FULL LENGTH RESEARCH ARTICLE

HIGH TRYPANOSOME INFECTIONS IN *Glossina palpalis palpalis* ROBINEAU-DESVOIDY 1830 IN SOUTHERN KADUNA STATE, NIGERIA

A. B. AHMED

Department of Biological Sciences
Kaduna State University
PMB 2339, Kaduna, Nigeria.
adoahmed2001@yahoo.com

ABSTRACT

A survey was undertaken to determine the prevalence of trypanosome infection in *Glossina* species in Kaura Local Government Area (LGA) of Kaduna State, Southern Guinea Savanna, Nigeria, aimed at identifying areas to be prioritized for area-wide tsetse eradication. The flies were trapped from a relic forest and also from 22 locations spread within the LGA and dissected to determine infection rates and infection types. *Glossina palpalis palpalis* Robineau-Desvoidy 1830 was the only tsetse species encountered both within the relic forest and the 22 locations sampled; its distribution was strictly riverine. Out of the 409 non-teneral flies dissected in the relic forest, 18.1 ± 0.02%, were infected with trypanosomes, with infections of the *vivax*-group dominating (76.92%) over the *congolense*-group (23.01%). Of the 690 flies caught from 22 locations, 9.9 ± 1.0% were infected, 69.12% with *vivax*-group and 30.88% with *congolense*-group. Infections of the *brucei*-group were not encountered throughout the investigation period. The high prevalent figure of 12.64% recorded in the flies from both the relic forest and other locations portray the area as highly risky, with Bondong, Manchok and Kadarko districts being highly endemic, followed by a region of medium prevalence at Kukum district and a region of low endemicity within the mountain ranges of Zankan district. A well articulated vector eradication programme that will target *G. p. palpalis* and the various species of other biting dipterans is recommended as the solution to the recurring nagana problem in the area.

***Keywords*:** *Glossina palpalis palpalis, Trypanosoma vivax, T. congolense,* Kaduna State, Nigeria

INTRODUCTION

Animal Trypanosomiasis is a disease complex caused by protozoa in the genus *Trypanosoma* which develops cyclically in the vector, the tsetse-fly. It has been ranked the fourth most important disease of cattle in Nigeria after rinderpest, contagious pleuropneumonia (CBPP) and dermatophilosis (streptothricosis) (Ademosun 1973). The disease is widespread and endemic in Nigeria, occurring in all the areas infested by tsetse (Onyiah *et al.* (1983) and including the arid tsetse-free areas of the north that is infested by other biting flies (Nawathe *et al*. 1988; Ahmed *et al.* 1994; Nawathe *et al*. 1995) where it is transmitted mechanically.

Eleven of the twenty-three known species of tsetse flies are found in Nigeria (Baldry 1964), infesting approximately 74% (686,488 km^2) of the country's landmass from approximately latitudes 4^{o}N to latitudes 12^{o}N covering all the agroecological zones of the country (Jawonisi 1988), including the highlands of Jos, Mambilla and Obudu plateux, which were hitherto described as tsetse and trypanosomiasis free (Marshall 1947; Esuoroso 1973).

So much have been done to control the menace of tsetse and the disease it transmits across the continent, yet only about 10% of the infested area has been reclaimed (Holmes 1991). An extensive and final onslaught on the vector is being planned under the aegis of the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) of the African Union. Because of the direct influence that the levels of infection of the vector has on the epidemiology of the disease and in the planning of effective control strategies, this investigation examined the trypanosome infection rates in *Glossina* in pasture-rich Manchok, a small settlement in Kaura Local Government Area (LGA) of Kaduna State, Nigeria aimed at identifying priority areas to be targeted by the campaign. This is justified because the tsetse-infested area in Nigeria is large and available resources and capacity so limited, so that prioritisation of intervention areas becomes more important.

MATERIALS AND METHODS

Study area: Details of the study area have been given (Ahmed 2003). Ecological studies were conducted within a relic forest, an area of approximately 0.03 km^2, while spot sampling were conducted in 22 locations spread across the LGA (Fig. 1).

Tsetse sampling: Flies were caught from 2 sources: (1) from the relic forest at River Kajim during routine monthly entomological survey and from (2) 22 sites within the LGA during spot samplings. The flies were caught using the blue Biconical traps (Challier & Larvessiere 1973) and the cylindrical Nitse traps (Omoogun 1994). Within the relic forest, flies were sampled for 5 days each month between November 1999 to October 2001 while flies from other locations were sampled for 24 hr before harvesting traps.

Dissection of flies to determine trypanosome infections: The flies caught from the two sources were dissected for trypanosome infections according to the rapid technique of Penchenier & Itard (1981) and the parasites identified and differentiated into species by their location within the insect (Lloyd & Johnson 1924).

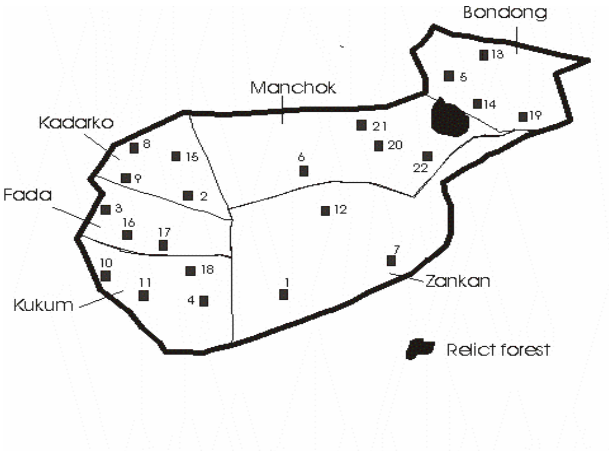

FIG. 1. MAP OF KAURA LGA SHOWING THE SAMPLING SITES

Mature and immature infections were distinguished; mature, when found in the hypopharynx, and immature, when only the gut was involved (Moloo *et al.* 1973). Mixed infections were not assessed. Only one-third of the total flies caught at the relic forest were dissected to minimize the depletion of resident fly populations (van Wetere 1975) while all those caught from the 22 sites across the LGA were dissected.

RESULTS

Species composition: *G. p. palpalis* Robineau-Desvoidy 1830 was the only tsetse species encountered both within the relic forest (Table 1) and the 22 locations sampled (Table 2); its distribution was strictly riverine.

TABLE 1: MONTHLY TRYPANOSOME INFECTION RATES OF *G. P. PALPALIS* IN THE RELIC FOREST

Month/yr	Sex	No. examined	Trypanosoma species *Tv*	*Tc*	*Tb*	Immature (gut only)
Nov 1999	M	3	0	1	0	0
	F	12	2(13.3)	0(6.7)	0(0)	0(0.0)
Dec	M	5	0	1	0	0
	F	9	1(7.1)	0(7.1)	0(0)	1(7.1)
Jan 00	M	5	0	0	0	0
	F	7	2(16.7)	0(0)	0(0)	1(8.3)
Feb	M	5	0	1	0	0
	F	7	1(8.3)	0(8.3)	0(0)	2(16.7)
Mar	M	4	0	1	0	0
	F	7	2(18.2)	0(9.1)	0(0)	1(9.1)
Apr	M	4	0	0	0	1
	F	6	2(20.0)	0(0)	0(0)	1(20.0)
May	NO OBSERVATIONS					
Jun	M	9	1	0	0	0
	F	8	0(5.6)	1(5.6)	0(0)	0(0)
Jul	M	8	0	1	0	0
	F	8	1(6.3)	0(6.3)	0(0)	0(0)
Aug	M	9	0	0	0	1
	F	15	2(8.3)	0(0)	0(0)	0(4.2)
Sep	M	8	0	1	0	1
	F	15	3(13.0)	0(4.3)	0(0)	1(8.7)
Oct	M	8	1	0	0	1
	F	10	2(16.7)	0(0)	0(0)	1(11.1)
Nov	M	9	1	0	0	0
	F	10	1(10.5)	1(5.6)	0(0)	1(5.6)
Dec	M	7	1	0	0	0
	F	9	2(18.8)	0(0)	0(0)	0(0.0)
Jan 01	M	6	0	0	0	0
	F	12	2(11.1)	1(5.6)	0(0)	0(0.0)
Feb	M	7	0	0	0	1
	F	8	2(13.3)	0(0)	0(0)	1(13.3)
Mar	M	6	0	0	0	0
	F	8	1(7.1)	0(0)	0(0)	2(14.3)
Apr	M	6	2	0	0	0
	F	8	1(21.4)	0(0)	0(0)	0(0.0)
May	M	6	0	0	0	1
	F	11	1(5.9)	0(0)	0(0)	0(5.9)
Jun	M	9	0	0	0	1
	F	13	1(4.5)	1(4.5)	0(0)	0(4.5)
Jul	M	9	0	1	0	0
	F	11	0(0)	0(5.0)	0(0)	1(5.0)
Aug	M	10	0	0	0	1
	F	16	1(3.8)	0(0)	0(0)	0(3.8)
Sep	M	10	0	0	0	1
	F	19	1(3.4)	1(3.4)	0(0)	0(3.4)
Oct	M	10	1	0	0	0
	F	17	2(11.1)	0(0)	0(0)	0(0.0)
Total		**409**	**40**	**12**	**0**	**22**

Figures in parentheses are percent infections for the combined sexes.

TABLE 2. TRYPANOSOME PREVALENCE AND DISTRIBUTION OF GLOSSINA

Sampling Spot No.*	Village	Month	No.flies caught	No. +ve	Trypanosoma species		
					T. vivax	*T. congolense*	*T. brucei*
1.	Mafam	Nov 99	23	1(4.3)	1(100.0)	0	0
2.	Kadarko	Nov	18	1(5.6)	1(100.0)	0	0
3.	F/Daji	Dec	31	3(9.7)	2(66.7)	0	0
4.	Tsonje	Jan 00	22	1(4.5)	1(100.0)	1(13.3)	0
5.	U/Shemang	Feb	11	2(18.2)	2(100.0)	0	0
6.	Asu	Mar	29	4(13.8)	2(50.0)	2(50.0)	0
7.	Zilang	Apr	24	1(4.2)	1(100.0)	0	0
8.	Malgum	Apr	32	6(18.8)	4(66.7)	2(33.3)	0
9.	Tum	May	49	6(12.2)	5(83.3)	1(16.7)	0
10.	Zakwa	Jun	44	6(13.6)	3(50.0)	3(50.0)	0
11.	K/Daji	Jun	53	7(4.4)	4(57.1)	3(42.9)	0
12.	Ashim	Jul	45	2(4.4)	1(50.0)	1(50.0)	0
13.	Chori	Aug	43	4(9.3)	3(75.0)	1(25.0)	0
14.	Biniki	Sep	52	5(9.6)	3(60.0)	2(40.0)	0
15.	Madamai	Oct	34	4(11.8)	3(75.0)	1(25.0)	0
16.	Tuyet	Nov	26	3(11.5)	2(66.7)	1(33.3)	0
17.	Kpak	Nov	12	1(8.3)	1(100.0)	0	0
18.	Agbam	Dec	21	1(4.3)	1(100.0)	0	0
19.	U/gata	Jan 01	18	1(5.6)	0	1(100.0)	0
20.	Gizagwai	Feb	16	1(6.3)	1(100.0)	0	0
21.	Randiyam	Sep	49	3(6.1)	2(66.7)	1(33.3)	0
22.	Bungel	Oct	38	5(13.2)	4(80.0)	1(20.0)	0
Total			**690**	**68(9.86)**	**47(69.12)**	**21(30.88)**	**0**

*See Fig. 1 for locations of numbered villages on the map

Prevalence of trypanosome infections in tsetse: Out of the 409 non-teneral flies dissected in the relic forest, 18.1 ± 0.02%, were infected with various species of trypanosomes, with 68.92% females significantly accounting for higher infections, including immature ones (F=31.7; df=1,44; P<0.05). The infection rates according to seasons for flies caught within the relic forest was not significant (Table 3) (F=0.9; df=4,18; P>0.05). The mean infection rate of the 690 flies caught at 22 different locations was 9.9 ± 1.0%, ranging from 4.3% at Mafam/Agbam villages (sites 1 & 18) in the dry season to 18.8% at Malagum village (site 8) in the early wet season (Table s 2 & 3); seasonal difference between locations was significant (F=4.2; df=4,17; P<0.05) (Table 4). Mean seasonal infection rates of flies from different locations varies, with a minimum 0.9 ± 0.003% in the early dry season and a maximum 6.3 ± 0.02% in the late wet season.

Within the flies harbouring mature infections in the relic forest, the *vivax*-group significantly dominated with 76.92% over the *congolense*-group with 23.01% (F=17.1; df=1,44; P<0.05). Infections due to immature procyclics accounted for 29.73 ± 5.31% of the total infections, with 59.10 ± 10.48% occurring in females (F=1.0; df=1,44; P>0.05). Infections of the *brucei*-group were not encountered.

Age of flies: The ageing of the fly population using wing-fray technique (Potts 1970) showed that even though the mean age of males was 34 days (Mean Wing Fray Value of 4.3) and 32 days (Mean Wing fray Value of 4.0) for females, both sexes had similar age distribution pattern (Fig. 2). No infections were recorded in younger wing-fray categories 1A and 1B in both sexes but only in categories 2-6.

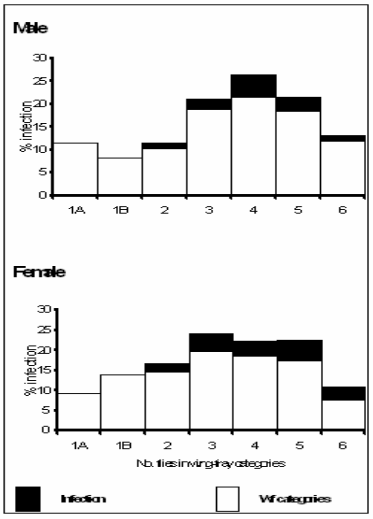

FIG. 2. TRYPANOSOME INFECTIONS AMONG AGE GROUPS IN TSETSE (CLASSIFIED BY THE WING-FRAY METHOD)

DISCUSSION

G. p. palpalis was the only tsetse species encountered at the relic forest and the 22 other locations sampled within the LGA, contrary to earlier reports (Agu *et al.* 1983; Maikaje 1998) that indicated the presence of *G. tachinodes* Westwood 1850 as a second species. Given the frequency of sampling, the duration and the area covered by the present investigation, it appears that *G. tachinoides* populations might have been significantly reduced in this locality. Even though earlier observations (Glover & Aitchison 1966) had described the distribution of the species in the area as patchy, the possible reasons for the apparent disappearance might be linked to the elimination from the area of the domestic pig that had been identified as an important host of *G. tachinoides* in Nigeria (Baldry 1964; Madubunyi 1988) and Congo (Gouteux *et al.* 1987).

The trypanosome infection rates in tsetse showed that a large proportion of the flies were infected. The total infection rate of 18.1% recorded included the immature that accounted for almost 30% of the total infections. Discarding them would have influenced the final figure (Harley 1966; van Wettere 1975). The infection rate recorded in the flies in this study is higher than the 13.5% and 13.9% obtained by Onah *et al.* (1985) and Ahmed *et al.* (2000) at Pandam and Kainji Lake wildlife parks respectively. It is possible that the rate obtained in the present investigation could have been higher, if a more sensitive method, such as the dot-Elisa (Bossempem *et al.* 1995; Bossempem 1996) was used.

The results showed a significantly higher percent of females harbouring infections than the males. Harley (1967) attributed difference in infection rates between sexes to the catching method. However, it is possible that the feeding habits of the sexes are also important because males only feed every 3-4 days (Davies 1977) while females take a blood meal more regularly because of the demand of their role in reproduction (Moloo 1976), which increases their chances of feeding on an infected host and acquiring an infection.

TABLE 3: SEASONAL VARIATION OF INFECTED TSETSE AT THE RELIC FOREST

Season	Total catch	No +ve	% Mean infection ± SE*
Early dry	94	19	20.2 ± 0.04
Late dry	52	15	28.8 ± 0.06
Early wet	80	14	17.5 ± 0.04
Peak wet	138	18	13.0 ± 0.02
Late wet	45	8	17.8 ± 0.06

*Not significant at 5% level.

TABLE 4: SEASONAL VARIATION OF INFECTED TSETSE COLLECTED FROM DIFFERENT LOCATIONS OUTSIDE THE RELIC FOREST

Season	No sites	Total catch	% Infection per site± SE*
Early dry	8	171	0.9 ± 0.003
Late dry	3	56	4.2 ± 0.01
Early wet	5	202	2.1 ± 0.004
Peak wet	4	189	2.5 ± 0.7
Late wet	2	72	6.3 ± 0.02

* Significant at the 5% level.

The *Palpalis* group, to which *G. p. palpalis* belongs, has been considered an inefficient vector of animal trypanosomiasis, with an average infection rate of only 5% in the savanna zone (Maclennan 1976), compared to the *Morsitans* group that exhibits infection rates of up to 25% (Davies 1977). The absence of the later species in the study area, the combined high trypanosome infections of 12.64% recorded in the flies caught in both the relic forest and other locations implicate *G. p. palpalis* as the major vector responsible for the cyclical transmission of animal trypanosomiasis in the area.

The mature and immature infection rates of 12.7% and 5.4% respectively observed in this study probably reflected a population of *G. p. palpalis* with high vectorial capacity. Madubunyi (1990) dissected 10,208 *G. tachiniodes* in the Nsukka area and obtained only 1.08% (mature) and 2.02% (procyclics) infections. Trypanosomes are known to undergo a complex cycle in *Glossina* before they are transformed into the infective metacyclic stages (Pollock 1982; Murray *et al.* 1983). *T. vivax* Ziemann 1905 takes an average of 5 days to mature at 29^{o}C and up to 13 days at a lower temperature of 22^{o}C (Desowitz & Fairbain 1955). *T. congolense* Broden 1904 takes 7-53 days and *T. brucei* Plimmer & Bradford 1899 between 12 days at 30^{o}C and up to 60 days at 16^{o}C (Buxton 1955; Itard 1989) to mature. With a mean recorded age of more than 30 days recorded for both sexes in the present studies, the tsetse population studied was therefore potentially capable of transmitting *T. vivax, T. congolense* and *T. brucei.*

Several reasons may account for the observed preponderance of *T. vivax* over *T. congolence* infections in the present studies. It has been established that *T. vivax* dominates whenever there was a breakdown in the natural protective immunity conferred by high tsetse challenge (Godfrey & Killick-Kendrick 1961; Killick-Kendrick 1963). This is probably the case in the present study area, because tsetse challenge was high (Ahmed 2003). It is also known that natural infections with *congolense*-type parasites are generally low, with characteristically lower parasitaemia than those of *T. vivax* (Stephen 1986). It is therefore possible that such scanty parasites are rarely picked up by the flies during feeding, which may account for the inability of the parasites to get established in the vector. The irregular appearance of *T. congolense* parasites in the blood of animals previously treated with trypanocides (Stephen 1962) is another possibility since uncontrolled use of trypanocides was prevalent in the area (Ahmed 2003).

In the study area, Berenil and Samorin are widely used and administered by the stockmen, without benefit of scientific assessment and any attempt to control the vector. This may be responsible for suppressing the disease below outbreak thresholds most of the time, thereby creating a false image of stability. With the confirmation of the presence of several drug-resistant strains of trypanosomes circulating in the area (Maikaje 1998) and linking it to the efficiency *G. p. palpalis* in transmitting drug-resistant strains of trypanosomes (Stephen 1963), it is glaring that chemotherapy, to the exclusion of other approaches is not adequate to manage the problem in the area. From the results obtained, the study area can therefore be divided into three zones:

-Region of high endemicity at Bondong, Manchok and Kadarko districts in the north-west and north east.

-A region of medium prevalence at Kukum district in the north-west.

-A region of low prevalence in the mountain ranges of Zankan district in the south-east.

A successful solution to the nagana problem must focus on a sustained area-wide eradication of the entire tsetse population as well as the numerous species of other biting dipterans (Ahmed *et al.* 2005) in the area that may be acting as mechanical transmitters. This can be achieved through a well designed community based programme that will use simple tools such as traps, impregnated screens and strategic locations of cattle dips. Luckily, the present study area has satisfied the criteria for the application of the area-wide concept of PATTEC because it is partially isolated by the Jos plateau to the east and the Kagoro and Attakar hills to the south. Once eradication is achieved, efforts can be made to barricade the northern and western boundaries using traps and screens to prevent re-infestations, thereby creating the desired tsetse free zone.

REFERENCES

Ademosun, A. A. 1973. The development of the livestock industry in Nigeria: Ruminants'. *Proceedings of Agricultural Society of Nigeria.* 10:13-20.

Agu, W. E.; Katab, U. Z.; Haruna, E. A.; Ayandele, J.; Aina, A.; Baah, M. M. & Adamu, S. 1983. *Field survey for bovine trypanosomiasis in parts of Kaduna and Plateau States.* Annual Scientific Report, NITR, 1980-83. Himma Press Ltd, Kaduna, Nigeria

Ahmed, M. I.; Osiyemi, T. I. O. & Ardo, M. B. 1994. Prevalence of bovine trypanosomiasis infection in Damboa Local Government Area, Borno State. *Nigerian Journal of Animal Production* 21 (1/2):186-187.

Ahmed, A. B.; Omoogun, & G. A., Shaida, S. S. 2000. Trypanosome infections in *Glossina* species at the Kainji Wild life Park, Nigeria. *Entomological Society of Nigeria Occasional Publications*, *32*: 57-62.

Ahmed, A. B. 2003. Population ecology of *Glossina palpalis palpalis* Robineau-Desvoidy (Diptera: Glossinidae) in relation to animal trypanosomiasis in Southern Guinea Savanna, Nigeria, Ph.D Dissertation University of Port Harcourt, Nigeria, 378 pp.

Ahmed, A. B.; Okiwelu, S. N. & Samdi**,** S. M. 2005. Species diversity, abundance and seasonal occurrence of some biting flies in southern Kaduna, Nigeria. *African Journal of Biomedical Research 8:*113-118

Baldry, D. A. T. 1964. Observations on a close association between *G. tachinoides* and domestic pigs near Nsukka, Eastern Nigeria II. Ecology and trypanosome infection in *G. tachinoides*. *Annals of Tropical Medicine & Parasitology, 58*:32-44.

Bossempem, K. M.; Moloo, S.K.; Assoukou, R. K. G. & Nantulya, V.M. 1995. Detection and differentiation between trypanosome species in experimentally infected tsetse flies (*Glossina* spp) using dot-Elisa. *Acta Tropica*, *60*:81-96.

Bossempem, K. M.; Assoukou, R. K. G. & Nantulya, V. M. 1996. Differenciation between culture derived insect stages of *T. brucei, T. vivax, T. congolense* and *T. simiae* using a monoclonal antibody-based dot-Elisa. *Parasitology*, *112*:59-66.

Buxton, P. A. 1955. *The natural history of tsetse flies*. London School of Hygiene and tropical Medicine. *Memoir* 10.

Challier, A. & Larvessiere, C. 1973. Un nouveau piege pour la capture des Glossines (Glossina: Diptera, Muscidae) description et Essays sur le terrain. *Cashier ORSTOM. Series Entomologie Medicale et Parasitologie*, *11*:251-262.

Davies, H. 1977. *Tsetse flies of Nigeria*. Oxford University Press, Ibadan.

Desowitz, R. S. & Fairbain, H. 1955. The influence of temperature on the length of the development of *Trypanosome vivax* in *Glossina palpalis. Annals of Tropical Medicine & Parasitology 49*:161.

Esuruoso, G. O. 1973. The epizootiology, prevalence and economic aspects of bovine trypanosomiasis in Nigeria. *Proceedings of 7th USA Animal Health Association, Missouri,* Oct 13-19, 1973:160-174.

Glover, P. E. & Aitchison, P. J. 1966. *Tsetse Control and Land use in Northern Nigeria: a feasibility study of area I.* Baraka Press, Kaduna,

Godfrey, D. G. & Killick-Kendrick, R. 1961. Bovine trypanosomiasis in Nigeria. I. The inoculation of blood into rats as a method of survey in the Donga Valley, Benue Province. *Annals of Tropical Medicine & Parasitology 55*:287-297.

Gouteux, J. P.; Eouzan, J. P. & Noireu, F. 1987. Modification of the behaviour of *Glossina palpalis palpalis* linked to the 1982 swine fever epizootic in a Congolese village. *Acta Tropica, 44*(3):333-337.

Harley, J. M. B. 1966. Seasonal and diurnal variations in physiological age and trypanosome infection rate of female *Glossina pallidipes* Aust., *G. palpalis fuscipes* Newstead and *G. brevipalis* Newstead. *Bulletin Entomological Reserach*, *56* (4):595-614

Harley, J. M. B. 1967. Further studies on age and trypanosome infection rate in *Glossina pallidipes*. Austen. *Bulletin Entomological Research*, 57: 459.

Holmes, P. H. 1991. New opportunities for the diagnosis and control of animal diseases in the tropics. *Transactions Royal Society Tropical Medicine & Hygiene*, (85):165-167.

Itard, J. 1989. *African animal trypanosomiasis*. In. Manual of Tropical Veterinary Parasitology. M. Shah-Fischer & R. Ralph Say. (eds) (English translators). CAB International, UK..

Jawonisi, I. E. 1988. Tsetse control/eradication in Nigeria: history, achievements and future plans. *Invited paper, FAO/IAEA Regional Training Course on 'Integrated Control of Tsetse flies with emphasis on SIT', Vom, Nigeria,* 23 May-17 June, 1988.

Killick-Kendrick, R. & Godfrey, D. G. 1963. Bovine trypanosomiasis in Nigeria. II. The incidence among some migrating cattle, with observations on the examination of wet blood preparation as a method of survey. *Annals Tropical Medicine & Parasitology*, *57*:117-126.

Lloyd, L. & Johnson, W.B. 1924. The trypanosome infections of tsetse flies in northern Nigeria. *Bulletin Entomological Research, 14: 265-288.*

Maclennan, K. J. R. 1976. Summary of the present situation concerning the epidemiolgy of tsetse transmitted trypanosomiases. Joint WHO Expert Committee and FAO Expert consultation on the African Trypanosomiasis. AGA TRYP/WP/76.36,

Madubunyi, L. C. 1988. The collapse of *Glossina tachinoides* (Diptera: Glossinidae) populations in two peridomestic agroecosystems in the Nsukka area of Anambra State, Nigeria. *Insect Science & its Applications, 9(3):361-366.*

Madubunyi, L. C. 1990. Ecology of *Glossina* species inhabiting peridomestic agroecosystems in relation to options for tsetse fly control. In: *Sterile Insect Technique for Tsetse Control & Eradication. Proceedings of the Final Research Coordination Meeting, Vom, Nigeria.*

Maikaje, D. B. 1998. Some aspects of the epidemiology and drug sensitivity of bovine trypanosomoses in Kaura Local Government Area of Kaduna State. Ph.D Thesis, Ahmadu Bello University, Zaria, Nigeria, 1998, 147pp

Marshall, R. S. 1948. *Annual report of the Veterinary Department, Northern Provinces,* 1947. Government Press, Lagos..

Moloo, S. K.; Steiger, R. F. & Brun, R. 1973. Trypanosome infection rates in *G. swynnertoni* and *G. pallidipes* in Ikoma Musoma district, Tanzania. *Parasitology*, 66:259.

Moloo, S. K. 1976. Aspects of the nutrition of adult female *Glossina morsitans* during pregnancy. *Journal of Insect Physiology, 22:563-567.*

Murray, M.; Trail, J. C. M.; Turner, D. A. & Wissocq, Y. 1983. *Livestock productivity and trypanotolerant*. Training manual, ILCA, Ethiopia.

Nawathe, D. R.; Sinha, P. K. & Abechi, A. S. 1988. Acute bovine trypanosomiasis in a tsetse free zone of Nigeria. *Tropical Animal Health & Production*, 20(3):141-142.

Nawathe, D. R.; Srivastava, G. C.; Basal, A. K. & Kolleri, M. A. 1995. Trypanosomiasis in small ruminants in the arid zone, Nigeria. *Bulletin Animal Health Production in Africa*, 43(4):293-294.

Omoogun, G. A. 1994. The design and construction of the Nitse trap. *Insect Science & its Applications*, 15 (4/5):535-539.

Onah, J. A.; Onyeka, J. O. A. & Tenabe, S. O. 1985. Studies on trypanosome infection rates of *Glossina* (Diptera: Glossinidae) in Pandam Wildlife Park, Nigeria. *Nigerian Journal of Entomology* 1985, 6:53-59.

Onyiah, J. A.; Na'isa, B.K.; Riordan, K. & Gregory, W. 1983. Tsetse distribution in Nigeria. *Bulletin Animal Health & Production in Afirica*, 31(2):141-150.

Penchenier, L., Itard, J. 1981. A new technique for the rapid dissection of salivary glands and gut of tsetse. *Cahiers ORSTOM series Entomology Medical Parasitology,* 19:55-57.

Pollock, J. N. 1982. (Ed). *Training manual for tsetse control personnel*. Vol 1.FAO Publ. No M/P5178/E.

Potts, W. H. 1970. Miscellaneous techniques used in study of Glossina. In: *The African Trypanosomiases*. Mulligan, H.W. W. H. Potts (eds), Allen & Unwin, London.

Stephen, L. E. 1962. Some observations on the behaviour of trypanosomiasis occurring in cattle previously treated with prophylactic drugs. *Annals of Tropical Medicine & Parasitology*, 56:415-421.

Stephen, L. E. 1963. An attempt to produce resistance to homidium in a strain of *Trypanosoma vivax* transmitted by tsetse fly. *Journal of Comparative Pathology & Therapeutics*, 73:76.

Stephen, L. E. 1986. *Trypanosomiasis: A veterinary perspective*. Pergamon Press,

van Wettere, P. H. J. 1975. A study of the ecology of *Glossina palpalis* (Rob.-Desv. 1830) in lower Zaire in connection with the epidemiology of human sleeping sickness caused by *Trypanosoma brucei gambiense.* Ph.D Thesis, Univerisity of Amsterdam. 286