

Prevalence of Bovine Trypanosomiasis in Selected Border Areas of Boloso Bombe and Boloso Sore Districts, Southern Ethiopia

Enkeshe Loha Yada¹, Gizaw Mekonnen Meku²

¹Department of Veterinary Public Health, Wolaita Zone Live Stock and Fishery Department, Wolaita Sodo, Ethiopia

²Department of Veterinary Obstetrics and Gynaecology, Wolaita Sodo University, Wolaita Sodo, Ethiopia

Email address:

tsebaot20009@gmail.com (E. L. Yada), doctorgizaw@gmail.com (G. M. Meku)

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Abstract: Across-sectional study on bovine trypanosomiasis was conducted to determine the prevalence, to identify species of trypanosomes involved and to assess associated risk factors in Boloso sore and Boloso Bombe districts, Wolaita zone, south Ethiopia. In the current study, overall prevalence of 7.2% Bovine trypanosomiasis was recorded. Prevalence of 5.1% and 5.4%, and 6.7% and 10% was recorded in altitude of Midland (Matala Hemebecho and Tiyo Hemebecho, 1595m mater) and lowland (Ajora and Bombe PA, 1206m mater) respectively. Relatively, a higher level of trypanosome prevalence (7.6%) was observed in male cattle than in female (6.6%) cattle. Prevalence of 8.8% and 5% were recorded in cattle of one to three and greater than three years age of cattle. Based on coat color, the finding of 10.5%, 7.5%, and 4.6% were recorded in red, black and mixed color respectively. Trypanosomes were not detected in cattle less than one year of age. Two species of trypanosomes; Trypanosome congolense, and Trypanosome vivax were detected with a prevalence of 7.2% and 27.8% respectively. On the basis of hematological finding, for PCV < 24 and PCV > 24 were 9.2% and 6.1% respectively. In conclusion, the study indicated that trypanosomiasis was the major constraint of livestock production in the study area; therefore, concerned bodies should strengthen and continue their effort against this vector-borne parasitic disease.

Keywords: Bovine Trypanosomosis, Prevalence, Trypanosome Congolense and Trypanosome Vivax

1. Introduction

Trypanosomosis is the main hemoparasitic disease in domestic animals and is caused by the protozoan parasite called Trypanosoma. It is one of the major constraints on animal production in African which have the greatest potential for significant increase in domestic livestock production. The parasite is transmitted biologically by the tsetse-fly (*Glossina*) species and infects animal over an area known as the 'tsetse belt'; which extends approximately 10 million km² across 37 countries in Africa, from the Sahara Desert in the North to South Africa in the south [24]. In Africa, the overall loss /both direct & indirect/ is estimated to be about 500 billion dollars a year in terms of mortality, abortion, reduced fertility, milk and meat production, and ability to work as traction animals [11]. In addition to these,

the disease is also responsible for an annual loss of millions of dollars in livestock production as a result of the cost related to treatment, prevention & Vector control efforts [3].

The disease is more prevalent in the southern, western & Northwestern parts of the country where the primary vectors exist along the great river basin of Abay, omo, Ghibe and Baro. The fly has infested an estimated 130,000 - 200,000 square kilometer of fertile land in the country. But some reporters showed the disease to be important in non-tsetse infested high land part of the country [19]. In general, the country losses 20,000 head of cattle in every year by death that declines the number of cattle particularly, drought oxen [4]. In Ethiopia 14 million heads of Bovina are at risk of contracting trypanosomiasis at any time [43]. Among these clinical manifestation anemia & emaciation occurred when becomes chronic [66]. Concentration technique by

using microhematocrit centrifuge at 1200 revolution by the end of 5 minutes and identification of motile trypanosomiasis in the buffy coat zone of microhematocrit capillary tube using dark field illumination is most accurate of all diagnostic methods [47].

In general, diagnosis is solely attained by parasitological methods like dark ground phase contrast. Buffy coat technique which can be used under field condition to detect the presence or absence of trypanosomiasis is one of common & economically [47].

1.1. Statement of the Problem

The problem was seen in both boloso Bombe and Boloso sore area of bordering erring the Omo river basin where both cyclically & mechanically transmitted trypanosomiasis where reported. The study area districts, where there was a serious complaint of the disease in some of kola kebles which have direct and indirect borders Omo river basin such as Bombe peasant association (Sangana), Ajora, Matala Hembecho, Tiyo Hembecho, Achura. Though Ethiopia is 10th in the world ranking of total livestock population & 1st in the case of Africa, the productivity of livestock is low in the world as well as in Africa or in the country as compared with this population. Despite the large size of livestock population, health care system, nutritional status, reproduction or genetic and management system are very poor. As a result cattle, sheep, Goat and equines mortality rates are very high and productivity is decreased when compared to the developed countries. Due to these overall problems, Ethiopia leveled s one of the last developing nation in sub-Saharan Africa [27].

The economic base of farmers in both Boloso Bombe and Boloso sore woreda is agriculture. It employs about 93% of the total population and agriculture is mainly mixed. Livestock production at the area is cattle sheep and Goat & crops are produced in agriculture. As a result of the backward farming practice of agriculture's its productivity is low. Agricultural productivity has been usually low and food insecurity is a frequent problem of the woreda [117]. Even though the Trypanosomiasis was distributed in different wored's of the zone due to manly time and financial constraints, the scope of this research will concentrate on the prevalence assessment of Bovine Trypanosomiasis in both Boloso Bombe and Boloso sore woreda selected kebeles.

1.2. Objectives of the Study

Therefore, general objective of this study was to determine the prevalence of bovine Trypanosomiasis in area between border of Boloso Bombe and Boloso sore districts.

Specific objective:

1. Estimating and comparing the prevalence of bovine Trypanosomiasis in Boloso Bombe and Boloso sore woreda selected kebeles.
2. Identifying the species of Trypanosomes in the study area and assessing of risk factor of the disease.

2. Literature Review

2.1. Epidemiology and Risk Factors of Bovine Trypanosomosis

2.1.1. Etiology (Trypanosomes)

Trypanosomosis epidemiology depends on the interaction between the ecological actors i.e. parasite, vector and host factors. The disease severity depends on the species of the trypanosomes that has infected the animal. The bovine trypanosome species like the *T. congolense*, *T. vivax* and *T. brucei* are normally associated with the humid and sub humid areas of Africa (15°N and 25°S), that is inhabited by their intermediate host the *Glossina*. Tsetse transmitted trypanosomosis mostly depends on the distribution and the capacity of the vector *Glossina* species for transmission. The savannah and riverine are the most ones that inhabit the grazing and watering areas [73]. The different trypanosome species differ in morphological characteristics as described by [95].

Trypanosomosis (It is also known “Nagana”) is a disease complex caused by several species of unicellular protozoan parasites of the phylum Sarcomastigophora, order Kinetoplastida, family Trypanosomatidae and genus Trypanosoma. It is mainly transmitted cyclically by the genus *Glossina* (Tsetse flies), but also transmitted mechanically by several biting flies (*Tabanids*, *stomoxys*, etc.) The disease can affect various species of mammals but from an economic point of view, tsetse-transmitted trypanosomosis is particularly important in cattle [25]. Three species of trypanosomes are recorded in Ethiopia; these are *T. congolense*, *T. vivax* and *T. brucei*. *T. vivax* and *T. congolense* are the main pathogens of cattle. Trypanosomosis outside “tsetse belt” is caused by mechanically biting flies; the main etiological agent of mechanically transmitted trypanosomosis is *T. vivax* [15].

Morphology Trypanosomes are flagellated protozoan parasites that live in the blood and other body fluids of vertebrate hosts. They swim in body fluids by flagellum, boring their way between cells. They generally possess a kinetoplast [50]. The kinetoplast is typically positioned behind the nucleus, at the posterior part of the cell. A second form is the epimastigote, which has the kinetoplast located more in the centre, and before the nucleus. The length and position of the trypanosome's flagellum is variable. In trypanosomes from the blood of a host, the flagellum originates near the posterior end of the cell and passes forward over the cell surface to extend freely at the anterior end. Where the flagellum is adherent to the cell surface, its sheath is expanded and forms a wavy flange, called the undulating membrane [38, 58].

Trypanosoma congolense (Figure 1) is smaller in size, usually without free-flagellum, but has marginally located medium sized kinetoplast [73]. It is divided into four subtypes, with different distributions and pathogenicity: savannah type, forest type, Tsavo type, and Kilifi type [96]. *Trypanosoma congolense* savannah type is the most pathogenic of the four and is capable of causing severe anaemia and even death of infected cattle [97]. Other *T. congolense* types cause mild disease that in certain instances does self-cure.

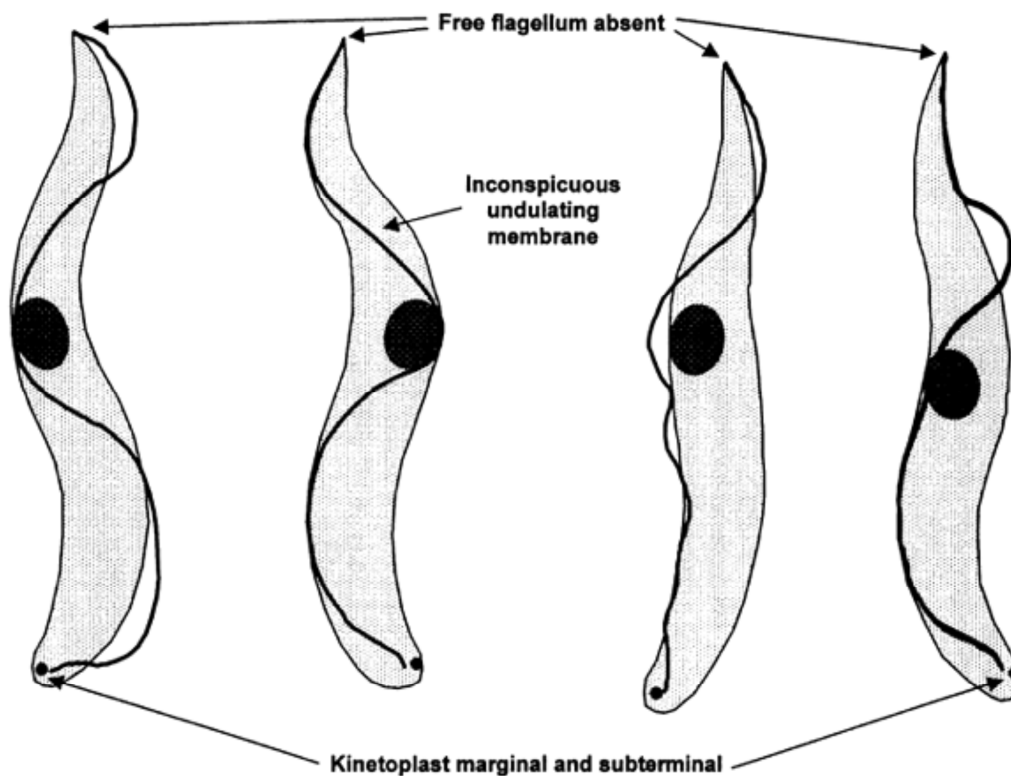


Figure 1. *Trypanosoma congolense* blood stream forms (Source:[1]).

Trypanosoma vivax is a monomorphic parasite with distinct free flagellum and larger and terminal kinetoplast (Figure 2). It shows variable levels of virulence and distinct pathogenicity in West African isolates, causing an acute disease in cattle often accompanied by weight loss, reduced milk yield, abortions and mortality, whereas the East African isolates largely cause

chronic infection [98]. In East Africa, there are two types of *T. vivax* isolates: the haemorrhagic *T. vivax* that causes an acute haemorrhagic syndrome and the mild strain [50]. Cattle infected with the haemorrhagic *T. vivax* produce auto-antibodies to red blood cells, a phenomenon that is not observed in the non-haemorrhagic *T. vivax* [13].

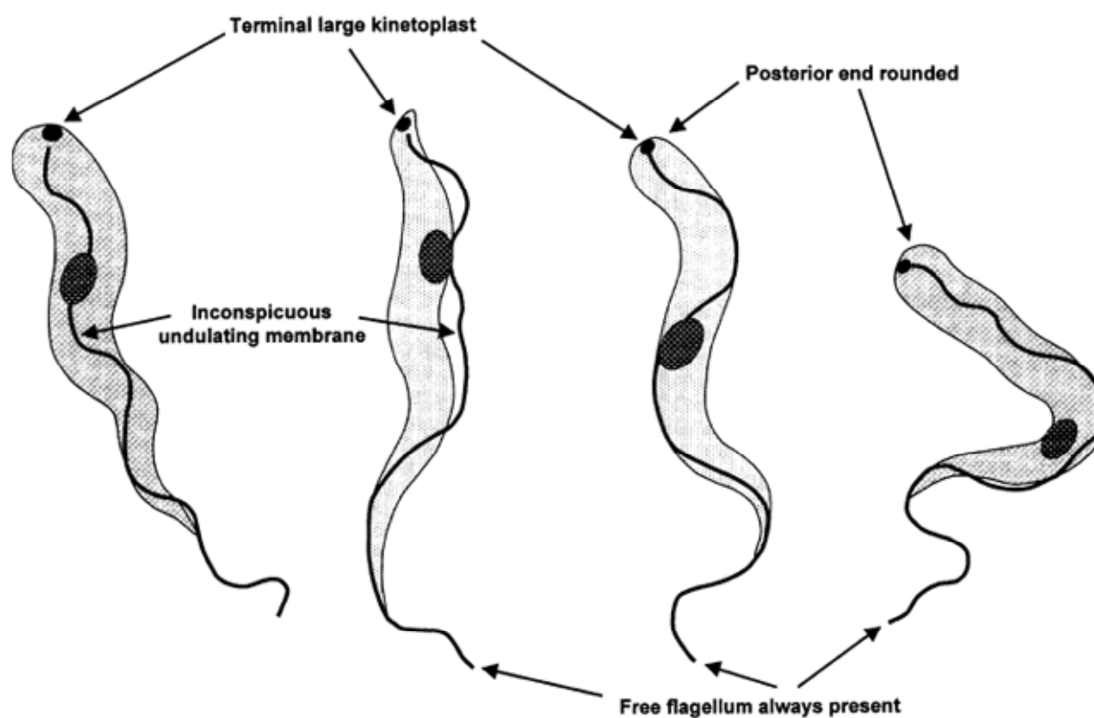


Figure 2. *Trypanosoma vivax* blood stream forms (Source: Uilenberg, 1998).

2.1.2. Vector of African Animal Trypanosomosis

The vector for trypanosomosis, the tsetse fly (*Glossina* spp), requires a habitat that strongly influenced by ecological and climatic features particularly rainfall, soil type, temperature and vegetation type. Fly larvae can die as a result of drying soils. Tsetse flies, the vectors for AAT, belong to the family *Glossinidae*, order *Diptera* – the two-winged flies. There are 31 recognized *Glossina* species and sub-species, divided into three groups (*morsitans*, *palpalis* and *fusca*) which have been given sub-generic status [99]. Recently, comparative gene sequence analysis and geometric wing morphometry have been proposed to help in the *Glossina* group identification [100]. The *morsitans* group that includes *G. morsitans morsitans*, *G. m. submorsitans*, *G. pallidipes*, *G. longipalis* and *G. austeni* is found mainly in the savannah ecosystems. They are the most important vectors of bovine trypanosomosis [45]. The *palpalis* fly species are less mobile than the *morsitans* group, often relying on sight rather than smell to locate their hosts [44]. In West Africa, important bovine trypanosomosis vectors among the *palpalis* group include *G. palpalis palpalis*, *G. p. gambiensis* and *G. tachinoides* [99].

2.1.3. Hosts

Trypanosoma vivax is one of the most important *Trypanosoma* species known to infect both domestic and wild animals [41]. *Trypanosomavivax* reported from cattle, dromedary camel [14], goat, sheep, pig, dog [60], horse, donkey [65], both domesticated and wild buffalo, warthog, hippopotamus, reedbuck, waterbuck [90], giraffe [92], rodents, pangolins, primates, reptiles and different wild ungulates and carnivores [101].

The silvatic cycle that involves wild animals is known to greatly influence the epidemiology of trypanosomosis since wild animals serve as reservoirs for both human and animal trypanosomosis. The physiological status of the host, as well as nutritional and environmental factors, further play important roles in modulating the severity of the disease [77].

The environment Trypanosomosis maintains large areas of Africa (so-called “fly belts”) and it is presumed that wildlife have contributed a lot in the maintenance of the diseases in a relatively defined ecosystem [67]. The environment allows for the interaction between the *Glossina* species, vertebrate hosts and the trypanosomes in order for trypanosomosis to be produced. In West Africa, tsetse habitats have been subdivided along distinct north-south climatic gradients, with predominantly riverine tsetse species in the north and a mixture in the south [35]. In the north, arid conditions prevent fly spread and riparian vegetation constitutes suitable niches for the localized, well-demarcated pockets of tsetse populations. Outside these favourable micro-climates, tsetse hardly survives and it would appear that no links exist between pockets, except occasionally and in spatially limited neighboring areas during the rainy seasons. In the intermediary band, climatic conditions and vegetation become gradually more suitable. Distinct fly pockets tend to

merge and tsetse distribution patterns become more linear along main streams. Tsetse populations still remain concentrated in pockets during the dry season, but disperse [99] during the rainy season over large parts of the river systems, including important tributaries and savannah buffers. In the humid south, there are no climatic limitations to fly distribution and flies are present along river systems and even the surrounding humid woodlands and forests.

Due to increasing human population and consequently the opening up of more land for crops, the *morsitans* group is disappearing in most places of Africa [25]. Riparian tsetse species on the other hand are more versatile and can co-exist with human development. They are opportunistic feeders; where agricultural intensity is low; they feed on wild reptiles and rarely carry pathogenic trypanosomes [68]. Temperature extremes, particularly above 36 °C and below 10°C also lead to adult fly mortality through starvation and water loss via respiration. Moisture levels directly related to precipitation is also involved in fly mortality, though the exact mechanism is not clear [54].

2.2. Transmission

The transmission of the disease is either cyclically by tsetse flies or mechanically by other biting flies. Transmission by tsetse fly is a complex mechanism in which the fly remains lifelong carrier. In the vector trypanosome changes through several morphological distinct stages (amastigote, promastigote and epimastigote) until it reaches trypomastigote (metacyclic stage) which is infective for mammals [84].

When multiplication occurs in digestive tract or proboscis, so that the new infection is transmitted when feeding, the process is called anterior station development. The species of trypanosome which use this process is called salivarian. In other trypanosomes, multiplication and transformation occurs in the gut and the effective forms migrate to the rectum and are passed with the faeces; this process is called posterior station development. The trypanosome having this pattern of development and transmission are called stercorarian section [52]. Non-cyclical transmission is essential mechanical transmission in which the trypanosomes are transferred from one host to another by the interrupted feeding of biting insects, notably *Tabanids* and *Stomoxys* [78].

2.3. Pathogenesis and Clinical Signs

Pathogenesis of trypanosomosis in most species is a progressive, but not always fatal disease; the main features are anemia tissue damage and immunosuppressant. Metacyclic trypanosomes are inoculated intradermally as the fly feeds. Their behavior thereafter depends largely on the species of trypanosome transmitted and the host [20]. *Trypanosoma 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. *Trypanosoma 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 [4, 48].

The cardinal clinical sign observed in AAT is anaemia. Within a week of infection with the haematic trypanosomes (*T. congolense* and *T. vivax*) there is usually a pronounced decrease in packed cell volume (PCV), haemoglobin and red blood cells, and within 2–3 months the PCVs may drop to below 30 percent of their preinfection values. Also, invariably, present are intermittent fever, oedema and loss of condition. The severity of the clinical response is dependent on the species and the breed of affected animals and the dose and virulence of the infecting trypanosome. Stress, such as poor nutrition or concurrent disease, plays a prominent role in the disease process [77].

2.4. Diagnosis

Diagnosis of trypanosome infections in humans or domestic livestock is a basic requirement for prevalence determination as well as for planning and implementing chemotherapy and for monitoring vector control operations [16]. Accurate diagnosis of trypanosome infection in livestock is required for a proper appreciation of the epidemiology of the disease in any geographical locality. Besides clinical diagnosis, parasitological diagnostic methods are available for detection of trypanosomes [70]. Blood and lymph fluid can be directly examined as wet smears and trypanosomes are detected to be present by light microscopy using unstained wet smears or Giemsa-stained thick and thin smears [19]. Although highly specific, microscopy often lacks sensitivity [21].

2.5. Treatment and Control

If detected early, trypanosomosis can be treated with trypanocidal drug. Therapeutic drugs for treatment include: diminazene aceturate, quinapyriminesulphate, homidium bromide and homidium chloride. Prophylactic drugs for cattle include homidium bromide, homidium chloride and isometamidium [6]. Prevention and control of tsetse-transmitted trypanosomosis depends on minimizing contact between domestic livestock, game animals and tsetse fly. There are a number of control measures directed to the parasite, vector and host. However, uses of these methods are highly variable. The methods include reducing tsetse fly population with different techniques, treating infected animals with drug, preventing animals from the disease using prophylactic drugs and also using indigenous breeds of livestock that are genetically resistant to the disease. And also, insecticide impregnated, odour-baited traps and targets which attract and kill tsetse flies. And also, application of deltamethrin pour-on to cattle against tsetse flies has proved to be very efficient in controlling tsetse fly vectors [13, 40].

3. Materials and Methods

3.1. Study Area

The study was conducted in four peasant associations (PAs) of 2 districts (Boloso Bombe and Boloso sore) which included Tiyo Hembecho, matala hemebecho (from Boloso sore), Ajora and Bombe PA (Boloso Bombe) which have directed geographical relation with Omo-Ghibe tsetse belt located in Southern Nations, Nationalities and Peoples Regional State. The study area at some part is characterized by wooded grasslands and riverian vegetation. The study area is located about 400 km south of Addis Abeba, 210 km from Hawassa and 40 km from town of wolaita Soddo. Total the human population in 2 districts was estimated at 226,690. Among total population 226,510 house hold who are participant of animal production extension in 4 PA of two distinct Altitudes of the study area ranges from 1200 m -1600 m above sea level. Mean annual rainfall range from 1500mm- 1700mm [109].

Rainfall is almost uniform, the mixed agricultural production system is practiced, which included wheat, barley, and insect, bean mainly, fruits such as avocado, bananas, and mango are widely grown. Because of the perennial nature of the crops and the small holding size, which is between 0.25-05-hectare, hand hoeing is the predominant method of cultivation. Livestock is oxen for farming, meat and mainly dairy cows kept for their milk and manure. Manure is commonly applied to inset, ginger, and taro and for others. Inset and coffee are cultivated near the homesteads. Extensive grazing areas which are about 5.14% of the total area are used for herding the oxen, cattle, donkey, goat, and sheep. In study area the livestock production system is extensive and a population of 205119 cattle, 56296 sheep, 44574 goats, 13488 donkeys, 289 mules, 228 horses, and 306050 poultry [102].

3.2. Study Population

All the study animals were indigenous cattle breeds that kept under an extensive husbandry system, free grazing, and usually kept mixed with other livestock species in communal grazing areas [26]. The age of animals also will be group, less than 1 year, 1-3 years and greater than 3 years of age. Also, the body condition of animals will be group as good, medium, or poor based on [103] method of body causation scoring for zebu cattle.

3.3. Study Design

The study was conducted during from January 2020 to August 2020. A cross-sectional study type was used to estimate the prevalence of cattle trypanosomosis.

3.4. Sampling Method

Animals were randomly selected by taking an age, sex, and skin color & body condition from four peasant association (Bombe PA, Ajora, Tiyo-Hembecho and Matala-Hembecho).

3.5. Sample Size Determination

The previous study on trypanosome reported the prevalence of 17% [46], therefore total sample size was calculated following parameters of 95% level of confidence interval (CI), 5% desired level of precision. So, the sample sizes were determined using the formula given in [82]:

$$n = [1.96^2 \text{Pexp} (1 - \text{Pexp})] / d^2$$

Where: n=required sample size; Pexp=expected prevalence; d=desired absolute precision.

Accordingly, a total of 217 sample sizes, but to increase result precocious sample size population increased to 250, which were randomly selected from four peasant associations accordingly proportionally to their total Bovine population.

3.6. Sample Collection and Laboratory Examination

3.6.1. Sample Collection and Transport

Blood samples were collected after properly restraining the animal and aseptically preparing the sampling site. It was collected from the ear vein by using sterile blood lancet and hematocrit capillary tubes. A pair of heparinized hematocrit capillary tubes were filled with blood from animals to $\frac{3}{4}$ of the height and sealed at one end with crystal sealing material.

3.6.2. Laboratory Examination

The capillary tubes were loaded on the micro hematocrit centrifuge symmetrically and centrifuged at 1200 rpm for 5 min [107]. PCV was determined using hematocrit reader, which is used for the determination of anemia and comparison of infected animals with non-infected animals [89]. After the PCV was read, capillary tubes were broken 1 mm below the buffy coat to include the red blood cell layer and the content were expressed on microscopic slide and mixed and covered with a 22×22 mm cover slip, ground buffy coat technique. The capillary tube was cut using a diamond tipped pen 1 mm below the buffy coat to include the upper most layers of the red blood cells and 3 mm above to include the plasma. Thin blood smears will stain with Giemsa stain to identify species of trypanosome. The content of the capillary tube was expressed on to a glass slide, and covered with cover slip. The slide was examined under x40 objective and x10 eye piece for movement of parasite was used. Trypanosome species were identified according to their morphological descriptions as well as movement in wet film preparations by [107].

3.7. Statistical Analysis

Data about study sites and individual study animals were entered into Microsoft Excel. Hematological and parasitological data were managed very carefully. Then, the data from the Microsoft excel sheet were processed. Prevalence of trypanosomes was expressed as a percentage by dividing a total number of samples or animals positive to trypanosome to the total number of samples or the total number of animals examined.

4. Results and Desiccation

4.1. Results

Out of 250 cattle (145 male and 105 female) examined, 7.2% (18 of 250) were found carrying trypanosomes. The highest prevalence (10%) was observed in Bombe PA while the lowest 5.1% was observed in Matala Hemebecho Peasant association (Table 1). Relatively, a higher level of trypanosome prevalence (7.6%) was observed in male cattle when compared to the prevalence of trypanosomes observed in female (6.6%) cattle (Table 2). Among three age groups, a higher prevalence (8.8%) was observed in greater than three years of age groups of cattle followed by in age 1-3 years 5%. and trypanosomes were not detected in a group of cattle less than one year of age (Table 3). The prevalence of 10.5%, 7.5% and 4.6% were observed in black, red and mixed skin color of cattle respectively on the bases of skin color. The animals with black and red skin color are highly exposed for Trypanosomiasis than mixed colored animals (Table 4). On the basis of altitude, trypanosome prevalence of 5.3% and 8.4% were detected in Midland and lowland respectively (Table 5). On the basis of species, both *T. congolense* and *T. Vivax* were identified in the current study area. *T. congolense* was seen in higher rate (72.2%) than *T. Vivax* which was observed in a rate of 27.8% (Table 6). The Cattle having PCV < 24% (an anemic) was affected by the rate of 9.2% while in the cattle having PCV > 24% (non -anemic) was exposed in a rate of 6.1% as indicated in (Table 7).

Table 1. Prevalence of Trypanosomiasis in site basis.

Risk factors	No. Examined	No. positive	Prevalence (%)
Peasant associations			
Tiyo Hemebecho	37	2	5.4
Matala Hemebecho	58	3	5.1
Ajora	75	5	6.7
Bombe PA	80	8	10
Total	250	18	7.2

Table 2. Prevalence of Trypanosomiasis on a sex Basis.

Risk factors	No. Examined	No. positive	Prevalence (%)
Sex			
Male	145	11	7.6
Female	105	7	6.6
Total	250	18	7.2

Table 3. Prevalence of Trypanosomiasis on the basis of age.

Risk factors	No. Examined	No. positive	Prevalence (%)
Age			
>3 years	170	15	8.8
1-3 years	60	3	5
< 1 year	20	0	0
Total	250	18	7.2

Table 4. Prevalence of Trypanosomes on the basis of skin color.

Risk factors	No. Examined	No. positive	Prevalence (%)
Skin Colors			
Red	147	11	7.5
Black	38	4	10.5
Mixed	65	3	4.6
Total	250	18	7.2

Table 5. Prevalence of Trypanosomiasis on the basis of altitude.

Risk factors	No. Examined	No. positive	Prevalence (%)
Altitude			
Midland (1595m)	95	5	5.3
Lowland (1206m)	155	13	8.4
Total	250	18	7.2

Table 6. Prevalence of Trypanosomiasis on the basis of Trypanosome species involved.

Trypanosome species	Infection	Prevalence (%)
T. congolense	13	72.2
T. Vivax	5	27.8
Total	18	7.2%

Table 7. Prevalence of Trypanosomiasis on the basis of Hematology.

PCV –Value	No. Examined	No. positive	Prevalence (%)
Pcv<24	87	8	9.2
Pcv>24	163	10	6.1
Total	250	18	7.2

4.2. Discussion

The present study revealed that out of total 250 randomly selected cattle in study area, 18 (7.2%) were affected by Trypanosomiasis of which 3 (5.1%), 2 (5.4%), 5 (6.7%) and 8 (10%) were recorded in Matala Hemebecho, Tiyo Hemebecho, Ajora and Bombe PA respectively. The current finding was much lower than the finding (17%) reported by Soddo Regional Veterinary Laboratory [104] and the work of [105] who reported trypanosomiasis with infection prevalence of 22% at pawe, and the work of [106] who reported trypanosomiasis with prevalence of 14.2% at Merab Abaya, Southern Ethiopia. However, it was higher than the work of [47] at Boloso Bombe and [108] whom reported a prevalence of 5.2% and 4.8% respectively. Relatively the current study agreement with study reported by [35] at Humbo Larena of Wolaita zone 9.3%, [110] at Maraka Woreda of Dawuro Zone, Southern Ethiopia.

Based on sex, 7.6% and 6.6% prevalence were observed in female and male cattle respectively. Concerning on sex similar result was reported by [50, 12] whom reported that males had a non-significant higher prevalence of trypanosomosis than females. The current finding showed that male animals were more affected than female animals this may due to management difference which means lactating and pregnancies female animals were confined (kept) in house and around near the house at study area. In other hand the study showed both male and female animals are exposed to the same communal grazing land under extensive production system in the areas where tsetse challenge is equal for both sexes. When infection

prevalence of trypanosomiasis was calculated among three age groups, a higher prevalence (8.8%) was observed in greater than three years of age groups of cattle followed by in age 1-3 years 5%. in the current study, trypanosomes were not detected in a group of cattle less than one year of age. This great difference in prevalence between less than one year of age group and the rest two age groups of cattle might be explained from the point of differences in management practices [47]. Calves were managed by keeping them around houses and under shade in the night and in most part of day times unless in the morning and late in the afternoon. Higher prevalence from age above 3 years (adult and old) may be associated the fact that adult and old animals travel long distance for grazing and draught as well as harvesting crops in areas of high tsetse challenge than calves [11].

Comparison based on between different skin colors of cattle showered that, slightly higher prevalence was observed in cattle's having black skin color (10.5%) followed by 7.5% in red and 4.6% in mixed skin color. Tsetse flies by nature, attracted toward black and a red skin color, (Loha, 2019) so in animals having black skin color, there was a high prevalence of trypanosomiasis recorded. Area which has low vegetation cover including Matala Hemebecho and Tiyo Hemebecho, relatively lower prevalence 3 (5.1%), 2 (5.4%) but area which have high vegetation cover including Ajora and Bombe PA was higher prevalence, 5 (6.7%) and 8 (10%), of trypanosomiasis infected bovines. According to the study, geographical location of the peasant association could be mattering a prevalence difference even though association were located in the same climatic zones, moreover, the study showed that distribution of tsetse fly challenge in good forest coverage which is the suitable habitat for tsetse flies [12].

In other hand the current study resulted two species of trypanosomes (*T. congolense* and *T. vivax*) had been identified. Out of the 18 trypanosomiasis *T. congolense* contributes 72.2% (13/18) while the rest 27.8% (5/18) was contributed by *T. vivax*. *T. congolense* was identified at a higher prevalence in all the four peasant associations. Higher prevalence of *T. congolense* compared to the prevalence of *T. vivax* was in agreement with previous works of [47, 111] and Tewolde (2004) that identified *T. congolense* with the prevalence of 69.2%, 60.9%, and 75% in their study in Boloso Bombe, in pawe, and in western Ethiopia, respectively [46]. In Ethiopia, *T. congolense* is considered to be the most important trypanosome species. The prevalence of *T. vivax* most likely indicates the local transmission in the non-tsetse infested area by biting flies. It is indicated that *T. vivax* can adapt to a non-tsetse dependent transmission cycle [23]. The dominance of *T. congolense* infection in cattle may be due to its transmission only by tsetse flies and the high number of seroderms of *T. congolense* as compared to *T. vivax* and the development of better immune response to *T. vivax* by the infected animal [44].

During the study period cattle with PCV< 24% were considered anemic [112] which was said to be a principal

sign of trypanosomiasis in livestock. However, in the current study total proportion of infected animals from PCV < 24% were lower (44.4%, 8/18) than PCV>24 animals (55.6%, 10/18), the finding result showed that the highest prevalence (9.2%) was obtained from PCV < 24% animals. This is in agreement with the report of [47] in Omo valley at Boloso Bombe, south Ethiopia, which was stated that the average PCV of parasitologically positive animals was significantly higher infected by trypanosomiasis (76.9%, 10/13) than the average PCV of parasitological negative animals (23.1%). But agreement with the report of [115] in Gihibe valley at south western Ethiopia, which was stated that the average PCV of parasitological negative animals was significantly higher than the average PCV of parasitological positive animals. In the current study the lower infected animals (9.2%) by trypanosomiasis from average PCV of parasitological positive animals may have occurred due to the inadequacy of detection method used [113] or delayed recovery of anemic situations after recent treatment with trypanocidal drugs or may be due to the compound effect of poor nutrition and hematophagous helminth infection such as haemonchosis and bunostomiasis [114]. The present study also revealed that 6.1% of the cattle have a PCV value in the normal range (PCV > 24%) were reacting positively to trypanosomiasis infection and this may have occurred due to recent infection with trypanosomiasis. This result agrees with the previous result of [47, 116] whom conclude that cattle's having PCV value of normal range were shown to be infected with trypanosome parasite.

Haematocrit centrifugation technique (HCT) was used in all the studies considered for the meta-analysis. Parasitological techniques like the HCT have been reported to be of low sensitivity but good specificity [31]. These techniques are of limited significance especially when parasitaemias are low as often observed in endemic areas [24].

5. Conclusion and Recommendations

In this cross-sectional study of trypanosomiasis in cattle, overall prevalence of 7.2% was observed. Trypanosomiasis was an important priority disease of cattle in Boloso Bombe and Boloso Sore districts in selected peasant associations. Coat color, sex, altitude (site) and age of cattle are important factors affecting the occurrence of trypanosomiasis. Different level of prevalence was recorded in the different studied peasant associations while the highest prevalence being observed in Bomebe PA. Higher prevalence was observed in male cattle and in cattle greater than three years of age, but there were no positive cattle in a group of cattle less than one year of age. Two species of trypanosomiasis, *T. congolense*, and *T. vivax* were identified. In conclusion, the study indicated that trypanosomiasis was the major constraint of livestock production in the study area. Based on the above conclusion, the following recommendations are forwarded:

1. Strategic control of Bovine trypanosomiasis especially

tsetse and trypanosomiasis control program should be strengthened to improve livestock production in the area.

2. Attempt should be made to expand government and private veterinary services to serve the community properly, proper and strict trypanocidal drug utilization.
3. Awareness creation to the farmers about the role of tsetse in transmission of the disease should be made.
4. Further surveys and studies should be conducted and appropriate, feasible control of trypanosomiasis and/or vectors should be implemented at the area.

Lists of Abbreviation

AAT	African Animal Trypanosomosis
CSA	Central Statistical Agency
FAO	Food and Agricultural Organization
F/T/D	Flies per Trap per Day
ILCA	International Livestock Center for Africa
ILRAD	International Laboratory for Research on Animal Diseases
MoARD	Ministry of Agriculture and Rural Development
NTTICC	National Tsetse and Trypanosomosis Investigation and Control Center
OIE	Office International des Epizooties
PAAT	Programme against Animal Trypanosomosis
PAs	Peasant Associations
PATTEC	Pan African Tsetse and Trypanosomosis Eradication Campaign
PCV	Packed Cell Volume
SNNPRS	South Nation Nationality and People Regional State
SPSS	Statistical Package for Social Sciences
T.b	Trypanosome brucei
T.c	Trypanosome congolense
T.v	Trypanosome vivax
TLTF	T lymphocyte Triggering Factors
VSC	Variant Surface Glycoprote
WZLSFD	Wolaita zone livestock and fishery department

References

- [1] Uilenberg, G. (1998): A Field Guide for the Diagnosis, Treatment and Prevention of African Animal Trypanosomosis. FAO, Rome, Italy. vol. 154: 145-148.
- [2] Abebayehu, T. and Biniam, T. (2010): Bovine trypanosomosis and its vectors in two districts of Bench Maji zone, South Western Ethiopia. *Tropical Animal Health and Production*, 42: 1757-1762.
- [3] Abebe M, Daniel A, Yimtubezinash W, Genene T (2013): Identification and antimicrobial susceptibility of *Staphylococcus aureus* isolated from milk samples of dairy cows and nasal swabs of farm workers in selected dairy farms around Addis Ababa, Ethiopia. *African Journal of Microbiology Research*, 7 (27): 3501-3510.

- [4] Abebe, G. (1991): The integrity of the hypothalamic-pituitary-adrenal axis in Boran (*Bos indicus*) cattle infected with *Trypanosoma congolense*. Brunel University, UK, PhD Thesis. *Annals of tropical medicine and parasitology*, 83: 133-150.
- [5] Abebe, Y. D. (2010): Wildlife and Natural History Society. A Glimpse at Biodiversity Hotspots of Ethiopia. *Ethiopian Wildlife and Natural History Society*, pp: 1-94.
- [6] Achenef, M. and Bekele, B. (2013): Drug and Drug Resistance in Africa Animal Trypanomosis. *European Journal of Applied Science*, 5 (3): 84-91.
- [7] Andrews, H., Blowery, A., Boyd, H. and Eddy, R. G. (2008): Bovine medicine diseases and husbandry of cattle. 2: 756-761.
- [8] Aschalew, A., Shimels, A., Samuel, D., Shewatek, M., Hailemariam, H., Shiret, B. and Natnael, M. (2015): Review on Bovine Trypanosomosis in Ethiopia. *Acta Parasitological Globalis*, 6 (3): 136-146.
- [9] Awoke K/Mariam (2000): Study of trypanosomosis and its vectors in merabworeda. *Journal An Med.*, 4 (1): pp. 61.
- [10] Awulachew, S. B., Yilma, A. D., Loulseged, M., Loiskandl, W., Ayana, M., Alamirew, T. (2011): Ethiopian water resources potential and development in Africa. Rep Minist Water Energy, 1: 82.
- [11] Ayele, T., Ephrem, D., Elias, K., Tamiru, B., Gizaw, D., Mebrahtu, G, et al. (2012): Prevalence of Bovine Trypanosomiasis and its Vector Density in Daramallo District, South Western Ethiopia. *Journal of Veterinary Advances*, 2: 266-272.
- [12] Balcha E (2019). A Study on the Prevalence of Bovine Trypanosomiasis and its Associated Risk Factors in Tarcha Zuria District, Dawuro Zone Southern Ethiopia PP 4-10 2349-0365.
- [13] Bauer, B., Amsler, S., Clausen, P. H., Kebore, I., Petrich, J. (1995): Successful application of deltamethrin pour-on to cattle in a campaign against tsetse flies (*Glossina* species) in the pastoral zones of Samorogouan, Burkina Faso. *Tropical medicine and parasitology*, 46: 256-266.
- [14] Birhanu H, Fikru R, Said M, Kidane W, Gebrehiwot T, Hagos A, et al. Epi- demiology of *Trypanosoma evansi* and *Trypanosoma vivax* in domestic animals from selected districts of Tigray and Afar regions, Northern Ethiopia. *Parasite Vectors*. 2015; 8: 212.
- [15] Broun, D. M., Reid, R. S., Rogers, D. J., Shinow, W. F., Wint, W. (2001): Environmental Change and the autoumous control of tsetse and Trypanosomosis in Sub-Saharan Africa. Case histories from Ethiopia, Pp: 9-24.
- [16] Brun, R., Blum, J., Chappuis, F and Burri, C (2010): Human African Trypanosomiasis. *Lancet Infectious Disease*, 375: 148-159.
- [17] Central Statistical Agency (CSA). (2016): Agricultural sample survey results for Ethiopia. Report on livestock and livestock characteristics (Private peasant holdings). Volume II, Addis Ababa, Ethiopia.
- [18] Central Statistical Authority (CSA). (2005): Livestock Population of Ethiopia Central Statistical Authority (CSA), Addis Ababa, Ethiopia.
- [19] Chappuis, F., Loutan, L., Simarro, P., Lejon, V. and Buscher, P. (2005): Options for field diagnosis of Human African Trypanosomiasis. *Clinical Microbiology Reviews*, 18: 133-46.
- [20] Coetzer, J. G., Thomson, A. and Tustin, R. (1994): Infectious diseases of livestock. Capetown Clyson press, Maitland. pp: 167-193.
- [21] Coonor, R. J. and Halliwell, R. W (1987): Bovine trypanosomiasis in southern Tanzania, Parasitological and serological survey of prevalence. *Animal Health and Production*, 19: 165-72.
- [22] Dagnachew, S. and Shibeshi, S, (2006): Prevalence and vector distributions of bovine trypanosomosis in control (Sibu Sire) and non-control (GutoGida) districts bordering upper Anger valley in East Wollega Zone, Western Ethiopia. *Ethiopian Veterinary Journal*, 15: 77-86.
- [23] Davila AM, Silva RA (2009). Animal trypanosomiasis in South America. Current status, partnership, and information technology. *Annals of the New York Academy of Sciences*, 916: 199-212.
- [24] Desquesnes M. (1997) Evaluation of a simple PCR technique for the diagnosis of *Trypanosoma vivax* infection in the serum of cattle in comparison to parasitological techniques and antigen-enzyme-linked immuno sorbent assay. *Acta Tropica*, 65: 139-48.
- [25] Desquesnes, M. and Davila, A. (2002): Applications of PCR-based tools for detection and easy method for species-specific diagnosis of *Trypanosoma* species in cattle. *Veterinary Parasitology*, 110: 171-180.
- [26] Duguma, R., Tasew, S., Olani, A., Damena, D., Alemu, D., Mulatu, T., Alemayehu, Y. (2015): Spatial distribution of *Glossina* spp. and *Trypanosoma* spp. in south-western Ethiopia. *Parasites and Vectors*, 8: 430.
- [27] Ethiopian Electric Power Corporation (EEPCO). (2006): Gibe III Hydroelectric Project. Hydrology Report, Volume I, Addis Ababa.
- [28] Fetehanegest, D., Berhanu, A., Tewodros. F and Chanie, M. (2012): Occurrence of Bovine Trypanosomosis, in the Blue Nile River Basin, Northwest Ethiopia. *European Journal of Applied Sciences*, 4 (3): 129-135.
- [29] Food and Agricultural Organization (FAO) (1992): Training manual for tsetse control personnel. FAO, Vol. 5, Rome, Italy.
- [30] Food and Agricultural Organization (FAO). (2002): Food, Agriculture and Food security; the global dimension. FAO, Rome. Tech. Advance unedited version. Pp: 19-28.
- [31] Gardiner, P. (1989): Recent studies of the biology of *Trypanosoma vivax*. *Advances in Parasitology*, 28: 229 317.
- [32] Getachew, A. (2005): Review article Trypanosomosis in Ethiopia. *Ethiopian Journal of Biological Society*, 4: 75-121.
- [33] Gill, G. V., Beeching, N. J. (2009): Lecture Notes. Tropical Medicine (6th Edition). Blackwell Science, UK., pp: 28-36.
- [34] Gona, Z., Teshale, A. and Tilahun, A. (2016): Study on prevalence of bovine trypanosomosis and density of its vectors in three selected districts of Wolaita Zone, Southern Ethiopia. *J. Vet. Med. Anim. Health.*, pp: 129.
- [35] Habtewold T (1993): Bovine trypanosomosis in Wolaita: Prevalence and Assessment of drug efficacy. DVM Thesis. Addis Abeba University, Debre Zeit, Ethiopia.

- [36] Hargrove, J. (2004): Tsetse population dynamics in the Trypanosomiasis. Pp: 113–138.
- [37] Igibokawe, I. O. (1994): Mechanisms of cellular injury in African trypanosomiasis. *Vet. Bull.*, 64: 611-62.
- [38] Itard J. (1989): African animal trypanosomoses. *Manual of tropical veterinary parasitology*, pp: 177-290.
- [39] Jonathan, A., Thaddeus, K., Graczyk, N., Gellera, A. and Vitto, Y. (2000): Effects of environmental change on emerging parasitic diseases. *International Journal for Parasitology*, 3: 1-11.
- [40] Jordan, A. M. (1986): Trypanosomiasis Control and African Rural Development. Longman, London. Pp: 43.
- [41] Kassian EN, Simuunza MC, Silayo RS, Moonga L, Ndebe J, Sugimoto C, et al. (2017): Prevalence and risk factors of bovine trypanosomosis in Kilwa district, Lindi region of southern Tanzania. *Vet Parasitol Reg Stud Reports*. 9: 1–5.
- [42] Kitila, G., Kebede, B., Guta, D., Bekele, F., Wagari, M., Tilahun, B. and Jaleta, D. (2016): Epidemiological Investigation of Bovine Trypanosomosis and its Vector Apparent Densities in Yayo District Illuababora Zone. *Journal of Veterinary Sciences*, 3 (2): 8.
- [43] Langridge, W. P (1976): Tsetse and trypanosomosis survey in Ethiopia, Addis Ababa Ethiopia. ministry of overseas development of British and ministry of Agriculture of Ethiopia, pp: 97-103.
- [44] Leak, S. G. A. (1999): Tsetse Biology and Ecology: Their Role in the Epidemiology and Control of Trypanosomosis. International Livestock Research Institute, Kenya, 70 (4): 172–176.
- [45] Leak, S. G. A., Woume, K. A., Colardeue, C., Duffera, W., Feron, A., Mulingo, M., Tikubet, G., Toure, M., Yangari, G. (1987): Determination of tsetse challenge and its relationship with trypanosomosis prevalence. In livestock production in tsetse infested areas of Africa, pp: 43-52.
- [46] Leta Samson, Gezahegn Alemayehu, Zewdu Seyoumand Melkamu Bezie, (2016): Prevalence of bovine trypanosomosis in Ethiopia: a metaanalysis.
- [47] Loha Y. (2019): Prevalence of Bovine Trypanosomiasis in Boloso Bombe Wereda, Southern Ethiopia *Int. J. Adv. Res. Biol. Sci.* 6 (1): 56-62.
- [48] Luckins, A. G., Sutherland, D., Mwangi, D., Hopkins, J. (1994): Early stages of infection with *Trypanosoma congolense* parasite kinetics and expression of metacyclic variable antigen types. *Acta Trop.*, 58: 199-206.
- [49] Luckins, A. G. (1992): Trypanosomosis in small ruminants; a major constraint to livestock production. *British Veterinary Journal*, 148: 471.
- [50] Magona, J., Mayende, J., Olaho, M., Coleman, P., Jonsson, N., Welburn, S. and Eisler, M. (2003): comparative study on the clinical, parasitological and molecular diagnosis of bovine trypanosomosis in Uganda. *J Vet Res.*, 70: 213-218.
- [51] Ministry of Agriculture and Rural Development of the Government of Ethiopia (MoARD) (2004): Tsetse and trypanosomosis prevention and control strategies. In: Paper Presented on Farming Tsetse Controlled Areas Ethiopia. Final Work Shop, December, 27–28. Adama, Ethiopia.
- [52] Mirashah, F. and Ralph, S. (1989): Manual of tropical veterinary parasitology 3 ed. English, pp: 181-210.
- [53] Moloo, S. K. (1993): The Distribution of Glossina Species and their Natural Hosts. *Insect Sci. Applic.*, 14: 511-527.
- [54] Moore, N. and Messina, J. (2010): A Landscape and Climate Data Logistic Model of Tsetse Distribution in Kenya. *Plos one*. 5 (7): 1371.
- [55] Mulumba, K. (2003): Socio-economic and agricultural factors in the research and control of trypanosomiasis. PAAT Technical and Scientific Series, vol. 4. FAO. Rome.
- [56] Murray, M., (1988): Trypanotolerance, its criteria and genetic and environmental influences. Proceedings of a meeting held in Nairobi, Kenya from the 23rd-27th November 1987 organized by the International Livestock Center for Africa and the International Laboratory for Research on Animal Diseases. ILCA/ILRAD., pp: 133-151.
- [57] Murray, M., Trial, T. C. M., Stephen, L. E. (1983): Livestock productivity and trypanosomosis, ILCA, Addis Ababa, Ethiopia. 4 (3); Pp: 36-41.
- [58] Namangala B., Odongo S., (2014): Animal African trypanosomosis in Sub-Saharan Africa and beyond African borders. Trypanosomes and trypanosomiasis, pp: 239-260.
- [59] National Tsetse and Trypanosomosis. Investigation and Control Center (NTTICC) (2004): Annual Report on Tsetse and Trypanosomosis Survey, Bedelle, Ethiopia.
- [60] Nimpaye H, Njiokou F, Njine T, Njitchouang GR, Cuny G, Herder S, et al. (2011): *Trypanosoma vivax*, *T. congolense* “forest type” and *T. simiae*: prevalence in domestic animals of sleeping sickness foci of Cameroon. *Parasite*. 18: 171–9.
- [61] Office International des Epizooties (World Animal Health Organization), (2013): Trypanosomosis (Tsetse-transmitted). In: OIE Terrestrial Manual. Rome, Italy.
- [62] Oluwafemi, R. A., Ilemobade, A. A. and Laseinde, E. A. O. (2007): The Impact of African animal trypanosomosis and tsetse on the livelihood and wellbeing of cattle and their owners in study area of Nigeria. *Scientific Research and Essays*, 2: 380-383.
- [63] Pan African tsetse and trypanosomosis eradication campaign (PATTEC) (2001): A plan of action for the eradication of tsetse and trypanosomosis.
- [64] Paris, J., Murray, M. and Oimba, F. (2006): A comparative Evaluation of the Parasitological Techniques Currently Available for the Diagnosis of African Animal Trypanosomosis in Cattle. *American-Eurasian Journal of Scientific Research*, 1 (1): 52-54.
- [65] Pinchbeck GL, Morrison LJ, Tait A, Langford J, Meehan L, Jallow S, et al. Trypanosomosis in the gambia: prevalence in working horses and don- keys detected by whole genome amplification and PCR, and evidence for interactions between trypanosome species. *BMC Vet Res*. 2008; 4: 7.
- [66] Radostits, O. M. Blood, D. C. and Gay, C. C. (1994): A Textbook of the Diseases of cattle, sheep, pigs, goats and horses. *Vet. Med.*, pp: 1212-1221.
- [67] Rahmeto, A., Solomon G., Ijigu, S. (2016): Bovine trypanosomosis and vector density in Omo-Ghibe tsetse belt, South Ethiopia. *Acta Tropica*, 167: 79–85.

- [68] Rifkin, M. R. and. Lsberger, F. R. (1990): Trypanosome variant surface glycoprotein transfer to target membranes: A model for the pathogenesis of trypanosomiasis. In: Proc. Natl. Acad. Sci., pp: 801-805.
- [69] Robertson, H. (2004): Glossinidae (tsetse-flies). Biodiversity explorer, Iziko, Museums of Cape Town, South Africa. *Austin Journal of Veterinary Science and Animal Husbandry.*, 3 (2): 22.
- [70] Shimels, D. (2004): Epidemiology of bovine trypanosomosis in the Abbay basin areas of northwest Ethiopia. MSc, thesis Addis Ababa University, Faculty of veterinary Medicine, Debre. *Journal Veterinary and Animal science*, 5 (1): 132.
- [71] Sinshaw, A., Abebe, G., Desquesnes, M., Yoni, W. (2006): Biting flies and trypanosome vivax infections in three high land districts bordering Lake Tana. Ethiopia. *Veterinary parasitology*, 142: 3546.
- [72] Southern Regional State Veterinary Laboratory (SRVL) (2002): Annual report, Soddo, Ethiopia.
- [73] Sow, A. (2013): Trypanosomosis risk factors and impact assessment of tsetse and trypanosomosis eradication campaign in Burkina Faso. PATTEC (PhD thesis). University Gent, 5: 164-170.
- [74] Steverding, D. (2008): The history of African trypanosomiasis: review. *Parasites vectors*, 1: 3.
- [75] Tadesse, A., Tsegaye, B. (2010): Bovine trypanosomosis and its vectors in the two villages of Benchi Maji Zone: Southwestern Ethiopia. *Trop. Anim. Health. Prod.*, 42: 1757–1762.
- [76] Tafese, W., Melaku, A. and Fentahun, T. (2012): Prevalence of bovine trypanosomosis and its vectors in two districts of East Wollega Zone, Ethiopia. *J. Vet. Res.*, 79: 385.
- [77] Taylor, K., Authié, E. (2004): Pathogenesis of animal trypanosomiasis. The Trypanosomiasis. Wallingford, Oxfordshire. Pp: 331–353.
- [78] Taylor, M. A., Coop, R. L and Wall, R. (2007): Veterinary Parasitology. 3 ed. UK: Balckwell Publisher, 41 (2): 752.
- [79] Teka, W., Terefe, D. and Wondimu, A. (2012): Prevalence study of bovine trypanosomosis and tsetse density in selected villages of Arbaminch, Ethiopia. *Journal of Veterinary Medicine and Animal Health*, Vol. 4 (3): 36-41.
- [80] Terzu, D. (2006): The distribution of tsetse fly and trypanosomosis in Southern Region of Ethiopia. In: Tsetse fly and trypanosomosis control approaches and Southern tsets e and trypanosomosis control actors' forum establishment, proceeding of Regional Workshop, Hawassa. pp: 1-8.
- [81] Teshome, S. (2015): Modeling of Cascade Dams and Reservoirs Operation for Optimal Water Use: Application to Omo Gibe River Basin, Ethiopia. Pp: 6-12.
- [82] Thrusfield M. 2005. Surveys in veterinary epidemiology. 3rd ed. Singapore: Black well science Ltd.
- [83] Tola, M., Kebede, B., Kitila, G. and Gezehegn, E. (2016): Prevalence of bovine trypanosomosis and its vector apparent density in Chora District of Illuababora Western Oromia, Ethiopia. *Journal of. Veterinary Medicine and Animal Health*, Vol. 8 (7): pp. 64-71.
- [84] Urquhart, G. M., Armoker, j., Duncan, A. M. and Dunnand, F. W. (1987): Veterinary Parasitology. Blackwell Science, pp: 206-210.
- [85] Urquhart, G. M., Armour, J., Duncan, J. L., Dunn, A. M., Jennings, F. W. (2006): Veterinary Parasitology 2nd edition. Blackwell Publishing, Scotland. Pp: 212-224.
- [86] Vincendeau, P. and Bouteille, B. (2006): Immunology and immunopathology of African trypanosomiasis. *Ann. Braz. Acad. Sci.*, 78: 645-665.
- [87] Wale, R. and Shearer, D. (1997): Arthropod ectoparasites of veterinary importance. *Veterinary Entomology*, Pp: 141-193.
- [88] Wondewosen, T., Dechasa, T. Anteneh, W. (2012): Prevalence study of bovine trypanosomosis and tsetse density in selected villages of Arbaminch, Ethiopia. *J. Vet. Med. Anim. Health.*, 4 (3): 36-41.
- [89] Woo, P. T. K. (1996): The hematological centrifugation. Technique for the detection of trypanosomes; *Canadian Journal*, 47: 921-923.
- [90] Anderson NE, Mubanga J, Fevre EM, Picozzi K, Eisler MC, Thomas R, et al. (2001): Characterisation of the wildlife reservoir community for human and animal trypanosomiasis in the Luangwa Valley, Zambia. *PLOS Neglected Tropical Diseases*, 5: e1211.
- [91] Pendjari biosphere reservation in the Republic of Benin. *Ann Soc Belg Med Trop.* 1992; 72: 113–20.
- [92] Auty H, Anderson NE, Picozzi K, Lembo T, Mubanga J, Hoare R, et al. (2012): Trypanosome diversity in wildlife species from the Serengeti and Luangwa Valley Ecosystems. *PLOS Neglected Tropical Diseases*, 6: 1828.
- [93] Njiokou, F., Simo, G., Nkinin, S., Laveisseire, C., Herder, S. (2004): Infection rate of Trypanosoma bruceis. I., T. vivax T. congolense “forest type”, and T simiae in small wild vertebrates in south Cameroon. *Acta Tropica*, 92: 139–46.
- [94] Suh PF, Njiokou F, Mamoudou A, Ahmadou TM, Mouhaman A, Garabed R. Bovine trypanosomiasis in tsetse-free pastoral zone of the far-North region, Cameroon. *J Vector Borne Dis.* 2017; 54: 263–9.
- [95] Maudlin I, Welburn SC, Milligan PJM. Trypanosome infections and survival in tsetse. *Parasitology.* 2004; 116: S23–S28.
- [96] Majiwa, P. A. O., Ole Moi-Yoi, O. K., Nantulya, V. M., (1993): New techniques for diagnosis of the African trypanosomiasis. *AgBiotech News and Information*, 5, 115–120.
- [97] Bengaly, Z., Sidibé, I., Boly, H., Sawadogo, L., Desquesnes, M., (2002): Comparative pathogenicity of three genetically distinct Trypanosoma congolense-types in inbred Balb/c mice. *Veterinary Parasitology*, 105, 111–118.
- [98] Gardiner P., Mahmoud M. (1992): In: Salivarian trypanosomes. Baker JR, editor. Vol. 3. New York, NY, USA: Academic Press. pp. 1–6.
- [99] Solano P, Kaba D, Ravel S, Dyer N, Sall B, Vreysen MJB, Seck MT, Darbyshir H, Gardes L, Donnely MJ, De Meeûs T, Bouyer J, (2010): Population genetics as a tool to select tsetse control strategies: suppression or eradication of Glossina palpalis gambiensis in the Niayes of Senegal. *PLoS NTD.* 4 (5): p. 692.

- [100] Patterson J. and Schofield C. (2005): Preliminary study of wing morphometry in relation to tsetse population genetics. *S Afr J Sci.*, 101: 132-134.
- [101] Njiokou F, Simo G, Nkinin SW, Laveisseire C, Herder S. (2004): Infection rate of *Trypanosoma brucei* s. l., *T. vivax*, *T. congolense* “forest type”, and *T. simiae* in small wild vertebrates in south Cameroon. *Acta Trop.* 92: 139–46.
- [102] WZLRFD, (2018): Wolaita Zone livestock resources and Fishery department.
- [103] Nicholson, J. and Butterworth, H. (1986): A guide to condition scoring of zebu cattle. International Livestock Centre for Africa, Addis Ababa, Ethiopia.
- [104] FAO (2005): Program for the control of African Animal Trypanosomiasis and related development. Annual report of the year 2005. Food and Agricultural Organization of the United Nations, Rome.
- [105] Tilahun, G., Baltacha, F., Kassa, T., Birre, H and Gemechu, T. (1997): Tsetse and trypanosomiasis pilot control trial at Pawe Settlement area, Tanna Bells Valley, Metekel Zone, Region 6, North Western Ethiopia. Proceeding of the 13th conference of Ethiopia Veterinary Association. Addis Ababa, Ethiopia. pp 74-78.
- [106] Muturi, K. (1999): Epidemiology of bovine trypanosomosis in selected sites of the Southern Rift Valley of Ethiopia. Msc thesis, Addis Ababa University with Freie Universitäts, Berlin.
- [107] Murray, N, Murran, K., McIntyre, M. (1977): An Improved Parasitological Diagnosis of African Trypanosomosis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 71: 325-326.
- [108] Miruk, A., Hagos, A., Yacob, H., Asnake, F., Basu A. (2008): Prevalence of bovine trypanosomosis and trypanocidal drug sensitivity studies on *Trypanosoma congolense* in Wolyta and Dawero zones of southern Ethiopia. *Veterinary Parasitology*, 152: 141–7.
- [109] MOA. (2002): Annual report Humbo Wereda agricultural office, Wolaita Zone, SNNPRS.
- [110] Eshetu, E., Barata, B., Butako, B. (2017): The prevalence of bovine trypanosomosis and associated risk factors in Mareka Woreda of Dawuro zone, southern Ethiopia. *Journal of Parasitology and Vector Biology*. 9: 39–46.
- [111] Afewerk, Y., Clausen, P., Abebe, G., and Mehlitz, D. (2000): Multiple-drug resistant *Trypanosoma congolense* populations in village cattle of Metekel district, north-west Ethiopia. *Acta Tropica*, 76: 231-238.
- [112] Vanden B., Shumba W. and Makhambra, P. (2000): The distribution and epidemiology of bovine trypanosomosis in Malawi. *Veterinary Parasitology*, 88: 163-176.
- [113] Murry, M. Murray, p. k and McIntyre, W. I. M., 1997. An approved parasitological technique for the diagnosis of African animal trypanosomosis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 71-326.
- [114] Afewerk, Y., 1998. Field investigation on the appearance of drug resistant population of trypanosomes in Metekel district, northwest Ethiopia. Addis Ababa University and Freiuниверst at Berlin, Faculty of Veterinary Medicine, Ethiopia, MSc Thesis.
- [115] Rowlands, G. J; Mulatu, W; Authie, E; Leak, S. G. A and Peregrine, A. S., (1995): Epidemiology of bovine trypanosomosis in the Ghibe valley, Southwest Ethiopia. *Acta Tropica*. 53, 135-150.
- [116] Garoma, D. (2009): The prevalence of bovine trypanosomosis in Gari settlement area of East Wollega Zone. DVM Thesis. Jimma University, FVM, Jimma, Ethiopia, pp.
- [117] IAEA (1996): Government of Federal Democratic Republic of Ethiopia. Draft Projects Document Integrating the Sterile Insect Technique to Eradicate tsetse from the Southern Rift Valley of Ethiopia.