academicJournals

Vol. 9(9), pp. 122-131, September 2017
DOI: 10.5897/JPVB2015.0213
Article Number: 7BEBD6365569
ISSN 2141-2510

http://www.academicjournals.org/JPVB

Journal of Parasitology and Vector Biology

Review

A review on epidemiological distribution, impacts and integrated control approach of tsetse fly

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Received 10 July, 2015; Accepted 4 August, 2015

Tsetse flies are hematophagous insects of the genus *Glossina* that belong to the family Glossinidae. They are important because of their ability to spread disease among men and among domestic animals. Tsetse flies are strictly blood feeders, and in the act of piercing the skin and sucking blood, the flies transmit blood parasite trypanosomes to previously uninfected animals or man, causing the disease nagana, which is the most important economically devastating disease in tropical countries. The tsetse transmitted trypanosomosis, hinders the effort being made for food self sufficiency. In Ethiopia, about 240,000 km^2 of the land is infested with tsetse flies and the main pathogenic trypanosomiasis that need tsetse as a biological vector are Trypanosoma congolense, Trypanosoma vivax and Trypanosoma brucei. In current Ethiopia, trypanosomosis is one of the most important diseases which contribute to direct and indirect economic losses on livestock productivity, and the extent of the disease prevalence in relation to tsetse fly control. 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.

Key words: Glossina, insecticide, Nagana, sterile insect techniques, tsetse fly.

INTRODUCTION

Tsetse flies are blood sucking flies of the genus Glossina that belong to the family glossinidae (Radostitis et al., 2007). They occur only in tropical Africa, and they are important as vectors of African trypanosomosis in both animals and man. In Africa, about 10 km^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).

The occurrence and impacts of African trypanosomosis on the other hand, depends on tsetse challenge, host distribution, livestock breeds, farming practice and control practices. Tsetse challenge is determined by the product of relative tsetse density, trypanosome prevalence in tsetse and the proportion of meals obtained by the tsetse from a defined host (Leak, 1999).Tsetse transmitted trypanosomosis (nagana) is one of the most ubiquitous and important constraints to agricultural development in

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sub humid and humid zones of Africa. In Ethiopia, a total area infested by tsetse flies is estimated to be 240,000 km^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 (Radostitis 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 (Afewerk, 1998; 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 the most commonly used methods to control these vectors include insecticides, sterile insect techniques, trap and targets and disruption to their ecology (Oloo et al., 2000). Therefore, the objectives of this study are:

(1) To assess some of the integrated control approach of Tsetse fly.
(2) To review Tsetse fly biology, distribution and its economic impact.

REVIEW OF LITERATURE

Biology of tsetse fly morphology

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). When resting, their wings are held over the back in a scissor like configuration with a characteristics hatched shaped cell in the center of the wings (Itard, 1989). They can be identified by their honey bee like appearance and the long proboscis 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. The proboscis is composed of a lower U-shaped labium with rasp like labella terminally and an upper narrow labrum, which together creates a food channel. Within this food channel sits the slender hypophrynx that carries saliva and anticoagulant down into the wound formed during feeding. Each antenna of Glossina has a long arista that is feathered along one edge (Urquhart et al., 1996) (Figure 1).

Life cycle

Both sexes of the tsetse are blood feeders. They depend only on vertebrate bloods for their survival (Wall and Shearer, 1997). One copulation renders a female fly fertile for her life time during which she can produce as many as 12 larvae. The females, in contrast to other muscidae, are viviparous and produce only one larva at a time, up to a total of 8 to12 larvae (Kahn, 2005).

Maturation in the uterus from fertilized egg to the mobile, 8 to 10 mm long, 3rd stage larva deposited by the adult takes approximately 10 days. The larva develops in the uterus over a period of 10 days and then deposited fully grown on moist soil or sand in shaded places, usually under bushes fallen, logs, large stones and buttress roots (Leak, 1999). Larval development is completed in the abdomen of the mother, with all three stages feeding on fluids from special uterine glands. It buries itself immediately and begins pupation within 60 to 90 min. The pupal period is relatively long taking 4 to 5 weeks, or more in cool weather. The adult flies emerge at about 22 to 60 days, depending on the temperature. Breeding generally continuous throughout the year with peak fly numbers occurring at the end of the rainy season (Symith, 1996) (Figure 2).

Epidemiological distribution

General ecology

The tsetse flies are found exclusively on the African continent, between 5°N to 20°S latitudes (Wint and Rogers, 2000). 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 (Radostitis et al., 2007). 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 vegetations, 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).

Along with the macro habitat, it is also important to know which of the microhabitats of tsetse flies are

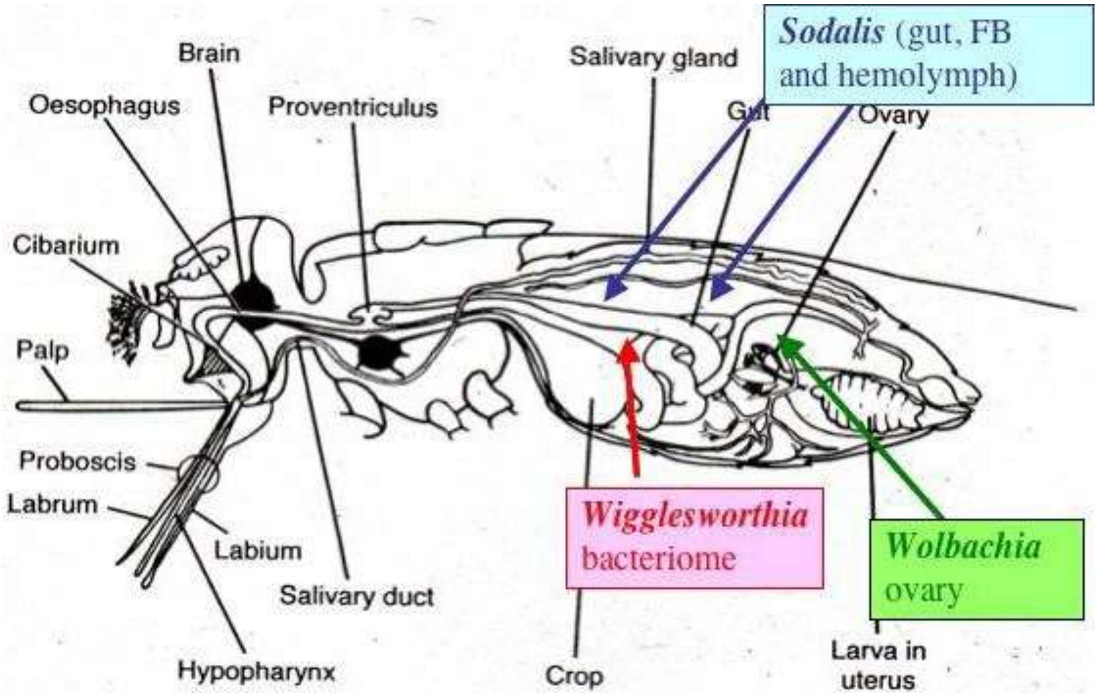

Figure 1. Anatomy and morphology of glossina (Itard, 1989).

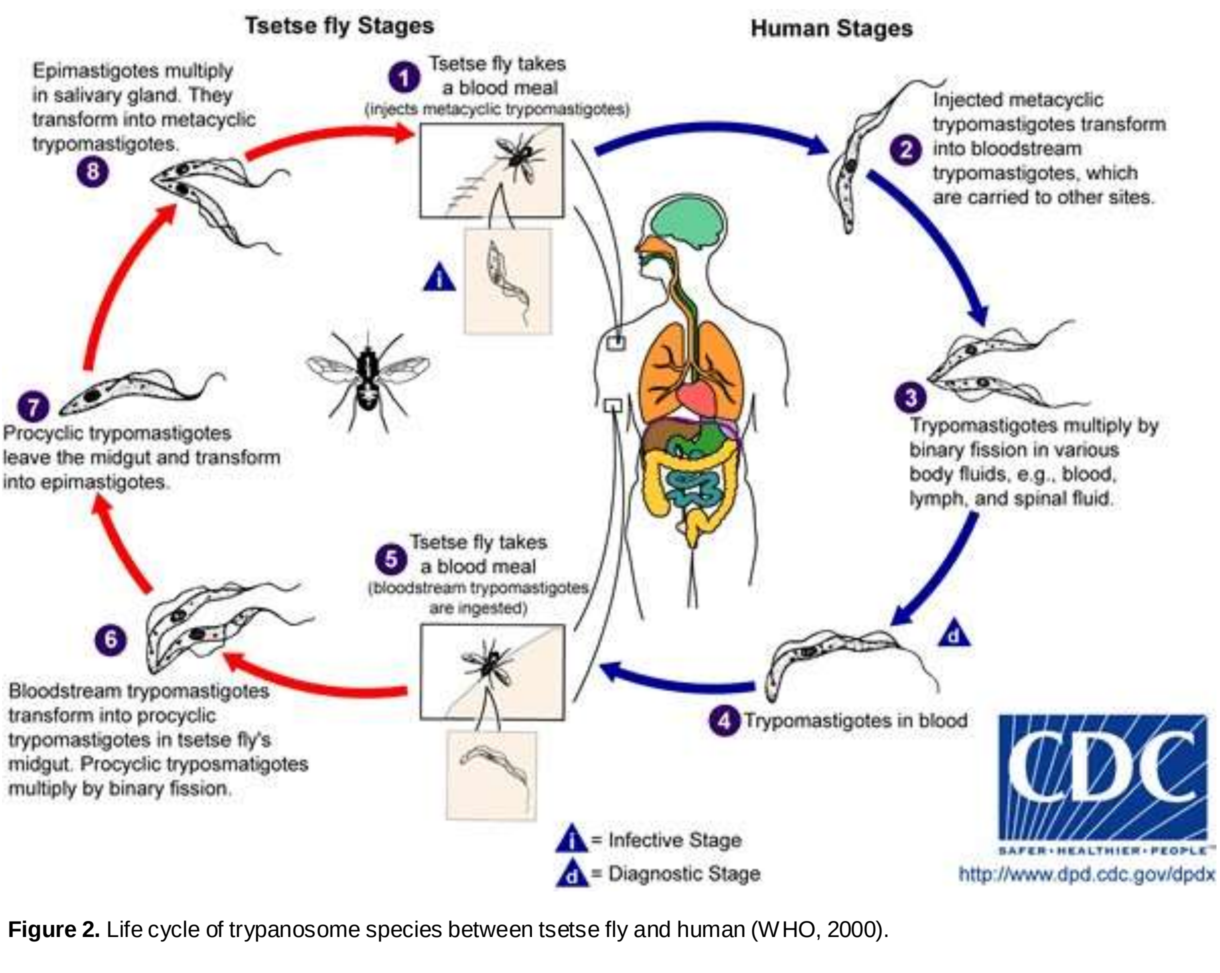

Figure 2. Life cycle of trypanosome species between tsetse fly and human (WHO, 2000).

suitable places for a species that can be depicted at a finer resolution. They can significantly differ from the surrounding areas in many ways, including the climate (Vanden et al., 2000). Suitable microhabitats for tsetse are able to provide cooler or more humid conditions, especially in particularly harsh seasons or times of the day. The fly's behavior can bring it into these places where it can survive better than if it had to suffer the general climatic conditions of the area. Vegetation is affected by temperature and humidity, the two major abiotic determinants of tsetse distribution; trees in particular provide shade for developing pupae and resting sites for adults. The analysis of the vegetation cover has often played a major role in the estimates of the tsetse distribution and in the description of their habitat (Taylor et al., 2007).

Ecological classification

Based on climates, vegetations and fauna characteristics of ecology, tsetse flies are classified into three groups (Wint and Rogers, 2000). 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 distribution

There are many ecological factors which influence the distribution of tsetse flies, of which temperature, rainfall and vegetation type are the most important ones limiting their distribution (Kahn, 2005). Very cold and hot temperatures are not favorable for their activities as well as infective rates. The mortality rate is very high at temperatures exceeding 30 to 32°C (Leak, 1999).Their distribution is limited by low rain fall, and they are highly populated in the regions receiving more than 1000 mm rain fall (Ford and Katonondo, 1971). Vegetation is also another most important ecological factor. Their habitat is situated in the areas where forest is dense, bushy lands and savanna grass lands which protect them from disasters due to sun light and wind (Wint and Rogers, 2000) (Tables 1 and 2).

Impacts of tsetse flies

Disease transmission

The relationship between tsetse flies and trypanosomosis was first suspected in 1879. In 1895, in Zululand, Bruce discovered the causative agent of nagana established the role of *G. morsitans* as a vector of the disease (Itard, 1989). In 1902, Dutton discovered trypanosomes in the blood of sleeping sickness patients. In 1903, Bruce, Nabarro and Greing showed that the trypanosomes of man are transmitted by tsetse flies (Itard, 1989). Of the three groups of tsetse flies, the savanna and riverine are the most important vectors of nagana since they inhabit areas suitable for grazing and watering of livestock (Taylor et al., 2007).

Species of Glossina 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 (Woolhous et 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 (Krafsur, 2009). These infection rates are determined by the parasite, the vector, the host and the environment (Msang, 1999).

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

Table 1. The distribution and habitat of tsetse flies in Africa (Vanden Bosche and Vale, 2000).

Group	Specie	Habitat
The fusca group	*G. nigrofusca* *G. haningtoni* *G. nashi*	Lowland rain forest and forested areas outside of it in central and West Africa
	G. tabani formis *G. severini* *G. vanhoofi*	Low land rain forest in central and West Africa
	G. fusca *G. frezili* *G. medicorum* *G. schwetzi* *G. fusciplerius*	Forested areas outside the lowland rain forest in central and West Africa
	G. brevipalpis	Islands of in East Africa including Ethiopia, often associated with water courses
	G. longipennis	Arid habitat in East Africa
The palpalis group	*G. palpalis*	Lowland rain forest and extends into drier savanna zones along riparian vegetation of West Africa
	G. fuscipes	Lowland rain forest and extends into drier savanna zones along riparian vegetation of central Africa and also occurs in western Ethiopia and in lacustrine vegetation of lake Victoria and Tanganyika
	G. pallicera	Restricted to rain forest of West Africa
	G. caligenea	Coastal mangrove and rain forest of west Africa
	G. techinoides	Mainly along the rivers and streams in the savanna of west Africa with isolated pockets in similar vegetation in western Ethiopia
The morsitans group	*G. m. morsitans*	Savanna wood lands in Mozambique and Zimbabwe in the South to southern Tanzania
	G. m. centralis	Savanna wood lands in Botswana, Namibia and Angola into southern Uganda
	G. m. submorsitans	Savanna wood lands in Ethiopia and Uganda in the East to Senegal. It occurs in moist vegetation of southern Guinea savanna and in the drier vegetation of the Sudan zone in the North where it is seasonally concentrated along water courses
	G. swennertoni	Restricted to acacia commiphora vegetation in northern Zanzibar and extends into south Kenya
	G. longi palpis	Occurs in thickets, riparian vegetation and forest edge vegetation in west Africa
	G. pallidipes	Occurs in Eastern Africa from Ethiopia to Mozambique in thicket from dry thorn scrub through every type of bush land to light rain forest or even to the margin of rain forest
	G. austeni	Occupies scrub thicket and islands of forest along the East Africa coast from Somalia to Mozambique

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

Table 2. Tsetse fly species found in Ethiopia (Leak, 1999).

Tsetse fly species	Marking of the back of the abdominal segment	Coloration of tarsal segments	Size of the fly (mm)	Others
G. pallidipes	The middle of the first segments yellowish	The last two segments of the tarsus of the front leg are not black	8.5-11	The thorax is wider than other species Upper claspers in the male are short, black and flat
G. morsitans	The middle of the first segment is yellowish. Other segments are black	The last two segments of the tarsus of the hind leg are black. The last segments of the front tarsus is black	8-11	Upper claspers in the male are short, black and flat
G. fuscipes	The middle of the first segment is gray or yellow. All other segments are black	All segments of the hind tarsus are black	8-11	Mating scar in the female. Upper claspers in the male are long, black and tapered
G. tachinoides	The middle of the first segment is yellowish square in shape. Black bands running running across the middle	All segments of the hind tarsus are black	6.5-6.9	Mating scar in the female. Upper claspers in the male are long, black and tapered
G. longipennis	Pale reddish brown and no black bands on the back of the abdomen	Stocking reach from the foot to the knee. Socks are short	11.5-13.5	The bulb of the proboscis is dark colored

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 (Radostits et al., 2007). Tsetse flies occur in 36 countries of 10 million squarekilometer (km^2) of Africa. The risk of trypanosomosis in much of these areas precludes farmers from keeping cattle, and small ruminants. This fact largely accounts for Africa's low livestock productivity. The animal protein produce per hectare on the continent is only one seventieth of that produced in Europe (Brown and Gilfoyle, 2010).

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).

Tsetse transmitted animal trypanosomosis is one of the most significant and costly disease in the country where tsetse flies are highly distributed, hindering the effort being made for food self-sufficiency. In Ethiopia, about 240,000 km^2 of the land is infested with tsetse flies and preclude farmers from rearing livestock. Disease could affect development through its historical effect on shaping institutions and/or through contemporaneous impacts on health (Bourn and Scott, 1978). 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).

Control methods

Chemical control methods

Currently, most anti-tsetse measures relay on the use of insecticides applied from the ground or by air craft. Insecticidal control is the only proven method available for large-scale use at the present time. Various methods of application are given and, of these, selective residual ground spraying and the aerosol aerial technique are more fully assessed (Vale et al., 1999).

Control by traps insecticide impregnated

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). Since tsetses have a high metabolic rate and feed exclusively on vertebrate blood, their survival depends on detecting and encountering suitable hosts on which to feed. This principle can be exploited in the design of traps which mimic key features of host animals, attracting the tsetse in such a way that they are then captured or killed. The flies search for blood meals or resting places partly or wholly by sight, and are attracted by large objects that move or contrast with the landscape (Leak, 1999). Certain colors especially blue attract many tsetse flies. 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 (Vanden-Bosche et al., 2001).

Effective traps attract all the flies from a distance of approximately 50 m. 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 (Terblanche et al., 2008). Impregnated traps have the extra advantage of flies settling on the outside, but not entering are also killed. Attractive odours 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 basic design of traps are applicable in all areas of Africa with tsetse flies, but some modifications maybe needed to make them more effective under local condition. The efficiency of the traps, however, varies for different species of tsetse flies. Some of the traps available and currently used for tsetse flies in the target area include monoconical, biconical, epsilon, pyramidal and vavoua (NTTICC 1996).

Targets (insecticide treated cloth)

Targets are pieces of insecticide treated cloth measuring about 1.15 m^2 which are deployed in tsetse habitat in a similar way as traps (Hao et al., 2001). 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.

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 (Vande and Vale, 2000).

Insecticides aerosols (SAT)

Aerial applications of insecticides to control tsetse is based on the sequential aerosol technique where 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, 1998). 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).

Some species of Glossina such as G. morsitans, *G. sywnertoni* and *G. pallidipes* in East Africa occur over wide area of country, often many hundreds of square miles in extent, and for the control of such species, the use of aircraft for the application of insecticide has obvious advantages, the chief of which is their ability to cover large areas quickly (Afewerk, 1998). An application from the air has been found to be uneconomical even where it is possible against species living in high forest such as *G. palpalis* (Rogers et al., 1994). It is less adequate than ground application against riverine species like *G. palpalis*, and only small amount of insecticides reaches each individual fly; gravid females are less susceptible to insecticides than males (Leak, 1995).

Ground spray

Residual treatment of tsetse fly 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. 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 by dieldrin 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 (Terblanche et al., 2008).

Live bait techniques

This involves treating livestock with appropriate insecticide formulations, mostly Deltamethrin 1% usually by means of dips, or as pour-on, spot-on or spray-on veterinary formulations along the back of the animal (Leak et al., 1995). The spraying solution of this deltamethrin is prepared by adding, for example, 50 ml of the concentration to every 10 L 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. These are highly effective against tsetse flies, and have the additional advantage of controlling other flies and cattle ticks (Aksoy et al., 2001).

Non chemical control methods

Control by sterile insect techniques (SIT)

The fact that all species of tsetse normally only mate once during their life, the sperm being stored in the spermathaecae of the female, gives rise to the possibility that sterilization of the males could result in a population decrease and eventual eradication. Several investigations and field trials into the practical feasibility of utilizing this technique have been conducted in recent years (Krafsur, 2009). Normally, the policy has been the rearing of large tsetse populations in the laboratory followed by sterilization of the pupae obtained, usually by the use of radioactivity, and the dissemination of these into the field where the sterile males produced compete with wild flies for the fertilization of females. The rearing of large numbers of flies under laboratory conditions, in order to obtain sufficient numbers of pupae and the dissemination of the pupae obtained over large areas have remained insurmountable problems (Hawse, 2005). Of the species of tsetse that exist, only a few have been laboratory bred in large numbers. In addition, the advanced technology and expertise required to successfully rear large colonies is not always available in many African countries. 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).

SIT relies on rearing large numbers of insects in purpose built “fly factories” sterilizing the males with carefully controlled doses of gamma radiation and finally releasing them over the targeted area (Hawse, 2005). The radiation induces sterility, but treated male flies can still fly and mate with the females. Mating between sterile released males and forest female tsetse flies produces no 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 technique is a safe and environmentally sound method that employs a nuclear technology as a form of insect control. Sterilization can be induced by chemicals or ionizing radiation. Chemical sterilization was used in early works, but because of the hazard of environmental contamination, it is replaced by irradiation (Dame and Schmidt, 1998). When biological material is irradiated, free radicals are formed, and breaks are created in the chromosomes of the germ line and this leads to the formation of dominant lethal mutations in eggs and sperm cells. Radiation is simple process with easy and reliable quality control procedures (Dwight and Bowman, 2003). If the control of tsetse by sterilisation is to be pursued, then, in view of recent advances made in the identification of tsetse attractive odours and the development of more efficient trapping systems, consideration should be given to the capture, chemo sterilisation and release of the natural population (Brightwell et al., 1997).

Control by bush clearing

Early studies into the behavior and ecology of tsetse flies indicated that the various species showed specific preferences for certain types of habitat related to the vegetation available. This indicated the possibility of achieving eradication by the destruction of this natural vegetation and its replacement by planned land resettlement (Hawse, 2005). This method, aimed at both control and eradication, was used more extensively in the early years, but has since been abandoned mainly for two reasons: first, the implementation of planned land resettlement and soil conservation was very seldom practiced thus leading to poor utilization and consequent soil erosion. Second, in many cases, where selective destruction of the habitat was carried out rather than sheer clearing, the tsetse demonstrated the ability to adapt to the new conditions (Itard, 1989).

The method has also proved to be expensive to implement, requiring the use of heavy mechanical equipment. Nevertheless, it is still considered to be of use in reducing man/fly or cattle/fly contact in specific areas such as at water points and around small agricultural settlements. As human populations in African countries increase, the demand for land results in the destruction of tsetse habitat as an incidental achievement and in this way large area have been cleared of fly in Nigeria and more recently in Ethiopia (NTTICC, 1996). With the high rates of population increase being experienced and the consequent accelerated demand for land it may not be impractical to assume that, with the passage of time, tsetse may be eradicated from large areas of Africa without the implementation of deliberate control measures (Urquhart et al., 1996).

Control by game destruction

Tsetse flies are haematophagous insects and depend on a regular blood meal for all their nutritional requirements and to provide energy for the development of their young ones. During the transitional phase from larva to adult, insufficient host animals should be available to ensure an adequate and regular food supply, and then the tsetse population would experience conditions of stress resulting in a population decline and subsequent control (Robertson, 1991). This fact is the basis used for the destruction of wild animal species which have been identified as preferred tsetse hosts. The method was used extensively in the past, particularly in Uganda and Zimbabwe, with reasonable control being achieved but there are several limitations. When denied a preferred host species, tsetse fly are able to adapt to feeding off other animals thus increasing the number of species that have to be destroyed (Robertson, 1991).

Obviously, this is not a method that could be implemented in many African game parks and nature reserves nor could it be applied to areas where settlement with domestic stock occurs. There are very few records of eradication having been achieved by game destruction although satisfactory control of fly populations and the prevention of their re-invasion into reclaimed areas have been reported. This method has very limited practical application in modern times except in those areas where game and cattle free hunting barriers can be maintained between tsetse belts and settled areas (Feyesa, 2004).

CONCLUSION AND RECOMMENDATIONS

Tsetse flies are hematophagous insects of the family glossinidae and are biological vectors of African trypanosomosis in both animals and man. Their distribution and prevalence are most influenced by special factors such as climate, vegetation and land utilization.

African trypanosomiasis continues to have a profound effect on sustainable development in rural sub-Saharan Africa as it affects not only the well-being of the poor and compromises their ability to produce food efficiently, but also their livestock on which their livelihoods are heavily dependent. 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:

1. All victimed communities, veterinary authorities and government should participate in control strategies of these vectors of African trypanosomosis.
2. Educating animal owners on the problems of trypanosoma infection and on its control measure is more essential.
3. 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.
4. Strategic tsetse fly control is very important in order to avoid economic impacts due to nagana where tsetse flies are densely populated.
5. 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.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

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