COMPARISON OF THE EFFECTIVENESS OF BOVINE TRYPANOSOMOSIS CONTROL TECHNOLOGIES USED IN BUIKWE COUNTY MUKONO DISTRICT SOUTHEASTERN UGANDA

DAVID WAISWA KAKAIRE

THESIS SUBMITTED AS A REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE IN VETERINARY MEDICINE OF MAKERERE UNIVERSITY

2004

DECLARATION

I David Kakaire declare that this thesis contains my original work. I also declare that this work has never been submitted to any University or Institution for the award of a degree or any other qualification.

Signed: _____ Date 21/03/05

Tis thesis has been submitted with approval of following supervisors.

1). Prof. Rubaire – Akiiki
Faculty of Veterinary Medicine
Makerere University,
P.O. Box 7062,
Kampala – Uganda

Signed: _____ Date 21/3/05

2. Prof. Katunguka-Rwakishaya E
Faculty of Veterinary Medicine
Makerere University,
P.O. Box 7062,
Kampala – Uganda

Signed: _____ Date 21/3/05

DEDICATION

This work is dedicated to my family.

TABLE OF CONTENTS

	PAGE
Declaration	ii
Dedication	iii
Table of contents	iv
List of figures	viii
List of Tables	ix
Acknowledgements	x
List of abbreviations	xii
Abstract	xii
CHAPTERER ONE:	
1.1 Introduction	1
1.2 Objectives of the Study	7
1.3 Hypothesis	8
CHAPTER TWO: LITERATUE REVIEW	9
2.1 Epidemiology of Animal Trypanosomosis	9
2.2 Control of Nagana	11
2.3 Control of Tsetse Flies	12
2.4 Summary of the literature review	22
CHAPTER THREE: MATERIAL AND METHODS	23
3. 1 Study Area	23
3. 2 People and Farming system in the area	23
3. 3. Sites selection	26

3. 4 Experimental Design 26

3.5. Baseline Data Collection 26

3.5.1 Entomological Survey 26

3.5.2 Animal trypanosomosis survey 27

3.6 Assessment of effectiveness of Treatments 29

3.6.1 Trypanosome infection rates in cattle 29

3.6.2 Tsetse fly apparent density 30

3.6.3 Tsetse Control by trapping 30

3.6.4 Tsetse trypanosome infection rates 30

3.7 Applications of Treatments 32

3.7.1 Deltamethrin-impregnated pyramidal traps plus diminazene aceturate treatment 32

3.7.2 Deltamethrin-impregnated Pyramidal traps Plus Isometamidium chloride treatment 32

3.7.3 Cattle sprayed with Deltamethrin (Live bait) combined with isometamidium chloride treatment 33

3.7.4 Cattle sprayed with Deltamethrin (Live bait) combined with Diminazene aceturate treatment 33

3.7.5 Treatment of cattle with Diminazene Aceturate 33

3.7.6 Deltamethrin-impregnated pyramidal traps 34

3.7.7 The Controls 34

3.7.8 Tsetse fly records 34

3.8 Statistical analysis 34

CHAPTER FOUR: RESULTS 35

4.1 Effect of treatment of Trypanosome infection rates in cattle 35

4.1.2 Chemotherapy with Diminazene aceturate alone 32

4.1.3 Traps Only Treatment 37

4.1.4 Deltamethrin spray plus Diminazene aceturate treatment 37

4.1.5 Traps/Isometamidium chloride prophylaxis treatment 37

4.1.6 Traps/ Diminazene aceturate Chemotherapy 37

4.1.7 Deltamethrin /Isometamidium chloride Treatment 38

4.2. Effect of treatment on Tsetse trypanosome Infection Rates 38

4.2.1 Control group 38

4.2.2 Diminazene aceturate Treatment 39

4.2.3 Traps Treatment 41

4.2.4 Deltamethrin/ Diminazene aceturate Treatment 41

4.2.5 Traps/Isometamidium chloride Treatment 41

4.2.6 Traps/ Diminazene aceturate Treatment 41

4.2.7 Deltamethrin/Isometamidium chloride Treatment 42

4.3 Tsetse Apparent Density under the different Treatment 42

4.3.1 Diminazene aceturate Treatment 42

4.3.2 Deltamethrin/ Diminazene aceturate Treatment 44

4.3.3 Traps/ Diminazene aceturate Treatment 44

4.3.4 Deltamethrin/ Isometamidium chloride Treatment 45

4.4. Packed Cell Volume (PCV) as an indicator of the effectiveness of the

tsetse and trypanosomosis control Treatment 47

4.4.1 Traps Treatment 49

4.4.2 Deltamethrin/ Diminazene aceturate Treatment 49

4.4.3 Traps/Isometamidium chloride combination treatment 49

4.4.4 Traps/ Diminazene aceturate Treatment 50

4.4.5 deltamethrine/Isometamidium chloride Treatment 50

CHAPTER FIVE: DISCUSSION 52

5.1 Trapping Treatment 53

5.2 Use of Diminazene aceturate chemotherapy treatment 54

5.3 Traps and Diminazene aceturate treatment 55

5.4 Traps and Isometamidium chloride treatment 55

5.5 Deltamethrin and Diminazene aceturate treatment 56

5.6 Deltamethrin and Isometamedium chloride treatment 56

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS 58

6.1 Conclusion 58

6.2 Recommendations 58

CHAPTER SEVEN : REFERENCES 59

CHAPTER EIGHT :APPENDIX 1: Fly dissection record 76

APPENDIX II : Fly Trapping record 77

LIST OF FIGURES

PAGE

Figure 1: Map showing the distribution of cattle and tsetse flies in Africa 3

Figure 2: Map of Uganda showing the location of Mukono District 24

Figure 3: Map of Mukono District showing the study area 25

Figure 4: Biconical trap 28

Figure 5: Pyramidal trap 31

Figure 6: Prevalence of trypanosomes in cattle under different trypanosomosis control technologies in Buikwe county, Mukono District 36

Figure 7. Trypanosome infection rates in tsetse flies by treatment group in Buikwe county, Mukono district 40

Figure 8. Tsetse fly apparent density under different trypanosomosis control technologies in Buikwe County, Mukono district 43

Figure 9. Packed cell volume (PCV) in cattle under different trypanosomosis control technologies in Buikwe county, Mukono district 48

LIST OF TABLES

PAGE

Table 1. P-values from Turkey multiple comparison test for tsetse apparent density under various treatment groups 46

Table 2. P-values from Tukey multiple comparison test for PCV in cattle in various treatment groups 51

AKNOWLEDGEMENT

I wish to extend my thanks to my supervisors Prof. Dr. C. Rubaire-Akiiki, and Prof. Dr. E. Katunguka-Rwakishaya for their immense assistance and guidance during my research work and final write up of this Thesis.

I further thank Dr. C.P. Otim, the Acting Director LIRI, for scientific and logistical assistance rendered to me during field work and writing up the Thesis.

Thanks go to Drs. C. Waiswa, E. Kabagambe and Wampande of Makerere University, Dr. E. Matovu, LIRI – Tororo for the assistance extended to me during the time I needed it most.

I am very grateful to Livestock Systems Research Programme and Farming in Tsetse Controlled areas for sponsoring my course.

I am also grateful to laboratory staff and entire staff of LIRI for the support they offered me during my course.

LIST OF ACRYNMS

HCT	Haematocrit centrifugation technique
PCV	Packed cell volume
Wt	Body weight
COCTU	Coordinating office for the control of trypanosomiasis in Uganda
PIC	Permanent Inter- ministerial committee
DDT	Dichlorodiphenyl trichloroethane
BHC	Benzene hexachloride
SIT	Sterile insect technique
IAEA	International atomic energy agency
WHO	World health organasation
BCT	Buffy coat technique
FTD	Flies per trap per day
AD	Apparent density
NGO	None government organasation
RP	Rinderpest
PMA	Plan for modernastion of Agriculture

ABSTRACT

In Buikwe Country, Mukono District, between April 2001 and March 2002, the effectiveness of the following methods of controlling nagana in cattle: Diminazene aceturate therapy; deltamethrine impregnated pyramidal traps; Diminazene aceturate chemotherapy plus application of deltamethrin on cattle; isometamidium chemoprophylaxis plus deltamethrine impregnated traps; deminazene aceturate chemotherapy plus deltamethrine impregnated traps and isometamidium chloride chemoprophylasxis plus deltamethrine application on cattle were evaluated. The evaluation was done by assessing the effect of the control strategy on trypanosome infection rates in cattle and in tsetse flies; the haematocrit of cattle and the apparent density of tsetse flies in the study area.

The combination of prophylactic treatment with isometamiduim chloride plus deltamethrine application on cattle (live bait) performed the best by way of reducing the tsetse apparent density ($P<0.05$), improving haematocrit ($P<0.05$) and reducing the trypanosome infection rates in cattle and tsetse flies.

Sole use of traps and Diminazene aceturate treatments separately performed worst. Therefore, it was recommended that for control of bovine trypanosomosis, isometamedium chloride chemoprophylaxis plus deltamethrine application on cattle should be advocated for; preferably after the cost effectiveness of this strategy has been studies later.

Chemotherapy with Diminazene aceturate should be reserved for clearing of cattle herds of trypanosomes and not for prophyloxis.

CHAPTERER ONE:

1.1 Introduction

African animal trypanosomosis (Nagana) is one of the most important vector borne diseases affecting livestock production in the humid and sub- humid zones of sub-Saharan Africa (Greekmore, 1989). The disease is caused by protozoan parasites of the genus *Trypanosoma* and transmitted through the bites of tsetse fly (*Glossina species*) when it takes a blood meal from its hosts (humans, domestic or wild animals). The disease affects humans, ruminants, porcines, equines, camelidae, rodents and dogs. The common species of veterinary importance include those causing nagana in cattle (*T.congolense T.vivax Trypanosoma brucei brucei,* and *T.simiae* (in pigs), *T.evansi* and *T. equiperdum (in camelidae & equines)*, among others. Those of medical importance (causing sleeping sickness) include *T.b.gambiense & T.b.rhodesiense.* Cattle have the ability to maintain human infective trypanosomes and hence act as reservoir of human infective trypanosomes (Okuna *et al.*, 1986; Maudlin *et al.*, 1990; Tietjen *et al.*, 1992).

African trypanosomosis is found between 15^0N and 31^0S covering a total surface area of approximately 10 million square kilometers of fertile land (Kuzoe, 1993). The disease affects 37 African countries (Figure 1) (Holmes, 1991; Greekmore, 1989; Thomposon, 1992; Janke and Tacher, 1998). Trypanosomosis leads to reduction in productivity of milk and meat (Robertson *et al.*,1958), retarded growth rates in calves (Rowlands *et al.*,1993), abortion in livestock, sterility, lack of vigour (Camus,1981) and mortality among infected animals and people, if they are not treated in time with appropriate drugs (Mbulamberi,1990; WHO, 1986). Agyemang *et al.* (1990; 1991) demostrated that trypanosome infections in N'dama cattle, which are considered to be

trypanolerant, can lead to a considerably reduced milk production causing losses due to trypanosome infection. Animal trypanosomosis also causes immunosuppression leading to low antibody response to rinderpest (RP) vaccination (Twinamasiko and Kakaire,1994), hence affecting the RP control programs. In addition, trypanosomosis infected cattle cannot be available for draught power, hence cultivation is carried out by hand and hoe (Jordan,1987).

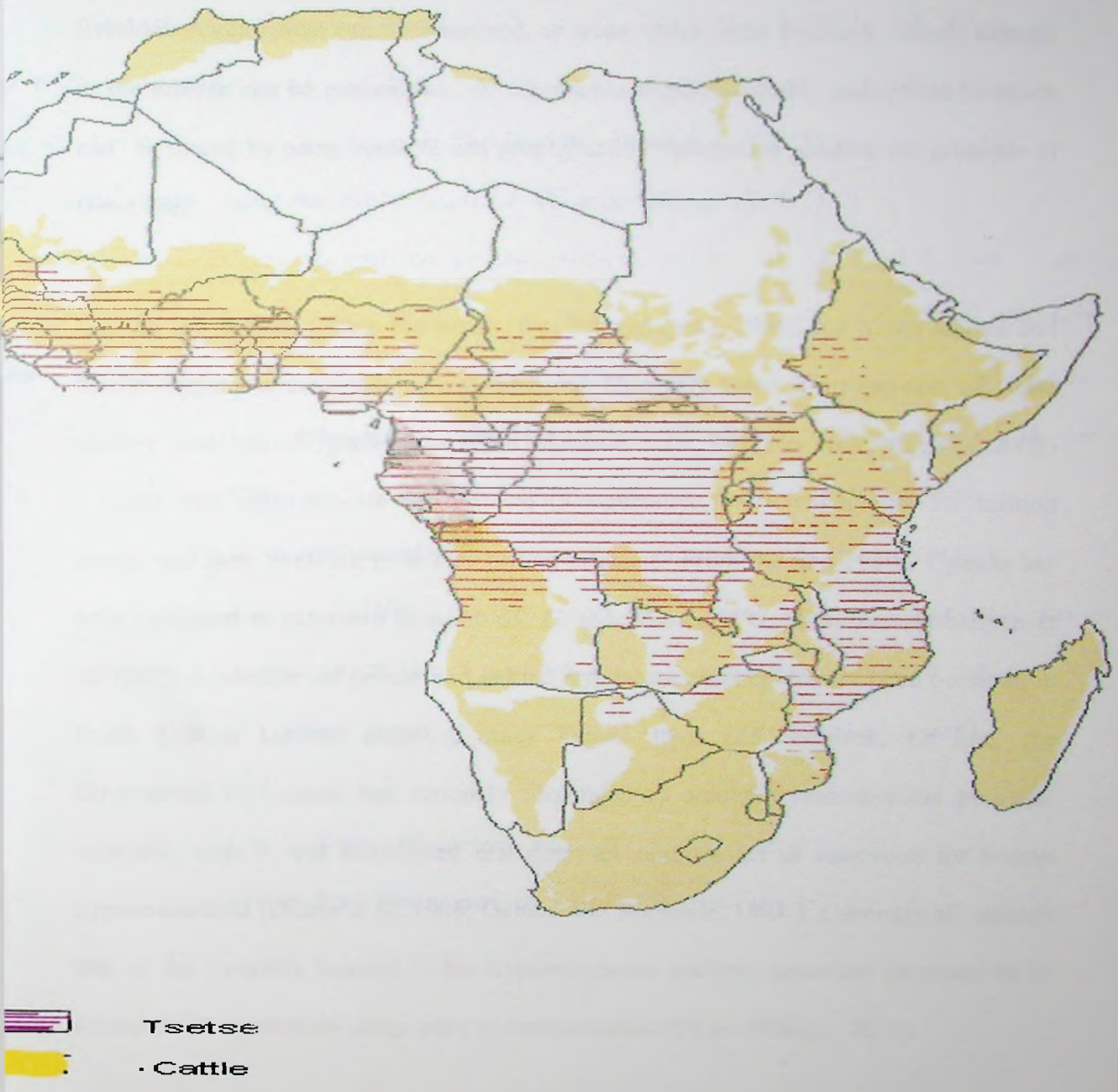
In spite of its acknowledged importance, the extent of the trypanosomosis problem has been expressed crudely in terms of the size of the land area infested by tsetse flies or the proportion of livestock population at risk (Holmes, 1991).

The disease lowers incomes of homesteads due to losses in numerical livestock units due to mortalities, milk, meat sales and draught power (Jordan, 1987). As a result, most farm labour is by hand (Janke and Tacher, 1998) and the small earnings from livestock products have to be spent on treatment of sick animals and implementation of tsetse control programmes (Molyneux, 1982).

A number of indirect losses include financial requirements for tsetse and trypanosomosis control operations. Agricultural production is also affected through lack of manure and in the end national food security is greatly affected (Jordan,1987).

ıre 1: Map shows the distribution of cattle and tsetse flies in Africa.

ppted from ILRAD 1991 Annual Report.



The incidence and severity of the disease are dependent upon local conditions, vector population and presence of susceptible animals. Thus, there are areas where virtually no livestock development can be attempted, or areas where some livestock breeds tolerant to the disease can be maintained. In other areas trypanosomosis susceptible livestock can be reared by using curative and prophylactic trypanocides despite the presence of tsetse flies.

Uganda is located within the tsetse fly belt (Magona, 1996) and hence animal and human trypanosomiasis are a big problem. Currently there is an increase of tsetse infested landmass of Uganda from 40% (Ndyabahinduka, 1993) to 70% (Mugenyi, 2003) infested with eight species of *Glossina* (Kangwangye,1987) which puts 5.1 million people and their livestock to risk of getting infected. From the mid-1930s, Uganda has been subjected to extensive invasion of *G. morsitans* and *G. pallidipes* (Robertson *et al.*,1958). A number of human and animal trypanosomiasis epidemics have occurred in South Eastern Uganda claiming many human lives and livestock. Of late, the Government of Uganda has seriously responded to animal trypanosomosis problem, especially after it was established that domestic animals act as reservoirs for human trypanosomiasis (Okuna *et al.*,1986; Okuna and Mayende, 1981). Currently all animals sold in the livestock markets in the trypanosomosis endemic areas are supposed to be treated with trypanocidal drugs prior to transportation (Olaho-Mukani, 2002).

Because of the negative impact of tsetse and trypanosomosis on the human population and livestock, much effort has been put in place to develop vector and trypanosomosis control technologies. The war against tsetse flies started as far back as 1895 when African

rinderpest cleared wild and domestic animals, which resulted into tsetse flies disappearance (ILRAD, 1993) in Zambezi basin. This confirmed that without a source of blood meals, tsetse flies will die or take refuge in a new place. On this basis, it was established that denying tsetse flies blood meals can work as a control strategy for tsetse that could lead to trypanosomosis eradication (Ford, 1970).

Programmes for tsetse and trypanosomosis control have consumed huge amounts of local and foreign money (Hursey, 1985), but still eradication of the vector and the diseases have not been achieved partly because there is little capacity to sustain control programmes due to lack of logistics (Okoth *et al.*, 1991). To improve adaption of tsetse and trypanosomosis control technologies, it requires the parties affected to take part in planning and carrying out control programme either financially or by providing labour force in order to create a sustainable control strategy (Okoth *et al.*, 1991).

Lack of accurate estimations of the costs of tsetse and trypanosomosis control and the economics of alternative control strategies employed under different livestock production systems has hindered better understanding of the disease problem in a given area and the right control strategies to be applied.

Mukono District is an endemic area for human and animal trypanosomosis which is mainly transmitted by *Glossina fuscipes fuscipes* (Siemon *et al.*, 1993). In the eighties, human sleeping sickness epidemics broke out in Mukono, Tororo districts and Busoga region (Mbulamberi, 1990). During the early 1990s, control measures were undertaken

and the tsetse population in the area was reduced by 85% using pyramidal traps (Kakaire *et al.*,1993). Similarly, the tsetse fly trypanosome infection rate was reduced by 100% after the application of deltamethrin on cattle and pigs (Siemon *et al.*, 1993) in Buikwe county, Mukono district.

In Buikwe County, the control measures put in place during the 1990s seemed to be insufficient as both animal and human trypanosomiasis were still being reported in the area, Waiswa, 2002) and therefore, it was selected as a study area. Due to the problems caused by the disease, the community was willing to cooperate in the study.

Different trypanosomosis and tsetse control methods have been used and greatly improved in the last fifty years and these include: vector control by ground and aerial spraying with insecticides (Woolfe, 1965); use of impregnated traps and targets (Vale, 1982); chemotherapy and chemoprophylaxis (Fussiganger and Baker, 1960), rearing of trypanotolerant animals (Stephen, 1966) and of recent, the Sterile Insect Technique (Allsopp, 2001).

However, it is an epidemiological maxim that disease in any production system is only part of the system and that it needs to be investigated with consideration given to both the complex interactions between factors that influence disease levels and to the possible ramifications of control procedures (Martin *et al.*, 1987). In proposing practical control measures, all aspects of the ecology of tsetse and the disease must be taken into consideration and alternative options should be compared with a view of selecting the most cost-effective and easily applied and adopatable strategy for a particular area. This

study compared diffrent technologies used singly or in an integrated manner by farmers, government departments and international organisations in the control of trypanosomiasis. Chemotherapy (diminazene aceturate treatment) and prophylactic (isometamidium chloride treatment) approaches, artificial baits (traps imprignated) and natural bait (cattle sprayed with pyrethroid compounds) systems were compared.

This study looked at two singly applied methods: (Chemotherapy with diminazene aceturate treatment and Sole use of traps) and four combined bovine trypanosomosis control methods: (Chemotherapy with diminazene aceturate and deltamethrine treatment; Chemotherapy with isometamedium chloride plus traps; Chemotherapy with diminazene aceturate plus traps and Chemotherapy with isometamedium chloride plus deltamethrine spraying).

1.2 Objectives of the Study

The objective of the study was to evaluate the effectiveness of technologies by comparing their effect on:

a) the prevalence of bovine trypanosomiasis

b) haematocrit status (packed cell volume) of the animals kept in the study area

c) tsetse trypanosome infection rates

d) tsetse apparent density

1.3 The Hypothesis

Use of traps alone; diminazene aceturate therapy, cattle spray with deltamethrine plus diminazene aceturate therapy; traps plus isometamediun chloride therapy; traps plus diminazene aceturate therapy and deltamethrine plus isometamedium chloride therapy are equally effective in animal trypanosomosis control.

CHAPTER TWO

2.0 Literature Review

2.1 Epidemiology of Animal Trypanosomosis

Animal trypanosomosis is caused by protozoan parasites of the genus *Trypanosoma* namely, *T.vivax*, *T.congolense* and *T.brucei* (Kinghorn,1925; Heisch *et al.*,1958). The disease is debilitating and in most cases fatal to cattle, small ruminants, equidae and camelidae. The disease is peracute in case of some strains of *T.vivax (e.g. haemorrhagic T.vivax)*, acute and chronic in other *Trypanosoma* species infections (Hoare, 1948; 1970). The severity of the disease depends on the species of the host and trypanosome species (Hoare, 1970). *T. congolense* and *T.vivax* are confined to blood vessels and *T. brucei* species colonize plasma and intercellular tissues (Losos & Ikede, (1972)

The epidemiology of animal trypanosomosis is complex, but consists of a number of major components, each modified by many variables that interact. The major components are climate, animal management, livestock and trypanosomes (Leak, 1999).

That the factors which influence the rate of trypanosomes infection in tsetse are so many that it is impossible to estimate with any degree of accuracy the transmissibility of any particular strain of trypanosomes (Lloyd, 1930). Jordan (1974) Endogenous factors associated with tsetse, ecological factors; parasite and host factors; sex of tsetse and infection, temperature, age of the fly at time of infective feed; and the tsetse species influence the development of trypasomes in the fly (Jordan, 1974 and Molyneux, 1982).

Trypanosome infection rates in the vector are generally quite low for the three salivarian trypanosome sub-genera, especially for *Trypanosoma brucei* subgroup infections (Jordan, 1974). The infection rates were thought to be determined mainly by the biology of the parasite and by the host animals. *Trypanosoma vivax*, having the simplest life cycle is expected to have the highest infection rates, which it usually does, whilst *T.brucei* which has the most complicated development cycle (Pollock, 1980) has the lowest infection rate. In natural field situations, female tsetse usually have higher infection rates than males; however, this is to some extent because females live longer than males and therefore have a greater likelihood of feeding on an infected host and picking up and maturing an infection. When age is taken into account, infection rates of males and females are more or less equal. However, in the laboratory experiments, male tsetse have higher mature infections with both Nannomonas and Trypanozoon trypanosomes (Leak, 1999). Because *T.vivax* develops only in the proboscis, it is less exposed to antitrypanosomal factors in the gut of the fly than other trypanosome species, and differences in their activity between male and female flies do not appear to play a significant role in determining infection rates with this species. The question of whether sex of a fly influences infection rates has still not been definitely answered (Leak, 1999).

Infection rates are positively correlated with temperature (Hoare, 1970). Climate is influential in the existence of tsetse flies and transmission of the diseases, in tsetse-infested areas (Lancien *et al.*, 1987). Optimum temperature and humidity are required for tsetse flies to survive. In dry and high temperature conditions, the flies will find it difficult to fly looking for blood meal, under such adverse conditions, they are normally found in resting sites and young flies will not pupate, leading to a decrease in the tsetse

fly population. Hence in dry seasons, tsetse fly population is reduced without any control measures (Nowak *et al.*, 1992). In such circumstances small tsetse fly numbers remain around water sources which in most cases act as animal watering points. As the rains start, the few live flies build up the population.

After feeding the fly must survive long enough for the parasite to develop in it. This time is variable and varies from 5-53 days for different trypanosomes and different species of tsetse (Leak, 1999). However, age is less critical for infection of *G.fuscipes* with *T.b.rhodesiense* (Hoare, 1970).

Fly species differ in their capacity to transmit trypanosomes. *Morsitans* group (*G.swynnerton and G. pallidipes* tsetse flies except for *G.austeni)*, are good vectors of all trypanosome species (Leak, 1999); the *G. Palpalis* group of tsetse flies appear to be poor vectors of most trypanosome species except some trypanosome stocks of West African *T.vivax*. Whilst on the other hand, *G.f.fuscipes* can be an important vector of human infective trypanosomes (Leak, 1999). Otieno and Darji (1979) reported that *G.pallidipes* from Lambwe valley, Kenya, secretes saliva heavily infested with *T.b.brucei*. so it is a good transmitter of trypanosomes.

2.2 Control of Nagana

Trypanosomosis control is not exclusively a technical problem; it must be viewed against the wider background of the general social and economical needs of the country/area (Finelle, 1983a). The criterion for control of Nagana is socio-economic (Finelle, 1983). Selection of control procedures depends on: a). tsetse species; b). habitat involved in the

local conditions and animal reservoirs management which will affect tsetse A.D. (Finelle, 1983b).

The control of Nagana is based on intergration of management of cattle, vector control, chemotherapy, chemoprophylaxis, sterile insect technique and rearing of trypanotolerant breeds (Leak, 1999) depending on the tsetse challenge, fly age at infective feed, susceptibility of the fly trypanosome infection, species of trypanosomes, density and infection rates and host preference..

2.2.1 Control of Tsetse flies

Total destruction of trees and bushes is the oldest tsetse control method (Ford, 1970) and was regarded as an effective strategy for tsetse control. In East Africa, *Glossina morsitans* was controlled by elimination of habitat-denying tsetse flies breeding and resting sites when the trees and bushes were cleared (Brandl, 1998). The method of total vegetation clearance was rejected by the environmentalists as it reduces rainfall, causes soil erosion and undermines the tourism industry. Partial clearing of vegetation was introduced in 1930 after total bush destruction was abolished. This method was used successfully in controlling *G. tachinoides* and *G. palpalis* in Western African woodlands (Ford,1970). During the human trypanosomosis outbreaks in southeastern Uganda in 1970s, vegetation was cleared to remove tsetse fly breeding and resting sites in three epidemic areas. Thickets of *Lantana camara* were cleared as part of control of *G.f. fuscipis* (Okoth, 1986) in conjuction with pyramidal impregnated traps (Lancien and Gouteux,1987).

The practice of game animal elimination was used as means of tsetse eradication in Uganda between 1947 and 1973 (Woff, 1968), and in between 1949 and 1959 in

Tanzania and in Mozambique and Zimbabwe (Koeman and Takken, 1977). The game animals played a big role in maintaining endemic and enzootic trypanosomosis (Allsopp, 1972). Animals, particularly elephants, were reduced in order to reduce on the hosts of tsetse fly (Brandl, 1998) and reservoirs of animal and human trypanosomosis (Robertson *et al.*, 1958). Later, animal elimination method was abolished because it had a negative impact on the tourism Industry and because once the animals were wiped out, the immediate alternative host for the tsetse flies was man (Okoth, 1986).

Uganda was invaded by *G. morsitans* and *G. pallidepes*, and there was sleeping sickness epidemics in Busoga, Buvuma and Ssesse Islands in 1896. As a control measure, people in tsetse-infested areas were evacuated to tsetse free location (Mulligan, 1970). The evacuation strategy went on up to 1920 (Robertson, 1958). It was possible to use evacuation method at that time because human population was still low. To date it is not possible to apply the same method as it can also introduce tsetse and trypanosomosis in a tsetse free area (Kakaire *et al*, 1993) and would cause a lot of socio-economic and political problems on the Government side.

The use of insecticide for tsetse control in the field came in use after bush clearance and game elimination methods were found unsuitable (Mulligan 1970). Insecticides have been applied by ground and aerial spray. It is used to impregnate traps, targets and applied for live bait technology particularly on cattle which act as a moving targets.

Following the discovery of DDT and other insectcides in 1945, ground spraying became the main line of defence against tsetse and the primary option for controlling trypanosomosis throughout Africa for over 40 years (Allsopp, 2001).

It was used to control *G. morsitans* in Uganda (Woolfe,1965) and *G. swymmertoni* in Tanzania (Chadwick *et al.*,1964). DDT was used to control tsetse flies in Zambia (Gledhill *et al.*,1963), Congo (Adam *et al.*, 1969), Kenya (Wilson, 1953) and Nigeria (Davies,1964). Dieldrin in many countries was used to control *G. pallidipes* (Thompson *et al.*,1992). Later DDT was phased out mainly because of environmental reasons (Hursey,1988; Vale, 1982) and was replaced by benzene hexachloride (BHC) which appeared to be cheap with quick action. This method was intensively used for both small and large-scale control of tsetse flies and mosquitoes. It was applied in tsetse fly hot spots in many countries including Uganda, Kenya, Zimbabwe and Nigeria (Koeman *et al.*, 1977).

Aerial application of residual insectcides were used with considerable success in south Africa as early as the 1940s (Park, 1972). Aerial spraying has been carried out during human trypanosomosis epidemics to cover a wide area in Uganda by using either fixed wing planes or helicopter (Lancien, *et al.* 1990, Lancien *et al.*, 1987). This was aimed at reducing the tsetse fly population in a short time and break down trypanosomosis transmission between wild animals, man and livestock (Allsop, 1994). Both aerial and ground spraying methods are costly.

Traps are artificial bait tools (Green, 1994a) used to catch and kill tsetse flies while targets kill flies when they land on the targets impregnated with deltamethrin

(Vale,1982). Earlier, traps were expensive, heavy and less effective without attractants so alternative trap designs were developed in order to come up with light and cheap traps (Vale,1982).

Efforts to increase the efficacy and to reduce the cost of biconical traps led to a series of monoconical traps which were developed. Currently, trapping is the main method used against *G. f. fuscipes* in South East Uganda (Lancien *et al.*,1990; Okoth *et al.*,1991). To date synthetic pyrethroids are used in artificial bait (trap) and natural (live bait) systems (Green, 1994a). Traps of different types for tsetse control are impregnated with deltamethrin 0.01% and they have been found to reduce tsetse fly populations such as *G. fuscipes fuscipes* in South East Uganda (Lancien *et al.*,1987; Kakaire *et al.*,1993).

The development of live bait (Green, 1994a) technology followed studies that showed that livestock odours were attractive to tsetse flies (Vale *et al.*, 1985). In addition, the live bait method has excellent performance as a single (Siemons *et al.*, 1993; Palzelt *et al* .,1995) or combination with other technologies (Magona *et al.*,1998). Tsetse flies have been caught on sticky screens carried on backs of people (Maldonado,1910). It was a dangerous technology because it exposed people to tsetse fly bites. The method was tedious and impractical for wide application therefore it was abandoned. Later in 1940s, cattle were sprayed with DDT to control tsetse flies (Whiteside,1949). However, frequent treatment of cattle with DDT led to accumulation of chemical toxic residues in livestock products (Thompson *et al.*,1992) and use of DDT was hence banned.

Other methods include painting trunks of trees with oil paint mixed with insecticide, and using old vehicle tyres with other local materials for making traps or targets (Okoth, 1999). Trapping and ground spraying were applied in West Nile and South-East Uganda to control human and animal trypanosomosis epidemics (Kangwangye,1987).

Trapping technology has a number of limitations and problems, e.g traps are made of imported materials and impregnated with insecticide every 6 months, which makes trapping expensive, tedious and difficult to sustain. (Allsop, 1994). In addition, traps are vandalised by people and animals or destroyed by fire (Allsop, 1994).

Currently, live bait technology involves the application of insecticide directly to livestock, primarily cattle and pigs (Patzelt, 1995), which act as lethal moving targets for tsetse flies. This technology employs mainly pyrethroids, for instance, deltamethrin, flumethrin and alphacypermethrin. Pyrethroids have low levels of mammalian toxicity which makes them safe to apply to the target animals and the meat and milk from treated animals may be used for human consumption immediately after treatment (FAO,1993). This technology has been used on livestock to control ectoparasites since 1970s with encouranging results (Chizyuka *et al.;*1986; Bauer *et al.,* 1989; Okello-Onen *et al.,*1993; Ssekitto, 1997: Vale *et al.*,1999). The most commonly used pyrethroid in tsetse control is deltamethrin which provides residual efficacy against tsetse flies. Deltamethrin has a prolonged photo-stability (Hardway *et al.,* 1976) and low mammalian toxicity (Thompson *et al.;*1992). The efficacy of deltamethrin has been tested in and outside Uganda. The results achieved in Mkwaja Tanzania (Fox *et al.*,1993), Zambia (Chizyuka *et al.;* 1986), Zanzibar (Fox *et al.*, 1993), Uganda (Okello-Onen *et al.,* 1994; Palzelt *et*

al., 1995), Kenya (Thompson *et al.*;1992); Burkino Faso (Bauer *et al.*; 1992); Zimbabwe (Thompson *et al.*; 1992); showed that deltamethrin can effectively control tsetse flies by either dipping or spraying cattle. For economical purposes, field studies have been carried out and they have showed that sustainability of tsetse control can be achieved by treatment of 10% of cattle population with 1% w/v deltamethrin (Okiria *et al.*, 2002).

For live bait technology, using dipping or pour-on , to achieve either high level of tsetse and trypanosomosis suppression or possible localised eradication, it is necessary that the following criteria be met (FAO, 1993): 1) Domestic livestock must be in present in the area in sufficiet numbers, (> 10 h/c/km^2) 2) a high proportion of cattle must be present for regular insecticide treatment, and 3) domestic livestock should form a high proportion of the tsetse population's blood meal host.

Use of sterile insects to control or eradicate insects population is one of the revolutionary departures in modern entomology. Sterility is inability to produce offspring, i.e. sterile individuals cannot contribute to a genome to the next generation. Sterile tsetse fly males are produced by ionizing radiation. The common requirement is that the general vigour, longevity, sexual competitiveness and mating behaviour of the insect should not be severely impaired by the treatment. The sterile males are released into the wild in the hope that they will out-compete the fertile males for mating partners, thereby reducing the number of viable offsprings and eventual eradication of the insect in question.

The principle is to reduce the target population to levels commensurate with the release capacity and then use the sterile insects to achieve control or eradication. This is because

under most circumstances, the desirable ratio of sterile flies to wild male flies at the beginning of a control programme would be 3:1. However, the release of 3 sterile males for each wild male into a dense population of a fly like *G.morsitans* might require 6,000 or more flies per km^2 per month. Releases of such magnitude are clearly neither feasible nor practical for tsetse flies. So, limited insecticidal applications should provide acceptable, cost – efficient method of reducing the indigenous tsetse population to a manageable level. This requirement, the sophistication and financial implications associated with this technology, limits it adoption. It is most likely to succeed when the targeted area is isolated; an island situation like the Unguja Island in Tanzania.

This technology has successfully controlled tsetse flies in some countries in Africa like in West Africa (Vale *et al.;* 1985) and it has been used to eradicate *G.austeni* from 1600km^2 Unguja island in Zanzibar (Feldmann and Hendrichs, 1998). Various levels of success have been achieved in many infested areas by using this strategy (Gates *et al., 1983*; Ogwal *et al.,* 1990).

The review of this subject tends to be reviews of reviews because of the almost complete absence of new drugs since the 1950s (Williamson, 1980). The period between 1950 and the early 1960s was the most active for the introduction of present day drugs and their testing in the laboratory and in the field (Leach and Roberts, 1981). Our undertsanding of the action of drugs, their usefulness in different situations, the dangers and limitations involved in their use, their safety in foods for human consumption, the significance and extent of drug resistance, cost benefit ratios is only commensurate with the time, money and effort that has been expended by Governement departments and research institutes to study the subject (Stephen, 1986).

The rationale of chemotherapy is to use a drug that can cleanse the animals of any infections, while chemprophylaxis provides a protective effect due to the longer residual period of the drugs used which reduces infection or transmission following a tsetse blood meal. Chemotherapy and chemoprophylaxis has been used to control animal trypanosomosis in tropical and sub-tropical African countries for more than 40 years by farmers and field staff dealing with animal health. It is estimated that about 35 million doses of curative and prophylactic drugs are used in Africa per year (Geerts and Holmes,1998). Trypanocidal drugs used for trypanosomosis control are mainly diminazine aceturate (Berenil®, Hoest-German) and isometamedium chloride (Samorin®, RMB Animal Health Ltd.,U.K). The rest of the drugs have been withdrawn from the market due to drug resistance(Leach and Roberts,1981).

Diminazine aceturate(4:4-diamididino-diazoamino-benzene-diaceturate) has been found effective against *T.vivax*, *T.congolense* at 3.5mgkg^{-1} body weight and *T.brucei* group at 7mg/kg to clear the infection (Fussiganger and Baker,1960). Diminazene aceturate is purely a curative drug. On the other hand, isometamidium chloride is used both for therapy and prophylaxis (Ogun and Eghianruwa, 1993) of animal trypanosomosis. It is administered intramuscularly as 1%, 2% and 4% aqueous solution at 0.5-1mg/kg body weight. In Uganda, Diminazene aceturate is commonly used for chemotherapy while Isometamedium chloride is commonly used for chemoprophylaxis (Fussganger and Baker, 1960; Magona, 1996).

The use of chemotherapeutic agents at underdose (Hawking, 1963) inevitably can lead to the development of resistance in trypanosome strains in a certain location. Chemotherapy of animal trypanosomosis has been comprehensively reviewed over the last two decades (Finelle, 1962; Holmes, 1991). Over this period, the number of compounds on the market, have dwindled as some compounds have been withdrawn because of occurrence of drug-resistant trypanosome strains.

Chronic infections with *Trypanosoma* species of the subgenus Trypanozoon are frequently reported to relapse following treatment with drug doses sufficient to cure accutely infected animals (Whitelaw *et al.*, 1985). There is evidence that parasites constituting the relapse population originate from the central nervious system (Jennings *et al.*, 1979) since trypanosomes sequestered in the central nervous system are inaccessible to the trypanaocidal drugs.

Trypanosomes are usually not resistant to both diminazene aceturate and isometamidium chloride and these two compounds have been termed a sanative pair (Whiteside,1962). Strains, resistant to one drug, will require the application of the other drug of the sanative pair to control the disease. However, recent reports on multiple drug resistance in Burkino Faso and Ethiopia (Clausen *et al.*, 1992; Codija *et al.*, 1993) suggest that, the concept of sanative pair might no longer be valid. Indeed resistance has been reported to diminazene aceturate (Peregrine and Mamman, 1993 and Codija *et al.*, 1993) and isometamedium chloride (Schönefeld *et al.*,1987 and Clausen *et al.*, 1992).

Desowitz (1959) showed that even though the hampless cattle of West Africa lived in tsetse fly infested regions and had high level of resistance to trypanosomosis, they were not totally immune under conditions of stress, could develop clinical symptoms of the disease similar to that of susceptible breeds. This led to the conclusion that the term "trypanotolerance" was more appropriate than "trypanoresistance". Trypanotolerant animals have much better control over parasitemia than susceptible animals and this ability is correlated with less severe anemia and less severe disease (Murry *et al.*, 1983). It would improve tsetse and trypanosomosis control if trypanotolerant cattle are integrated in the current control technologies outside West Africa (Teale, 1991, Holmes, 1991). The economics of trypanosomosis control using trypanotolerant cattle and chemotherapy has been investigated by the African Trypanotolerant Livestock Network (Itty *et al.*, 1993). It was shown that trypanotolerant cattle are suited for situations with low to medium trypanosome prevalence, but that import of trypanotolerant stock is not necessarily profitable. Not profitable because trypanotolerance is found in animals staying in an enclosed area where a distinct serodeme is present. This serodeme must not be interfered with by other serodemes through routes of wild animals or transhumance. The animals acquire a weak immunity against the serodeme's relatively small number of major VAT's. Although trypanotolerance is a valuable trait, it is not *per se* a solution to the general problem of trypanosomosis in Africa, since trpanotolerant animals still suffer loss of productivity due to chronic infection and can succumb to the disease under high challenge (Stephen, 1966). Furthermore trypanotolerant animals are only a small proportion of the total cattle population in Africa at the risk of disease.

2.4 Summary of the literature review

A lot is known about the factors that influence the levels of nagana, for example absolute population size of the flies, mortality rates of tsetse flies, feeding patterns and host-fly contacts (Leak, 1999). However, information about the possible ramification of control procedures in specific control areas like Buikwe is glaringly unavailable. Hence the impetus to carry out this study to compare the effectiveness of different control technologies in controlling nagana in the area with the view of selecting the adoptable strategy for Buikwe county, Mukono District.

CHAPTER THREE

3.0 Material and Methods

3. 1 Study Area.

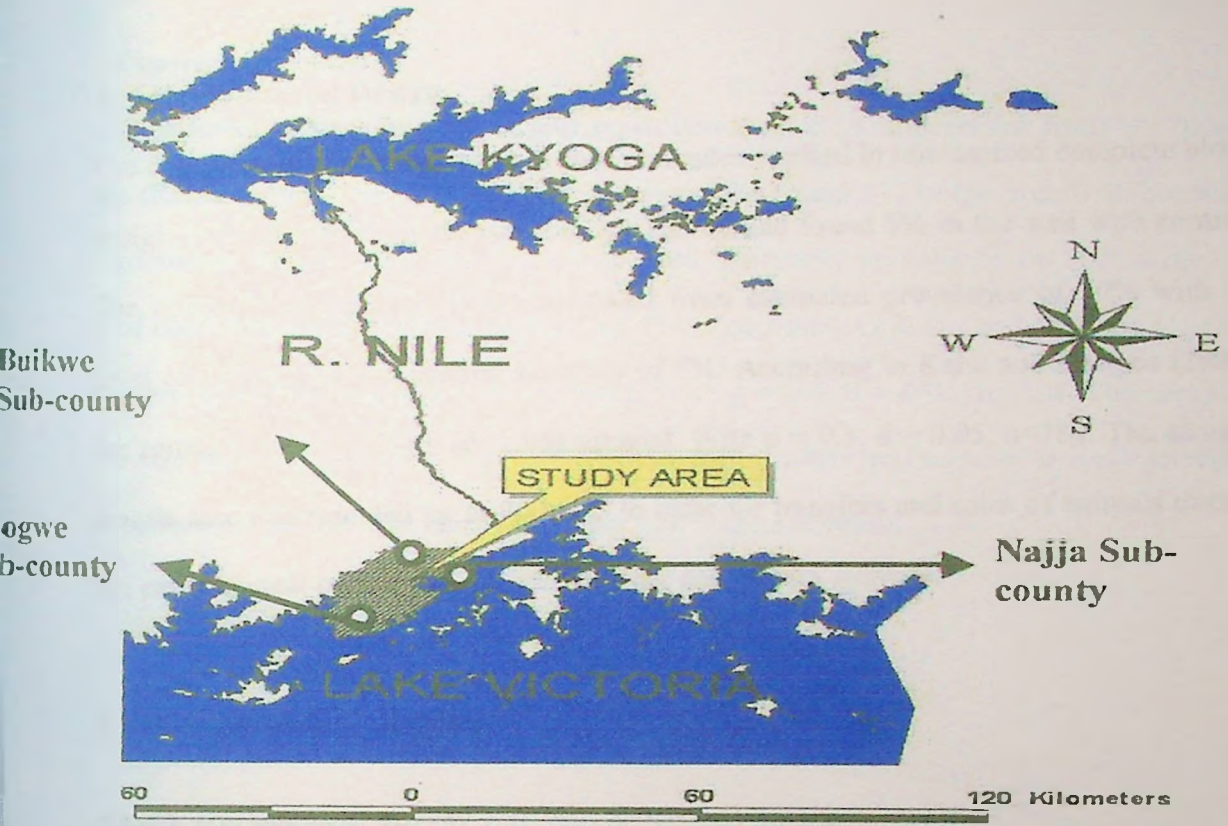
The study was undertaken in three sub counties of Najja, Buikwe and Ngogwe in Buikwe County, Mukono District, South East Uganda (Fig.2 &3). This is 60 km eastwards, on the Kampala-Jinja Road and it borders with Mukono County in the North, Jinja District in East, Wakiso District in West and Lake Victoria in the South. The area receives 1100-1500mm of rainfall annually in two seasons (March-May and October-December). Two dry seasons (December-February and June-August) are expected with maximum temperature of 29.5^{0}C and a relative humidity of 65%.

3. 2 People and Farming system in the area.

Buikwe County falls in the intensive banana-coffee-lakeshore agroecological system which includes animal husbandry. There are 15,000 people practising mixed farming of crops, livestock and fishing. Food crops include sweet potatoes, maize, beans and cash crops such as coffee, cocoa, vanilla and sugar cane. Cattle is grazed variously mainly tethering, communal grazing and fenced paddocking. Short horn Zebu is the most prevalent local breed followed by crosses of Ankole and Zebu (Nganda breeds). The vegetation cover is mainly made of *Lantana camara* and lakeshore forests interspersed with food crops (cassava, banana, sweet potatoes, cocoa, coffee and sugar cane). There are many streams running from highlands into Lake Victoria through shrubs, which provide suitable breeding and resting sites for *G. f. fuscipes.*

g 2. Map of Uganda showing Mukono District

Fig: 3. **Map of Mukono district showing the study area (Najja, Buikwe and Ngogwe sub counties in)**



Buikwe Sub-county

ogwe b-county

3. 3 Sites selection.

Reports from Tsetse Control and Veterinary Departments were used to select the sites in the study area. The sites selected were those with tsetse apparent density above 5 flies per trap per day and a prevalence of animal trypanosomosis above 10%.

3. 4 Experimental Design

The six different treatments were in four replicates applied in randomized complete block design (RCBD). Previous trypanosomosis survey had found 5% in the area with control. The minimum sample size was calculated from estimated prevalence of 50% with 95 level of confidence and desired accuracy of 5%. According to Kahn and Sempos (1989) the sample size n= p (1-p)/ (d/ 1.96) squared. With p = 0.5, d = 0.05, n=384. The sample simple size was rounded up to 700 H/C to cater for transfers and sales of animals during the experimental period. The sample size per site was 25 animals.

3.5 Baseline Data Collection

3.5.1 Entomological Survey

The tsetse fly baseline survey was conducted to establish the initial tsetse species spectrum, tsetse density and infection rates. Biconical traps (fig 4) were deployed in the field for four days and flies were harvested for the next 24 hours hours. The apparent density per location was calculated in terms of captured flies/trap/day (FTD). The flies were dissected to establish infection rates.

3.5.2 Animal trypanosomosis survey.

A total of 2001 head of cattle were screened for trypanosomosis using haematocrit centrifugation techniques (Woo, 1970, Murry *et al.*, 1977). Packed cell volume (PCV)

Figure 4: Biconical trap

was concomitantly determined using microhaematocrit reader (Woo, 1970). Thin and thick blood smears were prepared, stained with 10% Giemsa and examined under the compound microscope to determine the trypanosome species.

3.6 Assessment of effectiveness of treatment

The effectiveness of all treatments was assessed using the following parameters:

a). Trypanosome infection rates in cattle

b). Packed Cell Volume (PCV)

c). Tsetse fly apparent density (AD)

d). Tsetse fly trypanosome infection rates

3.6.1 Trypanosome infection rates in cattle

Animals were gathered at treatment centers and 1ml blood samples were collected using a syringe from the jugular vein.

Heparinized haematocrit capillary tubes were three quarter filled with blood and one end of each tube was sealed with plasticine. The tubes were placed in a centrifuge and were span for 5 minutes at 1500 revolution per minute (Woo, 1970; Walker, 1972, Murry 1977). Packed cell volume was read using microhaematocrit reader (Hawksley®, London). The buffy coat area was examined under compound microscope with blue or green filter for presence trypanosomes. Trypanosome species were identified according to their morphological appearance and the characteristic movements. For example, *T. vivax* swims fast across the field; *T. brucei* tend to form clusters and *T. congolense*, the smallest of them all, tends to hide underneath blood cells.

Thick and thin blood films were stained with 10% Giemsa solution and examined under a compound microscope (MacLennan, 1957).

3.6.2 Tsetse Apparent Density

Biconical traps (Fig 4) were set in areas where high trapping success was expected. These were man-fly-animal contact was expected to be high. Biconical traps were used because they catch flies for apparent density and tsetse infection rates better than pyramidal traps. Pyramindal traps are better for tsetse control purposes. Apparent density (AD) was determined by dividing the total number of captured flies by number of traps multiplied by the number of days the traps were in the field.

$$AD = \frac{\text{Number of flies}}{\text{Number of traps X Number of days the traps in the field}} = F/T/D$$

3.6.3 Tsetse control by trapping

Pyramidal traps (Fig 5) impregnated with 0.01% deltamethrin (Lancien and Gouteux, 1987) were deployed at 10 traps per km^2 at water crossings, kraals, coffee, banana plantations, protected wells and edges of gardens and forests. The traps were suspended on branches of trees or banana leaves. The area beneath the traps were cleared of vegetation to increase trap visibility.

3.6.4 Tsetse Trypanosome infection rates

Trypanosome infection rates in flies were detected by microscopical examination of salivary gland, mudgut and proboscis (Baker, 1970). Flies were identified by numbers. The fly was immobilized by plucking off wings and legs. The proboscis was removed

Figure 5: Pyramidal trap

from the head and put in a drop of normal saline on a glass slide. The abdomen and thorax were separated by two cuts made with fine blades at thoraco-abdomen junction and separately put in a drop of normal saline on a glass slide. These parts were covered with cover slips and each examined under compound microscope for trypanosome species.

3.7 Application of Treatments

3.7. 1 Deltamethrin-impregnated pyramidal traps plus diminazene aceturate treatment:

Pyramidal traps (Lancien *et al.;* 1987) were deployed in four sites at 10 traps per square kilometer (Musisi *et al.;* 1993). Initially all cattle in these sites received blanket treatment with diminazine aceturate intramuscularly at a dosage of 7mg/kg body weight (Cunningham, 1964). Once every month, animal trypanosomose infection rate in cattle and flies and the tsetse flies population were determined. New positive cases within the experimental herds were recorded and treated with diminazine aceturate to clear them of the infection.

3.7.2 Deltamethrin-impregnated pyramidal traps with Isometamidium chloride Treatment.

Pyramidal traps (Lancien *et al;* 1987) were deployed as in 3.6.1. Cattle received isometamidium chloride at 1mg/kgbw two weeks after the treatment with diminazine aceturate and then every three months. Every month the cattle were handled as in 3.6.1

3.7.3 Cattle sprayed with Deltamethrin (Live bait) combined with isometamidium chloride treatment.

Cattle (> 10 head of cattle/ km^2) in this treatment were sprayed with deltamethrin (0.01%v/v) once a month using a hand spray pump and at the same time they received deep intramuscular injections of isometamidium chloride at 1 mg/kg body weight (Kanabo, 1988) every three months during the study period. Efficacy was assessed as in 3.7.1.

3.7.4 Cattle sprayed with Deltamethrin (Live bait) combined with diminazene aceturate treatment.

Cattle (> 10 head of cattle/ km^2) in this treatment were sprayed with deltamethrin (0.01% v/v) using a hand pump once a month (Palzelt *et al.*; 1995) and new cases were treated with diminazine aceturate 7mg/kgbw to clear the infection. Biconical traps were staged in the field for 4 days to assess reduction of tsetse apparent density and tsetse infection rate once a month.

3.7.5 Treatment of cattle with diminazene aceturate.

200-250 head of cattle in this treatment received 7mg/kgbw diminazine aceturate to clear them of current trypanosome infection. Then 25 animals were examined for trypanosomosis after control technologies were introduced and positive cases were treated with the same drug and dosage.

3.7.6 Deltamethrin-impregnated pyramidal traps.

Deltamethrin treated pyramidal traps were deployed in the field. The animals were not treated against trypanosomosis. The animals were screened monthly for trypanosomosis and positive cases were treated with Diminazene aceturate 7mg/kg bw.

3.7.7 Control

In the four control sites there was no tsetse and trypanosomosis control measures in place throughout the observation period. Samples were collected from animals and analysed as for the other sites similar to tsetse work.

3.7.8 Tsetse fly records:

The harvesting protocol indicating the data recorded at every field visit is given in appendices I and II.

3.8 Statistical analysis

Data on PCV and trypanosome infection rates in cattle and tsetse flies was analysed by the chi-square test while data on apparent density was analysed by ANOVA first and then by Turkey's test to pin point where the variations (differences) were. Further, graphs to show the variations with time in the PCVs, infection rates and apparent density were drawn.

CHAPTER FOUR

4.0 Results

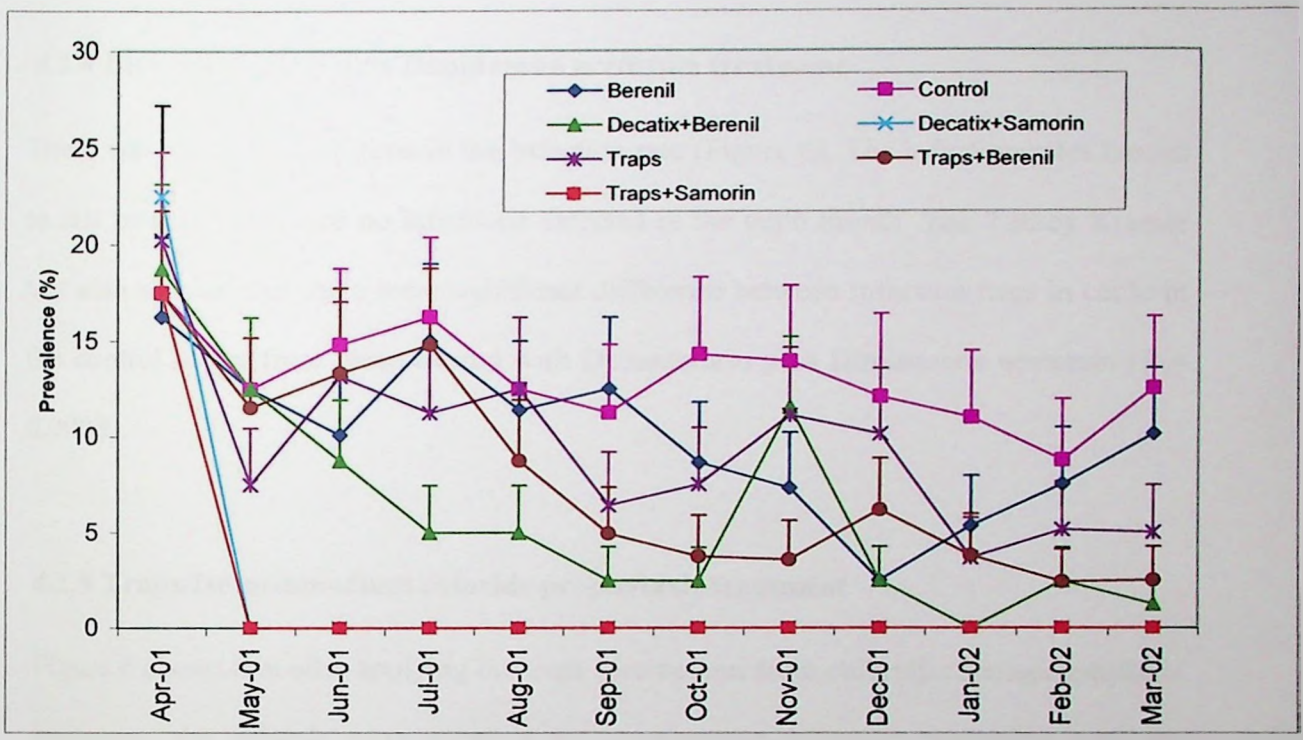
4.1 Effect of Treatments on Trypanosome infection rates in cattle

Figure 4 shows variations with time in trypanosome infection rates in cattle. The likelihood ratio test (LRT) showed that when taken together the predictors (treatment categories) contributed significantly ($P<0.0001$) to the prediction of the infection rates in cattle.

4.1.2 Chemotherapy with Diminazene aceturate

In the case of Chemotherapy with diminazene aceturate, there was variation with time in the infection rate (Figure 6). The infection rates tended to fall with time so that the infection rate in the eleventh month was significantly different from that in the first month. However, the Turkey Kramer test showed that there was no significant difference ($P = 0.2631$) between infection rates in cattle in the control group and cattle treated with Diminazene aceturate alone.

Figure 6.Prevalence of trypanosomes in cattle under different trypanosomosis control technologies in Buikwe county, Mukono district.



4.1.3 Traps Only

In the case of traps treatment (Fig. 6), there was variation with time in the trypanosome infection rates in cattle and the infections tended to fall with time. There was significant difference between the control group and this treatment group in the infection rates when the Turkey Kramer was applied ($P < 0.0001$).

4.1.4 Live bait system plus Diminazene aceturate treatment

There was variation with time in the infection rate (Figure 6). The infection rates tended to fall so that there were no infections detected in the tenth month. The Turkey Kramer test also showed that there were significant difference between infection rates in cattle in the control group from those treated with Deltamethrin plus Diminazene aceturate ($P = 0.0008$).

4.1.5 Traps/Isometamedium chloride prophylaxis treatment

Figure 6 shows that after applying the traps / isometamedium chloride chemoprophylaxis treatment, the animals were negative for trypanosome infection beginning with the second month and remained so throughout the study. The Turkey Kramer test showed that there was a significant ($P < 0.0001$) difference between infection rates in cattle in this group and the cattle in the control.

4.1.6 Traps/Diminazene aceturate Chemotherapy

There was variation with time in the infection rate (Figure 6) in the group where traps / diminazine aceturate chemotherapy was applied. The infection rates tended to fall so that

the infection rate in the eleventh month was significantly different from that in the first month. However, the Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between infection rates in cattle in the control group and that in the area where traps and diminazene aceturate treatment was used.

4.1.7 Deltamethrin /Isometamedium chloride Treatment

In the deltamethrin / isometamedium chloride treatment group, the animals were negative for trypanosome infection beginning with the second month (Figure 6) and remained so throughout the study. The Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between infection rates in cattle in this deltamethrin plus isometamidium chloride and that in the control.

4.2: Effect of treatment on Tsetse trypanosome Infection Rates

Figure 7 gives a summary of the results from all the treatment groups and the salient findings are outlined for each group below.

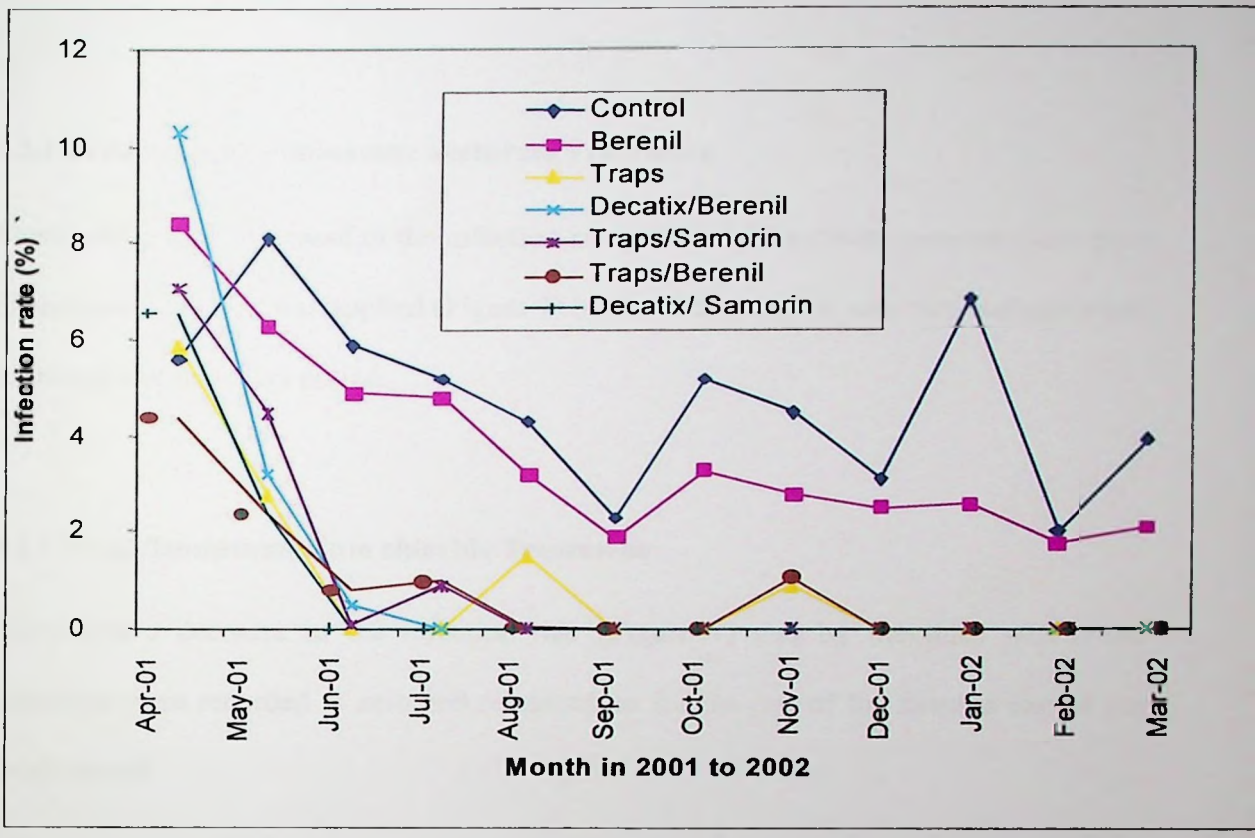
4.2.1 Control group

In the control group, there were variations in the tsetse infection rates throughout the study period. The infection rate in this group was always higher than those recorded for other treatment groups. (Figure 7).

4.2.2 Diminazene aceturate:

There was a gradual decrease in tsetse infection rates in the group where diminazene aceturate treatment was applied (Figure 7) with the lowest infection rate recorded in the sixth month. The infection rate was always lower than that recorded in the control group (Figure 7). $P<0.0001$ Turker Kramer Test.

Figure 7. Trypanosome infection rates in tsetse flies collected from areas under different control technologies



4.2.3 Traps Treatment

There was variation with time in the infection rate in flies where trypanosomes were applied (Figure 7). The infection rate fell to zero by the third month and remained so for the rest of the months except for the sixth and ninth months.

4.2.4 Deltamethrin/Diminazene aceturate Treatment

There was gradual decrease in the infection rate where deltamethrin spray on cattle plus diminazene aceturate was applied (Figure 7) by the fifth month it was zero and remained so throughout the study period.

4.2.5 Traps/Isometamedium chloride Treatment

There was a decrease in the infection rate (Figure 7) and by the third month the infections were recorded at zero and remained so for the rest of the months except the fourth month.

4.2.6 Traps/Diminazene aceturate Treatment

There was a gradual decrease in the infection rate in traps / diminazene aceturate treatment was applied (Figure 7) and by the fifth month the infections were recorded at zero and remained so for the rest of the months except for the eighth month.

4.2.7 Deltamethrin /Isometamedium chloride Treatment

There was a decrease in the infection rate where deltamethrin / isometamedium chloride treatment was applied (Figure 7) it was zero starting with the third month and remained so throughout the study period

4.3 Effect of Treatments on Tsetse Apparent Density

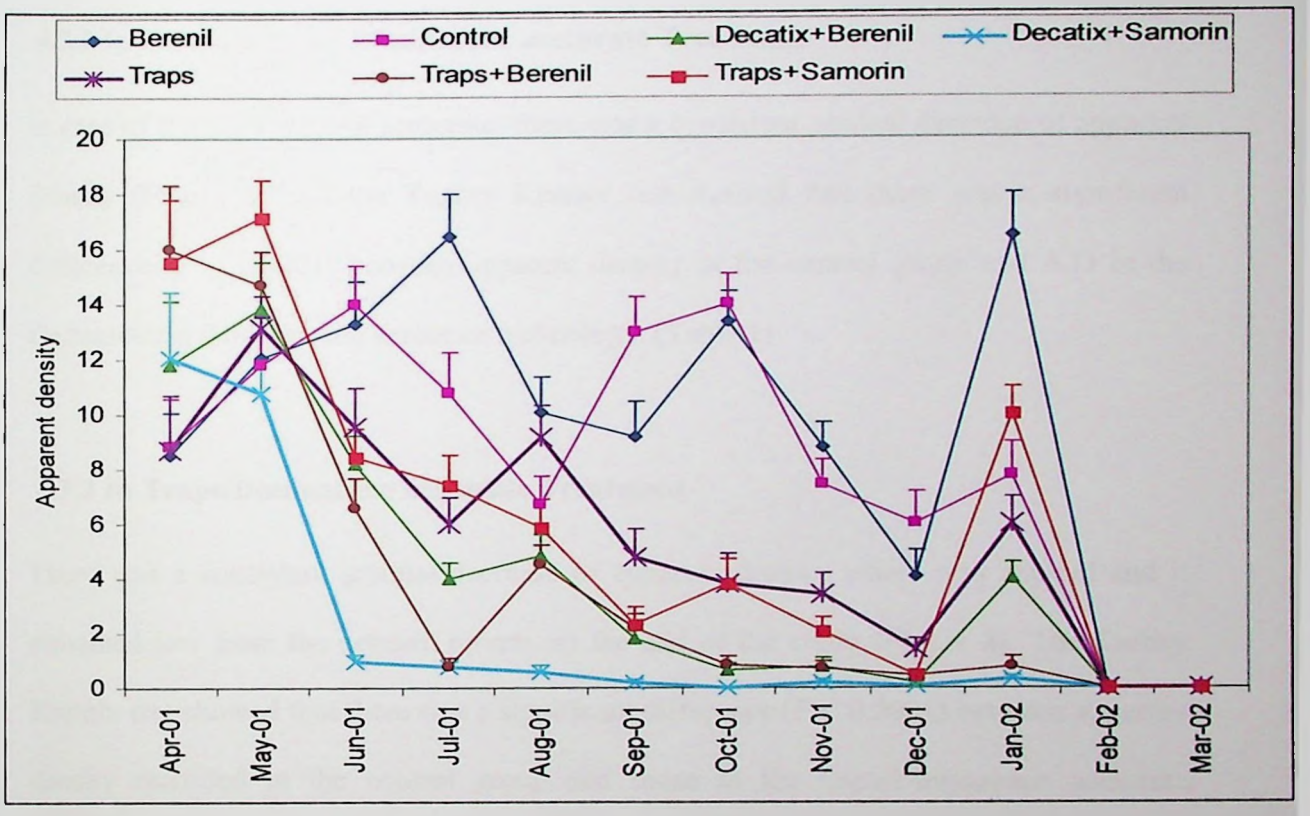
Figure 8 give a summary of the results from all the treatment groups and table 1 gives the statistical analysis results. Statistical analysis (ANOVA) showed that A.D varied with control technology ($P<0.0001$).

There was variation with time in the apparent density in the control group (Figure 8). The apparent density was zero from the eleventh month to the end.

4.3.1 Diminazene aceturate Treatment

There was variation with time in the apparent density with month eleven recording an apparent density of zero (Figure 8). The Turkey Kramer test showed that there were no significant differences alone ($P = 0.8985$) between apparent density recorded in the control group and that recorded in the group treated with Diminazene aceturate. (Table 1)

Figure 8. Tsetse fly apparent density under different trypanosomosis control technologies in Buikwe County, Mukono district.



There was variation with time in the apparent density where traps were deployed showing a gradual decrease throughout the study (figure 8). The Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between apparent density in the control group and that in the traps only technology. (Table 1)

4.3.2 In Deltamethrin / Diminazene aceturate Treatment

In case of the deltamethrin aceturate, there was a consistent gradual decrease of apparent density (Figure 8) and the Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between apparent density in the control group and A.D in the Deltamethrin /Diminazene aceturate technology. (Table 1)

4.3.3 In Traps/Diminazene aceturate Treatment

There was a consistent gradual decrease of apparent density where was applied and it remained low from the seventh month till the end of the study (Figure 8). The Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between apparent density recorded in the control group and those in the traps/Diminazene aceturate technology. (Table 1)

4.3.4 Deltamethrin / Isometamedium Treatment

In the deltamethrin / isometamedium chloride treatment, there was a decrease of apparent density and it remained low from the third month till the end of the study (Figure 8). The Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between apparent density recorded in the control group and that in the deltamethrin spray plus isometamidium chloride treatment (Table 1).

Table 1. P-values from Turkey multiple comparison test for tsetse apparent density under various treatment groups

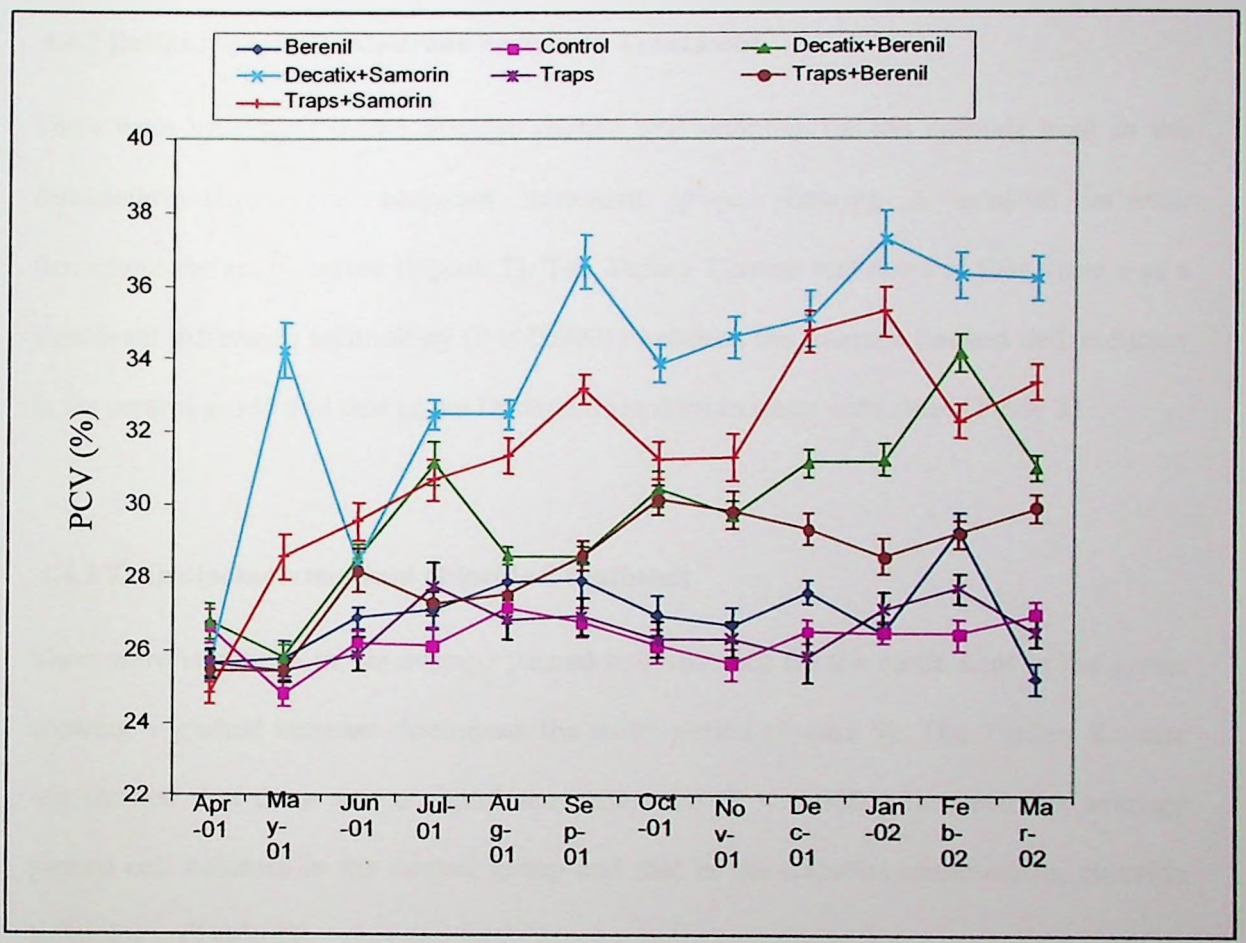
Treatment comparisons		P-value*
Diminazene aceturate	Control	0.8985
Diminazene aceturate	Deltamethrin and Diminazene aceturate	<. 0001
Diminazene aceturate	Deltamethrin and Isometamedium chloride	<.0001
Diminazene aceturate	Traps only	<.0001
Diminazene aceturate	Traps and Diminazene aceturate	<. 0001
Diminazene aceturate	Traps and Isometamedium chlorine	0.0011
Control	Deltamethrin and Diminazene aceturate	<. 0001
Control	Deltamethrin and Isometamedium chloride	<. 0001
Control	Traps only	<. 0001
Control	Traps and Diminazene aceturate	<. 0001
Control	Traps and Isometamedium chloride	0.0017
Deltamethrin and Diminazene aceturate	Deltamethrin and Isometamedium chloride	0.0001
Deltamethrin and Diminazene aceturate	Traps only	0.0374
Deltamethrin and Diminazene aceturate	Traps and Diminazene aceturate	0.9998
Deltamethrin and Diminazene aceturate	Traps and Isometamedium chloride	0.0030
Deltamethrin and Isometamedium chloride	Traps only	<. 0001
Deltamethrin and Isometamedium chloride	Traps and Diminazene aceturate	0.0050
Deltamethrin and Isometamedium chloride	Traps and Isometamedium chloride	<. 0001
Traps only	Traps and Diminazene aceturate	0.0293
Traps only	Traps and Isometamedium chloride	0.7741
Traps and Diminazene aceturate	Traps and Isometamedium chloride	0.0026

4.4. Effect of treatments on Packed Cell Volume (PCV)

Figure 9 summarises the findings from all the groups of treatments and there was no significant difference between control and diminazene aceturate and traps only shown by overlapping error bars (Figure 9).

Figure 9 shows that there were no variations in the average packed cell volumes for the animals in the variated diminazene aceturate group throughout the study period. The Turkey Kramer test and overlapping error bars showed that there was no significant difference between the average packed cell volumes in the control group and that in the Diminazene aceturate treated group ($P = 0.0343$, $CI = 95\%$) (Table 2).

Figure 9. Packed cell volume (PCV) in cattle kept under different trypanosomosis control technologies in Buikwe county, Mukono district



4.4.1 Traps treatment

There were minor variations in the average packed cell volumes for the animals kept in the traps treatment group throughout the study period (Figure 9). The Turkey Kramer test showed that there was no significant difference ($P = 0.9998$) between the average packed cell volumes in the control group and that in the traps only technology. (Table 2)

4.4.2 Deltamethrin /Diminazene aceturate Treatment

There were variations in the average packed cell volumes for the animals kept in the deltamethrin/deminazene aceturate treatment group showing a gradual increase throughout the study period (Figure 7). The Turkey Kramer test showed that there was a significant difference technology ($P < 0.0001$) between the average packed cell volumes in the control group and that in the Deltamethrin /Diminazene aceturate. (Table 2)

4.4.3 Traps/Isometamedium chloride Treatment

There were variations in the average packed cell volumes for the cattle kept in the group showing a gradual increase throughout the study period (Figure 9). The Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between the average packed cell volumes in the control group and that in the traps/Isometamedium chloride technology. (Table 2)

Table 2. P-values from Tukey multiple comparison test for PCV in cattle in various treatment groups.

Treatment comparisons		p-value
Diminazene aceturate	Control	0.0343
Diminazene aceturate	Deltamethrin and Diminazene aceturate	<. 0001
Diminazene aceturate	Deltamethrin and Isometamedium chloride	<. 0001
Diminazene aceturate	Traps only	0.0845
Diminazene aceturate	Traps and Diminazene aceturate	<. 0001
Diminazene aceturate	Traps and Isometamedium chlorine	<. 0001
Control	Deltamethrin and Diminazene aceturate	<. 0001
Control	Deltamethrin and Isometamedium chloride	<. 0001
Control	Traps only	0.9998
Control	Traps and Diminazene aceturate	<. 0001
Control	Traps and Isometamedium chloride	<. 0001
Deltamethrin and Diminazene aceturate	Deltamethrin and Isometamedium chloride	<. 0001
Deltamethrin and Diminazene aceturate	Traps only	<. 0001
Deltamethrin and Diminazene aceturate	Traps and Diminazene aceturate	<. 0001
Deltamethrin and Diminazene aceturate	Traps and Isometamedium chloride	<. 0001
Deltamethrin and Isometamedium chloride	Traps only	<. 0001
Deltamethrin and Isometamedium chloride	Traps and Diminazene aceturate	<. 0001
Deltamethrin and Isometamedium chloride	Traps and Isometamedium chloride	<.0001
Traps only	Traps and Diminazene aceturate	<.0001
Traps only	Traps and Isometamedium chloride	<. 0001
Traps and Diminazene aceturate	Traps and Isometamedium chloride	<. 0001

4.4.4 Traps/Diminazene aceturate Treatment

There were minor variations in the average packed cell volumes for the animals kept in the traps / diminazene aceturate treatment group showing a gradual increase throughout the study period (Figure 9). The Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between the average packed cell volumes in the control group and that in the traps/Diminazene aceturate treatment. (Table 2)

4.4.5 Deltamethrin/ Isometamedium chloride Treatment

There was a systematic increase in the average packed cell volume throughout the study period in the deltamethrin spray on cattle/ isometamedium chloride treatment group (Figure 9). The Turkey Kramer test showed that there was a significant difference ($P < 0.0001$) between the average packed cell volumes in the control group and Deltamethrin /Isometamedium chloride treatment. (Table 2)

CHAPTER FIVE

5.0 Discussion

Before 1988, control of trypanosomosis in south-eastern Uganda was based on tsetse control and treatment of livestock or human cases, all carried out separately (Lanciene, 1987). Large-scale tsetse control programmes in the past relied heavily on ground and aerial spraying, which was expensive and environmentally damaging (Tingle, 1993). In addition, block treatment campaigns were used in the control of animal trypanosomosis (Mangeni, 1996). Despite the success achieved by these approaches of tsetse and trypanosomosis control, it was rather difficult to sustain control and to achieve reasonable impact, since disease and the vector control were not synchronised. To improve on the control methods, integrating tsetse control and trypanosomosis control using various methods like traps, live bait technology, chemotherapy all executed under the same co-ordination was introduced (Cox, 2004). This approach has been employed to control tsetse and trypanosomiasis in Southeast Uganda since 1988. In the present study, the effectiveness of the integrated methods in bovine trypanosomosis control technologies in Mukono district were compared.

Tsetse control measures (integrated) significantly reduced the apparent density. Similar results were earlier reported by Nowak, (1993), Lancien (1993) and Muguwa *et al.* (1993). Correspondingly, the prevalence of trypanosomosis in cattle was significantly lower in the areas with bovine trypnosomosis control technologies in comparision to the areas without control. It is observed that this reduction in the prevalence of trypanosomosis in cattle was at different levels for the different technologies. Successful

the trap and the fact that stakeholders do not easily notice its impact and therefore its sustainability by the community might not be possible. Promotion of this technology is also affected by its failure to reduce bovine trypanosomosis below the desired National target of 5% (Semakula, Director COCTU, Personal communication). The requirement to supervise the trapping and service the traps does not make the technique user friendly.

5.2 Use of Diminazene Aceturate Treatment Group

There was no significant difference (P=0.8985) between the apparent densities recorded in the Diminazene Aceturate Treatement group when compared with those in the control block. This was due to the absence of tsetse control activities in this group. The variations recorded in the different month were attributed to natural causes like dry season and preparation of gardens for farming. Although this intervention seemed to decrease on the prevalence of the trypanosomiasis within the block, there was no significant difference (P = 0.02631) when the trypanosome infection were compared with those in the control group. It is important to note that diminazene aceturate sometimes does not cross the blood-brain barrier in adequate quantities and may not be effective in cases where tissue invasion has already occurred (Jennings *et al.*, 1979, Whitelaw *et al.*, 1985). Although the PCV average for diminazene aceturate treatment this group was better than that recorded in the control group, failure to notice significant differences in bovine trypanosomosis with the control group shows that this approach in control is not very useful in the improvement of the overall herd health.

reduction in the prevalence of trypanosomosis in cattle to a prevalence of <5% in the areas where integrated control technologies were applied is similar to earlier observations made by Okuna *et al.* (1993) in Tororo and by Tretjen *et al.* (1992) in Mukono district.

Anaemia is known as a key symptom in bovine trypanosomosis (Magona, 1998) and PCV was used as a measure of this clinical symptom. A decline in the prevalence of trypanosomosis in cattle was accompanied with elevation of PCV with many animals having their PCV >23% (the value where the animal is regarded to be anaemic, Zieger, 1995). Based on the mean PCV, cattle in the area with control were healthier than those in the area without control. The results obtained in this study showed a similar trend to that recorded by Fox *et al.* (1993) where a study at Mkwaja ranch in Tanzania showed that there was an increase of the mean PCV to 30% after tsetse control with deltamethrine as compared to 26% before control.

5.1 Trapping Treatment

The apparent density before trapping technology intervention was 8.5 flies/trap/day. This was drastically reduced to 0.01 flies/trap per day twelve months after the intervention indicating the use of the traps alone was very effective as a vector control strategy. There was also a significant decrease in the bovine trypanosome infection rate although the 5.4% infection rate was above the target of 5% at which the disease is thought to be under control in Uganda when parasitological techniques are employed (Katunguka *et al.*, 1997). Failure to notice any difference in the averages PCV's in this study could be attributed to the fact that trapping alone does not eliminate infection already existing. The adoption of traps only technology might not receive high demand due to the high cost of

5.3 Traps and Diminazene aceturate Treatment

The tsetse population was gradually suppressed from the apparent density of 13.7 flies/trap/day to zero flies/trap/day by the eleventh month in the traps and diminazene aceturate treatment group. Maintenance of the apparent density at low levels by this technology is complicated by the possibility of re-invasion of the area following the decrease in strength of the insecticides in the impregnated traps at the end of the six months (Lancien *et al.* (1990). By the eleventh month there were no trypanosome infections detected in cattle although the reduction of infection to less than the target of 5% was only achieved in the 9^{th} month. The average PCV of the cattle in this block raised from 25.5% (recorded at month 1) to about 30% recorded in month 12. The usefulness of this technology is demonstrated by the fact that there was a significant difference in apparent density when this group was compared with the control (Table 2).

5.4 Traps and isometamidium chloride Treatment

After intervention in traps and isometamidium chloride treatment the animals were negative for trypanosome infection beginning with the second month, showing a significant difference ($P < 0.0001$) between infection rates in cattle in this group and the control. The usefulness of this control approach as recorded in this study is similar to findings by Jenna *et al.* (2004), who have recorded a significant decrease in bovine trypanosomosis in the FITCA-Uganda project areas where these technologies were applied. The average PCV for the cattle in this block was significantly increased. Similarly there was a decrease in the tsetse infection rate and the tsetse population was gradually suppressed from the apparent density of 15.8 flies/trap/day to zero

flies/trap/day by the twelfth month. The greatest limitation of this technology is the high cost of the traps and the decrease in the insecticide concentration in the traps with time, necessitating regular re-impregnation.

5.5 Deltamethrin and Diminazene aceturate treatment group

After only one month of applying the deltamethrin and diminazene aceturate treatment group, the tsetse AD was recorded at half that recorded during the first month and bovine trypanosomosis was less than 5% after the 5^{th} month. The long time taken to bring the trypanosome prevalence to zero in this group can be attributed to the low protection provided by diminazene aceturate, thus allowing a possibility of re-infection. The average packed cell volumes for the animals kept in this group showed a gradual increase throughout the study period and there was a significant difference ($P < 0.0001$) between the average packed cell volumes in the control group and that in the Deltamethrin /Diminazene aceturate treatment.

5.6 Deltamethrin and Isometamedium chloride treatment group

There was a decrease in the trypanosome infection rates both in tsetse and cattle in deltamethrin and isometamedium chloride treatment group. The trypanosome infection in tsetse flies was zero starting with the third month and remained so throughout the study period. The animals were negative for trypanosome infection beginning with the second month after introduction of the above treatment and remained so throughout the study, showing a significant difference ($P < 0.0001$) between infection rates in cattle in this group and that in the control. Meanwhile, there was also a decrease of tsetse

apparent density which remained low from the third month till the end of the study. The increase in the average packed cell volume of cattle in this group throughout the study period show evidence of the value of this technology in the improvement of the animal health status. This combination proved one of the best integrated approach to the control of bovine trypanosomiasis Olilla *et al.*, (2002) and Patzelt *et al.*, (1995). It was also shown that trypanosome strains in the study area were sensitive to isometamidium chloride. Clausen *et al.*, (2001) and Olilla *et al.*, (2002) had earlier reported similar results in Mukono county, Mukono district

Deltamethrin and isometamedium chloride treatment was the best combination in the control of tsetse and trypanosomiasis. In addition to the frequency of application of this treatment is user friendly to the farmers - they only have to treat cattle with isometamidium chloride 2-4 times a year (Kanabo, 1988; Clausen, *et al.*, 2001) in order to maintain a 0% prevalence in their herds as seen in this study. The live bait technology using deltamethrin has the advantage of reducing the vector population density and also break the transmission cycle. In addition it controls other biting flies and ticks (Elliots, 1970; Okello-Onen, 1994). Other technologies that involve the use of traps give limited success as shown in this study and are expensive. (US$10/trap) (Magona, 1996). Moreover a farmer will need to have many traps to cover the whole grazing area at the recommended 10 traps per square km (Musisi *et al.*, 1993). The greatest advantage of the live bait technology lies in the fact that farmers are encouraged to use it as the impact is observable by the reduction in tick numbers unlike other technologies that target tsetse alone.

CHAPTER SIX

Conclusion and Recommendations

6.1 Conclusion

1. Prophylactic treatment (samorin therapy) combined with live bait technology (deltamethrin application on cattle) performed best in controlling nagana in Buikwe County, Mukono District.
2. Sole use of diminazene aceturate and traps did the worst.

6.2 Recommendations

1. For control of nagana samorin chemoprophylaxis plus deltamethrin application on cattle should be advocated for.
2. Chemotherapy with berenil should be reserved for clearing of cattle herds of trypanosomes.
3. Further studies about the cost-effectiveness of isometamidium choloride with deltamethin spray under different agro-ecological zones of the trypanosomosis endemic areas of Uganda should be undertaken to what farmers are appraised of the costs involved in this technically effective integrated control strategy.

CHAPTER SEVEN

7.0 References

Adam, J.P., Challier, F. (1969) Le pont: Etude ele la tramission de la maladie du sommeil dans le foyer resuent de Loudima. Organisation d'une campagne de lutte centre les glossines. Rap. Multigr. ORSTOM Brazzaville : 1-22.

Agyemang, K., R.H., Jeanini, P., Leperre, P., gireve, A.S., Bah, M.L. (1990) Biological and Economic Impact of Trypanosome infections on milk production in N'Dama cattle managed under village conditions in Gambia. *Anim. Prod.*, 50:383-389.

Agyemang, K., Little, D.A., Mathioli, R., Bah, M.L., Sonko, E., and Janneh, L. (1991). Reproductive performance of N'Dama cows as influenced by tyrpanosome infection and postpartum liveweight change. *ISCTRC21st meeting, Yamoussoukro, Cote d'Ivoire, 2-22 Oct 1991.*

Allsopp, R. (1972). The role of game animals in the maintenance of endemic and enzootic trypanosomiasis in the Lambwe Valley, S. Nyanza , Kenya. Bull. Wld Hlth Org. 47: 719-726.

Allsopp, N, J. (1994). A review of recent approaches to sustainable control and analysis of the potential of modern techniques for large-scale use. In: Asystematic approach to tsetse and trypanosomiasis control. FAO Panel of Experts Report.Rome: FAO 137-147.(FAO Technical Papers Series; 121)

Allsopp N.J and Reg (2001) Options for vector control against trypanosomiasis in Africa. Trends in Parasitology 17(1): 15 - 19.

Baker, J.R. (1970). Techniques for detection of trypanosome infection. In: the African Trypanosomiosis. Ed. H.W. Mulligen. London: 68.

Bauer, B., Kabore, I., Liebish, A., Mayer, F., Petrich-Baner, J. (1992). Simultaneous control of ticks and tsetse files in Satiri Burkina Faso, by use of flumethrin pour on for cattle. *Trop. Med. Parasit.* 43:41-46.

Bauer, B., Kabore, J., Petrich Baner, J. (1992). The residual effect of deltamethrin spot-on when tested against *Glossina palpalis* under fly chamber conditions. *Trop. Med. Parasitol,* 43: 35-40.

Bauer, B., Meyer, F., Kabore, I. (1989) Effects of flumethrin pour-on against *Glossina palpalis gambiense* (Diptera, Glossinidae) during releases in a fly-proof stable. *Trop. Med. Parasitol,* 40:478-479

Brandl, F. E. (1998). Economics of Trypanosomiasis Control in Cattle. Farming systems and resources, *Economic in the Tropics Vol. 1. Wissenchaftverlag Vauk kiel, GTZ Federal Republic of German.*

Buxton. P. A. (1955). The natural history of Tsetse flies. London school of hygiene and tropical Medicine. *Memoir* 10: 1-816.

Camus, E. (1981). Epidemiologie et incidence clinique de la lypanosonise clans la nord de la co^te d'Ivoire. Revue de l'elevage et me'dicine vite'rinaire clans les pays tropicaux, 34 (3): 289-295.

Chadwick, P.R., Beesley, J.S.S., white, P.J., and Matechi, H.T. (1964). An experiment on radiation of *G.Swynnertoni* by treatment of its resting sites. *Bull ent. Res.*, 55, 411.

Challier, A. (1965). Amelioration de la methode de determination de l'age physioloque des lossione. *Bull. Soc. Path exot*, 58: 250.

Chizyuka, H.G.B., and Luguru, S.M.K. (1986). Dipping to control vectors of cattle arasites.*Parasitology Today*, 2:123.

Clausen P.N., Sidebe,I., Kabore, I and Baner, B. (1992). Development of multiple drug resistance of *Trypanosoma conglense* in Zebu under high natural tsetse challenge in the pastoral zone of Samorogonan, Burkina Faso. *Acta Tropica* 51:229-236.

Codjia, V., Majiwa, P.A.O., Leak, S.G.A., Rowland, G.J., Authie, E., Dreteren, G.D.M., and Peregrine, A.S. (1993). Epidemiology of Bovine trypanosomosis in the Ghibe valley, South-west Ethiopia. 3 Occurrence of populations of *Trypanosoma conglense* resistant to diminazene, isometamidium and hiomidium. *Acta Trop* 15: 151-163.

Cox, F.E. (2004). History of sleeping sickness (African trypanosomiasis). Infect Dis Clin North Am. 18(2):231-45.

Cunningham, M.P., van Hoeve and W.H.R. Lumsden (1064): A bioessay technique for determination of hypanocidal drug levels and its application in estimating the duration of activity of Berenil in treated cattle. In Proc. 1st Internat. Conf. Protoz., Rome.

Curson, H. H. (1928). Nagana in Zululand. 13th and 14th Repts. Dir. Vet. Educ. & Res. Dept. Agric. S. Africa. Part1, 309

Davies, H. (1964). "Eradication of tsetse in the Chad river system of North in Nigeria" *J. app. Ecol.*, 1,137.

Desowitze, R.S. and Fairbaurn, H. (1963). The influence of temperature and length of developmental cycle of *T.vivax* in *Glossina palpalis*. Ann. Trop. Med. Parasit. 49: 161-163.

Desowitz (1959). Studies on immunity and host-parasite relationships. The immunological response of resistant and susceptible breeds of cattle trypanosomal challenge. Ann. Trop. Med. Parasit. 53: 293-313

Djiteye, A., Moloo, S. K., Foua Bi, K., Coulibaly, E., Diarra, M., Outtara,I., Traore, D., Coulialy, Z. , Diarra, A. (1997). Seasonal variations of the apparent density and trypanosome infection rates of *G. gambiensis* in the Sudanese zone of Mali. *Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux,* 50 (2): 133- 137.

Elliots, R.N. (1973). Photostable pyrethroids, *Nature*, London, 169-170.

F AO, (1993). Training Manual for Tsetse Control Personnel, Vol. 5, 59

Feldmann, U. and Hendrich, J. (1998). Integrating the sterile Insect Technique as a key component of area-wide tsetse and trypanosomosis intervention (PAAT Position paper in No. 6 FAO, Rome.

Fenille, P. (1962). Progress report on the recent chemothreapeutic advances in trypanosomiasis in animals. *Proc, 9th, ISCTRC* (Onakry, 88, pp. 55).

Fenille, P. (1983a) African animal trypanosomiasis Part 1 & Disease and Chemotherapy. African animal trypanosomiasis. Selected articles from the world animal review. FAO, Rome, 1983.

Ford, J. (1970). The role of the trypanosomes in Africa ecology. A study of the tsetse fly problem, London, Clarendon. *Press Oxford.* Pp. 1-568.

Fox, R., G., R., Mmbando, S., Wilson, A. (1993). Effect on herd health and productivity of controlling tsetse and trypanosomiasis by applying deltamethrin to cattle. Trop. Anim. Health Prod. **25**, 203-214.

Fussiganger, R., Baker, F. (1960)."Investigations on Berenil resistance of trypanosomes. *Vet Rec.*, 72: 11-18

Gates D.B., Cobb, P.E., Williamson, D.I., Bakuli, B., and Dame, D.A., (1983) Integrated of insect sterility and insecticides for control of G. morsitans morsitans

Westwood (Aiptera:Glossinidae) in Tanzania III. Test site characteristics and the national distribution of tsetse flies. Bulletin of entomological Rsearch, 73, 373-381.

Geerts, S. and Holmes, P.H. (1998). Drug management and parasite resistance in animal trypanosomiasis in Africa. In proceedings of the 24th Meeting of the International Scintific Council for Trypanosomiasis Research and Control (ISCTRC, p.371-85). Maputo, Mozambique, OAU/ISCTRC.

Gled hill, J.A., and Caughey, W. (1963). Report on a field trial in the use of Dieldrin for the control of *G. Morsitans* in the Zambezi valley- 1961. *ISCTRC* (1963) P. 239

Goodwin, LG and Rollo, I.M. (1955). The chemotherapy malaria, piroplasomiosis, Trypanosomiasis and leishmaniasis. In Biochemistry and Physiology of Protozoa, etc S.H Hutner & A Lwaff, Vet. 2 New York: Academic Proceedings Soulsby, E.J. (1986)

Greekmore, C. (1989), Agric. Intl. 41 (4) 99.

Green, C.H., (1994a). Bait methods for tsetse fly control. Adv. Parasitol. 34, 229–291.

Hardways (1976). The susceptibility of different species of tsetse flies to some insecticides. Centre for Overseas Pest Research, *Miscellaneous report* No. 234. 4 pp 4.

Hawking, H. (1963) Action of drugs upon *T.congelence, T. Vivax T.rhodesiense* in tsetse flies and in culture. Annals of Tropical Medicine and Parasitology, 57, 255-261.

Heisch, R. B., McMahon, J.P and Manson-Bahr, P.E.C. (1958). The isolation of Trypanosoma rhodesiense from Bushback. Brit. Med. Journal 2: 1202-1204.

Hoare, C.A. (1948). Reservoir hosts of human trypanosomiasis. Proc. R.. Soc. Med. 41: 553.

Hoare, C.A. (1948), The relationship of haemoflagellates. Proc. IV Intern. Cong. Trop. Mod. Malaria, Washington, 2, 1110.

Hoare C. A. (1970). The mammalian trypanosomes in Africa. In: Mulligan H. W (ed). The African trypanosomiasis. George Allen and Unwin, London. Pp 3-23

Holmes, P.H. (1991). New opportunities for diagnosis and control of animal diseases in the tropics. *Trans R. Soc Trop. Med Hygiene 8ST* 163 – 167

Hursey, B .S.(1985). Tsetse control. A report presented at the 6th Conference of the OIE Region Commission for Africa, Harare, 22-25 January 1985. Pp 299-310.

Hursey, B.S. (1988). The integration of insecticidal techniques for the control and eradication of *Glossina morsitans* in northeast Zimbabwe. In OAU/ISTRC publications, Nairobi No. 114, 555.

IAEA. (1993). IAEA report of The 22nd meeting of the International Scientific Council for Trypanosomiasis Research and Control, Kampala Uganda.

ILRAD. (1993). Medium and long-term plan for research on Livestock disease prospectors 1994 - 1998,Nairobi.

Itty, P and Swallow, B. (1993). The economics of trypanotolerant cattle production in region of origin and areas of introduction. Paper presented at the ILRAD workshop. Towards increasing utilisation and adoption of trypanotolerance-current status of research and future direction, Nairobi, Kenya, 26-29.

Janke, H.E., Tacher, G. (1998). Livestock production in Africa with special reference to the tsetse affected areas. In: Proceedings of an ILCA/ILRAD Meeting on livestock production in tsetse affected areas of Africa 1987, Nairobi.

Jenna Fyfe, K. Picozzi, E.M. Fevre, C. Waiswa, J. McDermott, S.C. Welburn (2003). Assesment of trypanosome prevalence in FITCA high risk areas. *Newsletter on Integrated Control of Pathogenic Trypanosomes and their Vectors* (ICPTV) No.8:25-26.

Jennings, F.W., Whitelaw, D.D., Chizylia, H.G.B., Holmes, P.H. and Urquhart, G. (1979)- The brain as a source of relapsing trypanosoma brucei infectious in mice after chemotherapy. International Journal for Parasitology 9, 381-384.

Jordan A.M. (1974). Recent developments in the ecology and methods of control of tsetse flies (Glossina spp) (Diptera, Glossinidae) - a review. Bulletin of entomological research, 63, 361-399.

Jordan, A.M. (1987). The Roll of Tsetse in Africa Animal Trypanosomiasis. ATLN Proceedings held in Nairobi.

Khan, A. H., Sempos, C. T. (1989). Statistical methods in Epidemiology.New York, Oxford: Oxford University press, pp. 24-26

Kakaire, D., Katabazi, B., Nowaj, F., Laqya, H., Hartman, G., Tiejen, U., Lancien, J., Mbulamberi, D.B., Mehlitz, D. (1993). Success in monitoring of control measures against sleeping sickness in Mukono district. Southeast Uganda. *22nd ISCTRC, Kampala, Uganda*

Kahn, A.H., Sempos, C.T. (1989). Statistical method in Epidemiology. New York, Oxford; Oxford University press, pp. 24-26.

Kangwangye, T.N. (1987). Trapping and ground spraying against *Glossina fuscipes-fuscipes* in control of human trypanosomiasis epidemics in Northwest and Southeast Uganda, *ISCTRC, 16th meet. Lome, Togo, pp, 413.*

Katunguka-Rwakishaya; D. Mckechnie, J.J. Parkins, M. Murry, P.H. Holmes. (1997). The influence of dietary protein in live bodyweight, degree of anaemia and

erythropoietic responses of Scottish Black face sheep infected experimentally with trypanosome congolense Research in Veterinary Science **63**, 273 – 277.

Kanabo, L.D.B. and Bogan, J.A. (1988) Pharmacokinetic and histopathological investigations of isometamidium chloride in cattle. Research in veterinary science 44, 267-269.

Kinghorn A. (1925). Human trypanosomiasis in the Luangwa Valley, Nothern Rhodesia. *Ann of tropical Medicine and Parasitol* 19:281-300.

Koemau, J.H. and Talaken. W. (1977). The environmental impact of tsetse operations: A report on present knowledge Rome: FAO 14 - 15. (FAO Animal Production and Health Paper Series: 7)

Kuzoe, F.A.S. (1993). Current status situation of African trypanosomiasis. Acta Tropica 54, 13-162

Lancien, J., and Gouteux, J.P. (1987). Le piege pryamidial a mouche tsetse (DipteraGlossinidae). *Afrique medicale* 26: 647-6552.

Lancien, J., Muguwa, J., Lannes, C., and Bouvier, J.B. (1990). Tsetse and Human trypanosomiasis challenge in Southeast Uganda. *Inset. Sci applic.* Vol. 11, No. 3, pp, 411-416.

Laucien, J. (1993). La malodie du sommeil controlee an sud de l'Ouganda (control of sleeping sickness in southern Uganda). ORSTOM Actualites. 41, 7-10.

Leach, T.M., and Roberts, C.J. (1981). Present status of chemotherapy and chemoprophylaxis of animal trypanosomiasis in Eastern Hemisphere, *Pharmac.* 13: 91-147.

Leak, (1999) Tsetse Biology and Ecology, their role in the epidemiology and control of trypanosomiasis. International Livestock Research Institute Nairobi. CABI Publishing.

Leak, S.G.A. (1999). Host-Parasite interactions. In Tsetse biology and ecology (ed). 11:181-227.

Lloyd, L. (1930). Some factors influencing the trypanosome infection rates in tsetse flies. Transactions of the royal society of Tropical Medicine and Hygiene, 23, 533-542.

Losos, G.J., and Ikede, B.O. (1972). Review of Pathology of disease in domestic and Laboratory animals caused by *T. conglense, T.vivax, T. Brucei, T. rhodesiense and T. gambiense. Veterinary Pathology*, 9: 1-7.

MacLennan, K. J. R. (1957). A staining technique for identification of trypanosomes in thick blood films. *Trans. R. Soc. Trop. Med. Hyg.* 51, 301.

Magona, J.W. (1996). Control of tsetse and trypanosomosis using combination of tsetse trapping, pour-on and chemotherapy along the Uganda-Kenya boarder. Masters thesis. Free University of Berlin, Germany.

Magona, J.W. Okuna, N.M., Katabazi, B.K. Omollo, P., Okoth J.O.Mayende, J.S. P. Drabile, D.C. (1998). Control of Tsetse and animal trypanosomiasis using a combination of tsetse trapping, pour-on and Chemotherapy along the Uganda - Kenya border. Revie Elev. *Med. Vet. Pays trop,* 51 (4): 311 - 315

Maldonado, - (1910). English abstract of Portuguese texts of 1906 and 1909, sleeping sickness *Bureau Bull.*, 2, 26.

Mangeni, J. (1996). Review of animal trypanosomosis in Uganda. Masters thesis, Free University of Berlin, German.

Martin, S.W., Meek, A.H, Willeberg. P. (1987). Veterinary Epidemiology, Principals and methods lowa, United States: lowa State University Press.

Maudlin, I., Welburn, S. C., Gashumba, J. K., Okuna, N. M. and Kakunda, M. (1990). The roll of cattle in the epidemiology of sleeping sickness in Uganda. *Bulletin de la Societe Francaise de Parasitologie* 8, 788.

Mbulamberi, D.B. (1990). The sleeping sickness situation in Uganda: Past and Present. *Insect. Sci. Applic*, **1**: 289-292.

Molyneux, D. H. (1982). Vector relationshps in the trypanosomatidae. Advances Mosers **D. R; Cook, G. A; Ochs, D. E; Baily, C. P; Mckane, M. R; and Donelson, J. E (1989).** Detection of *Trypanosoma congolense* and *Tyrpanosoma brucei* subspecies by DNA amplification using the polymerase chain reaction. *Parasitology*, **99**: 57-66.

Mugenyi, M. (2003). Tsetse flies have spread to 70% of the territory of Uganda, putting 5.1 million people at risk of catching sleeping sickness. In: Open speech of sensitization workshop for district leaders in Kampala. Sited in Tsetse and Trypanosomiasis information quarterly, Vol. **26**. Part 1, 2003. No.12485-12569.

Muguwa, J., Obayi, H., Musisi, R., Tibaingana, M., Drabile, C., Magona, J., Okoth, J. and Lancien, J. (1993). The effect of supplementing trapping control with deltamethrin pour-on formulation against tsetse flies (Glossina fuscipes fuscipes Newstead) in Buteba subcounty Tororo district, Uganda. The 22 nd Meeting of the ISCTRC in Kampala, Uganda.

Murray, M., Traril, J.C.M., Tarner, D.A. and Wissocq (1983). Livestock productivity and trypanotolerance. Network training manual. International Livestock centre for Africa. P.O.Box 5689, Addis Ababa, Ethiopia.

Musisi. R., Muguwa, J., Obay, H., Tibsangerua,; M. Drabile C., Magona J., Okoth, K.O, Lancien, J. (1993): The effect of supplementary trapping control with Deltmethrin "pouron" formulation against *G.f.fuscipes* in Buteba Sub County Tororo District. Uganda.

The 22nd meeting of the Internation Scientific Research Council for Trypanosomiasis Research and control in Kampala, Uganda.

Mulligan, W. H. C (1970). The African trypanosomes 1st edition. 4: 67-88.

Murry, M., P.K. and Meltntyre, W.I.N. (1977). An improved parasitological technique for the diagnosis of African trypanosomosis. *Trans. R. Soc. Trop. Med. Hyg*, 71: 325-326.

Ndyabahinduka, D. G. K. (1993). Uganda Country Report. The 22nd International Scientific Council for Trypanosomiasis Research and Control Kampala, Uganda.

Newstead, R., Evans, A. M and Potts, W. H. (1924). Guide to the study of Tsetse flies. London, The University press of Liver pool.

Nowak, F., Kakaire, D. W., Tietjen, S., Katabazi, B. and Mehlitz, D. (1992). *Glossina fuscipes fuscipes* as a vector of animal and human trypanosomes in South East Uganda: Determination of season fly density: host preferences and infection rates. *Zbl. Bakt. Hyg.*, 325, 60-61

Ogun, C.O. and Eghianruwa, K.I. (1993). A preliminary study on the absorption of Isometamidium chloride (Samorin) in the stomach and small intestine of Rat. *Journal of Chemotherapy Vol.5 – n. 2 (107-109)*

Ogunsanmi, A.O., Ikeda, B.O. and Akpavie, S.O.(2000). Effect of management, season, vegetation zone and breed on the prevalence of trypanosomosis in southwestern Nigeria. Israel Journal of Veterinary Medicine, 55 (2): 69-73.

Ogwal, L.M., Kangwagwe, N.T. (1990). Population dynamics of *Glossina fuscipes fuscipes* on Buvuma Islands, Lake Victoria in Uganda. In: Sterile Insect Technique for Tsetse Control and Eradication. Proceedings of a meeting, Von, Plateau State, Nigeria, 6-10 June 1988, 67-77.

Okello-Onen, J., Seitto, R., Mwayi, W., and Kabarema, M. (1993). The simultaneous control of tsetse flies and ticks in Uganda by dipping cattle in Deltamethrin. *Insect Science audits Application* 13 (4), 657-660.

Okello- Onen, J., Heinonen, R., Sekitto, C.M.B., Mwayi, W.T., Kakaire, D.W. and Kabarema, M. (1994). Control of tsetse flies in Uganda by dipping cattle in deltamethrin. *Trop. Anim. Hlth. Prod.* 26, 12-26

Okiria, R., Okuna, N. M., Magona, J.W. and Mayende, J.S.P. (2002). Sustainability of tsetse control by subsequent treatment of 10% Ugandan cattle population with 1% w/v deltamethrin. *Trop. Anim. Hlth.* **34** (2): 105-114

Okoth, J.O., Kirumira, E.K., Kapaata, R. (1991). A new approach to community Participation in tsetse control in the Busoga sleeping sickness focus, Uganda. A preliminary report. *Annals of Trop. Med. Parasite.* Vol. 85, No.3, 315-322.

Okoth J. (1999). Tsetse and trypanosomiasis control problems in southeastern Uganda. Past present and alternative strategies. *Schweiz, Med, Wochenschr.* 10: 129 (31-32): 1091-8.

Okuna, N. M., Mayende, J. S.P. (1981). The incidence of trypanosomiasis in domestic animals and their roll in the sleeping sickness epidemics in Busoga. The 17 th meeting of the International Scientific Council for Trypanosomosis Research and Control, Arusha, Tanzania.

Okuna, N.M., Mayende, J.S.P. Guloba A. (1986). *Trypanosoma brucei* infectious in domestic pigs in sleeping sickness epidemic areas of Uganda. *Acta Trop. 43,* 183 - *184*

Okuna, N.M., Mayende, J.S.P., Magona, J. (1993). The validation of an Ag-ELISA for the diagnosis of trypanosomiasis in cattle in Uganda and its use in assessing the efficacy of a control programme

Olaho-Mukani, W. (2002). Uganda revises cattle treatment to protect humans from sleeping sickness. News in The Lancet. Vol. 359(9302):239.

Olila D., Mcdermott, J.J. Eisler, M.C. Mitema, E.S. Patzelt, R.J Causen P.H., Poetzch.C.P Zeissin, K.H. Mehlitz, D and Pergrine, A.S. (2002). Drug sensitivity of trypanosome population from cattle in peri-urban dairy production system in Uganda. *Acta Tropica*, 84 (1): 19 - 30

Otieno, L.H. & Darji, N. (1979) The abandance of pathogenic African Trypanosomes in the salivary secretion of wild glossina pallidipes. Ann. Trop. Med. Parasit. 73, 583.

Park, P.O (1972). A large scale scheme for eradication of *G. morsitans* western in the western region of Zambia by aerial ultra low volume application of endosulfan. Bull. Entomol. Res. 61:373-384

Patzelt, R.J., Kakaire, D., Katabazi, B., and Mehlitz, D. (1995). Efficacy of Deltamethrin spot-on treatment of livestock control of tsetse files and Trypanosomiasis transmission in rain forest vegetation at shores of lake Victoria In Uganda. *23rd meeting ISCTRC, Banjul, Gambia.*

Peregrine, A.S. (1987). Therapeutic and prophylactic activity of Samorin in Boran cattle against T. vivax transmitted by *Glossina morsitans centralis. Research in Vet scie.* 43: 268-270

Plan for Modernisation of Agriculture (PMA) (2000): Eradicating poverty in Uganda. Document by the Ministry of Agriculture, Animal Industry and Fisheries, Entebbe, Uganda.

Robertson, A.G., and Bernacca, J.P. (1958). Game elimination as a tsetse control Measure in Uganda. ISCTRC (1958) p. 103.

Robertson, D.H.H. and Baker, J.R. (1958). Human trypanosomiasis in South East Uganda. *Transaction of the Royal Society of Tropical Medicine and Hygiene* 52, 327 - 348

Rotteher, D., and Schillinger, D. (1985). Multiple drug resistance in *Trypanosoma vivax* In the Tana river district of Kenya. *Ve t. Rec.*, 557-558.

Rowlands, G.J., Wondyalew Mulafu Anthie, E.G.m. d'leteren, Leak, Nagda, S.M. (1993). Effects of trypanosomiasis on growth and mortality of young East Africa zebu cattle exposed to drug-resistant trypanosomes. *Prevet. Vet Med.* 21:87-101.

Schonefeld, A., Rottcher, D., and Moloo, S.K. (1987). The sensitivity to trypanocidal drugs of Trypanosoma *vivax* isolated in Kenya and Somalia. *Trop. Med. Parasitol.* **38**: 178-189.

Siemons, A., Kakaire, D.W. , and Patzelt. (1993). The effect of Treatment of Cattle with Deltamethrin SPOT- ON the risk of infection of Trypanosomiasis in Matale Sub-parish, Mukono district. Proceedings of the 3rd Workshop on Epidemiology, 30/8-10/9/1993, Entebbe, Uganda.

Stephen, L.E (1966). Observation on the resistance of west African N'dama and zebu cattle to trypanosomiasis following challenge by wild *G. morsitans* from early age. *Ann. Trop. Med. Parasit.* 60:230

Ssekitto, C.M.B. (1997). The potential use of synthetic pyrethroids in the control of tsetse and Ticks in Hoima District. Msc.thesis, Faculty of Science, Makerere University, Uganda

Stephen, L.E (1966). Observations on the resistance of west african N'dama and Zebu cattle to trypanosomaisis following challenge by wild G. morsitans from early age. Ann. Trop. Med. Parasit. 60:230

Stephen and Lorne, E (ed). Trypanosomiasis. A Veterinary perspective. Pergamon Press. 1986. Oxford, New York, Frankfurt, Toronto.

Teale, A. (1991). Mapping and trypanotolerance. Proceeding, of a workshop of Bovine Genome Mapping and Trypanotolerance, held at ILRAD, Nairobi, Kenya 9 - 11th April 1991, pp 5 -7

Tingle, C.C.D (1993). Bait location by ground foraging ants (Hymenoptera:Formicidae) in Mopane woodland selectively sprayed to control tsetse flies (Diptera:Glossinidae) in Zimbabwe. Bulletin of Entomological Research, 83, 259-265

Thompson, W.J., and Wilson, A. (1992). A review of developments in tsetse fly (*Glossina spp)* control by application of insecticide to cattle. *Bull. Anim. Orod.* **40**: 1-4.

Tretjen,,S., Nowak, F., Kakaire, D., Hohmann, L., Katabazi, B. and Mehlitz, D. (1992) *Glossina f. fuscipes* as a vector for human and animal trypanosomes in South East Uganda. Determination of seasonal fly density, host preferences and infection rates. *Zbl. Bsky.Gi.***325**: 60-61.

Twinamasiko, E., and Kakaire, D. (1994). The impact of Bovine trypanosomosis on the Antibody response to rinder pest vaccination under field conditions. *Bull. Anim. Prod. Afri* **42**, 297-301.

Vale, G.A. (1982). The trap orientated behaviors of tsetse flies (Glossinidae) and other Diptera. *Bullettin of Entomological Research* **72**:71-93.

Vale, G.A., Burcell, Hargrove, J.W. (1985). Catching - out the Tsetse fly. *Parasitol, Today I*, 106 - 110.

Vale, G. A., Mutika, G. and Lovemore, D. F. (1999). Insecticide- treated cattle for controlling tsetse flies (Diptera: Glossinidae): some question answered, many posed. *Bulletin of Entomological Research*, **89** (6): 569-578

Stephen and Lorne, E (ed). Trypanosomiasis. A Veterinary perspective. Pergamon Press. 1986. Oxford, New York, Frankfurt, Toronto.

Teale, A. (1991). Mapping and trypanotolerance. Proceeding, of a workshop of Bovine Genome Mapping and Trypanotolerance, held at ILRAD, Nairobi, Kenya 9 - 11th April 1991, pp 5 -7

Tingle, C.C.D (1993). Bait location by ground foraging ants (Hymenoptera:Formicidae) in Mopane woodland selectively sprayed to control tsetse flies (Diptera:Glossinidae) in Zimbabwe. Bulletin of Entomological Research, 83, 259-265

Thompson, W.J., and Wilson, A. (1992). A review of developments in tsetse fly (*Glossina **spp)*** control by application of insecticide to cattle. *Bull. Anim. Orod.* **40**: 1-4.

Tretjen,,S., Nowak, F., Kakaire, D., Hohmann, L., Katabazi, B. and Mehlitz, D. (1992) *Glossina f. fuscipes* as a vector for human and animal trypanosomes in South East Uganda. Determination of seasonal fly density, host preferences and infection rates. *Zbl. Bsky.Gi.***325**: 60-61.

Twinamasiko, E., and Kakaire, D. (1994). The impact of Bovine trypanosomosis on the Antibody response to rinder pest vaccination under field conditions. *Bull. Anim. Prod. Afri* **42**, 297-301.

Vale, G.A. (1982). The trap orientated behaviors of tsetse flies (Glossinidae) and other Diptera. *Bullettin of Entomological Research* **72**:71-93.

Vale, G.A., Burcell, Hargrove, J.W. (1985). Catching - out the Tsetse fly. *Parasitol, Today 1*, 106 - 110.

Vale, G. A., Mutika, G. and Lovemore, D. F. (1999). Insecticide- treated cattle for controlling tsetse flies (Diptera: Glossinidae): some question answered, many posed. *Bulletin of Entomological Research*, **89** (6): 569-578

W.H.O. (1986). Epidemiology and control of African trypanosomiasis. Geneva, World Health Orgainsation, Technical report series 739, Geneva.

Waiswa, C., Katunguka-Rwakishaya, E. and Wangoola, R.M. (2000). Control of sleeping sickness in south-eastern Uganda: Factors affecting tsetse and trypanosomosis control in Iganga and Kamuli districts. *Uganda Veterinary Journal,* 6(1):147-152

Walker, P.J. (1972). Capillary concentration technique applications of *T. conglense* in Cattle. *Trans. R. Soc. Med. Hyg.* 66. 348.

Whitelaw, D, D., Moulton, J. E., Morrison W. Murray, M. (1985) and I. Central nervous system involvement in goats under going primary infection with *T.brucei* and relapse infection after Chemotherapy. *Parasitol.* 90: 255-268.

Whiteside, E.F. (1949) An experiment in control of tsetse with DDT - treated oxen, Bull. Ent. Res. 40, 123.

Whiteside, E.F. (1962). "The control of cattle trypanosomosis with drugs in Kenya. Methods and costs*: E.African Agricultureal Jornal* 28:

Willet K.C. (1955) A special method for the dissection of Glossina annals of Tropical medicine and parasitology, 49, 376 - 383.

Williamson, J. (1980). Present situation of research for new trypanocidal drugs. Report on the expert consultation on research on trypanosomiasis. Pp 90. Food and Agricultural Organisation of the United Nations, Rome

Wilson, S.G. (1953) The control of glossina palpalis fuscipes Newstead in Kenya colony. Bulletin of entomological research, 44, 711-728.

Woo, P.T.K. (1970). The haemaocrit centrifuge techniques for the diagnosis of African trypanosomiasis. *Acta Trop.* 27: 384-386.

Woolfe, G. (1965). Trypanocidal action of Phenathridium. *Brit. J. Pharmacol.* 11: 330-334.

Woff, W. R. (1968). The eradication of the tsetse Glossina morsitans west. And Glossina Pallidipes Aust. by hunting. The 12th meeting of the ISCTRC, Bangui, Gambia.

Zieger, U (1995). Veterinary Clinical Pathology Laboratory Manual: Table of haematological values. Students training manual Faculty of Veterinary Medicine, Makerere University.

Appendix I

Fly dissection record **Date:** **Place:**

ly o.	Trap No.	Sex		Mid-gut	Sal-gland	Labium	Hypoph	Remarks
		M	F					

Appendix II

Fly Trapping record 2001 **Place:**

Date	Trap No.	No.		No. ten	Tmp min	Tmp Max	Rel hum	Description of weather and habitat	Remarks
		M	F						