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An Overview of the Occurrence of FMD in Thailand and Policies for its Control

by

Tatjana Kehren and Clem Tisdell

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'The overall goal of this project is to develop and evaluate the .necessary tools to provide decision-makers with reliable animal health information which is placed in context and analysed appropriately in both Thailand and Australia. This goal will be achieved by improving laboratory diagnostic procedures; undertaking research to obtain cost-effective population referenced data; integrating data sets using modern information management technology, namely a Geographical Information System (GIS); and providing a framework for the economic evaluation of the impact of animal diseases and their control.

A number of important diseases will be targeted in the project to test the systems being developed. In Thailand, the focus will be on smallholder livestock systems. In Australia, research will be directed at the northern beef industry as animal health information for this sector of livestock production is presently scarce.'

For more information on *Research Papers and Reports Animal Health Economics* write to Professor Clem Tisdell (c.tisdell@economics.uq.edu.au) or Dr Steve Harrison,(s.harrison@uq.edu.au) Department of Economics, University of Queensland, Brisbane, Australia, 4072.

AN OVERVIEW OF THE OCCURRENCE OF FMD IN THAILAND AND POLICIES FOR ITS CONTROL

ABSTRACT

At the third meeting of the Office International des Epizooties (OIE) Sub-Commission for Foot-and-Mouth Disease in Southeast Asia in February 1997, it was acknowledged that foot-and- mouth disease (FMD) is still present in most Southeast Asian countries, in particular Bangladesh, Cambodia, Laos, Malaysia, Myanmar, the Philippines, Sri Lanka, Thailand and Vietnam (OIE Press Release 1997). Direct losses equivalent to more than a quarter of the cattle, buffalo and pig production and considerable indirect losses for agriculture due to a shortage of working cattle are the consequences of FMD.

Generally, the incubation period for FMD is three to four days, but can range from two to fourteen days (Kitching and Mackay 1995). Up to 80 per cent of ruminants may become persistently infected after recovery from FMD, which means that these carriers can initiate fresh outbreaks (Donaldson 1994a). Immunity to FMD following vaccination is short lived and even vaccinated animals exposed to infection may become carriers. Moreover, even after recovery from infection with one serotype, animals still remain susceptible to infection with any of the other six types (Kitching and Mackay 1995). These factors outline some of the difficulties involved in any attempts of FMD elimination.

Keywords: Foot and mouth disease; Thailand; livestock disease; livestock vaccination;

JEL Classifications: Q160

AN OVERVIEW OF THE OCCURRENCE OF FMD IN THAILAND AND POLICIES FOR ITS CONTROL

1. Overview

At the third meeting of the Office International des Epizooties (OIE) Sub-Commission for Foot-and-Mouth Disease in Southeast Asia in February 1997, it was acknowledged that foot-and-mouth disease (FMD) is still present in most Southeast Asian countries, in particular Bangladesh, Cambodia, Laos, Malaysia, Myanmar, the Philippines, Sri Lanka, Thailand and Vietnam (OIE Press Release 1997). Direct losses equivalent to more than a quarter of the cattle, buffalo and pig production and considerable indirect losses for agriculture due to a shortage of working cattle are the consequences of FMD.

Outbreaks of infectious diseases such as FMD are quite common in rural Thailand. FMD was first recorded in Thailand in 1953. Control measures managed to eradicate the disease from Southern Thailand by 1959, but numerous outbreaks of FMD have been detected since the early 1970s, with type O predominating (Von Kruedener 1985). Today, the disease is virtually endemic in Thailand, apart from the Southern area. With the growing commercialisation of the Thai cattle industry, the elimination or at least control of this disease is vital for the country's trade in cattle.

The FMD virus is capable of persisting in cattle for two to three years (Doel, Williams and Barnett 1994). Seven serotypes (A, C, O, Asia 1, SAT-I, SAT-2 and SAT-3) of FMD exist which can be further subdivided into a number of subtypes and variants (Malirat et al. 1994, Kitching and Mackay 1995). Three strains of the foot-and-mouth disease virus were reported in Thailand during the 1950s and despite the implementation of control measures since 1956 are still endemic throughout the country except the Southern area (Kehren and Tisdell 1997). The vast majority of recent FMD outbreaks in Thailand consisted of types O and Asia 1, a small number of outbreaks were caused by the type A virus, and a large number of animals were affected by one or several still unidentified virus types.

FMD is regarded as one of the most contagious of all animal diseases. There is contradicting evidence as to the most common means of infection of animals with the FMD virus. Infection of cattle and buffaloes seems to most commonly occur via the respiratory route, but can also

take place through wounded or damaged skin of the animal (Donaldson 1994a). Animal movement (and movement of contaminated animal products) is therefore most important in the transmission of FMD, followed by people in contact with incubating or diseased animals, vehicles which transport infected animals, airborne spread and spread by carriers.

Generally, the incubation period for FMD is three to four days, but can range from two to fourteen days (Kitching and Mackay 1995). Up to 80 per cent of ruminants may become persistently infected after recovery from FMD, which means that these carriers can initiate fresh outbreaks (Donaldson 1994a). Immunity to FMD following vaccination is shortlived and even vaccinated animals exposed to infection may become carriers. Moreover, even after recovery from infection with one serotype, animals still remain susceptible to infection with any of the other six types (Kitching and Mackay 1995). These factors outline some of the difficulties involved in any attempts of FMD elimination.

2. Official and Unofficial Data on FMD in Thailand

In order to realize the impact of FMD in Thailand and possible measures for elimination of the ease, one has to analyse the data available. It is very difficult to obtain reliable information on the incidence of FMD in Thailand. Outbreaks are not always reported to authorities, nor are the animals infected fully vaccinated. In addition, incidences may be underreported to international bodies, including the Office International Des Epizooties. Table 1 displays recent data available from the OIE and from various records of the Department of Livestock Development in Thailand on the number of animals infected by FMD in Thailand.

Table 1: Number of FMD infected animals in Thailand according to various OIE and DLD sources

	1992	1993	1994	1995	1996
OIE Animal Epidemiology Reports	7,246	18,090	1,361	63	2,235
OIE World Animal Health in 1993		2,521			
FMD Information Centre, Division of Disease Control, DLD	339,268				
Unpublished Report of the DLD			1,885	1,012	187
Yearly Statistics Report, DLD				6,330	

It is obvious that these figures from different sources vary immensely. If the OIE's figure of FMD infected animals for the year 1992 is compared with the one given by the FMD Information Centre at the Department of Livestock Development in Thailand, a vast difference is visible (see Table 1). While the OIE's total number of infected animals is only 7,246, the figure given by the FMD Information Centre at the DLD is 339,268. However, discrepancies in data from the OIE and the DLD should theoretically be impossible, as weekly and monthly surveillance reports of FMD provided by the FMD Information Centre are also sent to international agencies, including the OIE (Chaisrisongkram 1994).

Yet, similar inconsistencies exist concerning data for other years. In 1994, the number of infected animals amounted to 1,885 according to the Department of Livestock Development, whereas the figure provided by the OIE is 1,362 animals. In 1996, the number of cases amounts to 2,235 according to the OIE, but only 187 according to the Department of Livestock Development. More distinct discrepancies exist for the year 1995. In fact, there are even contradictory figures which both are provided by the Department of Livestock Development in Thailand. According to the figure cited in the Department's Yearly Statistics Report 1995, the total number of FMD infected animals in Thailand in 1995 amounts to 6,330. Yet, in another publication by the same Department, the number of infected animals for has shrunk to 1,012. Both of these figures are in stark contrast to the figure published by

the OIE for the same year, which is only 63.

However, the Department of Livestock Development is not the only source with contradicting figures, the OIE itself also provides differing and contradictory statistics. While the number of infected animals in 1993 amounts to 18,090 according to their Animal Epidemiology Reports, the figure for the same year is 2,521[1] in their *World Animal Health in 1993 (Part 2)* publication. These inconsistencies serve as an indication of the extent of underreporting in official data regarding FMD in Thailand. With these contradictory figures, it is extremely difficult, if not impossible, to undertake accurate and reliable studies and predictions on the occurrence of FMD and its control in Thailand.

Considering that FMD is endemic in most of the regions in Thailand, one obvious impact of FMD to be expected is the resulting numbers of deaths of animals. According to official figures given by the. Office of Agricultural Economics in Thailand, there have been relatively few deaths of cattle and buffaloes from epidemic diseases in the country. Table 2 displays the number of deaths from epidemic diseases in Thailand from 1982 to 1995. Unfortunately, it is unknown which diseases are contained in these statistics, but it can be assumed that FMD was incorporated, considering its endemic nature in the country. FMD in adult animals does not usually result in a mortality rate above 5 per cent, but this rate can be up to 90 per cent in young stock (Donaldson 1994a). In comparison to the possible numbers of animals infected by FMD each year (see Table 1), the numbers of deaths of cattle, buffaloes and pigs from epidemic diseases in Thailand appear rather low.

[1] The accuracy of this figure might also be questioned, as the sum of individual cases infected by various FMD virus types (on the same page) yields 2,494. For more details, see OIE 1994b), p. 758.

Table 2: The number of animal deaths in Thailand from epidemic diseases, 1982-1995

Year	Buffaloes	Cattle	Swine	Total
1982	266	87	311	585
1983	36	18	40	94
1984	6	75	1,609	1,690
19	134	139	288	561
1986	34	9	-	43
1987	10	4	-	14
1988	3	1	28	4
1989	-	17	2	15
1990	35	44	1,231	1,310
1991	8	151	119	278
1992	1	57	57	115
1993	12	48	9	69
1994	38	444	81	563
1995	72	106	74	252

Source: Office of Agricultural Economics (1992) & DLD (1996) "Yearly Statistics Report 1995".

A neglected aspect in analyses of FMD in Thailand is the impact of the disease on pigs. Chamnanpood et al. (1995) claim in their study of the involvement of pigs in FMD outbreaks in Northern Thailand, that pigs rarely become clinically infected during outbreaks and play a minor role in spreading the disease. This result seems to contradict the high number of pigs infected by FMD. As can be seen from Table 3, the number of pigs infected by the disease in 1992 is more than double the number of cattle and buffaloes combined. In January/February 1993, a severe FMD outbreak occurred in Chachoengsao Province which affected over 60,000 pigs (Welte 1994).

Table 3: Foot-and-mouth disease outbreaks in Thailand in 1992 and number of animals infected

TYPE	NO. OF OUTBREAKS	NO. OF ANIMALS INFECTED		
		Cattle	Buffaloes	Pigs
O	54	16,599	7,044	185,685
A	14	5,527	1,476	-
ASIA 1	89	30,340	9,854	21,676
UNKNOWN*	39	31,207	4,369	25,491
TOTAL	196	83,673	22,743	232,852

* Old lesions; virus difficult to isolate or sample was too small.
Source: FMD Information Centre, Division of Disease Control, Department of Livestock Development; cited in Hanyanum et al. (1994), p.193.

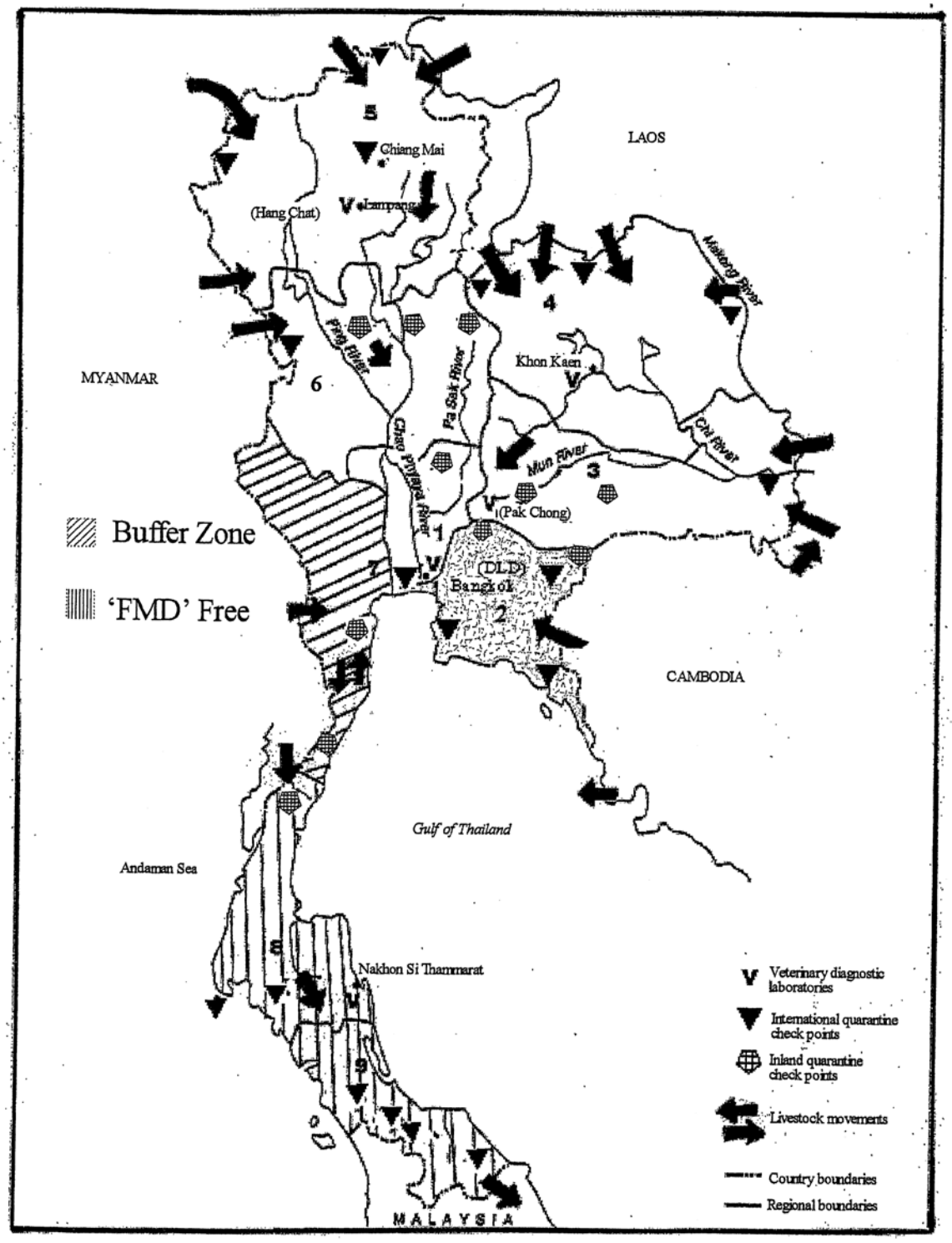
Compared with infectious excretions of cattle, buffalo, sheep and goats, the up to 400 million infectious units per day excreted by an infected pig are 3000 times higher (Kitching 1997). This means that even if the number of pigs infected by FMD is small, the risk of the disease spreading very quickly is high and suggests that increased attention of economists, scientists and veterinarians ought to be directed towards studying the impact and consequences of FMD on pigs in Thailand.

3. Control of FMD in Thailand

3.1 Animal movement

Attempts continue to be made in an effort to control outbreaks of FMD in Thailand and minimise their impact. For the study and evaluation of the dynamics of FMD, the Department of Livestock Development in Thailand commenced in 1991 the Foot-and-Mouth Disease Prevention and Eradication Project, which included the establishment of a FMD Information Centre (Meephuch 1994).

It is known that FMD is endemic not only in Thailand, but also in Cambodia, Laos, Malaysia, Myanmar and Vietnam, which are the countries bordering Thailand, as well as in the Philippines. It is also known that both legal and illegal movements of animals across the borders of these countries are increasing every year. Figure 1 illustrates the movement patterns of cattle and buffaloes in Southeast Asia.



Source: Based on Haryanum et al. (1994), p.195.

Figure 1: Quarantine check points and livestock movements in Thailand

Due to these movements of livestock across national borders, control programmes to eradicate FMD in Thailand can only be successful if they are designed to include and cooperate with the control programmes of other Southeast Asian countries. As previously mentioned, animal movement is by far the most important method of FMD transmission. Restriction of animal movement across borders is likely to be difficult to implement in Southeast Asia, as the import of animals is not likely to cease in the near future.

A number of strategies for the control of FMD in Thailand have been implemented with little success, involving the establishment of an FMD information system, control of animal movements, stamping out and mass vaccination programmes (Hanyanum et al. 1994). Stamping out is the approach involving the slaughtering of infected herds as well as animals in direct or indirect contact with the disease. While this policy can be very effective in the termination of an epidemic in the short term, the control of a rapidly spreading outbreak is likely to be problematic, considering the logistical and financial problems involved in an extensive slaughtering policy.

3.2 Vaccination

Two types of vaccinations can be used to eliminate or control FMD: ring vaccination and barrier vaccination. The former involves vaccination around the outbreak to contain the disease to a specific geographical area, whereas the latter refers to vaccination of susceptible animals in a buffer zone to prevent the spread of FMD. Animal movement control and vaccination are the main strategies for the control of FMD in Thailand.

Details concerning the types of vaccines used in Thailand against foot-and-mouth disease seem to be inconsistent. According to Doughty et al. (1995b), three monovalent vaccines have formed the basis of the vaccination programme at the time of his study. However, as can be seen from Table 4, the use of monovalent vaccines was rather sporadic and irregular in 1995. Compared with the use of bivalent and trivalent vaccines against FMD (Table 5), the number of animals vaccinated with monovalent vaccines was very small.

Chaisrisongkram (1994) from the Department of Livestock Development in Thailand, on the other hand, claims that the Northern and North eastern regions of the country (regions 3, 4, 5 and 6, see Figure I) receive around 4 million doses of trivalent and 5 million doses of monovalent vaccines per year. Trivalent vaccines are supposedly only used for animals on the move, in the border areas and at auction markets. Table 5 displays the provincial reports on

the number of animals vaccinated against FMD in Thailand according to the DLD's Yearly Statistics Report 1995. With the exception of region 6, the use of bivalent vaccines is much greater than trivalent vaccines for both cattle and buffaloes. Similar use of vaccines is also practised with pigs, with bivalent vaccines being used to a much greater extent than trivalent vaccines throughout Thailand, apart from regions 5 and 6.

Table 4: Number of animals vaccinated against FMD in Thailand in 1995 by type of monovalent vaccine

	TYPE O			TYPE A			TYPE ASIA 1		
	Cattle	Buffalo	Pigs	Cattle	Buffalo	Pigs	Cattle	Buffalo	Pigs
Region 1	0	0	2,590	0	0	0	0	0	37
Region 2	0	0	17,125	204	26	0	0	429	
Region 3	7,280	0	80	1,050	10,538	0	100	5,728	
Region 4	0	0	125	52	96	0	94,254	138,194	6,975
Region 5	0	0	1,075	4,133	2,030	0	298	11,458	2,181
Region 6	202	0	460	2,179	173	453	4,699	425	
Region 7	0	0	0	13,414	2,841	-	-	-	-
Region 8	0	0	0	0	0	0	0	0	
Region 9	0	0	0	490	0	0	0	0	
TOTAL	7,482	0	21,455	21,522	15,704	453	99,351	156,234	9,531

Source: Based on DLD (1996) "Yearly Statistics Report 1995".

Table 5: Number of animals vaccinated against FMD in Thailand in 1995 by type of bivalent and trivalent vaccine

	TYPE O-A & TYPE O-ASIA 1			TYPE O-A-ASIA 1		
	Cattle	Buffalo	Pigs	Cattle	Buffalo	Pigs
Region 1	712,307	76,155	113,930	175,340	24,506	67,106
Region 2	236,711	165,116	615,652	2,320	278	277,601
Region 3	773,791	1,066,354	10,844	601,399	303,486	5,625
Region 4	1,357,586	1,652,093	25,445	168,990	196,054	9,000
Region 5	705,161	170,989	358	354,825	74,313	4,136
Region 6	385,736	90,277	4,768	501,498	136,883	18,045
Region 7	1,114,068	24,967	1,032,211	1,407	1	373,380
Region 8	54,656	4,039	10,874	1,467	1,989	5,025
Region 9	12,408	260	3,345	9,518	54	0
TOTAL	5,352,424	3,250,250	1,817,427	1,816,764	737,564	759,918

Source: Based on DLD (1996) "Yearly Statistics Report 1995".

According to Chamnanpood et al. (1994a), one of the principal features of the mass vaccination of cattle and buffaloes in Thailand is a coverage of at least 70 per cent in villages twice a year. However, studies indicate that vaccinating 70 per cent of village cattle and buffaloes twice per year is not sufficient to prevent the spread of the FMD virus, and vaccination levels of over 80 per cent, preferably as close to 100 per cent as possible, are required to ensure herd immunity (Cleland et al. 1994, Gleeson et al. 1994b). An alternative of a course of two vaccinations one month apart followed by six monthly boosters substantially enhanced the overall level of herd immunity, but still required coverage rates in excess of 80 per cent for continuous protection against outbreaks (Cleland et al. 1994).

Several reasons for the failure of vaccinations against FMD in Thailand exist. Unti11991, a type O vaccine was mainly used even though types Asia 1, A and O have been prevalent in outbreaks. A further reason relates to inadequate vaccination of animals. Twice-yearly vaccination of approximately 70 per cent and non-vaccination of some herds because of a fear of abortion are insufficient to ensure herd immunity (Cleland et al. 1995). In addition, strain differentiation studies carried out by Gleeson et al. (1994a) indicate that two subtypes of type A viruses are present in Thailand, A15 and A22. While the historical A15 vaccine can offer protection against most of the other type A strains, it cannot protect against the A22-related viruses. It is unknown whether an A22-related vaccine would protect against the A15-related viruses. Moreover, Straub (1995) explains that type A has always been known to mutate frequently and rapidly, resulting in identification difficulties. This seems to be an important point for future research. Since antigenic variation among FMD viruses can affect the protective capacity of vaccines used in control programmes, field strains ought to be actively monitored in order to use the appropriate vaccine strain, in particular as a large number of animals infected by unidentified FMD virus types still exist in Thailand.

Not only the appropriate types of vaccines used, but also their effectiveness and correct application for the prevention of FMD in Thailand need to be ensured. Some veterinarians question the usefulness of trivalent vaccines and deem their effectiveness reduced. Moreover, the situation at the village level and the implementation of vaccinations by farmers require increased attention. In a survey of sixty villages in Northern Thailand where 90 per cent of villages had reported at least one outbreak of FMD in the past five years prior to the interview, it was found that the introduction of infected animals from a public market or surrounding village, and the mingling of infected cattle and buffalo while grazing or watering

with those of an infected neighbouring village were the most common sources of the most recent outbreak (Cleland et al. 1995). Most outbreaks occurred during the wet season, suggesting that vaccinations should be most effective just before the onset of the wet season. Farmers did not regard FMD as a major health threat and substantial differences in vaccination cover existed between the villages. Fear of abortion resulting from vaccination and the difficulties involved in gathering animals for vaccination were the principal reasons for not vaccinating.

Moreover, until very recently, vaccine production in Thailand was insufficient and vaccines had to be imported. Mass vaccination of all susceptible animals in Thailand also involves substantial costs. According to Chaisrisongkram (1994), 42 million doses of vaccine would be required per year which exceeded the vaccination possibilities at the time of writing by far. Tables 6 and 7 illustrate the production of virus vaccines against FMD in Thailand in recent years. Since 1986, production capacities have increased considerably overall, yet not without substantial fluctuations. In 1995, only 615,900 doses of type A vaccine and around 11.5 million doses of type O-Asia 1 vaccine were produced for cattle, and close to 11 million doses of type O-Asia 1 and trivalent vaccines were produced for pigs (see Table 5). These figures still fall far short of the required amounts of FMD vaccines in Thailand.

However, Thailand now claims to have achieved self-sufficiency in vaccine production. The purpose of the new vaccine factory at Pak Chong was for the production of sufficient trivalent FMD vaccines for the mass vaccination programme. It is planned to fully vaccinate animals in regions 2 and 7 as well as animals at risk in region 1, but to only vaccinate congregating cattle and buffaloes in regions 8 and 9 (see Figure 1). Considering the impossibility of managing FMD in Thailand through the control of animal movement, the focus should be on mass vaccinations, and more attention and research needs to be directed towards the types of vaccines used in Thailand.

Table 6: Production of FMD Vaccine Doses in Thailand from 1986 to 1995

Year	Doses
1986	6,953,400
1987	10,527,750
1988	9,448,500
1989	10,983,400
1990	7,395,100
1991	3,181,300
1992	12,950,150
1993	33,146,100
1994	19,839,275
1995	22,926,325

Source: DLD (1996) "Yearly Statistics Report 1995", p.143.

Table 7: Production of FMD Virus Vaccines in 1995

Vaccine Type	Jan.-March	Apr.-June	July-Sept.	Oct.-Dec.	Total
O (cattle)	-	-	-	-	0
A (cattle)	615,900	-	-	-	615,900
Asia 1 (cattle)	-	-	-	-	0
trivalent (cattle)	-	-	-	-	0
O-Asia 1 (cattle)	1,043,250	10,501,975	-	-	11,545,225
O (pigs)	-	-	-	-	0
A (pigs)	-	-	-	-	0
Asia 1 (pigs)	-	-	-	-	0
O-Asia 1 (pigs)	5,951,250	825,000	1,060,125	-	7,836,375
trivalent (pigs)	-	-	-	2,928,825	2,928,825
TOTAL	7,610,400	11,326,975	1,060,125	2,928,825	22,926,325

Source: DLD (1996) "Yearly Statistics Report 1995", p. 104.

4. The FMD Control Program in Thailand

The income for Thailand from livestock development is up to 10,000 million baht per year and the Department of Livestock Development is responsible for the control, prevention and eradication of infectious diseases in Thailand according to the Animal Epidemic Act B.E. 2499. A national Foot-and-Mouth Disease Control and Eradication Project has been implemented in 1991 under the supervision of the Division of Disease Control. Because of continuing spread of FMD due to inadequate vaccine supplies and a lack of cooperation from farmers and livestock traders according to the DLD, a new plan was developed in 1995 which consists of six basic elements[2]:

4.1 A mass vaccination campaign

It has finally been realized that at least 80 per cent of animals in a herd have to be vaccinated for a decreased severity of the FMD outbreak and a development of livestock immunity. It is planned that all cattle, buffaloes, sheep, goats and pigs are vaccinated twice a year, involving livestock officers and selected key men from each village. In the case of an outbreak, ring vaccination of all susceptible animals within 5 kilometres of the outbreak is implemented to control the spread of the virus. The time for animals from neighbouring countries in quarantine was increased from 10 to 21 days and they have to be vaccinated against FMD prior to being relocated to other areas.

A particular effort is made to vaccinate all susceptible animals in Regions 2 and 7 (see Figure 1). Region 7 is a buffer to Regions 8 and 9 on the Isthmus of Kra which is considered to be FMD free. Spot vaccinations only occur in Regions 8 and 9. Complete vaccination in region 2 is attempted in order to keep it free from FMD outbreaks, and regions 2, 8 and 9 are under preparation to be declared disease-free zones. Vaccinated animals are issued with vaccination certificates and ear tags or tail tags with an identifying code.

4.2 Animal movement control

A system of livestock movement licences and quarantine check points exists within the country to control and prevent illegal movement of animals. The number of international check points was reduced from 18 to 13, and there are 11 domestic check points. Provincial and regional livestock officers are responsible for the establishment of check points at other

[2] The following description of the Thai FMD Control and Eradication Project is primarily based upon an unpublished report by the DLD.

places, such as animal auction markets, along the border to other countries as well as mobile units. Furthermore, animals brought to auction are required to have an FMD vaccination certificate and movement documentation. The effectiveness of these measures is not necessarily clear, as they may be circumvented. It is well known that a number of animals are smuggled across borders, and animals are sometimes sold very quickly when being diagnosed as diseased. Since FMD infected animals do not display any obvious signs at the very beginning of the infection, inadvertent sales of infected cattle and buffaloes may also occur.

4.3 Public relations activities

In order for a vaccination programme against a disease to be successful, all participants have to cooperate. The necessity to control and eradicate FMD is advertised through the mass media to inform livestock fanners, vendors, the agribusiness industry, officials and government agencies, as well as other people responsible for the implementation of the project.

4.4 Epidemiological studies

Epidemiological studies will provide important information to plan an effective control and eradication programme and support the existing one. They involve an investigation of the causes of FMD outbreaks, the pattern of disease occurrence, the factors influencing the spread of the disease and the development of an FMD information system for the collection and analysis of information on outbreaks, including active serological testing to search for any possible carriers.

4.5 Stamping out

Stamping out is used as a means to decrease the likelihood of spreading the FMD virus, involving the slaughtering of infected herds as well as animals in direct or indirect contact with the disease. This measure is emphasised in areas with low incidence of the disease or when FMD has not been widely spread. In a 1994 OIE publication, it was stated that farmers do not receive compensation from the DLD for the slaughtering of FMD infected animals, but according to an unpublished recent report by the DLD, the farmer owning the infected animals will receive compensation according to the rules of the Department of Livestock Development. Details about these rules are not mentioned.

4.6 Technical cooperation with neighbouring countries

Considering Thailand's geographical position, an effort to control FMD outbreaks and the control of animal movement along the country's border requires strong cooperation with neighbouring countries, including Cambodia, Laos, Myanmar and Vietnam. With the support of the international community, Thailand expects to serve as a centre for FMD diagnosis, vaccine production, staff training and epidemiological studies.

5. Conclusion

The elimination of FMD is difficult due to the disease's considerable number of serotypes and subtypes, and its highly contagious nature. In Thailand, the elimination of FMD is even more difficult because data regarding disease incidences is contradictory and not easily available. In addition, vaccination of animals is insufficient and inadequate, and respective data on the types and doses of vaccines used also display inconsistencies. The role of pigs in Thailand with respect to FMD control has been neglected, and inevitable movements of livestock within Thailand and across borders increase the likelihood of FMD transmission.

If the new plan for FMD elimination in Thailand is to be successful, more efforts need to be directed towards the causes of FMD outbreaks, the appropriate use of vaccine types in Thailand, the factors affecting the spread of the disease, the cooperation between all neighbouring countries, and the full disclosure of genuine data concerning FMD in Thailand.

6. Bibliography

Baldock, F.C., Cleland, P.C., Chamnanpood, P. and L.J. Gleeson (1994), pp. 26-32 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Larnpang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Blacksell, S.D., Gleeson, L.J., Chamnanpood, C., Nakarungkul, N. And C. Megkamol (1992) 'A Comparison of Type 0 Foot and Mouth Disease Virus Field Isolates from Northern Thailand', *Revue Scientifique et Technique Office International Des Epizooties*, **11**(3), 761-767.

Cameron, AR., Baldock, F.C., Chamnanpood, P., Cleland, P.C. and M.J. Johnson (1994) 'Estimating Sample Sizes for a Two Stage Sampling Survey of the Level of Protection Against Foot and Mouth Disease in Northern Thailand', *The Kenya Veterinarian*, 18(2), 198-201.

Chaisrisongkram, W. (1994), pp. 23-25 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Chamnanpood, P., Cleland, P.C., Baldock, F.C. and L.J. Gleeson (1994a) 'Epidemiological Investigations of Foot-and-Mouth Disease Outbreaks in Northern Thai Villages', pp. 33-37 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Chamnanpood, P., Cleland, P.C., Baldock, F.C. and LJ. Gleeson (1995) 'The Minor Role of Pigs in Outbreaks of Foot-and-Mouth Disease of Northern Thailand', *Australian Veterinary Journal*, **72** (4), 142-144.

Chamnanpood, C., Gleeson, L.J. and M.D. Robertson (1994b) 'Antibody Responses to Foot-and- Mouth Disease Virus VIA Antigen Monitored During a Field Vaccination Trial', pp. 45-48 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Cleland, P.C., Baldock, F.C., Chamnanpood, P. and L.J. Gleeson (1996) 'Village Level Risk factors for Foot-and-Mouth Disease in Northern Thailand', *Preventive Veterinary Medicine*, **26** (3-4) 253-261.

Cleland, P.C., Baldock, F.C., Gleeson, L.J. and P. Chamnanpood (1994) 'A Modelling Approach to the Investigation of Vaccination Strategies for Foot and Mouth Disease in Thailand', *The Kenya Veterinarian*, **18(**2), 394-397.

Cleland, P.C., Chamnanpood, P., Baldock, F.C. and L.J. Gleeson (1995) 'Questionnaire Survey of Foot and Mouth Disease (FMD) and of FMD Control by Vaccination in Villages in Northern Thailand', *Revue Scientifique et Technique Office International Des Epizooties*, **14**(3), 567-575.

Department of Livestock Development (DLD) (1996) '*Yearly Statistics Report 1995'*, DLD, Bangkok.

Doel, T.R, Williams, L. and P.V. Barnett (1994) 'Emergency Vaccination Against Foot-and-Mouth Disease: Rate of Development of Immunity and its Implications for the Carrier State', *Vaccine*, **12** (17), 592-600.

Donaldson, A.I. (1994a) 'Epidemiology ofFoot-and-Mouth Disease: The Current Situation and New Perspectives', pp. 9-15 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Donaldson, A.I. (1994b) 'Role of Refernce Laboratories in Foot-and-Mouth Disease Control Programs', pp. 100-103 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Doughty, W.J., Gleeson, L.J., Prasatsuwan, K. And A. Kongthon (1995a) 'Serological Comparison of Type A Foot and Mouth Disease Virus Isolates from Thailand', *Revue Scientifique et Technique Office International Des Epizooties,* **14** (3), 539-546.

Doughty, W.J., Lunt, R.A., Lingchongsubonkoch, W., Gleeson, L.J. and A. Kongthon (1995b) 'Serological Comparison of Type Asia1 Foot and Mouth Disease Virus Isolates from Thailand', *Revue Scientifique et Technique Office International Des Epizooties*, **14** (3), 547-555.

Ellis, P.R.(1994a) 'Information Systems in Disease Control Programs', pp.111-115 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International

Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Ellis, P.R. (1994b) 'The Economics of Foot-and-Mouth Disease Control, pp. 57-63 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Ferris, N.P. and AI. Donaldson (1992) 'The World Reference Laboratory for Foot and Mouth Disease: A Review of Thirty-Three Years of Activity (1958-1991)', *Revue Scientifique et Technique Office International Des Epizooties*, **11** (3), 657-684.

Ferris, N.P., Oxtoby, J.M. and J.F. Hughes (1995) 'Multiple-infected Diagnostic Specimens from Foot and Mouth Disease Endemic Regions', *Revue Scientifique ei Technique Office International Des Epizooties*, **14** (3), 557-565.

Gleeson, L.J., Chamnanpood, P., Cheunprasert, C., Srimasartitkol, N. and A. Trisasarom (1995) 'Investigation of an Outbreak of Foot-and-Mouth Disease in Vaccinated Dairy Cattle in Thailand', *Australian Veterinary Journal*, **72** (1), 21-24.

Gleeson, L.J. Doughty, W.J., Lunt, R.A., Linchongsubongkoch, W. and S.D. Blacksell (1994a) 'A Review of Strain Differentiation Studies in Thailand: Implications for Vaccination Programs', pp. 91-99 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Gleeson, L.J., Robertson, M.D., Doughty, W.J., Chamnanpood, C., Cleland, P.C., Chamnanpood, P. and F.C. Baldock (1994b) 'Serological Response of Village Cattle and Buffaloes in Northern Thailand to a Newly Introduced Trivalent Foot-and-Mouth Disease Vaccine', pp. 38-44 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Hanyanum, W., Awaiyawanon, K., Wongdee, R. And P. Musikul (1994) 'Thailand', pp.l9l-196 in Copland, J.W., Gleeson, L.J. and C. Charrmanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Horst, H.S., Dijkhuizen, A.A. and R.B.M. Huirne (1994) 'Modelling Risk and Economic Consequences of Contagious Animal Disease Outbreaks', The Kenya Veterinarian, **18** (2), 408-410.

Kehren, T. And Tisdell, C. (1997) 'The Thai Dairy Industry: Its Economic Evolution and Problems Raised by Land Rights and Cattle Diseases', forthcoming in Journal of the Asia-Pacific Economym Campbelltown.

Kitching, R.P. (1997) '*Review of FMD'*, http://www-pdic.vet.cam.ac.uk/Dis_Info/fmd2.html, [accessed 14/03/1997].

Kitching, R.P. and K. Mackay (1995) 'Foot-and-Mouth Disease', *State Veterinary Journal*, **S**(3), 4-8.

Kitching, R.P. and Salt, J.S. (1995) 'The Interference by Maternally-Derived Antibody with Active Immunization of Farm Animals against Foot-and-Mouth Disease', *British Veterinary Journal*, **151** (4), 379-389.

Konghton, A. (1994) 'Development of Laboratory Diagnosis of Foot-and-Mouth Disease in Thailand', pp. 87-90 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Kruedener, Baron von R. (1985) 'National Foot and Mouth Disease Control in Thailand', *GTZ*, January 1985, Eschborn.

Liebermann, H.T., Thalmann, G., Bartels, T. and A. Nockler (1993) 'Experiments on an Early Protection Against Foot-and-Mouth Disease Virus', *Acta Virologica*, **37**(2-3), 181-183.

Lombard, M.F. and C.G. Schermbrucker (1994), pp. 16-20 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Malirat, V., De Mello, P.A., Tiraboschi, B., Beck, E., Gomes, I. And I.E. Bergman (1994) 'Genetic Variation of Foot-and-Mouth Disease Virus During Persistent Infection in Cattle', *Virus Research*, **34** (1), 31-48.

Meephuch, Y. (1994) 'An Information System Developed for Montoring Foot-and-Mouth Disease Control in Thailand', pp. 116-118 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Murphy, T.D. (1995) Economics of Livestock Disease Control, Master Thesis (unpublished), The University of Queensland, Brisbane.

Office of Agricultural Economics (1992) *Agricultural Statistics of Thailand*, Office of Agricultural Economics, Bangkok.

Office of Agricultural Economics (1997) *Agricultural Statistics of Thailand*, Office of Agricultural Economics, Bangkok.

Office International des Epizooties (OIE) Press Release, 28 February 1997, 'Strengthening the Control of Foot and Mouth Disease in South-East Asia', Third Meeting of the OIE Sub- Commission for Foot and Mouth Disease in South-East Asia, Manila, http://194.2.74.10/press/a_280297.htm

Office International des Epizooties (OlE) (1994a) 'World Animal Health in 1993' Part 1, OIE, 1994, Paris.

Office International des Epizooties (OIE)(1994b) 'World Animal Health in 1993', Part 2, OIE, 1994, Paris.

Ozawa, Y. (1994), pp. 79-84 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*,

Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.•

Sasaki, M. (1994), pp. 75-78 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Sharma, P. (1994), pp. 116-125 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, September 6-9, 1993, ACIAR Proceedings No. 51, Canberra.

Straub, O.C. (1995) 'Foot-and-Mouth Disease. Challenge of Cattle after Multiple Vaccinations', *Comparative Immunology, Microbiology and Infectious Diseases*, **18**(4), 253-257.

Tisdell, C.A., Harrison, S. And Baldock, F.C. (1994) 'Assessing Public Programmes for Control of Animal Diseases in Developing Countries: General Economic Issues with Thai Examples', *The Kenya Veterinarian*, **18**(2), 236-238.

Welte, V.R. (ed.) (1994) 'Animal Health Yearbook 1993', *FAO, OIE and WHO*, Rome.

Welte, V.R. (ed.) (1995) 'Animal Health Yearbook 1994', *FAO, OIE and WHO*, Rome.

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