Epidemiology, pathogenesis and surveillance of the pig adapted strain of foot and mouth disease in Taiwan

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This thesis is presented for the degree of Doctor of Philosophy, Murdoch University, 2008.
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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SHIH-PING CHEN
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Abstract

Foot-and-mouth disease (FMD) is one of the most contagious infectious diseases of domestic and wild cloven-hoofed animals, particular in cattle, sheep, pigs, goats and domestic buffalo, as well as wild ruminants such as deer. In Taiwan, there was a severe outbreak of FMD after more than 60 years freedom from the disease. The virus strain, O Taiwan 97 from the March 1997 outbreak of FMD in Taiwan, however, has been shown to have a species-specific adaptation to pigs. Although there are 7 distinct serotypes of FMD found in different regions of the world, this study focuses on the pig-adapted type O strain of FMD.

After the FMD outbreak commenced in Taiwan, the spread of disease was very rapid and the whole of the western parts of Taiwan was affected within a few days after the diagnosis of FMD was confirmed. In some situations airborne transmission of FMD virus was suspected and it was speculated that this was the explanation for such rapid spread in Taiwan. Therefore, studies were conducted to investigate the transmissibility of O Taiwan/97 FMDV to susceptible pigs by direct and indirect spread including airborne spread in an enclosed animal house. This study showed that pigs in direct contact with challenged pigs became infected but none of the close-contact pigs became infected. These experiments clearly demonstrated that the pig adapted strain O Taiwan/97 was only efficiently transmitted by direct contact. This indicates that effective control against future outbreaks of pig adapted FMDV strains could be achieved by restriction of pig movement and stamping out if the outbreak has been detected in the early stages and prior to the
movements of pigs from the infected premises.

The measures used to control the Taiwanese FMD outbreak in 1997 were initially the slaughter of whole herds in the infected premises. However, with the rapid spread and large numbers of cases, the decision was taken to use universal compulsory vaccination of pig herds to control the outbreak when sufficient supply of vaccines was organized. Type O FMD vaccines were imported from a number of major FMD vaccine manufactures from around the world. Initially, vaccine efficacy for the imported vaccines was tested by measurement of neutralizing antibody titers in vaccinated pigs. To establish the relationship between serum neutralizing titers and protection from foot and mouth disease in pigs after vaccination, challenge studies were conducted with O/Taiwan/97 FMD in vaccinated pigs. Additionally, antibody responses to structural (neutralizing antibody) and non-structural proteins (NSP) were evaluated in vaccinated pig herds after primary and secondary vaccination in herds infected before and after vaccination.

In order to be able to monitor the circulation of virus in vaccinated pig populations, valid diagnostic kits based on the detection of antibody against NSP were required. These tests needed to be evaluated against pig sera derived from challenge studies and natural FMD outbreaks. Three commercially available ELISAs (Cedi, UBI and Checkit), which were available to differentiate infected from vaccinated pigs, were tested and results showed that the Cedi test had the optimal sensitivity and specificity for pig adapted type O FMD testing. This test was used to retrospectively evaluate the sera collected from infected and non-infected pig herds collected sequentially in the year after the 1997 FMD outbreak in
Taiwan. These studies also showed that the early vaccines used, stimulated NSP antibody production in swine herds that were vaccinated but not infected. This resulted in the requirement for purified FMD vaccines to be used when monitoring programs for FMD infection by NSP testing were in place. In these studies, it was also demonstrated that the purified FMD vaccines used later in the control program did not induce NSP antibody after multiple double dosage to pigs.

Although clinical FMD appeared to be successfully controlled with vaccination program in Taiwan it was essential for the eradication plan to maintain active surveillance for NSP reactors in the pig population. The UBI and Cedi NSP kits were applied as screening and confirmatory tests, respectively, to pig sera collected in auction markets distributed around Taiwan to monitor for evidence of the circulation of FMD virus. Herds with positive reactors were followed-up by clinical inspection and 15 sera from suspected herds were further sampled. Negative results were obtained from all these investigation. With the absence of clinical outbreaks and the lack of evidence of FMDV circulation in the field from the NSP reactor surveillance, the Taiwanese government has progressed the eradication plan to a progressive cessation of vaccination, commencing with banning of vaccination on one isolated island in December 2006. The absence of outbreaks on that island, paved the way for further cessation of FMD vaccination in Taiwan from July 2008.
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