MANAGING PIG HEALTH THROUGH BIOSECURITY PRACTICES

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ABSTRACT

The potential risk of animal infectious diseases is determined by considering the three components of the "disease triangle" that may combine to cause its occurrence: pathogen, host, and environment. If all the routes between every two of the three components are broken down, disease won't occur. Although the routine practice of vaccination is used for strengthening the potential resistance to disease of swine all over the world, the accumulation of pathogens leading to contain high titer pathogens in the environment may result in the infection of vaccinated pigs. In recent years, novel porcine epidemic diarrhea virus (PEDV) has spread worldwide. Even though pigs are vaccinated against PEDV, they may not get an enough level of protection against this disease. It is revealed that elimination of the pathogens existed in the environment can be achieved by following the biosecurity practices in the farm. This has been found essential in the prevention and control of diseases.

Keywords: Animal Infectious Disease, Management, Transportation Biosecurity, On-farm Biosecurity, Manure, Porcine Epidemic Diarrhea, Disease Control

INTRODUCTION

The importance of swine industry is spreading more and more worldwide. According to the report of the Foreign Agricultural Service, United States Department of Agriculture, global pork production is raised at 1.8 million tons compared to the forecast in November 2013, with the main growth mostly occurring in China and Russia. This is especially true in China, where not only the fewer outbreaks of swine diseases occur, but there is also better animal nutrition and the improvement of pigs' genetics has resulted in heavier marketing schemes. Also, government intervention programs to prevent the significant fluctuations in pork production led to a 2.3 million tons pork production increase. Now, China produces 57.0 million pork and accounts for over half of global pork production despite its low prices. We should have the precaution that China expands the pork production over the rest of world flat since 2012 (Fig. 1) (USDA FAS, 2014).

Taiwan and China are separated by Taiwan Channel in geography. People from both countries often visit each other, paving the way for the easy transmission of trans-boundary infectious diseases. Besides, the high frequency of human interaction via the international activities is also an important factor for the diseases to spread. There is an obvious example to give the evidence that is the spreading of novel porcine epidemic diarrhea virus (PEDV). The infection of novel PEDV showed significant morbidity and mortality in neonatal piglets. The virus is first identified in Europe and became the problems of swine production in Germany, France, Switzerland, Hungary, Italy, China, South Korea, Thailand, and Vietnam (Song and Park 2012). PEDV infection was first identified in the United States in May 2013. By the end of January 2014, the outbreak had occurred in 23 US states (Wang *et al*, 2014). The PEDV infection became a highlight in Taiwan in the beginning of 2014. All of these outbreaks of PED caused severe economic impacts in each country, and resulted in with increased costs related to vaccination and disinfection. The most important issue is that the PED has affected production

estimates in a number of North American, Asian, and South American countries. For example, the pork production of Taiwan may be low at 25,000 tons due to the PED outbreaks which are expected to reduce slaughter hog supplies (USDA FAS 2014, http://www.fas.usda.gov/data/livestock-and-poultry-world-markets-and-trade). This fact can be seen in the monthly statistic data of animal products' price reported by the National Animal Industry Foundation, which the price of marketing pig per kilograms in February and March 2014 is obviously higher than that of 2012 and 2013 (Fig. 2).

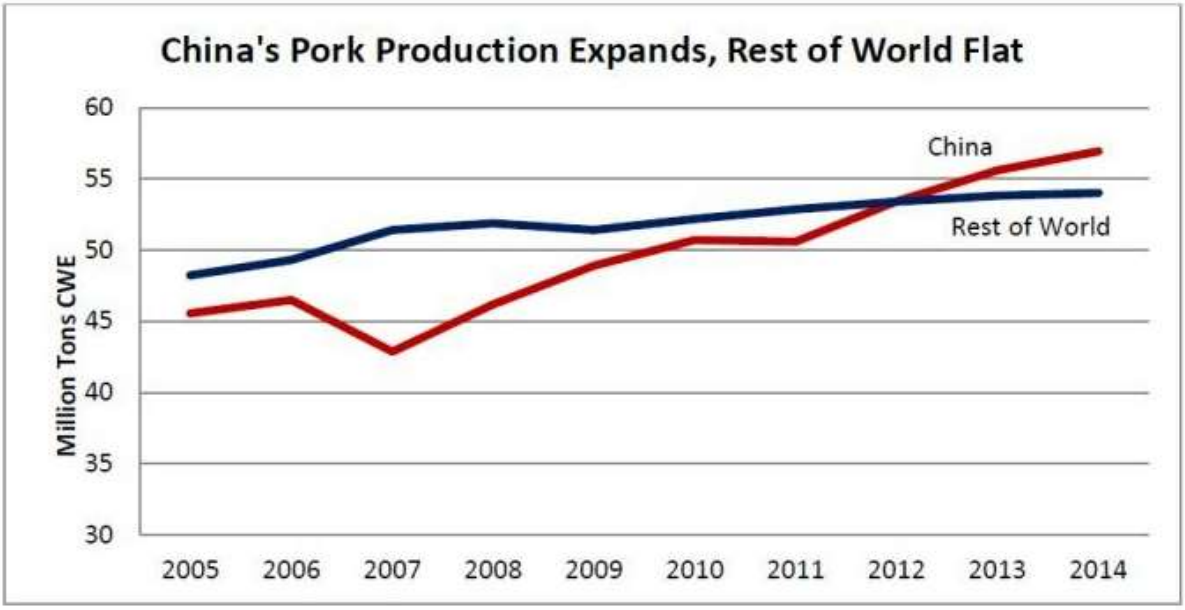

Fig. 1. China expands the pork production over the rest of world flat. (Come from Livestock and Poultry: World Markets and Trade. USDA FAS)
(http://www.fas.usda.gov/data/livestock-and-poultry-world-markets-and-trade)

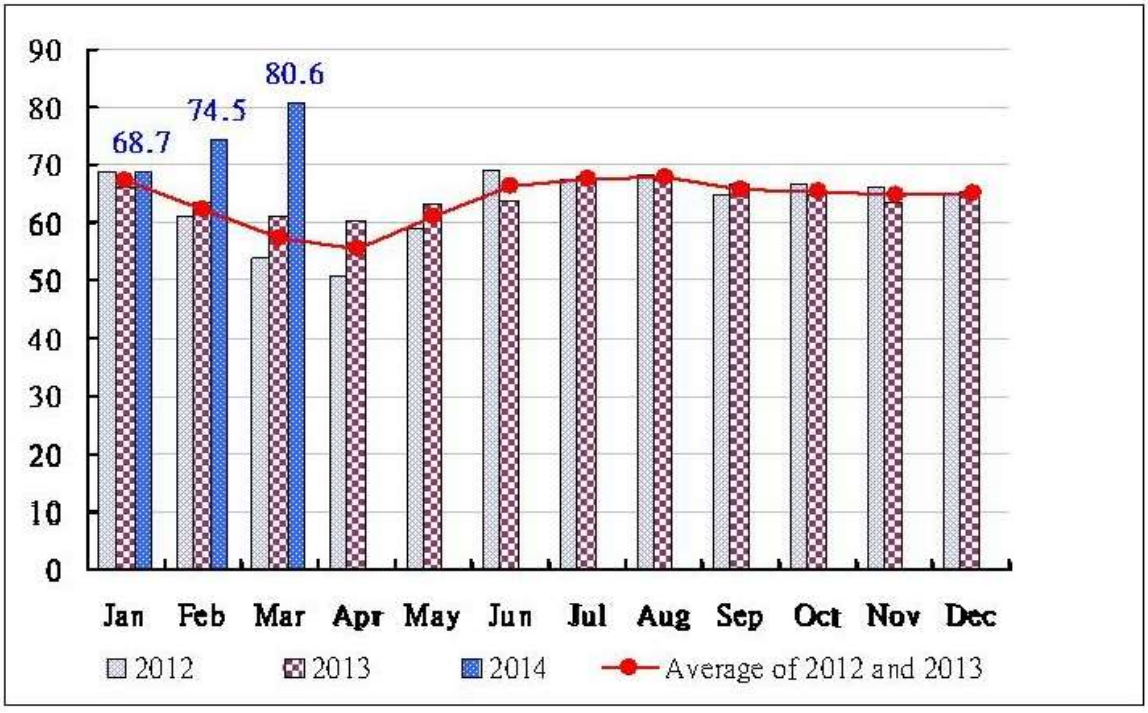

Fig. 2. The average price of marketing pig between 2012 and 2014 in Taiwan, the price is showed as NT$/kg.
(http://www.naif.org.tw/infoMonthly.aspx?pn=1&frontMenuID=46&sDate=&eDate=&key1=&frontTitleMenuID=37)

Pathogen, host, and environment compose the disease triangle. It attends to be used for the determination of the potential risk of animal infectious diseases. If the routes between two out of the three components are broken down, disease won't happen. Therefore, how to build a barrier between each two of the three components is very important, especially for the prevention and control of highly contagious animal diseases. To block down the route between pathogen and host, vaccinating pigs against pathogen to strengthen the resistant ability to pigs' diseases is the most common used measure. Besides, to block down the route between environment and host or pathogen, disinfecting the environment to eliminate its existing pathogen reduces the possibility of infection in pigs. The management of pigs' health and safety is essential in dealing with the management control of pig diseases. There are three reasons that have been addressed in the book "Managing pigs health". The first is "Some of the environmental hazards commonly associated with pig production can affect the health of both people and pigs; the second is "A positive pro-active approach to health and safety, just as with disease control, is helpful to the maximizing production, reducing costs and increasing profitability; and the third is "Good management practice is now as applicable to health and safety as it is to the activities of finance, personnel management and the control of pig diseases." (Muirhead and Alexander, 1997).

Management plays a biggest role in how disease is expressed in a pig herd; it can limit the transmission of disease within the farm as well as between farms. Biosecurity is one of the most important management tools to prevent disease transmission and expression. It refers to the protection of health through avoidance of diseases. To practice biosecurity at the farm level is a major measure of managing pigs' health. A broader definition of biosecurity is that farm managers implement measures to prevent the introduction of new infectious agents (viral, bacterial, fungal, parasitic, etc.) into a herd and to restrict the spread of already existed pathogens within a herd. Hence, biosecurity is presented as bio-exclusion (or external biosecurity) that combines all activities to preclude the introduction of disease to the farm; and bio-containment (or internal biosecurity) that refers to efforts to prevent the spread of a disease within the farm herd and to other farms (FAO/OIE/WB 2010). The introduction of infectious agents is not necessary in introducing diseases; owing to the infectious agents which do not always cause serious infections in pigs. It should be based on the situations of the routes among the components of disease triangle. If the infectious agent contains high pathogenicity, the pigs are weak, or high concentration of pathogens has been accumulated in the environment, then the infectious agents may cause serious infections in pigs. Besides, proper nutrition, care, and reduction of stress can also impact the clinical course of a disease. Since the performance of biosecurity is different in each farm; there is no "one size fits all" biosecurity plan. However, there are several science-based best practices, including controlled introduction of new stock onto a site, cleaning and disinfection of transport vehicles, all in all out production and the control of rodent vectors, etc, are considered practical for all producers.

This paper introduces a continuous farm as an example to describe the biosecurity practice at farm for managing pigs' health. The prevention and control measures are used to protect a farm from both entry of pathogens and internal transfer among different barns of the farm.

BIOSECURITY PRACTICE IN A CONTINUOUS PIG FARM

The infectious agents that are concerned in biosecurity

The infectious agents can be classified by different ways; those are microscopic and macroscopic, pathogenic (disease causing) and nonpathogenic to pigs, zoonotic (transmissible from animals to people) and non-zoonotic, and others. However, only two categories of infectious agents are a concern in biosecurity, including agents that are pathogenic in pigs and agents that are zoonotic.

1. Agents that are pathogenic in pigs

   There are numerous infectious agents that are pathogenic in pigs. Sometimes it is heard that producers do not worry about biosecurity because every disease has already existed in their pigs. However, only death is the true indicator that a pig that has contacted practically every disease available. At such situation, all of the producer's pigs should die. There is no more pig existing. Therefore, if every swine producer is still having pigs, the biosecurity is very important to them.

   Management is to minimize or eliminate the infectious agents to their effects on the health of a swineherd. It can control most infectious agents very well. However, few infectious agents can cause disease by themselves. Besides, multiple infectious agents will not be managed easily. Spending some cost for managing these inevitable infectious agents can prohibit disease outbreaks. Therefore, to implement the biosecurity practice is crucial for high health and conventional health herds. In fact, only producers who are utilizing relatively unobtrusive biosecurity protocols can maintain high health herds for decades.

2. Agents that are zoonotic

The definition of zoonotic is that disease caused by infectious agents can be transmitted between species. It can be from animals to humans or vice versa. Fortunately, there are very few zoonotic agents in pigs under modern swine husbandry. It is due to the fact that well cooked pork can eliminate food borne illnesses associated with pork production. However, good biosecurity practice is still an important element to maintain pork's excellent reputation in the marketplace.

The reasons to keep infectious agents out of pig herds

If pathogens have been introduced into a pig farm, compared to pigs free from these pathogenic agents, it will take more time, more work, and more money to raise pigs. Only the producers change their attitude to hold farm biosecurity completely, a new production world with lower working time, higher producing efficiency and lower disease management cost will come true.

There are four reasons to maintain adequate biosecurity in a pig farm. he First, the production associated with swine diseases will increase the cost for pork production. Second, making sure that there are provisions made to have a safe and wholesome products available to the consumers. Third, is producer enthusiasm, which is very important in pig production. The last reason is related to the trend towards restricting the use of antimicrobial agents in swine production. The ability to treat new infections in a swine herd may become more difficult due to the more restrictive livestock medicines. Therefore, to prevent new diseases from entering a pig farm will become more important.

Background of the continuous pig farm

The continuous pig farm located at middle of Taiwan and has been established for more than 30 years. A total of 6000 heads of pigs for fattening and 500 heads of sows are raised in this farm. Six workers and one veterinarian are employed. The efficiency of the farm: Liveborn piglets of per sow per litter are 9.28. The average litters of per sow per year are 2.24. The average death percentage of weaned piglets and fattening pigs is 0.73% and 8.29% respectively. This farm defended the FMDV invasion since the 1997 FMD epidemics in Taiwan successfully. The farm also has successfully prevented the novel PEDV invasion in the PED epidemic in Taiwan.

The 1997 FMD epidemics in Taiwan

On March 14, 1997, the first suspected samples of FMDV infection are sent to the Animal Health Research Institute (AHRI). The first identified FMD cases are confirmed on March 19, 1997 and located at two prefectures of northern Taiwan; the situation where Taiwan had been free from FMD for almost 68 years is terminated. Unfortunately, the FMD epidemic has spread around other 9 prefectures on March 22 in Western Taiwan. On April 11, the FMD epidemic almost covered the entire prefectures of western Taiwan (Fig. 3). The devastating outbreak of FMD in Taiwan resulted in the depopulation of more than 4 million of pigs and financial losses worth over 1.6 billion of U.S. dollars (Shieh, 1997; Tsai *et al*., 2000; Yang *et al.,* 1999).

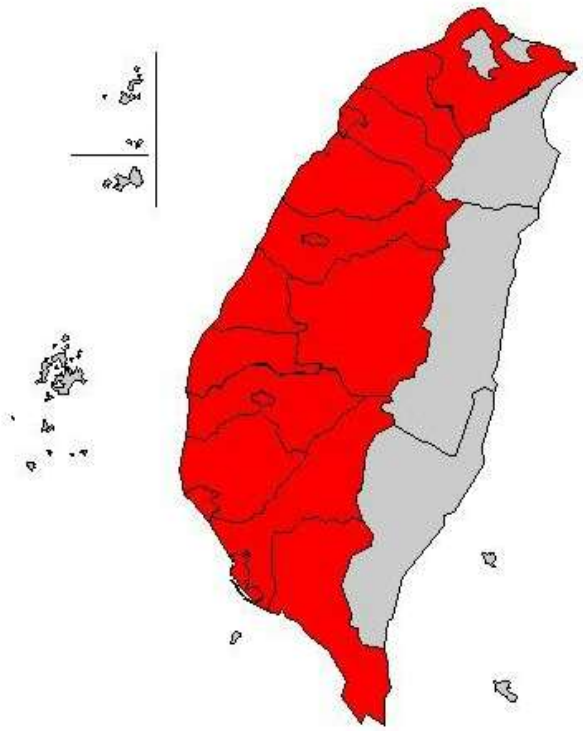

Fig. 3. The red area indicated that the outbreaks of FMD extended to the western part of Taiwan on April 11, 1997.

The novel PED epidemic in Taiwan

The novel PED epidemic could have possibly begun in October 2013 and has been terminated in early March 2014 in Taiwan. Basing on the animal industry monthly report of National Animal Industry Foundation, totally 1223 herds had been infected by the novel PEDV. The amounts of dead piglets that may be caused by the novel PEDV infection which totaled more than 200,000 during the PED epidemic in Taiwan. Table 1 showed monthly that the number of infected herds and the amount of dead piglets, which all suffered in diarrhea and brought to clinics, during the novel PED epidemic. (http://www.naif.org.tw/infoPublicationList.aspx?frontTitleMenuID=37&frontMenuID=44). According to the report of The China Post on March 5, 2014, the pork prices reached a 10-year high of NT$82.31 per kilogram because of the anticipation of shortages that may be caused by the PED outbreaks. The devastation outbreaks of novel PED also led the price of per piglet to increase up to NT$1,950 in late February 2014 (http://www.chinapost.com.tw/taiwan/business/2014/03/05/402036/Pork-prices.htm).

Table 1. The number of infected herds and the amount of dead piglets during the novel PED epidemic in Taiwan

Year. Month	Number of infected herds	Amount of dead piglets[a]
2013.10	**39**	**7529**
2013.11	**144**	**32853**
2013.12	**308**	**85061**
2014.01	**383**	**91532**
2014.02	**315**	**52927**
2014.03	**34**	**8555**
Total	**1223**	**219756**

[a]The dead piglets are showed diarrhea in clinics, which may be caused by the infection of novel PEDV.

The continuous farm competing against the invasion of FMDV during the epidemics

The owner of this continuous farm does his best to participate each workshop/symposium related to the management of farm. He says that he gets not only farm management knowledge but also information on the new epidemics on national level and international levels from the workshop/symposia. He can assess the risk basing on the new information. For example, he called for a meeting with his staff when there was an FMD outbreak in Taiwan in 1997. They discussed about the epidemic of FMD. Since Taiwan has been free from FMD for almost 68 years, they knew that the FMD epidemic would seriously damage the swine industry in Taiwan at that time. He asked his staff members to express their opinions on the decision of whether to continue or halt the operations of the business. He told to his staff that, if they won't work together to prevent the FMDV invasion, he could give the severance pay to them and he won't raise pigs again. But if they were willing to reserve this work, they should prevent the invasion of FMDV together. Consequently, they passed by the risk of FMD epidemic.

The biosecurity practice in the continuous farm

1. The farm implemented an effective external biosecurity practice, which is as following:
   (1) Quarantine replacement stock
   Owing to transportation of live pigs can potentially be a significant risk to herd health. There is a quarantine house for the observation of newly introduced pigs before entering the farm. The owner of this continuous farm will ensure that the health status of pigs is compatible with his herd. For this point, he always discussed with the owner or veterinarian of the donor farm about the health status of pigs. Besides, he attended to the regional production and marketing meetings to collect the information of swine production. He also exchanged the experiences of raising pigs and disease information with other farmers.
   (2) Restricted entry
   There is a gate to restrict the visitors and vehicles to enter the farm. Only the veterinarians of local disease diagnosis center and investigators can enter the farm. Normally, they will be asked to stay at the administration building of this farm. The salesmen of each animal drugs company will never get the permission to go into the administration of this farm. There is a visitor record book for the signature of visitors. The visitors should wash hands with disinfectant and wear shoes' cover before entering the farm. The feeds truck stopped outside the gate, the bagged feeds are transferred into the feeds warehouse of this farm by using the owner's pick-up truck.
   (3) Minimize entry of equipment and take appropriate precautions
   The entry of any new equipment or supplies may increase the possibility of carrying the pathogens into the farm. Therefore, shipping boxes of any equipment or supplies are taken appropriate disinfection before being sent into the farm. Even the boxes of packaged vaccines or drugs are disinfected in advance.
   (4) Prevent entry by wild animals or pets
   In order to prevent the wild animals (rats, birds, insects) or pets (dogs, cats) to enter the farm, there are doors and brick perimeter walls for isolating the farm. The ground inside the farm is covered by cement that can give certain prevention against the entry of rodents. Each barn is covered with purse nets to prevent the entrance of birds.
   (5) Artificial insemination
   The farm used a semen supplier that is free from pseudorabies and PRRS viruses. Testing for PRRS virus and other infectious agents is routinely implemented. The packages of materials for artificial insemination are disinfected upon entering the farm.
   (6) Feed and water sources
   For ensuring the feed and water sources are free from infectious agents, the farm purchased bagged feeds from contracted company, water is supplied from well(s) at least 15 meters deep in the farm.
   (7) Loading place
   Transportation of pigs can indeed be a key to avoid the introduction of infectious agents into the farm. Since this continuous farm located beside a main road, the traffic is very busy. Moreover, truck may carry pigs from farm to farm or from farm to auction market, and can be contaminated by different infectious agents that may be pathogenic to pigs at a new farm. In order to eliminate the risk of introducing pathogens into the farm via the market truck, the owner set the loading place for marketing pigs at road side, which is far away from the gate of this farm. Furthermore, the owner of this continuous farm used a inter-sanctum truck to transfer the finishing pigs to the market truck at the loading place.
   Finishing barn/loading crew personnel are on the chute to gather the pigs uploading to the inter-sanctum truck. Two load-out crews are driven the truck to the loading place and helped to upload pigs to the market truck. The loading crew personnel do not enter the market truck. The inter-sanctum truck will be disinfected before moved back inside the farm. The loading crew personnel will dress a new set of coveralls and boots when the inter-sanctum truck has been disinfected, and farm personnel will clean and

disinfect hoses before carrying them back into the farm.

2. The farm also performs an effective internal biosecurity practice, which is as following:
   (1) Personnel movement within the farm
   Normally, visitors will not be allowed to enter the farm, only with the exception of the auditor and pigs' health inspectors which doe their routinely duties. The visitors will be asked to follow the basic biosecurity principles of the farm; they should wear the visitor's boots and coveralls, then wash their hands with disinfectant and walk through a disinfectant trough to get them to enter the farm.
   Staff members should change into dedicated boots and coveralls and wash hands with disinfectant and walk through a disinfectant trough upon entering the farm. Inside the farm, there is a clean footbath in each barn. Visitors or staff members should always dip their boots into the footbath before entering each barn. Visitor or staff members should follow the order of movement that is moving downstream within the farm. For example, movement between rooms and/or barns should be from the healthiest to the sickest pigs, it is usually from youngest to oldest.
   (2) Boots hygiene
   Since boots are easily contaminated with manure in pig farms, it will reduce the efficiency of disinfectant, even though there are boot baths in the barn's entrance. Basing on the study of Dr. Amass *et al* in 2000, scrubbing visible manure off in a water or disinfectant bath can reduce bacterial counts in the surface of boots. It meant that removing manure from boots will enhance the efficacious of disinfectant.
   There is a long-handle brush that is used to scrub the boots near the entrance of each barn. Visitors or employees should scrub their boots with hose water, then to pit in the boot baths before entering the barn. The used boots should be scrubbed and washed in the boot station, then soaking the boots in a clean bath of disinfectant for 30 minutes. After washing with water, the boots are air dried for further use.
   (3) Prevent entry by pets or mosquitoes and rodents
   There are no dogs or cats allowed in the farm. Besides, there is an evaporative cooling system, in which the incoming air is pulled through a corrugated fiberboard through which water is circulated over, for raising the last stage of fattening pigs. This system has an environment controller to set the desired room temperature, fan speed/run time settings, may prevent the entry of mosquitoes and rodents. The farm patched potholes have been routinely installed to eliminate the stagnant water that may breed mosquitoes; it has also implemented strategic insecticide spraying during the summer months. The most important event is that the farm has kept facilities clean every day and has performed a whole farm regular disinfection each week.
   (4) Loose pigs
   Unidentified pigs are not allowed back into the barn when they have been found to escape from the barn during handling or loading. Only the loading cull or market pigs will be loaded directly into the market truck. The rest are kept in the quarantine house for further identification.
   (5) The disposal of dead pigs from the farm
   Dead pigs are collected daily at each barn. The dead pigs will be gathered by using a Bobcat from the opposite side of the dead container and will be moved to the location of dead container that is outside the farm. The Bobcat will be cleaned and disinfected thoroughly after the dead pigs have been deposited in the container. Then the Bobcat will be moved back to the production side by the same route.
   (6) Farm sanitation at empty status
   In breeding and gestation barn, the vacated crates, troughs, floors, aisles, walls, and ceilings will be washed with a high-pressure washer when a group of sows are moved. Hallways are cleaned whenever the movement of sows is completed. This will be followed by further washing and cleaning and disinfecting. Then, the pigs will be kept air dry for at least three days. Disinfection will be carried out before new sows are moved in.
   In the farrowing house**,** a thorough cleaning will be implemented when the house is empty. The cleaning included the walkways and the crate assemblies and floors, sow feeders and creep feeders, the walls, ceilings, and water lines, wall fans and buckets, scrapers, foot pans, feed carts, and any equipment used in the farrowing house. Disinfectant is applied by using a hand sprayer and kept air dried for at least three days. The disinfection of farrowing houses and walkways with another disinfectant will be carried out before moving the sows from gestation to the house.
   In nursery and finishing barn, the floors, walls, and feeders will be washed with a high-pressure washer when pigs are moved. Alleyways are cleaned. Disinfectant is applied by using a hand sprayer and kept air dried for at least three days.
3. Review of biosecurity plan and herd health status
   For evaluating whether the farm biosecurity plan is effective or not, the owner regularly discussed with his veterinarian. Meanwhile, he also made a conversation with his staff members. If some of the plan is difficult to implement, they will discuss more details and make a modified plan to replace the original one. On the other hand, the owner paid much attention to the vaccination efficiency. He always checked the antibodies

level, which are induced by vaccination, of vaccinated pigs at a certain period after vaccination. For example, he implemented four kinds of vaccination programs against FMDV. Those are, pigs received the first dose of FMD vaccine at 8, 10, 12, and 14 week-old, and are boosted at four weeks after the first vaccination. The sera samples are collected from tested pigs before vaccination and at four weeks post vaccination, and are sent to the national laboratory (AHRI) for detecting the serum neutralization (SN) antibody titers. The SN antibodies titers are expressed as the reciprocal of the highest serum dilution neutralizing the virus at the 50% end point. Based on the results, he found that the best vaccination program of FMD is vaccinating pigs at 14 week-old and boosting at 18 week-old in his farm (Fig. 4).

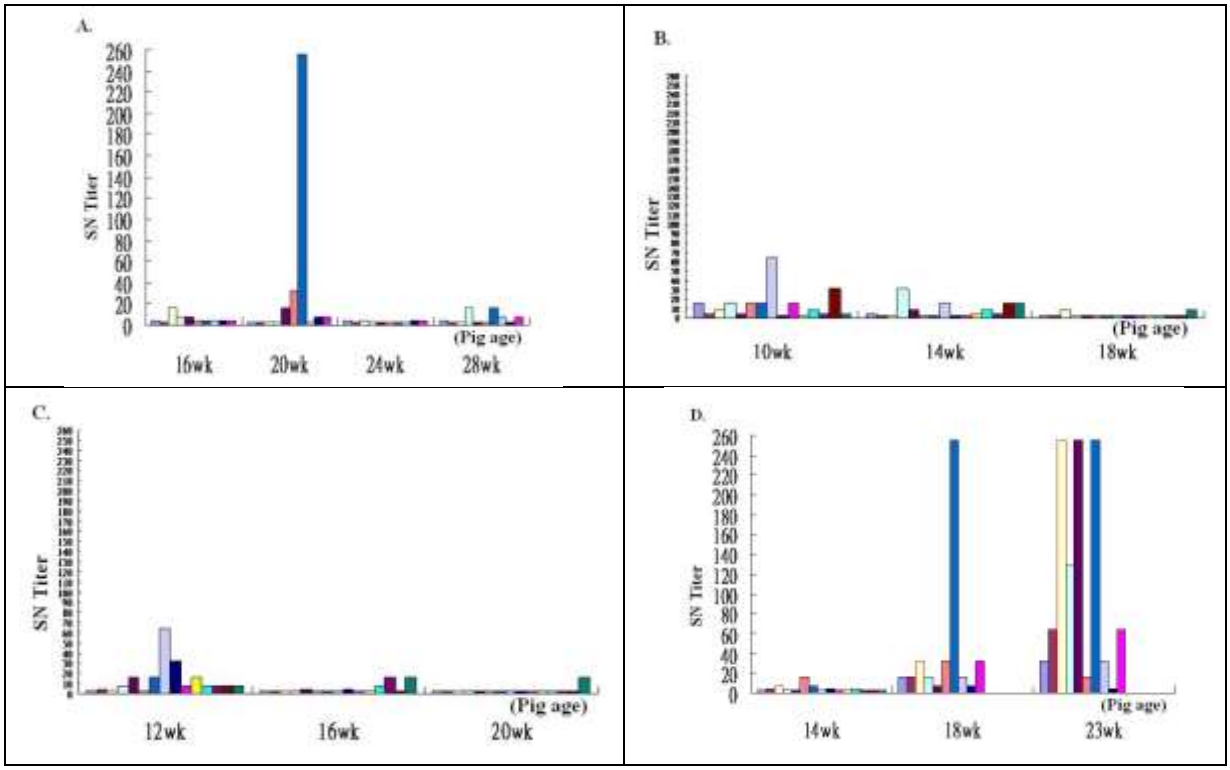

Fig. 4. To assess the vaccination efficiency of different vaccination program in the continuous farm. A showed that the sera SN antibody titers of those pigs received the first dose of FMD vaccine at 8 week-old, and are boosted at 12 week-old; B indicated that the sera SN antibody titers of those pigs received the first dose of FMD vaccine at 10 week-old, and are boosted at 14 week-old; C demonstrated that the sera SN antibody titers of those pigs received the first dose of FMD vaccine at 12 week-old, and are boosted at 16 week-old; D shown that the sera SN antibody titers of those pigs received the first dose of FMD vaccine at 14 week-old, and are boosted at 18 week-old.

CONCLUSION

Owing to convenient transportation, animal diseases are now easily categorized as “transboundary”. Not only humans but also animals can carry the pathogens. Three elements compose the disease triangle. The pathogen plays an important role in the disease formation. The easiest way to infect a pig herd with a new infectious agent is with an already infected pig or pigs. In other words, pigs are the best source of these infectious agents. Every infectious agent that enters a swine farm potentially increases the cost of production; the time spent in the barn, and this can decrease productivity and producer enthusiasm. When a farm overloads the infectious agents, there is no drugs, no barn design, no manager’s expertise can compensate. The most important key to limit the transmission of disease within the farm and between farms is biosecurity practice. From the example of continuous farm, biosecurity is not just an issue for high health herds but also is considered an important key to maintaining productivity, profitability, and producer enthusiasm and food safety.

REFERENCES

Amass SF, Vyverberg BD, Ragland D, Dowell CA, Anderson CD, Stover JH, Beaudry DJ. 2000. Evaluating the efficacy of boot baths in biosecurity protocols. *Swine Health Prod*. 8(4): 169-173.

Chen Ted. 2014. Pork prices reach 10-year high amid epidemic. The China Post. (http://www.chinapost.com.tw/taiwan/business/2014/03/05/402036/Pork-prices.htm)

Food and Agriculture Organization of the United Nations/World Organisation for Animal Health/World Bank. 2010. Good practices for biosecurity in the pig sector – Issues and options in developing and transition countries. FAO Animal Production and Health Paper No. 169. Rome, FAO.

Livestock and poultry: world markets and trade. United States Department of Agriculture, Foreign Agricultural Service, April 2014. (http://www.fas.usda.gov/data/livestock-and-poultry-world-markets-and-trade).

Monthly statistics of animal products' price, National Animal Industry Foundation. (http://www.naif.org.tw/infoPublicationList.aspx?frontTitleMenuID=37&frontMenuID=44).

Muirhead M R, Alexander T J L. 1997. Managing Pig Health. 5m Publishing, United Kindom.

Shieh HK. The FMD situation in Taiwan. *J Chin Vet Sci* 23: 395–402, 1997.

Song D, Park B. 2012. Porcine epidemic diarrhoea virus: a comprehensive review of molecular epidemiology, diagnosis, and vaccines. Virus Genes 44(2):167-75.

Tsai, CP, Pan, CH, Liu, MY, Lin, YL, Chen, CM, Huang, TS, Cheng, IC, Jong, MH, Yang, PC, 2000, Molecular epidemiological studies on foot-and-mouth disease type O Taiwan viruses from the 1997 epidemic. *Vet. Microbiol*. 74, 207-216.

Wang L, Byrum B, and Zhang Y. 2014. New variant of porcine epidemic diarrhea virus, United States, 2014. Emerging Infectious Diseases 20(5):917-919.

Yang, PC, Chu, RM, Chung, WB, Sung, HT, 1999, Epidemiological characteristics and financial costs of the 1997 foot-and-mouth disease epidemic in Taiwan. Vet. Rec. 145, 731-734.