

Understanding and predicting the influence
of animal movement on the spread of
transboundary animal diseases

Ben Madin

BSc (Vet Biol) BVMS MVPHMgmt

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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.



Ben Madin

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Abstract

The aim of this thesis is to evaluate the potential of using existing and new data on disease outbreaks, livestock movements and prices to predict where outbreaks may occur.

An evaluation of the information on disease outbreaks stored in the regional animal health database was undertaken to determine if any relationship could be seen between outbreak locations over time and whether it would be possible to identify disease outbreaks early enough that they could be used in the prediction of disease spread. This work showed that disease reporting is incomplete and inconsistent, making it vital that increased effort is put into better outbreak investigation (including laboratory confirmation) and more timely reporting.

Information on the movement of animals through Cambodia and Laos was obtained to investigate patterns of movement. These data were incomplete, however application of network analysis techniques offered important insights into high risk areas for disease management. The full potential of this approach was established by applying it to Western Australian data from the National Livestock Information System.

Data on price were obtained in Cambodia and Laos to compare with the known movements to identify whether this could be used to predict animal movements. To overcome the complexity of collecting comprehensive data about different classes of animals, multilevel modelling was used to investigate the association of livestock movement with price difference between provinces.

Although the control of transboundary animal diseases is critically important for the economy of South East Asia, at the moment it is ineffective. It is unlikely that regional disease control programmes such as the South East Asia and China foot and mouth disease campaign will reach their potential until reliable, high-quality reports of disease are available to guide their design and implementation. Adding to the difficulty of this is the very sparse information available on the movement of animals across the region and the difficulty and expense involved in obtaining these data. Differences in market price between provinces may have a role in predicting animal movements; however, matching price to movements is difficult, and in this study appeared to only be useful over relatively short distances by regional standards.

Lack of a reliable means of identifying individual animals, regulatory and financial disincentives for using formal pathways for animal movement and a disregard for complying with government requirements to advise of animal movements make it difficult to follow animals as they move rapidly across the region. A new approach to animal movement management is required in which hazard reduction instead of revenue collection is the focus.

A Note on Style for Foot and Mouth Disease

There is little agreement on the correct syntax for foot and mouth disease (FMD). For this thesis I have adopted the same approach as the World Organisation for Animal Health (OIE), that is to use lower case for all words (except where the expression begins a sentence or is in a title) and not to hyphenate the first three words. This is consistent with the American Psychological Association Publication Manual (6th edition) recommendation of not using hyphens when the meaning is established¹.

¹<http://www.apastyle.org/learn/faqs/when-use-hyphen.aspx>, accessed 15/9/2011.

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Approvals

Animal Ethics Approval

The Murdoch University Animal Ethics Research Committee approved the ear-tagging trial in Laos, as the project “Livestock tracking in the Greater Mekong subregion”, Permit No. R2201/08. This approval was also recognised by the Department of Agriculture and Food WA Animal Ethics Research Committee.

FAO Statistics Division Approval

Permission was received from the FAO Statistics Division to use their data.

SaTScan

SaTScanTM is a trademark of Martin Kulldorff. The SaTScan software was developed under the joint auspices of (i) Martin Kulldorff, (ii) the National Cancer Institute, and (iii) Farzad Mostashari of the New York City Department of Health and Mental Hygiene.

SaTScan was used in the evaluation of the FMD reports to identify clusters of disease across the region during the 10 year period that was assessed.

Glossary

ACIAR	Australian Centre for International Agricultural Research
AIC	Akaike's 'An Information Criteria'
ARAHIS	ASEAN Regional Animal Health Information System
ASEAN	Association of South-East Asian Nations
AUD	Australian Dollar (currency)
CAMIS	Cambodian Agricultural Market Information System
CSF	Classical swine fever
DAFWA	Department of Agriculture and Food Western Australia
DAHP	Department of Animal Health and Production, Cambodia
DCW	Digital Chart of the World
DLD	Department of Livestock Development, Thailand
DLF	Department of Livestock and Fisheries, Lao PDR
EM	Expectation-Maximisation algorithm for Maximum Likelihood
FAO	Food and Agriculture Organisation of the United Nations
FMD	Foot and mouth disease
FMDV	Foot and mouth disease Virus
FOSS	Free and Open Source Software
GDP	Gross Domestic Product
GIS	Geographic Information System (sometimes Geographic Information Science)
GMS	Greater Mekong Subregion (includes Yunnan China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam)

GPS	Global Positioning System
GSM	Global System for Mobile Communications (Groupe Speciale Mobile)
HPAI	Highly pathogenic avian influenza
IMEI	International Mobile Equipment Identity
ISO	International Organisation for Standardisation
KHR	Cambodian Riel (currency)
LAK	Lao Kip (currency)
LGA	Local Government Area (terminology used in Australia)
LMCZ	Lower Mekong Control Zone
LMWG	Lower Mekong Working Group (representatives of the countries involved in the Lower Mekong Control Zone)
MCMC	Markov Chain Monte Carlo
MDS	Multi-Dimensional Scaling
ML	Maximum Likelihood
MLA	Meat and Livestock Australia
ND	Newcastle Disease
NLIS	National Livestock Identification System (Australia)
NLRS	National Livestock Reporting System (Australia)
OIE	World Organisation for Animal Health (Office International des Épizooties)
PIC	Property Identification Code
R	The R Statistical Environment and Language
RCU	Regional Coordinating Unit (of the OIE)
RDBMS	Relational Database Management System
REML	Restricted Maximum Likelihood
RFID	Radio Frequency Identification Device
RMB	Chinese Yuan Renminbi (currency)

RRL	Regional Reference Laboratory for foot and mouth disease (Pak Chong, Thailand)
SAHMBA	Strengthening Animal Health Management and Biosecurity in ASEAN
SEA	South-East Asia
SEAFMD	South-East Asia foot and mouth disease [Campaign / Programme] (until 2010)
SEACFMD	South-East Asia and China foot and mouth disease [Campaign / Programme] (from 2010)
Shapefile	Shapefile is a file format for GIS data developed by ESRI Pty Ltd. Although it is a de-facto standard for exchange of spatial data it suffers from a number of limitations which are now much better handled using spatially enabled relational databases.
SIR	Susceptible–Infected–Recovered (or Removed) a model where animals are either removed after infection (for example, they die) or recover but retain long term immunity.
SIRS	Susceptible–Infected–Recovered–Susceptible—a model with four states, representing a scenario where recovered animals become susceptible to the disease process again.
SMR	Standardised Morbidity Ratio
SMS	Short Message Service
SQL	Structured Query Language—a standard language for querying relational databases. SQL is used by most large databases (although each one may have some slight variations).
THB	Thai Baht (currency)
ULM	Understanding Livestock Movements—the short title of ACIAR project AH/2006/025
UMCZ	Upper Mekong Control Zone
UMWG	Upper Mekong Working Group (representatives of the countries involved in the Upper Mekong Control Zone)
Unicode	A standard for encoding text on computers that represents all known characters individually. It can also account for variations in character form when combined in Indic languages.

USD	United States Dollar (currency)
VAHW	Village Animal Health Worker (Cambodia)
VMAP	Vector Map Format
VND	Vietnam Dong (VND) (currency)
VVW	Village Veterinary Worker (Lao PDR)
WA	Western Australia
WHO	World Health Organisation
WRL	World Reference Laboratory for foot and mouth disease (Pirbright, United Kingdom)

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The Big Picture

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Movements - Western Australia

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Movements - Greater Mekong Subregion

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The smaller picture

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