Epidemiological study to support the establishment of a progressive zoning approach for the control of Foot and Mouth Disease in Myanmar

By

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

2010

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.

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Kyaw Naing Oo

Personal Declaration

ငယ်စဉ်တောင်ကျေး ကလေးဘဝမှ စ၍
မိဘတို့၏ကြီးမားသော မေတ္တာဖြင့်ကျွေးမွေးပြုစုခဲ့ပြီး
အဆင့်မြင့် ပညာများကို လေ့လာသင်ယူခွင့် ရရှိသည်အထိ
တိုးတက် အောင်မြင်မှု့ရှိလာတဲ့သားကောင်းတစ်ယောက်ဖြစ်အောင်
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တို့၏တုန္ဒိုင်းမရနိုင်သော ကျေးဇူးအား မမေ့ မလျော့ အစဉ်သတိရနေစေရန်နှင့်
ဤကျမ်းကို ဩစတြေးလျှနိုင်ငံ မားဒေါ့ တက္ကသိုလ်တွင် ပြုစုရေးသားနေချိန်မှာ
မြန်မာပြည်မှာ နေခဲ့တဲ့ မိသားစုကို ဦးဆောင်ပြီး အစစ လိုလေသေးမရှိအောင်
အားပေးကူညီပံ့ပိုးပေးခဲ့ တဲ့ ဇနီး ဒေါက်တာနီလာကျော်နှင့်
အဖေကို အစဉ်အမြဲသတိတရ နဲ့အားပေးခဲ့ကြတဲ့
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ချစ်သားငယ်လေး မောင်ဇေယျာထွန်း
တို့ အတွက်

Dedicated to my parents U Kyi Sein and Daw Tin Tin Aye
for their unconditional love and constant support throughout my life,
to my wife Dr Nilar Kyaw whose strength and love has supported and
carried our family during my years studying in Australia and
to my beloved daughter Su Yamone and son Zayar Htun
for being a constant source of encouragement and
for remembering their father during his absence

Abstract

Epidemiological study to support the establishment of a progressive zoning approach for the control of Foot and Mouth Disease in Myanmar

Foot and mouth disease (FMD) is a highly contagious viral disease which has a significant impact on the economy and livestock productivity of affected countries. The research reported in this thesis involved investigation of the epidemiology of FMD in a potentially free (Tanintharyi) and an endemic (Sagaing) region of Myanmar. The animal level sero-prevalence in the Sagaing was high (42%, 95% CI 37.7 - 47.1) in contrast to that in Tanintharyi Division (11.7%, 5.9 - 17.4). Possible source of FMD in those locations may be due to communal grazing, using only underground water sources, purchasing cattle in March annually as a logestic regression model. In contrast, FMD was negative associated with trading of cattle within the same village where the farmers possessed less than only 10 cattle.

During this study, the traditional Dutaik meeting approach which is conducted in rural area of Myanmar ,was developed as a participatory disease tool and was validated with data collected from serological surveys and questionnaire interviews. It was concluded that the MTD meeting approach is a suitable technique to use for detecting FMD with the significant advantages of time and cost effectiveness. It is proposed that the MTD meeting approach is suitable for use in progressive zoning for the control of FMD in Myanmar and can be used to actively involve farmers in the control program and to increase their awareness of the impact of FMD.

In this study, a partial budgeting model with Monte Carlo simulation was developed to understand the influence of FMD on the economics of animal draught power, which is the major livestock input into the nation's agricultural enterprise. The model revealed losses to farmers were very high if outbreaks occurred every year. The

findings of this study are useful for convincing farmers of the potential losses from FMD and the financial benefit in controlling the disease.

The movements of livestock in the Sagaing Division and in the Tanintharyi Division were different, with movements in the Sagaing being more complex. These movement data support the decision to develop a potential free zone area for FMD without vaccination in the Tanintharyi Division (Myanmar MTM area). Positive results from a sero-surveillance study conducted in 2005 in the Tanintharyi Division were most likely false positive results. This was supported by findings from the MTD meetings where no evidence of clinical disease was reported by farmers in contrast to areas where the disease was endemic.

It is concluded that the use of a zoning approach with vaccination in the endemic area of the Sagaing Division is an appropriate option for the control of FMD. At this stage it is not feasible to undertake control and eradication of FMD in the whole country. The complex animal movement patterns and the endemic nature of the disease pose real challenges for its control. However, in Myanmar the MTD meeting approach is a cost-effective option for surveillance to improve the FMD status early in an eradication campaign.

Table of contents

List of Tables

Table of Figures

Acknowledgements

I sincerely appreciate Director General U Maung Maung Nyunt giving me the precious opportunity to come to Australia to undertake my PhD study and Professor John Edwards, former Regional Coordinator of the Regional Coordination Unit for the Southeast Asia Foot and Mouth Disease Campaign, for his understanding of the people from developing countries, his strong willingness to educate students from these countries and great effort to help me obtain the opportunity to study in Australia.

I would like to thank the Australian Biosecurity Cooperative Research Centre for Emerging Infectious Disease for providing a scholarship which enabled me to undertake my PhD research project.

I believe that this thesis would not have been completed in time without strong support and fast response to my drafts from my principal supervisor Associate Professor Ian Robertson who allowed me to study in his Masters class on epidemiology which was the backbone of my understanding on that subject and which proved very useful for my thesis. I appreciate the assistance from my cosupervisor Dr Peter Black for his very logical thinking and support for my research and help even during his holidays. I am very much grateful to my cosupervisor Professor John Edwards for his encouragement and guidance with the use of the traditional Dutaik meeting approach as a tool for the detection of FMD in Myanmar. I wish to thank Drs Simon Reid, Rob Dobson and Myo Nyunt for their valuable advice in my partial budgeting analysis study of my PhD project.

I would like to thank Dr Shih Ping Chen and the Animal Technology Institute, Taiwan, for providing Cedi® FMDV NS ELISA test kits which were used in my research study.

I wish to thank Dr Maung Maung Kyin, Dr Yan Naing Swe, Dr Maung Maung, Dr Met Aung and staff from the Sagaing, Chaung-U, Monywa and Shwebo Districts for assisting with my field work and for providing valuable administrative support.

I wish to thank Dr Khin Maung Latt, Head of FMD laboratory, Dr Cho Cho Htun, and Dr Thet Khaing from the National FMD laboratory of Myanmar for their strong support and help in organizing my field trip and reviewing parts of my thesis.

The participatory study in the Sagaing Division would not have been achieved without the strong support of Dr Min Nyunt Oo who was the main facilitator of the Modified Traditional Dutaik meeting approach and provided me accommodation in his house as a "five star hotel" and for his very valuable information on FMD including providing the photographs of the clinical lesions of FMD. I also appreciate the support, cooperation and contribution of farmers for their active participation during the Dutaik meetings in the Sagaing Division.

I appreciate my friends at Murdoch University especially my "Trailer Trash" mates including Siti Zubaidah Ramanoon, Tum Sothrya, Polly Cocks, Domingo (Jim) Caro, Elaine Llarena, Jarunee Siengsanan, Acacio Cardoso Amaral, Alan P Dargantes, Pebi Purwo Suseno, Songhua Shan, Tze Hoong Chua, Yazid Abdad, Micheal Banazis, Celia Margaretha Smuts and Peter Adams for their help during my study and their kind friendship. I would like to make a special thanks to Siti and Tum for their technical advice in my research with fantastic personal "MOU".

I wish to thank my landlord Jack Teo for his kindness and strong encouragement during my stay in Australia and all my housemates for their valuable discussions on my research project and also for helping with my leisure adventures in Australia.

And special appreciation must go to my parents U Kyee Sein, Daw Tin Tin Aye and my sisters Khin Cho Htet, Khin Kyawt Shin, Theint Thinzar Htwe, and my grandmother Daw Nyunt Nyunt who looked after my kids during I stay in Australia.

Finally I am forever indebted to my wife Dr Nilar Kyaw, and my beloved daughter and son: Su Yamone and Zayar Htun, for their ever understanding, patience and support to allow me to complete my studies in Australia.

Introduction

1.1 Background Information

Foot and Mouth Disease (FMD) is a highly contagious viral disease affecting all cloven hoofed animals. It causes significant economic loss in affected countries and is one of the most important transboundary animal diseases. The disease has been endemic in Myanmar since at least 1887 (Sitt, 1978) and it is one of the main obstacles to the nation's economy which relies heavily on agriculture (Cox, 2001).

1.1.1 Country location and administrative pattern

Myanmar (formally known as "Burma" until 1989) is a member of the Association of South-East Asian Nations (ASEAN). The country is located in Southeast Asia and its neighbouring countries are Bangladesh and India to the west and China, Lao PDR and Thailand to the North, Northeast and East respectively. Myanmar is divided into nine States and eight Divisions according to geographical barriers and administrative areas. In Myanmar, States and Divisions are equivalent to Provinces with States being slightly larger than Divisions (see Figure 1.1). Under the Ministry of Livestock and Fisheries (MLF), the Livestock Breeding and Veterinary Department (LBVD) is responsible for animal health and disease control (Anon, 2008a).

1.1.2 Veterinary Infrastructure of Myanmar

The first veterinary department in Myanmar commenced when a veterinarian was hired to control FMD and Rinderpest during the colonial period (Sitt, 1978). The principal policies and objectives of the MLF are: to produce quality breeds of livestock and fish; to promote integrated development of livestock and fisheries; to produce sufficient meat and fish to meet local demand; to export surplus product to promote investment in the livestock and fishery sectors; and to promote the socio-economic status of the people involved in the livestock and fishery sectors. The LBVD is responsible for the implementation of the development of the livestock sector in line with the objectives of the MLF. The Department employs more than 600 veterinary graduates, over 300 veterinary assistants who have undertaken a two-year training course and 43 animal health assistants who have been trained for six months.

The LBVD has two main functions in the livestock sector: disease control and development issues. The main strategy for animal disease control relies upon the production of biologics and undertaking diagnostic services. In addition, monitoring and inspection of animals and animal products for export and import, and inspection of slaughter animals are part of the disease control program of the LBVD. Active epidemiological surveillance is not well established within the country because of the limited number of staff and a lack of technical knowledge on specific diseases. To foster the development of the livestock sector, the LBVD has encouraged the use of artificial insemination and frozen semen has been used to improve the quality of draught cattle, dairy cattle and pigs. Veterinary extension services include regular training of departmental staff and farmers and the demonstration of good farming practices on model farms throughout the country. These are intended not only to improve the private sector but also to encourage development in remote areas adjacent to neighbouring countries.

1.1.3 Livestock population

Myanmar has a large population of livestock (12 million cattle, 2.9 million buffalo, 3.1 million sheep and goats and 7.6 million pigs) which are a valuable resource for the country (MLF, 2008) (Table 1.1). There are only a small number of dairy cattle, which are raised near the larger cities to supply milk and milk products. Each year the LBVD estimates the animal population and these numbers are used for developing short and long term national plans.

Over 50% of the total cattle population is located in the divisions of Sagaing, Mandalay and Magway. Over two million cattle live in the Sagaing Division, particularly in the lower third where there are approximately 1.5 million cattle. In contrast, there are only 0.4 million sheep and goats in the Sagaing Division. The divisions of Mandalay and Magway have 0.8 and 0.7 million sheep and goats respectively. In general, the number of small and large ruminants in the middle of Myanmar is high.

1.1.4 Cattle markets and animal movements

There are 47 cattle markets located in two States and six Divisions in Myanmar, where livetock trade within the divisions were officially permitted by government authorities (Figure 1.1). These markets are opened on a regular basis of either every 5th or 7th day in a week depending upon the local administration. Most markets are located in the Bago and Mandalay Divisions and in Shan State, and approximately half are located in the centre of Myanmar. Some markets are only for cattle and buffalo, while others are for all livestock types. In the cattle market, traditional medicine, utilities and equipment used for tethering working cattle (e.g. rope and nose strings) are sold. Based on information in 2005 from the LBVD, over 250,000 head of cattle were taken to cattle markets in Myanmar and 60% of these were sold. Of the ones sold, approximately 40% were sold for slaughter, 37.5% for draught power, 20% for breeding and 2.5% were calves sold for growing into adult cattle. In contrast, in the Sagaing Division, 71.5%

were sold for slaughter, 21% for draught power, 4.7% for breeding and 2.7% were calves sold for growing-out.

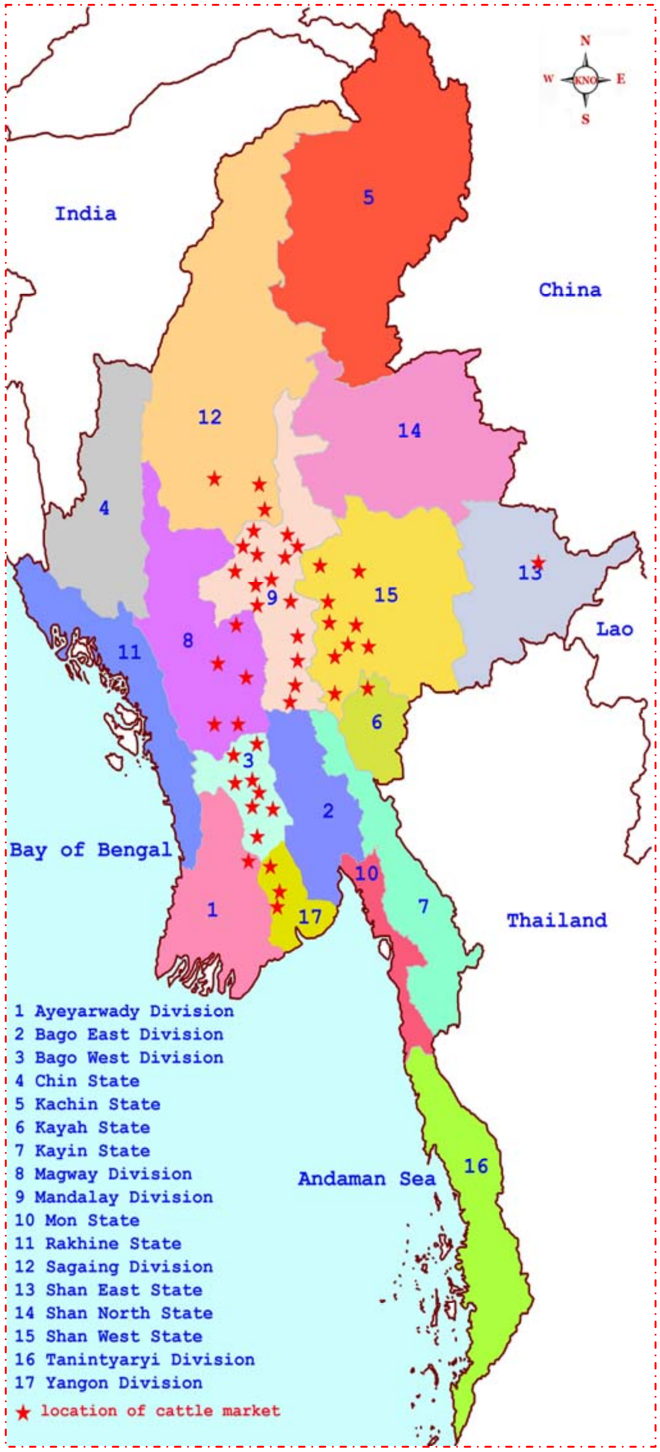


Figure 1.1 Map of Myanmar showing the States and Divisions and the location of cattle markets

Table 1.1 Summary of the livestock population in Myanmar in March 2008
(Population in millions) (MLF, 2008)

State/Division	Cattle	Buffalo	Sheep/goats	Pigs
Kachin	0.285	0.200	0.037	0.577
Kayar	0.078	0.029	0.003	0.092
Kayin	0.311	0.077	0.056	0.245
Chin	0.135	0.041	0.068	0.241
Sagaing	2.162	0.414	0.436	0.805
Tanintharyi	0.140	0.137	0.028	0.144
Bago(East)	0.670	0.231	0.020	0.391
Bago(West)	0.670	0.044	0.024	0.243
Magway	2.112	0.109	1.133	1.077
Mandalay	2.094	0.123	0.901	0.570
Mon	0.420	0.080	0.071	0.242
Rakhine	0.757	0.302	0.166	0.196
Yangon	0.560	0.132	0.075	0.622
Shan (South)	0.654	0.263	0.008	0.356
Shan (East)	0.126	0.132	0.011	0.204
Shan (North)	0.487	0.263	0.027	0.492
Ayeyarwady	1.268	0.346	0.085	1.180
Total	**12.929**	**2.923**	**3.149**	**7.677**

Myanmar has an animal movement management system that is controlled by the local authority within the Divisions and States; however, there is no uniform national animal movement management and identification system. Consequently, it is difficult to trace back to the origin of a particular animal. The Government enacted the Animal Health and Development Law in 1993 and issued related rules and regulations in 1999. Although these regulations mention the general process to control infectious animal diseases, they do not include detailed procedures for controlling animal movement (Burma Lawyers' Council, 2006).

There are a total of six established animal check points along the border with China, India and Thailand, of which five include quarantine stations that were established to foster trade with neighbouring countries (MLF, 2006) (Figure 1.2).

No movement of livestock into Myanmar is reported and most of the complex animal movements are in the middle and lower parts of Myanmar (Ozawa, 1993). Outward movements are prominent in the Sagaing and Magway Divisions towards their neighbouring States and Divisions (from Sagaing Division to Kachin State, Chin State and Mandalay Division; and from Magway Division to Mandalay and Bago Divisions) and the prominent inward movements are in the States of Shan, Kayin and Kayah (coming from the Divisions of Mandalay and Bago).

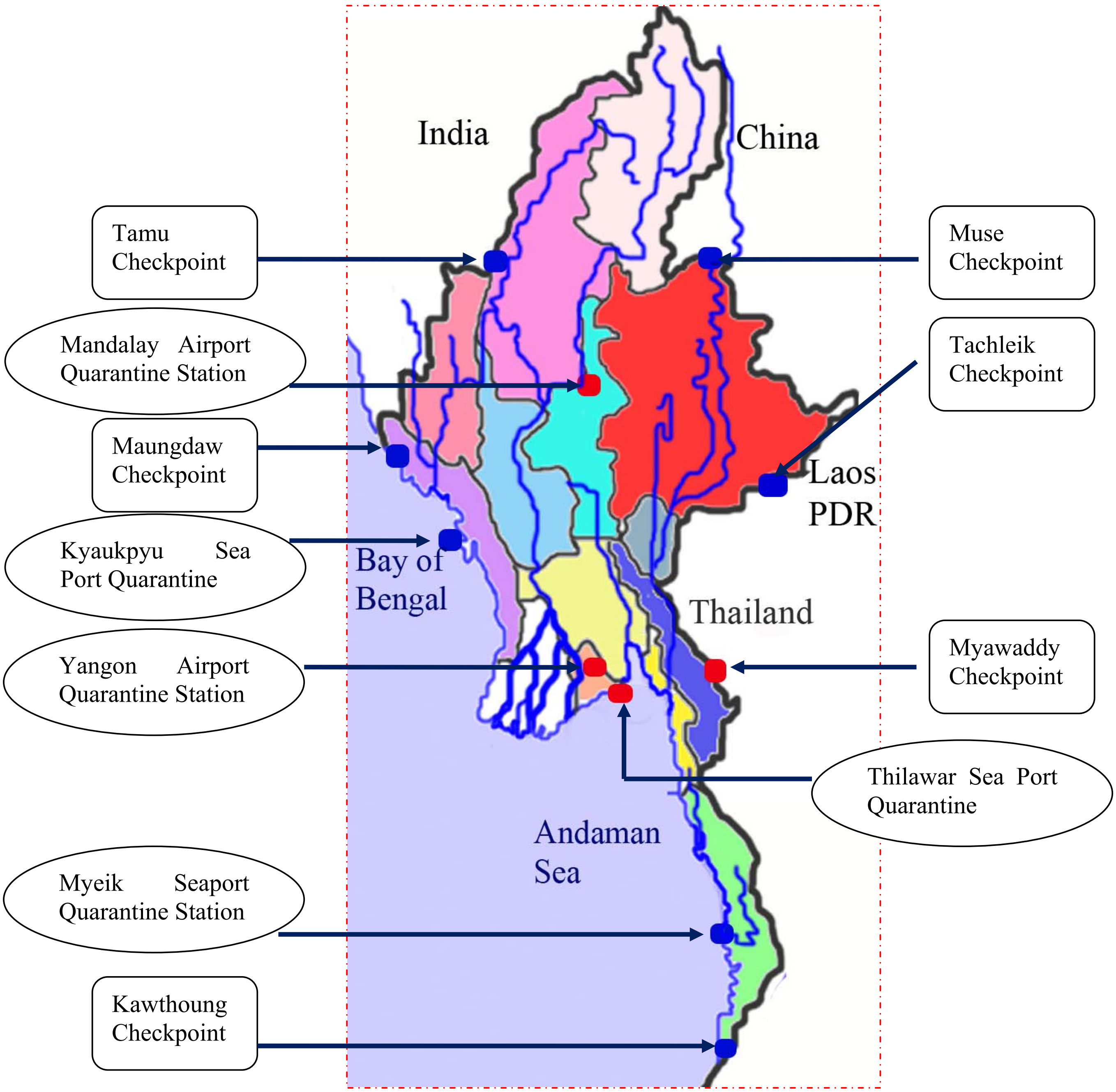


Figure 1.2 Location of check points and quarantine stations in Myanmar

1.1.5 Common livestock infectious diseases in Myanmar

The common prevailing diseases of small and large ruminants reported to the Office International des Epizootics (OIE) since 2000 were Anthrax, Black Quarter (Black leg), Classical Swine Fever, Coccidiosis, Foot and Mouth Disease, Haemorrhagic Septicaemia, Fascioliasis and Tuberculosis (OIE, 2008a,2009b). Among them,FMD, Haemorrhagic Septicaemia, Black leg and Anthrax are found to be common infectious diseases in Myanmar. There are several vaccines including Anthrax, Black Quarter, Haemorrhagic Septicaemia and FMD manufactured by Research and Disease Control Division, Insein, Yangon under LBVD (Table 1.2). However, FMD is still endemic in the country and many cases of FMD are reported each year to the OIE, in contrast to the other diseases vaccinated against. Although the earliest official records of outbreaks of FMD were reported in 1969 the disease has been recognised in the country for over 100 years (Sitt, 1978). Between 1969 and 1976, a total of 1,284,904 animals were infected and 420 animals died (On average, 160,613 animals are affected each year with 420 deaths (median 26 deaths).

The first reported experimental challenge involving FMD virus was conducted in Myanmar in 1959 when the virus was inoculated intradermally into the footpad of a guinea pig and a calves tongue. In 1960 samples were sent to Pirbright Laboratory, United Kingdom and Type O and Asia 1 were isolated (Myint, 1978). The first successful isolation of FMD virus (FMDV) (Type O) in Myanmar was performed in 1975 at the National FMD laboratory by using tissue culture techniques. The first inactivated Aluminium Hydroxide gel adsorbed monovalent O type of FMD vaccine was tested in Hlegu Township, Yangon Division in May 1975 (Sitt, 1978).

Table 1.2 Type of animal vaccines and doses produced by the LBVD

(Doses in millions)

No	Name of Vaccine	Years				
		2003	2004	2005	2006	2007
I.	Cattle					
	a) Foot and Mouth Disease	1.05	1.05	1.13	1.66	1.07
	b) Haemorrhagic Septicaemia	22.93	19.68	24.85	27.78	28.56
	c) Anthrax	21.29	19.27	22.44	23.09	23.18
	d) Black Quarter	13.57	10.36	14.49	14.28	14.37
	e) Brucella	-	-	0.02	-	-
II.	Swine					
	a) Hog Cholera	1.02	1.41	2.11	2.29	1.37
	b) Foot and Mouth Disease	-	0.04	0.06	0.27	0.43
III.	Chicken					
	a) Avian Pasteurella (injection)	40.64	41.78	2.86	1.10	1.18
	b) Avian Pasteurella (Wing wet)	-	-	41.16	41.17	40.74
	c) Newcastle Disease (CF + K)	346.37	604.73	8.39	8.01	4.95
	d) Newcastle Disease (I_2)	-	-	653.00	728.62	679.37
	e) Pox	3.01	5.51	1.89	-	1.89
	f) Gumboro	24.49	8.93	5.06	-	2.56
IV.	Others					
	a) Rabies	0.001	0.025	0.004	0.01	-
	b) Elephant Anthrax	0.001	0.04	0.05	0.04	0.05
	c) Goat Anthrax	-	0.43	-	0.32	0.002
V	Antigens					
	a) Pullorum	0.20	0.21	0.14	0.12	0.56
	b) Rose Bengal Antigen			0.17	-	0.10
	c) Brucella tube agglutination antigen			0.02	-	0.006

Between 2001 and 2005 there were many outbreaks of FMD throughout Myanmar. The majority of these outbreaks occurred in six Divisions and one State namely Mandalay, Bago, Sagaing, Magway, Ayeyarwady, Yangon and Rakhine (6%, 10%, 10%, 11% 16%, 16%, 20% of all outbreaks respectively). A total of 19,576 individual cases in cattle were reported during this period (SEAFMD, 2009). The incidence of FMD was higher in the month of June and most outbreaks were associated with owners moving animals on hoof from their village or traders moving animals on hoof from market to market (Brian *et al.*, 2003). Each year outbreaks of FMD occur in various parts of Myanmar, especially during the monsoon season when local farmers start to cultivate their fields. Outbreaks occur at the beginning of the cultivation season and reach a peak in the middle of the year especially in June and July (Figure 1.3). This disease results in many difficulties for farmers including delays in cultivating fields, loss of time waiting for the animals to recover, the unwanted additional cost of treating sick animals and the cost of obtaining other cattle for ploughing .

The prevalent serotypes of FMDV in Myanmar are type O and Asia 1, with Type O being more prevalent than Asia 1. The first case of Type A was detected between 1978 and 1980 (Kyin, 1999) and was confirmed with a Complement Fixation Test (CFT) during the FAO/UNDP Co-operation Project which focused on raising the ability to perform virus typing using serological techniques (Kyin, 1999). Type A was detected again in a disease outbreak in Myanmar in 1991 (OIE-report, 1991). The last Type A outbreak was reported in 1999 in only a single outbreak in the Tanintharyi Division (Black, 2003) .

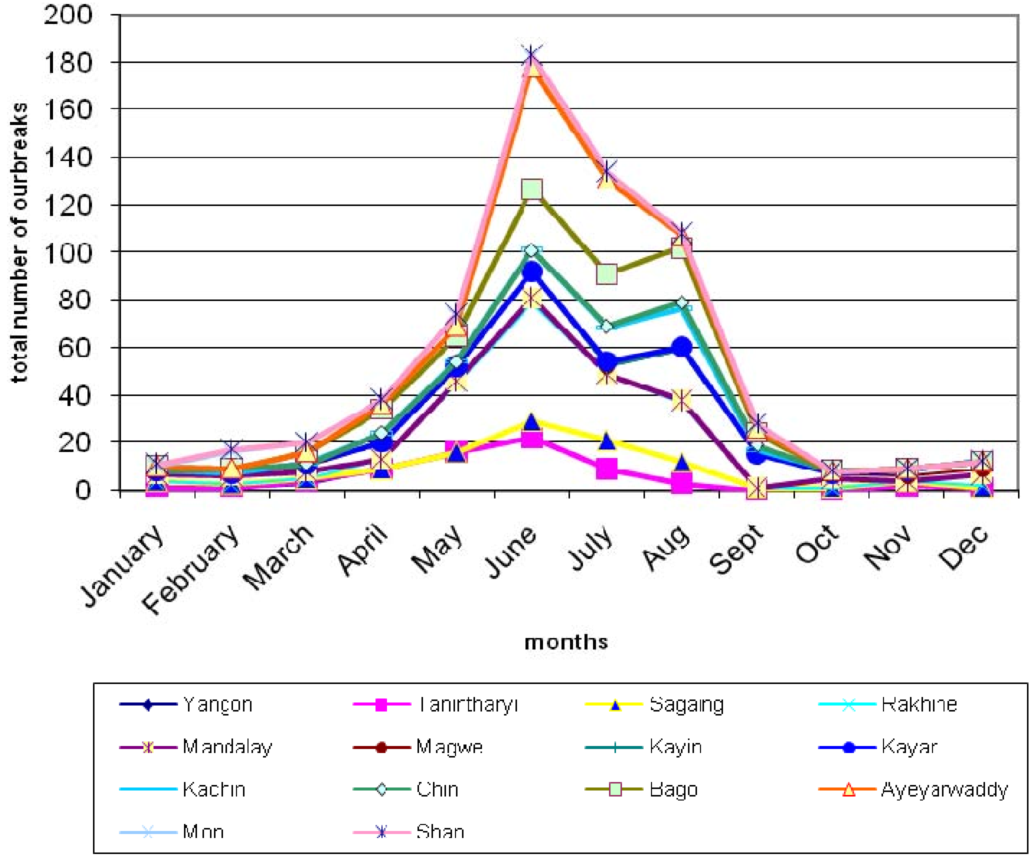


Figure 1.3 Summary of FMD occurrence between 1994 and 2005*

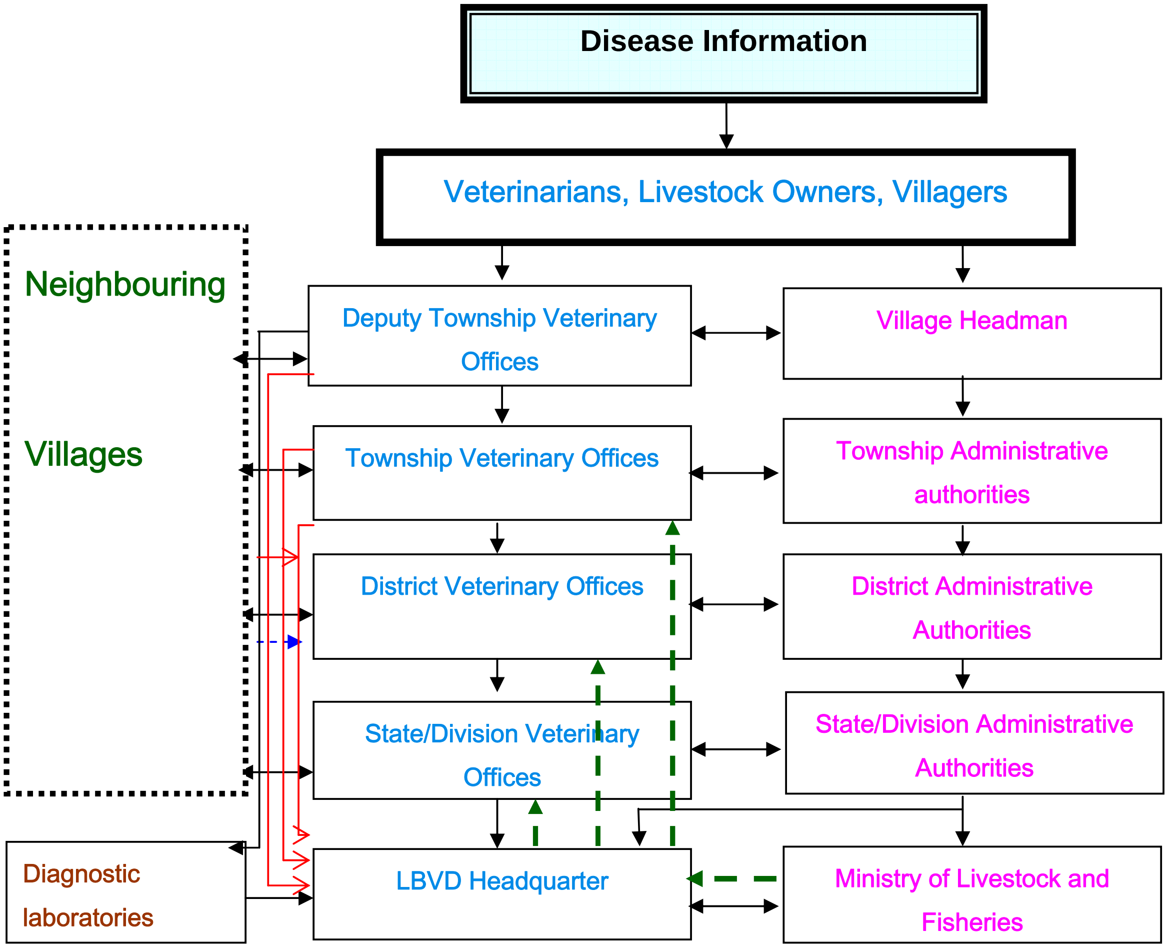
**data source - LBVD planning and statictic section*

1.1.6 Control of FMD in Myanmar

The LBVD has developed and is applying a National FMD control plan (Strategic Framework for National FMD Disease Control in Myanmar) in line with the eight components of the Southeast Asia Foot and Mouth Disease campaign (SEAFMD). The eight components are: international coordination and support; program management, resources and funding; public awareness and communication; disease surveillance, diagnosis, reporting and control; policy and legislation to support disease control and zone establishment; regional research and technology transfer; livestock sector development including private sector integration; and monitoring and evaluation. This plan relies upon the use of a locally produced monovalent vaccine (Type O or Asia 1), with a strategic zoning approach to control FMD.

The control of FMD and the success of the eradication program are important for both Myanmar and its neighbouring countries because of the potential for the rapid spread of FMD within the region. Control of animal movements has been identified as an important factor in the control of FMD in Myanmar. However, Myanmar has only recently implemented regulations for controlling animal movements (Sasaki, 1993). In 1993, the Animal Health and Development Law was enacted by the State Law and Order Restoration Council of Myanmar, and after that, the MLF issued Notification No.45/99 for the prevention and control of contagious disease in animals. Since enacting the new law, control of animal movements has been more systematically conducted by the LBVD throughout Myanmar. However, the LBVD still has to overcome many obstacles in controlling the movement of animals because of the lack of an animal identification system.

There is a disease information pathway currently used by the LBVD as a passive reporting system for all infectious disease of livestock (See Figure 1.4). Any disease information can be reported by private veterinarians or livestock owners or villagers to the nearest deputy veterinary office of the LBVD which are located throughout the country. Basically, the deputy township veterinary officer has to report to their immediate senior officer and then the township officer submits a report to the district and so on. At the same time, the deputy veterinary officer has to send a copy of their report to the headquarters of the LBVD for all notifiable diseases announced by the MLF. In addition, a copy of the report has to be sent to the village headman where the deputy veterinary office is situated and to the headmen of neighbouring villages.



Reporting of disease outbreak (Proper channel)

Reporting of disease outbreak (Direct channel)

Instruction & support for the control of disease outbreak

Figure 1.4 Disease information pathway of the LBVD

1.1.6.1 Research and Vaccine production section for FMD

The National Foot and Mouth Disease Diagnostic Laboratory was established on the 18th August, 1975 (Pers. com. Dr Maung Maung Kyin). Surveillance for FMD and the investigation of specific serotypes were commenced in 1977 with the support of the FAO/UNDP (Kyin, 1999). This was the first step for the control of FMD in the region. The National FMD laboratory (renamed Research and Vaccine Production Section for FMD in 1984) consists of a vaccine production unit and a unit for identifying serotypes involved in outbreaks (Turton, 2002). Serotypes O, A and Asia 1 were initially detected with a CFT. In 1995, the CFT was replaced by the Enzyme Linked Immunosorbent Assay (ELISA) with support from the International Atomic Energy Agency (IAEA) Technical Co-operation project. After that, detection of antigen and antibody to FMD was conducted with the support of the IAEA. Currently the laboratory is capable of performing limited diagnostic and serological tests such as the Indirect sandwich ELISA test for antigen, liquid phase blocking ELISA test for antibody, FMDV non-structural protein test (NSP), viral neutralization test, and virus isolation by inoculation of mice and by using the BHK 21 cell line. Provision of laboratory test kits depends upon donations from international organizations and funding from the LBVD. In addition to the central laboratory at Insein, there are three regional laboratories located in Mandalay, Taunggyi and Pathein. Of these regional laboratories, only the laboratory at Mandalay is able to diagnose FMD (provided test kits for FMD are available).

The Research and Vaccine Production Section for FMD of the LBVD is divided into five main units for the diagnosis of FMD and production of vaccine: epidemiology, virus typing and serology, cell production, vaccine production and quality control units. Eleven veterinarians and other laboratory assistants work for the diagnostic and vaccination sections. All units are located in a building located in Insein, Yangon. A branch of the FMD vaccine production unit has also been established in Myinmu Township, Sagaing Division to increase the future production of vaccine. Prior to 1994 the vaccine was inactivated by formalin, however since 1994 Binary ethyleneimine (BEI) has been used as it provides a better inactivation process (Latt, 2006b). There is an annual capacity of 100,000 doses of monovalent vaccine (Gleeson and Ozawa, 2002), but it is planned to increase this to 0.5 million doses with support from the Japanese International Cooperation Agency (JICA). However, the total livestock population in Myanmar is more than 10 million, therefore only a small proportion of the population can be vaccinated in any one year.

1.1.6.2 International support

Myanmar first obtained international support for the control of FMD to establish a laboratory for serotyping FMDV in October 1977 from a project of the United Nations Development Programme (UNDP) (Kyin, 1999). The IAEA provided ELISA test kits and technical advice for the diagnosis of FMD to replace the use of the CFT in 1995 (Kyin, 1999). A public awareness programme to support the Rakhine State FMD free zone project was funded by the Korean Overseas International Cooperation Agency (KOICA) in 2001 (Khin, 2008).

The Thailand based JICA established a five year project in December 2001 for the control of livestock diseases in Thailand and neighbouring countries (Sasaki, 2003). It supported two-month training courses for the diagnosis of FMD and four-month training courses for vaccine production and quality control at the Regional FMD Reference Laboratory in Pak Chong, Thailand. A total of four staff from Myanmar FMD laboratory joined the training courses. In addition, JICA supported a training course to produce oil adjuvant FMD vaccine for pigs as well as purchasing some laboratory equipment. The LBVD also obtained technical support from the SEAFMD campaign of the Office International des Epizootics Regional Coordination Unit (OIE RCU) to enhance sero-surveillance, vaccine production and epidemiological surveys.

The LBVD has been actively participating in the SEAFMD campaign since its establishment in September 1997. The first Myanmar Zoning Working Group (MZWG) meeting was held on the 5th - 6th January 2004 in Yangon, Myanmar. Four different areas: the Rakhine State zoning approach; the Malaysia Thailand Myanmar (MTM) peninsular campaign; the Sagaing Zoning approach and the establishment of a buffer zone to support the Upper Mekong Working Group (UMWG) in the eastern border of Shan State were proposed to assist with the control of FMD in Myanmar. A task group was established to plan an epidemiological study to determine the prevalence and incidence of FMD, and to identify the risks associated with livestock movements in the prospective zones.

The second meeting of the MZWG was held in Mandalay, Myanmar from the 20^{th} to the 22^{nd} of August 2004. At this meeting it was recommended to: finalise the surveillance proposal for the Myanmar MTM area; confirm the animal movement patterns of the Sagaing Division; refine the proposed control zone boundaries to extend to the whole Sagaing Division; and finalise the plan for the surveillance and epidemiological studies.

The third MZWG meeting was conducted at the same time with the fourth meeting of the working group on zoning for FMD and animal movement management in the Upper Mekong region. Recommendations from the third MZWG included to request the PR China for an extension of the bilateral agreement on animal disease control between the two countries and to conduct sero-surveillance in the targeted areas for the control of FMD.

The fourth meeting was held in Mandalay during 13th and 14th December, 2006 and recommended to designate 15 townships of Sagaing located in a lowland area bounded by two rivers of Ayeyarwady and Chindwin as a control zone. It was also agreed to upgrade the buffer zone in Myeik District to control zone status and expand the buffer zone to include the Dawei District and to upgrade Kawthoung District from control to eradication zone. A recommendation was made to validate the Dutaik meeting technique as a means of improving public awareness and as a participatory epidemiological investigation.

Myanmar has developed as FMD National Control Plan to overcome annual disease outbreaks in line with the eight components of the SEAFMD Campaign (See 1.1.6)

1.1.6.3 MTM campaign

For the MTM campaign, a Memorandum of Understanding (MOU) was signed between Malaysia, Thailand and Myanmar on the 6th November 2003 in Bangkok; and a Tristate Commission was established to implement the program. An area of the MTM Peninsular which includes part of Malaysia, Thailand and Myanmar was selected as a potential Free Zone for FMD because there is a relatively high chance of success and it was considered to be a good example of the need for international cooperation and benefits could be shared between the participating countries (SEAFMD, 2006). The MTM campaign is considered to be a good model for implementing a zoning approach to control FMD, not only in Southeast Asia but also in other parts of the world.

In the Myanmar MTM area, FMD had not been detected for many years prior to 1975 in the proposed control zone (Kawthoung District) but one outbreak, affecting 9 cattle, was reported in the proposed buffer zone (Myeik District) in 1999. Since then, there have been no further reported outbreaks. The LBVD initiated a preliminary sero-surveillance survey between 2001 and 2004. At the end of 2004, an active surveillance programme, funded by the Australian Sanitary Phytosanitary Capacity Building (SPSCB) project, was undertaken in the Myanmar MTM area. This programme included a public awareness programme, training of farmers and sample collection. It was completed at the end of 2005 and disease free status was achieved in the area (whole of Kawthoung District as an eradication zone status and whole of Myeik District as a control zone status) in accordance with the minimum standard requirements of the MTM campaign.

At the 7th Meeting of the Tristate Commission on the Establishment of the MTM Peninsular Campaign for Freedom in Chaam, Petchaburi, Thailand from 1-3 February 2006, it was recommended to upgrade the zone status of the Myanmar MTM area. This recommendation meant that the buffer zone progressed to a control zone, the control zone progressed to an eradication zone and the infected zone changed to a buffer zone. To maintain and transform the zone status in the area, further epidemiological studies were required. These studies form the basis for part of the work outlined in this thesis.

1.1.6.4 Sagaing Zoning Approach

Myanmar is an important country for the control of FMD in South-East Asia because it has a large population of ruminants and it is a potential source of infection for neighbouring countries (Gleeson, 2002). Within Myanmar, the Sagaing Division is also an epidemiological significant region because it has a very large population of ruminants and there are a large number of animals moving out of the region with very few movements into the region. The Division has been considered as a potential source of FMD for Myanmar and neighbouring countries. The Sagaing zoning approach was strongly recommended by the first MZWG Meeting and has been implemented by staff of the LBVD with international support from JICA. Initially, the lower third of the division, which is located between two large rivers, the Ayeyarwady and Chindwin, and rugged mountains, was proposed as a control zone. After a surveillance programme is conducted, demarcation of the buffer and control zones can then be designated. Intensive surveillance is still being conducted to understand the pattern of FMD in the region, to designate the zone status and to expand the zone status in the future. A better understanding of the epidemiology of FMD in the Sagaing Division is an important issue for the future control of FMD throughout the country. This work forms a part of this study.

1.2 Literature Review

Foot and mouth disease is a highly contagious viral disease causing illness and vesicular lesions in both domesticated and wild cloven-hoofed animals. It has been reported to affect many species of ruminants and more than 70 wildlife species (Coetzer *et al.*, 1994; Sobrino *et al.*, 2001; Pinto, 2004). It is one of a list of notifiable diseases that affects multiple species of animals (OIE, 2008e). The disease is of great concern to veterinarians, farmers, and animal and animal product traders because of three main factors: its highly contagious nature; its ability to persist in carriers; and the fact that there is no cross protection between serotypes of virus (Alexandersen *et al.*, 2003a). The disease was first described in 1546 by a monk, Hieronymous Fracastorius, as an epidemic disease of cattle which occurred near Verona, Italy (Mahy, 2005b). The virus was the first animal virus to be discovered in 1898 by Loeffler and Frosch (Brock, 1998). In a list generated by the OIE in 2008, 64 countries were classified as FMD free without vaccination; two countries were classified as free with vaccination; nine countries had free zones without vaccination and five countries had free zones with vaccination (OIE, 2008d). Foot and Mouth Disease can cause significant economic losses both in countries where the disease is endemic and in countries which are free and have an outbreak of disease. For example in outbreaks in Taiwan (1997) and the United Kingdom (2001), over four million pigs and six million cattle were destroyed resulting in a cost of USD $378.6 million (Yang *et al.*, 1999), and GBP £3.2 billion (Thompson *et al.*, 2002) respectively.

1.2.1 Type of strains

There are seven serotypes of FMDV recognised: SAT 1, SAT 2, SAT 3, O, A, C and Asia 1 (Hedger, 1972; Knowles and Samuel, 2003; Rowlands, 2004; Knowles *et al.*, 2005). The three serotypes of SAT 1, SAT 2 and SAT 3 are prevalent in South Africa and are maintained in African Buffalo (Condy, 1979). Knowles and Samuel (2003) stated that the two serotypes, O and A, were widely distributed in many countries in South America, southern Asia and Africa. Asia 1 is found in Asia (Brown, 2003).

There is no cross protection between the types (Garland and Donaldson, 1990) and the clinical disease induced by the different serotypes is indistinguishable. Among the Southeast Asian countries, Lao PDR, Malaysia, Myanmar, Thailand and Vietnam have reported the presence of serotypes O, A and Asia 1 between 1996 and 2005, whereas in Cambodia Types O and Asia 1 have been detected and only type O (Cathay topotype) has been recorded in the Philippines and Vietnam (Gleeson, 2002; SEAFMD, 2009).

1.2.2 Epidemiology

1.2.2.1 Animals affected

All cloven hoofed domesticated and wild animals are susceptible to infection including cattle, buffalo, sheep, goats, pigs and bison (*Bison bison*) (Allanspach, 1950; Lindau, 1964). The disease can also affect all members of the order of Arteriodactyla such as deer, camels, llamas, alpacas, and Asian and African Elephants (Schaftenaar, 2002; Alexandersen and Mowat, 2005). Although camelids are listed as susceptible animals for FMD in the OIE animal code, they are less susceptible than cattle, are probably not carrier animals and are not important in the transmission of the disease to other livestock (Fondevila *et al.*, 1995; Wernery and Kaaden, 2004). Australian marsupials, birds, guinea pigs and suckling mice can be experimentally infected, and infection of humans has also been demonstrated (Rowlands, 2004). However, infection of humans is often mistaken for hand, foot and mouth disease syndrome which is caused by both Coxsackieviruses and Enteroviruses (Peter, 2002; Andrew and Matthias, 2006).

1.2.2.2 Transmission

The major routes of transmission are by direct or indirect contact with infected animals or contaminated animal products and by exposure to virus infected material. Transmission can occur via aerosol, contact or oral routes (See Table 1.3) (Henderson, 1969; Tinline, 1970; Sellers and Forman, 1973; Tomasula and Konstance, 2004). In cattle air borne transmission, via the respiratory route, is the most common means of transmission (Donaldson *et al.*, 1987). Any person who has been exposed to the virus can transmit the infection by exhalation of viral particles to susceptible animals within 28 hours of exposure but there are no detectable viral particles in the human respiratory tract 48 hours after exposure (Amass *et al.*, 2003). Although pigs are less susceptible to aerosol infection than cattle, they produce more virus per day in acute infections than do cattle (Kitching *et al.*, 2005). For transmission by direct contact, pigs are as likely as cattle or sheep to get infected (Aggarwal *et al.*, 2002). The onset of viraemia depends on the dose of virus a pig is exposed to, and the lower the challenge dose, the longer the duration of active viraemia (Quan *et al.*, 2004). Spread of FMDV from sheep and goats to other susceptible species is elusive (Barnett and Cox, 1999) and some studies reported it as having an insignificant role in disease transmission (Anderson *et al.*, 1976; Garland *et al.*, 1981; Fondevila *et al.*, 1996) while some studies have refuted this (Sharma, 1981; Gurhan *et al.*, 1993). It is less urgent for sheep showing older lesions of FMD to be immediately slaughtered as these animals are less infectious than are sheep with younger lesions (Honhold *et al.*, 2004). The significance of the carrier status of sheep and goats is not clear or well documented in the veterinary literature (Aggarwal *et al.*, 2002). Although FMDV has been detected in the semen of boars that were naturally infected with FMD, the risk of sexual transmission is not high (Guerin and Pozzi, 2005).

Table 1.3 Summary of transmission of FMDV

Species	Aerosol	Contact	Oral
Sheep and Goats	Highly susceptible but less likely to become infected by aerosol than cattle (Kitching and Hughes, 2002)	Susceptible by direct contact (most often) (Kitching and Hughes, 2002)	Least susceptible (Alexandersen *et al.*, 2003b)
Cattle	Very susceptible (Kitching, 2002a)	Susceptible by contact (Kitching, 2002a)	Least susceptible (Kitching, 2002a)
Pigs	Least susceptible (need more than 600 times the dose to infect pigs than cattle and sheep) (Donaldson *et al.*, 1987)	Direct contact (Kitching and Alexandersen, 2002)	More susceptible (Kitching and Alexandersen, 2002)

1.2.2.3 Source of Infection

Cattle and pigs can exhale viral particles, and nasal fluid and saliva of infected animals can also be a potential source of infection (Alexandersen *et al.*, 2003a). The visceral organs and hides of infected animals are also potential sources of virus. In contrast, boneless meat is free of virus. Exposure of vaccinated cattle to the live virus can result in carrier animals, even in the absence of clinical signs. In this situation, these animals can be a source of infection for other susceptible animals and vaccination cannot prevent the carrier stages of FMD from developing (Ekboir *et al.*, 2002; Alexandersen *et al.*, 2003a; Niedbalski and Haas, 2003; Clavijo *et al.*, 2004). Convalescent cattle and sheep frequently become carriers and are an important source of new outbreaks of disease (Shen *et al.*, 1999). The FMDV can also persist in the throat of affected animals (Knowles and Collen, 1992) and cattle have experimentally been shown to acquire infection from carrier buffalo and this carrier period can be for up to 5 months (Dawe *et al.*, 1994). The FMDV can be detected in cattle for over 3 years, in sheep up to nine months, in goats up to four months and the virus cannot be detected in pigs 28 days following infection (Kitching, 2002b).

1.2.2.4 Survival on Fomites

The virus can survive outside the animal in secretions and excretions from infected animals (see Table 1.4), however the estimated survival period on fomites is considered to be a maximum of three months (Bartley *et al.*, 2002). Under laboratory conditions FMDV has been shown to survive on bran, damp hay, cow hair, wool, sand and straw (Table 1.4) (Bedson *et al.*, 1927; Eisner and Mcvicar, 1980; McColl *et al.*, 1995) and milk (Tomasula and Konstance, 2004). In a field study, it has been shown that the virus can survive for up to 24 days in soil depending upon the humidity and temperature (Podrezova, 1969). The virus can also survive in faeces for than two months (Table 1.4) (Haas *et al.*, 1995). Bedson *et al.* (1927) mentioned that the virus could survive longer on dry hay and bran than under damp conditions and Donaldson (1983) indicated that the survival of airborne FMDV was dependent upon the nature of the suspending fluid and relative humidity (Bartley *et al.*, 2002). Therefore, the survival time of FMDV on fomites depends on the relative humidity, pH, strain of virus and nature of infected material (Donaldson and Alexandersen, 2003). The duration of survival of viruses under different environmental conditions is influenced by the climate from where the virus originated (Donaldson, 1983).

Table 1.4 Summary of survival of FMDV in various fomites

	Fomites	Survival period	Reference
1.	Milk	33 hours	Tomasula and Konstance, 2004
2.	Faeces/ liquid manure	79 days at 17° C 100 days at 4° C	Haas *et al.,* 1995, Parker, 1971
3.	Cow Hair	35 days	Bedson *et al.,* 1927
4.	Wool	2.5 days at 21° C	Eisner and McVicar, 1980
5.	Wool (Merino greasy)	60 days at 4° C	McColl *et al.*, 1995
6.	Soil	24 days at 5° C	Podrezova, 1969
7.	Straw	35 days	Bedson *et al.*, 1927
8.	Hay	105 days	Bedson *et al.*, 1927
9.	Bran	154 days	Bedson *et al.,* 1927
10.	Sand	17 days	Bedson *et al.,* 1927

1.2.2.5 Incubation period

The incubation period in cattle depends upon the individual animal, the virulence of the virus and its strain, the dose of virus received, the route of transmission and the husbandry conditions. It is highly variable and ranges between two days and two weeks (Kitching, 2002a; Alexandersen and Mowat, 2005). The mean incubation period for pig to pig transmission is shorter than that for cattle to cattle transmission: 1 to 3 and 3 to 4 days respectively (Alexandersen *et al.*, 2003a).

1.2.2.6 Risk factors

Risk factors for infection can be divided into two groups: risk factors for introducing infection into an FMD free area and risk factors for the recurrence of an outbreak in an FMD infected area.

The risk factors for introduction of disease into FMD free countries include the movement of livestock and livestock products (Woolhouse and Donaldson, 2001; Sutmoller and Casas Olascoaga, 2003), feeding of garbage or swill to pigs (USDA-APHIS-VS, 1994; Costelloe *et al.*, 2002; Garner *et al.*, 2002), and transmission from wild life reservoirs (Sumption *et al.*, 2007). Potential factors for the spread of FMD include contamination resulting from surveillance activities, inappropriate disposal of infected cadavers, improper disinfection of equipment and vehicles, infected embryos and dispersion by wind (Sutmoller and Wrathall, 1997; Cannon and Garner, 1999; Barteling and Sutmoller, 2002). In a risk analysis model for Great Britain, Hartnett *et al.* (2007) considered that risk factors for introducing FMD into the country were the illegal importation of FMD contaminated meat and other animal products including bone-in or dried de-boned products. Untreated milk from infected animals could result in infection in free animals through ingestion or inhalation (Donaldson, 1997). Bovine embryos from infected animals were considered to be capable of introducing FMD into a free country (Sutmoller and Wrathall, 1997). The risk factors for the initial spread of the disease in the UK outbreak in 2001 were identified as movements and mixing of animals in livestock markets (Ferguson *et al.*, 2001; Gibbens *et al.*, 2001; Robinson and Christley, 2007).

The risk factors of spreading FMD for countries where the disease is endemic include swill feeding, fomites, sharing water sources (Cleland *et al.*, 1996), and inadequate vaccination strategies (Sumption *et al.*, 2007). Bronsvoort *et al.* (2004b) administered questionnaires to 147 producers in the Adamawa Province of Cameroon to identify herd-level risk factors for FMD. They found that transhumance, buying cattle from markets, mixing of herds at water points, feeding cotton seed, and the presence of buffalo near herds were risk factors for disease (Bronsvoort *et al.*, 2004a). In a group interview study in Southeast Asia, farmers reported that risk factors for spreading infection were the movement of animals and humans from infected villages, mixing of animals on communal grazing land and purchase of meat from local markets (Perry *et al.*, 2002).

1.2.3 Pathological Effects

1.2.3.1 Clinical Signs

There are several other diseases which cause lesions in the mouth, nares and feet similar to those found with FMD including Vesicular Stomatitis and Swine Vesicular disease (Anon, 2000a; OIE, 2008e). The clinical signs of FMD depend on the strain of virus, the challenge dose, the host species and the susceptibility of the individual animal (Kitching *et al.*, 2005). The mortality rate in adult animals of any species is very low in contrast to the morbidity rate (Aggarwal *et al.*, 2002).

1.2.3.1.1 Clinical lesions in cattle and buffalo

Cattle are one of the most susceptible species of cloven hoofed animals. They show severe clinical disease (Hedger *et al.*, 1972) with the main features being pyrexia, inappetence, mucoid to mucopurulent nasal discharge, mild to severe vesicular lesions in the oral cavity and/or the feet, especially around the coronary band followed by lameness, decreased milk production, weight loss, abortion and infertility. Young calves may die from heart failure because of the virus invading the cardiac muscles (Kitching, 2002a; Rowlands, 2004). Hedger *et al.* (1972) mentioned that buffalo were highly susceptible to FMD but clinical disease was not apparent other than for very small vesicular lesions.

1.2.3.1.2 Clinical lesions in pigs

In pigs, clinical signs are the same as for cattle and include fever, loss of appetite, lameness, vesicles around the tongue, lower jaw and snout, abrasive skin lesions around the feet and coronary band followed by sloughing of the horn from the hoof and lameness (Kitching and Alexandersen, 2002). Clinical signs of FMD in pigs are very similar to those of vesicular stomatitis and vesicular exanthema (Nardelli *et al.*, 1968). Kitching and Alexander (2002) also reported that subclinical infection can occur in pigs depending upon the challenge dose of virus and the viral strain. Subclinical infection leads to a short viraemic stage and a very low level of antibody response. A highly virulent strain of virus, the Cathay topotype of serotype O, was responsible for the outbreak in pigs in Taiwan in 1997 (Samuel and Knowles, 2001).

1.2.3.1.3 Clinical lesions in elephants

Signs in elephants include high fever, loss of appetite, reluctance to move, salivation, swollen buccal cavity with aphthae, lameness, and sloughing of the sole following eruption of the vesicles (Pyakural *et al.*, 1976). The clinical picture is similar for both African and Asian elephants (Hedger and Brooksby, 1976).

1.2.3.1.4 Clinical lesions in sheep and goats

Clinical signs in sheep and goats are mild and sub-clinical, and are also difficult to differentiate from other common diseases such as blue tongue (Ganter *et al.*, 2001; Kitching and Hughes, 2002; Clavijo *et al.*, 2004). Hughes *et al*. (2002) mentioned that the mean duration of clinical disease was only 2.2 days (95% CI 1.8 - 2.6). Over 90 per cent of lesions in sheep are on the interdigital skin of the feet with only 4% of sheep infected with FMD displaying oral lesions (Hughes *et al.*, 2002). Although lameness is a typical clinical sign of FMD in sheep, as sheep show less severe clinical signs than cattle, the disease could be easily mistaken for other diseases (Ayers *et al.*, 2001; Patil *et al.*, 2002).

1.2.3.2 Pathogenicity

Infection can enter the host by many different ways including from contaminated material, food, milk, semen, droplets, secretions, utensils, and vehicles through the oral and nasal cavity, abrasions, cuts or lacerated wounds (Garland and Donaldson, 1990; Bastos *et al.*, 1999; Donaldson and Alexandersen, 2002; Kitching, 2002a; Guerin and Pozzi, 2005). The likelihood of infection depends on the animal species, the meteorological conditions, and the environmental location (Alexandersen *et al.*, 2003b). Alexandersen *et al.* (2003b) also stated that animals can be experimentally infected via the subcutaneous, intradermal, intramuscular, intravenous or intranasal routes. Cattle are more likely to be infected from an aerosol (which is produced by other species especially from pigs) than are sheep and goats because cattle have a greater volume of inspired air than do smaller ruminants (Donaldson, 1987). The most common site of primary infection is the pharyngeal area, and this area is often sampled (using a probang) for virus detection (Garland and Donaldson, 1990). After the infection enters the host, the virus replicates and enters the regional lymph nodes and then spreads through the lymphoid system to the circulation (Garland and Donaldson, 1990). Viral replication occurs in the cornified stratified squamous epithelium (Alexandersen *et al.*, 2003b; Alexandersen and Mowat, 2005).

1.2.3.3 Pathological changes

In the early stages of infection, pathological changes are not evident. The first histopathological lesions can be seen on the cornified squamous epithelium with intracellular oedema and prominent cytoplasmic eosinophilic staining of the affected cells (Kitching and Alexandersen, 2002). This is followed by visible lesions of necrosis and the formation of vesicles and separation of epithelium from the underlying tissue. The mortality rate is high in young animals, and on post mortem examination, the most typical lesions can be seen in the heart with the presence of stripes and white greyish spots which has led to the term "tiger heart" (Garland and Donaldson, 1990; Alexandersen and Mowat, 2005).

1.2.4 Diagnosis

In the Manual of Diagnostic Test and Vaccines for Terrestrial Animals of the Office International Epizootic (OIE, 2008b), it is recommended to use virus isolation by cell culture or from unweaned mice followed by an ELISA for the identification of the virus and its serotype. However a CFT can be used if an ELISA is not available.

Suckling mice and guinea pigs are important animals for laboratory confirmation of FMDV (Rowlands, 1999; Yang *et al.*, 2005). The reverse-transcription polymerase chain reaction (RT-PCR) is a more advanced technology to detect viral antigens and specific types and it has been increasingly used in developed countries. Viral Neutralization tests or competitive, blocking or liquid-phase blocking ELISAs can be used to detect specific antibody responses to FMDV. Non Structural Protein tests (NSPs) are used to differentiate antibodies produced in response to vaccination from those produced by natural infection. The NSP ELISA is a sensitive method to differentiate the carrier stages of vaccinated cattle (Moonen *et al.*, 2004a). Although the Serum Neutralization Test (SNT) has been used for many years it has the disadvantage that the test must be left for at least 3 days prior to reading, as it uses cell cultures. Consequently, the liquid phase blocking ELISA, which can be read within 24 hours, has replaced the SNT (Maanen, 1990).

1.2.4.1 Diagnostic Tests for FMD

Clinically FMD is indistinguishable from other vesicular diseases such as swine vesicular disease, vesicular stomatitis and vesicular exanthema, consequently laboratory diagnosis is essential for confirmation of the disease (Mowat *et al.*, 1972; Anon, 2000a). The OIE recommends confirming a diagnosis of FMD by isolation of virus or by the detection of antigen and virus-specific antibodies (Table 1.5). Commonly used laboratory tests include the CFT, ELISA, Viral Neutralization tests and RT PCR tests (OIE, 2008b). These are used to detect FMDV antibody from serum or tissue samples and have different sensitivities and specificities (Westbury *et al.*, 1988; Brocchi *et al.*, 2006).

Table 1.5 OIE recommended tests for the diagnosis of FMD

No	Methods	Tests*
1.	Identification of the agent	a. Virus isolation b. Immunological methods 1. ELISA 2. CFT c. Nucleic acid recognition methods 1. Agarose gel-based RT-PCR assay 2. Real-time RT PCR assay 3. Molecular epidemiology
2.	Serological tests	a. Viral neutralization test b. Solid-phase competition ELISA c. Liquid-phase blocking ELISA d. Non-structural protein antibodies tests 1. Indirect ELISA 2. Enzyme-linked immunoelectrotransfer blot assay (EITB)

*(OIE, 2008b)

1.2.4.2 Complement Fixation Test

The CFT test, which is serotype dependent, is still recommended in the OIE manual and has been used in many FMD laboratories for the last decade (De Clercq, 2003). It has been used to detect antigen to FMD in samples of epithelial tissue and freshly ruptured vesicular samples collected from cattle and buffalo. Based on research performed on tissue samples in Northern Thailand, the sensitivity and specificity were calculated as approximately 24% and 98% (Westbury *et al.*, 1988) and in research in Brazil, 43.3% and 100% respectively on tissue samples (Prado, 1997). It did not produce any positive results in pig samples whereas bovine and buffalo samples produced some positive results. Consequently this test is not sufficiently sensitive to detect infection (antigen) in pigs (Westbury *et al.*, 1988). The CFT has more cross-reactions than the ELISA and the sensitivity of the test depends on the type of sample. When the test is performed on fresh and good quality samples it is more sensitive than if performed on older samples where there has been cellular breakdown, loss of viral integrity or from the improper storage and transport of samples (Hamblin *et al.*, 1984).

1.2.4.3 Cell culture and Virus Isolation

Cell culture has been used for many years in diagnostic laboratories to detect FMDV and is recommended in the OIE manual (OIE, 2008b). Virus isolation by using cell culture is an important test to prove the presence of live virus in samples of suspected material. The virus is cultivated on cell lines such as: calf thyroid (Snowdon, 1966), lamb kidney, pig cells and baby hamster kidney cell lines, BHK 21 (Clarke and Spier, 1980). The former two cell lines are very sensitive but difficult to maintain to get the same sensitivity results (De Clercq, 2003). Pig cell lines are not always suitable for the isolation of virus from sheep and goats because the quantity of virus in samples from these species is usually low (Bouma *et al.*, 2001).

1.2.4.4 Virus Neutralization Test

The Virus Neutralization Test (VNT) is used as a gold standard for the diagnosis of FMD (Clavijo *et al.*, 2004; Kitching, 2004) and is recommended by the OIE as the prescribed test for trade (OIE, 2008b). However, it is very laborious and is not a reliable test to use in routine laboratory situations. The results are variable because of its biological nature and it cannot differentiate between antibodies arising from infection and those from vaccination (Moonen *et al.*, 2004b). If the titre to the VNT is less than or equal to 1:1, between 1:16 and 1:32, or greater than 1:45 then the results are categorised as negative, doubtful or positive respectively (Mackay *et al.*, 2001).

1.2.4.5 Serum Neutralization Test

The Serum Neutralization test (SNT) can identify and measure the serological response against FMDV, and gives a reaction similar to ELISAs. It has been used in the FMD vaccine potency test in sheep in Egypt (Deghaidy *et al.*, 2002). It cannot exactly measure immunological protection but can measure the antibody response amongst a population (McCullough *et al.*, 1992; El-Shehawy *et al.*, 2004). The SNT and Liquid Phase Blocking ELISA tests are closely correlated (McCullough *et al.*, 1992; Haas, 2004).

1.2.4.6 Agar Gel Diffusion Test

The agar gel diffusion precipitation test, which has been validated in cattle, sheep, goats and pigs, has been used for detecting antibody to FMD Virus-Infection-Associated antigen (McVicar and Sutmoller, 1970).

1.2.4.7 Enzyme Immunotransfer Blot Assay

The Enzyme Immunotransfer Blot assay (EITB) is used with the 3ABC ELISA test for the confirmation of positive samples in some FMD eradication programmes (Clavijo *et al.*, 2004).

1.2.4.8 Enzyme Linked Immunosorbent Assays

The ELISA has replaced the CFT during the last decade. The ELISA can be used to detect and type infections with FMDV. There are three types of ELISA: Liquid Phase Blocking ELISA (LPBE), Solid Phase Blocking ELISA (SPBE) and Non Structural Protein (NSP) ELISA tests. The advantages of ELISAs are that they are easy to perform, their sensitivity is higher than the CFT and they are quick to perform so that rapid confirmation of results can be obtained (Caballero *et al.*, 1997; Smitsaart *et al.*, 1997).

1.2.4.9 Liquid Phase Blocking ELISA (LPBE)

The LPBE has been used in many diagnostic laboratories to replace the VNT test. However it has some problems which include low specificity, lack of stability of inactivated antigens (Clavijo *et al.*, 2004) and unsuitability for large numbers of samples because of the many steps involved (Chenard *et al.*, 2003). Most of the indirect ELISAs are species dependent, whereas blocking ELISAs are species independent and consequently do not require the use of specific conjugates. In addition, the LPBE can be used to test different animal species simultaneously which is useful as a range of species are often involved in an outbreak (Sorensen *et al.*, 2005). Liquid phase blocking ELISA has been used to detect the antibody of vaccinated animals and to evaluate the potency of vaccines against FMD (Hamblin *et al.*, 1987; Van Maanen and Terpstra, 1989; Robiolo *et al.*, 1995). It also can be used to detect the disease in an area where vaccination has not been applied (Sugiura *et al.*, 2001). A cut-off value of 90 has been used to determine positivity irrespective of vaccine status (Kodituwakku, 1999; Sugiura *et al.*, 2001). The antibody to the structural protein induced by infection of FMDV can be detected by LP ELISA more than 304 days post infection (Mackay *et al.*, 1998b).

1.2.4.10 Solid Phase Blocking ELISA (SPBE)

The SPBE has been used to detect antibodies to the FMDV for many years (Have and Jensen, 1983). This test has been used on cattle for the detection of antibodies to Type O virus and has been validated as a screening test and for the detection of antibody titre (Chenard *et al.*, 2003).

1.2.4.11 Solid Phase Competitive ELISA

The Solid Phase Competitive ELISA (SPCE) was developed by the Institute for Animal Health (IAH, Pirbright) for the detection of antibody to FMD. This test was modified from the SPBE test developed by Hamblin *et al.* (1986), and uses the same reagents as the LPBE (Have and Jensen, 1983). It has been shown that the SPCE is more sensitive than the VNT in samples from sheep (Paiba *et al.*, 2004). Although the SPCE has the same performance as the LP ELISA and VNT, it has less cross reactivity between serotypes and is more serotype specific than these tests (Mackay *et al.*, 2001). The monoclonal antibody of this test has a high level of accuracy (99.3% specificity and 99.7% sensitivity) (Brocchi *et al.*, 2004).

1.2.4.12 Non Structural Protein ELISA (2C, 3B, 3AB, and 3ABC)

The use of Non Structural Protein (NSP) serology is important to allow differentiation of infected from vaccinated animals following an outbreak (Kweon *et al.*, 2003) and to help substantiate freedom from FMD (Paton *et al.*, 2006).

The genome of the FMDV consists of single stranded linear RNA which has a single open reading frame (ORF) encoding one long polypeptide that is processed to 12 viral proteins (Forss *et al.*, 1984; Kweon *et al.*, 2002). Among these viral proteins which can induce an antibody response, the four major subunit viral capsids are VP1, VP2, VP3 and VP4. These capsids are structural proteins, in contrast to the remaining 8 minor proteins (L, 2A, 2B, 2C, 3A, 3B, 3C, and 3D) which are non-structural (Berger *et al.*, 1990; Bergmann *et al.*, 2000; Grubman and Barry, 2004). The currently available commercial vaccines contain capsid proteins which are less likely to induce antibody against the non-structural proteins (Silberstein *et al.*, 1997; Mackay *et al.*, 1998a; Sorensen *et al.*, 1998b). To distinguish between animals infected with FMD from those that have been vaccinated against FMD, NSP serology is used (Kweon *et al.*, 2003). The NSP test is the preferred diagnostic method to differentiate vaccinated from convalescent animals and to determine the carrier status of animals (Niedbalski and Haas, 2003; Clavijo *et al.*, 2004). There are several types of NSP tests used in laboratories e.g. 2C, 3B, 3AB, and 3ABC NSP tests. Among them, the polypeptide 3ABC is recognized as the most appropriate antigen because it has a high immunogenicity and a relatively low concentration in infected cell lysates (Bergmann *et al.*, 2000; Robiolo *et al.*, 2006).

There are several NSP tests available including CHEKIT FMD-3ABC, produced by Bommeli Diagnostic, Switzerland, which uses *E. coli* as a recombinant 3ABC antigen; UBI FMDV NS EIA, which uses a synthetic 3B peptide and is produced by United Biomedical Inc., New York, USA; the DVIVR NSP ELISA (C-ELISA) (Sorensen *et al.*, 1998a) which is produced by the Danish Veterinary Institute and uses a baculovirus-expressed 3AB antigen; and the Ceditest FMDV-NS, Cedi Diagnostics BV, Lelystad, The Netherlands; Panaftosa (PAHO/WHO), Brazil (Lee *et al.*, 2004; Robiolo *et al.*, 2006). Synthesized NSPs 2C and 3 ABC ELISA can detect antibody up to one year after infection (Shen *et al.*, 1999). Although the CHEKIT kit (Bommeli) has a high specificity of 98%, its sensitivity is only 23% in cattle (Bronsvoort *et al.*, 2004b). The UBI test has a higher sensitivity than the CHEKIT on field samples (Table 1.6) and can be used in the early stages of infection whereas the DVIVR kit is not commercially available (Lee *et al.*, 2004). Non-Structural Protein tests are not able to detect NSP antibodies for all species, especially in sheep and pigs (Kitching, 2002b), because the severity of infection with FMDV is predominantly sub-clinical and is not as high as in cattle (Clavijo *et al.*, 2004). The NSP based tests are not considered to be able to differentiate between recovered and carrier animals (Paton *et al.*, 2006). It was noted that NSP tests have not been useful for individual animals, and cannot show the status of viraemia (Clavijo *et al.*, 2004). In repeatedly vaccinated cattle in Taiwan with up to 5 times more than the recommended dosage, NSP was detected in some cases and it was suspected that commercial vaccines were not completely purified or NSP had not been completely removed from the vaccine (Lee *et al.*, 2006).

Table 1.6 Summary of the accuracy of diagnostic tests for FMD

No	Name of Diagnostic test	Animal	Sensitivity % (95%CI)*	Specificity % (95%CI)*	Experimental status
1	CHEKIT ELISA (Bommeli)	Cattle	23 (20-26)	98 (96-99)	naturally infected animals (Bronsvoort *et al.*, 2004b)
2	CHEKIT ELISA (Bommeli)	Cattle	100	99	experimentally infected animals (20 days after infection) (Malirat *et al.*, 1998)
3	DVIVR NSP ELISA C-ELISA	African cattle	71 (68-74)	90 (87-93)	naturally infected animals (Bronsvoort *et al.*, 2004b)
4	DVIVR NSP ELISA C-ELISA	Chinese cattle	64 (56 - 71)	99 (94- 100)	sensitivity test was conducted in naturally infected animals (Huang *et al.*, 2002)
5	DVIVR NSP ELISA C-ELISA	Pig	73	90	(Chung *et al.*, 2002)
6	DVIVR NSP ELISA C-ELISA	Pig	96	99	(Chung *et al.*, 2003)
7	DVIVR NSP ELISA C-ELISA	Cattle	88	99.8	experimental infection (Sorensen *et al.*, 1998b)
8	CFT	Cattle buffalo	24	98	(Westbury *et al.*, 1988)
9	Chekit ELISA	Cattle	38-5	98.9	6-21 days after infection (Moonen *et al.*, 2004b)
10	Chekit ELISA	Cattle	84.1	98.9	21-180 days after infection (Moonen *et al.*, 2004b)
11	Chekit	Cattle	64.7	98.9	>180 days after infection (Moonen *et*

No	Name of Diagnostic test	Animal	Sensitivity % (95%CI)*	Specificity % (95%CI)*	Experimental status
	ELISA				*al.*, 2004b)
12	EBK930-Aftosa-bovine EMBRABIO	Cattle	56	59.4	6-21 days after infection (Moonen *et al.*, 2004b)
13	EBK930-Aftosa-bovine EMBRABIO	Cattle	98.4	59.4	21-180 days after infection (Moonen *et al.*, 2004b)
14	EBK930-Aftosa-bovine EMBRABIO	Cattle	100	59.4	>180 days after infection (Moonen *et al.*, 2004b)
15	UBI FMDV NS EIA	Cattle	26.2	99.2	6-21 days after infection (Moonen *et al.*, 2004b)
16	UBI FMDV NS EIA	Cattle	85.7	99.2	21-180 days after infection (Moonen *et al.*, 2004b)
17	UBI FMDV NS EIA	Cattle	70.6	99.2	>180 days after infection (Moonen *et al.*, 2004b)
18	Cedi	Buffalo/ cattle	87.7	87.3	(Bronsvoort *et al.*, 2008)

*95% binomial confidence limits (Daly, 1992) were calculated based on the information provided by the authors in each article. Some papers did not provide enough data to allow calculations to be made.

1.2.4.13 Reverse Transcription-Polymerase Chain Reaction Test

There are many different types of Reverse Transcription-Polymerase Chain Reaction (RT-PCR) Tests capable of detecting FMDV. Among these, the fluorogenic RT-PCR is a rapid technique with a higher sensitivity and specificity than the conventional RT-PCR. This test is more sensitive to Type O, A, C, and Asia1 than to SAT 1 and 2 (Reid *et al.*, 2002). The other PCR, TaqMan assays, which target the FMDV internal ribosome entry site (IRES) region and the FMDV polymerase coding region, have also been evaluated in Australia for the rapid detection of FMDV in index cases (Boyle *et al.*, 2004).

1.2.4.14 Pen-side Tests

Pen-side diagnostic tests, which can detect viral antigen and NSP antibody, would not only be beneficial in emergency cases but would also be useful for allowing immediate action being taken to control an outbreak (Reid *et al.*, 2001; Bulut *et al.*, 2004). The chromatographic strip test was evaluated by the OIE/FAO World Reference laboratory for FMD (WRL for FMD), Pirbright as a rapid test for field conditions. This test can also detect viral antigen and was proposed to be useful in diagnosing FMD in the field (Reida *et al.*, 2000).

1.2.4.15 Samples

Foot and mouth disease is commonly diagnosed from serum samples (whole and clotted blood samples; vesicular fluid or epithelium taken from the vesicles of the gum, scraped epithelium from foot lesions; heart muscle from carcasses; and probang samples and nasal samples (Reid *et al.*, 2001; Kitching, 2004). Milk samples can also be used to detect antibodies to FMDV by the LPBE ELISA (Armstrong, 1997).

1.2.5 Disease investigation using a participatory approach

The participatory approach has been used widely in a range of disciplines including the social, medical and veterinary sciences. It has been used to conduct surveys, and to undertake disease control and research since the late 1970s (Ericson, 2006). The approach encourages participants or interest groups (relevant to the specific research) to become involved in the project to facilitate reaching the planned objectives, for example, participation in control of vector borne disease (*Aedes aegypti*) (Winch *et al.*, 1992) and participation in disease investigations (bovine trypanosomiasis) (Catley *et al.*, 2002a). The participation can involve decision making, implementation, assessment of benefits or overall evaluation (Cohen and Uphoff, 1980) and it can be active (self motivated and independent participation and in identifying problems and solutions) or passive (participants are silent and influenced by outsiders) (Ericson, 2006). To obtain a successful participatory process, the necessary criteria are representation by all stakeholders, transparency, compatibility, a degree of awareness and adequate knowledge by the participants (Rosenstrom and Kyllonen, 2007).

The participatory approach (participatory appraisal methods) was introduced in the early 1980's into veterinary epidemiology to investigate diseases based on the observation of farmers (Catley *et al.*, 2002b). Even though there are many different names and techniques for using a participatory approach (participatory rural appraisal, rapid rural appraisal), the basic concept is to collect information from people at the grass root level (Paskin, 1999).

The participatory disease investigation approach has been used in veterinary epidemiology for the study of many diseases including Rinderpest (Mariner and Paskin, 2000; Mariner and Roeder, 2003; Rasheed, 2007), bovine trypanosomiasis (Catley *et al.*, 2002a), FMD (Catley *et al.*, 2004; Admassu and Ababa, 2006), avian influenza

(Normile, 2007), diseases of camels (Mochabo *et al.*, 2005), the seasonal incidence of parasitic diseases, contagious bovine pleuropneumonia, FMD, fascioliasis, brucellosis, and the husbandry and trade of indigenous chickens (Catley *et al.*, 2002b; Henning *et al.*, 2006).

The techniques for a participatory approach have been fully described in the manual on participatory epidemiology issued by the FAO (Mariner and Paskin, 2000). The manual describes that a participatory approach is mainly based on the gathering of information by using a qualitative technique and relies upon the experience of stakeholders and their involvement which includes two principles: triangulation and flexibility. To validate the information gathered from the participants (triangulation process), different approaches are applied including informal meetings and/or interviews with farmers or key informants; mapping; proportional piling; matrix scoring, seasonal calendars and observations in the targeted areas (Catley *et al.*, 2001; Mariner and Roeder, 2003; Rasheed, 2007). Matrix scoring has been applied to understand the knowledge of participants on the typical clinical signs of various diseases whereas proportional piling has been used to estimate the incidence of different diseases within different age classes (Catley *et al.*, 2002a). The seasonal calendar has been used to match season with other variables of interest such as disease vectors, livestock movement and animal management practices (Mearns *et al.*, 1994; Elos *et al.*, 1995; Catley and Aden, 1996). The techniques used in the participatory approach are not fixed and can be changed during the investigation (Mariner and Paskin, 2000). Randomized sample collection (selection of villages or participants) can be used in a participatory approach however it is not practical to adopt in some situations. For example, if the target population is scattered or located in remote areas or the study requires a large number of variables to be identified (Mariner and Paskin, 2000).

The advantages of the participatory approach are many: it is cheap, easy to apply, leads to a rapid result and it is very appropriate for remote areas (Mariner and Paskin, 2000). In quantitative studies although statistical analysis can be used to measure associations between variables, they cannot directly identify causal relationships and it is necessary to use qualitative judgements. However, the participatory appraisal method is suitable in the development of an epidemiological causal model (Moris and Copestake, 1993; Mariner and Paskin, 2000).

This approach can introduce bias including spatial, project, personal, seasonal, diplomatic and professional biases (Chambers, 1983). If the disease incidence is low and the clinical signs are not characteristic then the participation of farmers may not be relevant (Catley *et al.*, 2004).

1.2.6 Control and Eradication

Control programmes for FMD depend upon the background history of the disease, the ability of the affected countries to fund the disease control programme, the availability of technical expertise, the geography of the region/country, and the application of legislation for animal health.

There are many different techniques used for the control and eradication of FMD around the world. The initial step for effective control is early detection of disease (timely information on the FMD type) followed by laboratory confirmation (Anon, 2007; Fernandez *et al.*, 2008). The control and eradication measures adopted include stamping out measures (King, 2001; Thrusfield *et al.*, 2005a), zoning approaches (Edwards, 2004b), vaccination (Perez *et al.*, 2004a; Paton *et al.*, 2006), movement control of infected animals, in contact animals and any contaminated materials (Rweyemamu, 1984; Perez *et al.*, 2004a) and instigation of appropriate sanitary measures (cleaning and disinfection) on affected premises (Mahy, 2004). The appropriate combination of these techniques will depend upon the previous status of a country and its control policy (Joo *et al.*, 2002). Effective control programmes used in the FMD epidemics in Canada in 1951/52, Hampshire in 1967 and Northumberland in 1966 indicated that immediate reporting of outbreaks followed by rapid confirmation, control of animal movements and tracing of the source to prevent further spread was essential (Sellers, 2006).

Member countries of the World Animal Health Organization can be divided into two groups on the basis of their FMD status; free countries and endemic countries. If an outbreak occurs in a country with a long history of FMD, it can be extremely difficult to reach a free status. This in part is due to a poor understanding of the epidemiology of the disease, a lack of an appropriate surveillance system, inadequate facilities for disease diagnosis and lack of effective vaccines (Henderson, 1982; Rweyemamu, 1984). Use of a single vaccination programme in an outbreak, without a booster dose, may not be sufficient to control an extensive outbreak as induced immunity may only last for four months. Furthermore young animals, which may not be included in the primary vaccination programme, need to be vaccinated in a subsequent vaccination campaign (booster vaccination) (Kitching, 2004). Even in a free country, it is very difficult to eradicate FMD after introducing a new infection because the virus can persist in the environment, fomites and reservoirs (Joo *et al.*, 2002).

1.2.6.1 Stamping out policy

If outbreaks of FMD occur in a country that was previously free from the disease, it is crucial to regain the free status for trading purposes. Such countries generally apply a stamping out policy with or without vaccination and a zoning approach (Berentsen *et al.*, 1992) and could regain FMD free status within a few months or years. In favourable geographical situations, such as in the United Kingdom, a stamping out policy has been developed and has been applied to control and eradicate FMD since 1892 (Sutmoller *et al.*, 2003). Two main control strategies used during the 2001 FMD epidemic in UK were: the rapid identification of infected, dangerous contact animals; and the culling of susceptible animals from infected premises and those from dangerous contact premises (Honhold *et al.*, 2004). In contrast, countries that have had FMD for many years apply vaccination and movement controls for a temporary control of outbreaks in their region (SEAFMD, 2009). In most FMD free countries, maintaining a free status is an important issue which mainly depends on quarantine barriers, an active disease surveillance system to detect the disease and a high quality diagnostic laboratory capable of diagnosing the disease rapidly and accurately (Boyle *et al.*, 2004).

1.2.6.2 Vaccination

Stamping out is the compulsory policy used in FMD-free-countries. In contrast vaccination is mainly used for disease control in countries where the disease is endemic as well as in some eradication zones (Kitching, 2002a). Ring vaccination of all susceptible animals within three kilometres, which can reduce the spread and shorten the outbreak duration, in combination with sanitary measures is often applied (Barteling and Vreeswijk, 1991).

Although vaccination is a convenient way of controlling FMD, other supporting factors including control of animal movement, appropriate contingency plans, and reliable animal health legislation are required for a successful eradication campaign (Garland, 1999). Furthermore there are a large number of FMD strains, and vaccination does not offer protection against heterologous strains (Niedbalski and Haas, 2003). Consequently the strain of FMDV incorporated into a vaccine must be a close antigenic match with the outbreak strain to obtain protective immunity (Kitching *et al.*, 1989).

The use of systematic annual vaccination programmes for cattle against FMD was first applied in Holland in 1952 (Brown, 1992), and has subsequently been applied in other European countries (Barteling and Vreeswijk, 1991). In some European countries, susceptible zoo animals have also been vaccinated (Schaftenaar, 2002). Eradication campaigns of FMD in pigs in Asia have demonstrated that mass vaccination can be an alternative to mass culling (Poulin and Christianson, 2006). Guidelines for the use of vaccines to prevent FMD in domestic animals are described in the Manual of Standards for Diagnostic Tests and Vaccines for Terrestrial Animals of the Office International des Epizooties (OIE, 2008b). In general, most vaccines are produced in BHK-21 suspension cell cultures and the virus is inactivated by binary ethyleneimine (BEI). A few vaccines are produced by using rabbits for virus growth (lapinised); and some are produced in bovine tongue epithelium cell lines (Frenkel method) (Clavijo *et al.*, 2004). Formaldehyde inactivated vaccine is no longer used because the virus inactivation process cannot be guaranteed to be 100% effective. In sheep, a vaccine incorporating an oil adjuvant will induce a better immune response than a vaccine using aluminium hydroxide as the adjuvant (Patil *et al.*, 2002). However, both oil and aqueous vaccines can be used for any emergency vaccination programme and can induce protective immunity in cattle, pigs, sheep and goats (Cox *et al.*, 1999).

The main reasons for using vaccine in outbreaks is to protect susceptible animals (protective vaccination) or to reduce the production/shedding of virus (suppressive vaccination) (Kitching, 2004). Cox *et al.* (1999) reported that replication of the virus in the oropharynx region of sheep was minimized by vaccination. Adverse reactions to vaccines produced in BHK21 and containing aluminium hydroxide and saponin as preservatives have been observed in cattle. These reactions included skin lesions (urticaria, dermatitis and hair loss) and the formation of vesicles 10 days after vaccination. The lesions remained for at least two to three weeks (Yeruham *et al.*, 2001). The use of commercial FMD vaccines (WRLFMD, 2006) produced with satisfactory antigen purification are the best way to control infection and do not induce production of antibodies against NSP (Espinoza *et al.*, 2004). DNA vaccine against FMDV infection and viral challenge experiments have been tested in suckling mice, cattle, guinea pigs and pigs (Dunn *et al.*, 1998; Mayr *et al.*, 2001; Yang *et al.*, 2005) because conventional vaccines, which contain inactivated whole virus, have many disadvantages. Conventional vaccines can contain unpurified NSP and viral particles that can interfere with diagnosis by NSP tests. Vaccine stability relies upon an effective cool chain system, and incomplete inactivation can cause the reintroduction of the disease and consequently lead to carrier animals. Vaccinated animals and infected animals are difficult to differentiate serologically because of the presence of non-structural viral protein in some vaccines (Pinto and Garland, 1979; Taboga *et al.*, 1997). The efficacy of a synthetic peptide based vaccine against FMDV has been tested in pigs and no local adverse reactions were found (Wang *et al.*, 2001).

1.2.6.3 Zoning approach

According to the animal health code of the OIE, countries can declare an FMD free region with or without vaccination. Zone boundaries can be designated by using natural, artificial, legal or risk based boundaries (Donnelly, 2006). Zoning is a procedure to aid disease control and animal trade in defined subpopulations of different animal health status and is recognized as an appropriate way to control FMD (OIE, 2008f). It has been effectively applied in many parts of the world and is also a good model with a high level of success in Southeast Asian Countries (Edwards, 2004b). It has also been evaluated as a potential means for controlling FMD in Australia in the event of an outbreak (Garner and Lack, 1995). In addition, it can be used in combination with strict movement control and ring vaccination in countries where a stamping out policy is difficult to apply (Ozawa, 1993).

The zoning approach is a procedure to control disease in defined subpopulations of animals with different health statuses and is recognized as an appropriate way to control FMD (OIE, 2008f). The modern concept of zoning allows for a part (or zone) of a country to be defined as disease free, compared to the previous situation where a whole country was required to be classified as free from disease. Zoning was first introduced into Myanmar after the first MZWG (MZWG 1, 2004b) when four zoning options were agreed upon (See 1.1.6.2).

1.2.7 Simulation models for the control of FMD

Simulation models have been developed in FMD-free-countries for the effective control of potential outbreaks and to predict the progress of an epidemic (Doran and Laffan, 2005). They are also designed to aid management of future outbreaks and to identify aspects which are critical for the rapid control and eradication of an outbreak (Yoon *et al.*, 2006). In simulation models, the role of several risk factors such as the potential role of wild and feral animals as reservoirs (Ward *et al.*, 2007), distribution of airborne particles emitted by healthy and infected pigs (Gloster *et al.*, 2007), and wind direction and velocity on airborne spread of virus between farms (Gerbier *et al.*, 2002) have been evaluated. In Australia, the suggested model for controlling the spread of FMD involved quarantine and movement restrictions, stamping out, surveillance, tracing, pre-emptive slaughter and vaccination (Garner and Beckett, 2005).

1.2.8 Risk analysis for the control of FMD

Countries which have a free status of FMD mostly use a strategic risk analysis plan to prevent the introduction of the disease through the importation of live animals or animal products (Pharo, 1999). The risk analysis plan is also expanded to other possible factors to protect the free status of FMD including illegally imported meat (Wooldridge *et al.*, 2006; Hartnett *et al.*, 2007); environmental impacts by activities of people in the country; air borne spread (Cannon and Garner, 1999; Taylor, 2002); and transmission through water (Schijven *et al.*, 2005).

1.2.9 Economic Impact of Disease

Foot and Mouth disease is a devastating disease and can cause significant economic losses to affected countries, especially to people involved in the livestock industries (Garner *et al.*, 2002; James and Rushton, 2002). Most industrialized and developed countries are free from FMD while many developing nations remain infected. It is also an important obstacle in some developing and less developed countries in which animal draught power is used to perform agriculture work. James and Rushton (2002) stated that the main impacts of FMD on animal production were: reduced milk yields, abortions and delayed conceptions, perinatal mortality, lameness in draught animals, and weight loss. Consequently, this disease becomes a significant barrier for the trade of animals and animal products in developing countries (Rweyemamu and Astudillo, 2002). Moreover, there are two separate international markets: an FMD-free market and an FMD-endemic market; and the price of animal products from FMD free countries is over 60% higher than that from endemic countries (Ekboir *et al.*, 2002).

In 1976 systematic FMD control programmes were launched in India, where an average of 15% of the nation's livestock population were affected each year and the estimated loss of production exceeded 4,000 million rupees (approximately £200,000,000) (Ellis, 1993). During the 1997 FMD outbreak in Taiwan, 6,000 farms were infected and 20 million doses of vaccine were used to control the outbreak (Kitching, 1999). In the United Kingdom, the recent epidemic in 2001 resulted in losses in excess of £ 12 billion and culling of 3.9 million animals (Aggarwal *et al.*, 2002). In an economic study of the potential impact of FMD in Australia, the estimated cost for outbreak control by vaccination in two studied regions varied from AUD 1 to 4 million with additional costs from of AUD 11 to 21 million (Garner *et al.*, 1997). In the event of an outbreak of FMD in Australia, Garner *et al.* (2002) estimated that adopting a zoning approach in Australia would be less costly than if control without zoning was adopted.

Several studies on the economic impact of FMD in Southeast Asian countries have been undertaken (Perry *et al.*, 1999; Perry *et al.*, 2002; Randolph *et al.*, 2002). A regional study on the potential control of FMD and a cost benefit analysis was performed in 1983 (Forman *et al.*, 1983). It revealed that the benefit cost ratio was 5:1 in the beef industry over a 30-year period following the eradication of FMD from Thailand; and a ratio of 7:1 for the pig industry in the Philippines over a 30-year period. Another study (FAO, 1997) confirmed that the economic return for controlling the disease was higher in the smallholder dairy system than for draught animal production. However in areas with a shortage of draught animals the financial benefit from controlling FMD was significantly higher than in areas where there was a surplus of draught animals.

1.2.10 Foot and Mouth Disease in Asia

In Asia, there are 22 countries recognized as infected with FMD. Only 10 countries can produce vaccine against FMD for local use and the total number of doses produced is equivalent to one-fifth of the total animal population of Asia (Lombard and Schermbrucker, 1993). Fifteen Asian countries have submitted official reports to the OIE since 2000. Types O, A and Asia 1 have been detected in most of the infected countries and the disease is endemic in India, Bangladesh, parts of China and some of the Southeast Asian countries (OIE, 2009a).

1.2.11 Situation of Foot and Mouth Disease in Southeast Asia

Among the Southeast Asian countries, Indonesia, Brunei and Singapore are free of FMD (OIE, 2009a). In the remaining countries, some parts of the Philippines and Malaysia have FMD free regions whereas the other countries, (Cambodia, Lao PDR, Myanmar, Vietnam and Thailand) are still infected with FMD. Types O, A and Asia 1 are prevalent in Myanmar, Thailand and Lao PDR and the Malaysian peninsular and Type O has been a common serotype in infected countries in Southeast Asia for many years. Information reported to the Office International des Epizootics Regional Coordination Unit between 2001 and 2009 (SEAFMD, 2009), on the serotypes present in seven countries is listed in Table 1.7 (Gleeson, 2002; Abila and Forman, 2006).

Table 1.7 Serotypes of FMDV in countries in Southeast Asia (1996-2009)[#]

Year	Cambodia	Lao PDR	Malaysia	Myanmar	Philippines	Thailand	Vietnam
1996	Unknown	Unknown	O, A, Asia1	O, Asia1	O	O, Asia1	O
1997	O, Asia1	Asia1	O, A, Asia1	O, Asia1	O	O, A, Asia1	O
1998	Unknown	O, Asia1	A	O, Asia1	O	O, A, Asia1	O
1999	O	O, Asia1	O, Asia1	O, A, Asia1	O	O,A	O
2000	O	O	O	O, Asia1	O	O, A	O
2001	Unknown	O, Asia1	O	O, Asia1	O	O, A, Asia1	O
2002	Unknown	O, Asia1	Unknown	O	O	O, A	O
2003	Unknown	O, A	O, A	O	O	O, A	Unknown
2004	Unknown	O,	O, A	O	O	O, A	O, A
2005	Unknown	O	O, A	O, Asia 1	O	O, A	O, A, Asia1
2006	O	Unknown	O	O	-*	O, A	O, A
2007	Unknown	-**	O, A	O	-*	O, A, Asia1	O, Asia1
2008	Unknown	O	O, A	O	-*	O, A	O, Asia1
2009[@]	Unknown	Unknown	O	O	-*	O, A	O, Asia1

**no reported outbreak
[@] until March 2009
*no outbreak
[#] SEAFMD (2009)

1.3 Aims and Objectives of this thesis

The purpose of this thesis is:

1. To support the Myanmar Zoning Working Group to facilitate control of FMD by using a zoning approach and to achieve the objectives of the SEAFMD campaign, especially in the MTM area and the Sagaing Division of Myanmar.
2. To support the zone progression of the Tanintharyi Division of the Myanmar MTM area from eradication zone to freedom of disease without vaccination.
3. To carry out a planned targeted surveillance study to assist in understanding the epidemiology and pattern of FMD in the Sagaing Division as the first step in designing and implementing a progressive zoning approach for the control of FMD in Myanmar.
4. To determine the economic impact of FMD and the benefits of its control in the Sagaing Division.
5. To identify possible risk factors for infection.
6. To validate the traditional Dutaik meeting approach which was conducted in rural of Myanmar as a tool for surveillance and control of FMD in Myanmar.
7. To monitor and evaluate control strategies in the defined zones and to extend the zone status for the long term FMD control program in Myanmar.
8. To advise on the technical and economic feasibility of the Sagaing zoning proposal

1.4 Summary of the PhD thesis research plan

To achieve the aims and objectives of this PhD research plan, it was conducted in line with the procedure outlined in Figure 1.5. There are two main targeted areas in this research plan: the Sagaing Division known as an endemic area and the Tanintharyi Division known as the Myanmar MTM area and considered to be a potentially free area for FMD.

In Chapter 2, the results of a questionnaire interview study conducted in 2006 in the Sagaing Division and putative risk factors for FMD are reported. During this study the existing traditional meeting style (Dutaik meeting) is evaluated as a participatory approach and is modified and validated as a tool for use in this epidemiological study (Chapter 3). The validation process was conducted in both endemic and potential free areas (Chapter 4). Chapter 5 described the results of a serological survey conducted in 2005 to achieve zone progression for the Myanmar MTM area. These results were reported from a participatory approach conducted in 2008. In Chapter 6, the results of an economic survey conducted in 17 villages of the Sagaing Township are reported. A partial budget analysis was conducted to understand the influence of FMD on the agricultural enterprises and in particular the influence on draft cattle. The results from an animal movement study in the endemic and potential free areas, using a participatory approach and expert opinions, are reported in Chapter 7.

The conclusions are summarised in Chapter 8 and the findings of this thesis will be submitted to a MZWG meeting for progression of the zoning approach for the control of FMD in Myanmar.

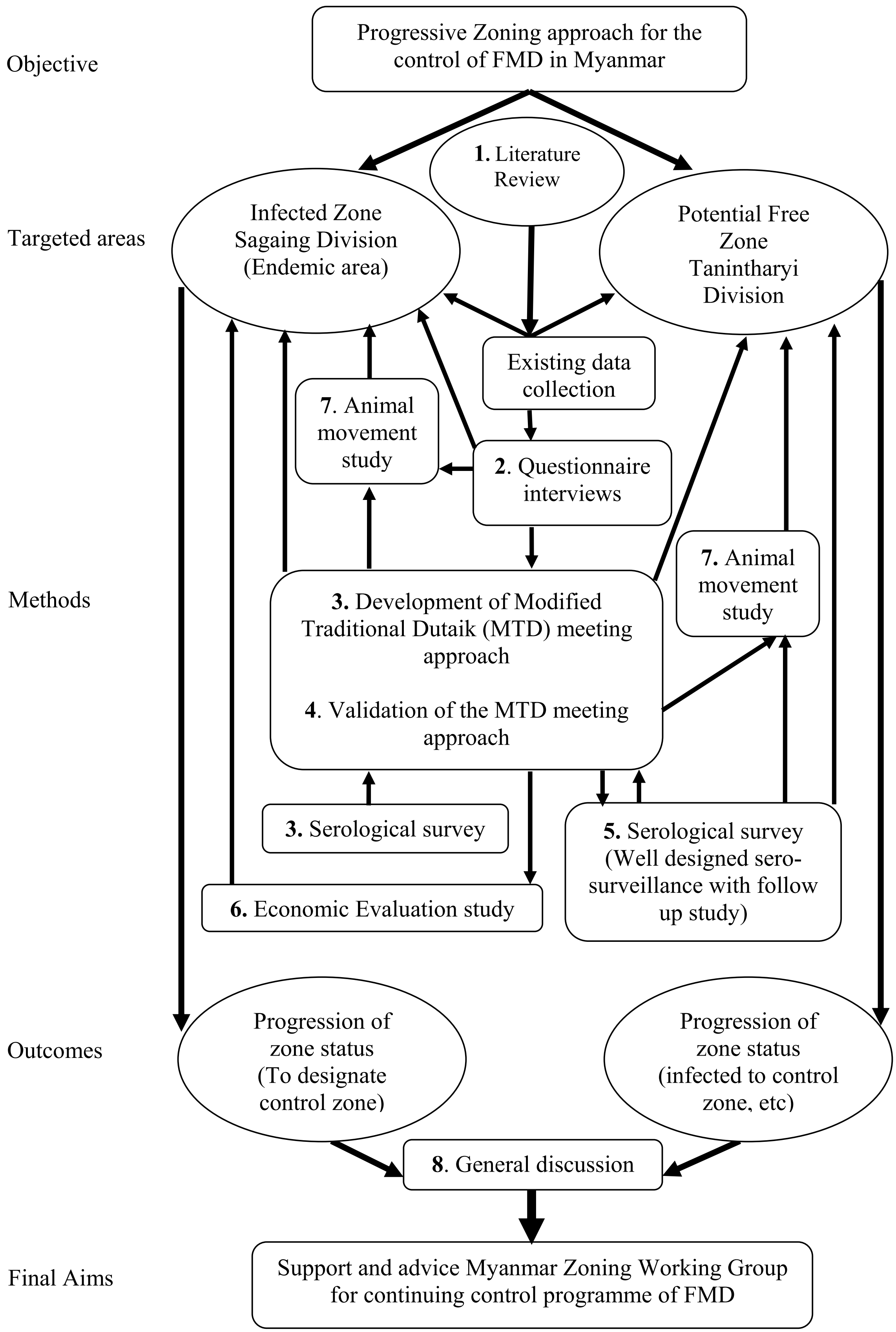


Figure 1.5 Summary of research plan of this PhD thesis

CHAPTER 2

DISEASE INVESTIGATION AND IDENTIFICATION OF RISK FACTORS FOR FOOT AND MOUTH DISEASE USING QUESTIONNAIRE INTERVIEWS

2.1 Introduction

Foot and mouth disease is a highly contagious viral disease affecting all cloven hoofed animals. It can be spread by direct or indirect contact with infected animals, animal products or contaminated materials. This disease is still endemic in Southeast Asian countries (including Myanmar) except for some part of Malaysia, Brunei, Indonesia, Singapore and the Philippines (OIE, 2008d). The most important risk factor for the spread of FMD in countries where the disease is endemic is livestock movement (Rweyemamu, 1984; Ferris *et al.*, 1992).

Questionnaire surveys have been used to understand the epidemiology of many infectious diseases (Dufour, 1999) and thus assist in the development of effective control measures. They have previously been used to understand the epidemiology of FMD and the attitudes of farmers in control programmes in Thailand (Cleland *et al.*, 1995).

Myanmar's economy is predominantly based on agricultural products and draught cattle play an important role in the agricultural industry. Eighty five percent of animal draught power is provided by 55% of the cattle and buffalo population (Kyin, 1999). Local farmers, who have many years of experience with draught cattle, were seen as potential sources of information on prevailing livestock diseases and animal movements. The potential for FMD to spread has previously been investigated by using farmers' reports in New Zealand to construct a realistic simulation model based on animal movements (Sanson, 2005). It is essential for local people/farmers to take part in the development of control zones because of their knowledge and understanding of animals and their movements and management (Mariner and Paskin, 2000). Information on how the livestock industry has dealt with different disease outbreaks is valuable for developing future disease control programs. The Sagaing Division, which is located in the north western part of Myanmar, is considered to be a source of FMD for the country because of the high population density of cattle and the outward movement of animals from that division. At the first MZWG it was strongly recommended to develop a control zone in the Sagaing Division (Anon, 2004b). The area containing 15 townships (Ayadaw, Budalin, Chaung-U, Tabayin, Kanbalu, Kani, Khin-U, Monywa, Myaung, Myinmu, Sagaing, Shwebo, Taze, Wetlet and Ye-U) in this Division, located between two big rivers and rugged mountain ranges, was proposed as a potential control zone in the second MZWG meeting (Anon, 2004c).

The study outlined in this chapter was conducted to: determine the husbandry procedures commonly adopted by farmers in the proposed control zone; to identify potential risk factors for the spread of FMD in the locality; to understand the attitudes of farmers to an outbreak of FMD; to estimate the prevalence of FMD as reported by farmers; and to understand the current animal movement routes.

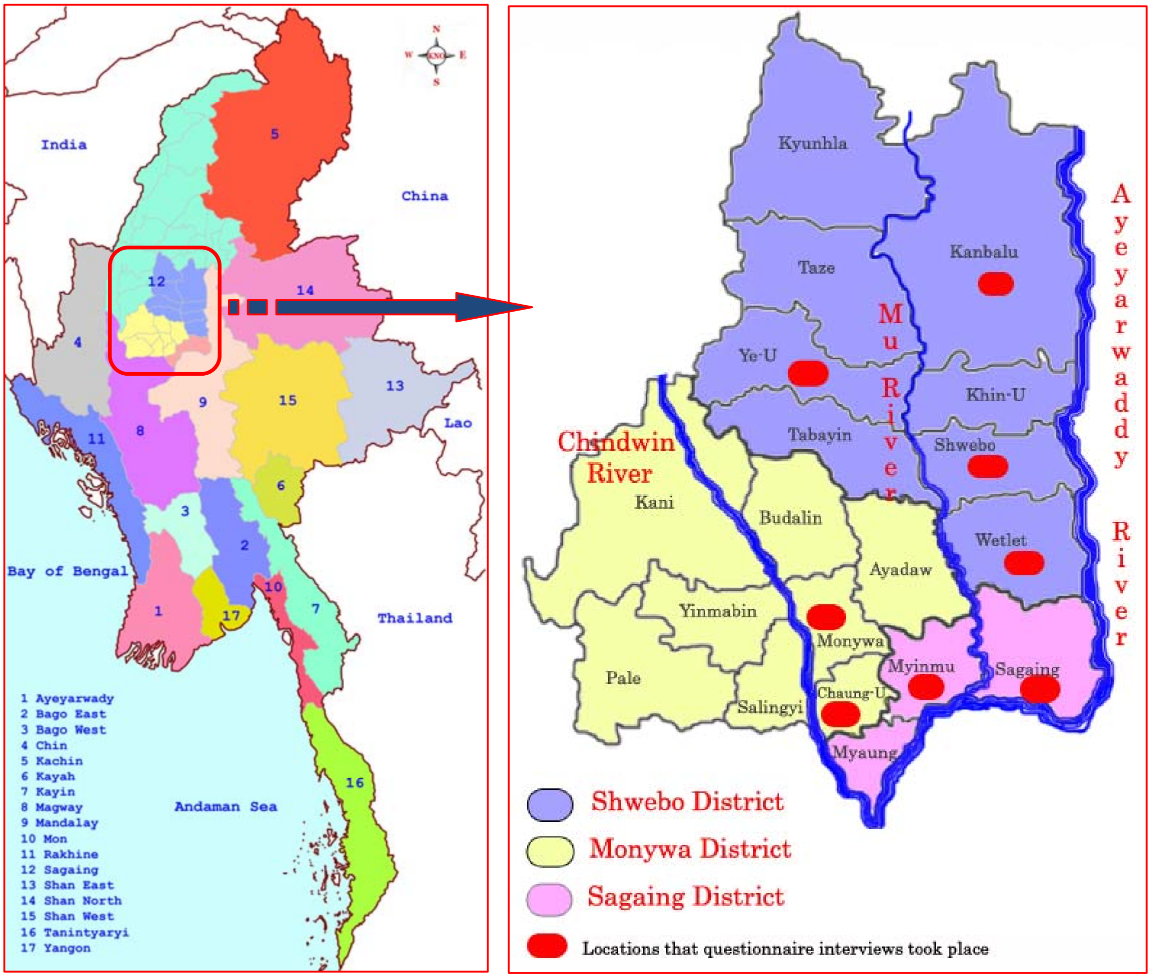


Figure 2.1 Locations where questionnaire interviews were undertaken

2.2 Materials and methods

Data were collected from the LBVD and from questionnaires administered to local farmers in selected villages of the Sagaing Division. These data were analysed with both univariable and binary logistic regression methods.

2.2.1 Existing data collection

The existing data collected included disease information, veterinary capacity, animal population, reports of outbreaks from the headquarters of the LBVD, the results of active and passive surveillance from the National FMD Laboratory, and maps of the districts and townships of the Sagaing Division provided by the Land Survey Department. An informal meeting with local veterinarians, who were working in the LBVD, was held in the Sagaing District Veterinary Office to collect information on the pathways of animal movement and to select places to administer the questionnaire.

2.2.2 Questionnaire interviews

Informal meetings and questionnaire interviews were conducted in June 2006 and focused on the proposed control zone (Figure 2.1) of the Sagaing Division. An eight page questionnaire (Appendix 1) was administered. Data were collected on the geographical location of the village, information on the participation of the family in livestock breeding, the type of livestock raised by the household, the feeding and raising system used, the diseases found in livestock, animal movements, and feed supplements and vaccines used. The questionnaire was initially prepared in English and then translated into the Myanmar language. The translated questionnaire was modified slightly following discussion with local veterinary staff in the National FMD Laboratory. Approval to use questionnaire was obtained from the Murdoch University Human Ethics Committee.

These questionnaire interviews were conducted in 3 districts of the Sagaing Division. A total of 7 townships were involved in this study: two townships in Monywa District (Monywa and Chaung-U); two townships in the Sagaing District (Myinmu and Sagaing); and three townships in the Shwebo District (Kanbalu, Shwebo and Wetlet).

2.2.2.1 Selection of village tracts and respondents

Of 15 townships within the proposed control zone in the Sagaing Division (MZWG 1, 2004b), eight townships were purposively selected using expert opinion of experienced local veterinarians working in the Sagaing Division who considered these townships as high risk areas for infection with FMD because of animal movements, high cattle population and cattle trading.

Serological data were also obtained from the National FMD laboratory of LBVD (Kyin, 2005a,b). These data were from surveys conducted in 2004 and 2005 and included samples collected from eight townships in the three Districts of Sagaing, Shwebo and Monywa selected in the present questionnaire survey. During the 2004 and 2005 studies animals were purposively collected from those village tracts with a perceived high risk of infection based on animal movements and the opinions of local veterinarians (Pers. comm. Dr Khin Maung Latt).

In the current study five village tracts, which were located near the main road, were purposively chosen in each selected Township. It was assumed that these villages would have a greater likelihood of having an outbreak of FMD than village tracts further from the main road. In each village tract 5 respondents were selected for interviewing. Generally, each village tract was divided into five parts: east, west, south, north and the central part. One respondent, who had a good background in livestock and was aware of livestock diseases, was selected from each part by the village headman.

The respondents were organized to assemble in the village headman's house with the help of Peace and Development Council members.

2.2.2.2 Questionnaire Interview Procedure

In each village tract, questionnaire interviews were conducted at the village headman's house. Before the interviews started, the visiting team was introduced and the objectives of the project were explained. Participants were asked about livestock problems and were provided with general information about FMD. They were informed that the disease was infectious, was not a traumatic injury and should not be confused with other diseases such as traumatic lesions and lameness. The reason for this was that the name of FMD in Myanmar language means the "disease showing foot and mouth lesions". Following this, questionnaires were administered to the farmers. Most of the farmers actively participated in the interviews. Local veterinarians and team members administered the questionnaires to individual farmers. The awareness of FMD and the priority/ranking of existing livestock diseases in cattle were also obtained. Finally farmers were asked to draw the routes of animal movement around their village tract on prepared maps. In every village, data were collected from a billboard (posted at the centre of village tract beside the road) listing the total number of households, the human population and the number of houses present in that village.

2.2.3 Data analysis

Data were entered into a Microsoft EXCEL 2007 spreadsheet and transferred into a statistical package (SPSS Statistics version 17.0) for subsequent univariable and multivariable analyses.

For univariable analysis, potential risk factors were classified into 3 groups and different variables from each group were compared with the farmers' personal experience of FMD (i.e. Yes or No to FMD) using the Pearson's chi-square test for independence. A *p*-value less than 0.05 was taken as evidence of significance. Odds ratios (OR) and their 95% confidence intervals were also calculated to measure the magnitude of association between factors and the presence of FMD.

Variables which were significant at $p \leq 0.25$ in the univariable analyses were selected for inclusion into a logistic regression model (Hosmer and Lemeshow, 2000; Vittinghoff *et al.*, 2005). The experience of farmers on FMD (the occurrence of FMD based on the farmers observing clinical lesions in their animals) was considered as the dependent variable and risk factors (management of livestock, feeding, source of water and number of cattle in each herd) were considered as independent variables in the logistic regression model. The model was generated using backward conditional testing (Baker *et al.*, 1999; Solymosi *et al.*, 2004) and odds ratios calculated. In the final model variables with *p*-values > 0.05 and which had the value 1 in the 95% confidence intervals of the OR were excluded. The model was evaluated by calculating the Hosmer Lemeshow statistic (Hosmer and Lemeshow, 2000).

2.3 Results

2.3.1 Existing Veterinary Records

The LBVD supplied data on the study areas including the livestock population and veterinary staffing (See Tables 2.1 and 2.2). On average 4.6 buffalo, 5.5 cattle, 18.5 sheep and goats and 6.1 pigs were owned. Among susceptible animals for FMD, cattle comprised the majority of livestock and represented more than 50% of the total number of livestock in each township except for Chaung-U Township (Figure 2.2). Buffalo made up the smallest number of livestock owned in all studied areas. Kanbalu, Sagaing and Wetlet Townships had the highest number of cattle (Table 2.1) and Kanbalu, Shwebo and Wetlet possessed the largest number and proportion of buffalo (Figure 2.2). Chaung-U Township was the only township which had approximately equal numbers of small and large ruminants (Figure 2.2). Myinmu Township had the smallest number of buffalo. Thirty-six field veterinary staff were employed in the studied areas (Table 2.2) and on average looked after 1,171 buffalo, 19,326 cattle, 4,715 sheep and goats and 3,821 pigs The Deputy Director, Assistant Director and District Officer undertook office duties.

Table 2.1 Livestock population in surveyed townships (July 2006)*

Townships	Buffalo		Cattle		Sheep and goat		Pig	
	Owners	**Animals**	**Owners**	**Animals**	**Owners**	**Animals**	**Owners**	**Animals**
Chaung-U	377	1414	7322	28597	602	28790	3225	17592
Kanbalu	5229	21714	21138	148755	587	7376	5494	31077
Monywa	173	988	12996	61346	1396	35899	2856	15624
Myinmu	18	93	10395	60411	659	30156	861	9982
Sagaing	262	573	22258	111926	4581	34483	2896	11000
Shwebo	1058	9723	16702	99853	410	12403	3178	15073
Wetlet	1697	6450	20087	123904	782	17532	2529	28709
Ye-U	415	1225	14714	60977	161	3131	1566	8518
Total	**9229**	**42180**	**125612**	**695769**	**9178**	**169770**	**22605**	**137575**

*Source from Planning and Statistics Section, Livestock Breeding and Veterinary Department

Table 2.2 Veterinary capacity in townships surveyed (July 2006)

Townships	Deputy Director		Assistant Director		District Officer		Deputy Vet	
	BVS*	VA**	BVS*	VA**	BVS*	VA**	BVS*	VA**
Chaung-U					1		1	
Kanbalu							4	1
Monywa	1		1		1		2	1
Myinmu					1	2	4	
Sagaing	1					1	3	
Shwebo			1		1		6	2
Wetlet					1		6	
Ye-U					2		5	1
Total field veterinarians							**31**	**5**

*BVS - Bachelor of Veterinary Science degree holder
**VA- Veterinary assistant who obtained a certificate and had attended 2 years veterinary training course

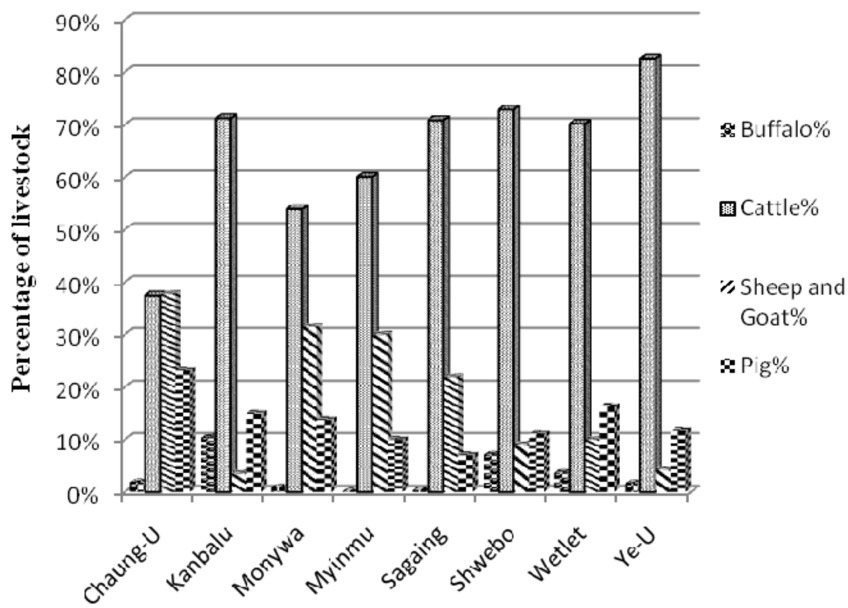


Figure 2.2 The proportion of livestock in the studied townships

2.3.1.1 Serological results from the National FMD Laboratory, Myanmar

Active sero-surveillance was conducted throughout the country in 2004 with a total of 506 serum samples collected from 6 States and Divisions. All samples were tested at the National FMD Laboratory, Insein, Yangon, Myanmar by using the LPB ELISA and NSP ELISA (Kyin, 2005a). During the serological survey, a total of 147 samples of cattle from Sagaing, Myinmu and Monywa Townships of the Sagaing Division were included and these test results are outlined in Table 2.3. Kyin (2005a) reported that this survey involved targeted sampling of areas with high populations of animals due to a lack of laboratory facilities and financial constraints. Most of the samples were collected using convenience sampling, targeting available animals owned by farmers recommended by the village authorities (Pers. com. Dr Khin Maung Latt).

A preliminary epidemiological survey was conducted in 2005 to support the establishment of a progressive zoning approach for the control of FMD in the Sagaing Division. This was funded by JICA as part of the animal disease control project of Thailand and neighbouring countries. In the survey, four townships in the Sagaing Division (Chaung-U, Shwebo, Kanbalu and Kalay) were selected and a total of 400 sera collected from cattle and buffalo. All sera were tested in the National FMD Laboratory with FMDV 3ABC ELISA test kits (Kyin, 2005b). The results of testing cattle from three of these townships, which were also selected for the questionnaire interviews, are detailed in Tables 2.3 and 2.4.

Table 2.3 Serological results (NSP test) of the proposed control zone (2004)*

Township	Number of sera (cattle)	NSP test positive	Test Prevalence (%)	95% Confidence Intervals (%)
Sagaing	50	3	6.0	1.2 - 16.5
Myinmu	50	5	10.0	3.3 - 21.8
Monywa	47	2	4.3	0.5 - 14.5

*(Kyin, 2005a)

Table 2.4 Serological results (NSP test) of the proposed control zone (2005)*

Township	Number of sera (cattle)	NSP test Positive	Test Prevalence (%)	95% Confidence Intervals (%)
Chaung-U	48	21	43.8	29.4 - 58.8
Shwebo	49	6	12.2	4.6 - 24.8
Kanbalu	47	4	8.5	2.4 - 20.4

*(Kyin, 2005b)

2.3.1.2 Existing information of FMD from LBVD

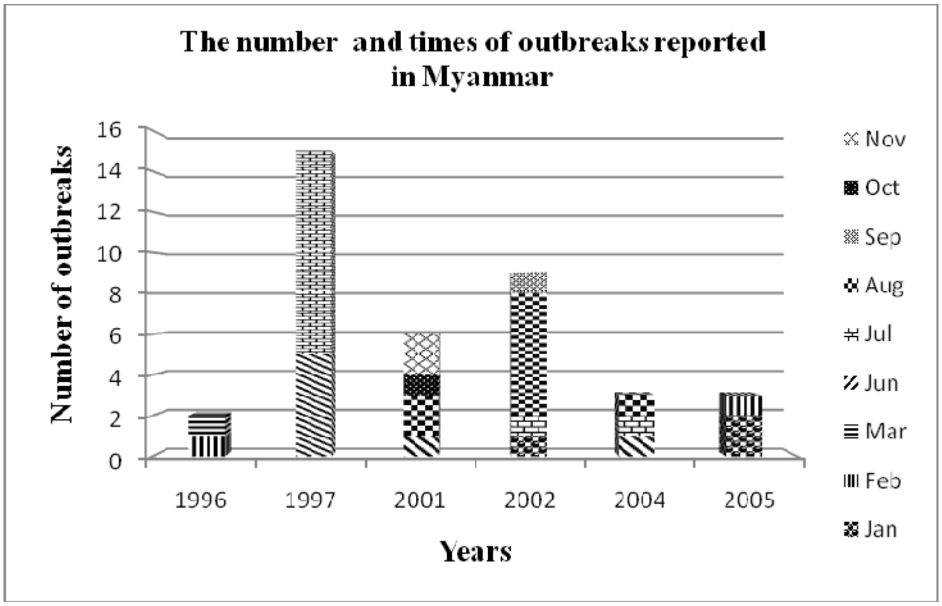
Information about reports on outbreaks of FMD were obtained from the Planning and Statistics Section (San, 2006) of the LBVD Headquarters (Figure 2.3 A and B). These were passive surveillance reports obtained between the years of 1996 and 2005. During this period outbreaks of FMD occurred sporadically within the Sagaing Division. A total of 38 outbreaks were reported involving infection in over 2000 animals with seven cattle dying. The majority of the outbreaks (33 of the 38) occurred outside of the proposed control zone of the Sagaing Division (data not shown). Only five outbreaks occurred in the studied area within the 10-year period. The highest number of outbreaks occurred in the monsoon season (June, July and August) of 1997 and no outbreaks were reported in the months of April, May and December. In Figure 2.3 B it can be seen that most cases in the Sagaing Division also occurred from June to August; September to November and January to March. However the time of an individual outbreak varied between years in the Sagaing Division (Figure 2.4).

2.3.2 Results of questionnaire interviews

A total of 160 people were interviewed using the questionnaire (Appendix 1). These respondents originated from 42 villages of 8 townships of the Sagaing Division (Table 2.5). The majority of the respondents were from Monywa, Myinmu, Sagaing and Shwebo Townships. The least number of respondents were from the villages of Kanbalu and Wetlet Townships where farmers were working in their fields at the time of the interviews. In Kanbalu Township, only five respondents could be interviewed because local staff were busy with office work and consequently farmers were not informed of the planned research.

Table 2.5 Total number of respondents in each township

District	**Township**	**Number of respondents**
Monywa	Chaung-U	19
	Monywa	26
Sagaing	Myinmu	30
	Sagaing	29
Shwebo	Kanbalu	5
	Shwebo	26
	Wetlet	10
	Ye-U	15
Total		**160**



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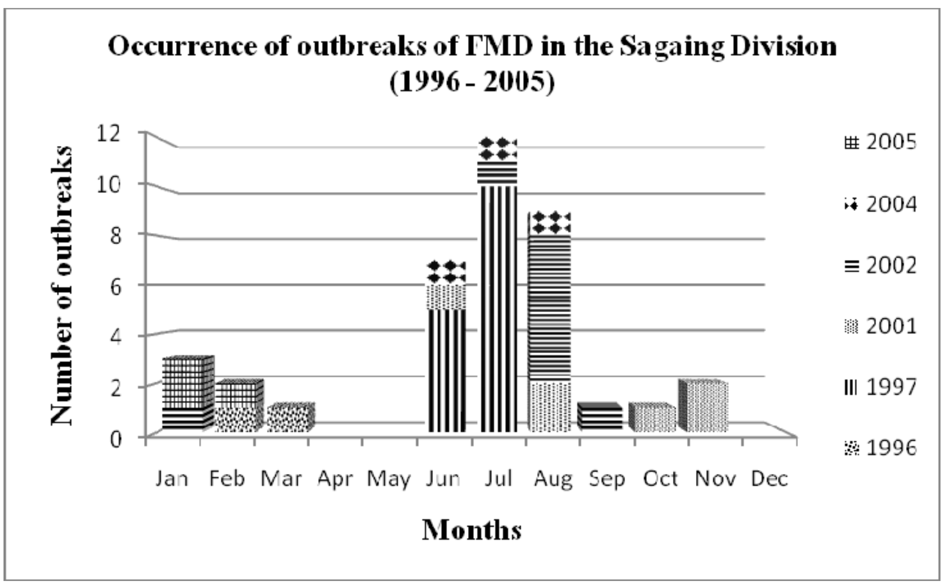


B

Figure 2.3 Summary of FMD outbreak of Sagaing Division (1996 - 2005)*

*Source from Planning and Statistics Section, Livestock Breeding and Veterinary Department

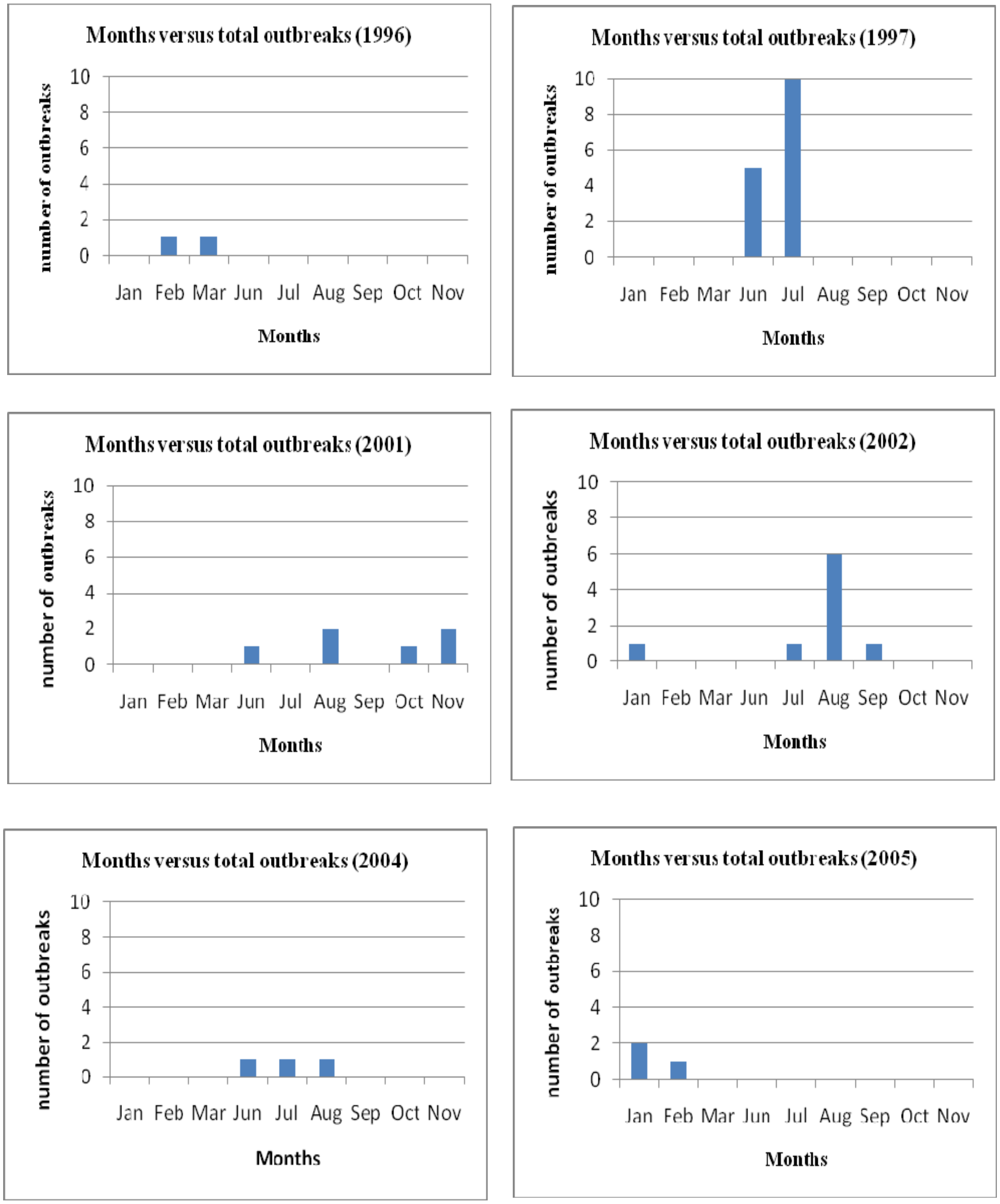


Figure 2.4 Month of outbreak of FMD in the Sagaing Division (1996-2005)

2.3.2.1 Information on family business and participation in livestock breeding

Of the 160 farmers interviewed 144 were male and 16 female. The minimum number of family members in a household was 2 and the maximum 32 (median 6). Most (81.3%) respondents (n=130) were engaged solely in farming work (agriculture) with draught cattle, 8.8% (n=14) worked in dairy farming and 6.3% (n=10) were engaged in both agriculture and dairy farming. A few respondents (0.6%) were not involved in agriculture or dairy farming but raised cattle for renting or selling. Some (0.6%) had a poultry business and the remainder operated non-farming businesses (2.5%). Most respondents (n=143, 89.4%) owned land for cultivation and most of these grew both rice and horticultural produce. Some respondents who owned cattle had no cultivation land and used their draught cattle to cultivate land owned by other farmers or for carrying/carting goods. On average 11.8 acres (median 10 acres) of cultivation land was owned. There was a high level of family participation in farming and the livestock industry. Extended families were common in the studied areas with 11.5% of respondents reporting that all family members participated in the farming work (up to 30 family members). Between 1 and 6 family members were involved in farming work for the remaining 88.5% (n=138) of respondents.

2.3.2.2 Information on the livestock raised by households

Most respondents (98.1%, n=157) owned cattle (draught or dairy cattle) at the time of the study with the remainder (n=3) currently not owning cattle. The median number of cattle owned was four (range 0 to 72). This study focused only on the owners of livestock. The majority (85.6%, n = 137) of respondents owned draught cattle, with a median of 3 owned (range 0 to 45). Dairy farmers represented only 8.8% of the respondents with a median number of 4 owned (range 1 to 68). The dairy farms were situated in the industrial zones of Monywa and Shwebo Townships and the area around Sagaing and Ywathitgyi where fresh milk is easy to carry and sell to wholesale milk collectors. Another reason for raising dairy cattle in this location was that farmers could easily obtain fermented bean solution from nearby vermicelli factories to feed their cattle.

Most respondents (95.6%, n = 153) acquired cattle from a variety of places. Among these respondents animals were purchased from within the village (32%), in the village tract (14.4%), within the township (17%), within the district (9.8%), within the division (2%) and from cattle markets (0.7%). One quarter (24.2%) of the respondents bred animals themselves and did not purchase cattle from external sources.

The majority (89.4%, n = 143) of respondents had experience in selling cattle. Cattle were sold within the village (23.1%), within the village tract (21.9%), within the township (11.9%), within the district (6.3%), to the cattle market (6.9%), and to anyone who wanted to buy cattle (8.8%). A few (n = 17, 10.6%) respondents did not answer this question. Many respondents (70.1%) purchased or sold (63.2%) cattle within the district. Some respondents did not answer these questions (4.4 and 10.6% respectively).

Approximately one third of respondents (31.4%) regularly purchased cattle. Of these respondents (n=50) cattle were purchased once a year by 27.3% of the farmers; twice a year (3%); and once every two (9.1%); three (13.6%); four (3%); five (10.6%); six (7.6%) or seven years (1.5%). Cattle were purchased throughout the year except for the months of July to October. Some (18.2%) respondents reported that cattle were most likely to be purchased during the months of February to April.

Cattle had been sold by 41.9% of respondents, 5% of farmers had never sold cattle and 53.1% failed to answer this question. Among the farmers who answered this question, a total of 27 (36%) sold cattle once a year while three (4%), 13 (17.3%), 10

(13.3%), two (2.7%), six (8%), four (5.3%) and two (2.7%) sold them twice a year, every two, three, four, five, six, and seven years respectively.

Only 30.6% (n = 49) of the respondents could identify the month they sold cattle. Of these the majority (65.3%) sold animals between the months of February and April and the remainder (34.7%) in the months of January, May, June, October, November and December. Buffalo were raised by one cattle farmer (0.6%), pigs by 15.6% (n=25) and sheep and goats by 2.5% of cattle owners (n=4).

Figure 2.5 Chopping grass and straw using a homemade cutter

Figure 2.6 Cattle collectively tethered in a village

2.3.2.3 Animal raising and feeding systems

A traditional system is used in Myanmar for feeding livestock. Most (95.6%) farmers prepared homemade feed using available feedstuffs from their cultivation land including straw (66.3%), grass (51.9 %) and agricultural by-products such as sesame cake, maize straw, rice bran, bean husk, broken rice, wheat straw and groundnut cake (Table 2.6). Respondents used more than one ingredient in a variety of combinations depending upon the availability of the by-products. They frequently used a handmade cutter (Figure 2.5) to chop grass and straw which was fed daily to their cattle. No farmers fed a commercial feed even on the dairy farms, and only 2% of farmers (n=3) fed kitchen waste to cattle. This kitchen waste did not contain meat or meat products but consisted of ingredients such as chopped vegetables, potato skins, bananas, kidney beans and the water from cooking rice. Approximately one third (38.1%) of respondents grazed their animals on common village grazing land. Among these farmers (n=61), cattle were managed in a variety of ways including with an attendant (43.3%), tethered (46.7%) (Figure 2.6), and without attendants and free roaming at the communal grazing grounds (15%) (Some farmers used multiple methods of managing their cattle).

Table 2.6 Products fed to cattle

Feedstuff	% of respondents using this ingredient*
Sesame cake	51.3
Maize Straw	46.3
Rice bran	38.3
Bean husk	32.5
Broken rice	18.8
Wheat Straw	17.5
Ground nut cake	14.4

*Some farmers used more than one ingredient

2.3.2.4 Source of drinking water

The main sources of water in the studied areas were from private wells (42.5%), underground sources (34.4%), ponds (15.6%), public wells (11.9%), rivers (6.9%) or scheme/tap (2.5%). Respondents did not have a problem with a shortage of drinking water for their animals in the proposed control zone and 87.5% of them responded that water was available all-year. Some (12.5%) reported having a shortage of water between the months of December and March. During this time these farmers had to buy water from private wells or had to cart water (Figure 2.7) from natural ponds around the village tract.

2.3.2.5 Reporting of information on FMD by farmers

Most farmers (89.2 %, n=157) from all studied townships reported that they were aware of outbreaks of FMD around their region (Table 2.7). Many (41.3%, n=69) had seen lesions of FMD once a year in their locality and 5% (n=8) had seen evidence of infection twice in a year in their locality. Approximately one third (31.3%, n=50) hadn't seen or were not aware of FMD in their area and 20.6% of respondents failed to answer this question.

Half of the farmers reported outbreaks in all months except for July, August and September (Table 2.8). More outbreaks were reported in the months of December and March.

Figure 2.7 Carrying water by bullock cart

Table 2.7 Farmers' awareness of the presence of FMD in the studied townships*

Townships	**Awareness of FMD by farmers**		**Total**
	Yes	**No**	
Chaung-U	15	1	16
Kanbalu	5	0	5
Monywa	24	2	26
Myinmu	29	1	30
Sagaing	29	0	29
Shwebo	24	2	26
Wetlet	7	3	10
Ye-U	7	8	15
Total	**140**	**17**	**157****

*Information on FMD collected for the period 2003-2006
** 3 with missing information are not included

Table 2.8 Time (month) of the most recent outbreak of FMD

Month	**Number of respondents**	**Percentage of most recent outbreak***
January	1	0.6
February	1	0.6
March	17	10.6
April	13	8.1
May	7	4.4
June	9	5.6
July	-	-
August	-	-
September	-	-
October	3	1.9
November	6	3.8
December	23	14.4
No answer	80	50
Total	**160**	**100**

*Representing the period 2005 to 2006

Approximately half (51.3%, n=82) of the respondents had experienced FMD in their herds. Of these only 20.7% had reported the outbreak to the nearest Township LBVD compared with 51.2% who contacted a private veterinarian, animal health worker or staff of the LBVD to obtain treatment for their sick animal(s). Almost three quarters (73.2%, 60 of 82) of the farmers had treated sick cattle with traditional treatments including rubbing banana, astringent leaves and chilli powder on tongue lesions, putting coal tar and kerosene on hoof lesions, and letting the cattle walk on hot sand to heal the hoof lesions. Some farmers (45.1%, 37 of 82) did not treat some infected cattle because the disease was common in the region and they had experienced the disease many times previously. No farmers killed infected animals during an outbreak. Less than half of the farmers (40.6%, 65 out of 160) had used the FMD vaccine produced by the LBVD.

2.3.2.6 Animal movements

Over half (52.5%) of the respondents (n=84) were aware of the route of animal movements in their region. They reported that the majority (89.3%) of these movements were on foot; whereas 14.3% were by vehicle and 4.8% by ship (More than one option was reported). Since 2004 in the Sagaing Division, the local authority had banned the movement of animals without receiving prior permission from authorized persons in the Regional General Administration Department (Min, 2007). Even though 52.5% of respondents (n=84) were aware of animal movements, only 48.8% (n=78) provided details on the route of movement. Approximately one quarter (23.8%, n = 38) reported that movements were towards the sole cattle market in the Sagaing District and 25% reported only local movements.

2.3.2.7 General information

Questions were incorporated to gather information about the method of livestock husbandry, including the use of anthelmintics, feed supplements and vaccines. Only 21.3% of the respondents (n=34) had used anthelmintics, but not on a regular basis. A similar percentage (20.6%) used supplements such as vitamins or tonics which included multivitamins imported from abroad. Other bovine diseases found commonly in the Sagaing Division include Anthrax, Black Quarter and Haemorrhagic Septicemia and the LBVD has been producing local vaccines against these diseases for many years as part of a regular vaccination programme. However, only 51.9, 59.4 and 23.8% of respondents vaccinated against these diseases respectively.

The actual use of cattle and the duration of use of any single draught animal was very variable between respondents. The minimum duration for using draught cattle was 2 years with a maximum of 20 years and a median of 8 years. Consequently some farmers did not sell their working draught cattle if they did not have disease problems, and often the draught cattle were almost regarded as a family member or friend.

2.3.4.8 Identification of potential risk factors of FMD by using univariate analysis

Several risk factors were investigated that have the potential to be involved in the spread of FMD in the studied areas. Potential risk factors were grouped into four categories: livestock management practices, feeding system, source of drinking water, and herd size. The results of the univariable analysis of these risk factors are summarised in Tables 2.9 to 2.11.

Management practices examined included the rearing of unrestrained cattle; use of temporary yards or permanent buildings; tethering animals and the use of a common village grazing ground (Table 2.9 - 1 to 6). After working in the fields the livestock were kept in a variety of ways either near the farmer's house or at the grazing ground.

Data on the source and frequency of buying and selling cattle and when this was conducted were also collected and analysed. Information was also collected on the area of land owned and if draught or dairy cattle were owned.

Analysis of the feeding system is reported in Table 2.10. Data were collected on the type of food fed, use of free grazing ground and method of husbandry including tethering (Table 2.10).

Risk factors for water included the source (private well, public well, pond, tap, river, or underground) and whether the water was available throughout the year (Table 2.11).

Table 2.9 Influence of management and husbandry on the occurrence of FMD

No	Variables	% FMD Positive	Odds ratios (95% CI)	*p*-value
1.	Free roaming	45.5	0.8 (0.2 - 2.7)	0.69
	Not free roaming	51.7		
2.	Rearing cattle in temporary yards	46.2	0.8 (0.3 - 2.5)	0.70
	Not rearing cattle in temporary yards	51.7		
3.	Rearing cattle in permanent buildings	47.8	0.8 (0.4 - 1.6)	0.58
	Not rearing cattle in permanent buildings	52.6		
4.	Cattle reared in closed pens	43.5	0.7 (0.3 - 1.7)	0.42
	Cattle not reared in enclosed pens	52.6		
5.	Cattle tethered	58.5	2.4 (1.2 - 4.7)	0.01*
	Cattle not tethered	37.0		
6.	Rearing cattle in village grazing grounds	36.4	0.5 (0.2 - 1.9)	0.36[a]
	Cattle not reared in grazing grounds	52.3		
7	Own dairy cattle	53.5	1.1 (0.6 - 2.3)	0.73
	No dairy cattle owned	50.4		
8.	Own draught cattle	52.6	1.4 (0.6 - 3.5)	0.42
	No draught cattle owned	43.5		
9.	Farmer owns sheep and goats as well as cattle	60	1.4 (0.2 - 9.0)	1.0[a]
	Farmer own only cattle	50.6		
10.	Buy cattle once a year	72.2	2.7 (0.9 -8.1)	0.06*
	Cattle were not purchased every year	48.6		
11.	Buy cattle twice a year	50.0	0.9 (0.6 - 15.5)	1[a]
	Cattle were not purchased twice a year	51.3		

[a] result of Fisher's exact test because one or more cells were less than 5

* Selected variables used in the logistic regression model

Table 2.9 (continued)

No	Variables	% FMD Positive	Odds ratios (95% CI)	*p*-value
12.	Buy cattle every two years	100	2 (1.7 - 2.3)	0.1[a]
	Cattle were not bought every two years	50		
13.	Buy cattle every three years	55.6	1.2 (0.3 - 4.6)	1[a]
	Cattle were not bought every three years	51.0		
14.	Buy cattle every four years	50	0.9 (0.1 - 15.5)	1[a]
	Cattle were not bought every four years	51.3		
15.	Buy cattle every five years	80	3.9 (0.4 - 36.1)	0.4[a]
	Cattle were not bought every five years	50.3		
16.	Buy cattle every six years	20	0.2 (0.02 -2.1)	0.2[a]
	Cattle were not bought every six years	52.3		
17.	Buy cattle every seven years	100	1.9 (1.6 - 2.3)	0.4[a]
	Cattle were not bought every seven years	50.6		
18.	Never buy from outside their farm	66.7	1.9 (0.2 - 21.7)	1[a]
	Buy cattle from outside their farm	51.0		
19.	Buy cattle in January	100	1.9 (1.6 - 2.3)	0.5[a]
	Buy cattle in other months expect January	50.6		
20.	Buy cattle in February	42.9	0.7 (0.1 - 3.2)	0.7[a]
	Buy cattle in other months expect February	51.6		
21.	Buy cattle in March	85.7	6.5 (1.4 - 30.1)	0.01[a]*
	Buy cattle in other months expect March	47.9		
22.	Buy cattle in April	60	1.4 (0.2 - 8.9)	1[a]
	Buy cattle in other months expect April	51		
23.	Buy cattle in May	100	1.9 (1.6 - 2.3)	0.5[a]
	Buy cattle in other months expect May	50.6		
24.	Buy cattle in June	100	1.9 (1.6 - 2.3)	0.5[a]
	Buy cattle in other months expect June	50.6		

(Continued)

[a] result of Fisher's exact test because one or more cells were less than 5

* Selected variables used in the logistic regression model

Table 2.9 (continued)

No	Variables	% FMD Positive	Odds ratio (95% CI)	*p*-value
25.	Buy cattle from within the village only	44.9	0.8 (0.5 - 1.2)	0.3
	Buy cattle from other places	54.1		
26.	Buy cattle from within the village tract	72.2	2.9 (1.1 - 7.8)	0.03*
	Buy cattle from other places	47.8		
27.	Buy cattle from within the township	20	0.2 (0.07 - 0.5)	0.001*
	Buy cattle from other places	57		
28.	Buy cattle from within the district	42.1	0.7 (0.3 - 1.7)	0.4
	Buy cattle from the other places	52.5		
29.	Buy cattle from the market	100	1.9 (1.7 - 2.3)	1[a]
	Not buying cattle from the market	50.9		
30.	Bred animals themselves	67.6	2.4 (1.1 - 5.2)	0.2*
	Cattle not bred	46.3		
31.	Own 1-5 head of cattle	46.1	0.5 (0.2 - 1.0)	0.06
	Own more than 5 head	61.8		
32.	Own 1-10 head of cattle	46.9	0.3 (0.1 - 0.7)	0.01*
	Own more than 10 head	74.1		
33.	Own 1-15 head of cattle	47.5	0.2 (0.05 - 0.6)	0.005[a]**
	Own more than 15 herd	83.3		
34.	Own1-20 head of cattle	47.9	0.1 (0.03 - 0.6)	0.005[a]**
	Own more than 20 head	86.7		
35.	Own1-30 head of cattle	51.3	0.7 (0.1 - 4.3)	1[a]
	Own more than 30 head	60.0		

(Continued)

[a] result of Fisher's exact test because one or more cells were less than 5

* Selected variables used in the logistic regression model

** Although these variables had *p*-value <0.25, they were excluded from the model because the majority of farmers owned less than 10 cattle

Table 2.9 (continued)

No	Variables	% FMD Positive	Odds ratio (95% CI)	*p*-value
36.	Sell once a year	65	1.9 (0.7 - 5.1)	0.2*
	Not selling once a year	49.3		
37.	Sell twice a year	33.3	0.5 (0.04 - 5.2)	0.61[a]
	Not selling twice year	51.6		
38.	Sell every two years	90.9	10.7 (1.3 - 85.6)	0.009[a]
	Not selling every two years	48.3		
39.	Sell every three years	60	1.4 (0.4 - 5.3)	0.7[a]
	Not selling every three years	50.7		
40.	Sell every four years	50	0.9 (0.06 - 15.5)	1[a]
	Not selling every four years	51.3		
41.	Sell every five years	80	3.9 (0.4 - 36.1)	0.3[a]
	Not selling every five years	50.3		
42.	Sell every six years	25	0.3 (0.03 - 3.03)	0.3[a]
	Not selling every six years	51.9		
43.	Sell in February	44.4	0.7 (0.2 - 2.8)	0.7[a]
	Not selling in February	51.7		
44.	Sell in March	78.9	4.1 (1.3 - 13.1)	0.01[a]*
	Not selling in March	47.5		
45.	Sell in April	66.7	1.9 (0.2 - 21.7)	1[a]
	Not selling in April	51.0		
46.	Sell in June	50	0.9 (0.06 - 15.5)	1[a]
	Not selling in June	51.3		
47.	Sell in October	100	0	0.5[a]
	Not selling in October	51.3		
48.	Sell in November	66.7	1.9 (0.2 - 21.6)	1[a]
	Not selling in November	51.0		
49.	Sell in December	100	0	0.12[a]
	Not selling in December	50.0		

(Continued)

[a] result of Fisher's exact test because one or more cells were less than 5

* Selected variables used in the logistic regression model

Table 2.9 (continued)

No	Variables	% FMD Positive	Odds ratio (95% CI)	*p*-value
50.	Sell within village	34.1	0.4 (0.2 - 0.8)	0.01*
	Sell outside village	57.1		
51.	Sell within village tract	70	2.9 (1.3 - 6.1)	0.006*
	Sell outside village tract	45		
52.	Sell within township	47.4	0.8 (0.3 - 2.1)	0.7
	Sell outside township	51.8		
53.	Sell within district	44.4	0.75 (0.2 - 2.9)	0.7[a]
	Sell outside district	51.7		
54.	Sell to market	30.0	0.4 (0.1 - 1.5)	0.2[a]
	Never sell to market	52.7		
55.	Sell to anyone who wants cattle	50	0.9 (0.3 - 3.0)	0.9
	Not selling cattle to other people	51.4		
56.	Never sell animals	50	0.95 (0.3 - 3.4)	0.9
	Has sold animals	51.3		
57.	Owns 1 to 5 acres of land	52.2	1 (0.4 - 2.3)	0.9
	Owns more than 5 acres of land	53.3		
58.	Owns up to 10 acres of land	51.8	0.8 (0.5 - 1.7)	0.7
	Owns more than 10 acres of land	55.0		
59.	Owns up to 15 acres of land	50.9	0.7 (0.3 - 1.5)	0.4
	Owns more than 15 acres of land	59.5		
60.	Owns up to 20 acres of land	50	0.3 (0.1 - 1.0)	0.05**
	Owns more than 20 acres of land	73.7		
61.	Owns up to 30 acres of land	52.6	0.5 (0.09 - 3.1)	0.7[a]
	Owns more than 30 acres of land	66.7		
62.	Owns up to 40 acres of land	52.5	0.4 (0.03 - 3.6)	0.6[a]
	Owns more than 40 acres of land	75.0		

[a] result of Fisher's exact test because one or more cells were less than 5

* Selected variables used in the logistic regression model

** Although these variables had *p*-value <0.25, they were excluded from the model because the majority of farmers owned less than 10 cattle

Table 2.10 Influence of feeding system on the presence of FMD

No	Variables	% FMD Positive	Odds ratio (95% CI)	*p*-value
1.	Feeding cattle home-made prepared feed	51.6	1.4(0.3 - 6.6)	0.71[a]
	Not feeding home-made food	42.9		
2.	Use free grazing ground	63.9	2.3(1.2 - 4.5)	0.01*
	Not using free grazing ground	43.4		
3.	Feeding kitchen waste	0	0(0)	0.11[a]
	Not feeding kitchen waste	52.2		
4.	Feeding grass	54.2	1.3 (0.7 - 2.4)	0.44
	Not feeding grass	48.1		
5.	Feeding bran	48.4	0.8 (0.4 - 1.6)	0.56
	Not feeding bran	53.1		
6.	Feeding straw	55.7	1.7 (0.9 - 3.3)	0.12*
	Not feeding straw	42.6		
7.	Feeding sesame cake	59.8	2.0 (1.1 - 3.8)	0.03*
	Not feeding sesame cake	42.3		
8.	Feeding peanut cake	43.5	0.7 (0.3 -1.7)	0.42
	Not feeding peanut cake	52.6		
9.	Feeding by-products	33.3	0.5 (0.1 - 1.9)	0.31[a]
	Not feeding by-products	52.3		
10.	Feeding maize straw	56.8	1.5 (0.8 - 2.82)	0.2*
	Not feeding maize straw	46.5		
11.	Feeding bean husk	50	0.9 (0.5 - 1.8)	0.83
	Not feeding bean husk	51.9		
12.	Feeding broken rice	33.3	0.4 (0.2 - 0.9)	0.03*
	Not feeding broken rice	55.4		
13.	Feeding wheat straw	75	3.5 (1.4 - 8.8)	0.01*
	Not feeding wheat straw	46.2		
14.	Grazing with an attendant	57.9	1.4 (0.7 - 3.0)	0.33
	Use other grazing options	48.8		
15.	Grazing without attendant	50	0.9 (0.1 - 15.7)	1.00[a]
	Use other grazing options	51		
16.	Tethered at communal grazing ground	58.8	1.5 (0.7 - 3.2)	0.3
	Use other grazing options	48.8		
17.	Free movement at grazing ground	57.1	1.3(0.3 - 6.0)	1.0[a]
	Use other grazing options	50.9		

[a] result of Fisher's exact test because one or more cells were less than 5

* Selected variables used in the logistic regression model

Table 2.11 Influence of source of drinking water on the presence of FMD

No	Variables	% FMD Positive	Odds ratio (95% CI)	*p*-value
1.	Use private well only	45.6	0.7(0.3- 1.3)	0.22*
	Use other water sources	55.4		
2.	Use public well only	31.6	0.4(0.1 - 1.1)	0.07*
	Use other water sources	53.9		
3.	Use pond water only	64	1.8(0.8 - 4.4)	0.16*
	Use other water sources	48.9		
4.	Use tap water only	0	0(0)	0.05[a]*
	Use other water sources	52.6		
5.	Use river water only	63.6	0.5(0.1 - 1.8)	0.36[a]
	Use other water sources	47.7		
6.	Use underground water points only	65.5	2.4(1.2 - 4.8)	0.01*
	Use other water sources	43.8		
7.	Water source available year round	51.8	1.3 (0.5 -3.3)	0.57
	Water not available all year long	45		

[a] result of Fisher's exact test because one or more cells were less than 5
* The variable used in the logistic regression model ($p<0.25$)

Table 2.12 Best fit logistic regression model for the presence of FMD

	β	OR	95% C.I		Sig.	Wald
			Lower	Upper		
Own less than 10 cattle	-1.44	0.24	0.07	0.76	0.02	5.82
Buy cattle within township	-2.21	0.11	0.03	0.38	0.00	12.10
Sell cattle within village	-2.37	0.09	0.03	0.29	0.00	17.33
Buy cattle every year	1.53	4.60	1.19	17.75	0.03	4.92
Buy cattle in the month of March	2.55	12.77	2.26	72.03	0.00	8.33
Practice communal grazing	1.30	3.67	1.54	8.75	0.00	8.57
Use underground water points	1.05	2.87	1.21	6.77	0.02	5.75
Constant	-1.38	0.25			0.24	1.40

2.3.4.9 Logistic regression model

A total of 21 variables with *p*-values < 0.25 were offered to the multivariable logistic regression model. Variables had to have a $p < 0.05$ to remain in the final model.

The result of the logistic regression model is outlined in Table 2.12. Farmers who purchased cattle every year were 4.6 (1.2 -17.7 95% CI) times more likely to report FMD than those who didn't purchase cattle each year. Farmers who purchased cattle in March were 12.8 times (2.3, 72) more likely to have livestock affected by FMD than those who didn't purchase cattle in that month. Similarly using communal grazing land (OR 3.7, 95% CI 1.5, 8.8) and sourcing water from underground places (2.9; 1.2, 6.7) increased the risk of a report of FMD. Protective factors included owning less than 10 head of cattle, buying cattle from within the township and selling cattle within the village. The Hosmer-Lemeshow statistic demonstrated that the model fitted the data well (χ^2 =10.05, df =7, $p = 0.185$).

2.4. Discussion

Foot and mouth disease is a highly contagious viral disease which can be spread by direct or indirect contact with infected animals. The clinical signs are well defined and easily recognized by livestock managers in cattle (Gibbs, 2003; McLaws *et al.*, 2007). Information reported by the farmers during the interviews on monthly outbreaks of FMD (Table 2.8) was not consistent with reports obtained from the LBVD (Figure 2.3B). According to the reports from the LBVD, outbreaks occurred in all calendar months expect for April, May and December. In contrast outbreaks were reported by farmers in all months except for July, August and September. This difference is likely to be due to underreporting as in this study only 20.5% of farmers informed the local authority of outbreaks.

The risk factors for the transmission of the virus to susceptible animals can be divided into two groups: controllable and uncontrollable (Donaldson *et al.*, 2001). The uncontrollable risk factors consist of wind direction, air transmission, birds and contaminated food (Cannon and Garner, 1999; Donaldson *et al.*, 2001; Sellers, 2006). In the study described in this chapter, uncontrollable risk factors for the spread of FMD were not investigated. The controllable risk factors in countries where the disease is endemic include movement of infected animals, mixing animals on common grazing land, sharing water sources and buying cattle from cattle markets (Horst *et al.*, 1996; Donaldson *et al.*, 2001; Bronsvoort *et al.*, 2004a; Sellers, 2006). This study focused on the controllable risk factors including the feeding and management system adopted in the study area.

Many factors were analysed (Table 2.9 - 2.11) and those factors which had a $p < 0.25$ were then offered to the logistic regression model. In this model four factors were positively associated with FMD and three negatively associated. All but one of these factors (owning less than 10 head of cattle) (Table 2.12) were related with the movement of animals and contact between animals.

In this study, the median herd size was 4 (range 0 to 72). In an epidemiological study of FMD conducted in Argentina (Perez *et al.*, 2004b) herd density was strongly linked ($p < 0.01$) with disease outbreaks. Smaller herds are less likely to have individual animal contact with other herds and not surprisingly "small herds" was found to be a protective factor in the present study. Similarly buying and selling of cattle within a township reduces exposure to other animals lessening the probability of exposure to FMDV. The variable buying cattle within the township (OR 0.1; 0.0 – 0.3) was a protective factor in this study. Similarly selling cattle within the village (OR 0.09; 0.0 – 0.2) reduced the spread of FMD. In the logistic regression model it was found that the odds of disease when cattle were purchased in March was 12.7 times (2.2 - 72.0) higher than if animals were purchased at other times of the year (Table 2.12). It is likely that this month was found to have a higher risk for disease as it is the time when animals are purchased or sold. In the Sagaing Division it was found that farmers buy and sell cattle between the times of harvesting and the start of the next working season (between February and April).

Practicing communal grazing (OR 3.6; 1.5 - 8.7) and contact between livestock at watering points where the water is sourced from underground (OR 2.8; 1.2 - 6.7) also were significantly associated with disease. A similar finding was reported in a study in northern Thailand (Cleland *et al.*, 1996) and close contact between susceptible animals is the main method of spread of FMD. After the crops are harvested in the study area, cattle are allowed to graze on the communal grazing ground. At this time cattle are mixed and potentially could be exposed to animals from neighboring villages. If an infected animal shared this communal grazing ground, disease could easily spread to susceptible cattle.

Even though a variety of water sources were used in the study area, cattle watered at places where water was sourced from underground were 2.8 times (1.2 - 6.7) more likely to get infection than water sourced from other places (Table 2.11). It is likely that cattle come into contact with other animals at the ground water extraction point, which may be less likely when water is sourced from rivers or ponds. Other studies have similarly highlighted the importance of shared grazing land and watering points in the spread of FMD (Cleland *et al.*, 1996; Bronsvoort *et al.*, 2004a).

Although a study in Cameroon (Bronsvoort *et al.,* 2004) reported that the close proximity of buffalo to a cattle herd was an important risk factor for the spread of FMD, in the Sagaing control zone the buffalo population is very low. Although sheep and goats are the second most common species after cattle (Figure 2.2 B) these animals were not found to be important in the transmission of FMD. In contrast others (Megersa *et al.*, 2009) have highlighted the importance of sheep and goats in disease transmission in Ethiopia. The current investigation focused on farmers who owned cattle and very few owners had cattle and sheep and goats which may have reduced the apparent impact of these species in the spread of FMD.

In a study to investigate the epidemiology of FMD in cattle in Ecuador (Lindholm *et al.*, 2007), purchasing of cattle from the livestock market was identified as a significant risk factor (OR 10.3; 1.82 - 65.0) for FMD when compared to purchasing cattle directly from other farms. However in the current study only one farmer reported purchasing draught cattle from the market, although many farmers did sell non-draught animals to the markets. The markets are predominantly used for the sale of meat cattle and consequently are not suitable venues for purchasing draught cattle.

Social visits from family members, neighbours and friends contributed to 25% of contacts with animals reported during an outbreak of FMD in the Netherlands (Nielen *et al.*, 1996). These visits could allow for further dispersion of the virus during an outbreak, particularly given the cooperative and helping nature of farmers. In the study area of the Sagaing Division, there were 36 veterinarians and veterinary assistants (Table 2.2) to service more than 737,000 cattle and buffalo present in the Division (Table 2.1). Therefore, each veterinarian is responsible for over 20,000 head and consequently if a veterinarian transmits the virus there can be rapid transmission between animals. Nielen *et al.* (1996) described the risk of transmission of FMDV by veterinarians, artificial inseminators and animal traders who were more likely to have contact with animals. Sanson (1993) reported that a public awareness campaign was necessary to educate farmers and field veterinarians on methods of transmitting FMD and practices that could increase the risk of spread.

Therefore, for the establishment of future control plans for FMD with a progressive zoning approach in the study area of the Sagaing Division, more public awareness programmes need to be instigated for farmers, veterinarians and other stakeholders. These programmes need to include topics on the mode of transmission, suitable biosecurity measures to prevent infection, and potential risk factors for infection. In addition, a targeted strategic vaccination campaign is needed to increase immunity to the disease. Currently in Myanmar there are many financial and technical constraints to the effective control of FMD. To address these constraints, in the following chapter the development of a participatory approach using a traditional meeting style is outlined. This approach was used to gather information to better understand the epidemiology of the disease, in a way that was faster and potentially more representative than with questionnaire data.

Use of Modified Traditional Dutaik meetings for disease surveillance to support the progressive zoning approach of FMD Control in Myanmar

3.1 Introduction

Dutaik is a Myanmar word which means sitting together with knees touching on the same level and is usually conducted on a low "daybed" rather than on chairs. It is usually used to discuss specific issues or topics with set objectives. There is no rank or class differentiation between participants or between visitors and hosts. It is based on mutual understanding and collaboration and consequently usually results in a good output. The use of Dutaik talk is a traditional way of undertaking meetings in villages in Myanmar to discuss or "brainstorm" topics. It is also used to discuss new ideas or approaches with local people who appreciate talking with knowledgeable people in an open and transparent manner. It can be used as a tool to intervene and fill the gap between the modern sciences and traditional beliefs. A Dutaik meeting generally involves a small group (up to 20 people), and is more reliable and practical for participants from rural areas than are direct questionnaires or interviews (Sturges and Chimseu, 1996). For example it can be used to persuade farmers to participate in control programmes for FMD or to obtain information from local people who often have many years of experience in animal husbandry and livestock disease. The Dutaik meeting approach has been applied in public awareness programmes in the Myanmar MTM area since 2005. This kind of approach can be used to collect disease information, organize local people to participate in a project, monitor output of a project, and evaluate a projects outcome (Nalitolela and Allport, 2002). It is also a cost effective powerful tool for community development programmes and has a similar format to Participatory

Rural Appraisals which have been used in rural areas of many developing countries (Bayemi *et al.*, 2005).

Myanmar people are very creative and they usually solve daily livestock problems by using their own problem solving abilities, experiences and ideas, as well as by following the advice of older and more experienced persons. As part of their social lives, people who live in rural areas of Myanmar often come together at someone's place after lunch or dinner to talk. They are accustomed to sharing the experiences that they have encountered and this helps overcome any difficulties that may arise in their daily agricultural work. When they need a specific solution for an important topic they invite older experienced or more knowledgeable persons to discuss possible solutions. Such a brainstorming meeting (Dutaik meeting) is a traditional way of rural life in Myanmar. In this study the traditional Dutaik meeting was modified for use as a tool for disease surveillance. A Modified Traditional Dutaik (MTD) Approach was used and combined with other participatory disease investigation methods (Mariner and Paskin, 2000) that have been used in other developing countries (Catley *et al.*, 2002a).

Myanmar is planning to establish FMD control zones in the southern and northern parts of the country (the Tanintharyi and Sagaing Divisions) (MZWG 2, 2004). To achieve the objectives in line with the aims of the SEAFMD campaign, it is necessary to use simple, cost effective, repeatable, reliable and familiar approaches and methods within the country because of a shortage of resources and funds. This pilot study was conducted in four Townships located in the proposed control zone of the Sagaing Division in December 2006.

The aims of this study were to assess whether the MTD approach could be used as a tool to gather disease information for epidemiological studies and whether it is a reliable approach to apply in Myanmar within the existing constraints of limitations of financial and human resources. The MTD approach was also used to support the MZWG in the establishment of progressive zoning for the control of FMD and to improve public awareness of this disease.

3.2 Materials and methods

The methodology involved validating the outcome of the MTD meeting approach by comparing data acquired from three different sources (Figure 3.1).

3.2.1 Existing data collection

Existing data were collected from the National FMD Laboratory, Insein, Yangon and from the Divisional Office of the Sagaing Division of the LBVD. The author also obtained information concerning the movement of livestock (expert opinions), reports of outbreaks (official reports) of FMD and potential risks of FMD (expert opinions) from veterinarians who were in charge of the particular village tracts where the Dutaik meetings were held. These data were obtained by informal meetings at the District Veterinary Office before the Dutaik meetings were conducted. Meteorological data were collected from the Monywa Meteorological station for the year 2005. The expert opinions on FMD information were taken from middle men, traders and local veterinarians of LBVD.

3.2.2 Serological survey

A sero-surveillance study was conducted in the Sagaing Division through funding from JICA for the establishment of a control zone for FMD in the lower part of the Sagaing Division in 2005 (See detail in Chapter 2, section 2.2.2.1).

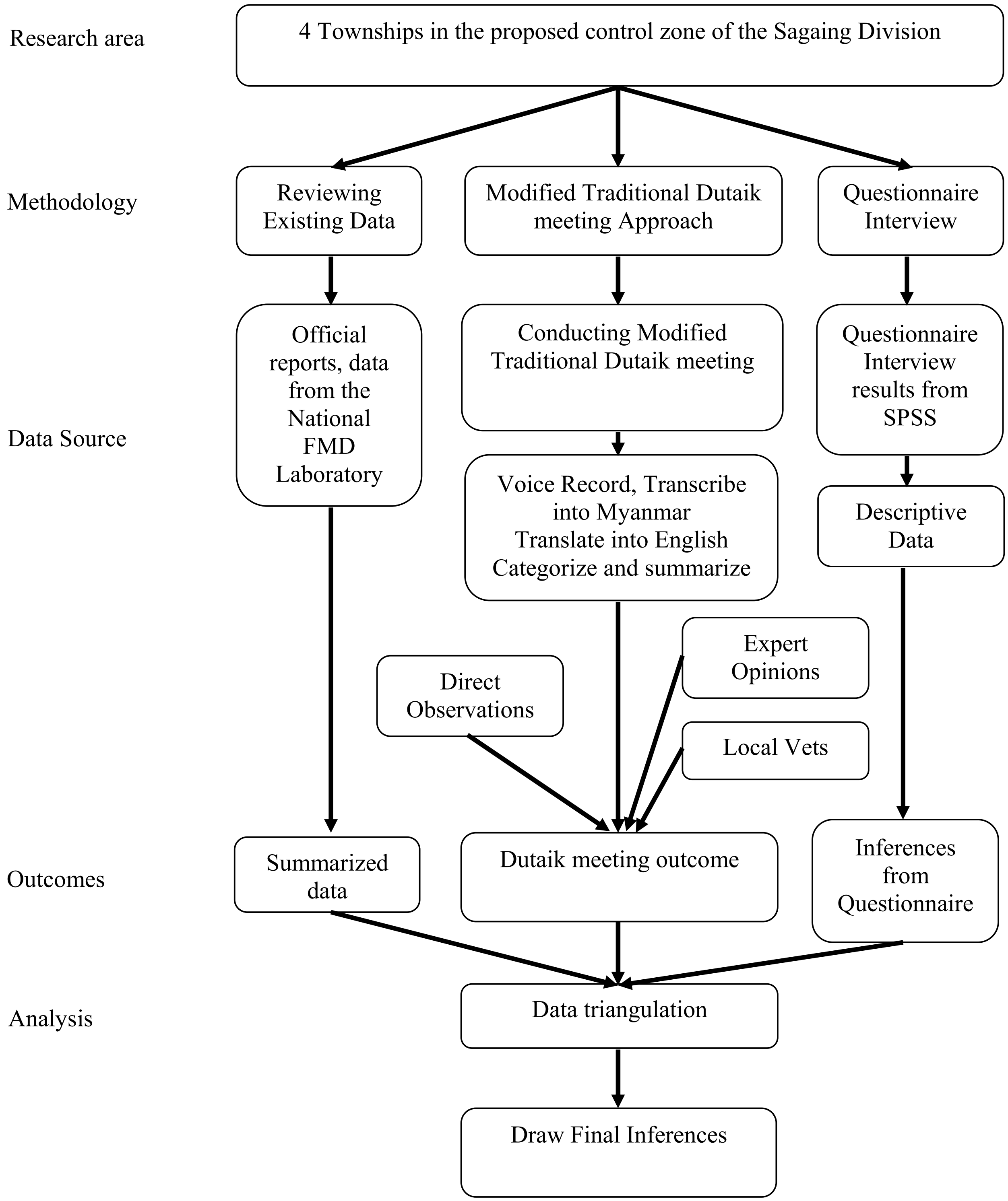


Figure 3.1 Summary of research design using the MTD meeting approach.

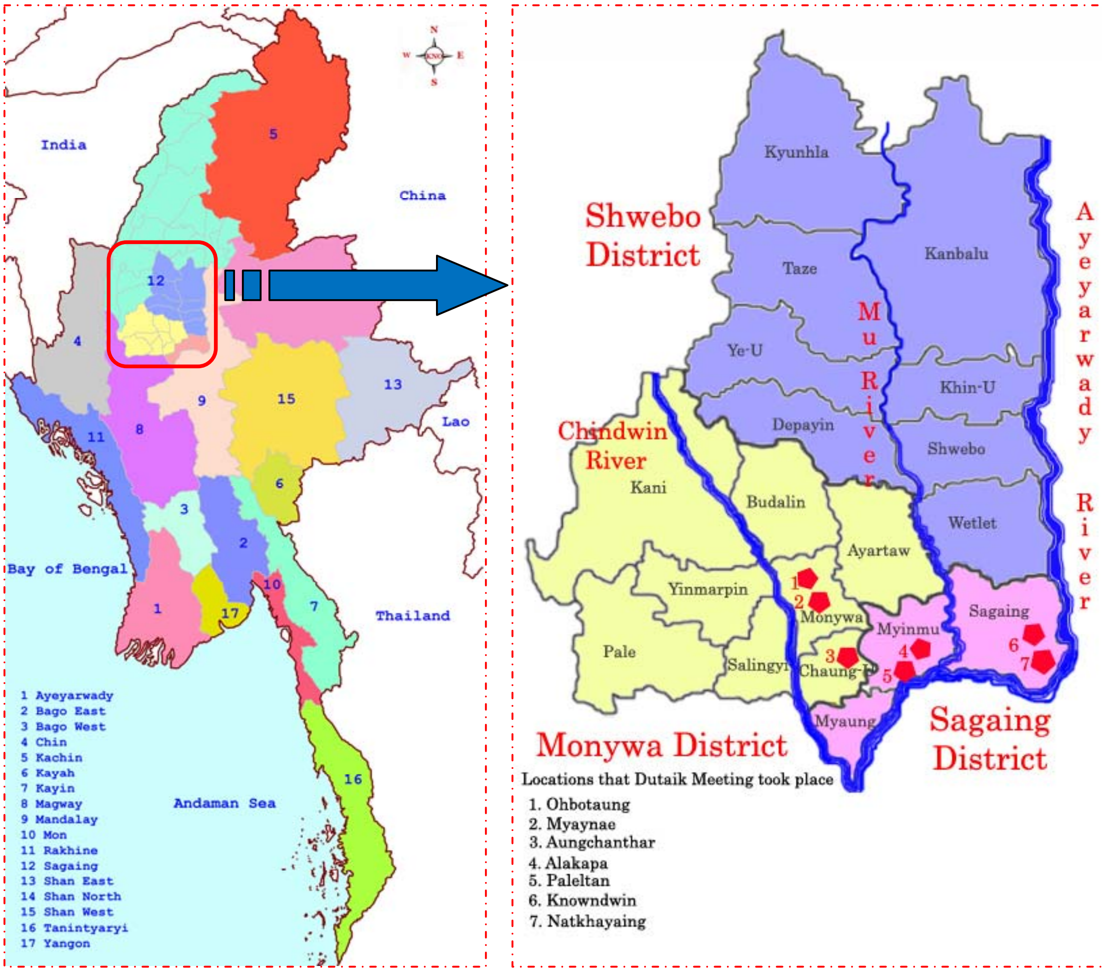


Figure 3.2 The locations where Dutaik meetings took place

3.2.3 Questionnaire Interviews

Five months before the MTD approaches were conducted; individual preset questionnaires (Appendix 1) were performed in 42 Village tracts of 8 Townships in Shwebo, Monywa and Sagaing Districts. The questionnaire data were entered into an Excel spreadsheet (Microsoft Office EXCEL 2003) and analysed with the statistical package SPSS version 17 for Windows (See Chapter 2). Of the eight Townships where questionnaire interviews were conducted, results from Chaung-U, Monywa, Sagaing and Myinmu Townships were compared with results from the MTD approach (Figure 3.1).

3.2.4 Modified Traditional Dutaik meeting approach

The MTD approach was conducted in seven village tracts of the four townships (See Figure 3.2). The four townships were selected because of the recent sero-survey conducted with the support of JICA and it was intended to triangulate the outcome of these serological results with the MTD meeting approach. Although the same villages were not used for the MTD meetings as the serological surveys, they were considered to be representative of the Townships. However the villages where the MTD were conducted were the same as those where questionnaire interviews were conducted in 2006.

The MTD approach has five main steps: collection of existing data; preparation of the meeting site; holding the Dutaik meeting; data recording; and data analysis. The locations for the MTD meetings were chosen to minimize the social stress by formal investigation; to maximize active participation and to persuade respondents to talk openly. Formal meetings are generally held in the village Peace and Development

Council Office or similar places while in contrast the MTD meetings took place in a villager's home or compound.

Firstly a team was established composed of staff-members from the Research and Vaccine Production Unit for FMD, a veterinarian from the Sagaing Division who was well known to the participants and who could act as a facilitator, and the author. A local native veterinarian was selected as a facilitator to avoid potential misunderstanding with the local dialect, to aid the flow of the informal discussions and to obtain the trust of participants for the project as the others involved in the project were strangers to the local people.

Approval was obtained from the Director General of the LBVD to hold the MTD meeting in the Sagaing Division as part of the research for this thesis and from the Murdoch University Human Ethics Committee. The team visited the Divisional Office of the Sagaing Division to undertake the necessary preparations and arrangements for the meeting. The MTD meetings were supported by local staff of LBVD in the individual townships of the Sagaing Division where the meetings occurred.

At first, the team visited the targeted village tracts where the MTD meetings were planned to take place. Before the meeting, team members (local veterinary staff) arranged an appropriate place for holding the MTD meeting. This was conducted in consultation with the village tract authorized person and the veterinarian in charge of the particular village tract. People invited to attend the MTD meetings were well experienced livestock owners, interested persons (farmers), wide knowledge older man, the person grown up within traditional farming system and a member of the Village Peace and Development Council. The local veterinarians for the particular villages were also invited to join the meetings. No incentives were used to encourage participants to attend the MTD meetings and research team members and participants sat in a circle together. Team members took a place among participants during the meeting (See Figure 3.3).

The author prepared an agenda for the MTD meeting and it was given to the facilitator. Topics to be covered during the meeting were written down on an inconspicuous piece of paper to ensure that all topics were covered but also to make the meeting less formal and to encourage villagers to actively participate. Topics covered in the MTD meeting included an introduction of team members, enquiries about the total number of households, total number of animals, herd size, husbandry system including feeding, housing and management, seasonal working calendar, common livestock diseases which the local farmers had encountered over the past few years, the disease that they considered was the most important, animal movements around the village tract, and clinical signs of the common livestock diseases (See Table 3.1).

Table 3.1 The topics covered during the MTD meetings

No	Topics	Sub topics
1.	Introduction of team members	• Welcome to participants in the MTD meeting
		• Why we are here
2.	Geographical, environmental and general demographic information	• Location
		• Number of households
		• Common livestock (cattle, buffalo, pigs, sheep and goats)
		• Total number of livestock, herd size
		• Species
3.	Economy of village tracts	• Type of cultivation
		• Selling and buying cattle and reasons
		• Seasonal cultivation pattern (seasonal calendar)
4	Husbandry System	• Feeding system, grazing system, water sources, housing and management
		• Use of grazing ground and cultivation work
5.	Common livestock diseases in the village tracts (over the last few years)	• Discussion depended upon the name of the diseases raised by participants, clinical signs
		• What were the impacts and economic loss from disease
6.	Most important livestock disease in the village tract	• Let the participants choose
		• Why it was important?
		• How the disease is controlled?
7.	Information on FMD	• History (epidemic, endemic or sporadic)
		• Disease occurrence
		• Last outbreak
		• Affected number
		• Clinical signs
		• Type of treatment
		• Methods of disease control
		• Vaccination programme
8.	Confirmation of FMD lesions	• Showing pictures of lesions of FMD taken recently in the Sagaing Division
9.	Animal movements	• Type of movement (small, large or medium)
		• Time
		• Carrying/transport methods
		• Frequency
10.	General discussion	• Personal experiences about outbreaks of FMD
		• Comments on FMD

Figure 3.3 A Dutaik meeting in a village

Participants were served with Myanmar traditional green tea and pickle-tea salad (Myanmar culture) through out the meeting. The facilitator of the team introduced the team members and explained the reasons for their visit to the village. The facilitator asked participants to talk freely about livestock diseases and currently adopted husbandry systems. The meeting commenced with a discussion about the agricultural work undertaken by the farmers. The facilitator asked general questions about the number of households in the village tract and the total number of livestock (cattle, sheep and goats and pigs) present in the village. Data on the maximum and minimum number of livestock owned per farmer was collected. The facilitator then changed the topic to the economy of the village tract and asked general questions about seasonal cultivation patterns and use of draught cattle. This was followed by questions on the feeding system, water sources, housing and management of livestock.

The next topic was to find out the common livestock diseases which occurred in the village tracts and to allow participants to prioritize these diseases. If participants reported that FMD was an important concern for animal health, the team members would direct the discussion towards this disease and related topics. Although it was anticipated that FMD would be chosen as the most important disease for local farmers, some farmers might identify other diseases as more important. If participants considered that FMD was not an important animal health concern, the team members then compared FMD with other common diseases and asked participants to consider the importance of FMD as a cause of economic loss for the individual farmer, the particular village tract and their region. During the last part of the meeting the team showed pictures of lesions of FMD taken recently in the Sagaing Division and asked whether the clinical cases that farmers had seen had signs similar to the displayed pictures. Then, they were asked about movement of livestock in and around the village. After the MTD meeting, team members observed the village tracts to obtain a better understanding of the issues raised in the MTD meeting. Geographical locations were recorded by using hand held GPS units (GARMIN, eTrex Legend personal navigator, manufactured by GARMIN (Asia) Corporation, No 68, Jangshu 2nd Rd.,Shijr, Taipei County, Taiwan).

A digitized voice recorder was used to record all MTD meetings similar to that used in other group and individual interviews (Michael, 2000) and these were saved both on computer and also on CD. Recordings were taken to ensure no information was overlooked during the meeting and these recordings were subsequently transcribed in Myanmar language. The transcribed record of each MTD meeting was then translated from Myanmar into English and kept in a separate file.

Before qualitative data analysis, the records of MTD meetings were summarized by category and by topics and were tabulated as outlined in Table 3.1. Some of the summarized outcomes (e.g. - affected number of cattle in disease outbreaks) were categorised as severe, moderate, mild or low.

3.2.5 Triangulation and validation of the MTD meeting approach

Data collected from the MTD approach were cross-checked with existing data collected from the LBVD and the results of questionnaire interviews (See Chapter 2) which were undertaken in the same location five months prior to the MTD meetings. This included information on the pattern and distribution of FMD and to identify potential risk factors relevant to the occurrence of FMD in the study area. This triangulation process (Figure 3.1) was intended to evaluate the MTD approach as a future tool for disease surveillance in Myanmar.

3.2.6 Statistical calculations

Confidence intervals for proportions were calculated by using binomial exact methods (Daly, 1992).

3.3 Results

3.3.1 Existing Information

Data on the livestock population and the total number of owners was collected from the LBVD (Table 3.2). More cattle than other livestock were kept in the region. In contrast few buffalo were kept.

Table 3.2 The animal population and total number of livestock owners
data source - (LBVD, 2006)

Township	Buffalo		Cattle		Sheep and goats		Pigs	
	Owners	Animals	Owners	Animals	Owners	Animals	Owners	Animals
Chaung-U	377	1,414	7,322	28,597	602	28,790	3,225	17,592
Monywa	173	988	12,996	61,346	1,396	35,899	2,856	15,624
Myinmu	18	93	10,395	60,411	659	30,156	861	9,982
Sagaing	262	573	22,258	111,926	4,581	34,483	2,896	11,000
Total	**830**	**3,068**	**52,971**	**262,280**	**7,238**	**129,328**	**9,838**	**54,198**

According to the official report for outbreaks of FMD in the Sagaing Division, the disease occurred sporadically every year (two or three times per year) (Figure 2.3 of Chapter 2). A large number of outbreaks occurred in 1997 (10 outbreaks in July) and 2002 (6 outbreaks in August). The majority of outbreaks occurred in the monsoon season (June, July and August) (Figure 2.3).

3.3.2 Results of the serological survey

The results from the recent sero-surveillance study in the Sagaing Division were obtained from the National FMD laboratory. In 2004, a total of 506 serum samples were collected from four divisions and two states for sero-surveillance of FMD. The Sagaing Division was included and these results were reported to the 11th OIE Subcommission for the Control of FMD (Kyin, 2005a). Among these, serological results from three Townships (Chaung-U, Monywa and Myinmu Townships) are outlined in Table 3.3. Again, in 2005, active serological surveys were conducted to support the establishment of a progressive zoning approach for FMD in the Sagaing Division. A total of 400 serum samples were collected from four townships in the Sagaing Division and the result of samples from the Sagaing Township of the division (Kyin, 2005b) are also outlined in Table 3.3. The other three townships were located outside the proposed control zone of the Sagaing Division and are not included in Table 3.3.

Table 3.3 Serological results from surveys conducted in 2005

(Source - National FMD Laboratory)

Township	Total number of sera collected	Number of positive results	Percent positive (95% CI)
Chaung-U	48	21	43.8 (29.7-57.8)
Monywa	47	2	4.3 (0.0-10.0)
Myinmu	50	5	10.0 (1.7-18.3)
Sagaing	50	3	6.0 (0.0-12.6)

The serum samples from Chaung-U, Monywa and Myinmu Townships were collected in the middle of 2005 and from the Sagaing Township early in 2005. These samples were tested by an NSP ELISA at the National FMD Laboratory. The prevalence in Chaung-U (43.8%) was significantly higher than that in each of the three other townships ($P < 0.0001$). There was no significance difference in the prevalence from Monywa, Myinmu and Sagaing Townships. The lowest prevalence was in

Monywa (4.3%). In Chaung-U Township the ratio of cattle to sheep and goats was approximately 1, in contrast to the other townships which had approximately twice as many cattle as sheep and goats (Table 3.2).

3.3.3 Results of Questionnaire Interviews

In Table 3.4 a summary of answers given to questions included in the questionnaire is outlined with relation to livestock feeding, animal management and FMD. A total of 38 respondents were interviewed from the four townships. All respondents reported that they had not used commercial feedstuff, swill feeding (feeding kitchen waste) or communal grazing ground without an attendant for their draught cattle. However the majority used homemade feed and were aware of an outbreak of FMD in their village during the previous two years. The number of animals affected during the outbreak varied between villages from 2 to 1,000 (respondents from Aungchanthar village did not answer this question). More than half of the respondents were aware of animal movements for trading purposes in their Townships. As local authorities had officially outlawed animal movements, this may have resulted in fewer responses to the question on animal movement when compared with the question on whether animals were moved on foot (droved). More than half of the farmers provided data on the month of the last outbreak except for farmers from Myayne village. Outbreaks of FMD occurred more frequently in March, April, May, June and December.

Table 3.4 Summary of the affirmative (i.e. yes) responses from the questionnaire interview

Township		Chau[1]	Monywa		Myinmu		Sagaing		
Village tract		**Aung[2]**	**Ohbo[3]**	**Myay[4]**	**Alaka[5]**	**Palae[6]**	**Know[7]**	**Nat[8]**	**Total (%)**
Total Respondents		5	5	6	6	6	4	6	38
Questions		**Number answering yes to relevant question**							
Do you feed commercial feed?		0	0	0	0	0	0	0	0
Do you feed home made feed?		5	5	5	5	5	4	5	34 (89)
Do you use common grazing land?		0	1	0	3	5	1	3	13 (34)
Do you feed swill (kitchen waste)?		0	0	0	0	0	0	0	0
Do cattle graze common grazing ground with attendants?		0	1	0	1	1	2	2	7 (18)
Do cattle graze common grazing ground without attendants?		0	0	0	0	0	0	0	0
Are cattle tethered at the grazing ground?		0	0	1	1	3	0	2	7 (18)
Are the cattle free to wander around?		0	0	0	0	1	0	0	1 (3)
What is the source of water for cattle?	Private well	3	4	5	1	2	2	2	19 (5)
	Public well	0	1	0	0	0	0	0	1 (3)
	Pond well	0	1	0	1	0	1	2	5 (13)
	River water	0	0	0	0	4	0	0	4 (11)
	Underground water	2	1	1	4	2	2	4	16 (42)
Have you heard of an outbreak of FMD in the village tract before this survey?		3	5	5	6	6	4	6	35 (92)
One outbreak in past two years		1	2	1	2	4	4	6	20 (53)
Two outbreaks in past two years		0	0	0	1	1	0	0	
Are you aware of animal movements (for trading purposes only) in the village tract?		2	2	4	5	0	2	5	20 (53)
Are animals moved on foot?		2	2	5	6	2	3	5	25 (66)
Are animals carried by vehicles?		0	1	1	0	0	0	1	3 (8)
Awareness of the respondents to the number of cattle in FMD outbreak?		0	2	3	5	2	1	3	16 (42)
Maximum numbers of cattle involved in the most recent outbreak		0	10	5	1000	2	4	5	
The number of people who remembered when the last outbreak occurred.		1	2	0	6	5	3	6	23 (61)
Time of last outbreak		Dec	Dec	-	Mar, Apr, May	Mar, Apr, May	Apr, Dec	Mar, Jun, Dec	

Explanation
[1]Chaung-U, [2]Aungchanthar, ,[3]Ohbotaung, [4]Myayne, [5]Alakapa, [6]Paleltan, [7]Knowndwin, [8]Natkhayaing,

3.3.4 MTD Meeting Outcomes

The outcome of the MTD meetings were categorized and summarized under different topics. A total of 129 participants from 7 villages were involved in this study and provided information whereas in the questionnaire interview, only 38 respondents from the same village tracts were engaged (See Table 3.5).

Table 3.5 General information on the MTD meetings

Township	Village tract	Number of Participants (MTD meeting)*	Number of Respondents to individual questionnaires
Chaung-U	Aungchanthar	22	5
Monywa	Ohbotaung	15	5
	Myaynae	17	6
Myinmu	Alakapa	19	6
	Paleltan	16	6
Sagaing	Knowndwin	15	4
	Natkhayaing	25	6
Total number of people		129	38

*In each village tract only one MTD meeting was conducted

3.3.4.1 Geographical, environmental and general information

The locations of the MTD meeting places are listed in Table 3.6.

Table 3.6 Geographical locations of MTD meetings

Geographical location			
Village tract	Latitude(North)	Longitude(East)	Height above sea level (metres)
Aungchanthar	21.5856	95.1535	62.5
Ohbotaung	22.1007	95.0600	71.6
Myaynae	22.0348	95.1198	68.3
Alakapa	21.5585	95.2944	67.4
Paleltan	21.5590	95.3641	64.0
Knowndwin	21.5908	95.4253	53.3
Natkhayaing	21.5847	95.4716	76.2

The most commonly kept livestock were cattle. Some sheep and goats, pigs and poultry were also kept but no buffalo. The total number of households and the estimated number of livestock in each village tract is tabulated in Table 3.7. Most households owned a pair of draught cattle and some also had a cow and a calf. Farmers reported that the average herd size for cattle was 3 to 5. There were only two to three sheep and goat farmers in each village tract and these owned on average 200 to 300 head. Pigs were raised either as a source of income or a means of saving for future expenses and in general 1 to 2 pigs were owned by the households. Some farmers owned cultivation land but did not own any draught cattle. There were also a few semi-intensive poultry (layers) farms in all village tracts.

Table 3.7 Summary of data on animal population and households collected during the MTD meeting

Village tracts	Number of households present	Number of livestock in village tracts				
		Cattle	Buffalo	Sheep	Goats	Pig
Aungchanthar	350	1300	0	250	250	500
Ohbotaung	757	700	0	0	100	100
Myaynae	300	600	0	150	150	100
Alakapa	1500	3000	0	350	350	1000
Paleltan	170	500	0	0	0	250
Knowndwin	187	1200	0	250	250	200
Natkhayaing	500	1100	0	400	400	50

3.3.4.2 Economy of village tracts

The income of local people is mainly dependent upon the agricultural industry. Some farmers also had backyard dairy farms or kept sheep and goats to supplement their income. One commercial dairy farm was located in the Aungchanthar village tract. This farm has approximately 500 dairy cattle compared with backyard dairy farms which had only one to five head of dairy cattle. There was a high demand for raw milk in Monywa and Sagaing where small scale condensed milk production factories were run as family businesses. A small number of backyard sheep and goat farms were located in all village tracts except for Paleltan village tract. Selling and buying cattle occurred throughout the year. Farmers sold their surplus cattle to "middle men" if they needed money; sold their draught cattle if they were old or had health problems; or sold existing cattle if they were not suitable for working. The majority of farmers reported that selling and buying of cattle primarily occurred at either the beginning or the end of the agricultural working season. Farmers obtained information from other farmers on the best place to purchase draught cattle, and many preferred to buy animals privately rather than through a trader. There was no sheep and goat market in the Sagaing Division, therefore, farmers sold small ruminants to livestock traders/middle men who came directly to their farms and who then sold these animals in the Mandalay Division.

3.3.4.3 Husbandry system

The husbandry system adopted in all the village tracts was similar. Farmers housed/stabled their draught cattle at their homes. All animals were fed on home-made food; however two village tracts also used communal grazing grounds to pasture their animals. Drinking water for the cattle was sourced from either a pond or underground sources (Table 3.8).

Table 3.8 Feeding management practices reported in the MTD meetings

Village tract	Feed			Source of drinking water (cattle)			
	Home made feeding	Common grazing ground	Buy feed from other sources	River	Pond	Under ground	Shortage of water
Aungchanthar	Yes	No	Yes	No	Yes	Yes	No
Ohbotaung	Yes	No	Yes	Yes	Yes	Yes	No
Myaynae	Yes	No	No	No	Yes	Yes	No
Alakapa	Yes	Yes	No	No	Yes	Yes	No
Paleltan	Yes	No	No	Yes	Yes	Yes	No
Knowndwin	Yes	No	No	No	Yes	Yes	Yes
Natkhayaing	Yes	Yes	Yes	No	Yes	Yes	Yes

Cattle were fed in long wooden troughs with approximately two to four animals sharing one trough (see Figures 3.4 and 3.5). Feed was mixed with water, chopped hay and other supplements including peanut cake, sesame cake, bean powder and husk. Farmers tended to preferentially feed more nutritious feed (such as peanut cake and sesame cake) to draught cattle than to other animals such as cows, calves or young adults. The village tracts located near the river used river water as a water source for both human and animal use. In some areas during the summer (dry) season, there was a shortage of water for the cattle, especially in the months of March, April and May. Farmers paid more attention to draught cattle than to other cattle as the draught cattle were essential machines for their agricultural industry. As well as draught cattle receiving more nutritious food they were more likely to receive treatments in the event of an illness.

When farmers wanted to use cattle for working, they walked them to their fields via a public road. Additional cattle were also taken and allowed to graze near the agricultural land. Some cattle grazed land not being used for cultivation or on cultivation land after crops had been harvested (Figure 3.6). Most farmers used their cattle from the beginning of the dry season to the beginning of the cold season (Figure 3.6). In some village tracts with permanent water sources, such as those located near rivers or lakes, farmers used cattle throughout the year as crops could be irrigated.

Figure 3.4 Feeding cattle from a wooden trough (feeding from one side)

Figure 3.5 Feeding cattle from a wooden trough (feeding from both sides)

Figure 3.6 Seasonal Calender of the participants (MTD approach)

Farmers' Seasonal calendar in the Sagaing Division												
English calendar	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
International Calendar	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Climate	**Winter season**		**Summer Season**			**Rainy Season**					**Winter season**	
Myanmar calendar	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Myanmar Calendar	**Pyathou**	**Tapoutwe**	**Tapaun**	**Tankhu**	**Kahsoun**	**Nayoun**	**Wahsou**	**Wakhaun**	**Tothalin**	**Thitintyut**	**Tanhsaunmoun**	**Natto**
Use cattle	⇢	⇢	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⇢
Explanation for use of cattle ⟶ most farmers used cattle ⇢ some farmers use cattle where water is available (irrigation system is effective for cultivation)												
Use Pasture	⟶	⟶	⟶	⟶	⇢	⇢	⇢	⇢	⇢	⇢	⇢	⇢
Explaination for use pasture ⟶ pasture season because harvesting time is over (nearly all cattle) ⇢ cattle pastured by tethering between cultivation plots (only few cows)												
Water shortage				⟶	⟶							
During dry season, some parts of Sagaing Division encountered a water shortage												
Feedstuff shortage							⟶	⟶				
Heavy rainfall results in a shortage of feedstuffs in some parts of Sagaing Divsion												
FMD outbreaks	★	★	★		★	★	★	★				
Wind speed (miles/hr)	1.9	2.5	2.6	2.7	2.7	4.6	3.2	4.1	1.9	1.4	1.2	1.4
Humidity (%)	73	60	62	54	56	72	71	75	98	83	78	79
Rain Days/mth	-	-	1	3	4	6	4	6	13	7	3	4
Rain Fall (inches)	a few	-	0.16	1.02	0.59	4.77	0.70	4.88	9.30	3.38	0.32	1.18

3.3.4.4 Common and important livestock diseases

The livestock diseases that participants had experienced in their cattle were FMD, Haemorrhagic Septicaemia, Black Leg, “common cold” and other unidentified diseases with signs including loss of appetite, fever, constipation and reduced urination. They also encountered some other problems such as trauma, abscesses, lameness and parasitic infestations. Farmers reported that most diseases were seasonal with more disease present in times of extreme heat or cold. Therefore, they commented that FMD outbreaks were mostly related with the time of changing weather, especially the interface time between the dry and the wet season (Table 3.9). They reported that the most important livestock diseases were FMD and Black Leg because these diseases had the potential to make a significant impact on their agricultural work and animals took time to recover from the diseases. As outbreaks of FMD tended to coincide with the time of the cultivation season, farmers believed the disease was important. They also reported the presence of diseases similar to FMD which involved traumatic lesions to the feet and concurrent lameness but without the presence of mouth lesions.

3.3.4.5 Information on FMD

Participants from all village tracts where MTD meetings took place reported that they had seen outbreaks of FMD in their region and the disease had been endemic for many years with outbreaks occurring either every year or every two to three years. The oldest participant, who was 82 years at the time of the MTD meeting from Paleltan village tract, said that he noticed FMD when he was 20 years old and the clinical signs observed in recent outbreaks were similar to those observed when he was young. A 70 year old participant from Natkhayaing village tract responded similarly and first remembered seeing lesions of FMD when he was 15 years old. Outbreaks were reported more frequently at the time of changing seasons (Table 3.9).

Table 3.9 Seasonal occurrence of FMD as determined by the MTD meetings

Village tracts	**Outbreak season**	
	Months	Comments
Aungchanthar	July, August	Especially in wet season
Ohbotaung	February, March	At the time of changing season between cold and hot seasons
Myaynae	June, July	At the time of changing season between hot and wet seasons
Alakapa	July, August	Especially in wet season
Paleltan	February, March	At the time of changing season between cold and hot seasons
Knowndwin	January to May	At the time of hot season when water and feed shortage occurred
Natkhayaing	February, March	At the time of changing season between cold and hot seasons

The number of animals infected with FMD varied from a few to all susceptible cattle in a village. The number of animals and history of the most recent outbreak is summarised in Table 3.10. The most recent outbreak was reported in Alakapa village tract in 2006, with outbreaks in 2005 in Myaynae and Paleltan village tracts. Participants from all studied villages reported that they had seen cases of FMD in their village and the disease had been endemic for many years. In addition, they confirmed that these studied villages were located along the animal movement route that most traders used.

Table 3.10 General information on FMD obtained in the MTD meetings

Village tract	Last outbreak	Year of most recent outbreak	Number of cattle affected ♦
Aungchanthar	4 years ago	2002	Very severe
Ohbotaung	3 years ago	2003	Low
Myaynae	Last year	2005	Low
Alakapa	Twice in this year	2006	Moderate
Paleltan	Last year	2005	Very low
Knowndwin	3 years ago	2003	Low
Natkhayaing	Last year	2005	Very low

♦**Affected number -**
Very severe = nearly all animals in the village tract affected
Severe = 75% of animals in the village tract affected
Moderate = 50% of animals in the village tract affected
Low = about 25% of animals in the village tract affected
Very low = less than 25% of animals in the village tract affected

The clinical signs of FMD reported by participants included excess salivation, lesions in the cleft of the hoof and sloughing of epithelium of the tongue and lameness. Foot lesions were frequently complicated with secondary screw worm infestation. Although participants were aware of the infectious nature of FMD, they mentioned that clinical signs were not observed in all cattle within a herd when an outbreak occurred. Cattle were not regularly vaccinated against FMD in all village tracts, with the use of FMD vaccine dependent upon the individual farmer. Usually very few farmers vaccinated their cattle, however, when they heard of a disease outbreak farmers requested that their draught animals were vaccinated. When infected cattle became weak or debilitated, farmers frequently called a veterinary practitioner to give supportive treatment otherwise they used traditional treatments including rubbing with banana and honey on the tongue lesions, forcing cattle to walk on hot sand for foot lesions, and putting naphthalene powder on foot lesions. Most respondents said that draught cattle were very resistant to infection and that they recovered within a fortnight of showing signs of clinical disease. Most could use FMD infected cattle within one month of the onset of clinical signs. In contrast calves and old cattle had little resistance to infection and some died from debilitation and weakness. Lesions in pigs, sheep and goats were not reported by any participants. Some appointed veterinary officers were working at these areas. The authorized persons reported to the LBVD for the outbreaks that occurred within the area.

Before the end of each MTD meeting, the facilitator showed pictures of lesions of FMD to the participants to confirm that the disease mentioned during the talk was FMD. The results were categorised as summarised in Table 3.11. The most familiar lesions were tongue lesions and foot lesions (Table 3.11 pictures 1 and 2). Only a few farmers had seen lesions on the udder or teats.

In Ohbotaung village, farmers reported that they had not seen lesions on the tongue but had seen lesions on the feet and muzzles of affected animals. Overall, FMD was endemic in all studied villages.

Table 3.11 Presence of FMD lesions in villages where MTD meetings were held

No.	Pictures	Ohbotaung	Myaynae	Aungchanthar	Alakapa	Paleltan	Knowndwin	Natkhayaing
1		not seen	seen (MS)	seen (MS)	seen (MS)	seen (MS)	seen (MS)	seen (MS)
2.		seen (MS)	seen (MS)	seen (MS)	seen (MS)	seen (MS)	seen (MS)	seen (MS)
3.		not seen	not seen	not seen	seen (HS)	not seen	seen (HS)	seen (HS)
4.		seen (MS)	seen (MS)	seen (MS)	not seen	seen (HS)	seen (MS)	seen (MS)

MS - more than half of the participants had seen the lesions,
HS - less than half of the participants had seen the lesions

3.3.4.6 Information on animal movement collected during the MTD meetings

Participants reported three different types of animal movements: movement of animals from the study village tracts to the farmers' working places; introduction of animals from other village tracts into the study village tracts which included newly purchased animals, bulls for breeding purposes and bullocks for transporting goods; and long distance movements made by animal traders who passed through the study village tracts when droving animals towards markets.

Farmers used cattle for ploughing, carrying water and goods and transportation throughout the year. Consequently such animal movements also occurred throughout the year. Although a farmer may own a large number of cattle they often still want to buy good quality draught cattle from other places and wish to breed their cow with a good bull from another village tract. In the latter situation the owner of the bull is asked to bring their bull to mate with the farmer’s cow. Farmers regularly used bullock carts for transporting goods. These last two types of movement were very complex and difficult to trace because they were not consistent. All of these movements were on foot. At the time of this study, local authorities had issued an order regarding the legalities of cattle movement. It was legal for farmers to lead two to three cattle behind their bullock cart as it was assumed they were going to their paddy field (See Figure 3.7). However, driving cattle on foot or without a bullock cart (as in Figure 3.8) was deemed to be illegal. This was because only a pair of cattle is required for working in a field.

Finally illegal movements in the Sagaing Division for the purposes of animal trading were reported. The local authorities had banned these types of animal movements since 2004 in all areas of the Division but some movements still occurred. The movement of sheep and goats by traders occurred throughout the year. Local farmers did not report on movement restrictions for sheep and goats. Sheep and goat owners tended to pay little attention to sickness within individual animals. Even though FMD is endemic in the Sagaing Division, most farmers had not seen lesions in sheep or goats. When the farmers noticed that a large number of sheep and goats were not in good health, they usually sold them to a butcher via a middle-man or trader. These middle men kept such animals at collection places near the village before transporting them to either a livestock market (Meik Hti Lar District of Mandalay Division) or a slaughter house. Movements of animals (by animal traders) were principally along the main roads to Sagaing where the cattle market was situated. Most cattle were driven on foot, however, this type of cattle movement was illegal and consequently the majority of traders drove cattle at night. Maps of animal movement are outlined and discussed in detail in Chapter 5.

Figure 3.7 Moving cattle by bullock cart (allowed animal movement)

Figure 3.8 Driving cattle (banned animal movement)

3.3.4.7 General comments from the participants

At the end of the MTD meeting, participants were asked to comment on outbreaks of FMD and to identify possible risk factors for the disease. Most participants highlighted the increased level of disease at the change of seasons especially between winter and summer time and before cultivation commenced when it changed from the dry to the wet season. In general farmers purchased cattle before the cultivation season commenced, and only purchased them during the cultivation season in an emergency. At the end of the cultivation season (end of winter and start of summer), most farmers sold, purchased or changed their draught cattle. At this time there were empty fields and a potential shortage of feed because of the dry season. Also at this time animals were often allowed to graze freely and cattle had a greater chance of interacting with other animals.

Participants highlighted the movement of animals by traders and the subsequent outbreaks of FMD, even though the local authority had banned the movement of animals from district to district. In contrast to other places of Myanmar, the participants tended to use cattle throughout the year because they had access to irrigation systems from the Ayeyarwady and Chindwin Rivers. However even in these areas cattle lost weight in the dry season.

3.3.4.8 Triangulation of the outcomes of the MTD meetings

A triangulation process to validate the outcome of the MTD meeting approach was conducted by matching up information collected during the MTD meetings with data collected from the LBVD and National FMD Laboratory, the questionnaire interviews and from experts.

Existing data and the MTD approach provided similar data on the population size in the studied area. Both sources described that cattle were the major animal kept, followed by small ruminants (sheep and goats) and pigs. In the official records the number of buffalo present in the studied area was the smallest for all livestock and in the MTD meeting no buffalo were reported in the studied area. In both the questionnaire and the MTD meeting the small number of dairy cattle was also highlighted. Both the questionnaire interview and the MTD meeting highlighted the importance of agricultural products for the local economy. The majority of farmers used draught cattle as an alternative to fossil fuel in their daily work.

The individual questionnaires and MTD meeting collected similar data on the system of livestock husbandry practiced. Both highlighted that the majority of farmers used home-made feeding and communal grazing land. Most people used underground water sources for both animal and human purposes. The farmers' knowledge on the common diseases of livestock mentioned during the MTD meeting approach was similar to the existing veterinary records from the LBVD and that obtained by expert opinion. Foot and Mouth disease, Haemorrhagic Septicaemia, Anthrax, Black Quarters were identified as common diseases by all sources.

Official reports from the LBVD described that most outbreaks of FMD occurred between June and September (rainy season) and January and February (Figure 2.4). These reports and expert opinions and results from laboratory tests agreed with the observation of farmers at the MTD meetings who reported that most outbreaks occurred during the transition period between the cold and dry seasons and at the beginning of the wet season. The disease has been endemic in this area for many years and sporadic outbreaks occur every year. Even though outbreaks are reported by the LBVD every year, it does not necessarily mean that outbreaks occur in the same areas as reported in the MTD meeting. In the MTD meeting outbreaks were reported to occur every two to three years in a particular village.

In both the questionnaire interviews and the MTD meeting, nearly all participants were familiar with the clinical signs of FMD, especially the foot and oral lesions. The number of cattle affected during the preceding year in the studied area from the questionnaire interview was different to that reported in the MTD meeting. Farmers attending the MTD meetings reported more cattle affected with FMD than was reported in either the direct questionnaires or the official LBVD reports. This could arise from underreporting in the official reports or an overestimation by the MTD meeting. However expert opinion (veterinarians who have worked in the area for many years) considered that the information from the MTD meeting was likely to be more accurate.

The number of cattle involved in the most recent outbreaks was compared from data obtained by questionnaire interviews and by the MTD meeting approach (Table 3.12). There was a large difference in the number from these two sources, with the number from questionnaires being far lower than that from the MTD meeting. The number of cattle affected was estimated from the MTD meeting by multiplying the proportion of livestock affected (Table 3.12) by the estimated cattle population.

With respect to animal movements, the MTD meeting produced more information than did the questionnaire interview. This most probably arose because the group recollection of past information was most likely better than an individual's recollection and the potentially sensitive nature of this question in a questionnaire interview. Both approaches provided evidence to indicate that long distance animal movements for cattle trading existed in the area and that most farmers moved their animals a short distance. This latter observation was a consistent response from questionnaire interviews, expert opinion and the MTD meeting.

Table 3.12 The number of cattle involved in the last outbreak of FMD

Townships	Number of cattle affected as determined from questionnaire data					Number of cattle affected as determined from the MTD meetings			
	1-10 cattle	11-30 cattle	large[1]	Total responses[2]	Number of respondents[3]	Affected population	Affected number	Estimated total population	Number of participants
Aungchanthar	1	0	0	4	5	Severe	~1300	1300	22
Ohbotaung	2	0	0	3	5	Low	~175	700	15
Myaynae	3	0	0	3	6	Low	~150	600	17
Alakapa	3	1	2	0	6	Moderate	>1500	3000	19
Paleltan	2	0	0	4	6	very low	<125	500	16
Knowndwin	1	0	0	4	5	Low	~300	1200	15
Natkhayaing	3	0	0	3	6	very low	<275	1100	25
Total	**15**	**1**	**2**	**21**	**39**				**129**

[1]Nearly all susceptible animals affected from the particular village
[2]Total number of respondents who provided data on the question about FMD outbreaks
[3]Total number of people who were asked this question

Table 3.13 Summary of the outcome of FMD disease information
(Questionnaire interviews, MTD meeting and serology)

Townships	Village tracts	Questionnaires	MTD meeting[#]	Serological results*
Chaung-U	Aungchanthar	80% (n=4) were not aware and did not know the number affected 20% (n=1) said less than 10 were affected	Very severe	43.8%
Monywa	Ohbotaung	60% (n=3) were not aware and did not know the number affected 40% (n=2) said less than 10 were affected	Low	4%
	Myaynae	50% (n=3) were not aware and did not know the number affected 50% (n=3) said less than 10 were affected	Low	
Myinmu	Alakapa	50% (n=3) said less than 10 16% (n=1) said around 10-30, 33% (n=2) said a large number were affected	Moderate	10%
	Palaetan	66% (n=4) were not aware and did not know the number affected 33% (n=2) said less than 10 were affected	Very low	
Sagaing	Knowdwin	80% (n=4) were not aware and did not know the number affected 20% (n=1) said less than 10 were affected	Low	6%
	Natkhayaing	50% (n=3) were not aware and did not know the number affected 50% (n=3) said less than 10 were affected	Very low	

[#]Very severe = nearly all animal in village tract
Severe = approximately 75% of animals in village tract affected
Moderate = approximately 50% of animals in village tract affected
Low = approximately 25% of animals in village tract affected
Very low = less than 25% of animals in village tract affected

*Serological results were not taken from the particular village tract, but from the respective township.

3.4 Discussion

3.4.1 Constraints in the studied areas

Myanmar has a large livestock population and the agricultural industry plays an important role in the economy. The industry relies significantly upon animal draught power from cattle and buffalo (Duh, 1993). Current control of FMD in Myanmar relies upon a locally produced monovalent vaccine, however enough doses of vaccine are produced each year to vaccinate only 10% of the at-risk population (Gleeson, 2002). Even though the Sagaing Division was selected as a control zone for FMD (MZWG 1, 2004b), the control activities have not been well funded and have utilised existing local staff for the project. As part of their routine work, local staff of the LBVD work to control outbreaks of FMD without extra financial or technical support. In outbreaks, local farmers can buy a limited number of doses of vaccine to prevent the spread of the disease to their own cattle (Pers. com. Dr Min Nyunt Oo). Consequently this results in extra work for the staff who are also responsible for the prevention and control of other diseases of livestock and animal health care (See Tables 2.1 and 2.2 of Chapter 2). Local farmers adopt fairly primitive farming methods and have little knowledge of biosecurity measures (Pers. com. Dr Khin Maung Latt). To date there have been no studies or surveys undertaken to identify suitable methods of disease control in the targeted area. Consequently it is necessary to conduct observational studies to support the MZWG for the control of FMD and to understand the epidemiology of FMD in the region.

Control of FMD in the region is a long term process (SEAFMD, 2007). It is crucial for the success of the programme, and to save time and money, to involve local people from village tracts in the project (Cornwall and Jewkes, 1995) and to involve them in meetings as they are important stakeholders who work with livestock every day. In the current study it was not possible to hold large village tract meetings for two main reasons. Firstly all farmers could not attend because of their daily work requirements and secondly such village tract meetings are very formal and it is necessary to obtain permission from the authorities to satisfy political requirements. All agendas are required to be set with time limits and every attendant would not get an opportunity to discuss their ideas with others. Furthermore, individuals are often reluctant to speak freely because of the formal nature of the meeting.

3.4.2 Introduction to discuss FMD

Foot and mouth disease has been a common disease of livestock in Myanmar for many years. It is relatively easy for a farmer to recognize this disease and the Myanmar words for the disease are "Kwar Nar Shar Nar" or "Shar Nar Kwar Nar". As "Kwar" means hoof, "Shar" means tongue and "Nar" means lesion, the literal translation refers to a disease causing hoof and tongue lesions. According to the official report to the OIE from the LBVD, FMD is the only disease showing lesions on the mouth, nares and foot in Myanmar (OIE, 2008a).

3.4.3 Concept of the MTD meeting approach

A participatory approach has been used for the diagnosis of animal diseases and surveys in developing countries for many years and includes literature searches, participatory mapping, matrix scoring (for differentiation of clinical signs of disease, causes and sources of infection by using a scoring response by participants), proportional piling (a technique to estimate the relative incidence of a disease of interest in different age groups of a targeted population within a specified period of time), seasonal calendar (for the occurrence of livestock disease, presence of biting flies, ticks or flies over time), and semi structured interviews (Catley and Irungu, 2000; Admassu and Ababa, 2006). The MTD meeting is a form of participatory approach. It is based on the traditional meeting style in Myanmar and was modified for epidemiological purposes. It also covers the basic principle of rapid appraisal methods (Mariner and Paskin, 2000). Rapid assessment techniques, including rapid rural appraisals (Chambers, 1981; Haywood, 1990), rapid epidemiological assessments (Bradt and Drummond, 2002) and rapid assessment procedures (Gittelsohn *et al.*, 1998), have been developed for research in health sciences. Similar techniques are used in a MTD meeting including using interviewing, mapping, and participation of respondents.

Observations of participants have been used by researchers in the health science field and by anthropologists for many years (Manderson and Aaby, 1992). In modern veterinary science, participatory epidemiology has been applied to obtain information on the incidence, distribution, risk factors and persistence of specific diseases with characteristic (pathognomonic) clinical signs. Some examples include investigation of FMD in the Erzurum Province (Admassu and Ababa, 2006) and persistence of Rinderpest virus in East Africa (Mariner and Roeder, 2003).

The MTD meeting approach was used to collect data about a disease with very distinct clinical lesions, and most farmers reported that they could recognize cases of FMD in their own cattle based on the presence of these clinical signs in a similar manner to other participatory disease surveys (Admassu and Ababa, 2006).

This traditional style meeting is still adopted in most rural areas of Myanmar and use of this technique with FMD has some significant advantages. Most farmers own only a small number of animals and consequently they have close associations with their animals and a good knowledge of the presence of lesions or clinical signs in individual animals. In addition, farmers in Myanmar are, by nature, collaborative and this form of meeting builds on that nature. By using a facilitator and a relatively informal meeting format the MTD meeting was found to be a valuable epidemiological tool for the collection of information on FMD as well as routine animal husbandry and livestock management. The MTD is a meeting with a targeted or specific group of people and is very similar to a discussion with an expert group in the village tract. Focus groups are used in the social sciences to determine the experiences of participants and to obtain several perspectives about specific topics (Gibbs, 1997). The MTD approach was valuable for collecting information on the routes of animal movement and the use of cattle throughout the calendar year. From these data, potential risk factors for the spread of FMD could be identified and taken into consideration for further analyses.

The participants in the MTD meeting were assumed to be knowledgeable and informed people within the village tract who could provide information about their village tract. In addition, using a group approach led to gathering collective information which was confirmed by group discussion.

3.4.4 The outcome of the MTD and triangulation

In this study, the outcomes of the MTD meeting approach were validated by three different sources of information (existing data, questionnaire interview results and expert opinion). The results of the questionnaires and expert opinion were collected through active surveys. The village tracts selected for inclusion in this study were the same as those used in the recent serological survey. Consequently the association between existing serological data on FMD and data collected from the MTD meetings could be examined.

In the serological survey, the serum of individual animals can provide specific information about the level of antibody or antigen in that animal, that is, quantitative data is collected. However in this study only the presence or absence of disease was calculated (Table 3.3); moreover, samples gathered in the serological study were not collected using appropriate (random) sampling techniques because of a lack of technical knowledge and facilities (Pers. com. Dr Khin Maung Latt). However the results of serology indicate that FMD is present in the area. In contrast in the MTD approach, disease information is obtained from participants of a particular village tract and is an indirect method for collecting information about disease. During the meeting, some villagers voluntarily joined the meeting because they wanted to improve/upgrade their knowledge on livestock disease, to discuss their livestock problems (e.g. an animal had died of respiratory distress and they wanted to know what was the possible cause and how to prevent it in the future) and to contribute their personal experience to the meeting.

3.4.5 Comparison of the results between MTD meetings and questionnaire surveys

Bias could have been introduced by the method of selecting farmers for the questionnaire survey and for the participants of the MTD meetings. Selection of respondents for the questionnaire interviews was based on their location in the village tracts to ensure there was a good geographical representation of farmers from the tract and some were selected by the village headman who considered they were representative of a location within the village. In both the questionnaire interview and the MTD meeting, information on FMD was obtained from the experience and knowledge of the farmers and was assumed to reflect the whole village or village tract. It is probable that in the questionnaire interview, the level of experience of the participants was less likely to represent the total body of village experience compared with the MTD meetings because of the smaller numbers involved. It is probable that data collected in an MTD meeting would be more reliable than data collected by personal interview because the MTD meeting approach relied upon input from a group of people, who had the opportunity to validate the data. The term "triangulation" has been applied in other participatory epidemiological investigations in developing nations to validate the data collected (Catley *et al.*, 2002b; Admassu and Ababa, 2006).

Usually random sampling is used to collect information about a specific population; however, this method is not appropriate for MTD meetings, where the group represents a select or expert group. If participants had been randomly selected from the village tracts, they may not have been suitable for collecting information about diseases of livestock or may not have known about husbandry issues as not all households owned livestock. If participants who owned livestock were coerced to participate in the MTD meeting by local authorities, the participants may have either been deliberately unavailable or been reluctant to provide sufficient information for the needs of the author's objectives. Consequently it was considered that using interested volunteers, without the use of any direct incentives, was the best method of acquiring information about husbandry and disease matters. Giving direct incentives could have introduced further bias (Giger, 1999) because some participants may have volunteered only because of the incentive and not to provide their knowledge or insight into the disease situation in their village. However, it was considered that discussion about livestock problems and exchange of knowledge between the researchers and participants during the MTD meeting was a sufficient incentive for the participants. At the introduction of the meeting the facilitator mentioned that the researchers had come to obtain information about the current livestock husbandry system and the presence of disease, as well as providing advice on methods to prevent the occurrence of disease in livestock in the village tract.

Some differences were detected in the data collected from the questionnaires administered to individuals and that collected from the MTD meetings. When questionnaires were administered, the respondents could outline their individual experiences through their answers of a limited number of preset questions. In contrast, participants were more actively involved in the MTD and discussed issues based on their own experiences which could also be verified by other participants in the meeting. When farmers had different perspectives or experiences these were discussed between the participants in the meeting. This allowed collection of more thorough information about the situation in the village, as well as allowing participants to discuss different points of view. For example with the number of cattle involved in an outbreak, participants had different observations and consequently the collective discussion resulted in a more accurate estimate of the total number of cattle infected with FMD. In the personal questionnaires, some individuals did not recall specific outbreaks of disease or specific events. In contrast in the MTD other individuals could recall these outbreaks or events. Also with individual questionnaires some respondents did not answer all questions. This could be because they could not remember certain facts or they were not sure of the answer.

Some results from the individual questionnaires and the MTD meeting were similar, for example in the feeding management of livestock (Tables 3.4 and 3.8). Both methods found that most farmers fed homemade feeds to livestock, a few used common grazing land and village tracts that were close to the river used river water as a source of water for both human and livestock uses. In contrast some results from the questionnaire survey were not consistent with that obtained from the MTD meetings, for example the results collected on disease information (Table 3.12). In the questionnaire interviews, not all interviewees provided information on the number of affected animals in the last outbreak (54% of respondents from Alakapa did not answer this question). Furthermore their estimation of the number of cattle affected with FMD in the last outbreak was lower than that obtained from the MTD meeting where nearly half of the cattle population were reported to be involved in the last outbreak (Table 3.12). This number was confirmed by a third source - the local veterinary staff. Consequently the MTD approach is likely to be more sensitive for disease information than personal questionnaire interviews.

Occurrences of FMD with respect to the season were also compared with the existing data from the LBVD, the MTD meetings and questionnaire interviews (Figure 3A.5, 3A.8; Tables 3.4 and 3.9). Most outbreaks occurred during the monsoon season (June, July and August), while a few outbreaks occurred in the transition period between seasons (from summer to monsoon season or from the monsoon season to winter). The answers collected from the respondents to the personal questionnaires were inconsistent with the existing data and with the data collected by the MTD approach because of the low response rate in the personal surveys (as mentioned above).

There are some advantages in undertaking questionnaires rather than the MTD meetings. For example, with the questions "Did you inform the village headman, or authorized persons from the Livestock Breeding and Veterinary Department on the outbreak in your cattle?" or "Did you notice animal movements around your village tract?" are better answered by individuals anonymously without the pressure of answering in a group or public situation.

Although the MTD and individual questionnaires provided similar information about the epidemiology of FMD in the research area, the MTD meeting approach was more likely to yield information on disease in the population than with individual questionnaires which represented a smaller subset of the total livestock-owning population in the village tract. The MTD meeting approach is easier, cheaper, quicker and results in the collection of more information than the use of questionnaire interviews.

3.4.6 Identification of risk factors from the MTD meeting approach

Based on the outcomes of the MTD meeting approach, potential risk factors for FMD were identified in the Sagaing Division. These included social customs and behaviours of local farmers, husbandry systems, herd size and knowledge about the disease and its impact.

3.4.6.1 Social culture and behaviour of local farmers

Farmers considered the transition period between two seasons (winter and summer, summer and raining seasons) as a risky period for the spread of FMD. During this time there were more animal and human movements which potentially could lead to the spread of the disease. Farmers reported that at these times middle men were involved in buying and selling cattle in the village tracts. These middle men might wander within and between the village tracts for trading purposes. During the 2001 FMD outbreak in the United Kingdom, mechanical spread of the infection by human contact was reported (Kitching and Hughes, 2002). It is highly likely that traders are involved in the spread of disease in the village tracts studied.

When outbreaks occurred, farmers gave many different treatments including using traditional medicine, and supportive treatment by local veterinarians (private), staff from the LBVD or non-veterinary people. Until the time of the most recent outbreak, human and animal movement control between infected and other susceptible areas was not well established (Pers. com. Dr Min Nyunt Oo). Furthermore, staff from LBVD had to look after a large number of livestock in their appointed areas and control of FMD outbreaks was only part of their routine daily duty. Therefore, it could be possible for these staff to transmit virus between infected and susceptible animals. Veterinarians and people who regularly deal with animals are a high risk group (Sanson, 1993) and can easily spread infection (Nielen *et al.*, 1996).

Farmers increasingly used communal grazing land and common watering points for their cattle, sheep and goats after crops were harvested. As a consequence, the number of potential contacts between livestock is increased; further enhancing the probability of contact with an FMD infected animal and the potential for virus dispersal.

3.4.6.2 Currently adopted husbandry system

Tethering and housing animals at home and feeding animals in shared troughs would be considered management systems that may facilitate virus spread within a village tract. Similarly the sharing (for both animal and human purposes) of watering points in a village tract would be another potential risk factor. Often these watering points were visited by the farmers with their bullocks and drays to enable water to be carried to their homes for personal use.

Rearing of cattle with sheep and goats could also be a potential risk factor for the spread of FMD in the studied area (Megersa *et al.*, 2009). Sheep and goats were raised together with cattle in all village tracts except for Paleltan, and there was close contact between cattle and sheep and goat within these tracts. However no participants in the MTD meetings reported having seen lesions of FMD in small ruminants. When sheep or goats did become ill they were sold to middle men. Kitching and Hughes (2002) reported that clinical diagnosis of FMD in sheep and goats was difficult and mentioned the important role of sheep and goats in the spread of FMD in Morocco, Tunisia and Greece in 1983, 1989 and 1994.

The majority of samples from sheep and goats submitted from Myanmar to the World Reference Laboratory for FMD, Pirbright, U.K were serotype O and Asia 1

(Kitching and Hughes, 2002). These serotypes are the most prevalent type in Myanmar (Duh, 1993; Kyin, 1999). In outbreaks of FMD, sheep and goats could be infected but not show clinical signs and subsequently transmit infection to other susceptible species (especially to cattle). In the serological results conducted before this study, the sero-prevalence in Chaung-U, which has nearly equal proportions of cattle and sheep and goats, was significantly higher than in Monywa, Myinmu and Sagaing which have a lower proportion of sheep and goats (Table 3.3). Although, small ruminants could play a role in the spread of infection within the region the actual involvement of small ruminants in outbreaks in the Sagaing Division is still not clearly understood. There were no laboratory records of sheep and goats tested for antibody to FMD prior to the MTD meeting approach. Subsequently sheep and goats were tested as part of the validation process for the MTD meeting approach (See Chapter 4).

3.4.6.3 Poor awareness of the disease and its impact

Farmers regularly share equipment, water troughs and buckets and purchase hay and straw from farmers who have surplus. They only have a rudimentary knowledge of FMD and when outbreaks occur they help each other without taking any biosecurity measures. They considered the disease was caused by changes in the weather rather than by an infectious agent. Uncontrolled human movements between the studied villages during the time of an FMD outbreak are potential means for virus distribution. Similarly staff from the LBVD, non-government veterinary practitioners and animal health workers could disperse the virus.

3.4.7 Advantages of the MTD meeting approach

The MTD meetings were friendly and cooperative and encouraged participation by all farmers. Information raised by one farmer could also be confirmed by other respondents. It is likely that the information collected from the MTD meetings was more representative for the population of that particular village tract than data collected from individual questionnaires. In contrast, the attitude of all participants would not be homogenous in a village (Tumwine, 1989) and participants have the potential to change the direction of discussion or to introduce different topics to that which the researcher expects. However having a facilitator ensured that the MTD meeting was productive and the outcomes relevant to the research being undertaken. It is important the facilitator is well trained.

Advantages of the MTD meeting include that it is a very cheap and time efficient method to gather relevant information. When the questionnaires were administered to individuals each questionnaire took at least 15 minutes allowing only about 3 questionnaires per hour and does not cover the entire village tract. In contrast the MTD approach took approximately one hour to collect information from the whole village tract. The MTD is a reliable and safe way to approach people in rural areas of Myanmar to collect information on diseases and this form of meeting is matched with the lifestyle of the local people. No special incentive is necessary to persuade people to be involved in these meetings as they are a common form of everyday life. It is an appropriate technique for local staff to apply repeatedly to get updated information in their field work. It can be applied as a basic step to establish a disease control programme and can be used as a tool to evaluate the success of a project. It could also increase the involvement of stakeholders in the project. Disease investigation and public awareness could also be undertaken at the same time. Participants are unlikely to feel nervous about talking freely of their experiences as may occur in personal one-on-one interviews.

3.4.8 Disadvantages of the MTD meeting approach

In the MTD meeting, nearly all respondents could recall the occurrence of outbreaks. This, in part, is likely to have arisen from prompting or clues from others involved in the meeting. This may lead to an overestimation of the occurrence of FMD and certainly was more likely to lead to more outbreaks being reported compared with information collected by questionnaire.

In this study, a purposive selection was used to choose the participants who were assumed to be knowledgeable on livestock and livestock diseases. Although this could introduce a selection bias (Fox *et al.*, 2005; Geneletti *et al.*, 2009), alternatives such as random sampling would not be appropriate because the concept of the MTD approach is based on the use of existing veterinary knowledge of farmers (Mariner and Paskin, 2000).

A potential disadvantage of the MTD approach could be that influential persons might "lead" the discussions and other participants might follow the other respondents' ideas. Consequently it is important to have a facilitator who is familiar with the local dialect, is knowledgeable about the region and can ensure that the discussion is not commandeered by one individual and that all participants have an equal chance to provide their findings. Thus the facilitator should be organized to ensure that the most appropriate information could be collected from the MTD meeting. (Gibbs, 1997).

One limitation of the MTD approach is that it needs a good facilitator to handle the meeting to ensure the objectives are reached. That person must be respected by and be familiar to the farmers, preferably have worked with the farmers and must be able to direct and control the meeting as required. It is also necessary to understand the social and cultural background of the participants and be able to speak the local dialect. Diseases with pathognomonic clinical signs are relevant for discussion in MTD meetings and include FMD, Haemorrhagic Septicaemia, Anthrax and Black Leg. There is the potential for disagreement to occur during a meeting. In most rural areas of Myanmar, being respectful of older people and people who are working in the village administration is an important aspect of the culture. These people could potentially lead the talk and influence the topic of discussion by their personal experiences. Consequently the role of the facilitator is crucial in such conditions to ensure that all people are given the chance to participate in the discussion.

3.4.9 Conclusion

In conclusion, the MTD meeting approach allowed collection of epidemiological information from experienced farmers. This appears an appropriate method for the investigation of FMD in Myanmar, particularly given the limited resources and diagnostic tests available. To continue to use the MTD meeting approach in Myanmar, it is necessary to know the reliability and accuracy of this approach. The next chapter outlines the validation of the MTD meeting approach and compares data from this method with that obtained by questionnaire interview, expert opinion and serological surveys.

Validation of the Modified Traditional Dutaik meeting for disease surveillance to support the progressive zoning approach for control of FMD in Myanmar

4.1 Introduction

The traditional Dutaik meeting approach has been developed for disease surveillance in the proposed control zone of the Sagaing Division. A pilot study was conducted in four townships of the Sagaing Division (See Chapter 3) and a triangulation process was also undertaken by using existing data and questionnaire results to validate the outcome of the MTD meeting approach. For further validation of this approach, observational and serological surveys were conducted in the Sagaing Township of the Sagaing Division.

This study was conducted to analyse the "sensitivity" and "specificity" of the MTD meeting approach as an epidemiological tool to understand FMD in Myanmar. The study was applied in the Sagaing Township of the Sagaing Division where FMD is considered to be endemic (MZWG 1, 2004b) and in the Myeik Township of the Tanintharyi Division, which is now considered as an FMD-free area (MTM 8, 2007).

The Sagaing Township was selected as it was anticipated to have the highest prevalence of FMD in the Sagaing Division. This is because it contains the only cattle market in the division and the vast majority of livestock movements in the division lead to this market. In an epidemiological study conducted in Ecuador an increased risk of FMD was associated with proximity to a cattle market (OR of 4.8 and 14.4 for 21 and 12 km respectively from markets compared with 47 km) (Lindholm *et al.*, 2007). Subsequent to the Sagaing Township, animals move to the Mandalay Division through the Ayeyarwady River near the Sagaing Township.

The Myeik Township, was selected as it was considered as a potential free zone (control zone status at the time of study), and would be a useful area to compare with the Sagaing Township to validate the MTD meeting approach.

The purpose of this study is to validate the use of the MTD meeting approach and to compare the findings with those from serological surveys and questionnaire interviews in the endemic area of the Sagaing Division and in the potentially free area of the Tanintharyi Division.

4.2 Materials and methods

In this study, basically, three main methodologies were used: the MTD meeting approach, a preset questionnaire interview and a serological survey. At the end of the study, all outcomes from the different approaches were compared to determine the value of the MTD meeting approach for the detection of FMD. In the Sagaing Township study all three methodologies were used (See Figure 4.1). However in the Myeik Township study, only the MTD meeting approach and serological testing were used (see Figure 4.2). Questionnaire interviews were not conducted in the Myeik Township due to language difficulties (lack of a permanent local interpreter) and security issues.

4.2.1 Preliminary preparation

A research team was organized to conduct this study in the Sagaing Division of Myanmar after receiving permission from the Director General of the LBVD. At first, an informal meeting was conducted with the staff including the District Officer of the Sagaing District, other veterinary staff from the LBVD, private veterinary practitioners, and butchers from the Sagaing Township in the Sagaing District Office. The meeting was arranged to collect information about the existing animal movements and the presence or absence of sheep and goats in each village. By using information on the existing animal movements and currently adopted administration units (village tract, ward and village), the villages were divided into two groups. One group included villages that were located along the animal movement route (used for trading) and the second group included villages located far from this route. The terms of 'village' and 'ward' are used as the lowest unit in the current government administration in Myanmar.

4.2.2 Preparation of sampling frame and sample selection

A cross sectional study design with multistage sampling was used in this research (Ertug *et al.*, 2005; Stafford *et al.*, 2006). For the serological survey, the expected village level prevalence was estimated from existing information from the National FMD Laboratory of the LBVD. In a preliminary epidemiological survey report (Kyin, 2005b) for the Sagaing Zoning approach an overall sero-prevalence for FMD of 37, 20, 40% were reported for virus Types O, A and Asia1 respectively.

In this study, villages, individual owners and individual animals were designated as primary, secondary and tertiary sampling units respectively. Expected prevalence for the village level was estimated to be 15% and for individual animals 20%. This is a conservative estimate and takes into account the fact that the survey in 2005 did not use random sampling. To achieve 95% confidence levels for the expected prevalence in both sampling units, at least 15 villages from the whole of the Sagaing Township and 14 individual animals were necessary to be sampled from each selected village assuming perfect sensitivity and specificity (Cannon and Roe, 1982).

In total there were 223 units of interest (all wards and villages) in the Sagaing Township. Of these, 17 wards located near the centre of the Sagaing Town had no livestock and were excluded from the sampling frame. The remaining 206 villages were divided into two groups based on location relative to animal movement routes. Eighty-five villages were located along the animal movement route and 121 villages were located far from this route. A random number was generated in Excel for each village. A coin was then tossed to determine if the random numbers for each group should be sorted in ascending or in descending order. The villages were then sorted and the required number of villages selected. In each group, villages were stratified depending on whether they had cattle only or had cattle, sheep and goats. Fifteen of the initially selected villages from the group located along the animal movement route and 5 from the group far from the route were replaced by the next villages in the sorted lists. Reasons for this were because of difficulty accessing these villages (no vehicular access – only pedestrian paths) and/or these villages had cattle, sheep and goats and the required number of villages which had both cattle and sheep and goats had already been selected. The purpose was to compare the FMD status between villages which had cattle only with those which had cattle as well as sheep and goats. In each selected village, sera were collected from cattle. Farmers whose cattle were blood sampled were also interviewed and one MTD meeting was conducted in each of the selected villages.

The selection of villages in the Myeik Township was based on the previous survey (seven villages had sero-positive results). Of these villages, six were selected for re-sampling. One was omitted because of transportation difficulties and concerns about safety/security.

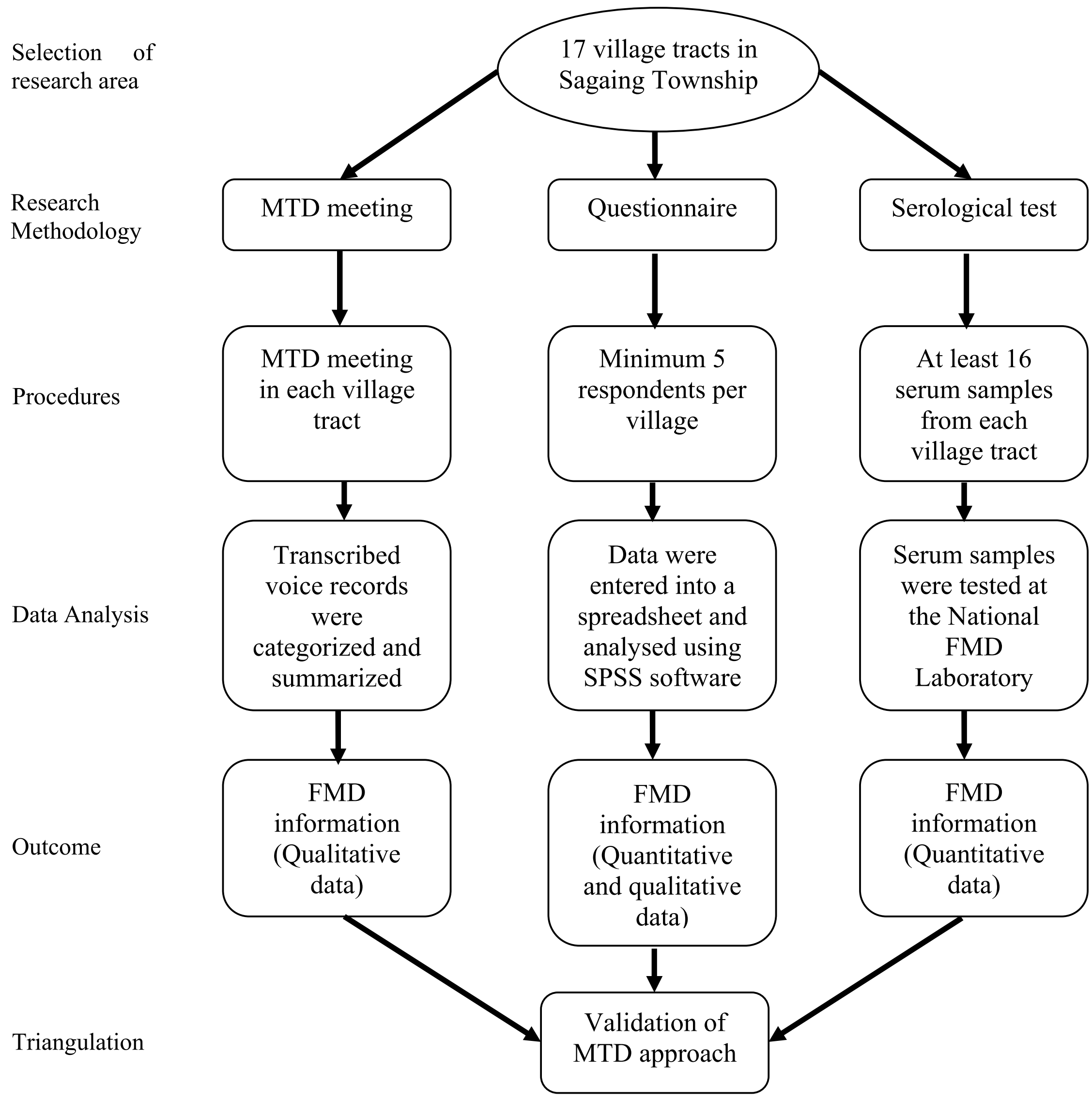


Figure 4.1 Study design for the Sagaing Township

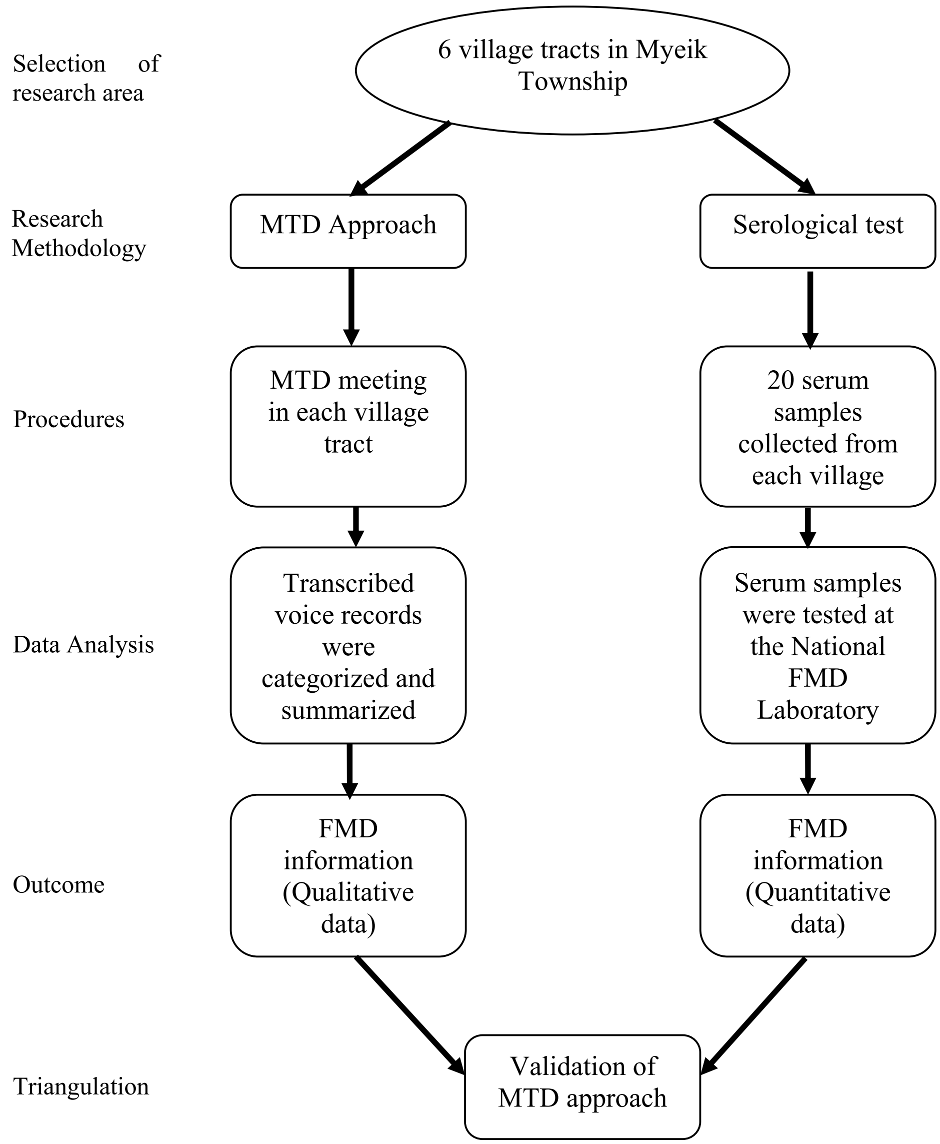


Figure 4.2 Study design for Myanmar MTM area

4.2.3 Selection of villages

A total of 17 villages were selected in the endemic area of the Sagaing Township. The eight villages selected along the animal movement route were Byaetayaw, Knowndwin, Koneywa, Natkhayaing, Sintat, Taeintel, Paukma and Ywama, and the nine far from the route were Kaingpyin, Kyakhat, Ma-U-Pin, Myinsel, Ngatayaw, Padu, U-Eain-kyun, Yetwinkhaung and Ywathitgyi (See Figure 4.3).

A total of 6 villages (Myeik Taung, Kahan, Shar Taw Wa (Kalwin village tract), Kywe Ku Yatanar (Sandawut village tract), Taung Shae and Pathaung) were selected in the potential free area of FMD in the Myeik Township which previously had positive results in the 2005 sero-surveillance programme (See Figure 5.3 of Chapter 5). All these villages were purposively selected because it (Myeik Township) was assumed to be a free area.

4.2.3.1 Villages located along the animal movement route

The eight selected villages located along the animal movement route were subdivided into two groups based on only having cattle or having cattle along with sheep and goats. The villages which had cattle only were Byaetayaw, Sintat and Ywama.

4.2.3.2 Villages located far from the animal movement route

The nine selected villages far from the animal movement route were also subdivided into two groups on the presence or absence of sheep and goats. The four villages which only raised cattle were Kaingpyin, Ma-U-Pin, Myinsel and U-Eain-kyun.

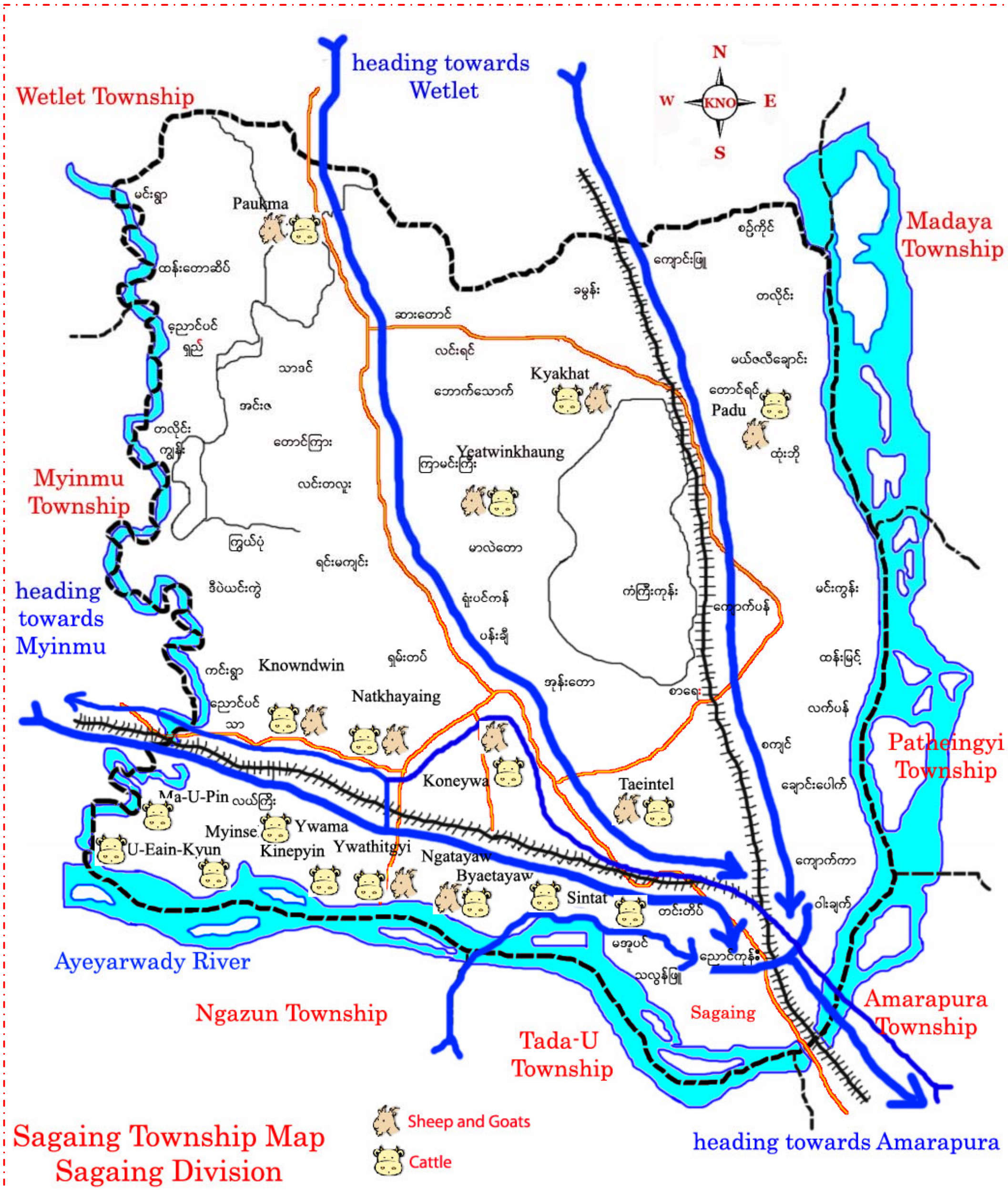


Figure 4.3 Location of the villages included in this survey

4.2.4 The MTD meeting procedures

The MTD meeting procedures and selection of participants were as outlined in Chapter 3. It included five steps: collection of existing data, preparation of the meeting site, holding of the Dutaik meeting, data recording and data analysis. The discussion in the Dutaik meetings was also recorded by voice recorder and all recordings were transcribed into Myanmar language. These were translated into English and were categorized in Microsoft Word in a table by different topics.

In seven villages (Byaetayaw, Kinepyin, Koneywa, Myinsell, Knowndwin, Paukma, U-Eain-kyun) the MTD meetings were held prior to the collection of serum samples while in 10 villages (Kyakhat, Ma-U-Pin, Natkhayaing, Ngatayaw, Padu, Sintat, Taeintel, Yeatwinkhaung, Ywama, Ywathitgyi) the MTD meetings were held after the serum collection. When the research team arrived at a village late in the afternoon, sera was collected before dark and then the MTD meeting held late in that day.

In the MTD meeting procedure for Sagaing, a new topic about the economic impact of FMD for the farmers was added. Participants shared their personal experiences on the cost of traditional and veterinary treatments for the disease. The cost of hiring draught cattle when cattle were infected with FMD and other consequences of the disease, such as hoof problems or intolerance to heat, were also discussed.

4.2.5 Serological surveys

Selection of individual animals for collection of blood samples was conducted from a list of households generated in each village. A list of all households within a village was provided by the village level authorities. In Myanmar, villages are sub-divided into groups of approximately 10 households (range 8 to 12). In each "ten-household-group" one volunteer is appointed as the head of the group (called "Sel-Ein-Gaung" which literally translates as "leader of ten-households"). Any Government staff who deal with villages, usually asks for a list of the "heads of ten-household-group", and this can be used to estimate the number of households in that village. In this study, staff from the LBVD were given a list of the ten-household groups and this was used as the sampling frame. From this list 18 household heads were randomly selected in each pre-selected village. In the studied villages the average number of household groups was 36 representing approximately 360 households (range 100 to 975 per village). From each selected group of ten households, one owner was randomly selected by using a random number generator in Excel. It was not possible to select individual animals at random because most cattle were away on common grazing land and only draught cattle were with the selected owners at the time of visit.

Cattle owners from 10 villages (Koneywa, Myinsell, Paukma, Kyakhat, Ma-U-Pin, Natkhayaing, Ngatayaw, Padu, Yeatwinkhaung, Ywathitgyi) were selected conveniently because either there was no ten-household-head list, the clerk responsible for the village level administration could not be contacted, or it was not possible to select a random sample of farmers as they were already in their working places and would not return to the village until very late. In addition, some farmers that were selected were very busy in their field. A random sampling technique was applied to select owners in 7 villages (Byaetayaw, Kinepyin, Knowndwin, U-Eain-kyun, Sintat, Taeintel, Ywama). Again in these villages only tethered draught cattle were sampled as non-draught cattle were grazing with other cattle from the village. Consequently, the majority of the cattle selected for sampling were draught cattle, although some dairy cattle were also sampled. For the selection of sheep and goats, the oldest five animals were sampled in the selected herd. This was based on the assumption that the oldest animals had the greatest likelihood of exposure to infection (Cottral, 1969; Megersa *et al.*, 2009).

Serological tests were performed in the National FMD Laboratory in Yangon, Myanmar. All serum samples were collected in 10 ml disposable plastic syringes and then allowed to clot. Samples were transferred from the syringes to plastic tubes and kept chilled at the base camp in the Sagaing Township and also during transport to the laboratory. All samples were centrifuged at the laboratory and sera transferred into plastic tubes. These samples were tested with a Cedi® FMDV NS ELISA test kits using the protocol recommended by the manufacturer. All results were entered into a Microsoft EXCEL spreadsheet and analysed using SPSS 17.0 for Windows.

4.2.6 Questionnaire survey

A six page questionnaire was prepared in English (Appendix 2) and included questions about the respondent, the animals sampled, ownership of livestock, the husbandry system adopted, economic costs and returns, awareness of FMD (using pictures of lesions of FMD), previous outbreaks of FMD and animal movements. The Murdoch University Human Ethics Committee approved the use of this questionnaire. The questionnaire was translated into Myanmar language by three veterinarians working in the National FMD Laboratory. A final translated version was prepared by a group meeting with local veterinarians in Myanmar reviewing the translation and evaluating the questionnaire. The questionnaires were administered by research team members to farmers whose cattle were bled. The questionnaire data were entered into a spreadsheet of Microsoft Excel 2007 and subsequently transferred into SPSS 17.0 for Windows for statistical analysis.

A questionnaire was administered to all cattle and sheep and goats owners (n=288) with some (n=136) receiving a longer version and some (n=152) a shorter version (First two pages of the long questionnaire – Appendix 2). In some villages (Byaetayaw, Koneywa, Ma-U-Pin, Knowndwin, Padu, Yeatwinkhaung, Ywama and Ywathitgyi) less than 10 questionnaires were administered in each village because of a lack of time or because the farmers were too busy. In the village of Ngatayaw, no questionnaires could be conducted as the research team arrived very late in the day and there was no electricity or accommodation in the village. In this village only the MTD meeting and serum collection were conducted.

Further limitations arose during this study, as some selected villages had not been informed of the visit and as a consequence, the farmers were not ready for the research. However an advantage of not informing the village of the proposed visit was that respondents in the villages were not influenced by the authorities in either the questionnaire interviews or in the MTD meetings. Furthermore in all selected villages, except for Ywathitgyi, no electricity or ice was available to chill blood samples. Therefore, the research team could not stop over in all studied villages and had to go back to the base camp in Ywathitgyi village. This resulted in reducing the number of questionnaire interviews as outlined previously as the MTD meeting and serological study were considered to be higher priorities.

4.2.7 Expert opinions

Expert opinions were collected in some villages after the MTD meetings. These "experts" included the village head man, local veterinary staff and the clerk from the Village Peace and Development Council. After the meeting, information provided by villagers that was suspected to be incorrect was confirmed by local veterinary staff and village authorities. For example, some farmers reported that their cattle had been vaccinated against FMD when they had in fact been vaccinated against another disease.

4.2.8 Data analysis

Before analysis, the MTD meetings discussions were transcribed into Myanmar language and recorded in Microsoft Word 2007. The MTD meeting records were then categorized and entered in different tables in English. The results of the questionnaire interviews and the serological results were entered into one spreadsheet of Microsoft EXCEL 2007 and were linked together by a unique farmer code. The results from the MTD meeting approach and combined results from serological results and interviews were matched by the same topic. Triangulation to validate the MTD meeting approach was conducted by using the questionnaire interviews, current serological test results, and personal interviews with the veterinarian in-charge of the relevant area. Statistical analysis (association tests, two samples T test etc.) was conducted by using Statistix version 9 (Analytical software, Tallahassee).

4.3 Results

4.3.1 The MTD meeting

A total of 17 MTD meetings (one in each village) were conducted in Sagaing Township of the Sagaing Division. The number of households in a village varied from 100 to 975. In each village, an average of 15 farmers/livestock owners attended an MTD meeting (range 8 to 22) (Table 4.1). The participants estimated the total number of livestock present in their village from calculations involving the total number of households in the village, the number of households with no livestock, and the minimum, maximum and average number of livestock owned (Table 4.1). The majority of farmers owned a pair of working draught cattle and one to two other cattle. Eventhough a total of 9 MTD meetings were conducted in Tanintaryi Division, the results of those were omitted because no one reported information on FMD.

The participants advised that the main business in the studied villages was agricultural production using animal draught power. The time when the land was cultivated was similar in all villages and commenced around the middle of May and finished at the end of January or in early February. During this time, they grew two types of crops: a monsoon crop and a winter crop. No farmers fed commercial feed to their cattle and most prepared homemade feed for their livestock. Farmers advised that they usually bought and sold cattle before and after the cultivation season for a variety of reasons including to get better and stronger draught cattle, existing animals were not fit to be used in the following year or that they needed money for their personal use.

The participants reported that common livestock diseases seen, other than FMD, included Anthrax, Black leg and Haemorrhagic Septicaemia. Among these diseases, they could easily identify FMD because of its distinct clinical signs. As outlined in Chapter 3, the majority of participants gave traditional treatments to animals infected with FMD. Some respondents did not pay much attention to FMD as it had been a common disease for many years.

The participants who joined the MTD meeting in all villages reported that they were aware of the local name for FMD ("Kwar Nar Shar Nar") and had previously seen lesions of FMD in their locality. Most of them described the lesions and symptoms of the disease including mouth lesions, cud chewing and drooling and lameness. These lesions were confirmed when pictures of similar lesions from an outbreak in 2006 in the Sagaing Division were shown to the farmers. The majority of the participants had previously seen lesions similar to those displayed. They reported that the disease did not seem to spread to other cattle kept on the same premise.

The estimated number of cattle involved in the last outbreak of FMD is outlined in Table 4.2. No lesions in pigs were reported in the studied areas. The participants also mentioned that the disease mostly occurred in winter (between September and December) and in the dry season (between March and May). Some villages had the disease every year with between 40 to 50 cattle affected while in others the disease occurred every three or four year, when it affected a large number of cattle. Although all adult cattle recovered after outbreaks not all could be used for agricultural purposes after the outbreak. Farmers reported that if the disease course was prolonged (more than 15 days), then the animal was more likely to get complications including a lack of stamina, excessive hair growth, over-growth of the hoof, heat intolerance and weakness.

The majority of farmers reported that they did not clearly understand the transmission of FMD among their herd and within the village because in-contact animals often did not show/develop clinical signs. Most participants said they were not willing to vaccinate their cattle annually because the disease did not occur each year and was not lethal. Some farmers commented that the disease occurred because of extreme (hot) weather or when there were weather changes.

Farmers were aware of the movement of animals, especially for trading purposes, and they could identify the movement of cattle because these movements involved a large number of draught cattle. Even though some villages did not have public transportation, local people used bullock carts for their own transportation. Consequently even in remote villages, farmers were able to visit neighbouring/surrounding villages for business and social reasons.

At the end of the MTD meetings, farmers gave individual comments on the disease which included "even though the disease is not lethal, it can influence agricultural enterprises and was troublesome to farmers"; "it is a kind of wasting disease as we need to hire healthy cattle for work purposes and to look after the sick animals"; "if the disease infects a cow with a calf, all calves would definitely die"; "if disease infects a milking dairy cow, the cow cannot produce milk and the owner must be prepared to sell their animal at a lower price"; "if disease spreads to a large number of cattle in a village, it must be FMD".

Table 4.1 Estimated summary of general information obtained from the studied villages

Village name	Number of participants attending	Total number of households in the village	Animal population		
			Cattle	Goats	Sheep
Villages located along the animal movement route (cattle only)					
Byaetayaw	21	495	500	0	0
Sintat	15	-	987	0	0
Ywama	11	477	1760	0	0
Villages located along the animal movement route (mixed species)					
Knowndwin	12	200	2000	150	150
Koneywa	8	520	2000	150	400
Natkhayaing	18	300	1500	250	250
Paukma	8	165	300	NA	NA
Taeintel	15	300	800	NA	NA
Villages located far from the animal movement route (cattle only)					
Kinepyin	20	-	450	0	0
Ma-U-Pin	15	150	500	0	0
Myinsel	17	364	2000	0	0
U-Eain-kyun	22	100	280	0	0
Villages located far from the animal movement route (mixed species)					
Kyakhat	22	121	750	120	NA
Ngatayaw	13	446	3000	0	160
Padu	16	975	5000	1000	0
Yeatwinkhaung	16	700	2500	140	400
Ywathitgyi	13	160	500	NA	NA
Total	**262**	**5473**	**24827**	**1965**	**1510**

NA – Data not available

Table 4.2 Estimated summary of information on FMD from each village

Village name	Year of last FMD outbreak	Month of last outbreak	Number of animals affected in the most recent outbreak	Number of outbreaks per year
Villages located along the animal movement route (cattle only)				
Byaetayaw	2004	Nov, Dec	500	3
Sintat	2004	-*	100	-*
Ywama	2007	July	-*	2
Villages located along the animal movement route (mixed species)				
Knowndwin	2003	Feb, Mar	-*	4
Koneywa	2007	Sept	-*	2
Natkhayaing	2006	Dec	900	-*
Paukma	2005	Nov,Dec	25	2
Taeintel	2003	-*	-*	-*
Villages located far from the animal movement route (cattle only)				
Kinepyin	2006	July, Aug, Dec	-*	1
Ma-U-Pin	2005	-*	500	2
Myinsel	2006	Feb,Mar	500	2
U-Eain-kyun	2005	Nov, Dec, Mar	90	2
Villages located far from the animal movement route (mixed species)				
Kyakhat	2006	Nov, Dec	500	1
Ngatayaw	2006	-*	-*	2
Padu	2003	-*	1000	-*
Yeatwinkhaung	2003	-*	-*	-*
Ywathitgyi	2004	-*	-*	-*

** Data not available.*

4.3.2 Serological results

A total of 422 samples were collected: 304 from cattle,33 from sheep and 85 from goats. These animals were owned by 288 livestock owners (Table 4.3). The overall animal level sero-prevalence (test/apparent prevalence) of the Sagaing Township (all species) was 42% (179/422, 95% CI 37.7 - 47.3). The lowest animal level sero-prevalence in a village was 22.2% (4/18, 95% CI 6.4 - 47.6) and the highest 68.1% (32/47, 95% CI 52.9 - 80.9) (Tables 4.5 and 4.6). The village level sero-prevalence was 100% i.e. all villages had at least one sero-positive animal.

In the potential FMD free area in the Myeik Township, the overall apparent animal level sero-prevalence was 11.7% (14/120, 95% CI 6.5 - 18.8) (Table 4.4). The within village sero-prevalence varied from 0 to 25% (Table 4.7).

The PI (percent inhibition) for the ELISA of cattle samples from villages which only had cattle (Byaetayaw, Sintat, Ywama, Kaingpyin, Ma-U-Pin, Myinsel and U-Eain-kyun) was similar to that of cattle from villages which had cattle and sheep and goats (Knowndwin, Koneywa, Natkhayaing, Taeintel, Paukma, Kyakhat, Ngatayaw, Padu, Yetwinkhaung and Ywathitgyi) (df = 120, t = 1.9, p = 0.06). Similarly the prevalence (apparent) of cattle from villages with cattle (40%) was similar to that in villages with cattle and sheep and goats (40.2%) (χ^2 = 0.0, df 1, 1, p = 0.96).

The mean PI values for cattle from villages located close to the animal movement routes (14.3) (Byaetayaw, Sintat, Ywama, Knowndwin, Koneywa, Natkhayaing, Taeintel, Paukma) was similar to that of villages far from the animal movement routes (Kaingpyin, Ma-U-Pin, Myinsel, U-Eain-kyun, Kyakhat, Ngatayaw, Padu, Yetwinkhaung, Ywathitgyi) (17.4) (df = 180, t = -1.14, p = 0.25). Similarly, the apparent prevalence in villages close to the animal movement route (35%) was not significantly different from that of villages far from the route (45%) (χ^2 = 2.84, p = 0.09).

The overall apparent prevalence of Myeik (11.6%) was significantly less than that from the Sagaing Township (40.1%) ($\chi^2 = 38.53$, $p < 0.001$). Similarly the mean PI value for Sagaing was significantly higher than that of Myeik (df = 134, t = -3.45, $p < 0.001$).

During the study, 179 of the 422 samples were positive in the Sagaing Township. These originated from 139 households/herds of the 288 sampled (48%, 95% CI: 42.3 - 54.2%). Of the 118 sheep and goat samples collected from the Sagaing Township, 57 were positive (animal level prevalence of 48%, 39 - 57%). Of the 22 herds of sheep and goats tested, 21 had at least one positive animal (flock prevalence of 95%: 77.2, 99.8%). All samples from goats (n=12) collected from the Myeik Township were negative.

For cattle from the Sagaing Township, 118 positive animals originated from 118 households (44%) of the 270 sampled. In this township the herd level prevalence for cattle (44%) was significantly lower than for sheep and goat flocks (95%) (Fishers exact test $p < 0.001$; OR 22.5: 2.9 - 169.5).

Table 4.3 Summary of serum collection and location of villages from the Sagaing Township

Villages	Number of positives /Number of samples collected (Positive %)			
	Cattle	**Goats**	**Sheep**	**Total**
Villages located along the animal movement route (cattle only)				
Byaetayaw	4/18 (22)			4/18 (22)
Sintat	10/18 (55)			10/18 (55)
Ywama	7/19 (36)			7/19 (36)
Villages located along the animal movement route (mixed species)				
Knowndwin	5/18 (27)	8/9 (88)	5/10 (50)	18/37 (48)
Koneywa	6/18 (33)			6/18 (33)
Natkhayaing	9/19 (47)	7/12 (58)	0/2 (0)	16/33 (48)
Paukma	7/17 (41)	4/15 (26)		11/32 (34)
Taeintel	3/18 (16)	7/14 (50)		10/32 (31)
Villages located far from the animal movement route (cattle only)				
Kinepyin	6/18 (33)			6/18 (33)
Ma-U-Pin	7/16 (43)			7/16 (43)
Myinsel	10/18 (55)			10/18 (55)
U-Eain-kyun	6/18 (33)			6/18 (33)
Villages located far from the animal movement route (mixed species)				
Kyakhat	21/27(77)	6/7 (85)	5/13 (38)	32/47 (68)
Ngatayaw	9/20 (45)			9/20 (45)
Padu	7/19 (36)	5/10 (50)	3/8 (37)	15/37 (40)
Yeatwinkhaung	1/5 (20)	7/18 (38)		8/23 (34)
Ywathitgyi	4/18 (22)			4/18 (22)
Total	**122/304 (40)**	**44/85 (51)**	**13/33 (39)**	**179/422 (42)**

Table 4.4 Summary of results from the Sagaing and Myeik townships

Sagaing Township		Myeik township	
Total samples collected	Number of positive samples (AP%, 95% CI)*	Total samples collected	Number of positive samples (AP%, 95% CI)*
422	179 (42, 37.7 - 47.3)	120	14 (11.7, 6.5 - 18.8)

**prevalence was significantly different (χ^2 38.53, P <0.001)*
AP = apparent (test) prevalence

Table 4.5 The results of the ELISA for samples collected from villages in the Sagaing Township located along the animal movement route

Villages which only had cattle	Number positive/Total number sampled (AP%,95% CI)	Villages which had both cattle and sheep and goats	Number positive/Total number sampled (AP%,95% CI)
Byaetayaw	4/18 (22.2, 6.4 - 47.6)	Knowndwin	18/37 (48.6, 31.9 - 65.6)
Sintat	10/18 (55.6, 30.8 - 78.5)	Koneywa	6/18 (33.3, 13.3 - 59.0)
Ywama	7/19 (36.8, 16.3 - 61.6)	Natkhayaing	16/33 (48.5, 30.8 - 66.5)
		Taeintel	10/32 (31.3, 16.12 - 50.01)
		Paukma	11/32 (34.4, 18.6 - 53.2)

AP = apparent (test) prevalence

Table 4.6 The ELISA results of animals from villages in the Sagaing Township located far from the animal movement route

Villages which only had cattle	Number positive/Total number sampled (AP%,95% CI)	Villages which had both cattle and sheep and goats	Number positive/Total number sampled (AP%,95% CI)
Kaingpyin	6/18 (33.3, 13.3 - 59.0)	Kyakhat	32/47 (68.1, 52.9 - 80.9)
Ma-U-Pin	7/16 (43.8, 19.8 - 70.1)	Ngatayaw	9/20 (45, 23.1 - 68.5)
Myinsel	10/18 (55.6, 30.8 - 78.5)	Padu	15/37 (40.5, 24.8 - 57.9)
U-Eain-kyun	6/18 (33.3, 13.3 - 59.0)	Yetwinkhaung	8/23 (34.8, 16.4 - 57.3)
		Ywathitgyi	4/18 (22.2, 6.4 - 47.6)

Table 4.7 Summary of the ELISA results for Myeik Township

Villages visited in the potentially free area of FMD	Number positive/Total number sampled (AP%,95% CI)
Myeik Taung	0/20 (0, 0.0 16.8)
Kalwin	2/20 (10, 1.2 - 31.7)
Kahan	4/20 (20, 5.7 - 43.7)
Sadawut	5/20 (25, 8.7 - 49.1)
Taung Shae	2/20 (10, 1.2 - 31.7)
Pathaung	1/20 (5, 0.1 - 24.9)

4.3.4 Interview results

A total of 288 livestock owners were administered questionnaires. Of these, the full questionnaire was administered to 136, and 130 of these provided general information about FMD in their locality (Table 4.8). Approximately two thirds (69%) of respondents were aware of the disease in their locality during the preceding three years. Only some (n=49) respondents could estimate the total number of affected cattle in their village during the last outbreak of FMD with the number of cattle involved varying from one to 500. One hundred and seven of the 288 respondents were shown pictures of lesions of FMD taken during a recent outbreak of FMD in the Sagaing Division. The pictures included salivation and hoof, tongue, and mouth lesions which were recognised by 43, 41, 39, and 31% of farmers respectively. Very few respondents (9%) had seen lesions in the mammary gland or hoof lesions in pigs.

Owners could remember the FMD history of 209 of the 304 cattle bled. Only 18.2% (n=38) of these had previously displayed clinical signs and 76.6% (n=160) had not displayed signs as far as the owners were aware of. Of these 209, only a few owners (n=37) had seen lesions in their cattle, including in the hoof (n= 33), tongue (n=33) and udder (n=3). Of 202 cattle that had information on their origin 41% (n=82) were purchased while the remainder were bred on the farmers own farm. Cattle currently owned were purchased as early as 2001 or as late as 2007. Only 15% of farmers recalled purchasing cattle between 2001 and 2003 with the remaining purchasing cattle between 2004 and 2007. There was no significant difference in the sero-prevalence in purchased cattle (86.4%, 72.7 - 94.8%) and animals raised on their own farm (57.89%: 46.0 - 69.14%) ($\chi^2 = 1.89$, $p = 0.16$). Only half (n = 68) of the farmers administered the full questionnaire (Table 4.8) answered the question on animal movements for trading purposes.

Table 4.8 General information of questionnaire interviews in the Sagaing Township

Name of village	Completed the full questionnaire	Completed the short questionnaire	Total number of respondents	Total number of sera collected
Byaetayaw	4	14	18	18
Kinepyin	15	1	16	18
Koneywa	6	12	18	18
Kyakhat	15	14	29	47
Ma-U-Pin	4	12	16	16
Myinsel	11	6	17	18
Natkhayaing	5	8	13	33
Ngatayaw	0	18	18	20
Knowndwin	7	13	20	37
Padu	4	13	17	37
Paukma	11	3	14	32
Sintat	13	5	18	18
Taeintel	13	5	18	32
U-Eain-kyun	11	6	17	18
Yeatwinkhaung	4	2	6	23
Ywama	7	9	16	19
Ywathitgyi	6	11	17	18
Total	**136**	**152**	**288**	**422**

4.3.5 Results from expert opinion

The expert opinions were taken from private veterinarians and staff from the LBVD who were practicing in the research areas of the Sagaing Township. These experts reported that FMD occurred sporadically in the Sagaing Township. The latest serious outbreak was reported to have occurred in 2006 when the disease spread through the Sagaing Division. The severity of the outbreak of FMD was very unpredictable and sometimes only involved a small number of animals. At other times it affected nearly all susceptible animals which had a big impact on the farming enterprise of the farmers. The experts believed that some subclinical cases were not recognised by the farmers.

In Myeik Township the Township Veterinary Officer, who had been working in the Township for many years, reported that the last case of FMD occurred in 1999. Prior to 1999, only a few cases of FMD were reported in the Township. Traders that were interviewed reported that FMD has not been present for many years in Myeik Township although some remembered the clinical signs of the disease from when they were young.

4.4 Discussion

This study was conducted to verify the ability of a participatory approach (conducting MTD meetings), to determine the situation of FMD at the township and village level. In general the outcomes from the Dutaik meetings and the serological results were consistent with information on FMD in the Sagaing Township. Both demonstrated the presence of FMD in all of the studied villages in the Sagaing Township.

To determine the capability of the MTD meeting approach to demonstrate free status for FMD, a study was carried out in a potentially free zone of southern Myanmar. Even though several positive serological results were obtained, the MTD meeting approach did not support the presence of FMD in Myeik Township at the time of the study. The serological results were questionable and may have represented false positive results. It could be argued that the MTD meeting was more specific than the Cedi® FMDV NS ELISA tests as clinical signs of FMD are very obvious in unvaccinated susceptible cattle (Kitching, 2002a); the disease would expect to affect a large number of susceptible animals in the area if disease occurred and farmers would be expected to have recognised these characteristic signs from the displayed photographs. The use of pictures to determine the occurrence of FMD in an area is a better way for farmers to understand the disease and has been used in participatory disease surveillance studies (Hussain *et al.*, 2005). Vaccine had not been used in this area for more than 10 years and consequently animals would be expected to be naïve. The responses of participants in the endemic area were significantly different from that of farmers in the potentially free area. Farmers (even young teenagers) from endemic areas easily recognized pictures of lesions of FMD whereas those from the potentially free zone were not familiar with the lesions except for a few old farmers.

The results of this study on the status of FMD in the endemic area and potential free areas were compared with the existing veterinary records from the LBVD. Between 2004 and 2009 there were 9 reported outbreaks of disease in the Sagaing Division. These occurred within a 100 kilometre radius of the studied area and only type O was isolated from these outbreaks. In contrast in Myeik there were no reported cases between 2000 and 2009, although two outbreaks were reported in 2007 in the northern part of Dawei, 200 kilometres north of Myeik Township (SEAFMD, 2009).

This validation process for the MTD meeting approach was mainly based on the use of Cedi® FMDV NS ELISA tests followed by administering a questionnaire and was conducted with a limited budget. This is the only diagnostic test which could be used during the study and it was provided by the Animal Technology Institute, Taiwan. This ELISA test has been recommended as a screening test for FMD regardless of the vaccination status, serotype of FMDV present or animal species (Paton *et al.*, 2006; Bronsvoort *et al.*, 2008). This study combines two different approaches: a qualitative and a quantitative approach. For the qualitative study, the source of information on FMD was based on the existing knowledge of the participants about FMD and this was obtained from the MTD meetings. In the quantitative study, information was based on serology however samples were not collected randomly in the Myeik Township but were collected randomly in the Sagaing. Even though, there were some differences between the serological survey and the MTD approach in the two areas, the results from the two surveys were assumed to be representative of the real situation of FMD at the township and village level in an endemic area and in a potentially free area.

In the Sagaing, during the MTD meetings, participants provided information on the recent outbreaks of FMD with affected numbers and the year of that outbreak. To limit recall bias, information was restricted to the preceding four years. Farmers reported clinical signs of FMD similar to those displayed in the pictures used during the meeting. In Myeik Township, the few farmers who could recognise the lesions were older people. In contrast young people and most participants were not familiar with the clinical lesions. This supports the case that the disease had not been in the area for some time. The detailed results of the MTD meetings of Myeik were not presented because there was no reported clinical evidence of FMD in the region.

The Cedi® FMDV NS ELISA tests can detect antibodies at least 395 days after experimental challenge (Sorensen *et al.*, 1998a). It also can be used to determine herd level prevalence in a region. At the time of this sero-surveillance study in 2007, it was more than 6 years since the last reported outbreak in the Myeik Township; therefore, the positive results could not be associated with that outbreak. If infection had been introduced into the study area, the participants would be expected to have seen lesions of FMD because the clinical lesions in cattle are very distinct and the population would be susceptible to infection (Kitching, 2002a).

Different sensitivities and specificities of the Cedi® FMDV NS ELISA test have been reported (Niedbalski, 2005; Brocchi *et al.*, 2006; Kyin, 2007; Linchongsubongkoch *et al.*, 2007; Lu *et al.*, 2007; Bronsvoort *et al.*, 2008) and these can be influenced by the timing of sample collection after infection (Brocchi *et al.*, 2006; Paton *et al.*, 2006). If it were assumed that the ELISA test was perfect, it could be concluded that the animal level sero-prevalence of FMD in the studied area of the Sagaing Division was high (40.1% with 95% CI 37.7 - 47.3) and those in Myeik low (11.6% with 95% CI 6.5 - 18.8). The FMD status was significantly different between the two targeted areas (χ^2 38.53, $p < 0.001$). In contrast if it is assumed that the test is not perfect, using a sensitivity and specificity of 92.4% and 82.5% respectively (Kyin, 2007), the true (real) animal level disease prevalence (for both cattle and sheep and goat samples) would be 33% (30 - 35%) for the Sagaing Township (179/422) and below 1% for Myeik (14/120).

All sampled villages in the Sagaing Township had some sero-positive reactors and it could be concluded that all villages were infected with FMD even though there were no clinical lesions at the time of serum collection. Correspondingly, in the MTD meeting approach respondents reported that they had seen outbreaks of FMD and nobody said their locality was free of FMD. Both the serological and the MTD approach supported the conclusion that FMD is endemic in the area and sporadic outbreaks could occur at any time. In contrast in the Myeik Township, even though there were some sero-positive animals; the prevalence of FMD was significantly lower than that in the Sagaing Division and the results of the MTD meeting would indicate that the disease had not occurred for many years. Expert opinions also supported the belief that FMD is endemic in the Sagaing with sporadic outbreaks occurring every year while the last outbreak of FMD in the Myeik Township was in 1999 involving type A (Black, 2003).

The merits of the MTD meeting approach include: a cost effective technique to detect FMD in cattle; there is no need to carry expensive instruments; a rapid response for the control of the disease can be implemented; it is an appropriate and easy method to use in rural areas; it could be used to educate participants and is a relevant technique to apply in developing countries which have a limited budget for disease surveillance.

The use of clinical diagnosis to detect FMD is a powerful method and it was used during the 2001 epidemic in UK. The herd sensitivity and specificity of clinical diagnosis in cattle by veterinarians has been reported as 97.6 and 95.2% respectively (McLaws *et al.*, 2007). The MTD meeting is a form of participatory approach which has been successfully used as a disease surveillance tool to collect data for the control and eradication of animal disease in Pakistan (Hussain *et al.*, 2005).

The limitations of the MTD meeting are: it is inappropriate for the detection of subclinical disease or diseases without distinct clinical signs; it requires the organisation of knowledgeable people in an area; the accuracy of the information depends on the participants who join the meeting and it requires a good facilitator.

During this study, even though there were many positive reactors in sheep and goats from the Sagaing Township, participants did not report that they had seen lesions in these animals. This is most likely because clinical signs in sheep and goats are not obvious unlike those in cattle (Kitching and Hughes, 2002). Information received on the type of vaccine used in a village and the total number of affected animals in an outbreak was not accurate and was based on the farmer's observation and interest. Some farmers who attended the MTD meeting were not knowledgeable on all aspects of FMD.

The role of a facilitator is important in an MTD meeting because people frequently use local dialects and expressions. In addition, the facilitator has to handle the meeting to give an equal chance for all attendees to participate and to prevent an individual dominating the discussions. In a participatory surveillance investigation of livestock disease in the Islamabad Capital Territory (Hussain *et al.*, 2005), the research team members (veterinarians) needed to learn the local names of the disease to obtain a better understanding of the disease situation. In the MTD meeting, the facilitators were staff from LBVD working in the respective areas for more than five years and they could help mediate between the researchers and the participants.

It is concluded that the MTD meeting approach is a valuable method of collecting information about FMD in Myanmar. The following chapter outlines the use of the MTD meeting approach to support the requirements of the surveillance study for establishing the freedom of FMD in the potential free area of Myanmar.

Retrospective and Cross sectional surveillance/ study of FMD in the Malaysia-Thailand-Myanmar (MTM) project area

5.1 Introduction

The Malaysia-Thailand-Myanmar (MTM) project was established after a Memorandum of Understanding (MOU) between the three countries was signed in Bangkok on 6th November 2003. The Myanmar MTM area (Tanintharyi) is located in the southern part of the country and is a narrow coastal region between the Andaman Sea and Thailand (See Figure 1.1). The plan to establish a free zone in this area by applying a zoning approach was supported because there are several advantages which increase the likelihood of success. These factors include the topography of the border between Thailand and Myanmar with rugged mountain ranges which decreases livestock movement; the small amount of animal movement into the region from other parts of Myanmar; and the recent history of a very low incidence of outbreaks in this region. These areas have only 0.5% of the cattle, 2.8% of the buffalo and 1.3% of the pig population of Myanmar as determined by the census conducted in 2003 (Anon, 2003).

The establishment of this zone would also serve as a good model of international cooperation within Southeast Asia. The boundary for the proposed control zone was the whole of the Kawthoung District in Myanmar that contains two townships - Kawthoung and Byokpyin and the boundary for the proposed buffer zone was the Myeik District which contains four townships - Myeik, Kyunsu, Palaw and Tanintharyi. The Dawei District, which contains four townships - Dawai, Yebyu, Launglon and Thayetchaung, was designated as an infected zone (Figure 5.1).

Prior to the 2004 sero-surveillance programme, the official cattle population in the proposed buffer zone (Myeik District) of the Tanintharyi Division was 50,493, with 60,613 buffalo, 9,257 sheep and goats and 50,550 pigs. In the proposed control zone (Kawthoung District) the cattle population was 6,954, the buffalo population 11,015, sheep and goats 2,957 and pigs 7,820 (LBVD, 2003). The sero-surveillance programme conducted in 2001 revealed that the prevalence of FMD in the Tanintharyi Division was low (Kyin, 2002) and the last outbreak was reported in the Kawthoung District prior to 1975. There were no reported outbreaks of FMD between 1990 and 1998 in the Tanintharyi Division. However in 1999 Type A FMDV was detected in one outbreak affecting 9 dairy cattle in the Myeik district (Black, 2003). There was no other evidence of Type A infection in this district. It is possible that the infection was introduced from Thailand which, at that time, had been experiencing outbreaks from Type A and Myeik District also is less than 100 kilometres from Thailand. Evidence of the reintroduction of some confiscated cattle from the Thai border to Myeik town centre was reported at that time (Edwards, 2004a). No further outbreaks have been reported in the Myanmar MTM area since 1999.

There are a few movements of pigs by truck or boat to Myeik for slaughter. The Tanintharyi Division has many rugged mountains and the roads between the mountain ranges are very narrow. There are only four places for animals to move out of the country from Myanmar to Thailand, two in the north of the proposed buffer zone, one in the proposed buffer zone and one in the proposed control zone (Edwards, 2004a). For the control of animal movements in the project area, there are two checkpoints - one is located between the proposed buffer zone (Dawei District) and the proposed control zone (Myeik District) and one is located between the proposed control zone and the proposed eradication zone (Kawthoung District). Two quarantine stations are located in Myeik District (see Figure 5.2).

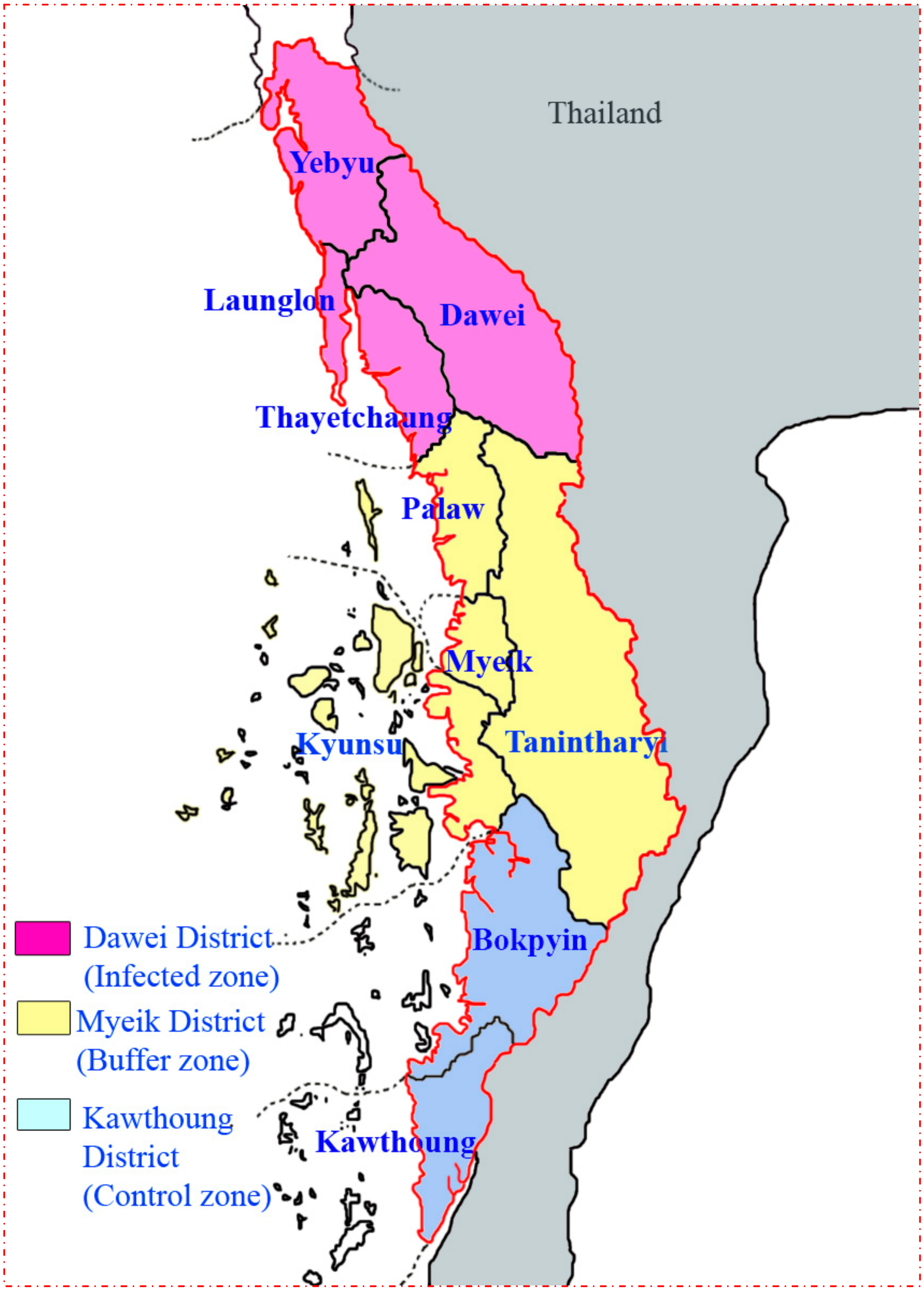


Figure 5.1 Map of Tanintharyi Division with with the boundaries of the Districts and Townships

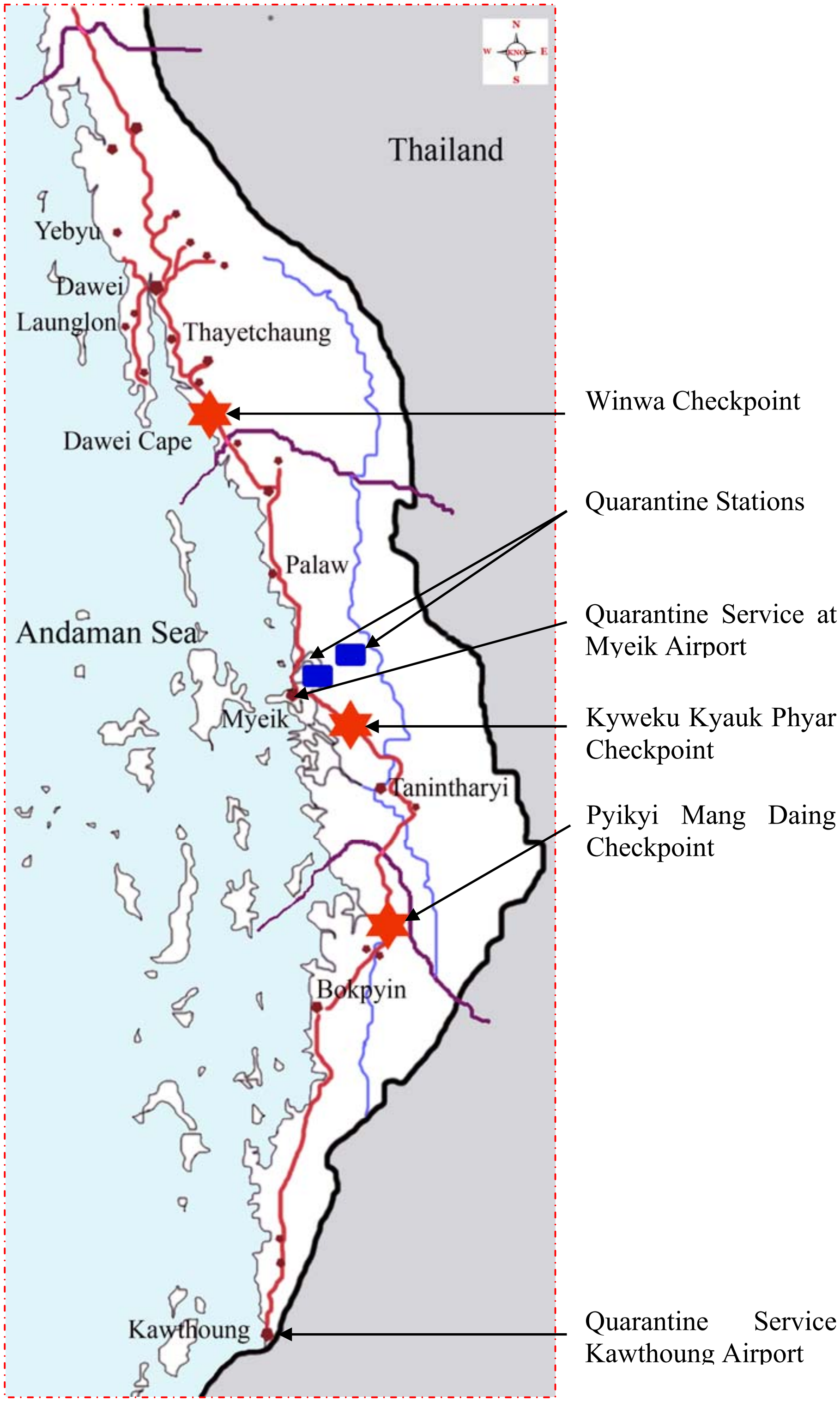


Figure 5.2 Map of Tanintharyi Division with District boundaries and location of quarantine stations and check points

Passive and active surveillance programmes have been conducted in the proposed areas. Passive surveillance, which relies almost entirely on reporting of suspect clinical disease to the MTM Tri-State Commission through the LBVD, was carried out by the local veterinary staff from the LBVD and active surveillance was undertaken by staff from the National FMD Diagnostic Laboratory during 2001 and 2004 (Htun and Kyin, 2006). The disease information pathway (Figure 1.4) has been approved and developed in Myanmar after the Act of Animal Health and Development was issued by the State Law and Order Restoration Council in 1993.

Between the years of 2001 and 2004 more active surveillance activities were conducted in the Tanintharyi Division. A total of 306 serum samples were collected between 2001 and 2002 from animals originating from either the proposed control or buffer zones. The apparent (test) prevalence was 2.8% (4/143; 0.8 - 7.0% 95% CI) using a LPB ELISA and 10% (2/20;1.2 - 31.7% 95% CI) using an NSP ELISA in the proposed buffer zone (Myeik District); and 0% (0/163; 0.0 - 2.2%) using a LPB ELISA, and also 0% (0/82; 0.0 - 4.4%) using a NSP ELISA in the proposed control zone (Kawthoung District). Vaccination has not been used in these areas since approximately 2000. In 2001 and 2002 antibodies against Type O and Type A were detected in samples collected from cattle from Myeik (143 samples) (Black, 2003). A total of 2.7% (4/143) animals were positive to Type A during that study in the Myeik Township, however further information on Type O was not provided in the report (Kyin, 2002).

To support the SEAFMD campaign and to understand the proposed zone status of the Myanmar MTM area (Black, 2003; Turton, 2004), a surveillance proposal was developed with the assistance of the former regional coordinator Dr John Edwards late in 2004 by the author. This was submitted to the OIE (Office International des Epizooties) Regional Coordination Unit (OIERCU) located in Bangkok to obtain the necessary funding for the 2005 surveillance programme. Dr Kachin Wonsathaponchi, at the time a PhD student at Colorado State University, assisted with the development of the surveillance design and Dr Ronello Abila, Regional Coordinator for SEAFMD campaign OIE RCU, assisted and finalised calculations to determine the necessary sample size. The proposal and sample size calculations were confirmed at the 11th MTM TriState commission meeting held in the Philippines in March 2005 after discussion with the OIE RCU (Abila, 2007).

The objective of this 2005 cross-sectional survey was to demonstrate freedom of disease in the Myanmar MTM area, especially in the proposed control and buffer zones. The sample size was selected based on a prevalence of 5% for the primary sampling unit and to estimate prevalence within 95% confidence intervals as outlined in the Standard Definition and Rules (SDRs) of the MTM campaign.

After the sero-surveillance programme, follow up targeted serological surveys and participatory disease investigation techniques were conducted to support and upgrade the zone status. The findings were submitted to the MTM Tri-State Commission meeting for zone progression.

The overall objective of this study was to assist the MZWG to prepare a proposal underpinned by credible data and information to progress the zone status in the Myanmar MTM area and to support the SEAFMD campaign.

5.2 Materials and methods

The existing data from reports of outbreaks of FMD in the Tanintharyi Division were collected from the National Foot and Mouth Disease Diagnosis and Vaccine Production Section and the Planning and Statistics Section of the LBVD. The animal population in this Division was collected under the supervision of the divisional head of the Tanintharyi Division and was used to establish the sampling frame for the work outlined in this chapter. A systematic sero-surveillance study was conducted in the proposed buffer and control zones of the Myanmar MTM area in 2005 with support from AusAID through the SEAFMD campaign.

5.2.1 Sero-surveillance study in 2005

A two stage random sampling technique (Cameron and Baldock, 1998) was employed with village tracts and large ruminants used as the primary and secondary sampling units respectively. The sample size was calculated using FreeCalc (Cameron and Baldock, 1998). The sample size calculated to be 95% confident of proving freedom of disease was based on a 5% village tract prevalence and a within village tract animal prevalence of 20%. The estimated prevalence of 5% and 20% were used to formalize the study consistent with the SDRs for the MTM. Livestock population data from the Tanintharyi Division were used as a sampling frame. In that sampling frame, there were 143 village tracts in the study area (Myeik and Kawthoung District). The primary sampling units were stratified into two strata: village tracts with less than 500 large ruminants and those with more than 500. Fourteen village tracts were omitted from sampling because there were no large ruminants present. To satisfy the sampling design it was necessary to randomly sample 74 of the available 129 village tracts. Although it had been planned to select individual animals for sampling randomly for the secondary sampling unit, the majority of samples were collected by convenience because of security concerns for staff, lack of cooperation by farmers and the fact that many cattle were kept far from the selected villages. Therefore, most samples collected came from animals whose owners kept livestock at their house and in some areas samples for the whole village tract were collected from only one farm. (The author noted that this was in the Kyunsu Township of Myeik District at the time of the visit of the Regional Coordinator during the middle of the 2005 sero-surveillance campaign).

There were a total of 101,986 cattle and buffalo in both districts. A total of 1,106 samples from 78 primary sampling units were collected (the calculated sample size was 1036 based on collecting 14 samples from 74 selected village tracts - (Abila, 2007). Some selected village tracts could not be sampled in remote areas where visits from government officials were known to be unsafe. These omitted village tracts were replaced by closer, safer village tracts. A total of 1098 of the 1106 samples were tested at the National FMD Laboratory, Insein, Yangon, Myanmar. Eight samples were not tested because either there was insufficient serum, or the samples were haemolysed or contaminated (Pers. com. Dr Maung Maung Kyin). The CHEKIT FMD 3ABC bo-ov enzyme immunoassay (EIA) kit manufactured by Bommeli Diagnostics was used to detect and measure antibody. This test was selected by participants of the OIE meeting before conducting the 2005 sero-surveillance study.

The serological results were released by the National FMD laboratory in the middle of 2005 (Hla, 2005). Forty-two samples which showed positive, suspect or negative results (cut off points were not mentioned in the official results from the National FMD Laboratory of Myanmar) were also sent to the Regional Reference Laboratory, Pak Chong, Thailand for confirmation of the antibody result (Abila, 2007). All positive results were investigated further. This involved revisiting the villages in November 2005 and re-sampling the animals (n=18) belonging to livestock owners whose cattle showed positive or suspect results on the first test.

Follow up investigations, including active and passive surveillance and participatory investigations, were conducted after the 2005 sero-surveillance study. Between 2005 (during the sero-surveillance project) and 2007, Dutaik meeting approaches were conducted in the Myeik and Kawthoung Districts for public awareness campaigns and targeted sero-surveillance activities were conducted after the 2005 serological survey until the 2007 fiscal year of the LBVD (Abila, 2007; Win, 2007).

Confidence limits of the laboratory test results were calculated using the binomial exact methods (Daly, 1992).

5.2.1.1 Bommeli test procedure

A total of 1098 samples collected in 2005 from the proposed control and buffer zones were tested in the National FMD Laboratory with the Bommeli test following the manufacturer's instructions. (It was noticed that the official result issued at the end of 2005 from the National FMD laboratory did not use the cut off points recommended by the manufacturer however in the research reported here the cut off points recommended by the manufacturer were used).

5.2.1.2 Re-evaluation of the 2005 sero-surveillance results

The results from the sero-surveillance study in 2005 were re-evaluated. The raw results were re-evaluated and all PI values checked by using cut off points recommended by the manufacturer. The Bommeli test results were obtained in hard copy from the National FMD laboratory of Myanmar. These were scanned and transferred into a spreadsheet (Excel ver. 2003, Microsoft). The names of the village tracts in the Tanintharyi Division were obtained from a booklet issued by the Ministry of Home Affairs of Myanmar (Anon, 2004a). These were entered into the spreadsheet and cross-checked with the village tracts recorded in the sero-surveillance report. The original report from the field survey to the laboratory had been submitted in the Myanmar language and had never been translated into English. There are several townships within the Tanintharyi Division that have very similar names (in terms of pronunciation) and these names could easily have been confused in the initial translation process. All village tracts and township names were entered into a spreadsheet in both English and Myanmar and cross-matched. The re-evaluated data was triangulated by using all available information, including an official report to the SEAFMD campaign. In the spreadsheet, the different serum numbers were entered into rows and data such as the names of districts, townships, village tracts, and owners and PI values were entered into columns. The data were then sorted and positive, suspect and negative results categorised by using the manufacturer's recommended cut-off points.

The sample sizes were rechecked with Win Episcope 2 (Thrusfield *et al.*, 2001) using the assumption of perfect test accuracy and the Bommeli test results were checked with Survey Tool box (Cameron, 1999) to prove freedom of disease.

5.2.2 Follow up disease investigation study (2007 - 2009)

During 2007 and 2008, Modified Traditional Dutaik meeting approaches were conducted by author in the proposed eradication zone (Kawthoung District) and control zone (Myeik District). Those village tracts which had shown positive serological results in Myeik Township and a village tract of Kawthoung Township were specifically targeted for these meetings. A further limited sero-surveillance study (2008) was conducted in 6 of 7 village tracts in the Myeik Township which had positive results during the 2005 sero-survey (Figure 5.3). Amongst these 7 villages Thit Yar Wa village, which had two positives and one suspect result during the sero-surveillance in 2005, was not revisited because of security reasons and difficult accessibility. For this sero-surveillance study, a Cedi® FMDV NS ELISA test was used to detect NSP in the sample. This test was provided by the Institute of Animal Health, Taiwan and was conducted at the National FMD Laboratory. The remainder of the village tracts which had shown positive and suspect results in 2005 were not revisited because of limitations in time and funding, and difficulties with transportation and security. The recent sero-surveillance study was conducted within Kawthoung and Myeik Districts with targeted sampling approach in May, 2009 by the staff of FMD section of LBVD.

5.2.2.1 Modified Traditional Dutaik meeting approach

The Modified Traditional Dutaik meetings were conducted in January 2007 and February 2008 in the places with positive results in the 2005 sero-surveillance project. The format of these meetings was as outlined in Chapter 3.

The main topics covered during the Dutaik meetings included the number of animals susceptible to FMD and the number of households in the village tract, the feeding and husbandry system adopted by farmers, the diseases commonly found in livestock in the locality, the participants awareness of the lesions of FMD, the number of livestock affected in the last outbreak of FMD and the movement of livestock for sale or purchase and the past and current status of FMD in the study area.

5.2.2.1.1 Dutaik meeting approach in Kawthoung Township (2007)

A Dutaik meeting with 12 participants was conducted in the 10 Mile Village tract of Kawthoung Township in January 2007. This village tract was selected because of its high livestock population density compared with other village tracts.

5.2.2.1.2 Dutaik meeting approach in Myeik Township (2008)

A total of 105 participants from the 6 village tracts targeted participated in the Dutaik meetings, with the majority of these being livestock owners (Table 5.1).

Table 5.1 Number of participants and samples collected from the Myeik Township

Village	Number of participants attending	Number of samples collected			
		Cattle	Buffalo	Goats	Total number of animals sampled
Myeik Taung	20	20	0	0	20
Kalwin	15	18	2	0	20
Kahan	18	20	0	0	20
Sandawut	18	10	10	0	20
Taung Shae	22	15	0	5	20
Pathaung	12	13	0	7	20
Total	**105**	**96**	**12**	**12**	**120**

5.2.2.2 Expert opinion

Expert opinions were obtained from the butchers, traders and staff of the LBVD in the study area of Kawthoung and Myeik Districts. One local butcher, one large scale livestock owner (owning multiple species including cattle, sheep and goats and poultry) and a district officer from the Kawthoung District were interviewed and three staff of LBVD, two butchers and one trader were interviewed from the Myeik District.

5.2.2.3 Targeted sero-surveillance in 2008

A targeted sero-surveillance study was conducted in Myeik in February 2008. Six of the 7 village tracts which had positive results in the 2005 serological survey were selected and 20 samples were collected from each selected village. The sample size calculation was based on the 2005 survey design and an expected prevalence of 20%. The number was restricted to 20 because of limitations on the availability of the test kits. The high risk areas identified (targeted) for sampling were based on a high livestock population density, areas located along the animal movement routes and areas where the majority of livestock shared common grazing land.

5.2.2.4 Targeted sero-surveillance in 2009

A targeted sero-surveillance study was also conducted in Myeik and Kawthoung District in May 2009 by the staff from LBVD. Four village tracts from Kawthoung and five villages from Myeik Districts were purposively selected with expert opinion as high risk areas (Pers. com. Dr Khin Maung Latt) and a total of 180 samples were collected. It included 97 samples from Kawthoung and 83 samples from Myeik Districts. The samples were tested by Cedi® FMDV NS ELISA tests in National FMD laboratory of Myanmar.

5.2.2.5 Cedi test procedure

The collected sera were kept in an ice box during the trip and transferred into cryovial tubes after centrifugation at 2000 RPM for 20 minutes (Pers. com. Dr Khin Maung Latt). All collected sera were tested at the National FMD Laboratory, Insein, Yangon, Myanmar. The Cedi ELISA test was conducted according to the manufacturer's instructions.

5.2.2.6 Confirmatory test in the Regional Reference Laboratory (Pak Chong)

At the time of the 2008 and 2009 sero-surveillance study, the Cedi ELISA test was the only available NSP test in the FMD laboratory of Myanmar. The serological results of 2008 and 2009 were presented at the MTM Tristate Commission Meeting which was held in June, 2009 in Yangon, Myanmar. During the meeting participants from member countries discussed the results and suggested all positive samples should be sent to the Regional Reference Laboratory (Pak Chong, Thailand) for confirmation. These positive samples were tested by the Cedi test and LP ELISA.

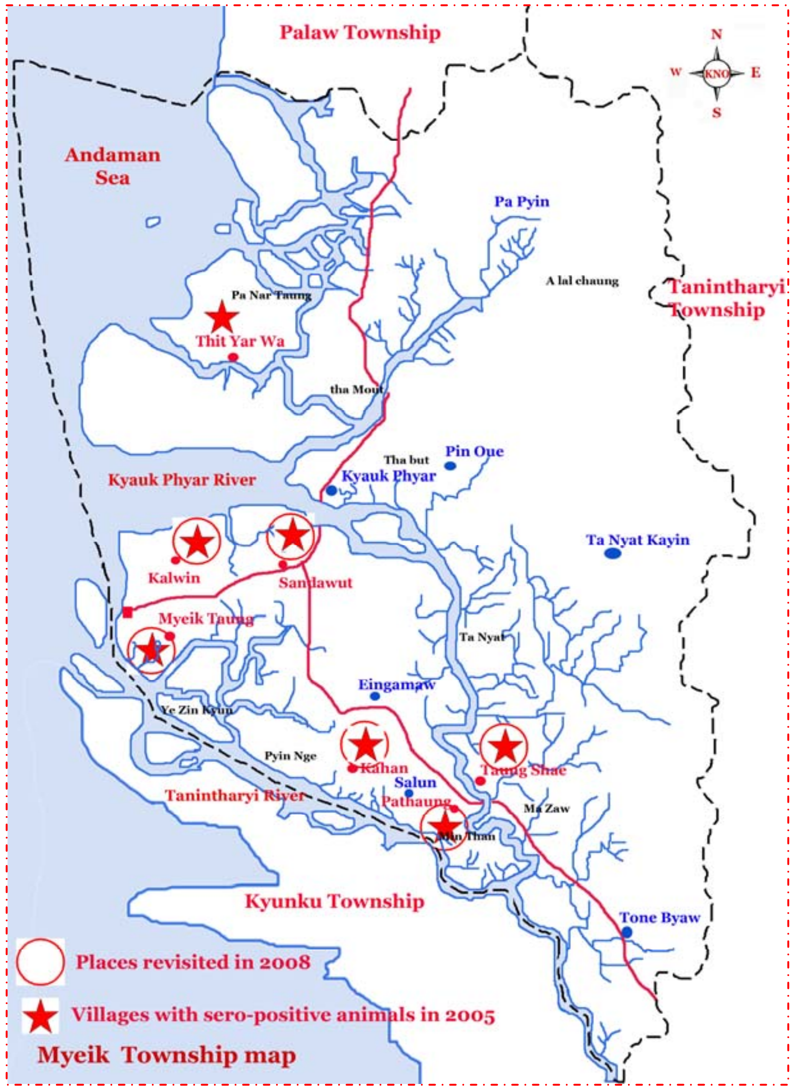


Figure 5.3 Map showing Myeik Township with the villages that had positive serological results in 2005 and the places revisited in 2008

5.3. Results

Different cut-off points for discriminating between positive, suspect and negative samples were used in the 2005 serological survey compared with the 2008 survey. Consequently direct comparison of the results is difficult.

5.3.1 Results of the 2005 first survey from LBVD

The sero-surveillance study was completed by the end of July 2005. There were 7 positive (test prevalence 0.64%; 95% CI 0.26, 1.31%) and 11 suspect results of the 1098 tested (Table 5.2) (Hla, 2005). After the 2005 sero-surveillance programme, the passive surveillance results revealed that there were no positive cases (Latt, 2006a), no report of outbreaks of FMD (SEAFMD, 2009) and no suspect cases reported in the proposed eradication and control zones (Win, 2007).

5.3.2 Results of the second sampling in 2005 by the LBVD

All of the 18 sera collected during the second sampling were negative to the Bommeli test kits (Abila, 2007). Those samples showed positive in the first test and resampling was conducted from the same animals and retested. This is second test result.

5.3.3 Results of the 2005 survey from Pak Chong Laboratory

A total of 42 samples were sent to the Regional Reference Laboratory (RRL), Pak Chong for confirmation of the results (Table 5.4). Clear positive results were found in 13 of the 42 sera, whereas 14 were ambiguous to the Cedi test at Pak Chong and the other 15 sera were clearly negative. The Liquid Phase ELISA results revealed that no or low titres of antibodies were detected and in some samples antibodies to types O, A and

Asia1 were detected (Abila, 2007). No antibody to FMDV type C was detected by a LP ELISA.

Table 5.2 Results from the 2005 sero-surveillance (official results)

District	Township	Number of positive results	Number of suspect results	Total samples collected
Myeik	Myeik	3	9	197
	Palaw	1	2	317
	Kyunsu	1	0	94
	Tanintharyi	2	0	193
Kawthoung	Kawthoung	0	0	154
	Bokpyin	0	0	143
Total		**7**	**11**	**1098**

Table 5.3 Summary of the sero-surveillance results of Myanmar MTM in 2005 using the Bommeli test kit

District	Number of positive samples (prevalence %, 95% CI)	Number of suspect results	Total number of samples
Myeik	7 (0.87, 0.35 - 1.79)	11	801
Kawthoung	0 (0.0, 0.0 - 1.24)	0	297
Total	7 (0.64, 0.26 - 1.31)	11	1098

Table 5.4 Results for individual sera from the National FMD and Pak Chong Laboratories

Township	Village tract	Results from the National FMD Laboratory**	Results from Pak Chong Laboratory				
		ELISA (Bommeli test)	ELISA (Cedi Test)	LP ELISA results			
				"O"	"A"	"Asia1"	"C"
Kawthoung	Prasai	-	+/-	<40	40	<40	<40
Kawthoung	Prasai	-	+	<40	80	80	<40
Kawthoung	Prasai	-	+/-	<40	40	<40	<40
Kawthoung	Prasai	-	-	<40	40	<40	<40
Kawthoung	Prasai	-	+/-	<40	<40	<40	<40
Kawthoung	Prasai	-	+/-	<40	80	<40	<40
Palaw	Leck Ku	-	-	<40	40	<40	<40
Palaw	Leck Ku	-	-	<40	40	<40	<40
Palaw	Nan Taung	-	+	<40	40	80	<40
Palaw	Nan Taung	-	+	<40	80	40	<40
Palaw	Hta Min Ma Sar	+	+	<40	<40	<40	<40
Palaw	Sin Htoe	-	-	<40	40	<40	<40
Palaw	Sin Htoe	+/-	+	<40	40	<40	<40
Palaw	Pu Lauk	-	+/-	<40	40	<40	<40
Palaw	Min Htain	+/-	+	<40	40	<40	<40
Palaw	Myo Ma	-	-	<40	<40	<40	<40
Myeik	Ma Zaw	+	+	80	320	80	40
Myeik	Ma Zaw	+	-	<40	<40	<40	<40
Myeik	Ma Zaw	+	+/-	<40	<40	<40	<40
Myeik	Ka Lwin	+	+	<40	<40	<40	<40
Myeik	San Da Wut	+	+	160	320	320	40
Tanintharyi	Chaung Nge	-	-	<40	40	<40	<40
Tanintharyi	Chaung Nge	-	+/-	<40	40	<40	<40
Tanintharyi	Chaung Nge	-	-	<40	40	<40	<40
Tanintharyi	East Maw Ton	-	+/-	<40	40	<40	<40
Tanintharyi	East Maw Ton	-	+/-	<40	40	<40	<40
Tanintharyi	East Maw Ton	-	+	<40	40	<40	<40
Tanintharyi	Sin Chae Phone	-	-	<40	40	<40	<40
Tanintharyi	Nyaung Pin Kwin	-	+/-	<40	40	<40	<40
Kyunsu	War Yit	+	+/-	<40	80	<40	<40
Bokpyin	Htaung Su Ma Htet	+/-	+	<40	<40	<40	<40
Bokpyin	Htaung Su Ma Htet	-	+	<40	40	40	<40
Bokpyin	Htaung Su Ma Htet	-	+	<40	<40	<40	<40
Bokpyin	Htaung Su Ma Htet	-	+/-	<40	<40	<40	<40
Bokpyin	Chauk Ka Yat	-	-	<40	<40	<40	<40
Kyunsu	Katalu	-	-	<40	40	<40	<40
Kyunsu	Ma Yan Chaung	-	+/-	<40	40	<40	<40
Myeik	Myeik Taung	+	-	<40	320	<40	<40
Myeik	Thit Ywar Wa	+	+/-	<40	<40	<40	<40
Myeik	Thit Ywar Wa	+	-	<40	40	<40	<40
Kyunsu	Metaw	-	-	<40	40	<40	<40
Kyunsu	Metaw	-	-	<40	40	<40	<40

The original report from the Pak Chong Laboratory did not mention the results from the National FMD Laboratory of Myanmar. An additional column was added in this table and results matched with those from the Pak Chong Laboratory. The results from the National FMD laboratory of Myanmar, which are mentioned in this table, were re-evaluated results and were not consistent with the official report which only mentioned 7 positives and 11 suspects.

LB ELISA result interpretation, <40 = negative, 40 = suspect, >40 = positive

5.3.4 Re-evaluated results of 2005

The raw data from the National FMD Laboratory were reviewed. The data were rechecked according to the manufacturer's instructions and using the cut-off point outlined in the instructional sheet that accompanied the test. There were 16 positive and 16 suspect results among 1108 samples (Table 5.5). All 16 positive and 15 of the suspected samples originated from the Myeik District (Figure 5.3) and only one suspect sample was detected from samples collected from the Kawthoung District. The samples (from the 2005 sero-surveillance study) which had been sent for confirmation to the Pak Chong laboratory did not include all positive and suspect samples from the re-evaluation results because it was conducted in 2008. Consequently all results could not be included in Table 5.4 which displays a comparison of the results from the National FMD Laboratory and the Regional Reference Laboratory, Pak Chong.

Among the positive samples from the Myeik District, 11 originated from Myeik Township, one from Kyunsu Township and two each from Palaw and Tanintharyi Townships (Table 5.6).

In Myeik Township, positive results came from 7 different village tracts: Ka Han, Ka Lwin, Myeik Taung, Pa Thaung, San Da Wut, Taung Shae and Thit Yar Wa. The highest test prevalence was in Ka Lwin Village tract which showed two positive results (Table 5.7). In Kyunsu Township, only one village tract showed a single positive result of the 13 samples from the War Yit village tract (Table 5.8).

In Palaw Township, two positive and six suspect results were detected from the 317 animals sampled. The highest test prevalence was in No 2 ward (Table 5.9).

In Tanintharyi Township, two positive and two suspect results were found in the 193 animals tested and the village tract level test prevalence was 7.1% in Thar Ya Bwin village tracts (Table 5.10).

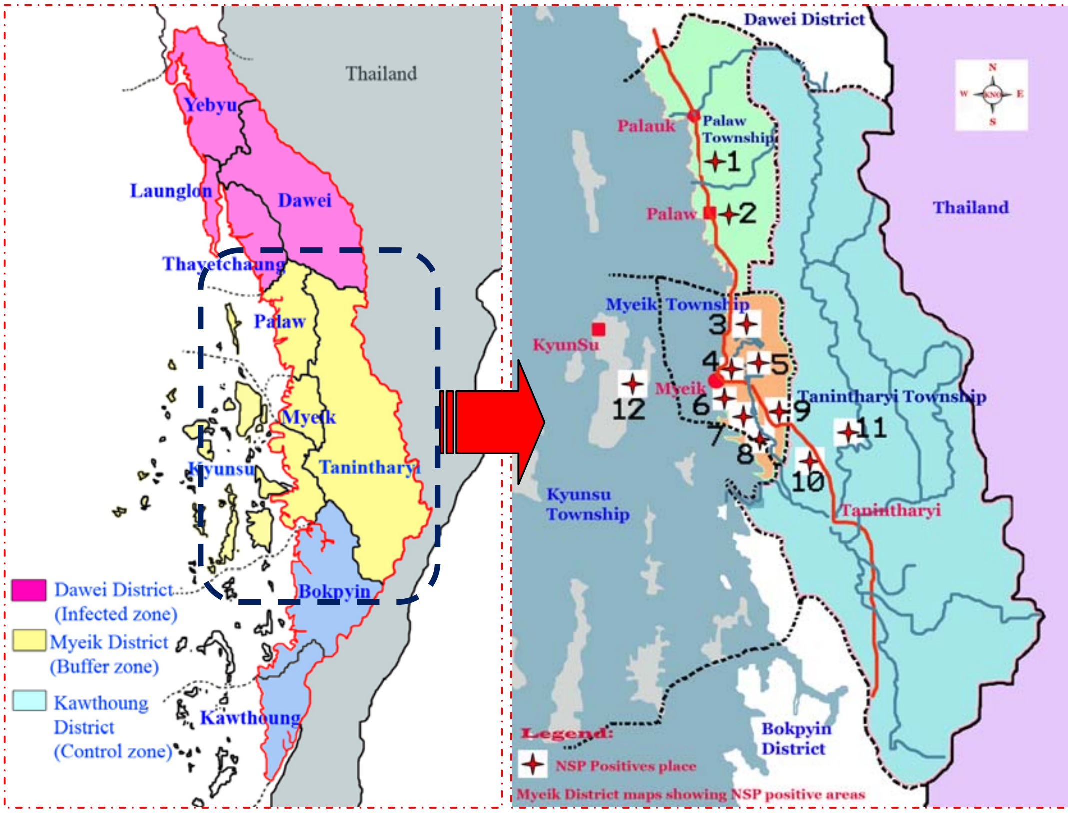


Figure 5.4 Detailed map of Myeik District with the places where NSP positives were detected in the 2005 serological surveillance

Legend:

1. Pyi Char - Palaw Township
2. No 2 ward - Palaw Township
3. Thit Yar Wa - Myeik Township
4. Ka Lwin - Myeik Township
5. Sandawut - Myeik Township
6. Myeik Taung - Myeik Township
7. Ka Han - Myeik Township
8. Pathaung - Myeik Township
9. Taung Shae - Myeik Township
10. Ma Zaw - Tanintharyi Township
12. War Yit - Kyunsu Township

Table 5.5 District of origin of re-evaluated samples

District	**FMDV NSP 3 ABC ELISA results**				
	Number of positives	Percent +ve (95% CI)	Number of suspects	% Suspect (95% CI)	Total
Myeik	16	2.0 (1.15, 3.22)	15	1.87 (1.05, 3.07)	801
Kawthoung	0	0.0 (0.0, 1.24)	1	0.34 (0.1, 1.86)	297
Total	**16**	**1.46 (0.84,2.36)**	**16**	**1.46 (0.84,2.36)**	**1098**

Table 5.6 Township of origin for re-evaluated samples

Township	ELISA results				
	Number of positives	Percent +ve (95% CI)	Number of suspects	% Suspect (95% CI)	Total
Bokpyin	0	0.0 (0.0, 2.55)	1	0.7 (0.02,3.83)	143
Kawthoung	0	0.0 (0.0, 2.37)	0	0.0 (0.0, 2.37)	154
Kyunsu	1	1.06 (0.03,5.79)	1	1.06 (0.03, 5.79)	94
Myeik	11	5.58 (2.82, 9.77)	6	3.05 (1.13, 6.51)	197
Palaw	2	0.63 (0.08, 2.26)	6	1.89 (0.70, 4.07)	317
Tanintharyi	2	1.04 (0.13, 3.69)	2	1.04 (0.13, 3.69)	193
Total	**16**	**1.46 (0.84, 2.36)**	**16**	**1.46 (0.84, 2.36)**	**1098**

Table 5.7 Serological results from the Myeik Township after re-evaluation

Village tract	Number of positives	Percent +ve (95% CI)	Number of suspects	% Suspect (95% CI)	Total
Ein Ga Maw	0	0 (0.0, 24.77)	0	0 (0.0, 24.77)	13
Ka Han	1	7.14 (0.18, 33.87)	0	0 (0.0, 23.21)	14
Ka Lwin	2	16.67 (2.09, 48.42)	0	0 (0.0, 26.50)	12
Kyauk Phyar	0	0 (0.0, 26.5)	2	16.67 (2.09, 48.42)	12
Myeik Taung	1	7.69 (0.19, 36.03)	0	0 (0.0, 24.77)	13
Pa Pyin	0	0 (0.0,23.21)	1	7.14 (0.18, 33.87)	14
Pa Thaung	3	11.54 (2.45, 30.15)	1	3.85 (0.1, 19.64)	26
Pin Ou	0	0 (0.0, 23.21)	0	0 (0.0, 23.21)	14
Sa Lun	0	0 (0.0, 23.21)	1	7.14 (0.18, 33.87)	14
San Da Wut	1	11.1(0.28, 48.25)	0	0 (0.0, 33.67)	9
Ta Nyat(Kayin)	0	0 (0.0, 24.77)	0	0 (0.0, 24.77)	13
Taung Shae	1	5.56 (0.14, 27.29)	0	0 (0.0, 18.56)	18
Thit Yar Wa	2	13.3 (1.66, 40.46)	1	6.67 (0.17, 31.95)	15
Tone Byaw	0	0 (0.0,33.67)	0	0 (0.0, 33.67)	9
Data Missing	0	0	0	0	1
Total	**11**	**5.58 (2.82, 9.77)**	**6**	**3.05 (1.13,, 6.51)**	**197**

Table 5.8 Serological results from Kyunsu Township after re-evaluation

Village tract	Number of positives	Percent +ve (95% CI)	Number of suspects	% Suspect (95% CI)	Total
Banda Nae	0	0 (0.0, 46.0)	1	16.67 (0.42, 64.13)	6
Ka Pa	0	0 (0.0, 52.2)	0	0 (0.0, 52.2)	5
Kat Ta Lu	0	0 (0.0, 18.56)	0	0 (0.0, 18.56)	18
Mae Taw	0	0 (0.0, 23.21)	0	0 (0.0, 23.21)	14
Maung Hlaw	0	0 (0.0, 21.87)	0	0 (0.0, 21.87)	15
Than Dout	0	0 (0.0, 28.55)	0	0 (0.0, 28.55)	11
War Yit	1	7.69 (0.19, 36.03)	0	0 (0.0, 24.77)	13
Zae Ka Mi	0	0 (0.0, 26.5)	0	0 (0.0, 26.5)	12
Total	**1**	**1.06 (0.03, 5.79)**	**1**	**1.06 (0.03, 5.79)**	**94**

Table 5.9 Serological results from Palaw Township after re-evaluation

Village tract	Number of positives	Percent +ve (95% CI)	Number of suspects	% Suspect (95% CI)	Total
Hta Min Ma Sar	0	0 (0.0, 23.21)	1	7.14 (0.18, 33.87)	14
Ka Dae	0	0 (0.0, 19.53)	0	0 (0.0, 19.53)	17
Kyae	0	0 (0.0, 12.36)	0	0 (0.0, 12.36)	28
Kyauk Lone Kyi	0	0 (0.0, 23.21)	1	7.14 (0.18, 33.87)	14
Lat Ku	0	0 (0.0, 11.23)	0	0 (0.0,11.23)	31
Ma Gyi Kone	0	0 (0.0, 33.67)	1	11.1 (0.28, 48.25)	9
Min Htein	0	0 (0.0, 14.83)	2	8.7 (1.07, 28.04)	23
Nan Taung	0	0 (0.0, 23.21)	0	0 (0.0, 23.21)	14
No 1 Ward	0	0 (0.0, 20.63)	0	0 (0.0, 20.63)	16
No 2 Ward	1	7.69 (0.19, 36.03)	0	0 (0.0,24.77)	13
No 4 Ward	0	0 (0.0, 12.36)	0	0 (0.0, 12.36)	28
No 5 Ward	0	0 (0.0, 26.5)	0	0 (0.0, 26.5)	12
Pa La	0	0 (0.0, 23.21)	0	0 (0.0, 23.21)	14
Pyi Char	1	3.57 (0.09, 18.35)	0	0 (0.0, 12.36)	28
Shat Pon	0	0 (0.0, 23.21)	0	0 (0.0, 23.21)	14
Sin Htoe Kyi	0	0 (0.0, 14.25)	1	4.17 (1.1, 21.12)	24
Taung Yan Kan	0	0 (0.0, 23.21)	0	0 (0.0, 23.21)	14
Toa	0	0 (0.0, 60.25)	0	0 (0.0, 60.25)	4
Total	**2**	**0.63 (0.08, 2.26)**	**6**	**1.89 (0.7, 4.07)**	**317**

Table 5.10 Serological results from Tanintharyi Township after re-evaluation

Village tracts	Number of positives	Percent +ve (95% CI)	Number of suspects	% Suspect (95% CI)	Total
A Shae Maw Taung	0	0 (0.0, 21.87)	0	0 (0.0, 21.87)	15
Ban Hlaw	0	0 (0.0, 21.87)	0	0 (0.0, 21.87)	15
Chaung Nge Ward	0	0 (0.0, 24.77)	0	0 (0.0, 24.77)	13
Kauk Ma Pyin	0	0 (0.0, 13.72)	0	0 (0.0, 13.72)	25
Pa Wa	0	0 (0.0, 24.77)	0	0 (0.0, 24.77)	13
Ta Ku	0	0 (0.0, 23.21)	0	0 (0.0, 23.21)	14
Tanintharyi Sin Chae Phone	0	0 (0.0, 12.36)	0	0 (0.0, 12.36)	28
Tha Kyat	0	0 (0.0, 24.77)	0	0 (0.0, 24.77)	13
Thar Ya Bwin	1	7.14 (0.18, 33.87)	0	0 (0.0, 23.21)	14
Thar Ya Phon	0	0 (0.0, 23.21)	0	0 (0.0, 23.21)	14
Thein Daw	0	0 (0.0, 23.21)	1	7.14 (0.18, 33.87)	14
Za Wae	1	6.67 (0.17, 31.95)	1	6.67 (0.17, 31.95)	15
Total	**2**	**1.04 (0.13, 3.69)**	**2**	**1.04 (0.13, 3.69)**	**193**

Table 5.11 Comparison of different factors and the ELISA test results

Factors	**Disease positive**	**Disease negative**	**Odds Ratio**	**95% CI**	**χ^2value**	***p*-value**
Species						
Cattle	16	1056	-	-	0.38	0.53
Buffalo	0	25	-	-		
Gender						
Male	12	598	2.42	0.78 - 7.56	2.47	0.11
Female	4	483	1	-		
Age						
1-7 Years	11	946	1	-		
8-17 years	5	134	3.21	1.10 - 9.38	5.05	0.02[#]

In the 2005 sero surveillance study, it was found that there was no significant difference in the prevalence for species and gender whereas older animals (8 to 17 years) were more likely to be infected than younger animals (1 to 7 years) (Table 5.11). The sample size used in the 2005 surveillance programme was found to be adequate to detect a prevalence of 5% and the probability of detecting at least one true positive was 100% (Win Episcope).

The total number of positive results (n=16), sensitivity (96%) and specificity (98%) and estimated prevalence (5%) were entered into Survey Toolbox and analysed. These findings demonstrated that the sample size was also adequate to reject the null hypothesis and it can be concluded that the population is free from disease at an expected minimum prevalence of 5% with 100% confidence.

5.3.5 Follow up investigation results

Information collected during the MTD meeting indicated that the prevalence of FMD in the studied area was extremely low or even zero (free of disease) at the time of the study. It appeared that FMD had not been present in the Kawthoung District for at least 10 years. In Myeik Township, the information provided by the participants also indicated that the prevalence was very low and the disease had not spread very widely, even considering the outbreak in 1999 in Myeik Township.

5.3.5.1 The MTD meeting results of Kawthoung Township

During the Dutaik meeting in the 10 Mile village tract of Kawthoung Township in January 2007, farmers reported that cattle were fed in two ways: either by feeding home prepared feed or by tethering them in areas near their work places. No cattle were allowed to graze freely. There were few cattle in the village tracts. Local farmers did not buy cattle from other places such as from Myeik District or from places far from

Kawthoung Township. They were purchased from within the township because of transportation difficulties and the prohibition of animal movement by the local authorities in the Kawthoung District. The reasons for the banning of animal movements were not clear, however it could be related to national security because of the close proximity of the area to the border with Thailand. There was a check-point located between the Kawthoung and Myeik Districts (Figure 5.2) which adopted a policy of investigating both human and livestock movements. Local people were reluctant to go through this checkpoint because they had to provide their personal identity card and official documents for livestock to pass through the gate.

No participants had seen lesions characteristic of FMD or had heard of cases of the disease for more than 10 years. The movement of animals was minimal because of both the low numbers of animals, the difficulty in transporting the animals and the practice of raising the cattle separately from the farmer's house and land.

5.3.5.2 The MTD meeting results of Myeik Township

A total of six MTD meetings involving 105 participants were conducted in Myeik Township. Farmers actively participated in the meetings and provided information on the number of villages, households and people in the village tract, and information on the last outbreak of FMD, the common routes for animal movement and the system of raising livestock.

Between 3 and 13 villages were located in each village tract in the studied area. Although there were a large number of households in the village tracts, there were few livestock (Table 5.12). In some villages no livestock were kept, for example in Myeik Taung and Kalwin village tracts, there were a total of 13 villages in each village tract but only half of the villages had livestock because the main business in the villages was associated with fishing and the land was not suitable for cultivation because of tidal influences resulting in the land being inundated with salt water.

In the studied villages, farmers grazed their surplus cattle and buffalo on common grazing land. Only cattle used for agricultural (draught) purposes were fed. These received hay and straw only without any other additional feed supplementation. During summer cattle grazed the common grazing land with other cattle from the same village tract. In the rainy season, farmers sent their cattle to areas where there was more feed. One of these areas was located in the Tanintharyi Township and one was near the Sandawut village tract.

Participants reported periodical animal movements within the Myeik Township. Farmers shared common grazing land both in the summer and wet season when they encountered a shortage of feed. Among 7 village tracts which had animals with positive serology in the 2005 survey, animals moved between all of the villages except for Myeik Taung and Thit Yar Wa (Figure 5.5). Buffalo moved from Palaw and Palauk (within Myeik District) to Kalwin and Sandawut for slaughter (route 1). Other movements included from Kahan and Pathaung to Tanintharyi Township (routes 4 and 6, respectively), from Kahan to Sandawut (route 2), and from Kahan to a neighbouring village (route 3) for the purpose of moving animals to common grazing ground. Route 5 between Pathaung and Taung Shae was for livestock exchange (farmers sold old draft cattle and purchased new ones if the farmer wasn't satisfied with their existing animals) after the working season had finished (Table 5.13).

Pictures of typical clinical lesions of FMD were used in the Dutaik meetings to determine the participant's knowledge of the disease and its frequency of occurrence in the area. Respondents from all 6 village tracts, except for Kalwin village tract, said they had not seen similar lesions in their cattle for many years. One farmer from Kalwin village reported that he had seen similar lesions in his 20 year-old cattle in the preceding 3 years. These cattle recovered from the disease after 10 days and the owner showed an old scar wound in one of his cattle from these lesions. None of his neighbours had seen lesions typical of FMD in their livestock. Serum samples were collected from cattle belonging to the man who had seen lesions and were tested for antibodies to FMD. Among the samples collected from his village, the two positives with PI values of 67 and 60 belonged to this farmer. All other samples from Kalwin village were negative and the owners of these cattle had not seen lesions of FMD in the preceding 7 years.

Table 5.12 Animal population as determined by the Dutaik meetings

Name of village tracts	Total number of villages	Total number of households	Animal Population		
			Cattle	Buffalo	Sheep/ Goats
Kahan	4	400	500	400	0
Kalwin	13	2000	300	35	15
Myeik Taung	13	3000	300	0	0
Pathaung	3	300	-*	-*	300
Sandawut	12	2500	380	990	260
Taung Shae	5	552	600	100	100

**Data not available*

Table 5.13 Routes of animal movements within the Myeik Township

Route number*	Species moved	Frequency	Number	Purpose
1	Buffalo	All year round	40 to 200 head per month	For slaughter
2	Buffalo and cattle	Summer and rainy season	50 to 100 head per season	To share grazing ground
3	Buffalo and cattle	Summer and rainy season	20-30 head per season	To share grazing ground
4	Buffalo and cattle	Summer and rainy season	500 to 700 head per season	To share grazing ground
5	Buffalo and cattle	Summer and rainy season	10-20 head per season	To change livestock
6	Buffalo and cattle	Summer and rainy season	300 to 500 head per season	To share grazing ground

** See details in Figure 5.5*

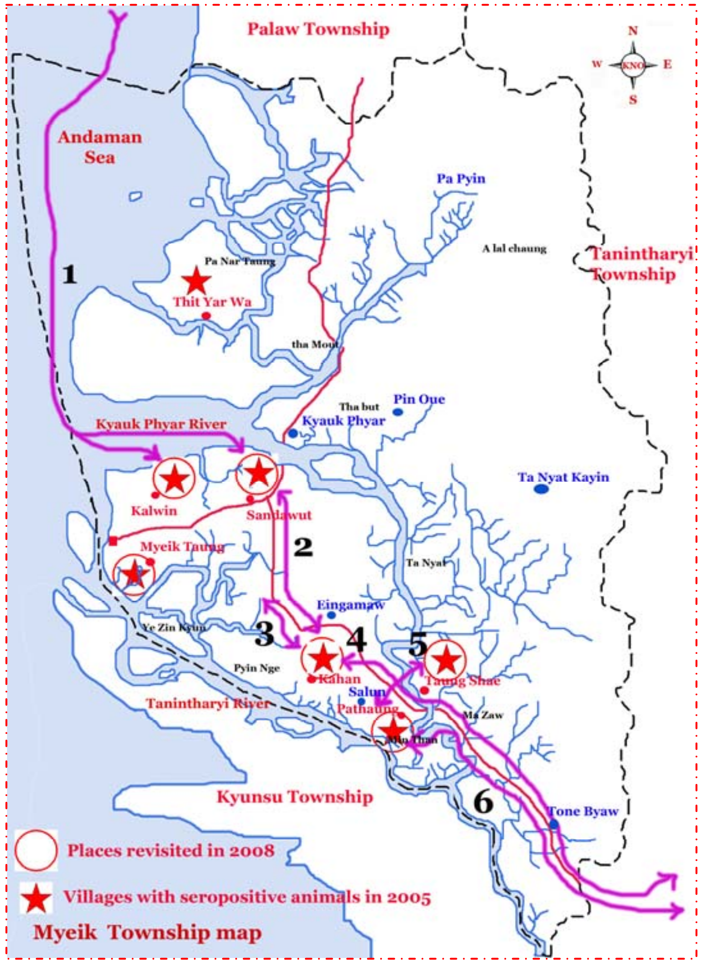


Figure 5.5 Animal movements in the Myeik Township as reported by the farmers.

1. Buffalo movement from Palaw and Palauk for slaughter
2. Cattle movement to share grazing ground from Kahan to Sandawut
3. Cattle movement from Kahan to share grazing ground
4. Cattle movement from Kahan to share grazing ground in Tanintharyi Township
5. Livestock movement for exchange of cattle
6. Cattle movement from Pathaung to Tanintharyi Township to share grazing ground

5.3.5.3 Results of expert opinion

A large scale livestock owner reported that FMD had not been recognised in Kawthoung District for many years. Similarly a licensed butcher in Kawthoung had not seen lesions of FMD. The district officer of Kawthoung District was also interviewed and had not observed lesions of FMD for more than 10 years. Although a goat had demonstrated oral lesions, after treatment with antibiotics this recovered and the condition was not believed to have been FMD. In Myeik District, a township veterinary officer who had worked in Myeik Township for more than 20 years reported that the last outbreak occurred in 1999. Also in Myeik a butcher who was interviewed had not previously seen clinical lesions of FMD.

5.3.5.4 Serological results of 2008 survey

The Cedi® FMDV NS ELISA test revealed 14 positives of the 120 samples tested (11.67, 95% CI 6.53, 18.8) (Table 5.14 - a). The number of positives varied from 5 (of 20) in Sandawut Township to 0 (of 20) in Myeik Taung village tracts.

5.3.5.5 Serological results of 2009 survey

The Cedi® FMDV NS ELISA test revealed 13 positives of the 180 samples tested (7.2, 95% CI 3.9, 12.03) (Table 5.15 - a). The maximum number of positives was detected in Kalwin village tract and minimum number in Kanpyar, Myeik Taung and Sandawut village tracts.

5.3.5.6. Confirmatory result from Pak Chong Laboratory

The confirmatory results for positive samples from the 2008 and 2009 survey of the Myanmar MTM area were issued by the Regional Reference Laboratory (See Table 5.14 - b). Only four samples were positive on Cedi® FMDV NS ELISA test out of 14 samples from the 2008 survey and eight of 13 samples positive from 2009. In addition, LP ELISA results revealed that two samples were positive to Type A and one to Type Asia 1 for the 2008 samples. No samples were positive for Type O. In 2009, one was positive to Type O, four to Type A and five to Type Asia 1.

5.3.5.7 Summary of the follow up investigation results (2007 - 2009)

According to the Dutaik meetings conducted in 2007 and 2009, no participants from the targeted areas, which were considered to be high risk for FMD, had seen clinical signs of FMD in the control and eradication zones for more than 10 years. However the laboratory tests revealed a few positive results on both the Cedi® FMDV NS ELISA test and LP ELISA test.

Table 5.14 (a) ELISA test results from the targeted 6 village tracts in Myeik Township sampled in Feb 2008

Village tract	Cedi ELISA test results (Myanmar FMD lab)		
	Number of Positives	Prevalence (95% CI)	Total
Kahan	4	20 (5.73, 43.66)	20
Kalwin	2	10 (1.23, 31.70)	20
Myeik Taung	0	0 (0.0, 16.85)	20
Pathaung	1	5 (0.13, 24.87)	20
Sandawut	5	25 (8.66, 49.11)	20
Taung Shae	2	10 (1.23, 31.7)	20
Total	**14**	**11.67 (6.53, 18.8)**	**120**

Table 5.14 (b) Detailed LP ELISA results of the positive 14 samples (RRL)

	Village tract		LP ELISA results		
		NS results*	Type O	Type A	Type Asia1
1	KaHan	0	<40	120	40
2	KaHan	0	<40	60	<40
3	KaHan	0	<40	<40	<40
4	KaHan	0	<40	<40	<40
5	KaLwin	1	40	60	53
6	KaLwin	0	<40	40	<40
7	Pathaung	0	<40	<40	<40
8	Sandawut	0	<40	160	<40
9	Sandawut	1	<40	40	<40
10	Sandawut	0	<40	<40	<40
11	Sandawut	1	60	60	320
12	Sandawut	1	<40	<40	<40
13	Taung Shae	0	<40	<40	<40
14	Taung Shae	0	<40	<40	<40
	Total	**14**	**0**	**2**	**1**

**Cedi® FMDV NS ELISA test*

Table 5.15 (a) ELISA test results from Myeik and Kawthoung Districts sampled in May 2009

	Cedi ELISA test results (Myanmar FMD lab)		
Village tract	**Number of Positives**	**Prevalence (95% CI)**	**Total**
Kawthoung District			
10 miles	3	8.5 (1.8, 23.06)	35
Bankachon	1	6.2 (0.16, 30.2)	16
Khamaukkyi	1	33.3 (0.84, 90.57)	3
Shwepyisoe	1	2.3 (0.06, 12.29)	43
Myeik District			
Kalwin	5	20.8 (7.1, 42.1)	24
Kankaung	2	10 (1.23, 31.7)	20
Kanphyar	0	0 (0.0, 23.16)	14
Myeik Taung	0	13.3 (1.6, 40.46)	15
Sandawut	0	0 (0.0, 30.85)	10
Total	**13**	**7.2 (3.9, 12.03)**	**180**

Table 5.15 (b) Detailed LP ELISA results of the positive 13 samples (RRL)

	District	**Village tract**	**NS results***	**LP ELISA results**		
				Type O	**Type A**	**Type Asia1**
1.	Kawthoung	10 Miles	1	<40	<60	<53
2.	Kawthoung	10 Miles	0	<40	<40	<40
3.	Kawthoung	10 Miles	0	<40	<40	53
4.	Kawthoung	BanKaChon	1	<40	<40	<40
5.	Kawthoung	KhaMoutKyee	0	<40	<40	<40
6.	Kawthoung	Shwe Pyi Soe	0	<40	<40	<40
7.	Myeik	Kalwin	1	<40	80	146
8.	Myeik	Kalwin	1	320	320	1813
9.	Myeik	Kalwin	1	40	<40	173
10.	Myeik	Kalwin	1	<40	100	333
11.	Myeik	Kalwin	1	<40	320	373
12.	Myeik	KanKhaung	0	<40	<40	<40
13.	Myeik	KanKhaung	1	<40	<40	<40
	Total		**8**	**1**	**4**	**5**

**Cedi® FMDV NS ELISA test*

5.4. Discussion

The results of the active sero-surveillance in 2005 revealed a prevalence (test/apparent prevalence) of 0.64% (95% CI 0.26, 1.31%) (Table 5.3) and consequently the region was approved as a control zone for FMD in accordance with the minimum requirements of the Standard Rules and Regulations for the MTM (Turton, 2004). In contrast, the test prevalence of the re-evaluation for 2005 survey (Table 5.5) was 1.46% (95% CI 0.84, 2.36%). The positive samples were not clustered in Myeik Township but were scattered among 10 village tracts. The maximum number of positives from any one village tract was three (3/26 in Pa Thaung village tract - Table 5.7).

All positives results (before the re-evaluation study) were retested in November 2005 and confirmed as false positive results. If these results had been true positives, they could have come from two sources: FMDV circulating among susceptible animals in the region by carrier animals, or from previously infected or carrier animals introduced from outside the Myanmar MTM area.

If FMDV was still circulating in the Myanmar MTM area it would have originated from the last outbreak in February 1999. The serological survey was conducted in mid-2005, six years after the last reported outbreak in the Myanmar MTM area. Although cattle can carry the virus for over 3 years (Kitching, 2002b), the chance of a susceptible animal acquiring infection from a carrier is low, even when the susceptible animals are stressed (Sutmoller and Casas, 2002). Therefore, it is extremely unlikely that the virus was circulating in the Myanmar MTM zone at the time of the sero-surveillance study.

If an animal with past exposure, as indicated by the presence of antibody, was introduced it may have arrived in two ways. The animals may have been returned from the border with Thailand to the Myanmar MTM area, which was reported after the confiscation of cattle late in 2002 by the military following the illegal movement of livestock (Edwards, 2004a). It is likely that this form of livestock movement is rarely used by traders. Secondly animals may have come from other parts of Myanmar, such as the close states of Mon and Kayin or from Yangon Division, to the MTM zone. Again this is considered extremely unlikely because transportation is both difficult and costly. Furthermore the value of cattle is consistent across Myanmar and the MTM area and hence there is no economic incentive to move cattle south into the MTM zone. However, buffalo were moved to Myeik for slaughter (Figure 5.5), and it is difficult to establish exactly how well the movements are controlled once the animals arrive in the Myeik Township. Consequently it is believed that either route of introduction of previously infected animals is possible i.e. from the border areas to Myanmar MTM or from futher north within Myanmar.

If the illegal movement of carrier cattle, in contrast to cattle with antibody, is considered to be a possibility, then it would be expected that susceptible animals would have become affected. No vaccine had been used in the proposed control and eradication zones for more than 7 years, so there should be no immunity present in animals from this area. Consequently one would have expected that in the susceptible population evidence of clinical disease would have occurred if FMD was truly present. The fact that focused questioning of villagers in the zone failed to detect a history of FMD would indicate that the disease was not present. It is important to note that there is no incentive or disincentive for villagers to report outbreaks of FMD, and therefore the information obtained during interview could be expected to be relatively unbiased and given the close association between farmers and their animals, sensitive.

The positive test results in 2005 were most probably false positive reactions. The specificity of the Bommeli test kit is 98% based on testing cattle in an endemic area (Bronsvoort *et al.*, 2004b) and therefore approximately 2% of non-diseased animals would be expected to be test-positive. The specificity of the Bommeli test kit was described in a study conducted in New Zealand, a free country for FMD, in 2008. This study reported a specificity after using one test of 99.7% (Kittelberger *et al.*, 2008). If this test is used in a country/region free of FMD, the specificity would result in some false positive results. The results of the 2005 serological survey in the Myanmar MTM area (test/apparent prevalence in re-evaluated samples was 1.46%, 95% CI 0.84 - 2.36) which was not different to that expected (2%) given the tests specificity.

After the 2005 sero-surveillance campaign, staff of the LBVD were asked to report any suspected cases of FMD, and to collect serum samples for testing for the presence of FMDV antibodies in the region. There were no suspected cases reported between the end of the sero-surveillance study in 2005 and the time of this study.

Associations between the likelihood of testing positive and risk factors including gender, species and age groups were also calculated for the results of the 2005 survey. Gender and species had no influence on the sero-prevalence. In contrast older animals (between 8 and 17 years) were 3.6 times (95% CI 1.3, 9.1) more likely to be sero-positive to the Bommeli test than were younger animals (between 1 and 7 years). A study investigating potential risk factors for FMD in Southern Ethiopia also reported that increasing age was associated with the occurrence of FMD because young animals had less opportunity for exposure to infection (Megersa *et al.*, 2009). This could be interpreted as meaning that the older animals were more likely to have been exposed to FMDV and could be viral carriers in the Myanmar MTM area. Alternatively age could be a confounder. In fact, according to the passive and active surveillance results, the last reported outbreak in the Myeik District was in 1999 (Latt, 2006a) and there have been no further outbreaks reported in the Myeik District. Therefore, it is possible that the statistical association between age and positivity is confounded by another factor. However, there is little evidence that older animals would be more likely to be introduced to the Myeik district. There is evidence to suggest that neutralizing antibodies from natural infection could last for more than 5 years (Doel, 2005). In one experimental study, the CHEKIT FMD 3ABC bo-ov kit could detect antibodies to the NSP in sera 609 days after infection, but the virus could not be isolated after 553 days (Moonen *et al.*, 2004a). If some cattle had indeed become carriers after the 1999 outbreak, the very low prevalence in 2005 would indicate that the virus had not spread from the carriers to susceptible animals within the 6-year period. Similar findings have been reported by others highlighting the very low risk of transmission of FMD from carrier to susceptible animals by direct contact (Sutmoller *et al.*, 2003). In fact, if infection had spread to susceptible animals in the Myeik District, there would almost certainly be animals displaying clinical signs since all cattle were naïve. There were no clinical cases of FMD between the outbreak in 1999 and the 2005 sero-surveillance programme in the district and positive samples that were retested in 2005 were negative.

Some samples from the Myanmar MTM area were tested at the Regional Reference Laboratory, Pak Chong, Thailand using three different tests: Check Kit, Cedi and LP ELISA. Although some positive results were found on both the Bommeli and Cedi tests (Table 5.4), the LP ELISA at the Regional Reference Laboratory revealed there was no antibody or a very low antibody level to types O, A and Asia1 (Abila, 2007). In a study conducted in Myanmar in 2006 for the differentiation between vaccinated and non-vaccinated cattle, specificities of 92.2, 90.5 and 76.5 % were found for the Bommeli, UBI and Cedi ELISA tests respectively (Kyin, 2007). Another study in East and Central Africa using Cedi tests to measure the sero-prevalence of FMD in buffalo showed a specificity of 87.3% in that species (Barrette *et al.*, 2006; Perkins *et al.*, 2007; Xiao *et al.*, 2007; Bronsvoort *et al.*, 2008). The authors reported similar estimates for the specificity of the Cedi test in other domestic bovine species and suggested that this test was suitable for screening of FMD. Using these specificity values, the positive results from the targeted sero-surveillance of Myanmar MTM areas in 2008 and in 2009 (Table 5.14 (a) and 5.15 (b)) could possibly be false positive results.

The results from the follow-up investigation in 2007 and 2008 revealed that clinical disease was not present, even though 14 of 120 samples in 2008 and 13 of 180 samples in 2009 were positive to the Cedi® FMDV NS ELISA. These positive results could be assumed to be false positives because of the specificity of the Cedi test kit (mean of 82.5% in the National FMD laboratory of Myanmar where the samples from the current study were tested) (Kyin, 2007). However if the most authoritative sensivivity and specificity figures of Cedi® FMDV NS ELISA tests (Engel *et al.*, 2008) are used to estimate true prevalence with the formula using sensitivity, specificity, apparent prevalence (Rogan and Gladen, 1978; Martin *et al.*, 1987) for the 2008 and 2009 survey, then the true prevalence estimates are 9.2% and 4.5% respectively. Again if these results are assumed to be true positives then this would most likely be an indication of movement of previously exposed animals from an infected area of FMD to the study area. This is possible given that the NSP can detect infection up to 609 days after infection (Moonen *et al.*, 2004a) and there was no clinical evidence of FMD in the study area. The liquid phase blocking ELISA can detect the antibodies of FMD (≥Log10 = 2.1 or > 1:80) 150 days post vaccination (Periolo *et al.*, 1993) and 304 days post infection with log 10 > 3.1 or >1320 (Mackay *et al.*, 1998b). Antibodies to more than one specific serotype can be detected in mixed infections but the probability of getting these results is low (Woodbury *et al.*, 1994). Therefore, these animals might have been exposed to FMDV before they were introduced to the study area if they were truely not vaccinated against FMD.

At the time of the 2008 and 2009 sero-surveillance study, the only available test in Myanmar was the Cedi® FMDV NS ELISA test and there were no other alternative serological assays. Subsequent testing of these positive samples was undertaken at the Regional Reference Laboratory Pak Choung. The LP ELISA results as received indicated some evidence of exposure to Type Asia 1, Type A and Type O among the samples collected in 2008 and 2009. The most prominent Type was Type Asia 1. These results were unexpected and require further follow up investigation. However possible explanations include: Type Asia 1 has been present undetected in Myanmar; laboratory error (contamination during the stages of storage, transfer of serum); illegal use of vaccine; or movement of cattle from neighbouring countries where Type Asia 1 is present such as India and Bangladesh. More detailed research is required to explain why evidence of exposure to Type Asia 1 was found in the MTM area of Myanmar after the last reported outbreak in 2005 in Kayar State of Myanmar.

During an earlier follow up investigation study, participants who engaged in the Dutaik meeting reported the animal movement routes between the targeted village tracts. Therefore, if FMD occurred in a particular village tract, it would be transmitted very easily to other village tracts. However, no reports of clinical cases were documented during this study. Among fully susceptible non-vaccinated cattle, the clinical lesions of FMD are very severe and obvious (Kitching, 2002a). In contrast subclinical infection is common in sheep and goats and it can be difficult to detect clinical lesions (Kitching and Hughes, 2002). Most of the participants engaged in the

Dutaik meeting were cattle owners and had not seen lesions of FMD in the Kawthoung District for more than 15 years and for more than 10 years in Myeik. In a report submitted to the FAO on the participatory disease investigation of FMD in Turkey, it was mentioned that farmers could accurately identify the clinical signs of FMD (Admassu and Ababa, 2006). Similarly in the MTD meeting in this study, some old people reported having seen the signs of FMD when they were young and they could easily remember the characteristic clinical lesions. These experienced persons insisted that the disease is infectious in nature and they were aware that in an outbreak a large number of animals would be affected. It has been reported that the sensitivity and specificity of clinical observation by farmers and veterinarians are relatively high (McLaws *et al.*, 2006) and clinical observations were used to diagnose the disease in the 2001 outbreak in the UK. This would indicate that FMD had not occurred in the Myanmar MTM area for quite some time.

In the participatory approach it is possible that subclinical lesions in cattle were not observed or detected by owners. However,if the cattle which showed LP ELISA positive reactions (Tables 5.14 - b and 5.15 - b) were considered as subclinical animals, these cattle most probably had been vaccinated against FMD and were exposed to FMDV (Kitching, 2002b) and consequently these cattle pose a risk to a naïve population. In the Myanmar MTM area, vaccination against FMD has not been used for many years, therefore if there was an introduction of a subclinical carrier to a naïve population of cattle, the clinical signs of FMD would be expected to be dramatic (Kitching, 2002b). During the MTD meetings conducted in the villages where samples were collected, no farmer reported the presence of clinical signs characteristic of FMD. Therefore, the chance of being a subclinical animal would be expected to be very low. All experts interviewed were of the opinion that the prevalence of FMD in the MTM area of Myanmar was very low and positive results from the 2005 serological survey were highly likely to be false positive results. Subsequent detection of more seropositives has raised the question of whether previously exposed animals may have moved into the MTM area and this requires further investigation.

In conclusion, the Myanmar MTM region possesses natural barriers to minimise the introduction and dissemination of FMDV (Sobrino and Domingo, 2001), a highly susceptible population, and outward movement of livestock from the proposed control and buffer zones. These factors favour this region in Myanmar to be naturally free from FMD at the time of this study. To substantiate freedom of FMD as an OIE recognized zone in the Myanmar MTM area, more surveillance is required with appropriate study design including consideration of the sensivity and specificity of a test, survey design and effectiveness of control measures (Paton *et al.*, 2006). Foot and Mouth Disease has a large impact on livestock production and productivity in affected countries, however in countries where the disease is endemic farmers frequently do not appreciate the financial losses from this disease. In the next chapter the financial impact of FMD in Myanmar on animal draught power and farming enterprises are outlined.

The establishment of a disease control zone in the Sagaing Division and the influence of Foot and Mouth Disease on agricultural production and economic return

6.1 Introduction

Foot and Mouth Disease results in a significant economic loss for countries that are infected. It reduces animal production through reduced milk yields, abortions and decreased conception rate, increased foetal mortality, lameness in draught animals and weight loss (James and Rushton, 2002; Grubman and Barry, 2004). It is recognized as one of the most important transboundary animal diseases (Rweyemamu and Astudillo, 2002; Sumption *et al.*, 2007). The disease results in a large financial burden for affected countries which primarily are developing or underdeveloped nations (James and Ellis, 1978; Saxena, 1994). However it also leads to economic losses for individual farmers through reduced production and loss of use of draught cattle (Mersie *et al.*, 1992).

The impact of FMD depends on the country's status. The disease has a large impact on previously free countries who export livestock, while the impact on infected countries which do not export livestock is less (James and Rushton, 2002). Myanmar possesses a large number of surplus livestock and is a potential source of livestock for other Southeast Asian countries. In Myanmar animal draught power is used in agricultural work and transportation in most rural areas (Gleeson, 2002). Within the country, the Sagaing Division has been considered to be a source of FMD, not only for Myanmar, but also for neighbouring countries because it has more surplus livestock than other divisions and animal movement is predominantly outward (MZWG 1, 2004a; Rweyemamu *et al.*, 2008b). Therefore, the establishment of a control zone for FMD would have a great impact for the country in terms of both the national economy and for individual farmers. Understanding the impact of FMD is crucial for the establishment of a control zone in the Sagaing Division. Awareness of the impact of FMD by farmers has been shown to be correlated with the success of control programmes against FMD (Saini *et al.*, 1992). Heightened awareness of the disease's impact overcomes problems with farmers who may be unwilling to participate in a disease control programme or be reluctant to vaccinate their animals (Mendoza *et al.*, 1978).

Before this study, questionnaire interviews and the MTD meetings were conducted in other parts of the Sagaing Division (See Chapters 2 and 3). Some information from these studies was also used to study the economic impact of FMD. During these studies, participants reported the influence of FMD on their agricultural work. Most participants focused on the direct impact of FMD on draught power, which is one of the main inputs for livestock in the agricultural system in Myanmar.

6.1.1 Farmer's perspectives on livestock management

During the MTD meetings, participants reported that they were very much aware of FMD in their locality. The disease caused different problems and constraints to farmers who owned draught or dairy cattle (Figure 6.1). Reported consequences in draught cattle were loss of draught power, loss of money and time to look after the infected (sick) animals and the cost of hiring other draft cattle to continue their agricultural work. Farmers commented that it was better to have infected cattle recover quickly within one or two weeks, than to have chronic cases. For chronic cases, the additional consequences were hoof problems (lameness and excessive horn growth of the toe), heat intolerance due to overgrowth of body hair, lack of stamina (could not work as before and became easily tired), weakness, and debility followed by death.

When farmers wanted to sell these cattle, their value was decreased by as much as 50% of the pre-infected value (Figure 6.1).

In Myanmar, there are two cultivation seasons in a year: the monsoon season and the winter season. The number of working days in the monsoon season is greater (approximately 60% of all working days) (Min, 2006) than for the winter season. Farmers reported in the MTD meetings that they could not use their draught cattle for a part of a working season if their animals were infected with FMD.

This study was conducted in the Sagaing Township and focused on the issues relating to animal draught power. The objective of the study outlined in this chapter was to understand the economic impact of FMD at a local (farmer) and national level.

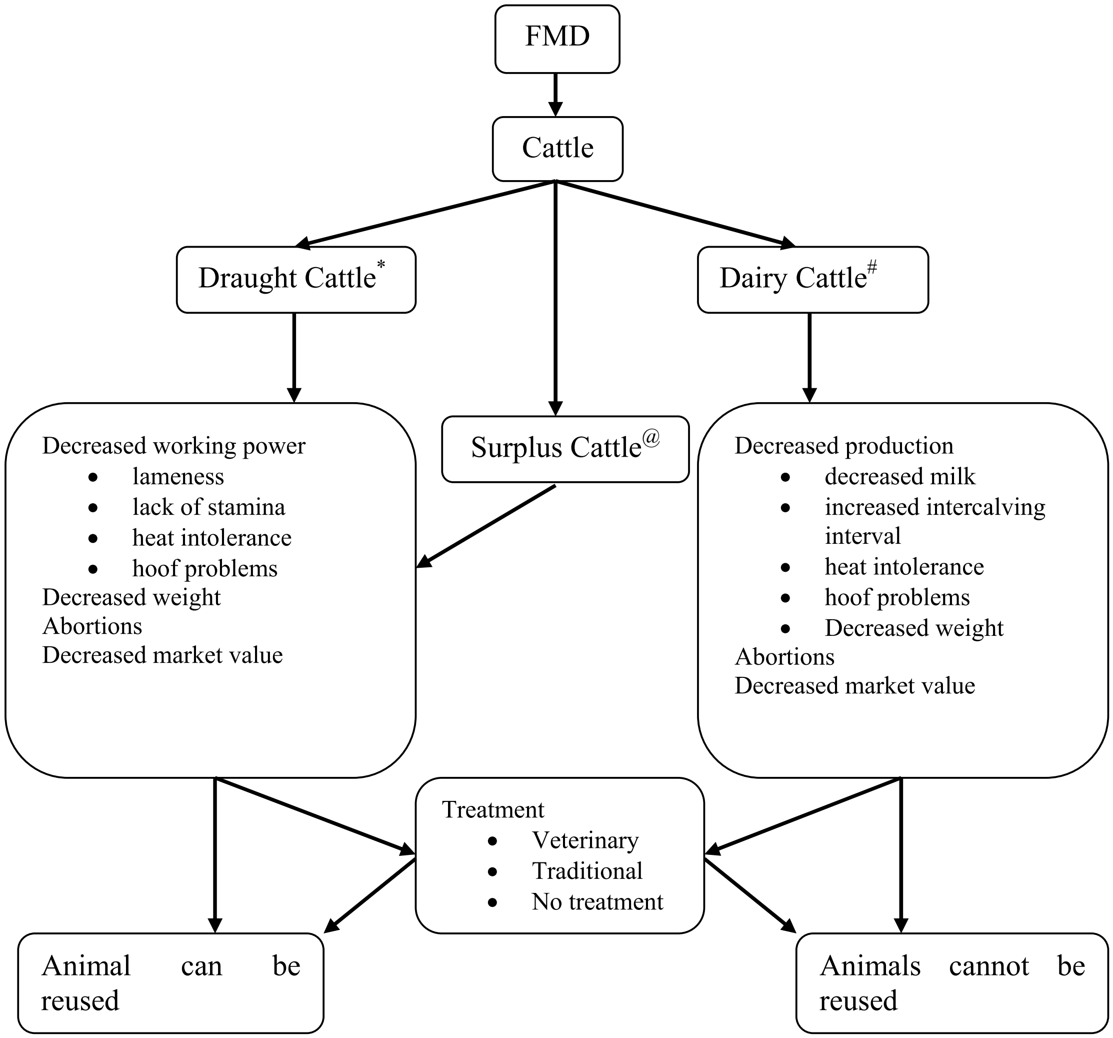


Figure 6.1 Influence of FMD on cattle as reported by farmers of the Sagaing Division

*Draught cattle - Adult male cattle used in the field
#Dairy cattle - Milk producing cattle (25% to 65% cross bred Holstein Friesian)
@Surplus cattle - calves, female local cattle and cattle not used in field

6.2 Materials and methods

Two economic studies were conducted in the proposed control zone of the Sagaing Division. The first was done in late 2007 in the selected 17 villages of the Sagaing Township (See Chapter 4). During that study, the information on the influence of FMD on draught animals was collected from both the MTD meeting approach and from questionnaire interviews. This study was conducted at the same time as the study to validate the MTD meeting approach with sera collected from animals from the same villages (Chapter 4). The collected information was summarized and the data tabulated. Information was gathered at the village level rather than the individual farmer level.

In questionnaire interviews, farmers were asked about their personal experience with FMD in their cattle. The questionnaire included experiences with outbreaks of FMD, cost of hiring draught cattle, type and cost of treatment of infected animals, use and cost of vaccines against FMD and the current market value of draught cattle before and after infection with FMD. In addition, supporting information was taken from the previous studies reported in Chapters 2 and 3.

Both the MTD meeting and questionnaires were conducted in each village on the same day and included topics on the influence of FMD on the agricultural industry of the region. Discussions were recorded and transcribed into Myanmar language and summarized in English. In this study, the influence of FMD at the village level was modelled using Monte Carlo simulations with the assumptions outlined below.

A second study was undertaken in January 2009. This was a farmer household survey which was conducted in seven villages of the Sagaing Township to understand the potential consequence of FMD at the individual farmer level. These seven villages were previously visited in the 2007 survey. These villages were selected from the 17 previously visited villages based on availability of staff from the LBVD. In this study, two techniques were used, the MTD meeting approach and questionnaire interviews. The questionnaires were different to those administered in the previous economic survey and focused on the individual household. The questionnaires are attached in Appendix 3.

6.2.1 Assumptions used to determine the influence of FMD at the village level

To estimate the influence of FMD on a village, several assumptions were made. The analysis was calculated at the village level rather that at the individual farmer level. Although an outbreak of FMD could occur at any time of the working seasons (monsoon or winter crop cultivation season), it was assumed that the outbreak occurred at the beginning of the monsoon season because of existing data from the LBVD (Figure 1.3). An assumption of one outbreak per year was used. Farmers reported that there were several treatment options for affected cattle including using traditional medicines, calling a private veterinarian or veterinary staff from the LBVD or allowing the animals to recover without treatment. In this analysis, the proportion of farmers using the services of veterinarians was obtained by using expert opinion of local staff. The cost of the treatment administered by a veterinarian was estimated from the MTD meeting. Although FMD can result in abortions, decreased milk production, lameness and foetal death (James and Rushton, 2002; Grubman and Barry, 2004), in this study only loss of animal draught power (Mathew and Menon, 2008) and related issues were considered.

6.2.2 Economic Analysis (Monte Carlo simulation model)

The influence of FMD in the studied areas was analysed using a partial budget analysis (Marsh, 1999; Swinkels *et al.*, 2005). The input variables are listed in Table

6.2. Total cattle refer to the total number of cattle in the particular village including calves, cows, castrated and entire cattle and dairy cattle. The proportion of draught cattle is the proportion of all cattle used for draught purposes in a particular village. The average market value of draught cattle is the value when farmers buy or sell these cattle and was calculated from the questionnaire interviews. The total number of working days was the number of days which farmers used their draught cattle in the field for cultivation purposes only. The proportion of working days needed to hire draught cattle was the proportion of the total working days that farmers needed to hire draught cattle for their work when FMD occurred. The cost of hiring cattle was the daily cost to hire a pair of cattle and included the cost of feeding. The probability of getting infection was provided by local farmers during the MTD meeting and questionnaire interviews and was the chance of cattle being involved in an outbreak. The proportion of farmers using traditional treatments was obtained by expert opinion. The cost of traditional treatments and treatment by a veterinarian were taken from the questionnaires and information from the MTD meetings. The proportion of draught cattle sold in a year was the subset of draught cattle which were sold in a year because they were not fit for work or the farmers wanted to replace them with better ones. The devalued percentage is the reduction in the market value for draught cattle after they had been infected with FMD. The cost of vaccination was the amount farmers were required to pay to vaccinate their draught cattle against FMD. The frequency of vaccine was the number of times animals were vaccinated each year.

In the model, the incidence of FMD was classified as one of four categories: an outbreak every year, and one every two, three or four years based on information from the MTD meetings. The model was evaluated for 12 years using these four incidences. The assumptions were put in a Pert distribution for analysis. The minimum and maximum percentages for infection with FMD were based on information collected from the MTD meetings (Table 6.1). If vaccine was used in the proposed area, the minimum incidence was 0 and the maximum 10% with a likely incidence of 5% per year (Table 6.1) because the efficacy of FMD vaccine would not be 100% (Periolo *et al.*, 1993; Barnett and Carabin, 2002). These assumptions were entered into the formulas outlined in Section 6.2.2.1.

In this study, feeding and management costs were not included as farmers would not change their cattle's ration irrespective if they were infected or not. Moreover, when they hire other cattle because their own cattle were infected with FMD, they did not need to pay for the feed of the hired cattle as the cost of hiring cattle included the cost of feeding.

Table 6.1 Assumptions used in modelling disease over a 12-year period

	Likelihood of value		
Outbreak of FMD	Minimum	Most likely	Maximum
Every year	20%	25%	30%
Every two years	40%	50%	60%
Every three years	65%	75%	80%
Every four years	85%	90%	95%
Vaccine used	0	5%	10%
Total number of cattle	800	987	1500
Proportion of affected animals	0.3	0.4	0.7

Table 6.2 Names of variables used in the partial budget analysis

Input variables	Acronym	Unit
Total cattle	TC	whole number
Proportion of draught cattle	PrDr	whole number
Average market value of draught cattle	MVdr	Kyats
Total working days	TWD	Days
Proportion of working days needed to hire draught cattle	PrDh	%
Cost of hiring draught cattle per day	CHC	Kyats
Probability of getting FMD	PrFMD	%
Proportion of farmers used traditional treatments	PrTT	%
Cost of traditional treatment	CTT	Kyats
Cost of veterinary treatment	CTV	Kyats
Proportion of draught cattle sold in a year	PrSel	%
Depreciated value (percentage) from presence of FMD	DeV	%
Cost of Vaccination	CVx	Kyats
Frequency of vaccination	FrV	times

6.2.2.1 Calculation for Monte Carlo Simulation model

The net benefit for the control of FMD with vaccination was calculated as

Additional Benefit = Benefit without FMD - Benefit with FMD

Reduced cost = Cost with FMD - Cost without FMD

Total Benefit = Additional Benefit + Reduced cost

The equations used to calculate the benefit of selling draught animals are outlined in Table 6.3.

Information from the questionnaires and MTD meetings was used to calculate the total number of draught cattle sold each year (Table 6.3). It was assumed that a certain proportion of cattle sold by farmers were draught cattle (Eq1 - Table 6.3). If there was no FMD, they would receive the maximum market value (Eq2 - Table 6.3). If FMD occurred farmers would receive a depreciated value equivalent to the value of the meat (Eq3 - Table 6.3) whereas other healthy cattle would realise the maximum value (Eq4 - Table 6.3). The difference between the value of draught cattle sold per year without FMD and with FMD was then calculated (Eq 5 - Table 6.3).

Table 6.3 Calculation of benefit of draught animals sold

Equations	Variables	Acronym	Calculations
Eq 1	Total number of draught cattle sold each year	TDCS	TC*PrDr*PrSel
Eq 2	Total value of cattle sold each year (No FMD)	TVC1	TDCS*MVdr
Eq 3	Total value of cattle sold each year (With FMD1)	TVC2	TDCS*PrFMD*MVdr*DeV
Eq 4	Total value of cattle sold each year (With FMD2)	TVC3	TDCS*(1-PrFMD)*MVdr
Eq 5	Net Benefit from value of cattle sold	NBVC	TVC1-(TVC2+TVC3)

Table 6.4 Calculation of the benefit on animal draught cattle power

Equations	Variables	Acronym	Calculations
Eq 6	Total number of cattle used for draught power	TDCDP	TC*PrDr
Eq 7	Total value of draught power (No FMD)	TDP1	TDCDP*TWD*(CHC/2)
Eq 8	Total number of cattle infected	TDCIn	TC*PrDr*PrFMD
Eq 9	Total value of draught power from infected cattle (With FMD1)	TDP2	TDCIn*(TWD*(1-PrDh))*(CHC/2)
Eq 10	Total value of draught cattle not infected	TDCUn	TC*PrDr*(1-PrFMD)
Eq 11	Total value of draught power (With FMD2)	TDP3	TDCUn*TWD*(CHC/2)
Eq 12	Net Benefit from value of draught cattle power	NBVDP	TDP1-(TDP2+TDP3)

Table 6.5 Total net benefit on value of draught animal and its working power

Equations	Variables	Acronym	Calculations
Eq 13	Net Benefit on draught animal and draught power	NBCSD	NBVC+NBVDP

Table 6.6 Total cost of the consequence of FMD

Equations	Variables	Acronym	Calculations
Eq 14	Total cost of treatment for traditional treatments	TCTT	TDCIn*PrTT*CTT
Eq 15	Total cost of treatment with veterinary treatments	TCTV	TDCIn*(1-PrTT)*CTV
Eq 16	Total cost of hiring cattle	TCHC	TDCIn*TWD*PrDh*(CHC/2)
Eq 17	Total cost with FMD	TCF	TCTT+TCTV+TCHC

Table 6.7 Total cost without FMD

Equations	Variables	Acronym	Calculations
Eq 18	Cost of vaccination	CVx	TC*PrDr*CVx*FrV
Eq 19	Total cost without FMD	TCWF	CVx

Table 6.8 Incremental benefit due to FMD and without FMD

Equations	Variables	Acronym	Calculations
Eq 20	Total cost reduction	TCR	TCF-TCWF

Table 6.9 Aggregated net benefit of the control of FMD on draught cattle

Equations	Variables	Acronym	Calculations
Eq 21	Net benefit for the control of FMD	NB	NBCSD+TCR

To calculate the benefit on the value of draught power, it is necessary to know the total number of working cattle in a village (Eq6 - Table 6.4), the cost of hiring draught cattle and the total number of working days animals would be hired for. In this study, the value of the total draught power for cattle from a village without FMD was calculated from the total number of working days and the cost of hiring cattle (Eq7 - Table 6.4). It did not include the use of animals for transportation, carrying goods, or for crushing sesame seeds or peanuts for producing oil. In this calculation, participants reported the cost of hiring a pair of draught cattle for one day. Therefore to determine the total cost of hiring cattle this number was divided by 2 and multiplied by the total number of cattle used for draught cattle power in a village and the total number of working days (Eq7 - Table 6.4).

If FMD occurred, farmers could not obtain the full working power from their own cattle. They could only use their cattle for a proportion of the required number of working days in a year. To calculate the value of draught working capacity of those cattle which were infected within a working season, it is first necessary to know the total number of infected cattle in a given year (Eq8 - Table 6.4). Then, the infected number of cattle was multiplied by the remaining total number of working days and the cost of hiring one draught cattle (Eq9 - Table 6.4). In the year in which outbreaks of FMD occur, only uninfected cattle could provide full draught capacity. The total number of draught cattle which were not infected was calculated by using the total number of cattle in a village, the proportion of draught cattle and the probability of getting FMD (Eq10 - Table 6.4). The value of draught cattle which were not infected during an outbreak was calculated by multiplying the total number of uninfected animals, the total number of working days and the cost of hiring cattle for a day (Eq11 - Table 6.4). During the period in which draught cattle were infected with FMD, farmers needed to hire other healthy draught cattle. Therefore, the net loss of draught cattle power could be calculated by the difference between the value when FMD was not present with the value when FMD was present (Eq12 - Table 6.4). The net loss of the value of draught animals and the value of draught power could then be calculated (Eq13 - Table 6.5).

If FMD occurred, it was assumed that farmers would have two additional costs: treatment of sick animals; and the hiring of replacement draught cattle. Other costs, such as the labour costs involved in looking after sick animals, costs from providing more nutritious feed by feeding sesame or peanut cake, were not considered in this analysis. To know the cost of treating sick cattle after being infected with FMD, the total number of draught cattle which could be infected with FMD was first estimated (Eq8 - Table 6.4). Even though some farmers did not treat their infected animals, it was assumed that all farmers treated all sick animals with either traditional medicines or by using the services of a veterinarian practitioner. The proportion of farmers who used traditional treatments was estimated from expert opinion of staff working in the studied areas. Data on the cost of treatment for each type was taken from the questionnaires and the MTD meetings. It was extrapolated by using the total number of infected animals, the proportion of farmers who used traditional treatments (Eq14 –Table 6.6), the proportion who did not use traditional treatments (Eq15 - Table 6.6) and the cost of traditional and veterinary treatments. The cost of hiring a pair of draught cattle (Eq16 – Table 6.6) was added to these treatment costs (Eq17 - Table 6.6).

If FMD could be controlled by vaccination, farmers would not be required to spend the cost mentioned above; however they would have to pay for the cost of vaccination. To prevent FMD, cattle have to be vaccinated twice a year (LBVD vaccination plan for FMD - Pers. com. Dr Min Nyunt Oo and Dr Khin Maung Latt).

Some farmers used vaccine in the study area and information on the cost of this vaccine was obtained from these farmers from the MTD meeting (Table 6.13). The cost of vaccination was derived by multiplying the total number of cattle, the proportion of draught cattle, the cost of a dose of vaccine and the frequency of vaccination (Eq18 - Table 6.7). Therefore, it was assumed that the total cost for farmers who had no problems with FMD would be the cost of vaccination even though the vaccine was not 100% efficacious (Rweyemamu and Astudillo, 2002; Keeling *et al.*, 2003). (Eq19 - Table 6.7).

The difference between the total cost with FMD and the total cost without FMD was calculated (Eq20 - Table 6.8) to measure the benefit of controlling FMD by vaccination. The overall benefit for the control of FMD in draught animals in a village was calculated by adding the net benefit of animals sold, the net benefit of draught output and the value of the additional costs (Eq 21 - Table 6.9).

All equations were entered into Microsoft Office Excel 2007 (Microsoft Inc. USA) to calculate the loss due to FMD. Pop Tools version 3.0, build 4, Release date: 4 Mar 2008 (CSIRO, Australia) was used to undertake the Monte Carlo simulation. The total losses for each category (every one, two, three or four years) were calculated by running a Monte Carlo simulation 10,000 times and the results saved to separate Excel sheets. The results were then summarized and charted (Figures 6.2 to 6.5).

6.2.3 Sensitivity analysis

Sensitivity analysis (Wittum, 1996) was undertaken (manually by Microsoft EXCEL) to determine the impact of changes in the proportion of draught animals, percentage loss on selling infected cattle, proportion of days needed to hire cattle, cost of vaccination, value of draught cattle and value of draught power on the influence of the benefit of controlling FMD. For estimating the effect of changing a particular variable, the other variables were set at the original median value.

6.2.4 Farm household survey

During the survey in January 2009, the farm household head was interviewed using a questionnaire (Appendix 3). Information and data about the economic condition of each household, including the household income and expenditure was collected. Total household income was recorded along with total household expenditure for both agricultural and non-agricultural enterprises including the household personal expenditures. A household was classified as a group which shared the same budget income, lived under the same roof and ate meals together. The questionnaire gathered information on the following items: composition of the household, area of land and land use, total farm production and output, income and expenditures, ownership of livestock and species owned and the knowledge and experiences of the effect of FMD within the preceding two years. Each household was asked to determine if household income was greater than household expenditures.

6.2.5 Statistical analysis and data management

The collected data were entered into an Excel spreadsheet and the normality of these data was checked by the Shapiro-Wilk test using Statistix 9 analytical software. Amongst the data (Tables 6.10 and 6.13) collected from the MTD meeting and the questionnaire interviews, the median values of the total number of cattle, market value of cattle, total working days, cost of hiring cattle and cost of treatment were used in the partial budget analysis and Monte Carlo simulation model. To reduce the impact of skewness of the economic variables from the household survey data, the geometric mean was used to measure the central tendency of both income and expenditure for farm household survey data (Sheskin, 2004; Elliott and Payne, 2005).

6.3 Results

A summary of villages, total participants, and animal population was obtained from the MTD meeting in 2007 and is summarised in Table 6.10. The studied villages were divided into two groups to identify potential risk factors of having large ruminants and/or small ruminants and the animal movement route (See Chapter 4). The total number of cattle in a village varied from 280 to 5000 head (Table 6.10). Even though there was a wide range in the number of animals in the villages, the sero-prevalence was high in all villages (Table 6.11). Antibodies to FMD were detected from some animals from all villages indicating that FMD had a potential influence on draught cattle from all villages.

6.3.1 Management, disease information and impact of FMD at the village level

In the MTD meeting in 2007, the majority of participants reported that they gave treatments to their draught cattle when they were infected. In contrast, for surplus cattle either no treatments were given or only traditional treatments were used. Farmers reported that they paid more attention to working draught cattle than to surplus cattle as the draught cattle were very important for their agricultural enterprise. If the disease was severe or they did not give proper treatment to their draught cattle, they encountered hoof problems and heat intolerance in affected animals. Even though animals which recovered from FMD were subsequently used, some animals could not be used because of such complications.

Table 6.10 Summary of villages, participants and total livestock population

Village	Number of participants [a]	Number of households [a]	Animal Population [a]		
			Cattle	Sheep	Goat
Byaetayaw	21	495	500	0	0
Kinepyin	20	*	450	0	0
Koneywa	8	520	2000	150	150
Kyakhat	22	121	350	*	*
Ma-U-Pin	15	150	500	5	5
Myinsel	17	364	2000	0	0
Natkhayaing	18	300	1500	250	250
Ngatayaw	13	446	3000	0	0
Knowndwin	12	200	2000	150	150
Padu	16	975	5000	1000	1000
Paukma	8	165	300	*	*
Sintat	15	*	987	0	0
Taeintel	15	300	800	*	*
U-Eain-kyun	22	100	280	0	0
Yeatwinkhaung	16	700	2500	140	140
Ywama	11	477	1760	150	150
Ywathitgyi	13	160	500	*	*

[a] Data from the MTD meeting
**Data not available*

Table 6.11 Summary of serological results in the studied villages

Village name	Serological results		History of Last Outbreak	
	AP[#]%	95% CI	Month	Year
Byaetayaw	22.2	3 - 41.4	Nov, Dec	2004
Kinepyin	33.3	11.6 - 55.1	July,Aug,Dec	2006
Koneywa	33.3	11.6 - 55.1	Sept	2007
Kyakhat	68.1	54.8 - 81.4	Nov, Dec	2006
Ma-U-Pin	43.8	19.4 - 68.1	-*	2005
Myinsel	55.6	32.6 - 78.5	Feb,Mar	2006
Natkhayaing	48.5	31.4 - 65.5	Dec	2006
Ngatayaw	45	23.2 - 66.8	-*	2006
Knowndwin	48.6	32.5 - 64.8	Feb,Mar	2003
Padu	40.5	24.7 - 56.4		2003
Paukma	34.4	17.9 - 50.8	Nov,Dec	2005
Sintat	55.6	32.6 - 78.5	-*	2004
Taeintel	31.3	15.2 - 47.3	-*	2003
U-Eain-kyun	33.3	11.6 - 55.1	Nov,Dec,Mar	2005
Yeatwinkhaung	34.8	15.3 - 54.2	-*	2003
Ywama	36.8	15.2 - 58.5	July	2007
Ywathitgyi	22.2	3 - 41.4	-*	2004

** Data not available*
[#]Apparent prevalence

Table 6.12 Management, disease information and impact of FMD at the village level

Name of village	Market Value[2] (no FMD) (Kyats)	Total Working Days[1]	Cost of hiring cattle[1] (Kyats)	Cost of Treatment[2] (Kyats)
Code	CMV	TWD	CHC	CT
Byaetayaw	425000	200	3000	3500
Kinepyin	500000	250	2500	4000
Koneywa	510000	250	3000	3400
Kyakhat	175000	200	2000	2250
Ma-U-Pin	425000	250	2500	8000
Myinsel	525000	250	3000	4250
Natkhayaing	400000	250	3000	12500
Ngatayaw	470000	300	2500	8500
Knowndwin	500000	250	2500	6250
Padu	500000	300	3500	2500
Paukma	350000	200	2500	6500
Sintat	500000	250	3000	7500
Taeintel	350000	270	3000	9250
U-Eain-kyun	450000	120	4500	2000
Yeatwinkhaung	100000	150	3000	3000
Ywama	450000	300	2500	5500
Ywathitgyi	475000	250	3500	12500

[1]*Value from the MTD meetings*
[2]*Median value from questionnaire interview*

Table 6.13 Summary of the variables for the partial budgeting analysis

Input variables	Acronym	Unit	Input value
Total cattle	TC	whole number	987*
Proportion of draught cattle	PrDr	number	0.4
Market value of draught cattle	MVdr	Kyats	450,000*
Total working days	TWD	Days	250*
Proportion of working days need to hire	PrDh	%	0.6
Cost of hiring cattle/day	CHC	Kyats	3,000*
Probability of getting FMD	PrFMD	%	0.5[a]
Proportion of farmers used traditional treatment	PrTT		0.65
Cost of Treatment (traditional)	CTT	Kyats	125.3*
Cost of Treatment (Vet)	CTV	Kyats	5,500*
Proportion of draught cattle being sold in a year	PrSel		0.1[b]
Depreciated value %	DeV	%	0.55
Cost of Vaccination	CVx	Kyats	600[a]
Frequency of vaccine	FrV	times	2[a]

* *Median value from the MTD and questionnaire interview*
[a] *Estimated value based on expert opinion*
[b] *Data reported in Chapter 2*

The current market value of draught cattle was estimated by respondents in the questionnaire interviews after their cattle were bled. This ranged from 100,000 to 900,000 Kyats (median value of 450,000 Kyats). Data on the Total Working days was obtained from the MTD meeting with a median of 250 working days per year (minimum 120 to maximum 300 days)

The input values for the parameters of the partial budget analysis are summarized in Table 6.13.

6.3.2 Incidence and number of cattle affected in an outbreak

During the MTD meetings farmers reported that some villages had an outbreak of FMD every year whereas others occurred less frequently. They commented that if an outbreak occurred every year, the number of animals with clinical disease was lower than when an outbreak occurred less frequently.

6.3.3 Impact of FMD in the survey area

The impact of FMD included both direct and indirect losses. Direct losses included the loss of draught power and additional expenses for the treatment of infected animals. Indirect losses include reduced agricultural output and income because of delays in performing agricultural work, and for the additional cost to hire substitute draught cattle to complete ploughing (field work) and crop cultivation in time. The number of animals affected each year was determined from information provided in the MTD meeting. If an outbreak of FMD occurred every year, the total number of cattle infected was approximately 25% of the cattle in the village, in contrast 50%, 75% and 90% of animals were infected when outbreaks occurred every 2, 3 or 4 years respectively.

Infected animals included both draught cattle that were currently being used and surplus cattle (cows, calves and immature young cattle). According to data recorded during the MTD meeting, participants paid more attention to the recovery of draught animals than for surplus cattle. They understood that FMD was not a highly lethal disease and the surplus animals could recover reasonably quickly. Consequently for surplus cattle a variety of cheap traditional treatments were used. Expert opinion was used to determine the proportion of farmers who used traditional treatments and those who used the services of veterinarians to treat their infected cattle (Min, 2006).

When draught cattle were infected with FMD during the working season, the owners needed to hire other healthy draught cattle to allow completion of their cultivation in time. The requirement to hire other draught cattle depended upon the time of the outbreak. In this study, the median total working days of a particular village were obtained from the MTD meeting after discussion with the participants (Table 6.13). The most serious impacts of FMD were hoof problems and lack of stamina after recovery from FMD. Not all infected animals developed these complications but they were reported in all villages during the MTD meeting. Owners who encountered FMD induced lameness and decreased working power had to sell their draught cattle to replace those used in their daily work. Some farmers could not afford to replace their draught cattle immediately because of personal financial problems and consequently they had to use these cattle in their work. They reported lowered draught power and as a result their agricultural work was not finished in time resulting in decreased agricultural production.

6.3.4 Farmer perspectives on livestock management and its influences

The information of the proportion of draught cattle and total number of cattle owned by a farmer was extracted from the questionnaire interviews. In the Sagaing Division, even though a farmer owned a large area of cultivation land, the number of draught cattle owned was similar to the number owned by farmers with a small area of land. Although some farmers owned a large number of cattle, not all were draught cattle and on average 40% to 60% of the cattle owned were draught cattle (Min, 2006).

In addition, during the questionnaire interviews, 16% and 13% of respondents, who had experience with FMD in their herd, sold and bought cattle once a year, respectively (Section 2.3.2.2).

6.3.5 Impact of FMD on draught animals (Monte Carlo Simulation result)

This study revealed the variation in benefit was dependent upon the conditions present in the villages. In all villages the benefit from vaccinating exceeded the cost of purchasing and administering the vaccine. The higher the prevalence, the greater the net benefit obtained from the control of FMD by the use of vaccination.

If an outbreak occurred in a village, the impact was influenced by the time of the outbreak, the severity of the outbreak, the season when the outbreak occurred and whether the draught cattle were infected during the outbreak or not. If the outbreak occurred at the start of field work for a crop season, affected cattle could not be employed for the whole of that growing season.

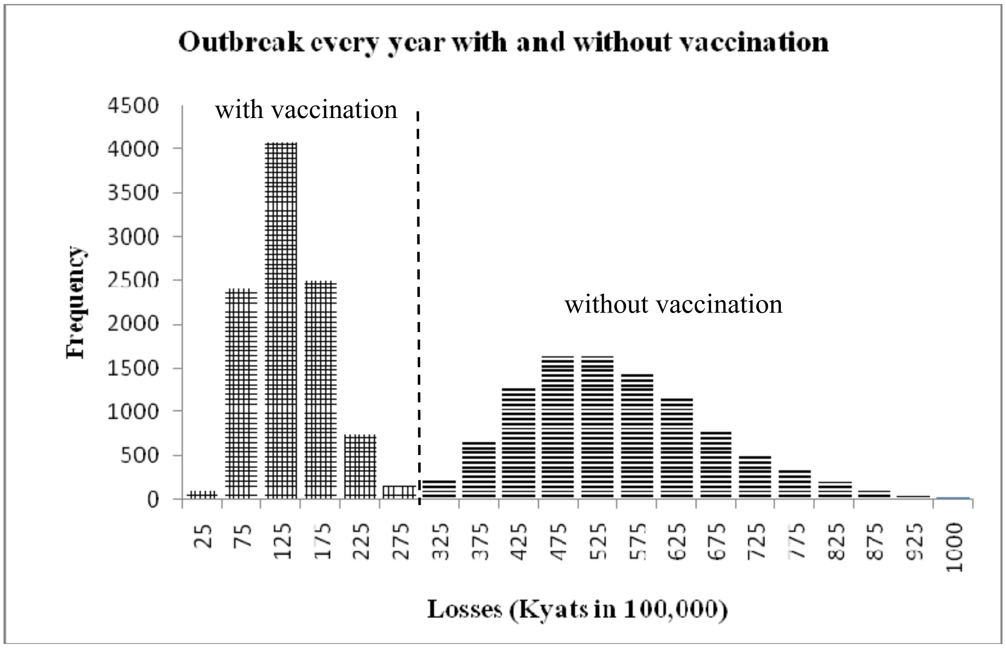


Figure 6.2 Consequences of yearly outbreaks of FMD on the economic condition for farmers who have draught animals

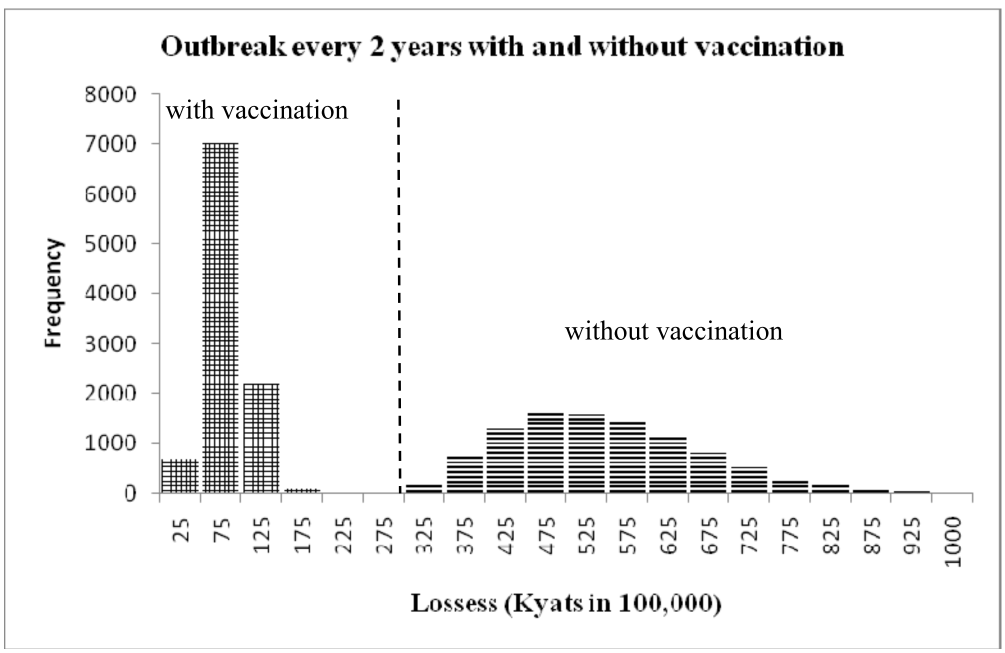


Figure 6.3 Consequences of outbreaks of FMD occurring every 2 years on the economy for farmers who have draught animals

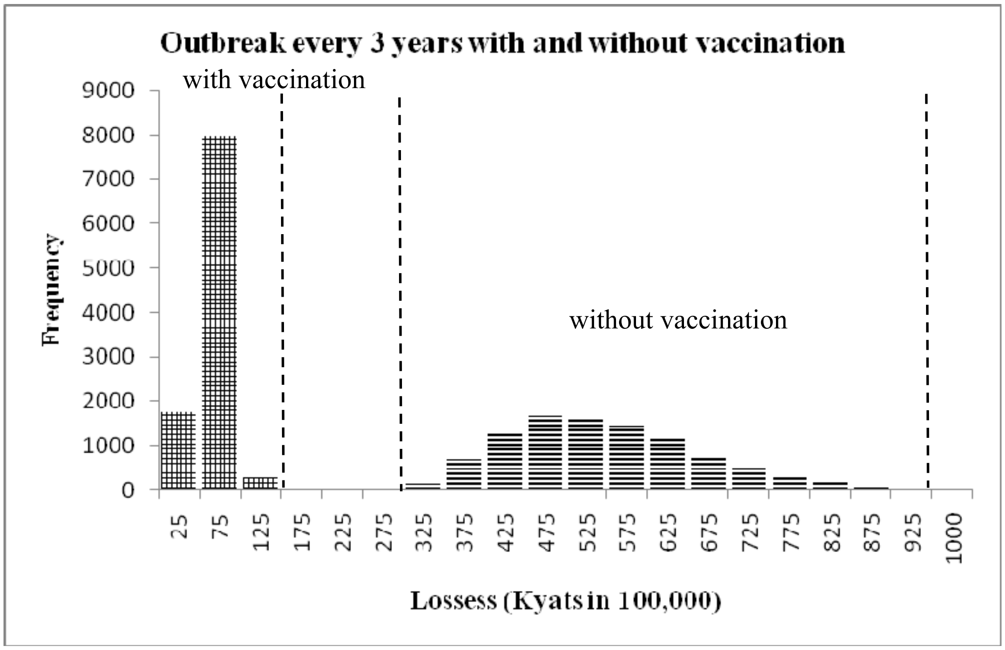


Figure 6.4 Consequences of outbreaks of FMD occurring every three years on the economy for farmers who have draught animal

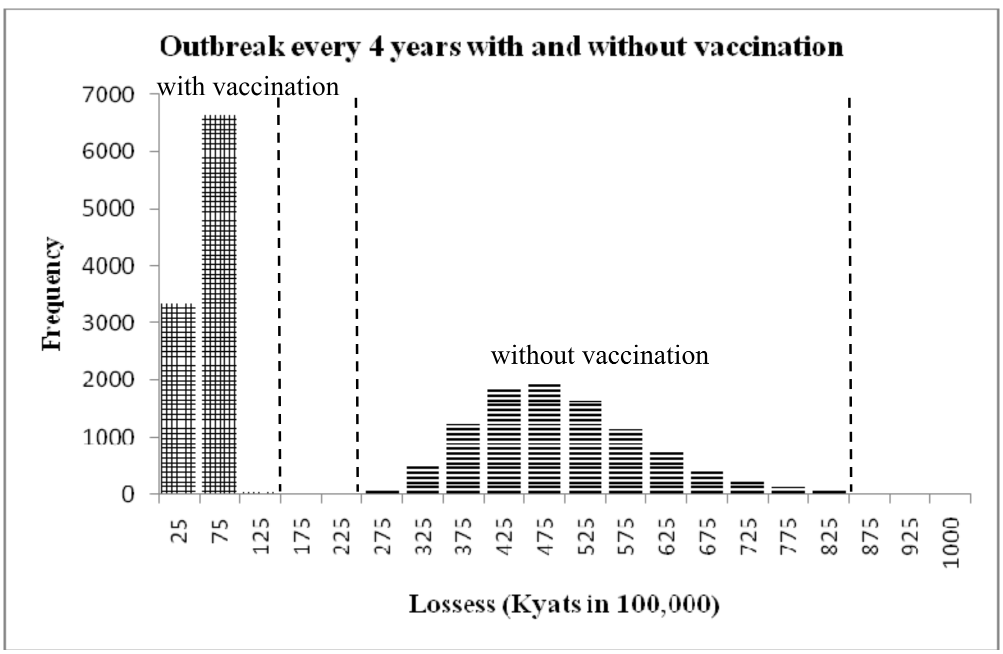
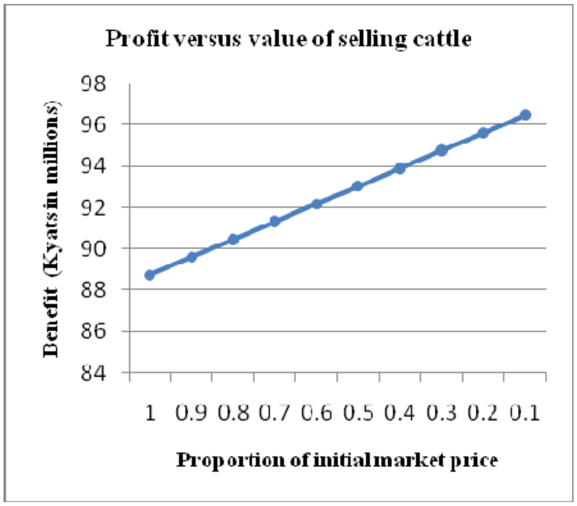


Figure 6.5 Consequences of outbreaks of FMD occurring every four years on the economy for farmers who have draught animal

6.3.6 Results from the Sensitivity Analysis

Sensitivity analysis revealed that the net benefit or loss at the village level was fairly insensitive to changes in the variables (Table 6.13). If the market value of cattle sold decreased (up to 10 percent of the initial market price) because of FMD, the use of vaccine would still remain profitable (Figure 6.6 A). When the proportion of draught cattle owned by a farmer increased from 20 to 80 percent of the total number of cattle, the predicted profit increased from 49 million to 190 million Kyats (Figure 6.6 B). If an outbreak occurred during the working season, farmers needed to hire draught cattle for their agricultural work. When the proportion of days needed to hire draught cattle increased (from 10 percent of the total working days to the entire working days), the control of FMD by vaccination was more profitable (Figure 6.6 C). If the cost of the FMD vaccine increased from the current value 600 Kyats to 1900 Kyats, the benefit to the farmers would be decreased (Figure 6.6 D). It is not surprising that the profit for individual farmers increased when the market value of draught cattle increased to 15 million Kyats per head for each draught cattle (Figure 6.6 E). During the study period, the cost of hiring draught cattle was around 3,000 Kyats per pair of draught cattle per day. If this hiring cost increased from 2,000 Kyats to 15,000 Kyats for a pair of draught cattle, the control by vaccination was more profitable (Figure 6.6 F).



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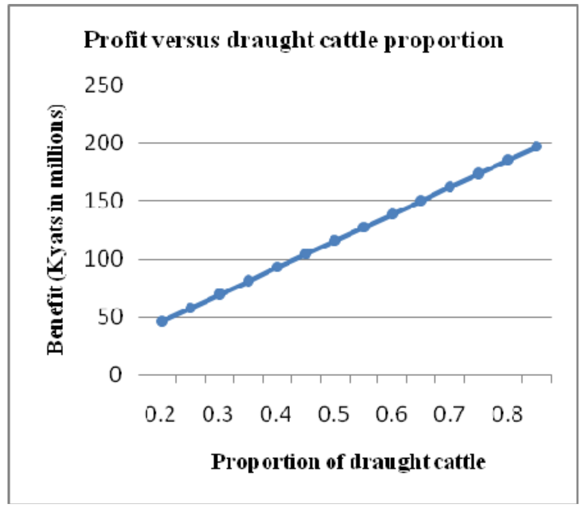

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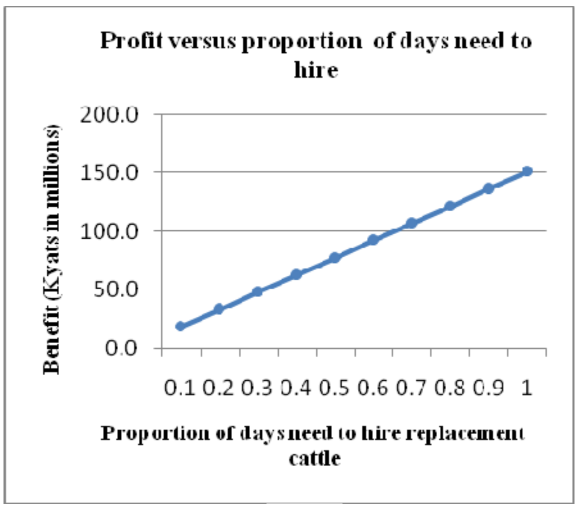

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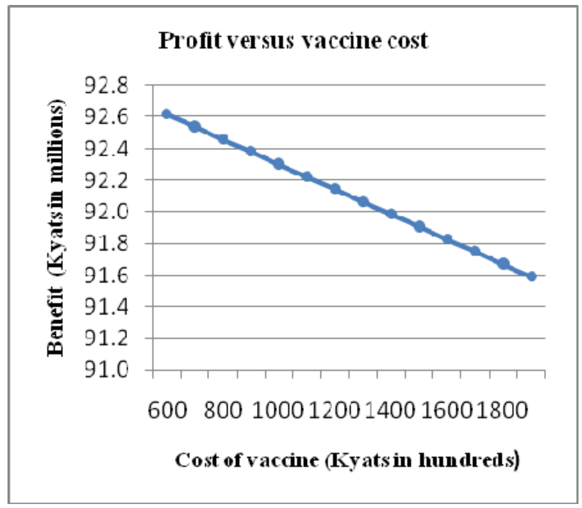

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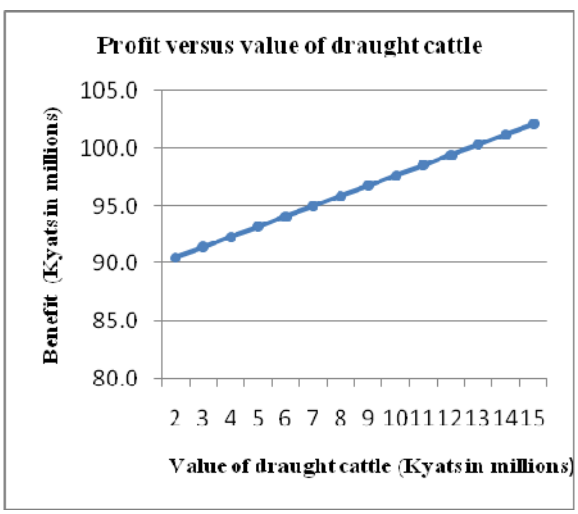

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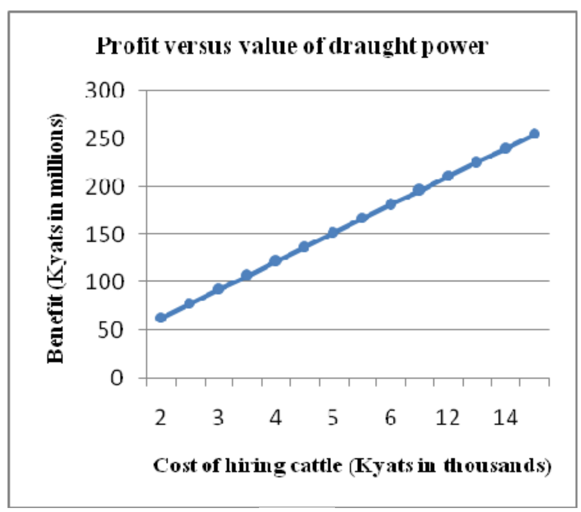

F

Figure 6.6 Sensitivity analysis results

6.3.7 Results from the surveys of farm households

Data on farm household was collected for the 2007 budget year (April 2007 to March 2008). During the 2009 study of the survey period, no outbreaks of FMD were reported in the survey villages; however information of FMD was taken from the reported experiences of the farmers over the preceding 3 years.

In the surveyed villages, four types of farm enterprises existed: crop farming; dairy farming; livestock related enterprises including breeding bulls and the leasing and hiring of draught cattle; and non farming business including the selling of goods at a market, running a small video theatre from their home, working in government service and/or working as a carpenter. During the interviews many farmers reported operating more than one type of business (Table 6.14).

A total of 41 respondents were interviewed from 7 villages and the mean, median, minimum and maximum number for the variables: total number of cattle, number of draught cattle, the proportion of draught cattle and acres of land owned were calculated (Table 6.15).

Table 6.14 Economic activity of survey respondents (n = 41)

Economic activities of the household	Number of respondents involved	Type of activities
Cultivation	39	Cultivation of paddy, pulses and beans, sesame, sorghum, cotton etc and banana, plum and mango orchards.
Dairy farm	19	Raising dairy cattle for milk production and sale of male calves
Livestock enterprise	7	Raising extra working draught cattle to lease for ploughing and transportation and breeding bulls
Non farming enterprise	26	Working as a labourer on another farm, running a video theatre, selling grocery and small goods at home or market, staff in government service, middle man for cattle trading, carpenter, hiring part of land to other farmers, private small scale factory to produce preserved food

From the village survey data, the mean, median, minimum and maximum value of the following variables: farm income, farm expenditures, total income and total expenditures of the villages were calculated (Table 6.16)

Table 6.15 Number of cattle and area of land owned by respondents

Villages	Number of respondents	Units	Total number of cattle owned	Total number of draught cattle owned	Proportion of draught cattle owned (%)	Total area of land owned (acres)
Knowndwin	6	Mean	10.3	2.8	27	13.5
		Geometric mean	6.5	2.6	40	10
		Median	6	2	33	9.1
		Min	2	2	100	4
		Max	33	5	15	34
Myinsel	3	Mean	10.3	4.7	46	12.3
		Geometric mean	9.6	4.6	48	10.6
		Median	8	5	63	12
		Min	7	4	57	5
		Max	16	5	31	20
Natkhayaing	7	Mean	3.9	1.4	36	9.9
		Geometric mean	3.4	0.8	25	8.2
		Median	4	2	50	10
		Min	2	0*	0	2
		Max	7	2	29	17
Ngatayaw	5	Mean	6.8	2	29	8.6
		Geometric mean	6.1	2	33	5.4
		Median	6	2	33	5
		Min	3	2	67	2
		Max	12	2	17	20
Ma-U-Pin	5	Mean	3.8	2.8	74	10.9
		Geometric mean	3.6	1.7	47	8.5
		Median	4	4	100	8
		Min	2	0*	0	4
		Max	5	4	80	25
Ywama	5	Mean	7	2	29	10.9
		Geometric mean	6.2	1.3	20	8.5
		Median	5	2	40	10
		Min	4	0*	0	2
		Max	15	4	27	19
Ywathitgyi	10	Mean	5.6	1.7	30	8.2
		Geometric mean	4.9	0.9	18	3.4
		Median	5	2	40	8.5
		Min	2	0*	0	0*
		Max	12	5	42	16
Total	41	Mean	6.4	2.3	35	10.2
		Geometric mean	5.1	1.4	28	6.6
		Median	5	2	40	10
		Min	2	0*	0	0*
		Max	33	5	15	34

For calculating the geometric mean of data with a value of zero, 0.1 was added. These were for total draught cattle and total land owned by a farmer.

Table 6.16 Income and expenditure by farm households

Village	Units	Farm income*	Farm Expenditure*	Total Income*	Total Expenditure*
Knowndwin	Mean	17.81	3.63	31.45	31.04
	Geometric mean	15.66	3.23	24.49	29.10
	Median	18.65	3.70	29.48	27.76
	Minimum	5.12	1.05	5.12	15.97
	Maximum	26.45	5.60	61.89	45.80
Myinsel	Mean	36.87	11.83	37.87	54.02
	Geometric mean	33.20	3.90	34.49	42.66
	Median	24.80	7.00	27.80	31.45
	Minimum	23.80	0.30	23.80	22.92
	Maximum	62.00	28.20	62.00	107.70
Natkhayaing	Mean	11.66	2.92	17.63	18.73
	Geometric mean	9.95	1.58	15.32	17.13
	Median	11.70	1.15	13.15	14.53
	Minimum	2.72	0.67	9.00	11.14
	Maximum	22.00	13.30	42.00	38.30
Ngatayaw	Mean	27.58	6.37	35.78	36.30
	Geometric mean	19.68	2.19	26.45	28.76
	Median	19.20	1.30	44.40	36.67
	Minimum	6.05	0.35	4.75	6.73
	Maximum	52.60	23.00	56.50	62.76
Ma-U-Pin	Mean	25.31	6.85	39.61	38.59
	Geometric mean	20.64	5.02	34.87	33.34
	Median	18.10	2.90	41.10	37.80
	Minimum	10.16	2.35	17.36	15.27
	Maximum	53.59	13.80	72.59	70.98
Ywama	Mean	25.13	3.44	31.97	26.57
	Geometric mean	23.74	3.19	30.63	25.45
	Median	26.20	2.60	32.75	24.32
	Minimum	12.20	2.10	19.28	16.49
	Maximum	32.75	5.50	46.70	39.86
Ywathitgyi	Mean	23.55	7.18	29.74	26.42
	Geometric mean	20.54	4.18	26.30	22.94
	Median	23.02	7.28	28.73	23.66
	Minimum	5.10	0.20	7.60	9.47
	Maximum	43.92	17.30	57.02	64.42
Total	Mean	22.55	5.68	30.73	30.51
	Geometric mean	18.30	3.10	25.54	25.77
	Median	21.00	3.21	26.15	25.47
	Minimum	2.72	0.20	4.75	6.73
	Maximum	62.00	28.20	72.59	107.70

*(Hundred thousand Kyats)

Data were collected from most respondents (75.6%) on the minimum and maximum number of working days draught cattle were used in a year, their cost and the cost of treatment during an outbreak of FMD (Table 6.17).

Table 6.17 Summary of total working days and cost of hiring and treatment of draught cattle

	Total working days (Minimum)	Total working days (Maximum)	Cost of hiring a pair of cattle per day (Kyats)	Cost of treating an animal during an outbreak of FMD (Kyats)
Mean	243	285	2375	9142
Median	250	300	2500	5000
Minimum	120	150	1500	4000
Maximum	300	350	3000	30000

Even though there was no outbreak of FMD in the 2007 budget year, some respondents did not make a profit from their agricultural work because of low production resulting from other factors (Table 6.18). Income from cultivation was not sufficient by itself for a family and consequently families were required to run other businesses to cover daily living expenses. Households which had all types of business or had a dairy farm along with non-farming business were more profitable.

Table 6.18 Summary of the business and household profitability in the budget year 2007 (Number of respondents)

Type of business	Income greater than expenses	Expenses greater than income	Total
c	2	5	7
cb	7	5	12
cd	2	1	3
cdb	7	3	10
cdl	1	1	2
cdlb	2	0	2
cl	1	2	3
db	2	0	2
Total	**24**	**17**	**41**

c - Cultivation, b - Non farming business, d - Dairy farm, l - Livestock related works,

6.3.7.1 Estimation of the benefit of the use of a pair of draught cattle

Among the respondents who had a pair of draught cattle, those with 12 acres of cultivation land or less, undertook no other livestock related work and did not run a non-farming business were selected to study the impact of FMD on the use of draught cattle in the cultivation. A pair of draught cattle is considered suitable to be used by a household owning a maximum of 12 acres of land and is regarded as suitable for a basic agricultural enterprise in Myanmar (Pers. com. Dr Myo Nyunt). Four respondents only relied on their farming enterprise using animal draught power for their household income. These four farmers were purposively selected to determine profit from their enterprise. A profit of 16.2 hundred thousand Kyats per year (Table 6.19) was obtained for these four households.

Among these four respondents, only one respondent with 6 family members completed the year without debt because some jewellery was sold to cover family expenditures. In contrast the other 3 respondents had a financial deficit and the income from their farming enterprise was not sufficient to cover their family needs. Consequently the income from farming for all four farmers was less than the total family expenditures. The geometric mean loss for these farmers was 490,000 Kyats (Table 6.19) in 2007.

Table 6.19 The income and expenditures of four selected farmers

(In hundred thousand Kyats)

	Farm income	Farm Expenditure	Balance[1]	Total Expenditures #	Benefit[2]
Mean	19.1	1.8	17.4	26.1	-7.0
Geometric mean	17.7	1.4	16.2	22.5	-4.9
Median	16.1	1.7	14.3	21.6	-5.6
Minimum	11.7	0.7	11.0	13.3	-1.6
Maximum	32.8	2.9	29.9	47.9	-15.2

[1] Balance between farm income and farm expenditure
[2] Balance between farm income and total expenditures
Including farming expenditure

6.3.7.2 Information on FMD in the studied areas

Information on FMD and its consequences was collected for the three years preceding the survey which included the budget years of 2005 to 2007 (April 2005 to March 2008). During the interviews 14 respondents (34%) reported that they had experienced an outbreak of FMD in their herd and five of these (35.7%) provided data on the cost of hiring cattle, 7 (50%) on the cost of treatments used during an outbreak and five (35.7%) on the number of days needed to hire draught cattle and the number of cattle needed to be hired. During the questionnaire interview these five respondents reported the associated costs of treating and hiring cattle. These costs were similar to those reported in the MTD meeting in the same villages. Even though 14 respondents had experienced an outbreak, two of these (14.3%) did not hire draught cattle because the outbreak did not coincide with their working season, and some (n=3) reported that the outbreak only affected their surplus cattle. The participants reported in the MTD meeting that some farmers who could not afford to hire cattle during an outbreak had to use sick animals to complete their work. As a consequence, these farmers could not finish their agricultural work in time and their agricultural production was reduced when compared with farmers who used healthy draught cattle. The cost of hiring a pair of draught cattle was the same as reported in the first economic survey which was done in 2007 with a range of 1500 to 3000 Kyats (Tables 6.17 and 6.20). Two (14.3%) respondents reported complications in their animals after these animals were affected with FMD.

Table 6.20 Summary of the information relating to experience with FMD in respondents

	Number of respondents	Minimum	Maximum	Mean	Geometric mean
Total area of land (acres)	14	2	17	9.61	7.78
Number of draught cattle owned	14	2	5	2.64	2.48
Total number of cattle owned	14	2	15	6.93	6.03
Total number of working days	14	150	350	253.57	247.29
Cost of hiring a pair of draught cattle per day (in Kyats)	4	1500	3000	2375.00	2341.30
Cost of treatment (Kyats)	7	4000	30000	9142.86	6907.08
Farm Income (Kyats)	14	510000	5050000	2362892.60	1876538.87
Farm expenditures (Kyats)	14	35000	2300000	696871.43	334607.73
Number of cattle hired (head)	5	2	100	7.71	4.37
Days required to hire draught animals	5	5	50	21.00	14.96

6.3.8 MTD meeting results

The topics discussed during the MTD meetings mainly focused on the impact of FMD and related issues. Participants reported that FMD not only resulted in a loss of animal draught power but also seriously impacted on the production of their farming enterprises. Participants insisted that they were more concerned about production losses from their agricultural enterprise rather than the direct losses from their diseased draught cattle. Even though some farmers whose draught animals were not affected shared these with farmers who had affected cattle, this was not totally satisfactory as the receiving farmer had to wait until the donor farmer had finished their cultivation. In farming enterprises, soil moisture, rainfall and the impact of weeds significantly influences the yield of crops and consequently a delay in cultivation can have a significant impact on productivity (Storrier, 1965; Bhatt and Tewari, 2006; Ya-Jie *et al.*, 2008).

The majority of participants provided data on the minimum feed requirements for working draught cattle with a draught animal requiring 50 to 60 bundles of hay per day (approximately 55 to 65 Kilograms/day) if they did not receive any other green feed. At the time of study this cost approximately 15 Kyats per day. If sorghum forage was available, working cattle were fed both hay and sorghum. The number of bundles of hay was reduced to 30 bundles when 2 bundles of sorghum (approximately 3.5 kilograms of sorghum) were fed with the hay. Each bundle of sorghum costs approximately 250 to 300 Kyats. On average the feeding cost of adult draught cattle was approximately 750 to 1500 Kyats per day. If draught cattle were not used after the end of the working season, farmers' let their cattle graze on communal grazing land as well as feeding them 10 to 20 bundles of hay per day at home. Sick animals were fed at home until they had recovered. Consequently additional costs were spent on feed, treatment and the cost to hire cattle.

6.3.9 Summary of the impact of FMD in the surveyed villages

No outbreaks of FMD occurred in the 2007 budget year in the surveyed villages. This would indicate that FMD is more likely to occur once every two to three years. If the disease occurred during the working season, it has a serious impact on the production of the current crop. In all the studied areas farmers own an average of two draught cattle and 10 acres of land. If the other businesses farmers are involved in are ignored, the influence of FMD on animal draught power significantly impacts on their farming income. Significant farm costs were associated with hiring of replacement draught cattle, extra feeding costs for affected animals, cost of treatment of affected animals, unexpected complications after recovery from the disease, and the time needed to care for the sick animals. The majority of the farmers surveyed did not receive a large enough income for their family livelihood, even if no outbreak of FMD was reported. Consequently if FMD occurs, there would be an even greater financial burden on these low income farmers.

6.4 Discussion

Livestock play a major role in the economy of the studied areas, as is the case in many developing countries. Livestock provide an alternative to fossil fuel as well as providing meat, milk and organic fertilizer (Ear, 2005; Millar and Photakoun, 2008). Generally, most villagers own cultivation land and a small number of livestock, similar to that found in other Asian countries (Millar and Photakoun, 2008). These farm enterprises rely predominantly upon animal draught power. Outbreaks of FMD have a significant influence on the economy and income earning capacity of farmers who rely on animal draught power (FAO, 1997; Vion *et al.*, 2003). It was observed that farmers who had encountered FMD cases in their own cattle were highly aware of the nature of FMD and its consequence. But, some of them did not realize the negative financial impacts of FMD in the Sagaing Division. It is a great challenge to the Myanmar Veterinary Department to convince local farmers of the impact of FMD in the region. A long term disease control programme for FMD is critical for control of the disease (Gleeson and Ozawa, 2002). There are some important reasons for this conclusion. Firstly, local farmers in the studied area/villages were operating other non-farming businesses to support their households' income, and consequently could incur the required expenses for the treatment and hiring of cattle in the case of an outbreak of FMD. Secondly, as most costs associated with FMD are incurred over a period of time, the farmers often did not realize the size of these costs. In contrast diseases with a high case fatality result in a sudden loss of money. Thirdly, FMD is not an acute fatal disease and cattle can recover, even without treatment, within a short period of time (Vion *et al.*, 2003). If no outbreak occurs in a year, the net benefit of control by vaccination results in a reduced return because of additional expenses associated with vaccination. However, it is better to control disease as when an outbreak does occur there are significant economic losses to the affected farmers. At the early stage of the control of FMD in an endemic country, vaccination may be considered an effective tool even though there are alternative options for the control of the disease (Sutmoller *et al.*, 2003).

If FMD occurred during the non-working season, the impact is less as farmers work activities are not affected greatly by the loss of draught cattle power at these times. In these situations they might treat their animals with traditional medicines. Farmers in the study believed that FMD might not occur every year, an outbreak might not coincide with the working season and that it is not an acute fatal disease (Vion *et al.*, 2003). In addition, the farmer's view is that the majority of draught animals could be re-used after a certain period of rest after being infected with FMD. Therefore, even though they understood that FMD had an influence on their draught animals' working capability, they were not concerned enough to regularly vaccinate their animals against FMD. As outbreaks of FMD are likely to occur during the crop working season in Myanmar (See Figure 1.3) or the crop harvesting period, the disease can have a significant impact on agriculture (Doel, 2003). They were, however, accustomed to vaccinating against FMD when they received information about outbreaks of FMD in their own or neighbouring villages.

Although participants in the village survey reported that there was no outbreak of FMD in the year preceding the survey in their villages, the results of serology indicated some positive reactors (Table 6.11). This may result from underreporting of clinical cases (the MTD meeting approach could not detect subclinical cases of FMD - Chapter 7) or the presence of animals with subclinical disease. It was concluded that FMD occurred nearly every year in all studied villages at a low level of prevalence. Therefore, a certain number of farmers might have had animals affected with FMD and its concurrent impact on farm income. It is necessary to conduct follow up surveys to investigate the influence of FMD on other factors such as increased calving intervals, foetal deaths, and abortions. In an economic study in India, the economic loss was calculated for the loss from deaths of affected animals and from a reduction in the milk production. In the Kerala State this was calculated as AuD 160,000 and 300,000 respectively (Mathew and Menon, 2008).

The partial budget model assisted in understanding the influence of FMD on the animal draught power of working cattle in Myanmar and its impact on the economic livelihood of Myanmar farmers. Even though some assumptions were used, the results are useful to convince farmers of the potential losses from FMD and the financial benefit in controlling the disease regardless of the frequency of outbreaks.

The survey of farm households found that when an outbreak of FMD occurred during the crop working season, a farm household had to hire a pair of draught cattle for 50 days (equivalent to 100 draught cattle days). In addition, these farmers needed to treat their sick animals resulting in an outlay of 4,000 to 30,000 Kyats. In a report presented at the Second International Symposium on Veterinary Epidemiology and Economics (Hugh-Jones, 1979), it was mentioned that 60 -70% of draught power could be lost during the first month after an outbreak. Moreover, feeding costs for sick animals would be a minimum of 750 to 1,500 Kyats per animal per day. After recovery from the disease, complications could still occur (14.3% of farmers with animals with FMD reported complications). When these cattle were sold the amount received was decreased to approximately half of the original value. Therefore, losses to these farmers would be even greater than those calculated here if other losses from foetal deaths and decreased milk yield were also included.

In conclusion there is a significant influence of FMD on animal draught power during an outbreak. The movement of livestock has been identified as an important factor contributing to the spread and distribution of FMD. In the following chapter the movement of livestock, in particular cattle, in the two targeted areas of the Sagaing and Tanintharyi Division, is discussed.

The study of livestock movement in the Sagaing Division using a participatory approach

7.1 Introduction

Foot and Mouth Disease is a highly contagious viral disease that is disseminated to susceptible animals by direct or indirect contact with infected animals or materials. High risk factors for the spread of FMD include the movement of animals, persons or vehicles, animal products (including meat and milk) and non-animal products such as animal feeds and utensils that have been contaminated with infected materials (Sanson, 1993; Kitching, 2002a). Among these, the movement of animals is one of the main factors contributing to the spread of FMD in infected countries (Rosenberg *et al.*, 1979; Rweyemamu, 1984) and restriction of animal-movement plays an important role in the control of FMD (Joo *et al.*, 2002; Perez *et al.*, 2004a; Thrusfield *et al.*, 2005b; Sellers, 2006) as these animals could be subclinical carriers, incubating infection or be infected. Restricting in animal movements during outbreaks needs to be optimised to ensure effective control is achieved without forcing producers to undertake illegal movements or to make management of movement control under field conditions impractical (Sutmoller, 1984).

Animal draught power is important for the local farmers of Myanmar and acts as an alternative to fossil fuel. According to the recommendation of the Second MZWG meeting, the lower one third of the Sagaing Division should be a control zone as it has natural boundaries (large rivers and mountain ranges), only one cattle market and most movement of animals are out of the Division (MZWG 2, 2004). In that meeting, it was also recommended to develop a free zone of FMD in the southern part of the country in the Tanintharyi Division.The proposed control zone for FMD is located between two large rivers, the Ayeyarwady and Chindwin, and there are mountain ranges to the north. Such natural boundaries help minimise livestock movement to restricted routes. However the division conjoins with Mandalay and Magway Divisions and Kachin State.

The Tanintharyi Division is situated in the southern part of Myanmar and is a narrow coastal region bounded by the Andaman Sea, Thailand and Mon State of Myanmar. It has the second lowest number of animals susceptible to FMD in Myanmar (Figures 7.1 and 7.2). In the Tanintharyi Division, the movement study was conducted in the proposed control zone (Myeik District) and in the proposed eradication zone (Kawthoung District) and infected zone (Dawei District).

Currently Myanmar is actively involved in a progressive zoning approach for the control of FMD with technical support from the SEAFMD campaign. Understanding the pattern of animal movements in the targeted project areas will be beneficial for the effective control of FMD. The information from this study will be submitted to the MZWG to establish the progressive zoning approach for the control of FMD in Myanmar.

The aim of this study is to understand the pattern of animal movements in the proposed control zone of the Sagaing Division and the potential free zone of the Tanintharyi Division to support the MZWG to upgrade the zone status of regions in Myanmar.

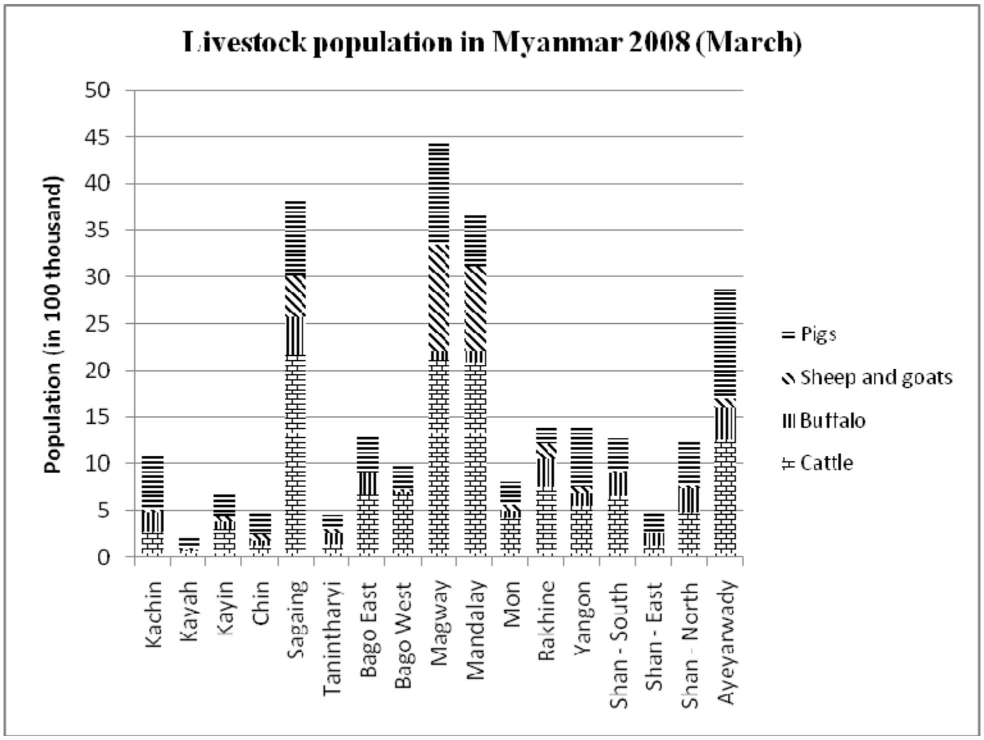

Figure 7.1 Total livestock population of Myanmar 2008 (March)

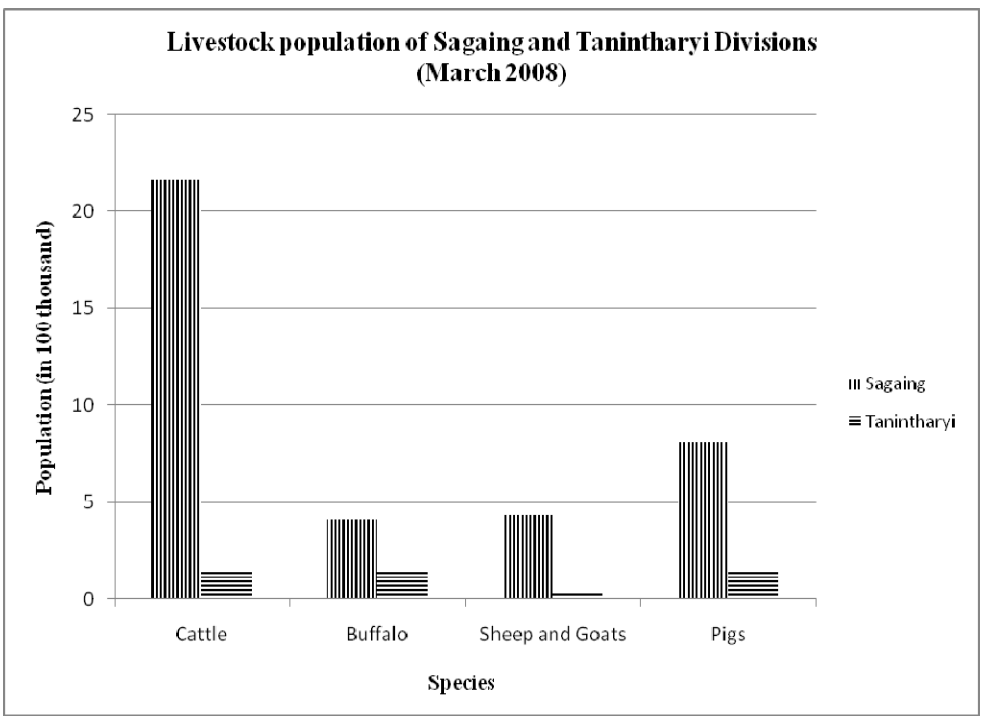

Figure 7.2 Comparison of livestock population between the two studied areas

7.2 Materials and methods

This study focused on the movement of animals within and between townships by traders and farmers for trading purposes and did not include the movement of cattle to places of work or for transportation purposes. These latter movements were not included because it was more complicated to trace day to day movements and the major disease threat was considered to be the movement of animals on longer distances when they were more likely to interact with potentially infected animals. At the commencement of this study, existing information from the outcomes of the participatory workshops of the MZWG was reviewed. Maps of the township, district and divisions of Sagaing and Tanintharyi were collected from two sources: the General Administration Department, District and the Divisional LBVD for use in the questionnaire interviews in June 2006 and the Dutaik meeting in December 2006. Movement routes were assigned a number.

7.2.1 Participatory Workshop for animal movement

At the first MZWG meeting held in Yangon 2004, a participatory workshop was included on the meeting agenda. All participants were divided into groups and were asked to draw animal movements throughout the country on a map. Each group presented their findings and these were subsequently combined into one map. The results from that meeting are included in this study on animal movements.

7.2.2 Questionnaire Interviews

In 2006, a team led by the author undertook surveys in 7 townships (Sagaing, Myinmu, Chaung-U, Monywa, Shwebo, Wetlet and Kanbalu). Questionnaires were administered in June 2006 to 160 participants who lived in the rural area of the proposed control zone in the Sagaing Division (as outlined in Chapter 2). One section of these questionnaires involved collecting information on animal movements (Appendix 1). The data gathered was displayed on township and district maps to summarise the movement of livestock in the study area. The location of the townships where questionnaire interviews were conducted in June 2006 is displayed in Figure 7.3.

7.2.3 Expert opinions

During the field visit in June 2006 to the Sagaing Division, expert opinions (cattle traders, brokers and experienced persons) were collected to obtain information on animal movements. In each village tract a minimum of two and a maximum of four participants (cattle traders, brokers or experienced persons recommended by villagers) were chosen to gather information on animal movement through the use of unstructured interviews. All information on animal movements was recorded onto maps.

In January 2007, expert opinions were collected from participants from the Kawthoung and Dawei Districts (Figure 7.3) on the movement of cattle. Local staff from LBVD, butchers, licensed contractors and village headmen were also interviewed to obtain information on animal movements. In addition, in early 2008, informal meetings with local staff of the Dawei and Myeik Districts (during the study of the validation of MTD approach outlined in Chapter 3) were conducted and during that time data on existing animal movements were collected from staff of the LBVD, village headmen and butchers.

7.2.4 Dutaik meeting approach

In December 2006, the author undertook Dutaik meetings with farmers and stakeholders in four townships (Sagaing, Myinmu, Monywa, Chaung-U, locations 1 to 4 - Figure 7.3 B). Data on animal movements were collected and recorded onto maps. All gathered data were put onto the relevant township map and summarized to understand the animal movements in the Division.

In January 2008, an epidemiological study was conducted in six villages of Myeik Township and three villages of Dawei Township of Tanintharyi Division for the validation of the MTD approach (outlined in Chapter 3). During the MTD meeting, animal movement information was also gathered.

7.2.5 Recording

All face to face discussions, meetings and interviews were recorded by using a voice recorder. All voice recordings were digitised and saved as separate files for future reference. These recordings were subsequently transcribed into Myanmar language and then translated into English.

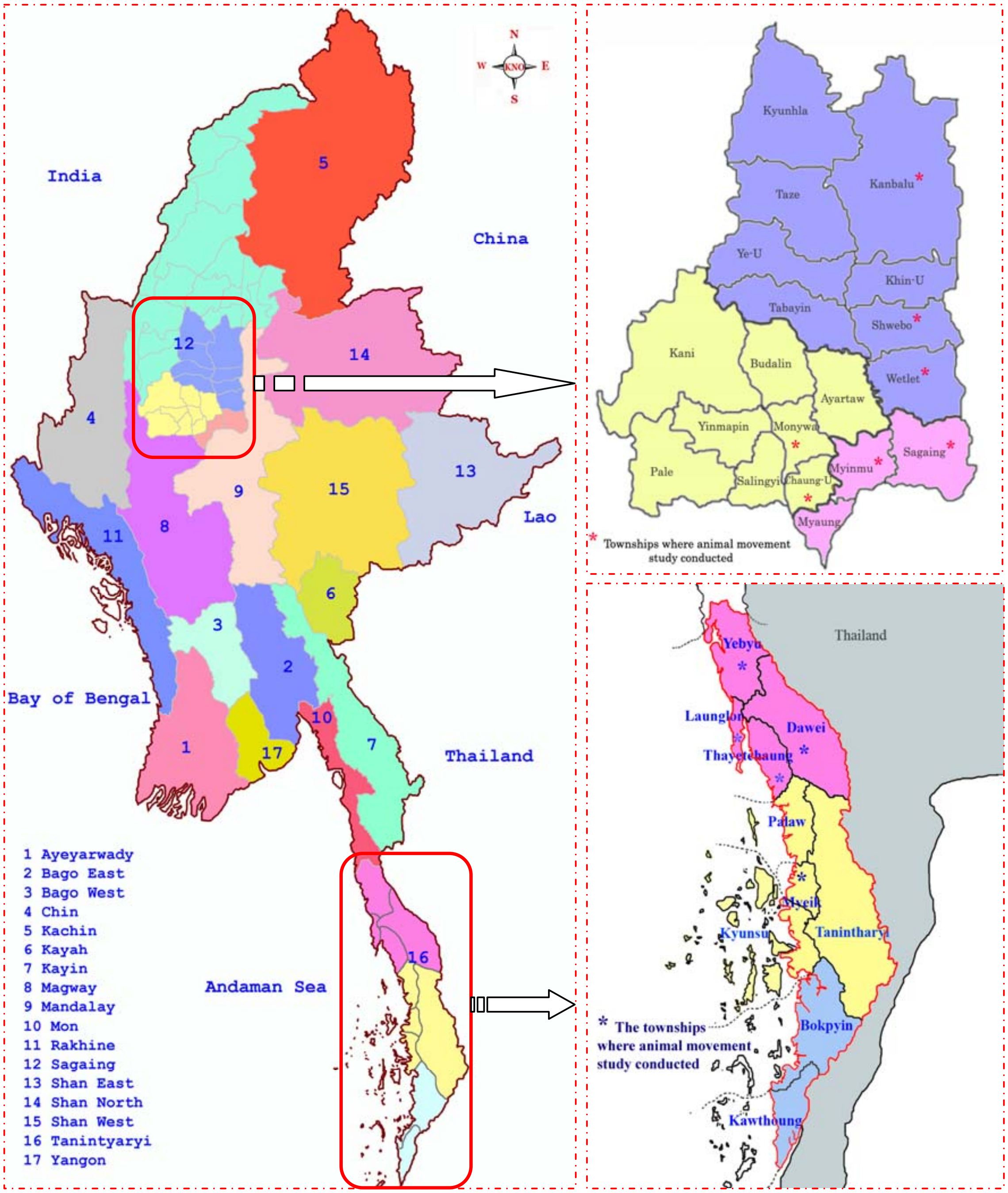

Figure 7.3 Locations of the animal movement study

7.3 Results

A summary of the outcome from the participatory workshop at the MZWG is outlined in the related maps (Figures 7.10 and 7.11). The data obtained from the questionnaire interviews are summarised in Table 7.1 and detailed information on the animal movement routes displayed in the township maps (Figures 7.4 to 7.10). The results from the Dutaik meeting approaches were put together in the relevant maps (See Figures 7.6, 7.7, 7.12, 7.13 and 7.16). Expert opinions were also added in the relevant maps (See Figures 7.4, 7.5, 7.9, 7.11, 7.13, 7.14, 7.15 and 7.16).

In general, most livestock movement for slaughter was out of the Sagaing Division. Within the Sagaing Division, all movement for sale or trading of animals led directly to the only cattle market in the Division. Approximately one half (52.5% - 84 of 160) of the respondents were aware of animal movements passing through their townships and 68% of cattle movements were "on hoof" whereas very few (11%) were by vehicle (Table 7.1). Twenty one percent (35/160) of respondents believed these movements led to the Sagaing Cattle market.

In the Tanintharyi Division, there were no inward cattle movements, there were some intra-divisional movements and the majority of movements were out of the Division towards the Thai-Myanmar border.

Table 7.1 Results of questionnaire interviews on the movement of livestock

Township	Total number of respondents	Respondents aware of animal movement*	Movement of livestock on hoof**	Movement of livestock by vehicle**
Chaung-U	19	10 (52.6%)	9 (47.4%)	3 (15.7%)
Kanbalu	5	4 (80%)	4 (80%)	0 (0%)
Monywa	26	12 (46.2%)	16 (61.5%)	4 (15.38%)
Myinmu	30	19 (63.3%)	21 (70%)	2 (6.6%)
Sagaing	29	22 (75.9%)	21 (72.4%)	3 (10.3%)
Shwebo	26	11 (42.3%)	17 (65.4%)	2 (7.69%)
Wetlet	10	3 (30%)	7 (70%)	1 (10%)
Ye-U	15	3 (20%)	13 (86.7%)	4 (26.6%)
Total	160	84 (52.5%)	109 (68.1%)	19 (11.87%)

Questions were :
"Do you know the common route (road) of animal movements in your District?"
****"If you want to buy or sell cattle what kind of route do you use? (On foot, by vehicle, by ship or other?)"***

Some respondents (52.5%) who were aware of animal movements chose more than one option for means of transportation in the questionnaire interview conducted in 2006. Some respondents (47.5%) did not answer the question on the awareness of animal movement but answered the means for moving animals.

7.3.1 Cattle movement in the Sagaing Township

The only cattle market for the whole of the Sagaing Division is located in the Sagaing Township. This market is located at the junction between the Sagaing Division and the Mandalay Division by the Sagaing Bridge which is built across the Ayeyarwady River. Four inward movements into the Township were recorded in the questionnaire interviews (Figure 7.4): through the route of Monywa-Sagaing motor road (route 3), Shwebo-Sagaing motor road (route 2), Shwebo-Sagaing railway road (route 1) and Ngazun-Sagaing route by passing through the Ayeyarwady River (route 4). The destination for all routes (especially for trading purpose) led to the Sagaing cattle market. A total of 21 (72.4%) respondents in the Sagaing Township said that movements were on foot whereas 10% used motor vehicles (Table 7.1). Most of the traders stopped temporarily at nearby village tracts along the road to the cattle market. Most of the cattle were driven on foot through routes 1, 2 and 3, and the majority of cattle that were driven on foot along route 3 originated from Myinmu Township and its surrounding area (Aung Soe, 2006). From the Sagaing cattle market, cattle were carried to the Mandalay Division and to other regions through the Mandalay Division. The average number of cattle moved was between 30-70 per day through the Ayeyarwady River via route 6 (Aung Soe, 2006). There was some reverse movements of dairy cattle by route 5 from the Mandalay Division and from Ywarthit Kyi village (where there are a lot of backyard dairy farmers) to the Sagaing Township (Min, 2006).

7.3.2 Cattle movement in Myinmu Township

Myinmu Township is located between the bustling cities of Monywa and Sagaing in the Sagaing Division. A total of 21 (70%) respondents from Myinmu Township said that most movements (route 1) were on foot from Monywa to Sagaing via the footpath along the railway and motor road to Sagaing (See Figure 7.5). The respondents also mentioned that the average number of animals driven on foot was 10 to 15 per time at a frequency of two to three times a month. Sometimes, these cattle passed through village tracts near the main roads so that they can escape checks by authorized persons. Information on movement of animals along Route 2 was collected by expert opinion. This movement involved dairy cattle originating from Sagaing and Mandalay towards Monywa where dairying existed. Dairy cattle were carried by vehicle but only a small number were moved when compared with route 1.

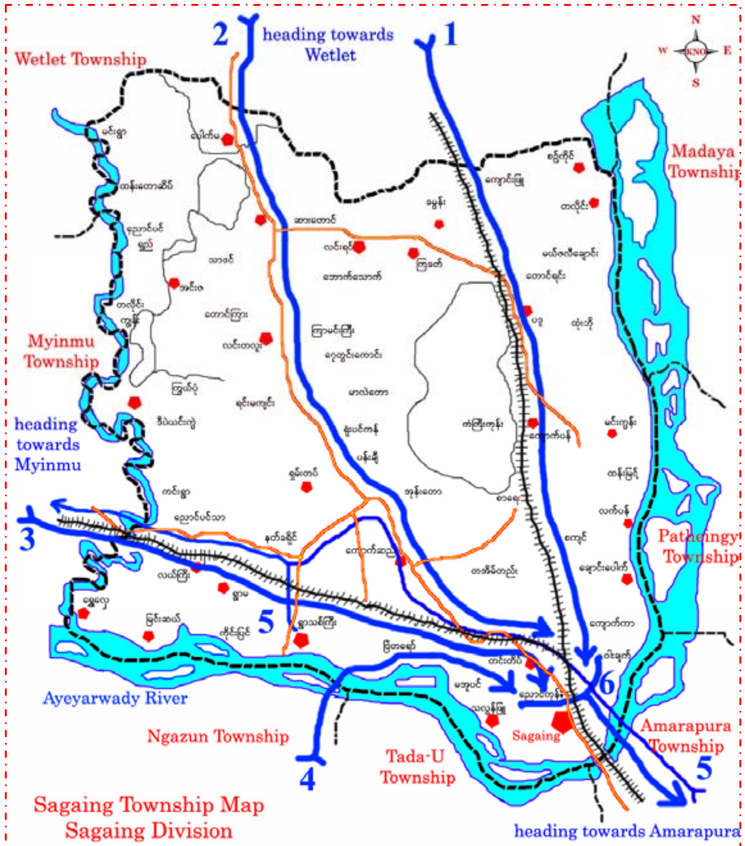

Figure 7.4 Animal movements in Sagaing Township

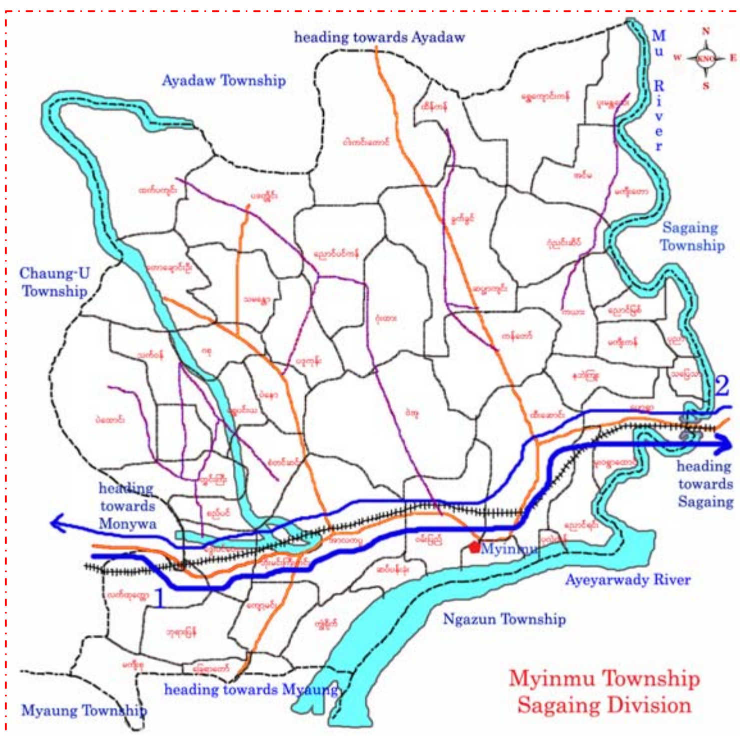

Figure 7.5 Animal movements in Myinmu Township

7.5.3 Cattle movement in Chaung-U Township

Chaung-U Township is located between Sagaing and Monywa and is adjacent to Monywa Township. The neighbouring Townships are Salaingyi, Monywa, Myinmu, Myaung and Yesagyo Townships. The railway line and road connects this township with Monywa and Sagaing. The livestock movements (See Figure 7.6) were mostly from the north to the south where the cattle market was located. Approximately one half (47.4% - 9 of 19) of the respondents from the Chaung-U Township revealed that cattle were driven on foot adjacent to the vehicular road and railway line. In contrast few (15.8%, 3/19) reported that cattle were transported by vehicles.

In December 2006 at the Dutaik Meeting, the participants confirmed that they had seen animals being driven along the road leading to the Sagaing and the number of cattle which had been driven on foot was at least 90 head per month. Route number 1 was confirmed as the route coming down from Monywa Township towards the Sagaing cattle market in both the questionnaire study and in the MTD meeting.

7.3.4 Cattle movement in Monywa Township

From the questionnaires both movements into and out of Monywa Township were reported (Figure 7.7). Animal route numbers 1 to 7 were inward movements towards Monywa Township and numbers 8 and 9 were outward movements from the township (Figure 7.7). Routes 1 to 6 involved movements of draught cattle, and route 7 involved only inward movements of dairy cattle coming from the southern part of the division as within the Monywa Township there was an industrial zone which contained many backyard dairy farmers. Routes 8 and 9, which were outward movements, had destinations of Myitkyinar, Kachin State and the Sagaing Cattle market. Most of the movements of cattle were on foot (61.5% - 16 of 26 respondents); however, some movements involved use of trucks (15.4%, 4/26). The outcomes of the Dutaik meetings identified the movement of cattle towards the Sagaing Cattle market and towards the northern part of Monywa Township. The within-township movements mostly involved passing through village tracts far from Monywa city.

7.3.5 Cattle movement in Wetlet Township

Wetlet Township is located in the Shwebo District and has the second highest cattle population in the Sagaing Division. The results from the questionnaire interviews indicated that it had only one major movement route (number 1). Seven (70%) respondents said that cattle were driven on foot along the motor roads down towards the Sagaing Cattle market whereas 10% (1/10) said they were carried by truck. Route numbers 2 and 3 (Figure 7.8) were commonly used by local farmers as a by-pass route for movements between Wetlet and neighbouring Townships. These routes were used less frequently by small scale-animal dealers when compared with route 1.

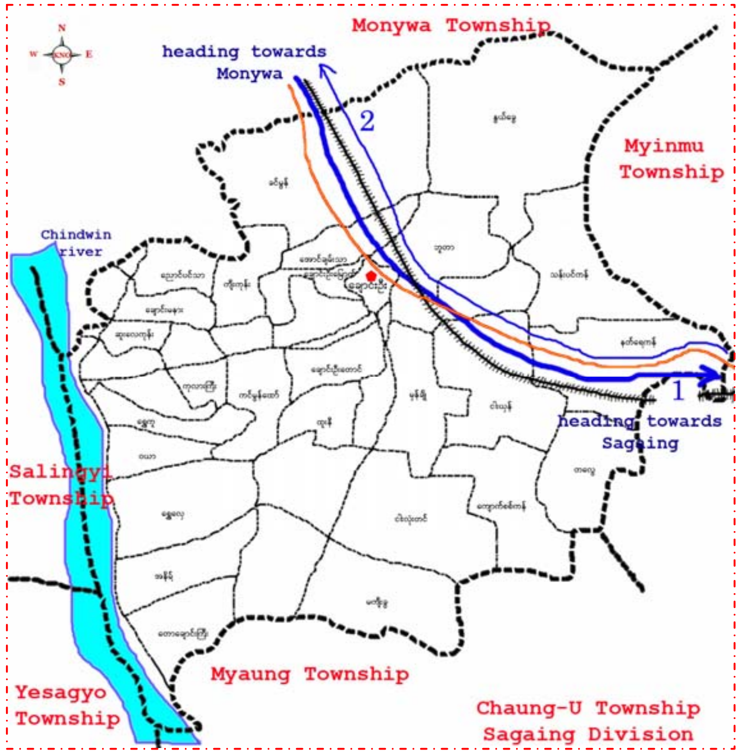

Figure 7.6 Animal movements in Chaung-U

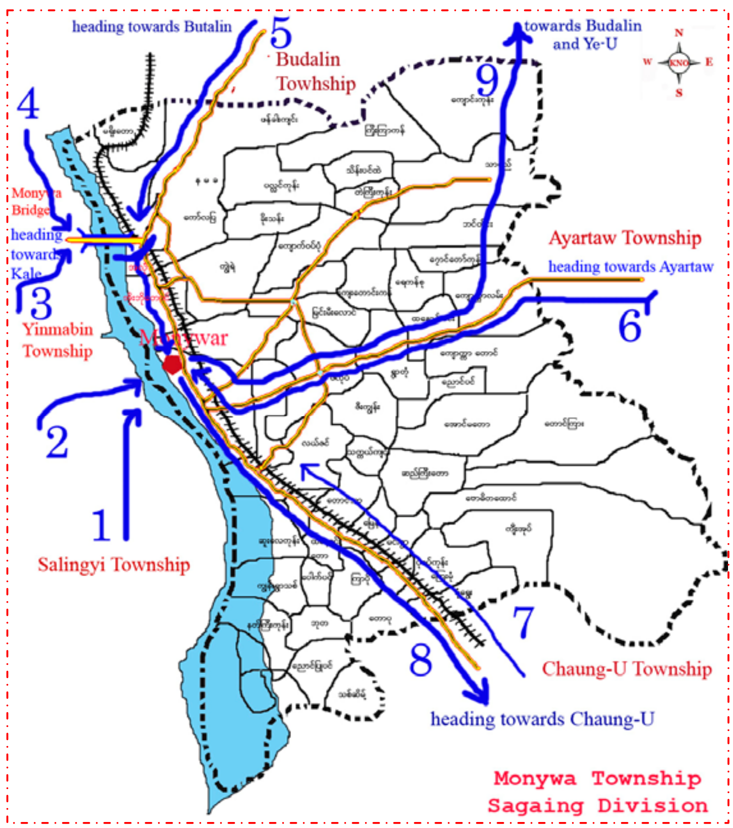

Figure 7.7 Animal movements in Monywa Township

7.3.6 Cattle movement in Shwebo Township

Eleven respondents (43%) were aware of animal movements within the township of Shwebo. They mentioned that cattle movements (routes 1, 2 and 5 in Figure 7.9) were mainly outward to Myitkyina and the Sagaing Cattle market. Seventeen (65.4%) respondents mentioned that livestock movements were on foot while only two (7.7%) said that motor vehicles were used to carry cattle. A few respondents (11%) said that a small number of cattle were moved out to Mandalay Division through routes 3 and 4. Reverse movements to Shwebo Townships were mainly for slaughter in Shwebo using route 6 from the Khin-U Township. The expert believed movements varied depending upon the demands of the market. During the interview period in June 2006 cattle were driven to the north of the Shwebo Township because the local authority had banned the movement of animals to the south.

7.3.7 Cattle movement in Kanbalu Township

Kanbalu Township is within the Shwebo District and is located in the middle of the Sagaing Division. It has the highest population of livestock, not only in the Sagaing Division but also in the whole of Myanmar. According to the participatory workshop for animal movement in the First MZWG meeting, most livestock movement was directed to the north of the township to Myitkyina which is the major city of Kachin State. There were also some movements (routes number 2 and 3 in Figure 7.10) from neighbouring townships via Taze Township which merged with the major movement route number 1 (Figure 7.10) (MZWG 1, 2004b). In interviews conducted in July 2006 the respondents revealed that they had seen cattle move through some village tracts near the mountain ranges and forest. These were not using the existing railway or motor roads.

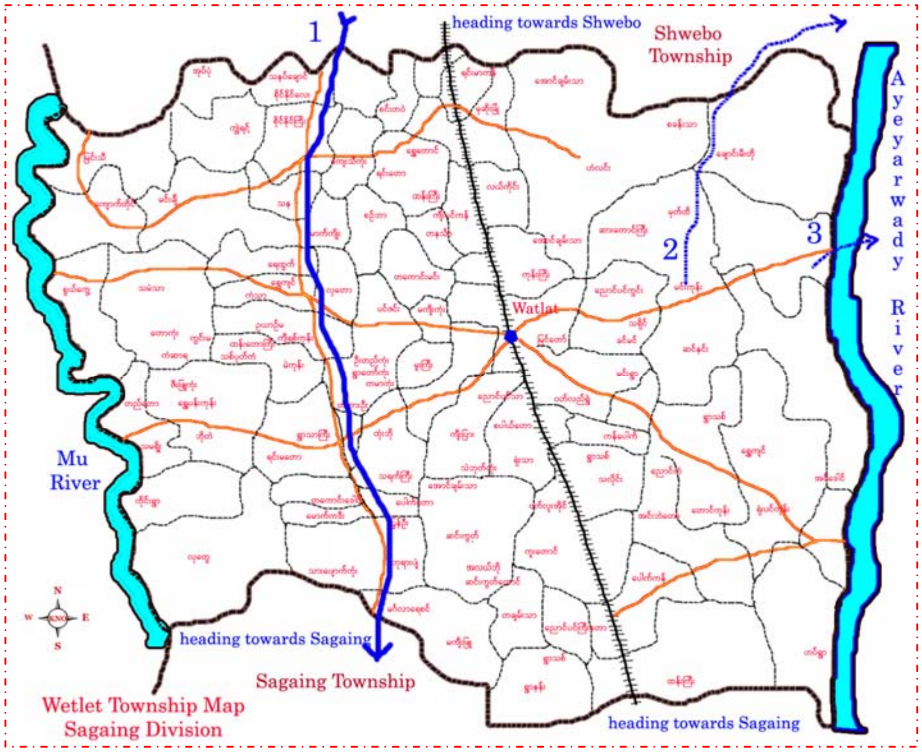

Figure 7.8 Animal movements in Wetlet Township

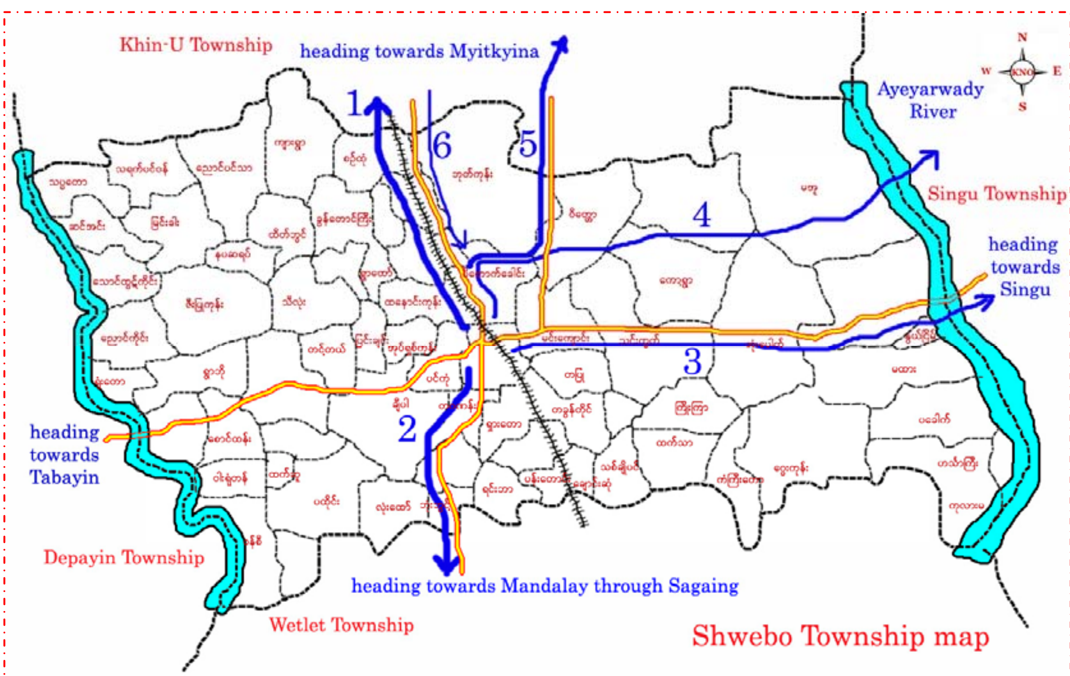

Figure 7.9 Animal movements in Shwebo Township

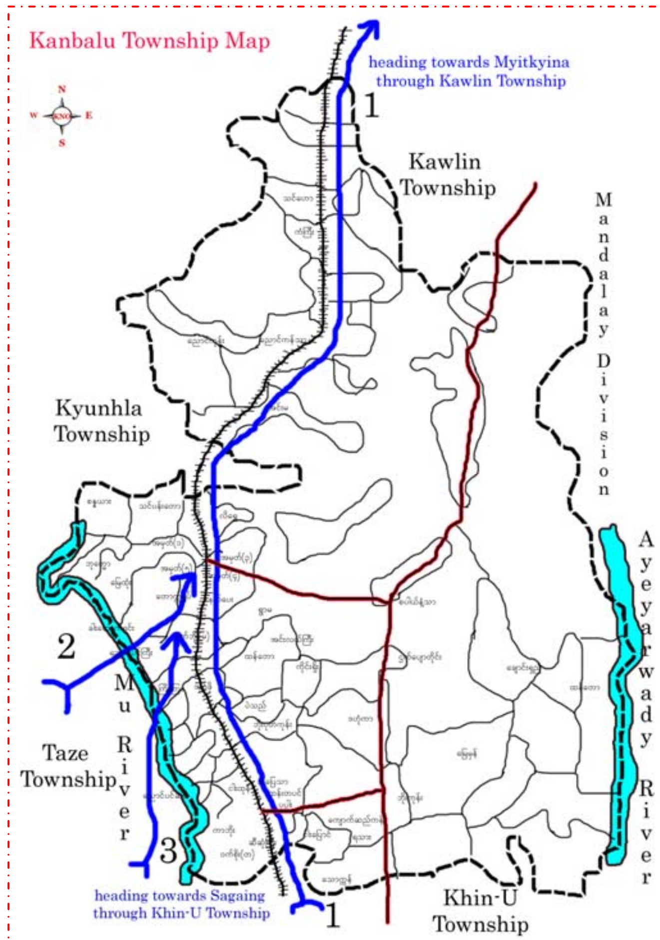

Figure 7.10 Animal movements in Kanbalu Township

7.3.8 Summary of movements in the proposed control zone of the Sagaing Division

In summary, most of the movements in the Sagaing Division were out of the Division with very few inward movements from the Mandalay Division (See Figure 7.11). Among the movement routes, number 1 was the major route out of the Division (Aung Soe, 2006). The second most important route was number 2 which led to Myitkyina in Kachin State. Routes 3 and 4 led to Mandalay Division and neighbouring countries respectively (MZWG 1, 2004b). The estimated average number of cattle moving from the Sagaing Township to Mandalay Division by boat along the Ayeyarwady River was between 100 and 300 per month (Aung Soe, 2006). Route number 5 had three branches and all originated from the lower part of the Sagaing Division and led to Chin State. Although the number of animals moved along this route was not documented during the participatory workshop, this was a well known route for livestock moving out of the Sagaing Division. Route number 6 originated from three different areas which led towards Monywa. Route number 8 was the only inward movement leading to the Sagaing cattle market. The other routes (numbers 7, 9 and 10) were intra-divisional movements within the Sagaing Division.

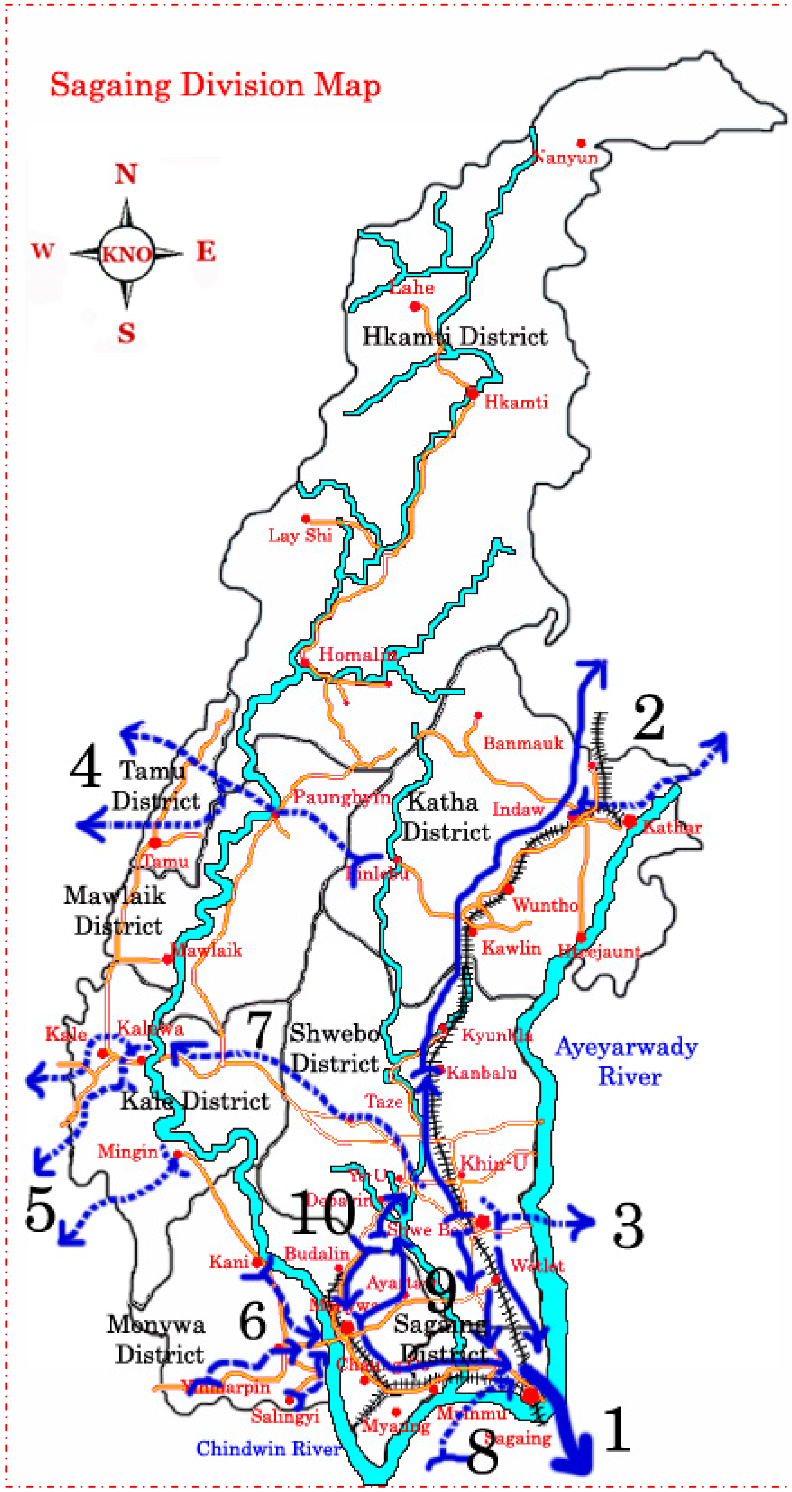

Figure 7.11 Summary of animal movements in the Sagaing Division

7.3.9 Cattle movement in Myeik District

Myeik Township is located in the centre of Myeik District and is close to the Andaman Sea. The capital city of Tanintharyi Division is Myeik Town and it has a seaport and a domestic airport. It has a higher number of cattle compared with other townships in the district. Participants reported in the MTD meetings that cattle movements were primarily within the district and there were no inward movements of cattle and buffalo from other districts or divisions. Some movements occurred regularly to provide slaughter animals for local consumption and some were seasonal movements involving moving cattle between pastures. No reports of long distance movement (for cattle trading) were made from other Districts or Divisions by sea or air. During the participatory workshop a well known movement route in Myeik District leading towards the Thai-Myanmar border was noted (named the Maw Taung route) (MZWG 1, 2004a).

7.3.9.1 Cattle movement in Myeik Township

During the MTD meeting conducted in early 2008 in six villages of Myeik Township, participants reported routes of movements for cattle and buffalo (Figure 7.12) in Myeik Township. Apart from route number one, others involved seasonal movements for changing pastures. Farmers sent surplus cattle from their villages to areas with available pasture and empty land (not used for cultivation) during the monsoon season (beginning of June to the middle of November). It was estimated that 70 to 80% of the total cattle in each village were moved to pasture. Approximately 100 head were shifted from Kahan to Sandawut villages for changing pasture (Route 2 in Figure 7.12). Participants from Pathaung Village revealed that their cattle were sent to Ma Zaw Village of Tanintharyi Township (routes 4 and 6 in Figure 7.12). They reported that some parts of Tanintharyi Township, where it was hilly and could not be cultivated, were used as communal grazing grounds during the monsoon season. These areas were located around Ma Zaw, Pa Wa, Tha Ya Phone, Maw Tone and Tone Byaw villages. Wild animals, such as feral pigs, deer and chamois, were present in such areas. Some villagers from Myeik and Tanintharyi Townships were accustomed to using that empty land for grazing cattle. During the monsoon, many cattle from various villages were taken to the common grazing grounds. Local farmers tended to buy and sell cattle within their township because inter-district movements of cattle and buffalo were strictly restricted and transportation was expensive. Butchers purchased cattle from various villages around Myeik Township and they then moved these cattle to the nearest motor road where the animals were then transported by vehicle. Most of the farmers revealed that they sold their cattle to butchers when they needed money.

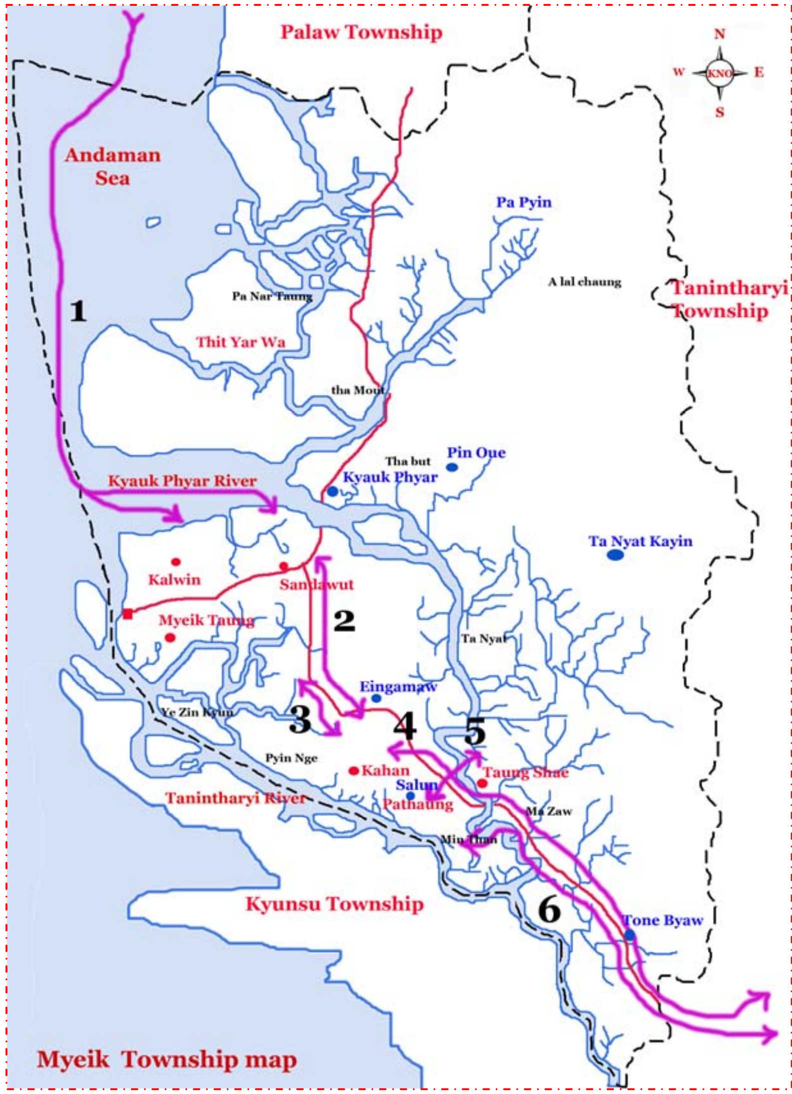

Figure 7.12 Animal movements in Myeik Township

7.3.10 Cattle movement in Dawei District

Information was collected on animal movements during the MTD meetings in some villages of Dawei, Thayetchaung and Yebyu Townships and for movements in the whole of Dawei District from local staff of LBVD (expert opinion). The majority of the movements within the Dawei District originated from the Thayetchaung Township (Figure 7.16). Four animal species (cattle, sheep and goats and pigs) were involved in these movements, however most movements involved cattle. Very few pig movements from Thayetchaung Township to Myeik District were reported by staff of the LBVD.

7.3.10.1 Cattle movement in Yebyu Township

During the MTD meeting conducted in Kyauk Ka Nyar Village of Yebyu Township, participants revealed that they moved buffalo between pastures similar to that reported in Myeik Township. They reported that most cattle were fed at home and were not sent to the communal grazing grounds. A well known seasonal communal grazing ground (used during the monsoon season) was located near Ka Lone Htar Village.

Farmers purchased cattle for draught purposes from neighbouring villages. Data on the mass movement of cattle for trading purposes were collected from local staff (experts) of Yebyu Township. Most of the animal movements were directed towards the eastern part of Yebyu Township and these were originated from Launglon Township in Dawei District. The market value of cattle was higher in Yebyu than in other neighbouring townships.

The majority of animal movements led to the Thai-Myanmar border along four major routes (Figure 7.13). These animal movement routes originated from neighbouring township such as Launglon, Dawei and Thayetchaung to Yebyu. The number of animals using each route depended upon the demand for animals, however at least 25 cattle were regularly driven by traders each month (Thein Zaw, 2007).

Figure 7.13 Animal movements in Yebyu Township

Figure 7.14 Animal movements in Launglon Township

7.3.10.2 Cattle movement in Launglon Township

Animal movement information from Launglon Township was collected by expert opinion. Launglon is located in the western part of the Dawei District and is a narrow coastal area surrounded by sea and the Dawei River. There was no movement into the township and all movements were outwards and towards Dawei and Yebyu Townships. The number of cattle moving out of the region varied with the demand of traders (Thein Zaw, 2007).

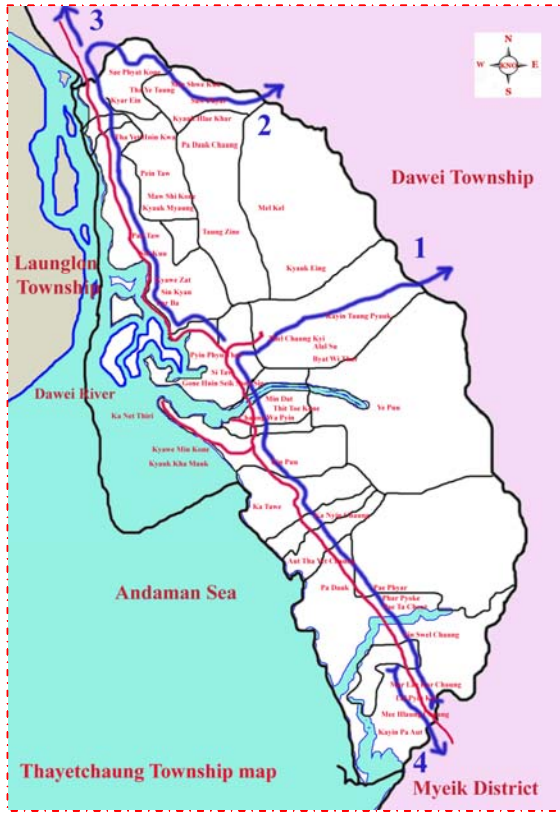

Figure 7.15 Animal movements in Thayetchaung Township

7.3.10.3 Cattle movement in Thayetchaung Township

This information was collected from local staff of the LBVD. In Thayetchaung Township, there is a relatively large number of cattle and the majority of animal movements originated from villages located along the motor road and led north of the township (Figure 7.15). The average number of cattle which were driven along the four routes towards Dawei and Yebyu Townships was between 75 and 100 head per month (Aung Htein, 2007).

Figure 7.16 Summary of animal movements in the Dawei District

7.3.11 Cattle movement in the Kawthoung District

Most of the information on cattle movement in the Kawthoung District was collected from experts because there were few cattle in Kawthoung Township and the principle business of local people was not agriculture (Khin Maung, 2007). In addition, participants reported in the MTD meeting in early 2007 there were no or very few livestock movements from one township to another because of the complicated paper work required and difficulties with transportation. If farmers needed cattle for their agricultural work, they purchased them within the township as this was cheap and convenient for them.

There were only a small number of cattle in the Kawthoung District and consequently chilled meat was often flown from Yangon (Thein Win, 2007). However this meat was expensive and was primarily used in the hotel and restaurant trade. The only time that farmers sold cattle was prior to Muslim religious festivals when the price was high. For the rest of the year, it was very rare for farmers to sell cattle (Khin Maung, 2007).

7.3.12 Summary of cattle movement in the Tanintharyi Division

This division is a narrow coastal area and inter-district movements were very rare. Generally, the majority of movements were intra-township movements for changing pasture and for moving animals for slaughter. Up to the time of this study, inward animal movement from outside the Division had not been reported. Most of the movements led to the Thai-Myanmar border region.

7.4 Discussion

There were significant differences in the geography and livestock density in the two areas involved in this study. The husbandry system adopted and geographical locations are important in the spread and potential impact of FMD in Southeast Asia (Cleland *et al.*, 1995; Cleland *et al.*, 1996). The Sagaing Division is over two times larger than the Tanintharyi Division (94,000 and 43,000 km^2 respectively) (Anon, 2000b). Furthermore, the Sagaing Division is surrounded by neighbouring states and divisions of Myanmar and there is good transportation infrastructure with all neighbours. In contrast Tanintharyi is surrounded by the Andaman Sea to the west and international borders to the east and south. It has only one neighbouring state (Mon State) connected by a single motor road and railway line.

The Sagaing Division has a large number of cattle (2.1 million) compared with 140,000 in the Tanintharyi Division (MLF, 2008). There is a cattle market in the Sagaing Division but not in the Tanintharyi Division. In the Tanintharyi Division agricultural work is more mechanised than in the Sagaing Division (Aung Htein, 2007; Thein Zaw, 2007) but farmers in the Tanintharyi Division still keep livestock because they prefer to use natural fertilizer (manure) on their agricultural land.

In the Sagaing Division, there were more frequent outbreaks of FMD than in Tanintharyi. The Sagaing Division has a better transportation system than in the Tanintharyi Division and the attitudes of farmers from both divisions were remarkably different in terms of managing draft cattle and the husbandry systems adopted. During the MTD meetings, it was found that more farmers from the Sagaing Division replaced their draft cattle each year than did those from the Tanintharyi Division. This could be a traditional practice or it could be that they borrow money before the start of work each year and purchase cattle for the season and then sell the cattle at the end of the working season. This latter option is likely given the poverty of the local people and their lack of investment. This practice results in more movements of cattle among farmers and between villages. There is a local word in villages of the Sagaing Division - "Kwar Yae Thauk Chein" which literally means "the time of changing cattle at the end of working season". In the Tanintharyi Division, this practice was not reported during the MTD meetings.

A different feeding system was reported between the two divisions. In the Sagaing Division most farmers added a variety of feed supplements (sesame cake, groundnut cake, wheat straw) to the home made feed for their cattle (see Chapter 2) whereas in the Tanintharyi Division, most farmers did not add supplement to their home made feed. In a study conducted in the Adamawa Province of Cameroon (Bronsvoort *et* *al.*, 2004a), an increased risk of FMD was reported when cotton seed was fed. Within the Tanintharyi Division, the Kawthoung District has the least number of animal movements whereas the Dawei District has the most. It can be assumed that in the Dawei District there are more outbreaks because of the more complex animal movement patterns and the larger number of animals moved.

When comparing animal movements in the two divisions, there are more complex animal movement patterns in the Sagaing Division and this division also has more outbreaks of FMD. The sero-prevalence of FMD in the villages (Chapter 4) located in the Sagaing Township, where the only cattle market existed, was high and all villages contained seropositive animals. The disease could be transmitted through the movements of cattle to and around the cattle market. During the 2001 UK outbreak of FMD, the movement of animals through cattle markets was considered an important aspect in the spread of the disease (Robinson and Christley, 2007) and it is similarly likely that in Myanmar animal movement is one of the major factors in the spread of the disease.

In conclusion, the Tanintharyi Division is more isolated than the Sagaing Division in terms of animal and human movements and transportation routes and consequently fewer outbreaks are likely to occur in Tanintharyi than in the Sagaing Division.

General Discussion

Foot and mouth disease is endemic in Myanmar and the disease has a severe impact not only on the country but also on the whole of Southeast Asia (Anon, 2007; Rweyemamu *et al.*, 2007). Agriculture is the main industry in the country and the majority of farmers use draught animal power as an alternative to expensive fossil fuel (Gleeson, 2002). The LBVD has implemented plans to control FMD in the country since the establishment of the FMD laboratory in Insein, Yangon, Myanmar and the first vaccine trial was conducted in Yangon Division in 1975 (Sitt, 1978). In the 1990s Myanmar joined the SEAFMD campaign and the progressive zoning approach for the control of FMD was launched after the first MZWG meeting held in Yangon in 2004 (MZWG 1, 2004b). Understanding the epidemiology of FMD within the country is crucial for developing and instigating an effective long term control/eradication plan against the disease (Saraiva, 2004). Controlling FMD will not only benefit Myanmar but also neighbouring countries for the regional control of the disease (Gleeson and Ozawa, 2002; SEAFMD, 2007).

This study is the first scientific research undertaken on the epidemiology of FMD in Myanmar to support the establishment of the progressive zoning approach for the control of the disease in line with the SEAFMD campaign (SEAFMD, 2007).

This study was designed to:

1. Understand the epidemiology of FMD in both endemic and potentially free areas including the identification of putative risk factors for the spread of the disease in the Sagaing Division (endemic area).

2. Develop a cost effective participatory approach (the MTD meeting) to be used as an epidemiological tool for the detection of FMD in the early stages of the control of FMD.
3. Understand the influence of FMD on animal draught power and its consequent economic impact on local farmers whose farming enterprise is mainly based on draught cattle.
4. Support the zone progression for the Myanmar MTM areas without vaccination (Tanintharyi Division).
5. Advise the MZWG on the future control programme of FMD for, not only the Sagaing Division, but the whole country.

The epidemiology of FMD in Myanmar

Foot and mouth disease has been present in Myanmar since at least 1887 (Sitt, 1978). Sitt (1978) reported the presence of Types O, A and Asia 1 in Myanmar in the 1970's and these three types were still present in the 1980's (Duh, 1993). In the 1990's Types O and Asia 1 predominated with only one outbreak caused by type A affecting 9 cattle in Myeik (Duh, 1993; Gleeson, 2002; Black, 2003). This was the last reported outbreak of Type A in Myanmar. Between 2000 and 2009, the most common serotype was Type O, and Type Asia 1 was only detected in 2000, 2001 and 2005 (SEAFMD, 2009).

The serological study demonstrated that the prevalence of FMD in the Sagaing Township was very high with an overall sero-prevalence (individual level) of 42% (95% CI 37.7 - 47.1). However, the prevalence varied from 22.2% (95% CI 3 - 41.4) to 68.1% (95% CI 54.8 - 81.4) (Chapter 4) in the studied villages. All villages sampled (n=17) had some positive reactors in cattle to the Cedi® FMDV NS ELISA tests and it is assumed the virus is circulating within and between the villages by a variety of means. The village level prevalence was 100% if a village was considered infected if one or more animals were positive (Gray and Martin, 1980; Dohoo *et al.*, 2003; De *et al.*, 2006). Active sero-surveillance conducted in Thailand in 2003, revealed that the overall prevalence (animal level) of FMD for 9 regions in Thailand was 4.2% (3.6 - 4.9 % 95% CI) with a range from 0 to 8.1% (Wongsathapornchai *et al.*, 2008). Even though Thailand has a large scale vaccine production plant (Lombard and Schermbrucker, 1993) and has applied mass vaccination for the control of FMD within the country (Kongthon, 1991; Cleland *et al.*, 1996), the disease is still endemic. However, the prevalence is lower than that detected in the study area of the Sagaing Division. The MTD meetings conducted in the Sagaing Division indicated that FMD has been present in the Division for many years. Local people from the Sagaing Township were familiar with FMD and they could easily recognise its clinical lesions. In contrast in Myeik (Tanintharyi Division) only old people recognised the signs and the majority of the participants (young people) had never seen lesions characteristic of FMD, indicating a very low prevalence of the disease (Kitching, 2002a). As there has not been an outbreak reported for more than 15 years in the Kawthoung District, and the last outbreak was reported in 1999 in the Myeik District, this area can be assumed to be a potentially free area for FMD (Dufour *et al.*, 2001).

In the current study, a few factors were positively associated with the presence of FMD. These included purchasing cattle in March, purchasing cattle every year, practicing communal grazing and contact at watering points. In contrast owning less than 10 head of cattle, buying cattle within the township and selling cattle within the village were protective factors and were negatively associated with disease (Chapter 2). Amongst the positive risk factors, all are related with the movement of and contact between animals which are recognised as common methods for the spread of FMD (Ferris *et al.*, 1992; Cleland *et al.*, 1996; Sutmoller *et al.*, 2003). Purchasing cattle every year involves movement of cattle and it is also a common risk factor for the spread of FMD among susceptible animals (Woolhouse and Donaldson, 2001). These animals could be carrier animals or infected animals with mild clinical signs. Even though disease transmission from carriers to susceptible animals is considered rare, it still could be an important risk factor for disease (Niedbalski and Haas, 2003).

There were more movements of livestock in the Sagaing Division than in the Tanintharyi Division. Livestock movements in the Sagaing Division were complex because of a favourable geographical situation and the socio-economy of the local people. In contrast in the MTM area, the Tanintharyi Division is a narrow coastal area and relies heavily on transportation by water which reduces the potential for animal movements. The major direction of cattle moving in the Sagaing Division was towards the larger markets in the southern part of the Division and towards China in the north because of market forces (Chapter 7).

The economy of Myanmar depends largely on agriculture and more than 65% of the work force is involved in the industry (Duh, 1993). Animal draught power is essential for local farmers due to the high cost and poor availability of fossil fuels. The influence of FMD on animal draught power was evaluated by developing a Monte Carlo model (Chapter 6) which used information from the questionnaire interview (Chapter 2), the MTD meeting (Chapter 5) and the farm household surveys (Chapter 6). As a consequence of FMD, loss of animal draught power led to the loss of production and had a negative impact on the economy for both farmers and the country.

The capability of the LBVD to implement a disease control programme is limited and the LBVD mainly relies upon international support to control FMD.

Although there is a vaccine production unit within the LBVD, it can only produce approximately 100,000 doses per year, which is not enough for the total cattle population of the country (Gleeson and Ozawa, 2002; Anon, 2008b). There are plans to increase the vaccine producing capacity in the country by establishing a new vaccine production laboratory in Myinmu Township. However, it is still unlikely that sufficient vaccine can be produced to vaccinate all the nations cattle (Pers. com. Dr Khin Maung Latt). Nevertheless, a zoning approach with strategic use of vaccine in high-risk areas (Figure 7.11), as identified in this study, would allow prudent use of a scarce resource. As of 2009, LBVD should focus to establish a progressive zoning approach for the control of FMD within the country because an eradication programme for the whole country using a stamping out policy (King, 2001; Mahy, 2004; Sellers, 2006) or mass vaccination campaign (Hunter, 1998; Rweyemamu *et al.*, 2008a) would not be feasible.

Modified Traditional Dutaik meeting approach in two areas

During this study a participatory method, the Modified Traditional Dutaik meeting approach, was developed and used as a tool for disease surveillance. This method was validated against data collected from other forms of study: testing cattle with the Cedi® FMDV NS ELISA, conducting questionnaire interviews, and obtaining expert opinions. Many researchers have reported that participatory methods have been used to detect a range of diseases in different countries (Loewenson, 2004; Chibeu, 2005; Mariner *et al.*, 2005; Mariner *et al.*, 2006; Jost, 2007). Although the MTD meeting has some limitations, it is a powerful tool to detect FMD in Myanmar and is an appropriate technique to use in a country with significant financial constraints and a lack of adequate laboratory facilities. This approach can be used to collect data about the presence of FMD because of the diseases characteristic clinical signs as well as the epidemiology of the disease (Chapter 3). The traditional Dutaik meeting approach has also been used as a tool for increasing public awareness in the Myanmar MTM area prior to this study (Abila, 2007). It can be used to educate and involve farmers in the control of FMD and is a cost-effective component in the implementation of a disease control program.

There are, however, limitations with the MTD meeting approach. These include:

1. In a large village such as Pa Du village, which has more than 500 households, one MTD meeting is not sufficient to collect data or provide information as a maximum of 20 to 25 persons attend each meeting. However one meeting could be used to collect general information about the village or the presence of clinical disease rather than very specific information.
2. It requires a good facilitator to handle the meeting to ensure the meeting is not dominated by individuals or does not deviate from the topic of interest but it is necessary to avoid facilitator bias (Cooke and Kothari, 2001; Ericson, 2006).
3. The success of the MTD meeting depends upon the knowledge of the participants and consequently requires identification and inclusion of appropriate people from the village.
4. There can be confusion between the researchers and participants if there are specific local terms for the disease being discussed because it could lead to vagueness and lack of rigor (Ericson, 2006) on the information provided by participants. Consequently it is necessary to avoid using technical terms and words which are not familiar to the local people.
5. The MTD is suitable for diseases with distinct clinical signs but was less suitable for FMD in sheep and goats which often have subclinical infections (Donaldson and Sellers, 2000; Clavijo *et al.*, 2004). It can also be less sensitive for the

detection of mild forms of FMD. The overall sensitivity of the approach would be improved by conducting effective public awareness campaigns to ensure villagers were aware of the possible role of small ruminants in FMD and by placing extra vigilance on the clinical lesions of FMD in sheep and goats (McLaws *et al.*, 2006).

Support of zone progression of the Myanmar MTM zone

After the 2005 sero-surveillance programme in the Myanmar MTM area, some positive serological results were found in livestock from the Myeik Township. During the recent 2008 study, the results from MTD meetings were combined with the results from a sero-surveillance study in this region to clarify the true situation with respect to FMD. The study provided evidence to indicate that the serological results were likely to have been false positive results. All findings were submitted to the MTM tristate commission meeting in Malaysia in 2008. Based on this work the Commission agreed to upgrade the status of each zone within the Myanmar MTM zone. This meant that the control zone progressed to eradication zone, the buffer to control zone and the infected zone to a buffer zone. To achieve the target of the free zone without vaccination recommended by OIE, it is necessary to do more detailed studies in Kawthoung and Myeik Districts including recording processes in place to control animal movements. Any future surveillance programme should include an early warning system and awareness programme to maintain confidence that any suspected cases of FMD are reported (OIE, 2008c).

Supporting the MZWG for the control of FMD

One of the objectives of this study was to support the MZWG for the establishment of a progressive zoning approach. Since the 4th MZWG meeting in

Mandalay, Myanmar in 2006, research findings from the current study have been submitted to this group (MZWG 4, 2006). During this study, the status of the Sagaing Zone has been modified. In the 2008 MZWG meeting, the total number of townships within the control zone was reduced from 15 to 13 to exclude two townships each with more than 100,000 cattle. In addition, the establishment of a progressive zoning approach was proposed to be combined with a vaccination programme. This option was chosen taking into account the complex animal movements, the large number of susceptible animals and the fact that the disease has been endemic for many years. Furthermore, this approach has been considered by others as an appropriate option for the control of FMD among Southeast Asian countries (Ozawa, 1993; Edwards, 2004b). Expected international support for vaccine supply is likely to be limited, so that reducing the number of susceptible animals in the control zone decreases the requirement for the number of vaccine doses required. At this meeting a buffer zone was proposed and established for the future control of the disease. In an endemic country in addition to the use of a coordinated vaccination programme and zoning approach for the progressive control of FMD, other key issues such as control of animal movement, and understanding the socio-economic impact of the disease and prevailing serotypes (Rweyemamu *et al.*, 2008a) must be addressed. However, the failure of the vaccination campaign for the eradication of FMD in Brazil (Mayen, 2003), where FMD had been endemic since the 1980s, has been reported. This was due to: antigenic drift of the virus which was not recognized immediately and consequently the vaccine did not protect against the new strain of FMD; improper use of cold chain to transport and store the vaccine; and not including all susceptible animals in the vaccination campaign apart from cattle (Mayen, 2003). These facts should be considered in the design of any programme in Myanmar that includes vaccination.

Comparison of the status between the Sagaing Division and the Tanintharyi Division

There are differences between the two areas targeted in this study (the Sagaing zone and the Myanmar MTM zone). In the study area of the Sagaing zone, all villages possessed cattle, participants could easily estimate the total population of cattle in their village and every household had at least a pair of draught cattle. In contrast in the Myanmar MTM zone of the Tanintharyi Division, not all villages contained cattle and only some people used cattle for draught power. Farmers mainly raised cattle to produce milk and for breeding and meat supply. The lower population density in the MTM zone also reduces the risk of FMD (Leforban, 1999; Perez *et al.*, 2004b).

In the Sagaing Division there are complex movements of livestock. The major movements involve the use of bullock carts for transportation by locals. In addition, the habit of changing cattle at the end of their working season, allowing surplus cattle to graze freely on common grazing pasture, and using common grazing ground for sheep and goats throughout the year adds to this complexity. The movement of livestock was recognized as an important factor in the dissemination of FMD across the United Kingdom during the outbreaks in 2001 (Woolhouse and Donaldson, 2001; Fèvre *et al.*, 2006) and sharing communal grazing ground and water points were considered risk factors for the spread of the disease in Thailand (Cleland *et al.*, 1996).

In contrast in the Myanmar MTM area of the Tanintharyi Division, only a few villages use common grazing grounds and they are only used for a restricted period of time. Farmers do not change their cattle at the end of the working season and the use of draught power has been replaced by light tractor power. There is no cattle market in the whole of the Tanintharyi Division and the only animal movements were for slaughter purposes by butchers who were licensed to move cattle.

In the studied areas of the Sagaing zone, farmers mainly cultivate seasonal crops such as rice, wheat, beans, sunflower, sesame, and other horticultural crops using animal draught power, whereas in the Myanmar MTM area, only a few farmers grow rice. Villagers in the MTM area often work as labourers in other places including the fish factories and rubber plantations. This contributes to the difference in the susceptible population between the two areas. The low density of susceptible animals in the MTM area reduces the risk of FMD spread in this region.

The Tanintharyi Division possesses better natural boundaries than does the Sagaing Division because it is located in a narrow coastal area with the Andaman Sea in the west and mountain ranges in the east. Local people have to use boats and vehicles to travel within the Division. The roads are very narrow when compared with the roads in the Sagaing Division. The Sagaing Division does contain two big rivers, Ayeyarwady and Chindwin Rivers, but there are better roads and people and cattle can move throughout the division and can easily cross the rivers via the large bridges. These differences make the control of animal movements in the Tanintharyi Division easier to implement and consequently the control of FMD is easier. The natural boundaries provides barriers for the spread of FMD (Sobrino and Domingo, 2001) and provides more favourable conditions for the use of a progressive zoning approach for the control of FMD.

In the Sagaing Division, only a few people were aware of the impact of FMD. Most farmers paid more attention to Anthrax and black quarter (black leg disease) because these diseases are acute and lethal. Although more public awareness campaigns have been conducted in the control (Myeik District) and eradication zone (Kawthoung District) of the Tanintharyi Division because of the MTM campaign, few farmers were aware of the impact of FMD. This would indicate that these campaigns have not been successful at raising awareness about the disease. Awareness of all stakeholders in all targeted areas on the impact of FMD is a critical issue for achieving success in the control and eradication of the disease (Meisenzahl, 2008; SEAFMD, 2008).

There are many vacant LBVD positions in the Sagaing Division and staff are required to look after more than 10,000 cattle in their sub-township area. In the Tanintharyi Division, LBVD appoint staff according to the veterinary infrastructure plan. One veterinarian ideally should look after less than 5,000 cattle in an area and consequently more staff are required in the Sagaing Division.

In the Sagaing Division, outbreaks of FMD occurred every one or two years in all villages studied. In contrast in the Tanintharyi Division the last outbreak occurred in 1999 in the control zone and in the eradication zone the last outbreak occurred prior to 1975. So far there have been no outbreaks in this studied area except in the Dawei District.

Constraints and limitations of this study

There were many time and financial constraints for this study. The Cedi® FMDV NS ELISA test could be used only to validate the MTD meeting approach in the Sagaing and Myeik Township areas. Other laboratory results were obtained from the National FMD Laboratory and serotypes associated with outbreaks were obtained from the SEAFMD website. The field trip in the Sagaing Division was conducted within a limited time frame because the accompanying staff of the LBVD also had other work to do and some villages had no accommodation or electricity. As a consequence, it was not possible to collect some data and some bias may have been introduced. For example, in Ngatayaw village, the questionnaire interviews were not administered and sera were collected by convenience sampling as opposed to the random sampling that was used elsewhere. Similar constraints were encountered in the study in the Myeik Township because of security and accommodation difficulties. The use of a local dialect also posed challenges resulting in the MTD meetings in Myeik being slower than those conducted in the Sagaing Division. These reflect the difficulties of conducting research in the real world.

Suggestions for further research

Understanding the epidemiology of FMD is an important aspect for the establishment of an effective control programme (Rweyemamu *et al.*, 2008a). The impact and epidemiology of FMD is expected to vary between different regions (OIE, 2008c). There are many issues that need to be investigated to improve the understanding of FMD in Myanmar. There are a large number of sheep and goats in the study area of the Sagaing Division (Table 3.2 and Figure 3.4). In this study, the role of sheep and goats on the epidemiology of FMD could not be clarified. This was because the MTD meeting approach was based mainly on the prominent clinical signs in animals and the observations of the farmers. Clinical lesions in sheep are not distinct and the duration of clinical lesions is short (only one to two days) (Donaldson and Sellers, 2000; Hughes *et al.*, 2002). Therefore, an appropriate methodology should be applied to study the importance of sheep and goats in the epidemiology of FMD in Myanmar.

The potential carrier status of wild animals (Pinto, 2004) is an important issue to consider in the control of FMD because there are two wildlife sanctuaries in the Sagaing Division: "Alaungdaw Kathapa " and "Chatthin", which are bordered by villages. These have areas of 620 and 103 square miles, respectively and are located at the western and northern part of the Sagaing Division (Aung *et al.*, 2004; Anon, 2009). There are many cloven hoofed animals in these sanctuaries which are susceptible to FMD including gaur (*Bos gaurus*), samber deer (*Cervus unicolor*), hog deer (*Axis porcinus*), muntjac (*Muntiacus mun tjak*) and brow-antlered deer (*Cervus eldi thamin*) (Gibbs *et al.*, 1975; Aung *et al.*, 2004; Pinto, 2004; Anon, 2009).

More studies also need to be done in the neighbouring divisions of the Sagaing Division because Mandalay Division has many cattle markets and these are known to be an important issue in the spread of FMD (Woolhouse and Donaldson, 2001; Lindholm *et al.*, 2007).

A risk analysis study should be done in the potential free area of Kawthoung and Myeik District for the maintenance of the zone status and freedom of FMD in future. The main issue relates to the movement of chilled meat from Yangon to Kawthoung by air and from Dawei Township by vessels to Kawthoung market (reported in an informal meeting with butchers in 2008). Many authors have reported that the importation of animal and animal products, including meat, is considered a risk factor for the introduction of FMD into previously free areas (Sanson, 1994; Rapoport and Shimshony, 1997; Yu *et al.*, 1997; Kitching and Alexandersen, 2002; Mahy, 2005a) because FMD virus can survive meat processing such as chilling, steaming and drying (Blackwell *et al.*, 1982; Chou and Yang, 2004).

A molecular epidemiological study (Beck and Strohmaier, 1987; Knowles and Samuel, 2003) should be conducted in the targeted study area of the Sagaing Division to identify the potential routes for the introduction of new strains from outside the division, the source of outbreaks (Samuel and Knowles, 2001) and to confirm the presence or absence of virus mutation within the division. The mutation rate of FMD virus has been reported to be very high resulting in rapid evolution of serotypes and consequently failure of vaccines to protect against the disease (Domingo *et al.*, 2002). Identification of virus strains and understanding the movement of the virus strains between regions would be useful information for the future control of FMD (Knowles and Samuel, 2003).

The existing disease control programme should be reviewed and appropriate approaches investigated by the LBVD to reduce the occurrence of FMD within the Division. The currently applied approaches such as ring vaccination, sanitary measures and temporary animal movement control (Pers. com. Dr Khin Maung Latt) do not seem sufficient. The use of vaccine during outbreaks could lead to susceptible animals becoming carriers (McVicar and Sutmoller, 1976; Salt *et al.*, 1996; Barnett and Carabin, 2002) and may not effectively stop the reoccurrence of FMD within the division. Good veterinary infrastructure and efficient service delivery are important aspects for an effective disease control programme (Thiermann, 2004; Fèvre *et al.*, 2006; Max *et al.*, 2007).

Even though pigs do not become carrier animals (Salt, 1998; Kitching and Alexandersen, 2002), the prevalence of FMD in backyard pig systems in Myanmar is not clearly understood. Further study should be done to understand what role pigs play, if any, with respect to the epidemiology of FMD in Myanmar. This is important because there are many uncontrolled movements of pigs by traders within the Sagaing Division (Pers. com. Dr Min Nyunt Oo) and villages along the trading routes are considered risk areas for FMD (Kitching and Hughes, 2002; Perry *et al.*, 2002).

Outbreaks of FMD have great economic influence on affected countries (Krystynak and Charlebois, 1987; Randolph *et al.*, 2002). In Myanmar, it is also necessary to understand in more detail the socio-economic impact of the disease within the country. This study, focused on the influence of FMD on animal draught power. Further studies, including benefit cost analysis of vaccination, are required for the future control of FMD in Myanmar.

Conclusions

The study reported in this thesis has demonstrated that FMD is an important disease of cattle in Myanmar. The financial loss from this disease has previously been under-estimated in Myanmar. With the current situation in the country and the existing veterinary infrastructure, the use of a zoning approach with a strategic vaccination programme is a suitable approach for the effective control of the disease. This is because FMD has been endemic within the country for many years and financial and technical constraints to control the disease still exist. Control and eradication of the disease from the whole country is not feasible at the moment given the existing veterinary infrastructure (Edwards, 2004b; Fujita, 2004; Rweyemamu *et al.*, 2008a). However, it is feasible to establish a progressive zoning approach for the control of FMD in the Myanmar MTM area without vaccination and in the Sagaing Division with vaccination. The control of FMD within the country will have significant benefits for, not only individual farmers, but also to the economy of the country and consequently the majority of the Myanmar population.

Appendix 1

Epidemiological Survey to support the establishment of a progressive Foot and Mouth Disease Zoning approach in Myanmar

Date......./......./............

Code	
Name of Interviewer	

Q1. Geographical location of village

Division/ State	District	Township	Village tract	Village

Q2. Information of family and participation in livestock breeding

a. Name of participant.. ❑ Male ❑ Female

b. How many family members are there in your family?

c. Who is the main animal attendant in your family? ....

d. What is your family business? ....

e. How many of your family participates in your family business?

f. Do you own farmable land? ❑ No. ❑ Yes.

g. (If Yes) How much land do you own for your cultivation?

Q3. Information of Livestock raised in household

1. Do you own cattle? ❑ Yes. ❑ No.

(If yes) 1. a. How many cattle do you own? 1. b. Are they dairy or draught cattle? 1. c. What are their ages?

Species		Particular		Sex	up to 6 months	6-12 months	1-5 years	5-10 years	10 years and above
Cattle		Dairy		male					
				female					
		Draught		male					
				female					

1. d. where do you usually buy cattle from?		
1. e. where do you usually sell cattle?		
1. f. How many times do you usually buy cattle in a year?		1. g. At which months?
1. h.How many times do you usually sell cattle in a year?		1. i. At which months?

2. Do you own buffalo? ❑ No. ❑ Yes.
(If Yes.) 2. a. How many buffalo do you have? 2. b. Are they dairy or draught? 3. c. What are their ages?

Species		Particular		Sex	up to 6 months	6-12 months	1-5 years	5-10 years	10 years and above
Buffalo		Dairy		male					
				female					
		Draught		male					
				female					

2. D. where do you usually buy buffalo from?		
2. E. where do you usually sell buffalo?		
2. F. How many times do you usually buy buffalo in a year?		2. G. At which months?
2. H. How many times do you usually sell buffalo in a year?		2. I. At which months?

3. Do you own pigs? ❑ No. ❑ Yes.

(If Yes) 3. A. How many pigs do you own? 3. B. What are their ages?

Species		Sex	up to 6 months	6-12 months	1-5 years	5-10 years	10 years and above
Pig		male					
		female					

3. d. where do you usually buy pigs from?		
3. e. where do you usually sell pigs?		
3. F. How many times do you usually buy pigs in a year?		3. G. At which month?
3. H. How many times do you usually sell pigs in a year?		3. I. At which month?

4. Do you own poultry? ❑ No. ❑ Yes.

(If Yes) 4. a. How many poultry including ducks do you have? 4. b. What are their ages?

Species		**Sex**	**days old**	**1 month**	**1-6months**	**6month above**	**1 year and above**
Chicken		male					
		female					
Duck		male					
		female					

4. D. where do you usually buy them from?		
4. E. where do you usually sell them?		
4. F. How many times do you need to buy in a year?		4. G. At which month?
4. H. How many times do you need to sell in a year?		4. I. At which month?

5. Do you own sheep and goats? ❑ Yes ❑ No.

(If Yes) 5. A. How many sheep and goat do you have? 5.B. What are their ages?

Particular		**Sex**	**up to 6 months**	**6-12 months**	**1-5 years**	**5-10 years**	**10 years and above**
Sheep		male					
		female					
Goat		male					
		female					

5. D. where do you usually buy them from?		
5. E. where do you usually sell them?		
5. F. How many times do you need to buy in a year?		5. G. At which month?
5. F. How many times do you need to sell in a year?		5. I. At which month?

Q4. Feeding and raising system

1. How do you feed your animals? (Please tick the appropriate boxes)

	commercial ration	homemade ration	free grazing or wondering freely	swill feeding	Please specify
cattle					
buffalo					
pigs					
sheep					
goats					
chicken					
ducks					

2. If you use commercial feed what are the brand names?

....

3. If you use homemade feed, how do you prepare it and what are the ingredients?

	Ingredient	Preparation
1.		
2.		
3.		
4.		
5.		

4. If you use a free grazing system please identify the following.

❑with attendant ❑without attendant ❑tethered ❑free movement

5. If you use swill feeding, how do you collect it and where do you get it from?

....

Q5. Water

1. What is the source of water for animals?

❑Private well ❑Public well ❑Pond ❑Tap water ❑River

❑Other...

2. Is it available all year round? ❑ Yes. ❑ No.

3. (If no) In which months of the year do you have a water shortage?

....

4. What is the water source during that time?

....

Q6. Raising system

How do you raise your animals? (Please fill up in the table mentioned below)

	Free living in your compound	with temporary yard	with permanent building	Closed pen	Tie up at home	Let them in the grazing ground near the village with tie	Let them in the grazing ground free	Let them in the forest for a season	Others
cattle									
buffalo									
pigs									
sheep									
goats									
chicken									
ducks									

Q7. Disease Information

A. General Information

1.	Have you heard of an FMD outbreak in your village before? □ **Yes.** □ **No**
2.	**(If Yes)** How many outbreaks have you heard in the past 2 years? **..**
3.	When was the last outbreak in your village? **..**
4.	How many animals were affected in your village in the last outbreak? **..**
5.	What do you think caused the outbreak? **..** **..**
6.	What were the symptoms? ....

B. Personal experience

1.	Do you use FMD vaccine in your backyard farm? ❑ **No.** ❑ **Yes.**
2	(**If No**) Why don't you use FMD vaccine? ....
3.	(**If Yes**)How many animals did you vaccinate against FMD last year? ❑All ❑Some, What is your priority?... Why...
4.	How many times do you vaccinate your cattle? ❑ Every year (once) ❑ Every year (twice) Why do you vaccinate your cattle against FMD? ❑ Aware of FMD disease ❑ When you heard of an outbreak ❑ When LBVD organizes to vaccinate animals
5.	What is the result of FMD vaccination? (your suggestion and comment on FMD vaccine) ....
6.	Have you experienced an FMD outbreak in your cattle? ❑ **Yes.** ❑ **No.**
7.	(**If Yes**), - How many animals in your house were infected in the most recent outbreak? ☐☐

			Yes	**No**
8.	What did you do about the FMD diseased animals?	Inform headman	❑	❑
		Inform LBVD	❑	❑
		Call the vet to get treatment	❑	❑
		Use traditional treatment	❑	❑
		Sell to slaughter house	❑	❑
		Let them to get recover without treatment	❑	❑
9.	How many animals died of FMD in your backyard farm in last year? ☐☐			

10.	How long did they take to recover?		☐☐ Days
11.	What do you believe was the source of the outbreak?		
12.	How much did you spend on treating cattle that recovered with FMD?		**..........Kyat**
13.	What is the constraint of the FMD outbreak in your backyard farm? ❑loss of labour, ❑loss of money, ❑wasting the time to look after the sick animals ❑others (please specify)..		
14.	What type of medicine did you use to treat your animals with FMD?	....	
15.	Did you make contact with local veterinary staff of LBVD with respect to outbreak? ❑ **Yes.** ❑ **No.**		
16.	Have you received any instructions and guidelines during the outbreak from the LBVD?		❑ Yes**.** ❑ No**.**
17.	**(If Yes)**What kind of instructions did you receive and from whom? ❑ Leaflet or Pamphlet. ❑Personal information. ❑From headman. ❑From Veterinary Officer ❑Others.		❑movement control ❑to slaughter ❑to do treatment ❑to move out from the village ❑ to report back LBVD

Q8. Information concerning animal movement

1. Do you know the common route (road) of animal movements in your District?

❑ **No.** ❑**Yes. - Please mention it**...

……………………………………………………………………………………………………

……………………………………………………………………………………………………

2. If you want to buy or sell cattle what kind of route do you use?

(❑ On foot, ❑ by vehicle, ❑ by ship ❑ other ....)

Q9. General Questions

1. Do you use any anti-worming preparations in your animals?

❑ **No.** ❑**Yes .** What kind of anti-worming preparations do you use and Why?

....

2. How many times have you used anti-worming preparations in the past year? | | |

3. Do you use other vaccines on your animals?

❑ H.S. ❑ Anthrax ❑ Black Leg ❑ Hog Cholera

❑ Others...

4. Have you given any Vitamin supplement to your animals in the last year?

❑ **No** ❑**Yes** What kind of supplement did you use?

....

....

5. How many draught animals are you using now?.......... And for how many acres?........

6. How many years do you use the same cattle for cultivating your land? | | | Years

7. How many veterinarians are doing general practice within 10 miles of your village?

....

8. They are

❑ Private veterinarian

❑ LBVD staff and

❑Assistant veterinarian worker

****

Appendix 2

Questionnaire for Sagaing Zoning approach

Date	..................................(Day/month/year)
Serum sample number	....
Name of Interviewer	

Q1. General information

1.1.	District	Sagaing ❑ Myinmu ❑ Monywa ❑	
1.2.	Township	Sagaing ❑	
1.3.	Village		
1.4.	Name of respondent		
1.5	Age		Years ...., Months..........
1.6	Sex		Male ❑ Female ❑

Q2. Information of cattle which is bled for test

2.1.	Age	Years ......, Months..........
2.2.	Sex	Male ❑ Female ❑
2.3.	Breed	Dairy ❑ Draught ❑
2.4.	Have you applied vaccination against FMD?	Yes ❑ No ❑
2.4.1.	If yes, when was the last vaccination date?	............/................./.............
2.4.2.	If yes, who vaccinate your cattle?	Staff ❑ Private ❑ Yourself ❑ Other ❑
2.5.	Has this cattle been infected with FMD before?	Yes ❑ No ❑
2.5.1.	If you answer yes, when was the last time?	............/................./.............
2.5.2.	What were the lesions?	Foot ❑ Mouth ❑ Teat ❑
2.5.3.	If it is still infected with FMD, when did it start?	Days ....
2.5.4.	If it was a long time ago, how long did it take to get recovery?	Days ....
2.5.5.	Did you inform the FMD case to authority?	Yes ❑ No ❑
2.5.6.	If so, to whom?	
2.5.7.	What kind of treatment did you give during the FMD infection?	Call a vet from LBVD ❑ Call a private vet ❑ Traditional way ❑ No treatment ❑
2.5.8.	How did your cattle get FMD infection?	

2.6. When did you buy these cattle? ..../................./.............

2.7. Where did you buy from? or from your own?

2.8. Where do you usually keep this cattle?

2.9. Have you given any other treatment during the last year? Yes ❑ No ❑

2.9.1. If so, why and what were the signs of illness?

....

....

2.9.2. What were the treatments?

....

....

2.9.3. How long did it take to recover from that illness? Days

2.10. How do you feed this cattle?

....

....

Q3. Ownership of livestock

3.1 Which livestock species do you have in your farm?

3.1.1.	❑ Cattle (Local cattle)	less than 1 year		Between 1-5 years		Total
		5- 10 years		10 years and above		
3.1.2.	❑ Cattle (Foreign breed dairy cattle only)	less than 1 year		Between 1-5 years		Total
		5- 10 years		10 years and above		
3.1.3.	❑ Buffalo	less than 1 year		Between 1-5 years		Total
		5- 10 years		10 years and above		
3.1.4.	❑ Sheep	less than 1 year		Between 1-5 years		Total
		5- 10 years		10 years and above		
3.1.5.	❑ Goat	less than 1 year		Between 1-5 years		Total
		5- 10 years		10 years and above		
3.1.6.	❑ Pig	less than 6 months		6 months to 1 years		Total
		1-5 years		5 years and above		
		6 months to 1 year		above 1 year		

Q4.	**Husbandry system**							
4.1.	How do you feed your livestock?							
	Commercial feed ❑ Homemade feed ❑	Grazing with attendant ❑ Grazing without attendant ❑	Self supported ❑ others ❑					
4.2.	Feeding		Catt	Buff	Sheep	Goat	Pig	Poult
	What do you feed your livestock?	Grass	❑	❑	❑	❑	❑	❑
		Straw/hay	❑	❑	❑	❑	❑	❑
		Bran	❑	❑	❑	❑	❑	❑
		Wheat straw	❑	❑	❑	❑	❑	❑
		Sesame cake	❑	❑	❑	❑	❑	❑
		Peanut cake	❑	❑	❑	❑	❑	❑
		Broken rice	❑	❑	❑	❑	❑	❑
		Bean power	❑	❑	❑	❑	❑	❑
		Bean husk	❑	❑	❑	❑	❑	❑
		Swill feeding	❑	❑	❑	❑	❑	❑
		others	❑	❑	❑	❑	❑	❑
		…………………………………………………………………………………… ……………………………………………………………………………………						
4.3.	Drinking water		Catt:	Buff:	Sheep	Goat	Pig	Poult:
	What is your water source for your livestock?	Well (Private)	❑	❑	❑	❑	❑	❑
		Well (Public)	❑	❑	❑	❑	❑	❑
		River	❑	❑	❑	❑	❑	❑
		Under ground(hand pump)	❑	❑	❑	❑	❑	❑
		Ponds	❑	❑	❑	❑	❑	❑
		Lake	❑	❑	❑	❑	❑	❑
		Others	❑	❑	❑	❑	❑	❑
		…………………………………………………………………………………………… ………………………………………………………………………………						
4.4.	Housing		Catt:	Buff:	Sheep	Goat	Pig	Poult:
	How do you raise your animal in your house?	Free range	❑	❑	❑	❑	❑	❑
		Tether	❑	❑	❑	❑	❑	❑
		Cowshed	❑	❑	❑	❑	❑	❑
		Pen	❑	❑	❑	❑	❑	❑

Q5. Economic survey

5.1. Have you experienced FMD outbreak in your herd? Yes ❑ No ❑

5.2. How many livestock species were involved in the FMD outbreak from your herd in last two years?
- Cattle ❑
- Buffalo ❑
- Sheep ❑
- Goat ❑
- Pig ❑

5.3. During the outbreak, did you need to hire draught cattle from others for your work? Yes ❑ No ❑

5.3.1. Why did you need to hire other draught cattle?

....

5.3.2. If so, how much money did you pay for each day? .... Kyats

5.3.3. How many days did you hire? .... Days

5.4. What kind of treatment did you give to the cattle infected with FMD?
- Call a vet ❑
- Traditional way ❑
- No treatment ❑

5.5. How much money did you spend for the treatment of the cattle infected with FMD? .... Kyats

5.6. After recovery, did you see any problems to use in your work? Yes ❑ No ❑

5.6.1. If so, what were these?

....

5.6.2 Are you still using the cattle being infected with FMD? Yes ❑ No ❑

5.7. Have you sold out the cattle after infected with FMD? Yes ❑ No ❑

5.7.1. If so, why were the problems?

....

5.8. Have you used vaccination against FMD in your herd? Yes ❑ No ❑

5.8.1. If so, how much did you pay for one dose of vaccine? .... Kyats

5.9. How many draught cattle do you have? .... heads

5.10. How many cultivation acres do you have? .... acres

5.11. What are your cultivation crops?

....

5.12. What is the current market value of your draught cattle? (for one head on average) .... Kyats

5.13. If you sell your draught cattle after being infected with FMD what will be the market value? .... Kyats

Q6. Awareness of FMD

6.1. Have you seen the following lesions in your village?

	Salivation (Cattle)	Yes	❑
		No	❑
		Not sure	❑
	Ulcer on tongue (Cattle)	Yes	❑
		No	❑
		Not sure	❑
	Lesion on hoof (Cattle)	Yes	❑
		No	❑
		Not sure	❑
	Lesion on gum (Cattle)	Yes	❑
		No	❑
		Not sure	❑
	Lesions on udder and teat (pig)	Yes	❑
		No	❑
		Not sure	❑
	Lesions on hoof (pig)	Yes	❑
		No	❑
		Not sure	❑

Q7. FMD information

7.1. Have you heard about an FMD outbreak in your village tract? Yes ❑ No ❑

7.2. If yes, when was the last outbreak? ..../............./...................

7.3. Within one year, how many outbreaks of FMD have you heard in your village tract? .... Don't know❑

7.4. How many cattle were involved in the outbreak occurred in last year? .... Don't know❑

7.5. How many animal species were involved in the FMD outbreak in the last year?

Cattle	❑	Buffalo	❑
Sheep	❑	Goat	❑
Pig	❑	Other	❑

7.6. How many animals were dead in the outbreak within last year? .... Don't know❑

Q8. Animal movement information

8.1. Do you know the animal movements around your village tract? (for trading) Yes ❑ No ❑

8.2. If yes, how do they carry livestock for trading?

drive on foot	❑
by car	❑
by ship	❑
by train	❑
other	❑

8.3. How many animals were involved in a group for trading? .... Don't know❑

8.4. How many times did you see that they were carried in a month? .... Don't know❑

8.5. Did they stop over in your village tract before they move on? Yes ❑ No❑ Don't know❑

8.6. If so, how many times in a month they did they come to your village tract? .... Don't know❑

8.7. Have you seen any sick animal in their group? Yes ❑ No❑ Don't know❑

8.8 If so, what species and how many?

Q9. General Information

9.1. How many households are there in your village? .... Don't know❑

9.2. How many cattle are there in your village? .... Don't know❑

9.3. How many buffalo are there in your village tract? .... Don't know❑

9.4. How many sheep and goats are there in your village? .... Don't know❑

9.5. How many pigs are there in your village tract? .... Don't know❑

9.6. Do you know that what are the common livestock diseases in your village? If you know, please mention.

Yes, I know❑ Don't know❑

1.	
2.	
3.	

9.7. Do you know which disease is the most economic important disease in your village? If you know, pleas mention.

Yes, I know❑ Don't know❑

1.	
2.	
3.	

9.8. Why it is important?

....

....

Appendix 3

Questionnaire form to study economic losses in household level by the consequences of FMD

Date …………………..
Code number Interviewer …………………..
Interviewer General Questions [ ]

1.	General Questions		
1.1.	District	………………….	
1.2.	Township	………………….	
1.3.	Village tract	[ ]	Village [ ]
1.4.	Name of respondent		[ ]
1.5	Age		………Years
1.6	Sex		Male ❑ Female ❑

2.	General information of household (from 1st April, 2007 to 31st March, 2008)					
2.1.	How many people share fund, have meal in your household? ………people					
2.2.	Do you own cultivation land Yes ❑ No ❑ If yes, how many acres own?		Paddy land …....... acres Plantation plot ....acres Culinary garden land ....acres			
2.3	How many participate in your farming enterprise?		………people			
	Kind of cultivating crop and production?		Crop	Production	Sell	Incomes
		1/				
		2/				
		3/				
		4/				
		5/				
		6/				
2.4.	Do you own livestock? Yes ❑ No ❑ If yes, what sort of species do you have?		Buffalo ❑ Cattle ❑ Sheep❑ Goat ❑ Pig ❑			
2.5.	How many new born livestock have you got from your farm during the studied period?		Buffalo ❑ Cattle ❑ Sheep❑ Goat ❑ Pig ❑			
2.6.	How was its market value of new born?		…………..Kyats			
2.7	How many animals died during the studied period?		……Buffalo …….Cattle…….Sheep …...Goat …….Pig			
2.8	What was the total value of loss of those animals?		…………..Kyats			
2.9.	What was the cause of death?					

3.1.	How many income businesses do you own in your household? List the type of business such as cultivation farm, selling glossary, dairy farm.	1/	
		2/	
		3/	
		4/	
		5/	
		6/	
3.2.	Which business tends to get the most income in your household?		
3.3.	Household income (any sort of income for the studied period)	Type of incomes	In Kyats
3.4.	Total household incomes (2007 Budget year)		
3.5.	Total household expenditure	**Type of expenditures**	In Kyats
		perishable expenditures	
		School fees	
		Family health	
		Charity	
		Animal feedstuff	
		Cost treatment of animal	
		Cost to buy new livestock	
		others	
		Total Expenditure	
3.6.	Explanations and calculations (if needed)		

4.1

How many cattle do you own?	total……….heads	
Calf	male …….heads	female …...heads
Adult	male …….heads	female …...heads
Old	male …….heads	female …...heads
Total	male …….heads	female …...heads
Working draught cattle	male …….heads	
Breeding cow		female …...heads

4.2.

How many buffalo do you own?	total……….heads	
Calf	male …….heads	female …...heads
Adult	male …….heads	female …...heads
Old	male …….heads	female …...heads
Total	male …….heads	female …...heads
Working draught buffalo	male …….heads	
Breeding female buffalo		female …...heads

4.3. If you are a cultivator

		minimum	most likely	maximum
1/	Total working day in a year			
2/	Cost of traditional treatment (in case of FMD)			
3/	Cost of treatment with vet (in case of FMD)			
4/	Total days used working draught cattle			
5/	Market value of a draught cattle (to buy)			
6/	Market value of a draught cattle without FMD (to sell)			
7/	Market value of a draught cattle after FMD (to sell)			
10/	Was there a progress at the end of working season of 2007 budget year? Explain?			

5.FMD information on the studied villages

5.1.	Have you experienced FMD outbreak in your herd since 2005 until now?	Yes ❑ No ❑
5.2.	How many livestock species were involved in the FMD outbreak from your herd in last two years?	Cattle ❑ Buffalo ❑ Sheep ❑ Goat ❑ Pig ❑
5.3.	During the outbreak, did you need to hire draught cattle from other for your work?	Yes ❑ No ❑
5.3.1.	Why did you need to hire other draught cattle?	
5.3.2.	How many working draught you hired?	…… heads hired
5.3.3.	If so, how much money did you pay for each day?	.... Kyats
5.3.4.	How many days did you hire?	.... days
5.4.	What kind of treatment did you give to the cattle infected with FMD?	Call a vet ❑ Traditional way ❑ No treatment ❑
5.5.	How much money did you spend for the treatment to the cattle infected with FMD?	.... Kyats
5.6.	After getting recovery, did you see any problems to use in your work?	Yes ❑ No ❑
5.6.1.	If so, what were these?	
5.6.2	Are you still using the cattle being infected with FMD?	Are you still using the cattle being infected with FMD?
5.7.	Have you sold out the cattle after infected with FMD?	Yes ❑ No ❑
5.7.1.	If so, why were the problems?	
5.8.	Have you administered vaccine against FMD to your cattle?	Yes ❑ No ❑ Not remember ❑
5.8.1.	How much does it cost for one dose?	.... Kyats
	....	
5.9.	What is the current market value of your draught cattle? (for one head on average)	.... Kyats
5.10.	If you sell your draught cattle after being infected with FMD what will be the market value?	.... Kyats

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