UNIVERSITI PUTRA MALAYSIA

EPIDEMIOLOGY AND ECONOMIC IMPACT OF BOVINE BRUCELLOSIS
IN PENINSULAR MALAYSIA

MUKHTAR SALIHU ANKA

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EPIDEMIOLOGY AND ECONOMIC IMPACT OF BOVINE BRUCELLOSIS
IN PENINSULAR MALAYSIA

By
MUKHTAR SALIHU ANKA

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

January 2014
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DEDICATION

Dedicated to my mum Hajiya Safiya Salihu Anka for her love and support.
Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

EPIDEMIOLOGY AND ECONOMIC IMPACT OF BOVINE BRUCELLOSIS IN PENINSULAR MALAYSIA

By

MUKHTAR SALIHU ANKA

January 2014

Chairman: Latiffah Hassan, PhD
Faculty: Veterinary Medicine

Bovine brucellosis is an important bacterial disease in cattle and other bovine species including bison, elk and buffalo and is mainly caused by the bacterium *Brucella abortus*. Brucellosis is a zoonotic disease with serious economic impact to livestock industry in both developed and developing countries. The present study was carried out to understand the epidemiology of bovine brucellosis in Peninsular Malaysia; to describe its occurrence and distribution, to evaluate spatial and temporal clusters pattern and distribution, to identify potential risk factors associated with bovine brucellosis, to assess economic impact of bovine brucellosis to farmers and costs of monitoring, control and eradication to government and finally to evaluate the effectiveness of culling policy of area-wise eradication program of brucellosis in Peninsular Malaysia.

A retrospective examination of surveillance data between 2000 and 2008 was carried out to investigate the presence and occurrence of bovine brucellosis in Peninsular Malaysia. The findings showed that bovine brucellosis is widely distributed across the peninsula. The annual seroprevalence for the 9-year study period was 2.7% and 21.7% for individual animal and herd level prevalence respectively. The herd prevalence fluctuated but remained high within the period of the study while animal prevalence was comparatively low but has a more discerning trend over the study period. In the second study, data on the surveillance activities was aggregated into district level due to lack of farm coordinate and confidentiality of the farm centriole of the districts was used as the coordinate to run spatial and temporal cluster, the ArcGIS and Sat Scan softwares were used for the analysis. The result showed that bovine brucellosis clustered in both space and time and cluster pattern confirmed the earlier finding of similar trend. Three clusters were detected: the first cluster around the state of Pahang and part of Johor covering 5 districts with 68 km radius, the second cluster was situated in Kelantan covering large area of 230 km with 51 districts and the third cluster was in Selangor affecting 6 districts covering 34 km. However, the cluster was not statistically significant. High risk areas (hot spot) were also detected to be around the clusters identified.
A case-control study was conducted in four states of Peninsular Malaysia: Kelantan, Pahang, Negeri Sembilan and Selangor whereby 71 farmers were interviewed to investigate the potential risk factors associated with bovine brucellosis in Peninsular Malaysia. Blood and vaginal swabs from cattle, whenever permissible, were collected to detect *Brucella abortus*. Questionnaire on the herd-level risk factors was developed including information on general farm management, biosecurity, medical history and public health awareness. Serological tests as well as culture and identification test were performed on the samples using Rose Bengal Plate Test and *Brucella* agar with supplement respectively. Univariate analysis was conducted for the potential risk factors and disease status and variables significant on the analysis were modeled into multivariate logistic regression. Seroprevalence was 1.8% (n=282) but samples were cultured negative. The Potential risk factors included farmers with more than one species of animals, presence of wildlife and history of abortion. About 78.9% of the farmers participated in the survey reported assisting their animals during delivery and 71.8% had not been using basic personal protective equipments such as glove and face mask to protect them from potentially contracting the infection. Similarly, 2.8% reported consumed unpasteurized milk from their animals. In addition, 19.7% have had episodes of fever with one farmers experienced undulant fever, and was later diagnosed as infected with brucellosis.

A case-control study assessed the direct economic impact of bovine brucellosis in Peninsular Malaysia. This study incorporated the data from 71 farms based on the record of year 2010, surveillance data from DVS, data from DVS statistics on estimated cattle population and some conservative assumption based on proxy. The estimated direct economic cost of bovine brucellosis in Peninsular Malaysia was calculated using a simple spread sheet tool based on established method by Bennett et al 2003. The total economic loss in 2010 from sampled farms due to bovine brucellosis was estimated to be RM 1,445,367.30. Resources spent for the control and eradication accounted for 21% (RM302, 036) of the lost. This included the cost of vaccination of RM 13,736.00 and compensation cost of RM 288, 300.00 There were also significant devastating impacts to livestock farmers which accounted for 79% (RM 1,143,331.30) of the cost which included milk reduction losses of RM54, 581.30, partial carcass condemnation of RM 961,000.00 and loss due to abortion accounted for RM 127,750.00.

A cross-sectional survey was carried out to evaluate the efficiency of the culling process prescribed for seroreactor cattle in Malaysia. Fourteen abattoirs in four states: Kelantan, Pahang, Negeri Sembilan and Selangor were visited and data on culled cattle from 2005 to 2008 were examined. The data was managed and analysed using Microsoft Excel. A total of 1,954 cattle were culled in the 14 abattoirs in the four states from 2005 to 2008. In 2005, 157.9% seropositive cattle were culled and for 2006, 2007 and 2008 only 51.5, 41.0 and 88.4% were culled respectively. The state of Selangor has the highest culling rate of 114.2%, followed by Pahang (94.0%), Negeri Sembilan (22.0%) while Kelantan had no record of culling within the study period. The overall culling rate for the studied states within the study period was 72.16%.

In conclusion, bovine brucellosis in Peninsular Malaysia is widely distributed with major clustering of high risk areas. The disease occurrence was associated with several factors such as system of management, other species of animal in the farm and history of abortion. The economic burden of the disease was significant and
estimated to be RM 1,445,367.30 in the year 2010. The area-wise eradication program of brucellosis was shown to be effective in reducing the prevalence. However, there is a need for improvement especially in area of enforcement of the culling policy.
Abstrak tesis yang dipersembahkan kepada senat University Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

EPIDEMIOLOGI DAN IMPAK EKONOMI BRUSOLOSIS BOVIN DI
SEMENANJUNG MALAYSIA

Oleh

MUKHTAR SALIHU ANKA

January 2014

Pengerusi: Latiffah Hassan, PhD
Fakulti: Perubatan Veterinar

Bruselosis bovin merupakan penyakit yang disebabkan oleh bakteria *Brucella abortus* pada lembu dan spesies lain termasuk banteng, rusa dan kerbau. Brucelosis adalah penyakit zoonosis yang memberi kesan ekonomi yang serius kepada industri ternakan di negara maju dan membangun. Kajian ini telah dijalankan untuk memahami epidemiologi bruselosis lembu di Semenanjung Malaysia, untuk menggambarkan kejadian dan taburan, untuk menilai corak gugusan ruang dan masa dan taburan, untuk mengenalpasti faktor risiko berkaitan dengan bruselosis lembu, untuk menilai kesan ekonomi disebabkan oleh penyakit ini kepada petani dan kos kepada kerajaan untuk program pemantauan, kawalan dan pembasmian dan akhirnya untuk menila keberkesanan dasar penusunan program pembasmi bruselosis di Semenanjung Malaysia.


Satu kajian kes-kawal telah dijalankan di empat negeri di Semenanjung Malaysia; Kelantan, Pahang, Negeri Sembilan dan Selangor di mana 71 petani telah ditemuramah tentang faktor risiko yang berpotensi berkait dengan bruselosis lembu.
di Semenanjung Malaysia. Darah dan swab vagina lembu, bilamane dibenarkan, dikumpulkan untuk mengesan Brucella abortus.. Soal selidik faktor risiko kumpulan peringkat telah dibina termasuk maklumat mengenai pengurusan am ladang, biosekuriti, sejarah perubatan dan kesedaran kesihatan awam kepada petani. Serologi dan kultur dan pengenalpastian telah dijalankan ke atas sampel menggunakan Ujian Rose Bengal dan agar Brucella dengan makanan tambahan. Analisis univariat telah dijalankan untuk faktor risiko yang berpotensi dan status penyakit dan pembolehubah yang bekecierian pada analisis dimasukkan ke model regresi logistik multivariat. Seroprevalens yang diperolehi ialah 1.8% (n = 282) tetapi sampel diempati negeri pada kultur. Faktor risiko potensi yang dikenalpasti adalah petani dengan lebih dari satu spesies haiwan, kewujudan hidupan liar dan sejarah keguguran. Lebih kurang 78.9% daripada petani mengambil bahagian dalam kajian melaporkan membantu haiwan mereka sewaktu proses kelahiran dan 71.8% didapati tidak pernah menggunakan peralatan asas perlindungan peribadi seperti sarung tangan dan topeng muka untuk melindungi mereka daripada dijangkiti oleh jangkitan tersebut. Begitu juga 2.8% dilaporkan minum susu dari haiwan mereka yang tidak dipasturkan. Di samping itu, 19.7% mempunyai episod demam dimana seorang daripada petani tersebut mengalami demam undulan, dan kemudiannya telah didiagnosis dengan bruselosis.


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I certify that a thesis examination committee has met on 08/01/2014 to conduct the final examination of Mukhtar Salihu Anka on his thesis entitle “Epidemiology and Economic Impact of Bovine brucellosis in Peninsular Malaysia” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 march 1998. The Committee recommends that the student be awarded the degree of Doctor of Philosophy

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<td>CFT</td>
<td>Complement Fixation Test</td>
<td></td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
<td></td>
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<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid</td>
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<tr>
<td>DSM</td>
<td>Department of Statistics Malaysia</td>
<td></td>
</tr>
<tr>
<td>DVS</td>
<td>Department of Veterinary Services</td>
<td></td>
</tr>
<tr>
<td>EFSA</td>
<td>European Food Safety Authority</td>
<td></td>
</tr>
<tr>
<td>ELISA</td>
<td>Enzyme-linked immunosorbent assay</td>
<td></td>
</tr>
<tr>
<td>ESRI</td>
<td>Economic and Social Research Institute</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>FAO</td>
<td>Food and Agricultural organization of united nation</td>
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<tr>
<td>FMD</td>
<td>Food and Mouth Disease</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
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<tr>
<td>HPAI</td>
<td>Highly Pathogenic Avian Influenza</td>
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</tr>
<tr>
<td>IgM</td>
<td>Immunoglobulin M</td>
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</tr>
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<td>Institute Haiwan</td>
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<tr>
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<td>Johns Hopkins Bloomberg School of Public Health</td>
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<td>JUPEM</td>
<td>Department of Survey and Mapping</td>
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<tr>
<td>LPS</td>
<td>Lipopolysaccharide</td>
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<tr>
<td>MOA</td>
<td>Ministry of Agriculture</td>
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<tr>
<td>MTM</td>
<td>Malaysia-Thailand-Myanmar peninsula</td>
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<tr>
<td>NPC</td>
<td>National Poison Centre</td>
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<td>OIE</td>
<td>International Organization for Animal Health</td>
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</tr>
<tr>
<td>OR</td>
<td>Odds ratio</td>
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<td>Pan American Health Organization</td>
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<tr>
<td>PCR</td>
<td>Polymerase chain reaction</td>
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<tr>
<td>PFGE</td>
<td>Pulsed field gel electrophoresis</td>
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</tr>
<tr>
<td>PPE</td>
<td>Personal Protective Equipment</td>
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<tr>
<td>RB51</td>
<td>Strain RB51 vaccine</td>
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<tr>
<td>RBPT</td>
<td>Rose Bengal Plate Test</td>
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<tr>
<td>RM</td>
<td>Malaysian Ringgit</td>
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<tr>
<td>rRNA</td>
<td>Ribosomal ribonucleic acid</td>
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<tr>
<td>S19</td>
<td>Strain 19</td>
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<tr>
<td>SNP</td>
<td>Single nucleotide polymorphism</td>
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<tr>
<td>VRI</td>
<td>Veterinary Research Institute</td>
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<td>World Health Organization</td>
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CHAPTER 1

INTRODUCTION

Bovine brucellosis (Bang’s disease, Enzootic Abortion, Epizootic Abortion, Slinking of Calves, and Contagious Abortion) is an infectious disease in cattle and other species including bison, buffalo and elk caused by the bacterium Brucella abortus. This organism is a facultative intracellular pathogen with up to seven biovars (1-6 and 9) have been reported. Some of these biovars differ only slightly from each other biochemically (OIE, 2009). Other Brucella species that have been uncommonly associated with the disease in cattle including B. melitensis and B. suis (Carvalho et al., 2010).

Brucellosis is considered as a highly infectious zoonotic disease with a serious economic repercussion on both humans and animals (Radostits et al., 2000; Abernethy et al., 2006). Occupational exposure to Brucella has been reported in laboratory workers, farmers, veterinarians and others who are in contact with infected animals or tissues. Brucellosis is one of the most easily acquired laboratory infections (Robichaud et al., 2004). In addition, individuals who do not work with animals or tissues may become infected by ingesting unpasteurized contaminated milk or dairy products (Corbel, 2003). Infection in humans is manifested in the form of fever, lethargy and night sweats as initial symptoms. However, complication may set in as a result of chronic infection, which follows involvement of many organs and system such as liver, spleen, kidney and skeleton among others (Wright, 1997).

Major efforts have been undertaken around the world to control brucellosis in livestock due to its significant economic losses and the often debilitating consequences in humans (Halling & Boyle, 2002). The incidence of bovine brucellosis varies both within and between countries. Advances in the control and eradication practices have led to a significant reduction in the disease incidence or complete eradication in some countries, including the United Kingdom, Scandinavian countries, Australia, New Zealand, Canada, Finland, Norway and Sweden (Seleem et al., 2010). However, bovine brucellosis remains a significant threat in Africa, the Middle East, Central and South America, and Asia including Malaysia (Corbel, 2006). The disease is usually introduced into a herd from an infected animal, but may also enter the herd via semen from infected bulls and via contaminated fomites. Bovine brucellosis can be eradicated from a herd by test and culling or by depopulation. Other important measures for control and eradication are quarantine of infected animals and good surveillance system. Vaccination may be used to control this disease in endemic areas, or used as part of an eradication program (Nicoletti, 1984).

Spatial epidemiology has recently been used to aid in understanding of infectious diseases including those that are zoonotic in nature (Ostfeld et al., 2005). Understanding spatial distribution of diseases can provide an insight into their determinants and helps in their control (Ruankaew, 2005; JHSPH, 2006). Geographical distribution is a key element in the epidemiologic investigation, and several tools have been explored for spatial-related data (Auchincloss et al., 2012). The tools can be in the form of a simple map or more complex that includes modeling by which geographic distribution of diseases can be visualized and
analyzed in time. Therefore the map can reveal spatio-temporal trends, patterns, and relationships that are difficult to discover in tabular or other formats (Ruankaew, 2005). Spatial epidemiology of bovine brucellosis in Malaysia has not been explored. Knowledge about the spatial distribution is crucial for disease control and prevention.

Animal health economics is a growing discipline that is becoming more important as aid to decision making in livestock health at various stages. The stages of intervention and decision making range from individual animal to the national herd stage and largely to international disease mitigation effort (Otte & Chilonda, 1987). In recent years, there has been an increasing interest in estimating the magnitude of financial losses or impact of livestock diseases and control strategies (Bennett, 2003) in both developed and developing countries (FAO, 1962). Estimation of the overall financial losses due to bovine brucellosis in the country will help to demonstrate the magnitude of the economic damage caused by the disease, particularly to farmers, livestock industry and the country. Most of the study conducted in Malaysia concluded that bovine brucellosis is of economic importance. However, none has performed economic analysis to estimate the impact of disease on the livestock industry or farmers, nor evaluate possible cost of controlling the disease.

The study aimed to enhance the understanding on the epidemiology of bovine brucellosis in Peninsular Malaysia so that disease control can be tailored to the local disease situation. In addition, to substantiate the claim that the disease is of economic significance, an economic analysis was performed based on the data that were obtained during this research work and supported by other data that were not able to be gathered during this work.

Three major hypotheses were

1. Brucellosis is clustered in several areas in Peninsular Malaysia.
2. Several factors (risk) play a vital role in the occurrence of bovine brucellosis.
3. Bovine brucellosis causes a significant economic losses in the livestock industry in Malaysia

The specific objectives of this study were to:

1. determine the distribution, patterns and trends of the seroprevalence of bovine brucellosis in Malaysia between 2000 and 2008.
2. identify spatio-temporal distribution of bovine brucellosis in Peninsular Malaysia.
3. identify potential risk factors associated with bovine brucellosis among cattle herds.
4. estimate the direct economic impact of bovine brucellosis
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