis gambienseand a 92% reduction for *G. tachinoides*. Based on findings, they concluded that tsetse flies could be suppressed efficiently but their elimination from the targeted area may require theuse of integrated methods including the Sterile Insect Technique, which is programmed through the development of thePan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC). The challenge will remainthe sustainability of the achievement (Percoma *et al*., 2018).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

This study was conducted from November, 2017 to June, 2018 inDawuro zone which is one of the 14 zones in Southern Nations, Nationalities and Peoples Regional State. The zone is located at about 497 km far from Addis Ababa, capital city of Ethiopia and 319 km South West of Hawassa, the capital city of the SNNP regional state. Geographically, it is roughly lies between 6º59'-7º35' North Latitude and 36º6'-37º53' East Longitude and the altitude of the zone is between 1300-3500 meter a.s.l, (CSA, 2016). It is bordered with Oromiya region in the North West, KembataTembaro Zone in the North East, Wolaita Zone in the East, Gamo Gofa Zone in the South, and Konta special Woreda in the West. The total area of the zone is estimated to be 4,436 square kilometers and it shares 4.07% of the total area of the region. The population size of the zone is 617,897 accounting nearly 3.3% of the total population of the region. The average population density of the zone is 143 persons per square kilometer. The zone has five administrative districts and one town administration. The study area has a total human population of 103,898 from urban and 1, 29, 801 from rural. The livestock population of the zone comprises of 765,179 cattle, 366,342 sheep, 175,867 goats, 29,747 horses, 24,980 donkeys, 37,462 mules and 957,213 poultry. In study area, livestock are managed under traditional management system (DZLFDD, 2017).

The mean annual rain falls and the temperature of Dawuro Zone ranges from 1201-1800mm and 15.1-34.5°c, respectively. Among many rivers, Omo (Gilgel Gibe III hydroelectric power project is currently under operation) is one of the region's biggest drainage basins which flows and surrounded the zone. River Omo is the longest rivers bordering Dawuro zones and other river basins within the zone which create suitable agro-ecology for the tsetse fly include Gojeb and Manisa river basins. Due to the activities and intervention of man and animals, forest resource is changed in to crop and grazing land. The dominant natural vegetations are mainly broad-leafed forest like Weira, Tide, Zigba, Koso, Tikureinchet, Bamboo tree, etc. The zonal agro–ecological zones are midland, lowland, and highland. About 41%, 38% and 21% of the zonal land is expressed under midland, lowland and highland from the total agro-ecological zones, respectively. The three agro-ecological zones are suitable for agricultural production and human settlement. The mean annual temperature and rain fall of Tocha district are15.1-25^0C and 1401-1800mm respectively and the altitude is 501-3000m. In addition, the mean annual temperature and rain fall of Tarcha town are 20.1-25^0C and 1401-1800mm respectively and the altitude of 501-2500m(DZFEDD, 2017). The maps of the SNNP Region, Dawuro zone, study areas and kebelesin the studied areas were located in figure (3).

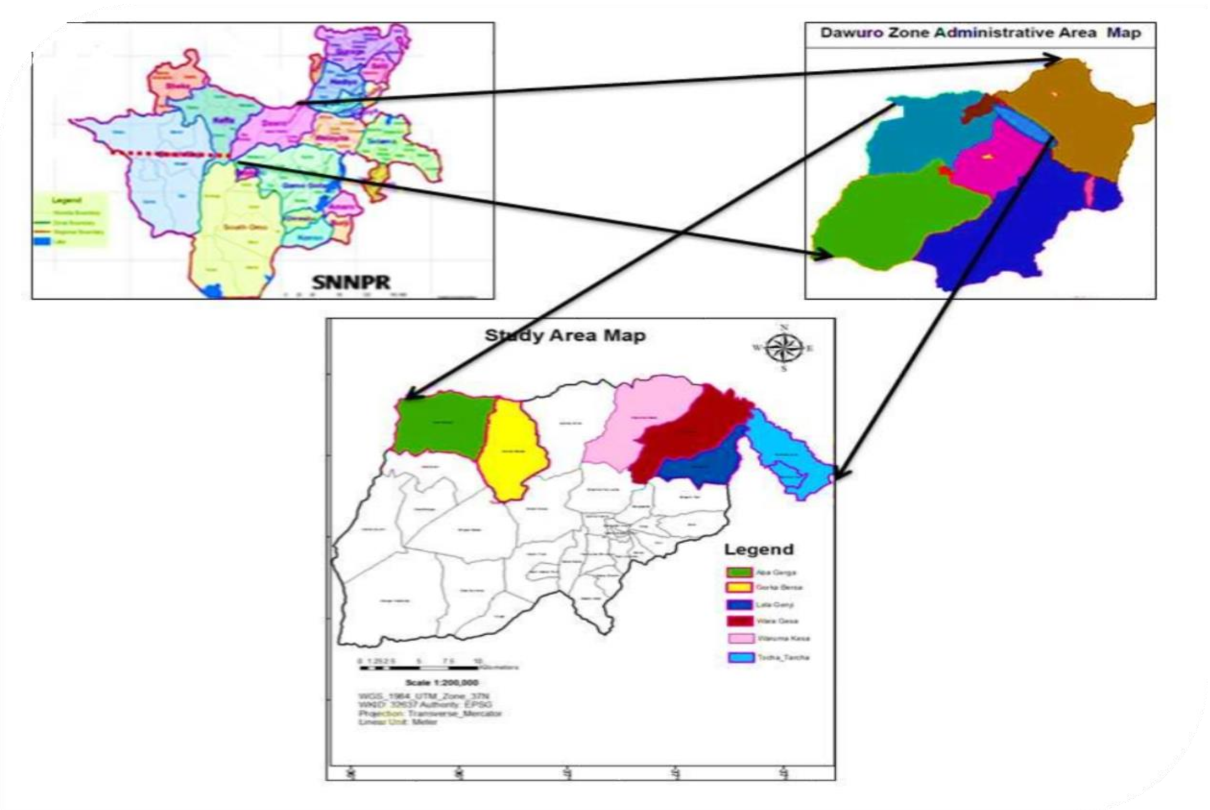

Figure 1.Themaps of the Southern Region, Dawuro zone,Tocha, Tarchaand kebeles
Source: SNNPR Map, (2018)

3.1.1. Socio-economic situation and farming system of the study area

Agriculture is the mainstay of the livelihood of people with a mixed farming system and livestock plays an integral role for agricultural activity. The crops commonly produced are maize, teff, sorghum, wheat, bean, chick pea, enset, groundnut, etc. The livestock species most commonly reared in the area include; cattle, sheep, goat, poultry and equines. Animals in most of the areas of the zone were kept in communal grazing system with group of herds locally they called it "wudiya". The herd is owned by a maximum of 4-8 owners or household levels with the average number of animals per herd are estimated to be 12 for cattle. The herds are managed in outdoor system for 8-10 hours by close supervision of one owner and animals at night kept in barn or" berete" system that found together with the owner house or different house close to them in cultivated land to fertilize the land (DZFEDD, 2017).

3.1.2. Constraints of livestock production in the study areas

The animal health problems such as infectious diseases, internal and external parasitic diseases, and protozoan diseases are the main constraints of livestock production and agricultural development in the study area (WSTTICC, 2017). Trypanosomosis, locally in the study areas is referred to us ``

Goloba`` has been considered as the highest ranking disease suffering their animals leading to different economic problems.

3.2.Study Design

In this study, cross-sectional study was performed for the achievement of the predetermined research objectives.

3.3. Study Population

Thetarget animal populations of the study areas are 135,912 cattle, 87,583 sheep and 34,047 goats. The study animals were indigenous local breeds of zebu cattle of the ages greater than or equals to one year and all shoat populations of six months and above ages old. All the studied animals were kept under traditional management (extensive) production systems.The ages of cattle were determined by the age determination formula developed by Pace and Wakeman, (2003) but the ages of shoats were determined based primarily on the history obtained from the farmers in the community or the owners of the animals (Annex II).

3.4. Sample Size Determination

Sample size was determined according to Thrusfield (2008) formula which stated as:

$$n = \frac{1.96^2 \times P\,(1-P)}{d^2}$$

Where: n = required sample size

P = expected prevalence

d = absolute precision

According to Teklebirhan *et al*., (2016), the prevalence of bovine trypanosomosis in similar agro-ecology in the zone of the study area was reported to be 26.82% and according to Bedaso *et al*., (2016), the prevalence of the disease in sheep and goats in nearly the same agro-ecology was 9% and 7.2%, respectively. The absolute precision at 95% CI is (0.05). By replacing each value in the above formula, was resulted in 302 cattle, 126 sheep and 103 goats. Therefore, the total numbers of domestic ruminants required to determine the prevalence of trypanosomosis in the current study areas were 531.

3.5. Sampling Strategy

In this study, Tocha district and Tarcha Town Administration of Dawuro zone were selected purposively. These two study areas were selected based on theprevalence of trypanosomosis, apparent tsetse density and the history of previous application ofcontrol intervention strategies of trypanosomosis and its vectors and the availability of study animal populations in the areas. From the two study areas, the numbers of Kebeles and study animals were determined by proportional sampling methods (all 3 kebeles in Tarcha and 17 kebeles from Tocha, the total of 20 Kebeles were lowland in agro-ecology with the history of trypanosomosis control interventions). Then, the determined 5 Kebeles from Tocha district and 1 Kebele from Tarcha town were selected by using simple random sampling methods from the lists of peasant associations with past and present history of tsetse and trypanosomosis intervention strategies in collaboration with the Dawuro Zone Livestock and Fishery Development Department. Study animals of all species were selected by using simple random sampling strategies. As a selection criterion, exotic breeds, young cattle with the ages of less than one year and shoats of less than six months were excluded because of their unavailability, tied in the house and less exposed to the vectors.

3.6. Sample Collection

3.6.1. Retrospective data collection

At the beginning of this study, retrospective data was collected from Wolaita Sodo Tsetse and Trypanosomosis Investigation and Control Centers which is the only center assigned to perform local trypanosomosis controlintervention and follow up the situation in the study area. Baseline data concerning the prevalence oftrypanosomosis and prevalent species in domestic ruminants, the apparent density and species of *Glossina* circulating in the study areas before intervention commencement were collected. Furthermore, the data related to the type, frequencies and efficacy of the control interventions that applied so far in the study areas were gathered. In this data collection, the laboratory procedures that were undertaken for animal species were the same and the sample sizes were also approximately the same.

3.6.2. Blood sample collection

To perform hematological and parasitological tests or to determinethe packed cell volume (PCV%) and the existing *Trypanosoma* parasite species, 7-10 ml of the blood samples were collected aseptically by puncturing the marginal ear veins of each animal species using sterile blood lancet and heparinized capillary tubesthat filled $3/4^{th}$ of the height and sealed with soap after restraining the animals according to the procedures and steps indicated in OIE terrestrial manual (OIE, 2008). Corresponding to each sample; the species, age, sex, coat color, body conditions, forest coverage, kebeles and herd or flock sizes registered on a separate data collection sheet (Annex IV).

3.6.3. Entomological Sample Collection

The retrospective pre-intervention entomological data was collected from Wolaita Tsetse and Trypanosomosis Investigation and Control Center of the region while the post intervention data was gathered by deploying traps in thesix selected kebeles according to Okoth *et al*., (1999).The general geographic information of all the kebeles under study were recorded by using GPS (Garmin 48 type).In each study kebele 5 NGU traps,making a total of 30 traps were deployed at approximate distance of 200-250 meters' intervals. Tsetse flies' attractants (acetone)was used and the underneath of each trap pole was smeared with grease in order to prevent tsetse predators like ants and other enemies climbing up the pole towards the collecting cage that could damage the tsetse flies.During deployments of the traps in each kebele, the forest coverage, trap type, starts date and start time were also registered. After 72 hours of deployment, the end date and end time were registered.Then the traps were collected, tsetse and other fly species were harvested and their species and sexes were identified based on sex organs on male tsetse(Okoth *et al*., 1999). Communities were participated in trap keeping from thief and fire exposure.

3.6.4.Questionnaire Survey

Questionnaires were required for assessment of the perception of the farmers towards the general understanding of domestic ruminants` trypanosomosis, type, frequencies and the efficacy of tsetse and trypanosomosis control interventions applied so far in the study areas. Representative sample size of the questionnaire survey was determined by using the formula which was developed by Yamane (1967);

$$n = \frac{N}{1+N(e)^2}$$

Where, n is sample size; N is target population and *e* is level of precision. Based on this formula, by assuming level of precision 9% and the number of total human population in the research areas is 142,861; the estimated sample size for the questionnaire survey was:

$$n = \frac{142{,}861}{1+142{,}861(0.09)^2} = 123$$

Based on the result above, 123 interviewers were required for the questionnaires survey. But for the ease of sampling and to give equal opportunity to the farmers in the kebeles under study, equal numbers of interviewers were selected. Therefore, 22 interviewers from each six studied kebeles, the total of 132 interviewers were selected and the semi-structured questionnaires were prepared and administered to randomly selected farmer communities in the study areas to act as a source of information (Annex I). The questionnaires were pre-tested by distributing it to the group of people having nearly the same status to the farmer communities for its organization and capacity to gather the required information. Then it was administered to the famers who lived for two years and above who have livestock by pre-introducing the purposes of the questionnaires.

3.7. Parasitological Laboratory Examination

A small quantity of blood samples werecollected into heparinized haematocrit capillary tubes(that filled up to about ¾ of its height) from marginal ear vein by pricking the tip with a sterile blood lancet after properly securing the animal and aseptically preparing the area according to the procedures indicated by OIE diagnostic manual(OIE, 2008).

3.71. Buffy Coat Technique

Buffy coat technique was performed. The capillary tube was cut 1 mm below and 3mm above the Buffy coat using diamond pencilsince *Trypanosoma* species are found in the Buffy coat layer of the blood sample. The content of the capillary tube was expressed onto a clean microscope slide and covered with a 22x22 mm cover slip. Then the slide was examined for *Trypanosoma* parasite based on the type of movement in the microscopic field with 40x objective and 10x eye piece lens magnification light microscopy (OIE, 2009).

3.8.Hematological Study

3.8.1 Packed Cell Volume (PCV) determination

The collected blood samples were centrifuged at 12,000 revolutions per minute for 5 minutes according to the steps stated by OIE laboratory manual (OIE, 2008). The centrifuged capillary tubes with blood were then measured by haematocrit readerand the reading was recorded in percentage. Then the packed cell volume (PCV) value of each domestic ruminant’s was recorded.Then the cattle with PCV<24% were considered as anaemic and those with PCV≥24% were taken as non-anaemic (OIE, 2009). The sheep and goats with PCV≥24% were judged as non-anaemic and those with PCV<24% were categorized as anaemic (Kemal, 2014).

3.9. Data Management and Analysis

Data was categorized, filtered, coded and entered in to MS Excel and was transferred to Statistical Package for Social Sciences (SPSS) Software version 20 (SPSS, 2007). The prevalence of *Trypanosoma* infection was calculated as the number of positive animals as examined by Buffy coat divided by the total number of animals examined at a particular time multiplied by 100. The statistical significance of prevalence of trypanosomosis in different explanatory variables (species, sex, breed, coat color, age, body condition, *Trypanosoma* species and forest coverage) wasdiscussed by analyzing the data with the binary logistic regression and using the *P-values* from analysis.A binary logistic regression analysis was also conducted in order to establish the association of different risk factors with Buffy coat trypanosomosis positivity. The mean PCV% of the parasitaemic and aparasitaemic for trypanosomosis were determined by Independent sample t-test analysis after classifying and grouping collected data with their disease status. The relative abundance (apparent density) of tsetse and other flies were calculated as the average number of flies (males and females) caught per trap per day. The relative abundance of mean tsetse fly population and the prevalence of ruminant trypanosomosis in pre-intervention and post-intervention of some of the control intervention strategies applied so far in the study areaswere assessed by using descriptive statistics. The Paired sample t-test was also used to estimate the mean changes of the apparent tsetse density and prevalence of trypanosomosis in ruminants before and after application of different control intervention strategies in the study areas for assessment of the effects of the control strategies. In all analysis, confidence level and absolute precision were held at 95% and 5% respectively and $P \leq 0.05$ was taken for significance.

3.10. The Ethical Consideration

The study was reviewed and approved by Jimma University College of Agriculture and Veterinary Medicine Ethical and research review board. The objectives were well explained to all participating farmers and oral consents were received from each participant in the questionnaire and farmers who allow their animals for this study. Questionnaires were given on a voluntary basis to all participants and respondents who were allowed to give their responses freely.During blood sample collection, all procedures that avoid pain, distress, morbidity, death or secure animal safety were applied. Blood samples were not taken from physically emaciated and known diseased animals. A very small milliliter of blood samples were collected. These concepts were reflected in the regulations and guidelines that govern this research to the end of the use of animals.

4. RESULTS

4.1. Parasitological Laboratory Findings

In the current study, 531 blood samples of domestic ruminants were collected and processed in the Tarcha Veterinary laboratory in collaboration with Wolaita Sodo Tsetse and Trypanosomosis Investigation and Control Center (WSTTICC).Out of them, 302 were cattle, 126 sheep and 103 goats.The present study showed the prevalence of 23.8%, 4% and 5.8% for cattle, sheep and goats respectively. The overall prevalence of trypanosomosis in domestic ruminants was estimated to be 15.6% (83/531x100) with the 95%CI (12.8%-19%). Among the different Kebeles from which samples were taken, the highest and lowest prevalence were recorded in Wara Wory and Gorika Bersa in cattle respectively. In sheep and goats the highest prevalence was recorded in Tarcha Zuria and Wara Wory Kebeles respectivelycompared to the other Kebeles indicated in Table (3).

Table 3.The prevalence of trypanosomosis in domestic ruminant in Kebeles, Dawuro, Ethiopia

Kebele	Animal species	No tested	No Positive	Prevalence(%)	95%CI Lower	95%CI Upper
Tarcha	Bovine	47	11	23.4	11.3	35.5
	Ovine	21	4	19	2.3	35.8
	Caprine	13	0	0.00	0.00	0.20
Lala	Bovine	51	12	23.5	11.9	35.2
	Ovine	21	0	0.00	0.00	0.13
	Caprine	18	2	11.1	3.4	25.6
Wara	Bovine	51	17	33.3	20.4	46.3
	Ovine	21	1	4.8	0.1	23.8
	Caprine	18	3	16.7	3.6	41.4
Waruma	Bovine	51	15	29.4	16.9	41.9
	Ovine	21	0	0.00	0.00	0.13
	Caprine	18	0	0.00	0.00	0.15
Gorika	Bovine	51	8	15.7	5.7	25.7
	Ovine	21	0	0.00	0.00	0.13
	Caprine	18	0	0.00	0.00	0.15
Abba	Bovine	51	9	17.6	7.2	28.1
	Ovine	21	0	0.00	0.00	0.13
	Caprine	18	0	0.00	0.00	0.15

4.2. The Prevalence Based on the Risk Factors

The findings of this study showed that the higher prevalence of *T. vivax* was recordedin cattle and sheep whereas the prevalence of *T. vivax, T. congolense* and *T. brucei* werefound to be the same (1.9%) in goats.The determined prevalence of *T. congolense* was highest next to *T. vivax* and *T. brucei* in cattle. The prevailing *Trypanosoma* species with their prevalence on the domestic ruminants under study were indicated in Table (4).

Table 4.The composition of *Trypanosoma* species from domestic ruminants in Dawuro, Ethiopia

Animal species	Tested animals	Positive animals	*Trypanosoma* species			Prevalence (%)			95CI (For overall)	
			T.v	T.c	T.b	T.v	T.c	T.b	upper	lower
Bovine	302	72	42	25	5	13.91	8.28	1.66	19	29
Ovine	126	5	3	2	0	2.4	1.6	0.00	1.7	9
Caprine	103	6	2	2	2	1.9	1.9	1.9	2.7	12.1
Over all	531	83	47	29	7	8.9	5.5	1.3	12.8	19.0

T.v = *Trypanosoma vivax,* T.c = *Trypanosoma congolense and* T.b = *Trypanosoma brucei*

The *Trypanosoma* prevalence in the three groups of domestic ruminants was determined from the findings of current study. From these findings, the highest and lowest prevalence was determined on cattle and sheep respectively. Out of the total animals reported to be positive for one or more species of *Trypanosoma,* the proportion for *T.vivax, T. congolense* and *T.brucei* was found to be 56.63%, 34.94% and 8.43%, respectively for all domestic ruminants under study (Table 4). The prevalence of trypanosomosis across animal species indicated statistically significant variation (*P-value* = 0.005) and the odds ratio of (3.8) indicated that the prevalence of trypanosomosis in cattle is 3.8 times more in exposed group of cattle than sheep and also the second odds ratio of (0.67) indicated that the prevalence of trypanosomosis in goats is 0.67 time less in exposed goats than cattle under study.

A comparison of *Trypanosoma* prevalence between sexes of cattle was made. The higher prevalence was determined in femalecattle. The variations in prevalence of disease based on sexes of study cattle was statistically not significant (*P-value* = 0.36) and the odds ratio of (0.7) shown that the disease prevalence was 0.7 times more likely less in exposed male than females. The prevalence of *Trypanosoma* infection was found higher in old age categories (45.2%) than in young cattle. This difference is statistically significant (*P-value* = 0.01) andthe strength of the association is high (OR=3.3) which means trypanosomosis is 3.3 times more likely common in old than in young cattle. The highest disease prevalence was recorded in black colored cattle where gray color cattle come next. This is statistically significant (*P-value* = 0.02) and the association strength is 2.6 (OR=2.6) indicating that the disease was 2.6 times more likely common in black colored than red cattle (Table 5).

The prevalence of trypanosomosis based on herd sizes was higher in small and medium but lower in large sized herd sizes of cattle. However, the trypanosomosis prevalence variation based on herd sizes shown statistically non-significant variation (*P-value* = 0.13) in reference herd size and the strength of association is also low (OR= 0.6) which shown that the prevalence of trypanosomosis in medium sized herd is 0.6 times more likely less than the small sized herd of cattle.The highest and lowest prevalence of trypanosomosis was recorded in poor and good body conditions of cattle. This was shown statistically significant variation (*P-value* = 0.008) and the association (OR= 0.36) indicated that the disease prevalenceis 0.36 times more likely lower in medium than poor conditioned cattle. In addition, the highest and lowest prevalence of trypanosomosis was recorded in Riverine forest and wooded grass land respectivelyin cattle. This disease prevalence difference indicated statistically significant association (*P-value* = 0.014) but the strength of association is low (OR = 0.3). It means that there is 0.3 times more likely less prevalence of trypanosomosis in wooded grass land than riverine forest.These findings of prevalence of trypanosomosis on cattle based on herd size, sex, age, body conditions and forest coverage of the study areas were shown on Table (5).

Table 5. Final model outputs for the prevalence of trypanosomosis incattle from Dawuro, Ethiopia

Species	Factors	Category	Total examined	No Positive	Prevalence (%)	OR (95%CI)	*P-value*
Bovine	Sexes	Male	121	21	17.4		
		Female	181	51	28.2	0.7(0.4-1)	0.36
		Total	302	72	23.8		
	Age	≥1year≤4years	111	21	19		0.02
		>4years≤7years	160	37	23.1	0.97(0.5-2)	0.94
		>7years≤10years	31	14	45.2	3.3(1.3-8.7)	0.01
	Coat color	Red	116	17	15		0.02
		White	33	3	9	0.8(0.25-2.7)	0.76
		Black	89	33	37	2.6(1.3-5.3)	0.009
		Gray	64	19	30	2(0.9-4.6)	0.06
	Herd size	1-10	209	55	26		0.13
		11-20	70	16	23	0.6(0.3-1.3)	0.21
		21-40	23	1	4	0.2(0.5-1.3)	0.09
	BCS	Poor	146	45	31		0.014
		Medium	77	13	17	0.36(0.2-0.8)	0.008
		Good	80	14	18	0.5(0.2-1)	0.05
	Forest coverage	Riverine forest	137	41	30		0.014
		Wooded grassland	91	11	12	0.3(0.1-0.7)	0.004
		Cultivated land	74	20	27	0.6(0.3-1.3)	0.2

The higher prevalence was determined in female of sheep and male of goats'respectively.The variations in prevalence of disease based on sexes of studiedshoats was statistically not significant (*P-value* = 0.13) and the strength of association is also low (OR = 0.4).It shows that the disease prevalence was 0.4 times more likely less in exposed female than males.The prevalence of small ruminant trypanosomosis was recorded higher in old and lower in young aged shoats. This variation in prevalence of trypanosomosis wasshowed statistically significant association (*P-value*= 0.03).The strength of association is low (OR = 0.03) which shown that the prevalence of trypanosomosis in old age is 0.03 times more likely less than the youngaged shoats.

The slightly higher prevalence of trypanosomosiswas recorded in blackshoatsfollowed byred colored andthe variation in prevalence based on coat colors of small ruminants wasstatistically significant (*P-value*= 0.005).But the strength of association was found low (OR = 0.17) which indicated that the disease occurrence in blackwas 0.17 times more likely less than red colored shoats. The higherand lower disease prevalence was recorded in poor and good body conditioned shoats respectively. This disease prevalence variation of shoats indicated statistically significant association (*P-value* = 0.005). However, the strength of association is low (OR = 0.07). This means that theprevalenceis 0.07 times more likely less in medium than poor body conditioned shoats. These findings of prevalence of trypanosomosis on the potential risk factors under consideration on shoats including herd size, sex, age, body conditions and forest coverage of the study areas were shown on Table (6).

The prevalence of trypanosomosis was higher in small and lower in large sized flocks of goats.However, the higher prevalence in large sizes but lower prevalence small flocks of sheep. However, the difference in prevalence was statistically insignificant in association (*P-value* = 0.057) and the strength of association is found low (OR = 0.3). This indicated that the disease prevalence in medium sized flock is 0.3 times more likely than the disease in small sized flock of small ruminants. The highest and lowest prevalence of trypanosomosis was recorded in Riverine forest and wooded grass land in goats. In addition, the same prevalence was identified in Riverine forest and cultivated land in sheep. This disease prevalence difference in occurrence in studied areas indicated statistically significant association (*P-value* = 0.04) and the strength of association is low (OR = 0.2). This indicated that the prevalence of disease was 0.2 times more likely lower in wooded grass land than riverine forest coverage. The prevalence of trypanosomosis based on flock sizes was higher in small but lower in large sized flocks of goats but the higher and lower prevalence of disease were recorded in large and small flocks of sheep respectively. However, the difference in prevalence was statistically insignificant in association (*P-value* = 0.057) and the strength of association is found low (OR = 0.3). This indicated that the disease prevalence in medium sized flock is 0.3 times more likely than the disease in small sized flock of small ruminants. The highest and lowest prevalence of trypanosomosis was recorded in Riverine forest and wooded grass land in goats. In addition, the same prevalence was identified in Riverine forest and cultivated land in sheep. This disease prevalence difference in occurrence in studied areas indicated statistically significant association (*P-value* = 0.04) and the strength of association is low (OR = 0.2). This indicated that the prevalence of disease was 0.2 times more likely lower in wooded grass land than riverine forest coverage. The prevalence of small ruminants` trypanosomosis based on the risk factors is summarized in Table (6).

Table 6.Final model outputs for the prevalence of trypanosomosis insmall ruminants from Dawuro Zone, Ethiopia

Species	Factors	Category	No of examined	Positive	Prevalence (%)	OR (95%CI)	*P-value*
Sheep	Sexes	Male	58	1	1.72		
		Female	68	4	5.8	.4(0.1-1.4)	0.13
		Total	126	5	4		
	Age	≥6month≤3yrs	41	1	2.4		0.05
		>3years≤6yrs	85	4	4.7	0.03(.1-0.9)	0.03
	Coat color	Red	41	2	4.9		0.05
		White	52	0	0	.1(.01-0.8)	0.029
		Black	33	3	9	.17(.05-0.5)	0.005
	Flock size	1-8	118	4	3.4		0.308
		9-20	8	1	12.5	0.3(0.1-1)	0.057
	BCS	Poor	44	4	9		0.02
		Medium	60	1	2	.07(.02-0.2)	0.005
		Good	22	0	0	.02(.01-.03)	0.05
	Forest coverage	Riverine forest	56	2	4		0.11
		Wooded grassland	42	2	5	.2(.04-.9)	0.04
		Cultivated land	27	1	4	1.2(.2-5.5)	0.8
Goat	Sexes	Male	40	3	7.5		
		Female	63	3	4.8		
		Total	103	6	5.8	*	*
	Age	>6month≤3yrs	26	1	3.8		*
		>3years≤6yrs	77	5	6.5	*	*
	Coat color	Red	40	2	5		*
		White	29	1	3.4	*	
		Black	34	3	8.8	*	*
	Flock size	1-8	80	6	7.5		*
		9-20	23	0	0	*	*
	BCS	Poor	35	3	9		*
		Medium	48	3	6	*	*
		Good	20	0	0	*	*
	Forest coverage	Riverine forest	46	2	13		*
		Wooded grassland	31	1	3	*	*
		Cultivated land	26	3	12	*	*

* = Reference (The OR and *P-value* for sheep are taken reference to goats in Table 6)

4.3. Hematological Findings

The present study estimatedan overall mean PCV% values for parasitaemic and aparasitaemic cattle which were 23.24±3.04SD and 27.37±4.18SD respectively. Similarly, the recorded mean PCV% for parasitaemic and aparasitaemic goats under study were 19.67±1.86SD and 26.73±4.19SD respectively. From these, the mean PCV% for parasitaemic and aparasitaemic shoats was estimated to be the same. The mean PCV% for parasitaemic animals was lower than the mean PCV% for aparasitaemic animals.

In the current study, 12.58% of cattle were both anemic (PCV<24%) and positive for trypanosomosis whereas; 15.24% were find to be non-anemic (PCV≥24%) but they were positive for the trypanosomosis. Whereas, for sheep under this study,3.17% of animals were found to be both anaemic and positive for the disease and1.08% of sheep were non-anaemic but determined as trypanosomosis positive. For goat group, 5.82% of the studied animals were both anaemic and diseased while21.36% of animals were found to be anaemic but free from disease.As it is indicated in the figure, the lowest and the highest PCV% values for cattle are 18% and 39% respectively with the most cattle under study fallen to PCV % value of 24%.

4.4. Entomological Study Findings

A total of 1,022 flies (483 tsetse flies, 35*Stomoxys* and 504 non-biting flies) were caught during the study period.The species of tsetse that have identified in this study was only *Glossina pallidipes*. The apparent density of tsetse, *Stomoxys*and other non-biting were 5.37f/t/d, 0.39f/t/d and 5.60f/t/d respectively. From all the study sites, the highest (5.93 f/t/d) and lowest (4.60f/t/d) tsetse fly densities were recorded in Wara Wory and Tarcha Zuria respectively. From total tsetse fly trapped, 259 (53.62%) flies were femaleswhich occupied larger proportion and the rest 186 (38.50%) flies were males while the remained 38 (7.86%) were unknown sex (Table 7).

Table 7.The tsetse, other biting and non-biting flies caught from Dawuro zone, Ethiopia

Kebele	Trap type	Forest coverage	Flies caught in traps						
			Tsetse fly (*G.palidipes*)					*Stomoxys*	
			M	F	unidentified	Total	Density	No	Density
Tarcha	NGU	RFF,WGL	27	37	5	69	4.60	0	0
Lala	NGU	RFF,WGL	32	46	9	87	5.80	8	0.53
Wara	NGU	RFF,WGL	35	44	10	89	5.93	8	0.53
Abba	NGU	WGL,Cul.L	24	48	6	78	5.20	10	0.67
Gorika	NGU	RFF,Cul.L	34	32	8	74	4.93	9	0.6
Waruma	NGU	RFF,WGL	34	52	0	86	5.73	0	0
Total			186	259	38	483		35	
	Apparent density		2.0	2.8	0.42	5.37	5.37		0.39

RFF = Riverine Forest, WGL = Wooded Grass Land, Cul.L = Cultivated Land

4.5. Effect of theControl Interventions

The findings of current study indicated that there was an increase in prevalence of the disease after the application of the control interventions of trypanosomosis in cattle, sheep and goats. The mean prevalence of the trypanosomosis in cattle, sheep and goats before the onset of the control intervention was lower than after the application of control interventions in the areas. Furthermore, the mean apparent density of the tsetse fly before the application of the control intervention strategies was also lower than mean apparent density of tsetse after the application of control interventions. The overall results show that there is no progressive reduction in both the apparent density of the tsetse fly and prevalence of trypanosomosis as it was indicated in tabulation (Table 8).

Table 8.The prevalence of trypanosomosis in pre and post control intervention period

Animal species	Mean prevalence before control	Mean prevalence after control
Cattle	13.50%±6.54SD	23.83%±6.43SD
Sheep	0.04%±0.62SD	4.00%±7.62SD
Goats	0.03%±0.41SD	4.67%±7.47SD
Overall	4.50%±7.44SD	10.83%±11.63SD
Apparent density	0.17±0.383SD	5.50±0.51SD

The Pearson Correlation of+1 which indicates strong positive correlation of disease prevalence and apparent vector density. Bothprevalence of trypanosomosis and apparent vector density indicated strong positive correlation in one directionso that when the vector density increases, then the disease prevalence also increases and vice versa. The disease prevalence on domestic ruminants and apparent density of vectors before the application of control methods refers to the retrospective data while after control methods belong to the current study data. The descriptive prevalence and apparent density before and after application of control interventions were indicated in tabulated (Table 9).

Table 9.The descriptive data of prevalence and apparent density before and after application of control interventions

Kebele	Animals species	Disease prevalence (%)		Apparent density (f/t/d)	
		Before control	After control	Before control	After control
Tarcha Zuria	Bovine	14.50	23.4	0.843	4.60
	Ovine	0.04	19	0.047	4.60
	Caprine	0.03	0	0.00	4.60
Lala Genji	Bovine	8.926	23.5	0.743	5.80
	Ovine	0.03	0	0.044	5.80
	Caprine	0.05	11.1	0.00	5.80
Wara Wory	Bovine	16.00	33.3	0.142	5.93
	Ovine	0.020	4.8	0.00	5.93
	Caprine	0.10	16.7	0.410	5.93
WarumaGalcha	Bovine	10	29.4	0.054	5.73
	Ovine	0.03	0	0.005	5.73
	Caprine	0.030	0	0.0547	5.73
Gorika Bersa	Bovine	25	15.7	0.333	4.93
	Ovine	0.062	0	0.041	4.93
	Caprine	0.041	0	0.684	4.93
Abba Dahi	Bovine	7.140	17.6	0.397	5.20
	Ovine	0.082	0	0.00	5.20
	Caprine	0.140	0	0.410	5.20

4.6 The Questionnaire Study Findings

The perception levels of farmers in the community were evaluated well during the interviewee period. The result indicated that aboutone hundred interviewers (75.80%) were lived above fifteen yearsin the study areas which indicated that they have good information about the status of the disease and the its control intervention methods that have been so far in application in their areas.All of the interviewed farmers (132) haveanimalsand thisencourage them withthe disease frequently suffering their animals and economically important in their residency.About one hundred-one respondents (76.50%) replied that the most common disease suffering their domestic ruminants were both trypanosomosis and anthrax that were found to be super importantly affecting their animal productivity and leading to higher morbidity and unplanned costs of health care.About eighty-eight respondents(66.70%) were replied that tethering was considered to be the management tools of their hands to reduce the exposure of their animals to the vectors. In addition, eighty-nine respondents (67.40%) were answered that the sourcesof trypanosomosis for their animals were believed to be both grazing land and watering points buttwenty-two (16.70%) of the respondentsreportedthat only grazing areawas found to be the basic source for their animals while twenty-one (15.90%) of them replied that the source of disease was only watering points.

Ninety-seven respondents (73.50%) were answered that the vector transmitting trypanosomosis is tsetse fly while twenty respondents (15.20%) were reflected that the transmitter of trypanosomosis is tick. According to the respondents, the source of the tsetse, sixteen (12.10%), thirty-three (25%), forty (30.30%) and ten (7.60%) respondents reflected that areas close to river and watering points, grass lands and areas close to watering points, grass lands and forests, cultivated land and areas close to river and watering points, respectively. Following to these, twenty-seven farmers (20.50%), twenty-nine farmers (22%) and 76 farmers (57.60%) were replied that the period when tsetse were very abundant in their areas was from June to August, December to February and June to August and April to May, respectively. Hundred fifteen farmers (87.10%) responded that they knew one or more of the diseases control interventions applied in their area whereas the remained seventeen farmers (12.9%) do not know. In the other side, seventy-eight respondents (59.10%) responded that tsetse and trypanosomosis control intervention began before fifteen years and forty-two (32.8%) respondents that the intervention was began before ten years. Seventy-four respondents (56.10%) responded that the fund for any of the control interventions was obtained from government while 38 farmers (28.80%) answered that their fund source was obtained from the government and community.

Furthermore, about sixty farmers (45.50%) were reflected that the major control intervention methods applied in the study areas were impregnated targets and traps, spot-on techniques, chemoprophylaxis and treating diseased animals and about twenty-four farmers (18.20%) were replied that only chemoprophylaxis and treating diseased animals werethe major intervention strategies common till upto date in practice. The responses indicating only impregnated targets and traps constitute fourteen respondents (10.60%) and those responded treating of diseased animals also constitutes fourteen respondents (10.60%).The responses for the frequency of interventions replied that thirty (22.70%), eighteen (13.605), thirty-five (26.50%), nineteen (14.40%) and seventeen (12.90%) constitute twice per year, three times per year, two and three times per year, three and four times per year and two and four times per year respectively. For assessment of the impacts of the control interventions; Chemoprophylaxis constitutes twenty-three (17.40%), Spot-on techniques shared fifty-one (38.60%), Spot-on techniques and treating of diseased animals constitutes forty-eight (36.40%) and impregnated targets and traps, spot-on techniques, chemoprophylaxis and treating of diseased animals was ten (7.60%).

For the generalassessment of the effects of the intervention methods applied so far, sixty five respondents (49.24%) were answered that the methods applied in their areas so far greatlyimproved the disease situation whereas sixty one respondents(46.21%) replied that the methods have no clear achievements while the remained six(4.55%) reported that they do not know what has been happened to the ruminant trypanosomosis and the tsetse.

5. DISCUSSION

The current study findings indicated that theprevalence of trypanosomosis in cattle was relatively lower than previous research findings including 26.82% prevalence of bovine trypanosomosis in the Loma District of Dawuro Zone (Teklebirhan *et al*., 2016), 50% prevalence in bovine in West Gojam of Amhara Regional State (Erkihun, 2015), 25.80% prevalence of the disease in bovine in AssosaDistrict of Benishangul Gumuz Regional State, Ethiopia (Tesfaye and Ibrahim, 2017) and the prevalence of 27.50% in bovine in Arba Minch District of Southern Ethiopia (Abraham and Tesfaheywet, 2012).However,the prevalence of trypanosomosis in cattle from the current study was higher than the prevalence findings of different authors including; 17.90% in cattle in Bale Zone, Southern Ethiopia (Abera *et al*., 2014), 15.57% in East Wellega Zone, Oromiya Region (Tekle and Mekonen, 2013), 13.30% in Mandura District of Benishangul Gumuz Region (Dinede and Aki, 2017), 6.25% in Chiliga, Northwest Ethiopia (Seyoum and Abera, 2016), 5.60% in Bullen district of Metekele zone (Aki and Godeso, 2016), 21.50% in Bambasi woreda, Western Ethiopia (Yalewand Fantahun, 2017), 3.70% in Abaya District, Borena Zone, Ethiopia, (Dawit *et al*., 2016), 5% in Northern Tanzania (Swai, 2011),Study on Parasitological Survey on Bovine Trypanosomosis, 2.5% in Upper West Region of Ghana (Adam *et al*., 2012), 21.33% With the Study on Prevalence of Bovine Trypanosomosis in selected areas of Konta Special District, Southern Ethiopia(Abera *et al*., 2016) and 1.3% in Gamo Gofa Zone, South Ethiopia(Girma *et al*., 2014).

The relatively higher prevalence of trypanosomosis in cattle in this study might be related to the low frequency of intervention strategies applied for tsetse and trypanosomosis, higher level of vector-host contact, illegal and non-prescribed use of treatments in suspected animals in the study areas, lower attentions given to control the mechanical vectors of the disease, less sustainability of the control interventions in the areas, the control strategies were unable cover wider areas, the higher distribution of the vectors, the impacts of Gilgel Give III hydroelectric power dam constructionand not practicing of new methods of tsetse and trypanosomosis control interventions in the areas such as Sterile Insect Techniques (SIT), ground spray or air spray in wider areas andmight be the use of lower numbers of impregnated targets and traps that were deployed in the studied each kebele before the time to estimate the tsetse density with the ongoing parasite and vector control programmes applied by National Tsetse and Trypanosomosis Investigation and Control Center.

The present disease findings of prevalence of trypanosomosisin sheep and goats were relatively higher than the prevalence findings of 3.75% in shoats in Upper Didessa Valley (Samson and Frehiwot, 2010), 3.82%and 1.76% in sheep and goats respectively in Benishangul Gumuz Regional State (Ayana*et al.*, 2015), 3.70 and 1.96% sheep and goats respectively in Dangur District of Benishangul Gumuz Region (Lelisa*et al*., 2016),3.33% and 4.67% prevalence in sheep and goatsrespectively in Kaduna of Nigeria (Ezebuiro *et al*., 2009), 3.6 % and 3.17% prevalence in sheep and goats respectively in AssosaDistrict of Benishangul Gumuz Regional State, Western Ethiopia (Bacha *et al*., 2013). But these findings showed relatively lower prevalence of the diseasein sheep and goats than the finding of the prevalence of 9% and 7.2% respectivelyin Mareka District of Dawuro Zone, Southern Ethiopia (Bedaso *et al*., 2016**)**,51.6% and 33.3% in sheep and goats respectively in Gboko local government area of Benue state, (Onyia, 1997)and 4.7% in sheep in Oyo Sate of Nigeria (Ameen *et al*., 2008*)*.The lower prevalence of the disease in sheep and goats were might be due to the reasons that the small ruminants most of the time have lower exposure to the vectorbecause they were tied and stay aroundthe human residency areas where their habitats were destroyed by human settlementand the smokers and other conditions make the areas uncomfortable for tsetse to approach.

The *Trypanosoma* species occurrence proportion of domestic ruminants under study were56.62%, 34.39% and 8.43% found to be *T. vivax, T. congolense* and of *T. brucei*respectively.Also the prevalence of *T. vivax was highest in cattle followed by T. congolense* and *T. brucei in* cattle and sheep butthe prevalence of *T. vivax*, *T. congolense* and *T. brucei* was found the similar in goats. Based on these findings, the variation in occurrence of *Trypanosoma* species in study animals is highly statistically significant (*P-value*=0.00).Thesefindings were in agreement with the findings of Dagnachew, *et al*., (2011), the study on the prevalence and vector distribution of bovine trypanosomosis in controlled and non-controlled districts bordering upper Anger Valley of East Wellega, Western Ethiopia, determined the prevalence of 63.6% and 36% for *T. vivax and T. congolense,* respectively in cattle and (Abera and Regassa, 2015), also reported that the prevalence of *Trypanosoma* species were *T. congolense* (69.2%), *T. vivax* (15.4%) *and T. brucei* (12.8%) in cattle. In addition, Bacha *et al*., (2013), the prevalence of small ruminants' trypanosomosis in AssosaDistrict of Benishangul Gumuz Regional State, Western Ethiopiadetermined the prevalence of 40%, 26.6%, 13.3% as *T. congolense, T. vivax* and *T. brucei* respectively in sheep, 46.1%, 23% and 7.7% were *T. congolense, T. vivax* and *T. brucei* respectively in goats. All the authors concluded that the difference in prevalence among *Trypanosoma* species was highly statistically significant ($P<0.05$).

The prevalence of *Trypanosoma* infection between age categories within cattle indicated lowest prevalence (19%) in young and highest in old animals (45.2%). The higher disease prevalence was recorded in old ages category whereas the lower prevalence in young animals respectively. The findings of the prevalence of disease based on age categories indicated statistically significant variation ($P<0.05$).

The findings of this study in the age category were similar to the findings of Tekle and Mekonen (2013), who determined the prevalence of infection in adult cattle was 19.03% which is a higher in that study in old and 10.53% for young ages andTesfaye and Ibrahim (2017), the study on prevalence of the bovine trypanosomosis in AssosaDistrict of Benishangul Gumuz Regional State, Ethiopia, were demonstrated variations in prevalence among different age groups and they all based on their findings concluded that the disease prevalence variation among ages of animals was statistically significant ($P<0.05$).However, the results shown disagreement to the study findings of Ayana *et al*., (2015), the study on the prevalence of small ruminant trypanosomosis in Assosa and Homosha districts of Benishangul Gumuz Regional State, Northwest Ethiopia, Lelisa *et al.*, (2015), the study on prevalence of bovine trypanosomosis and apparent density of tsetse and other biting flies in Mandura district, Northwest Ethiopia and Aki *et al.*, (2016), the research on the epidemiology of cattle trypanosomosis and its vector density in Bulletin district. All the authors based on their findings concluded that disease prevalence variation based on animals age categories was statistically insignificant ($P>0.05$).

Therefore, thesemight be the reason that calves and young animals were less exposed to the vector since they were either tethered or kept close to the homestead where tsetse habitat has been destroyed or the tsetse flies do not want to approach the areas because of smoking and other non-comfortable situations stated similar to this study. In addition, it can also be suggested that trypanosomes challenge is higher in older animals may be due to tsetse feeding preference for old animals, they have their immunities challenged and weakened and they were usually driven for grazing and watering to the habitats of vectors.

The present study determined the highestand lowest prevalenceof trypanosomosis in poor and good conditioned animals respectively. There was statistically significant variation ($P<0.05$) in prevalence of trypanosomosis among the differentbody conditions of cattle, sheep and goats.These findings of body conditions were in agreement with Abera *et al*., (2016), the study on prevalence of bovine trypanosomosis in selected areas of Konta Special Woreda, Southern Ethiopia, Girma *et al*., (2014), the study on bovine trypanosomosis in Arba Minch woreda of

Gamo Gofa zone, Southern Ethiopia, the study on prevalence bovine trypanosomosis in AssosaDistrict of Benishangul Gumuz Regional State, Ethiopia (Tesfaye and Ibrahim, 2017), Habte*et al*., (2015), the study on spatial distribution of tsetse fly and prevalence of bovine trypanosomosis and other risk factors: Case study in Darimu district, Ilu Aba Bora Zone, Western Ethiopia, Bacha*et al*., (2013), the study on the prevalence of small ruminants' trypanosomosis in Assosadistrict of Benishangul Gumuz Regional State, Western part of Ethiopiaand Swai and Kaaya (2012), the parasitological survey for bovine trypanosomosis in livestock/wildlife ecozone of Northern Tanzania. They reached in conclusion based on their findings that poor body conditioned animals were highly affected compared to the rest body condition.It can be concluded based on these results that the disease is responsible to reduce the body conditions of animals or trypanosomosis infection occurs in animals with poor body conditions which are likely to have poor immunity against the disease.

However, these results were in disagreement with the study findings of Lelisa *et al*., (2016) identified that the prevalence of trypanosomes among animals with poor,medium and good body condition were 7.69%, 1.55% and 2.5% respectively. They concluded that the variation in prevalence among the three body condition groups was shown statistically insignificant variations (P>0.05).

The results of prevalence of trypanosomosis based on coat colors werehigher in black (37%) and lowerin white(9%) colors compared to other colored cattle. The prevalence in shoats was showed higher in black and lower in white colors. The prevalence based on coat colors of cattle, sheep and goats under study, indicated statistically significant association (P<0.05)to domestic ruminant trypanosomosis. These findings of trypanosomosis prevalence based on coat colors is in agreement with the findings of Mekonen *et al*., (2017), the study on prevalence of bovine trypanosomosis in Dembecha woreda, Amhara Region, Northwest Ethiopia and Girma *et al*., (2014), the study on prevalence of bovine trypanosomosis, its vector density and distribution in and around Arba Minch, Gamo Gofa Zone, Ethiopia,their findingsshowed statistically significant association (p<0.05) in trypanosomosisprevalence. These authors concluded that the prevalence of trypanosomosis was significantly different among animals with different coat color, where the prevalence is higher in animals with black coat color. These findings based on animals coat colors might be suggested to the observation that Glossina species prefers black surfaces as its strongest landing response.

The results of current study were in disagreement with the findings of Teka *et al*., (2012), the study on the Prevalence of bovine trypanosomosis and tsetse density in selected villages of Arba Minch, Ethiopia. This study undergone comparison between the different skin colors of cattle and the disease occurrence indicated that slightly higher prevalence was observed in cattle's having mixed skin color (7.25%) followed by 4.88% in red, 3.57% in black, 1.56% in white and 0% in gray skin color. Their study indicated that the coat colors of animals have no statistically significant association (P>0.05).

The prevalence in cattle was higher in Riverine forest (30%) andslightlylower in Wooded grass land(12%). The prevalence was similar inRiverine forest (4%) and wooded grass land (4%) in sheep and the prevalence in goats was relatively higher in Riverine forest (13%) and lower in wooded grass land (3%). These results indicated that the forest coverage'sin the areas were shown statistically significant variation in disease prevalence (P<0.05).These findings are in agreement with the findings of Pagabeleguem*et al*., (2012), studied onClimate, Cattle Rearing Systems and African Animal Trypanosomosis risk in Burkina Faso and Majekodunmi *et al*., (2013), theLongitudinal Survey of African Animal Trypanosomosis in Domestic Cattle on the Jos Plateau, Nigeria. Theysuggested that parasitological and serological prevalence was different between sitesand forest coverage's of the area. The authors concluded that the trypanosomosis prevalence between different forest coverage`s shown statistically significant variation P<0.05).

The findings of this study indicated that the mean PCV% value for the parasitaemic andaparasitaemic cattle, sheep and goats under study were determined.In all animals, the mean PCV% values for aparasitaemic animals were found higher than the parasitaemic animals and the prevalence of trypanosomosis was higher in parasitaemic animals. The differences in findings of the mean PCV % for parasitaemic and aparasitaemic conditions in relation to disease prevalence in all animal species were found to be statistically significant in variation (P<0.05).These findings are in line withthe Study on Prevalence of Bovine Trypanosomosis in Selected Areas of Konta Special Woreda, Southern Ethiopia(Abera *et al*., 2016), Habte *et al*., (2015), the Study Spatial Distribution of Tsetse Fly and Prevalence ofBovine Trypanosomosis and Other Risk Factors: Case Study in Darimu District, Ilu Aba Bora zone, Western Ethiopia,Bacha *et al*., (2013), the Study on the Prevalence of Small Ruminants Trypanosomosis in AssosaDistrict of Benishangul Gumuz Regional State, Western part of Ethiopia and Aki *et al*. (2016), the Study Focused on the Epidemiology of Cattle Trypanosomosis and its Vector Density in Bullen District, indicated that the mean PCV of parasitaemic and aparasitaemic animals during the study period was 16.82% and 27.13% with a statistically significant difference ($P < 0.05$).

The study of entomological surveywas showedonly *Glossina pallidipes* and *Stomoxys*in Tochaand Tarcha areas of Dawuro zone. The apparent density of tsetse was 4.60 f/t/d in Tarcha and the apparent density of tsetse and *Stomoxys* were 5.52 f/t/d and 0.39f/t/d respectively in Tocha district. The overall apparent density of tsetse and *Stomoxys* were relatively high in the study areas. The apparent density findings of tsetse was higher than the study findings of Girma *et al*., (2014),theydetermined 3.88f/t/d of tsetse but the apparent density of *Stomoxys*is lower than their findings of 1.38 f/t/d *Stomoxys*in and Around Arba Minch, Gamo Gofa zone, South Ethiopia. But the overall apparent density of tsetse and *Stomoxys* were lower than the findings of Habte *et al*., (2015), the study spatial distribution of tsetse fly and prevalence of bovine trypanosomosis and other risk factors in Darimu District, Ilu Aba Bora Zone, Western Ethiopia, they determined overall apparent density of 6.87f/t/d and 1.05f/t/d for tsetse fly and *Stomoxys* respectively. Out of total tsetse fly harvested, females occupied larger proportion that creates suitable conditions for population density of tsetse species. These higher vector densities were directly related to the disease prevalence of domestic ruminants` trypanosomosis. The higher vector density might be due to the lower frequency, less sustainability and inability of the tsetse control interventions to cover wider areas in the study areas.

The results ofassessment of the effects of control intervention methods applied in the study areas for the control of tsetse and trypanosomosis were evaluated based on the data concerning the prevalence of the disease in each animal species and the apparent density of tsetse referring past timeand cross-sectional. The analysis results of the findings of the mean prevalence of the trypanosomosis in cattle beforethe application of controlintervention methods was lower than after the control application. In addition to this, the mean disease prevalence in sheep and goats before control intervention strategies was lower than after the control intervention methods in the study areas. Also the overall mean prevalence of the disease in domestic ruminant before the implementation of the intervention methods was lower than after the application of control interventions. The overall apparent density of tsetse fly after application of the control interventions was higher than before the application.

The findings of assessment of the effects of control methods were agreed and have faced the same challenges to Meyer *et al*., (2016), Conducted a Systematic Review on trypanosomosis control operations (some results of impact assessment) in fiveAfrican countries (Ethiopia, Burkina Faso, Zambia, Cameroon and Uganda) stated that there was a lack of evaluation of the impacts of control programmes, as well as a lack of a standardized methodology to conduct such evaluations. For more comparison of the current study findings on evaluation of the impacts of intervention strategies applied in the study areas to control tsetse and trypanosomosis, the study has faced the shortage of standard methods and evaluations that have been done before to compare and conclude whether the intervention methods were effectual or not based on the disease status and tsetse populations.

These results were in disagreement with the findings of Bekele *et al*., (2010), on the evaluation of the impacts of Deltamethrin applications in the control of tsetse and trypanosomosis in the Southern Rift Valley areas of Ethiopia. They have found that in the period of pre-intervention of Deltamethrin and chemical impregnated targets, they have higher prevalence (10.75%)of disease and apparent vector density of 1.35f/t/d which has been lowered (disease prevalence of 1.8% and apparent fly density of 0.05f/t/d) in post-intervention period. They concluded that a relatively better efficacy was attained by using Deltamethrin pour-on formulation than targets in controlling tsetse and trypanosomosis. However, they based on their study findings conclude that the difference in prevalence and apparent density after application of Deltamethrin, chemical impregnated traps and targets was found statistically not significant (P>0.05). They finally concluded their work based only on the variation in disease prevalence and apparent density of tsetse and closed that the findings were better in using Deltamethrin pour-on but without the using any standard methods to judge the final results of the study. These findings are not in line with the other study based on their findings showed that in the insecticide-impregnated targets applied area; the results of control methods showed that apparent density of tsetse flies declined from 10.73f/t/d to 0.43f/t/d. At the end of the campaign, an 83% reduction of apparent density of tsetse was observed for Glossina palpalis gambienseand a 92% reduction for G. tachinoides. Based on findings, they concluded and suggested that tsetse flies could be suppressed efficiently but their elimination from the target deployment areas may require theuse integrated methods including the Sterile Insect Technique. The challenge will remain the sustainability of the achievement (Percoma *et al*., (2018).

Thefindings of the impacts might have indicatedthatthe low frequency of control intervention strategies applied for tsetse and trypanosomosis per year, higher level of vector-host contact, illegal use of treatment in suspected animals by owners, the dose of treatment chemicals for suspected animals and spot-on chemicals would be inappropriate, lower attentions given to control the mechanical vectors of the disease, less sustainability of the control interventions, the control strategies were unable cover wider areas, the higher distribution of the vectors, the impacts of Gilgel Give III hydroelectric power dam construction and not practicing of new methods of tsetse and trypanosomosis control interventions in the areassuch as Sterile Insect Techniques (SIT), ground spray or air spray in wider areas andmight be the use of lower numbers of impregnated targets and traps that were deployed in the studied each kebele before the time to estimate the tsetse density with the ongoing parasite and vector control programmes applied by National Tsetse and Trypanosomosis Investigation and Control Center.

The higher proportions of the respondents (76.50%)replied that the most common disease suffering the domestic ruminants were both trypanosomosis and anthrax that were found to be super importantly affecting their animal productivity and leading to higher morbidity and unplanned costs of health care. These farmers` response in relation to the ruminant trypanosomosis were in line with Seyoum *et al*., (2013), the study on farmers' perception of impacts of bovine trypanosomosis and tsetse fly in selected districts in Baro-Akobo and Gojeb river basins, Southwestern Ethiopia, based on their results revealed that 94.1% of the respondents considered bovine trypanosomosis as aneconomically important cattle disease which accounted for 64.6% of the total annual deaths.

Most of the respondents (66.70%)) answered that tethering was considered to be the management tools of their hands to reduce the exposure of their animals to the vectors.Even though higher proportions of the interviewers responded that tethering is the best alternative for reduction of exposure to the vectors, when considered practically they were poor.In addition, more than half (67.40%) were answered that the sources of areas for trypanosomosis to their animals were both grazing land and watering points. The majority of farmers in the community reflected that they have been in practice and recently in use ofsmoking to prevent tsetse from blood meal in resting time. Following, 57.60% of the respondents were replied the period on which tsetse heavily suffering their animals was from June to August, December to February and June to August and April to May respectively. These responses were in agreement with Kamuanga*et al*., (2001) based on farmers responses the authors explained and conclude that the seasonality of the disease and its vectors in which the disease and vectors were in their peak risk months from May and June.

Furthermore, about 45.50% were reflected that the major intervention methods familiar to the study areas were impregnated targets and traps, spot-on techniques, chemoprophylaxis and treating diseased animals and about 18.20% were replied that only chemoprophylaxis and treating diseased animals are major intervention strategies common till upto date in practice. These findings were in agreement to Seyoum *et al.*, (2013), they concluded based on their findings that chemotherapy is the major method for combating the problem, mean frequency of treatment being 5.7 times per animal per year but the frequency of treatment of chemoprophylaxis was reported to be lower in this study.

The results of the response to the frequency of interventions in practice were, twice per year (22.70%), three times per year (13.60%), twoand three times per year (26.50%), three and four times per year (14.40%) and two and four times per year (12.90%). For the evaluations of the impacts of the control intervention methods, sixty five respondents (49.24%) were answered that the methods applied in their areas so far greatly improved the disease prevalence and vector density while sixty one respondents (46.21%) replied that the methods applied in their area have no clear achievements. The study findings of questionnaire survey shown that livestock keepers were familiar with ruminant trypanosomosis, its vectors as well as its impacts and the major control interventions applied in areas and in generally, most of the results of questionnaire study were supported the objectives of evaluations of the impacts of control interventions applied so far for control of livestock trypanosomosis in the studied areas. The results of the questionnaire surveys were in line with Kamuanga*et al*., (2001) andSeyoum *et al.*, (2013), they all based on the farmers' perception of impacts of bovine trypanosomosis and tsetse fly in selected districtsin Ethiopia and Burkina Faso respectively indicated and concluded that the perceptions of farmers in the communities were developed to higher levels and there is a need to work together with famers to reduce the disease prevalence.

6. CONCLUSIONAND RECOMMENDATION

The present study showed the prevalence of 23.8%, 4% and 5.8% for cattle, sheep and goats respectively with overall prevalence of trypanosomosis was estimated to be 15.6% (83/531x100) with the 95%CI. As the findings indicated that the potential risk factors facilitating the occurrence of trypanosomosis in domestic ruminants include age, body conditions, coat color and forest coverage which indicated significant associations. The apparent density of tsetse and *Stomoxys* was found to be slightly high and hasshowed positive correlation to the higher disease prevalence.There were some continuous tsetse and trypanosomosis control interventions that have been in practice for long times in Dawuro zone. However, the current study indicated that the trypanosomosis prevalence and its vector density are increasing. The questionnaire survey findings shown that livestock keepers were familiar with ruminant trypanosomosis, its vectors as well as the effect of the major control interventions applied in areas.Based on this conclusion, the following recommendations are forwarded;

- Based on the results, the prevalence of the trypanosomosis is increasing. Therefore, appropriate control measure like STI, air sprays and ground sprays that will be found better in efficacy will be needed to take in place.
- The control interventions of trypanosomosis that will be applied in the area would have to consider the potential risk factors of the disease before application like continuous treatment of diseased old, black colored and emaciated animals.
- Standards should be set by responsible professionals and a comprehensive national wise evaluation of the impacts of so far applied trypanosomosis control interventions is strongly needed.
- The perceptions of farmers in the communities were developed to best levels and there is a need of integrated approach with famers for the application of trypanosomosis control interventions in the areas.

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8. APPENDICES

AnnexI: Questionnaires filled by farmer communities in the study area

Trypanosomosis is the common economic problem and its vector, tsetse fly has high population in Tocha and Tarcha areas of Dawuro zone. Having the disease in the study area, the disease current information is highly necessary for implementation of control intervention strategies. This questionnaire was prepared to understand the community's perception level in study areas of Dawuro zone on the general situations and the effects of some of the intervention strategies of tsetse and trypanosomosis performed by national and regional governments of Ethiopia. Therefore, your genuine participation in providing information concerning the disease and the intervention scheme is key element in future planning and design of new control activities in the area.

I. Demographic information

1. Region_________ Zone ________Woreda _________Peasant Association__________

Village__________ Work _____________Sex______ Age________ Date____________

2. The educational status of the farmer is

A/ Uneducated B/Elementary C/ Certificate D/ College E/ First Degree F/ others (specify)

3. The family members managed by householder man/woman is/are; Males______ Female________ Sum________

II. The general information required

1. For how long have you been here?

A/ 1-2 years B. 2-4 years C/ 5-6 years D/ 7-10 years E/ Above 10 years

2. Do you keep domestic livestock? A. yes B. No

3. If your answer for question No.2 is yes, which species of animals?

A. Sheep B. Cattle C. Goats D. Equines E. Chicken

5. If you keep cattle in your herd, which cattle disease is most common in your locality?

A. Black leg B. Anthrax C. Trypanosomosis D. FMD E. Parasites

6. What management system do you use for your cattle?

A. Communal free grazing C. Tethering

B. Private free grazing D. Stall feeding E. Zero grazing

7. If your answer for question No. 4 is Trypanosomosis, where does you thick will be the source of exposure to your cattle?

A. Grazing land B. Watering point C. Stall D. Both A and B E. A, Band C

8. How important trypanosomosis is in your area compared to other diseases listed in question Number 4?

A. Super important B. Very important C. Important D. Less important E. Equally important

9. What is the transmitter (vector) of this disease do you think?

A. Tick B. Tsetse flies C. Spider D. I don't know E. Others (Specify) ______

10. If your answer for question No. 7 is "**B**", where are fly population very common in the area?

A. In grass land areas C. In areas close to river and watering points

B. In cultivated land D. In bush land E. In forests

11. In which season do you think your cattle will expose most for tsetse and trypanosomosis?

A. June-August B. September-November C. December-February D. April-May

12. Do you know any tsetse and trypanosomosis intervention scheme in your locality?
A. Yes B. No

13. If your answer for question No. 10 is yes, who is the source of the fund do you think?

A. Government B. Community C. NGO D. Not known

14. Do you recall when was this intervention begun in this area?

A. 1year ago B. 5 years C. 10 years ago D. 15 years ago

15. What were the major intervention schemes of tsetse and trypanosomosis in the area at that time? A. Impregnated targets and traps B. ChemoprophylaxisC. Spot-on or pour on techniqueD. Ground spray E. Air spray F. Treating of diseased animalsG. Bush clearing H. Use of resistance breedI. Sequential aerial J. Sterile Insect Technique (SIT)

K. Others (specify) ____________

16. Which intervention scheme is currently used in your locality from the listed interventions above in question No. 13?

16. What is the frequency of the intervention scheme used in the area?

A. Once per year C. Three times per year

B. Twice per year D. Four times per year E. Others (Specify?)___________

17. Among the intervention done in your area, which one do you think is most effective? (Express your opinion) ____

18. How do you evaluate the effect of the intervention in improving the situation?

A. Greatly improved the situation C. No clear achievement

B. Worsen it D. I can't say something on it E. I do not know it

Thank you for your time and energy!!

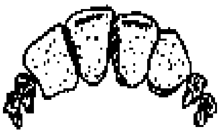
Annex II: Guideline for determining the age of cattle by the teeth

At birth to one month:

Two or more of the temporary incisor teeth present. Within first month, entire 8 temporary incisors appear

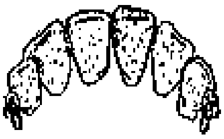
At 2 years:

As a long-yearling, the central pair of temporary incisor teeth or pinchers is replaced by the permanent pinchers. At 2years, the central permanent incisors attain full development



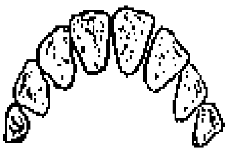
2-1/2years:

Permanent first intermediates, one on each side of the pinchers, are cut. Usually these are fully developed at 3 years.



3-1/2 years:

The second intermediates or laterals are cut. They are on a level with the first intermediates and begin to wear at 4 years.



4-1/2years:

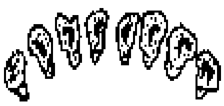
The corner teeth are replaced.

At 5 years:

The animal usually has the full complement of incisors with the corners fully developed 5 to 6 years: The permanent pinchers are leveled, both pairs of intermediates are partially leveled, and the corner incisors show wear.

7 - 10 years:

At 7 or 8 years the pinchers show noticeable wear; at 8 or 9 years the middle pairs show noticeable wear.



12 years:

The teeth gradually become triangular in shape, distinctly separated, and show progressive wearing to stubs (Pace and Wakeman,2003).

Annex III: Body Condition Scoring

In the Following, **BCS 1** cow is extremely thin and emaciated and the **BCS9** cow is very fat and obese. According to the Rasby *et al.,* (2014), the body conditions of the study animas will be classified in to poor, medium and good based up on body condition scoring method.

Body condition score **1**: Thin

Bone structure of shoulder, ribs, back, hooks, and pins are sharp to touch and easily visible. No evidence of fat deposits or muscling.

Body condition score **2**: Thin

No evidence of fat deposition and there is muscle loss especially in the hindquarters. The spinous processes feel sharp to the touch and are easily seen with space between them.

Body condition score **3**: Thin

Very little fat cover over the loin, back, and fore-ribs. The backbone is still highly visible. Processes of the spine can be identified individually by touch and may still be visible. Spaces between the processes are less pronounced. Muscle loss in hind quarter.

Body condition score **4**: Borderline

Fore-ribs are slightly noticeable and the 12^{th} and 13^{th} ribs are still very noticeable to the eye. The transverse spinous processes can be identified only by palpation (with slight pressure) and feel rounded rather than sharp. Slight muscle loss in hind quarter.

Body condition score **5**: Moderate

The 12^{th} and 13^{th} ribs are not visible to the eye unless the animal has been shrunk. The transverse spinous processes can only be felt with firm pressure and feel rounded but are not noticeable to the eye. Spaces between the processes are not visible and are only distinguishable with firm pressure. Areas on each side of the tail-head are starting to fill.

Body condition score **6**: Moderate

Ribs are fully covered and are not noticeable to the eye. Hindquarters are plump and full. Noticeable springiness over the fore-ribs and on each side of the tail-head. Firm pressure is now required to feel the transverse processes. Brisket has some fat.

Body condition score **7**: Fleshy

Ends of the spinous processes can only be felt with very firm pressure. Spaces between processes can barely be distinguished. Abundant fat cover on either side of the tail-head with evident patchiness.Fat in the brisket.

Body condition score **8**: Fleshy

Animal takes on a smooth, blocky appearance. Bone structure disappears from sight. Fat cover is thick and spongy and patchiness is likely. Brisket is full.

Body condition score **9**: Fleshy

Bone structure is not seen or easily felt. The tail-head is buried in fat. The animal's mobility may actually be impaired by excessive fat. Square appearance.Body condition of animal will have classified in to three as, poor, medium and good;

Body Condition Scores 1 to 4 are classified as ``Poor``
Body Condition Scores 5 and 6are classified as ``Medium`` and
Body Condition Scores 7 to 9 are classified as ``Good``

Annex IV: The data collection formats for hematology and entomology laboratory in study

1. Data collection formats for Laboratory data in the ______District ______Kebele

S.No	Owner`s name	Kebele	Animal species	Sex	Age	Body condition	Herd/ Flock size	Vegetation	Test result	Tryps species	PCV %	Data date	Remark
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													

2. Data collection formats for tsetse and other flies in the ___District ___Kebele in Study

S.No	Kebele	Trap Types	Latitude	Longitude	Altitude	Veg. Type	Start Date	Start time	End Date	End Time	Tsetse species				Other flies	
											M	F	unsex	Total	Biting	Others
1																
2																
3																
4																
5																
6																

Annex V: The Parasitological Laboratory Activities Conducted in this study

1. The Packed Cell Volume (PCV %) Determination Procedures

- The animals were restrained and 7-10 ml of the blood samples were collected aseptically by puncturing the marginal ear veins of each animal species
- This was performed by using sterile blood lancet and heparinized capillary tubes
- The capillary tubes were filled to 3/4th of their height and sealed with soap
- Then the pair of capillary tubes were placed in centrifuge machine(12pairs)
- Then the tubes were centrifuged at 12,000 revolutions per minute for 5 minutes
- The centrifuged capillary tubes with blood were then measured by haematocrit reader and the reading was recorded in percentage
- Then the packed cell volume (PCV) value of each domestic ruminant's was recorded in data sheets
- Then the cattle with PCV<24% were considered as anaemic and those with PCV≥24% were taken as non-anaemic (OIE, 2009)
- The sheep and goats with PCV≥24% were judged as non-anaemic and those with PCV<24% were categorized as anaemic (Kemal, 2014)

Normal value

- Bovine 24 - 55 % (45%)
- Ovine 24 - 50 % (38%)
- Caprine 24 - 50 % (40%)

2.Buffy Coat Technique

- The capillary tube with blood was cut 1 mm below the Buffy Coat using diamond pencil
- The content of the capillary tube was expressed onto a clean microscope slide and covered with a 22x22 mm cover slip
- Then the slide was examined for *Trypanosoma* parasite based on the type of movement in the microscopic field
- With 40X objective and 10xlens magnification according to the OIE manual (OIE, 2009).

Annex VI:The Prevalence of Shoats' Trypanosomosis with Risk Factors(Prevalence 95%CI)

Species	Factors	Category	No of examined	Positive	Prevalence (%)	95%CI	*P-value*
Ovine	Sexes	Male	58	1	1.72	0-9	
		Female	68	4	5.8	2-14	
		Total	126	5	4	6-7.4	0.13
	Age	>6month≤3years	41	1	2.4	2.3-7.2	
		>3years≤6years	85	4	4.7	0.2-9.5	0.03
	Coat color	Red	41	2	4.9	1.7-11.5	0.05
		White	52	0	0	0	0.01
		Black	33	3	9.1	0.7-18.9	0.005
	Flock size	1-8	118	4	3.4	0.1-6.7	0.308
		9-20	8	1	12.5	10-35.4	0.050
	BCS	Poor	44	4	9	4-21	0.02
		Medium	60	1	2	0-9	0.005
		Good	22	0	0	0-15	0.05
	Forest coverage	Riverine forest	56	2	4	1-12	0.11
		Wooded grassland	42	2	5	1-16	0.04
		Cultivated land	27	1	4	1-18	0.8
Caprine	Sexes	Male	40	3	7.5	0.7-15.7	*
		Female	63	3	4.8	0.5-10	*
		Total	103	6	5.8	1.3-10.3	*
	Age	≥6month≤3years	26	1	3.8	3.5-11.2	*
		>3years≤6years	77	5	6.5	1-12	*
	Coat color	Red	40	2	5	1.8-11.8	*
		White	29	1	3.4	3.2-10.1	*
		Black	34	3	8.8	0.7-18.4	*
		Gray	12	0	0	0	*
	Flock size	1-8	80	6	7.5	3-12	*
		9-20	23	0	0	0-6.6	*
	BCS	Poor	35	3	9	3-22	*
		Medium	48	3	6	2-17	*
		Good	20	0	0	0-16	*
	Forest coverage	Riverine forest	46	2	13	6-26	*
		Wooded grassland	31	1	3	1-16	*
		Cultivated land	26	3	12	4-29	*

* = All the Odds Ratio and P-values of sheep are taken the reference for goats

Annex VII: The Prevalence of Trypanosomosis with Risk Factors on Cattle (95%CI for Prevalence)

Species	Factors	Category	No of examined	Positive	Prevalence (%)	95%CI	*P-value*
Bovine	Sexes	Male	121	21	17	11-24	
		Female	181	51	28	22-35	
		Total	302	72	23.8	19-28.6	0.36
	Age	≥1year≤4years	111	21	19	11.6-26.2	0.02
		>4years≤7years	160	37	23.1	16.6-29.7	0.94
		>7years≤10years	31	14	45.2	27.6-62.7	0.01
	Coat color	Red	116	17	15	9-22	0.02
		White	33	3	9	3-24	0.76
		Black	89	33	37	28-47	0.009
		Gray	64	19	30	20-42	0.06
	Herd size	1-10	209	55	26	20-32	0.13
		11-20	70	16	23	13-33	0.21
		21-40	23	1	4	3.89-13	0.09
	BCS	Poor	146	45	31	24-39	0.014
		Medium	77	13	17	10-27	0.008
		Good	80	14	18	11-27	0.05
	Forest	Riverine forest	137	41	30	23-38	0.014
		Wooded grassland	91	11	12	7-20	0.004
		Cultivated land	74	20	27	18-38	0.2