International Scholars Journals

African Journal of Agriculture ISSN 2375-1134 Vol. 12 (5), pp. 001-007, May, 2025. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Ecological Determinants of Tsetse Fly Distribution Limits and Their Impact on Livestock Production in Tanzania

Imna Malele*, Hamisi Nyingilili and Atway Msangi

Tsetse and Trypanosomiasis Research Institute, Majani Mapana, Off Korogwe Road, P. O. Box 1026 Tanga, Tanzania.

Accepted 5 April, 2025

Tsetse survey to re-define its distribution limit in Tanzania was conducted from 2005 to 2009. Based on the old tsetse infestation map, tsetse sampling using odour baited biconical traps were deployed and emptied after 24 h during the onset of dry season. The survey covered the southern, western, northern and north eastern regions of the country. Obtained results indicated that *Glossina morsitans sl* and *G. pallidipes* were the dominant and widely distributed tsetse species, although their boundaries had shrank. Changes in land use, which include human settlement and associated activities, infrastructure development and land reform policies, were the major reason for the new tsetse distribution limit. Movement and settlement of huge stocks of insecticide baited livestock in once tsetse infested areas significantly altered the ecology of favored tsetse habitats and their hosts leading to the disappearance of tsetse breeding sites and tsetse species. Human population increase in formally tsetse infested areas also contributed to the disappearance of tsetse. The most affected regions were found to be Rukwa and Mtwara. Chi square test indicated a significant difference on number of collected tsetse in different location; highest density observed in game reserve and the lower in areas near wild animal migratory corridor and protected forest areas. Tsetse flies were confined to protected areas, which include national parks, game and forest reserves. The new tsetse distribution limit is set to influence the epidemiology of African Trypanosomiasis, tsetse control initiatives and the future of livestock sector in Tanzania.

Key words: Tsetse ecology, African trypanosomiasis, land use, conserved areas, livestock.

INTRODUCTION

Information on tsetse distribution in Tanzania dates back from the colonial rule. Production of new maps was carried out basing on the old map without ground truthing (Ford and Katondo, 1973). This leaves the country with information on tsetse distribution that does not represent the actual situation. Tsetse flies are vectors of trypanosomes that cause African Trypanosomiasis (sleeping sickness in human and nagana in livestock) (Leak, 1999). Tsetse flies thrive in fertile areas which could be used for agro-pastoral activities, but tsetse infestation has restricted its use. Tsetse, transmit trypanosomes that cause trypanosomiasis; nagana and sleeping sickness; and the diseases cause morbidity and mortality to livestock and death to humans if the infection is not treated. The animal disease, nagana, occurs in all tsetse infested areas, though some mechanical transmission may occur in none tsetse areas, through biting flies. The human disease occurrence is grouped into three zones. The very active focus which occurs on the western part of the country around Kigoma, Tabora and Rukwa regions (Kibona et al., 2002; Malele et al., 2006), the occasionally active area in north-western zone which include Mara, Arusha and Manyara regions (Jelinek et al., 2002; Kaare et al., 2007) and the southern zone (Mtwara, Lindi and Ruvuma) where the focus is considered relatively silent.

The old map shows that 2/3 of 945,090 sq km of the land is infested by 10 species and sub species of *Glossina*. The species include both the Savannah (Morsitans): *G. morsitans morsitans*, *G. m. centralis* Mochado 1970, *G. swynnertoni, G. pallidipes* and

*Corresponding author. E-mail: malele2i@yahoo.com. Tel: +255 784 407276. Fax: +255 27 2642577.

G. austeni; Forest species (Fusca): *G. longipennis, G. brevipalpis* and *G. fuscipleuris,* and to a lesser extent the palpalis (Nermohina): *G. fuscipes*, *G. f. martini* Zumpt 1933, which are restricted towards Lakes Victoria and Tanganyika respectively (Ford and Katondo, 1977). 1/3 of the total land is a protected land in the form of national parks, game and forest reserves. Tsetse control methods have changed dramatically over the years, from ground and aerial spraying especially in the North-eastern belt (Jordan, 1986), trapping and use of insecticide-impregnated targets especially in national parks and around communities (Kasilagila, 2003), through live animal baits (in ranches and at household levels) (Hargrove et al., 2000; Fox et al., 1993) to sterile insect technique (SIT) (Mkwaja – *G. m. morsitans* and *G. austeni* in Unguja Island, Zanzibar) (Williamson et al., 1983; Msangi et al., 2000). These have also affected the distribution limit of tsetse flies.

The objective of this study was centered on collecting information that could be used in halting the transmission of trypanosomiasis by eliminating tsetse populations and so reducing poverty by enabling improved agricultural development through increased use of livestock for agricultural traction and for milk and meat production. To achieve this, in collaboration with Pan African Tsetse and Trypanosomiasis Control Campaign (PATTEC) as stipulated by Kabayo (2002), the study aimed at updating the information on the distribution limit of tsetse in Tanzania and identifying major tsetse species found along the borders. The information will be used to produce new tsetse maps and use the information to plan for optimal placing of barriers during the course of control interventions between countries so as to monitor sustainability areas of population of any flies subsequently encountered in intervened areas. We present the results following ground truthing of once tsetse infested areas along the boarders and the information about tsetse infestation will be used to plan for successful implementation of mixed agricultural activities in the country and in collaboration with other countries as coordinated by PATTEC initiative.

METHODOLOGY

Study sites

Renowned tsetse infested areas were visited and tsetse sampling within and along Tanzania borders with neighboring countries were carried out. Sampling was conducted by deployment of odour baited biconical traps with acetone for 24 h, during the onset of dry season. About four to five biconical traps per sq km were used (depending on vegetation on site) along transects at the interval not less than 200 m apart. Deployments were also done following information from relevant offices in the region and district levels specifically those in Agricultural and Livestock Development sectors. Geo coordinates of all deployed traps were recorded and a total of 13 regions were covered. These are the regions indicated as being tsetse infested in the old tsetse maps. We visited these areas in order to confirm what is indicated in the old maps. Any change from what was expected (tsetse infestation) was recorded. The changes recorded included farming activities and, infrastructure developments and any activities which resulted on the modification or removal of tsetse habitats. Harvested flies were sorted into respective species and sexed, counted and recorded as indicated in the FAO manual (FAO, 1980).

Detailed information on tsetse apparent densities on sampled areas in this study and from other previous studies are presented in Table 1.

RESULTS

The overall result indicate that *G. morsitans* is currently the most widely distributed species followed by *G. pallidipes* (Table 1). Results from the Tanzania boarder with Mozambique in the south indicated that the main tsetse species occurring in the area were *G. m. morsitans* and G. *pallidipes* with apparent densities (fly/trap/day - FTD) of 2 for *G. morsistans* and 2.2 for *G. pallidipes* in Ruvuma and 1 for G. *morsitans* and 12.5 for *G. pallidipes* in Mtwara (Table 2). Flies were caught near protected areas in the two regions and non in other areas away from protected areas. From the Western Tanzanian Boarder with Zambia, Democratic Republic of Congo (DRC) and Burundi the species found were *G. m. morsitans, G. morsitans centralis, G. f. fuscipes* and *G. f. martini* whereas on the Northern boarder with Kenya, the species were *G. f. fuscipes, G. swynnertoni* and G. *pallidipes.* The *G. morsitans sl* group were the most dominant species in the western part of the country whereas *G. pallidipes* and *G. swynnertoni* were the most abundant species in the Tanzanian boarder with Kenya. Other caught tsetse species include *G. m. morsitans* and *G. brevipalpis* but these were in insignificant numbers. Areas, which were earlier tsetse infested were found to have no tsetse and areas were cleared for agricultural activities for both food and cash crops. Shifting cultivation was observed to be the main practiced form of farming of food crops and this significantly reduced suitable habitat for tsetse due to continual clearance of new areas for farming.

Livestock keeping, infrastructure development, human settlement, new land use reform policy (privatization/investors) and mining activities have also occupied many of once tsetse infested areas. Out of the 13 sampled regions, tsetse flies were only caught in areas which were adjacent to the protected areas which include National parks, forest and game reserves. In Mtwara, tsetse flies were found near the Lukwika Lumesule game reserve, and along the wild animal migratory corridor between Tanzania and Mozambique. In Ruvuma, flies were found in protected areas along Ruvuma River and along the migratory corridor between Selous game reserve and Niassa (Mozambique). In Rukwa, flies were only found near Lwafi, Ruangwa and Lyazumbi game reserves and non in other former infested areas. No flies were caught along the Tanzania and Uganda boarder except for few *G. pallidipes* along

Table 1. Summary of tsetse densities (F/T/D) in sampled areas.

Study sites (region)	Tsetse species						
	G. swynnertoni	*G. morsitans (sl)*	*G. pallidipes*	*G. brevipalpis*	*G. longipennis*	*G. fuscipes martinii/ fuscipes*	*G. austeni*
Manyara	377	239	65	0.5	13	0	0
Arusha	85	42	25	0	1	0	0
Dodoma	0	26	0	0	0	0	0
Tanga	0	173	668	123	0	0	1.3
Shinyanga	97	3	103	0	0	0	0
Mara	923	12	20	0.5	0.5	1.3	0
Tabora	0	158*	0	0	0	0	0
Kigoma	0	17	0	0	0	15.3	0
Rukwa	0	210*	0	0	0	0	0
Mtwara	0	1	12.5	0	0	0	0
Ruvuma	0	2	2.2	0	0	0	0
Morogoro	0	34	0	0	0	0	6
Iringa	0	9	0	0	0	0	0

*Mostly *Glossina morsitans morsitans* and few *G. morsitans centralis.*

Table 2. Factors affecting tsetse infestations.

Region	Study site (districts)	Site	Total trap number	Species collected	Total tsetse trapped	Tsetse density (F/T/D)	Remarks
Mtwara	Masasi 1	Old camp	5	*G. morsitans morsitans.*	50	10	Trapped near Lukwika Lumesule game reserve; animal corridor to Mozambique.
	2	Old camp IV	4	*G.m. morsitans and G. pallidipes.*	50	12.5	Trapped near Lukwika Lumesule game reserve; near Ruvuma river bank.
	Mtwara rural	Old camp 2	5	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 1	5	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 2	5	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 3	5	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 4	5	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 5	5	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 6	5	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 7	5	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 8	5	None	0	0	Extensive agricultural activities

Table 2. Contd.

	Mtwara rural	Site 2	4	None	0	0	Extensive agricultural activities
	Mtwara rural	Site 3	5	None	0	0	Extensive agricultural activities
Ruvuma	Namtumbo	Likuyuseka	4	*G. m. morsitans*	2	0.5	Animal migratory corridor between Selous game reserve and Niassa in Mozambique.
	Tunduru	Njenga cham	5	*G. m. morsitans* *G. pallidipes* *G. brevipalpis*	6	1.17	Trapped near protected area along Ruvuma river.
	Songea rural	Site 1	5	*G. m. morsitans* *G. pallidipes*	3	0.58	Trapped near protected area along Ruvuma river.
	Songea rural	Site 2	5	None	0	0	Extensive agricultural activities
	Songea rural	Site 3	4	None	0	0	Extensive agricultural activities
	Songea rural	Site 4	5	None	0	0	Extensive agricultural activities
	Songea rural	Site 5	5	None	0	0	Extensive agricultural activities
	Songea rural	Site 6	5	None	0	0	Extensive agricultural activities
	Songea rural	Site 7	5	None	0	0	Extensive agricultural activities
	Songea rural	Site 8	5	None	0	0	Extensive agricultural activities
Rukwa	Sumbawanga rural 1	Kasekela B	5	*G. morsitans s.l*	125	25	Near Rungwa Game Reserve (GR)
	Sumbawanga rural 2	Kasekela Kitu	5	*G. morsitans s.l*	125	25	Near Rungwa GR
	Nkasi	Kambakang'o	4	*G. morsitans s.l*	58	14.5	Near Lwafi GR (extensive human activities)
	Nkasi	Kambakang'o	5	*G. morsitans s.l*	15	15	Near Lwafi GR
	Nkasi	Kamba Kilima	5	*G. morsitans s.l*	147	29.3	Near Lwafi GR
	Nkasi	Kamba Mwish	5	*G. morsitans s.l*	57	11.3	Near Lwafi GR
	Nkas	Kizi	4	*G. morsitans s.l*	90	22.5	Near Lwafi GR
	Nkasi	Lyazumbi	4	*G. morsitans s.l*	125	31.25	Near Lyazumbi GR
	Nkasi	Lyazumbi GR	5	*G. morsitans s.l*	125	25	Near Lyazumbi GR
	Nkasi	Lyazumbi GR	4	*G. morsitans s.l*	43	10.75	Near Lyazumbi GR

the Tanzania and Rwanda boarder. The same trend appeared for areas which are adjacent national parks like the Serengeti and Tarangire, Mkomazi, Ruaha and Saadani. *G. pallidipes* appear to be very much affected and this could be attributed by habitat removal, which changes the suitability of the ecology for the species. Areas near protected areas had high tsetse densities which could indicate that flies were breeding in

Table 3a. Observed activities in sampled areas (remarks) and tsetse density.

	Observed N	Expected N	Residual
Close to game reserve	1010	340.3	669.7
Near wild animal migratory corridor	2	340.3	-338.3
Near protected forest area	9	340.3	-331.3
Total	1021		

Table 3b. Test statistics.

	Remarks
Chi-square (a)	1976.605
df	2
Asymp. Sig.	0.000

protected areas and thus dispersing in non protected areas.

Chi square test indicated a significant difference on number of collected tsetse in different location; highest density observed in game reserve and the lower in areas near wild animal migratory corridor and protected forest areas (Tables 3a and 3b).

DISCUSSION

Factors behind the current tsetse distribution

The study found that most areas which were once tsetse infested are currently without tsetse. Several reasons were found to be behind this change. First we noted an increase in human activities in once tsetse infested areas as a result of increased human population. This has resulted into extensive Land use which has had a big impact on tsetse favored habitats and breeding sites. Agricultural activities especially shifting cultivation and cash crop farming, increasing livestock keeping, as well as settling in of mixed farmers from the northern regions, have resulted in the modification of tsetse habitats and tsetse have disappeared. Infrastructure development and human settlement have contributed to the removal of favorable tsetse breeding sites. Mostly affected regions were found to be Mtwara and Rukwa. Change in land use reform policy (privatization/investors) and increase in insecticide use against tsetse as a result of free market and readily availability of insecticide have enabled farmers to move their livestock in tsetse infested areas without fear of loosing their animals. Insecticide baited animals has contributed to decline in tsetse and alter their distribution.

Insecticide uses in Kagera region have resulted in a decrease and disappearance of tsetse along the boarder with Uganda. This is due to large groups of livestock, which are insecticide baited and when they graze in tsetse infested areas, tsetse flies that come in contact with insecticide baited animals are killed (Hagrove et al., 2000). This buttresses (Reid et al., 2000) prediction which indicates that socioeconomic factors, especially infrastructure development, human population growth and distribution, and evolving agricultural and livestock production systems tend to have adverse force which directly affect tsetse. Increase in livestock migration (immigration) was noted mostly in Rukwa where more pastoralists are moving into from neighboring Tabora and Shinyanga regions in search of land, pasture and water for their cattle (Kilemwa, 1999) than those going out (NPC, 2002). As a result there is an increase in demand for fuel (fire woods), construction materials, infrastructures etc. The pastoralists who have settled in Rukwa have also embraced the use of animal traction for farming. Clearing of large areas which were tsetse infested for farming (Kilemwa, 1999) have destroyed favoured tsetse breeding and resting sites.

Table 4 gives a summary of population increase in 5 regions from 1967 to 2002 as noted from the National Population census (2002) report.

The implications of the new tsetse distribution limit

African trypanosomiasis (AT) epidemiology and tsetse control initiatives

The findings indicate that the vectors of AT are disappearing due to habitat change caused by human activities and encroachment in once tsetse infested areas. Habitat fragmentations tend to affect tsetse abundance. Ducheyne et al. (2009) noted that heavy fragmentation of natural habitats results in decrease of tsetse numbers. In this study, tsetse flies were found in protected areas which are spared from human activities such that the ecology is relatively undisturbed. In this scenario, protected areas are the source of tsetse flies that tend to infest adjacent areas. Tsetse survival is dependent on the presence of suitable habitat and hosts. Their seasonal distribution is correlated with the distribution of their main hosts; and influences their feeding preferences. Increased human population means increased encroachment or nearness to protected areas and this tend to increase tsetse-man contact, with the end result of increased incidence of human trypanosomiasis. A case in point is the Urambo –Ugalla

Table 4. Population increase rate in 5 sampled highly tsetse infested regions 1967 to 2002.

Region	Years				Population growth rates	
	1967	1978	1988	2002	1978 - 1988	1988 - 2002
Mtwara	621,293	771,818	889,100	1,128,523	1.4	1.7
Ruvuma	395,447	561,574	779,875	1,117,166	3.4	2.5
Tabora	502,068	817,907	1,036,150	1,717,908	2.4	3.6
Rukwa	276,091	451,897	698,718	1,141,743	4.3	3.6
Kigoma	473,443	648,941	856,770	1,679,109	2.8	4.8

Source: Tanzania 2002 population sensors.

protected area, where in recent years the number of sleeping sickness in neighboring villages have increased due to increased tsetse – man contact following an increase in forest related activities like honey gathering, fishing, timbering, charcoal, livestock grazing and other social needs (Malele et al., 2006).

In Palpalis tsetse infested areas, documented reports indicate that human encroachments in infested areas have resulted into more peridomestic tsetse with consequences of more human disease cases (Okoth, 1982). Decrease in suitable habitats has been shown to have an impact on the savannah tsetse which tends to decrease and even disappear if the human population rises above 15 sq km and between 40 to 60 people per sq km respectively (Reid et al., 2000). During the 1988 National Census, it was found that the population density in Mtwara was 53.2 people per sq km. This could be one of the reasons behind declining tsetse population in this region. Forest tsetse species tend to disappear when human densities rise to between 38 and 77 people per sq km. This is true for southern Tanzania, whereas a result of population increase especially in Mtwara, tsetse have been pushed to and restricted to conserved areas only. It is postulated that while climate change is also likely to have an impact by gradually modifying tsetse distribution over next 30 years and beyond, changes due to increases in human population and associated habitat modification are rapid. McDermott et al. (2001) hypothesized that human population is highly correlated with the area of tsetse habitat cleared for cultivation. The author further postulates that declining of tsetse numbers in increasingly populated area will result in reduction of trypanosomiasis risks as a result of decline of tsetse, the vectors of trypanosomiasis. Hence population pressure and increased use of insecticide use for baiting their livestock against tsetse (Hargrove et al., 2000) contributes towards destruction of tsetse favorable resting and breeding sites as well as killing tsetse which come in contact with baited animals with insecticides.

Although some suitable tsetse habitats are still present in the sampled areas despite the extensive fragmentation of the habitat, it is assumed that fragmentation will affect movements of tsetse flies in their quest for food. Fragmentation will result into most of the wild hosts disappearing from most of the study areas, such that tsetse flies will become more dependent on livestock for survival (Van den Bossche and Staak, 1997). The livestock availability in the highly fragmented landscape varies seasonally as animals are moved to other areas in search of green pastures and water especially during the dry season. This is likely to affect the feeding behavior of tsetse such that they will feed on the readily available hosts and man inclusive and this could have an impact of human trypanosomiasis prevalence in active foci (Van den Bossche and De Deken, 2002; Okoth, 1982). Hence, fragmentation will affect fly movements, which in-turn will affect fly feeding behavior, survival (Ducheyne et al., 2009) and the epidemiology of African trypanosomiasis in Tanzania and the entire tsetse infested belt. Encroachment in once tsetse endemic areas will result into more island-like areas being created. This opens or simplifies tsetse control using the “roll over carpet model” where one tsetse infested island could be reclaimed. This might be good news for PATTEC and local governments who see tsetse control as one of the priorities to tackle in order to expand the livestock sector in their areas (Kabayo, 2002).

Disappearing of tsetse is likely to lead to overstocking of animals which could lead to land degradation hence proper planning needs to be in place on how to make use of the reclaimed areas from tsetse infestation to counteract claims that tsetse prevent people and their livestock from over using vast areas of the continent of Africa (Reid et al., 2000).

Conclusion

The distribution of tsetse flies, the vectors of African Trypanosomiasis has changed greatly over the years due to pressures associated with land use and increased movement of human population into once tsetse infested areas. The situation could favor expansion of livestock sector but also lead to land degradation. Fragmentation of tsetse habitat opens a way for controlling tsetse in a carpet model “roll over” hence one tsetse infested island can be easily reclaimed at a time. Tsetse control should take or involve several sectors which are affected in one

way or another by the presence of tsetse. Wildlife authority should take a lead in the control of tsetse or put barriers between villages and conserved areas which are the source of tsetse infestations into adjacent areas. Changing tsetse distribution limits open an opportunity for livestock sector expansion, hence efforts should be in place to make use of shrinking tsetse boundaries, while putting in place proper land use policy to avoid overstocking and land degradation.

ACKNOWLEDGEMENTS

We acknowledge Leverhulme Tsetse and Trypanosomiasis Research Network for funding this study, Mr. Kapange for helping with sampling, the Regional Agricultural and Livestock Development Officers (RALDO's) and District Officers (DALDO's) and village leaders in respective study areas. Dr. Togolai Mbilu for statistical analysis.

REFERENCES

Ducheyne E, Mweempwa C, De Pus C, Vernieuwe H, De Deken R, Hendrickx G, Van den Bossche P (2009). The impact of habitat fragmentation on tsetse abundance on the plateau of eastern Zambia. Prev. Vet. Med., 91: 11-18.

Ford J, Katondo, KM (1977). Maps of tsetse flies (*Glossina*) distribution in Africa, 1973, according to sub generic groups on scale of 1: 5,000,000 (plus a set of 9 maps in colour). Bull. Anim. Hlth. Prod. Afr., 2: 187-193.

Fox R, Mmbando GR, Fox SO, Wilson MSA (1993). Effect on herd health and productivity of controlling tsetse and trypanosomosis by applying deltamethrin to cattle. Trop. Anim. Health Prod., 25(4): 203-14.

Hargrove J, Omolo SW, Msalilwa JSI, Fox B (2000). Insecticide-treated cattle for tsetse control: the power and the problems. Med. Vet. Entomol., 14: 123-130.

Jelinek T, Bisoffi Z, Bonazzi L, van Thiel P, Bronner U, De Frey A (2002). Cluster of African trypanosomiasis in travelers to Tanzanian national parks. Emerging Infect. Dis., pp. 634-635.

Jordan AM (1986). Trypanosomiasis Control and African Rural Development, Longman Inc., New York.

Kaare TM, Picozzi K, Mlengeya T, Fe`vre ME, Mellaua SL (2007). Sleeping sickness - A re-emerging disease in the Serengeti? Travel Med. Infect. Dis., 5: 117-124.

Kabayo JP (2002). Aiming to eliminate tsetse from Africa. Trends Parasitol., 18: 473-475.

Kasilagila G (2003). Studies on trap effectiveness of tsetse flies (*Glossina* spp. (Diptera: Glossinidae)) in the Tanga Region of north eastern Tanzania. Acta Trop., 87(3): 385-392.

Kibona SN, Nkya GM, Matemba L (2002). Sleeping sickness situation in Tanzania. Tanzania Health Res. Bull., 4(2): 27-29

Kilemwa AM (1999). Environmental impact of animal traction in Rukwa region, Tanzania in P. Starkey and Kaumbutho P (eds). Meeting the challenges of animal traction. A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA), Harare, Zimbabwe, London, p. 326.

Leak SGA (1999). Tsetse Biology and Ecology. Their Role in the Epidemiology and Control of Trypanosomosis. CAB International, Oxford, pp. 98-100.

Malele I, Kibona S, Matemba L, Sahani K, Swilla J, Mwalimu CD, Mayala BK, Kimaro E, Msumary C, Kalinga RBM (2006). Human African Trypanosomiasis and challenges to its control in Urambo, Kasulu and Kibondo Districts, Western Tanzania. Tanzania Health Res. Bull., 8(2): 80-85.

McDermott JJ, Kristianson PM, Kruska RL, Reid RS, Robinson TP (2001). Effects of Climate, Human Population and Socio-Economic Changes on Tsetse-Transmitted Trypanosomiasis to 2050. In: Black SJ SJ, Seed JR, editors. The African Trypanosomes. Boston: Kluwer Academic Publishers, p. 179.

Msangi AR, Salehe KM, Kiwia NE, Malele II, Musa WA, Mramba F, Juma KG, Dyck VA, Vreysen MJB, Parker AG, Feldmann U, Zhu Z-R, Pan H (2000). Success in Zanzibar: Eradication of Tsetse. In Tan, K.

H. (Ed.) Area-wide management of fruit flies and other major insect pests. Penang, Penerbit Universiti Sains Malaysia, pp. 55-66

Okoth JO (1982). Further observations on the composition of *Glossina* population at Lugala, South Busoga. Uganda East Afr. Med. J., 59: 582-584.

Reid RS, Kruska LRL, Deichmann U, Thornton PK, Leak SGA (2000). Human population growth and the extinction of the tsetse fly. Agric. Ecosyst. Environ., 77: 227-236.

Torr SJ, Hagrove JW, Vale GA (2005). Towards a rational policy for dealing with tsetse. Trends Parasitol., 21(11): 539-541.

Van den Bossche P, Staak C (1997). The importance of cattle as a food source for *Glossina morsitans morsitans* Westwood (Diptera: Glossinidae) in Katete District, Eastern Province, Zambia. Acta Trop., 65: 105-109.

Van den Bossche P, De Deken (2002). Seasonal variations in the distribution and abundance of the tsetse fly, *Glossina morsitans morsitans* in eastern Zambia. Med. Vet. Entomol., 16: 170-176.

Williamson DL, Dame DA, Gates DB, Cobb PE, Bakuli B, Warner PV (1983). Integration of insect sterility and insecticides for control of *Glossina morsitans morsitans* Westwood (Diptera: Glossinidae) in Tanzania. V. The impact of sequential releases of sterilized tsetse flies. Bull. Entomol. Res., 73: 391-404.

www.tanzania.go.tz/census/census/htm - 20k.

www.nbs.go.tz/population.htm - 116k.