

**EPIDEMIOLOGY OF BOVINE TRYPANOSOMOSIS AND ITS ECONOMIC  
IMPACT IN TSETSE-INFESTED AND TSETSE-FREE AREAS OF AMHARA  
REGION, NORTH-WEST ETHIOPIA**

**By**

**THOMAS CHERENET ASFAW**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in  
Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

**July 2004**

**DEDICATION**

**TO MY CHILDREN DAGMAWI, HENOK AND YARED, TO MY WIFE MULU,  
TO MY LATE MOTHER TIGAE AND FATHER CHERENET FOR THEIR  
LOVE, AFFECTION AND ENCOURAGEMENT  
THAT ELEVATED MY SPIRITS**

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

**EPIDEMIOLOGY OF BOVINE TRYPANOSOMOSIS AND ITS ECONOMIC  
IMPACT IN TSETSE-INFESTED AND TSETSE-FREE AREAS OF AMHARA  
REGION, NORTH-WEST ETHIOPIA**

**By**

**THOMAS CHERENET ASFAW**

**July 2004**

**Chairman: Associate Professor Rehana Abdullah Sani, Ph.D.**

**Faculty: Veterinary Medicine**

The epidemiology of bovine trypanosomosis was studied in tsetse-infested and tsetse-free areas of Amhara Regional State, North-West Ethiopia. A multidisciplinary work was undertaken to elucidate the key factors determining the presence of tsetse flies and magnitude of bovine trypanosomosis. Cattle were selected from tsetse-infested and tsetse-free areas for monthly monitoring of trypanosome infection by blood sampling on glass slides, dried blood spot and buffy coat spot on filter papers. In this study, parasitological, serological (Ab-ELISA) and PCR methods were used to characterize trypanosomes infecting the vector and the host.

A total of 795 blood samples from cattle were examined from the tsetse-infested and tsetse-free areas; 13.5% of wet blood film and 15.6% of thin blood film were found positive for trypanosomes while PCR detected 18 % trypanosome infections. The dominant species was *T.vivax*, followed by *T.congolense* and *T.brucei*. *T.vivax* was

higher in tsetse-free areas, whereas *T.congolense* was more in tsetse-infested areas, *T.brucei* and mixed infection of *T.congolense* and *T.vivax* were only present in tsetse-infested areas. The monthly trypanosome prevalence in tsetse-infested areas varied from 15 to 28% and in tsetse-free areas was 9 to 27%, with December having the highest prevalence in both study areas. Sera and dried blood spot on filter paper in Ab-ELISA showed strong correlation, providing for the use of the more convenient dried blood spot.

In the retrospective study 7079 samples and accompanying data were analyzed for 5 consecutive years from the year 1997 till 2001. The prevalence of trypanosome infections was highest during the early dry season (September to December). Trypanosome infections were mainly due to *T. vivax*. Trypanosomosis reduced significantly the average packed cell volume and the body condition of the host. The monthly prevalence of infection was correlated with the density of biting flies suggesting their important role in transmission of trypanosomosis in the tsetse-infested and tsetse-free areas of the Amhara Region of north-west Ethiopia.

Flies were trapped for 3 days each month in the study period using 4 types of traps ('Biconical', 'NGU', 'Pyramidal' and hand net). A total of 5652 tsetse and other biting flies were captured; 3532 flies from tsetse-infested areas and 2120 flies from tsetse-free areas. PCR amplification analyses for trypanosome identification were carried out on 3751 flies, with primer sets specific for *Trypanosoma (Duttonella) vivax*, *T. (Nannomonas) congolense* and *T. (Trypanozoon) brucei*. Of 3751 flies; 699 (18.64%) were positive in PCR analysis with 132 (12.13 %) from tsetse-free areas and 567 (21.29

%) from tsetse-infested areas. Comparing within the type of flies, out of 1314 tsetse flies (*Glossina morsitans submorsitans* and *Glossina tachinoides*) 366 (27.85 %) were positive and out of 2437 other biting flies 333 (13.66 %) were found positive ( $P < 0.01$ ). Therefore PCR can be used to generate baseline data for fly infection.

From the 15 risk factors identified for trypanosome infection, multivariable logistic regression model produced the final logistic model containing seven variables (biting fly density, season, transhumance grazing, traction oxen, origin of the herd, area (tsetse-infested and tsetse-free) and Packed Cell Volume). Their significance was  $P = 0.05$  which showed a significant association with trypanosome infection.

The socio-economic effect of trypanosomosis was evaluated using Participatory Rural Appraisal (PRA) technique. Selected districts with three different trypanosomosis risk (high, medium and low) demonstrated much overlap between the farmers' perception of the disease (*gendi*) and bovine trypanosomosis. For example, '*gendi*' was associated with chronic weight loss, abortion, calf mortality and decrease milk yield in the high trypanosomosis risk area compared to the other two areas.

In conclusion, this study reported for the first time the use of PCR based assay on sample obtained from Amhara Region, North West Ethiopia to detect trypanosome from naturally infected biting flies (dried blood meal residue) and dried buffy coat spot on filter paper from cattle. The dominant species noted was *T. vivax*. The epidemiology of trypanosomosis in cattle is also dependent on other biting flies apart from tsetse flies.

Consequently, the eradication of tsetse flies alone will not necessarily lead to eradication of trypanosomosis.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**EPIDEMIOLOGI TRIPANOSOMOSIS BOVIN DAN IMPAK TERHADAP EKONOMIK DI KAWASAN TSETSE DAN KAWASAN BEBAS TSETSE DI NEGERI AMHARA, UTARA-BARAT ETHIOPIA**

**Oleh**

**THOMAS CHERENET ASFAW**

**Julai 2004**

**Pengerusi: Profesor Madya Rehana Abdullah Sani, Ph.D.**

**Fakulti: Perubatan Veterinar**

Epidemiologi tripanosomosis bovin telah di kaji di kawasan tsetse dan kawasan bebas tsetse di negeri Amhara, Utara-Barat Ethiopia. Kajian berbagai disiplin telah dilakukan bagi menyiasat faktor utama yang menentukan kehadiran lalat tsetse serta keluasan tripanosomosis bovin. Lembu dipilih dari kawasan tsetse dan kawasan bebas tsetse untuk tinjauan bulanan bagi mengesan jangkitan tripanosom dengan sampel darah atas slaid kaca, titik darah kering dan titik lapisan buf atas kertas turas. Dalam kajian ini tripanosom yang menjangkiti vektor dan perumah di kenalpasti menggunakan teknik parasitologi, serologi dan PCR.

Sejumlah 795 sampel darah lembu di kaji dari kawasan tsetse dan kawasan bebas tsetse; 13.5% calitan darah basah dan 15.6% filem darah nipis didapati positif dan PCR mengesan 18% jangkitan tripanosom. Spesis yang dominan adalah *T.vivax*, diikuti

*T.congolense* dan *T.brucei*. *T.vivax* lebih banyak di kawasan bebas tsetse, *T.congolense* lebih di kawasan tsetse, *T.brucei* dan jangkitan campuran *T.vivax-T.congolense* hanya wujud di kawasan tsetse. Prevalens bulanan di kawasan tsetse antara 15-28% dan di kawasan bebas tsetse 9-27%, dengan prevalens tertinggi pada bulan Disember di kedua kawasan. Sera dan titik darah kering atas kertas turas dalam teknik Ab-ELISA menunjukkan korelasi yang kuat. Ini menunjukkan kegunaan titik darah kering atas kertas turas, suatu sampel yang lebih mudah diambil.

Dalam kajian retrospektif 7079 data sampel dianalisa selama lima tahun dari 1997 hingga 2001. Prevalens jangkitan tripanosom tertinggi dalam awal musim kering (September hingga December). Jangkitan tripanosom kebanyakannya disebabkan oleh *T.vivax*, dan menurunkan secara ketara PCV purata serta keadaan badan perumah. Prevalens jangkitan bulanan ada korelasi dengan ketumpatan lalat menggigit. Ini membuktikan peranan penting lalat menggigit dalam transmisi tripanosomosis di kawasan tsetse dan kawasan bebas tsetse di negeri Amhara, Utara-Barat Ethiopia.

Lalat di tangkap selama 3 hari setiap bulan dalam jangkamasa kajian dengan menggunakan 4 jenis perangkap ('Biconical', 'NGU', 'Pyramidal' dan pukot tangan). Sebanyak 5652 lalat tsetse dan lalat menggigit lain ditangkap; 3532 lalat dari kawasan tsetse dan 2120 lalat dari kawasan bebas tsetse. Analisis PCR bagi mengenalpasti tripanosom dijalankan atas 3751 lalat, mengguna set primer khusus untuk *Trypanosoma vivax*, *T. congolense* dan *T.brucei*. Dari 3751 lalat; 699 (18.64%) positif dalam analisis PCR dengan 132 (12.13%) dari kawasan tsetse dan 567 (21.29%) dari kawasan bebas

tsetse. Perbandingan antara lalat menunjukkan dari 1314 lalat tsetse (*Glossina morsitans submorsitans* dan *Glossina tachinoides*), 366 (27.85%) didapati positif dan dari 2437 lalat menggigit lain, 333 (13.66%) didapati positif ( $P < 0.01$ ). Maka PCR boleh digunakan untuk menjana data asas bagi jangkitan lalat.

Dari 15 faktor risiko yang dikenalpasti untuk jangkitan tripanosom model 'multivariable logistic regression' telah mengeluarkan model logistik terakhir yang mengandungi tujuh 'variable' (kepadatan lalat menggigit, musim, ragutan 'transhumance', lembu bertenaga kerja, asal-usul lembu, kawasan dan PCV). Ketaraan sebanyak  $P = 0.05$  menunjukkan pertalian kuat antara faktor risiko tersebut dengan jangkitan tripanosom. Kesan sosio-ekonomi tripanosomosis dinilai dengan teknik 'Participatory Rural Appraisal' (PRA). Daerah terpilih yang mempunyai tiga tahap risiko bagi tripanosomosis (tinggi, sederhana dan rendah) menunjukkan ketidihan antara persepsi peladang mengenai penyakit 'gendi' dan tripanosomosis bovin. Sebagai contoh, 'gendi' dikait dengan penurunan berat badan jangka panjang, kematian anak lembu dan penurunan produksi susu di kawasan tripanosomosis berisiko tinggi berbanding dengan kedua kawasan yang lain.

Kesimpulannya kajian ini melaporkan buat pertama kali perkembangan asai PCR bagi mengesan tripanosom dari lalat menggigit yang dijangkiti secara asli (dari darah kering yang dihisap) dan titik kering lapisan buf atas kertas turas. Spesis tripanosom yang dominan ialah *T. vivax*. Epidemiologi tripanosomosis pada lembu juga bergantung kepada lalat menggigit selain lalat tsetse. Akibatnya, permusnahan lalat tsetse sahaja tidak bermakna permansuhan penyakit tripanosomosis.



## ACKNOWLEDGEMENTS

I would like to express my most sincere gratitude and deep appreciation to Associate Professor Dr. Rehana Abdullah Sani, Faculty of Veterinary Medicine as the Chairman of the Supervisory Committee for her encouragement and constructive comments in the preparation of this thesis.

I am deeply indebted to my co-supervisors Dr. Jothi M Panandam and Dr. Nadzri Salim, for their constant encouragement and unfailing help during the research work.

My gratitude is also extended to my external advisors:-

**1. Dr. Getachew Abebe, Ph.D.**

Professor  
Faculty of Veterinary Medicine  
Addis Ababa University  
Ethiopia

**2. Dr. Peter Van den Bossche, Ph.D.**

Professor  
Institute of Tropical Medicine  
Veterinary Department  
Belgium

for their fruitful suggestions, invaluable guidance and effective comments in order to improve the quality of the research.

I gratefully acknowledge the people of Ethiopia, The Amhara Regional Agricultural Bureau and The Amhara Regional Agricultural Research Institute for providing the scholarship.

I wish to express the assistance of the Bahir Dar Regional Veterinary Research Laboratory, The Ethiopian Science and Technology Commission and Sebeta National Animal Health Research Institute for providing the research facilities.

I would like to express gratitude to the staff members of Sebeta National Animal Health Research Institute; Dr.Hailmariam, Dr. Sentayehu, Ato Abera, Ato Tadiwos, W/r Genet and also to staff at Bahir Dar Veterinary Research Laboratory; Dr. Solomon, Dr. Almaze, Dr. Legesse, Ato Habtamu, Ato Sahile and Ato Mesele for always being so willing to render assistance throughout the course of the study.

It is worthy to mention my friends and colleagues from whom I received direct and indirect support. I would like to thank Dr.Sabri, Mrs. Maizatul-Akmal, Mr.Lee Chu Chong, Mr.Nazari, Mr. Rashid and Mr. Krishnan, for their companionship and concern.

Last but not least, very special thanks to my brothers and my wife, W/r Mulu Ejigu for their sacrifices, patience, understanding, help and encouragement throughout the study. My children; Dagmawi Thomas, Henok Thomas and Yared Thomas also deserve appreciation for their co-operation.

I certify that an Examination Committee met on 8<sup>th</sup> July 2004 to conduct the final Examination of Thomas Cherenet Asfaw on his Doctor of Philosophy thesis entitled “Epidemiology of bovine trypanosomosis and its economic impact in tsetse-infested and tsetse-free areas of Amhara Region, North-west Ethiopia” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

**Abdul Rani Bahaman, Ph.D.**

Professor  
Faculty of Veterinary Medicine  
Universiti Putra Malaysia  
(Chairman)

**Shaik Mohd Amin Babjee, Ph.D.**

Associate Professor  
Faculty of Veterinary Medicine  
Universiti Putra Malaysia  
(Member)

**Latiffah Hassan, Ph.D.**

Faculty of Veterinary Medicine  
Universiti Putra Malaysia  
(Member)

**S. Geerts, Ph.D.**

Professor  
Prins Leopold Instituut  
Institute of Tropical Medicine  
Antwerp, Belgium  
(Independent Examiner)

---

**GULAM RASUL RAHMAT ALI, Ph.D.**

Professor/Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

**Rehana Abdullah Sani, Ph.D.**

Associate Professor  
Faculty of Veterinary Medicine  
Universiti Putra Malaysia  
(Chairman)

**Jothi M Panandam, Ph.D.**

Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Nadzri Salim, MPVS.**

Lecturer  
Faculty of Veterinary Medicine  
Universiti Putra Malaysia  
(Member)

---

**AINI IDERIS, Ph.D.**

Professor/Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date:

## **DECLARATION**

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

---

**THOMAS CHERENET ASFAW**

Date:

## TABLE OF CONTENTS

	<b>Page</b>
<b>DEDICATION</b>	2
<b>ABSTRACT</b>	3
<b>ABSTRAK</b>	6
<b>ACKNOWLEDGEMENTS</b>	9
<b>APPROVAL</b>	11
<b>DECLARATION</b>	13
<b>LIST OF TABLES</b>	19
<b>LIST OF FIGURES</b>	22
<b>LIST OF PLATES</b>	24
<b>LIST OF ABBREVIATIONS</b>	25
<b>CHAPTER</b>	
<b>1 INTRODUCTION</b>	<b>27</b>
1.1 Research Hypothesis	29
1.2 Aim of the Research	30
1.3 Specific Objectives	30
<b>2 LITERATURE REVIEW</b>	<b>31</b>
2.1. The Organism and Disease	31
2.1.1 Classification	31
2.1.2 History	33
2.1.3 Clinical Signs	34
2.1.4 Clinical Pathology and Pathophysiology	36
2.1.4.1 Anaemia	36
2.1.4.2 Myocarditis and myositis	38
2.1.4.3 Immunosuppression	38
2.1.5 Immunity	41
2.1.5.1 Trypanotolerance	41
2.1.5.2 Acquired tolerance to trypanosomal infections	42
2.2. Epidemiology of Bovine Trypanosomosis	44
2.2.1 The host-vector contact	44

2.2.2	The coefficient of transmission of a trypanosomal infection	45
2.2.3	Trypanosomosis Distribution in Ethiopia	46
2.2.4	Trypanosome development in the host	47
2.3.	Vectors of Bovine Trypanosomosis and Their Role in Transmission	49
2.3.1	Mechanical transmission of trypanosomes	49
2.3.2	Cyclical development of trypanosomes in the tsetse fly	50
2.3.3	Population Density of Tsetse and Other Biting Flies	52
2.3.4	Feeding behavior of the vector.	54
2.3.5	Factors affecting the prevalence of trypanosomal infections in tsetse	55
2.3.6	Methods to detect trypanosomal infections in tsetse	56
2.4	Diagnosis	58
2.4.1	Parasitological techniques	58
2.4.2	Anti-trypanosomal antibody detecting ELISA	61
2.4.3	Molecular techniques Polymerase chain reaction ( PCR)	62
2.4.4	Advantages of Use of Dried Blood Spot	64
2.5	Effect of Bovine Trypanosomosis on Productivity	65
2.6.	Control of Bovine Trypanosomosis	68
2.6.1	Control of the parasite	71
2.6.1.1	History of trypanocidal drug development	71
2.6.1.2	Resistance of trypanosomes to trypanocides	74
2.6.2	Control of the vector	76
2.6.2.1	Indirect control methods	76
	Vegetation clearance	76
	Game elimination and game fences	76
2.6.2.2	Direct control methods	76
	Application of insecticides to vegetation	77
	Application of insecticides to bait systems	78

### 3

#### **RETROSPECTIVE STUDY ON BOVINE TRYPANOSOMOSIS IN THE AMHARA REGION, NORTH WEST ETHIOPIA**

3.1	Introduction	83
3.2	Material and Methods	84
3.2.1	The Amhara Region – Geographical and biophysical characteristics	84
3.2.2	Study design	90
3.2.3	Target and study population	91
3.2.4	Classification of the study area	92

3.2.5	Direct examination techniques used	95
3.2.6	Haematological examination	96
3.2.7	Clinical examination of cattle during sampling	96
3.2.8	Body Condition scoring	98
3.2.9	Statistical analysis	98
3.3	Results	99
3.4	Discussion	109

#### 4

### **LONGITUDINAL OBSERVATION OF BOVINE TRYPANOSOMOSIS FROM SELECTED DISTRICTS OF TSETSE-INFESTED AND TSETSE-FREE AREAS USING PCR, ELISA AND PARASITOLOGICAL TECHNIQUES**

4.1	Introduction	116
4.2	Materials and Methods	117
4.2.1	Study Design	117
4.2.2	The study area	117
4.2.1.1	Topography and vegetation	119
4.2.3	Climate	119
4.2.4	Social and Economic background	120
4.2.5	Selection of study area and farms	120
4.2.5.1	Direct examination techniques used	121
	Identification of trypanosome	121
4.2.6	Hematological examination	122
4.2.7	Ab-ELISA using dried blood spot on filter paper	123
	Examination using Ab-ELISA	124
	Determination of the diagnostic cut off value	124
4.2.8	Polymerase Chain Reaction (PCR Molecular Analysis) for detection of trypanosome	124
	Dried buffy coat on filter paper samples	124
	DNA extraction	125
	DNA amplification	125
4.2.9	Body condition scoring & clinical aspect	127
4.2.10	Statistical analysis	128
4.2.11	Treatment of positive cattle	128
4.3	RESULTS	128
4.3.1	Parasitological results	128
4.3.2	Ab-ELISA	129
4.3.3	PCR results	129
4.3.4	Comparison between parasitological and PCR results	133
4.3.5	Concordance of results for sera and bloodspots	133
4.3.6	Relative prevalence of trypanosome	138
4.3.7	Haematological findings	136
4.3.8	Host Factors	136
4.3.9	Proportions of <i>T.congolense</i> , <i>T.vivax</i> and	138



	<i>T. brucei</i> infections	
	4.3.10 Relationship of trypanosome infection with different clinical signs	140
	4.4 Discussion	141
<b>5</b>	<b>MECHANISM OF TRANSMISSION OF BOVINE TRYPANOSOMOSIS IN TSETSE-INFESTED AND TSETSE-FREE AREAS OF AMHARA REGION, NORTH WEST ETHIOPIA</b>	
	5.1 Introduction	147
	5.2 Materials and Methods	148
	5.2.1 Study design	148
	5.2.2 Study area	149
	5.2.3 Monitoring of tsetse flies and biting flies	149
	5.2.4 Capturing of biting flies and tsetse flies by hand nets	152
	5.2.5 Identification of tsetse and biting flies	153
	5.2.6 Preparation of tsetse samples for PCR	154
	5.2.7 Primers	154
	5.2.8 PCR Protocol	154
	5.2.9 Data analysis	155
	5.3. Results	156
	5.3.1 Fly captured	156
	5.3.2 Trap efficacy	156
	5.3.3 Index of Apparent Abundance (IAA) of flies	158
	5.3.4 Seasonal Index of apparent abundance of flies	158
	5.3.5 Fly infection rate	160
	5.3.6 Seasonal infection rate of flies	163
	5.3.7 Comparing the monthly infection rate of vector (flies) and host (cattle)	164
	5.4 Discussion	165
<b>6</b>	<b>RISK FACTORS OF BOVINE TRYPANOSOMOSIS IN AMHARA REGION, NORTH WEST ETHIOPIA</b>	
	6.1 Introduction	170
	6.2 Materials and Methods	171
	6.2.1 Study design	171
	6.2.2 Study areas	171
	6.2.3 Statistical analysis	172
	6.3. Results	173
	6.3.1 Logistic regression	173
	6.3.2. Multivariable regression model	176
	6.3.3 Risk factor ranking	178
	6.4. Discussion	179
<b>7</b>	<b>THE SOCIO-ECONOMIC IMPACT OF BOVINE</b>	

	<b>TRYPANOSOMOSIS TO SMALLHOLDER FARMERS IN AMHARA REGION, NORTH-WEST ETHIOPIA</b>	
	7.1 Introduction	186
	7.2 Methods	188
	7.2.1. Study Design	188
	7.2.2. The study area	189
	7.2.3 Classification of the study area	190
	7.2.4 Sources of primary data	191
	7.2.5 Secondary data and interviews	192
	7.2.6 Participative appraisal for data collection	193
	7.2.7 Matrix scoring	193
	7.2.7.1. Disease-effect	193
	7.2.7.2 Disease-causes	194
	7.2.7.3 Seasonal calendars	195
	7.2.8 Statistical analyses	195
	7.3. RESULTS	196
	7.3.1 Effects of trypanosomosis incidence on productivity	196
	7.3.2 Characterization of trypanosomosis effects and other diseases	199
	7.3.3 Impacts of trypanosomosis incidence on animal traction	202
	7.3.4 Trypanocidal drug utilization	203
	7.3.5 Seasonal factors	205
	7.4 Discussion	206
<b>8</b>	<b>GENERAL DISCUSSION AND CONCLUSION</b>	214
	<b>RECOMMENDATION</b>	220
	<b>BIBLIOGRAPHY</b>	221
	<b>APPENDICES</b>	254
	A Buffer and Stain	255
	B Ab-ELISA	257
	C Preparation of agarose gel	258
	D Questionnaire	259
	E Maps	278
	<b>BIODATA OF THE AUTHOR</b>	280
	<b>LIST OF PUBLICATIONS</b>	282

## LIST OF TABLES

<b>Table</b>		<b>Page</b>
2.1	Coefficient of transmission (C.T.) of trypanosomes from infected tsetse to susceptible hosts	45
2.2	Prevalence of bovine trypanosomosis reported from some areas in Ethiopia (1986 – 1999)	46
2.3	Effect of bovine trypanosomosis on various production variables	66
2.4	Summary of the parameters used by Wilson and Njogu (1981) to study the epidemiology of animal trypanosomosis in selected areas of Kenya	70
2.5	Chemotherapeutic and chemoprophylactic compounds currently used for tsetse-transmitted bovine trypanosomosis	75
2.6	Summary of costs of different approaches to trypanosomiasis control	82
3.2.1	Agro-ecological classification of land in the Amhara Region	87
3.2.2	Livestock population of the Amhara Region of North Ethiopia	89
3.2.3	Study areas and number of samples for the study in Amhara region north west Ethiopia	92
3.2.4	Description of condition scoring	96
3.3.1	Prevalence of bovine trypanosomosis in five administrative zone of Amhara region North west Ethiopia	101

3.3.2	Monthly (Seasonal) prevalence of bovine trypanosomosis for the last five years from (1997 – 2001) in the Amhara Region North west Ethiopia	102
3.3.3	Monthly total number of cattle with a <i>T. vivax</i> , <i>T. congolense</i> , <i>T. brucei</i> or mixed infection in the tsetse-free and tsetse-infested areas	102
3.3.4	Relative proportion of bovine trypanosome in five Administrative Zone of Amhara Region North west Ethiopia for five years (1997 – 2001)	103
3.3.5	Age specific prevalence of bovine trypanosomosis in different age group	103
3.3.6	Prevalence of bovine trypanosomes in North-West Ethiopia by Sex	104
3.3.7	Mean PCVs of parasitemic (P) and aparasitemic (AP) animals	104
3.3.8	Correlation of clinical signs with the bovine trypanosome infection from 7079 samples examined from Amhara region North west Ethiopia	104
4.2.1	Livestock population in the study areas	119
4.2.2	The different vegetation types are as follows	119
4.2.3	Primers used in the Polymerase Chain Reaction in the study	127
4.3.1	Prevalence of trypanosomosis based on different tests during the study period in both tsetse-infested and tsetse free areas of the Amhara region	130
4.3.2	Monthly prevalence of bovine trypanosomosis in tsetse-infested (Jawi Dangla) and Tsetse-free (Bahir Dar Zuria) districts of Amhara Regional State northwest Ethiopia (2002 -2003)	134
4.3.3	Relative prevalence of trypanosome in tsetse-infested and tsetse-free areas by PCR in Amhara Region, Northwest Ethiopia	136
4.3.4	Mean PCVs of parasitemic and aparasitemic cattle using PCR	137
4.3.5	Age-specific prevalence rate of bovine trypanosomosis in the	138

	study areas	
4.3.6	Sex-specific prevalence rate of bovine trypanosomosis in the study areas	138
4.3.7	Relative infection rate of trypanosome and cattle mortality rate in age group	139
5.3.1	Biting flies collected in tsetse-infested and tsetse-free areas using four different types of traps in the Amhara regional State, North west Ethiopia	157
5.3.2	Index of Apparent Abundance of flies during the study from Oct/2002 – May/2003 in tsetse-infested and tsetse-free areas	158
5.3.3	Seasonal Index of Apparent Abundance of biting flies from Oct/2002 – May/2003 in tsetse-infested and tsetse-free areas	159
5.3.4	Infection rate of biting flies with trypanosome in tsetse-infested and tsetse-free areas of the study	161
5.3.5	Seasonal (monthly) infection rate of tsetse flies and other biting flies by trypanosome in tsetse-infested and tsetse-free areas of the study	163
5.3.6	Correlation between infection of vector (flies) and Host (cattle) by trypanosome in tsetse-infested and tsetse-free areas of the study	164
6.3.1	Crude description of risk factors for trypanosome infection status and univariate significance test using parasitological diagnosis	174
6.3.2	Main parameters in the reduced logistic regression model of studied risk factors in relation to bovine trypanosomosis parasitological positive at the Amhara region of north west Ethiopia (1997 – 2000) <sup>a</sup> .	177
7.2.1	Livestock population in the study areas	189
7.2.2	Classification of the study areas in trypanosomosis prevalence and tsetse challenge	190
7.3.1	Livestock functions as perceived by farmers – Amhara region	197

7.3.2	Relation between level of trypanosomosis risk and number of animal owned, Amhara region north west Ethiopia.	197
7.3.3	Comparison of productivity impacts at herd level in different trypanosomosis risk and level of tsetse challenge in the Amhara region northwest Ethiopia.	198
7.3.4	Comparison of herd dynamic with different trypanosomosis risk and level of tsetse challenge in the Amhara region northwest Ethiopia.	198
7.3.5	Trypanocidal drugs used in the Amhara region from 1997 to 2001	204

## LIST OF FIGURES

<b>Figure</b>	<b>Page</b>	
2.1	The classification of trypanosomes of economic and epidemiological Importance (Source: Leak,1999)	32
2.2	Impacts of trypanosomosis on farming and fivelihoods	68
2.3	Factors involved and options available for the control of trypanosomosis	71
3.1.1	Location map of the study area Amhara region in Ethiopia.	86
3.1.2	Agro-ecological zones – Amhara region	87
3.1.3	Livestock population in the Amhara region as a proportion of national livestock population of Ethiopia	89
3.2.1	Location map showing the study areas tsetse-infested and tsetse-free in the Amhara regional State, north west Ethiopia	94
3.3.1	Monthly average prevalence of trypanosome infections in cattle in a tsetse-infested ( $\Delta$ ) and tsetse-free ( $\blacktriangle$ ) area of the Amhara region of north western Ethiopia	105
3.3.2	Monthly average PCV of parasitologically positive ( $\square$ ) and	106

negative (■) cattle

3.3.3	Seasonal variation of bovine trypanosomosis infection in the Amhara regional state, north-west Ethiopia	107
3.3.4	Proportion of the total number of cattle, infected or not-infected with trypanosomes, belonging to different body condition scoring categories	108
4.2.1	Location map showing the study districts tsetse-infested and tsetse-free in the Amhara regional state, north-west Ethiopia	118
4.3.1	Taxonomic identifications of trypanosome infections detected by PCR and parasitological methods in 750 cattle samples	134
4.3.2	Schematic representation of stained agarose gel showing amplification product from cattle dried buffy coat spot on filter paper	132
4.3.3	Comparisons of infections rate detected between different diagnostic methods in Amhara regional state, north-west Ethiopia	135
4.3.4	Monthly packed cell volume (PCV %) and trypanosome infection rate in the study areas	137
4.3.5	Relationship of cattle infection rate with different observed clinical signs	140
5.3.1	Relationship between cattle infection rate and fly infection rate diagnosed using PCR against apparent density of fly every month from both tsetse-infested and tsetse-free areas.	160
5.3.2	Schematic representation of amplification product from biting flies dried blood meal from north west Ethiopia	162
6.3.1	Ranking of risk factor based on multivariable logistic regression	178
7.2.1	Location map showing the study district with high, medium and low trypanosomosis risk in the Amhara regional state, north-west Ethiopia	191
7.3.1	Summarized matrix scoring of disease-effects	200
7.3.2	Summarized matrix scoring of disease-causes	201

7.3.3	Impact of trypanosomosis level and tsetse challenge on cultivation in selected districts of Amhara regional state north west Ethiopia.	202
7.3.4	Veterinary drug wholesale and retail sale Bahir Dar drug shops (tsetse-free area) 2001/2002	203
7.3.5	Summarised seasonal calendar for livestock diseases and biting flies Contact	205

#### **LIST OF PLATES**

<b>Plate</b>		<b>Page</b>
4.3.1	Trypanosome infection revealed by PCR amplification product from cattle dried buffy coat spot on filter paper	132
5.2.1	NGU trap deployed around bushy area	150
5.2.2	NGU trap deployed near river side	151
5.2.3	Pyramidal trap deployed very near to cattle grazing areas	151
5.2.4	Pyramidal or monoconical trap deployed near bush area.	152
5.3.1	Ethidium bromide stained agarose gel showing amplification product from biting flies dried blood meal	161