

**Review Article**

# Tsetse Flies (Diptera: Glossinidae) Population in Ethiopia: A Review

Abate Waldetensai\*, Alemenesh Hailemariam, Wondatir Nigatu, Fekadu Gemechu, Geremew Tasew, Araya Eukubay

Ethiopian Public Health Institute (EPHI), Addis Ababa, Ethiopia

**Email address:**

abyw.res31@gmail.com (A. Waldetensai), entomologyat@yahoo.com (A. Hailemariam), wnigatu1891@yahoo.co.uk (W. Nigatu), fekadu\_geme@yahoo.com (F. Gemechu), getas73@yahoo.com (G. Tasew), eukubay.araya.12@gmail.com (A. Eukubay)

\*Corresponding author

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**Abstract:** Tsetse flies (*Glossina*) are obligate bloodsucking medical and veterinary important vectors of trypanosome which causes African sleeping sickness in humans and nagana in live stocks. There are 31 *Glossina* species in Africa of which *Glossina pallidipes*, *G. morsitans*, *G. fuscipes*, *G. tachinoides* and *G. longipennis* are found in different regions of Ethiopia particularly, in Amhara, Benishangul Gumuz, Gambella, Oromia and Southern part of Ethiopia. The distribution of the genus *Glossina* is restricted to lowland rainforest and wooded savannah regions and not uniform but often patchy. The fly has a significant impact on human health and rural development, probably capable of transmitting pathogenic trypanosomes that affect humans and domestic animals. In advance to any tsetse control operation, surveys are required to identify which flies are present in the area and determine their distribution. Towards designing suitable control methods and monitoring of Tsetse flies, it is important to first understand the behavior of the fly. Though there are human Trypanosomiasis studies and reports in Ethiopia, there are no current evidences on the extent of the disease, vector distribution and the magnitude of the problem. Therefore this review provides some background information on the taxonomical distribution of tsetse flies, their unique way of reproduction, and how their ecological affinities, their distribution and population dynamics influence and dictate control efforts. The paper also discusses the vector importance and the different strategies for tsetse control. Recommendations and future research needs are also suggested based on the reviewed literature.

**Keywords:** Glossinidae, Trypanosomiasis, Tsetse Fly Population, Distribution, Biology, Ethiopia

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## 1. Introduction

Tsetse fly (Diptera, Glossinidae) is large biting fly that inhabit about 10 million km<sup>2</sup> of area in 37 sub-Saharan Africa countries [1] and are distributed discontinuously throughout their range, and each taxon is restricted to a relatively specific habitat [2]. Adults of Tsetse fly species range in length from approximately 6 mm to 15 mm with generally dull yellow, pale brown or dark brown in colour, with occasional black markings and strictly hematophagous. Adults newly emerged from the puparia are soft to the touch and referred to as 'teneral', a stage which ends with the first blood meal [3]. Tsetse are remarkable for their viviparity in shady places and

usually burrow a short distance into the soil where they pupariate within a few minutes and complete development to the adult stage in approximately three weeks [2]. Both male and female taken blood from vertebrate by using their stylet-like proboscis [4]. Flies live independently of their vertebrate hosts, except during the short periods of contact required for blood feeding, and are thus likely to encounter a variety of host individuals and/or species during their life-long quest for food [3].

Depending on the environmental type, there are three main subgroups of Tsetse flies: Palpalis (riverine), Morsitans (savannah) and Fusca (forest-dwelling) [5]. Approximately one-third of Africa's total landmass is infested by these flies

[6]. Vector distribution mainly confined to the southern and western regions between longitude of 33° and 38°E and latitude of 5° and 12°N [7]. Among 31 species of tsetse flies, five species:- *Glossina pallidipes*, *G. morsitans*, *G. fuscipes*, *G. tachinoides* and *G. longipennis* are known in different regions of Ethiopia (Amahara, Benishangul Gumuz, Gambella, Oromia and Southern Ethiopia [1]. The fly has a significant impact on human health and rural development, probably capable of transmitting pathogenic trypanosomes that affect humans (African sleeping sickness) and domestic animals (nagana) [8].

Even as much is known about the biology and ecology of the vector and transmission of the disease, trypanosomiasis is still a major constraint on animal production [9], human health and agricultural livelihoods in many parts of Africa including Ethiopia [10]. The economic impacts of trypanosomiasis because of largely distribution of vectors in Ethiopia are diverse and complex, with direct effects on animal production and human health, as well as indirect effects on settlement patterns, land use, draught power use, animal husbandry and farming. Quantifying these wide-ranging effects may be difficult because, not much considerable evidence has been gathered through numerous vector focused studies of specific situations in the country. The importance of livestock to such people is very high, not only as a source of food, draught power, and money, but also for the important role that livestock, especially cattle, play in cultural affairs [5, 11, 12]. Under these circumstances understanding the vectors, ecology, behaviors and distribution are essential to control the diseases of livestock and human. In advance to any tsetse control operation, surveys are required to identify which flies are present in the area and their distribution. Towards designing suitable control methods and monitoring of Tsetse flies, it is important to first understand the behavior of the fly. Though there are human trypanosomiasis studies and reports in Ethiopia, there are no current adequate surveys on the extent of disease and vector distribution and the magnitude of the problem. Therefore this review was importantly aimed to review basic information on vector species distribution, ecology, behaviors, and role in diseases transmission and control methods in Ethiopia together with the factors (environmental, physiological, host/vector interactions, etc.) that can influence the transmission of the pathogen by the vector. The review was done from different literature based on Google scholars and Pub med searches using Glossinidae, Tsetse fly, human trypanosomiasis, Bovine trypanosomiasis, tsetse control key words.

## 2. Tsetse Flies and Their Characteristics

Tsetse flies (Diptera: Glossinidae) are blood sucking and important vectors of African trypanosomiasis in animals [13]. Tsetse flies are 6 to 15 mm long, narrow bodied, and yellow to dark brown with dull greenish color thorax having inconspicuous spots or stripes and light to dark brown abdomen with visible six segments [3]. They gave honey bee like appearance and their wings with the characteristics

hatched shaped cell in the center are held over the back in a scissor like configuration when rest [13]. They have the long proboscis (hypopharynx) with its onion shaped bulb at the base, which helps the flies to easily pierce the skin to suck blood. It is held horizontally between long pulps which are of an even thickness throughout [3]. Tsetse flies have evolved through the millennia, feeding on a broad range of animals and flexibility in their feeding preferences. Adult tsetse feed every 2 or 3 days, the salivary secretion contains a powerful anticoagulant which keeps the blood fluid so the fly can continue feeding. When they bite an animal, they create a pool of blood at the site of the bite; they pump saliva into this blood pool through the hypopharynx [2, 14]. In areas of human settlement, tsetse may feed on cattle, sheep, goats, pigs, horses, donkeys, camels, and man. When a tsetse fly feeds on an infected animal the parasite is ingested with the host's blood and develops in to an infective stage inside the insect [15]. The highly infective forms of the parasite called metacyclic trypanosomes found in saliva of the fly are injected into the blood pool every time the fly feeds and continue to transmit trypanosomes for the rest of their lives [16].

## 3. Taxonomical Distribution of Tsetse Flies

Tsetse flies are classified into three groups: *Morsitans*, *Palpalis*, and *Fusca* based largely on morphological differences in structure of the genitalia, and the naming is associated with the commonest species in each of the sub-genera [4]. The distribution of the genus *Glossina* is restricted to lowland rainforest and wooded savannah regions [12] and not uniform but often patchy. Mountains exceeding 1600m of height and low temperature at the high altitude [17], climate, vegetation and land utilization may limit the distribution of tsetse flies [18]. In Ethiopia, at about areas of 200,000 Km<sup>2</sup> Tsetse flies are confined to southern and western regions between longitude 33° and 38° East and latitude 5° and 12° North, lied in the low lands and also in the river valleys of Blue Nile, Baro Akobo, Didessa, Ghibe and Omo [19]. Five species of tsetse flies were identified as *G. pallidipes*, *G. fuscipes*, *G. longipennis*, *G. tachnoides* and *G. morsistans* exists commonly in the aforementioned areas of Ethiopia under specified groups [20]. Tsetse flies are active for something like 30 minutes each day and can fly at about 20km/h, could travel up to 10 km every day. However, they tend to make many short flights every day and these are not all in the same direction [15]. Hence, in practice savannah species such as *G. morsitans* and *G. pallidipes* move about one kilometer a day and a fly front can advance about 25 kilometers in a year, important to rapidly reinvade from adjacent infested area [21].

*Morsitans* group: Are also called the savannah flies due to their preference to this environment and the most important vectors as the African savannah is a vast area and the flies come into contact with man, livestock and wild game animals [7]. In Ethiopia, this group is distributed in Didessa valley

near the village of Wonago and Lado on the eastern side of Lake Abaya, Shambo, on the Muger River, on the Dabous River (Wollega), on the Baro and Gilo Rivers (Gambella district), Illubabor associated with Akobo river, in the Savannah near Turmi and near Mizan Teferi [22]. It is highly dominant in the areas where large numbers of pastoralists graze their livestock [23]. All species belonging to this group are restricted to savannah woodlands and their distribution and abundance is tied with wild animals distribution. During dry season they are concentrated near the source of water courses and spread out in wooden savanna during the rainy season [24]. Activity always occurs in short bursts and female *G. m. morsitans* probably do not spent more than a few minutes a day in flight, young males about 15 min and older males 30 - 50 min [15].

The species under this group are *G. morsitans ugandensis* and *G. pallidipes* identified from Ethiopia [7]. *G. pallidipes* is highland species being present in some coastal areas and rift valley [13]. Omo Bottego, the lower Omo up to Omorate and Gojeb are infested with *G. pallidipes* extending about 20 km above the bridge on the Jimma to Bonga road [25]. *G. pallidipes* in Rift valley is connected with those in Omo River area, likely to be across the narrow strip which separates the upper part of the Galana Dulei valley (Woitto) with the Maze River valley (Daramalo) [22]. The infestation in Sidamo is also extended from lower Gidabo River down the eastern sides of Lake Abaya and Chamo to the Sagan River along which it extends to Lake Chew Bahir including large Galana River valley between Amaro Mountains and the southern highlands [7]. Its population density is now decreased due to the recent settling in the region and agricultural development in the Rift valley [13]. *G. pallidipes* in the southern rift valley of Ethiopia has extended its altitudinal range from 1,700 m.a.s. and it had reached the limit of its movement eastwards to the southern high lands where it was prevented from going any further by the mountains. This species had also extended along the southern border of Wollega linked with Baro river vegetation and its upper tributaries [22]. *G. m. ugandensis* identified to be distributed in Ethiopia around Didessa Valley, Berberuaha River in Wellega, and Abobo River in Illubabor, near Lake Hawassa in Sidama, Birbir, Chibise, Gojjam, Shoa and Keffa [7, 13].

Palpalis group: The distribution of the palpalis group species is likewise associated with lowland rain forest [15], specific vegetation like riparian forests that line the hydrographical network or plantations of certain crops and extended along river systems in the humid savannah [22]. They are also called riverine tsetse fly groups and can tolerate a wide range of climatic conditions [15]. There are two species of palpalis group in Ethiopia; *G. tachinoides* and *G. fuscipes fuscipes* [7]. *G. fuscipes* is found in Maze, Gorgora, Bazo and Cuccia Rivers (Gamo Gofa) [26], on the Ketto tributary and at Degen of the Birbir (Wellega), on the tributary of the Gojeb (Kaffa), and near the bridge on the Omo River and Addis to Jimma high way [13]. The Ghibe and the whole upper and lower Omo infested with *G. fuscipes* as other species have found above the bridge [7]. *G. tachinoides* is distributed along

the Abay (Blue Nile) River system, Belles River valley and Akobo River system [9, 13, 22].

Fusca Group: The forest tsetse flies and are densely colonized where vegetations are found [13]. In transition zones between true forest and wooden lands, they prefer dense shade and riverine thickets [27]. This mainly forest-dwelling group consequently have little epidemiological significance [3]. In Ethiopia, the distribution of this vector is along the Walmal River (Bale), at tributary of Wabe Shebele in (on Daghatto River) in the Ogaden and near Lake Abaya, Gamogoffa and Keffa [7, 9]. Under this group, there are two species of Tsetse flies i.e. *G. brevipalpis* and *G. longipennis*. *G. brevipalpis* is found only at the lower part of the Omo River [13].

## 4. Biology of Tsetse Flies

The mating of tsetse flies probably takes place near to or on host animals. Females are mated young, usually only once or some times more than once in their lives [28]. This is because of the sperm remain active in the spermathecae for the rest of the female's life. Though males can mate several times, older males are better able to mate successfully than very young ones [2]. The most distinctive feature that makes tsetse flies different from other insects is that the development of both eggs and larval stages take place within the female [15]. The female flies have two ovaries, each of which has two ovarioles. Eggs develop sequentially in the four ovarioles starting from the right internal ovariole [29]. The egg (about 1.6 mm long) is fertilized by sperm from the spermathecae is immediately enters the uterus and stay for about four days. There are three larval instars in Glossina up to the time when the fully grown larva is dropped by the female fly: the first, second and third instar [27]. The larva has a mouth at the anterior end, and two posterior spiracles. The larval period with in uterus of tsetse fly is 8-10 days which is 3 day for egg, 1.5 day for 1<sup>st</sup> instar larva, 2.5 days for 2<sup>nd</sup> instar larva and 3 day for 3<sup>rd</sup> instar larva [15]. Before the development to the third instars, the larval instars have white polypneustic lobes. First instar larva (1.8 mm long) is a stage that emerges from the egg, breaks out of the chorion using a sharp egg tooth [16]. 2<sup>nd</sup> instar larva (a stage of rapid growth and development) which is white in colour is grows to 4.5 mm long. 3<sup>rd</sup> instar (a stage of rapid growth and development) with a pair of large black swellings (polypneustic lobes with many small holes) at the posterior end through which the larva breathes. Most of the weight and volume of the third instar larva is due to the gut which contains large amounts of unassimilated food [27].

The 3<sup>rd</sup> instar larva is full grown and under favorable temperature (24-25°C), the larva enters into soil and become pupa. The pupal period ends 25-35 days; the period is 2-3 days shorter for females than for males [30]. After emerged from pupal case (young fly) the first larviposition occurs between 15-20 days. The next larviposition occurs at an interval of 9-10 days. Totally female tsetse flies produce 8-10 larvae [15]. The accurate determination of the physiological age of a female Tsetse fly population is allowed by cyclical

development in maturation of the four follicles in relation to the content of the uterus [31]. Their life span is 90-120 days so they have the lowest reproduction potential of any insect [3].

‘Apart from the food already in the egg, all the food of the three larval instars comes from the milk gland of the mother fly, poured out of the duct of the gland, at the head end of the larva;. The larva sucks up this secretion and passes it straight to the mid-gut and slowly digested and assimilated [15 -16]. The female flies start to look for a suitable area, usually where there is a patch of loose sandy soil, sheltered by an overhanging rock, branch or twig to lay the larva [27]. The larva burrows into the ground and out of sight and becomes barrel-shaped, darkens and may then be called a pupa within two one hour. There is no feeding by the larva after it is dropped by the female [16].

The pupa is shorter than larva looks a dark brown rounded object with polypneustic lobes at the posterior end which helps to distinguish it from the other flies pupae. The food remains in the midgut in the pupa is digested and assimilated and the organs of the adult fly begin to form [27]. Based on the temperature, the pupal stage usually lasts about four to five weeks. ‘Higher temperatures shorten the pupal period; lower temperatures lengthen the pupal period (to more than 50 days in some climates)’ [32]. The young adult fly expands its ptilinum to burst open the end of the outer part of the pupa (puparium). The young fly’s body is very soft and the wings are small and crumpled, struggles to the top of the soil and out into the open air. They urinate to expand their wings to reach their proper sizes [27]. The young fly taking the first meal is called a teneral fly with the whitish and semi-transparent underside of the abdomen. The underside of the abdomen appears more creamy yellow, and when held up to the light the dark shape of the last meal can be seen after the first blood meal [15, 31]. They develop firmer and harder thorax, due to greater muscles development and the fly is called a non-teneral fly [27].

## 5. Behavioral Activities

Tsetse flies behaviors are directly and indirectly correlated with light intensity and temperature, and relative humidity respectively. Low temperatures (less than 14°C) can hold back the early morning peak of activity and high temperature (>32°C) during afternoon can suppress the afternoon activity [27]. They are highly active during morning and late afternoon with specified and spontaneous V shape activity [12]. The savannah species (*G. morsitans* and *G. pallidipes*) are active mostly for the first two hours and the last two hours of the day (very hot days) where, several of the riverine species (*G. fuscipes*) are active in the middle of the day [26]. Resting sites of savannah tsetse flies during night times are the leaves and woody parts (branch, creeper, liana, root, stem, trunk and twig). Gallery forest and thicket are the resting sites of forest Tsetse flies. Depending on tsetse species and temperature, Tsetse flies prefer to rest on the ground or trees as high as <1m, < 3m or up to 5-6m above the ground [26, 28]. Both male and female tsetse flies are obligate blood feeders and have two

mechanisms of searching their hosts. These mechanism are lie in wait and hunt/search actively for the host [12]. Most of the flies arriving at a trap or target are probably actively hunting for a host and attracted to moving objects (moving car, man fly-round, ox fly- round or mobile electric net) are probably tsetse flies that were sitting and waiting for a host to pass [15, 26, 31]. Resting sites for Glossina are categorized as: True resting-sites, which are purely for resting, flies will not leave these places even to look for food unless they are very hungry [26]. These sites are night resting (just for normal resting because of being inactive) and day resting (during the warmest part of the day in hot weather; the hotter the weather, the lower on the vegetation the fly settles) [28]. Watching sites, not the main purpose of resting that includes hunting and following sites. During hunting sites, flies perch on these spots waiting for hosts to come along where, following sites are important to follow a moving object which stops, they may land on vegetation/ground until it moves again [24].

Tsetse flies feed exclusively on blood from particular animals which determined by blood meal analysis [28]. The general food sources of tsetse flies are dependent on the diurnal activities of vertebrates (reptiles carnivores, domestic ungulates, primates, insectivores and bats, rodents and birds) [16, 24]. The differences in the prey of different species of fly are the result of varying habitat combinations which bring flies into contact with different combinations of food animals [31]. For case in point, *G. palpalis* is lives near water and having contact with crocodiles and monitor lizards [27]. *G. tachinoides*, *G. morsitans* and *G. swynnertoni* can be independent on game and therefore their habits are closely adapted to game animals [24, 26]. *G. brevipalpis* found at dense thickets and riverine vegetation, would be more in contact with forest animals such as bush pig, buffalo, elephant, baboon, hippopotamus [24].

## 6. Tsetse Flies Importance

It is believed (although not demonstrated in every case) that all species and subspecies of tsetse are potential vectors of trypanosomes [33]. Wherever wild tsetse populations are present, animal trypanosomiasis can essentially be found [15]. However, human trypanosomiasis has a much more focal distribution, associated with strong epidemic potential [33]. Species of the fusca group are important vectors of animal trypanosomiasis, and are generally not considered as a significant vectors of the human-infective forms [19]. In Ethiopia, trypanosomiasis is one of the most important diseases that limit livestock productivity and agricultural development especially, in the most arable and fertile land of southwest and northwest parts [25]. The most important tsetse borne trypanosomes in terms of economic loss in domestic livestock are *Trypanosome congolense*, *T. vivax* and *T. brucei* [4]. About 4 million heads of cattle and small ruminants, nearly 7 million equines and 1.8 million camels are at risk of Trypanosomiasis [34]. The socioeconomic impact of trypanosomiasis is reflected on direct losses of economy [35]. Mortality, morbidity, reduction in milk and meat production,

and still birth of domestic animals are the cause of this economic loss [13]. Therefore animal trypanosomiasis is the cause for food insecurity in all tsetse distribution area with wide range of grazing land which favors animal production within agricultural development [36]. In between 1967 and 1970, Human trypanosomiasis was existed in Maji, Keffa, Gambella, Illubabor, Nekemte (Wollega). In 1980, other cases were reported from South Omo in southern Ethiopia [37]. Since then, there are no adequate surveys on the extent of disease and vector distribution and the magnitude of the problem in Ethiopia.

## 7. Control of Tsetse Flies

Theoretically, Vector control remains the most attractive way of containing the disease [38]. In advance to any tsetse control operation, surveys are required to identify which flies are present in the area and their distribution [39]. Towards designing suitable control methods and monitoring of Tsetse flies, it is important to first understand the behavior of the fly [14]. In terms of controlling tsetse flies, only one stage (adult) is easily assess-able for control due to the absence of eggs, a free larval stage in nature and the fact that the pupal development occurs in the soil [15]. The vector controls methods range from synthetic insecticides to those non-insecticidal uses [38]. The non-insecticidal methods, the widely effective but no longer recommended control methods are selective elimination of wild animal hosts and bush clearing and non-insecticide impregnated traps [39]. It is designed to eliminate the shaded places where tsetse rest and lay their larvae and eliminate the wild blood sources used by the tsetse [33].

A synthetic insecticides based control methods are aerial spraying and ground spraying, odor baited and insecticide impregnated odor baited traps/targets, sterile insect technique (SIT) [22], insecticide treated cattle, and use of trypanocidal drugs [15]. Persistence insecticide application to tsetse resting sites is very widely used control method is now discouraged due to effects on non-target organisms [33]. High levels of tsetse control can be achieved by sequential aerial spraying of ultra low dosages of biodegradable products that involved the use of using pyrethroids such as deltamethrin at doses that are generally too low to provoke significant effects on other fauna [14].

A simpler and cheaper device involves a suspended screen of blue and black cloth impregnated with a biodegradable pyrethroid insecticide such as deltamethrin [33] can attract the Flies to land on the black segment, quickly succumbing to the insecticide [40]. The effectiveness of traps and targets can be greatly enhanced by addition of appropriate odor bait [30, 41]. The live bait technique is a highly effective with additional advantage of controlling other flies and cattle tick [33]. This technique involves treating cattle with appropriate insecticide formulations (means of cattle dips, or as pour-on, spot-on, or spray-on). SIT in which females mated with sterile males are unable to produce offspring [16]. In this technique male flies are mass reared in the laboratory, sterilized by irradiation, and

released to mate with wild females [33]. SIT has no effect on non-target organisms and more efficient at lower fly densities, and is ideally suited to the final phase of local tsetse eradication [15, 30]. These all techniques are all field based vector control methods and reflect the fact that cost-effectiveness of evolving techniques are studied in the field as part of entomological experiments to test the efficacy of different approaches [39].

## 8. Conclusion

The distribution of the genus *Glossina* is restricted to lowland rainforest and wooded savannah regions and not uniform but often patchy and to southern and western regions. Amahara, Benishangul Gumuz, Gambella, Oromia and Southern Ethiopia are infested with this vectors and animal Trypanosomiasis. However, there are no recent studies or reports on human trypanosomiasis in the country. The fly has a significant impact on human health and rural development, probably capable of transmitting pathogenic trypanosomes that affect humans (African sleeping sickness) and domestic animals (nagana). In advance to any tsetse control operation, surveys are required to identify which flies are present in the area and their distribution. Towards designing suitable control methods and monitoring of Tsetse flies, it is important to first understand the behavior of the fly. Though there are previous human Trypanosomiasis studies and reports in Ethiopia, there are no current evidences on the extent of the disease and vector distribution and the magnitude of the problem. A serious study has to be conducted in the future on human Trypanosomiasis in Ethiopia to find out the extent of its distribution and the magnitude of the problem.

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## Conflict of Interest

All the authors do not have any possible conflicts of interest.

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