UNIVERSITI PUTRA MALAYSIA

EVALUATION, AWARENESS AND USE OF CATTLE IDENTIFICATION AND TRACEABILITY SYSTEM IN PENINSULAR MALAYSIA

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By

SALINA BINTI AMAD BUGIS

Thesis submitted to the School of Graduate Studies
Universiti Putra Malaysia, in fulfilment of the Requirements for the
Degree of Doctor of Philosophy

January 2018

DEDICATION

Dedicated to my husband Mat Fuat, my sons Qusyairee and Qhairulfahmie, and my father Amad Bugis.

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

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Chairperson: Prof Latiffah binti Hassan, PhD
Faculty: Veterinary Medicine

Traceability of animal and animal products are tools to overcome animal and public health or food safety issues. In 2009, the Malaysian government initiated a new traceability system which included the use of radio frequency identification (RFID) tag as an animal identification (ID) and the electronic animal movement tracking system known as ePermit2 system as an initiative to control foot and mouth disease (FMD). This study was conducted to evaluate the effectiveness of the current animal identification and traceability system in the FMD control program, to determine the performance of several commercial ear tags in terms of their retention and readability, to evaluate the level of farmers and traders knowledge, attitude and practice (KAP) of traceability, to describe the inter-state movement of cattle in the FMD control program from 2010 to 2015 and to quantify the similarity of the cattle movement network from one calendar year to the next.

A total of 127 cattle ID from the ePermit2 system from 11 states in Peninsular Malaysia were randomly selected and were traced to their recorded destination to see if the cattle truly arrived to the designated destination. Scoring system was developed to categorize the findings for successful or unsuccessful trace forward or trace back. To ensure that animal movement requirement for the FMD control program is fulfilled, information on the presence or absence of the selected animal ID records from FMD antibody detection (FMDL-Ab) form were collected at the Regional Veterinary Laboratory, Kota Bharu, Kelantan. The overall traceability success rate was 21.3% among cattle that were moved for breeding and slaughter in 2013. Out of 127 cattle selected and traced at the FMD Laboratory, only five cattle (3.9%) were successfully traced to their laboratory records.

A field trial on 848 cattle was conducted to evaluate four types of RFID tags (Allflex, Cybortra, TSG and Ecosensa) and three types of visual tags (Allflex, Cybortra and Ecosensa) for retention and readability. After one year, Allflex and Cyborta RFID ID devices were well retained at 89.5% and 87.8%, respectively while TSG had the poorest retention at 69.1%. For visual ID device, Allflex has the highest retention at 98.3% while Ecosensa has the lowest retention at 86.8%. Among intact RFID ear tags, 45 (6.7%) failed to be read. Allflex ID device had the highest readability (98.8%), whereas TSG brand had the lowest (79.2%). The mean of survival time for RFID ID device was highest for Cybortra and lowest for TSG brand at 487 and 416 days, respectively. For visual ID devices, the survival time was highest at 515 and lowest at 478 days for Allflex and Ecosensa, respectively.

In a cross sectional survey, a total of 543 farmers and traders in Peninsular Malaysia completed a questionnaire which aimed to evaluate their KAP domains of traceability. The results showed that 61% of the respondents had good knowledge on traceability. Though the percentage of the farmers and traders that had good knowledge was moderate, their attitude (53%) and practices (52%) to be traceability compliant was slightly lower. Respondents who had secondary level of education, involved in both farming and trading and had more than 20 years' experience in cattle industry, were more likely to have good knowledge on traceability. In addition, respondents who had more than 20 years' experience in cattle industry and practiced intensive or feedlot husbandry system were twice more likely to have good attitude towards traceability. Respondents with tertiary level of education, who reared or traded between 101 and 1000 heads of cattle and practiced semi-intensive and intensive or feedlot husbandry system were more likely to be traceability compliant. In contrast, respondents who had never attended any courses or received training in cattle farming were less likely to have positive responses in the KAP questions.

Data on cattle movements registered in the ePermit2 system from 2010 to 2015 was examined using the social network analysis (SNA). A total of 24,508 movement events were recorded involving 530,064 cattle. In 2010, a large number of out-bound movements from Kelantan and Perlis was observed. However between 2013 and 2015, the pattern of cattle movement changed with Selangor showed the largest number of out-bound cattle movements, while Kelantan had the highest number of in-bound cattle movements. State of Pahang showed a consistent increased of out-bound cattle movement from 2011-2015. All districts (a total of 90 nodes) in Peninsular Malaysia were involved in the cattle movement network for the period 2010 to 2015 with the greatest number of directed links (n = 2,972) between districts occurred in 2014. This study found that the movement of cattle was associated with Hari Raya Aidil-Fitri festive celebration which occurred between July and September each year and, to a lesser extent, Hari Raya Aidil-Adha which occurred between September and November in the period of this study. Analyses showed that the Peninsular Malaysia cattle movement network had scale-free properties where small number of districts had a large number of

reported movement events, while many districts had small numbers of reported movement events. Each of the social networks constructed from 2010 to 2015 were found correlated to each other. Therefore disease surveillance efforts do not need to vary from year to year as the pattern of animal movement is similar and predictable.

This study has provided comprehensive information about traceability system that is practiced in Peninsular Malaysia. Matching the physical location of cattle after inter-state movements and tracing vital laboratory records was poor. Linking the two live cattle movement module systems with the laboratory system is expected to accelerate trace back or trace forward of cattle during disease incursion. Retention and readability are part of the criteria to be emphasized when choosing RFID and visual ear tag identification devices. The current RFID device brand TSG used widely in Malaysia had the poorest readability and retention and therefore is less suitable for traceability system. The KAP of local farmers and traders were modest which suggested that more efforts for structured education and training program is necessary and needed to highlight the benefits of the traceability system. States and districts with high frequencies of out-bound cattle movement are more likely to spread a disease to other parts of the country, while states and districts with high frequencies of in-bound movements are more likely to become recipients of a disease in the event of an infectious disease incursion.

Thus, those districts with high in-bound and out-bound cattle movements must strengthen the existing disease control measures to ensure reduction of disease spread and outbreaks.

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

PENILAIAN, KESEDARAN DAN PENGGUNAAN TANDA PENGENALAN LEMBU DAN SISTEM DAYAJEJAK DI SEMENANJUNG MALAYSIA

Oleh

SALINA BINTI AMAD BUGIS

Januari 2018

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Dayajejak haiwan dan produk haiwan merupakan alat untuk mengatasi isu kesihatan haiwan dan awam atau keselamatan makanan. Pada tahun 2009, kerajaan Malaysia telah memulakan sistem dayajejak baru merangkumi penggunaan tag *radio frequency identification* (RFID) sebagai tanda pengenalan haiwan dan sistem pengesanan pemindahan haiwan secara elektronik dikenali sebagai sistem ePermit2 sebagai inisiatif untuk mengawal penyakit kuku dan mulut (FMD). Kajian ini dijalankan untuk menilai keberkesanan sistem pengenalan dan dayajejak haiwan dalam program kawalan FMD, untuk menentukan prestasi beberapa tag telinga komersil daripada segi pengekalan dan kebolehbacaan, untuk menilai tahap pengetahuan, sikap dan amalan (KAP) dayajejak penternak dan pedagang lembu, dan untuk menerangkan pemindahaan lembu antara negeri dalam program kawalan FMD dari tahun 2010 hingga 2015 serta untuk mengukur persamaan rangkaian pemindahan lembu antara satu tahun ke tahun yang berikutnya.

Sejumlah 127 ekor lembu dari sistem ePermit2 telah dikenalpasti secara rawak dari 11 buah negeri di Semenanjung Malaysia dan telah dikesan ke destinasi yang direkodkan untuk melihat sama ada lembu itu benar-benar sampai ke destinasi yang ditetapkan. Sistem pemarkahan (skor) telah diwujudkan untuk mengkategorikan penemuan yang berjaya atau tidak berjaya dijejaki. Untuk memastikan bahawa keperluan pergerakan haiwan untuk program kawalan FMD dipenuhi, maklumat mengenai keberadaan atau ketiadaan rekod pengenalan haiwan yang dipilih daripada borang ujian pengesanan antibodi (FMDL-Ab) dikumpulkan di Makmal Veterinar Kawasan, Kota Bharu, Kelantan. Secara keseluruhan, sebanyak 21.3% lembu yang dipindahkan untuk tujuan pembiakan dan penyembelihan berjaya dijejaki pada tahun 2013. Daripada 127 ekor lembu yang dipilih dan dikesan rekodnya di makmal FMD, hanya lima (3.9%) rekod makmal berjaya dijejaki.

Kajian di lapangan pada 848 ekor lembu telah dijalankan untuk menilai empat jenis tag RFID (Allflex, Cybortra, TSG dan Ecosensa) dan tiga jenis tag visual (Allflex, Cybortra dan Ecosensa) daripada segi pengekalan dan kebolehbacaan. Selepas setahun, tanda pengenalan RFID Allflex dan Cyborta menunjukkan kadar pengekalan yang tinggi masing-masing pada 89.5% dan 87.8%, sementara TSG menunjukkan kadar pengekalan yang paling rendah pada 69.1%. Untuk tanda pengenalan visual, Allflex menunjukkan kadar pengekalan tertinggi pada 98.3% manakala Ecosensa (86.8%) menunjukkan kadar pengekalan terendah. Daripada tag RFID yang masih kekal, 45 (6.7%) gagal dibaca. Tanda pengenalan RFID Allflex menunjukkan kebolehbacaan tertinggi (98.8%), manakala jenama TSG menunjukkan kebolehbacaan yang paling rendah (79.2%). Purata masa kewujudan untuk tanda pengenalan RFID adalah tertinggi untuk Cybortra dan terendah untuk jenama TSG masing-masing pada 487 dan 416 hari. Manakala untuk tanda pengenalan visual, masa kewujudan adalah tertinggi pada 515 dan terendah pada 478 hari masing-masing untuk Allflex dan Ecosensa.

Di dalam kajian keratan rentas, seramai 543 penternak dan pedagang lembu di Semenanjung Malaysia telah melengkapkan soal selidik yang bertujuan untuk menilai domain KAP terhadap dayajejak haiwan. Keputusan kajian menunjukkan bahawa 61% daripada responden mempunyai pengetahuan yang baik mengenai dayajejak haiwan. Walaupun peratusan penternak dan pedagang lembu yang mempunyai pengetahuan yang baik adalah sederhana, sikap (53%) dan amalan (52%) mereka untuk mematuhi sistem dayajejak sedikit rendah. Responden yang mempunyai tahap pendidikan menengah, terlibat dalam kedua-dua aktiviti penternakan dan perdagangan, dan mempunyai lebih daripada 20 tahun pengalaman dalam industri penternakan lembu lebih cenderung mempunyai pengetahuan yang baik mengenai dayajejak. Selain itu, responden yang mempunyai lebih daripada 20 tahun pengalaman dalam industri ternakan dan mengamalkan sistem penternakan secara intensif atau fidlot mempunyai sikap dua kali lebih baik terhadap dayajejak. Responden yang mempunyai tahap pendidikan tinggi, memelihara atau berdagang antara 101 hingga 1000 ekor lembu dan mengamalkan sistem penternakan separa intensif, dan intensif atau fidlot lebih cenderung patuh dayajejak. Sebaliknya, responden yang tidak pernah menghadiri kursus atau menerima latihan dalam penternakan lembu lebih cenderung memberi maklumbalas negatif terhadap soalan-soalan mengenai pengetahuan, sikap dan amalan dayajejak.

Data pergerakan lembu yang didaftarkan di dalam sistem ePermit2 dari tahun 2010 hingga 2015 telah diperiksa menggunakan analisis jaringan social (SNA). Sejumlah 24,508 pergerakan yang melibatkan 530,064 lembu telah berlaku. Pada tahun 2010, banyak pergerakan keluar dari negeri Kelantan dan Perlis diperhatikan. Bagaimanapun, pada tahun 2013 hingga 2015, corak pergerakan lembu berubah dimana negeri Selangor menunjukkan bilangan pergerakan lembu keluar terbanyak, manakala Kelantan menunjukkan jumlah ternakan lembu masuk yang paling tinggi. Negeri Pahang telah menunjukkan pertambahan pergerakan lembu keluar yang konsisten dari tahun 2011 hingga

2015. Semua daerah (90 nod) di Semenanjung Malaysia terlibat dalam rangkaian pergerakan lembu untuk tempoh 2010 hingga 2015 dengan bilangan pautan terarah (n = 2,972) di antara daerah yang berlaku pada tahun 2014. Kajian ini mendapati bahawa pergerakan lembu adalah berkait dengan perayaan Hari Raya Aidil-Fitri yang berlaku antara bulan Julai dan September setiap tahun dan, Hari Raya Aidil-Adha yang berlaku antara September dan November dalam tempoh kajian ini. Analisis kami menunjukkan bahawa rangkaian pergerakan lembu di Semenanjung Malaysia mempunyai ciri skala bebas di mana sedikit daerah dilaporkan mempunyai bilangan pergerakan haiwan yang tinggi, sementara banyak daerah dilaporkan mempunyai bilangan pergerakan yang rendah. Setiap rangkaian sosial yang dibina untuk tahun 2010 hingga 2015 didapati mempunyai korelasi antara satu sama lain. Oleh itu, usaha survelan penyakit tidak perlu kerap berubah-ubah dari tahun ke tahun kerana corak pergerakan haiwan adalah sama dan boleh diramalkan.

Kajian ini telah memberikan maklumat yang komprehensif mengenai sistem dayajejak yang diamalkan di Semenanjung Malaysia. Pemadanan kedudukan fizikal lembu selepas pergerakan antara negeri dan pengesanan rekod makmal adalah kurang baik. Menghubungkan kedua-dua sistem modul pergerakan lembu hidup dengan sistem makmal dijangka akan mempercepatkan pengesanan lembu semasa kejadian penyakit. Pengekalan dan kebolehbacaan adalah sebahagian daripada kriteria yang perlu diberi penekanan semasa memilih tanda pengenalan tag telinga RFID dan visual. Tanda pengenalan RFID jenama TSG yang digunakan secara meluas di Malaysia pada masa ini mempunyai kebolehbacaan dan pengekalan yang kurang baik, oleh itu kurang sesuai digunakan untuk sistem dayajejak. KAP penternak dan pedagang lembu tempatan adalah sederhana yang memerlukan lebih banyak usaha untuk mengadakan program pendidikan dan latihan berstruktur, dan perlu menekankan manfaat sistem dayajejak. Negeri dan daerah yang mempunyai frekuensi pergerakan lembu keluar yang tinggi lebih cenderung menyebarkan penyakit ke bahagian lain di negara ini, sementara negeri-negeri dan daerah-daerah dengan frekuensi pergerakan masuk yang tinggi lebih cenderung menjadi penerima penyakit dalam kejadian penyakit berjangkit. Daerah-daerah yang mempunyai pergerakan lembu masuk dan keluar yang tinggi mesti mengukuhkan langkah kawalan penyakit sedia ada untuk memastikan pengurangan penyebaran penyakit dan wabak.

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

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ADIC	Animal Disease Information System
AI	Avian influenza
BSE	Bovine spongiform encephalopathy
CI	Confidence Interval
CTS	Cattle Tracing System
Cum	cumulative
D	diameter
DVO	District veterinary office
DVS	Department of Veterinary Services Malaysia
EU	European Union
FMD	Foot and mouth disease
FMDL-Ab	Foot and mouth disease antibody detection
gm	gram
GIS	Geographic Information System
GPS	Geographical Positioning System
H	height
HPAI	Highly pathogenic avian influenza
IBM	International Business Machines
ICAR	International committee for animal recording
ID	Identification
I&R	Identification and registration
ISO	International Organization for Standardization
JUPEM	The Department of Survey and Mapping Malaysia
KAP	Knowledge, attitude, practice
kHz	kilohertz
km^2	square kilometer
Lab	laboratory
MAQIS	Malaysian Quarantine and Inspection Services
Department	
MATs	Malaysia Animal Traceability System
MLA	Meat Livestock Australia
mm	milimeter
mo	month
Movts	movements
MTM	Malaysia-Thailand-Myanmar
MVSOP	Malaysian Veterinary Standard Operating Procedures
NAIS	National Animal Identification System
N	Number
n	number
NA	Not applicable
NLIS	National Livestock Identification System
No.	Number
NSP	Non-structured protein
OGA	Other Government Agencies
OIE	World Organisation for Animal Health
OR	Odds ratio
PIA	Permit Issuing Agencies
PIC	Premise identification code

P1	primary vaccination
P2	revaccination
QAP	Quadratic assignment procedure
RFID	Radio frequency identification
RM	Ringgit Malaysia
SEA	Southeast Asia
SENASA	National Service for Agrifood Health and Quality
SGS	Sanitary management system
SMK	Sistem Maklumat Kastam
SNA	Social network analysis
SPS	Sanitary and phytosanitary
SPSS	Statistical Package for the Social Sciences
TAC	Target area concentration
TB	Tuberculosis
UK	United Kingdom
US	United States
USDA	United States Department of Agriculture
VHC	Veterinary health certificate
WP	Wilayah Persekutuan
%	percentage
σ	standard deviation

CHAPTER 1

INTRODUCTION

1.1 Background

Traceability system for live animals and animal products is an important tool to monitor animal health, animal husbandry, public health, food safety and trade (OIE, 2016a). A complete animal traceability system comprises of three main components: animal identification, premise registration and animal movement tracking (Schroeder and Tonsor, 2012). Most developed countries have placed traceability of animal and animal products as a priority to ensure food safety and security (Caporale et al., 2001).

Animal identification is used to identify individual or group of animals. It is the most important tool to achieve traceability along the food supply chain. Common methods used to mark the animals especially cattle, buffaloes, sheep and goats are ear tags, neck chains, freeze brands, rumen boluses, tattoos and leg bands (Neary and Yager, 2002). Animal identification has long been introduced in Malaysia to improve animal traceability (Salina and Azmie, 2013). In cattle, a visual ear tag is the most common identification used. This method of identification is easy to apply and cheap. However, the drawback of this method is the lack of standard numbering system which increase the chance of duplication of ID numbers.

The RFID tag manufacturing sector has grown in tandem with the growth of the livestock industry worldwide (Voulodimos et al., 2010). Animal identification using radio frequency identification (RFID) technology has been introduced to the local animal sector in 2009. The RFID tag is able to keep information of individual animal, which enable tracking of animals being done more effectively throughout the supply chain (Mennecke and Townsend, 2005). Furthermore, Malaysia has been identified as the first Asian nation to implement the livestock tracking program based on RFID technology. This ID system was introduced to control animal disease outbreak especially the foot and mouth disease (FMD) (Swift, 2009). Initially, RFID ear tags were enforced on imported livestock including cattle, buffaloes, sheep and goats. For local animals, this type of ID was implemented on voluntary basis (Salina and Azmie, 2013).

One particular brand of RFID tag has been used by cattle farmers and traders in Malaysia since it was first introduced. This tag was supplied on a complimentary basis to the local smallholder farmers during the FMD vaccination program. However, cattle traders have to bear the cost of RFID tags for their imported cattle (Salina et al., 2015). During the implementation of the RFID tag, numerous complaints have been received from the traders

which included the tag dropped or lost at the quarantine stations and failure to read the tags.

FMD is endemic in Peninsular Malaysia but is working towards disease freedom with vaccination by 2021 (DVS, 2018) . Sabah and Sarawak or East Malaysia has been declared as the FMD free zone without vaccination since December 2003 (OIE, 2016b). In 2012, the DVS Malaysia began implementing FMD-free zones in Peninsular Malaysia. Movement control is part of the strategy to achieve disease freedom along with FMD vaccination, FMD non-structured protein testing, veterinary inspection, disinfection, vehicle seal and animal movement documentation (Naheed et al., 2011). It is mandatory to have a veterinary health certificate (VHC) attached with the movement permit for every inter-state consignment. The permit is issued by the state veterinary authority as enforced in Sections 34, 51, 57 and 58, Animal Act 1953 (Revised 2006). Cattle movement for slaughter require an additional slaughter permit (Maznah and Azmie, 2010).

As part of the FMD control program, the DVS Malaysia has developed an online system named ePermit2 system. The system stores information on the animal identification and registration, premises (farm) registration, and inter- and intra-state animal movement (Salina and Azmie, 2013). Animals especially cattle, buffaloes, sheep and goats to be moved to another location are required to have an individual animal identification (Azmie et al., 2010). However, this system is new and need to be evaluated. The present study assesses the ePermit2 system in terms of data adequacy and procedures which will help to uncover issues and gaps in the system.

In this study, social network analysis (SNA) is used to characterize the connections between farms or districts that are involved in the cattle movement events. SNA is a set of mathematical, graphical and theoretical tools for describing networks and their structure. The unit of analysis in network analysis is an entity consisting of a collection of individuals and the linkages among them (Wasserman and Faust, 1994). Ortiz-Pelaez et al. (2006) use SNA to characterize the pattern of animal movements in the FMD epidemic in UK while, Aznar et al. (2011) used it to characterize the movement connections made between regions and districts as a result of cattle movement events in Argentina. In this study, SNA is used to describe the cattle movement in Peninsular Malaysia using data extracted from the ePermit2 system.

1.2 Objectives

The specific objectives of the study were:

1. to evaluate the effectiveness of traceability system for FMD control in Peninsular Malaysia.
2. to determine the performance of several commercial ear tags in terms of their retention and readability in cattle.
3. to evaluate the level of farmers and traders knowledge, attitude, and practices of traceability system.
4. to describe the inter-state movement of cattle in the FMD control program from year 2010 to 2015, and to quantify the similarity of the cattle movement network from one calendar year to the next.

1.3 Hypotheses

In this study, it was hypothesized that:

1. The effectiveness of the system in tracing the physical location of cattle after the inter-state movement is poor.
2. The retention and readability is different given the type of animal identification.
3. The levels of farmers and traders knowledge, attitude and practices of traceability system are poor.
4. Cattle farm-to-farm and farm-to-slaughter movement patterns vary throughout the year and the movement connections made between nodes (districts) from the cattle movement events are concentrated during festive seasons.

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