UNIVERSITI PUTRA MALAYSIA

COMPARATIVE DIAGNOSIS, PATHOGENICITY AND IMMUNOSUPPRESSIVE EFFECT OF Trypanosoma evansi INFECTION IN GOATS

IBRAHIM ABUBAKAR ANKA 1

FPV 2012 4

COMPARATIVE DIAGNOSIS, PATHOGENICITY AND IMMUNOSUPPRESSIVE EFFECT OF *Trypanosoma evansi* INFECTION IN GOATS

By

IBRAHIM ABUBAKAR ANKA 1

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

JANUARY 2012

DEDICATION

This study is dedicated to:

- our master and seal of the Prophets, Muhammad (P.B.U.H);
- my late father Alhaji Abubakar Anka 1 (Allah Rufa Asiri) and my mother Hajiya Fatima 'Yar-Hawwa;
- my wife Rukayyah Usman Danladi and children: Ahmad ('Karibullah) and Hamidah;
- my late brother Alhaji Abdullahi (Mai-Gwandu) and late sister Hajiya Maryam (Yalwa), may their souls rest in Allah's Rahma, amin!
- Every healthy mind. A mind which puts truth to test and knows it from the wreck of the wrong. A mind which weighs all that has been said in the scale of justice and always comes out in favour of reason. A mind which compares words and sayings, and has the ability to distinguish between the logical and not so logical, and between strong and feeble.

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

COMPARATIVE DIAGNOSIS, PATHOGENICITY AND IMMUNOSUPPRESSIVE EFFECT OF *Trypanosoma evansi* INFECTION IN GOATS

By

IBRAHIM ABUBAKAR ANKA 1

January 2012

Chairman: Assoc. Prof. Rehana Abdullah Sani, PhD

Faculty: Faculty of Veterinary Medicine

Conflicting information exist on the pathogenicity of *T. evansi* infection (Surra) in goats. This has made the diagnosis and reservoir status of goats in the epidemiology of *T. evansi* infection uncertain. Therefore, Surra remains a significant challenge and threat in endemic and disease free areas. This study was therefore designed to answer the questions whether one, the pathogenicity of *T. evansi* infection in goats depends on the isolate? two, CATT/ *T. evansi*® kit can be used in seromonitoring Malaysian isolates of *T. evansi* infection in goats? and three, *T. evansi* infection can compromise caprine immune response to intranasal pneumonic Mannheimiosis vaccination (IPMV)?

Experimental infection of goats was carried out for the assessment of CATT/*T. evansi*® in the detection of predominant RoTat 1.2 antibodies in three Malaysian (two bovine and a deer) isolates of *T. evansi* to determine its usefulness in the diagnosis of caprine Surra in relation to parasitaemia. During the same experiment comparison of the pathogenicity of two out of the three *T. evansi* (bovine and deer) isolates was investigated; and a field survey was carried out in eight goat farms from six districts in the state of Selangor to determine the prevalence of *T. evansi* infection in 228 goats using CATT/*T. evansi* and Haematocrit Centrifugation Technique (HCT). In another experiment, the immunosuppressive effect of *T. evansi* infection in goats vaccinated with IPMV was investigated using cellular and antibody (lung IgA and serum IgG) responses.

The first experiment showed that all infected goats remained positive for *T. evansi* until termination of the experiment on day 62 post-infection following treatment with diminazine diacetate injection. Both isolates of *T. evansi* induced fever (except in one goat), anaemia (more severe in the group infected wirh the bovine *T. evansi* isolate), neutrophilia, oesinophilia, lymphocytosis and moncytosis, and hyperproteinemia, hypoalbuminemia, decreased albumin-to-globulin ratio, hyperbilirubinemia, decreased alanine transaminase and creatine kinase and mild weight loss. No mortality was recorded among the infected goats which recovered after treatment.

The CATT/*T. evansi* results for the three infected groups maintained similar high scores average of >3 until the animals were treated when the scores dropped drastically thereafter with a score average of <2. No trypanosomes were detected after treatment.

The prevalence study shows high seroprevalence of 61.4% using CATT/*T. evansi*. Only 6 (4.3%) among the seropositive goats had CATT/*T. evansi* score of >3. However, no parasite was detected by HCT.

Neutrophilia and eosinophilia in the peripheral blood suggests evidence of immunosuppression in the experiment. However, no significant difference ($P>0.05$) was found in the serum and lung lavage fluid antibody titers between the *T. evansi* infected, infected-treated and control groups.

It was concluded that firstly, the CATT/*T. evansi*® is useful in the seromonitoring of *T. evansi* infection in goats, secondly, the two isolates of *T. evansi* induced similar pathogenicity in goats, thirdly, there was high seroprevalence of *T. evansi* in the study area suggesting that the goats were exposed to the natural infection and fourthly, at a given infective dose of 10^4 *T. evansi* per animal, did not prevent goats from mounting protective immune response against lethal *Mannheimia haemolytica* challenge following IPMV.

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

PERBANDINGAN DIAGNOSTIK, KEPATOGENAN DAN KESAN IMMUNOSUPRESIF OLEH JANGKITAN *Trypanosoma evansi* DI DALAM KAMBING

Oleh

IBRAHIM ABUBAKAR ANKA 1

Januari 2012

Pengerusi: Prof. Madya Rehana Abdullah Sani, PhD

Fakulti: Fakulti Perubatan Veterinar

Kekeliruan fakta berlaku mengenai kepatogenan jangkitan *T. evansi* di dalam kambing. Ini menyebabkan diagnostik dan status takungan (‘reservoir) di dalam epidemiologi *T. evansi* tidak menentu. Oleh yang demikian, Surra kekal sebagai cabaran yang signikan dan ancaman di kawasan yang endemik mahupun di kawasan bebas penyakit. Kajian ini direka bagi menjawab kepada soalan-soalan seperti: satu, kepatogenan jangkitan *T. evansi* dalam kambing bergantung kepada isolasi? dua, Kit CATT/*T. evansi*® boleh digunakan dalam pemantauan isolasi Malaysia dalam jangkitan *T. evansi* dalam kambing? tiga, dan infeksi *T. evansi* boleh mengkropomi respons

keimunan kambing untuk 'intranasal pneumonic Mannheimiosis vaccination (IPMV)'?

Ujikaji jangkitan dalam kambing dijalankan dalam mentaksirkan kit CATT/*T. evansi*® dalam pengesanan antibodi predominan RoTat 1.2 dalam tiga isolasi *T. evansi* Malaysia (dua lembu dan satu rusa) untuk menentukan kegunaannya dalam diagnosis Surra di dalam kambing dalam hubungannya dengan parasitemia. Semasa ujikaji yang sama, perbandingan patogenik dalam dua isolasi *T. evansi* (lembu dan rusa) disiasat; dan kajian lapangan dijalankan dalam lapan ladang kambing daripada enam daerah Selangor untuk menentukan jangkitan *T. evansi* prevalensi dalam 228 kambing dengan menggunakan CATT/*T. evansi* dan Haematocrit Centrifugation Techniques (HCT). Dalam ujikaji yang berlainan, kesan immunosupresif dalam infeksi *T. evansi* dalam kambing yang diberi pemvaksisnan dengan IPMV disiasat menggunakan selular dan antibodi (IgA paru-paru dan serum IgG) jawapan.

Keputusan ujikaji yang pertama menunjukkan bahawa kesemua kambing yang dijangkiti kekal positif untuk *T. evansi* sehingga penghabisan ujikaji hari ke 62 iaitu diikuti dengan suntikan diminazine diacetate. Kedua-dua isolasi menyebabkan demam (kecuali dalam seekor kambing), anemia, neutrofilia, oesinofilia, limphositosis dan monositosis, dan hyperproteinemia, Hypoalbuminemia, pengurangan albumin-kepada-globulin ratio, hyperbilirubinemia, penguranganalanine transaminase dan creatine kinase

dan kehilangan berat badan. Tiada kematian direkodkan dalam kambing yang dijangkiti dimana pulih selepas rawatan.

Keputusan CATT/*T. evansi* untuk dua kumpulan kambing yang dijangkiti kekal sama dengan skor tertinggia dalah >3 sehingga haiwan tersebut dirawat dimana skor jatuh secara drastic dengan purata <2. Tiada trypanosome ditemui selepa rawatan kepada kambing.

Prevalens kajian menunjukkan seroprevalens yang tinggi 61.4% dengan menggunakan CATT/*T. evansi*. Hanya 6 (4.3%) dikalangan kambing yang seropositif mempunyai CATT/*T. evansi* >3. Akan tetapi, tiada parasit ditemui dalam HCT.

Neutrofilia dan eosinofilia didalam darah periferal menunjukkan bukti berlakunya immunosupresi di dalam ujikaji imunosupresif. Akan tetapi, perbezaan yang signifikan dijumpai dalam antibodi serum dan 'lavage' cecair peparu diantara haiwan yang dijangkiti *T. evansi*, dijangkiti *T. evansi* dan dirawat dan kumpulan kawalan.

Dapat disimpulkan bahawa, pertamanya, CATT/*T. evansi* adalah berguna di dalam kawalan serologi dalam jangkitan *T. evansi* dalam kambing, kedua, dua isolasi *T. evansi* mendorong kepatogenan yang sama di dalam kambing, ketiga, terdapat seroprevalens yang tinggi dalam kawasan kajian yang mencadangkan kambing adalah kerap terdedah kepada infeksi semula jadi

dan, keempatnya, untuk dos 10^4 *T. evansi* (per haiwan), jangkitan tidak akan mencegah kambing untuk meninggikan respons keimunan setelah cabaran dengan *Mannheimia haemolytica* maut susulan daripada IPMV.

ACKNOWLEDGEMENTS

All thanks to Almighty Allah for guiding and protecting me through all aspects of life.

I am sincerely grateful to the Chairperson of my Supervisory committee, Assoc. Prof. Dr. Rehana Abdullah Sani and co-supervisors Dr. Reuben Sunil Kumar Sharma and Prof. Dr. Muhammad Zamri-Saad for the candid suggestions, guidance, constructive advice, criticism, patience, fruitful discussions and encouragement given to me during the course of my candidature. Special thanks to Dr. Md Sabri Mohd Yusoff for donating Mannheimiosis vaccine and guidance during my experiment.

The efforts of Assoc. Professors Drs. Bahaman Abu Samah, Goh Yong Meng, Latiffah Hassan and Ahmad Bin Selamat in removing the 'statistic phobia' in me and guiding me through the dark waters of its application are highly appreciated. I remain grateful to Dr. Ang Lay Hoon of Faculty of Modern Language and Communication, Universiti Putra Malaysia, for her consideration in an English translation of a Chinese manuscript. Thanks to Professor Dato' Dr. Sheikh Omar Abdul Rahman , Prof. Datin Paduka Dr. Aini Ideris, Assoc. Professor Dr. Sheik Mohamed Amin Badjee and Assoc. Professor Dr. Abdulkarim Sabo Mohammed for their motivating talks on survival strategies during the postgraduate journey. The mentorship in research writing and art of publishing received from Dr. Vijay Kumar Malam

and his team and that of Prof. Dr. Kamaruzaman Jusoff have been a great opportunity. Ms. Affahuraizah Abdul Rahman, officer in charge of postgraduate learning support and student affairs is also commendable. I commend Universiti Putra Malaysia for its composition of great minds.

The care of experimental goats by the experienced staff Mr. Isla, Mr. Izat and Mr. Budak were appreciated.

I thank Usmanu Danfodiyo University Sokoto, Nigeria, for granting me study leave to undertake this study. Special thank goes to Zamfara state government for the financial assistance given to me to support my studies.

Many thanks to Prof. Carlos Gutierrez from the Veterinary Faculty of the University of Las Palmas, Arucas, Gran Canaria, Spain, for sending relevant publications. Also my appreciation goes to Dr Aminu Shittu from the Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto, Nigeria, for his valuable assistance in sourcing some relevant articles through his ingenious network. The tireless assistance and concern given to me by the Universiti Putra Malaysia library staff at the Main, Veterinary and Medical faculties was highly commendable. The kind gesture of the Universiti Putra Malaysia security guard is worth mentioning, please keep it up. I cannot quantify the technical assistance and expertise of Mrs. Maizatul Akmal Moktar, Mr. Rashid Abdul Rahman, Ms. Amlizawaty Amzah (Parasitology Laboratory), Mr. Mohamed Halmi Othman, Mr. Abdullah (Hematology and Clinical Biochemistry Laboratory), Mrs. Latifah Mohd Hanan, Mrs. Jamilah

Jahari (Histopathology Laboratory), Mr. Mohd Azri Roslan (Molecular Biology Laboratory), Mr. Apparau Somanaidu (Postmortem Staff), Mr. Md Nazim Razali, Mr. Veloo Munusamy (University Veterinary Hospital) and Mr. Krishnan Mariappan (Information System Officer). The attention of Mrs. Aminah Ja'arus, Ms. Noor Ashikin Shahrudin and Ms. Nur Ashidah Adam (Administrative Staff) was much recognized.

Words cannot described the value of the moments I have spent with my friendly, helpful, understanding, tolerant and cooperative lab mates during the happy and harsh moments of my study period. This include (not in order!) El Shafie Ibrahim El Shafie, Ho Gim Chong, Wong Meng Tack (Alex), Chin Yun Yan, Nur Mahiza Md-Isa, Mahira Watanabe, Thirumahgal, Lee Col Lin, Ponnusamy, Priya Mahalingam, Anna Louisa John, Lat Lat Htun, Nor Azlina, Tan Hwee Mien, Basripuzi Nurul Hayyan binti Hassan Basri.

I am delighted to acknowledge the assistance, concern, and goodwill of Salisu Buhari, Mukhtar Salihu Anka, Muhammad Ado Abubakar, Abdulkadir Magaji Magashi, Faruku Bande, Mustapha Abubakar, Tijjani Rufai, Samaila Bawa Waje, Faruk Ahmed Ali, Muhammad Ajiya, Umar Gaya, Aminu Tori, Ibrahim AbdulAziz, AbdulAziz Ibrahim, Alhassan Muhammad Alhassan , Sa’ad AbdulMumin, AbdulSalam, Muhammad Ibrahim Saeed, Nasiruddeen Umar Matazu, Kabiru Gamagiwa, Aliyu D. Usman, Bello Magaji, Ahmad Gusau, Umar Faruk Yusuf, Baba Shehu Umar Ibn Abubakar, Ibrahim Dooba, AbdulRasheed Bello Aliyu, AbdulRahman Daha, Sani Ismaila, Almustapha

Imam, Salisu Abubakar, Gidado, Lawal Alkali Argungu, Abubakar Roko, Rafin Dadi, Ibrahim Sa'idu, Jafaru Malam Ahmed, Sani Dangulbi, Abubakar Chika Junaidu, Abubakar Alhaji, Ashraf, Kabiru Mustapha Umar, Faruku Ambursa, Khumran Mada, Nasiru Umar Tsafe, Kabi, Nabil, Sani Dahiru Buba, Adamu Yarima, Muhammad Waziri Yusuf, Muhammad Gidado Liman, Nur Husain, Bukar Modu, Lawan Adamu, Hassan Ismaila Musa, other colleagues and friends whose names have not been mentioned.

I am thankful to the goat owners for enrolling in my study and the permission to collect samples from their animals.

Last but not the least, I deeply appreciate the patient of my family whose moral and psychological support made this work a reality. Lt. Col. Mustapha Abubakar Anka 1 deserved a special thank for his persistent social and spiritual support. Thank you for been there for me despite the distance far apart.

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

Rehana Abdullah Sani, PhD
Associate professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Chairman)

Reuben Sunil Kumar Sharma, PhD
Senior Lecturer
Faculty of veterinary Medicine
Universiti Putra Malaysia
(Member)

Muhammad Zamri-Saad, PhD
Professor
Faculty of veterinary Medicine
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

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

Ibrahim Abubakar Anka 1
Date: 11th January 2012

LIST OF TABLES

LIST OF PLATES

Plate **Page**

LIST OF FIGURES

LIST OF ABBREVIATIONS

-	Negative
±	Weakly positive
+	Positive
++	Strongly positive
+++	Very strongly positive
°C	Degree celcius
ALT	Alamine aminotransferase
AST	Aspartate aminotransferase
CATT	Card Agglutination for Trypanosomiasis
CATT/*T. evansi*	Card Agglutination for Trypanosomiasis for
CATT/*T. evansi*	*Trypanosoma evansi*
CK	Creatine kinase
DNA	Deoxyribonucleic acid
DVS	Department of Veterinary services
EDTA	Ethylenediaminetetraacetic acid
ELISA	Enzyme-linked immunosorbent assay
HCT	Haematocrit centrifugation technique
Hgb	Haemoglobin
ID	Identification number
IPVM	Intranasal pneumonic Mannheimiosis vaccination

MCHC	Mean haemoglobin concentration
MCHC	Mean cell haemoglobin concentration
MCV	Mean cell volum
PCR	Polymerase chain reaction
RBC	Red blood cell
RoTat 1.2	Rhode antat 1.2
Sp.	Species
T Lymphocyte	Thymus dependant lymphocyte
TP	Total protein
VSG	Variable surface glycoprotein

TABLE OF CONTENT

CHAPTER ONE

INTRODUCTION

Trypanosoma evansi is a flagellated obligate blood protozoa, and is transmitted mechanically by biting flies mainly tabanids (Reid, 2002). It has the widest geographical distribution among the pathogenic trypanosome species, existing in Africa, South America, most of Asia and some parts of Europe. *T. evansi* infection affects a wide range of domestic and wild mammals including horses, donkeys, camels, buffaloes, cattle, sheep, goats and pigs. The disease is called "Surra" and causes serious economic losses due to vaccination failure, weight loss, abortion and mortality (Gutierrez *et al.*, 2006).

It was previously thought that goats are refractory host for *T. evansi* (Gill, 1977). However, existing literature show conflicting reports on the pathogenic effect of *T. evansi* in goats. Some studies have reported severe disease with mortalities (Manuel, 1998; Gutierrez *et al.*, 2005), while others documented mild and asymptomatic infections in both naturally and experimentally infected goats (Otieno and Gacanja, 1976; Boid *et al.*, 1981). This could be attributed to variation in pathogenicity and virulence of the *T. evansi* strains involved, different breeds of goats, size of inoculum, route of

infection, host and geographical origin of the parasite (Dia, 1995; Queiroz *et al*., 2000). However, there are no comparative studies on the pathogenicity using different isolates of *T. evansi* in goats, which could enable proper assessment of the role of goats in the epidemiology of Surra.

The diagnosis of caprine Surra is difficult due to the lack of pathognomonic clinical signs, low levels of parasitaemia coupled with the few available reports on prevalence and incidence of caprine Surra, has made the reservoir status of goats uncertain (Gutierrez *et al*., 2006). The Card Agglutination Test for Trypanosomiasis (CATT/*T. evansi*), is a widely used rapid serological test for detection of *T. evansi* (Bajyana Songa and Hamers, 1988). The test is only capable of detecting antibodies against the RoTat 1.2 predominant antigen of *T. evansi*, which is found to be absent in certain strains in Kenya (Ngaira *et al*., 2004) and Sudan (Salim *et al*., 2011). Therefore, it has become necessary to evaluate the effectiveness of CATT/*T. evansi* for local strains of *T. evansi* before it can be used for screening of samples in any geographical entity.

T. evansi infection is considered endemic in Peninsular Malaysia (Zainal-Abidin, 1992) where natural infection with occasional outbreaks have been reported in cattle, buffaloes (Abas-Mazni *et al*., 1987; Sani *et al*., 1989, 2009; Cheah *et al*., 1999; Md-Isa 2010), horses (Ng and Vanselow, 1978; Ikede *et al*., 1983; Cheah and Azman, 2000), deer (Adrian *et al*., 2010), pigs (Arunasalam *et al*., 1995), dogs (Rajamanickam *et al*., 1985) and rhinoceros

(Vellayan et al, 2004). Information is lacking, however, on the prevalence of *T. evansi* in goats in Malaysia (Zainal-Abidin, 1992). Goats are important in the Malaysian livestock industry with a growing population reaching about 500,000 heads due to high importation rate (DVS, 2008) and considered as potential reservoir of *T. evansi* infection (Gutierrez *et al.*, 2006). Therefore, it is necessary to investigate its possible role in the epidemiology of *T. evansi* infection in Malaysia.

Immunosuppression is a common feature associated with trypanosomosis in chronically infected animals, which can lead to immune compromise in vaccinated animals and secondary infection (Sileghem *et al.*, 1994). Previous studies (Singla *et al.*, 2010) had investigated the immune responses of *T. evansi*-infected animals which had been parenterally administered with vaccines against bacterial infections and correspondingly, there is no literature that documents the immusuppressive effect of *T. evansi* in animals vaccinated with intranasal vaccines against pneumonic mannheimiosis, in which vaccination failure has been frequently observed in Malaysia (Zamri-Saad and Sabri, 2008).

Therefore, Surra remains a significant challenge and threat in endemic and disease free areas, respectively. This study was therefore designed to address issues concerning the prevalence, diagnosis, comparative pathogenicity and immunosuppressive effect of *T. evansi* infection in goats.

The research hypotheses of the study are:

1. CATT/*T. evansi* can detect infection in goats;
2. *T. evansi* infection is endemic in goats in the state of Selangor, Malaysia;
3. pathogenicity depends on virulence of *T. evansi* isolate and;
4. *T. evansi* infection can compromise immune response of intranasal Pneumonic Mannheimiosis vaccine.

The objectives of the study are to:

1. determine the prevalence of *T. evansi* in goats in Selangor;
2. compare and assess the Card Agglutination Test for Trypanosomiasis (CATT) for the detection of antibodies in experimental infection of goats with three Malaysian field isolates of *T. evansi*;
3. compare the clinical and haematological changes in goats experimentally infected with two isolates of *T. evansi*;
4. compare the biochemical changes in goats experimentally infected with two isolates of *T. evansi* and;
5. determine the immunosuppressive effect of *T. evansi* infection in goats given intranasal Pneumonic Mannheimiosis vaccine.

REFERENCES

Abas-Mazni, O., Zainal-Abidin, A.H. and Ramakrishnan, P. (1987). Observations on the prevelence of *Trypanosoma evansi* infection in the swamp buffaloes at Bukit Ridah, Pahang Darul Makmur, West Malaysia. *Tropical Veterinarian*, 5, 127-301.

Abdelrahman, S.H, Elmalik, K.H, Khalid, H.S., Shamat, A.M.A. and Khojali, S.M.E. (2004). Biochemical changes in rats experimentally infected with *Trypanosoma evansi*. *Journal of Animal and Veterinary Advances*, 3(7), 483-486.

Adrian, M.S., Sani, R.A., Hassan, L. and Wong, M. (2010). Outbreaks of trypanosomiasis and the seroprevalence of *T. evansi* in a deer breeding centre in Perak, Malaysia. *Tropical Animal Health and Production*, 42**,** 145-150.

Akinbamijo, O.O., Pearson, R.A. and Jones, T.W. (1999). Work stress and innate resistance of working bulls on two planes of nutrition: lessons from the N'Dama cattle of West Africa. In: Kaumbutho P.G, Pearson, R.A. and Simalenga, T.E., eds. Proceedings of the workshop of the Animal Traction Network or Eastern and Southern Africa (ATNESA) held 20-24 September 1999, Mpumalanga, South Africa. 344p. Mpumalanga, South Africa.

Al-Khalifa, M., Hussein, H., Diab, F. and Khalil, G. (2009). Blood parasites of livestock in certain Regions in Saudi Arabia. *Saudi Journal of Biological Sciences*, 16**,** 63-67.

Al-Rawashdeh, O., Sharif, L. and Al-Ani, K.A.Q.F.K. (1999). *Trypanosoma evansi* infection in camels in Jordan. *Pathologie Infectieuse*, 52**,** 233-237.

Aquino, L.P.C.T., Machado, R.Z., Alessi, A.C., Marques, L.C., Castro, M.B. and Malheiros, E.B. (1999). Clinical, parasitological and immunological aspects of experimental infection with *Trypanosoma evansi* in dogs. *Memórias do Instituto Oswaldo Cruz*, 94**,** 255-260.

Aquino, L.P.C.T., Machado, R.Z., Alessi, A.C., Santana, A.E., Castro, M.B., Marques, L.C. and Malheiros, E.B. (2002). Hematological, biochemical and anatomopathological aspects of experimental infection with *Trypanosoma evansi* in dogs. *Arquivo Brasileiro de Medicina Veterinária Zootecnia*, 54, 255-260.

Anosa, V.O. and Isoun, T.T. (1976). Serum proteins, blood and plasma volumes in experimental *Trypanosoma vivax* infection of sheep and goats. *Tropical Animal Health and Production*, 8, 14-19.

Arunasalam, V., Chadrawaaathani, P. and Sivanandan, S. (1995). An outbreak of *Trypanosoma evansi* infection in pigs. *Jurnal Veterinar Malaysia* 7, 71-73.

Antoine-Moussiaux, N., Cornet, A., Cornet, F., Glineur, S., Dermine, M., Desmecht, D. and Rénia, L. (2009). A non-cytosolic protein of *Trypanosoma evansi* induces CD45-dependent lymphocyte death. *PloS one,* 4**,** 93-98.

Bajyana Songa, E. and Hamers, R. (1988). A card agglutination test (CATT) for veterinary use based on an early VAT RoTat 1.2 of *Trypanosoma evansi*. *Annales de la Société Belge de Médecine Tropicale,* 68, 233–240.

Bengaly, Z., Sidibe, I., Ganaba, R., Desquesnes, M., Boly, H. and Sawadogo, L. (2002a). Comparative pathogenicity of three genetically distinct types of *Trypanosoma congolense* in cattle: clinical observations and haematological changes, *Veterinary Parasitology,* 108**,** 1–19.

Bengaly, Z., Sidibe, I., Boly, H., Sawadogo, L. and Desquesnes, M. (2002b). Comparative pathogenicity of three genetically distinct *Trypanosoma congolense*-types in inbred Balb/c mice, *Veterinary Parasitology,* 105, 111–118.

Berlin, D., Nasereddin, A., Azmi, K., Ereqat, S., Abdeen, Z. and Baneth, G. (2010). Longitudinal study of an outbreak of *Trypanosoma evansi* infection in equids and dromedary camels in Israel. *Veterinary Parasitology*. 15; 174 (3-4), 317-22.

Boid, R., Luckins, A.G., Rae, P.F., Gray, A.R., Mahmoud, M.M. and Malik, K.H. (1980). Serum immunoglobulin levels and electrophoretic pattern of serum proteins in camels infected with *Trypanosoma evansi*. *Veterinary Parasitology*, 6, 333–45.

Boid, R., Amin, E., Mahmoud, M. and Luckins, A. (1981). *Trypanosoma evansi* infections and antibodies in goats, sheep and camels in the Sudan. *Tropical Animal Health and Production*, 13**,** 141-146.

Borst, P., Fase-Fowler, F. and Gibson, W.C. (1987). Kinetoplast DNA of *Trypanosoma evansi*. *Molecular and Biochemical Parasitology*, 23**,** 31-38.

Brun, R., Hecker, H. and Lun, Z.R. (1998). *Trypanosoma evansi* and T. equiperdum: distribution, biology, treatment and phylogenetic relationship (a review). *Veterinary Parasitology*, 79**,** 95-107.

Cadioli, F.A., Marques, L.C., Machado, R.Z., Alessi, A.C., Aquino, L.P.C.T. and Barnabe, P.A. (2006). Experimental *Trypanosoma evansi* infection in donkeys hematological, biochemical and histopatholoical changes. *Arquivo Brasileiro de Medicina Veterinária Zootecnia*, 58(5), 749-756.

Cano, R.C., Hliba, E. and Rubiolo, E.R., (2000). Creatine kinase and lactate dehydrogenase levels as potential indicators of *Trypanosoma cruzi* infectivity and histotropism in experimental Chagas' disease. *Parasitological Research,* 86, 244–252.

Cheah, T.S., Sani, R.A., Chandrawathani, P., Sansul Bahari. and Dahlan, I. (1999). Epidemiology of *Trypanosoma evansi* Infection in Crossbred Dairy Cattle in Malaysia. *Tropical Animal Health and Production*, 31 (1). 25-31.

Cheah, T.S. and Azman, A.M.S. (1999). A survey of trypanosomiasis and babesiosis in local ponies in Kelantan, Peninsuslar Malaysia. (2000). *In* :Proceeding of the 12th Scientific Veterinary Association of Malaysia Congress, 1-4 September 2000, Kuantan, Malaysia, p. 183-184.

Costa, M.M., Da Silva, A.S., Wolkmer, P., Zanette, R.A., França, R.T., Monteiro, S.G. and Dos Anjos Lopes, S.T. (2010). Serum proteinogram of cats experimentally infected by *Trypanosoma evansi*. *Preventive Veterinary Medicine*. 95(3-4), 301-4.

Damayanti, R, Graydon, R.J. and Ladds, P.W. (1994).The pathology of experimental *Trypanosoma evansi* infection in the Indonesian buffalo (*Bubalus bubalis*). *Journal of Comparative Pathology*, 110(3), 237-252.

Dargantes, A.P., Reid, S. and Copeman, B.D. (2005a). Experimental *Trypanosoma evansi* infection in the goat. I. Clinical signs and clinical pathology. *Journal of Comparative Pathology*, 133**,** 261-266.

Dargantes A.P., Reid S.A. and Copeman, D.B. (2005b). Experimental *Trypanosoma evansi* infection in the goat. II Pathology. *Journal of Comparative Pathology*, 133, 267–276.

Dargantes, A.P, Mercado, R., Dobson, R. and Reid, S. (2009). Estimating the impact of *Trypanosoma evansi* infection (surra) on buffalo population dynamics in southern Philippines using data from cross-sectional surveys. *International Journal for Parasitology*, 39**,** 1109-1114.

Das, S., Bhattacharya, P., Biswas, S. N., Bose, T., Sen, D., Das, D., Roy, S. and Lahiri, P. (2008). *Trypanosoma evansi* antibody levels in the goats from slaughter houses of Kolkata, India. New Orleans, LA The American Society of Tropical Medicine and Hygiene.

Da Silva, A.S., Carnelutti, J.F., Costa, M.M., Monteiro, S.G., Lopes, S.T.A. and Monteiro SG. (2007). Alterações bioquímicas em coelhos infectados experimentalmente pelo *Trypanosoma evansi*. *Revista Brasileira de Parasitologia Veterinária*, 16(1), 43-46.

Department of Veterinary Services, Animal Health Sevices in Malaysia; DVS, Ministry of Agriculture, Kuala lumpur Malaysia, (2008).

Department of Veterinary Services, Animal Health Sevices in Malaysia; DVS, Ministry of Agriculture, Kuala lumpur Malaysia, (2009).

De Souza, A.P., De Oliveira, G.M., Vanderpas, J., De Castro, S.L., Rivera, M.T. and Araújo-Jorge, T.C. (2003). Selenium supplementation at low doses contributes to the decrease in heart damage in experimental *Trypanosoma cruzi* infection. *Parasitology Research*, 91(1), 51-4.

Desquesnes, M. (2004). *Livestock trypanosomoses and their vectors in Latin America*, O.I.E. (World Organisation for Animal Health).

De Villa, R.M.C.N., Eduardo, S.L. and Denning, H.K. (1991). Clinico-pathologic and hematologic observations in goats experimentally infected with *Trypanosoma evansi* (Manila strain). *Philippine Journal of Veterinary and Animal Sciences*, 17(3-4) p. 131-142.

Dhollander, S., Bos, J., Kora, S., Sanneh, M., Gaye, M., Leak, S., Berkvens, D. and Geerts, S. (2005). Susceptibility of West African Dwarf goats and WAD×Saanen crosses to experimental infection with *Trypanosoma congolense*. *Veterinary Parasitology*, 130**,** 1-8.

Dia, M. (1995). Comparison of the pathogenic effect in mice between stocks of *Trypanosoma evansi* from Mauritania and from Kenya, Niger, Chad and China. *Revue D'élevage Et De Médecine Vétérinaire Des Pays Tropicaux*, 48**,** 21.

Dia, M.L., Diop, C., Aminetou, M., Jacquiet, P. and Thiam, A. (1997). Some factors affecting the prevalence of *Trypanosoma evansi* in camels in Mauritania. *Veterinary Parasitology*, 72(2), 111-120.

Dwinger, R.H., Clifford, D.J., Agyemang, K., Gettinby, G., Grieve, A.S., Kora, S. and Bojang, M.A. Comparative studies in N'Dama and Zebu cattle following repeated infections with *Trypanosoma congolense*. *Research in Veterinary Science*, 52: 292-298.

Effendy, A.W.M. (1998). The role of the respiratoty mucosal immunity in protection against *Pasteurella haemolytica* A2 infection in goats. PhD dissertation, Universiti Putra Malaysia.

Effendy, A.W.M. and Zamri-Saad, M.(1999). The effect of dexamethasone on the response of bronchus-associated lymphoid tissue to intranasal administration of formalin-killed *Pasteurella haemolytica* A2 infection in goats. *Veterinary Research Communications* 23(8), 467-473.

El-Metanawey, T.M., El-Beih, N.M, Abdel El-Aziz, M.M., Hassanane M.S. and Abd El-Aziz, T.H. (2009). Comparative studies on diagnosis of *Trypanosoma evansi* in experimentally infected goats. *Global Veterinaria*, 3(4), 348-353.

El Shafie, I.E (2011). Epidemiology of *Trypanosoma evansi* infection in Peninsular Malaysia in Horses and its varient surface glycoprotein repertior. PhD Thesis. Universiti Putra Malaysia.

Enwezor, F. N. C. and Sackey, A. K. B. (2005). Camel trypanosomosis-a review. *Veterinarski Arhiv*, 75**,** 439-452.

Esch, G. W. (2007). *Parasites and infectious disease: discovery by serendipity, and otherwise*, Cambridge University Press.

Foil, L. (1989). Tabanids as vectors of disease agents. *Parasitology Today*, 5**,** 88-96.

Franke, C. R., Greiner, M. and Mehlitz, D. (1994). Investigations on naturally occurring *Trypanosoma evansi* infections in horses, cattle, dogs and capybaras (Hydrochaeris hydrochaeris) in Pantanal de Poconé (Mato Grosso, Brazil). *Acta Tropica*, 58**,** 159-169.

Gardiner, C., Fayer, R. and Dubey, J. (1989). An atlas of protozoan parasites in animal tissues. Agriculture Handbook (Washington).

Gill, B. (1977). *Trypanosomes and trypanosomiases of Indian livestock*. Indian Council of Agricultural Research, New Delhi.

Gillingwater, K., Gutierrez, C., Bridges, A., Wu, H., Deborggraeve, S., Ekangu, R.A., Kumar, A., Ismail, M., Boykin, D. and Brun, R. (2011). Efficacy Study of Novel Diamidine Compounds in a *Trypanosoma evansi* Goat Model. PLoS ONE 6(6), e20836. Doi-10.1371/journal.pone.002083.

Griffin, L. and Allonby, E. (1979). Disease syndromes in sheep and goats naturally infected with *Trypanosoma congolense*. *Journal of Comparative Pathology*, 89**,** 457-464. Gilmour, N.J.L., Martin, W.B.,

Sharp, J.M., Thompson, D.A., Wells, P.W. and Donachie, W. (1983). Experimental immunisation of lambs against pneumonic pasteurellosis. *Research in Veterinary Science*, 47**,** 185-189.

Griffin, L., Waghela, S. and Allonby, E. (1980). The immunosuppressive effects of experimental *T. congolense* infections in goats. *Veterinary Parasitology*, 7**,** 11-18.

Gumar, Y. S., Ali, S. R. and Latif, B. (2011). Longevity and infectivity of *Trypanosoma evansi* isolated from the gut of the stable fly *Stomoxys calcitrans* (Diptera: Muscidae). *In:* Fung, D. W. S., ed. 47th Annual Conference of Malaysian Society of Parasitology and Tropical Medicine: Climate Change and its Impact on Public Health, 3rd and 4th March 2011 International Medical University, Kuala Lumpur, Malaysia.

Gutierrez, C., Corbera, J., Bayou, K. and Van Gool, F. (2008). Use of Cymelarsan in Goats Chronically Infected with *Trypanosoma evansi*. *Annals of the New York Academy of Sciences*, 1149**,** 331-333.

Gutierrez, C., Corbera, J., Juste, M., Doreste, F. and Morales, I. (2005). An outbreak of abortions and high neonatal mortality associated with *Trypanosoma evansi* infection in dromedary camels in the Canary Islands. *Veterinary Parasitology*, 130**,** 163-168.

Gutierrez, C., Corbera, J. A., Morales, M. and Büscher, P. (2006). Trypanosomosis in Goats. *Annals of the New York Academy of Sciences*, 1081**,** 300-310.

Gutierrez, C., Desquesnes, M., Touratier, L. and Büscher, P. (2010). *Trypanosoma evansi*: Recent outbreaks in Europe. *Veterinary parasitology*, 174, (1-2) 24 November 2010, Pages 26-29.

Hall, M.J.R. and Wall, R. (2004). Biting flies: their role in the mechanical transmission of trypanosomes to livestock and methods for their control. In: Maudlin, I., Holmes, P. H. & Miles, M. A. (eds.) *The trypanosomiases*. CABI Publishing.

Hawking, F. (1978). The resistance of *Trypanosoma congolense*, *T. vivax* and *T. evansi* to human plasma. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 72**,** 405-407.

Herrera, H.M., Aquino, L.P.C.T. and Menezes, R.F. (2002). *Trypanosoma evansi* experimental infection in the South American coati (Nasuna nasua); Hematological, biochemical and histopathological changes. *Acta Tropica*, 81, 203-210.

Hilali, M., Abdel-Gawad, A., Nassar, A., Abdel-Wahab, A., Magnus, E., and Buscher, P. (2004). Evaluation of the card agglutination test (CATT/*T. evansi)* for detection of *Trypanosoma evansi* infection in water buffaloes *(Bubalus bubalis)* in Egypt. *Veterinary Parasitology,* 121, 45-51.

Hoare, C.A. (1940). Studies on the behaviour of *Trypanosoma evansi* in tsetse-flies with special reference to its phylogeny. *Parasitology*, 32**,** 105-121.

Hoare, C.A. (1956). Morphological and taxonomic studies on mammalian trypanosomes. *Parasitology*, 46**,** 130-172.

Hoare, C.A. (1965). Vampire bats as vectors and hosts of equine and bovine trypanosomes. *Acta Tropica*, 22**,** 204.

Hoare, C.A. (1972). *The trypanosomes of mammals*. *A zoological monograph*. *The trypanosomes of mammals*. A zoological monograph. Blackwell Scientific Publications,Oxford.

Holland, W.G. (2003). The diagnosis of *Trypanosoma evansi* and its immunosuppressive effect in water buffaloes and pigs. PhD Dissertation. Universiteit Gent.

Holland, W., Claes, F., My, L., Thanh, N., Tam, P., Verloo, D., Büscher, P., Goddeeris, B. and Vercruysse, J. (2001a). A comparative evaluation of parasitological tests and a PCR for *Trypanosoma evansi* diagnosis in experimentally infected water buffaloes. *Veterinary Parasitology*, 97**,** 23-33.

Holland, W., My, L., Dung, T., Thanh, N., Tam, P., Vercruysse, J. and Goddeeris, B. (2001b). The influence of *T. evansi* infection on the immuno-responsiveness of experimentally infected water buffaloes. *Veterinary Parasitology*, 102**,** 225-234.

Hollander, A. and Wright, R. (1980). Impact of Tahanids on Cattle: Blood Meal Size and Preferred Feeding Sites. *Journal of Economic Entomology*, 73**,** 431-433.

Holmes, P., Mammo, E., Thomson, A., Knight, P., Lucken, R., Murray, P., Murray, M., Jennings, F. and Urquhart, G. (1974). Immunosuppression in bovine trypanosomiasis. *The Veterinary Record*, 95**,** 86.

Holzmuller, P., Grébaut, P., Peltier, J. B., Brizard, J. P., Perrone, T., Gonzatti, M., Bengaly, Z., Rossignol, M., Aso, P. M. and Vincendeau, P. (2008).

Secretome of animal trypanosomes. *Annals of the New York Academy of Sciences*, 1149**,** 337-342.

Hosseininejad, M., Shirani, D., Nabian, S., Nassiri, A.M., and Mazaheri, R. (2006). *Trypansosoma evansi* in three dogs in Iran: case report. *Comparative Clinical Pathology*, 16 (1), 69-81.

Idrus, Z., Bahyuddin, N., Yuen, W.H, Abdoreza, F.S., Awis Q.S., Mohamed, A.R. and Yong, M.G. (2010). Physiological responses in goats subjected to road transportation under the hot, humid tropical conditions. *International Journal of Agriculture and Biology*, 12, 840-844.

Ikede, B.O., Fatimah, W., Sharifuddin, W. and Bongso, T.A. (1983). Clinical and pathological features of natural *Trypanosoma evansi* infections in ponies in West Malaysia. *Tropical Veterinarian*, 1**,** 151-157.

Ikeme M.M., Aziz Saharee A., Zamri-Saad, M. and Koran, R. (1984). Effect of experimental *Trypanosoma evansi* infections in cattle and subsequent response to Haemorrhagic Septicaemia vaccine. *Tropical Veterinarian*, 2, 61-67.

Igbokwe, I.O. and Mohammed, A. (1992). Some plasma biochemical changes in experimental *Trypanosoma brucei* infection of Sokoto Red goats. *Revue d Elevage et de Medecine Veterinaire des Pays Tropicaux*. 45(3-4), 287-29.

Jacquiet, P., Cheikh, D., Thiam, A. and Dia, M. (1993). La trypanosomose a *Trypanosoma evansi* (Steel 1885). Balbiani 1888 chez les petits ruminants de Mauritanie: Resultats d'inoculation experimentale et d'enquetes sur le terrain. *Revue D Elevage Et De Medicine Veterinaire Des Pays Tropicaux*, 46**,** 574-574.

Jain, N.C. (1993). *Essentials of Veterinary Hematology*, Lea & Febinger, Philadelphia.

Jones, T.W. and McKinnell, C.D. (1985.) Antigenic variation in *Trypanosoma evansi:* variable antigen type development in mice, sheep and goats. *Tropical Medicine and Parasitology,* 36**,** 53-57.

Joshi, P.P., Chaudhari, A., Shegokar, V.R., Powar, R.M., Dani, V.S., Somalwar, A.M., Jannin, J. and Truc, P. (2006). Treatment and follow-up of the first case of human trypanosomiasis caused by *Trypanosoma evansi* in India. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 100**,** 989-991.

Joshi, P.P., Shegokar, V.R., Powar, R. M., Herder, S., Katti, R., Salkar, H.R., Dani, V.S., Bhargava, A., Jannin, J. and Truc, P. (2005). Human trypanosomiasis caused by *Trypanosoma evansi* in India: the first case report. *The American Journal of Tropical Medicine and Hygiene*, 73**,** 491.

Kadima, K. B., Gyan, E.O., Saror, D.I., and Esievo, K.A.N. (2000). Serum biochemical values of infected cattle and effect of lactose in saline infusion. *Veterinarski Archive*, 70(2), 67-74.

Kaneko, J.J., Harvey, J.W. and Bruss, M.L. (1997). *Clinical biochemistry of domestic animals, 5th ed*. Academic press.

Lai, D.H., Hashimi, H., Lun, Z. R., Ayala, F.J. and Lukeš, J. (2008). Adaptations of *Trypanosoma brucei* to gradual loss of kinetoplast DNA: *Trypanosoma equiperdum* and *Trypanosoma evansi* are petite mutants of *T. brucei*. *Proceedings of the National Academy of Sciences*, 105**,** 1999.

Lai, D.H., Wang, Q. P., Li, Z., Luckins, A.G., Reid, S.A. and Lun, Z.R. (2010). Investigations into human serum sensitivity expressed by stocks of *Trypanosoma brucei evansi*. *International Journal for Parasitology*, 40**,** 705-710.

Laohasinnarong, D., Thekisoe, O.M., Malele, I., Namangala, B., Ishii, A., Goto, Y., Kawazu, S.I., Sugimoto, C. and Inoue, N. (2011). Prevalence of *Trypanosome* sp. in cattle from Tanzania estimated by conventional PCR and loop-mediated isothermal amplification (LAMP). *Parasitology Research*, online DOI 10.1007/s00436-011-2513-2.

Leese, A.S. Tips on camels for veterinary surgeons on active service. Rome, FAO (Food and Agriculture Organization) (1969).

Levine, N.D. 1985. *Veterinary protozoology*, Wiley-Blackwell.

Levine, N.D., Corliss, J.O., Cox, F.E.G., Deroux, G., Grain, J., Honigberg, B. M., Leedale, G.F., Loeblich, A.R., Iii, Lom, J., Lynn, D., Merinfeld, E.G., Page, F.C., Poljansky, G., Sprague, V., Vavra, J. and Wallace, F.G. (1980). A newly revised classification of the Protozoa. *Journal of Protozoology*, 27**,** 37–58.

Littell, R.C., Milliken, G.A., Stroup, W.W., Wolfinger, R.D. (2006). *SAS for Mixed Models, 2nd ed*. SAS Publishing.

Lopes, E.R. and Chapadeiro, E. (2004). Pathogenesis of American trypansosomiasis. In: Maudlin, I., Holmes, P. & Miles, M. (eds.) *The trypanosomiases*. CABI Publishing.

Losos, G.J. (1980). Diseases caused by *Trypanosoma evansi*, a review. *Veterinary Research Communications*, 4**,** 165-181.

Losos, G.J. (1986). *Infectious tropical diseases of domestic animals*, Longman Scientific and Technical.

Luckins, A. and Dwinger, R. (2004). Non-tsetse-transmitted animal trypanosomiasis. In: Maudlin, I., Holmes, P. & Miles, M. (eds.) *The trypanosomiases*. CABI Publishing.

Luckins, A.G. (1988). *Trypanosoma evansi* in Asia. *Parasitology Today*, 4**,** 137-142.

Luckins, A.G., Mcintyre, N. and Rae, P. (1991). Multiplication of *Trypanosoma evansi* at the site of infection in skin of rabbits and cattle. *Acta Tropica*, 50**,** 19-27.

Luckins, A.G. (1996). Problems associated by infections caused by *Trypanosoma evansi* in Asia. *In*: Husein, A., Davison, H., C., Luckins, A., G., Partoutomo, S. and Thrusfield, M. V. ed. Proceedings of a seminar on diagnostic techniques for *Trypanosoma evansi* in Indonesia. 10th January 1996, Research Institute for Veterinary Science, Bogor, Indonesia.

Lukes, J. (2009). *Trypanosoma* (Gruby 1843), Version 02 January 2009. http://tolweb.org/*Trypanosoma*/98034/2009.01.02 in The Tree of Life Web Project, http://tolweb.org/.

Lun, Z.R., Lai, D. H., Li, F. J., Lukes , J. and Ayala, F.J. (2010). *Trypanosoma brucei*: two steps to spread out from Africa. *Trends in Parasitology*, 26**,** 424-427.

MacKenzie, P.K.I., Boyt, W.P., Nesham, V.M. and Pirie, E. (1978). The aetiology and significance of the phagocytosis of erythrocytes and leucocytes in sheep infected with *Trypanosoma congolense*. *Research in Veterinary Science*, 24, 4-7.

Mahmoud, M. and Gray, A. (1980). Trypanosomiasis due to *Trypanosoma evansi* (steel, 1885) balbiani, 1888. a review of recent research. *Tropical Animal Health and Production*, 12**,** 35-47.

Mahmoud, M.M. and El Malik, K.H. (1978). Properties and pathogenesis of *Trypanosoma congolense*, *T. vivax*, and *T. evansi* in The Sudan. *Sudan Journal of Veterinary Science and Animal Husbandry*, 19**,** 1-7.

Mandal, M., Laha, R. and Sasmal, N.K. (2008). First report of establishment of *Trypanosoma evansi* infection in pigeon nestlings (Columba livia). *Journal of Parasitology*, 94**,** 1428-1429.

Manjrekar, S. (1950). Trypanosomiasis in goats- a preliminary note. *Indian Veterinary Journal*, 27**,** 103-104.

Manuel, M. (1998). Sporadic outbreaks of Surra in the Philippines and its economic Impact. *Journal of Protozoology Research*,8**,** 131-138.

Md-Isa, N.M. (2010). Prevalence of haemoparasites and risk factors associated with *Trypanosoma evansi* infection in Malaysia. MSc thesis. Universiti Putra Malaysia.

Menezes, V.T., Queiroz, A.O., Gomes, M.A., Marques, M.A. and Jansen, A.M. (2004). *Trypanosoma evansi* in inbred and Swiss–Webster mice: distinct aspects of pathogenesis. *Parasitology Research*, 94, 193–200.

Minter-Goedbloed, E. (1981). The susceptibility of chickens to *Trypanosoma brucei* subspecies. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 75**,** 345-349.

Molina-Portela, M.P., Samanovic, M. and Raper, J. (2008). Distinct roles of apolipoprotein components within the trypanosome lytic factor complex revealed in a novel transgenic mouse model. *The Journal of Experimental Medicine,* 205**,** 1721.

Monzon, C.M. and Villavicencio, V.I. (1990). Serum proteins in guinea-pigs and horses infected with *Trypanosoma evansi* (Steel, 1885). *Veterinary Parasitology,* 36**,** 295-301.

Morty, R.E., Pellé, R., Vadász, I., Uzcanga, G. L., Seeger, W. and Bubis, J. (2005). Oligopeptidase B from *Trypanosoma evansi*. *Journal of Biological Chemistry,* 280**,** 10925–10937.

Mullen, G., Mullen, G.R. and Durden, L. (2009). *Medical and Veterinary Entomology*, Academic Press.

Ngaira, J., Njagi, E., Ngeranwa, J. and Olembo, N. (2004). PCR amplification of RoTat 1.2 VSG gene in *Trypanosoma evansi* isolates in Kenya. *Veterinary Parasitology*, 120**,** 23-33.

Ngeranwa, J.J.N., Gathumbi, P.K., Mutiga, E.R. and Agumbah, G.J.O. (1993). Pathogenesis of *Trypanosoma* (*brucei*) *evansi* in small east African goats. *Research in Veterinary Science*, 54**,** 283-289.

Ngeranwa, J.J.N. and Kilalo, D.C. (1994). The ability of *Stomoxys calcitrans* and mechanical means to transmit *Trypanosoma* (*brucei*) *evansi* from goats to camels in Kenya. *Veterinary Research Communications*, 18**,** 307-312.

Nurulaini, R., Jamnah, O., Adnan, M., Zaini, C., Khadijah, S., Rafiah, A. and Chandrawathani, P. (2007). Mortality of domesticated java deer attributed to Surra. *Tropical Biomedicine*, 24**,** 67-70.

Olaho-Mukani, W., Kakaire, D., Matovu, E., and Enyaru, J. (1998). Prevalence of Surra in Dromedary camels in Uganda. *Journal of Protozoology Research*, 8, 120-125.

Olaho-Mukani, W., Munyua, W. and Njogu, A. (1992). An enzyme-linked immunosorbent assay (ELISA) for the detection of trypanosomal antigens in goat serum using a monoclonal antibody. *Journal of Immunoassay*, 13**,** 217.

Onah, D.N., Hopkins, J. and Luckins, A.G. (1996). Haematological changes in sheep experimentally infected with *Trypanosoma evansi. Parasitology Research,* 82**,** 659-663.

Onah, D.N., Hopkins, J. and Luckins, A.G. (1997). Effects of *Trypanosoma evansi* on the output of cells from a lymph node draining the site of *Pasteurella haemolytica* vaccine administration. *Journal of Comparative Pathology,* 117, 73-82.

Osaer, S., Goossens, B., Kora, S., Gaye, M. and Darboe, L. (1999). Health and productivity of traditionally managed Djallonke sheep and West African Dwarf goats under high and moderate trypanosomosis risk. *Veterinary Parasitology*, 82, 101-119.

Osaer, S., Goossens, B., Eysker, M. and Geerts, S. (2000). The effects of prophylactic anthelmintic on the productivity of traditionally managed Djallonke sheep and West African Dwarf goats kept under high trypanosomosis risk. *Acta Tropica*, 74, 13-24.

Otieno, P. and Gacanja, J. (1976). Studies of experimental *Trypanosoma evansi* infection in goats. Bulletin of animal health and production in Africa. *Bulletin des santé et Production Animales en Afrique*, 24**,** 295.

Otto, M.A., Silva, A.S., Gressler, L.T., Farret, M.H., Tavares, K.C.S., Zanette, R.A., Miletti, L.C. and Monteiro, S.G. (2010). Susceptibility of *Trypanosoma evansi* to human blood and plasma in infected mice. *Veterinary Parasitology*, 168**,** 1-4.

Paris, Z., Hashimi, H., Lun, S., Alfonzo, J.D. and Lukes, J. (2010). Futile import of tRNAs and proteins into the mitochondrion of *Trypanosoma brucei evansi*. *Molecular and Biochemical Parasitology*, 176 (2):116-20.

Partoumoto, S. (1996). Trypanosomiasis caused by *Trypanosoma evansi* ("Surra") in Indonesia. *In*: Husein, A., Davison, H., C., Luckins, A., G., Partoutomo, S. and Thrusfield, M. V. ed. Proceedings of a seminar on diagnostic techniques for *Trypanosoma evansi* in Indonesia. 10th January 1996, Research Institute for Veterinary Science, Bogor, Indonesia.

Payne, R., Ward, D., Usman, M., Rusli, A., Djauhari, D. and Husein, A. (1988). Prevalence of bovine haemoparasites in Aceh Province of Northern Sumatra: implications for imported cattle. *Preventive Veterinary Medicine*, 6**,** 275-283.

Pruvot, M., Kamyingkird, K. Desquesnes, M., Sarataphan, N. and Jittapalapong, S. (2010). A comparison of six primer sets for detection of *Trypanosoma evansi* by polymerase chain reaction in rodents and Thai livestock. *Veterinary Parasitology*, 171(3-4), 185-93.

Queiroz, A., Cabello, P. and Jansen, A. (2000). Biological and biochemical characterization of isolates of *Trypanosoma evansi* from Pantanal of Matogrosso-Brazil. *Veterinary Parasitology*, 92**,** 107-118.

Radostits, O., Gay, C., Hinchcliff, K. and Constable, P. (2007). *Veterinary Medicine*, 10th. Ed., Saunders Elsevier. Oxford.

Rajamanickam, C., Wiesenhutter., E., Zin, F.M, and Hamid, J. (1985). The incidence of canine haematozoa in Peninsular Malaysia. *Veterinary parasitology,* 17(2), 151-7.

Ramirez, L., Dávila, A., Victório, A., Silva, R., Trajano, V. and Jansen, A.M. (1997). Measurements of *Trypanosoma evansi* from the Pantanal. *Memórias do Instituto Oswaldo Cruz,* 92**,** 483-484.

Reid, S.A. (2002). *Trypanosoma evansi* control and containment in Australasia. *Trends in Parasitology*, 18**,** 219-224.

Reid, S.A. and Copeman, D.B. (2000). Surveys in Papua New Guinea to detect the presence of *Trypanosoma evansi* infection. *Australian Veterinary Journal*, 78(12), 843-5.

Reid, S., Husein, A., Hutchinson, G. and Copeman, D. (1999). A possible role for rusa deer (Cervus timorensis russa) and wild pigs in spread of

Trypanosoma evansi from Indonesia to Papua New Guinea. *Memórias do Instituto Oswaldo Cruz*, 94**,** 195-197.

Rodrigues, A., Fighera, R.A., Souza, T.M., Schild, A.L. and Barros, C.S.L. (2009). Neuropathology of naturally occurring *Trypanosoma evansi* infection of horses. *Veterinary Pathology Online*, 46**,** 251.

Rurangirwa, F., Musoke, A., Nantulya, V. and Tabel, H. (1983). Immune depression in bovine trypanosomiasis: effects of acute and chronic *Trypanosoma congolense* and chronic *Trypanosoma vivax* infections on antibody response to *Brucella abortus* vaccine. *Parasite Immunology*, 5**,** 267-276.

Salim, B., Bakheit, M.A., Kamau, J., Nakamura, I. and Sugimoto, C. (2011). Molecular epidemiology of camel trypanosomiasis based on ITS 1 rDNA and RoTat 1. 2 VSG gene in the Sudan. *Parasites and Vectors*, 4**,** 31.

Sani, R.A., Chandrawathani, P. and Rosli, M. (1989). Gastrointestinal parasites and *Trypanosoma evansi* in buffaloes. *In*: Domestic buffalo production in Asia. Proceedings of the Final Research Co-ordination Meeting; Panel Proceedings Series (IAEA); Research Co-ordination Meeting on the Use of Nuclear Techniques to Improve Domestic Buffalo Production in Asia - Phase II, Rockhampton (Australia), 20-24 Feb 1989 / Joint FAO/IAEA Div. of Nuclear Techniques in Food and Agriculture, Vienna, Austria.

Sani, R.A. Cheah, T.S., Sharifah-Salmah, S.H. and Chin, P.L. (2007). *Trypanosoma evansi* in cattle farms in Malaysia. *In*: 21st International Conference of the World Association for the Advancement of Veterinary Parasitology. Ghent, Belgium, 19-23 August 2007.

Scott, J., Pegram, R., Holmes, P., Pay, T.W. F., Knight, P., Jennings, F. and Urquhart, G. (1977). Immunosuppression in bovine trypanosomiasis: field studies using foot-and-mouth disease vaccine and clostridial vaccine. *Tropical Animal Health and Production*, 9**,** 159-165.

Sileghem, M., Flynn, J., Darji, A., Baetselier, P., Naessens, J. and Kierszenbaum, F. Year. African trypanosomiasis. (1994) *In:* Kierszenbaum, F., ed. *Parasitic infections and the immune system*. Academic Press Inc.

Sharma, D.K., Chauhan, P.P.S., Agrawal, R.D., (2000). Interaction between *Trypanosoma evansi* and *Haemonchus contortus* infection in goats. *Veterinary Parasitology*, 92, 261-267.

Sharpe, R., Langley, A., Mowat, G., Macaskill, J. and Holmes, P. (1982). Immunosuppression in bovine trypanosomiasis: response of cattle infected with *Trypanosoma congolense* to foot-and-mouth disease vaccination and subsequent live virus challenge. *Research in Veterinary Science*, 32**,** 289.

Shegokar, V.R., Powar, R.M., Joshi, P.P., Bhargava, A., Dani, V.S., Katti, R., Zare, V.R., Khanande, V.D., Jannin, J. and Truc, P. (2006). Short report: Human trypanosomiasis caused by *Trypanosoma evansi* in a village in India: preliminary serologic survey of the local population. *The American Journal of Tropical Medicine and Hygiene*, 75**,** 869.

Shehu, S.A., Ibrahim, N.D.G., Esievo, K.A.N. and Mohammed, G. (2007). Role of erythrocyte surface sialic acid in inducing anaemia in Savannah Brown bucks experimentally infected with *Trypanosoma evansi*. *Veterinarski Arhiv*, 76**,** 521.

Shien, Y.S. (1979). Studies on immunosuppression in experimentally induced surra goat: I. Serological responses to *Brucella abortus* vaccinations before and after administration of naganol. *Journal of the Chinese Soceity of Veterinary Science*, 5**,** 19-22.

Shien, Y.S. and Wang, M. (1982). Immune inhibition of goats by artificial infection of goats with *Trypanosoma evansi*: active state of lymphoid tissue and lymphocyte. *Taiwan Medical Association Journal*, 8, 25-31. (Article in Chinenese).

Silva, R. A. M. S., Arosemena, N.A.E., Herrera, H.M., Sahib, C.A. and Ferreira, M.S.J. (1995). Outbreak of trypanosomosis due to *Trypanosoma evansi* in horses of Pantanal Mato-grossense, Brazil. *Veterinary Parasitology*, 60**,** 167-171.

Singla, L.D., Juyal, P.D. and Sharma, N.S. (2010). Immune responses to haemorrhagic septicaemia (HS) vaccination in *Trypanosoma evansi* infected buffalo-calves. *Tropical Animal Health and Production*, 42**,** 589-595.

Smith, M.C. and Sherman, D. M. (2009). *Goat medicine*, 2nd ed. Wiley-Blackwell.

Soulsby, E.J.L. (1982). *Helminths, arthropods and protozoa of domesticated animals*, Bailliere Tindall.

Stevens, J.R. and Brisse, S. (2004). Systematics of Trypanosomes of Medical and Veterinary Importance. *The trypanosomiases*. In: Maudlin, I., Holmes, P. and Miles, M. (eds.) *The trypanosomiases*. CABI Publishing.

Stockham, S.L. and Scott, M.A. (2008). *Fundamentals of Veterinary Clinical Pathology, 2nd ed*. Blackwell Publishing.

Tabel, H., Wei, G. and Shi, M. (2008). T cells and immunopathogenesis of experimental African trypanosomiasis. *Immunological Reviews*. 225, 128–139.

Tamarit, A., Gutierrez, C., Arroyo, R., Jimenez, V., Zagala, G., Bosch, I., Sirvent, J., Alberola, J., Alonso, I. and Caballero, C. (2010a). *Trypanosoma evansi* infection in mainland Spain. *Veterinary Parasitology*, 167**,** 74-76.

Tamarit, A., Tejedor-Junco, M., Gonzalez, M., Alberola, J. and Gutierrez, C. (2010b). Morphological and biometrical features of *Trypanosoma evansi* isolates from an outbreak in mainland Spain. *Veterinary Parasitology*, 177(1-2), 152-156.

Taracha, E.L.N., Irvin, A.D., Morzaria, S.P., Moloo, S.K. and Katende, J.M. (1988). Immunization against East Coast fever: effect of chronic trypanosomiasis on the development of immunity. *In*: Nuclear techniques in the study and control of parasitic diseases of livestock. Proceedings of the final Research Co-ordination Meeting ; Research Co-ordination Meeting on the Use of Nuclear Techniques in the Study and Control of Parasitic Diseases of Farm Animals, Vienna (Austria), 11-14 May 1987 / Joint FAO/IAEA Div. of Isotope and Radiation Applications of Atomic Energy for Food and Agricultural Development, Vienna, Austria.

Tavares, K.C.S., Da Silva, A.S., Wolkmer, P., Monteiro, S.G. and Miletti, L.C. (2010). Cryopreservation of *Trypanosoma evansi* after DEAE-cellulose purification: Evaluation of infective parameters. *Research in Veterinary Science*. 90(2), 257-259.

Tejero, F., Brun, S., Gonzalez, R.A., Velasco, E., Aso, P.M. and Finol, H.J. (2009). Renal ultrastructure in experimental murine infections with a Venezuelan isolate of *Trypanosoma evansi*. *Revista del Instituto Nacional de Higiene Rafael Rangel*, 40(2), 44-49.

Thrusfield, M. (1997). *Veterinary Epidemiology*, 2nd Ed. Blackwell Science, Oxford.

Truc, P., Gibson, W. and Herder, S. (2007). Genetic characterization of *Trypanosoma evansi* isolated from a patient in India. *Infection, Genetics and Evolution*, 7**,** 305-307.

Uilenberg, G. and Boyt, W. (1998). *A field guide for the diagnosis, treatment and prevention of African animal trypanosomosis*, Food & Agriculture Organization.

Urquhart, G. and Armour, J. Duncan Jl; Dunn AM and Jennings FW. (1987). *Veterinary parasitology*. Longman Scientific&Technical, Great Britain.

Vellayan, S., Aidi Mohamad, Robin, W., Radcliffe, Lowenstine, L.J., Epstein, J., Reid, S.A., Paglia, D.E., Radcliffe, R.M., Roth, T.L., Foose, T.J., Khan, M., Jayam, V., Reza, S. and Abraham, M. (2004). "Trypanosomiasis (surra) in the captive Sumatran rhinoceros (Dicerorhinus sumatrensis sumatrensis) in Peninsular Malaysia". Proceedings of the International Conference of the Association of Institutions for Tropical Veterinary Medicine 11, 187–189.

Vanhamme, L., Paturiaux-Hanocq, F., Poelvoorde, P., Nolan, D.P., Lins, L., Van Den Abbeele, J., Pays, A., Tebabi, P., Van Xong, H. and Jacquet, A. (2003). Apolipoprotein LI is the trypanosome lytic factor of human serum. *Nature*, 422**,** 83-87.

Vanhollebeke, B. and Pays, E. (2010). The trypanolytic factor of human serum: many ways to enter the parasite, a single way to kill. *Molecular Microbiology*, 76**,** 806-814.

Vanhollebeke, B., Truc, P., Poelvoorde, P., Pays, A., Joshi, P.P., Katti, R., Jannin, J.G. and Pays, E. (2006). Human *Trypanosoma evansi* infection linked to a lack of apolipoprotein L-1. *New England Journal of Medicine*, 355**,** 2752-2756.

Ventura, R., Takeda, G., Silva, R., Nunes, V., Buck, G. and Teixeira, M. (2002). Genetic relatedness among *Trypanosoma evansi* stocks by random amplification of polymorphic DNA and evaluation of a synapomorphic DNA fragment for species-specific diagnosis. *International Journal for Parasitology*, 32**,** 53-63.

Verloo D., Tibayrenc, R., Magnus, E., Büscher, P. and Van Meirvenne, N. (1998). Performance of serological tests for *Trypanosoma evansi* infections in camels from Niger. *Journal of Protozoology Research*, 8, 190–193.

Verma, B.B. and Gautam, P.O. (1978). Studies on experimental surra *Trypanosoma evansi* infection in buffalo and cow calves. *Indian Veterinary Journal*, 55, 648-653.

Wei, G. and Tabel, H. (2008). Regulatory T cells prevent control of experimental African trypanosomiasis. *Journal of Immunology*, 180, 2514-2521.

Whitelaw, D., Scott, J., Reid, H., Holmes, P., Jennings, F. and Urquhart, G. (1979). Immunosuppression in bovine trypanosomiasis: studies with louping-ill vaccine. *Research in Veterinary Science*, 26**,** 102.

Woo, P.T.K. (1969). The haematocrit centrifuge for the detection of trypanosomes in blood. *Canadian Journal of Zoology*, 47(5), 921-3.

Wong, M.T., Sani, R.A., Chin. Y.Y., Abubakar., I.A., and Sharma, R.S.K. (2009). Dynamics of parasitaemia and haematological changes associated with *Trypanosoma evansi* infection in local goats. *In Proceedings of the 45th Annual Seminar Malaysian Society of Parasitology and Tropical Medicine, 18th-19th arch 2009; Kuala Lumpur*. 2009, 68.

Wuyts, N., Chokesajjawatee, N. and Panyim, S. (1994). A simplified and highly sensitive detection of *Trypanosoma evansi* by DNA amplification. *The Southeast Asian Journal of Tropical Medicine and Public Health*, 25**,** 266.

Yang, C., Suo, X., Huang, X., Zhang, G., Jia, Y., Wang, Q. and Shen, J. (2007). Protection of mice against homologous or heterologous infections with antiserum mixture to the predominant variable antigen type repertoire of *Trypanosoma evansi* YNB stock. *Experimental Parasitology*, 116, 52-58.

Youssif, F.M., Mohammed, O.S.A. and Hassan, T. (2007). Efficacy and toxicity of cymelarsan® in Nubian goats infected with *Trypanosoma evansi*. *Journal of Cell and Animal Biology*, 2 (7), pp. 140-149.

Zamri-Saad, M. and Sabri, M.Y. (2008). Vaccination against pneumonic mannheimiosis to reduce mortality in sheep**.** *In*: Sujarit, V., Leowijuk, C, and Panichkriengkrai, W. ed. The 15th Congress of the Federation of Veterinary Associations and FAVA-OIE Joint Symposium. Food safety: Veterinary roles for the world chicken, 27-30th October 2008, Sofitel centara grand and Bangkok convention center, Bangkok, Thailand.

Zainal-Abidin, B.A.H. (1992). Infections caused by *Trypanosoma evansi* in Malaysia. *Malaysian Applied Biology*, 2(10), 1-8.