FOOT-AND-MOUTH DISEASE SEROPREVALENCE AND SOCIO-ECONOMIC IMPACT IN RELATION TO ANIMAL MOVEMENTS IN SELECTED WILDLIFE-LIVESTOCK INTERFACE AND NON INTERFACE AREAS OF TANZANIA

DANIEL PIUS MDETELE

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY OF SOKOINE UNIVERSITY OF AGRICULTURE.

MOROGORO, TANZANIA.

2014

EXTENDED ABSTRACT

Foot-and-mouth disease (FMD) is an acute, highly contagious viral infection of domestic and wild cloven-hoofed animals. In Tanzania the disease is known to be endemic with periodic outbreaks occurring in different geographical areas. This study was conducted to determine the seroprevalence and socio-economic impact of FMD in relation to livestock movements in a wildlife–livestock interface ecosystem (Serengeti and Bunda Districts) compared to a non-interface ecosystem (Iramba and Kongwa Districts). The study attempted to establish the socio-economic impact of FMD in these study districts. Four hundred serum samples were collected from Serengeti (n = 100), Bunda (n = 100), Kongwa (n = 100) and Iramba (n = 100) and tested for FMD antibodies presence using 3ABC-ELISA. In addition, forty questionnaire copies to establish the socio-economic impact of FMD were administered to livestock keepers: Serengeti (n = 10), Bunda (n = 10), Kongwa (n = 10) and Iramba (n = 10). Significantly higher association between geographical areas and seroprevalence was recorded in the wildlife-livestock interface areas (71.5%; 143/200) compared to non-interface areas (61.0%; 122/200) ($X^2 = 4.9308$, p = 0.0264, C.F 95%). Socially, FMD outbreaks impact on food insecurity (85.0%), failure to meet education costs (90.0%) and medical costs (77.5%). Economically, FMD impacts were observed in losses associated with treatment costs (87.5%), milk productivity (85.0%), draught power (80.0%), livestock market loss (67.5), lower livestock weight gain (60.0%), lower fertility (37.5%), abortion (35.0%), death of animals (25.0%) and vaccine supply costs (2.5%). In conclusion, FMD is more prevalent at the wildlife-livestock interface (71.5%) than in non-interface areas (61.0%). Higher percentages in case response on social impacts and economic losses

indicate magnitude of the problem and feelings of livestock keepers about FMD in both ecosystems. However, lower percentage on case response to vaccine supply cost indicates there is no control of FMD by vaccination.

DECLARATION

I, Daniel Pius Mdetele, hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and it has neither been submitted nor being concurrently submitted in any other University.

Signature…… Date……

Daniel Mdetele

(MPhil Candidate)

The above declaration is confirmed:

Signature …… Date……

Dr. Christopher J. Kasanga

(Supervisor)

Signature……. Date ……

Prof. Kim A. Kayunze

(Co – Supervisor)

COPYRIGHT

ACKNOWLEDGEMENTS

I wish to express my thanks to the Wellcome Trust for financial support for my studies and research work through the Southern African Centre for Infectious Disease Surveillance (SACIDS) and the Ministry of Livestock development and Fisheries for supporting and allowing me to go for postgraduate studies.

I am most thankful to Dr. Christopher J. Kasanga my principal supervisor and Prof. Kim A. Kayunze my co-supervisor for their guidance and encouragement from the proposal formulation up to the completion of this dissertation. I am also grateful to Dr. Ezekia Ranga and Dr. Michael Madege for their assistance during my struggle on search for sponsorship. Moreover, I thank Dr. Mathias Mkama, Mr. Raphael Sallu, and Dr. Charles Mayenga for their assistance during my laboratory work at the Tanzania Veterinary Laboratory Agency (TVLA) in Temeke, Dar es Salaam. My sincere gratitude goes to all staff of the Centre for Infectious Diseases and Biotechnology (CIDB) for being cooperative with me during my laboratory work. Also, I thank Dr. Misago Seth for technical support specifically during data analysis.

I am also grateful to the Offices of the District Veterinary Officers (DVOs) for Serengeti, Bunda, Kongwa and Iramba Districts for allowing their field staff to assist me with logistics for sample collection and preservation when I was working in their districts. Furthermore, I thank the field team from all those District Offices for helping me in sample collection. I also acknowledge the farmers for making their animals available for sampling and themselves by responding to the research questionnaires.

Also, I thank Dr. Winfredy Moshy, Dr. Subira Mwakabumbe and other fellow staff of ZVC Mwanza, Dr. Joseph Genchwere of TVL Mwanza and other staff of TVLA Mwanza for assistance and moral support they offered me during my study. Lastly, but not least, I am grateful to my family: my wife Martha Mayala, my daughter Rosemary and my sons Golden and William; for understanding, tolerance and moral support during the whole period of my study.

DEDICATION

This work is dedicated to my parents the late Mzee Pius Mdetele and my mother Fedelika Mwena, for nurturing my early childhood talents that made me reach where I am today. Also to my late wife Tecla Lucas Myumbilwa and my family, for their endurance and support whilst I was not at home when they needed me the most.

TABLE OF CONTENTS

LIST OF PUBLISHED PAPERS

1. **Mdetele, D**., C. Kassanga, M. Seth and K. Kayunze (2014). Seroprevalence of foot and mouth disease in the wildlife-livestock interface and non-interface areas in Tanzania. *Research Opinion in Animal and Veterinary Science*, 4(4): 208-211.

2. **Mdetele D.,** Kassanga C., Seth M. and Kim Kayunze K. (2014). Socio-Economic Impact of Foot and Mouth Disease in Wildlife-Livestock Interface and Non-Interface Areas in Tanzania. Submitted to the *Tanzania Veterinary Journal*

LIST OF ABREAVIATIONS AND SYMBOLS

%	Percent
<	Less than
>	Greater than
≤	Less than or equal to
≥	Greater than or equal to
½	Half
CF	Complement fixation
CFT	Complement fixation test
CIDB	Centre for infectious disease and biotechnology
DNA	Deoxyribonucleic acid
DVO	District Veterinary Officer
ELISA	Enzyme Linked Immuno Sorbent Assay
FAO	Food and Agriculture Organization
FMD	Foot and Mouth Disease
FMDV	Foot and Mouth Disease Virus
GDP	Gross Domestic Product
Gm	Grams
ID	Identity
LAMP	Loop mediated isothermal amplification
LFOs	Livestock field officers
LPBE	Liquid phase blocking ELISA
MLDF	Ministry of Livestock Development and Fisheries
NSPs	Nonstructural proteins

^{o}C	Degree Celsius
OD	Optic density
OIE	World Organisation for Animal Health
PBS	Phosphate buffer saline
PCR	Polymerase chain reaction
PI	Percentage inhibition
RNA	Ribonucleic acid
SACIDS	Southern African Centre for Infectious Disease Surveillance
SADC	Southern African Development Cooperation
SAT	Southern African Territories
Sec	Seconds
SP	Structural proteins
SPCE	Solid-phase competition ELISA
SPSS	Statistical Package for Social Sciences
TADs	Transboundary Animal Diseases
TVLA	Tanzania Veterinary Laboratory Agency
UK	United Kingdom
WHO	World Health Organization
Yr	Years
µl	microlitre

LIST OF APPENDICES

1.0 GENERAL INTRODUCTION

1.1 Background Information

Foot-and-mouth disease (FMD) is an acute, systemic disease of domestic and wild cloven-hoofed animal species and is caused by *Foot-and-mouth disease virus* (FMDV). The virus (FMDV) is classified within the genus *Aphthovirus* in the family *Picornaviridae* (Rancanielo, 2001). The virus exists in seven serologically and genetically distinguishable types, namely, O, A, C, Asia1, SAT1, SAT2 and SAT3, but a large number of subtypes have evolved within each serotype (Pereira, 1977). Among domesticated species; cattle, pigs, sheep, goats and water buffaloes are animals affected by FMD. Species of cloven-hoofed wildlife may become infected, and the virus has occasionally been recovered from other species as well (OIE, 2009). FMD is characterised by appearance of vesicles on the feet, in and around the oral cavity, and on mammary glands of female animals. Mastitis is a common sequel of FMD in dairy cattle. The severity of clinical signs depends on strain of virus, exposure dose, age and breed of affected animals, host species and immunity of affected animals. Mortality from a multifocal myocarditis is most seen in young than adult animals (OIE, 2009).

The highly contagious nature of FMDV and the associated productivity losses make it a primary animal health concern worldwide. The main constraints in controlling this disease and why it is considered as the most deadly viral disease are its high contagiousness, wide geographical distribution, broad host range, ability to establish carrier status, antigenic diversity leading to poor cross-immunity, and relatively short duration of immunity. Poor surveillance and diagnostic facilities as well as

inadequate control programmes are major problems in control of this disease in Tanzania (Kivaria, 2003). Besides causing direct losses to livestock economy, it also causes indirect losses in terms of severe trade restrictions, impacts which may be higher than direct losses. Effective vaccination and stringent control measures have enabled FMD eradication in most developed countries, which maintain unvaccinated, sero-negative herds in compliance with strict international trade policies. However, the disease remains enzootic in many regions of the world, posing a serious problem for commercial trade with FMD-free countries (Carrillo *et al.*, 2005).

Tanzania is endowed with a large number of animal resources heavily contributing to the wellbeing of her people by providing food security, employment, raw materials, transport/working and manure for crop production. According to 2007/2008 Tanzania livestock census (NBS, 2012), the country has a total of 2,329,942 households raising livestock. Tanzania ranks third in Africa in terms of cattle population after Ethiopia and Sudan with 21,280,875 cattle followed by goats (15,154,121), sheep (5,715,549) and pigs (1,584,411). Yet, livestock diseases, especially transboundary animal diseases (TADs), are threatening the survival of this important resource for survival of a large number of households. Of all the TADs, FMD was mentioned as the most important livestock disease in the Tanzania Livestock Census Report (NBS, 2012). About 73% of livestock populations in Tanzania are in a communal grazing livestock production system while 25% of the livestock population belongs to pure pastoral system and 2% are in semi-commercial production system (Kivaria, 2003). Commercialization is mainly found in highlands, urban and peri-urban areas. Pastoral and agro-pastoral livestock rearing systems are characterized by movement of

livestock from one area to another, and sometimes these livestock are moved and grazed across international borders, in game reserves, forest reserves and national parks. These patterns of livestock movements often follow seasons, the livestock owners moving and settling temporarily in areas where there is abundant pastures and water especially in game reserves, forest reserves and national parks. During these movements, cattle come into close contacts with resident herds at communal grazing and watering points. They also come into contact with wild animals which are mostly regarded as FMDV carriers. Moreover, livestock movements are generated as a result of farmers-livestock keepers' conflicts, cattle rustling, trade, breeding purposes and socio-economic reasons (gifts, debt repayment, and dowry). All movements substantially contribute to the countrywide spread and maintenance of FMD in the livestock population (Msami *et al*., 2006). However, there are forceful movements of pastoralists like eviction of pastoralists from Ihefu, Kilosa, Kilombelo and Nkasi which contributed to uncontrolled movement of livestock to places like Lindi and Ulanga. The movements have high risk of spreading infectious diseases including FMD.

The epidemiology of FMD in Tanzania is complicated by the presence of large numbers and types of wildlife that may harbour FMD-virus, in particular SAT-2 in the African buffalo, *Syncerus caffer* (Dawe *et al*., 1994). Buffaloes are known to harbour FMD viruses (Radostis *et al*., 2000) and are probably the major source of cattle infection in Tanzania. A single buffalo can become infected with all three of the endemic sero-types of FMD virus SAT-1, SAT-2, and SAT-3, posing a threat to other susceptible cloven-hoofed animals (Vosloo *et., al* 2001). FMD outbreaks have also

been confirmed in impala (*Aepyceros melampus*) in Kruger national park (Vosloo *et al.*, 2001) and unconfirmed cases of FMD were reported in giraffe calves (*Giraffa camelopardalis*) in Laikipia in Kenya (OIE, 1997). Thus, a large population of such wildlife present in Tanzania serves as an FMD virus reservoir increasing the risk of FMDV spill over into domestic livestock. On the other hand, it is well documented that domestic cattle are efficient maintenance hosts for FMD viruses (Radostis *et al*., 2000), if control is not maintained. Interaction of wild animals and domestic animals in places like Ngorongoro conservation area complicate the situation in case of introducing control measures for FMD in Tanzania.

The immediate economic impact of FMD in Tanzania is not obvious. Although FMD is endemic in Tanzania, the overall clinical-prevalence is low at about 3% (Shoo *et al*., 1992), presumably as a result of large population of Tanzania shorthorn zebu cattle in which the disease runs a gentle course. FMD is a serious impediment to the national livestock economy for two reasons. There is a constant risk that FMD virus may escape from FMD endemic traditional herds to the high-producing herds in the commercial sector. Secondly, the continual presence of FMD in the traditional sector and wildlife hinder access of livestock and livestock products from Tanzania to high-value international markets.

FMD was first reported in Tanzania in 1927, and efforts to eradicate and /or contain this economically important disease have not been fruitful. Implementation of vaccination programmes and control of livestock movements have not been efficiently executed such that FMD epidemics are still being experienced each year.

The presence of foot-and-mouth disease (FMD) in Tanzania is a major obstacle to the development of the national livestock industry because of its adverse effects on livestock production and on trade of animals and animal products into lucrative export markets. Uncontrolled livestock movements, presence of large populations of wildlife in regular contact with livestock, and general lack of enthusiasm for FMD control among key stakeholders, are some of the factors favouring the persistence of FMD in Tanzania (Kivaria, 2006). However, the extent to which uncontrolled livestock movements and other factors are related to FMD outbreaks is not known. Therefore, the goal of this study was to determine seroprevalence of foot and mouth disease in the wildlife-livestock interface and non-interface areas, to identify associations between livestock movement and other factors responsible for spread of FMD, to determine the extent of the FMD problem among livestock keepers in the two ecosystems and consider the best way of controlling the disease.

1.2 Objectives of the Study

1.2.1 General objectives

The general objectives of the study were to establish seroprevalence of foot-and-mouth disease in wildlife-livestock interface and in non-interface areas in relation to livestock movements and establish its socio-economic impact in Tanzania.

1.2.2 Specific objectives

The specific objectives were to:

(i) Establish seroprevalence of FMD in wildlife livestock interface areas and in non-interface areas.

(ii) Establish the socio-economic impact of FMD in study areas.

2.0 GENERAL MATERIALS AND METHODS

2.1 Study Design

A cross-sectional epidemiological study design was used, whereby households were randomly selected from purposively selected villages in the study districts. Each household was visited for administration of the structured questionnaire that was used and for blood sample collection from animals.

2.2 Study Area

The study areas were wildlife-livestock-interface areas, namely Serengeti ecosystem, Serengeti and Bunda District; and non-wildlife-livestock-interface areas which were central parts of Tanzania, particularly Kongwa District in Dodoma Rigion and Iramba District in Singida Region.

2.3 Sample Size

The sample size was calculated using an estimated prevalence of 45.3% (Chepkwoy *et al*., 2012). The formula is according to Dohoo *et al*. (2003), as follows:

$n = Z^2 P (1-P)/ d^2$, where:

n = required sample size,

z = 1.96 (95% confidence level of significance level),

p = expected prevalence (45.3%),

(1-p) = probability of having no disease,

d = precision level or allowable error (5%), and the design effect of 10%.

Four hundred (400) sera samples collected, 100 serum sample from each district. Moreover, 40 questionnaire copies were used, 10 copies per district.

2.0 CONCLUSIONS AND RECOMMENDATIONS

2.1 Conclusions

The study showed that foot-and-mouth disease is prevalent in Tanzania. Uncontrolled livestock movements resulted into higher prevalence of FMD in Kongwa district compared to districts found in wildlife-livestock interface areas. The disease is highly prevalent in the country. In addition to other factors, less investment in control of Foot-and-Mouth Disease is the major cause of its high prevalence. With such high FMD prevalence, FMD is a serious impediment to livestock production in Tanzania. Livestock keepers from the two ecosystems are traditionally knowledgeable on FMD clinical signs, risk factors as well as seasonality of outbreak.

Moreover, it was observed that there was no significant difference in opinions among livestock keepers from wildlife-livestock interface and non-interface areas as well as among study districts on foot-and-mouth disease impacts. However, higher percentages in case response in every aspect between the two ecological zones indicated the magnitude and feelings of livestock keepers about FMD. In addition to that, low percentage response on vaccine supply cost conveyed the feeling that nothing was being done on controlling the disease by vaccination. Considering the socio-economic impacts of FMD from the study and the importance of the livestock sector to Tanzania, FMD control could result into significant change in poverty

reduction among livestock keepers as well as contribution of the livestock sector to gross domestic product (GDP). Therefore, vaccination and controlled man-made animal movement is the best strategy for control of FMD in Tanzania.

2.2 Recommendations

1. There is need for awareness creation among livestock keepers on the importance of vaccination of animals against FMD, and animals should be vaccinated with appropriate vaccines.
2. Man made controlled livestock movements in association with epidemiological investigation of FMDV spread should be applied in Tanzania.
3. A further study should be conducted at a wider scale on socio-economic impacts of FMD in Tanzania and neighbouring countries.

REFERENCES

Allepuz, A., Stevenson, M., Kivaria, F., Berkvens, D., Casal, J., and Picado, A. (2006). Risk factors for Foot-and-Mouth Disease in Tanzania 2001-2006. *Transiboundary and Emerging diseases online journal* 58 (2011): 44 – 52.

Barasa M., Catley A., Machuchu D., Laqua H., Puot E., Tap Kot D. and Ikiror D. (2008). Foot-and-Mouth Disease Vaccination in South Sudan: Benefit–Cost Analysis and Livelihoods Impact. *Transboundary and Emerging Diseases* **55**:339–351.

Bayissa B., Ayelet G., Kyule M., Jibril Y. & Gelaye E. (2011). – Study on seroprevalence, risk factors, and economic impact of foot-and-mouth disease in Borena pastoral and agro-pastoral system, southern Ethiopia. *Tropical animal health and production* 43(4): 759-766.

Bulman G. and Terrazas M.I. (1976). Effect of foot-and-mouth disease on milk production at a model farm in Cochabamba, Bolivia. *Revista de Medicina Veterinaria*, *Argentina* **57**: 9-10.

Carrillo, C., Tulman, E. R., Delhon, G., Lu Z., Carreno, A., Vagnozzi, A., Kutish, G. F and Rock, D. L. (2005). Comparative Genomics of Foot-and-Mouth Disease Virus. *Journal of Virology* 79 (10): 6487 - 6504.

Chepkwony, E.C., Gitao C.G. and Muchemi G.M. (2012). Seroprevalence of Foot and Mouth disease in the somali Eco-system in Kenya. *International Journal of Animal and Veterinary Advances* 4 (3): 198 – 203.

Dawe, P.S., Flanagan, F.O., Madekurozwa, R.L., Sorenson, K.J., Anderson E.C., Foggin, C.M., Ferris, N.P. and Knowles, N.J. 1994. The natural transmission

of foot and mouth disease virus from African buffalo (*Syncerus caffer*) to cattle in a wildlife area in Zimbabwe. *Veterinary Record* 134: 230-232.

Dohoo, I., Martin, W. and Stryhn, H. (2003). *Veterinary Epidemiology Research*. AVC Inc., Canada, 41 pp.

Gall F.L., and Leboucq N. (2004). The role of animal disease control in poverty reduction, food safety, market access and food security in Africa. *OIE*.

James A.D. and Ellis P.R. (1978). Benefit-cost analysis in foot-and-mouth disease control programmes. *British Veterinary Journal* 134(1) :47-52.

Kivaria, F. M. (2003). Foot and mouth disease in Tanzania: An overview of its national status. *Veterinary Quarterly* **25**: 72–78.

Lembo, T., Kibona, T., Auty, H., Casey, H., Fumagwa, R., Haydon, D., Kassanga, C., Kazwala, R., King, D., Knowless, N., Marsh, T., Mshanda, D., Ngeleja C., Parekh, K., Parida S., Paton D., Reeve, R., Yoder, J., Yongolo, M. and Cleaveland, S. (2012). Patterns of exposure and infection and house hold implication of foot and mouth disease in endemic rural communities of northern Tanzania. *International Symposium on Veterinary Epidemiology and Economics –Book of Abstracts*.

Mdetele D, C Kassanga, M Seth and K Kayunze, (2014). Seroprevalence of foot and mouth disease in the wildlife-livestock interface and non-interface areas in Tanzania. *Research Opinion on Animal and Veterinary Science* 4(4): 208-211.

Mlangwa J. E.D. (1983). Foot-and-mouth disease (FMD) in Tanzania: Some problems associated with its control. *Veterinary Bulletin* 5 (4): 49-59.

National Bureau of Statistics (2012). National sample census of Agriculture, small holder Agriculture Volume III: *Livestock sector National report*.

Nyamrunda, C., Melewas, J. N., Sendalo, D. S., Mtenga, L. A. and Rwezaula, D. A. (2007). Sustaining livestock productivity in challenging tropical environments as a contribution towards achieving millennium development goals. In: *Proceeding of the 2nd Joint Tanzania Veterinary Association and Tanzania Society of Animal Production,* AICC-Arusha, 29 November - 1 December 2007.

OIE, (2000). World Organization for Animal Health. Manual of standards for diagnostic tests and Vaccines. *Office International des Epizootics, Paris*. 86pp.

Paton, D. J, Sumption, K.J, Charleston, B. (2009). Option for control of foot and mouth disease: knowledge, capability and policy. *Philosophical Transactions of the Royal Society Biological sciences* 364: 2657-2667.

Pereira, H.G. (1977). Subtyping of foot-and-Mouth disease virus, *Development in Biological standardization* 35: 167-174.

Perry B, Grace D (2009).The impacts of livestock diseases and their control on growth and development processes that are pro-poor. *Philosophical transaction of the Royal Society series B* 364: 2643-2655.

Perry B.D., Randolph T.F., Ashley S., Chimedza R., Forman A., Morrison J., Poulton C., *et al.* (2003). – The impact and poverty reduction implications of foot and mouth disease control in southern Africa Proceedings of the *10th International Symposium on Veterinary Epidemiology and Economics.*

Perry, B.D. and K.M. Rich, (2007). Poverty impacts of foot-and-mouth disease and the poverty reduction implications of its control. *Veterinary Record* 160: 238-241.

Picado, A., Speybroeck, N., Kivaria, F., Mosha, R. M., Sumaye, R. D., Casal, J. and Berkvens, D. (2011). Foot-and-Mouth Disease in Tanzania from 2001 to 2006. *Transboundary and Emerging Diseases* 58: 44 – 52.

Racaniello, V.R. "*Picornaviridae: the viruses and their replication," in Fields Virolog*. Lippincott Williams &Wilkins, Philadelphia, Pa, USA., 3rd edition 722 PP.

Radostits, O.M., Gay, C.C., Blood, D.C. and Hinchcliff, K.W, (2000). *Veterinary Medicine; A Textbook of Diseases of Cattle, Sheep, Pigs, Goats and Horses.* W.B. Saunders, London., 9th edition 1066 PP.

SNV, 2008. Red meat for local and export markets. Sub sector Analysis Tanzania Draft report.

Tanganyika Department of Veterinary Services (1927). Annual Livestock Investigation report. Government printer, Mpwapwa, Tanganyika. p.18.

Thomson G.R. (1994). *Infectious Disease of Livestock with Special Reference to Southern Africa* . J.A.W Coetzer and G.R. Thomson (Eds.) Oxford University press, Cape Town, London, New York., 992 PP.

Vosloo, W., Boshoff, K., Dwarka, R. and Bastos, A. (2001). The possible role that buffalo played in the recent outbreaks of foot and mouth disease in South Africa. *International Joint Conference, Society for Tropical Veterinary Medicine and the Wildlife Disease Association on Wildlife and Livestock Disease and Sustainability scientific conference* Book of abstracts

www.roavs.com EISSN: 2223-0343
RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Seroprevalence of foot and mouth disease in the wildlife-livestock interface and non-interface areas in Tanzania

[1]Daniel Mdetele[*], [1]Christopher Kassanga, [2,3]Misago Seth and [4]Kim Kayunze

[1]Sokoine University of Agriculture, Faculty of Veterinary Medicine, P. O. Box 3015, Chuo Kikuu Morogoro, Tanzania; [2]The Nelson Mandela African Institution of Science and Technology, School of Life Sciences and Bioengineering, P. O.Box 447, Arusha, Tanzania; [3] National Institute for Medical Research (NIMR), Tanga Medical Research Centre, P.O.Box 5004, Tanga, Tanzania; [4]Sokoine University of Agriculture, Development Studies Institute (DSI), P. O. Box 3024, Chuo Kikuu Morogoro, Tanzania

Abstract

A cross sectional study was conducted in the Serengeti ecosystem (wildlife-livestock interface) and central part of Tanzania (non-interface) area to determine the prevalence of foot and mouth disease (FMD) in Serengeti, Bunda, Kongwa and Iramba Districts. Seroprevalence investigation using 3ABC–ELISA technique indicated that the overall prevalence of antibodies against FMD virus was 66.3%. Significantly high prevalence was recorded in wildlife-livestock interface areas (71.5%) compared to non-interface areas (61.0%). District-wise, higher prevalence was recorded in Kongwa district (89.0%) followed by Serengeti (78.0%), Bunda (65.0%) and Iramba (33.0%). Species-wise, higher prevalence was found in bovines (69.8%), ovines (52.4%) and caprines (11.1%). From various risk factors, ecosystem distribution (X^2 = 4.9308, p = 0.0264) and species distribution (X^2 = 28.3236, P = 0.0001), the results indicated that FMD is highly prevalent in wildlife-livestock interface areas than in non-interface areas. However, uncontrolled livestock movement in Kongwa District resulted into much higher FMD prevalence than in districts where there is wildlife-livestock interface. The presence of antibodies against FMD virus in species other than cattle revealed that there is a need to consider other species in planning for FMD control.

Keywords: Interface; seroprevalence; foot and mouth disease

To cite this article: Mdetele D, C Kassanga, M Seth and K Kayunze, 2014. Seroprevalence of foot and mouth disease in the wildlife-livestock interface and non-interface areas in Tanzania. Res. Opin. Anim. Vet. Sci., 4(4): 208-211.

Introduction

Foot and mouth disease (FMD) is an acute, febrile, systemic disease of domestic and wild cloven-hoofed animal species and is caused by Foot and Mouth Disease Virus (FMDV). The FMDV virus is classified within the genus *Aphthovirus* in the family *Picornaviridae* (Racaniello, 2001). The virus exists in the form of seven serologically and genetically distinguishable types, namely, O, A, C, Asia1, SAT1, SAT2, and SAT3, but a large number of subtypes have evolved within each serotype (Pereira, 1977). Among domesticated species, cattle, pigs, sheep, goats and water buffalo are susceptible to FMD. Species of cloven-hoofed wildlife may become infected, and the virus has occasionally been recovered from other species as well (OIE, 2009). According to World Organization for Animal Health (OIE), FMD ranks first among noticeable infectious diseases of animals (OIE, 2000). The main constraints in controlling this disease and why it is considered as the most dreadful viral disease are its high contagiousness, wide geographical distribution, broad host range, ability to establish carrier status, antigenic diversity leading to poor cross-immunity, and relatively short-lived immunity. The epidemiology of FMD in Tanzania is complicated by presence of a big population of wildlife that may harbour FMDV, in particular SAT in African buffalo

[*]**Corresponding author:** Daniel Mdetele, Sokoine University of Agriculture, Faculty of Veterinary Medicine, P. O. Box 3015, Chuo Kikuu Morogoro, Tanzania. E-mail: daniel.mdetele@sacids.org

(*Syncerus caffer*) (Dawe et al., 1994). Buffaloes are known to harbour FMD viruses (Radostis et al., 2000), and are probably the major source of cattle infection in Tanzania. A single buffalo can become infected with all three of the endemic serotypes of FMD virus SAT-1, SAT-2, and SAT-3, posing a threat to other susceptible cloven-hoofed animals (Vosloo et al., 2001). Thus, the large population of such wildlife present in Tanzania serves as FMDV reservoir, with potential spill-over into domestic livestock. On the other hand, it is well documented that domestic cattle are efficient maintenance hosts for FMD viruses if control is not maintained (Radostis et al., 2000). Poor surveillance and diagnostic facilities as well as inadequate control programmes are major problems in control of this disease in Tanzania and elsewhere (Kivaria, 2003). Effective vaccination and stringent control measures have enabled FMD eradication in most developed countries, which maintain unvaccinated, seronegative herds in compliance with strict international trade policies. However, the disease remains enzootic in many regions of the world, posing a serious problem for commercial trade with FMD-free countries (Carrillo et al., 2005). Interaction between wild and domestic animals pose a great threat in implementing control measure against FMD. This study was conducted in order to determine seroprevalence of FMD in the wildlife-livestock interface and non-interface areas and propose control strategies for FMD in Tanzania.

Materials and Methods

This study was conducted in the wildlife-livestock interface areas of Serengeti ecosystem, which included areas around Serengeti National Park (Serengeti and Bunda districts) and non-interface areas in the Central part of Tanzania (Kongwa and Iramba districts) (Fig. 1). The study was conducted between March and November 2013.

Study design

Study animals were selected from wildlife-livestock interface and non-interface areas in the districts named above. Two hundred (200) animals were selected from wildlife-livestock interface areas and 200 from non-interface areas with 100 animals being selected randomly from each District. All the sampled animals had not been vaccinated against FMD.

A cross-sectional epidemiological study was conducted. The sample size (n) was estimated using estimated prevalence of 45.3% (Chepkwony et al., 2012) and the formula is according to (Dohoo et al., 2003); $n = Z^2 P (1-P)/ d^2$ where n = required sample size, Z = 1.96 (95% confidence level of significance level), P = expected prevalence (45.3%), (1-P) = probability of having no disease, d = precision level or allowable error (5%) and the design effect of 10%. Using this formula, a minimum

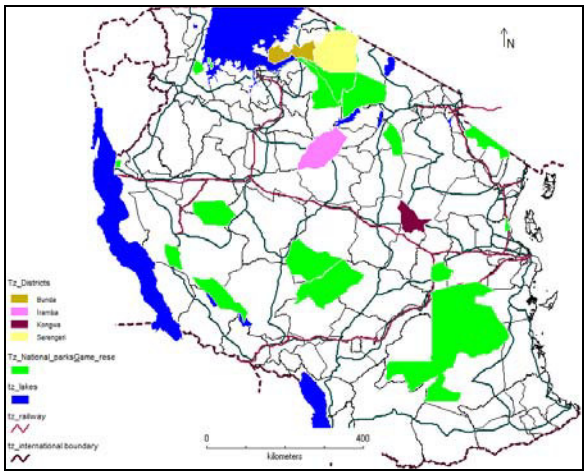

Fig. 1: Map of Tanzania showing study areas and FMD risky factors

sample size of approximately 400 animals was considered sufficient to provide sufficient power for the study. Blood samples were collected and transported under cold chain to the laboratory where serum was separated and stored at -20^0C until testing.

The PrioCHECK® foot and mouth disease virus 3ABC-Ab ELISA kit manufactured by Prionics Lelystad B.V of Netherland designed to detect FMD specific antibodies in sera samples was used according to manufacturer's instructions. Optical density (OD) was measured at 450 nm. According to the principle of this test, the percentage inhibition (PI) value increases with more FMDV antibodies, therefore, where PI was ≥50 that serum sample was regarded as a positive sample and where PI was <50 as an FMD negative sample.

The data collected was analyzed using statistical package SAS. Variation of the prevalence between the two different ecosystems; wildlife-livestock interface and non-interface, was determined using chi-square χ^2 test. In all analyses, confidence level was at 95% and $P<0.05$ set for significance.

Results

Out of 400 sera samples tested for the presence of antibodies to the 3 ABC non-structural protein of FMDV 66.3% (265/400) were positive. The highest prevalence was recorded in wildlife-livestock interface areas; it was significantly different ($X^2 = 4.9308$, $P = 0.0264$) from the prevalence recorded in non-interface areas where the prevalence was 61.0% (122/200) (Table 1). Higher FMD prevalence was recorded in Kongwa District (89%, 89/100) than in Serengeti (78%, 78/100), Bunda (65%, 65/100) and Iramba (33%, 33/100) (Table 2). The difference in FMD prevalence between districts was found to be statistically significant ($X^2 = 78.8372$, $P<0.0001$). Comparing species seroprevalence, the study

Table 1: Seroprevalence of FMD in study area

Location	Number of samples		Serological status		Prevalence
	N	%	Negative	Positive	%
Interface	200	50	57	143	71.50
Non-interface	200	50	78	122	61.00
Total	400	100	135	265	

$X^2 = 4.9308$; P=0.0264

Table 2: Seroprevalence of FMD in the study districts

District	Number of samples		Serological status		Prevalence
	N	%	Negative	Positive	%
Serengeti	100	25	22	78	78.00
Bunda	100	25	35	65	65.00
Kongwa	100	25	11	89	89.00
Iramba	100	25	67	33	33.00
Total	400	100	135	265	

($X^2 = 78.8372$; P<0.0001)

Table 3: Seroprevalence of FMD among species

Specie	Number of samples		Serological status		Prevalence
	N	%	Negative	Positive	%
Bovine	361	90.25	109	252	69.81
Caprine	18	4.5	16	2	11.11
Ovine	21	5.25	10	11	52.38
Total	400	100	135	265	

($X^2 = 28.3236$; P = 0.0001)

revealed a higher prevalence in bovines (69.8%, 252/361) followed by ovine (52.4%, 11/21) and caprine (11.1%, 2/18) (Table 3). The difference among prevalence in species was found to be statistically significant (X^2 = 28.3236, P = 0.0001).

Discussion

The overall prevalence of FMD in the wildlife-livestock interface areas and in non-interface areas was found to be high at 45.3%. A similar study by Lembo et al. (2012) in the northern zone wildlife-livestock interface area found a prevalence of 68% in Serengeti. Seroprevalence of FMD among different species in Serengeti was found to be 77%, 59% and 47% in bovine, caprine and ovine animals respectively, which was slightly different from what was found in this study where FMD prevalence was 69.8% (bovine), 52.4% (ovine) and 11.1% (caprine).

Although high prevalence was found in wildlife-livestock interface areas, Kongwa District not in wildlife-livestock interface area showed higher prevalence of FMD than Districts found in interface areas. This is mainly due to presence of large livestock market bringing animals from various places. Animals from pastoral society are grazing on maize leftovers after harvesting, Kongwa animals grazing in pastoral areas with pastoralists during cropping season as most areas of the district used for maize-growing resulting shortage of land for grazing. On top of that, presence of two major roads crossing the district and the district having favourable environment for resting transported animals make the district to be at high risk of the disease. Allepuz et al. (2006) also described the association between the risks of FMD occurrence and distance to main roads, railway lines, wildlife parks, international borders and cattle density.

In Tanzania, the highest prevalence of FMD has been recorded on pastoral herds (Lembo et al., 2012). The high prevalence can be attributed to lack of effective control measures under-reporting of FMD cases, absence of systematic disease surveillance and control measures like periodic vaccination. FMD is one of the major causes for considerable economic losses of the rural communities in Tanzania. In endemic countries, vaccination is the best control strategy that may be applied with controlled man-made animal movement. Vaccines should be formulated in considering circulating virus serotype and topotypes. However, vaccination programme must cover more than 80% of the susceptible population (OIE, 2000).

In conclusion, the study showed that foot and mouth disease is prevalent in Tanzania. Uncontrolled livestock movements resulted into higher prevalence of FMD in Kongwa district compared to districts found in wildlife livestock interface areas. The disease is highly prevalent in the country because of not investing in control of foot and mouth disease. With such higher FMD prevalence, FMD is a serious impediment to livestock production in Tanzania. Therefore, vaccination and controlled man-made animal movement is the best strategy for control of FMD in Tanzania.

Acknowledgement

The study was supported by Southern African Centre for Infectious Disease Surveillance (SACIDS) and Ministry of Livestock Development and Fisheries, both of which are highly thanked for the support. Moreover, willingness and cooperation of animal keepers and local Government Authorities and all their contributions and supports are gratefully acknowledged.

References

Allepuz, A., Stevenson, M., Kivaria, F., Berkvens, D., Casal, J. and Picado, A. 2006. Risk factors for Foot-and-Mouth Disease in Tanzania, 2001-2006. *Transboundary and Emerging diseases online journal*, 58: 44-52.

Carrillo, C., Tulman, E.R., Delhon, G., Lu Z., Carreno, A., Vagnozzi, A., Kutish, G.F. and Rock, D.L. 2005. Comparative genomics of foot-and-mouth disease virus. *Journal of Virology*, 79: 6487-6504.

Chepkwony, E.C., Gitao, C.G. and Muchemi, G.M. 2012. Seroprevalence of foot and mouth disease in the Somali Eco-system in Kenya. *International Journal of Animal and Veterinary Advances,* 4: 198-203.

Dawe, P.S., Flanagan, F.O., Madekurozwa, R.L., Sorenson, K.J., Anderson, E.C., Foggin, C.M., Ferris,

N.P. and Knowles, N.J. 1994. The natural transmission of foot and mouth disease virus from African buffalo (*Syncerus caffer*) to cattle in a wildlife area in Zimbabwe. *Veterinary Record,* 134: 230-232.

Dohoo, I., Martin, W. and Stryhn, H. 2003. Veterinary Epidemiology Research. 2nd (Ed.) AVC Inc., Canada, P: 41.

Kivaria, F.M. 2003. Foot and mouth disease in Tanzania: An overview of its national status. *Veterinary Quarterly,* 25: 72-78.

Lembo, T., Kibona, T., Auty, H., Casey, H., Fumagwa, R., Haydon, D., Kassanga, C., Kazwala, R., King, D., Knowles, N., Marsh, T., Mshanda, D., Ngeleja C., Parekh, K., Parida, S., Paton, D., Reeve, R., Yoder, J., Yongolo, M. and Cleaveland, S. 2012. Patterns of exposure and infection and house hold implication of foot and mouth disease in endemic rural communities of northern Tanzania. *ISVEE -Book of Abstracts*.

OIE, 2000. World Organization for Animal Health. Manual of standards for diagnostic tests and Vaccines. *Office International des Epizootics, Paris*. P:86.

OIE, 2009. *Terrestrial Manual:* Foot and mouth disease. Chapter 2.1.5. Paton, D.J., Sumption, K.J., Charleston. Option for control of foot and mouth disease: knowledge, capability and policy. *Phil. Trans. R. Soc. B* 364: 2657-2667.

Pereira, H.G. 1977. Subtyping of foot-and-Mouth disease virus. *Development in Biological Standardization*, 35: 167-174.

Racaniello, V.R. Picornaviridae: the viruses and their replication, in Knipe, D.M. and Howley, P.M. (editors), Fields Virology, 3rd edition, Lippincott Williams &Wilkins, Philadelphia, Pa, USA, pp: 685-722.

Radostis, O.M., Gay, C.C., Blood, D.C. and Hinchcliff, K.W. 2000. Veterinary Medicine; A Textbook of Diseases of Cattle, Sheep, Pigs, Goats and Horses. 9th (Ed). W.B. Saunders, London. P:1059-1066.

Vosloo, W., Boshoff, K., Dwarka, R. and Bastos, A. 2001. The possible role that buffalo played in the recent outbreaks of foot and mouth disease in South Africa. *International Joint Conference, Society for Tropical Veterinary Medicine and the Wildlife Disease Association. Wildlife and Livestock Disease and Sustainability:* Book of abstracts. Edited by Kwa Maritane Lodge and Bakubung Bush Lodge Pilanesberg National Park, South Africa.

Socio-economic Impact of Foot and Mouth Disease in Wildlife-Livestock Interface and Non-Interface Areas in Tanzania

[1]Daniel Mdetele*, [1]Christopher Kasanga,[2,3]Misago Seth and[4]Kim Kayunze

[1]Sokoine University of Agriculture, Faculty of Veterinary Medicine, P. O. Box 3015, Chuo Kikuu Morogoro, Tanzania
[2]The Nelson Mandela African Institution of Science and Technology, School of Life Sciences and Bioengineering, P. O.Box 447, Arusha, Tanzania
[3] National Institute for Medical Research (NIMR), Tanga Medical Research Centre, P.O.Box 5004, Tanga, Tanzania
[4]Sokoine University of Agriculture, Development Studies Institute (DSI), P. O. Box 3024, Chuo Kikuu Morogoro, Tanzania
*Corresponding author daniel.mdetele@sacids.org

Abstract

Background: Foot-and-Mouth Disease (FMD) is one of the major trans-boundary animal diseases (TADs) in Tanzania. The disease is an obstacle to development of the livestock sector because of its adverse effects to livestock production and trade of animals and animal products. The study aimed at documenting the social and economic impacts of FMD among livestock keepers in two different ecosystems (Wildlife-livestock interface areas and non interface areas) where pastoral and agro-pastoral modes of livestock rearing are predominant in Tanzania.

Materials and Methods: A cross-sectional study was conducted in Serengeti ecosystem (Wildlife-livestock Interface) and in the Central part of Tanzania (Non-interface) to determine the social and economic impacts of FMD in Serengeti, Bunda, Kongwa and Iramba Districts. A structured questionnaire was administered to 40 households, which included 10 from Serengeti, 10 from Bunda, 10 from Kongwa and 10 from Iramba.

Results: The results showed that, socially, FMD outbreaks impact on food insecurity (85.0%), failure to meet education costs (90.0%) and medical costs (77.5%). Economically, FMD impacts were observed in losses associated with treatment costs (87.5%), milk productivity (85.0%), draught power (80.0%), livestock market loss (67.5) lower weight gain (60.0%), lower fertility (37.5%), abortion (35.0%), death of animals (25.0%) and vaccine supply cost (2.5%). Statistically, there were no significant differences in case responses among livestock keepers from wildlife livestock interface and those from the non-interface area as well among districts of study.

Conclusion: The study found no significant difference in opinion among livestock keepers from wildlife-livestock interface and non-interface areas as well as among study districts on

foot-and mouth-disease impacts. Higher percentages in case responses on social impacts and economic losses indicated magnitude of the problem and feelings of livestock keepers about FMD. However, lower percentage in case response on vaccine supply cost indicated that there is no control of FMD by vaccination.

Key words: Interface, Social economic impact, FMD, Tanzania

Introduction

Foot-and-mouth disease (FMD) is an acute, systemic disease of domestic and wild cloven-hoofed animal species and is caused by Foot and mouth disease virus (FMDV). Among domesticated species; cattle, pigs, sheep, goats and water buffalo are susceptible to FMD. Species of cloven-hoofed wildlife may also become infected, and the virus has occasionally been recovered from other species as well (OIE, 2009). The disease is characterized by high fever, loss of appetite, salivation and vesicular eruptions on feet, mouth and teats (Thomson, 1994). Mastitis is a common sequel of FMD in dairy cattle. The severity of clinical signs varies with the strain of virus, exposure dose, age and breed of animals, host species and immunity of the animal. Mortality from a multifocal myocarditis is most commonly seen in young animals (OIE, 2009). The highly contagious nature of FMDV and the associated productivity losses make it a primary animal health concern worldwide. FMD results in poverty impacts either through production losses caused directly by the disease or the cost implications for FMD prevention (Perry and Rich, 2007).

FMD was first reported in Tanzania since 1927, in Arusha Region and Kahama District (Anonymous, 1927). Since then it has been reported every year, in almost every region. Outbreaks are associated with livestock movements, and it has been observed that major epidemics of FMD in Tanzania occur mostly during dry seasons and immediately after dry seasons, when livestock as well as wildlife congregate at water points. The long distance movement of livestock and wild animals for grazing increases during the drought periods. Besides, there are increased animal movements for slaughter around the end of the year and the time of religious festivals (Kivaria, 2003). During that time, animals are immuno-compromised because of insufficient water, pastures and long distance movement. It is at this time when animals from different places come into contact thereby increasing the risk of spreading the disease. It is also at this time when livestock are grazed illegally in game

reserves and national parks resulting in livestock coming into contact with wild animals which are considered to be carriers of FMDV.

The major problem in controlling FMD in Tanzania and why it is considered as the most dreadful viral disease are its high contagiousness, wide geographical distribution, broad host range, its ability to establish carrier status, antigenic diversity leading to poor cross-immunity, and relatively short duration of immunity. Poor surveillance and diagnostic facilities as well as inadequate control programmes add to the challenges in control of the disease in Tanzania (Kivaria, 2003). Besides causing direct losses to livestock economy, it also causes indirect losses in terms of severe trade restrictions, impacts which may be higher than direct losses (Mlangwa, 1983).

Tanzania's economy is mainly based on agriculture, a sector that employs about 85% of its population. Livestock production, which has been increasing in the past years, is limited by disease occurrence (e.g. FMD) and the presence of tsetse flies in wildlife protected zones in large areas of the country (Picado *et al.,* 2010). Tanzania is endowed with a large number of animal resources heavily contributing to the wellbeing of its people by providing food security, employment, raw materials, transport/working and manure for crop production. According to 2007/2008 Tanzania livestock census (NBS, 2012), the country has a total of 2,329,942 households raising livestock. Tanzania ranks third in Africa in terms of cattle population after Ethiopia and Sudan with 21,280,875 cattle followed by goats (15,154,121), sheep (5,715,549) and pigs (1,584,411). Yet, livestock diseases, especially TADS, are threatening the survival of this important resource for survival of a large number of households. The contribution of livestock sub-sector to total GDP has been recorded to be 4.7 percent and grew at a rate of 4.2 percent, according to 2007/2008 livestock census (NBS, 2012). Out of the livestock share of GDP of 4.7 percent, 40% comes from dairy cattle, 30% from beef cattle and the remaining 30% from shoats, pigs, poultry and game production. This sub-sector contribution is considered far below what would have been expected and most shortcomings can be attributed to presence of animal diseases that affect production and impact on local and international trade of animals and animal products (NBS, 2012). Of all TADS, FMD was mentioned as the most important livestock disease. Therefore, the aim of this study was to determine the extent of the FMD problem among livestock keepers in the two ecosystems and consider the best way of controlling the disease.

Materials and Methods

Study Area

The study was conducted in wildlife-livestock interface areas and non-interface areas in Tanzania. Interface area covered the Serengeti ecosystem, which included areas around Serengeti National park (Serengeti and Bunda Districts). Non-interface areas covered the Central part of Tanzania (Kongwa and Iramba Districts).

Study Design and Sampling

A cross-sectional study design was used, whereby District Veterinary officers (DVOs) from the study areas helped in identification of villages with prevailing and past FMD outbreaks. Villages in wildlife-livestock interface areas as well as those in non-interface areas were randomly selected. From the selected villages, livestock field officers (LFOs) assisted in identifying the households which had more than 10 cattle and other animal species. The households in each village were randomly selected (Lottery Method), and from each household a questionnaire was administered to livestock owners on each herd (household). Therefore, 40 households were interviewed, and the data obtained analyzed using the Statistical Package for Social Sciences (SPSS v16.0).

Results

From the study, the majority of respondents were male with the following proportions: in Serengeti 100%, in Bunda 90%, in Kongwa 80% and in Iramba 80%. The majority of respondents were above 50 years of age with primary school level of education. Most of the respondents had an experience of 11 to 20 years of livestock keeping, and the majority of breeds kept were local breeds managed in agro-pastoral system. The majority of respondents' source of FMD knowledge was traditional, whereby the disease is known as *Salata* in Iramba, *Magaga* in Kongwa, *Isinabi* in Serengeti and *Iyoho* in Bunda. All the respondents were aware of clinical signs as well as sequela features of FMD. However, most of them were not aware of the species of animals affected by the disease. In treatment, the majority used traditional methods to treat the lesions by using Aloe vera, salt and kitchen ashes. However, sometimes they used modern drugs, mostly *Penistrepto* and *Oxytetracycline.*

Livestock keepers' responses regarding social and economic impacts associated with FMD were as it is shown in Tables 1, 2 and 3

Table1: Social impact associated with FMD outbreak case response between interface and non interface area.

Social Impact of FMD out breaks	**Case response %**		**Statistical tests**
	Interface area	**Non interface area**	**Chi-sq(P-Value)**
Food insecurity due to FMD out break	89.5	81	0.568 (0.451)
Failure to meet medical costs due to FMD outbreak	89.5	66.7	2.976 (0.085)
Failure to meet education costs for school children	89.5	90.5	0.011 (0.916)

Table2: Social impact associated with FMD outbreak case response between study districts.

Social Impact of FMD out breaks	**Case response %**				**Statistical test**
	Serengeti	**Bunda**	**Kongwa**	**Iramba**	**Chi-sq(P-Value)**
Food insecurity due to FMD out break	90	90	90	70	2.253(0.502)
Failure to meet medical costs due to FMD outbreak	100	80	80	50	7.312(0.063)
Failure to meet education costs for school children	90	90	90	90	0.000(1.000)

Table 3: Economic impact associated with FMD outbreak case response in study area

Economic Impact of FMD out breaks	Case response %
Milk loss	85
Drought power loss	80
Lower weight gain	60
Animal death	25
Lower fertility	37.5
Treatment costs	87.5
Loss associated with abortion	35
Vaccine supply cost	2.5
Denied Livestock market	67.5
Permanent lameness	22.5

Discussion

In this study, a total of 40 open-ended questionnaire copies were administered face to face to livestock keepers in 4 districts from wildlife-livestock interface and non-interface areas of Tanzania. The data collected showed that FMD was well known to farmers, and they are well acquainted with the traditional knowledge. All the 40 respondents were aware of the disease, its clinical signs, morbidity and mortality with exception of the species of animals affected. The husbandry systems practised in the investigated herds were agro-pastoral with free animal movements. The prominent clinical signs mentioned by most of the farmers interviewed were: presence of vesicles in and around the buccal cavity, anorexia, excessive salivation and lameness; heat intolerance and long hair coat locally known in the Sukuma ethnic group of Bunda District as *luzwiga* and regarded as a sequela to FMD. The questionnaire data showed that FMD outbreaks often occur after rainy seasons (dry seasons), with less extent to rainy season and rare occurrence all the year round, despite variation in climate. It was predominantly encountered with the highest peaks just after long rains (*masika*) in May-June and at the end of short rains (*vuli*) in November-December. Farmers were using salt, crushed sisals mixed with ashes, Aloe vera locally known as *magaka* in the Sukuma ethnic group of Bunda to cure mouth ulcers as a local treatment. Modern treatment was also practised by farmers by applying antibiotics (*Penstreptomycin* and *Oxytetracyclin*) to protect infected animals from secondary bacterial infection. The study showed that the majority of the respondents were males. Normally, in most parts of Tanzania, men dominate and monopolize all means of production systems be it in pastoral or agro-pastoral system. Majority of the respondents were people aged above fifty and had owned animals for up to more than twenty years, something which indicates how experienced they were in livestock management and livestock diseases.

From this study, the average case response percentages on impacts associated with social issues were on food insecurity (85.0%), failure to meet education costs (90.0%) and medical costs (77.5%). These findings are in agreement with those of studies done by Perry *(*2003); Perry *(*1999) and Ellis, (1978) who reported that FMD productivity losses are particularly hard hitting to those that depend upon their stock for traction, particularly where outbreaks in cattle occur during planting season. With that effect, FMD outbreak during farming season limits livestock keepers from using their animals for ploughing. In dry seasons the animals cannot be used for transporting farm products from farms to homesteads and nearby crop market places. In addition to that, quarantine for livestock movement becomes mandatory following an FMD outbreak according to Animal Disease Act of 2003 in Tanzania. This entails closure of formal livestock markets, making it difficult to buy and sell animals. With such effect, livestock keepers are denied with means to raise money to buy food and meet medical, educational and other expenses and utilities.

During the study, it was observed that majority of traditional livestock keepers rely on milk and other milk products in daily meals as can be explained by high case response percentage on economic issues in case of an FMD outbreak, which was found to be 85%. This finding agrees with that of a study by Barasa (2008) who reported that, for many pastoralists, milk provides a vital source of nutrition, particularly in children, accounting for over 50% of gross energy intake. By reducing the supply of milk, FMD impacts on food security, particularly when outbreaks occur during the dry season of the year, when other food sources are in limited supply and dependency upon milk is at its maximum. Moreover, some other studies have also reported that chronic FMD typically reduces milk yields by 80% (Bayissa *et al*. 2011; Bulman & Terrazas, 1976).

Case response percentage of 2.5% on vaccine supply cost on economic impact have agreement with the low contribution of the livestock sector to GDP as it indicates that there are no efforts done to control FMD by vaccination. Considering a study done in other countries on FMD control by vaccination, benefit-cost analysis revealed that effective vaccination-based control of FMD in agro-pastoralist communities of South Sudan could yield $11.5 for every dollar invested. Also, it has been shown that, for every $1 that Zimbabwe disinvests from FMD control, $5 further are lost by the country (Perry *et al*., 2003). Through this study, literature has shown that some countries found in the same

region (SADC) as Tanzania have invested in FMD control through vaccination and benefitted much from the contribution of the livestock sector to those countries' GDP, unlike Tanzania irrespective of number of animals and land size suitable for livestock production. Tables 5, 6 and 7 show trends of exportation of livestock and livestock products from Tanzania and from other African-SADC countries with smaller land suitable for livestock production and less number of livestock compared to Tanzania; yet their livestock sectors contribute much to their GDP.

Table 4: Export of livestock and livestock products (2002-2008) (SNV,2008)

Period (Yearly)	**Product**	**Quantity Kgs/No**	**Value TShs**	**Destination**
2002	Cattle	382	114,600,000	Comoro
	Goats	140	2,800,000	
2003	Cattle	1,714	599,900,000	Comoro and Burundi
	Goat	411	10,275,000	Zanzibar and Comoro
	Sheep	2	40,000	Zanzibar
2004	Cattle	5,293	1,945,640,000	Comoro, Burundi and Zanzibar
	Goats	1,199	35,970,000	Comoro, Burundi and Uganda
	Sheep	2	50,000	Zanzibar
	Beef	1080	1,620,000	Zanzibar and Oman
2005	Cattle	4,075	1,684,550,000	Comoro, Kenya and Zanzibar
	Goats	2,177	65,310,000	Kenya and Comoro
	Beef	600	900,000	Zanzibar
2006	Cattle	6,486	2,808,040,000	Comoro, Kenya and Malawi
	Goats	2,753	96,455,000	Comoro, Malawi and Zanzibar
	Sheep	11	385,000	Zanzibar
	Beef	163	244,500	Oman
	Mutton	20,335	40,670,500	Oman, Dubai and Kuwait
	Goat meat	16,774	33,548,000	Oman, Dubai and Muscat
2007	Cattle	4081	1,906,600,000	Burundi, Comoro and Malawi
	Goats	736	29,440,000	Burundi, Comoro and Malawi
	Beef	10,737	16,105,500	Oman and UAE
	Mutton	76,592	153,184,000	Dubai, Kuwait and Oman
	Goat meat	25,345.5	50,691,000	Dubai, Kuwait and Oman
2008	Cattle	561	384,450,000	Comoro and Zanzibar
	Goats	213	10,650,000	Comoro and Burundi
	Beef	6,234.5	15,588,750	Comoro, DRC and Oman
	Mutton	16,648.5	33,081,200	Kuwait and Oman
	Goat meat	6,861.5	14,093,000	Kuwait and Oman

Table 5: Board of External trade (BET) on imports and Exports 2007 (SNV,2008)

Import/Export ID	Animal Product	Origin/Destination	Value Tshs	Quantity Kgs
Export 0210200	Meat of Bovine animals salted or smoked	Oman	310,973.00	163.00
Imports 0201	Fresh or chilled boneless bovine meat	UK, Italy, Kenya, S.Africa and Netherland	36,110,573.00	9,714.00
0202	Meat of bovine animals frozen	Kenya, Italy, S.Africa, UAE and India	603,430,384.00	72,511.00
1602	Other prepared or preserved meat, meat offal or blood	UAE, Kenya, German, UK, S.Africa, Bulgaria, Italy, China Philippines and Denmark	129,912,202.00	197,371.00

Table 6: Beef export from SADC states to the EU in the period 1995-2000 (Kivaria, 2003 as adopted from Perry *et al.,* 2003).

Country	Amount in Metric tones					
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Botswana	11,966	10,373	11,851	13,012	11,518	11,140
Namibia	10,177	8,546	7,143	8,898	10,365	8,641
Swaziland	379	520	326	303	417	728
Zimbabwe	10,766	6,266	7,120	6,797	6,762	7,047

Socio-economic impacts of FMD do not need much emphasis. A number of studies have already shown its importance. For example, in one study conducted in the UK following the UK's 2001 FMD outbreak, it was estimated that the outbreak cost £ 3.1 billion. US projects about US$ 40 billion losses in case of any FMD outbreak (Ekboir 1999, Thompson *et al.,* 2002*)*. This can almost be corroborated by Kivaria (2003), Perry and Grace (2009) who reported that FMD is the most economically damaging trans-boundary livestock disease worldwide and its control would also benefit the poorest livestock keepers. All these observations are in agreement with the findings of this study recorded in Tables 1, 2 and 3. The findings above are also supported by those of a study conducted by FAO whereby it was

found that, overall, direct losses limit livestock productivity, creating food insecurity and contributing to malnutrition. Furthermore, much of the global FMD burden of production losses falls on the world's poorest communities, and those which are most dependent upon the health of their livestock (FAO-OIE, 2012). In addition to that, a study by Gall and Leboucq, (2004) on questionnaire based survey of African veterinary services found, of all ruminant bacterial and viral diseases FMD have the greatest impact on poverty to livestock keepers.

Conclusion

This study found no significant difference in opinion among livestock keepers from wildlife-livestock interface and non-interface areas as well as among study districts on foot and mouth disease impacts. However, higher percentages in case response for every aspect in both ecological zones indicated the magnitude and feelings of livestock keepers about FMD. Moreover, low percentage response on vaccine supply cost conveyed the feeling that nothing is done on controlling disease by vaccination. Considering the socioeconomic impacts of FMD from the study and the importance of the livestock sector to Tanzania, FMD control could result into significant change in poverty reduction among livestock keepers as well as contribution of the livestock sector to GDP.

Acknowledgement

We wish to acknowledge the cooperation and contribution of animal keepers and local government authorities during administration of structured questionnaire for data colledtion. The work reported here was funded by the Wellcome Trust Grant WT087546MA to the Southern African Centre for Infectious Diseases and Surveillance (SACIDS)and the Ministry of Livestock Development and Fisheries of the United Republic of Tanzania.

REFERENCES

Anonymous. Annual Report, Tanganyika Department of Veterinary Services, 1927; p. 18.

Barasa M., Catley A., Machuchu D., Laqua H., Puot E., Tap Kot D. & Ikiror D. (2008). – Foot-and-Mouth Disease Vaccination in South Sudan: Benefit–Cost Analysis and Livelihoods Impact. *Transboundary and Emerging Diseases*, ***55***, 339–351.

Bulman G. & Terrazas M.I. (1976). – Effect of foot-and-mouth disease on milk production at a model farm in Cochabamba, Bolivia. [Spanish: Consideraciones sobre el efecto de la fiebre aftosa en la producción lacteade un tambo modelo en Cochabamba, Bolivia]. *Revista de Medicina Veterinaria*, *Argentina*, **57**, 1, 1-2, 5-6,9-10.

Gall F.L., & Leboucq N. (2004). – The role of animal disease control in poverty reduction, food safety, market access and food security in Africa. *OIE*.

James A.D. & Ellis P.R. (1978). – Benefit-cost analysis in foot-and-mouth disease control programmes. *British Veterinary Journal*, **134** (1), 47-52.

Kivaria, F. M. (2003). Foot and mouth disease in Tanzania: An overview of its national status. *Vet Q* **25**, 72–78.

Mdetele D, C Kassanga, M Seth and K Kayunze, 2014. Seroprevalence of foot and mouth disease in the wildlife-livestock interface and non-interface areas in Tanzania. Res. Opin. Anim. Vet. Sci., 4(4):208-211.

Mlangwa J. E.D. (1983). Foot-and-mouth disease (FMD) in Tanzania: Some problems associated with its control. *Tanz Vet Bull* 5(4): 49-59.

NBS (2012). National sample census of Agriculure, small holder Agriculture Volume III: Livestock sector National report.

Nyamrunda, C., Melewas, J. N., Sendalo, D. S., Mtenga, L. A. and Rwezaula, D. A. (2007). Sustaining livestock productivity in challenging tropical environments as a contribution towards achieving millennium development goals. In: *Proceeding of the 2nd Joint Tanzania Veterinary Association and Tanzania Society of Animal Production,* AICC-Arusha, 29 November - 1 December 2007.

OIE and FAO www.oie.int/doc/ged/D11888PDF

Perry B, Grace D (2009).The impacts of livestock diseases and their control on growth and development processes that are pro-poor. Philosophical transaction of the Royal Society series B 364:2643-2655 Bayissa B., Ayelet G., Kyule M., Jibril Y. & Gelaye E. (2011). – Study on seroprevalence, risk factors, and economic

impact of foot-and-mouth disease in Borena pastoral and agro-pastoral system, southern Ethiopia.*Tropical animal health and production*, **43** (4), 759-766.

Perry B.D., Randolph T.F., Ashley S., Chimedza R., Forman A., Morrison J., Poulton C., *et al.* (2003). – The impact and poverty reduction implications of foot and mouth disease control in southern Africa Proceedings of the 10th International Symposium on Veterinary Epidemiology and Economics. *Epidemiology*.

Perry, B.D. and K.M. Rich, 2007. Poverty impacts of foot-and-mouth disease and the poverty reduction implications of its control. Vet. Rec., 160: 238-241.

Picado, A., Speybroeck, N., Kivaria, F., Mosha, R. M., Sumaye, R. D., Casal, J. and Berkvens, D. (2011). Foot-and-Mouth Disease in Tanzania from 2001 to 2006. *Transboundary and Emerging Diseases* 58: 44 – 52.

SNV, 2008. Red meat for local and export markets. Sub sector Analysis Tanzania Draft report

Thomson G.R., 1994. Foot and mouth disease. In: J.A.W Coetzer and G.R. Thomson (Eds.). Infectious disease of livestock with special eference to Southern Africa, Oxford University press, Cape Town, London, New York, pp: 825-992.

4: Questionnaire survey

FOOT AND MOUTH DISEASE OUTBREAKS IN TANZANIA: MAPPING AND SOCIO-ECONOMIC IMPACT IN RELATION TO ANIMAL MOVEMENTS IN SELECTED WILDLIFE-LIVESTOCK INTERFACE AREAS

INTERVIEW SCHEDULE FOR INDIVIDUALS

SECTION A: STUDY AREA PROFILE AND ADMINISTRATION

Name of Interviewer……

Date: Day……..Month……Year……

Village….....……

Ward……

District……

Region…….

GPS.....

SECTION B: RESPONDENT PARTICULARS

1: Name of respondent…….

2: Sex of respondent: 1. Male ( ) 2.Female ( )

3: Age of respondent (years)…….

4: Level of education: 1.No formal education……2.Primary education…… 3.Secondary education…….. 4. Higher education……..

5: Main economic activities of respondent (Allow multiple responses): 1.Most practiced 6. Least practiced.

S/No	Economic activity	Participant response	Rank
1	Crop farming		
2	Livestock keeping and crop farming		
3	Livestock keeping only		

4	Salaried employment		
5	Livestock Business		
6	Other specify		

6: Respondent position in a family: 1.Father…. 2.Mother ……3.Chidrean…. 4.salary worker….5.Visitor…...

7: Years in livestock management……

8: Type of animals kept? (Allow multiple responses)

1. Sheep…… 2. Goat…… 3.Cattle ……4.Pigs.....

9: Breeds of livestock kept 1.Local..... 2. Exotic .....

10: Management system 1. Zero grazing..... 2. Ranching ..... 3. Agro pastoral ..... 4. Pastoral.....

SECTION C: GRAZING PATTERN, WATERING, HOUSING, MOVEMENT, TRADE

11: How do you graze your animals during rainy season? 1. Communal land ( ) 2.Private land ( ) 3.Protected land ( )

12: How do you graze your animals during draught season? 1. Communal land ..... 2. Private land..... 3. Protected land .....

13. Distance from residence to grazing area and watering area 1. Rain season..... 2. Draught season.....

14: How do animals drink water? 1. Communal points ( ) 2.Private points ( ) 3. Protected land ( )

15: Have you ever grazed your animals in protected area 1. Yes..... 2. No.....

16: Have you introduced any new animal for the past five years? 1. Yes…… 2.No……

17: If yes, how did you get new animals? 1. Most used means 5. Least used means

S/No	Means/ways used	Rank	Number of animal introduced		
			Cattle	Goat	Sheep
1	Buying				
2	Gift				

3	Bride price				
4	Temporary stocking				
5	Other means				

18: Have you recently moved any animal away from your village? 1. Yes…..2.No……..

19: If yes, did you get movement permit? 1. Yes…….. 2. No……

20: Where do you sell your animals? 1. Livestock local market…. 2. Nearby district…..3.Nearby country……..4.At home…….5.Other…….

21: How do you dip your animals? 1. Communal dip...… 2. Spray race….. 3. Private….

22: Do you have veterinary health centre in your area? 1. Yes……. 2. No…….

23: If yes, how frequently does livestock field officer visit your herd in a month?

1. Once…….. 2. Twice……. 3. Thrice……4.Other…….

24: Do you consult/call a livestock field officer for animal health services? 1. Yes……. 2. No…….

25: Qualification of LFO? 1. AHPC……2.AHD……3.AGC.....4.Other..... (Specifie)

26: Do you have livestock market around? 1. Yes…… 2.No……..

27: How frequent you visit livestock market 1.Weekly..... 2. Every 2 weeks.... 3. Monthly.....

SECTION D: DISEASES OF CATTLE,GOATS, SHEEP AND PIGS

28: What are the main diseases of cattle goats sheep and pig prevalent in your area? 1.FMD……..2. CBPP…… 3. Tickborn.....4. Helminthosis…… 5. Other specify……

29:What were the main clinical signs of the disease mentioned in 28……
……
……

30: Do you know the disease called FMD? 1. Yes…… 2. No…….

31: If yes, what was the source of Knowledge? 1. Livestock officer…… 2.Traditional…… 3.Media…….. 4. Fellow farmers…… 5. Others…….

32: What are animals most affected with disease 1. Goat..... 2. Cattle..... 3. Sheep..... 4.pig.....

33: Is the disease in D1 happened to affect your flock. 1. Yes…….. 2. No…….

34: If yes, when did it occur (Month)…….

35: During the outbreak of disease which age mostly affected ? Rank 1.Most affected 2. Moderately 3. Least affected

S/No.	Age Affected	Rank	Number died
1	Newborns		
2	Weaners		
3	Adults		

36: Is the disease occur frequently? 1. Yes…… 2.No…… 3.Don't know……..

37: What is the local name for disease .....

38: What are predominant clinical signs 1. Mouth..... 2. Foot.....

39: What are complication associated with FMD after recovery 1. Hair..... 2.Behaviour.....

40: Can you estimate the ratio of animal which get disease and animals die during outbreak ?

S/n	Morbidity (High/Low)	Morbidity (High/Low)	Mortality (High/low)	
1	Cattle			
2	Sheep			
3	Goats			
4	Pigs			

SECTION E : DISEASE SPREADING

41: Is FMD outbreak associated with the following features?

S/N	Risk factors	Yes	No
1	Livestock market		
2	Communal Grazing area		

3	Grazing on protected areas		
4	Dipping		
5	Visiting/visited/professionals from infected herds		
6	Introducing infected animal		
7	Drugs used to treat animals		
8	Wind		
9	Others		

SECTION F: FMD CONTROL

42: Which methods are you using to treat and control the FMD in your flock?

S/No.	Treatment and control	Response
1	Local treatment	
2	Conventional treatment	
3	Local control	
4	Conventional control	
5	Other specify	

43: During the outbreak of the disease in question D3 do you also vaccinate your animals. 1. Yes…….. 2. No……..

44: What is the source of vaccine used in your farm? 1. Neighbouring country……... 2. Government of Tanzania……..3. Private companies…… 4. Other specify……..

45: If ever participated in vaccination against FMD, how many times this was done and when?

S/No.	Frequency of vaccination	Reponses
1	Once	
2	Twice	
3	Thrice	

4	Other	

46: What are your experience /comment on the effectiveness of FMD vaccination? 1. Very effective…… 2. Not effective…… 3. Not sure…… 4. Other ……

SECTION G: SOCIAL ECONOMIC IMPACT ASSOCIATED WITH FMD OUTBREAK

47: Are the following losses common during FMD outbreak ?

S/N	Loss	Yes	No
1	Milk production		
2	Draught power		
3	Lower weight gain		
4	Dead animals		
5	Lower fertility		
6	Treatment cost		
7	Abortion		
8	Vaccination		
9	Vaccine delivery and storage		
10	Movement control		
11	Denied market		
12	Permanent lameness		

48: Quantify the named losses in Tanzanian shillings per animal.

S/N	Loss	Quantity
1	Milk production	
2	Draught power	

3	Lower weight gain	
4	Dead animals	
5	Lower fertility	
6	Treatment cost	
7	Abortion	
8	Vaccine	
9	Vaccine delivery and storage	
10	Movement control	
11	Denied market	
12	Permanent lameness	

49: Are you willing to pay for control of this disease 1) yes..... 2) No .....

50: How much can you pay per animal regarding the importance of disease.....

SECTION H: SOCIO-ECONOMIC WELL-BEING

51: Have you ever experienced any problems regarding the following issues during FMD outbreak?

S/N	Social well being	Yes	No
1	Fail to have meals as used to be in a family		
2	Fail to take a member of family to hospital when is sick		

3	Fail to pay school fees for secondary school children		
4	Fail to be self sufficient in crops in next season		
5	Fail to have water at house hold		

52: Kindly please explain/ give remarks on how the mentioned social well being problem come in because of FMD.

S/N	Social well being	Remarks
1	Fail to have meals as used to be in a family	
2	Fail to take a member of family to hospital when is sick	
3	Fail to pay school fees for secondary school children	
4	Fail to be self sufficient in crops in next season	
5	Fail to have water at house hold	

53:Other opinion…….....
.....
.....
.....
.....

File in Field Training and b.M.L

Ag CE - TVLA
7/8/2013

Zonal Veterinary Centre –Mwanza,

P.O Box 129,

Mwanza.

05/08/2013

Ref: No. MLDF/PF.9690.

RECEIVED
Date 06/08/2013

Chief Executive Officer,

TVLA ,

P.O Box 9254,

Dar es salaam.

U.F.S Director of Veterinary services,

Ministry of Livestock Development and Fisheries,

P.O Box 9152,

Dar es salaam.

It is highly recommended that you facilitate the applicant to fulfil his research work.

Ag DVS
05/08/2013

RE: USE OF TVLA LABORATORY IN MY FMD RESEARCH WORK

Kindly please refer to the heading above.

I, Daniel Mdetele employee of Ministry of Livestock development and fisheries at ZVC –Mwanza and studying Masters degree by research at Sokoine University of Agriculture department of Microbiology and parasitology majoring in Virology. I'm requesting your permission to use the TVLA laboratory facilities (CIDB) on my research work. I will be analyzing Foot and mouth disease sample at different time within six month from now. I have 400 sera sample which was collected from Serengeti, Bunda, Kongwa and Iramba districts.

Thanks in advance.

Yours sincerely,

Daniel Mdetele (BVM)

2. M-CIDB

Permission is hereby granted for Dr. Mdetele to undertake his field attachment at CIDB. Kindly grant him the necessary cooperation.

Ag DTD 07/08/2013

NSP ELISA PLATE LAYOUT

SHEET NUMBER: (1)
NAME/ID OF SAMPLES TESTED: Serengeti
PLATE NUMBER: (1) 236
DATE TESTED: STARTING TIME / / 2013, FINISHING TIME / / 2013
ROOM TEMPERATURE: (1)
HUMIDITY: ( )
RESULTS: DATE ISSUED / / 2013 AND DATE APPROVED / / 2013
TEST CONDUCTED BY: (1)..... (2).....
(3)..... (4)..... (5).....

	1	2	3	4	5	6	7	8	9	10	11	12
A	nc	3	11	19	27	35	43	51	59	67	75	83
B	nc	4	12	20	28	36	44	52	60	68	76	84
C	wpc	5	13	21	29	37	45	53	61	69	77	85
D	wpc	6	14	22	30	38	46	54	62	70	78	86
E	pc	7	15	23	31	39	47	55	63	71	79	87
F	pc	8	16	24	32	40	48	56	64	72	80	88
G	1	9	17	25	33	41	49	57	65	73	81	89
H	2	10	18	26	34	42	50	58	66	74	82	90

Serengeti

NAME/ ID OF SAMPLES TESTED: Bunda
PLATE NUMBER: (2) 247
DATE TESTED: STARTING TIME / / 2013, FINISHING TIME / / 2013
DATE TESTED: / / 2013
ROOM TEMPERATURE: ( )
HUMIDITY: ( )
RESULTS: DATE ISSUED / / 2013 AND DATE APPROVED / / 2013
TEST CONDUCTED BY: (1)..... (2).....
(3)..... (4)..... (5).....

	1	2	3	4	5	6	7	8	9	10	11	12
A	nc	3	11	19	27	35	43	51	59	67	75	83
B	nc	4	12	20	28	36	44	52	60	68	76	84
C	wpc	5	13	21	29	37	45	53	61	69	77	85
D	wpc	6	14	22	30	38	46	54	62	70	78	86
E	pc	7	15	23	31	39	47	55	63	71	79	87
F	pc	8	16	24	32	40	48	56	64	72	80	88
G	1	9	17	25	33	41	49	57	65	73	81	89
H	2	10	18	26	34	42	50	58	66	74	82	90

Bunda

NSP ELISA PLATE LAYOUT

SHEET NUMBER: (2)
NAME/ID OF SAMPLES TESTED: Kongwa
PLATE NUMBER: (3) 248
DATE TESTED: STARTING TIME / / 2013, FINISHING TIME / / 2013
ROOM TEMPERATURE: ( )
HUMIDITY: ( )
RESULTS: DATE ISSUED / / 2013 AND DATE APPROVED / / 2013
TEST CONDUCTED BY: (1)..... (2).....
(3)..... (4)..... (5).....

	1	2	3	4	5	6	7	8	9	10	11	12
A	nc	3	11	19	27	35	43	51	59	67	75	83
B	nc	4	12	20	28	36	44	52	60	68	76	84
C	wpc	5	13	21	29	37	45	53	61	69	77	85
D	wpc	6	14	22	30	38	46	54	62	70	78	86
E	pc	7	15	23	31	39	47	55	63	71	79	87
F	pc	8	16	24	32	40	48	56	64	72	80	88
G	1	9	17	25	33	41	49	57	65	73	81	89
H	2	10	18	26	34	42	50	58	66	74	82	90

Kongwa

NAME/ ID OF SAMPLES TESTED: Iramba
PLATE NUMBER: (4) 475
DATE TESTED: STARTING TIME / / 2013, FINISHING TIME / / 2013
DATE TESTED: / / 2013
ROOM TEMPERATURE: ( )
HUMIDITY: ( )
RESULTS: DATE ISSUED / / 2013 AND DATE APPROVED / / 2013
TEST CONDUCTED BY: (1)..... (2).....
(3)..... (4)..... (5).....

	1	2	3	4	5	6	7	8	9	10	11	12
A	nc	3	11	19	27	35	43	51	59	67	75	83
B	nc	4	12	20	28	36	44	52	60	68	76	84
C	wpc	5	13	21	29	37	45	53	61	69	77	85
D	wpc	6	14	22	30	38	46	54	62	70	78	86
E	pc	7	15	23	31	39	47	55	63	71	79	87
F	pc	8	16	24	32	40	48	56	64	72	80	88
G	1	9	17	25	33	41	49	57	65	73	81	89
H	2	10	18	26	34	42	50	58	66	74	82	90

Iramba

NSP ELISA PLATE LAYOUT

SHEET NUMBER: ( )
NAME/ID OF SAMPLES TESTED: Serengeti, Bunda, Kongwa & Iramba
PLATE NUMBER: (5) 476
DATE TESTED: STARTING TIME / / 2013, FINISHING TIME / / 2013
ROOM TEMPERATURE: ( )
HUMIDITY: ( )
RESULTS: DATE ISSUED / / 2013 AND DATE APPROVED / / 2013
TEST CONDUCTED BY: (1)..... (2).....
(3)..... (4)..... (5).....

	1	2	3	4	5	6	7	8	9	10	11	12
A	nc	93	91	99	97	95	93					
B	nc	94	92	100	98	96	94					
C	wpc	95	93	91	99	97	95					
D	wpc	96	94	92	100	98	96					
E	pc	97	95	93	91	99	97					
F	pc	98	96	94	92	100	98					
G	91	99	97	95	93	91	99					
H	92	100	98	96	94	92	100					

NAME/ ID OF SAMPLES TESTED: .....
PLATE NUMBER: ( )
DATE TESTED: STARTING TIME / / 2013, FINISHING TIME / / 2013
DATE TESTED: / / 2013
ROOM TEMPERATURE: ( )
HUMIDITY: ( )
RESULTS: DATE ISSUED / / 2013 AND DATE APPROVED / / 2013
TEST CONDUCTED BY: (1)..... (2).....
(3)..... (4)..... (5).....

	1	2	3	4	5	6	7	8	9	10	11	12
A	nc											
B	nc											
C	wpc											
D	wpc											
E	pc											
F	pc											
G												
H												

Where 1st - 91 — 100 - Serengeti
2nd - 91 — 100 - Bunda
3rd - 91 - 100 - Kongwa
4th — 91 - 100 - Iramba.

PrioCHECK® FMDV NS

ELISA for *in vitro* detection of antibodies against Foot and Mouth Disease Virus in serum of cattle, sheep, goats and pigs

5 plate kit for 450 samples

Version 1.0_e

Package Insert

For *in-vitro* veterinary diagnostic use only
Store at 5±3°C
Product No.: 7610440

Introduction

Foot and Mouth Disease (FMD) is the most important economic threat to the livestock industry. The highly contagious disease affects all cloven-hoofed animals and is wide-spread over the world. The FMD viruses are classified into 7 distinct serotypes which makes diagnosis using conventional serological methods complex. To control outbreaks in the future emergency vaccination will be carried out. Vaccines consist of (partly) purified structural proteins of the FMD virus and therefore vaccinated animals only elicit antibodies directed against the structural proteins of the virus. However, after infection with FMDV, antibodies directed against the structural and the non-structural proteins are produced. Therefore an ELISA detecting antibodies against non-structural proteins of FMDV detects not only infected animals but also discriminates between infected and vaccinated animals.
The PrioCHECK® FMDV NS detects antibodies directed against the non structural 3ABC protein of FMDV. The ELISA detects FMDV infected animals independent of the serotype that causes the infection and independent of the fact that the animal is vaccinated or not. The ELISA can be used to test serum samples of cattle, sheep, goats and pigs.

Test Principle

The PrioCHECK® FMDV NS is a blocking ELISA. The Test Plates are coated with 3ABC specific monoclonal antibody (mAb), followed by incubation with antigen (3ABC protein). Consequently, Test Plates of the kit contain FMDV NS antigen captured by the coated mAb.
The test is performed by dispensing the test samples to the wells of a Test Plate. After incubation the plate is washed and the Conjugate is added. FMDV NS specific antibodies, directed against the non-structural proteins, that may be present in the test sample will bind to the 3ABC protein and will block the binding of the mAb-HRPO. After incubation, the plate is washed and the Chromogen (TMB) Substrate is dispensed. After incubation at room temperature (22±3°C) the color development is stopped. Color development measured optically at a wavelength of 450 nm shows the presence of antibodies directed against Foot and Mouth Disease Virus.
The PrioCHECK® FMDV NS is a single dilution test. Serum samples are tested in a 1:5 dilution.

Kit Components

Store kit at 5±3°C until expiry date. See kit label for actual expiry date. The shelf life of diluted, opened or reconstituted components is noted below, when appropriate. Chemical hazard data are available in section "Safety Regulations and R&S Statements" (Appendix II).

Component 1
Test Plate
Five Test Plates are delivered in bags which contain a desiccant sachet.

Component 2
Conjugate (30x)
(30x concentrated, dilute before use).
One vial contains 2.5 ml Conjugate.
Diluted conjugate is not stable, prepare just before use.

Component 3
Dilution Buffer (2x)
(2x concentrated, dilute before use). One vial contains 60 ml Dilution Buffer.
Shelf life of the dilution buffer working solution: 24 hours at 5±3°C.

Component 4
Additive (lyophilized)
(Reconstitute and dilute before use).
Five vials, each contains 2.5 ml lyophilized Additive.
Shelf life of reconstituted additive: until expiry date at -20°C.

Component 5
Demineralized Water
Two vials, each contains 10 ml Demineralized Water.

Component 6
Washing Fluid (200x)
(200x concentrated, dilute before use). One vial contains 60 ml Washing Fluid.
Shelf life of washing solution: 1 week at 22±3°C.

Component 7
Positive Control (Ready-to-use)
One vial contains 0.6 ml Positive Control.

Component 8
Weak Positive Control (Ready-to-use)
One vial contains 0.6 ml Weak Positive Control.

Component 9
Negative Control (Ready-to-use)
One vial contains 0.6 ml Negative Control.

Component 10
Chromogen (TMB) Substrate (Ready-to-use)
One vial contains 60 ml Chromogen (TMB) Substrate.

Component 11
Stop Solution (Ready-to-use)
One vial contains 60 ml Stop Solution.

Additional Kit Contents:
- Package Insert
- 10 plate sealers
- Certificate of Analysis

Additional Material Required

General:
Laboratory equipment according to national safety regulations.

Analysis of Results:
Plate Reader e.g. Multiscan EX or equivalent.
The reader has to have an appropriate filter set to read the plates at 450 nm.

Optional:
Plate washer e.g. Tecan EIA Tray Washer or equivalent.

Test Procedure

Precautions
National guidelines for working with animal samples must be strictly followed. The PrioCHECK® FMDV NS must be performed in laboratories suited for this purpose.
Samples should be considered as potentially infectious and all items which contact the samples as potentially contaminated.
Chemical hazard data are available in section "Safety Regulations and R&S Statements" (Appendix II).

Notes
To achieve optimal results with the PrioCHECK® FMDV NS, the following aspects must be considered:

- **The Test Procedure protocol must be strictly followed.**
- All reagents of the kit must be equilibrated to room temperature (22±3°C) before use.
- Pipette tips have to be changed for every pipetting step.
- Separate solution reservoirs must be used for each reagent.
- Kit components must not be used after their expiry date or if changes in their appearance are observed.
- Kit components of different kit lot numbers must not be used together.
- Demineralized or water of equal quality must be used for the test.

SOLUTIONS TO BE MADE IN ADVANCE

Dilution buffer working solution
Dilute Dilution Buffer (2x) (Component 3) 1/2 in demineralized water; e.g. for one Test Plate prepare 24 ml (add 12 ml Dilution Buffer (2x) to 12 ml demineralized water). Can be stored at 5±3°C for up to 24 hours.

Additive
Equilibrate the vial to 22±3°C and reconstitute [1] the Additive (Component 4) with 2.5 ml Demineralized Water (Component 5). Can be stored at -20°C until expiry date.

ELISA buffer
Dilute reconstituted additive 1/10 in dilution buffer working solution; e.g. for one Test Plate prepare 24 ml (add 2.4 ml reconstituted additive to 21.6 ml dilution buffer working solution). Unused ELISA buffer can be stored at 5±3°C for up to 24 hours.

Conjugate dilution
Dilute Conjugate (30x) (Component 2) 1/30 in ELISA buffer; e.g. for one plate prepare 12 ml (add 400 µl Conjugate (30x) to 11.6 ml ELISA buffer).
Note: The diluted conjugate must be prepared just before use.

Washing solution
Dilute Washing Fluid (200x) (Component 6) 1/200 in demineralized water. The amount of Washing Fluid is sufficient to prepare a final volume of 12 liters washing solution.
Stability of washing solution: 1 week stored at 22±3°C.

[1] Reconstitution of the lyophilized Additive should be performed as follows:
- Equilibrate the vial to 22±3°C.
- With the vial in an upright position, tap the vial gently against the worktop to ensure that the content is on the bottom of the vial.
- Carefully open the vial.
- Add the specified amount of Demineralized Water (Component 5).
- Replace the stopper on the vial and allow the lyophilized material to dissolve.
- Gently agitate the vial so that any remaining dry material will be dissolved.
- Allow the material to stand at least for 15 minutes at 22±3°C before use.
- Mix gently and intermittently (formation of foam should be avoided).

Remark: Commercial available ELISA washers can be used. If not available, washing of the plates can be done by dispensing at least 200 µl of washing solution to all wells of the plate. Subsequently, empty the plate and repeat as many times as prescribed. It is not necessary to soak the plate between washings. Tap the plate firmly after the last washing step.

DAY 1

INCUBATION WITH TEST SERUM

1.1 Dispense 80 µl ELISA buffer to all wells of the Test Plate (Component 1).
1.2 Dispense 20 µl of Negative Control (Component 9) to wells A1 and B1.
1.3 Dispense 20 µl of Weak Positive Control (Component 8) to wells C1 and D1.
1.4 Dispense 20 µl of Positive Control (Component 7) to wells E1 and F1.
1.5 Dispense 20 µl of test samples to the remaining wells.
1.6 Seal the Test Plate using the enclosed plate sealers.
1.7 Shake the Test Plate gently.
1.8 Incubate overnight (16–18 hours) at 22±3°C.

DAY 2

INCUBATION WITH CONJUGATE

2.1 Empty the Test Plate after the incubation period and wash the plate 6 times with 200 to 300 µl washing solution. Tap the plate firmly after the last washing step.
2.2 Dispense 100 µl of diluted conjugate to all wells.
2.3 Seal the Test Plate using the enclosed plate sealers.
2.4 Incubate 60±5 minutes at 22±3°C.

INCUBATION WITH CHROMOGEN (TMB) SUBSTRATE

3.1 Empty the Test Plate after the incubation period and wash the plate 6 times with 200 to 300 µl washing solution. Tap the plate firmly after the last washing step.
3.2 Dispense 100 µl of Chromogen (TMB) Substrate (Component 10) to all wells.
3.3 Incubate 20 minutes at 22±3°C.
3.4 Add 100 µl of Stop Solution (Component 11) to all wells.
3.5 Mix the content of the wells of the Test Plate prior to measuring.

Note: Start the addition of Stop Solution 20 minutes after the first well was filled with Chromogen (TMB) Substrate. Add the Stop Solution in the same order and at the same pace as the Chromogen (TMB) Substrate was dispensed.

READING OF THE TEST AND CALCULATING THE RESULTS

4.1 Measure the optical density (OD) of the wells at 450 nm within 15 minutes after color development has been stopped.
4.2 Calculate the mean OD_{450} value of wells A1 and B1 (Negative Control = OD_{450} max).
4.3 The percentage inhibition (PI) of the Controls and the test sera are calculated according to the formula below.

The OD_{450} values of all samples are expressed as Percentage Inhibition (PI) relative to the OD_{450} max.

$$PI = 100 - \left[\frac{OD_{450}\ \text{test sample}}{OD_{450}\ \text{max}} \right] \times 100$$

RESULT INTERPRETATION

Validation criteria
5.1 The OD_{450} max (mean OD_{450} of the Negative Control) must be >1.000.
5.2 The mean percentage inhibition of the Weak Positive Control must be >50%.
5.3 The mean percentage inhibition of the Positive Control must be >70%.
5.4 Not meeting any of these criteria is reason to discard the results of that specific Test Plate.

Note: If the OD_{450} of a test sample is higher than the OD_{450} max, the Percent Inhibition can be interpreted as 0%. If the mean OD_{450} of the Negative Control is below 1.000 possibly the Chromogen (TMB) Substrate is too cold. In that case warm the solution to 22±3°C or incubate up to 30 minutes. If the mean OD_{450} of the Negative Control is above 2.000 a shorter incubation period with the Chromogen (TMB) Substrate is recommended.

Interpretation of the percent inhibition

PI = <50% (negative)
Antibodies against the NS protein of FMDV are absent in the test sample.

PI = ≥50% (positive)
Antibodies against the NS protein of FMDV are present in the test sample.

Appendix I

Notice
This manual is believed to be complete and accurate at the time of publication. In no event shall Prionics AG be liable for incidental or consequential damage in connection with or arising from the use of this manual.

Liability
Prionics AG warrants its products will meet their applicable published specification when used in accordance with their applicable instructions and within the declared products life time. Prionics AG makes no other warranty, expressed or implied. There is no warranty of merchantability or fitness for a particular purpose. The warranty provided herein and the data, specifications and descriptions of Prionics AG products appearing in Prionics AG published catalogues and product literature may not be altered except by express written agreement signed by an officer of Prionics AG. Representation, oral or written, which are inconsistent with this warranty or such publications are not authorized and if given, should not be relied upon.
In the event of a breach of the foregoing warranty, Prionics AG's sole obligation shall be to repair or replace, at its option, the applicable product or part thereof, provided the customer notifies Prionics AG promptly of any such breach. If after exercising reasonable efforts, Prionics AG is unable to repair or 2) replace the product or part, then Prionics AG shall refund to the customer all monies paid for such applicable product or part.

Prionics AG shall not be liable for consequential, incidental, special or any other indirect damages resulting from economic loss or property damage sustained by any customer from the use of its products.

Prionics AG and Prionics Lelystad B.V. are ISO 9001:2000 certified companies.

Appendix II

Safety Regulations and R&S Statements

National Safety Regulations must be strictly followed.

R&S Statements

Component 1
Test Plate
Hazard Code: This product is not classified according to EU regulations.

Component 2
Conjugate (30x)
Hazard Code: This product is not classified according to EU regulations.

Component 3
Dilution Buffer (2x)
Hazard Code: This product is not classified according to EU regulations.

Component 4
Additive (lyophilized)
Hazard Code: This product is not classified according to EU regulations.

Component 5
Demineralized Water
Hazard Code: This product is not classified according to EU regulations.

Component 6
Washing Fluid (200x)
Hazard Code: This product is not classified according to EU regulations.

Component 7
Positive Control (Ready-to-use)
Hazard Code: This product is not classified according to EU regulations.

Component 8
Weak Positive Control (Ready-to-use)
Hazard Code: This product is not classified according to EU regulations.

Component 9
Negative Control (Ready-to-use)
Hazard Code: This product is not classified according to EU regulations.

Component 10
Chromogen (TMB) Substrate (Ready-to-use)
Hazard Code: This product is not classified according to EU regulations.

Component 11
Stop Solution (Ready-to-use)
Hazard Code: R35: Causes severe burns.
S26: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39: Wear suitable protective clothing, gloves and eye/face protection.
S45: In case of accident or if feel unwell, seek medical advice immediately (show label on vial).

Appendix III

References
1) Sørensen K.J., Madsen K.G., Madsen E.S., Salt J.S. Nqindi J. Mackay D.K.J.
Differentiation of infection from vaccination in foot-and-mouth disease by the detection of antibodies to the non-structural proteins 3D, 3AB and 3ABC in ELISA using antigens expressed in baculovirus.
Arch Virol (1998) 143: 1461-1476

Contact

Prionics Lelystad B.V.
Platinastraat 33
P.O. Box 2271
NL-8203 AG Lelystad
The Netherlands
Tel. +31 320 714000
Fax +31 320 714029

Prionics AG
Wagistrasse 27a
CH-8952 Schlieren-Zurich
Switzerland
Tel. +41 44 200 2000
Fax +41 44 200 2010
www.prionics.com
info@prionics.com

0765
015878

For our distribution network, please refer to www.prionics.com