



Review on Epidemiology and Economic Impact of Tsetse Transmitted Bovine Trypanosomosis in Ethiopia

Birhanu Eticha¹ and Tadesse Yayeh²

¹ Benishangul Gumuz Regional State Bureau of Agriculture and Natural Resource, P. O. BOX: 30, Asossa, Ethiopia,
E-mail: brihanueticha12@gmail.com (DVM, MSc in Veterinary Epidemiology and Economics)

² Bahir Dar University, College of Agriculture and Environmental Science, School of Animal Science and
Veterinary Medicine (DVM, MSc, PhD, Associate Professor)

Abstract: Tsetse transmitted bovine trypanosomosis is widely distributed in tsetse infested parts of Ethiopia. Tsetse flies, in Ethiopia are confined to the southern and western regions between longitude 33° and 38° E and latitude 5° and 12° N and infested area extends from the southern part of the rift valley, around the south-western corner of the country and along the western lowlands and escarpments to the Blue Nile. Studies conducted in different parts of the country revealed that, tsetse transmitted bovine trypanosomosis is found widely distributed in Oromia, Amhara, South Nations Nationality people's, Benishangul Gumuz and Gambella regions with a prevalence that ranges from 2.1 to 19.5%. Four species of tsetse flies namely *G. pallidipes*, *G. m. submrsitans*, *G. fuscipes* and *G. tachnoides* are widely distribution in the country. The most common tsetse transmitted trypanosome species responsible for the disease in Ethiopia are *T. congolense*, *T. vivax* and *T. b. brucei*. The severity of the disease in the country is the result of interactions between hosts, agents and the environment. Since tsetse transmitted bovine trypanosomosis is a wasting disease, affected animals are unproductive in terms of milk, meat, manure and resulted in reduced birth rates, increased abortion rates and the mortality rate can be high and all of these affect the herd size and composition. Hence, participatory approach should be implemented so as to reduce vector density and prevalence of the disease to the level that they will not be major risk for cattle production.

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Introduction

African animal trypanosomes are extracellular protozoan parasites causing debilitating disease called trypanosomosis in animals and sleeping sickness in humans and have great socioeconomic impacts adversely affecting the economic development of Sub-Saharan Africa [1, 2, 3]. The distribution of the disease coincides with the habitat of the tsetse fly vector (*Glossing* species), and is called the tsetse fly belt or is sometimes referred to as green desert because 10 ~ million km² of potential fertile land is rendered to be unsuitable for cultivation [1]. Within this area, the majority of the tsetse- infested countries are underdeveloped, poor and food-deficit due to lack of productive animals as far as meat/milk production and draught power are concerned, resulting in an annual economic loss of about 5 billion US\$ [4, 5].

The disease caused by these extracellular hemoflagellates in domestic animals is called "Nagana" or African animal trypanosomosis (AAT). The intravascular parasites, *Trypanosoma congolense* and *Trypanosoma vivax* are considered to be the most important cause of AAT [6]. Yet, also *Trypanosoma b. brucei*, residing both in intravascular and extravascular

spaces within its host has been documented to contribute to livestock infection [6, 7]. In contrast to game animals, where these parasites cause only mild infection, the disease in domestic animal especially of cattle is severe and often fatal [5, 8].

Tsetse-transmitted trypanosomosis occurs only in Africa south of the Sahara where there are tsetse flies [9]. These flies, in Ethiopia are confined to the southern and western regions between longitude 33° and 38° E and latitude 5° and 12° N and infested area extends from the southern part of the rift valley, around the south-western corner of the country and along the western lowlands and escarpments to the Blue Nile [10].

Tsetse-borne trypanosome species affecting cattle in Ethiopia are *T. congolense*, *T. vivax* and *T. b. brucei* [11]. The presence of tsetse transmitted trypanosomosis is a major obstacle to the introduction of highly productive exotic dairy cattle and draught oxen to low land settlement and resettlement areas of the country for utilization of large land resources [12].

The epidemiology and economic impact of tsetse transmitted trypanosomosis on livestock especially cattle production are determined largely by prevalence and distribution of the disease and its vectors in the affected area [13]. In Ethiopia, a number of researches have been conducted to determine the prevalence of tsetse-transmitted bovine trypanosomosis. However, information about the epidemiology and factors associated with the occurrence of the disease as well as its economic impact is not compiled in an organized manner. Such information can be helpful for better understanding and choosing the right techniques and economically feasible control measures in endemic country like Ethiopia. Hence, the objectives of this seminar paper are to: review the epidemiology and status of tsetse-transmitted bovine trypanosomosis in Ethiopia and to review the economic impact of the disease in the country.

Literature Review

The Parasites

Trypanosomes are unicellular flagellated protozoa parasites of the phylum sarcomastigophora, order Kinetoplastida, family Trypanomastidae and genus Trypanosoma [14]. Trypanosomes are parasites that live in blood, plasma, lymph and several tissues of their vertebrate hosts and characterized by one nucleus and one flagellum, either free or attached to the parasite's body by means of undulating membrane. They also contain a small compact kinetoplast, a disc-shaped DNA-containing organelle, situated within a large mitochondrion [15, 16].

Epidemiology

Occurrence

African animal trypanosomosis can be found wherever the tsetse fly vectors exist. However, *T. vivax* can spread beyond the "tsetse fly belt" by transmission through mechanical vectors. Tsetse transmitted AAT is found between latitude 15° N and 29° S covering across over 37 countries in Africa, from the southern edge of the Sahara desert to Zimbabwe, Angola and Mozambique. It is the most economically important livestock disease in Africa especially of cattle [15].

The epidemiology of AAT depends on three factors which include the distribution of the vectors, the virulence of the parasite and the response of the host. When dealing with tsetse-transmitted trypanosomosis, much depends on the distribution and the capacity of the vectors, *Glossina* spp responsible for biological transmission of the disease to susceptible hosts [17]. Tsetse flies are classified in to (i) savannah woodland, (ii) the water courses and drainage systems (riverine type) and (iii) dense-forests groups [17].

In Ethiopia, trypanosomosis is widely spread in domestic livestock in the western, south and south-western low land region and the associated river

systems (Abay, Ghibe, Omo and Baro/Akobo) [18]. Out of the nine regions of the country, five (Oromia, Amhara, Southern Nations Nationalities and people's Region (SNNPR), Benishangul Gumuz (BG) and Gambella) are infested with more than one species of tsetse flies [19].

Four tsetse fly species (*G. pallidipes*, *G.m. submorsitans*, *G. fuscipes* and *G. tachnoides*) are found in Ethiopia of which, *G. tachnoides* has been observed in the Amhara region and *G.m. submorsitans* has been registered in Benishangul Gumuz region while more than one species of tsetse flies have been observed in Oromia region. Altitude plays the major role in the distribution of tsetse fly species indicating that geographical regions with an altitude lower or equal to 1200 meter above sea level showed higher average tsetse fly density (17.1 catches/trap/day) when compared to those above 1500 meter above sea level which was 12 catches/trap/day [20]. Study conducted in Mao-komo special woreda of Benishangul Gumuz region revealed that *G. fuscipes* and *G. pallidipes* are present in addition to *G.m. submorsitans* that has been already recorded to exist [21].

Locally in Amharic language trypanosomosis in cattle referred as "Gendi" is a serious constraint to livestock production in areas of the North and Southwest Ethiopia at an altitude of below 2000 meter above sea level [22]. The most important tsetse transmitted trypanosome species affecting cattle in Ethiopia are *T. congolense*, *T. vivax* and *T. brucei* [23].

Mode of transmission

Most trypanosomes must develop for one to a few weeks in tsetse flies (*Glossina* spp), which act as biological vectors before transmitted to susceptible hosts. The tsetse fly becomes infected with trypanosomes when feeding on an infected animal. When an infected tsetse fly bites an animal, the parasites are transmitted to susceptible host in the saliva [24]. Trypanosome species that commonly infect cattle in Ethiopia such as *T. congolense*, *T. vivax* and *T. brucei* are transmitted to cattle biologically via the bite of infected tsetse flies. Cattle whose residences were near major river systems such as Abay, Didessa, Dabus, BaroAkobo and Gibe rivers had been infected more frequently [20]. Other studies made in different parts of Ethiopia revealed that, in addition to *Glossina* spp, other biting flies such as *tabanids*, *haemtopota* and *stomoxys* are responsible for mechanical transmission of trypanosomes to susceptible animals [21, 25].

Risk factors

Host risk factor

Trypanosomes can infect all domesticated animals; clinical cases have been described in cattle, sheep, goats, camels, horses, donkeys and other

species of animals. In parts of Africa including Ethiopia, cattle are the main species affected due to the feeding preferences of tsetse flies [24]. However, the effect of infection varies with the host in that in most wild animals, such as warthogs, bushbucks, kudus or buffalos, trypanosomes become established but do not produce the disease. This is because these animals and the parasites have evolved for many years resulting in a balanced host/parasite relationship. In domestic animals the relationship with the parasite has not fully developed leading to development of the disease [26]. Trypanotolerance, the ability to control the proliferation of parasites and to limit their pathological effects, is widely employed in the context of African animal trypanosomosis. In cattle, trypanotolerance has been referred to as the capacity of an animal to control severe anemia development which is assumed to be independent of parasitemia levels [27]. In Ethiopian, four cattle breeds namely Abigar, Gurage, Horror and sheko have been thought to be relatively trypanotolerant when compared to the indigenous zebu cattle [28].

Pathogen risk factor

All of the important livestock trypanosomes in general and tsetse transmitted bovine trypanosomes in particular evade the host immune defenses by continuously changing their surface coat which is biologically active substances called variant surface glycoprotein (VSG) [29], one of the immune-evading mechanism that essentially preclude the development of conventional vaccines [30, 31].

The parasite virulence, immunogenicity and response to chemotherapeutics are also important factors in the epidemiology of trypanosomosis as trypanosome species occur in a remarkable variety of genotypes. Since Parasitemic animals commonly survive for prolonged periods, there are ample opportunities for fly transmission, especially of *T. brucei* and *T. congolense*. In contrast, some strains of *T. vivax* in cattle kill their hosts within 1-2 week, so that the chances of fly infection are more limited [32].

During Early stage of infection, trypanosomes release factors that alone or in concert with saliva components can impair the activation of the host's immune response, to generate a privileged micro-environment to allow the establishment of infection [33]. *Trypanosoma congolense* savannah type is the most pathogenic and is capable of causing severe anemia and even death of infected cattle [34]. *Trypanosoma brucei* species have a comparable host range and spatial distribution [35]. However, the prevalence and severity of clinical *T. congolense* infection in cattle has been reported to be higher than that of *T. brucei* species [36, 37]. These differences might be attributed to host susceptibility, intrinsic differences in trypanosome virulence and the vectorial

capacity of tsetse fly vectors for respective parasites [38]

Environmental risk factor

Since trypanosomosis interventions, environmental changes and encroachment of people have been an ongoing process, interactions between the host, parasite and vector would be influenced [39]. In Ethiopia, spatial factors such as low altitude (<1200 meter), major drainage system and local factors such as presence of game reserves and land utilization/encroachment determine the presence of major breeding habitats for tsetse flies and thus trypanosome transmission [20].

The vectors for trypanosomosis, the tsetse flies (*Glossina* spp) which are widely distributed in tsetse infested parts of Ethiopia, require habitat that is strongly influenced by ecological and climatic features particularly rainfall, soil type and temperature as well as vegetation type. Fly larvae can die as a result of drying soils. 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 [40].

The risk of infection with trypanosomes during the dry season was lower than the late rainy season [41]. The prevalence of trypanosomosis was affected by agro-climatic zone. Higher prevalence in lowland areas is related to the fact that animals in lowland areas are more challenged by vectors than those at higher altitudes. This is related to the temperature difference between these areas as temperature is one of the most important biotic factors that limit the distribution of tsetse fly vectors [42].

The high ratio of *T. congolense* in tsetse-infested area may be ascribed to the more efficient transmission of *T. congolense* [43] by major cyclical vectors than *T. vivax*. An increase in prevalence of *T. vivax* infections in cattle has been noted during rainy season which is attributed to higher density of tsetse flies and/or the abundant presence of mechanical vectors, such as *Tabanids* and *Stomoxys* spp [44]. Ecological conditions for tsetse on the edge of a fly belt are usually less favorable resulting in high mortality rate of tsetse and favoring the transmission of trypanosome species with a short developmental cycle such as *T. vivax* [45].

Status of Tsetse Transmitted Bovine Trypanosomosis in Ethiopia

Studies made to determine the prevalence of bovine trypanosomosis in Ethiopia showed that *T. congolense* and *T. vivax* are the most prevalent trypanosome species [22, 46]. In addition to the above mentioned two species of trypanosome, *T. brucei* is also found in the country [43]. Although, in Ethiopia

significantly a large number of studies have been conducted to determine the prevalence of bovine trypanosomosis, they were limited in spatial scope and the results significantly vary between the studies.

Some of the studies made in parts of the country to identify the species of trypanosomes responsible for the disease in cattle are summarized in (Table 1) below.

Table 1: Species of trypanosomes identified in different parts of Ethiopia

Species of trypanosome	Region	Site of occurrence	References
<i>T. congolese</i>		Sayo district of Kellem Wollega	[47]
<i>T. vivax</i>			
<i>T. congolense</i>	Oromia	Dideda district	[48]
<i>T. brucei</i>		Dale wabera district	[49]
<i>T. vivax</i>		Gidami district	[50]
		Quara district	[51]
<i>T. congolese</i>	Amhara	Debre Elias	
<i>T. vivax</i>		Dembech	[46]
		Jabitehenan district	
		Jawi district	[52]
<i>T. congolense</i>	SNNPR	Konta	[53]
<i>T. brucei</i>			
<i>T. vivax</i>			
<i>T. congolense</i>		Arab Minch district	[54]
<i>T. vivax</i>			
<i>T. congolese</i>	BGR	Guba district	[55]
<i>T. vivax</i>			
<i>T. congolense</i>		Odabildiglu district	[56]
<i>T. brucei</i>		Mao komo special district	[21]
<i>T. vivax</i>			

SNNPR= South Nations and Nationality and Peoples' Region, BGR= Benishangul Gumuz Region

Tsetse flies and trypanosomosis are still abundant and widely distributed in Ethiopia despite the different control efforts made. In addition to the four most commonly distributed species of tsetse flies namely *G. pallidipes*, *G.m. submorsitans*, *G. fuscipes* and *G. tachnoides* which are widely distributed in the country [20, 57], there are reports on the presence of *G. longipennis* but this species is not as such important tsetse fly species in Ethiopia

[58]. These vectors cyclically transmit three species of trypanosomes (*T. congolese*, *T. vivax*, and *T. brucei*) of livestock especially of cattle. The occurrence of trypanosomosis in Ethiopia was attributed to the existence of cyclical vectors. *Glossina* spp and the total infested lands and the distribution of tsetse fly species in a certain parts of infested areas in Ethiopia are summarized in (Tables 2 and 3) below respectively.

Table 2: Suitable areas for *Glossina* species in Ethiopia

<i>Glossina</i> spp	Suitable areas/regions	Total infested areas
<i>G.m. submorsitans</i>	Oromia Gambella, Benishangul Gumuz (SNNPR) Amhara	121,500 km ²
	Gambella SNNPR Benishangul Gumuz	
<i>G. pallidipes</i>	Gambella Benishangul Gumuz	59,687 km ²
<i>G.f. fuscipes</i>	Gambella Benishangul Gumuz Westem Oromia	52,692 km ²
<i>G. tachnoides</i>	Oromia, Gambella Benishangul Gumuz	44,417 km ²
Total		140,000 km²

Source: [58]

Table 3: Tsetse fly species identified and their fly/trap/day in Ethiopia

Tsetse fly species	Region	site	Overall fly/trap/day	References
<i>G.m. submorsitans</i> <i>G. pallidipes</i> <i>G. tachnoides</i>	Oromia	Dale wabera district	11.98	[49]
<i>G. tachnoides</i>	Amahra			[20]
		Knota	8.45	[53]
<i>G. pallidipes</i>	SNNPR	Arab Minch Andercha district	14.97 0.82	[54] [59]
<i>G.m. suborsitans</i>		Odabildiglu district	0.61	[56]
<i>G. m. submarsitans</i> <i>G. fuscipes</i> <i>G. pallidipes</i>	BGR	Mao-kobo special district	1.41	[21]

SNNPR= South Nations and Nationality and Peoples' Region, BGR= Benishangul Gumuz Region

Generally, studies made in different parties of Ethiopia indicated that *T. congolense* and *T. vivax* were found to be the most important trypanosome species affecting cattle. [60] in their study also showed that *T. congolense* and *T. vivax* were the two most

predominant trypanosome species affecting cattle in the country. Some studies made to determine the prevalence of bovine trypanosomosis in Ethiopia are summarized in (Table 4) below.

Table 4: Summary on prevalence of bovine trypanosomosis in Ethiopia

Authors (year)	Study site	Sample size	No positive	Prevalence (%)
[61]	Jawi district (Amhara)	300	34	11.33
[62]	Kamahi district (BGR)	413	37	8.96
[63]	Dale wabera and Dale Sadi districts (Oromia)	589	51	8.71
[64]	Dibate district (BGR)	384	75	19.53
[65]	Yoyo district (Oromia)	488	19	3.9
[66]	Chilga district (Amhara)	384	21	5.47
[59]	Andercha district (SNNPR)	383	8	2.1
[67]	Dembecha district (Amhara)	384	33	8.6
[68]	Bulen district (BGR)	306	18	5.88
[69]	Pawi district (BGR)	300	22	7.33

SNNPR= South Nations and Nationality and Peoples' Region, BGR= Benishangul Gumuz Region

Economic Impact

Trypanosomosis is considered to be the livestock disease with the highest impact on animal husbandry practice and agricultural production in Africa including Ethiopia causing annual losses that run to billions of US\$ [1]. The disease has devastating effects on the livelihoods of local farmers, for whom cattle represent not only the source of food (meat and milk), manure and draught power, but have also fundamental social roles as "living banks" and are used for social obligations such as dowry and ritual use) [70]. The overall negative impact extends to the access and availability of cultivable areas, changes in land use and exploitation of natural resources, restrain of opportunities for diversification and intensification of agricultural activity [71].

In Ethiopia, a study conducted on socio-economic impacts of trypanosomosis on cattle in Girja district of southern Oromia by [13] indicated that the total household expenditure on trypanocidal drugs was

increasing from time to time. The estimated annual expenditures on preventive and curative drugs cost were about 480 Ethiopian birr (ETB) per household (US\$ 28.23) and 320 ETB (US\$ 18.2) per household respectively. The finding of [13] also indicated that trypanosomosis has direct impact on livestock productivity by reducing 23% meat and milk off take, 5% increase in calving rate, 13.5% mortality and livestock management especially the number of livestock kept by farmers, the breed and species composition of the herd, 12% loss of draught power, 3% abortion and 28% cost of trypanocidal drugs and insecticides in the district.

Other study made by [72] on farmers' perception towards impacts of bovine trypanosomosis and tsetse fly in selected districts of Baro-Akobo and Gojeb river basins of southwestern Ethiopia revealed, trypanosomosis as the prime economically important cattle disease. According to the study, of the 65 cattle

death reported in the areas, trypanosomosis accounted for 64.6% (42 cattle) of the total annual deaths.

The estimated mean annual financial loss due to cattle mortality as a result of bovine trypanosomosis in the study districts (Gimbo from Gojeb and Gurafreda from Baro-Akobo river basins) was about 3502 ETB (US\$ 200, "according to the National Bank of Ethiopia 1 US\$ is equivalent to 17 ETB) per household. Draft power loss due to sickness of oxen, treatment cost, production losses (milk and growth reduction), interference with agricultural activities disease induced mortalities and replacement cost were considered as important impact of bovine trypanosomosis and accounts for 68.3%, 53.7%, 48.8%, 45.15%, 35.4% and 25.6% of the respondents respectively in the study districts [72]. Intervening against bovine trypanosomosis has significant benefits especially for Ethiopia, because of its very high livestock densities and the importance of animal traction. The benefit obtained by controlling tsetse flies and trypanosomosis per square kilometer of land in affected area is estimated to be US\$ 10,000 per annum. Consequently, the total maximum benefits from dealing with bovine trypanosomosis in Ethiopia could be as much as US\$ 1 billion a year [1].

In view of this, it is possible to infer that, Ethiopia has been losing a total benefit of about 1.4 billion US\$ per annum due to tsetse transmitted trypanosomosis (i.e. 140,000 km² of tsetse infested land (Table 2) x 10,000 US\$; total benefit obtained by controlling 1 km² of tsetse and trypanosomosis affected land in Ethiopia), [1].

Conclusion And Recommendations

Tsetse flies and trypanosomes are trill abundant and widely distributed in Ethiopia despite decades of control efforts and their abundance is influenced by factors such as altitude, river drainage system, presence of game reserves and land use and encroachment. This review paper underlined that tsetse transmitted trypanosomosis is a major animal health constraint in the country and found distributed in many parts of tsetse infested areas. Tsetse fly species responsible for cyclic transmission of trypanosomosis to cattle in Ethiopia include *G. pallidipes*, *G.m.submorsitans*, *G. fuscipes* and *G. tachnoides*. *Trypanosoma congolense*, *T. vivax* and *T. brucei* are transmitted to susceptible cattle via the bite of infected tsetse fly species and cause a serious impact both on production and productivity of animals. Although, the economic impact of the disease is significantly high, recently no well-organized document is available on the economic loss associated with the occurrence of the disease in the country. Therefore, based on the above conclusion the following recommendations can be forwarded:

- Farmers and livestock keepers all over tsetse and trypanosomosis affected regions should be educated about the economic impact of the disease;
- The economic impact of the disease should be well studied and documented at a national level so as to convince policy makers while designing prevention and control strategies;
- Participatory approach should be implemented so to reduce the tsetse fly vectors and the disease to the level that they will not be risk for cattle production.

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