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Original Article

Effect of Deltamethrin Aerial Spraying in Controlling African Animal Trypanosomosis in Cattle in the Sesheke and Shang'ombo Districts of Western, Zambia

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Abstract
Trypanosomosis is a vector-borne zoonotic disease transmitted by the tsetse fly (*Glossina* species). The condition is caused by protozoa known as Trypanosomes. In 2009, large-scale aerial spraying with deltamethrin at 0.26-0.3 g/ha, was undertaken in 5000 km^2 covering parts of the Sesheke and Shang'ombo districts to control tsetse flies animal trypanosomosis in cattle in the area. Cattle were sampled for prevalence and incidence of trypanosomosis before, during, and, after aerial spraying as a circuitous way of detecting the presence of the primary vector (tsetse flies). Buffy coats, thick and thin dry smears were applied in the parasitological tests. In the baseline survey, 1,866 cattle were presented, and 25.7% (n = 481) were sampled and examined. *Trypanosoma* spp. was detected in 1.9% (n = 9) of animals. Six sentinel herds (four treatments and two controls) with 20 animals per herd were monitored for the incidence of AAT during and after aerial spraying, and prevalence was compared among the three phases. The results showed that no new case of trypanosomosis was detected in the treatment herd during the aerial spraying and three months into the post-aerial spraying period except 0.83% (n = 1) in the control herd [Mid-P exact; p-value = 0.167 (1-tailed)]. This suggests an association between deltamethrin aerial spraying and trypanosomosis. In conclusion, there was a significant reduction in trypanosomosis prevalence following the aerial spraying operation. This indicates that aerial spraying significantly reduced the tsetse population and subsequently reduced disease transmission to cattle in the area. Furthermore, it indicates that aerial spraying was an effective method of controlling trypanosomosis in cattle. There is a need to extend this operation to other tsetse-infested areas in the country.
Keywords: Tsetse flies, Trypanosomosis, Deltamethrin, Aerial spraying, Zambia

Introduction

Trypanosomosis is a vector-borne zoonotic disease transmitted by the tsetse fly (*Glossina* species). Tsetse flies are responsible for the transmission of trypanosomes in cattle in large areas of Africa (Jordan, 1985), including Southern Africa (Sigauque et al., 2000; Van den Bossche et al., 2000; Van den Bossche, 2001).

The epidemiology of trypanosomosis is influenced by many factors, including the encroachment of people, with their livestock, into tsetse-infested areas (Van den Bossche, 2001).

In Southern Africa, four countries, namely, *Angola*, *Botswana*, *Namibia,* and *Zambia*, share the Kwando-Zambezi River basin, and the tsetse fly belt. This fly belt is inhabited by *Glossina morsitans centralis* tsetse fly subspecies (Willemse, 1991). In 2005, the four countries embarked on a regional campaign aimed at controlling tsetse flies using the aerial spraying method Sequential Aerosol Technique (SAT), where deltamethrin insecticide was applied over an area covering 10,000 km^2 of which 5,000 km^2 were in Zambia and the other 5,000 km^2 in Angola (Tsetse-PATTEC report, 2005). An estimated 36.8% of the Zambian land is tsetse infested, including *Glossina brevipalpis*, *Glossina morsitans centralis*, *Glossina morsitans morsitans*, *Glossina pallidipes*, and *Glossina fuscipes* (Fig. 1) which can transmit Trypanosoma species (Tsetse-PATTEC report, 2005; FAO, 1982; Cecchi et al., 2015). The *Trypanosoma congolense*, *Trypanosoma vivax*, and, *Trypanosoma brucei* are the important trypanosoma species that cause trypanosomosis in livestock in Zambia. Trypanosomosis has severe negative impact, including decreased livestock production and productivity, reduced availability of draught power, and an associated drop in crop production (Evison and Kathuria, 1982).

Fig. 1. Tsetse-fly (Source: Kozánek, 2019)

The history of the tsetse flies infestation and trypanosomosis in livestock dates as far back as the 1850s, and trypanosomosis model surveys (Wamwiri and Auma, 2021), by the Department of Veterinary Services in Zambia, continued to reveal increasing prevalence levels of the disease in Sesheke and Shang'ombo districts However, alternative control measures were put in place, which included the use of trypanocidal drugs and targets (odor baited techniques). Since the late 1980s, in Zambia, tsetse control methods have been dominated by the use of black cloth panels commonly known as targets, which was the primary method of controlling tsetse flies and, subsequently animal trypanosomosis (Willemse, 1991). However, there were some challenges with using odor-baited and insecticide-impregnated screens or targets, such as vandalism, maintenance costs, and reinvasion. For this reason, aerial spraying has become an alternative method to tsetse control and offers some advantages over Targets. Botswana pioneered the reintroduction of aerial spraying as an option in tsetse control between 2000 and 2002 (Allsopp and Phillemon-Motsu, 2002). Based on the model applied in Botswana, the

Kwando-Zambezi regional project adopted aerial spraying as the primary tsetse control method in the project. The study aimed to investigate the prevalence of trypanosomosis before, during, and three months after the aerial spraying period in cattle in Sesheke and Shang'ombo districts in the western province of Zambia. Consequently, our study circumlocutorily evaluated the effect of deltamethrin on tsetse flies by detecting *Trypanosoma* spp. in cattle in the study area.

Materials and methods

Study area

The study site covers parts of the Sesheke and Shang'ombo districts in the western province of Zambia and is located between longitudes 22.5833°E and 23.9167°E and latitudes 16.8333°S and 17.6667°S (Fig. 2). The vegetation is mainly savannah woodland and *Colosphospernum/Baikiae* ecotones on poor soils of the Kalahari sands. The area is interspersed with Itigi thickets, flood plains, and wood forest patches of *Combretum* and *Mopani* trees beside the grass plains that provide open grazing land. The main drainage is the Kwando-Zambezi River system bordering Zambia and Angola (Corten et al., 1988). Animal husbandry and crop production are the main economic activities, although there is low crop production due to poor soil. Cattle are the most abundant livestock reared because they provide draught power, income, and manure for crop production.

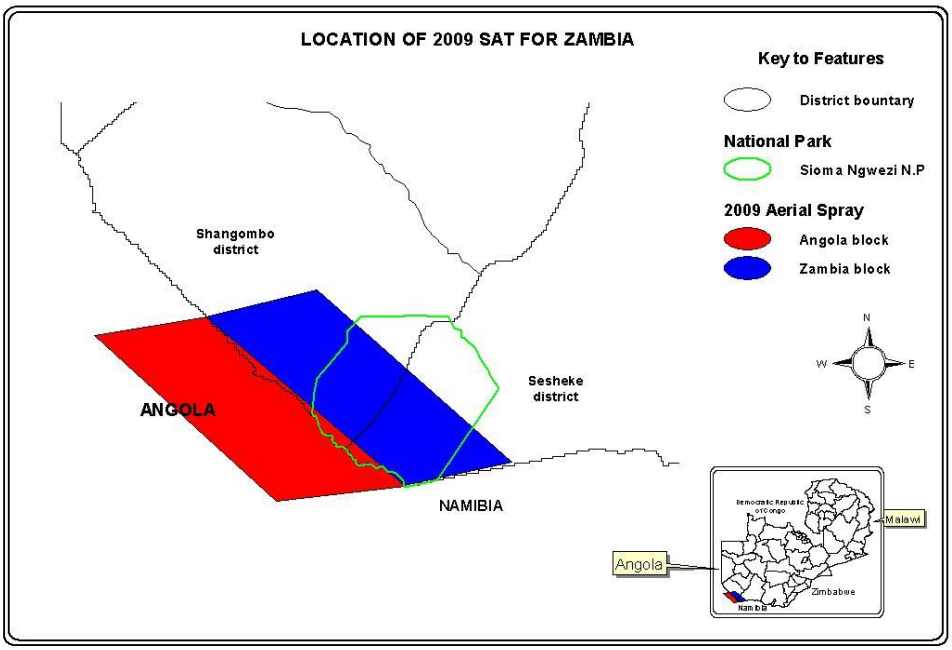

Fig. 2. Aerial spraying block in the Western Province of Zambia.

Study design

Monitoring of sentinel cattle herds for trypanosome infection was carried out in three stages, i.e. pre-spraying (baseline), aerial spraying, and post-spraying period. There were two monitoring sites, one inside the spraying block (treatment site) and one outside the spraying block (control site).

Sentinel herds

Four and two sentinel herds were set up in the treatment and control sites, respectively (Fig. 3). All animals in the sentinel herds were treated with

a double dose (7.0 mg/kg body weight) of diminazene aceturate (Berenil) administered intramuscularly at the beginning of the study. Monitoring the effect of aerial spraying involved collecting parasitological and PCV data from sentinel animals in June and July 2009. Animals positive for trypanosomosis were treated with a single curative dose of diminazene aceturate (Berenil) of 3.5 mg/kg body weight.

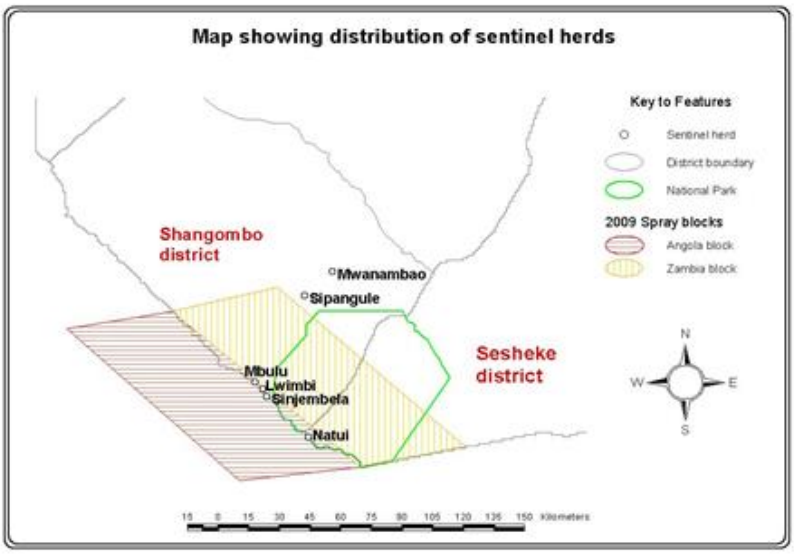

Fig. 3. Distribution of sentinel herds in the study area.

Sampling method

Cattle owners from both the treatment and control sites were engaged. Farmers were assured of free treatment of their cattle, particularly with trypanocidal drugs, whenever any of the animals in the sentinel herds were detected positive for the disease.

Crush pens were used as sampling frames, whereas villages were epidemiological units. On the sampling day, a questionnaire was administered to collect details about each farmer. Before aerial spraying, animals were systematically randomly selected for sampling. All animals were put in a crush pen, and every third cattle was identified and sampled. However, bias was sometimes given to clinically sick animals, although the sampling system changed during the monitoring (surveillance) phase since the same animals (sentinel herd) were sampled.

Diagnostic method

A combination of blood smear examinations and concentration (buffy coat) parasitological diagnostic techniques were used to detect the *Trypanosoma* species. However, the study relied more on the concentration buffy coat method because of its high sensitivity and specificity to demonstrate the live trypanosomes (Kalu et al., 1986; OIE, 2008).

During blood sample collection, a clean lancet was used to pierce the marginal ear vein, and the flowing blood was drawn into two heparinized capillary tubes and closed with a crystaseal at one end. The capillary tubes were spun in a microhaematocrit centrifuge for 5 minutes at 12000 rpm, and the PCV was read. The proportion of red blood cells was expressed as a percentage of the total blood volume (Murray et al., 1977). Using a diamond pencil, the capillary tube was cut 1 mm below and 3 mm above the buffy coat. The contents of the amputated capillary tube were expressed on a clean, dry, grease-free glass slide, mixed, and covered with a clean coverslip. The wet smear was examined under dark ground illumination to take advantage of its discrimination for both red and

white blood cells, while trypanosomes were recognized by their motility. Thick and thin blood smears were made according to OIE Terrestrial Manual (2008) guidelines. The thin blood smears were fixed using methanol for 3 minutes. Both thick and thin smears were stained in 10% Giemsa stain for 30 minutes, washed with buffered water, allowed to dry, and, examined under a light microscope with an oil immersion objective (Kalu et al 1986). Trypanosoma species identification was performed according to the OIE Terrestrial Manual (2008; Figure 4).

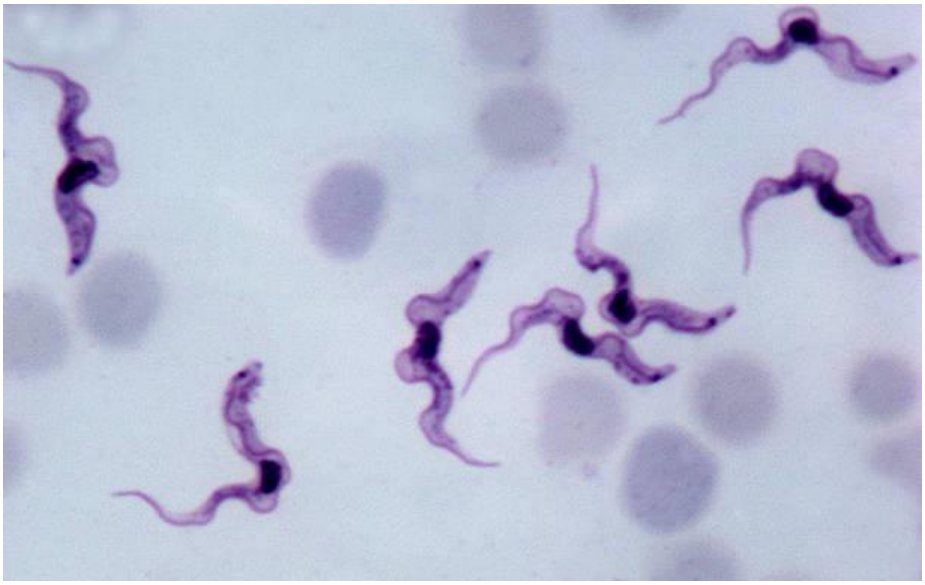

Fig. 4. Trypanosoma species stained with Giemsa.

Monitoring for trypanosomosis infection

The purpose of trypanosomosis monitoring during the treatment phase was to assess the impact of aerial spraying against tsetse flies circuitously.

Baseline survey (Pre-aerial spraying phase)

The purpose of the trypanosomosis survey during this phase was to collect baseline prevalence data from the study area and to create sentinel herds. A total of 12 sampling sites presented 1,866 cattle were identified, out of which 481 were randomly selected for sampling. The sample size was determined from the total cattle population at a designated sampling site (Cannon and Roe, 1972). During the baseline survey, sentinel animals were selected and ear tagged for subsequent monitoring during and after aerial spraying. Four and two permanent sentinel herds were established inside and outside the aerial spraying block, respectively, comprising 20 cattle per herd, for a total number of 120 cattle. The diagnostic techniques used were as described above. All positive animals for trypanosomosis were intramuscularly administered trypanocide (Diminazene Aceturate, Berenil®) at a curative dose of 3.5 mg/kg body weight.

Aerial spraying (May-July 2009)

The aerial spraying activity was conducted from May to July 2009. The insecticide sprayed was deltamethrin (Deltanex™), applied in five spray cycles. The dose was 0.3 g/ha in the first two spray cycles and 0.26 g/ha in the last three cycles. During this period, sampling for trypanosome infection in the sentinel herds was undertaken every four to five weeks.

Post-aerial spraying

The first sampling under post-spray monitoring was undertaken four months after the aerial spraying operation, i.e., in December 2009, the

second in April 2010, and the third in November 2010, respectively.

Data analysis

Field data were entered in Microsoft Excel and converted to text tab-delimited format before being transferred into R statistical analysis software (Hornik, 2011), where prevalence and *p*-value were calculated.

Results

Pre-aerial spraying phase

In the baseline survey, a total of 481 cattle were sampled for AAT, and 1.9% (n = 9) were positive for *T. congolense* and located at treatment site. The PCV values ranged from 15%-43%, with a mean of 29.8% (Table 1). No tsetse fly was trapped in the area.

Aerial spraying phase

All six sentinel herds were sampled during this phase, and no positive *Trypanosoma* spp. was detected in the treatment or control group. PCV levels ranged from 31-33% (Table 2).

Table 1. Prevalence and PCV values during baseline investigation.

Sampling site	Animals sampled	No. Infected	Prevalence %	Mean PCV%
Mbala	78	1	1.28	29.7
Nantuu	30	1	3.33	31.7
Sinjembela	40	0	0	28.1
Dihehe	47	0	0	28.9
Lwiimbi	35	5	14.29	28.0
Mbulu	30	2	6.67	31.3
Lusu	30	0	0	31.7
Neyanda	5	0	0	28.2
Kalobolelwa	64	0	0	29.2
Mwanambao	77	0	0	30.2
Sipangule	45	0	0	30.9
TOTAL	**481**	**9**	**1.9**	**29.8**

Table 2. Prevalence and PCV values during aerial spraying from the sentinel herd.

	June 2009				July 2009			
Crushpen	No sampled	No. Positives	Prev %	Mean PCV%	No sampled	No. infected	Prev %	Mean PCV%
Nantuu	20	0	0	33.6	20	0	0	35.0
Sipangule	20	0	0	33.0	18	0	0	31.4
Mwanambao	20	0	0	31.0	20	0	0	28.7
Lwiimbi	20	0	0	31.0	16	0	0	34.6
Mbulu	20	0	0	33.8	18	0	0	33.1
Sinjembela	20	0	0	32.0	19	0	0	32.3
TOTAL	**120**	**0**	**0**	**32.4**	**111**	**0**	**0**	**32.5**

Post-aerial spraying phase

All 120 sentinel cattle were sampled for AAT in December 2009 and April 2010. There was no positive AAT detected in December 2009, while there was one positive case [0.83%, Mid-P exact; *p*-value = 0.167 (1-tailed)] seen in April 2010 outside the spraying block. No positive case of AAT was detected in November 2010. The herds' mean PCV values ranged from 28.2-36.0%. The mean monthly PCV was 31.4, 32.7, and 31.3% in December 2009, April 2010, and November 2010, respectively (Table 3).

Table 3. Microscopy and PCV (%) results after aerial spraying period from the sentinel herd.

	December 2009				April 2010				November 2010			
Crushpen	**No. samples**	**No. positives**	**Inci. %**	**Mean PCV%**	**No. samples**	**No. positives**	**Inci. %**	**Mean PCV%**	**No. samples**	**No. positives**	**Inci. %**	**Mean PCV%**
Nantuu	20	0	0	33.9	20	0	0	35.0	20	0	0	31.8
Sinjembela Central	20	0	0	28.2	20	0	0	32.0	20	0	0	30.4
Mbulu	20	0	0	32.4	20	0	0	31.0	18	0	0	30.8
Lwimbi	20	0	0	29.0	20	0	0	29.0	14	0	0	29.2
Sipangule	20	0	0	32.7	20	1	0.83	33.0	20	0	0	31.6
Mwanambao	20	0	0	32.3	20	0	0	36.0	20	0	0	33.8
TOTAL	**120**	**0**	**0**	**31.4**	**120**	**1**	**0.83**	**32.7**	**112**	**0**	**0**	**31.3**

***Inci. = Incidence**

Discussion

No detection of trypanosomes in the treatment sentinel herd after aerial spraying, suggests that aerial spraying affected the vectors that transmit trypanosomes. The buffy coat method used in the study is considered a reliable field diagnostic technique for animal trypanosomosis. This technique has commonly been used to monitor the performance of several other tsetse control interventions in the past, such as in aerial spraying in Botswana in 2002 (Kgori et al., 2006) and the use of targets in eastern Zambia and the results have been successful (Van den Bossche et al., 2001). Monitoring for the prevalence of trypanosomosis to evaluate the performance of such interventions is often complemented with entomological monitoring, i.e., tracking the tsetse flies in the control block. However, baseline entomological surveillance indicated that the apparent density of tsetse was extremely low in the area, and monitoring for trypanosomosis prevalence/incidence was the most effective way to evaluate the performance of the aerial spraying operations (Allsopp and Phillemon-Motsu, 2002).

In the study, the sampling interval was 40 to 150 days, which was on average more extended than the trypanosomosis incubation period; increased the chances of disease manifestation in sentinel animals. The average incubation period for trypanosomes ranges from 4 to 40 days (Uilenburg, 1998). On the other hand, Berenil is known to have a maximum curative period of approximately 12 days in the animal body (Wellde and Chuma, 1983); therefore, treatment with berenil given at the baseline phase did not prevent trypanosome infection beyond two weeks from the time of the treatment, and the interval of sampling was much longer than the known curative period. The withdrawal period for berenil on the consumption of produce is from 21 days for meat and three days for milk (Desquesnes et al., 2013).

Our findings through trypanosomosis monitoring show that aerial spraying with insecticide deltamethrin was effective in controlling tsetse populations in the region (Allsopp and Phillemon-Motsu, 2002). Deltamethrin was more effective than alphacypermethrin because its active ingredient is mixed with oil to reduce evaporation and preserve efficacy. Deltamethrin is readily biodegradable, while alphacypermethrin is persistent in the environment. Nine months after aerial spraying, one positive case of trypanosomosis was found only outside the sprayed area, indicating that the control

intervention against tsetse flies in the treatment area was successful.

The mean PCV values of cattle remained normal at >25% throughout the study. This could be attributed to the lower tsetse fly challenge that was exhibited at the beginning of the research and further reduced following aerial spraying. According to Bossche and Duchateau (1998), AAT is among other haemoparasites that can affect PCV levels in cattle in addition to *Babesia*, *Anaplasma* species, and other blood-sucking parasites.

Conclusion

We conclude that aerial spraying with deltamethrin to control tsetse flies led to a reduction in trypanosomosis infection rate in cattle; therefore, there is a need to extend this practice to other areas infected with tsetse and to train the livestock farmers in the country.

Acknowledgments

We thank the Department of Veterinary Services for granting permission to conduct aerial spraying in the area.

Conflict of Interests

The authors declare no conflict of interest.

Ethical approval

The research project was approved by the Ministry of Fisheries and Livestock in the Department of Veterinary Services.

References

Allsopp R. & Phillemon-Motsu T.K. Tsetse control in Botswana-a reversal in strategy. *Pesticide Outlook*, 2002, *13*(2),73-76. https://doi.org/10.1039/B202993F

Cannon RM. & Roe R.T. Livestock disease surveys: A Field Manual for Veterinarians. *Australian Government Publishing Service*, 1982, 35.

Cecchi G., Paone M., Argilés Herrero R., Vreysen M.J. & Mattioli, R.C. Developing a continental atlas of the distribution and trypanosomal infection of tsetse flies (Glossina species). *Parasites & Vectors*, 2015, *8*(1), pp.1-10. https://doi.org/10.1186/s13071-015-0898-y

Corten J., Ter Huurne A., Morehouse P. & De Roou R. Prevalence of trypanosomiasis in cattle in South-west Zambia. *Tropical Animal Health and Production*, 1988, 20,78-84. https://doi.org/10.1007/bf02242230

Desquesnes M., Dargantes A., Lai DH., Lun Z.R., Holzmuller P. & Jittapalapong S. Trypanosoma evansi and surra: a review and perspectives on transmission, epidemiology and control, impact, and zoonotic aspects. *BioMed Research International*, 2013, 194176. https://doi.org/10.1155/2013/194176

Evison C. & Kathuria S. An introduction to status and control of tsetse (Glossina spp.) in Zambia. *Department of Veterinary and Tsetse Control Services, Lusaka*. 1982

Food and Agricultural Organization of the United Nations (FAO). Training Manual for Tsetse Control Personnel, 1982, (1)57.

Hornik K. The R FAQ, 2011, http://cran.r-project.org/doc/FAQ/R-FAQ.html

Jordan A.M. The vectors of African trypanosomiasis: Research towards non-insecticidal methods of control. *British Medical Bulletin*, 1985, 41(2),181-186. https://doi.org/10.1093/oxfordjournals.bmb.a072047

Kalu A.U., Edeghere H.U & Lawani F.A. Comparison of diagnostic techniques during subclinical single infections of trypanosomiasis in goats. *Veterinary Parasitology*, 1986, 22:37-47. https://doi.org/10.1016/0304-4017(86)90005-1

Kgori P.M., Modo S. & Torr S.J. The use of aerial spraying to eliminate tsetse from the Okavango Delta of Botswana. *Acta Tropica*, 2006, 99,184-199. https://doi.org/10.1016/j.actatropica.2006.07.007

Kozánek M. International Research Project Explores Novel Strategies to Improving the Sterile Insect Technique to Eradicate Tsetse Flies Through Enhancing Males Refractoriness to Trypanosome Infection, Tsetse fly G. fuscipes Scientica, 2019

Murray M., Murray P.K. & McIntyre W.I.M. An improved parasitological technique for the diagnosis of African trypanosomiasis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1977, 71(4),325-326. https://doi.org/10.1016/0035-9203(77)90110-9

OIE Terrestrial manual Trypanosomosis (Tsetse-transmitted), 2008, 813-822.

Sigauque L., Van den Bossche P., Moiana M., Jamal S. & NevesL. Distribution of tsetse (diptera: Glossinidae) and bovine trypanosomosis in the matutuine district,Maputo Province, Mozambique. *Onderspoort Journal of Veterinary Research*, 2000, 67,167-172. http://hdl.handle.net/2263/19417

Tsetse-PATTEC report. Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC). A continental plan of action for the eradication of tsetse and trypanosomosis, 2005

Uilenberg G. A field guide for the diagnosis, treatment and prevention of African Animal Trypanosomosis. FAO Corporate Document Repository, 1998, 1-158.

Van den Bossche P. Some general aspects of the distribution and epidemiology of bovine trypanosomosis in southern Africa. *International Journal for Parasitology*, 2001, 31,592-598. https://doi.org/10.1016/S0020-7519(01)00146-1

Van den Bossche P., Shumba W & Makhambera P. The distribution and epidemiology of bovine trypanosomosis in Malawi. *Veterinary Parasitology*, 2000, 88,163-176. https://doi.org/10.1016/S0304-4017(99)00222-8

Wamwiri F.N. & Auma, J.E. Overview of the Vectors and Their Role in Transmission of African Animal Trypanosomiasis. *Combating and Controlling Nagana and Tick-Borne Diseases in Livestock*, 2021, (pp. 53-72). https://doi.org/10.4018/978-1-7998-6433-2.ch003

Wellde B.T & Chumo D.A. Persistence of berenil in cattle. *Tropical Animal Health and Production*, 1983, 15,149-150. https://doi.org/10.1007/BF02239923

Willemse L. A trial of odour baited targets to control the tsetse fly, *Glossina morsitan centralis (Diptera: Glossinidae)* in west Zambia. *Bulletin of Entomological Research*, 1991, 81, 351. DOI: https://doi.org/10.1017/S0007485300033630