The Risk of Foot and Mouth Disease Entering China through the Movement of Animals from Upper Mekong Region Countries

CAI Chang

BAgr (Vet Med), MVSt (Vet Surv)

School of Veterinary and Biomedical Sciences

Faculty of Health Sciences, Murdoch University

Western Australia

This thesis is presented for the degree of Doctor of Philosophy
Murdoch University, 2012

DECLARATION

I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution.

Signature_ _____

Family Name: CAI

Given Name: CHANG

ABSTRACT

In the Greater Mekong Sub-region (GMS), Foot and Mouth Disease (FMD) is the most important trans-boundary animal disease affecting the livelihood of livestock owners. To contribute to the long term goal to control FMD in south-eastern Asia, the South East Asia and China FMD Campaign (SEACFMD) has been implementing a progressive control approach based on sound epidemiological inputs and principles. A major risk to the regional program is the emergence of new strains of FMD including the Pan-Asia topotype serotype O, the serotype type A and the serotype Asia 1 that was confirmed in China at the beginning of 2009.

Due to the rapid development of China, the price of meat and its demand have grown quickly over the past ten years. This trend has resulted in an increase in the number of livestock moving from south-eastern Asian countries to China. Although Chinese law and the import-export policy prohibit these movements, these informal movements pose a high risk of introducing new serotypes to China and spreading the disease to FMD free areas in China.

Prior to the study reported here, there was little information written in English concerning the development of veterinary science in China and the history of FMD outbreaks in the country. This study collected and analysed existing historical records of FMD in China, and hypothesised on the potential source of the disease for China. Subsequently, the study collected and analysed existing data on FMD from countries in the Upper Mekong Region to understand the disease's epidemiological pattern. Epidemiological tools, such as Geographical Information Systems (GIS), risk

assessment and epidemiological modelling, were used to study the epidemiology and the patterns of FMD spread into Yunnan and Guangxi Provinces in China.

This epidemiological study was the first study to evaluate the risk posed by informal animal movements between countries in the Upper Mekong Region and China. It was designed to provide the epidemiological basis for progressing zone status for FMD in the Upper Mekong Region with particular emphasis on the Yunnan and Guangxi Provinces. A systematic analysis was undertaken to evaluate the compulsory vaccination policy in China. The opinions of Chinese veterinary workers were also collected to identify the current problems with the control of FMD in China.

Foot and Mouth Disease was probably introduced into China from Europe in the 19th century. However the research reported in this thesis found that the current highest risk to China was through the movement of animals along the Mekong River, compared to movement along alternative land routes. The two most important factors influencing this risk were: the prevalence of FMD in the exporting country; and the control strategy adopted in China. The current control of FMD in China is based on compulsory vaccination of livestock and the prohibition of livestock movements between south-eastern countries and China. Although the vaccination program has been very successful in China, with more than 70% of animals protected, this strategy requires significant amounts of government financial support and could be more effective if targeted to areas of highest risk. The results of this research indicate that it is not feasible or possible to prevent all livestock movements into China from neighbouring countries. It is recommended that an intensive FMD vaccination program is developed

and implemented in the GMS to reduce the number of susceptible animals in the region. It is also recommended that the movement of livestock/animal products between the Upper Mekong Region countries and China be legalised through the development of formal and appropriate import regulations. Adopting these practices and developing an active surveillance system should help reduce the spread of FMD within the Greater Mekong Sub-region.

GLOSSARY

Abbreviation	Name
AB-CRC	Australian Biosecurity Cooperative Research Centre
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AgELISA	Antigen Enzyme-Linked Immunosorbent Assay
ASEAN	Association of Southeast Asian Nations
BEI	Binary ethylenimine
BHK	Baby Hamster Kidney
Brunei	The Nation of Brunei
CBR	Cost Benefit Ratio
C.I.Q	China Entry-Exit Inspection and Quarantine Bureau
CFT	Complement Fixation Test
China	People's Republic of China
DIVA	Differentiation of Infected from Vaccinated Animals
EDA	Exploratory Data Analysis
ELISA	Enzyme-Linked Immunosorbent Assay
EuFMD	European Commission for the control of Foot and Mouth Disease
FAO	Food and Agricultural Organisation
FMD	Foot and Mouth Disease
FMDV	Foot and Mouth Disease Virus

Abbreviation	Name
GDP	Gross Domestic Product
GIS	Geographical Information Systems
GMS	Greater Mekong Sub-region
Guangxi Province	Guangxi Zhuang Autonomous Region
HPAI	Highly Pathogenic Avian Influenza
LAMP	Loop Mediated Isothermal Amplification
LAOS	Lao People's Democratic Republic
LFD	Lateral Flow Device
LPBE	Liquid-Phase Blocking ELISA
LSD	Least Significant Difference post-hoc test
mAb	Monoclonal Antibodies
MOA	Ministry of Agriculture of the People's Republic of China
mPCR	multiplex Polymerase Chain Reaction
MTM	Malaysia-Thailand-Myanmar region
NCBI	National Center for Biotechnology Information
NIH	The National Institute of Health (United States of America)
NSPs	Nonstructural Proteins
OIE	Office International des Epizooties (World Organisation for Animal Health)
OIE RCU	Office International des Epizooties Regional Coordination Unit
OIE SRR	OIE Sub-Regional Representation

Abbreviation	Name
PCP-FMD	Progressive Control Pathway for Foot and Mouth Disease
PCR	Polymerase Chain Reaction
PLA	The Peoples' Liberation Army
RRL	Regional Reference Laboratory
RT-LAMP	Reverse Transcription-Loop Mediated Isothermal Amplification
RT-PCR	Reverse Transcription-Polymerase Chain Reaction
SEA	South East Asia
SEACFMD	OIE South East Asia and China Foot and Mouth Disease Campaign
SEAFMD	South East Asia Foot and Mouth Disease Campaign
Singapore	The Republic of Singapore
SRR	OIE Sub-Regional Representation
SRR SEA	OIE Sub-Regional Representation for South East Asia
TAD	Trans-boundary Animal Disease
UMWG	Upper Mekong Working Group
US$	United States of America dollar
VI	Virus Isolation
VNT	Virus Neutralization Test
WRL	World Reference Laboratory
WRLFMD	World Reference Laboratory for Foot and Mouth Disease
YASVI	Yunnan Animal Science and Veterinary Institute

Abbreviation	Name
YTSAVDL	Yunnan Tropical and Subtropical Animal Viral Disease Laboratory

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to all those who gave me the possibility to complete this thesis.

Firstly, this dissertation would not have been possible without the guidance of my principal supervisor Professor Ian Robertson from Murdoch University, co-supervisor Emeritus Professor of Murdoch University John Edwards, from the Food and Agriculture Organisation in the United Nations, co-supervisor Director Li Huachun from the Yunnan Animal Science and Veterinary Institute, and co-supervisor Dr Chris Hawkins from the Department of Agriculture and Food, Western Australia. These supervisors have contributed and extended their valuable professional guidance in the preparation and completion of this study. My deepest thanks would also be expressed for their unprecedented efforts on research funding applications and research data collection.

Secondly, this study would not have been possible without the financial support from Murdoch University, Australian Government Overseas Aid Program, Australian Biosecurity Cooperative Research Centre for Emerging Infectious Disease (AB-CRC), Australian Centre for International Agricultural Research (ACIAR), and Yunnan Animal Husbandry and Veterinary Science Institute. Thirdly, I want to extend my heartfelt thanks to Dr Ronello Abila, the Sub-Regional Representative of World Organisation for Animal Health (OIE), Sub-Regional Representation for South East Asia. Dr Ronello Abila's professional assistance on understanding the Foot and Mouth Disease (FMD) pattern in

South East Asia is one of the most important contributions to this study.

This thesis is also improved by valuable advice and information from many people who provided their knowledge, particular from Dr Guo Fusheng, Dr James Kerr, and Dr Wang Jinping. I also want to send my everlasting feelings of gratefulness and thanks to my friends studying at Murdoch University Dr Ben Madin, Dr Peter Adams, Dr Domingo (Jim) DC. Caro III, Dr Kyaw Naing Oo, Dr Blesilda C. Verin, Dr Polly Cocks, Elvina Lee and Dr Sharie Michelle R. Aviso. These friends of mine have provided selfless concern, care and help to me during my entire research time.

Last but not least, an extra special thanks to all my family members, especially my parents. They have been my powerful backbone providing both material and spiritual support. They also provided their unreserved trust in me when I doubted my capability of finishing this study.