International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 7, Issue 11 -2020
Review Article
DOI: http://dx.doi.org/10.22192/ijarbs.2020.07.11.010

Review on Ecology and Control of Tsetse fly

Wondimu Hailu Enaro and Tekalign Woldehana Uro
Arba Minch University, College of Agricultural Science, Ethiopia.

Abstract

Tsetse flies are found only in Africa, where they occur in a belt south of the Sahara deserts. They feed solely on blood of domestic and wild animals as well as human beings. In this way the tsetse flies cause serious illness in domestic animals and man eventually leading to death. The disease is called naganain cattle and sleeping sickness in human. They are such an important insect that transmit the deadly disease trypanosomosis and thus have drawn world-wide attention due to their devastating effects they cause in large areas of tropical Africa. Therefore, the objectives of this study are to review tsetse fly biology and ecology that is helps to increase the understanding of control strategy of tsetse fly. Tsetse fly control has a great impact on economic development in terms of its cost, and some control techniques are ecologically unacceptable. Nowadays, the cheapest and quickest way of controlling trypanosomosis is reducing the number of tsetse fly vectors than treating the infected animals. The tsetse unique beaver of reproductive rate, low dispersal capacity, and low genetic variability, combined with exceptional susceptibility to available insecticides–tsetse would appear to be highly vulnerable targets for well executed control measures. Indeed, review of the history of past attempts to control tsetse reveals that, without exception, all tsetse control campaigns were successful – until they stopped.

Keywords: Tsetse fly, ecology, biology, insecticide, sterile insect techniques.

1. Introduction

African trypanosomiasis and its major vector, the tsetse fly, have drawn world-wide attention due to the devasting effects they cause in large areas of tropical Africa. Trypanosomiasis is a parasitic disease which causes serious illness in domestic animals and man, eventually leading to death. In cattle, the disease is called nagana and in man, sleeping sickness (Aksoy *et al*, 2003). They occur only in tropical Africa, and they are important as vectors of African trypanosomosis in both animals and man. In Africa, about 10 millionkm^2 of the land is infested by these flies, and their distribution and prevalence are most influenced by spatial factors such as climate, vegetation, rain fall and land utilization (Rogers *et al*., 1996).

Tsetse flies are biological vectors of African trypanosomosis in animals and man.Tsetse transmitted trypanosomosis (nagana) is one of the most ubiquitous and important constraints to agricultural development in sub humid and humid zones of Africa. In Ethiopia, a total area infested by tsetse flies is estimated to be 240,000km^2(about 21.7% of the territory) located in the Southern, South western, Western and North western parts of the Country where, 14 million heads of cattle, equivalent number of small ruminants, nearly 7 million equines and 1.8 million camels are at risk of contracting trypanosomosis at any given time (Radostits *et al*., 2007). Knowing the ecology of tsetse fly where they highly prefer for their survival and their interaction with the parasites that they transmit is crucial in the future designing and implementation of control strategies (Tewelde, 2001). Efforts have been made by various governmental and non-governmental organizations to control the nagana which is transmitted by the tsetse flies and there is a long history of tsetse control and eradication programmes.

Initially, flies were eradicated by game destruction (shooting the wild animals) and bush-cleaning (Pilossof, 2016). In case of game destruction, natural host animals were eliminated, thus depriving the flies of their primary food sources and bush-cleaning, barrier-zones were made by clearing bushes and trees, thus preventing migration of flies from one area to another. Both methods have largely been dropped because of their adverse environmental impact and the method was gradually being replaced by other methods (Welburn and Maudlin, 1999). However, tsetse control method was shifted in the twentieth century, ranging from the initial methods of game destruction and bush-clearing, to ground and aerial spraying of insecticides, the sterile insect technique (SIT), tsetse trapping, and the use of insecticides applied to cattle or to artificial baits called targets(Hordofa and Haile, 2015).Sterile insect techniques (SIT) are most simply described as a form of insect birth control that is carried out on an area-wide basis. The SIT involves mass breeding huge quantities of target insect in a “factory” and sterilizing the males by exposing them to low doses of radiation. These sterile male flies are then released by air over infested areas, where they mate with wild females (FAO, 2000).As sterilized flies should not differ too much from wild flies laboratory-reared and irradiated flies are checked for their quality and behavior as compared to their wild counterparts (Takken and Weiss, 1997). Females mated with sterile males are unable to produce offspring. Unlike all other tsetse control techniques, SIT has no effect on non-target organisms. Also unlike other techniques, SIT becomes more efficient at lower fly densities, and is ideally suited to the final phase of local tsetse eradication (Kuzoe and Schofield, 2004).Therefore, the objectives of this review are:

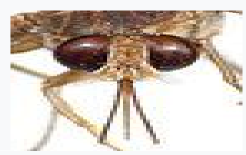
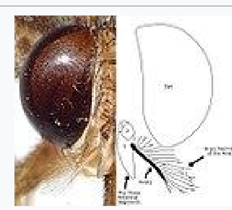
- ✓ To review Tsetse fly biology and ecology
- ✓ To assess some of the integrated control approach of Tsetse fly.

2. Tsetse biology and behavior

Tsetse fly morphology

Tsetse flies include all the species in the *genus-Glossina*, which are placed in their own family-Glossinidae. Tsetse can be distinguished from other large flies by two easily observed features. Tsetse folds their wings completely when they are resting so that one wing rests directly on top of the other over their-abdomens in ascissor like configuration. Tsetse also has a long-proboscis, which extends directly forward and is attached by a distinct bulb to the bottom of their heads (Hordofa and Haile, 2017).

Four characteristics definitively separate adult tsetse from other kinds of flies (Serap *et al*, 2014):

Proboscis	Tsetse has a distinct proboscis, a long thin structure attached to the bottom of the head and pointing forward.	
Folded wings	When at rest, tsetse fold their wings completely one on top of the other.	
Hatchet cell	The discal medial ("middle") cell of the wing has a characteristic hatchet shape resembling a meat cleaver or a hatchet.	
Branched arista hairs	The antennae have arista with hairs which are themselves branched.	

Tsetse flies are narrow bodied, yellow to dark brown and 6 to 13.5 mm long. The thorax has a dull greenish color with inconspicuous spots or stripes. The abdomen is light to dark brown with six segments that are visible from the dorsal aspects (Kahn, 2005).

Reproductive Cycle

One copulation is sufficient for the whole life of the female fertile but male mate several times during their life. Their life cycle is particularly unusual since they do not lay eggs. Instead, an inseminated female develops the egg and young larva within her uterus, laying the mature (3^{rd} stage) larva into moist soil or sand in shaded places, usually under bushes fallen, logs, large stones and buttress roots (Leak, 1999). The larva quickly burrows under the soil surface and begins pupation within 60 to 90 min and the adult emerges 20-45 days later depending on temperature (pupal development does not succeed below 17°C and above 32°C). Thus, each female produces only one offspring at a time, and can produce up to 12 offspring – at intervals of about 9-10 days – during her typical adult lifespan of 2-3 months. As a result, the intrinsic rate of tsetse population growth tends to be low, with the maximum rate of population increase estimated to be no more than 10-15 times per year (Kuzoe and Schofield, 2004). This means that even small increases in average daily mortality rate can cause a population to decline in number; even elimination of 1% of a population could provide effective control, while sustained elimination of 2-4% would generally lead to population extinction (Hargrove, 2003).

Feeding Behavior

Both sexes of the tsetse are blood feeders. They depend only on vertebrate bloods for their survival (Wall and Shearer, 1997). Adult tsetse feed every 2 or 3 days. 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, a long tube in the insect's proboscis. The salivary secretion contains a powerful anti- coagulant which keeps the blood fluid so the fly can continue feeding(Okhoya, 2004). Tsetse feed mostly in the daylight and rarely flies for more than 30 minutes a day and is known to disperse up to about 1km/day. They spend most of their time resting on vegetation. Recently engorged flies mostly rest with their heads directed upward, allowing excess water to be excreted away from their bodies. Hungry flies often rest horizontally, with the dorsal side down (Mullen and Durden, 2009).

When a tsetse fly feeds on an animal infected with trypanosomes, bloodstream forms of the parasite are ingested along with the bloodmeal and infection may become established in the fly. The saliva of an infected fly contains metacyclic trypanosomes, highly infective forms of the parasite, which are injected into the blood pool every time the fly feeds. Once infected, tsetse continues to transmit trypanosomes for the rest of their lives (Wall and Shearer, 1997).

Host attraction and host recognition are mediated by visual and olfactory cues. Their vision enables tsetse to react to a herd of moving cattle as far away as 180 meters (Mullen and Durden, 2009). Tsetse specious in the *morsitans* group, living in open spaces, has shown the greatest attraction to host odors. Certain tsetse species are attracted to components of ox breath, such as carbon dioxide, acetone and octenol and phenols found in mammalian urine (Belete *et al*, 2004). Host odors have been shown to be attractive to tsetse from distances up to 100 meters away.

Resting Places and Time

Tsetse flies pass most of their time at rest in shaded places in forested areas, and the preferred sites are the lower woody parts of vegetation’s, many of them hide in holes in the trunks of trees and between roots. They search for food only for very short periods during the day. The flies often rest close to food sources (Taylor *et al*., 2007). Common risk areas where animals and people are likely to be bitten by tsetse flies are on forest trails near water collection points in forest, and in vegetation close to bathing and water collection sites along the banks of rivers (Leak, 1999).

It is important to know about resting sites because these are the best places for spraying persistent insecticides for killing the tsetse. Insecticides placed at the resting sites and only at the resting sites will have the maximum effect against tsetse and minimum effect against other animal life.

3. Ecology of tsetse fly

Each specious of tsetse fly has a specific distribution area, characterized by climate, vegetation and soil which are important for larval deposit and pupal survival. The tsetse flies are found exclusively on the African continent, between 5°N to 20°S latitudes (Warnes *et al*, 1999). They are closely related to the vegetation which protects them from solar radiation and wind. The eco-climates generally corresponds to that of wood land areas situated in regions receiving more than 1000 mm of rain fall, but may also occur in areas with slightly lower rain fall (Meberate *et al*., 1999). The range of tsetse flies does not extend into areas with very high or low temperatures. Their geographical range is limited by the excessive drought conditions in the North, the cold temperature in the South and by high altitude regions (Maudlin, 2006).The tsetse flies only live in regions where the average annual temperature is above 20°C of which 25°C is the optimum temperature for their survival (Radostits *et al*., 2007). However, the rise in average temperatures may have two important impacts on the tsetse fly distribution:

1. It may make the Lowveld more inhospitable to flies and directly impact breeding patterns and survival rates. First, the high temperatures themselves killed flies, particularly teneral flies, unable to survive in high temperatures. Second, these heat waves also coincided with the lowest recorded rainfall in the area. As a result, fly numbers suffered not only from the effects of temperature, but also because of a decline in the number of mammalian hosts, which also died in large numbers due to the drought (Hargrove, 2003).

2. The rise in temperatures may make the Highveld areas currently unoccupied by flies more hospitable to fly invasion. Low winter temperatures on the Highveld have inhibited fly survival there. However, if these temperatures rise, so too do the chances of fly survival and reinvasion (Pilossof, 2016).

Based on climates, vegetations and fauna characteristics of ecology, tsetse flies are classified into three groups (Okoth *et al*, 1998). They are savanna, riverine and forest type. The savanna tsetse flies known as *Glossina morsitans*(*G.morsitans*) concentrate in the dry season, near the source of water courses, while during the rainy season they spread out in the wooden savanna. These group feeds mainly on large animals (Ford and Katonondo, 1971). They occur mainly in Sudanese savannas with *G. submorsitans* in West and Central Africa and *G.morsitans* in East Africa. *Glossina swynnertoni* and *Glossina pallidipes* are highland species of East Africa, the first being restricted to Kenya and Tanzania, and the second species occurring from Ethiopia to Mozambique and being present in some coastal areas (Smyth, 1995).

The riverine tsetse flies (*G. palpalis*), are widely distributed near the edge of river, where the vegetation is dense, rather than at the edge of the riverine forests. They occupy the forest areas of West and Central Africa, the riverine forest penetrating into the savanna regions. These flies feed primarily on reptiles and ungulates (Tikubet and Gemechu, 1994).

The forest tsetse flies (*fusca* group) are densely populated where vegetations are found in transition zones between true forest and wooden lands, preferring dense shade and riverine thickets. *G. longipennis* is species of the *fusca* group that restricted to Kenya, Ethiopia, South-Eastern Sudan, Southern Somali, North Western Uganda and Northern Tanzania (Aksoy *et al*., 2003).

Factors Affecting Tsetse Fly Distributions

The tsetse fly distribution and prevalence are most influenced by many ecological factors such as temperature, rainfall and vegetation type, which are the most important ones limiting their distribution (Rogers *et al*., 1994). Very cold and hot temperatures are not favorable for their activities as well as infective rates. The mortality rate is very high as temperatures exceeding 30 to 32°C (Leak, 1999). Their distributions reduce with low rainfall, and they are highly populated in the regions receiving more than 1000 mm rainfall (Ford and Katonondo, 1971). Vegetation is also another most important ecological factor that influences their distribution and abundance. Their habitat is suited in the areas with denseforest, bushy lands and Savanna grasslands which protect them from harms due to sun light and wind (Hordofa and Haile, 2015).

4. Impacts of tsetse flies

Disease Transmission

The Glossina Species that are important as vectors of African trypanosomosis includes *G. morsitans*, *G.palpalis, G.longipalpalis, G.pallidipes* and *G.austeni*. Since they do not feed on any other food rather than blood, they suck blood infected with the trypanosoma species and transmit this disease to previously uninfected animals (Woolhouse*t al*., 1994). Although, the infection rate of Glossina with trypanosomosis is usually low, ranging from 1 to 20% of the flies, each is infected for life, and their presence in any number makes the rearing of livestock extremely difficult. These infection rates are determined by the parasite, the vector, the host and the environmental factors (Krafsur, 2009).

In general, tsetse flies are important vectors of trypanosome species including *T. vivax, T. brucei* and T. *congolencei*, and transmit the disease nagana among animals and among men which can be fatal if not treated (FAO, 2000). These species of trypanosomes undergo a cyclic development and multiplication in the fly until the infective metacyclic trypanosomes are produced. The sites of the three trypanosomes species found in Ethiopia takes place in the fly as described as follows: The development of *T. vivax* is confined to the proboscis. The complete cycle of development takes 12 to 13 days at 22°C and 5 days at 29°C. The development *T.congolence* commences in the mid gut and complete in the hypophrynx (proboscis). The entire cycle of development takes 19 to 53 days. The development of T. brucei starts in the mid gut, pass through the esophagus and pharynx into the mouth parts, enter the hypophrynx at its open anterior end, and finally pass along the salivary ducts into the salivary glands where the final stage of development takes place. The entire cycle of development takes 17 to 45 days and even longer (Aksoy *et al*., 2003).

Economic Importance

Among the factors that limit the expected out come from animal production in tropical Africa is an animal disease. The disease in Africa costs livestock producers and consumers an estimated US$1340 million each year (Radostits *et al*., 2007).

Tsetse-transmitted animal trypanosomosis remains a major challenge to rural and agricultural development in western and south western parts of Ethiopia. Estimates made decades ago indicates that a total area of 240,000 km^2 is infested with different species of tsetse flies in which case livestock reared in this area are exposed to various levels of trypanosomosis risk. African trypanosomosis has both direct and indirect effects on the economic development of the tropical countries. Direct effect is that the infected livestock may have high mortality rate if not treated. Indirect effect is due to that nagana is a wasting disease and the affected animals are chronically unproductive in terms of milk, meat, manure and traction (FAO, 2000).Another indirect effect on the economic development of the country is the costs of drug to treat the disease and control of the tsetse flies. The added risk of human infections is due to sleeping sickness, the most fatal trypanosome disease transmitted by tsetse fly has also greatly affected social, economic and agricultural of the rural communities (WHO, 2000).

5. Control methods

A wide variety of tsetse control techniques have been initiated in Ethiopia and elsewhere to reduce tsetse populations, with earlier, crude methods recently replaced by methods that are cheaper, more directed, and ecologically friendly existing strategies thus far used are describes as follow with their advantages and disadvantages.

Bush and Game Clearance

In the late nineteenth century this technique was used to control tsetse included extensive bush clearance designed to eliminate the shaded places where tsetse rest and lays their larvae and extensive shooting of wild game animals designed to eliminate the wild blood sources used by the tsetse (Hocking *et al*, 1963). This early method indicates possibility of achieving eradication by the destruction of natural vegetation and elimination of wild blood source but the technique was not practice now a day because of several limitations and ecological consequences. Disadvantage of these method were more extensive, ecologically not better and hard to maintain. Such a method was officially fall by the government in many countries (Ford and Katanondo, 1971).

Live bait Techniques

The application of insecticides directly to cattle, the insecticide can be either is applied as a dip spray or as a pour-on formulation. The pour-on approach, applied monthly, is less error prone, and has been proven more flexible and adaptable in more remote regions, while allowing herders to adapt the approach as necessary (Aksoy *et al*., 2001). The spraying solution of deltamethrin is prepared by adding, for example, 50 ml of the concentration to every 10L of water in the knapsack sprayer and sprayed on the entire body of the animal. The insecticide treated animals are said to be mobile targets and are more attractive than the stationary targets and traps (Leak *et al*., 1995). However, this pour on method is relatively costly. The lower cost of the dip spray, and the ability to combine it with tick control, makes this a very cost-effective measure to curb animal trypanosomiasis (Chadenga, 1992).

Targets (Insecticide Treated Cloth)

It has been shown that the low reproductive rates of tsetse mean that the kill rate needs only to be relatively low in order to have a major control effect (Hargrove *et al*, 2003). This can be achieved with targets. The aim was to control tsetse flies by attracting them to visual targets, which are baited with odor attractants and coated with insecticide. The control of tsetse flies using cost-effective and practical devices target was initiated in 1970s (Nagagi *et al*, 2017). Targets are pieces of insecticide treated cloth measuring about 1.15 m^2 which are deployed in tsetse habitats. They are supported with either thin steel or wooded poles (Welburn and Maudlin, 1999). The color of the target is either black or a combination of blue black and deployed either hanged on the branches of a short tree, fixed to supporting poles or fixed to a thin stem of a plant (Hao*et al*., 2001).

Flies are attracted by the blue segments and land on the black segment. Preferably, only the black portion of the target should be painted with 0.4% of deltamethrin solution and when the flies come into the direct contact with the targets, they pick a sufficient amount of insecticide enough to knock down or kill the flies within few seconds to minutes. The technique is quite simple, effective, non pollutant, cost effective used for barrier establishment, integrated with other techniques and requires less frequent maintenance, but needs the use of insecticides and sometimes damaged bush fire, animals and people (Okhoya, 2004).

Control by Traps Insecticide Impregnated

Tsetse traps and targets (insecticide-impregnated screens) function by attracting the flies to a device that collects and/or kills them. Traps can be used for entomological surveillance, and also for control. Targets are simpler than traps, but are not used for surveillance. They are impregnated with biodegradable insecticides in order to kill any flies that alight on them. Traps can also be impregnated with insecticides. Traps and targets can both be used to eliminate a fraction of the tsetse population (Kuzoe and Schofield, 2004). Traps are devices made up of a piece of blue and black fabrics with white netting on the top creating a sharp corner, and act as an effective means of tsetse control. They are used to catch flies both for control and monitoring purpose (Vale *et al*., 1999).

Certain colors especially blue attract many tsetseflies. The blue screens of the traps are consternated with black screens to make flies settle. The flies subsequently move towards the upper parts of the trap in the direction of the light (Nagagi *et al*, 2017).Effective traps attract all the flies from a distance of approximately 50m. Flies that enter the trap may die because of exposure to an insecticide impregnated in the trap material or because they are exposed to the sun (Pilossof, 2016). Impregnated traps have the extra advantage of flies settling on the outside, but not entering are also killed. Attractiveodours are available for the control of the flies that transmit animal trypanosomosis. These attractants includes cow urine, acetone octenol and phenols. They are non-pollutant, and relatively cost effective (Robertson, 1991).

The effectiveness of traps and targets as control tools depends on their rate of removal of flies from the existing population. Evidence from field studies and theoretical work indicates a linear relationship between tsetse density and the likelihood of trypanosomiasis transmission. Trap and/or target deployment can therefore be recommended as a component of measures to control and prevent trypanosomiasis epidemics (Kuzoe and Schofield, 2004).

Ground Spray

The application of residual deposits of persistent insecticides to tsetse resting-places must be lethal if or the fly on short contact has a longer period than the maximum duration of the pupal life. In such conditions, only one spraying may be sufficient to control the species, and perhaps eradicate it in an isolated area. The first residual applications have been done against riverine species, like *G. palpalis* and *G. fuscipes*, with habitats restricted to water edge (Oladunmade *et al*, 1990). In larger gallery forests, it is sometimes possible to open paths in the forest, which will be extensively used by moving flies, and to treat then for controlling flies. DDT suspensions and emulsions, which have been used in the first experiments, have usually been replaced bydieldrin emulsions, which are assumed to be efficient almost one year, and sometimes more than one year if applied at 4% (Kernaghan, 1996). Tsetse fly control by residual insecticides has not been carried out against high forest species and is only promising when the fly habitats are restricted (Aksoy *et al*., 2003).

Sequential Aerial Technique (SAT)

Because of the tsetse flies exquisite susceptibility to modern insecticides, high levels of tsetse control can be achieved by sequential aerial spraying, the use of aircraft for the application of insecticide has obvious advantages, the chief of which is their ability to cover large areas quickly (Rogers *et al*, 1994). Using modern global positioning systems (GPS), SAT can now be applied highly accurately along pre-planned flight lines (Kuzoe and Schofield, 2004). Aerial applications of insecticides to control tsetse by the areas where tsetse live are sprayed with non-residual insecticide at interval designed to kill all adults initially and then subsequently to kill young adults after they emerge (Bourn and Scott, 1978). Insecticides aerosols have a very short residual effect and kill tsetse flies. It is essential that the area to be sprayed has economic potential and also negative impacts on the environment (Hao*et al*., 2001).

Control by Sterile Insect Techniques (SIT)

The principle of the SIT is that fertile female insects are unable to produce normal offspring when they have mated with sterile male. Therefore male flies are mass reared in the laboratory, sterilized by irradiation, and released to mate with wild females (Krafsur, 2009). Sterilized males are still able to do their "job" the insemination of females with sterile sperm. As sterilized flies should not differ too much from wild flies laboratory-reared and irradiated flies are checked for their quality and behavior as compared to their wild counterparts (Takken and Weiss, 1997). Females mated with sterile males are unable to produce offspring. When sufficient sterile males are released over a long enough period, fertile mating does not occur and the pupation is eliminated (Mehta and Parker, 2006).

The recurring costs of pupae production is high (currently approximately 0.25 US dollars each) and, in order to successfully compete with wild males, the numbers of sterilized pupae released must also be of a magnitude several times greater than the natural population (Mehta and Parker, 2006).

Unlike all other tsetse control techniques, SIT has no effect on non-target organisms. Also unlike other techniques, SIT becomes more efficient at lower fly densities, and is ideally suited to the final phase of local tsetse eradication (Kuzoe and Schofield, 2004).

6. Conclusion and Recommendations

This review paper has traced the history of tsetse biology and ecology to increase the understanding about tsetse control. Tsetse flies are hematophagous insects of the family glossinidae and are biological vectors of African trypanosomosis in both animals and man. Tsetse flies, through the cyclical transmission of trypanosomosis to both humans and their animals, greatly influence food production, natural resource utilization and the pattern of human settlement throughout much of sub-Saharan Africa. Knowing the vector parasite interaction and having a full understanding of the complex relationships between tsetse flies and there are various types of techniques that have been used to control tsetse flies in integrated ways, but all have their advantages and disadvantages. Based on the conclusion, the following recommendations are made:

- ✓ In addition to livestock health, tsetse have also public health impacts therefore, veterinarians should create awareness in communities about these vectors in order to help them protect themselves as well as their livestock.
- ✓ The tsetse control intervention was undertaken in the limited geographical coverage, it may be after control also possibility of tsetse reinvasion from neighboring area which control don’t undertaken.
- ✓ When planning to control tsetse flies in order to control tsetse-transmitted trypanosomosis, one should consider cost-benefit analysis and environmental impacts of the techniques of control.

7. References

Aksoy, S., Gibson, W.C., Lehane M.J. (2003): Interactions between tsetse and trypanosomes with implications for the control of trypanosomiasis. Adv. Parasitol. 53.1-83.

Aksoy, S., Maudlin, I., Dale, C., Robinson, A., O'Neill S. (2001): Prospects for control of African trypanosomiasis by tsetse vector manipulation. Trends Parasitol.17.29-35.

Belete, H., Tikubet, G., Petros, B., Oyibo, W.A., Otigbuo, I.N. (2004): Control of human African trypanosomiasis: trap and odour preference of tsetse flies (Glossinamorsitanssubmorsitans) in the upper Didessa river valley of Ethiopia. Tropical Medicine and International Health., 9(6). 710-714

Bourn, D., Scott, M. (1978): The successful use of work oxen in agricultural development of tsetse infected land in Ethiopia. Trop.Anim. Health Prod. 10.191-203.

Chadenga, V. (1992): Analysis of the efficacy, practicality ad cost of various tsetse and trypanosomiasis control techniques as used in Zimbabwe. Retrieved from http://www.fao.org/docrep/004/t0599e/T0599E08.htm.

Desta, M., Menkir, S., Kebede A. (2013): The study on tsetse fly (Glossina species) and their role in the trypanosome infection rate in Birbir valley, BaroAkobo River system, western Ethiopia. Journal of Veterinary Medicine and Animal Health.5(7). 186-194

FAO (2000): Training manual for tsetse control personnel. Food and agriculture Organization of the United Nations. Rome, Italy.1.

Ford, J., Katanondo, J.M. (1971): Maps of tsetse flies (Glossina) distribution in Africa. OAU/ISCTRC report. 105. 321-328

Hamon, J., Challier P., Mouchet J., Rageau J. (1965): Biology and Control of Tsetse Flies. Paris France.WHO inter regional seminar on entomological methods in vector control.VC/ENT.SEM/WP/4.65

Hao Z., Kasumba I., Lehane M.J., Gibson W.C., Kwon J., Aksoy S. (2001): Tsetse immune responses and trypanosome transmission: implications for the development of tsetse -based strategies to reduce trypanosomiasis. Proc. Natl. Acad. Sci.98.12648 -12653.

Hargrove, J.W. (2003): Optimised simulation of the control of tsetse fliesGlossinapallidipesand G. m.morsitans using odour-baited targets in Zimbabwe. Bulletin of Entomological Research.93.19-29.

Hocking K.S., Lamerton F., Lewis E.A.(1963): Tsetse-Fly Control and Eradication.Veterinary Research Station, Mpwapwa, Tanganyika.28.811-823

Hordofa, K.S., Haile, G. (2017): A review on epidemiological distribution, impacts and integrated control approach of tsetse fly. Journal of Parasitology and Vector Biology.9(9). 122-131

ILRAD Reports (1984): Tsetse flies vectors of trypanosomiasis. Nairobi, Kenya .Published by the International Laboratory for Research on Animal Diseases.2(3).167-177.

Krafsur, E.S. (2009): Tsetse flies: genetics, evolution and role as vectors. Infect. Genet.Evol.9.124-141.

Kuzoe, F.A.S., Schofield, C.J. (2004): Strategic review of traps and targets for tsetse and African trypanosomiasis control. World Health Organization on behalf of the Special Programme for Research and Training in Tropical Diseases.

Leak, S.G.A., (1999): Tsetse Biology and Ecology: Their Role in the Epidemiology and control of Trypanosomosis. CABI publishing in association with the ILRI. pp. 152-210.

Leak, S.G.A., Mulatu, W., Rowlands, G.J. &D'Ieteran, G.D.M. (1995): Atrial of cypermethrin 'pour-on' insecticide to control Glossinapallidipes, G. fuscipes and G. morsitanssubmorsitans in south-west Ethiopia. Bulletin of Entomological Research.85.241–251.

Leak, S.G.A., Mulatu, W., Rowlands, G.J., d'Ieteren, G.D.M. (1995): A trial of a cypermethrin pour-on insecticide to control G. pallidipes, G. fuscipes and G. morsitanssubmorsitans (Diptera Glossinidae) in South West Ethiopia. Bull. Entomol. Res. 85.241-251.

Maudlin , I. (2006): African trypanosomosis. Review Ann. Trop. Med. Parasitol. 8.679-708.

Meberate, A., MenjetaVreysen, M.J.B., Bencha, B., Woldyes, G., Bekele, K., Aboset, G. (1999): The distribution and relative abundance of tsetse flies in the Southern Rift valley of Ethiopia. 100(8). 679-701

Mehta, K., Parker, A.G. (2006): Sterile insect techniques. dose optimization, dosimetry and irradiation for improved sterile insect quality. Florida entomologists .89.537-542.

Mullen, G.R., Durden, L.A. (2009): Medical and Veterinary Entomology. In: Krinsky W.L. (2nd Edition). Tsetse Flies (Glossinidae). Academic press.288-299.

Nagagi, Y.P., Silayo, R.S., Kweka, E.J.(2017): Advancements in bait technology to control Glossinaswynnertoni Austen, the species of limited distribution in Kenya and Tanzania border: A review. J Vector Borne Dis. 54.16–24.

Okhoya, N. (2004).Small insect is a big problem for agriculture and health: Eradicating tsetse flies from Africa. Bull. Med. Mun. Switzer. 92. 12-14.

Okoth, J.O., Omare-Okuru, A., Eboyu, F. (1998): The use of theatre to mobilize and sensitize rural communities to participate in tsetse control in Bugiri district, Uganda: a case study. Annals of Tropical Medicine and Parasitology. 92. 127-128.

Oladunmade, M.A., Feldmann, U., Takken, W., Tenabe, S.O., Hamann, H.J., Onah, J., Dengwat, L., Vloedt, A.M.V.v.d., Gingrich, R.E. (1990): Eradication of Glossinapalpalispalpalis (Robineau-Desvoidy) (Diptera: Glossinidae) from agro-pastoral land in central Nigeria by means of the sterile insect technique. In Offori, E.D., Van der Vloedt, A.M.V. Eds. Sterile insect technique for tsetse control and eradication, IAEA: Vienna. 5-23.

Pilossof, R. (2016): A Brief History of Tsetse Control Methods in Zimbabwe and Possible Effects of Climate Change on Their Distribution. International Journal of African Development.University of the Free State, South Africa.4(1).432-443.

Radostits, O.M., Gay, C.C., Hinchcliff, K.W., Constable, P.D. (2007): Veterinary medicine. A text book of the disease of cattle, horse, sheep, pigs and goats, 10th edition. Saunders Elsevier, Edinburgh. 1531-1540.

Rogers, D.J., Hay, SI., Packer, M.J. (1996): Predicting the distribution of tsetse flies in West Africa using temporal Fourier processed meteorological satellite data. Trop.Med.Parasitol.96(3).225-241.

Rogers, D.J., G.Hendrickx, G., Slingenbergh, J.H.W. (1994): Tsetse flies and their control. Rev. sci. tech. Off. int. Epiz. 13(4).1075-1124.

Serap, A., Geoffrey, M.A., Sanger, M.B. (2014): Genome Sequence of the Tsetse fly (Glossinamorsitans): Vector of African Trypanosomiasis. Research Article.Science.344(6182). 380-386

Smyth, J.D. (2005). Introduction to animal parasitology, 3rd edition. Cambridge university press. 63-72

Takken, W., Weiss, M. (1997): The Sterile Insect Technique for Control of Tsetse Flies in Africa.IAEA bulletin.20(3). 20-24

Taylor, M.A., Coop, R.L., Wall, R.L. (2007): Veterinary parasitology, 3rd edition. Blackwell publishing.750-752.

Tikubet, G., Gemechu, T. (1984): Altitudinal distribution of tsetse flies in the Fincha valley (western part of Ethiopia). Insect Sci. Application.5.389-395.

Vale, G.M., Mutica, G., Lovemore, D.F. (1999): Insecticide treated cattle for controlling tsetse flies (Diptera: Glossina). Bull. Entomol.89.569-578.

Wale, R., Shearer D. (1997): Veterinary Etomology. Arthropod Ectoparasites of Veterinary Importance. Champman and Hall, London.141-193.

Warnes, M.L., Van Den Bossche, P., Chihiya, J., Mudenge, D., Robinson, T.P., Sherini, W. &Chadenga, V. (1999): Evaluation of insecticide-treated cattle as a barrier to reinvasion of tsetse to cleared areas in northeastern Zimbabwe. Medical and Veterinary Entomology. 13. 177–184.

Weitz, B.(1963): The feeding habits of Glossina. Bulletin of the world health organization.28.711-729.

Welburn, S.C., Maudlin I. (1999): Tsetse-trypanosome interactions. rites of passage. Parasitol.15.399-403.

WHO. (2000): Report on global surveillance of epidemic-prone infectious diseases – African trypanosomiasis. Geneva, World Health Organization. (http://www.who.int/emcdocuments/surveillance/docs/whocdscsrisr2001.html/African_Trypanosomiasis/A_Trypanosomiasis.htm)

Access this Article in Online	
	Website: www.ijarbs.com
Quick Response Code	Subject: Agriculture
DOI:10.22192/ijarbs.2020.07.11.009	

How to cite this article:
Wondimu Hailu Enaro and Tekalign Woldehana Uro. (2020). Review on Ecology and Control of Tsetse fly. Int. J. Adv. Res. Biol. Sci. 7(11): 73-82.
DOI: http://dx.doi.org/10.22192/ijarbs.2020.07.11.009