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# Review on Tsetse Management and Current Status of Tsetse Control in Ethiopia

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## Abstract

The tsetse fly and the disease trypanosomosis it transmits, is one of the most severe medical and veterinary problems in Africa. Tsetse flies (*Glossina* spp.) can be ranked among the world's most destructive pests and are the vectors of the causative agents for sleeping sickness in humans and African Animal Trypanosomosis (AAT) or Nagana in livestock. The general distribution of tsetse flies is determined principally by climate and influenced by altitude, vegetation and the presence of suitable host animals. There are five tsetse fly species reported in Ethiopia, four of them are found along the main river basins of Oromia. The most efficient way to control the disease is by the management of entire populations of the vector (area wide approach) using a combination of several control methods in an integrated pest management campaign. A very powerful method for integration as a final eradication component is the sterile insect technique (SIT). The technique relies on the rearing of the target insect in large numbers in specialized production centers, the sterilization with ionizing radiation of one of the sexes and the sustained sequential release of the sterilized insects over the target area.

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## Introduction

Tsetse are flies that are strictly hematophagous and confined almost exclusively to sub-Saharan Africa (Selamawi, 2016) although the biology of tsetse flies and their relationships with other organisms make them inherently interesting, it is their role as vectors of pathogenic trypanosomes, which has been known for over 100 years, that has provided the main impetus for research on tsetse. Tsetses are large biting flies that inhabit much of mid-continental Africa between the Sahara and Kalahari deserts. Tsetse flies (*Glossina spp.*), which are represented by many species in Africa south of Sahara, are well known for their role as vectors of human and animal trypanosomosis. They live by feeding on the blood of vertebrate animals and are the primary biological vectors of trypanosomes, which cause human sleeping sickness and animal trypanosomosis, also known as nagana (Tesema and Yitayew, 2015).

The cyclical vectors of trypanosomes, tsetse flies belong to the family *Glossinidae*, the single genus Glossina with 23 species and subspecies. The species of genus *Glossina* are arranged in three subgenuses: *austenina* (the fusca group/forest flies), *nemorhina* (the *palpalis* group/*riverine* flies) and *glossina* (the *morsitans* group/savannah flies) based on the different ecological settings (Alsan, 2012). Tsetse transmitted animal trypanosomosis is one of the most significant and costly disease in sub-Saharan African hindering the effort made for food-sufficiency. Approximately, 30% of the total cattle population in Africa, 46 million head, is exposed to the risk of contracting nagana (trypanosomosis in cattle) and 3 million die every year. In addition, over 60 million people living in 36 sub-Saharan countries are threatened with sleeping sickness and 48,000 deaths were reported in 2002. About 10 million km2 land of sub-Saharan Africa is covered by tsetse which represents 37% of the continent including Ethiopia (WHO, 2001).

Ethiopia is found on the eastern part of Africa near the north east limit of the tsetse belt area and has the largest domestic animal population. In Ethiopia, 14 million cattle are exposed to trypanosomosis and 20,000 heads die every year because of tsetse transmission. Inter Africa Bureau for Animal Resource (IRLI, 2002) reported that at least 6 million of the 45 million heads of cattle that are raised under trypanosomosis risk in Africa are, now found in the west and south west Ethiopia.

Tsetse flies have progressively invaded productive agricultural areas of the country and severely affected sound agricultural production. Tsetse distribution in Ethiopia shows that the three groups: *morsitans*, *fusca* and *palpalis* are present with varied combination particularly in the Abay, Baro-Akobo, Didessa, and Ghibe-Omo river basins and rift valley (Abebe, 2005). Understanding the distribution, biology, life-cycle and the role of tsetse flies in trypanosomes transmission is important in planning and designing appropriate vector control strategies.

Therefore, the objectives of this paper are to compile information on:

- Tsetse distribution in Ethiopia
- Tsetse control strategies
- Tsetse rearing and management

## Classification of Tsetse Flies

Tsetse include up to thirty four species and sub-species depending on the particular classification used. All current classifications place all the tsetse species in a single genus named *Glossina*. Most classifications place this genus as the sole member of the family *Glossinidae*. The *Glossinidae* are generally placed within the superfamily *Hippoboscoidea,* which contains other hematophagous families (Solomon, 2014).

The tsetse genus is generally split into three groups of species based on a combination of distributional, behavioral, molecular and morphological characteristics. The genus includes:

## Tsetse Distribution in Ethiopia

The tsetse flies in Ethiopia are confined to the southern and western regions between longitude 33$^{o}$ and 38$^{o}$ E and latitude 5$^{o}$ and 12$^{o}$ N which amounts to about 200,000 km2. Tsetse infested areas lie in the lowlands and also in the river valleys of Abay (Blue Nile), Baro-Akobo, Didessa, Ghibe and Omo (Temesgen *et al.*, 2014).

The 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. Restricting a further eastward spread is the cold limit imposed by highlands that rise to the height above which tsetse cannot survive, or the semi-desert condition along the southern border east of the Rift Valley (Fedesa *et al.,* 2015).

To date five species of *Glossina* (*G. m. submorsitans, G. pallidipes*, *G. tachinoides*, *G. f fuscipes and G. longipennis)* have been recorded from Ethiopia but only four are wide spread and significant economic importance. These are *G. m. submorsitans* and *G. tachinoides*, which have a west to east distribution across Africa south of the Sahara desert, and *G. pallidipes* and *G. f. fuscipes* which often occur together in East Africa, although the former extends far to the south whereas the latter has essentially central African distribution (Solomon, 2014). Out of the nine regions of Ethiopia five (Amhara, Beneshangul-Gumus, Gambella, Oromiya and SNNPR) are infested with more than one species of tsetse flies. 23 different species of the genus *Glossina* are recognized, belonging to three groups (Nigatuwa and Wondimagegnehu, 2016). The different groups of tsetse flies exploit ecologically different habitats in Ethiopia around Abay/Didessa; Baro/Akobo and Ghibe/Omo rift valley as savannah group (*morsitans* group): *Glossina morsitans sub morsitans, G. paldipies;* the riverine group (*palpalis* group*): G. fucipies; G. tachinoides;* and the forest group (*fusca* group): *G. longipennis*. In some situations species of the various groups overlap and co-exist in different parts of the same ecosystem (Abebe, 2005).

Ethiopian tsetse and trypanosomosis situation shares many characteristics with the rest of African countries occupied by the different species of the tsetse flies. Until 1976, a total of 98,000 km2 area of the country was infected by five species of tsetse flies (Kebede and Geremew, 2015). In more recent years, tsetse flies have progressively invaded productive agricultural areas in the west, south and south west parts of Ethiopia.

Consequently, it is estimated that a total area of 220,000 km2 is currently infested with different species of tsetse flies (NTTICC, 2004). As a result a total of 14.8 million cattle, 6.12 million goats, 1 million camels and 1.23 million equines are at risk of contracting trypanosomosis in Ethiopia (Abebe, 2005).

The general distribution of tsetse flies is determined principally by climate and influenced by altitude, vegetation and the presence of suitable host animals. The tsetse distributions are found along the main river basins of oromia (IRLI, 2002). The different species of tsetse have preferred host, with most species feeding on subset of bovids or suids available in many localities.

Riverine species also utilize reptiles, and odd hosts such as hippos. However, many tsetse species will feed opportunistically and hence will adapt to whatever hosts are available. In the absence of suitable wild life, tsetse will feed almost exclusively on livestock and humans, and therefore establish pre-domestic disease cycles with often very high infection rate in animals (Fedesa *et al.*, 2015).

## The Role F Tsetse in Trypanosomes Transmission

Tsetse flies are biological vectors of trypanosomes. They, in the process of feeding, acquire and then transmit small, single-celled organisms from infected vertebrate hosts to uninfected animals. Some tsetse transmitted trypanosome species cause trypanosomosis, an infectious disease. In humans, tsetse transmitted trypanosomiasis is called sleeping sickness (Mulugeta, 2014).

In animals, tsetse vectored trypanosomosis include nagana, souma, and surra according to the animal infected and the trypanosome species involved, although the usage is not strict and nagana is occasionally used for any form of animal trypanosomosis (Tesema and Yitayew, 2015). These trypanosomes are highly evolved and have developed a life cycle that requires periods in both the vertebrate and tsetse hosts.

The relative importance of these two modes of transmission for the propagation of tsetse-vectored trypanosomiases is not yet well understood. However, since the sexual phase of the trypanosome lifecycle occurs within the tsetse host, biological transmission is a required step in the life cycle of the tsetse vectored trypanosomes (van den Bossche, 2004). Tsetse transmits trypanosomes in two ways, mechanical and biological transmission.

### Mechanical Transmission

Mechanical transmission involves the direct transmission of the same individual trypanosomes taken from an infected host into an uninfected host. The name *mechanical* reflects the similarity of this mode of transmission to mechanical injection with a syringe. Mechanical transmission requires that tsetse feed on an infected host and acquire trypanosomes in the blood meal, and then, within a relatively short period, for tsetse to feed on an uninfected host and regurgitate some of the infected blood from the first blood meal into the tissue of the uninfected animal (Lehane, 2005). This type of transmission occurs most frequently when tsetse are interrupted during a blood meal and attempt to satiate themselves with another meal. Other flies, such as horse-flies, also can cause mechanical transmission of trypanosomes (van den Bossche, 2004). Examples of trypanosomes transmitted by this mode are; *T. vivax, T. evans, T. uniforme, T. equinum, T. equiperdum.*

### Biological Transmission

Biological transmission requires a period of incubation of the trypanosomes within the tsetse host. The term biological is used because trypanosomes must reproduce through several generations inside the tsetse host during the period of incubation, which requires extreme adaptation of the trypanosomes to their tsetse host. In this mode of transmission, trypanosomes reproduce through several generations, changing in morphology at certain periods. This mode of transmission also includes the sexual phase of the trypanosomes (Kedir *et al.*, 2016). Tsetses are believed to be more likely to become infected by trypanosomes during their first few blood meals. Tsetses infected by trypanosomes are thought to remain infected for the remainder of their lives. Because of the adaptations required for biological transmission, trypanosomes transmitted biologically by tsetse cannot be transmitted in this manner by other insects (Duguma *et al.*, 2015).

The cycle of biological transmission of trypanosomosis involves two phases, one inside the tsetse host and the other inside the vertebrate host. Trypanosomes are not passed between a pregnant tsetse and her offspring so all newly emerged tsetse adults are free of infection. An uninfected fly that feeds on an infected vertebrate animal may acquire trypanosomes in its proboscis or gut. These trypanosomes, depending on the species, may remain in place, move to a different part of the digestive tract, or migrate through the tsetse body into the salivary glands

(Tekebe *et al.,* 2012). When an infected tsetse bites a susceptible host, the fly may regurgitate part of a previous blood meal that contains trypanosomes, or may inject trypanosomes in its saliva. The trypanosomes are injected into vertebrate muscle tissue but make their way, first into the lymphatic system, then into the bloodstream, and eventually into the brain. The disease causes the swelling of the lymph glands, emaciation of the body, and eventually leads to death. Uninfected tsetse may bite the infected animal prior to its death and acquire the disease, thereby closing the transmission cycle (Tesema and Yitayew, 2015).

The tsetse vectored trypanosomoses affect various vertebrate species including humans, antelopes, cattle, camels, horses, sheep, goats, and pigs. These diseases are caused by several different trypanosome species that may also survive in wild animals such as crocodiles and monitor lizards. The diseases have different distributions across the African continent and are therefore transmitted by different species of tsetse. Some species of trypanosomes those are transmitted by biological mode of transmission; *T. congolense, T. cruzi, T. brucei.* (Dagnachew and Shibashi, 2011)

## Control Strategies

Tsetse control has been undertaken to reduce the incidence of the diseases the flies transmit. Two alternative strategies have been used in the attempts to reduce this African trypanosomosis. One, targeting the disease directly using monitoring, prophylaxis, treatment, and surveillance to reduce the number of organisms that carry the diseases (Kebede and Geremew, 2015). The second strategy is generally entomological, and intends to disrupt the cycle of transmission by reducing the number of flies. The idea of tsetse control implies a change in the relationship between people and these insects. Prior to the twentieth century, people in Africa had largely adapted to the presence of tsetse.

Human settlement patterns and agricultural practices had adapted to the presence of the fly. For example, in Ethiopia draft powered farming was restricted to the highland areas where the flies were absent, whereas lowland areas where tsetse are present were more sparsely populated by people living a nomadic, less agriculturally intensive lifestyle (Tekele and Mokonen, 2013). Tsetse control is a response to changing conditions. Tsetse control has been proposed as a way of reducing the incidence of the disease in the populations living in tsetse regions, of allowing the expansion of human settlement and agriculture into new areas, and of helping people previously relocated either in forced transfers or due to migration (Miles, 2004).

Tsetse control efforts have been undertaken throughout the African continent, but long-term, sustainable control has rarely been achieved. Tsetse control efforts invariably are tied to the complex problems of poverty, health, politics, and violence that have proved so disastrous for the African people. The reduction of fly numbers has generally been attempted with two different aims, either total eradication from the area, or control to just reduce the numbers (Bekele *et al.,* 2008). Eradication has often been imagined, has repeatedly been attempted, and is still proposed but many reasons suggest that control is a safer, cheaper, more realistic, and sustainable approach. Eradication refers to the successful killing of every tsetse, either in a region or, under more grandiose proposals, from the entire African continent. Local eradication efforts have repeatedly been undertaken and have achieved temporary success, only to fail in the long term because tsetse re-invaded (as in Zanzibar) (Miles, 2004).

All of the economic, ecological, political, and environmental justifications for eradication have been called into question. The economic justification for eradication offsets the immense costs of the eradication campaign against the medical and veterinary benefits that accrue in perpetuity. However, eradication campaigns may have unintended social consequences, as a successful campaign may open up lands for agriculture previously populated by nomadic hunters, which displaces the original population. (Mulugeta, 2014)

## Use of Insecticides

The use of special insecticide formulations applied to artificial attractive devices (insecticide-impregnated targets with or without available odor attractants) or to cattle is an efficient and sufficiently specific method to suppress tsetse target populations in most situations (Bekele *et al.,* 2010).

Success largely depends on the density and placement of the impregnated attractive devices in the fly habitat the availability of attractants for the target tsetse species (Torr *et al.,* 2006) the size of the control area; reinvasion pressure and the population dynamics of tsetse populations in adjacent areas tsetse host and pastoralist practices, i.e. the time and location of grazing and peaks of tsetse activity.

Fortunately, observations (NTTICC, 2012) show that *Glossina pallidipes* populations in Kenya apparently do not exhibit a reduced feeding response to the presence of pour-on insecticide formulations on cattle, indicating that "behavioural" insecticide resistance has not yet developed. However, it is likely that one or more of the pyrethroid resistance mechanisms already known from several other species of *Diptera* will manifest themselves in tsetse (STEP, 2007) in response to the increased selection engendered by wider adoption of deltamethrin-treated targets for tsetse control at the village level. As with trypanocides, the widespread, unsupervised and insufficiently coordinated use of insecticides on targets or animals risks promoting the development of insecticide resistance.

### Stationary Attractive Devices

The development of insecticide impregnated, odour-baited traps targets and insecticide treated cattle as pour-on (Geremew *et al.,* 2018) which attract and kill tsetse offer the prospect of cheaper alternative with less damage to the environment. On the other hand, baits (traps, targets or animals) are now-a- days used widely to replace ground broad casting of the insecticides. In Ethiopia, these techniques have been tried and are still in use in the different tsetse infested areas. The use of insecticide impregnated target and application of pour-on on cattle in the area has suppressed the tsetse population from 4.1 to 0.9 fly/ trap/day. As the result the prevalence of bovine trypanosomosis has dropped from 27 to 6 % in two years time (Abebe *et al.,* 2004). stressed that efficient tsetse control will lead to a reduction in use of trypanocidal drugs and this will leave their role as efficient means of cunning the disease in case of an outbreak. Several technical aspects are essential for the efficient application of this bait technology such as appropriate trap/target site selection, sufficient maintenance, periodic replacement and replenishment of the odors, appropriate reflectivity pattern of the used cloth, degradation of the insecticide deposits by UV light, etc The technique is suitable for deployment by the local farmer communities to protect small areas, but the high target densities required against certain species and in certain dense habitats make the use of these devices over large areas uneconomic (STEP, 2007).

### Live Bait Technique

This method is based on the insecticide treatment of livestock and exploits the blood sucking behaviors of both sexes of tsetse. Tsetse flies, attempting to feed on cattle or other treated domestic livestock are killed by picking up a lethal deposit of insecticide on the ventral tarsal spines and on pre-tarsi whilst feeding. The success of the method depends on a relatively large proportion of feeds being taken from domestic animals and a sufficient proportion of the livestock population being treated (Dagnachew and Shibashi, 2011). The use of persistent insecticides on livestock has proven to have a suppressive effect on certain tsetse populations in those areas with a high density of cattle and where adequate expert support was present, e.g. in Zimbabwe against *G. pallidipes* Austen (Geremew *et al.,* 2018) in Burkina Faso against *Glossina morsitans sub morsitans* Newstead and *Glossina palpalis gambiensis* Vanderplank and against *Glossina fuscipes fuscipes* Newstead and *G. pallidipes*in Ethiopia (ILRI, 2002). Unlike with stationary attractive devices, the technique is less prone to theft and does not suffer from maintenance problems. However, several issues such as the required cattle density, the proportion of the herd that requires treatment, host preference of different tsetse species, etc. require further research. Other disadvantages are the high treatment frequency, the high cost of the insecticides, insecticide residues in cattle dung, motivation and participation of farmers and the potential development of resistance to the insecticides in both tsetse and ticks (Oloo *et al.,* 2000).

### Sterile Insect Technique (SIT)

The sterile insect technique has been used to reduce tsetse populations. This technique involves the rearing of large numbers of tsetse, separation of the males, irradiation of these flies with large doses of gamma rays to make them sterile and then release into to the wild. Since females only mate a few times in their life, generally only once, any mating with a sterile male prevents that female from giving birth to any offspring (Mehta and Parker, 2006).

The SIT relies on the production of large numbers of the target insect in specialized production centers, the sterilization of the males pupae or adult fly (or sometimes both sexes), and the sustained and systematic release of the sterile males over the target area in numbers large enough in relation to the wild male population to out compete them for wild females Mating of the sterile insects with virgin, native females will result in no offspring (Kebede and Geremew, 2015). With each generation, the ratio of sterile to wild insects will increase and the technique becomes therefore more efficient with lower population densities (inversely density dependent). This novel approach has been used successfully in Burkina Faso, Tanzania, Nigeria and, most recently, in Zanzibar where it eradicated *Glossina austeni* from the 1600 km2 Unguja Island (PAAT, 2003). The SIT is no intrusive to the environment, has no adverse effects on non-target organisms, is species-specific and can easily be integrated with biological control methods such as parasitoids, predators and pathogens.

There is no development of resistance to the effects of the sterile males provided that adequate quality assurance is practiced in the production process and the sterile insects cannot get established in the released areas as with other biological control programmes (Vreysen *et al.,* 2000). The release of sterile insects is however only effective when the target population density is low, it requires detailed knowledge on the biology and ecology of the target pest, and the insect should be amenable to mass rearing. In addition, the SIT necessitates efficient release and monitoring methods, which have to be applied on an area-wide basis (Taye and Kumala, 2017).

In Ethiopia, a major SIT project coordinated by the Ministry of Science and Technology and implemented by the Agricultural Bureau of the Southern Nations and Peoples Administrative Region of Ethiopia in the Southern Rift Valley has been initiated (ILRI, 2002).

Southern Rift Valley Ethiopia Tsetse Eradication Project (STEP) is a ten-year tsetse Eradication programme of two five-year phase prepared in line with the understanding between the Ethiopian Government and the International Atomic Energy Agency (IAEA) of the United Nations (STEP, 2007). The SIT is envisaged to supplement the national effort of tsetse and trypanosomosis management, using area wide eradication approach of the resident fly species in the Rift Valley (Getachew *et al.,* 2004). The programme has two main components:

Establishment of sterile insect production plant, which is centrally organized and operated and The actual field operation of the fly eradication process, which is implemented on regional level.

## Biological Control Methods

Biological control of tsetse flies seems to be feasible only by means of predator, parasites, parasitoids or pathogens, which are either exclusively or at least to a large extent, specialized on tsetse flies (Kassaye, 2015).

## Slaughter of Wild Animals

One early technique involved slaughtering all the wild animals tsetse fed on. For example, the island of Principe off the west coast of Africa was entirely cleared of feral pigs in the 1930s, which led to the extirpation of the fly. While the fly eventually re-invaded in the 1950s, the new population of tsetse was free from the disease (Lelisa *et al.,* 2014).

## Land Clearing

Another early technique involved complete removal of brush and woody vegetation from an area. Tsetse tends to rest on the trunks of trees so removing woody vegetation made the area inhospitable to the flies. However, the technique was not widely used and has been abandoned (NTTICC, 2012). Preventing regrowth of woody vegetation requires continuous clearing efforts, which is only practical where large human populations are present. The clearing of woody vegetation has come to be seen as an environmental problem more than a benefit (Hunt, 2004).

## Pesticide Campaigns

Pesticides have been used to control tsetse starting initially during the early part of the twentieth century in localized efforts using the inorganic metal based pesticides, expanding after the Second World War into massive aerial and ground based campaigns with organochlorine pesticides such as DDT applied as aerosol sprays at Ultra-Low Volume rates. Later, more targeted techniques used *pour-on* formulations in which advanced organic pesticides were applied directly to the backs of cattle (Hunt, 2004).

## Trapping

Tsetse populations can be monitored and effectively controlled using simple, inexpensive traps. These often use electric blue cloth, since this color attracts the flies. Early traps mimicked the form of cattle but this seems unnecessary and recent traps are simple sheets or have a biconical form. The traps can kill by channeling the flies into a collection chamber or by exposing the flies to insecticide sprayed on the cloth. Tsetse's are also attracted to large dark colors like the hides of cow and buffaloes. Some scientists put forward the idea that zebra have evolved stripes, not as a camouflage in long grass, but because the black and white bands tend to confuse tsetse and prevent attack (Torr *et al.,* 2006).

**Table.1** Taxonomic classifications of tsetse fly.

| **Kingdom** | **Animalia** |
|---|---|
| **Phylum** | Arthropoda |
| **Class** | Insect |
| **Order** | Diptera |
| **Subsection** | Calyptratae |
| **Superfamily** | Hippoboscoidae |
| **Family** | Glossinidae |
| **Genus** | Glossina |
| **Species groups** | *G.morsitans* (savannah) *G.fusca* (forest) *G.palpalis*(riverine) |

Source: Gooding and Krafsur (2004)

**Table.2** Major tsetse flies species

| **The *savannah* flies: (Subgenus *Morsitans*, occasionally named *Glossina*):** | **The *forest* flies: (Subgenus *Fusca*, previously named *Austenia*):** | **The *riverine* flies:(Sub-genus *Palpalis*, previously named *Nemorhina*):** |
|---|---|---|
| ➢ ***Glossina austeni***<br>➢ ***Glossina morsitans***<br>➢ ***Glossina pallidipes***<br>➢ ***Glossina swynnertoni*** | ➢ ***Glossina fuscafusca***<br>➢ ***Glossina fuscipleuris***<br>➢ ***Glossina frezili***<br>➢ ***Glossina haningtoni***<br>➢ ***Glossina longipennis***<br>➢ ***Glossina medicorum***<br>➢ ***Glossina nashi***<br>➢ ***Glossina nigrofuscanigrofusca***<br>➢ ***Glossina severini***<br>➢ ***Glossina schwetzi***<br>➢ ***Glossina tabaniformis***<br>➢ ***Glossina vanhoofi*** | ➢ ***Glossina caliginea***<br>➢ ***Glossina fuscipesfuscipes***<br>➢ ***Glossina fuscipes martini***<br>➢ ***Glossina fuscipesquanzensis***<br>➢ ***Glossina pallicerapallicera***<br>➢ ***Glossina palliceranewsteadi***<br>➢ ***Glossina palpalispalpalis***<br>➢ ***Glossina palpalisgambiensis***<br>➢ ***Glossina tachinoides*** |

Source: Gooding and Krafsur (2004).

**Table.3** Tsetse infected region and major river basins of Ethiopia.

| **Region** | **Major river basins** | **Tsetse fly species** |
|---|---|---|
| **Amhara** | Abay/Blue nile | *G.m.submorsitans,.G.tachinoides* |
| **Oromia** | Abay/Didessa | *G.m.submoristans* |
| | Upper Ghibe/Omo | *G.tachinoides* |
| | Baro/Akobo | *G.f.fuscipes* |
| **SNNPR** | Ghibe/Omo | *G.pallidipes, G.longipennis* |
| | Rift valley | *G.pallidipes* |
| **Benishangul-gumuz** | Abay/Bluenile | *G.m.submoristans, G.tachinoides* |
| **Gambella** | Baro/Akobo | *G.m.submorsitans,, G.pallidipes, G.f.fuscipes* |

Sources: Abebe (2005)

The use of chemicals as attractants to lure tsetse to the traps has been studied extensively in the late 20th century, but this has mostly been of interest to scientists rather than as an economically reasonable solution. Attractants studied have been those tsetse might use to find food, like carbon dioxide, octenol, and acetone—which are given off in animals' breath and distributed downwind in an *odor plume*. Synthetic versions of these chemicals can create artificial odor plumes. A cheaper approach is to place cattle urine in a half gourd near the trap. For large trapping efforts, additional traps are generally cheaper than expensive artificial attractants (Temesgen *et al.*, 2014).

A special trapping method is applied in Ethiopia, where the BioFarm Consortium (ICIPE, BioVision Foundation, BEA, Helvetas, DLCO-EA, and Praxis Ethiopia) applies the traps in a sustainable agriculture and rural development context (SARD). The traps are just the entry point, followed by improved farming, human health and marketing inputs. This method is in the final stage of testing (as per 2006) (STEP, 2007).

## Tsetse Rearing and Management for Trypanosomes Control

Successful rearing of large number of insects for their continuous availability in the laboratory depends on the knowledge of insect biology, behavior, habitat and nutrition. An understanding of the mating habits, preoviposition and ovipositor periods, fecundity, longevity, sex ratio, environmental requirements, and food and feeding preferences of the insect is necessary in developing rearing techniques (Orozco-Davila *et al.*, 2007). Conservation of space is also a major consideration, especially when several days are required from the time of eggs in rearing containers until the desired life stage has been harvested (Alsan, 2012). During the process of establishing a strain, along the rearing process, and during treatment before release, the insects are subjects to highly artificial conditions, including extreme population densities, a sterilization process and sometimes genetic manipulation. These all factors highly affect the biological manes of the treated insects and their performance during Sterile Insect Technique operation (LUX *et al.*, 2002). The difficulties of mass rearing of an insect vary depending up on the nature of reproduction of an insect. For example, as compared to screwworm flies, moths, mass rearing of tsetse flies have more advantageous. The screwworm requires special resources and rearing conditions at all stages of its development but in the case of tsetse fly, only the pupal and adult stages have to be considered because the egg and larval stages remain within the pregnant female fly (Feldmann and Hendrichs, 2001). The larvae of tsetse fly do not have to be fed as they develop within the female fly. Adult tsetse flies do not required water or carbohydrates, only high-quality blood. Originally, living animals had to be used to provide tsetse flies with a movement. With the development of membrane feeding system, which flies accept as host skin and through which they ingest the blood, living animals are no longer required as hosts. Unlike the ingredients of screwworm diet, most of which have to be imported using hard currency, animal blood for tsetse rearing can be collected at a local abattoir and then treated with gamma radiation to eliminate any micro organisms. Once tsetse mass rearing has reached, there will be local commercial sources in Africa selling the required quantity of sterilized blood. At presented this product is lost at the slaughterhouse without any benefit to local economies (Taye and Kumala, 2017).

## Recommendations

The tsetse vectored trypanosomosis affect various vertebrate species including humans, antelopes, bovine cattle, camels, horses, sheep, goats, and pigs. Vector control remains the most promising approach to containing trypanosomosis, methods currently in use such as trapping and insecticides, are limited in that they require extensive community participation. For introducing effective control and eradication programs, the knowledge of the biology, ecology, host-vector-parasite interactions is very important. Successful rearing of large number of insects for their continuous availability in the laboratory depends on the knowledge of insect biology, behavior, habitat and nutrition. An understanding of the mating habits, preoviposition and ovipositor periods, fecundity, longevity, sex ratio, environmental requirements, and food and feeding preferences of the insect is necessary in developing rearing techniques.

So, based on the above conclusions the following recommendations are forwarded:

- Continuous reviews should be carried out and appropriate technologies and approaches should be adopted based on the results of regular monitoring and evaluation of ongoing projects.
- The choice of the intervention methods to be used in the tsetse eradication projects will be based on considerations of their direct and indirect impact on the environment as well as on their cost benefit analysis.
- Local communities need to be encouraged to support for tsetse eradication.
- Bilateral agreements between governments and donors to support tsetse eradication should be put in place.

- Future investigation should focus on organisms with potential treats to tsetse population
- Aerial **s**praying and ground spraying methods should be used in areas highly infested by tsetse flies.
- Male tsetse sterilization method has to be applied because of its effective eradication of tsetse population.

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